Appendix C
Civil Engineering

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1. EXISTING CONDITIONS

1.1. PROJECT LOCATION AND HISTORY

The study area is the area potentially benefitted or impacted by any alternative. Figure 1 shows the study area as the 5,930-acre (9.3 square mile) upper River Des Peres watershed, located in eastern Missouri just to the west of the City of Saint Louis. The upper River Des Peres headwaters flow west to east through the municipalities of Olivette and Overland before entering University City east of I-170. Per USACE policy, USACE authority begins at the point on the stream where the 10% Annual Exceedance Probability (AEP) flow exceeds 800 cfs. This point was identified at a location west of I-170 in the municipality of Olivette. All measures and alternatives examined are downstream of this point. The downstream extent of the study area is the point where the river goes underground into a large underground sewer system network known as "the Tubes" (see "River goes underground" in Figure 1).

The previously authorized project area is the reach of the River Des Peres between I-170 and Purdue Avenue at Heman Park. The 5,436-acre (22 km2) watershed upstream of Heman Park contains 11 miles (17 km) of streams. Downstream of the study area, River Des Peres is almost completely channelized, flowing through underground pipes and above ground channels until it finally reaches an outlet into the Mississippi River. Figure 1 shows the study area.

The watershed is essentially completely developed. Its land uses are moderate to high density residential, light to heavy industrial, and open public land. Substantial flooding results during and after intense rainfall events. This is the most serious stormwater problem in the watershed. The current dense development of the area makes further major land use changes, which would significantly alter stormwater runoff characteristics, unlikely.

Along the River Des Peres, the land use primarily contains low- and medium-density residential and commercial areas (including houses, apartments, businesses, and the campus of University City High School).

1.2. EXISTING FEATURES

The existing project area does not have any flood control measures, such as levees, berms, floodwalls, detention basins, etc. The Non-Federal Sponsor, University City, does have an existing partial flood warning system that was installed in 2018.

1.3. SURVEY DATA

The survey data used for the project was obtained from the MVS LiDAR database. The LiDAR data was flown in 2012 during a full LiDAR collection for Saint Louis County, MO.

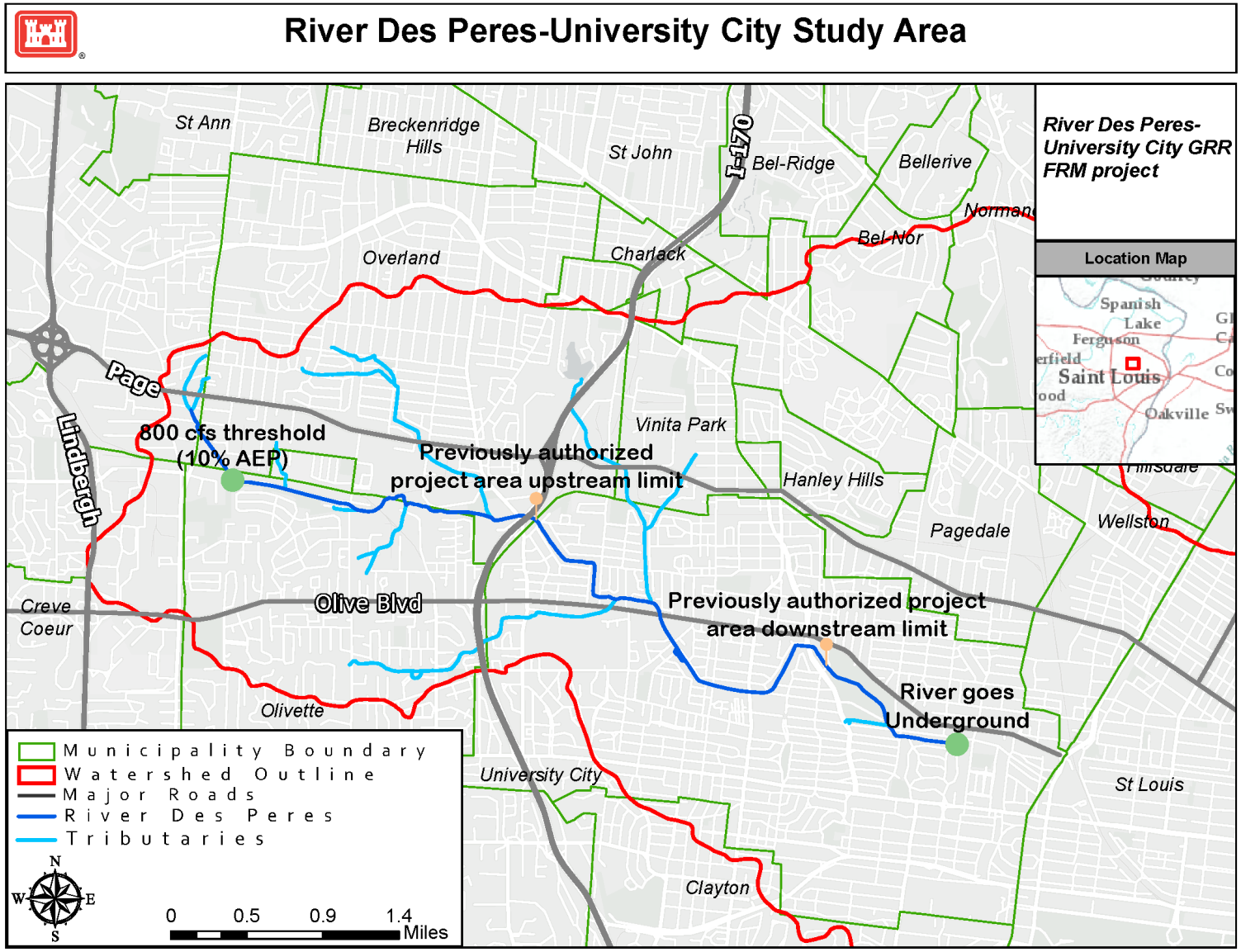


Figure 1. Map of the Study Area for the University City GRR.

2. ALTERNATIVES

2.1. ALTERNATIVE 1 - NO ACTION

No changes will be made to mitigate the flooding in the project area.

2.2. ALTERNATIVE 2 - AUTHORIZED PLAN WITH MODIFICATIONS

The previously authorized plan, from the 1988 Feasibility Study, was reviewed and analyzed with current project conditions and the findings showed an increase in the impacts on the downstream end of the study area, in addition to further downstream past the project area. It was found that the previously authorized plan could be viable if modifications were made to reduce these additional downstream impacts. Detention basins 3 & 4 would be added, which reduces the water surface level at the downstream end to an acceptable level.

2.2.1 Previously Authorized Plan (from 1988 Feasibility Study)

This measure is the portion of the authorized plan from the 1988 feasibility study located within the University City Branch of the River Des Peres. It included approximately 2.5 miles of channel modifications, a flood forecasting and warning system, and recreation features. Channel modifications (measure U-12) included items such as bridge replacements, bank stabilization, and grade control.

2.2.2 Modifications - Detention Basins 3 & 4

The addition of Detention Basins 3 & 4 reduces the impacts from the channel modifications proposed in the 1988 Feasibility Study to an acceptable level and makes the "Authorized Plan with Modifications" alternative viable. The detention basin alternatives will be further discussed in the following sections.

2.3. ALTERNATIVE 3A - DETENTION BASINS (DBS) 3 AND 4

This structural alternative includes two detention basins along River Des Peres to retain water during peak runoff events and gradually drain the excess water back to the river after the runoff event. Five detention basins were initially proposed by the hydraulics team, but only two of them provided enough benefit and impact reduction to be further analyzed by the entire PDT. This alternative includes both the constructable detention basins.

The design designation for the detention basin structures was discussed by members of the PDT and experts were sought out to try and pin down the structural components as levees or as a dam structure. According to ER 1110-2-11156 "Safety of Dams – Policy and Procedures", any structure over 6 feet in height or exceeds a total volume 15 acre-feet will be considered a dam. The final design of the detention basins, should they be brought forward, will almost certainly be above those thresholds. The proper levee or dam safety experts will need to be consulted regardless of the final design designation.

2.3.1 Detention Basin 3 (DB3)

The Detention Basin 3 site is made up of the 8008 Olive Blvd and 8080 Olive Blvd parcels, bound on the North by Olive Blvd, the East by River Des Peres, the South by the Westover Lane, and

the West by 81st Street. This site contains multiple businesses that would need to be relocated and two buildings that would need to be demolished to construct the detention basin. See Figure 2 for the plan view of the site.

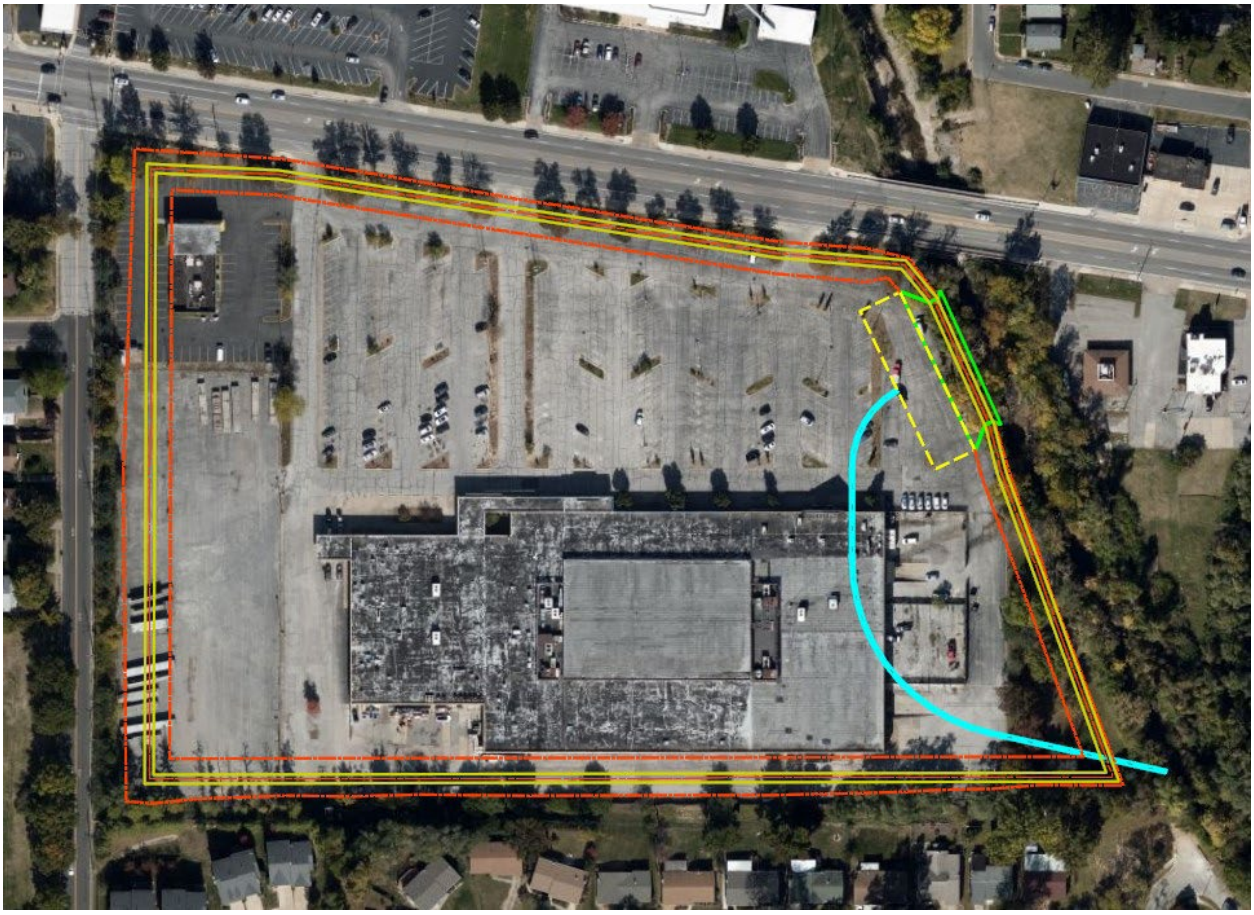


Figure 2. Plan View of Detention Basin 3 Site

Different iterations of the detention basin were analyzed hydraulically and for constructability. The structure will cover roughly 15 acres of space and consist of a containment levee running along the perimeter of the DB3 site, a weir control structure, a 36" diameter culvert for drainage, and a concrete swale connecting the two. The elevations for the containment levee, the weir control structure, and the bottom of the detention basin were set by the hydraulic calculations to:

- Containment Levee Elevation: 528.0 Feet
- Weir Control Structure Elevation: 524.0 Feet
- Basin Bottom Elevation: 519.0 Feet

The containment levees were designed with a 10-foot-wide flat top with 2:1 side slope up to the existing ground on the exterior of the basin and down to the basin bottom elevation on the interior side. The proposed elevations for the components of the detention basin are

significantly lower than the existing site elevation and will require extensive excavation for construction. The 2:1 side slope was used to gain maximum amount of water storage during peak runoff events. These will need to be further analyzed to find ways to mitigate the potential risks involved with slopes this steep.

The concrete weir control structure will be 150 feet wide and have concrete wing walls to account for the elevation difference between the containment levee and the weir elevation. See Figure 3 for a rough schematic of the weir control structure. The concrete for the structure was designed to be 12 inches thick, with the wing walls designed to be 6" thick. At this stage in the design process, foundation design work for the weir control structure has not been done. Better soil data for the project site is needed in order to perform a geotechnical review of the design to ensure that the current risks are reduced as the design progresses.

At the base of the weir control structure will sit a field of 12" riprap to form a dissipation zone for water spilling over the concrete weir and into the detention basin. This was added to reduce the velocity of the incoming water and prevent any scouring of the ground at the base of the weir structure. The water will then drain out of the basin via the 3-foot-wide concrete swale and through a 36-inch culvert through the base of the containment levee and back out to River Des Peres.

Figure 3. Detention Basin 3 Weir Control Structure and Drainage Structures

Some assumptions were made regarding the demolition of the existing buildings on the DB3 site that add some risk to the project at this point in its development. These assumptions were made to cover the gaps we have in our reference information, particularly when it comes to the building dimensions and utility locations. There were no architectural plans for the buildings on the site so rough measurements were taken in the field by PDT members. For underground utilities, only the MSD facility maps were available during the alternative design, but no other utility company maps. This leaves the project open to potential utility relocations and removals, which can be costly, especially in urban areas such as University City.

2.3.2 Detention Basin 4 (DB4)

The Detention Basin 4 is in the City of Overland and includes most of the area for Woodson Road Park, on the 1625 Woodson Road parcel, and a portion of the 1655 Woodson Road parcel, which is a federal government property. The site includes a dog park, a gazebo, a playground, overhead light banks, an asphalt parking lot, and an asphalt running track, along with the trees and vegetation you would expect to see in a public green space. All these amenities would need to be removed to construct the detention basin. At this point of the design process, relocation of the amenities has not been evaluated. See Figure 4 for plan view of the site.

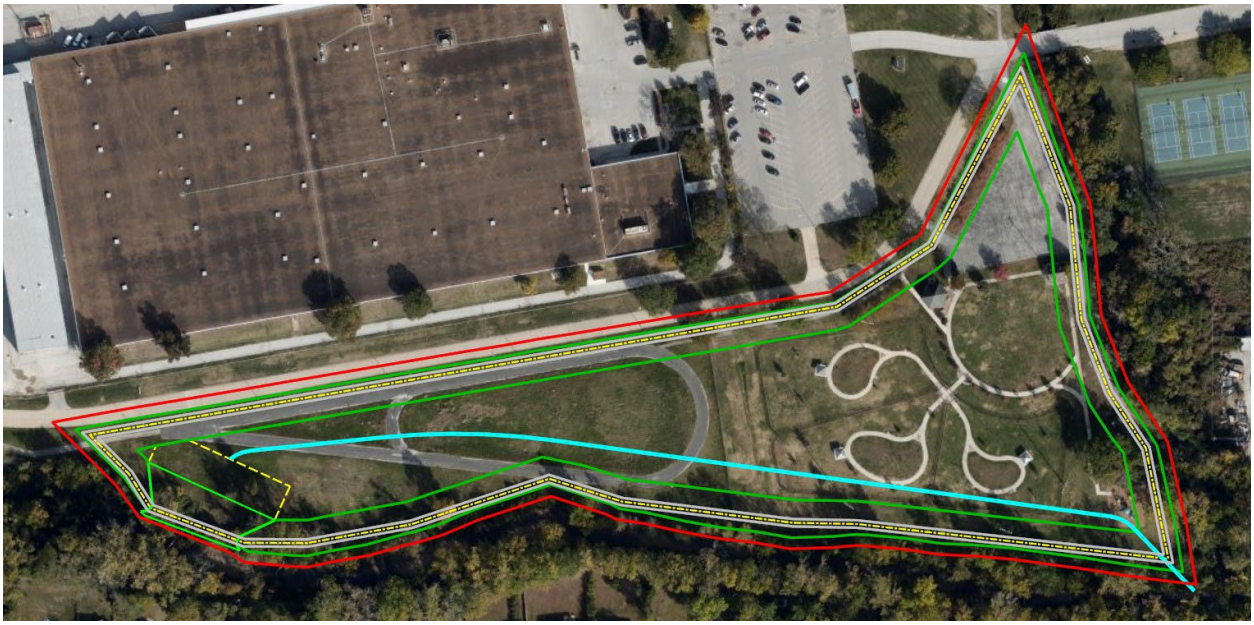


Figure 4. Plan View of Detention Basin 4 Site

This site was not the first area analyzed for detention basin 4. The original placement was made up of the 1575 Woodson Rd, 1601 Woodson Rd, and a portion of the 1625 Woodson Rd parcels, bound on the North by Pickering Drive, the East by Woodson Road, the South and West by River Des Peres. The design was moved away from this site due to major real estate cost concerns.

Different iterations of the detention basin were analyzed hydraulically and for constructability. The structure will cover roughly nine (9) acres of space and consist of a containment levee running along the perimeter of the DB4 site, a weir control structure, a 36" diameter culvert for drainage, and a concrete swale connecting the two. The elevations for the containment levee, the weir control structure, and the bottom of the detention basin were set by the hydraulic calculations to:

- Containment Levee Elevation: 563.0 Feet
- Weir Control Structure Elevation: 557.5 Feet
- Basin Bottom Elevation: 550.0 Feet

The containment levees were designed with a 10-foot-wide flat top with 2:1 side slope up to the existing ground on the exterior of the basin and down to the basin bottom elevation on the

interior side. The proposed elevations for the components of the detention basin are significantly lower than the existing site elevation and will require extensive excavation for construction. The 2:1 side slope was used to gain maximum amount of water storage during peak runoff events. These will need to be further analyzed to find ways to mitigate the potential risks involved with slopes this steep.

The concrete weir control structure will be 125 feet wide and have concrete wing walls to account for the elevation difference between the containment levee and the weir elevation. See Figure 5 for a rough schematic of the weir control structure. The concrete was designed to be 12 inches thick, with the wing walls designed to be 6" thick. At this stage in the design process, foundation design work for the weir control structure has not been done. We will need better soil data for the project site and a geotechnical review of the design to make sure that the risks we are seeing now are reduced as the design moves forward.

At the base of the weir control structure will sit a field of 12" riprap to form a dissipation zone for water spilling over the concrete weir and into the detention basin. This was added to reduce the velocity of the incoming water and prevent any scouring of the ground at the base of the weir structure. The water will then drain out of the basin via the 3-foot-wide concrete swale and through a 36-inch culvert through the base of the containment levee and back out to River Des Peres.

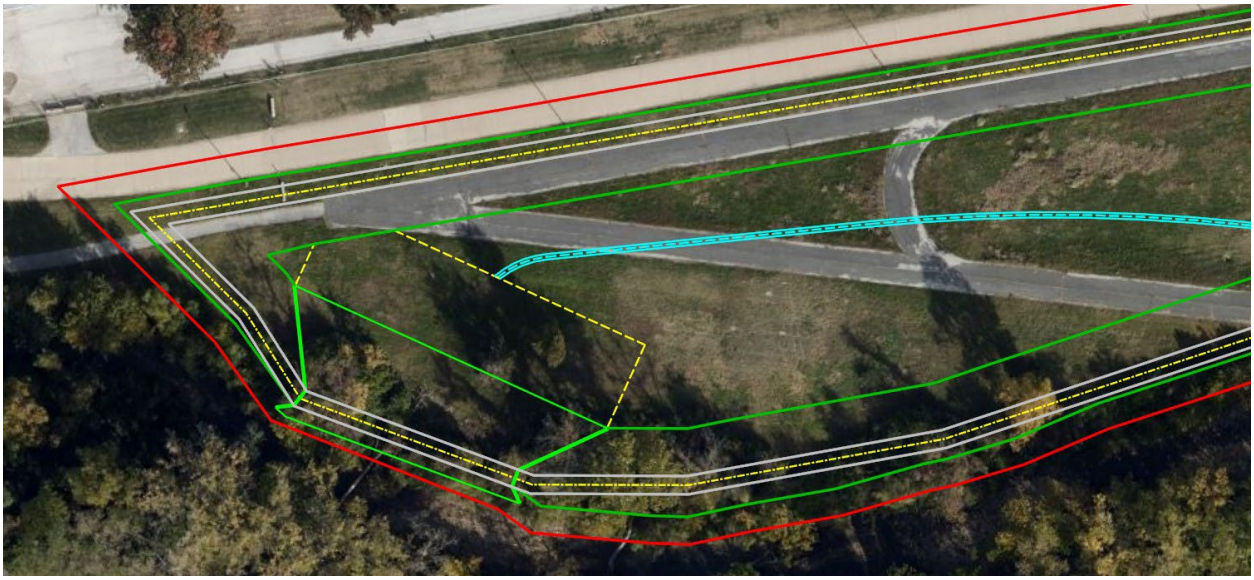


Figure 5. Detention Basin 4 Weir Control Structure

Some assumptions were made regarding the underground utilities for this site, the same that were made for the detention basin 3 site. Another assumption made for this site is that the City of Overland, MO would be willing to participate by selling the land for detention basin 4 despite not being the non-federal sponsor for the project. Without the parcels owned by the City of Overland and the federal government mentioned above, this alternative will not be a viable option.

2.4. ALTERNATIVE 3B - DETENTION BASIN 4 (DB4) ONLY

This structural alternative includes only Detention Basin 4, as it is highly viable on its own from a Cost-Benefit perspective. The design of DB4 is the same as mentioned above.

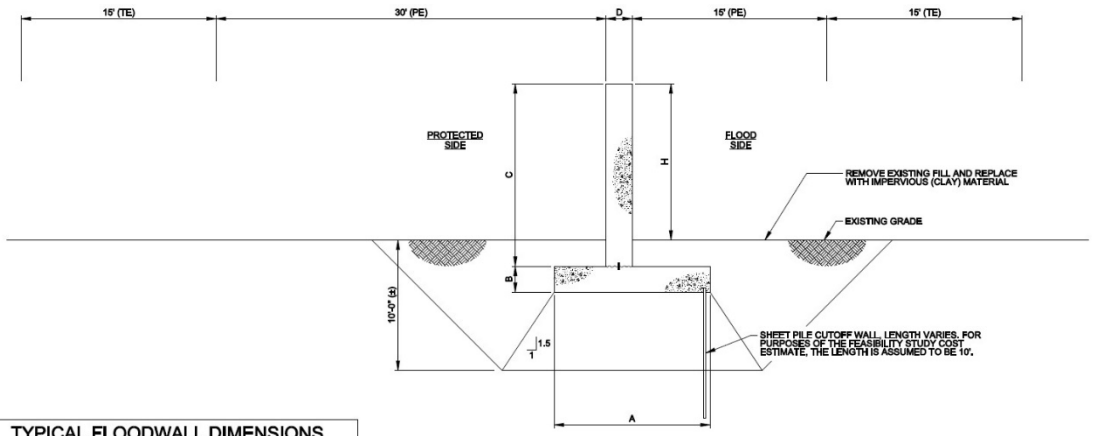
2.5. ALTERNATIVE 4 - LEVEE & FLOODWALL ALIGNMENT

This structural alternative includes a combination earthen levee and concrete floodwall that would stretch for roughly 8,650 feet along River Des Peres from the East side of the University City Rec Center to the West side of Groby Road. The alignment was placed as close to the river's edge as possible in order to reduce real estate costs for the alternative. See Figure 6 for a plan view of the Levee-Floodwall system.

Figure 6. Plan View of the Combination Earthen Levee – Concrete Floodwall Alignment

The earthen levees for the system are designed with a 10-foot-wide top with 3:1 side slopes down to the existing ground. There will be a permanent access easement 15 feet out from the toe of the levee and a temporary construction easement 15 feet beyond the permanent easement. The borrow for these levees will either come from the spoils of the detention basin sites or a borrow location will need to be identified off site to provide the necessary material. There are two runs of earthen levee in the combined system: One along the East side of the University City Rec Center and the other along the South side of Wilson Ave.

The concrete floodwall sections of the system were designed using a cross section from a Rock Island District (MVR) project in Cedar Rapids, IA (see Figure 7 below). The MVR "Typical Floodwall Section" provide the dimensions for the floodwall with varying heights, making our quantity estimates much simpler and more accurate to put together.



TYPICAL FLOODWALL DIMENSIONS				
H	A	B	C	D
24'-0"	28'-0"	3'-0"	25'-0"	3'-0"
21'-0"	21'-0"	3'-0"	22'-0"	2'-6"
18'-0"	18'-0"	2'-6"	19'-6"	2'-0"
15'-0"	15'-0"	2'-0"	17'-0"	2'-0"
12'-0"	12'-0"	2'-0"	14'-0"	2'-0"
9'-0"	8'-0"	2'-0"	11'-0"	2'-0"
6'-0"	5'-0"	1'-6"	8'-6"	1'-6"
3'-0"	5'-0"	1'-6"	5'-6"	1'-6"

ABBREVIATIONS

PE - PERMANENT EASEMENT
TE - TEMPORARY EASEMENT

TYPICAL FLOODWALL SECTION
SCALE: NO SCALE

Figure 7. Concrete Floodwall Typical Section

Another design obstacle that had to be overcome for the levee-floodwall system was the 6 road crossings that the system needed to make to complete the system. H&H determined that the floodgates needed to be automatic due to the short response time available to the authorities in University City prior to a major runoff event. The product chosen for this design was the automatic roadway floodgates made by the company Floodbreak. These gates are powered by the floodwater itself to engage the system (see Figure 8 below for a schematic of the gate system).

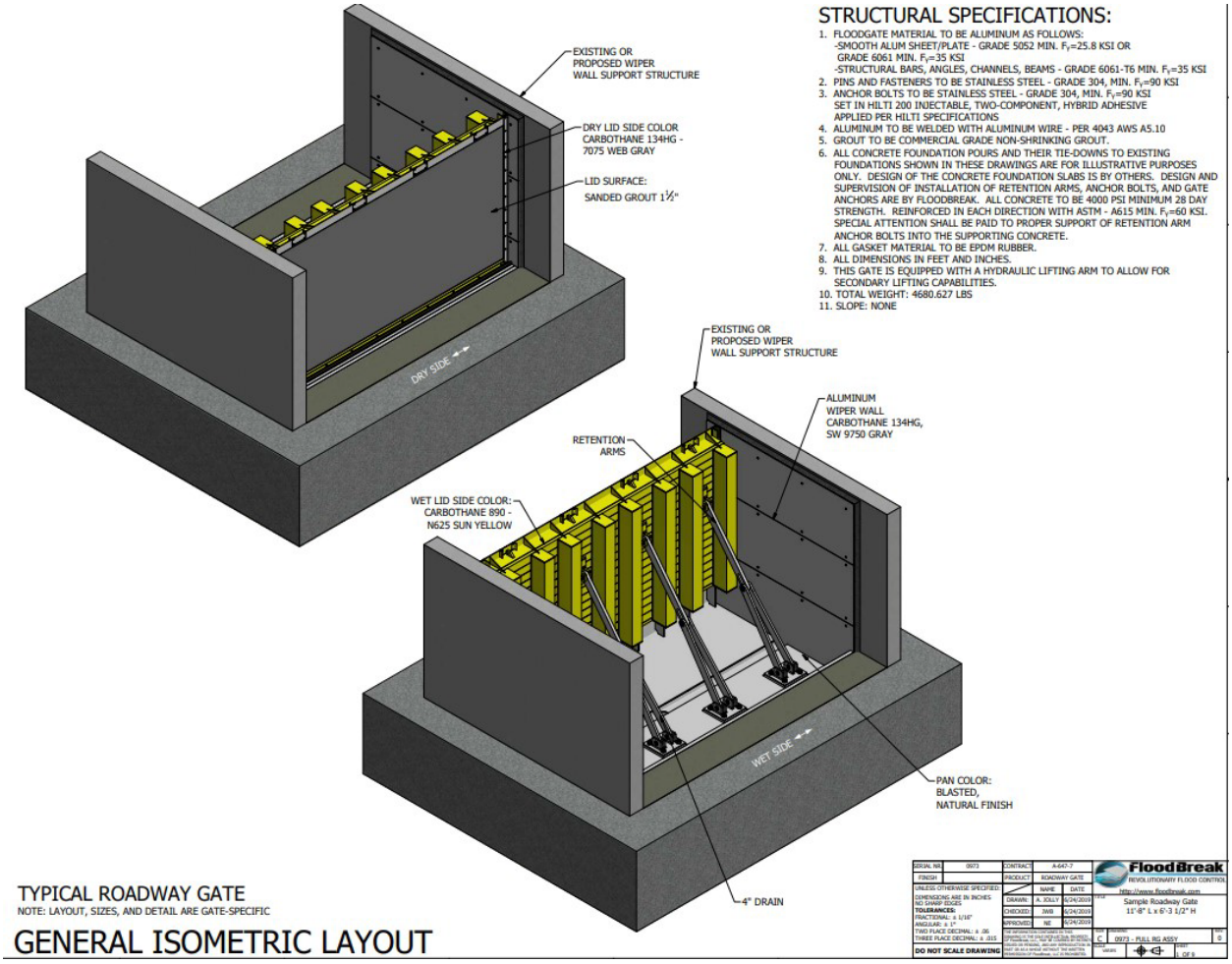


Figure 8. Floodbreak Automatic Floodgates Schematic

The design of the levee-floodwall system required many assumptions to be made for real estate, underground utility, and general constructability reasons. Though the system was moved as close to the river as possible to reduce property buyouts, there are still some properties that will be impacted, and many properties will require permanent access easements for maintenance on the system. The underground utility concerns mentioned for the detention basin alternatives are also present for the levee-floodwall system, though with much higher potential for conflicts due to its much larger footprint across many different public Right-of-Way zones. The constructability concerns stem from the system being so close to the river, causing the construction work in many sections of the concrete floodwalls to be done inside of the river channel. This work will be much more expensive and could cause environmental and life safety concerns. All these concerns will need to be further evaluated should this alternative be brought forward.

2.6. ALTERNATIVE 5 - NON-STRUCTURAL OPTION 1: ACQUISITION/BUYOUT

There are no civil engineering concerns with this alternative. The properties to be acquired will be selected using the hydraulic and economic models for the project.

2.7. ALTERNATIVE 6 - NON-STRUCTURAL OPTION 2: ELEVATION & FLOODPROOFING

This alternative involves the identification of properties that have a flooding level that could be mitigated by raising the bottom elevation of the structure in combination with wet and/or dry floodproofing that could be used to mitigate damage to the properties. The Economics and Hydraulics sections have been looking into the floodproofing options for this alternative but have much further to go to accurately identify which floodproofing measures will be used. To this point of the alternative design process, structural engineers have not been engaged on what design risks and assumptions would have to be made to pursue this option. This work will need to be done in the next phase should this alternative be brought forward.

2.8. ALTERNATIVE 7 - NON-STRUCTURAL OPTION 3: ELEVATION ONLY

This alternative involves the identification of properties that have a flooding level that could be mitigated by raising the bottom elevation of the structure. To this point of the alternative design process, structural engineers have not been engaged on what design risks and assumptions would have to be made to pursue this option. This work will need to be done in the next phase should this alternative be brought forward.

2.9. ALTERNATIVE 8 - COMBINATION STRUCTURAL & NON-STRUCTURAL: DB4 & ELEVATION

This alternative combines the structural alternative 3b (DB4) with the non-structural alternative of elevation raising. Each of these alternatives have been discussed above and have the same risks, benefits, and still required design work as previously stated.

3. UTILITIES AND RELOCATIONS

As mentioned earlier in this appendix, the design team did not have access to all the underground utilities in the project area. The MSD sanitary and stormwater facility maps were available and designed around. Some stormwater relocations were identified for the Detention Basins 3 & 4 sites, but no removals or relocations of water, gas, telephone, or electric utilities were designed. There were some overhead utility lines at each of the detention basin sites, but none that seemed to warrant relocations, only protection during construction. There were however multiple runs of overhead utilities within the footprint of the levee-floodwall system that would require removal and relocation. The cost for these relocations was estimated and included in the cost estimate for the alternative.

4. REFERENCES

EM 1110-2-1913 "Design and Construction of Levees"

EM 1110-2-2502 "Retaining and Flood Walls"

ER 1110-2-11156 "Safety of Dams – Policy and Procedures"