Table 7
Summary of Opinion of Probable Project Costs
for Blacksnake Design Event E Detention Basin [1]

Item	Alternative E Design Event E Detention Basin, $
Detention Basin	
Dam Embankment	1,380,000
Excavation	2,910,000
Piping	54,000
Riprap	611,000
Planting/Seeding/Mulch	70,000
Flood Protection/Fill (placeholder) [2]	0
Site Remediation (placeholder) [2]	0
Subtotal	*5,025,000*
Permitting	50,000
Subtotal	*5,075,000*
Sitework, Contractor General Requirements [3]	1,172,000
Subtotal	*6,247,000*
Contingency [4]	1,562,000
Land Acquisition (placeholder) [2, 5]	1,180,000
Opinion of Probable Construction Cost	**8,989,000**
Engineering, Legal, and Administration [6]	1,798,000
Opinion of Total Project Cost	**10,787,000**

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. It is assumed that these values are zero for the stormwater separation conduits.
3. Sitework projected at 10% of the total of equipment and structure costs. Contractor general requirements projected at 12% of the total of equipment, structures, and sitework costs.
4. Project contingency is projected at 25% of the total of all equipment, structures, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
5. Land acquisition cost is based on information provided by the City.
6. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.

The lowest cost alternative is Alternative C, which diverts Blacksnake Creek flows out of the Blacksnake Basin and into the Roy's Branch Basin. Roy's Branch Creek is an open channel that flows to the Missouri River and would therefore allow the creek flows to be diverted out of the CSS. However, Alternative C breaks one of the "rules of thumb" of stormwater management by allowing a cross-basin stormwater transfer. Typically, cross-basin transfers are avoided where possible because more flow is directed into a receiving stream than currently exists. Existing flooding problems and stream bank stability problems within Roy's Branch could become worse.

Furthermore, the City could be held responsible for any adverse changes this alternative might create in the Roy's Branch Basin. 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. Due to the aforementioned issues with Alternative C, it is not being recommended.

Of the remaining alternatives, Alternatives B and E have the next lowest project costs. Although Alternative B and E follow similar alignments, they are fundamentally different. Alternative B is a deep, gravity flowing, stormwater conduit sized to convey the peak flow from Design Event E (175 cfs) assuming no upstream detention. Alternative E assumes that an upstream detention basin and pump station captures and lifts water into a small open channel. The detention basin allows the peak flow from Design Event E to be attenuated from 175 cfs to 20 cfs. The open channel conveys the 20 cfs of flow to a 36 inch, near surface, stormwater pipe which leads to the Missouri River. The Alternative E stormwater channel/conduit is less expensive than the Alternative B conduit; however the upstream detention basin requires significant cost to excavate a storage volume to attenuate peak flows from 175 cfs to 20 cfs. In summary, the entire project cost of Alternative E, including both the conduit and the detention basin, is approximately $37.4 million compared to $39.7 million for Alternative B. Since these two values are within 10 percent of each other (i.e., 6 percent), at this level of study from an economic perspective, they are considered to be equal.

From a non-economic standpoint, however, the alternatives do have differences. Alternative B functionally adds 175 cfs of additional conveyance capacity to the Blacksnake Basin. As indicated previously, the Blacksnake Basin floods within the downstream CSS area, therefore, Alternative B would help offset some of the ongoing flooding problems within the basin. Alternative E only adds an additional 20 cfs of conveyance capacity and therefore would not help reduce flooding as much as Alternative B. Furthermore, Alternative E requires the use of a pump station for 24 hours a day, 365 days a year to divert base flows as well as divert wet weather flows up to those resulting from Design Event E out of the CSS. Alternative B relies upon gravity to divert

creek flows out of the CSS and therefore has no moving parts and no equipment to service.

In addition, because Alternative B is sized to convey the peak flow from Design Event E without upstream detention, it can always be configured to operate with a flood control focused (i.e., larger) detention basin. Alternative E is limited in that it requires a set detention volume to simply contain Design Event E so that the small pump station, sized for the attenuated peak flow, can divert the flows out of the basin. As a result, storage that could be dedicated to flood control and flood attenuation is being used to capture and divert small, CSO events.

Alternative B would be less expensive to operate and maintain than Alternative E. Alternative B would not require "regular" maintenance as this alternative would involve sporadic cleaning and upstream channel grubbing. Maintenance for Alternative B (as well as Alternatives A, C, and D) would depend upon the size, frequency, and duration of wet weather events along with the upstream creek conditions. For Alternative E, the pump station would require electricity to operate 24 hours a day, 365 days a year. In addition, an operator would need to visit the station on a somewhat regular basis to ensure that it is functioning properly.

The assumed operations and maintenance (O&M) unit costs are shown in Table 8, and Table 9 shows a projection for the Alternative E pump station annual O&M costs. As shown in Table 9, it is anticipated that a 20 cfs Blacksnake pump station would have an annual O&M cost of approximately $9,000. The gravity conduits (Alternatives A through D) would not require a consistent, regular O&M cost. All of the stormwater separation conduit alternatives assume that 0.1 percent of the capital cost is a typical annual value to be applied to operate and maintain the conduits. The annual O&M costs are presented in Table 10.

Table 8 O&M Unit Costs	
Power	$0.10/kW-hr
Labor (including benefits and overhead)	$32.78/hr
Notes: 1. All costs provided in May 2009 dollars. 2. Units costs based on data provided by the City.	

Table 9 Alternative E – Blacksnake Design Event E Pump Station Annual O&M Costs	
Dry Weather	$4,000
Wet Weather	$3,000
Maintenance	$2,000
Total	**$9,000**

Table 10 Blacksnake Stormwater Separation Conduit Alternatives Annual O&M Costs			
Alternative B, $	**Alternative C, $**	**Alternative D, $**	**Alternative E, $**
40,000	27,000	45,000	297,000
Notes: 1. O&M costs for the stormwater separation conduits are assumed to be 0.1% of the construction costs. These costs will help cover manhole cleaning, channel grubbing, and other miscellaneous repair activities. 2. The Alternative E O&M cost includes the $9,000 stormwater pump station cost, 0.1% of the conduit construction cost, and 3% of the detention basin construction cost.			

Based on project and O&M costs and the simplicity and flexibility, Alternative B appears to be preferable when excluding Alternative C. Although Alternative B is slightly more expensive (approximately 6 percent more than Alternative E), it has no moving parts, no pump station and associated O&M costs, and more flood control benefits. Therefore, Alternative B is the recommended alternative for the Blacksnake stormwater separation conduit.

6.0 Whitehead Detention Basin and Stormwater Separation Conduit

The Whitehead stormwater separation conduit is proposed to intercept and convey Whitehead Creek flows that are directed to the combined sewer system. Flows entering

the proposed Whitehead stormwater separation conduit will be directed to a dedicated stormwater outfall which will discharge flows to the Missouri River.

Four alternative alignments (Alternatives A, B, C, and D) were investigated for the Whitehead stormwater separation conduit. In addition, a variation to these alternatives (Alternative E) was investigated to determine whether the combination of a detention basin and smaller diameter stormwater conduit would be more cost effective than the other four alternatives. The benefits, drawbacks, and opinion of probable cost for each of these alternatives are presented in the following sections.

The Whitehead Creek separation conduit must be able to convey the peak flow from the Design Event E wet weather event (1.8 inch, 20 hour rain event) from the upstream drainage area of 5,220 acres. The Design Event E peak flow was derived from the calibrated hydrologic and hydraulic computer model developed for the 2008 LTCP and updated as part of the ongoing Facilities Plan. The model refinements accounted for updated 2008 flowmeter data collected as part of the Facilities Plan. The Whitehead Creek Design Event E peak flow is estimated to be approximately 263 cfs. This peak flow assumes no upstream detention and no peak flow attenuation. Stormwater conduit Alternatives A, B, C, and D are sized to covey this flow.

Alternative E assumes that a detention basin has been constructed upstream from the proposed stormwater separation conduit. Various locations for detention basins are being investigated and documented as part of Volume III (Whitehead Stormwater Detention Basin Facilities Assessment) of the Facilities Plan. However, to get a general sense of what a smaller detention basin, sized to hold Event E, might cost and how it would affect the size of the proposed stormwater conduit, a reasonable size and location was selected for an upstream Whitehead detention facility. A detention basin appears to be the most feasible near the location identified on Figure 9.

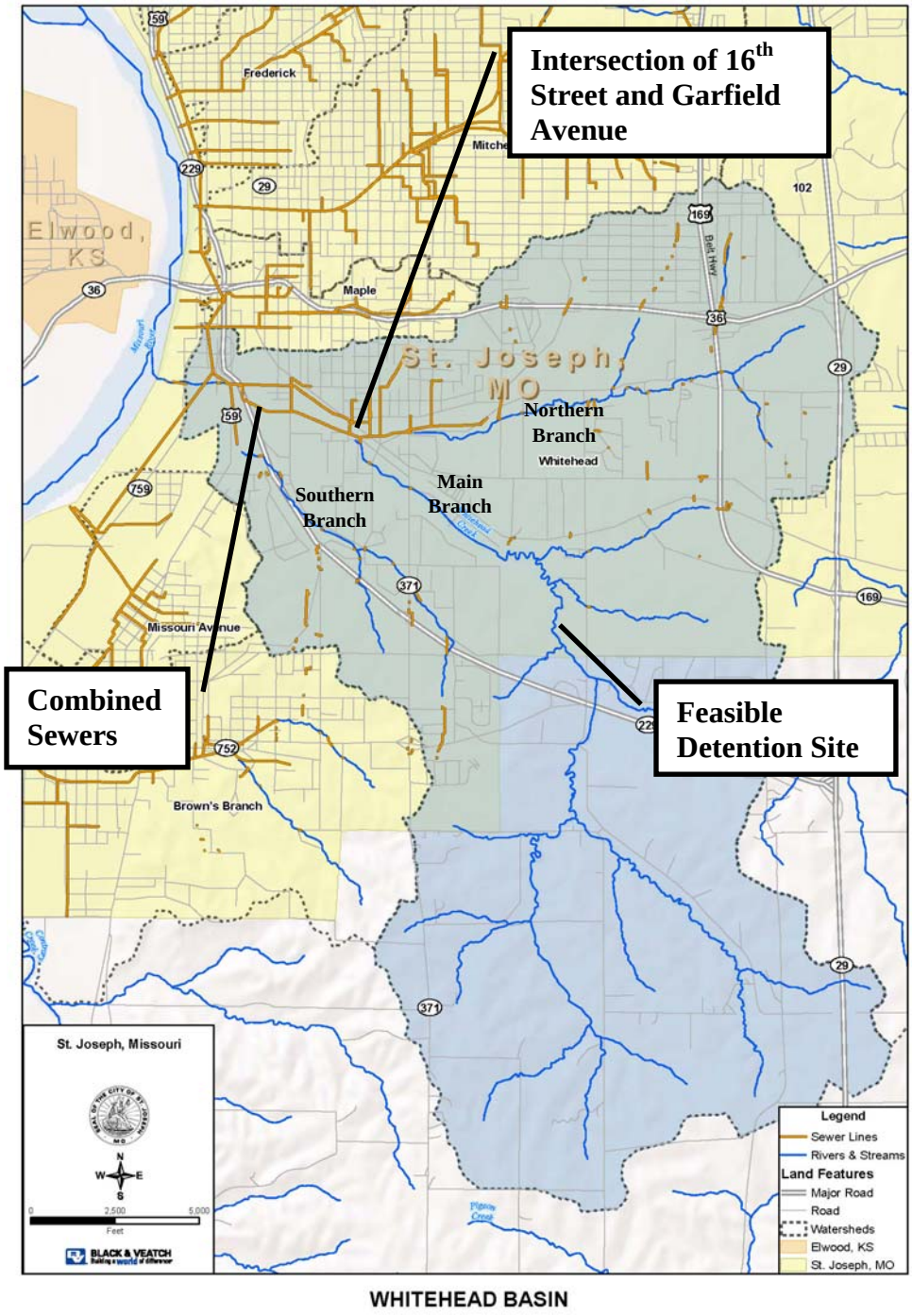


Figure 9 – Whitehead Basin Overview

It was assumed that a detention basin would require some aesthetic and community value besides being a dry bottomed "low spot" along the stream corridor. A wet detention basin was sized having a total storage volume of approximately 200 acre-

feet (120 acre-feet permanent pool, 80 acre-feet flood pool). The dam for the facility was sized to capture the existing conditions for an Event E runoff. The dam would be required to have a height of approximately 10 feet above the bottom of the creek bed and was assumed to be constructed using roller compacted concrete.

The upstream area would need to be significantly re-graded and excavated to provide a permanent pool. By cutting approximately 750,000 cubic yards of soil to make room for the wet pool and necessary storage volume, the detention basin would be approximately 500 feet wide. Modeling demonstrated that a facility having these characteristics reduced the Event E peak flow from 263 cfs to 85 cfs as it enters the existing CSS near 16th Street and Garfield Avenue.

All of the Whitehead stormwater separation alternatives have two basic structures in common, an upstream stormwater diversion structure/weir and a downstream outlet structure. The upstream diversion structure would be required to divert low flows into the separation conduit while allowing high flows (i.e., creek flows from events larger than Design Event E) to pass, via weir flow, back to the existing CSS. The diversion structure would be configured with the stormwater separation conduit located at the bottom of the structure and a high flow overflow weir to pass flows greater than the Design Event E peak flow back into the CSS.

The design of the upstream diversion structure must ensure that during high flows (i.e., flood flows), the structure itself does not cause any local flooding problems to worsen. This concern can be mitigated by selecting an appropriate weir crest height and weir length. For each of the five stormwater separation conduit alternatives (Alternatives A through E), an evaluation of an appropriate weir height and weir length was conducted to ensure that this potential problem was avoided.

The stormwater separation conduits are not sized to provide flood control. Significantly larger pipes would need to be installed to allow the 25-year storm to pass through the sewer system without the occurrence of flooding. The 1998 Comprehensive Stormwater Management Plan details the needed improvements to convey the 25-year event. The stormwater separation conduits recommended herein are sized to eliminate all base creek flows and the peak flows up to Design Event E (i.e., approximately a three

month storm) in an effort to achieve CSO control objectives as required by the USEPA and MDNR. Larger, more expensive separation conduits could be installed to provide both CSO and flood control, but this "buy-up" option is a decision that will need to be made by the City during preliminary design.

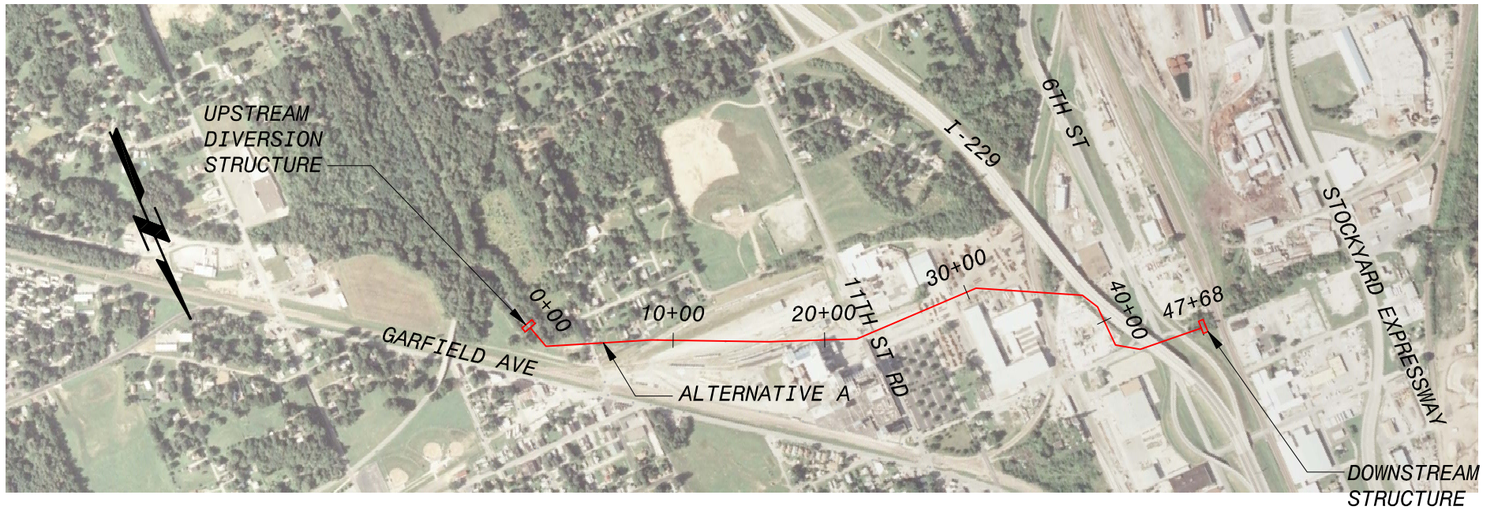
6.1 Alternative A – Pipe in Pipe

Whitehead Alternative A, as shown in Figure 10, proposes to place the stormwater separation conduit inside the existing large diameter combined sewer. Alternative A, also known as the pipe-in-pipe alternative, allows the existing large diameter combined sewer to serve as the encasement for the smaller stormwater separation conduit. This alternative would limit the amount of earthwork and excavation since the proposed pipe would be placed inside the existing combined sewer. In addition, at the downstream end of the Whitehead sewer, the existing diversion structure would need to be modified to allow the stormwater pipe to pass through or around it and to the Missouri River.

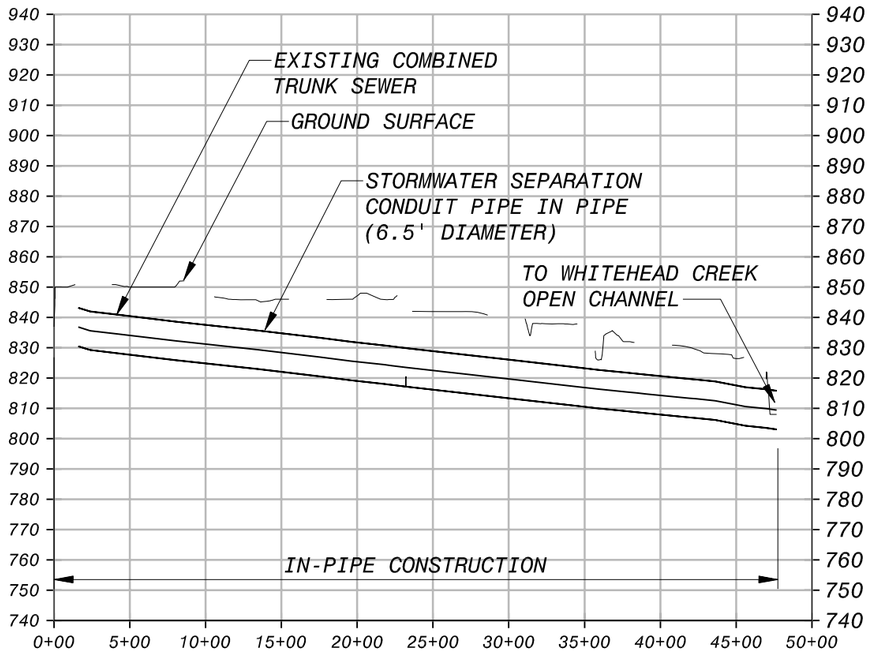
Similar to the Blacksnake Alternative A, the pipe-in-pipe alternative has significant drawbacks; therefore, this alternative is being removed from consideration. Unless future work performed as part of the Facilities Plan necessitates the need to revisit this approach, this alternative has been screened out and the associated opinion of probable cost is not presented.

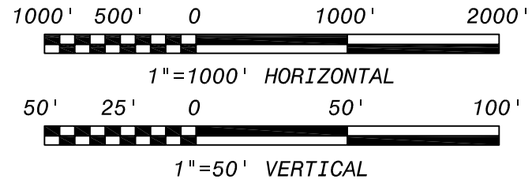
6.2 Alternative B – Stormwater Pipe South of Existing Combined Trunk Sewer

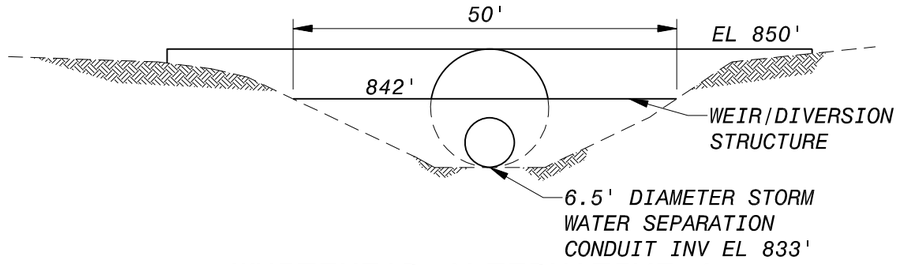
Whitehead Alternative B, as shown in Figure 11, proposes to place the stormwater separation conduit along the south side of the existing Whitehead combined trunk sewer. An advantage of Alternative B is that few existing combined sewers would need to be crossed. Near the downstream end of this alignment, the stormwater conduit would intercept an existing 8 foot combined sewer running along 6th Street. The existing 8 foot combined sewer conveys creek flows from the southern Whitehead Creek branch along with sanitary flows from local building sewer laterals. For Alternative B, the



ALTERNATIVE A (PIPE IN PIPE)
(47+75)







WHITEHEAD ALTERNATIVE A
WEIR STRUCTURE
1" = 20'-0"

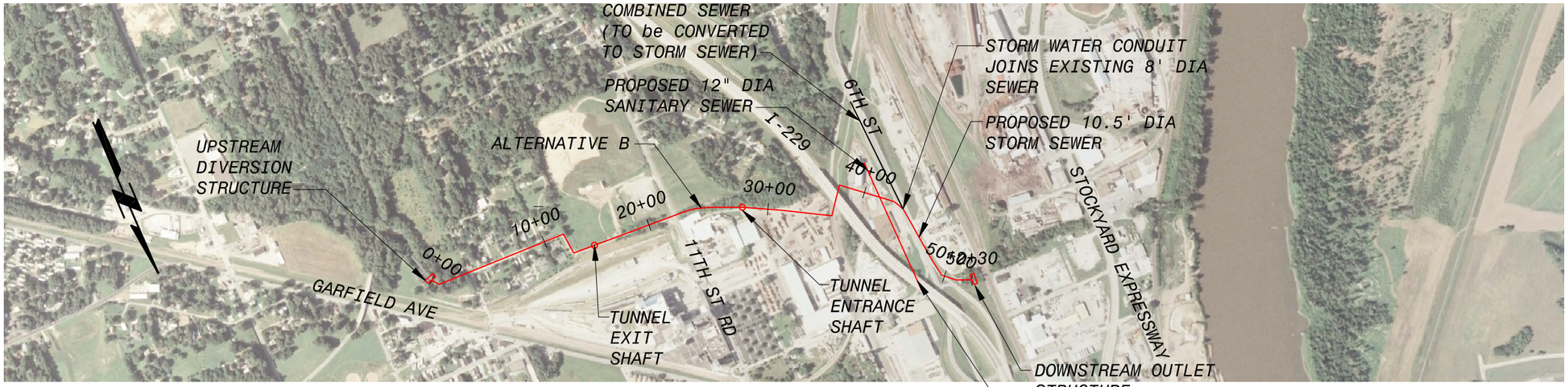
DATE	REVISION OR ISSUE	NO.	BY	CK	APP	DATE	REVISION OR ISSUE	NO.	BY	CK	APP

BLACK & VEATCH Corporation
PROJECT

ST. JOSEPH, MISSOURI
ALTERNATIVE A
WHITEHEAD CREEK STORMWATER
SEPARATION CONDUIT

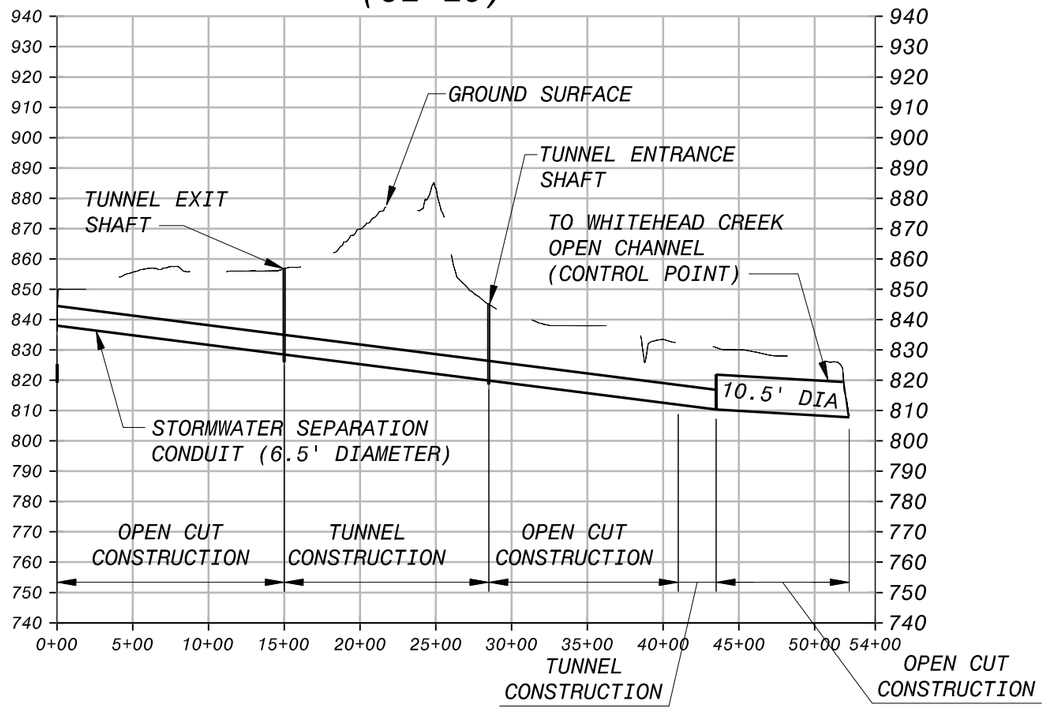
FIGURE 10

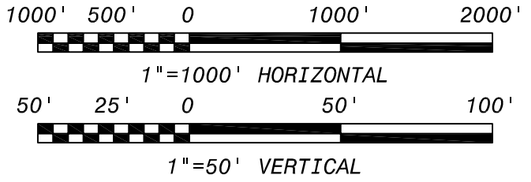
B50000
FB50000

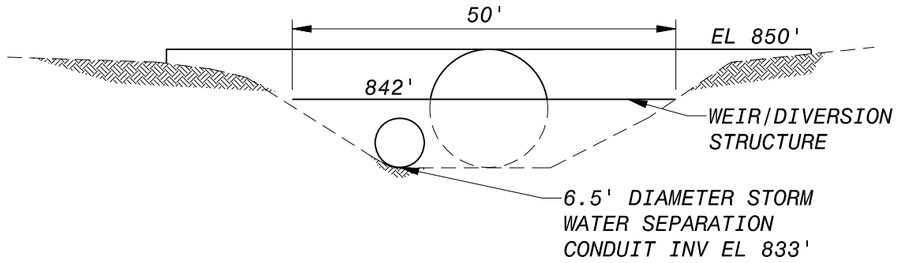


ALTERNATIVE B (SOUTHERN ROUTE)

(52+29)







WHITEHEAD ALTERNATIVE B

WEIR STRUCTURE

1" = 20'-0"

DATE	REVISION OR ISSUE	NO.	BY	CK	APP	DATE	REVISION OR ISSUE	NO.	BY	CK	APP

BLACK & VEATCH Corporation

PROJECT 163509

ST. JOSEPH, MISSOURI

ALTERNATIVE B

WHITEHEAD CREEK STORMWATER SEPARATION CONDUIT

FIGURE 11

B50000
FB50000

existing downstream 8 foot CSS is proposed to be separated and replaced with 870 feet of 10.5 foot stormwater pipe. This would allow creek flow from two major Whitehead Creek branches (i.e., southern and main branch) to be collected and removed from the CSS. In addition, a 12 inch diameter, 2,000 foot long sanitary pipe would need to be installed along 6th Street to collect the separated sewage and convey it to the CSS. Alternative B would require both open cut and tunneling construction methods.

On February 25, 2009, Black & Veatch and City staff conducted a field visit to review potential options for the Whitehead sewer separation conduit. One of the requests made by City staff was to consider an open channel segment for this stormwater conduit along the southern Whitehead route. This open channel configuration has been reviewed and the following are the positive and negative aspects of this option.

Positives

- The Comprehensive Stormwater Management Plan recommended that the Whitehead CSS undergo significant improvements to pass the 25-year design event peak flows. An open channel conveyance channel may have the potential to pass significantly more flow downstream than a buried pipe and may help to alleviate this problem. Flood control benefits could result from this proposed approach.

Negatives

- The stormwater conveyance conduit must pass creek base flows and all creek wet weather flows up to Design Event E peak flow before overflow is allowed to pass into the CSS. This requires that the stormwater conveyance conduit be constructed deep at the invert of the creek channel to allow dewatering of the upstream channel without ponding.
- Significant ponding is not feasible directly upstream of the existing CSS. There is inadequate freeboard (head) to raise the upstream water surface elevation by locating the conduit at a higher elevation. The stormwater conduit and upstream diversion structure must pass the creek base and peak wet weather flows without causing flooding of adjacent and

upstream businesses and residents. To function properly, the Whitehead stormwater conduit should be located at the creek invert.

- A 3:1 side sloped, natural channel does not appear to be feasible for the Whitehead separation conduit. If the stormwater separation conduit is located at the invert of the creek channel, it would be deep, ranging from 25 to 35 feet deep along the open channel segment. With the directly adjacent residential homes, a 3:1 side sloped natural channel would not be feasible.
- Tunneled street crossings would be needed for this alternative. If the conveyance area of the open channel is not conserved at the street crossings, then the conveyance benefits of an open channel are eliminated.
- With adjacent homes, a large, deep, concrete open channel would be a safety concern.
- Pumping does not appear to be a good alternative to dewater the upstream creek channel and allow the elevation of the stormwater separation conduit/channel to be raised to a near surface conveyance channel. A pump station with a peak flow of 263 cfs (170 mgd) (without upstream detention) or 85 cfs (55 mgd) (with upstream detention) would result in a significant capital and operational expense. A gravity system without pumping is the optimal approach for the Whitehead stormwater separation conduit.

Due to these concerns regarding an open channel configuration, this particular approach does not appear to be a feasible option for the Whitehead stormwater separation conduit as the negatives outweigh the positives. The best configuration for this alternative is to install a buried pipe to convey creek flows to the Missouri River and locate the upstream invert of the buried pipe at the invert of the existing creek channel.

Alternative B would include a section of open cut pipe and a section of tunneled pipe. The open cut and tunneled portions are shown in Figure 11. For costing purposes, the same tunneling assumptions used for the Blacksnake evaluation were used for

Whitehead Alternative B. Additional geotechnical investigations would be required to ensure that the assumptions are valid.

Table 11 presents the dimensions and characteristics of the Alternative B proposed separation conduit.

Table 11
Whitehead Alternative B
Stormwater Separation Conduit Characteristics

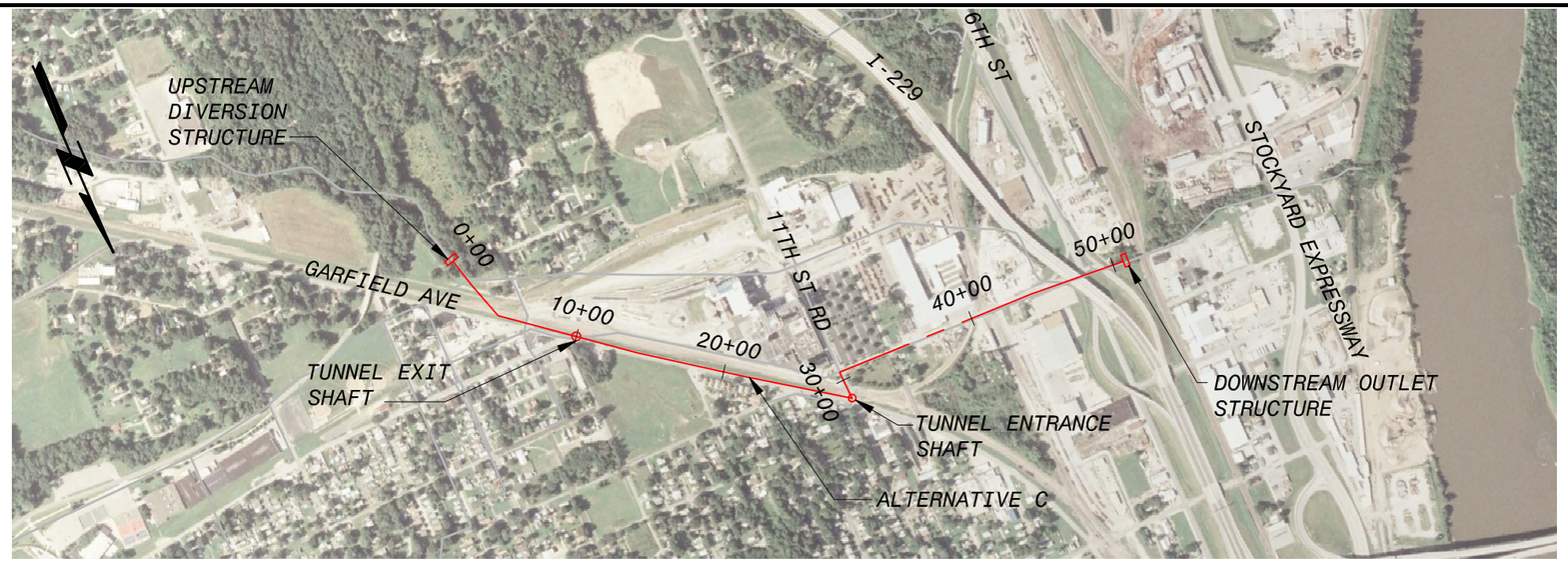
Conduit Total Length	5,230 feet
Tunneled Length	1,600 feet
Open Cut Length	3,630 feet
Conduit Diameter	6.5 feet
Conduit Material	Concrete

6.3 Alternative C – Stormwater Pipe North of Existing Combined Trunk Sewer

Whitehead Alternative C, as shown in Figure 12, proposes to place the stormwater separation conduit along the north side of the existing Whitehead combined trunk sewer. A disadvantage of this alternative is that several existing combined sewers would need to be crossed, including a major 9.5 foot combined sewer at the upstream end of the alignment. This would require the upstream end of the stormwater conduit to be constructed deep to pass underneath the existing combined sewer which increases cost. In addition, the northern alignment would require more street pavement replacement and possible reconstruction of existing, small diameter combined sewers.

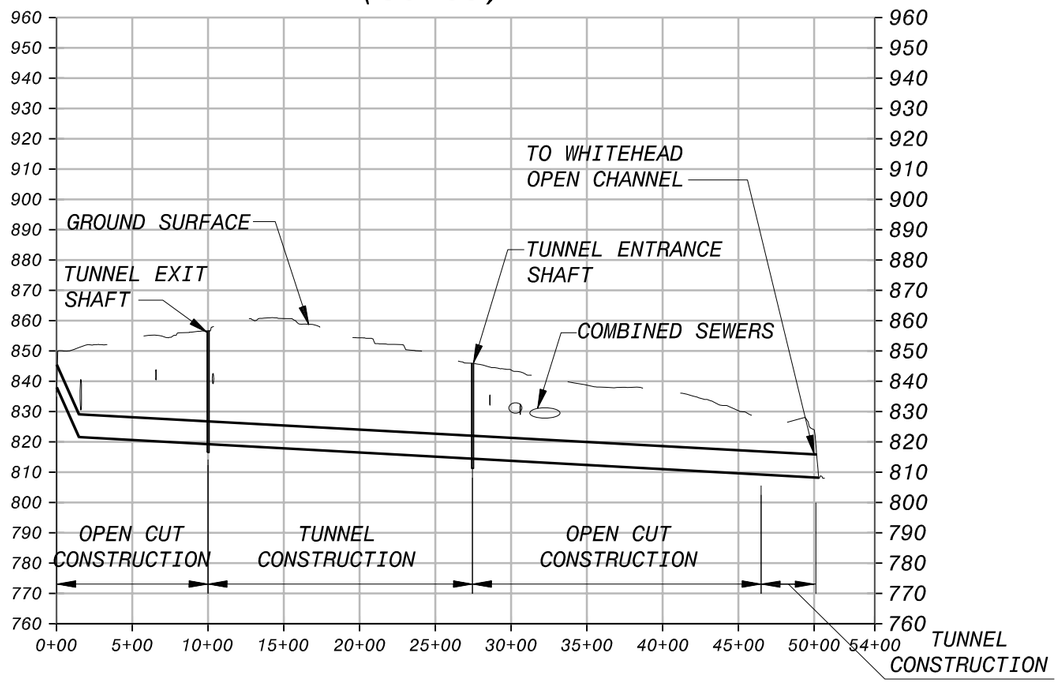
Alternative C would likely require both tunneling and open cut construction methods. The open cut and tunneled portions are shown in Figure 12. For costing purposes, the same tunneling assumptions used for the Blacksnake evaluation were used for Whitehead Alternative C. Additional geotechnical investigations would be required to ensure that the assumptions are valid.

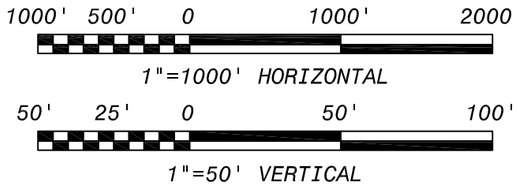
Table 12 presents the dimensions and characteristics of the Alternative C proposed separation conduit.

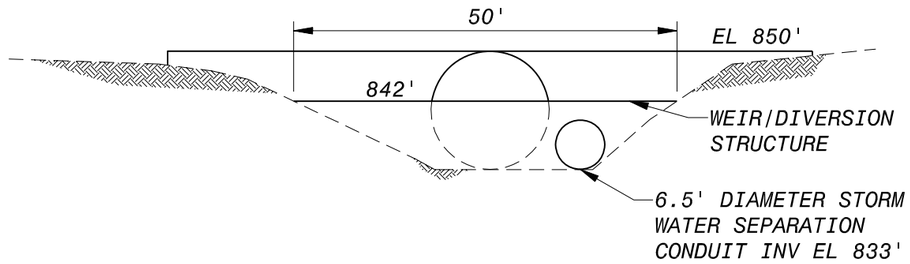


ALTERNATIVE C (NORTH ROUTE)

(50+69)







WHITEHEAD ALTERNATIVE C
WEIR STRUCTURE

1" = 20'-0"

DATE	REVISION OR ISSUE	NO.	BY	CK	APP

DATE	REVISION OR ISSUE	NO.	BY	CK	APP

BLACK & VEATCH Corporation

PROJECT 163509

ST. JOSEPH, MO

ALTERNATIVE C

WHITEHEAD CREEK STORMWATER SEPARATION CONDUIT

FIGURE 12

B50000
FB50000

Table 12 Whitehead Alternative C Stormwater Separation Conduit Characteristics	
Conduit Total Length	5,070 feet
Tunneled Length	2,000 feet
Open Cut Length	3,070 feet
Conduit Diameter	6.5 feet
Conduit Material	Concrete

6.4 Alternative D – New Combined Sewer

Whitehead Alternative D, as shown in Figure 13**,** proposes to convert the existing large diameter Whitehead trunk sewer from a combined sewer to a dedicated storm sewer. To accomplish this, a new combined sewer would need to be constructed that conveys flow from all existing small diameter combined sewer connections as well as the existing sewer laterals that connect to the large diameter Whitehead CSS trunk sewer. By picking up all of the sewer inflows, the existing combined trunk sewer would then be left in place to convey only stormwater creek flows to the Missouri River as a dedicated stormwater conveyance line.

This concept would require a new combined sewer line from the upstream extent of the existing Whitehead trunk sewer where sewage first mixes with Whitehead Creek stormwater flows. This location is shown in Figure 13 as "Station 0." As the proposed new combined sewer extends downstream, its size would need to increase as it intercepts additional small diameter combined sewer connections and sewer laterals. Figure 13 shows the approximate locations for all of the incoming smaller diameter combined sewers. However, it does not show the numerous sewer laterals that are currently directly connected to the Whitehead trunk sewer.

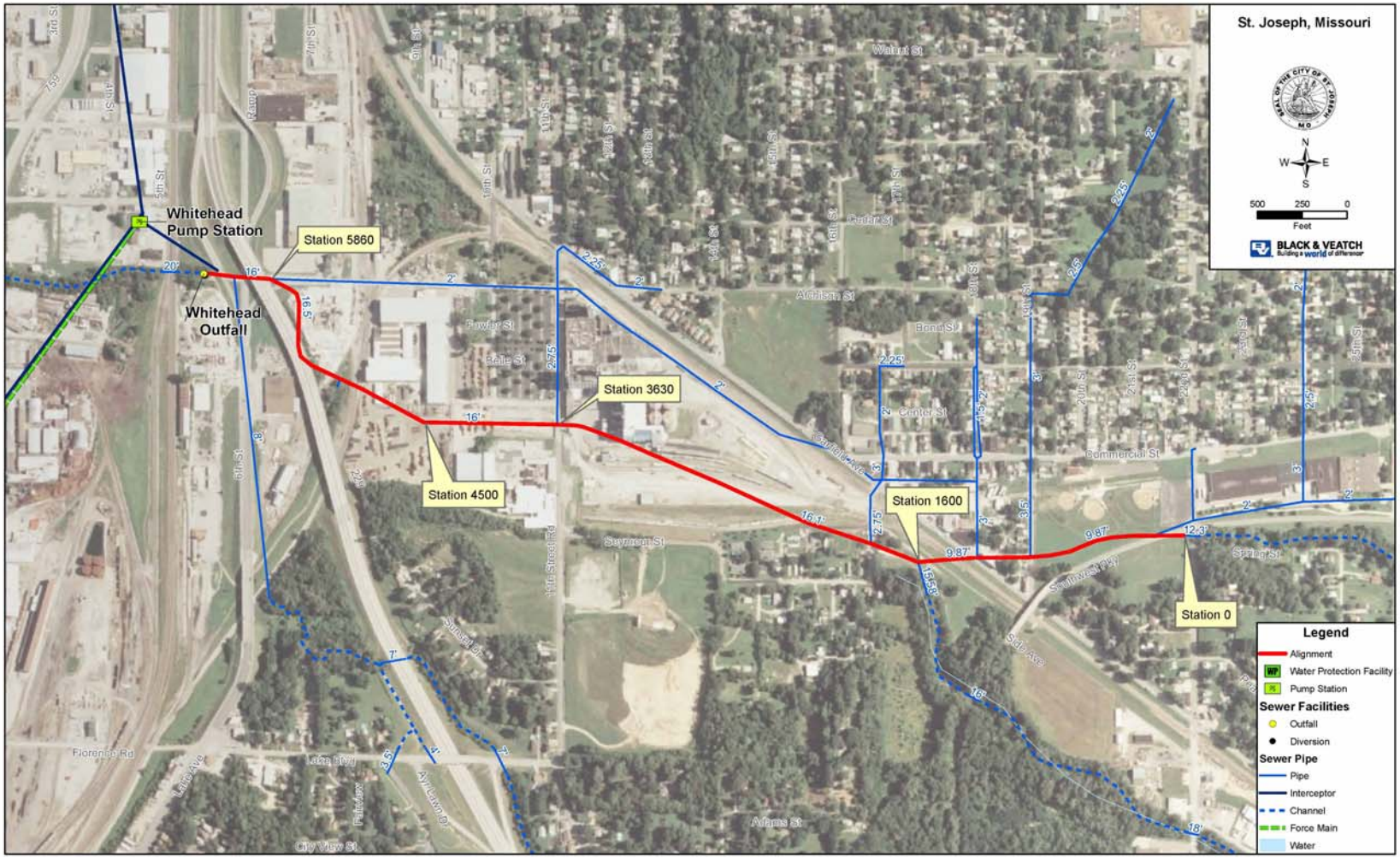


Figure 13 – Whitehead Alternative D (New Combined Sewer)

To obtain the location of all sewer connections along the Whitehead trunk sewer, the E. T. Archer Sewer Study (September 1985) was reviewed. There are 88 sewer connections to the Whitehead trunk sewer from the upstream end (Station 0 ft) to the downstream end of the proposed pipe (approximately Station 6,000 ft). Some of the connections are the existing small diameter combined sewers shown in Figure 13, some connections are sewer laterals directly connected to the trunk sewer, and other connections are stormwater connections (stormwater catch basins) directly connected to the Whitehead trunk sewer. Although the E.T. Archer sewer inspection of the Whitehead trunk sewer is detailed, it is not always clear from the notes whether the incoming connections are stormwater, sanitary, or combined sewer flows. Further review of these connections is required to determine which connections would need to be intercepted by the proposed combined sewer and which connections are stormwater only and could be left as-is. Based upon the E.T. Archer Study, only two of the 88 connections were identified specifically as stormwater connections. The remaining 86 connections are assumed to contain sanitary flow and to be redirected to the newly proposed combined sewer.

To size the proposed combined sewer, it was assumed that the conveyance area of the existing CSS (at a minimum) be conserved. For example, if the proposed combined sewer has a conveyance area of 5 square feet and intercepts a 3 square foot combined sewer line, the resulting combined sewer would need to be at least 8 square feet in conveyance area. This method was used to estimate the size of the proposed combined sewer required for Alternative D.

Furthermore, it was documented by the 1998 Comprehensive Stormwater Management Plan that the existing CSS is undersized to convey peak stormwater wet weather flood flows. Therefore, simply conserving the conveyance area of the existing combined sewer is not a conservative assumption. If this alternative was selected, the City may want to implement the recommendations from the 1998 Comprehensive Stormwater Management Plan which would require significantly larger pipes to be installed along the Whitehead trunk sewer. The diameter of Alternative D presented

within this TM is not sized to convey flood flows. This alternative is presented for cost comparison purposes only.

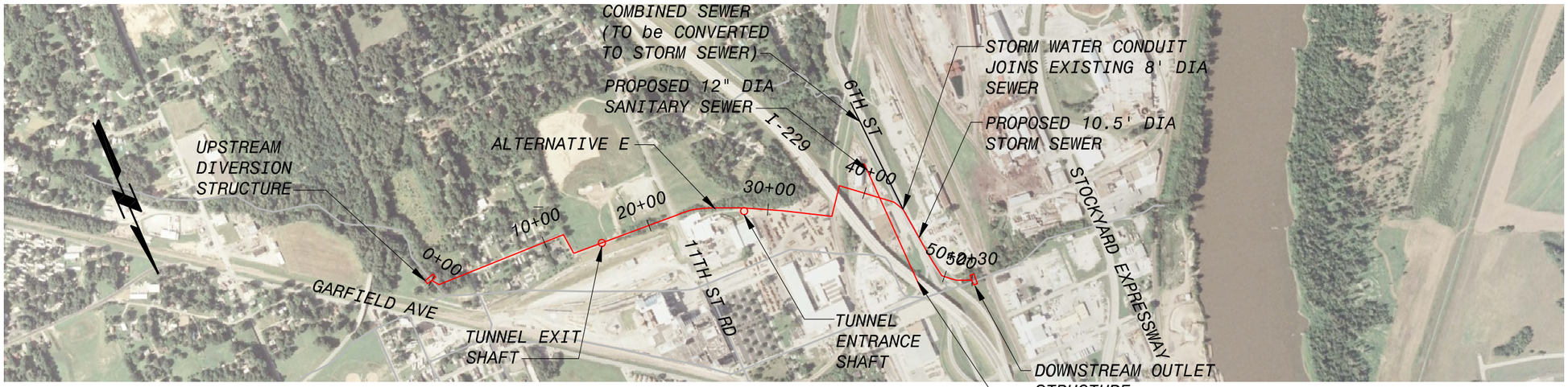
Based upon the conservation of conveyance area sizing methodology described above, the proposed combined sewer to convert the existing Whitehead combined trunk sewer into a stormwater only sewer would range in size from 2 feet at the upstream end to 13 feet at the downstream end. Furthermore, the line would be approximately 9 feet as it passes near/underneath the existing Lifeline Foods Facility. From a constructability standpoint, it does not appear likely that a new 9 foot combined sewer line would easily fit in the given alignment shown in Figure 13 (between the Whitehead trunk sewer and Lifeline Food buildings, located in railroad right of way). Furthermore, if the alignment was moved to avoid conflicts, sewer laterals and small diameter combined sewers would need to be redirected, closed, or reconstructed to convey the existing sanitary flows away from the Whitehead trunk sewer and into the proposed new combined sewer. Additional investigation would be required to determine how each of the sewer connections to the existing Whitehead trunk sewer could be disconnected and rerouted.

Due to the number of sewer connections, location of adjacent industries and railroads, constructability issues, and overall downstream pipe size, Alternative D is being screened out from consideration. Furthermore, due to the pipe sizes required, it would likely be more costly than the other alternatives. Alternatives B, C, and E appear to be more feasible than Alternative D.

6.5 Alternative E – Stormwater Pipe South of Existing Combined Trunk Sewer with Upstream Detention Basin

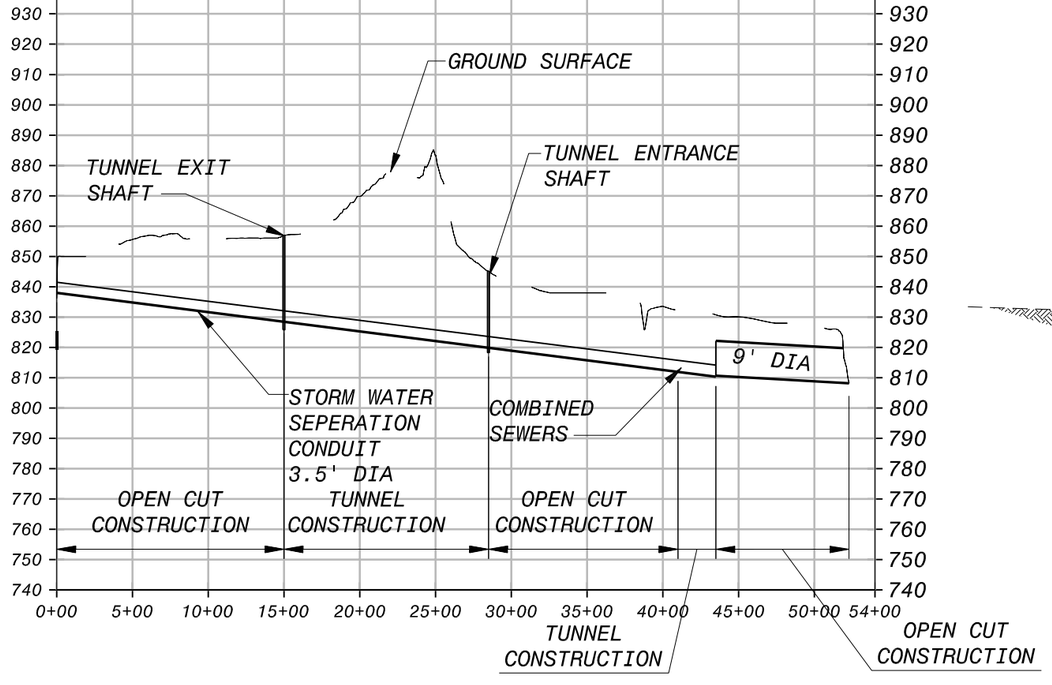
Alternative E has the same alignment as Alternative B, however, this alternative assumes that there is an upstream detention basin at the location shown in Figure 9. As stated previously, this detention basin reduces the peak flow from Design Event E from 263 cfs to 85 cfs. This allows the Whitehead stormwater separation conduit to be downsized from 6.5 feet in diameter to 3.5 feet.

Alternative E would likely require both tunneling and open cut construction methods. The open cut and tunneled portions are shown in Figure 14. For costing



ALTERNATIVE E (SOUTHERN ROUTE WITH UPSTREAM DETENTION BASIN)

(52+29)

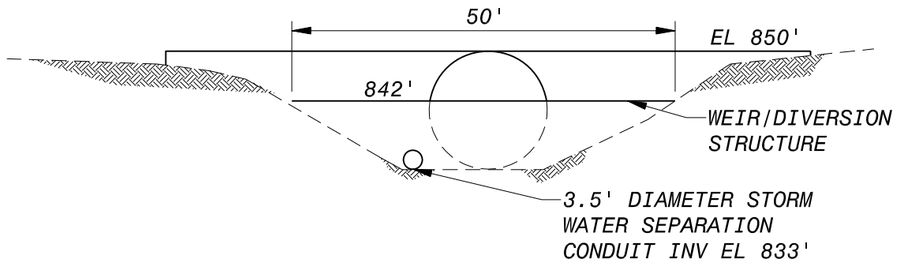


1000' 500' 0 1000' 2000'

1"=1000' HORIZONTAL

50' 25' 0 50' 100'

1"=50' VERTICAL



WHITEHEAD ALTERNATIVE E

WEIR STRUCTURE

1" = 20'-0"

DATE	REVISION OR ISSUE	NO.	BY	CK	APP

DATE	REVISION OR ISSUE	NO.	BY	CK	APP

BLACK & VEATCH Corporation

PROJECT 163509

ST. JOSEPH, MISSOURI

ALTERNATIVE E

WHITEHEAD CREEK STORMWATER SEPARATION CONDUIT

FIGURE 14

B50000 FB50000

purposes, the same tunneling assumptions used for the Blacksnake evaluation were used for Whitehead Alternative E. Additional geotechnical investigations would be required to ensure that the assumptions are valid.

Table 13 presents the dimensions and characteristics of the Alternative E proposed separation conduit.

Table 13
Whitehead Alternative E
Stormwater Separation Conduit Characteristics

Conduit Total Length	5,230 feet
Tunneled Length	1,600 feet
Open Cut Length	3,630 feet
Conduit Diameter	3.5 feet
Conduit Material	Concrete

6.6 Whitehead Costs and Recommendations

Five alternatives, A through E, were developed for the Whitehead stormwater separation conduits. Two alternatives, A and D, were dropped from consideration due to constructability and logistical issues. The remaining three alternatives, B, C, and E, are viable alternatives that could be used to remove creek base flows and flows up to the Design Event E peak flow. Alternatives B and C are larger conduits sized to convey the peak flow from Design Event E (263 cfs) assuming no upstream detention basin. Alternative E has the same alignment as Alternative B, but is a smaller diameter conduit because it assumes an upstream detention basin has been constructed.

The opinion of probable project costs for the Whitehead stormwater separation conduit alternatives and detention basin (for Alternative E only) are presented in Table 14. Table 15 presents the detailed opinion of probable project cost for the detention basin required to attenuate flow for Alternative E from 263 cfs to 85 cfs. Alternatives B and C have much lower project costs than Alternative E. Although the stormwater separation conduit is less expensive for Alternative E, the detention basin offsets any costs savings from a smaller diameter stormwater conduit. Appendix A presents additional details of the development of the conceptual project costs.

Table 14
Summary of Opinion of Probable Project Costs for Whitehead Stormwater Separation Conduits [1, 7]

Item	Alternative B, $	Alternative C, $	Alternative E, $
Stormwater Separation Conduit			
Open Cut Portion with Manholes	4,874,000	3,592,000	3,227,000
Tunneled Portion	3,744,000	4,680,000	2,745,000
Tunnel Shafts	975,000	1,050,000	0
Sewer Pipe Addition/Replacement	360,000	810,000	360,000
Upstream Diversion/Energy Dissipation Structure	500,000	500,000	500,000
Downstream Outlet Structure and Flap Gate	300,000	300,000	300,000
Concrete Replacement (street)	800,000	1,600,000	800,000
Flood Protection/Fill (placeholder) [2]	0	0	0
Site Remediation (placeholder) [2]	0	0	0
Subtotal	*11,553,000*	*12,532,000*	*7,932,000*
Sitework, Contractor General Requirements [3]	2,680,000	2,907,000	1,840,000
Subtotal	*14,233,000*	*15,439,000*	*9,772,000*
Contingency [4]	3,558,000	3,860,000	2,443,000
Land Acquisition (placeholder) [2, 5]	0	0	0
Opinion of Probable Construction Cost	**17,791,000**	**19,299,000**	**12,215,000**
Engineering, Legal, and Administration [6]	3,558,000	3,860,000	2,443,000
Opinion of Project Cost	**21,349,000**	**23,159,000**	**14,658,000**
Detention Basin Opinion of Project Cost (Design Event E, see Table 15 for basin cost details)	**0**	**0**	**19,416,000**
Opinion of Total Project Cost	**21,349,000**	**23,159,000**	**34,074,000**

Table 14
Summary of Opinion of Probable Project Costs for Whitehead Stormwater Separation Conduits [1, 7]

Item	Alternative B, $	Alternative C, $	Alternative E, $

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. It is assumed that these values are zero for the stormwater separation conduits.
3. Sitework projected at 10% of the total of equipment and structure costs. Contractor general requirements projected at 12% of the total of equipment, structures, and sitework costs.
4. Project contingency is projected at 25% of the total of all equipment, structures, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
5. Land acquisition is not anticipated for the stormwater separation conduits. The cost for easements is covered by engineering, legal, and administration (ELA).
6. ELA costs are projected at 20% of the total of all equipment, structures, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.
7. Diversion structure modifications are proposed for the existing Whitehead Diversion Structure. The retrofits as well as the costs are covered in TM-CSO-8 - CSO Diversion Structure Modifications.

Table 15
Summary of Opinion of Probable Project Costs
for Whitehead Design Event E Detention Basin [1]

Item	Alternative E Design Event E Detention Basin, $
Detention Basin	
Dam Embankment	1,380,000
Excavation	7,350,000
Piping	54,000
Riprap	532,000
Planting/Seeding/Mulch	105,000
Flood Protection/Fill (placeholder) [2]	0
Site Remediation (placeholder) [2]	0
Subtotal	*9,421,000*
Permitting	94,000
Subtotal	*9,515,000*
Sitework, Contractor General Requirements [3]	2,197,000
Subtotal	*11,712,000*
Contingency [4]	2,928,000
Land Acquisition (placeholder) [2, 5]	1,540,000
Opinion of Probable Construction Cost	**16,180,000**
Engineering, Legal, and Administration [6]	3,236,000
Opinion of Total Project Cost	**19,416,000**

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. It is assumed that these values are zero for the stormwater separation conduits.
3. Sitework projected at 10% of the total of equipment and structure costs. Contractor general requirements projected at 12% of the total of equipment, structures, and sitework costs.
4. Project contingency is projected at 25% of the total of all equipment, structures, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
5. Land acquisition cost is based on information provided by the City.
6. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition.

O&M costs were assigned to the gravity stormwater conduit alternatives by assuming that 0.1 percent of the capital cost would be required, annually, to operate and maintain them. The O&M costs are presented in Table 16

Table 16
Whitehead Stormwater Separation Conduit Alternatives
Annual O&M Costs

Alternative B, $	Alternative C, $	Alternative E,$
20,000	23,000	499,000

Notes:
1. O&M costs for the stormwater separation conduits are assumed to be 0.1% of the construction costs. These costs will help cover manhole cleaning, channel grubbing, and other miscellaneous repair activities.
2. The Alternative E O&M cost includes 0.1% of the conduit construction cost and 3% of the detention basin construction cost.

Alternative B is the least costly alternative as it minimizes the amount of utility and street disruption. Furthermore, Alternative B allows the southern branch of the Whitehead Creek to be fully separated allowing even more creek flows to be removed from the combined sewer system. Alternative B is recommended as the Whitehead Stormwater Separation alternative to be implemented during design.

7.0 Summary and Conclusions

A total of ten stormwater separation alternatives were investigated and evaluated to remove the Whitehead Creek and Blacksnake Creek storm Event E flows from the City's CSS. Based on this evaluation, it appears that gravity flowing stormwater separation conduits sized without upstream detention and without peak flow attenuation are the optimal alternatives to remove creek flows from the CSS in both basins. For the Blacksnake and Whitehead recommended alternatives, a detailed alignment study is recommended to confirm the specific alignment, investigate any major utility conflicts and/or geotechnical issues not already identified, and confirm there are no obstacles or subsurface interferences.

It is recommended that the City proceed with an alignment study and design of the Blacksnake Alternative B stormwater separation conduit and the Whitehead Alternative B stormwater separation conduit. An 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 conveyed to the existing CSS and will help the City achieve its LTCP Phase IA objective of 60 percent combined sewage wet weather capture.

8.0 References

1. Comprehensive Stormwater Management Plan (Black & Veatch, 1998).
2. Wastewater Treatment Facilities Geotechnical Engineering Report (Kimball Associates, 1974).

Appendix A

Opinion of Probable Project Cost Breakdown

St. Joseph, Missouri
TM-CSO-5 - Blacksnake and Whitehead Stormwater Separation Conduits
Alternative B - Blacksnake

Item Description	Units	Unit Cost, $	Quantity	Total Cost, $
Stormwater Conduit				
60" Finished Diameter Soft Ground Tunnel	ft	1,800.00	4,670	8,406,000
60" Open Cut Pipe	ft	900.00	9,700	8,730,000
Tunnel Entrance Shaft	ft	15,000.00	35	525,000
Tunnel Turning Shaft	ft	15,000.00	60	900,000
Tunnel Exit Shaft	ft	15,000.00	35	525,000
Upstream Diversion Structure/Energy Dissipation	Lump Sum			500,000
Downstream Outlet Structure	Lump Sum			250,000
Flap Gate	Lump Sum			50,000
Pavement Replacement	cu yd	800.00	2,000	1,600,000
Tunnel				***21,486,000***
Subtotal				***21,486,000***
Electrical, Instrumentation, & Controls	Lump Sum	0%		0
Subtotal				***21,486,000***
Sitework	Lump Sum	10%		2,149,000
Subtotal				***23,635,000***
General Requirements	Lump Sum	12%		2,836,000
Flood Protection (placeholder)	cu yd	25.00	0	0
Site Remediation (placeholder)	cu yd	150.00	0	0
Subtotal				***26,471,000***
Contingency	Lump Sum	25%		6,618,000
Land Acquisition (placeholder)	sq ft	1.33	0	0
Opinion of Probable Construction Cost				**33,089,000**
Engineering, Legal, & Administration	Lump Sum	20%		6,618,000
Opinion of Probable Project Cost				**39,707,000**

St. Joseph, Missouri
TM-CSO-5 - Blacksnake and Whitehead Stormwater Separation Conduits
Alternative C - Blacksnake

Item Description	Units	Unit Cost, $	Quantity	Total Cost, $
Stormwater Conduit				
72" Finished Diameter Soft Ground Tunnel	ft	2,160.00	3,500	7,560,000
72" Open Cut Pipe	ft	1,080.00	3,370	3,639,600
Tunnel Entrance Shaft	ft	15,000.00	30	450,000
Tunnel Turning Shaft	ft	15,000.00	0	0
Tunnel Exit Shaft	ft	15,000.00	20	300,000
Upstream Diversion Structure/Energy Dissipation	Lump Sum			500,000
Downstream Outlet Structure	Lump Sum			250,000
Flap Gate	Lump Sum			50,000
Pavement Replacement	cu yd	800.00	2,037	1,629,630
Tunnel				***14,379,000***
Subtotal				***14,379,000***
Electrical, Instrumentation, & Controls	Lump Sum	0%		0
Subtotal				***14,379,000***
Sitework	Lump Sum	10%		1,438,000
Subtotal				***15,817,000***
General Requirements	Lump Sum	12%		1,898,000
Flood Protection (placeholder)	cu yd	25.00	0	0
Site Remediation (placeholder)	cu yd	150.00	0	0
Subtotal				***17,715,000***
Contingency	Lump Sum	25%		4,429,000
Land Acquisition (placeholder)	sq ft	1.33	0	0
Opinion of Probable Construction Cost				**22,144,000**
Engineering, Legal, & Administration	Lump Sum	20%		4,429,000
Opinion of Probable Project Cost				**26,573,000**

St. Joseph, Missouri
TM-CSO-5 - Blacksnake and Whitehead Stormwater Separation Conduits
Alternative D - Blacksnake

Item Description	Units	Unit Cost, $	Quantity	Total Cost, $
Stormwater Conduit				
60" Finished Diameter Soft Ground Tunnel	ft	1,800.00	2,980	5,364,000
60" Open Cut Pipe	ft	900.00	10,000	9,000,000
Tunnel Entrance Shaft	ft	15,000.00	30	450,000
Tunnel Turning Shaft	ft	15,000.00	0	0
Tunnel Exit Shaft	ft	15,000.00	30	450,000
Upstream Diversion Structure/Energy Dissipation	Lump Sum			500,000
Downstream Outlet Structure	Lump Sum			250,000
Flap Gate	Lump Sum			50,000
Pavement Replacement	cu yd	800.00	10,370	8,296,296
Tunnel				***24,360,000***
Subtotal				***24,360,000***
Electrical, Instrumentation, & Controls	Lump Sum	0%		0
Subtotal				***24,360,000***
Sitework	Lump Sum	10%		2,436,000
Subtotal				***26,796,000***
General Requirements	Lump Sum	12%		3,216,000
Flood Protection (placeholder)	cu yd	25.00	0	0
Site Remediation (placeholder)	cu yd	150.00	0	0
Subtotal				***30,012,000***
Contingency	Lump Sum	25%		7,503,000
Land Acquisition (placeholder)	sq ft	1.33	0	0
Opinion of Probable Construction Cost				**37,515,000**
Engineering, Legal, & Administration	Lump Sum	20%		7,503,000
Opinion of Probable Project Cost				**45,018,000**

St. Joseph, Missouri
TM-CSO-5 - Blacksnake and Whitehead Stormwater Separation Conduits
Alternative E - Blacksnake

Item Description	Units	Unit Cost, $	Quantity	Total Cost, $
Stormwater Conduit				
Open Cut 36" Sewer	ft	540.00	5,000	2,700,000
Concrete for 5' by 5' by 5' Open Channel	yd	900.00	7,583	6,825,000
Tunnel Entrance Shaft	ft	15,000.00	0	0
Tunnel Turning Shaft	ft	15,000.00	0	0
Tunnel Exit Shaft	ft	15,000.00	0	0
Upstream Diversion Structure/Energy Dissipation	Lump Sum			500,000
Downstream Outlet Structure	Lump Sum			250,000
Flap Gate	Lump Sum			50,000
Pavement Replacement	cu yd	800.00	200	160,000
20 cfs Pump Station	Lump Sum			3,000,000
Open Channel Street Crossings	each	24,300.00	6	145,800
Tunnel				***13,631,000***
Subtotal				***13,631,000***
Electrical, Instrumentation, & Controls	Lump Sum	25%		750,000
Subtotal				***14,381,000***
Sitework	Lump Sum	10%		1,438,000
Subtotal				***15,819,000***
General Requirements	Lump Sum	12%		1,898,000
Flood Protection (placeholder)	cu yd	25.00	0	0
Site Remediation (placeholder)	cu yd	150.00	0	0
Subtotal				***17,717,000***
Contingency	Lump Sum	25%		4,429,000
Land Acquisition (placeholder)	sq ft	1.33	0	0
Opinion of Probable Construction Cost				**22,146,000**
Engineering, Legal, & Administration	Lump Sum	20%		4,429,000
Opinion of Probable Project Cost				**26,575,000**

St. Joseph, Missouri
TM-CSO-5 - Blacksnake and Whitehead Stormwater Separation Conduits
Alternative E - Blacksnake Detention Basin

Item Description	Units	Unit Cost, $	Quantity	Total Cost, $
Dam Construction - CSO				
24" Outlet Pipe	lin ft	360.00	100	36,000
12" Drain Pipe	lin ft	180.00	100	18,000
Excavation Including Clearing & Grubbing	cu yd	10.00	291,000	2,910,000
Planting, Seeding, Mulching	acres	3,500.00	20	70,000
Riprap	cu yd	110.00	5,555	611,050
Soil Cement (RCC)	cu yd	150.00	9,200	1,380,000
Dam Construction				***5,025,000***
Subtotal				***5,025,000***
Electrical, Instrumentation, & Controls	Lump Sum	0%		0
Subtotal				***5,025,000***
Sitework	Lump Sum	10%		503,000
Permitting	Lump Sum	1%		50,000
Subtotal				***5,578,000***
General Requirements	Lump Sum	12%		669,000
Flood Protection (placeholder)	cu yd	25.00	0	0
Site Remediation (placeholder)	cu yd	150.00	0	0
Subtotal				***6,247,000***
Contingency	Lump Sum	25%		1,562,000
Land Acquisition (placeholder)	Lump Sum			1,180,000
Opinion of Probable Construction Cost				**8,989,000**
Engineering, Legal, & Administration	Lump Sum	20%		1,798,000
Opinion of Probable Project Cost				**10,787,000**

St. Joseph, Missouri
TM-CSO-5 - Blacksnake and Whitehead Stormwater Separation Conduits
Alternative B - Whitehead

Item Description	Units	Unit Cost, $	Quantity	Total Cost, $
Stormwater Conduit				
78" Finished Diameter Soft Ground Tunnel	ft	2,340.00	1,350	3,159,000
126" Open Cut Pipe	ft	1,890.00	870	1,644,300
78" Open Cut Pipe	ft	1,170.00	2,760	3,229,200
78" 6th Street Tunnel	ft	2,340.00	250	585,000
Tunnel Entrance Shaft	ft	15,000.00	35	525,000
Tunnel Exit Shaft	ft	15,000.00	30	450,000
Upstream Diversion Structure/Energy Dissipation	Lump Sum			500,000
Downstream Stormwater Conduit Outlet Structure	Lump Sum			250,000
Flap Gate For Stormwater Separation Conduit	Lump Sum			50,000
Pavement Replacement	cu yd	800.00	1,000	800,000
12" Separate Sewer	ft	180.00	2,000	360,000
Whitehead Diversion Structure Modifications (Cost Covered in TM-CSO-8)	Lump Sum			0
Tunnel				***11,553,000***
Subtotal				***11,553,000***
Electrical, Instrumentation, & Controls	Lump Sum	0%		0
Subtotal				***11,553,000***
Sitework	Lump Sum	10%		1,155,000
Subtotal				***12,708,000***
General Requirements	Lump Sum	12%		1,525,000
Flood Protection (placeholder)	cu yd	25.00	0	0
Site Remediation (placeholder)	cu yd	150.00	0	0
Subtotal				***14,233,000***
Contingency	Lump Sum	25%		3,558,000
Land Acquisition (placeholder)	sq ft	1.33	0	0
Opinion of Probable Construction Cost				**17,791,000**
Engineering, Legal, & Administration	Lump Sum	20%		3,558,000
Opinion of Probable Project Cost				**21,349,000**

St. Joseph, Missouri
TM-CSO-5 - Blacksnake and Whitehead Stormwater Separation Conduits
Alternative C - Whitehead

Item Description	Units	Unit Cost, $	Quantity	Total Cost, $
Stormwater Conduit				
78" Finished Diameter Soft Ground Tunnel	ft	2,340.00	1,750	4,095,000
78" Open Cut Pipe	ft	1,170.00	3,070	3,591,900
78" 6th Street Tunnel	ft	2,340.00	250	585,000
Tunnel Entrance Shaft	ft	15,000.00	30	450,000
Tunnel Exit Shaft	ft	15,000.00	40	600,000
Upstream Diversion Structure/Energy Dissipation	Lump Sum			500,000
Downstream Stormwater Conduit Outlet Structure	Lump Sum			250,000
Flap Gate For Stormwater Separation Conduit	Lump Sum			50,000
Pavement Replacement	cu yd	800.00	2,000	1,600,000
24" CSO Sewer Replacement	ft	360.00	2,250	810,000
Whitehead Diversion Structure Modifications (Cost Covered in TM-CSO-8)	Lump Sum			0
Tunnel				***12,532,000***
Subtotal				***12,532,000***
Electrical, Instrumentation, & Controls	Lump Sum	0%		0
Subtotal				***12,532,000***
Sitework	Lump Sum	10%		1,253,000
Subtotal				***13,785,000***
General Requirements	Lump Sum	12%		1,654,000
Flood Protection (placeholder)	cu yd	25.00	0	0
Site Remediation (placeholder)	cu yd	150.00	0	0
Subtotal				***15,439,000***
Contingency	Lump Sum	25%		3,860,000
Land Acquisition (placeholder)	sq ft	1.33	0	0
Opinion of Probable Construction Cost				**19,299,000**
Engineering, Legal, & Administration	Lump Sum	20%		3,860,000
Opinion of Probable Project Cost				**23,159,000**

St. Joseph, Missouri
TM-CSO-5 - Blacksnake and Whitehead Stormwater Separation Conduits
Alternative E - Whitehead

Item Description	Units	Unit Cost, $	Quantity	Total Cost, $
Stormwater Conduit				
42" Finished Diameter Tunnel	ft	1,800.00	1,350	2,430,000
114" Open Cut Pipe	ft	1,710.00	870	1,487,700
42" Open Cut Pipe	ft	630.00	2,760	1,738,800
42" 6th Street Tunnel	ft	1,260.00	250	315,000
Tunnel Entrance Shaft	ft	15,000.00	0	0
Tunnel Exit Shaft	ft	15,000.00	0	0
Upstream Diversion Structure/Energy Dissipation	Lump Sum			500,000
Downstream Stormwater Conduit Outlet Structure	Lump Sum			250,000
Flap Gate For Stormwater Separation Conduit	Lump Sum			50,000
Pavement Replacement	cu yd	800.00	1,000	800,000
12" Separate Sewer	ft	180.00	2,000	360,000
Whitehead Diversion Structure Modifications (Cost Covered in TM-CSO-8)	Lump Sum			0
Tunnel				***7,932,000***
Subtotal				***7,932,000***
Electrical, Instrumentation, & Controls	Lump Sum	0%		0
Subtotal				***7,932,000***
Sitework	Lump Sum	10%		793,000
Subtotal				***8,725,000***
General Requirements	Lump Sum	12%		1,047,000
Flood Protection (placeholder)	cu yd	25.00	0	0
Site Remediation (placeholder)	cu yd	150.00	0	0
Subtotal				***9,772,000***
Contingency	Lump Sum	25%		2,443,000
Land Acquisition (placeholder)	sq ft	1.33	0	0
Opinion of Probable Construction Cost				**12,215,000**
Engineering, Legal, & Administration	Lump Sum	20%		2,443,000
Opinion of Probable Project Cost				**14,658,000**

St. Joseph, Missouri
TM-CSO-5 - Blacksnake and Whitehead Stormwater Separation Conduits
Alternative E - Whitehead Detention Basin

Item	Storm Event 'E' with Pool Detention Basin $
Detention Basin	
Dam Embankment (RCC) (9,200 cy @ $150/cy)	$1,380,000
Excavation (735,000 cy @ $10/cy)	$7,350,000
Piping (100 ft of 24" pipe @ $360/lf and 100 ft of 12" pipe @ $180/lf)	$54,000
Riprap (4,840 cy @ $110/cy)	$532,000
Planting/Seeding/Mulch (30 ac @ $3,500/ac)	$105,000
Flood Protection/Fill (placeholder) [2]	$0
Site Remediation (placeholder) [2]	$0
Subtotal	*$9,421,000*
Sitework	$942,000
Permitting	$94,000
Subtotal	*$10,457,000*
Contractor General Requirements	$1,255,000
Subtotal	*$11,712,000*
Contingency [3]	$2,928,000
Land Acquisition (placeholder) [4]	$1,540,000
Opinion of Probable Construction Cost	**$16,180,000**
Engineering, Legal, and Administration [5]	$3,236,000
Opinion of Probable Project Cost	**$19,416,000**

1. All costs presented in September 2009 dollars (ENR BCI = 4764).
2. Site related costs are placeholders and must be revised following final siting of the facilities. It is assumed that these values are zero at this point.
3. Project contingency is projected at 25% of the total of all equipment, structures, sitework, contractor general requirements, flood protection/fill, and site remediation costs.
4. Land acquisition cost is based on information provided by the City.
5. Engineering, legal, and administration (ELA) costs are projected at 20% of the total of all equipment, structures, sitework, contractor general requirements, flood protection/fill, site remediation costs,