# APPENDIX F

# KIMBERLEY LANE DRAINAGE IMPROVEMENTS
# PRELIMINARY ENGINEERING REPORT

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# PRELIMINARY ENGINEERING REPORT

Prepared for the

## MEMORIAL CITY REDEVELOPMENT AUTHORITY

On behalf of

## TAX INCREMENT REINVESTMENT ZONE NO. 17
(TIRZ No. 17)

prepared by


Lockwood, Andrews & Newnam, Inc.
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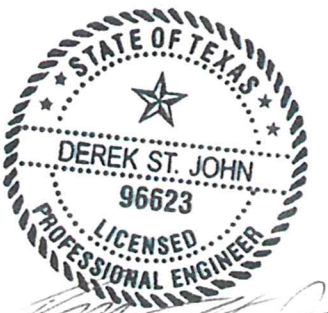


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LOCKWOOD, ANDREWS & NEWNAM, INC.
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# TABLE OF CONTENTS

# LIST OF EXHIBITS



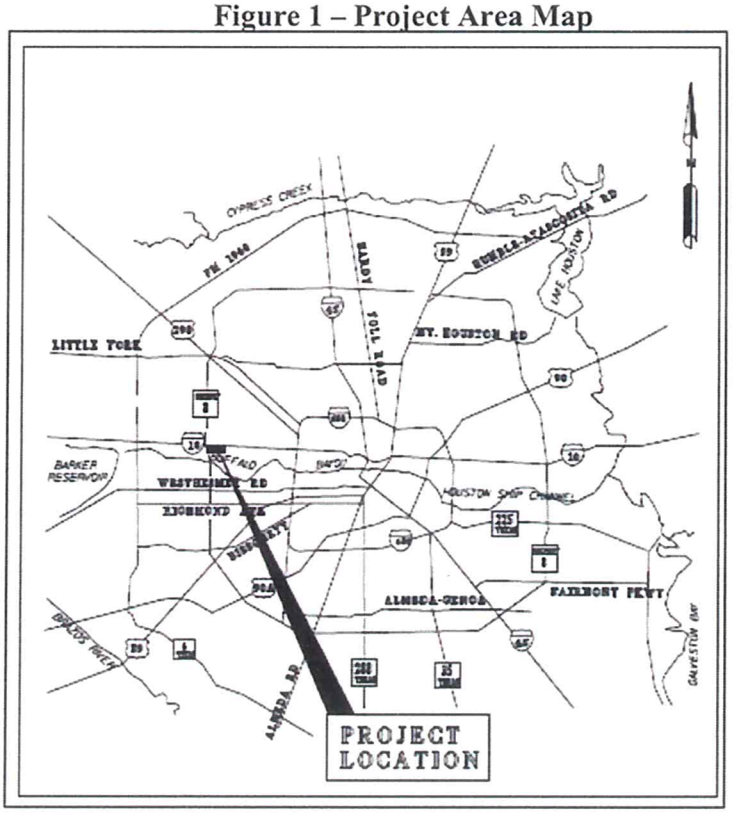
# LIST OF APPENDICES

# EXECUTIVE SUMMARY

## Project Location and Purpose

Located in Harris County and the City of Houston, the existing Kimberley Lane storm sewer consists of approximately 2,000 feet of storm sewer trunk line that serves Kimberley Lane and Town and Country Boulevard. The project limits extend along Kimberley Lane from the Sam Houston Tollway Frontage Road to the east side of West Bough Lane and Kimberley Lane. The limits also extend along Town and Country Boulevard as the majority of this roadway is served by the Kimberley Lane storm sewer trunk line. The Town and Country Boulevard storm sewer begins approximately 200feet south of Queensbury Lane and extends south where it combines with the Kimberley Lane storm sewer trunk line. The system receives flow from Kimberley Lane and the portion of Town and Country Boulevard north of Kimberley Lane and south of Queensbury as well as adjacent commercial and private developments. These developments include the Phase 1 portion of the Town and Country Village development, Wildcat Way School, Bendwood School, and Pines Presbyterian Church. Key Map pages 489C, D, G, and H contain the project limits. The general location for the project is shown in **Figure 1**. A more detailed map of the project location can be found in **Exhibit 1**.

**Figure 1 – Project Area Map**




The storm sewer trunk line that serves Kimberley Lane was identified by the City of Houston Comprehensive Drainage Plan as inadequately sized. The City of Houston Comprehensive Drainage Plan determined the adequacy of storm sewer sizes based on the hydraulic grade line

(HGL) elevation being no less than 2 feet below the manhole top elevation or natural ground elevation at each node. In order to reduce the flooding that has been witnessed within the project limits, the Tax Increment Reinvestment Zone No. 17 (TIRZ 17) has adopted the Kimberley Lane storm sewer project as part of their Drainage Action Plan. The purpose of this project is to provide a reasonable and efficient alternative to improve the drainage level of service for this roadway.

## Existing Conditions

The existing storm sewer trunk line was analyzed from the outfall at Buffalo Bayou to the northern upstream limits of the storm sewer system's drainage area. The roadway inlets and laterals within the Kimberley Lane Storm Sewer Project limits were included in the storm sewer hydraulics analysis using the City of Houston's HouStorm software. The existing conditions analysis found the existing storm sewer along Kimberley Lane and Town and Country Boulevard to be adequately designed for a 2-year storm in accordance with the *City of Houston Infrastructure Design Manual*. The City of Houston Comprehensive Drainage plan found the storm sewers within the project limits to be undersized. A possible reason for the difference in conclusions is that the Comprehensive Drainage Plan considered a storm sewer to be undersized if the HGL was within 2 feet of the manhole top or natural ground elevations, whereas the *Infrastructure Design Manual* only requires the HGL to be below the gutter line elevation. The CDP's deviation from the *Infrastructure Design Manual* is due in part to data availability. Manhole elevation data is more readily available city wide than inlet gutter line elevation data. The existing inlet spacing was determined to adequately drain the project site. Although the storm sewer system was determined to be adequate for a 2-year storm event, depressed areas along Kimberley Lane were identified to have the potential to experience large volumes of ponding for storm events when the capacity of the storm sewer or inlets is exceeded. Additionally, the maximum ponding elevation for the extreme event (100-year event) was found to exceed the natural ground elevation at the ROW line at some locations. Therefore the system does not satisfy the 100-year COH criteria. This is considered the critical factor in the analysis of the Kimberley Lane storm sewer. This project focuses on design alternatives that will reduce the amount of flooding experienced during lower frequency events without eliminating the overall amount of storage provided in the roadways and storm sewer under the existing conditions.

## Evaluation of Alternative Solutions

Multiple alternatives were considered in order to provide the optimal solution in terms of drainage benefit, cost, construction time, and construction impact. The proposed alternatives are intended to improve the level of service for the drainage system. Several options were considered to improve the level of service of the Kimberley Lane storm sewer system. Multiple variations of each option were considered in order to provide varying levels of service. Project life cycle cost was a major consideration in determining the different alternatives as short sighted options would cause increased costs in the near future. The different options considered for improving the level of service of the Kimberley Lane storm sewer system are described below:

- **Option 1: Remove Kimberley Lane Road high point and mitigate storage loss.**
  - Remove highpoints at intersections of Kimberley Lane; the Sam Houston Tollway Frontage Road, and Town and Country Boulevard
  - Allows sheetflow ponding within allowable depths
  - Mitigation volume for the lost storage volume would be required
  - Not feasible to tie into existing roadway elevations and provide minimum roadway slopes
- **Option 2: Raise Kimberley Lane road and mitigate storage loss.**
  - Raise roadway approximately 0.5 feet
  - Eliminates "bowl effect"
  - Includes 1,133 feet of 5'x3' boxes to mitigate loss of storage
  - Compliments and ties into reconstruction of Kimberley Lane east of West Bough Lane as part of the Fonn Villas neighbored improvement project
  - Complete Solution (other options offer varying levels of improvements)
  - Total Cost: $1,821,000
- **Option 3: Mitigate storage, increase level of service, and accommodate future improvements.**
  - Provide at minimum the amount of storage described in Option 2 without raising the roadway
  - Improves level of service by providing additional storm sewer volume
    - Provides a level of service between 10 and 25 years
  - Allows for raising of the roadway described in Option 2 at a later date if desired
  - Current Cost of Storm Sewer Improvements: $840,000
    - Future Cost of Raising Roadway: $1,140,000
    - Total Cost: $1,980,000
- **Option 4: Improve the storm sewer to provide greater level of service.**
  - Provide storage within the storm sewer to provide a desired level of service
  - Acceptable amount of storage for water within roadway
  - Current Cost of Storm Sewer Improvements: $1,004,000 (25-year LOS)
    $1,333,000 (100-year LOS)
    - Future Cost of Raising Roadway: $1,140,000
    - Total Cost: $2,251,000 (25-year LOS)
      $2,580,000 (100-year LOS)
- **Option 5: Do nothing.**
  - Leave the roadway and storm sewer system as-is and do not perform upgrades or improvements.

## Recommended Project

Option 2 is the recommendation for the Kimberley Lane Storm Sewer project. This option reconstructs and raises Kimberley Lane and places compensatory concrete box culverts to offset the loss of existing storage. This alternative has several benefits that distinguish it from the other alternatives. The 5'x 3' boxes are placed in a location where there are minimal utilities in the area This option addresses Kimberley Lane's need of reconstruction and provides a complete problem solution. In addition, Option 2 has the lowest total construction cost.

## Estimated Construction Costs and Time

Key items that differentiated the cost estimates for the different alternatives were concrete removal, concrete replacement, and concrete pipe. Tasks included in the construction time estimates are mobilization, traffic control, relocating major and minor utilities, removing concrete, placing storm sewer, relaying curb, project clean-up and inspection, storm water prevention plan, rain delays, and weekends. The estimated construction time and construction cost for each of the alternatives is shown in **Table 1**. For clarification, it is important to note that the costs shown in **Table 1** are only the construction costs. The total cost estimates are given in **Table 4** later in the report.

**Table 1 – Estimated Construction Costs and Time**

| Proposed Alternative | Estimated Construction Costs | Estimated Construction Time (working days) |
|---|---|---|
| Option 1 | N/A | N/A |
| Option 2 | $1,600,000 | 114 |
| Option 3 | $800,000* | 32 |
| Option 4 | $900,000* | 39 |
| Option 5 | $0 | 0 |

*Does not include future Kimberley Reconstruction Costs

The scheduling estimate also varies between the alternatives. The schedules for Option 3 and Option 4 are estimated to be nearly the same. Option 2 however has a greater construction time due to the removal and replacement of Kimberley Lane.

# Section 1 - Introduction

## 1.1 Project Location

Kimberley Lane is located in west Houston approximately one-half mile south of the intersection of Interstate 10 and the Sam Houston Tollway at the west end of the TIRZ 17 boundary. The Kimberley Lane storm sewer extends from the intersection of the Sam Houston Tollway Frontage Road and Kimberley Lane to just east of the intersection of West Bough Lane and Kimberley Lane. The storm sewer also branches at Town and Country Boulevard and continues approximately 750 feet north of Kimberley Lane on Town and Country Boulevard. The Kimberley Lane storm sewer merges with the Sam Houston Tollway Frontage Road trunk line which continues south to outfall at Buffalo Bayou. The project area can be found on Key Map page 489C, 489D, 489G, and 489H. **Exhibit 1** shows a detailed location of this project.

## 1.2 Project Authorization and Scope of Work

Lockwood, Andrews, & Newnam, Inc. has been requested by the Tax Increment Reinvestment Zone No. 17 (TIRZ 17) to prepare a Preliminary Engineering Report (PER) for the Kimberley Lane Storm Sewer Improvements Project. The Queensbury Storm Sewer Improvement Project originated in the City of Houston (COH) Comprehensive Drainage Plan which classified the level of service of the storm sewer as insufficient. The Comprehensive Drainage Plan (CDP) is a component of the Storm Drainage Facilities Improvements Program which is part of the City of Houston's overall Capital Improvement Program (CIP). The CDP identifies inadequate drainage systems that need to be upgraded. The Kimberley Lane Storm Sewer Project was also included in the TIRZ 17 Drainage Action Plan and identified as a high ranking project because of the adjacent planned redevelopment. The TIRZ 17 Drainage Action Plan summarized available drainage studies and reports for the region and identified potential drainage projects that impact the TIRZ 17.

The scope of work for the project includes several tasks necessary for the proposed storm sewer design. A summary of the tasks in the scope of this project are listed below and described in more detail in later parts of the report:

- Existing Utilities Research
- Drainage Area Maps
- Overland Flow Pattern Evaluation
- Existing System Analysis Problem Identification
- Preliminary Improvement Alternatives Preparation
- Proposed System Analysis
- Preliminary Engineering Report Preparation
- Project Management and Agency Coordination
- Appropriate Topographic Survey Acquisition

## 1.3 Design Criteria

The design criteria for this project are based on City of Houston (COH) standards which can be found in the *COH Infrastructure Design Manual*, October 2008. Storm Sewer design criteria can be found in Section 9.05 C of the *COH Infrastructure Design Manual.*

In accordance with City design standards, the first objective in the analysis of the existing Kimberley Lane storm sewer system is to determine the location of hydraulic grade line (HGL) in relation the gutter line for the 2 year storm event.

The second objective is to ensure that flow from an extreme event (100-year storm) can be conveyed in the storm sewer and through street sheet flow. The following regulations were used to establish roadway cross-sections and then calculate the flow conveyed by the cross-section:

- Streets shall be designed so that consecutive high points in the street will provide for a gravity flow of drainage to the ultimate outlet.
- The maximum depth of ponding at high points shall be 6" above top of curb.
- The maximum depth of ponding at low points shall be 18" above top of curb.
- The maximum ponding elevation for the 100-year event at any point along the street shall not be higher than the natural ground elevation at the ROW line.

Methods 1 through 3 from Section 9.05D of the *COH Infrastructure Design Manual* were used as guidance for analyzing the extreme event. Conduit flow ($Q_c$) was defined as the flow in the storm sewer for the 2 year design storm. The extreme event consideration requires that the flow from the 100 year event at the ultimate outlet ($Q_T$) can be carried by the flow in the storm sewer ($Q_C$), the overland flow in the street ($Q_O$), and the change in storage with respect to time ($\Delta S/T$).

Methods 1 and 2 from the *COH Infrastructure Design Manual* remove the storage consideration by determining if the total flow ($Q_T$) can be conveyed only using conduit flow ($Q_c$) and overland flow ($Q_O$).

The City of Houston's version of TxDOT WinStorm software, HouStorm, was used to model the existing and proposed storm sewer storm sewer networks. HouStorm utilizes the rational method to estimate peak run-off rates. The run-off coefficients were determined from the COH criteria shown in **Table 2**. The HouStorm output for this project can be found in **Appendix B**.

**Table 2 - COH Run-off Coefficients**

| Land Use Type | Run-off Coefficient (C) |
|---|---|
| Residential Districts | |
| Lots more than 1/2 acre | 0.35 |
| Lots 1/4 - 1/2 acre | 0.45 |
| Lots less than 1/4 acre | 0.55 |
| Multi-Family area | |
| Less than 20 Service Units/Acre | 0.65 |
| 20 Service Units/Acre or Greater | 0.80 |
| Business Districts | 0.80 |
| Industrial Districts | |
| Light Areas | 0.65 |
| Heavy Areas | 0.75 |
| Railroad Yard Areas | 0.30 |
| Parks/Open Areas | 0.30 |

Time of concentration was computed using the following equation:

$$TC = 10A^{0.1761}+15$$

Where: TC = time of concentration (minutes)

A = subarea (acres)

The design criteria used for storm sewers in the Queensbury Storm Sewer Project can be found in Section 9.05.C of the *COH Infrastructure Design Manual*.

# Section 2 - Existing Conditions

## 2.1 Overview of Existing Conditions

The Kimberley Lane project limits consists of commercial and private developments. The storm sewer along Kimberley Lane has a cumulative drainage area of approximately 25 acres. It is assumed that there will be no changes in land use or impervious area in the future. Existing public and private utilities are also discussed in this section.

### 2.1.1 Land Use and Development

The contributing drainage area for the Kimberley Lane Storm Sewer consists of commercial and private developments. The Town and Country Village Shopping Center comprises approximately sixty percent of the area that contributes to the Kimberley Lane storm sewer. The remainder of the contributing drainage area comes from private developments adjacent to Kimberley Lane. Bendwood Elementary School and Wildcat Way School drain to the system and are located on the north side of Kimberley lane and the east end of the contributing drainage area. On the south side of Kimberley Lane, a portion of the Pines Presbyterian Church property contributes to the Kimberley Lane Storm sewer while the rest drains south into the storm sewer system along Memorial Drive.

The Kimberley Lane storm sewer included in the project begins just east of West Bough Lane and extends west to the Sam Houston Tollway frontage road. The Kimberley Lane storm sewer system begins at a manhole just east of West Bough Lane and north of Kimberley Lane. This manhole receives flow from a detention pond for Bendwood Elementary School and serves as an interconnector for two different storm sewer systems. The storm sewer system to the east of the manhole serves the Fonn Villas subdivision. The storm sewer system to the west of the manhole is the system associated with this project referred to as the Kimberley Lane Storm Sewer System. For modeling purposes, the drainage areas were divided at this manhole and the interconnector pipe between the two systems was ignored. The Sam Houston Tollway lies west of the project limits and has only an indirect impact on the project because it serviced by its own storm sewer system.

### 2.1.2 Existing Pavement and Right-of-Way

The Kimberley Lane storm sewer system trunk line runs along Kimberley Lane. Kimberley Lane is a four-lane (two lanes in each direction) undivided curb and gutter roadway. Kimberley Lane is approximately 40 feet wide from the front of curb to the opposite front of curb. Approximately 10 feet of right-of-way exists on each side of the pavement for a total of 60 feet of roadway right-of-way.

Town and Country Boulevard north, of Kimberley Lane and south of Queensbury, also contains a portion of the Kimberley Lane storm sewer system. Town and Country Boulevard is a four-lane, (two lanes in each direction) roadway with a 30-foot wide grass median. The median is broken in several locations for entrances into the Town and Country Village Shopping Center areas. In addition, left turn bays exist at the approaches to the Queensbury and Kimberley Lane

intersections. A typical section of Town and Country Boulevard with the full width of median consists of 24 feet wide from front of curb to the opposite front of curb for both the northbound and southbound traffic lanes. A 30-foot wide median lies between the northbound and southbound roadways. There is an additional 11 feet of right-of-way behind the curb for both sides of the roadway comprising a total of 100 feet of right-of-way.

### 2.1.3 Existing Public Utilities

Water lines and sanitary sewers are found at a number of locations in the Kimberley Lane Storm Sewer Project vicinity. Information on these utilities was obtained from survey data, record drawings from the City of Houston, record drawings from AT&T that showed other utilities on the drawings, and the City of Houston Geographic Information & Management System (GIMS). **Exhibit 2** shows the existing public utilities for this project.

#### 2.1.3.1 Water Lines

An existing water line is located along the north side of Kimberley Lane within the roadway. The line consists of a portion of 6-inch cast iron pipe with an unknown construction date transitioning to an 8-inch cast iron pipe approximately 760 feet east of the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road. The 8 inch portion of line was constructed in 1962.

Several other waterlines are also located within the vicinity of the Kimberley Lane storm sewer. An 8-inch cast iron water line located 5 feet behind the back of curb in the east ROW of Town and Country Boulevard runs north from the 6 inch water line located within Kimberley Lane. According to as-built drawings, this line was built in 1962, but disagreement exists between the size and material of the line stated in the as-built drawings when compared to the City of Houston GIMS. The COH GIMS reports the waterline to be a 12 inch asbestos concrete waterline.

Approximately 570 feet north of the intersection of Kimberley Lane and Town and Country Boulevard, a 6-inch fire hydrant lead of unknown material crosses the northbound lanes of Town and Country Boulevard in an east west direction. Detailed plans were not available for this lead, so vertical elevations for this line are unknown, but the lead appears to tie into the above referenced water line in the east ROW of Town and Country Boulevard.

Approximately 310 feet east of the intersection of Kimberley Lane and Town and Country Boulevard an abandoned 8 inch waterline crosses Kimberley Lane. In 1996 this line was cut and plugged approximately 10 feet south of the 8 inch waterline that runs east west on Kimberley Lane. It is unknown if the northern portion of the line is still under pressure, but it is assumed the southern portion of the line is abandoned.

Approximately 340 feet east of the intersection of Kimberley Lane and Town and Country Boulevard an 8-inch cast iron waterline crosses beneath Kimberley Lane. Placed in 1996, this line crosses above the 54 inch sanitary sewer located in the south Kimberley ROW and ties into the 8-inch waterline running east/west along Kimberley Lane.

Slightly west of the intersection of Kimberley Lane and West Bough Lane, an 8-inch cast iron waterline crosses beneath Kimberley Lane. Detailed flowlines from as-built drawings for this waterline were not available, but this waterline is believed to tie into the 8-inch waterline running east/west along Kimberley Lane. This waterline was constructed in 1966. Near the same crossing, a fire hydrant lead runs south from the 8-inch waterline running east/east along Kimberley Lane to the southwest corner of the intersection of Kimberley Lane and West Bough Lane. This lead is of an unknown material, but is 6-inches in diameter and was constructed in 1962.

### 2.1.3.2 Sanitary Sewers

Active sanitary sewer lines cross the Kimberley Lane storm sewer in four different locations. The first crossing is located at the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road. The second crossing is located along Kimberley Lane approximately 210 feet east of the intersection of Kimberley Lane and Town and Country Boulevard. A third crossing is located along Kimberley Lane approximately 340 feet east of the intersection of Kimberley Lane and Town and Country Boulevard. The fourth intersection is located along Town and Country Boulevard approximately 545 feet north of the intersection of Kimberley Lane and Town and Country Boulevard.

At the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road a 54 inch monolithically reinforced concrete pipe passes below the Sam Houston Tollway Frontage Road storm sewer trunk. Installed in 1966, this sanitary sewer passes approximately 2 feet below the Sam Houston Tollway Frontage Road trunk line. This sanitary sewer is located approximately 3 feet behind back of curb in the south ROW of Kimberley Lane and continues to run east through the project area. Conflicts with this sanitary sewer are not anticipated.

Approximately 210 feet east of the intersection of Kimberley Lane and Town and Country Boulevard a 15 inch sanitary sewer (installed in 1966) crosses beneath Kimberley Lane. The sanitary sewer passes beneath the Kimberley Lane storm sewer with approximately 5-feet of vertical clearance. Conflicts with this sanitary sewer are not anticipated.

Approximately 340 feet east of the intersection of Kimberley Lane and Town and Country Boulevard an 8-inch PVC sanitary sewer (installed in 2001) crosses beneath Kimberley Lane. Detailed plans were not available for this sanitary sewer but it is estimated that this sanitary sewer passes beneath the Kimberley Lane storm sewer with a vertical clearance of approximately 3.5 feet. Conflicts with this sanitary sewer are not anticipated due to its depth.

The fourth sanitary sewer crossing is located along Town and Country Boulevard approximately 545 feet north of the intersection of Kimberley Lane and Town and Country Boulevard. A sanitary sewer crosses Town and Country Boulevard in an east west direction and consists of a 15-inch cast iron pipe (installed in 1966) passing approximately 5 feet beneath the storm sewer located on Town and Country Boulevard. While passing under the median of Town and Country Boulevard, the sanitary sewer intersects a manhole. Another 15 inch ASTM C-14 extra strength pipe (installed in 1996) runs north from this manhole to the northern extents of the Kimberley

Lane storm sewer project. This secondary 15 inch sanitary sewer is located approximately 12 feet west and approximately 5 feet beneath the Town and Country Boulevard storm sewer.

An abandoned 8 inch sanitary sewer is located approximately 165 feet north of the intersection of Kimberley Lane and Town and Country Boulevard. This line is located at an unknown depth, but according to City of Houston GIMS the line is listed as abandoned. Installed in 1958 and taken out of service at an unknown date, it is also possible that sections of the line may have already been removed.

### 2.1.4 Existing Private Utilities

CenterPoint Energy (CPE) and AT&T have private utilities in the Kimberley Lane storm sewer's vicinity. Utility information was requested and obtained from both companies. Texas One Call should be contacted at least 48 hours prior to excavation to establish the locations of all underground utilities. Contacts for these companies are shown in **Table 3**.

**Table 3 – Private Utility Contacts**

| Private Utility Owner | Contact | Contact Information |
|---|---|---|
| CenterPoint Energy | Cynthia Martinez | CenterPoint Energy<br>Eng. Department<br>1301 Travis Street,<br>Suite 762<br>Houston, Texas 77002<br>Phone: 713-207-4622 |
| AT&T | N/A | AT&T Texas<br>Conduit Group<br>6500 West Loop South<br>Zone 1.3<br>Bellaire, TX 77401 |
| Texas One Call | N/A | 1-800-669-8344<br>http://www.onecalltexas.com/centers.html |

#### 2.1.4.1 Existing CenterPoint Energy Gas Facilities

An existing 4 inch IP steel gas line is located in the south ROW of Kimberley Lane for the length of the Kimberley Storm Sewer project. The location of the line varies but is located between 4 and 6 feet north of the south ROW boundary. A 2 inch IP steel gas line crosses beneath Kimberley Lane approximately 810 feet east of the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road. It is unknown if this line crosses above or below the Kimberley Lane storm sewer due to lack of detailed plan information. A 4 inch IP steel gas line crosses beneath Kimberley Lane at the western edge of the Kimberley Lane and Town and Country Boulevard intersection. It is also unknown if this line crosses above or below the Kimberley Lane storm sewer due to lack of detailed plan information.

### 2.1.4.2 Underground Electric Facilities

Record drawings were obtained from CenterPoint Energy indicating underground electric facilities. An underground street light cable crosses Kimberley Drive just west of the intersection of Kimberley Drive and Town and Country Boulevard. After crossing Kimberley Drive, the cable splits to run north along both sides of Town and Country Boulevard. In order to reach the east side of Town and Country Boulevard, the underground street light cable crosses Town and Country Boulevard just north of the intersection of Town and Country Boulevard and Kimberley Road. The underground street light cables run north behind the curb and in the ROW located along Town and Country Boulevard.

A major underground line and easement is shown on the record drawings to be located at the northwest corner of the intersection of Kimberley Lane and Town and Country Boulevard. According to the record drawings this line and easement are located north of the ROW along Kimberley Lane and should not be in conflict with the Kimberley Lane storm sewer system. Additional underground lines run east/west along Kimberley Lane but are located south of the south ROW along Kimberley lane and should not be in conflict with the Kimberley Lane storm sewer system.

Several CenterPoint Energy easements are located in the vicinity of the Kimberley storm sewer system. A 10 foot wide easement crosses Town and Country Boulevard approximately 200 feet north of the intersection of Town and Country Boulevard and Kimberley Lane. An additional 10 foot wide easement runs north from the Memorial City Shopping Center and is located approximately 150 feet east of the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road. This easement extends approximately 10 feet north into the south ROW located along Kimberley Lane. Another 10 foot wide easement runs north from the Memorial City Shopping center and is located approximately 320 feet east of the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road. This easement also appears to extend approximately 10 feet north into the south ROW located along Kimberley Lane. A third 10 foot wide easement runs north from the Memorial City Shopping Center and is located approximately 530 feet east of the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road. This easement terminates at the edge of the south ROW located along Kimberley Lane. A fourth 10 foot wide easement runs north from the Memorial City Shopping Center and is located approximately 850 feet east from the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road. This easement appears to extend approximately 10 feet north into the south ROW located along Kimberley Lane.

### 2.1.4.3 Existing AT&T Facilities

Multiple AT&T conduits and crossings are located in the vicinity of the Kimberley Lane storm sewer. East of the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road a 2 – 4 inch 'C' PVC (2Wx1H, placed in 1996) duct crosses approximately 2 feet above the 36 inch Kimberley Lane storm sewer trunk line. Approximately 200 feet east of the Kimberley Lane and Sam Houston Tollway Frontage Road intersection a 2 – 4 inch GIP (2Wx1H, placed in 1997) crosses Kimberley Lane under the Kimberley Lane storm sewer trunk line. According to

the as-built plans, a minimum of 6 inch vertical clearance exists between the duct bank and Kimberley Lane storm sewer.

Approximately 100-feet east of the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road, a 4 – 4 inch 'C' PVC (2Wx2H, unknown install date) conduit exits from behind the Kimberley Lane south curb and enters the roadway. This conduit is located approximately 5 feet in the roadway from the south curb and runs west until the conduit crossing under Kimberley Lane. At the above mentioned Kimberley Lane crossing, the conduit increases in size to 8 – 4 inch PVC (4Wx2H, placed 1997). This conduit continues to run east in the roadway for approximately 615 feet before re-entering the south ROW located along Kimberley Lane. After entering the ROW, the conduit is located 2 feet behind front of curb and continues east out of the project vicinity. It appears this conduit may have been placed within the roadway in order to avoid sanitary sewer conflicts within the south ROW.

A second conduit crossing of Kimberley Lane is located approximately 845 feet east from the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road. The conduit consisting of 8 – 4 inch (4Wx2H, placed in 1997) PVC crosses under Kimberley Lane. It is unknown if this conduit passes above or below the Kimberley Lane storm sewer as plans were unavailable for this section of conduit passing near the Kimberley Lane storm sewer. This conduit will need to be critically located before construction takes place.

#### 2.1.4.4 Existing Aerial Facilities

Overhead electric lines are located along the entire project length behind the curb in the south ROW of Kimberley Lane. Two aerial facilities cross Kimberley Drive just west of the intersection of Kimberley Lane and Town and Country Boulevard. The poles for this crossing also appear to be located behind the curb and within the north ROW for Kimberley Lane. It is believed that these two crossings tie into the major underground line and easement as mentioned above. An additional aerial crossing is located approximately 150 feet east of the intersection of Kimberley Lane and Town and Country Boulevard. The pole for this crossing is located behind curb and within the north ROW for Kimberley Lane.

#### 2.1.4.5 Fiber Optic Communications

There is no evidence of Level 3 Communications or other private fiber optic lines within the project limits. It is recommended that Texas One Call be contacted prior to detailed design or construction to confirm this finding.

#### 2.1.4.6 Trees Inside ROW

A number of trees are located in the north and south ROW of Kimberley Lane as well as within the median of Town and Country Boulevard. The trees vary in species and size from 6 to 30 inches depending on location. A tree inventory was not performed as part of the PER, but is recommended as part of future design work.

#### 2.1.4.7 Miscellaneous Conflicts

Several sets of as-built documents from AT&T note but do not locate traffic signal conduit in the area of the Kimberley Lane and Town and Country Boulevard intersection. This conduit will likely need to be surveyed and critically located. Several light poles and street lights exist in the Kimberley Lane storm sewer vicinity. A total of six street lights are located within the south ROW of Kimberley Lane. Four street lights are located in the east and west ROW of Town and Country Boulevard for a total of eight street lights along Town and Country Boulevard. Abandoned chilled water lines may also be in the area.

#### 2.1.4.8 Utility Summary

Several utility lines have been identified as potential conflicts. It is recommended that non-intrusive excavation be performed to determine the extent of each conflict prior to construction.

### 2.1.5 Geotechnical Study

A geotechnical report was not available for the Kimberley Lane area and will need to be prepared prior to the onset of detailed design and construction.

### 2.1.6 Survey

Current survey data was not available for the Kimberley Lane area and will need to be gathered prior to the onset of detailed design and construction. Detailed information regarding the Kimberley Lane area was derived from City of Houston as-built drawings for various roadway, storm sewer, and sanitary sewer projects in the area. This information was supplemented through field visits, aerial photo imagery, and the City of Houston Geographic Information Management System. This combination of information proved to be sufficient for the level of detail required for this report.

### 2.1.7 Existing Drainage System

The existing storm sewer along Kimberley Lane consists of approximately 1,300 linear feet of 24-inch, 30-inch, and 36-inch reinforced concrete pipe (RCP). The trunk line begins at a manhole on the north side of the Kimberley Lane roadway just east of West Bough Lane. The manhole receives flow from a small detention pond for Bendwood Elementary School and is connected to two separate storm sewer systems. The storm sewer system to the east serves the Fonn Villas subdivision. The storm sewer system that continues west from the manhole serves the storm sewer system relevant to this project. The portion of Kimberley Lane within the project limits is drained by 6 type B-B inlets, 1 type C inlet, and two grate inlets. The system drains into the trunk line along the Sam Houston Tollway Frontage Road and ultimately outfalls into Buffalo Bayou.

Town and Country Boulevard north of Kimberley Lane and south of Queensbury lane was also included in the limits of this project. This is a four-lane (two in each direction) roadway with a 30-foot wide grass median. The median has several openings for the shopping center entrances

on both sides of Town and Country Boulevard as well as left turn bays for traffic approaching both the Queensbury and Kimberley Lane intersections along Town and Country Boulevard. Town and Country Boulevard is drained by a combination of 13 inlets of varying size and type.

The Kimberley Lane storm sewer has a contributing drainage area of 29 acres and the land use is classified as Business District. No changes in land use are expected in the near future. The contributing area is bound on the north by high points within the Memorial City Center. A portion of the shopping center drains northward to Queensbury Lane while the rest of the shopping center drains south towards Kimberley Lane. The Kimberley Lane storm sewer drainage area is bound on the west by the Sam Houston Tollway Frontage Road and on the east by relative high points located on Bendwood School property. To the south, the drainage area is bound by drainage divides located in the Memorial City Shopping Center just south of Kimberley Lane.

The storm sewer system along Town and Country Boulevard is fed by 10 type B inlets and the trunk line along Kimberley Lane is fed by 13 inlets of varying size and type. The existing Kimberley Lane trunk line system begins at the intersection of the Sam Houston Tollway Frontage Road and Kimberley Lane and runs east along Kimberley Lane. The Kimberley Lane trunk line consists of approximately 680 feet of 36 inch reinforced concrete pipe (RCP), 370 feet of 30 inch RCP, and 145 feet of 24 inch RCP.

The Sam Houston Tollway Frontage Road system begins as a 42" RCP and gradually increases downstream to a 9'x 8' box culvert. The trunk line transitions from a 90" RCP to a 9' x 8' box culvert at the Verde Pump Station. The Verde Pump Station serves the depressed section of the Sam Houston Tollway main lanes. The Verde Pump Station was determined to supply an additional 55 cfs of flow into the storm sewer for the 2 year storm event. This is equivalent to one of the two pumps flowing at full capacity. It was determined that the pump station supplies an additional 111 cfs of flow, both pumps at maximum capacity, for the extreme event. The system then continues downstream to Buffalo Bayou (W100-00-00). The existing and proposed conditions models include from the Queensbury Lane storm sewer system to the outfall at Buffalo Bayou.

#### 2.1.7.1 Existing Storm Sewer – 2-Year Event Analysis

In accordance with City of Houston design standards, the performance of the existing Kimberley Lane storm sewer system was determined under the 2-year event through the use of HouStorm. As required by City of Houston design standards, the location of the hydraulic grade line (HGL) in relation to the gutter line was determined. **Exhibit 9** shows profile plots of the main trunk line and HGL elevations for the existing conditions. It was ultimately determined that the HGL in all portions of the Kimberley Lane storm sewer system was below gutter line or critical elevations thus meeting City of Houston requirements.

The existing conditions of the Kimberley Lane storm sewer system satisfies the drainage criteria defined in the *City of Houston Infrastructure Design Manual* Criteria 9.05.C.1.b. Criteria section 9.05.C.1.b states that the hydraulic grade line must be at or below the gutter line at all points in the storm sewer. Throughout the Kimberley Lane storm sewer systems, the hydraulic grade lines

under the 2-year storm event are below the gutter line or critical elevations, fulfilling Criteria 9.05.C.1.b. See ***Appendix B*** for full HouStorm calculations and output for the 2-year event analysis.

### 2.1.7.2 Existing Storm Sewer – Extreme Event Analysis

Methods 1 through 3 from Section 9.05D of the *COH Infrastructure Design Manual* were used as guidance for analyzing the extreme event. Conduit flow ($Q_c$) was defined as the flow in the storm sewer for the 2 year design storm. The extreme event consideration requires that the flow from the 100 year event at the ultimate outlet ($Q_T$) be carried by the flow in the storm sewer ($Q_C$), the overland flow in the street ($Q_O$), and the change in storage with respect to time ($\Delta S/T$). Methods 1 and 2 from the *COH Infrastructure Design Manual* remove the storage consideration by determining if the total flow ($Q_T$) can be conveyed only using conduit flow ($Q_c$) and overland flow ($Q_O$).

It was determined that the required total required flow ($Q_T$) under the extreme event is 97.9 cubic-feet-per-second. The conduit flow at the critical roadway section was determined to be 48.6 cubic-feet-per-second so that the required overland flow ($Q_O$) under the extreme event is 49.3 cubic-feet-per-second. The overland flow capacity of the critical Kimberley Lane roadway sections at the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road and Town and Country Boulevard was calculated to be 77.9 cubic-feet-per-second. While the existing condition of the Kimberley Lane storm sewer system supplies the required drainage capacity defined in the *City of Houston Infrastructure Design Manual* Criteria 9.05.D, the roadway creates a hazardous ponding condition under the extreme event. The maximum ponding elevation for the 100-year event was found to exceed the natural ground elevation at the ROW line at some locations. Therefore, this system does not satisfy the 100-year COH criteria. The failure to meet the minimum COH criteria was considered the critical factor that justifies an improvement project for the Kimberley Lane storm sewer. **Appendix A** summarizes the 100-year analysis for Kimberley Lane in greater detail.

# Section 3 - Evaluations and Recommendations

## 3.1 Evaluation of Alternatives

The options provide different methods of analyzing the system and determining the amount of storage that needs to be provided for proposed conditions. Different sections of storm sewer were also considered for replacement for each of these options. The proposed pipe size is determined by the analysis option and the amount of storm sewer that is being replaced.

This section describes different alternatives considered for the improvement of the COH storm sewer. Alternatives were chosen based on cost efficiency, constructability, input from developers, and hydraulic efficiency. **Exhibits 6, 7,** and **8** show aerial views of the proposed project area. **Appendix C** details the cost for the alternatives. Each of these alternatives will provide a functional storm sewer that will convey the 2-year frequency event with a HGL below the elevation of the gutter as well as decreasing sheetflow ponding during the extreme event to a level required by the *City of Houston Infrastructure Design Manual*.

### 3.1.1 Option 1 – Remove Kimberley Road High Points & Provide Mitigation

Option 1 involved removing the relative high points adjacent to Kimberley Lane that contribute to ponding storage and preventing normal sheetflow. These relative high points at the intersection Kimberley Lane and the Sam Houston Tollway Frontage Road and south of the intersection of Kimberley Lane and Town and Country Boulevard prevent overland sheet flow from leaving the Kimberley Lane area and cause water to pond within the roadway. Under the current condition, water will continue to pond until reaching the elevation of the relative high point and then "spill over" to continue along overland sheet flow paths. Removing the relative high points along Kimberley Lane would allow the water to release at a lower depth and would prevent excessive ponding depth within the roadway. This option would also have to account for the storage that would be lost if the water was released at an earlier stage. However, this option was determined to be unfeasible because it would not be possible to tie back into the existing roadway elevations and provide a minimum roadway slope. Ultimately, excessive pavement reconstruction would be required for this option to be feasible. It is for this reason, that this option was not further investigated.

### 3.1.2 Option 2 – Raise Kimberley Road & Provide Mitigation

Option 2 provides a complete and comprehensive solution to the existing drainage problem. It will also match the Fonn Villas improvements. Option 2 has the greatest potential for utility conflicts and incurs a significant cost due to the reconstruction of Kimberley Lane. In addition, Option 2 has the longest construction time due to the extensive reconstruction of Kimberley Lane. However, the longer construction time and reconstruction of Kimberley Lane will create a new roadway in excellent condition.

Option 2 significantly decreases Kimberley Lane flooding frequency and increases the capacity of the Kimberley Lane storm sewer system. This option proposes that Kimberley Lane be reconstructed approximately 6 inches above the existing elevation. In order to mitigate the

storage lost by raising the roadway, this construction option requires 1,133-feet of 5' x 3' box culverts to be used as storage. The existing storm sewer along Kimberley Lane will remain in place and will be tied into the storage box culverts using existing lateral pipes. In order to minimize the potential number of utility conflicts in the Kimberley Lane area, the 5' x 3' box culverts will be placed beneath the west bound lanes of Kimberley Lane. The new 5' x 3' box culverts will only be used for storage purposes and will not provide additional downstream conveyance. After installation, the box culverts will provide between a 10-year to 25-year level of service.

Several hardscape improvements have recently been constructed including brick paver sidewalks and concrete retaining walls. All effort should be made to preserve and minimize reconstruction of these improvements during the roadway reconstruction.

At the intersection of Kimberley Lane and the Sam Houston Tollway Frontage road, several utilities cross near the proposed 5' x 3' box culverts and have been identified as potential conflicts. A 2 – 4 inch PVC AT&T crosses approximately 2 feet above the existing Kimberley Lane Storm Sewer. It is not anticipated this line will conflict, but must be flagged as a potential conflict. Approximately 200 feet east of the Kimberley Lane and Sam Houston Tollway Frontage road, a 2 – 4 inch GIP AT&T line crosses beneath the existing Kimberley Lane storm sewer with a 6 inch vertical clearance. This utility may need to be relocated in order to provide sufficient bedding of the proposed box culverts.

Near the intersection of Town and Country Boulevard and Kimberley Lane several utilities cross beneath Kimberley Lane and may be in conflict with the proposed box culverts. Slightly west of the Town and Country Boulevard and Kimberley Lane intersection, a Centerpoint Energy underground ground street light cable crosses Kimberley Lane. A 4-inch IP steel gas line also crosses beneath Kimberley Lane at the western edge of the intersection of Kimberley Lane and Town and Country Boulevard. The vertical location of these lines is unknown and must be flagged as potential conflicts.

Approximately 810-feet east of the intersection of Kimberley Lane and the Sam Houston Tollway Frontage Road a 2-inch IP steel gas line crosses beneath Kimberley Lane. This line must be flagged as a potential conflict as the vertical location of this line is not known. Located slightly east of the above gas line and east of the intersection of Kimberley Lane and Town and Country Boulevard a 15 inch extra strength pipe sanitary sewer (installed in 1966) crosses beneath Kimberley Lane. The sanitary sewer passes beneath the Kimberley Lane storm sewer with approximately 5 feet of vertical clearance. Conflicts with this sanitary sewer are not anticipated. In the vicinity of the above reference gas and sanitary lines, an 8 – 4 inch PVC AT&T conduit crosses under Kimberley Lane. Located approximately 845 feet east of the intersection of Kimberley lane and the Sam Houston Tollway Frontage road, it is unknown if this conduit passes above or below the existing Kimberley Lane storm sewer. This conduit must be flagged as a potential conflict. If it is found to be in conflict with the proposed box culverts, it will need to be lowered accordingly.

Approximately 310 feet east of the intersection of Kimberley Lane and Town and Country Boulevard an abandoned 8 inch waterline crosses Kimberley Lane. In 1996 this line was cut and

plugged approximately 10 feet south of the 8 inch waterline that runs east/west on Kimberley Lane. This line must be flagged as a potential conflict. If this line is indeed abandoned it may be cut, plugged, and removed as required. East of the above waterline and approximately 340 feet east of the intersection of Kimberley Lane and Town and Country Boulevard an 8 inch PVC sanitary sewer (installed in 2001) crosses beneath Kimberley Lane. Detailed plans were not available, but is estimated that the sanitary sewer passes beneath the existing Kimberley Lane trunk line by approximately 3.5 feet. This line should have adequate depth to not be in conflict with the proposed box culverts, but must be flagged as a potential conflict. Also in the immediate vicinity of the sanitary line is an 8-inch cast iron waterline with an unknown vertical location. This waterline must be flagged as a potential conflict and raised or lowered as required.

### 3.1.3 Option 3 – Add Box Culverts to Provide Additional Storage

Option 3 involves providing additional system storage in the form of concrete box culverts placed along Town and Country Boulevard. The box culverts would tie into the existing storm sewer along Town and Country Boulevard at each inlet lateral and at the Kimberley Lane storm sewer trunk line. This alternative would provide sufficient storage so that future repair and replacement of Kimberley Lane would be possible without providing additional storage. Additionally, this alternative will provide between a 10-year to 25-year level of service and decrease the depth and frequency of ponding within the Kimberley Lane roadway. In this option the existing storm sewer along Kimberley Lane and Town and Country Boulevard will remain in place and the additional box culverts will provide storage only. In order to provide mitigation for the future improvement of Kimberley Lane, Option 3 will place 570 feet of side by side 5' x 3' box culverts in the northbound left lane of Town and Country Boulevard.

Option 3 creates very few utility conflicts since very few public and private utilities run next to or cross Town and Country Boulevard. At the northern edge of the intersection of Kimberley Lane and Town and Country Boulevard, a CenterPoint underground light cable crosses from the west to east side of Town and Country Boulevard. It is unknown if this line crosses above or below the existing Town and Country Boulevard storm sewer so it must be flagged as a potential conflict. This cable will likely need to be relocated in order to provide adequate spacing between utilities. Approximately 545 feet north of the Kimberley Lane and Town and Country Boulevard intersection, a 15-inch cast iron sanitary sewer crosses Town and Country Boulevard in an east west direction. This sanitary sewer passes beneath the existing Town and Country Boulevard storm sewer by approximately 5 feet. Conflict with this sanitary sewer is not expected. An abandoned 8-inch sanitary sewer is located approximately 165 feet north of the intersection of Kimberley Lane and Town and Country Boulevard. This line is located at an unknown depth, but according to City of Houston GIMS the line is listed as abandoned. Installed in 1958 and taken out of service at an unknown date, it is also possible that sections of the line may have already been removed. This line may cut and removed as needed to prevent conflicts.

A potential conflict with a 6 inch fire hydrant lead of unknown material is located approximately 570 feet north of the intersection of Kimberley Lane and Town and Country Boulevard. This line is at an unknown vertical elevation and may need to be relocated if found to be in conflict with the proposed box culverts. This must be flagged as a potential conflict.

Option 3 improves the level of service and decreases the frequency that excessive sheetflow ponding is experienced. It also provides the necessary storage for a future roadway project to eliminate the depressed roadway. However, Option 3 does not raise the roadway and therefore does not completely solve the problem.

Option 3 uses larger box culverts than Option 2, but provides the same volume of storage over a shorter length of pipe. Option 3 however, involves far fewer potential utility conflicts than option 2.

### 3.1.4 Option 4 – Add Box Culverts for Storage to Provide a Given Level of Service

Option 4 is identical to Option 3 except that the box culverts placed under Kimberley Lane will be sized to provide a specific level of service rather than providing only the mitigation volume needed to raise and improve Kimberley Lane. This option would provide a 25-year or greater level of service. Additionally, since this option will be using larger box culverts than Option 2, this option will also create a larger area of pavement repair. This option will have the same potential utility conflicts as Option 3.

### 3.1.5 Option 5 – No Build / Do Nothing

Option 5 is a no build or do nothing scenario. In this option, the potential improvement cost is viewed as exceeding the potential benefit to the Kimberley Lane storm sewer system. This option would leave the conditions of the Kimberley Lane storm sewer in their current form.

## 3.2 Recommended Project

Option 2 is the recommended solution for improving the Kimberley Lane storm sewer because it is the overall most cost efficient option. Option 2 addresses not only the sheetflow ponding issue of Kimberley lane, but it also addresses Kimberley Lane's need of reconstruction. Options 3 and 4 replace only the portion of Kimberley Lane removed during storm sewer installation, but do not replace the entire roadway or provide a complete problem solution. Additionally, if the Kimberley Lane roadway is to be replaced in the future, Options 3 and 4 require that portions of Kimberley Lane be replaced a second time leading to increased overall cost. **Table 4** summarizes the advantages and disadvantages for each option.

Option 3 offers a decreased impact to traffic in the Kimberley Lane area when compared to Option 2. Option 3 avoids the closure of Kimberley Lane and allows continued traffic mobility in the area. Even under a phased lane closure plan, Option 2 could significantly impact traffic in the Kimberley Lane area.

The estimated construction cost for Option 2 is higher than the estimated construction cost of Option 3. Option 2 has a higher construction cost due to the entire reconstruction of Kimberley Lane between the Sam Houston Tollway Frontage Road and West Bough Lane. While the box culvert unit costs under Option 2 are lower than Option 3, Option 2 can use a smaller box culvert over a longer length while Option 3 compresses the length and must use a larger box culvert.

Option 3 requires the least amount of construction, overall pipe length, and construction time. Additionally, Option 3 requires the least removal of concrete thus saving in construction costs. The key difference between Option 2 and Option 3 is that Option 2 includes the entire reconstruction of Kimberley Lane between the Sam Houston Tollway Frontage Road and West Bough Lane while Option 3 only replaces concrete removed to install the proposed box culverts.

**Table 4 – Storm Sewer Alternatives Summary Table**

| Factors | Option 1 | Option 2 | Option 3 | Option 4 | Option 5 |
|---|---|---|---|---|---|
| Construction Time | N/A | 114 Days | 48 Days | 27 Days | 0 Days |
| Current Construction Costs | N/A | $1,600,000 | $800,000 | $900,000 | $0 |
| Current Total Cost | N/A | $1,821,000 | $840,000 | $1,004,000 | $0 |
| Future Reconstruction Costs | N/A | $0 | $1,100,000 | $1,100,000 | $0 |
| Future Total Costs | N/A | $0 | $1,247,000 | $1,247,000 | $0 |
| Total Current and Future Costs | N/A | $1,821,000 | $2,087,000 | $2,251,000 | $0 |
| Pros | Decreased Ponding in Kimberley Lane | Decreased Ponding In Kimbreley Lane<br>New Kimberley Lane Roadway | Decreased Ponding In Kimberley Lane<br>Least Amount of Pavement Reconstruction<br>Least Amount of Box Culvert Pipe<br>Lowest Construction Cost<br>Least Construction Time | Decreased Ponding In Kimberley Lane<br>Moderate Amount of Pavement Reconstruction<br>Moderate Construction Cost<br>Increased Level of Service | No Cost |
| Cons | Not Possible Due to Existing Surrounding Pavement | Highest Construction Cost<br>Extensive Pavement Reconstruction<br>Multiple Potential Utility Conflicts<br>Greatest Construction Time<br>Major Traffic Impact | Partial Roadway Reconstruction | Partial Roadway Reconstruction - More than Option 3 | Does Not Address System Deficiencies |

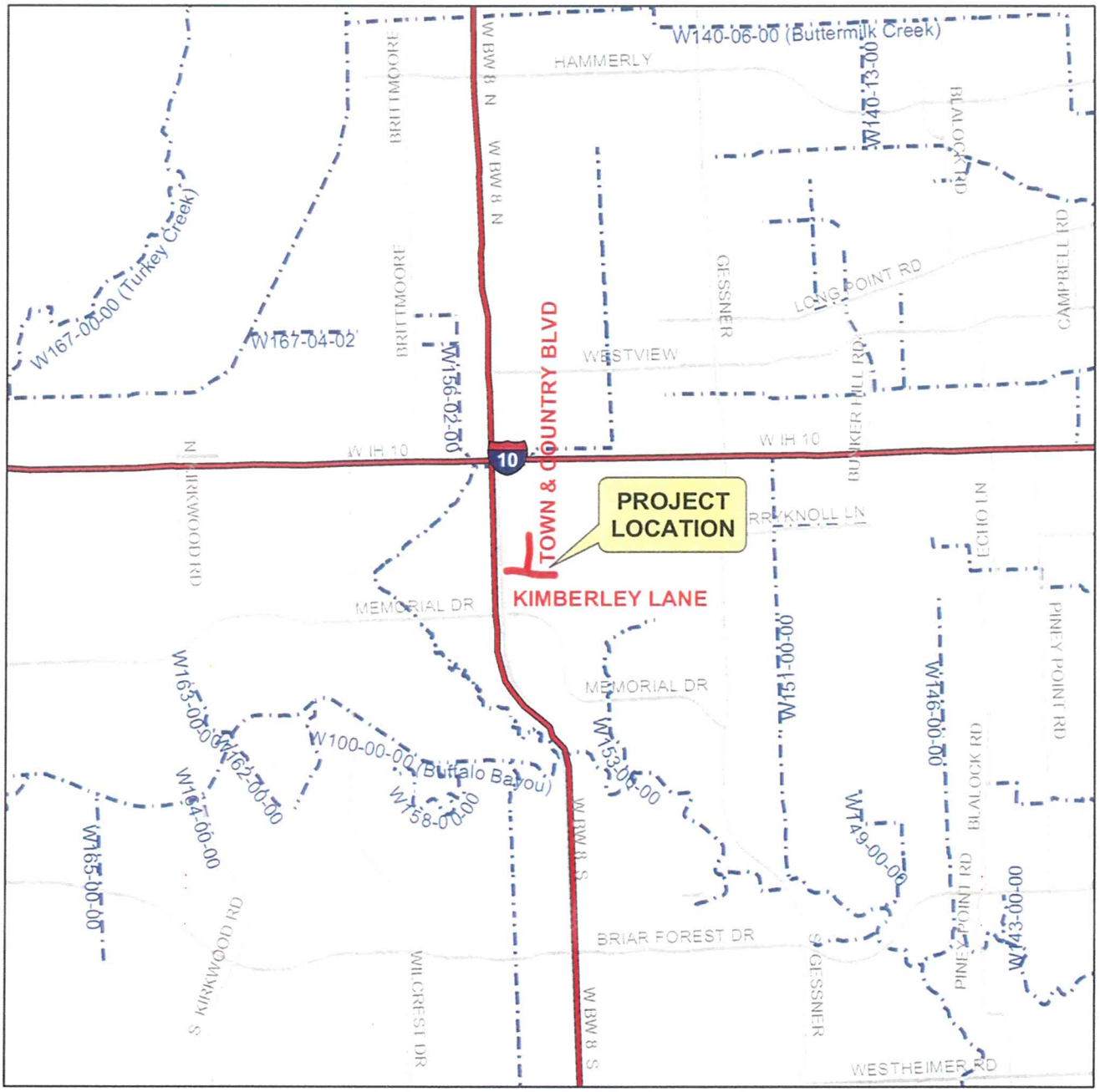
# Conclusion

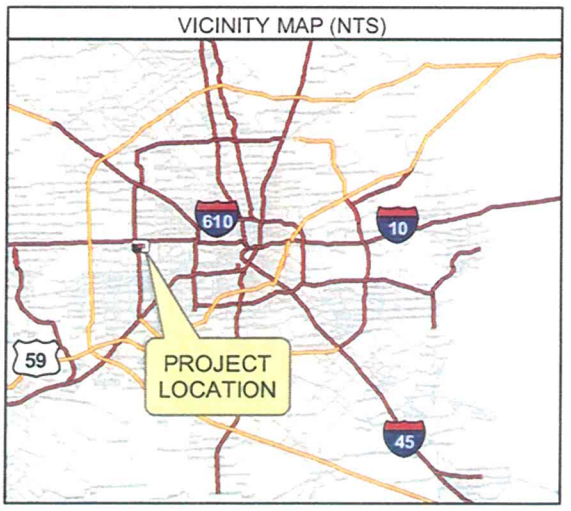
This report summarizes the preliminary engineering findings by Lockwood, Andrews, & Newnam, Inc. for storm sewer improvements to Queensbury Lane. Contrary to the City of Houston Comprehensive Drainage Plan, the existing modeling confirmed that the existing Kimberley Lane storm sewer was sufficient as defined by the City of Houston Infrastructure Design Guidelines. However, excessive ponding above maximum ponding elevations was the dominating criterion for the proposed Kimberley Lane Storm Sewer system improvements.

Storm sewer alternatives were chosen to provide the most benefit in terms of drainage level of service, cost, construction time, scheduling, and construction impact. Proposed hydraulic models were developed to ensure that City of Houston Drainage Criteria was satisfied. Cost estimates were performed for each of the alternatives and can be found in the **Appendix C**. Utility research was performed to determine what utilities were in the area and where potential conflicts existed. The utility and other miscellaneous conflicts and the necessary resolutions were identified in the report.

The recommended solution, Option 2, provides the maximum benefit in terms of a complete solution and construction price. This option is the lowest price when compared to the other construction options.

Following the official selection of one of the proposed alternatives, the detailed design phase for the proposed storm sewer is scheduled to begin. Necessary utility relocation requests will also need to be made at this time.

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MEMORIAL CITY
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Lockwood, Andrews & Newnam, Inc.
A LEO A DALY COMPANY

KIMBERLEY LANE
STORM SEWER IMPROVEMENT PER

PROJECT LOCATION MAP
HARRIS COUNTY, TEXAS

EXHIBIT 1

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Lockwood, Andrews & Newnam, Inc.
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# EXHIBIT 2 PUBLIC UTILITIES

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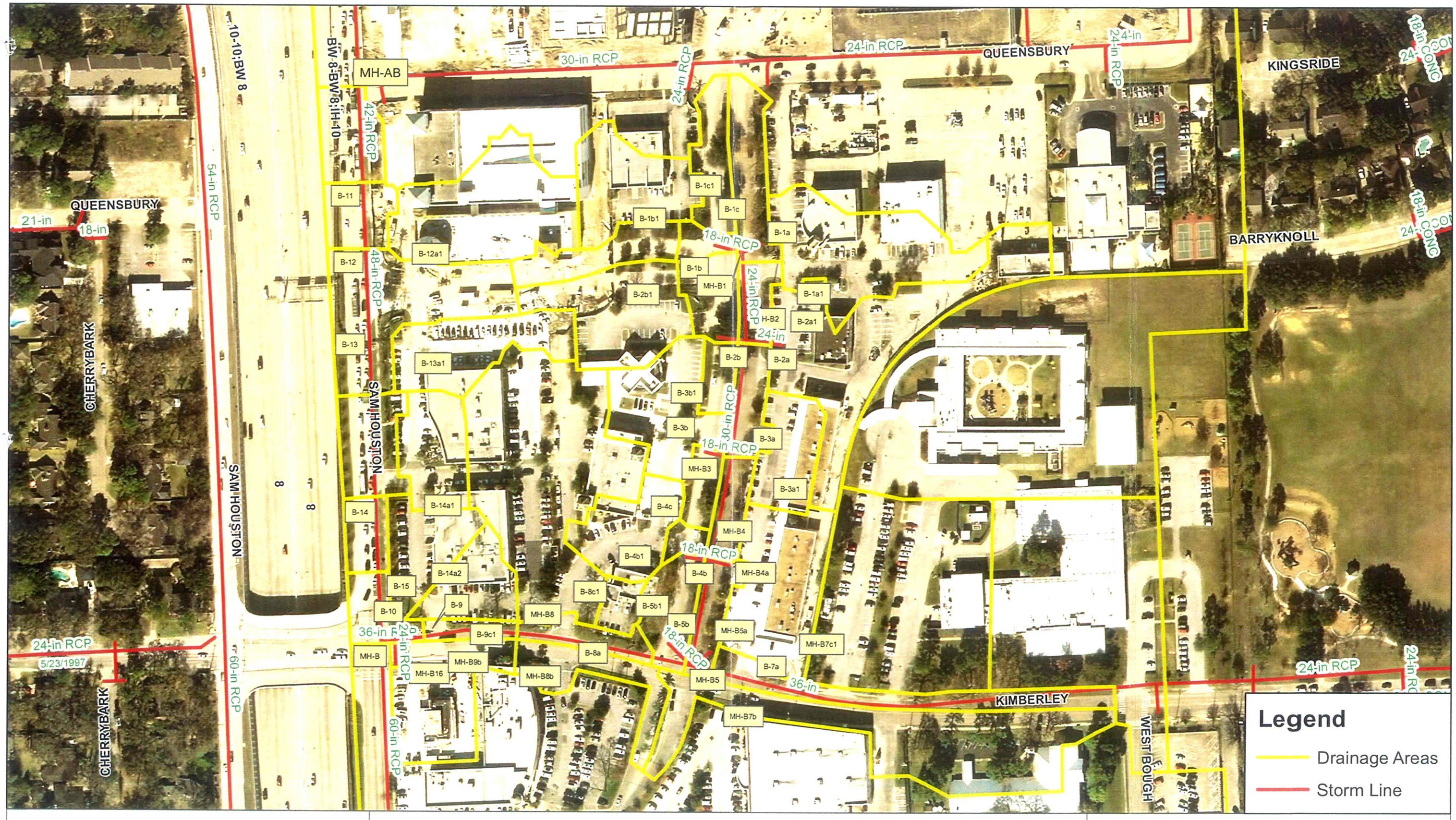


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# EXHIBIT 3 EXISTING DRAINAGE AREA MAP

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QUEENSBURY LN

CHERRYBARK LN

TOWN AND COUNTRY BLVD

QUEENSBURY LN

TOWN AND COUN

KINGSRIDE LN

BARRYKNOLL LN

KIMBERLEY LN

KIMBERLEY LN

WEST BOUGH LN

CHERRYBARK LN

## Legend

- TIRZ17 Boundary

**Ponding Depth**

- 0 - 0.1
- 0.1- 0.5
- 0.5 - 1
- 1 - 2
- Sheet Flow Lines
- DrainageLine25
- DrainageLine10
- DrainageLine5
- DrainageLine1

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# EXHIBIT 4 SHEET FLOW AND PONDING

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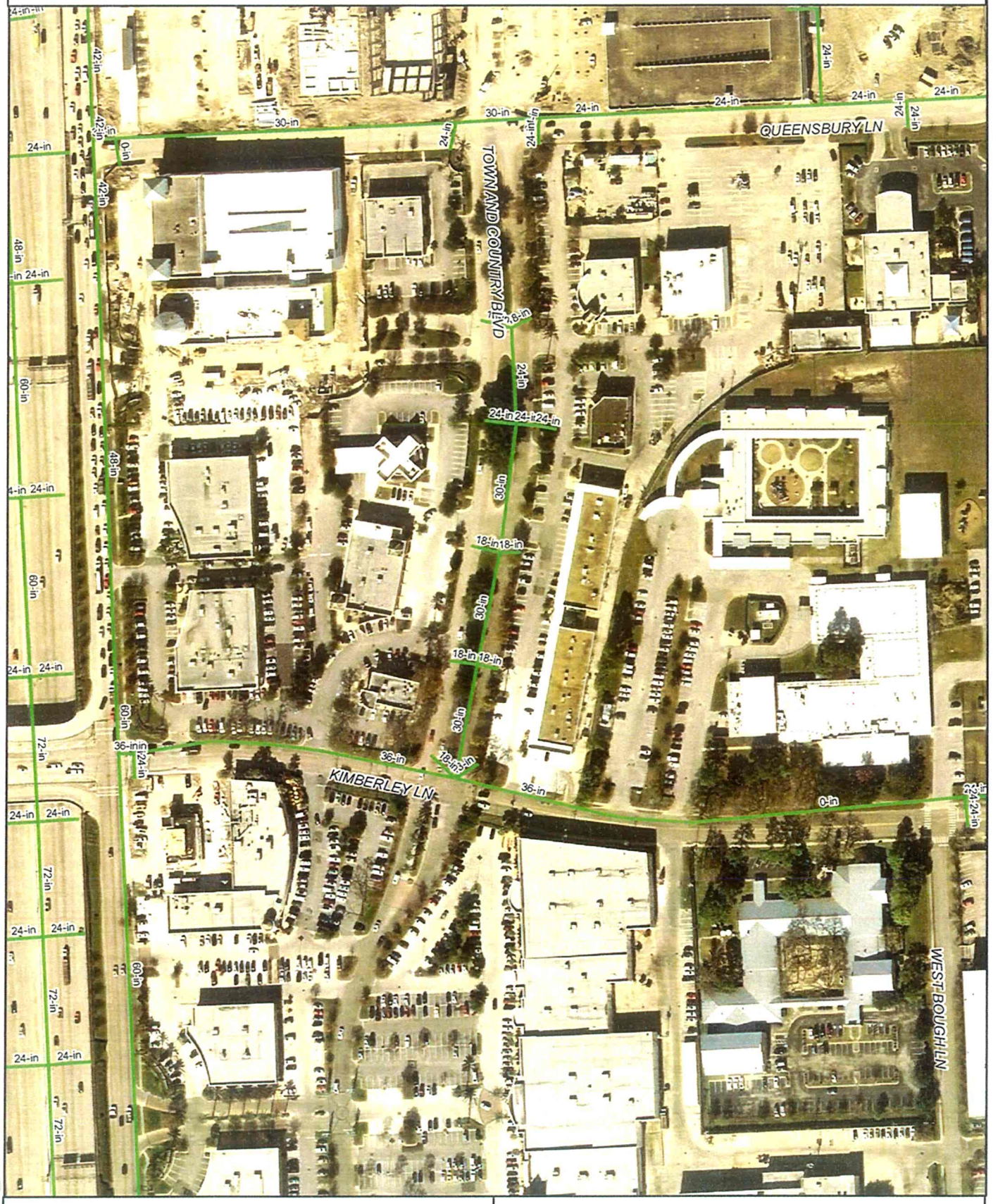
# EXHIBIT 5 - EXISTING KIMBERLEY LANE STORM SEWER

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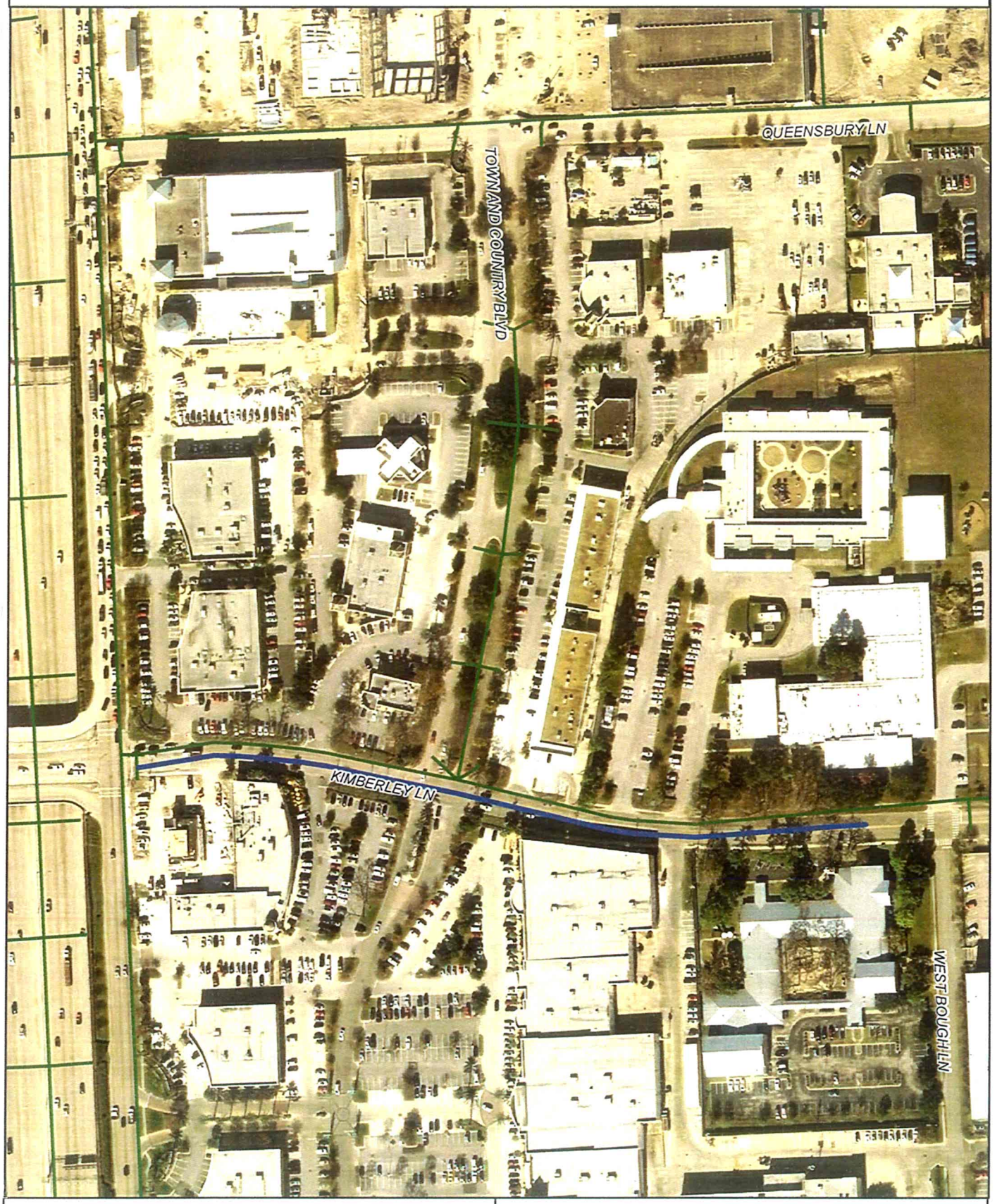
# EXHIBIT 6 - STORM SEWER OPTION 2

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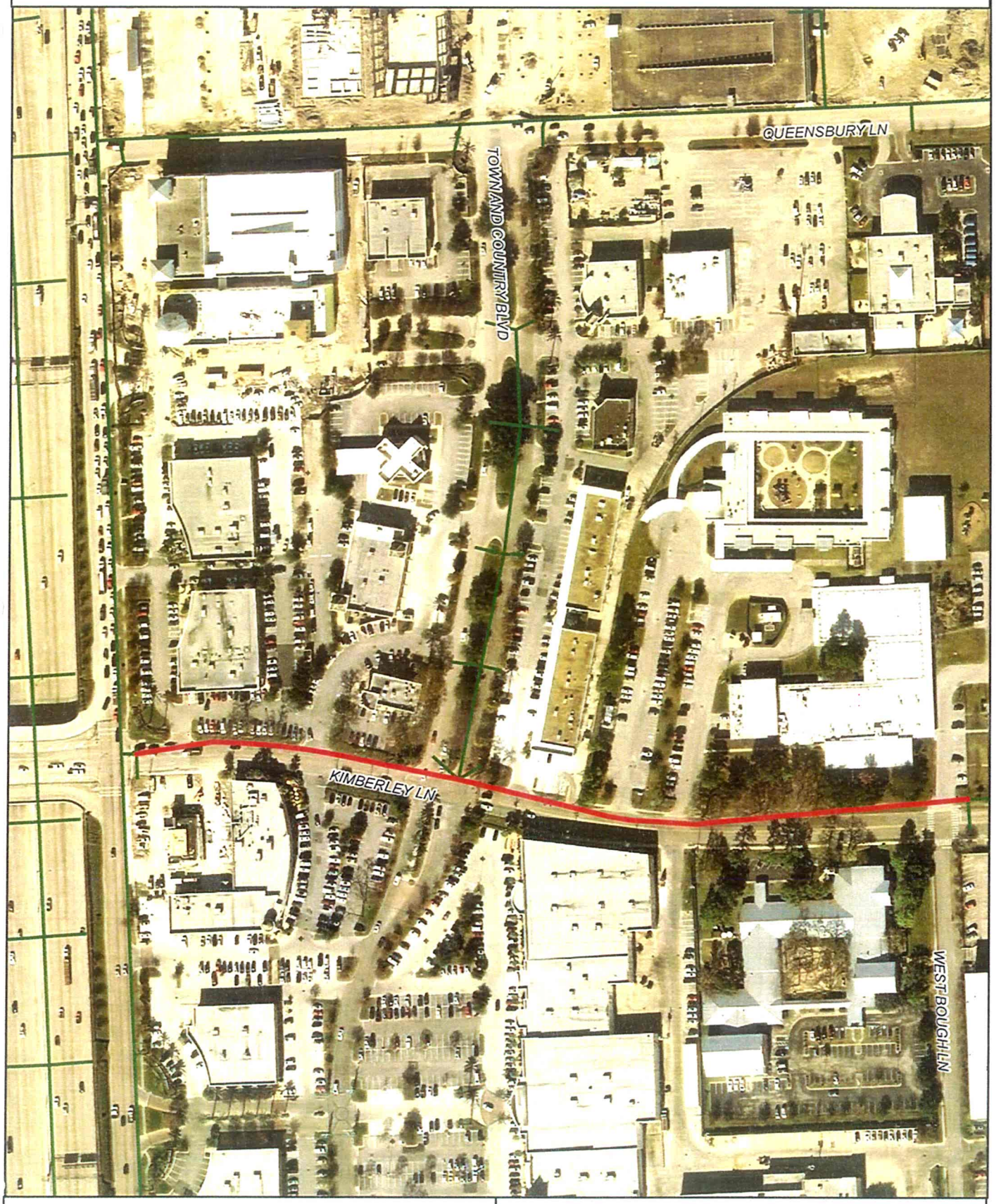
# EXHIBIT 7 - STORM SEWER OPTION 3

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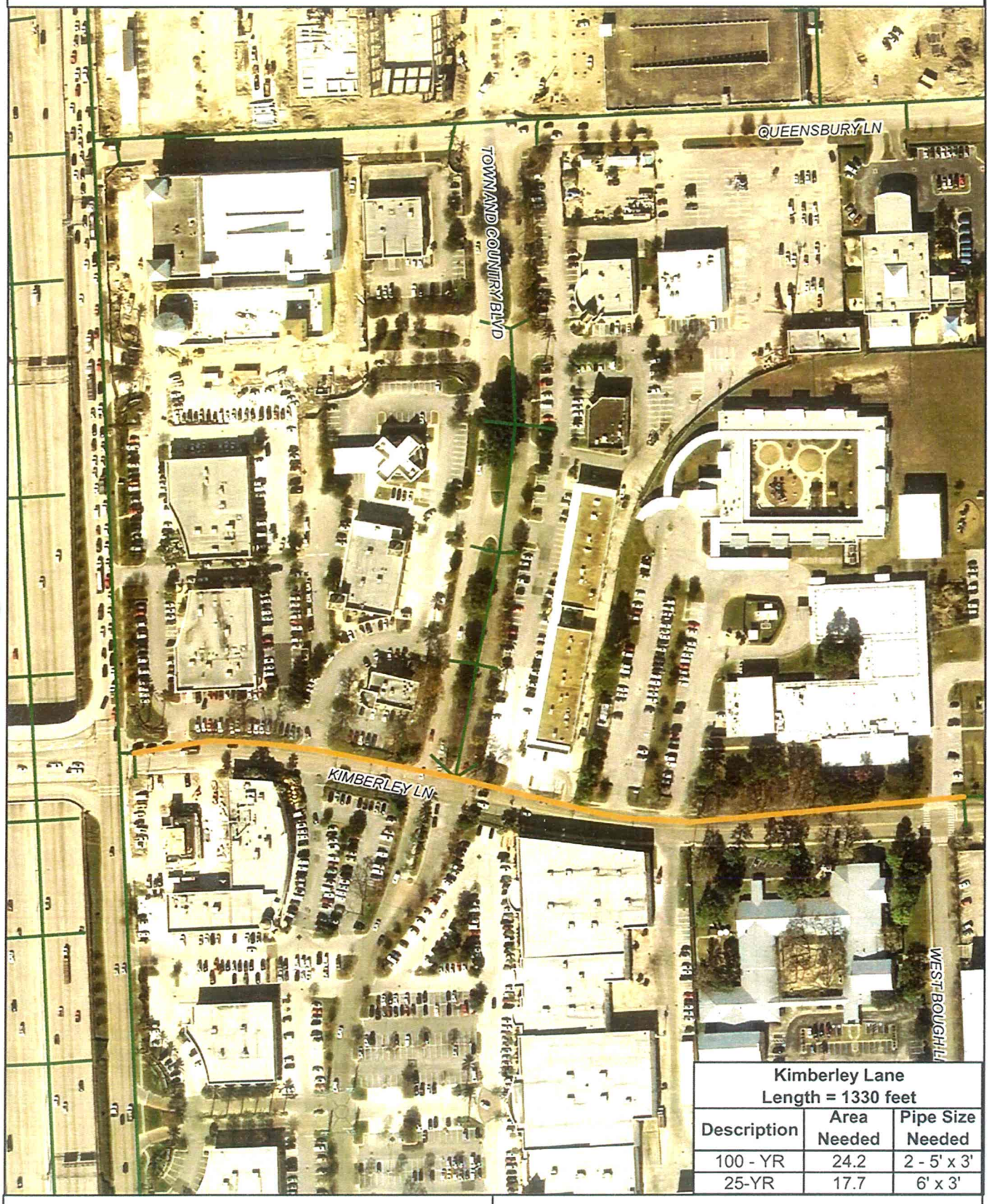
# EXHIBIT 8 - STORM SEWER OPTION 4




| Kimberley Lane<br>Length = 1330 feet | | |
|---|---|---|
| Description | Area Needed | Pipe Size Needed |
| 100 - YR | 24.2 | 2 - 5' x 3' |
| 25-YR | 17.7 | 6' x 3' |

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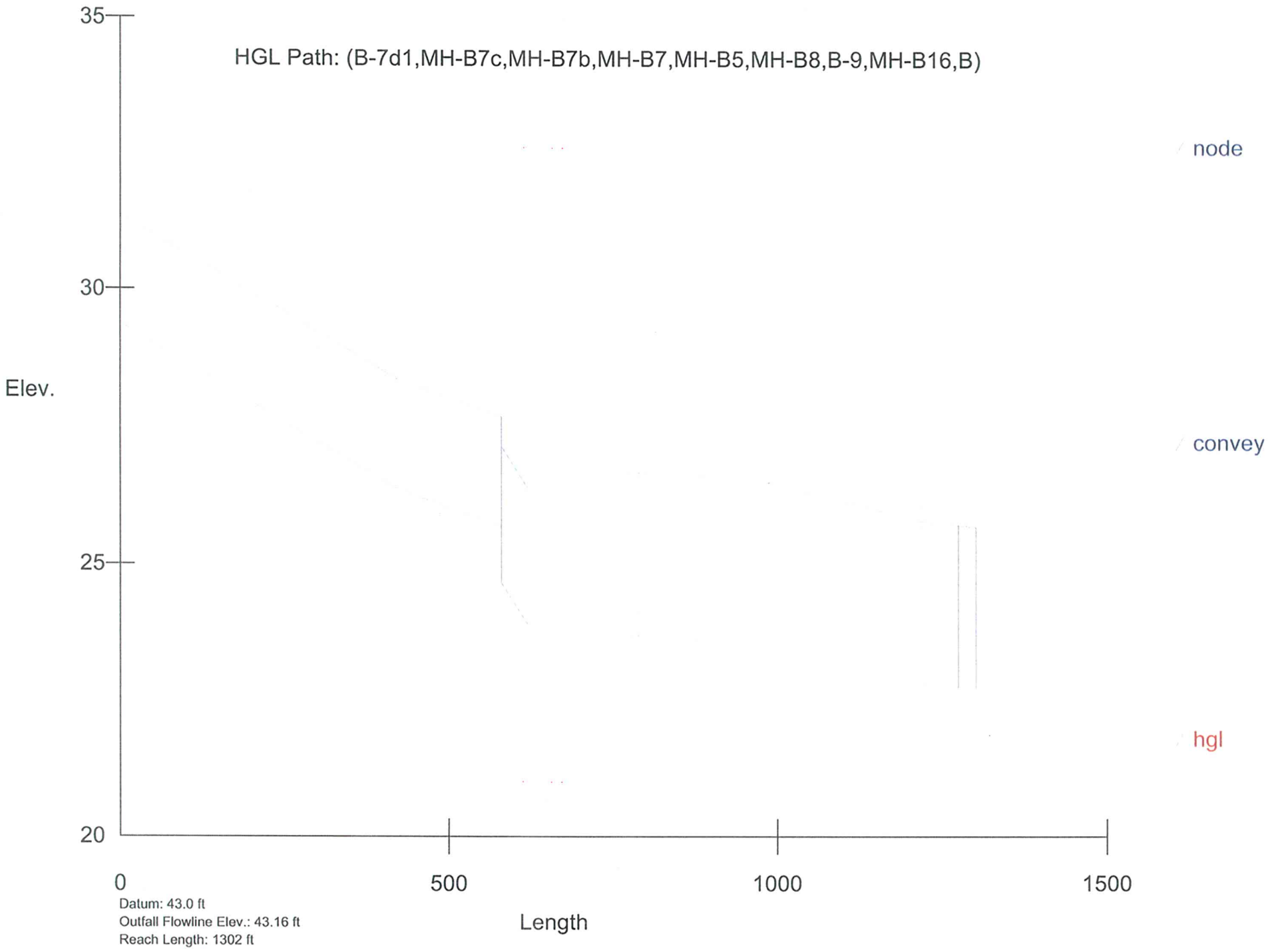
# EXHIBIT 9 - EXISTING KIMBERLE[illegible]NE STORM SEWER HGL PROFILE



# APPENDIX A – EXTREME EVENT OVERLAND SHEETFLOW ANALYSIS

# APPENDIX A - EXTREME EVENT ANALYSIS

## Method 3 100 - Year Analysis from Chapter 9 of City of Houston Infrastructure Design Manual

$$Qt = Qo + Qc + \frac{\Delta S}{T}$$

**Where:**
Qt is the total flow conveyed
Qo is the overland flow component*
Qc is the calculated flow in the conduit for the 2-Year design**
$\frac{\Delta S}{T}$ is the change in storage volume relative to time upstream of point of analysis.

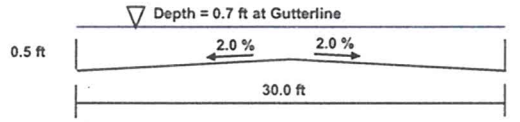
*Computed using Manning's Equation to a critical roadway cross section(See Below)
**Capacity of Run #20 in Houstorm Model

**Manning's Equation To Find** $Q_O$

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

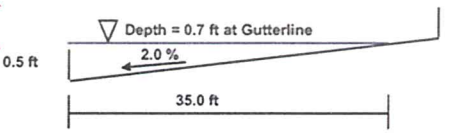
**Where:**
$n$ = 0.015 for street component and 0.02 for outside street component
A = Area in square feet
R = Hydraulic Radius in feet
S = Longitudinal slope

**Overland Outlet Location 1 - Town and Country Boulevard (south of Kimberly)**




| | |
|---|---|
| Area | 30 x (0.7) - 1/2 x (30) x (15x0.02) = 16.5 sf |
| Wetted Perimeter | 30 + 0.5 + 0.5 = 31.0 ft |
| Hydraulic Radius | 16.5/31 = 0.532 |
| Slope (from lidar) | 0.003 ft/ft |
| Manning's n | 0.015 |
| Manning's Capacity: $Q = \frac{1.49}{n} AR_H^{2/3} S_0^{1/2}$ | 1.49/0.015 x 16.5 x 0.532^(2/3) x 0.003^(1/2) **=59 cfs** |

**Overland Outlet Location 2 - Beltway 8 Frontage Road (south of Kimberly)**




| | |
|---|---|
| Area | 1/2 x (0.7) x (0.7/0.02) = 12.25 sf |
| Wetted Perimeter | 0.5 + 0.7/0.02 = 35.5 ft |
| Hydraulic Radius | 12.25/35.5 = 0.345 |
| Slope (from lidar) | 0.001 ft/ft |
| Manning's n | 0.015 |
| Manning's Capacity: $Q = \frac{1.49}{n} AR_H^{2/3} S_0^{1/2}$ | 1.49/0.015 x 12.25 x 0.345^(2/3) x 0.001^(1/2) **=18.9 cfs** |

## APPENDIX A - EXTREME EVENT ANALYSIS

| Drainage Area and Storm Sewer | |
|---|---|
| Drainage Area ID | MH-B16 |
| Run # | 20 |
| Diameter (in) | 36 |
| Length (ft) | 27 |
| Slope (%) | 0.148 |
| Cumulative Drainage Area (ac) | 24.17 |
| Cumulative Tc (min) | 32.71 |
| Cumulative C-value | 0.648 |
| 100-Yr Intensity (in/hr) | 6.3 |
| Qt | 97.9 |
| Qc | 48.6 |

| Method 1 | | | Method 2 | | | | |
|---|---|---|---|---|---|---|---|
| Maximum Ponding Elevation (MPE) | 100-Yr HGL Elevation | Check Is MPE>=HGL | Required Overland Flow $Q_{O,Required}$ | Overland Outlet Location | Overland Flow Qo $C_w bH^{1.5} - Weir$ $\frac{1.49}{n} AR^{\frac{2}{3}} S^{\frac{1}{2}} - Mannings$ | Cumulative Overland Flow $Q_{O,allow}$ | Is $Q_{o,allow} > Q_{o,Required}$? |
| (ft) | (ft) | Yes = Acceptable No = Unacceptable | (cfs) | - | (cfs) | (cfs) | Yes = Acceptable No = Unacceptable |
| 74.5 | 94.73 | No | 49.3 | 1 | 59.0 | 77.9 | Yes |
| | | | | 2 | 18.9 | | |
| | | IF **"YES"**, design for storm sewer segment meets City of Houston requirements. IF **"NO"**, design for storm sewer segment does not meet City of Houston requirements and adjustment in storm sewer size or additional analysis are needed | Qo,required = Qt - Qc | **Outlet Location 1:** Town and Country Boulevard (south of Kimberly) **Outlet Location 2:** Beltway 8 Frontage Road (south of Kimberly) | | Sum of Overland flows | IF **"YES"**, design for storm sewer segment meets City of Houston requirements. IF **"NO"**, design for storm sewer segment does not meet City of Houston requirements and adjustment in storm sewer size or additional analysis are needed |

| Method 3 | | | | | | |
|---|---|---|---|---|---|---|
| Percent Impervious | Runoff Depth | Runoff Volume (Vt) | Available Storage Volume $V_{s,avail}$ | Change in Available Storage Relative to Time $\frac{\Delta S}{T}$ | Required Overland Flow $Q_{O,Required}$ | Is $Q_o > Q_{o,Required}$? |
| (%) | (in) | (ac-ft) | (ac-ft) | (cfs) | (cfs) | Yes = Acceptable No = Unacceptable |
| 85 | 6.1 | 12.29 | 1.50 | 23.73 | 25.6 | Yes |
| | Runoff Depth based on Values listed below. | Vt = Runoff Depth x Acum | $V_{s,avail}$ found by calculating volume under fall sinks in lidar. | $\frac{\Delta S}{T} = \frac{V_{s,avail} \times Q_T^2}{V_T (Q_T - Q_C)}$ | $Q_{O,req} = Q_T - Q_c - ((V_{s,avail} \times Q_T^2)/(V_T (Q_T - Q_C))$ $V_{s,avail}$ _ & _ $V_T$ _ are _ cumulative _ values | IF **"YES"**, design for storm sewer segment meets City of Houston requirements. IF **"NO"**, design for storm sewer segment does not meet City of Houston requirements and adjustment in storm sewer size or additional analysis are needed |

| 100-Year Rainfall Depth (in) | | |
|---|---|---|
| % Impervious Cover | SCS Curve No. | 3-hr duration |
| 0% | 75 | 3.9 |
| 25% | 85 | 5 |
| 40% | 87 | 5.2 |
| 70% | 93 | 5.9 |
| 85% | 95 | 6.1 |
| 100% | 98 | 6.5 |

# APPENDIX B – HYDRAULIC CALCULATIONS
# HOUSTORM OUTPUT

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007

Run @ 5/1/2009 8:45:21 AM

PROJECT NAME : Kimberley Existing
JOB NUMBER :
PROJECT DESCRIPTION : Queensbury to Buffalo Bayou Outfall
PROJECT File: L:\120214\120-10308-000\460\Prod\Data\Refined\HOUStorm\Existing\

DESIGN FREQUENCY : 2 Years
MEASUREMENT UNITS: ENGLISH

OUTPUT FOR DESIGN FREQUENCY of: 2 Years

Runoff Computation for Design Frequency.

| ID | C Value | Area (acre) | Tc (min) | Tc Used (min) | Intensity (in/hr) | Supply Q (cfs) | Total Q (cfs) |
|---|---|---|---|---|---|---|---|
| B-14 | 0.59 | 0.40 | 23.50 | 23.50 | 3.51 | 0.000 | 0.829 |
| B-15 | 0.62 | 0.20 | 22.50 | 22.50 | 3.59 | 0.000 | 0.445 |
| MH-B16 | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| B-1a | 0.59 | 0.43 | 23.60 | 23.60 | 3.51 | 0.000 | 0.889 |
| B-1a1 | 0.76 | 1.02 | 25.00 | 25.00 | 3.41 | 0.000 | 2.641 |
| B-1b | 0.56 | 0.11 | 21.80 | 21.80 | 3.64 | 0.000 | 0.224 |
| B-1b1 | 0.55 | 0.35 | 23.30 | 23.30 | 3.53 | 0.000 | 0.679 |
| B-1c | 0.57 | 0.33 | 23.22 | 23.22 | 3.53 | 0.000 | 0.665 |
| B-2a | 0.61 | 0.19 | 22.50 | 22.50 | 3.59 | 0.000 | 0.416 |
| B-2a1 | 0.76 | 1.48 | 25.70 | 25.70 | 3.36 | 0.000 | 3.779 |
| B-2b | 0.59 | 0.29 | 23.00 | 23.00 | 3.55 | 0.000 | 0.608 |
| MH-E1 | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| MH-E2 | 0.5 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| MH-B1 | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| MH-B2 | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| MH-B3 | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| MH-B4 | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| MH-B5 | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| B-2b1 | 0.66 | 0.78 | 24.60 | 24.60 | 3.43 | 0.000 | 1.768 |
| B-3a | 0.65 | 0.27 | 23.00 | 23.00 | 3.55 | 0.000 | 0.623 |
| B-3a1 | 0.79 | 0.41 | 23.60 | 23.60 | 3.51 | 0.000 | 1.136 |
| B-3b | 0.75 | 0.69 | 24.40 | 24.40 | 3.45 | 0.000 | 1.785 |
| B-3b1 | 0.51 | 0.15 | 22.20 | 22.20 | 3.61 | 0.000 | 0.276 |
| B-4a | 0.63 | 0.22 | 22.60 | 22.60 | 3.58 | 0.000 | 0.496 |
| B-4b | 0.57 | 0.08 | 21.50 | 21.50 | 3.67 | 0.000 | 0.167 |
| B-4b1 | 0.76 | 0.51 | 23.90 | 23.90 | 3.48 | 0.000 | 1.350 |
| B-4c | 0.52 | 0.17 | 22.30 | 22.30 | 3.60 | 0.000 | 0.319 |
| B-5a | 0.66 | 0.26 | 22.90 | 22.90 | 3.56 | 0.000 | 0.611 |
| B-5b | 0.57 | 0.36 | 23.30 | 23.30 | 3.53 | 0.000 | 0.724 |
| B-5b1 | 0.8 | 0.13 | 22.00 | 22.00 | 3.63 | 0.000 | 0.377 |
| B-7a | 0.62 | 0.53 | 23.90 | 23.90 | 3.48 | 0.000 | 1.145 |
| B-7b | 0.67 | 1.53 | 25.80 | 25.80 | 3.35 | 0.000 | 3.437 |
| B-7c1 | 0.76 | 0.89 | 24.80 | 24.80 | 3.42 | 0.000 | 2.314 |
| B-8a | 0.59 | 0.22 | 22.60 | 22.60 | 3.58 | 0.000 | 0.465 |
| B-8b | 0.7 | 0.38 | 23.40 | 23.40 | 3.52 | 0.000 | 0.937 |
| B-8c1 | 0.76 | 2.04 | 26.30 | 26.30 | 3.32 | 0.000 | 5.147 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B-9b | 0.78 | 0.22 | 22.70 | 22.70 | 3.57 | 0.000 | 0.613 |
| B-12a1 | 0.73 | 1.09 | 25.20 | 25.20 | 3.39 | 0.000 | 2.700 |
| B-13a1 | 0.71 | 0.65 | 24.27 | 24.27 | 3.46 | 0.000 | 1.596 |
| B-14a1 | 0.79 | 0.49 | 23.80 | 23.80 | 3.49 | 0.000 | 1.352 |
| MH-A8 | 0.8 | 37.03 | 33.90 | 33.90 | 2.90 | 0.000 | 85.772 |
| A-1 | 0.47 | 1.14 | 25.20 | 25.20 | 3.39 | 0.000 | 1.818 |
| MH-B | 0.5 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| B | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.004 |
| C-1 | 0.76 | 44.66 | 34.50 | 34.50 | 2.87 | 0.000 | 97.305 |
| MH-D1 | 0.8 | 0.00 | 34.60 | 34.60 | 2.86 | 0.000 | 0.000 |
| D-1 | 0.47 | 47.99 | 34.80 | 34.80 | 2.85 | 0.000 | 64.346 |
| B-9c1 | 0.77 | 0.39 | 23.50 | 23.50 | 3.51 | 0.000 | 1.055 |
| B-14a2 | 0.68 | 0.46 | 23.70 | 23.70 | 3.50 | 0.000 | 1.094 |
| B-1c1 | 0.76 | 0.65 | 24.30 | 24.30 | 3.46 | 0.000 | 1.707 |
| MH-B7d | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.004 |
| B-7d1 | 0.62 | 2.33 | 26.60 | 26.60 | 3.30 | 0.000 | 4.768 |
| E-1 | 0.57 | 20.49 | 31.90 | 31.90 | 3.00 | 0.000 | 34.981 |
| MH-B7 | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| MH-B8 | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.000 |
| B-9 | 0.65 | 0.12 | 21.90 | 21.90 | 3.64 | 0.000 | 0.284 |
| B-10 | 0.68 | 0.23 | 22.70 | 22.70 | 3.57 | 0.000 | 0.559 |
| B-11 | 0.64 | 0.36 | 23.30 | 23.30 | 3.53 | 0.000 | 0.813 |
| B-12 | 0.66 | 0.28 | 23.00 | 23.00 | 3.55 | 0.000 | 0.656 |
| B-13 | 0.59 | 1.03 | 25.00 | 25.00 | 3.41 | 0.000 | 2.070 |
| MH-B7b | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.004 |
| MH-B7c | 0.8 | 0.00 | 10.00 | 10.00 | 4.96 | 0.000 | 0.004 |
| B-7d2 | 0.56 | 2.12 | 26.40 | 26.40 | 3.31 | 0.000 | 3.934 |
| B-7d3 | 0.49 | 4.05 | 27.80 | 27.80 | 3.23 | 0.000 | 6.401 |
| B-9b1 | 0.8 | 0.51 | 23.90 | 23.90 | 3.48 | 0.000 | 1.422 |

On Grade Inlet Configuration Data

| Inlet ID | Inlet Type | Inlet Length (ft) | Slopes Long (%) | Slopes Trans (%) | Gutter n | Gutter Depr. (ft) | Grate Width (ft) | Grate Type | Pond Width Allowed (ft) |
|---|---|---|---|---|---|---|---|---|---|
| B-10 | Combi | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | 0.75 | Reticu | 12.00 |
| B-11 | Curb | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| A-1 | Curb | 10.00 | 0.50 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-2a | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-2b | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-3a | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-3b | Grate | 1.33 | 0.30 | 2.00 | 0.014 | n/a | 0.75 | Reticu | 12.00 |
| B-3b1 | Combi | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | 0.75 | Reticu | 12.00 |
| B-4a | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-4b | Grate | 1.33 | 0.30 | 2.00 | 0.014 | n/a | 0.75 | Reticu | 12.00 |
| B-4c | Combi | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | 0.75 | Reticu | 12.00 |
| B-8a | Grate | 1.33 | 0.30 | 2.00 | 0.014 | n/a | 0.75 | Reticu | 12.00 |
| B-8b | Grate | 2.67 | 0.30 | 2.00 | 0.014 | n/a | 1.50 | Reticu | 12.00 |
| B-12 | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-14 | Curb | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-15 | Curb | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-1a | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-1b | Grate | 1.33 | 0.30 | 2.00 | 0.014 | n/a | 0.75 | Reticu | 12.00 |
| B-1c | Combi | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | 0.75 | Reticu | 12.00 |

On Grade Inlets Computation Data.

| Inlet ID | Inlet Type | Total Q (cfs) | Intercept Capacity (cfs) | Q Bypass Allow (cfs) | Q Bypass Actual (cfs) | To Inlet ID | Required Length (ft) | Actual Length (ft) | Ponded Width (ft) |
|---|---|---|---|---|---|---|---|---|---|
| B-10 | Combi | 0.559 | 0.883 | 0.224 | 0.000 | B-9 | n/a | 5.00 | 6.90 |
| B-11 | Curb | 0.813 | 0.813 | 0.325 | 0.000 | B-12 | 3.45 | 5.00 | 7.95 |
| A-1 | Curb | 1.818 | 1.818 | 0.000 | 0.000 | | 6.08 | 10.00 | 9.75 |
| B-2a | Curb | 0.524 | 0.517 | 0.209 | 0.006 | B-3a | 2.73 | 2.50 | 6.75 |
| B-2b | Curb | 0.719 | 0.670 | 0.000 | 0.050 | B-3b1 | 3.23 | 2.50 | 7.60 |
| B-3a | Curb | 0.629 | 0.604 | 0.252 | 0.025 | B-4a | 3.01 | 2.50 | 7.20 |
| B-3b | Grate | 1.785 | 0.466 | 0.714 | 1.319 | B-4c | n/a | 0.00 | 10.65 |
| B-3b1 | Combi | 0.326 | 0.552 | 0.130 | 0.000 | B-3b | n/a | 5.00 | 5.65 |
| B-4a | Curb | 0.522 | 0.516 | 0.209 | 0.006 | B-5a | 2.73 | 2.50 | 6.75 |
| B-4b | Grate | 0.167 | 0.091 | 0.067 | 0.076 | B-5b | n/a | 0.00 | 4.40 |
| B-4c | Combi | 1.637 | 1.886 | 0.655 | 0.000 | B-4b | n/a | 5.00 | 10.35 |
| B-8a | Grate | 0.465 | 0.189 | 0.186 | 0.276 | B-9 | n/a | 0.00 | 6.45 |
| B-8b | Grate | 0.937 | 0.623 | 0.375 | 0.314 | B-9b | n/a | 0.00 | 8.40 |
| B-12 | Curb | 0.656 | 0.624 | 0.262 | 0.032 | B-13 | 3.08 | 2.50 | 7.35 |
| B-14 | Curb | 0.829 | 0.829 | 0.332 | 0.000 | B-15 | 3.49 | 5.00 | 8.00 |
| B-15 | Curb | 0.445 | 0.445 | 0.178 | 0.000 | B-10 | 2.51 | 5.00 | 6.35 |
| B-1a | Curb | 0.889 | 0.782 | 0.356 | 0.108 | B-2a | 3.62 | 2.50 | 8.20 |
| B-1b | Grate | 0.224 | 0.113 | 0.090 | 0.112 | B-2b | n/a | 0.00 | 4.90 |
| B-1c | Combi | 0.665 | 1.010 | 0.266 | 0.000 | B-1b | n/a | 5.00 | 7.35 |

Sag Inlets Configuration Data.

| Inlet ID | Inlet Type | Length/ Perim (ft) | Grate Area (sf) | Left-Slope Longi (%) | Left-Slope Transv (%) | Right-Slope Longi (%) | Right-Slope Transv (%) | Gutter n | Gutter DeprW (ft) | Head Allowed (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| B-9 | Combi | 5.00 | 2.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-5a | Curb | 2.50 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-5b | Curb | 2.50 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-7a | Curb | 5.00 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-7b | Curb | 5.00 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-9b | Combi | 5.00 | 3.11 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-13 | Curb | 2.50 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |

Sag Inlets Computation Data.

| Inlet ID | Inlet Type | Length (ft) | Grate Perim (ft) | Grate Area (sf) | Total Q (cfs) | Inlet Capacity (cfs) | Actual Head (ft) | Ponded Width Left (ft) | Ponded Width Right (ft) |
|---|---|---|---|---|---|---|---|---|---|
| B-9 | Combi | 5.00 | 4.17 | 2.00 | 0.560 | 4.551 | 0.132 | 3.80 | 6.35 |
| B-5a | Curb | 2.50 | n/a | n/a | 0.617 | 2.057 | 0.159 | 6.60 | 3.90 |
| B-5b | Curb | 2.50 | n/a | n/a | 0.800 | 2.057 | 0.182 | 4.30 | 7.25 |
| B-7a | Curb | 5.00 | n/a | n/a | 1.145 | 4.114 | 0.154 | 6.95 | 6.95 |
| B-7b | Curb | 5.00 | n/a | n/a | 3.437 | 4.114 | 0.387 | 10.50 | 10.50 |
| B-9b | Combi | 5.00 | 5.00 | 3.11 | 0.927 | 5.457 | 0.144 | 6.45 | 6.45 |
| B-13 | Curb | 2.50 | n/a | n/a | 2.102 | 2.057 | 0.517 | 8.75 | 8.75 |

Cumulative Junction Discharge Computations

| Node I.D. | Node Type | Weighted C-Value | Cumulat. Dr.Area (acres) | Cumulat. Tc (min) | Intens. (in/hr) | User Supply Q cfs) | Additional Q in Node (cfs) | Total Disch. (cfs) |
|---|---|---|---|---|---|---|---|---|
| MH-B1 | CrcMh | 0.680 | 2.89 | 25.30 | 3.39 | | 0.00 | 6.655 |
| MH-B2 | CrcMh | 0.691 | 5.63 | 25.85 | 3.35 | | 0.00 | 13.034 |
| MH-B3 | CrcMh | 0.697 | 7.15 | 26.60 | 3.30 | | 0.00 | 16.452 |
| MH-B4 | CrcMh | 0.694 | 8.13 | 27.15 | 3.27 | | 0.00 | 18.435 |
| MH-B5 | CrcMh | 0.628 | 20.33 | 29.33 | 3.13 | | 0.00 | 40.046 |
| MH-B7 | CrcMh | 0.581 | 11.45 | 28.60 | 3.18 | | 0.00 | 21.124 |
| MH-B8 | CrcMh | 0.641 | 22.97 | 29.91 | 3.10 | | 0.00 | 45.662 |
| B-9 | Combi | 0.648 | 24.44 | 30.51 | 3.07 | | 0.00 | 48.599 |
| B-10 | Combi | 0.680 | 0.23 | 22.70 | 3.57 | | 0.00 | 0.559 |
| B-11 | Curb | 0.798 | 37.39 | 34.23 | 2.88 | | 0.00 | 85.968 |
| MH-A8 | CrcMh | 0.800 | 37.03 | 33.90 | 2.90 | | 0.00 | 85.772 |
| A-1 | Curb | 0.000 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.000 |
| MH-B | CrcMh | 0.000 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.000 |
| B | CrcMh | 0.735 | 66.43 | 35.57 | 2.82 | | 0.00 | 137.485 |
| C-1 | CrcMh | 0.745 | 111.09 | 38.11 | 2.71 | | 0.00 | 224.025 |
| MH-D1 | CrcMh | 0.745 | 111.09 | 38.11 | 2.71 | | 0.00 | 224.025 |
| D-1 | CrcMh | 0.662 | 159.08 | 39.67 | 2.64 | | 0.00 | 278.443 |
| MH-E1 | CrcMh | 0.651 | 179.57 | 40.65 | 2.61 | | 111.40 | 416.311 |
| MH-E2 | CrcMh | 0.651 | 179.57 | 40.65 | 2.61 | | 111.40 | 416.311 |
| E-1 | CrcMh | 0.651 | 179.57 | 40.65 | 2.61 | | 111.40 | 416.311 |
| B-2a | Curb | 0.743 | 1.67 | 25.79 | 3.35 | | 0.00 | 4.161 |
| B-2a1 | CrcMh | 0.760 | 1.48 | 25.70 | 3.36 | | 0.00 | 3.779 |
| B-2b | Curb | 0.641 | 1.07 | 24.97 | 3.41 | | 0.00 | 2.338 |
| B-2b1 | CrcMh | 0.660 | 0.78 | 24.60 | 3.43 | | 0.00 | 1.768 |
| B-3a | Curb | 0.734 | 0.68 | 23.85 | 3.49 | | 0.00 | 1.742 |
| B-3a1 | CrcMh | 0.790 | 0.41 | 23.60 | 3.51 | | 0.00 | 1.136 |
| B-3b | Grate | 0.707 | 0.84 | 24.40 | 3.45 | | 0.00 | 2.048 |
| B-3b1 | Combi | 0.510 | 0.15 | 22.20 | 3.61 | | 0.00 | 0.276 |
| B-4a | Curb | 0.630 | 0.22 | 22.60 | 3.58 | | 0.00 | 0.496 |
| B-4b | Grate | 0.686 | 0.76 | 24.13 | 3.47 | | 0.00 | 1.809 |
| B-12a1 | CrcMh | 0.730 | 1.09 | 25.20 | 3.39 | | 0.00 | 2.700 |
| B-13a1 | CrcMh | 0.710 | 0.65 | 24.27 | 3.46 | | 0.00 | 1.596 |
| B-14a1 | CrcMh | 0.737 | 0.95 | 24.59 | 3.44 | | 0.00 | 2.404 |
| B-4b1 | CrcMh | 0.760 | 0.51 | 23.90 | 3.48 | | 0.00 | 1.350 |
| B-4c | Combi | 0.520 | 0.17 | 22.30 | 3.60 | | 0.00 | 0.319 |
| B-5a | Curb | 0.660 | 0.26 | 22.90 | 3.56 | | 0.00 | 0.611 |
| B-5b | Curb | 0.631 | 0.49 | 23.30 | 3.53 | | 0.00 | 1.091 |
| B-5b1 | CrcMh | 0.800 | 0.13 | 22.00 | 3.63 | | 0.00 | 0.377 |
| B-7a | Curb | 0.657 | 2.06 | 26.03 | 3.34 | | 0.00 | 4.518 |
| B-7b | Curb | 0.670 | 1.53 | 25.80 | 3.35 | | 0.00 | 3.437 |
| B-7c1 | CrcMh | 0.760 | 0.89 | 24.80 | 3.42 | | 0.00 | 2.314 |
| B-8a | Grate | 0.660 | 0.60 | 23.78 | 3.49 | | 0.00 | 1.383 |
| B-8b | Grate | 0.700 | 0.38 | 23.40 | 3.52 | | 0.00 | 0.937 |
| B-8c1 | CrcMh | 0.760 | 2.04 | 26.30 | 3.32 | | 0.00 | 5.147 |
| B-9b | Combi | 0.794 | 0.73 | 24.05 | 3.47 | | 0.00 | 2.013 |
| B-9c1 | CrcMh | 0.770 | 0.39 | 23.50 | 3.51 | | 0.00 | 1.055 |
| B-14a2 | CrcMh | 0.680 | 0.46 | 23.70 | 3.50 | | 0.00 | 1.094 |
| B-1c1 | CrcMh | 0.760 | 0.65 | 24.30 | 3.46 | | 0.00 | 1.707 |
| MH-B7d | CrcMh | 0.000 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B-7d1 | CrcMh | 0.620 | 2.33 | 26.60 | 3.30 | 0.00 | 4.768 |
| MH-B7b | CrcMh | 0.543 | 8.50 | 28.53 | 3.18 | 0.00 | 14.692 |
| MH-B7c | CrcMh | 0.591 | 4.45 | 27.98 | 3.21 | 0.00 | 8.462 |
| B-7d2 | CrcMh | 0.560 | 2.12 | 26.40 | 3.31 | 0.00 | 3.934 |
| B-7d3 | CrcMh | 0.490 | 4.05 | 27.80 | 3.23 | 0.00 | 6.401 |
| B-9b1 | CrcMh | 0.800 | 0.51 | 23.90 | 3.48 | 0.00 | 1.422 |
| B-12 | Curb | 0.796 | 38.76 | 34.50 | 2.87 | 0.00 | 88.397 |
| B-13 | Curb | 0.789 | 40.44 | 34.74 | 2.86 | 0.00 | 91.106 |
| B-14 | Curb | 0.786 | 41.79 | 35.31 | 2.83 | 0.00 | 92.908 |
| B-15 | Curb | 0.785 | 41.99 | 35.31 | 2.83 | 0.00 | 93.259 |
| MH-B16 | CrcMh | 0.648 | 24.44 | 30.51 | 3.07 | 0.00 | 48.599 |
| B-1a | Curb | 0.710 | 1.45 | 25.18 | 3.39 | 0.00 | 3.493 |
| B-1a1 | CrcMh | 0.760 | 1.02 | 25.00 | 3.41 | 0.00 | 2.641 |
| B-1b | Grate | 0.650 | 1.44 | 24.79 | 3.42 | 0.00 | 3.203 |
| B-1b1 | CrcMh | 0.687 | 1.00 | 24.55 | 3.44 | 0.00 | 2.360 |
| B-1c | Combi | 0.570 | 0.33 | 23.22 | 3.53 | 0.00 | 0.665 |
| OUT | Outlt | 0.651 | 179.57 | 40.65 | 2.61 | 111.40 | 416.311 |

Conveyance Configuration Data

| Run # | Node US | I.D. DS | FlowLine Elev. US (ft) | DS (ft) | Shape # | Span (ft) | Rise (ft) | Length (ft) | Slope (%) | n_value |
|---|---|---|---|---|---|---|---|---|---|---|
| 27 | B-1a | MH-B1 | 69.68 | 69.43 | Cir 1 | 0.00 | 1.50 | 34.0 | 0.735 | 0.013 |
| 28 | B-1a1 | B-1a | 71.45 | 69.68 | Cir 1 | 0.00 | 1.00 | 74.0 | 2.393 | 0.013 |
| 29 | B-1b | MH-B1 | 69.65 | 69.36 | Cir 1 | 0.00 | 1.50 | 47.0 | 0.617 | 0.013 |
| 30 | B-1b1 | B-1b | 70.44 | 69.83 | Cir 1 | 0.00 | 1.50 | 67.0 | 0.910 | 0.013 |
| 31 | B-1c | B-1b | 72.07 | 71.70 | Cir 1 | 0.00 | 1.50 | 40.0 | 0.925 | 0.013 |
| 32 | B-2a | MH-B2 | 69.30 | 68.68 | Cir 1 | 0.00 | 1.50 | 29.0 | 2.138 | 0.013 |
| 33 | B-2a1 | B-2a | 70.90 | 69.30 | Cir 2 | 0.00 | 1.00 | 40.0 | 4.003 | 0.013 |
| 34 | B-2b | MH-B2 | 69.50 | 68.69 | Cir 1 | 0.00 | 1.50 | 50.0 | 1.620 | 0.013 |
| 35 | B-2b1 | B-2b | 70.34 | 69.50 | Cir 1 | 0.00 | 1.50 | 94.0 | 0.894 | 0.013 |
| 36 | B-3a | MH-B3 | 70.50 | 67.75 | Cir 1 | 0.00 | 1.50 | 32.0 | 8.626 | 0.013 |
| 37 | B-3a1 | B-3a | 70.80 | 70.50 | Cir 1 | 0.00 | 1.00 | 50.0 | 0.600 | 0.013 |
| 38 | B-3b | MH-B3 | 68.80 | 67.76 | Cir 1 | 0.00 | 1.50 | 47.0 | 2.213 | 0.013 |
| 39 | B-3b1 | B-3b | 70.32 | 69.85 | Cir 1 | 0.00 | 7.50 | 55.0 | 0.855 | 0.013 |
| 40 | B-4a | MH-B4 | 70.50 | 67.11 | Cir 1 | 0.00 | 1.50 | 30.0 | 11.373 | 0.013 |
| 42 | B-4b | MH-B4 | 68.24 | 67.21 | Cir 1 | 0.00 | 1.50 | 47.0 | 2.192 | 0.013 |
| 43 | B-4b1 | B-4b | 69.21 | 68.96 | Cir 1 | 0.00 | 1.00 | 46.0 | 0.543 | 0.013 |
| 44 | B-4c | B-4b | 69.57 | 69.33 | Cir 1 | 0.00 | 1.50 | 47.0 | 0.511 | 0.013 |
| 45 | B-5a | MH-B5 | 65.91 | 65.83 | Cir 1 | 0.00 | 1.50 | 39.0 | 0.205 | 0.013 |
| 46 | B-5b | MH-B5 | 68.53 | 67.01 | Cir 1 | 0.00 | 1.50 | 51.0 | 2.982 | 0.013 |
| 47 | B-5b1 | B-5b | 69.16 | 68.68 | Cir 1 | 0.00 | 1.00 | 60.0 | 0.800 | 0.013 |
| 48 | B-7a | MH-B7 | 66.90 | 66.89 | Cir 1 | 0.00 | 2.00 | 5.0 | 0.200 | 0.013 |
| 49 | B-7b | B-7a | 66.98 | 66.90 | Cir 1 | 0.00 | 2.00 | 40.0 | 0.200 | 0.013 |
| 50 | B-7c1 | MH-B7 | 68.50 | 66.89 | Cir 1 | 0.00 | 1.50 | 40.0 | 4.028 | 0.013 |
| 51 | B-8a | MH-B8 | 67.14 | 66.66 | Cir 1 | 0.00 | 2.00 | 5.0 | 9.645 | 0.013 |
| 52 | B-8b | B-8a | 67.19 | 67.14 | Cir 1 | 0.00 | 2.00 | 39.0 | 0.128 | 0.013 |
| 53 | B-8c1 | MH-B8 | 68.75 | 67.11 | Cir 1 | 0.00 | 2.00 | 40.0 | 4.103 | 0.013 |
| 54 | B-9b | B-9 | 66.43 | 66.35 | Cir 1 | 0.00 | 2.00 | 42.0 | 0.190 | 0.013 |
| 55 | B-12a1 | B-12 | 70.97 | 70.71 | Cir 1 | 0.00 | 1.00 | 64.0 | 0.406 | 0.013 |
| 56 | B-13a1 | B-13 | 71.95 | 71.67 | Cir 1 | 0.00 | 1.00 | 71.0 | 0.394 | 0.013 |
| 57 | B-14a1 | B-14 | 70.76 | 70.49 | Cir 1 | 0.00 | 1.00 | 68.0 | 0.397 | 0.013 |
| 59 | B-9c1 | B-9 | 71.07 | 66.35 | Cir 1 | 0.00 | 2.00 | 54.0 | 8.774 | 0.013 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 60 | B-14a2 | B-14a1 | 71.95 | 71.31 | Cir 1 | 0.00 | 0.83 | 168.0 | 0.381 | 0.011 |
| 61 | B-1c1 | B-1b1 | 71.11 | 70.63 | Cir 1 | 0.00 | 1.00 | 61.0 | 0.787 | 0.013 |
| 62 | B-10 | B-9 | 68.69 | 68.63 | Cir 1 | 0.00 | 2.00 | 29.0 | 0.207 | 0.013 |
| 2 | MH-A8 | B-11 | 68.17 | 67.60 | Cir 1 | 0.00 | 3.50 | 177.0 | 0.322 | 0.013 |
| 4 | B | C-1 | 64.21 | 61.36 | Cir 1 | 0.00 | 5.00 | 1140.0 | 0.250 | 0.013 |
| 5 | C-1 | MH-D1 | 58.84 | 56.27 | Cir 1 | 0.00 | 6.50 | 1227.0 | 0.209 | 0.013 |
| 6 | MH-D1 | D-1 | 55.77 | 54.37 | Cir 1 | 0.00 | 7.00 | 750.0 | 0.187 | 0.013 |
| 7 | D-1 | E-1 | 53.87 | 52.86 | Cir 1 | 0.00 | 7.50 | 506.0 | 0.200 | 0.013 |
| 8 | E-1 | MH-E1 | 52.36 | 49.52 | Box 1 | 9.00 | 8.00 | 1387.0 | 0.205 | 0.015 |
| 9 | MH-E1 | MH-E2 | 49.52 | 43.66 | Box 1 | 9.00 | 8.00 | 129.0 | 4.547 | 0.015 |
| 10 | MH-E2 | OUT | 43.66 | 43.16 | Cir 2 | 0.00 | 7.50 | 120.0 | 0.417 | 0.024 |
| 11 | MH-B1 | MH-B2 | 69.24 | 68.71 | Cir 1 | 0.00 | 2.00 | 144.0 | 0.368 | 0.013 |
| 12 | MH-B2 | MH-B3 | 68.30 | 67.84 | Cir 1 | 0.00 | 2.50 | 195.0 | 0.236 | 0.013 |
| 13 | MH-B3 | MH-B4 | 67.73 | 67.14 | Cir 1 | 0.00 | 2.50 | 173.0 | 0.341 | 0.013 |
| 14 | MH-B4 | MH-B5 | 67.14 | 66.91 | Cir 1 | 0.00 | 2.50 | 178.0 | 0.129 | 0.013 |
| 64 | MH-B7c | MH-B7b | 69.38 | 68.69 | Cir 1 | 0.00 | 2.00 | 160.0 | 0.431 | 0.013 |
| 15 | MH-B5 | MH-B8 | 66.67 | 66.49 | Cir 1 | 0.00 | 3.00 | 198.0 | 0.091 | 0.013 |
| 17 | MH-B7 | MH-B5 | 66.89 | 66.67 | Cir 1 | 0.00 | 3.00 | 169.0 | 0.130 | 0.013 |
| 18 | MH-B8 | B-9 | 66.50 | 65.80 | Cir 1 | 0.00 | 3.00 | 230.0 | 0.304 | 0.013 |
| 19 | B-9 | MH-B16 | 65.80 | 65.72 | Cir 1 | 0.00 | 3.00 | 58.0 | 0.138 | 0.013 |
| 20 | MH-B16 | B | 65.72 | 65.68 | Cir 1 | 0.00 | 3.00 | 27.0 | 0.148 | 0.013 |
| 21 | B-11 | B-12 | 67.20 | 66.97 | Cir 1 | 0.00 | 4.00 | 111.0 | 0.207 | 0.013 |
| 22 | B-12 | B-13 | 66.90 | 66.07 | Cir 1 | 0.00 | 4.00 | 140.0 | 0.593 | 0.013 |
| 23 | B-13 | B-14 | 66.02 | 64.93 | Cir 1 | 0.00 | 4.00 | 280.0 | 0.389 | 0.013 |
| 24 | B-14 | B-15 | 64.81 | 64.49 | Cir 1 | 0.00 | 4.00 | 130.0 | 0.246 | 0.013 |
| 25 | B-15 | B | 64.49 | 64.21 | Cir 1 | 0.00 | 5.00 | 112.0 | 0.250 | 0.013 |
| 63 | MH-B7b | MH-B7 | 67.65 | 66.89 | Cir 1 | 0.00 | 2.50 | 40.0 | 1.900 | 0.013 |
| 65 | B-7d1 | MH-B7c | 72.39 | 69.38 | Cir 1 | 0.00 | 2.00 | 420.0 | 0.717 | 0.013 |
| 66 | B-7d3 | MH-B7b | 67.72 | 67.65 | Cir 1 | 0.00 | 2.00 | 37.0 | 0.189 | 0.013 |
| 67 | B-7d2 | MH-B7c | 69.63 | 69.38 | Cir 1 | 0.00 | 2.00 | 55.0 | 0.455 | 0.013 |
| 68 | B-9b1 | B-9b | 66.47 | 66.43 | Cir 1 | 0.00 | 2.00 | 20.0 | 0.200 | 0.013 |

Conveyance Hydraulic Computations. Tailwater = 51.700 (ft)

| Run # | Hyd. US (ft) | Gr.line DS (ft) | Crit.Elev US (ft) | Fr.Slope (%) | Depth Unif. (ft) | Depth Actual (ft) | Velocity Unif. (f/s) | Velocity Actual (f/s) | Q (cfs) | Cap (cfs) | Junc Loss (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27* | 72.25 | 72.21 | 75.13 | 0.110 | 0.65 | 1.50 | 4.78 | 4.22 | 3.5 | 9.0 | 0.000 |
| 28* | 72.65 | 72.25 | 79.40 | 0.545 | 0.49 | 1.00 | 6.94 | 4.52 | 2.6 | 5.5 | 0.000 |
| 29* | 72.25 | 72.21 | 74.75 | 0.092 | 0.65 | 1.50 | 4.37 | 4.10 | 3.2 | 8.3 | 0.000 |
| 30* | 72.29 | 72.25 | 76.10 | 0.050 | 0.50 | 1.50 | 4.64 | 3.73 | 2.4 | 10.1 | 0.000 |
| 31* | 72.36 | 72.25 | 75.13 | 0.004 | 0.26 | 0.55 | 3.23 | 1.12 | 0.7 | 10.1 | 0.000 |
| 32* | 71.85 | 71.80 | 74.49 | 0.156 | 0.53 | 1.50 | 7.39 | 4.47 | 4.2 | 15.4 | 0.000 |
| 33* | 71.96 | 71.85 | 75.86 | 0.279 | 0.35 | 1.00 | 7.67 | 3.95 | 3.8 | 14.3 | 0.000 |
| 34* | 71.83 | 71.80 | 74.49 | 0.049 | 0.42 | 1.50 | 5.69 | 3.73 | 2.3 | 13.4 | 0.000 |
| 35* | 71.85 | 71.83 | 75.17 | 0.028 | 0.43 | 1.50 | 4.25 | 3.43 | 1.8 | 10.0 | 0.000 |
| 36* | 71.55 | 71.54 | 74.05 | 0.027 | 0.24 | 1.50 | 9.43 | 3.41 | 1.7 | 31.0 | 0.000 |
| 37* | 71.60 | 71.55 | 75.16 | 0.101 | 0.45 | 1.00 | 3.34 | 3.34 | 1.1 | 2.8 | 0.000 |
| 38* | 71.56 | 71.54 | 73.75 | 0.038 | 0.37 | 1.50 | 6.12 | 3.48 | 2.0 | 15.7 | 0.000 |
| 39* | 71.56 | 71.56 | 74.01 | 0.000 | 0.12 | 1.71 | 1.91 | 1.03 | 0.3 | 712.9 | 0.000 |
| 40* | 71.22 | 71.22 | 74.62 | 0.002 | 0.12 | 1.50 | 7.14 | 2.30 | 0.5 | 35.6 | 0.000 |
| 42* | 71.24 | 71.22 | 73.10 | 0.029 | 0.35 | 1.50 | 5.88 | 3.46 | 1.8 | 15.6 | 0.000 |
| 43 | 71.42 | 71.24 | 74.32 | 0.142 | 0.51 | 1.00 | 3.37 | 1.72 | 1.4 | 2.6 | 0.000 |
| 44 | 71.48 | 71.24 | 73.55 | 0.001 | 0.21 | 1.50 | 2.11 | 0.18 | 0.3 | 7.5 | 0.000 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | 70.95 | 70.87 | 72.60 | 0.003 | 0.36 | 1.50 | 1.85 | 0.35 | 0.6 | 4.8 | 0.000 |
| 46* | 70.87 | 70.87 | 72.60 | 0.011 | 0.25 | 1.50 | 5.65 | 2.99 | 1.1 | 18.2 | 0.000 |
| 47* | 70.88 | 70.87 | 74.46 | 0.011 | 0.23 | 1.00 | 2.73 | 1.40 | 0.4 | 3.2 | 0.000 |
| 48 | 70.93 | 70.92 | 72.98 | 0.040 | 0.94 | 2.00 | 3.12 | 1.44 | 4.5 | 10.2 | 0.000 |
| 49 | 71.00 | 70.93 | 72.98 | 0.023 | 0.80 | 2.00 | 2.92 | 1.09 | 3.4 | 10.2 | 0.000 |
| 50* | 70.94 | 70.92 | 73.38 | 0.048 | 0.34 | 1.50 | 7.84 | 3.71 | 2.3 | 21.2 | 0.000 |
| 51* | 70.16 | 70.16 | 72.81 | 0.004 | 0.19 | 2.00 | 8.82 | 3.02 | 1.4 | 70.6 | 0.000 |
| 52 | 70.21 | 70.16 | 72.81 | 0.002 | 0.46 | 2.00 | 1.72 | 0.30 | 0.9 | 8.1 | 0.000 |
| 53* | 70.18 | 70.16 | 73.65 | 0.051 | 0.45 | 2.00 | 9.65 | 4.39 | 5.1 | 46.0 | 0.000 |
| 54 | 69.17 | 69.09 | 72.33 | 0.008 | 0.61 | 2.00 | 2.46 | 0.64 | 2.0 | 9.9 | 0.000 |
| 55 | 72.03 | 70.93 | 75.25 | 0.569 | 1.00 | 1.00 | 3.44 | 3.44 | 2.7 | 2.3 | 0.000 |
| 56 | 72.81 | 72.67 | 75.30 | 0.199 | 0.62 | 1.00 | 3.10 | 2.03 | 1.6 | 2.2 | 0.000 |
| 57 | 71.80 | 71.49 | 75.34 | 0.452 | 0.91 | 1.00 | 3.19 | 3.06 | 2.4 | 2.3 | 0.000 |
| 59* | 71.43 | 69.09 | 74.05 | 0.002 | 0.17 | 2.00 | 7.86 | 0.34 | 1.1 | 67.3 | 0.000 |
| 60 | 72.46 | 71.80 | 73.50 | 0.178 | 0.51 | 0.51 | 3.15 | 3.15 | 1.1 | 1.6 | 0.000 |
| 61* | 72.43 | 72.29 | 75.74 | 0.228 | 0.52 | 1.00 | 4.10 | 3.78 | 1.7 | 3.2 | 0.000 |
| 62* | 69.09 | 69.09 | 72.48 | 0.001 | 0.32 | 0.46 | 1.75 | 1.37 | 0.6 | 10.3 | 0.000 |
| 2 | 72.62 | 71.35 | 78.50 | 0.721 | 3.50 | 3.50 | 8.92 | 8.92 | 85.8 | 57.3 | 0.000 |
| 4 | 68.62 | 63.82 | 72.34 | 0.276 | 4.41 | 4.41 | 7.49 | 7.49 | 137.5 | 130.8 | 0.000 |
| 5 | 63.82 | 60.56 | 76.00 | 0.181 | 4.98 | 4.98 | 8.22 | 8.22 | 224.0 | 241.0 | 0.000 |
| 6 | 60.56 | 59.00 | 74.00 | 0.122 | 4.79 | 4.79 | 7.99 | 7.99 | 224.0 | 277.2 | 0.000 |
| 7 | 59.00 | 57.97 | 72.00 | 0.130 | 5.13 | 5.13 | 8.65 | 8.65 | 278.4 | 344.5 | 0.000 |
| 8 | 57.97 | 53.57 | 67.00 | 0.125 | 5.61 | 5.61 | 8.25 | 8.25 | 416.3 | 532.3 | 0.000 |
| 9* | 53.57 | 51.90 | 70.00 | 0.125 | 1.83 | 8.00 | 25.21 | 5.78 | 416.3 | 2508.3 | 0.000 |
| 10 | 51.90 | 51.70 | 72.00 | 0.248 | 4.96 | 7.50 | 6.72 | 4.71 | 416.3 | 539.3 | 0.000 |
| 11 | 72.21 | 71.80 | 75.49 | 0.086 | 0.98 | 2.00 | 4.33 | 2.12 | 6.7 | 13.8 | 0.000 |
| 12 | 71.80 | 71.54 | 75.86 | 0.100 | 1.47 | 2.50 | 4.33 | 2.66 | 13.0 | 20.0 | 0.000 |
| 13 | 71.54 | 71.22 | 75.16 | 0.160 | 1.52 | 2.50 | 5.26 | 3.35 | 16.5 | 24.1 | 0.000 |
| 14 | 71.22 | 70.87 | 74.62 | 0.200 | 2.50 | 2.50 | 3.76 | 3.76 | 18.4 | 14.8 | 0.000 |
| 64 | 71.44 | 70.97 | 74.77 | 0.139 | 1.08 | 2.00 | 4.88 | 2.69 | 8.5 | 14.9 | 0.000 |
| 15 | 70.87 | 70.16 | 73.38 | 0.357 | 3.00 | 3.00 | 5.67 | 5.67 | 40.0 | 20.2 | 0.000 |
| 17 | 70.92 | 70.87 | 73.90 | 0.099 | 2.18 | 3.00 | 3.84 | 2.99 | 21.1 | 24.2 | 0.000 |
| 18 | 70.16 | 69.09 | 73.19 | 0.465 | 3.00 | 3.00 | 6.46 | 6.46 | 45.7 | 37.0 | 0.000 |
| 19 | 69.09 | 68.78 | 72.33 | 0.526 | 3.00 | 3.00 | 6.88 | 6.88 | 48.6 | 24.9 | 0.000 |
| 20 | 68.78 | 68.62 | 72.84 | 0.526 | 3.00 | 3.00 | 6.88 | 6.88 | 48.6 | 25.8 | 0.000 |
| 21 | 71.35 | 70.93 | 74.21 | 0.355 | 4.00 | 4.00 | 6.84 | 6.84 | 86.0 | 65.7 | 0.000 |
| 22* | 70.93 | 70.41 | 74.30 | 0.375 | 2.70 | 4.00 | 9.78 | 9.23 | 88.4 | 111.1 | 0.000 |
| 23 | 70.41 | 69.29 | 75.30 | 0.399 | 3.34 | 4.00 | 8.12 | 7.25 | 91.1 | 90.0 | 0.000 |
| 24 | 69.29 | 68.75 | 73.43 | 0.415 | 4.00 | 4.00 | 7.39 | 7.39 | 92.9 | 71.6 | 0.000 |
| 25 | 68.75 | 68.62 | 73.50 | 0.127 | 3.13 | 4.41 | 7.21 | 5.08 | 93.3 | 130.8 | 0.000 |
| 63* | 70.97 | 70.92 | 73.89 | 0.127 | 0.87 | 2.50 | 9.68 | 5.74 | 14.7 | 56.8 | 0.000 |
| 65* | 73.16 | 71.44 | 74.30 | 0.044 | 0.68 | 2.00 | 5.06 | 1.52 | 4.8 | 19.2 | 0.000 |
| 66 | 71.01 | 70.97 | 75.50 | 0.079 | 1.18 | 2.00 | 3.33 | 2.04 | 6.4 | 9.9 | 0.000 |
| 67* | 71.46 | 71.44 | 74.75 | 0.030 | 0.69 | 2.00 | 4.07 | 4.05 | 3.9 | 15.3 | 0.000 |
| 68 | 69.21 | 69.17 | 72.33 | 0.004 | 0.51 | 2.00 | 2.28 | 0.45 | 1.4 | 10.2 | 0.000 |

* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.
Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

| Type of Convey Structure | Material | Rise (ft) | Span (ft) | Number of Links of this type | Quantity (ft) |
|---|---|---|---|---|---|
| Circular | Concrete | 1.5 | 0.0 | 15 | 694.0 |
| Circular | Concrete | 1.0 | 0.0 | 9 | 574.0 |
| Circular | Concrete | 7.5 | 0.0 | 2 | 561.0 |
| Circular | Concrete | 2.0 | 0.0 | 14 | 1090.0 |
| Circular | Plastic | 0.833 | 0.0 | 1 | 168.0 |
| Circular | Concrete | 3.5 | 0.0 | 1 | 177.0 |
| Circular | Concrete | 5.0 | 0.0 | 2 | 1252.0 |
| Circular | Concrete | 6.5 | 0.0 | 1 | 1227.0 |
| Circular | Concrete | 7.0 | 0.0 | 1 | 750.0 |
| Box | Concrete | 8.0 | 9.0 | 2 | 1516.0 |
| Circular | Other | 7.5 | 0.0 | 1 | 240.0 |
| Circular | Concrete | 2.5 | 0.0 | 4 | 586.0 |
| Circular | Concrete | 3.0 | 0.0 | 5 | 682.0 |
| Circular | Concrete | 4.0 | 0.0 | 4 | 661.0 |

NODES:

| Type of Inlet Structure | Type of Grate | Inlet Length (ft) | Grate Width (ft) | Grate Length (ft) | Grate Area (ft) | Grate Perimeter (ft) | Quantity (each) |
|---|---|---|---|---|---|---|---|
| Circular Manhole | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 39 |
| Curb And Grate In Sag | Reticuline | 5.0 | 0.0 | 0.0 | 2.0 | 4.17 | 1 |
| Curb And Grate On Grade | Reticuline | 5.0 | 0.75 | 2.67 | 0.0 | 0.0 | 4 |
| Curb On Grade | | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3 |
| Curb On Grade | | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 |
| Curb On Grade | | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 6 |
| Grate On Grade | Reticuline | 0.0 | 0.75 | 1.33 | 0.0 | 0.0 | 4 |
| Curb In Sag | | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 3 |
| Curb In Sag | | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2 |
| Grate On Grade | Reticuline | 0.0 | 1.5 | 2.67 | 0.0 | 0.0 | 1 |
| Curb And Grate In Sag | Reticuline | 5.0 | 0.0 | 0.0 | 3.11 | 5.0 | 1 |
| Outlet | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 |

END

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 2 Years
Decreasing conduit size @ downstream Run# 38
Discharge decreased downstream node Id= B-15 Previous intensity used.
Discharge decreased downstream node Id= MH-B16 Previous intensity used.
Discharge decreased downstream node Id= MH-D1 Previous intensity used.
Discharge decreased downstream node Id= MH-E1 Previous intensity used.
Discharge decreased downstream node Id= MH-E2 Previous intensity used.
Decreasing conduit size @ downstream Run# 10
Capacity of grade inlet exceeded at inlet Id= B-2a
Capacity of grade inlet exceeded at inlet Id= B-2b
Capacity of grade inlet exceeded at inlet Id= B-3a
Capacity of grade inlet exceeded at inlet Id= B-3b

```
Capacity of grade inlet exceeded at inlet Id= B-4a
Capacity of grade inlet exceeded at inlet Id= B-4b
Capacity of grade inlet exceeded at inlet Id= B-8a
Capacity of grade inlet exceeded at inlet Id= B-8b
Capacity of grade inlet exceeded at inlet Id= B-12
Capacity of grade inlet exceeded at inlet Id= B-1a
Capacity of grade inlet exceeded at inlet Id= B-1b
Capacity of sag inlet exceeded at inlet Id= B-13
Run# 4  Insufficient capacity.
Run# 20  Insufficient capacity.
Run# 19  Insufficient capacity.
Run# 24  Insufficient capacity.
HGL elevation below invert. Downstream HGL set to soffit elevation at Run# 57
Run# 57  Insufficient capacity.
Run# 18  Insufficient capacity.
Run# 23  Insufficient capacity.
HGL elevation below invert. Downstream HGL set to soffit elevation at Run# 56
Run# 15  Insufficient capacity.
Run# 55  Insufficient capacity.
Run# 14  Insufficient capacity.
Run# 21  Insufficient capacity.
Run# 2  Insufficient capacity.
```

HouStorm (City Of Houston STORM DRAIN DESIGN) Version 2.1, Update: Nov/01/2007

Run @ 5/4/2009 10:58:34 AM

PROJECT NAME : Kimberley Lane
JOB NUMBER :
PROJECT DESCRIPTION : Kimberley Lane Drainage Improvements PER
PROJECT File: L:\120214\120-10308-000\465\Prod\Data\Refined\HOUStorm\Existing\

ANALYSYS FREQUENCY : 100 Years
MEASUREMENT UNITS: ENGLISH

==========

OUTPUT FOR ANALYSYS FREQUENCY of: 100 Years

Runoff Computation for Design Frequency.

| ID | C Value | Area (acre) | Tc (min) | Tc Used (min) | Intensity (in/hr) | Supply Q (cfs) | Total Q (cfs) |
|---|---|---|---|---|---|---|---|
| B-14 | 0.59 | 0.40 | 23.50 | 23.50 | 7.18 | 0.000 | 1.695 |
| B-15 | 0.62 | 0.20 | 22.50 | 22.50 | 7.30 | 0.000 | 0.906 |
| MH-B16 | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.000 |
| B-1a | 0.59 | 0.43 | 23.60 | 23.60 | 7.17 | 0.000 | 1.819 |
| B-1a1 | 0.76 | 1.02 | 25.00 | 25.00 | 7.01 | 0.000 | 5.433 |
| B-1b | 0.56 | 0.11 | 21.80 | 21.80 | 7.39 | 0.000 | 0.455 |
| B-1b1 | 0.55 | 0.35 | 23.30 | 23.30 | 7.21 | 0.000 | 1.387 |
| B-1c | 0.57 | 0.33 | 23.22 | 23.22 | 7.22 | 0.000 | 1.357 |
| B-2a | 0.61 | 0.19 | 22.50 | 22.50 | 7.30 | 0.000 | 0.846 |
| B-2a1 | 0.76 | 1.48 | 25.70 | 25.70 | 6.93 | 0.000 | 7.796 |
| B-2b | 0.59 | 0.29 | 23.00 | 23.00 | 7.24 | 0.000 | 1.239 |
| MH-E1 | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.001 |
| MH-E2 | 0.5 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.000 |
| MH-B1 | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.000 |
| MH-B2 | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.000 |
| MH-B3 | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.000 |
| MH-B4 | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.001 |
| MH-B5 | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.001 |
| B-2b1 | 0.66 | 0.78 | 24.60 | 24.60 | 7.05 | 0.000 | 3.631 |
| B-3a | 0.65 | 0.27 | 23.00 | 23.00 | 7.24 | 0.000 | 1.271 |
| B-3a1 | 0.79 | 0.41 | 23.60 | 23.60 | 7.17 | 0.000 | 2.322 |
| B-3b | 0.75 | 0.69 | 24.40 | 24.40 | 7.08 | 0.000 | 3.662 |
| B-3b1 | 0.51 | 0.15 | 22.20 | 22.20 | 7.34 | 0.000 | 0.562 |
| B-4a | 0.63 | 0.22 | 22.60 | 22.60 | 7.29 | 0.000 | 1.010 |
| B-4b | 0.57 | 0.08 | 21.50 | 21.50 | 7.43 | 0.000 | 0.339 |
| B-4b1 | 0.76 | 0.51 | 23.90 | 23.90 | 7.13 | 0.000 | 2.765 |
| B-4c | 0.52 | 0.17 | 22.30 | 22.30 | 7.33 | 0.000 | 0.648 |
| B-5a | 0.66 | 0.26 | 22.90 | 22.90 | 7.25 | 0.000 | 1.245 |
| B-5b | 0.57 | 0.36 | 23.30 | 23.30 | 7.21 | 0.000 | 1.479 |
| B-5b1 | 0.8 | 0.13 | 22.00 | 22.00 | 7.37 | 0.000 | 0.766 |
| B-7a | 0.62 | 0.53 | 23.90 | 23.90 | 7.13 | 0.000 | 2.344 |
| B-7b | 0.67 | 1.53 | 25.80 | 25.80 | 6.92 | 0.000 | 7.093 |
| B-7c1 | 0.76 | 0.89 | 24.80 | 24.80 | 7.03 | 0.000 | 4.756 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B-8a | 0.59 | 0.22 | 22.60 | 22.60 | 7.29 | 0.000 | 0.946 |
| B-8b | 0.7 | 0.38 | 23.40 | 23.40 | 7.19 | 0.000 | 1.913 |
| B-8c1 | 0.76 | 2.04 | 26.30 | 26.30 | 6.87 | 0.000 | 10.645 |
| B-9b | 0.78 | 0.22 | 22.70 | 22.70 | 7.28 | 0.000 | 1.249 |
| B-12a1 | 0.73 | 1.09 | 25.20 | 25.20 | 6.99 | 0.000 | 5.559 |
| B-13a1 | 0.71 | 0.65 | 24.27 | 24.27 | 7.09 | 0.000 | 3.273 |
| B-14a1 | 0.79 | 0.49 | 23.80 | 23.80 | 7.15 | 0.000 | 2.766 |
| MH-A8 | 0.8 | 37.03 | 33.90 | 33.90 | 6.15 | 0.000 | 182.201 |
| A-1 | 0.47 | 1.14 | 25.20 | 25.20 | 6.99 | 0.000 | 3.743 |
| MH-B | 0.5 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.000 |
| B | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.007 |
| C-1 | 0.76 | 44.66 | 34.50 | 34.50 | 6.10 | 0.000 | 207.085 |
| MH-D1 | 0.8 | 0.00 | 34.60 | 34.60 | 6.09 | 0.000 | 0.000 |
| D-1 | 0.47 | 47.99 | 34.80 | 34.80 | 6.08 | 0.000 | 137.067 |
| B-9c1 | 0.77 | 0.39 | 23.50 | 23.50 | 7.18 | 0.000 | 2.157 |
| B-14a2 | 0.68 | 0.46 | 23.70 | 23.70 | 7.16 | 0.000 | 2.239 |
| B-1c1 | 0.76 | 0.65 | 24.30 | 24.30 | 7.09 | 0.000 | 3.501 |
| MH-B7d | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.007 |
| B-7d1 | 0.62 | 2.33 | 26.60 | 26.60 | 6.83 | 0.000 | 9.872 |
| E-1 | 0.57 | 20.49 | 31.90 | 31.90 | 6.32 | 0.000 | 73.830 |
| MH-B7 | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.000 |
| MH-B8 | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.000 |
| B-9 | 0.65 | 0.12 | 21.90 | 21.90 | 7.38 | 0.000 | 0.575 |
| B-10 | 0.68 | 0.23 | 22.70 | 22.70 | 7.28 | 0.000 | 1.138 |
| B-11 | 0.64 | 0.36 | 23.30 | 23.30 | 7.21 | 0.000 | 1.660 |
| B-12 | 0.66 | 0.28 | 23.00 | 23.00 | 7.24 | 0.000 | 1.338 |
| B-13 | 0.59 | 1.03 | 25.00 | 25.00 | 7.01 | 0.000 | 4.259 |
| MH-B7b | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.007 |
| MH-B7c | 0.8 | 0.00 | 10.00 | 10.00 | 9.36 | 0.000 | 0.007 |
| B-7d2 | 0.56 | 2.12 | 26.40 | 26.40 | 6.86 | 0.000 | 8.138 |
| B-7d3 | 0.49 | 4.05 | 27.80 | 27.80 | 6.71 | 0.000 | 13.315 |
| B-9b1 | 0.8 | 0.51 | 23.90 | 23.90 | 7.13 | 0.000 | 2.911 |

On Grade Inlet Configuration Data

| Inlet ID | Inlet Type | Inlet Length (ft) | Slopes Long (%) | Slopes Trans (%) | Gutter n | Gutter Depr. (ft) | Grate Width (ft) | Grate Type | Pond Width Allowed (ft) |
|---|---|---|---|---|---|---|---|---|---|
| B-10 | Combi | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | 0.75 | Reticu | 12.00 |
| B-11 | Curb | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| A-1 | Curb | 10.00 | 0.50 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-2a | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-2b | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-3a | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-3b | Grate | 1.33 | 0.30 | 2.00 | 0.014 | n/a | 0.75 | Reticu | 12.00 |
| B-3b1 | Combi | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | 0.75 | Reticu | 12.00 |
| B-4a | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-4b | Grate | 1.33 | 0.30 | 2.00 | 0.014 | n/a | 0.75 | Reticu | 12.00 |
| B-4c | Combi | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | 0.75 | Reticu | 12.00 |
| B-8a | Grate | 1.33 | 0.30 | 2.00 | 0.014 | n/a | 0.75 | Reticu | 12.00 |
| B-8b | Grate | 2.67 | 0.30 | 2.00 | 0.014 | n/a | 1.50 | Reticu | 12.00 |
| B-12 | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-14 | Curb | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-15 | Curb | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| B-1a | Curb | 2.50 | 0.30 | 2.00 | 0.014 | 0.33 | n/a | n/a | 12.00 |
| B-1b | Grate | 1.33 | 0.30 | 2.00 | 0.014 | n/a | 0.75 | Reticu | 12.00 |
| B-1c | Combi | 5.00 | 0.30 | 2.00 | 0.014 | 0.33 | 0.75 | Reticu | 12.00 |

On Grade Inlets Computation Data.

| Inlet ID | Inlet Type | Total Q (cfs) | Intercept Capacity (cfs) | Q Bypass Allow (cfs) | Q Bypass Actual (cfs) | To Inlet ID | Required Length (ft) | Actual Length (ft) | Ponded Width (ft) |
|---|---|---|---|---|---|---|---|---|---|
| B-10 | Combi | 1.138 | 1.485 | 0.455 | 0.000 | B-9 | n/a | 5.00 | 9.00 |
| B-11 | Curb | 1.660 | 1.657 | 0.664 | 0.003 | B-12 | 5.16 | 5.00 | 10.40 |
| A-1 | Curb | 3.743 | 3.743 | 0.000 | 0.000 | | 9.30 | 10.00 | 12.80 |
| B-2a | Curb | 1.447 | 1.068 | 0.579 | 0.378 | B-3a | 4.76 | 2.50 | 9.85 |
| B-2b | Curb | 1.508 | 1.095 | 0.000 | 0.413 | B-3b1 | 4.87 | 2.50 | 10.00 |
| B-3a | Curb | 1.649 | 1.153 | 0.660 | 0.496 | B-4a | 5.13 | 2.50 | 10.35 |
| B-3b | Grate | 3.662 | 0.744 | 1.465 | 2.918 | B-4c | n/a | 0.00 | 14.00 |
| B-3b1 | Combi | 0.974 | 1.335 | 0.390 | 0.000 | B-3b | n/a | 5.00 | 8.50 |
| B-4a | Curb | 1.506 | 1.094 | 0.602 | 0.412 | B-5a | 4.87 | 2.50 | 10.00 |
| B-4b | Grate | 0.881 | 0.292 | 0.352 | 0.589 | B-5b | n/a | 0.00 | 8.20 |
| B-4c | Combi | 3.566 | 3.024 | 1.426 | 0.542 | B-4b | n/a | 5.00 | 13.85 |
| B-8a | Grate | 0.946 | 0.306 | 0.379 | 0.640 | B-9 | n/a | 0.00 | 8.40 |
| B-8b | Grate | 1.913 | 1.081 | 0.765 | 0.833 | B-9b | n/a | 0.00 | 10.95 |
| B-12 | Curb | 1.341 | 1.020 | 0.537 | 0.321 | B-13 | 4.56 | 2.50 | 9.60 |
| B-14 | Curb | 1.695 | 1.690 | 0.678 | 0.005 | B-15 | 5.21 | 5.00 | 10.45 |
| B-15 | Curb | 0.911 | 0.911 | 0.364 | 0.000 | B-10 | 3.67 | 5.00 | 8.30 |
| B-1a | Curb | 1.819 | 1.219 | 0.728 | 0.600 | B-2a | 5.44 | 2.50 | 10.75 |
| B-1b | Grate | 0.455 | 0.186 | 0.182 | 0.269 | B-2b | n/a | 0.00 | 6.40 |
| B-1c | Combi | 1.357 | 1.671 | 0.543 | 0.000 | B-1b | n/a | 5.00 | 9.65 |

Sag Inlets Configuration Data.

| Inlet ID | Inlet Type | Length/ Perim (ft) | Grate Area (sf) | Left-Slope Longi (%) | Left-Slope Transv (%) | Right-Slope Longi (%) | Right-Slope Transv (%) | Gutter n | Gutter DeprW (ft) | Head Allowed (ft) |
|---|---|---|---|---|---|---|---|---|---|---|
| B-9 | Combi | 5.00 | 2.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-5a | Curb | 2.50 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-5b | Curb | 2.50 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-7a | Curb | 5.00 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-7b | Curb | 5.00 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-9b | Combi | 5.00 | 3.11 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |
| B-13 | Curb | 2.50 | 0.00 | 0.30 | 2.00 | 0.30 | 2.00 | 0.014 | 1.50 | 0.50 |

Sag Inlets Computation Data.

| Inlet ID | Inlet Type | Length (ft) | Grate Perim (ft) | Grate Area (sf) | Total Q (cfs) | Inlet Capacity (cfs) | Actual Head (ft) | Ponded Width Left (ft) | Ponded Width Right (ft) |
|---|---|---|---|---|---|---|---|---|---|
| B-9 | Combi | 5.00 | 4.17 | 2.00 | 1.216 | 4.551 | 0.158 | 5.05 | 8.50 |
| B-5a | Curb | 2.50 | n/a | n/a | 1.657 | 2.057 | 0.368 | 9.55 | 5.70 |
| B-5b | Curb | 2.50 | n/a | n/a | 2.067 | 2.057 | 0.504 | 6.15 | 10.35 |
| B-7a | Curb | 5.00 | n/a | n/a | 2.344 | 4.114 | 0.247 | 9.10 | 9.10 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| B-7b | Curb | 5.00 | n/a | n/a | 7.093 | 4.114 | 1.240 | 13.80 | 13.80 |
| B-9b | Combi | 5.00 | 5.00 | 3.11 | 2.082 | 5.457 | 0.221 | 8.70 | 8.70 |
| B-13 | Curb | 2.50 | n/a | n/a | 4.580 | 2.057 | 1.984 | 11.70 | 11.70 |

Cumulative Junction Discharge Computations

| Node I.D. | Node Type | Weighted C-Value | Cumulat. Dr.Area (acres) | Cumulat. Tc (min) | Intens. (in/hr) | User Supply Q cfs) | Additional Q in Node (cfs) | Total Disch. (cfs) |
|---|---|---|---|---|---|---|---|---|
| MH-B1 | CrcMh | 0.680 | 2.89 | 25.25 | 6.98 | | 0.00 | 13.716 |
| MH-B2 | CrcMh | 0.691 | 5.63 | 25.83 | 6.92 | | 0.00 | 26.919 |
| MH-B3 | CrcMh | 0.697 | 7.15 | 26.42 | 6.85 | | 0.00 | 34.164 |
| MH-B4 | CrcMh | 0.694 | 8.13 | 26.83 | 6.81 | | 0.00 | 38.441 |
| MH-B5 | CrcMh | 0.628 | 20.33 | 28.72 | 6.62 | | 0.00 | 84.535 |
| MH-B7 | CrcMh | 0.581 | 11.45 | 28.27 | 6.66 | | 0.00 | 44.290 |
| MH-B8 | CrcMh | 0.641 | 22.97 | 29.00 | 6.59 | | 0.00 | 97.017 |
| B-9 | Combi | 0.648 | 24.44 | 29.28 | 6.56 | | 0.00 | 103.932 |
| B-10 | Combi | 0.680 | 0.23 | 22.70 | 7.28 | | 0.00 | 1.138 |
| B-11 | Curb | 0.798 | 37.39 | 34.06 | 6.14 | | 0.00 | 183.233 |
| MH-A8 | CrcMh | 0.800 | 37.03 | 33.90 | 6.15 | | 0.00 | 182.201 |
| A-1 | Curb | 0.000 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.000 |
| MH-B | CrcMh | 0.000 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.000 |
| B | CrcMh | 0.735 | 66.43 | 34.96 | 6.06 | | 0.00 | 295.935 |
| C-1 | CrcMh | 0.745 | 111.09 | 36.22 | 5.97 | | 0.00 | 493.568 |
| MH-D1 | CrcMh | 0.745 | 111.09 | 36.22 | 5.97 | | 0.00 | 493.568 |
| D-1 | CrcMh | 0.662 | 159.08 | 37.19 | 5.89 | | 0.00 | 620.316 |
| MH-E1 | CrcMh | 0.651 | 179.57 | 37.79 | 5.85 | | 111.40 | 795.305 |
| MH-E2 | CrcMh | 0.651 | 179.57 | 37.79 | 5.85 | | 111.40 | 795.305 |
| E-1 | CrcMh | 0.651 | 179.57 | 37.79 | 5.85 | | 111.40 | 795.304 |
| B-2a | Curb | 0.743 | 1.67 | 25.77 | 6.92 | | 0.00 | 8.589 |
| B-2a1 | CrcMh | 0.760 | 1.48 | 25.70 | 6.93 | | 0.00 | 7.796 |
| B-2b | Curb | 0.641 | 1.07 | 24.90 | 7.02 | | 0.00 | 4.815 |
| B-2b1 | CrcMh | 0.660 | 0.78 | 24.60 | 7.05 | | 0.00 | 3.631 |
| B-3a | Curb | 0.734 | 0.68 | 23.81 | 7.14 | | 0.00 | 3.568 |
| B-3a1 | CrcMh | 0.790 | 0.41 | 23.60 | 7.17 | | 0.00 | 2.322 |
| B-3b | Grate | 0.707 | 0.84 | 24.40 | 7.08 | | 0.00 | 4.203 |
| B-3b1 | Combi | 0.510 | 0.15 | 22.20 | 7.34 | | 0.00 | 0.562 |
| B-4a | Curb | 0.630 | 0.22 | 22.60 | 7.29 | | 0.00 | 1.010 |
| B-4b | Grate | 0.686 | 0.76 | 24.10 | 7.11 | | 0.00 | 3.709 |
| B-12a1 | CrcMh | 0.730 | 1.09 | 25.20 | 6.99 | | 0.00 | 5.559 |
| B-13a1 | CrcMh | 0.710 | 0.65 | 24.27 | 7.09 | | 0.00 | 3.273 |
| B-14a1 | CrcMh | 0.737 | 0.95 | 24.38 | 7.08 | | 0.00 | 4.954 |
| B-4b1 | CrcMh | 0.760 | 0.51 | 23.90 | 7.13 | | 0.00 | 2.765 |
| B-4c | Combi | 0.520 | 0.17 | 22.30 | 7.33 | | 0.00 | 0.648 |
| B-5a | Curb | 0.660 | 0.26 | 22.90 | 7.25 | | 0.00 | 1.245 |
| B-5b | Curb | 0.631 | 0.49 | 23.30 | 7.21 | | 0.00 | 2.228 |
| B-5b1 | CrcMh | 0.800 | 0.13 | 22.00 | 7.37 | | 0.00 | 0.766 |
| B-7a | Curb | 0.657 | 2.06 | 25.99 | 6.90 | | 0.00 | 9.339 |
| B-7b | Curb | 0.670 | 1.53 | 25.80 | 6.92 | | 0.00 | 7.093 |
| B-7c1 | CrcMh | 0.760 | 0.89 | 24.80 | 7.03 | | 0.00 | 4.756 |
| B-8a | Grate | 0.660 | 0.60 | 23.71 | 7.16 | | 0.00 | 2.833 |
| B-8b | Grate | 0.700 | 0.38 | 23.40 | 7.19 | | 0.00 | 1.913 |
| B-8c1 | CrcMh | 0.760 | 2.04 | 26.30 | 6.87 | | 0.00 | 10.645 |
| B-9b | Combi | 0.794 | 0.73 | 24.02 | 7.12 | | 0.00 | 4.127 |
| B-9c1 | CrcMh | 0.770 | 0.39 | 23.50 | 7.18 | | 0.00 | 2.157 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B-14a2 | CrcMh | 0.680 | 0.46 | 23.70 | 7.16 | 0.00 | 2.239 |
| B-1c1 | CrcMh | 0.760 | 0.65 | 24.30 | 7.09 | 0.00 | 3.501 |
| MH-B7d | CrcMh | 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.000 |
| B-7d1 | CrcMh | 0.620 | 2.33 | 26.60 | 6.83 | 0.00 | 9.872 |
| MH-B7b | CrcMh | 0.543 | 8.50 | 28.21 | 6.67 | 0.00 | 30.791 |
| MH-B7c | CrcMh | 0.591 | 4.45 | 27.74 | 6.72 | 0.00 | 17.679 |
| B-7d2 | CrcMh | 0.560 | 2.12 | 26.40 | 6.86 | 0.00 | 8.138 |
| B-7d3 | CrcMh | 0.490 | 4.05 | 27.80 | 6.71 | 0.00 | 13.315 |
| B-9b1 | CrcMh | 0.800 | 0.51 | 23.90 | 7.13 | 0.00 | 2.911 |
| B-12 | Curb | 0.796 | 38.76 | 34.18 | 6.13 | 0.00 | 188.930 |
| B-13 | Curb | 0.789 | 40.44 | 34.34 | 6.11 | 0.00 | 195.075 |
| B-14 | Curb | 0.786 | 41.79 | 34.64 | 6.09 | 0.00 | 199.995 |
| B-15 | Curb | 0.785 | 41.99 | 34.77 | 6.08 | 0.00 | 200.388 |
| MH-B16 | CrcMh | 0.648 | 24.44 | 29.28 | 6.56 | 0.00 | 103.933 |
| B-1a | Curb | 0.710 | 1.45 | 25.15 | 6.99 | 0.00 | 7.193 |
| B-1a1 | CrcMh | 0.760 | 1.02 | 25.00 | 7.01 | 0.00 | 5.433 |
| B-1b | Grate | 0.650 | 1.44 | 24.73 | 7.04 | 0.00 | 6.590 |
| B-1b1 | CrcMh | 0.687 | 1.00 | 24.53 | 7.06 | 0.00 | 4.848 |
| B-1c | Combi | 0.570 | 0.33 | 23.22 | 7.22 | 0.00 | 1.357 |
| OUT | Outlt | 0.651 | 179.57 | 37.79 | 5.85 | 111.40 | 795.305 |

Conveyance Configuration Data

| Run # | Node US | I.D. DS | FlowLine Elev. US (ft) | DS (ft) | Shape # | Span (ft) | Rise (ft) | Length (ft) | Slope (%) | n_value |
|---|---|---|---|---|---|---|---|---|---|---|
| 27 | B-1a | MH-B1 | 69.68 | 69.43 | Cir 1 | 0.00 | 1.50 | 34.0 | 0.735 | 0.013 |
| 28 | B-1a1 | B-1a | 71.45 | 69.68 | Cir 1 | 0.00 | 1.00 | 74.0 | 2.393 | 0.013 |
| 29 | B-1b | MH-B1 | 69.65 | 69.36 | Cir 1 | 0.00 | 1.50 | 47.0 | 0.617 | 0.013 |
| 30 | B-1b1 | B-1b | 70.44 | 69.83 | Cir 1 | 0.00 | 1.50 | 67.0 | 0.910 | 0.013 |
| 31 | B-1c | B-1b | 72.07 | 71.70 | Cir 1 | 0.00 | 1.50 | 40.0 | 0.925 | 0.013 |
| 32 | B-2a | MH-B2 | 69.30 | 68.68 | Cir 1 | 0.00 | 1.50 | 29.0 | 2.138 | 0.013 |
| 33 | B-2a1 | B-2a | 70.90 | 69.30 | Cir 2 | 0.00 | 1.00 | 40.0 | 4.003 | 0.013 |
| 34 | B-2b | MH-B2 | 69.50 | 68.69 | Cir 1 | 0.00 | 1.50 | 50.0 | 1.620 | 0.013 |
| 35 | B-2b1 | B-2b | 70.34 | 69.50 | Cir 1 | 0.00 | 1.50 | 94.0 | 0.894 | 0.013 |
| 36 | B-3a | MH-B3 | 70.50 | 67.75 | Cir 1 | 0.00 | 1.50 | 32.0 | 8.626 | 0.013 |
| 37 | B-3a1 | B-3a | 70.80 | 70.50 | Cir 1 | 0.00 | 1.00 | 50.0 | 0.600 | 0.013 |
| 38 | B-3b | MH-B3 | 68.80 | 67.76 | Cir 1 | 0.00 | 1.50 | 47.0 | 2.213 | 0.013 |
| 39 | B-3b1 | B-3b | 70.32 | 69.85 | Cir 1 | 0.00 | 7.50 | 55.0 | 0.855 | 0.013 |
| 40 | B-4a | MH-B4 | 70.50 | 67.11 | Cir 1 | 0.00 | 1.50 | 30.0 | 11.373 | 0.013 |
| 42 | B-4b | MH-B4 | 68.24 | 67.21 | Cir 1 | 0.00 | 1.50 | 47.0 | 2.192 | 0.013 |
| 43 | B-4b1 | B-4b | 69.21 | 68.96 | Cir 1 | 0.00 | 1.00 | 46.0 | 0.543 | 0.013 |
| 44 | B-4c | B-4b | 69.57 | 69.33 | Cir 1 | 0.00 | 1.50 | 47.0 | 0.511 | 0.013 |
| 45 | B-5a | MH-B5 | 65.91 | 65.83 | Cir 1 | 0.00 | 1.50 | 39.0 | 0.205 | 0.013 |
| 46 | B-5b | MH-B5 | 68.53 | 67.01 | Cir 1 | 0.00 | 1.50 | 51.0 | 2.982 | 0.013 |
| 47 | B-5b1 | B-5b | 69.16 | 68.68 | Cir 1 | 0.00 | 1.00 | 60.0 | 0.800 | 0.013 |
| 48 | B-7a | MH-B7 | 66.90 | 66.89 | Cir 1 | 0.00 | 2.00 | 5.0 | 0.200 | 0.013 |
| 49 | B-7b | B-7a | 66.98 | 66.90 | Cir 1 | 0.00 | 2.00 | 40.0 | 0.200 | 0.013 |
| 50 | B-7c1 | MH-B7 | 68.50 | 66.89 | Cir 1 | 0.00 | 1.50 | 40.0 | 4.028 | 0.013 |
| 51 | B-8a | MH-B8 | 67.14 | 66.66 | Cir 1 | 0.00 | 2.00 | 5.0 | 9.645 | 0.013 |
| 52 | B-8b | B-8a | 67.19 | 67.14 | Cir 1 | 0.00 | 2.00 | 39.0 | 0.128 | 0.013 |
| 53 | B-8c1 | MH-B8 | 68.75 | 67.11 | Cir 1 | 0.00 | 2.00 | 40.0 | 4.103 | 0.013 |
| 54 | B-9b | B-9 | 66.43 | 66.35 | Cir 1 | 0.00 | 2.00 | 42.0 | 0.190 | 0.013 |
| 55 | B-12a1 | B-12 | 70.97 | 70.71 | Cir 1 | 0.00 | 1.00 | 64.0 | 0.406 | 0.013 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 56 | B-13a1 | B-13 | 71.95 | 71.67 | Cir 1 | 0.00 | 1.00 | 71.0 | 0.394 | 0.013 |
| 57 | B-14a1 | B-14 | 70.76 | 70.49 | Cir 1 | 0.00 | 1.00 | 68.0 | 0.397 | 0.013 |
| 59 | B-9c1 | B-9 | 71.07 | 66.35 | Cir 1 | 0.00 | 2.00 | 54.0 | 8.774 | 0.013 |
| 60 | B-14a2 | B-14a1 | 71.95 | 71.31 | Cir 1 | 0.00 | 0.83 | 168.0 | 0.381 | 0.011 |
| 61 | B-1c1 | B-1b1 | 71.11 | 70.63 | Cir 1 | 0.00 | 1.00 | 61.0 | 0.787 | 0.013 |
| 62 | B-10 | B-9 | 68.69 | 68.63 | Cir 1 | 0.00 | 2.00 | 29.0 | 0.207 | 0.013 |
| 2 | MH-A8 | B-11 | 68.17 | 67.60 | Cir 1 | 0.00 | 3.50 | 177.0 | 0.322 | 0.013 |
| 4 | B | C-1 | 64.21 | 61.36 | Cir 1 | 0.00 | 5.00 | 1140.0 | 0.250 | 0.013 |
| 5 | C-1 | MH-D1 | 58.84 | 56.27 | Cir 1 | 0.00 | 6.50 | 1227.0 | 0.209 | 0.013 |
| 6 | MH-D1 | D-1 | 55.77 | 54.37 | Cir 1 | 0.00 | 7.00 | 750.0 | 0.187 | 0.013 |
| 7 | D-1 | E-1 | 53.87 | 52.86 | Cir 1 | 0.00 | 7.50 | 506.0 | 0.200 | 0.013 |
| 8 | E-1 | MH-E1 | 52.36 | 49.52 | Box 1 | 9.00 | 8.00 | 1387.0 | 0.205 | 0.015 |
| 9 | MH-E1 | MH-E2 | 49.52 | 43.66 | Box 1 | 9.00 | 8.00 | 129.0 | 4.547 | 0.015 |
| 10 | MH-E2 | OUT | 43.66 | 43.16 | Cir 2 | 0.00 | 7.50 | 120.0 | 0.417 | 0.024 |
| 11 | MH-B1 | MH-B2 | 69.24 | 68.71 | Cir 1 | 0.00 | 2.00 | 144.0 | 0.368 | 0.013 |
| 12 | MH-B2 | MH-B3 | 68.30 | 67.84 | Cir 1 | 0.00 | 2.50 | 195.0 | 0.236 | 0.013 |
| 13 | MH-B3 | MH-B4 | 67.73 | 67.14 | Cir 1 | 0.00 | 2.50 | 173.0 | 0.341 | 0.013 |
| 14 | MH-B4 | MH-B5 | 67.14 | 66.91 | Cir 1 | 0.00 | 2.50 | 178.0 | 0.129 | 0.013 |
| 64 | MH-B7c | MH-B7b | 69.38 | 68.69 | Cir 1 | 0.00 | 2.00 | 160.0 | 0.431 | 0.013 |
| 15 | MH-B5 | MH-B8 | 66.67 | 66.49 | Cir 1 | 0.00 | 3.00 | 198.0 | 0.091 | 0.013 |
| 17 | MH-B7 | MH-B5 | 66.89 | 66.67 | Cir 1 | 0.00 | 3.00 | 169.0 | 0.130 | 0.013 |
| 18 | MH-B8 | B-9 | 66.50 | 65.80 | Cir 1 | 0.00 | 3.00 | 230.0 | 0.304 | 0.013 |
| 19 | B-9 | MH-B16 | 65.80 | 65.72 | Cir 1 | 0.00 | 3.00 | 58.0 | 0.138 | 0.013 |
| 20 | MH-B16 | B | 65.72 | 65.68 | Cir 1 | 0.00 | 3.00 | 27.0 | 0.148 | 0.013 |
| 21 | B-11 | B-12 | 67.20 | 66.97 | Cir 1 | 0.00 | 4.00 | 111.0 | 0.207 | 0.013 |
| 22 | B-12 | B-13 | 66.90 | 66.07 | Cir 1 | 0.00 | 4.00 | 140.0 | 0.593 | 0.013 |
| 23 | B-13 | B-14 | 66.02 | 64.93 | Cir 1 | 0.00 | 4.00 | 280.0 | 0.389 | 0.013 |
| 24 | B-14 | B-15 | 64.81 | 64.49 | Cir 1 | 0.00 | 4.00 | 130.0 | 0.246 | 0.013 |
| 25 | B-15 | B | 64.49 | 64.21 | Cir 1 | 0.00 | 5.00 | 112.0 | 0.250 | 0.013 |
| 63 | MH-B7b | MH-B7 | 67.65 | 66.89 | Cir 1 | 0.00 | 2.50 | 40.0 | 1.900 | 0.013 |
| 65 | B-7d1 | MH-B7c | 72.39 | 69.38 | Cir 1 | 0.00 | 2.00 | 420.0 | 0.717 | 0.013 |
| 66 | B-7d3 | MH-B7b | 67.72 | 67.65 | Cir 1 | 0.00 | 2.00 | 37.0 | 0.189 | 0.013 |
| 67 | B-7d2 | MH-B7c | 69.63 | 69.38 | Cir 1 | 0.00 | 2.00 | 55.0 | 0.455 | 0.013 |
| 68 | B-9b1 | B-9b | 66.47 | 66.43 | Cir 1 | 0.00 | 2.00 | 20.0 | 0.200 | 0.013 |

Conveyance Hydraulic Computations. Tailwater = 51.700 (ft)

| Run # | Hyd. US (ft) | Gr.line DS (ft) | Crit.Elev US (ft) | Fr.Slope (%) | Depth Unif. (ft) | Depth Actual (ft) | Velocity Unif. (f/s) | Velocity Actual (f/s) | Q (cfs) | Cap (cfs) | Junc Loss (ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 27* | 110.35 | 110.19 | 0.00 | 0.465 | 1.01 | 1.50 | 5.66 | 5.51 | 7.2 | 9.0 | 0.000 |
| 28* | 112.05 | 110.35 | 0.00 | 2.306 | 0.81 | 1.00 | 8.00 | 7.11 | 5.4 | 5.5 | 0.000 |
| 29 | 110.30 | 110.19 | 0.00 | 0.390 | 1.01 | 1.50 | 5.19 | 3.73 | 6.6 | 8.3 | 0.000 |
| 30* | 110.44 | 110.30 | 0.00 | 0.211 | 0.74 | 1.50 | 5.63 | 4.72 | 4.8 | 10.1 | 0.000 |
| 31* | 110.30 | 110.30 | 0.00 | 0.017 | 0.37 | 1.50 | 3.98 | 3.19 | 1.4 | 10.1 | 0.000 |
| 32* | 110.37 | 110.18 | 0.00 | 0.663 | 0.80 | 1.50 | 8.94 | 5.99 | 8.6 | 15.4 | 0.000 |
| 33* | 110.85 | 110.37 | 0.00 | 1.187 | 0.53 | 1.00 | 9.28 | 5.54 | 7.8 | 14.3 | 0.000 |
| 34* | 110.29 | 110.18 | 0.00 | 0.208 | 0.62 | 1.50 | 6.95 | 4.70 | 4.8 | 13.4 | 0.000 |
| 35* | 110.40 | 110.29 | 0.00 | 0.118 | 0.63 | 1.50 | 5.18 | 4.27 | 3.6 | 10.0 | 0.000 |
| 36* | 109.39 | 109.35 | 0.00 | 0.114 | 0.34 | 1.50 | 11.64 | 4.23 | 3.6 | 31.0 | 0.000 |
| 37 | 109.48 | 109.39 | 0.00 | 0.421 | 0.70 | 1.00 | 3.94 | 2.96 | 2.3 | 2.8 | 0.000 |
| 38* | 109.42 | 109.35 | 0.00 | 0.159 | 0.53 | 1.50 | 7.50 | 4.49 | 4.2 | 15.7 | 0.000 |
| 39* | 109.42 | 109.42 | 0.00 | 0.000 | 0.16 | 7.50 | 2.38 | 2.04 | 0.6 | 712.9 | 0.000 |
| 40* | 108.16 | 108.16 | 0.00 | 0.009 | 0.17 | 1.50 | 8.84 | 2.92 | 1.0 | 35.6 | 0.000 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 42* | 108.22 | 108.16 | 0.00 | 0.124 | 0.50 | 1.50 | 7.22 | 4.30 | 3.7 | 15.6 | 0.000 |
| 43 | 108.49 | 108.22 | 0.00 | 0.597 | 0.88 | 1.00 | 3.78 | 3.52 | 2.8 | 2.6 | 0.000 |
| 44* | 108.22 | 108.22 | 0.00 | 0.004 | 0.30 | 1.50 | 2.60 | 2.59 | 0.6 | 7.5 | 0.000 |
| 45 | 106.68 | 106.61 | 0.00 | 0.014 | 0.52 | 1.50 | 2.27 | 0.70 | 1.2 | 4.8 | 0.000 |
| 46* | 106.63 | 106.61 | 0.00 | 0.045 | 0.35 | 1.50 | 6.97 | 3.67 | 2.2 | 18.2 | 0.000 |
| 47* | 106.66 | 106.63 | 0.00 | 0.046 | 0.33 | 1.00 | 3.34 | 2.97 | 0.8 | 3.2 | 0.000 |
| 48 | 107.35 | 107.35 | 0.00 | 0.169 | 1.52 | 2.00 | 3.66 | 2.97 | 9.3 | 10.2 | 0.000 |
| 49 | 107.39 | 107.35 | 0.00 | 0.097 | 1.23 | 2.00 | 3.49 | 2.26 | 7.1 | 10.2 | 0.000 |
| 50* | 107.43 | 107.35 | 0.00 | 0.203 | 0.48 | 1.50 | 9.64 | 4.66 | 4.8 | 21.2 | 0.000 |
| 51* | 103.46 | 103.46 | 0.00 | 0.016 | 0.27 | 2.00 | 10.93 | 3.68 | 2.8 | 70.6 | 0.000 |
| 52 | 103.50 | 103.46 | 0.00 | 0.007 | 0.66 | 2.00 | 2.11 | 0.61 | 1.9 | 8.1 | 0.000 |
| 53* | 103.54 | 103.46 | 0.00 | 0.220 | 0.66 | 2.00 | 11.88 | 5.58 | 10.6 | 46.0 | 0.000 |
| 54 | 98.70 | 98.63 | 0.00 | 0.033 | 0.90 | 2.00 | 3.00 | 1.31 | 4.1 | 9.9 | 0.000 |
| 55 | 108.81 | 107.26 | 0.00 | 2.414 | 1.00 | 1.00 | 7.08 | 7.08 | 5.6 | 2.3 | 0.000 |
| 56 | 105.45 | 104.86 | 0.00 | 0.837 | 1.00 | 1.00 | 4.17 | 4.17 | 3.3 | 2.2 | 0.000 |
| 57 | 101.04 | 99.74 | 0.00 | 1.917 | 1.00 | 1.00 | 6.31 | 6.31 | 5.0 | 2.3 | 0.000 |
| 59* | 98.64 | 98.63 | 0.00 | 0.009 | 0.25 | 2.00 | 9.75 | 3.41 | 2.2 | 67.3 | 0.000 |
| 60 | 102.29 | 101.04 | 0.00 | 0.743 | 0.83 | 0.83 | 4.11 | 4.11 | 2.2 | 1.6 | 0.000 |
| 61 | 111.02 | 110.44 | 0.00 | 0.958 | 1.00 | 1.00 | 4.46 | 4.46 | 3.5 | 3.2 | 0.000 |
| 62 | 98.69 | 98.63 | 0.00 | 0.003 | 0.45 | 2.00 | 2.16 | 0.36 | 1.1 | 10.3 | 0.000 |
| 2 | 114.81 | 109.05 | 74.57 | 3.252 | 3.50 | 3.50 | 18.94 | 18.94 | 182.2 | 57.3 | 0.000 |
| 4 | 96.58 | 81.99 | 73.20 | 1.280 | 5.00 | 5.00 | 15.07 | 15.07 | 295.9 | 130.8 | 0.000 |
| 5 | 81.99 | 71.21 | 72.20 | 0.879 | 6.50 | 6.50 | 14.87 | 14.87 | 493.6 | 241.0 | 0.000 |
| 6 | 71.21 | 66.77 | 68.20 | 0.592 | 7.00 | 7.00 | 12.83 | 12.83 | 493.6 | 277.2 | 0.000 |
| 7 | 66.77 | 63.49 | 68.20 | 0.647 | 7.50 | 7.50 | 14.04 | 14.04 | 620.3 | 344.5 | 0.000 |
| 8 | 63.49 | 55.76 | 0.00 | 0.457 | 8.00 | 8.00 | 11.05 | 11.05 | 795.3 | 532.3 | 0.000 |
| 9* | 55.76 | 52.79 | 67.20 | 0.457 | 2.88 | 8.00 | 30.73 | 11.05 | 795.3 | 2508.3 | 0.000 |
| 10 | 52.79 | 51.70 | 69.20 | 0.906 | 7.50 | 7.50 | 9.00 | 9.00 | 795.3 | 539.3 | 0.000 |
| 11 | 110.19 | 110.18 | 0.00 | 0.364 | 1.64 | 2.00 | 4.97 | 4.37 | 13.7 | 13.8 | 0.000 |
| 12 | 110.18 | 109.35 | 0.00 | 0.427 | 2.50 | 2.50 | 5.48 | 5.48 | 26.9 | 20.0 | 0.000 |
| 13 | 109.35 | 108.16 | 0.00 | 0.688 | 2.50 | 2.50 | 6.96 | 6.96 | 34.2 | 24.1 | 0.000 |
| 14 | 108.16 | 106.61 | 0.00 | 0.871 | 2.50 | 2.50 | 7.83 | 7.83 | 38.4 | 14.8 | 0.000 |
| 64 | 108.54 | 107.57 | 0.00 | 0.606 | 2.00 | 2.00 | 5.63 | 5.63 | 17.7 | 14.9 | 0.000 |
| 15 | 106.61 | 103.46 | 0.00 | 1.593 | 3.00 | 3.00 | 11.96 | 11.96 | 84.5 | 20.2 | 0.000 |
| 17 | 107.35 | 106.61 | 0.00 | 0.437 | 3.00 | 3.00 | 6.27 | 6.27 | 44.3 | 24.2 | 0.000 |
| 18 | 103.46 | 98.63 | 0.00 | 2.098 | 3.00 | 3.00 | 13.73 | 13.73 | 97.0 | 37.0 | 0.000 |
| 19 | 98.63 | 97.23 | 0.00 | 2.408 | 3.00 | 3.00 | 14.70 | 14.70 | 103.9 | 24.9 | 0.000 |
| 20 | 97.23 | 96.58 | 0.00 | 2.408 | 3.00 | 3.00 | 14.70 | 14.70 | 103.9 | 25.8 | 0.000 |
| 21 | 109.05 | 107.26 | 0.00 | 1.613 | 4.00 | 4.00 | 14.58 | 14.58 | 183.2 | 65.7 | 0.000 |
| 22 | 107.26 | 104.86 | 0.00 | 1.715 | 4.00 | 4.00 | 15.03 | 15.03 | 188.9 | 111.1 | 0.000 |
| 23 | 104.86 | 99.74 | 0.00 | 1.829 | 4.00 | 4.00 | 15.52 | 15.52 | 195.1 | 90.0 | 0.000 |
| 24 | 99.74 | 97.24 | 0.00 | 1.922 | 4.00 | 4.00 | 15.92 | 15.92 | 200.0 | 71.6 | 0.000 |
| 25 | 97.24 | 96.58 | 0.00 | 0.587 | 5.00 | 5.00 | 10.21 | 10.21 | 200.4 | 130.8 | 0.000 |
| 63* | 107.57 | 107.35 | 0.00 | 0.559 | 1.32 | 2.50 | 11.76 | 7.73 | 30.8 | 56.8 | 0.000 |
| 65* | 109.33 | 108.54 | 0.00 | 0.189 | 1.02 | 2.00 | 6.14 | 5.43 | 9.9 | 19.2 | 0.000 |
| 66 | 107.70 | 107.57 | 0.00 | 0.343 | 2.00 | 2.00 | 4.24 | 4.24 | 13.3 | 9.9 | 0.000 |
| 67 | 108.72 | 108.54 | 0.00 | 0.128 | 1.04 | 2.00 | 4.94 | 2.59 | 8.1 | 15.3 | 0.000 |
| 68 | 98.73 | 98.70 | 0.00 | 0.016 | 0.73 | 2.00 | 2.78 | 0.93 | 2.9 | 10.2 | 0.000 |

* Supercritical flow.

SUMMARY OF STORM DRAIN STRUCTURE QUANTITIES

NOTE:
The convey length should be from upstream to downstream inside box.
This length may also be used as Pay Item.

Using hydraulic length, from node center to node center, may result in profile error,
and this length should not be used as Pay Item.

LINKS:

| Type of Convey Structure | Material | Rise (ft) | Span (ft) | Number of Links of this type | Quantity (ft) |
|---|---|---|---|---|---|
| Circular | Concrete | 1.5 | 0.0 | 15 | 694.0 |
| Circular | Concrete | 1.0 | 0.0 | 9 | 574.0 |
| Circular | Concrete | 7.5 | 0.0 | 2 | 561.0 |
| Circular | Concrete | 2.0 | 0.0 | 14 | 1090.0 |
| Circular | Plastic | 0.833 | 0.0 | 1 | 168.0 |
| Circular | Concrete | 3.5 | 0.0 | 1 | 177.0 |
| Circular | Concrete | 5.0 | 0.0 | 2 | 1252.0 |
| Circular | Concrete | 6.5 | 0.0 | 1 | 1227.0 |
| Circular | Concrete | 7.0 | 0.0 | 1 | 750.0 |
| Box | Concrete | 8.0 | 9.0 | 2 | 1516.0 |
| Circular | Other | 7.5 | 0.0 | 1 | 240.0 |
| Circular | Concrete | 2.5 | 0.0 | 4 | 586.0 |
| Circular | Concrete | 3.0 | 0.0 | 5 | 682.0 |
| Circular | Concrete | 4.0 | 0.0 | 4 | 661.0 |

NODES:

| Type of Inlet Structure | Type of Grate | Inlet Length (ft) | Grate Width (ft) | Grate Length (ft) | Grate Area (ft) | Grate Perimeter (ft) | Quantity (each) |
|---|---|---|---|---|---|---|---|
| Circular Manhole | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 39 |
| Curb And Grate In Sag | Reticuline | 5.0 | 0.0 | 0.0 | 2.0 | 4.17 | 1 |
| Curb And Grate On Grade | Reticuline | 5.0 | 0.75 | 2.67 | 0.0 | 0.0 | 4 |
| Curb On Grade | | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3 |
| Curb On Grade | | 10.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 |
| Curb On Grade | | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 6 |
| Grate On Grade | Reticuline | 0.0 | 0.75 | 1.33 | 0.0 | 0.0 | 4 |
| Curb In Sag | | 2.5 | 0.0 | 0.0 | 0.0 | 0.0 | 3 |
| Curb In Sag | | 5.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2 |
| Grate On Grade | Reticuline | 0.0 | 1.5 | 2.67 | 0.0 | 0.0 | 1 |
| Curb And Grate In Sag | Reticuline | 5.0 | 0.0 | 0.0 | 3.11 | 5.0 | 1 |
| Outlet | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1 |

END

NORMAL TERMINATION OF HOUSTORM.

Warning Messages for current project:

Runoff Frequency of: 100 Years
Decreasing conduit size @ downstream Run# 38
Discharge decreased downstream node Id= MH-B16 Previous intensity used.
Discharge decreased downstream node Id= MH-D1 Previous intensity used.
Discharge decreased downstream node Id= MH-E1 Previous intensity used.
Discharge decreased downstream node Id= MH-E2 Previous intensity used.
Decreasing conduit size @ downstream Run# 10
Capacity of grade inlet exceeded at inlet Id= B-11
Computed ponded width exceeds allowable width at inlet Id= A-1

```
Capacity of grade inlet exceeded at inlet Id= B-2a
Capacity of grade inlet exceeded at inlet Id= B-2b
Capacity of grade inlet exceeded at inlet Id= B-3a
Capacity of grade inlet exceeded at inlet Id= B-3b
Computed ponded width exceeds allowable width at inlet Id= B-3b
Capacity of grade inlet exceeded at inlet Id= B-4a
Capacity of grade inlet exceeded at inlet Id= B-4b
Capacity of grade inlet exceeded at inlet Id= B-4c
Computed ponded width exceeds allowable width at inlet Id= B-4c
Capacity of grade inlet exceeded at inlet Id= B-8a
Capacity of grade inlet exceeded at inlet Id= B-8b
Capacity of grade inlet exceeded at inlet Id= B-12
Capacity of grade inlet exceeded at inlet Id= B-14
Capacity of grade inlet exceeded at inlet Id= B-1a
Capacity of grade inlet exceeded at inlet Id= B-1b
Capacity of sag inlet exceeded at inlet Id= B-5b
Computed right ponded width exceeds allowable width at inlet Id= B-7b
Computed left ponded width exceeds allowable width at inlet Id= B-7b
Capacity of sag inlet exceeded at inlet Id= B-7b
Capacity of sag inlet exceeded at inlet Id= B-13
Run# 10  Insufficient capacity.
Run# 8  Insufficient capacity.
Run# 7  Insufficient capacity.
Run# 6  Insufficient capacity.
Upstream HGL exceeds critical elevation (Analysis)at node Id= MH-D1 Run # 6
Run# 5  Insufficient capacity.
Upstream HGL exceeds critical elevation (Analysis)at node Id= C-1 Run # 5
Run# 4  Insufficient capacity.
Upstream HGL exceeds critical elevation (Analysis)at node Id= B Run # 4
Run# 20  Insufficient capacity.
Run# 25  Insufficient capacity.
Run# 19  Insufficient capacity.
Run# 24  Insufficient capacity.
Run# 57  Insufficient capacity.
Run# 60  Insufficient capacity.
Run# 18  Insufficient capacity.
Run# 23  Insufficient capacity.
Run# 56  Insufficient capacity.
Run# 15  Insufficient capacity.
Run# 17  Insufficient capacity.
Run# 22  Insufficient capacity.
Run# 66  Insufficient capacity.
Run# 55  Insufficient capacity.
Run# 14  Insufficient capacity.
Run# 64  Insufficient capacity.
Run# 21  Insufficient capacity.
Run# 43  Insufficient capacity.
Run# 2  Insufficient capacity.
Upstream HGL exceeds critical elevation (Analysis)at node Id= MH-A8 Run # 2
Run# 13  Insufficient capacity.
Run# 12  Insufficient capacity.
Run# 61  Insufficient capacity.
```

# APPENDIX C – CONSTRUCTION COST ESTIMATES

## APPENDIX C - STORM SEWER OPTION 2 COST ESTIMATE

# Kimberley Lane
## Storm Sewer Improvement - Option 2
### (Kimberley Lane from Sam Houston Tollway Frontage Road to West Bough Lane)

| Item Description | Unit | 2009 Unit Cost | Quantity | 2009 Subtotal |
|---|---|---|---|---|
| Mobilization (10%) | LS | | 1 | $116,377 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Barricades | MO | $2,500 | 6 | $15,000 |
| Flagmen | LS | $10,000 | 1 | $10,000 |
| Con Pvmnt - Remove & Replace | SY | $62 | 5922 | $367,164 |
| Cement Stabilized Base | SY | $20.00 | 5922 | $118,440 |
| Curb - Remove and Replace | LF | $11.00 | 2600 | $28,600 |
| 4' Sidewalk | SY | $45.00 | 1155 | $51,975 |
| Trench Safety System | LF | $1 | 1,155 | $1,155 |
| SWPPP | LS | $15,000 | 1 | $15,000 |
| Utility Relocation | LF | $75 | 1300 | $97,500 |
| 5' x3 ' Concrete Box Culvert | LF | $210 | 1133 | $237,930 |
| CSB for Culvert | LF | $27 | 1133 | $30,591 |
| Excavation | CY | $12 | 2535 | $30,420 |
| Dewatering | LF | $30 | 567 | $16,995 |
| Inlets | Ea | $3,000 | 6 | $18,000 |
| Manholes | Ea | $4,500 | 6 | $27,000 |
| Pavement Markings | LS | $10,000 | 1 | $10,000 |
| Temporary Signal | LS | $75,000 | 1 | $75,000 |

| | |
|---|---|
| Sub Total | $1,280,147 |
| Contingency - 25% | $320,037 |
| Total | $1,600,184 |

| | |
|---|---|
| Construction | **$1,600,000** |
| Engineering Design (COH Fee Curves - 9.737%) | $156,000 |
| Surveying ($5.00 per LF) | $6,500 |
| Geotechnical | $10,000 |
| Total | **$1,820,500** |

## Kimberley Lane
## Storm Sewer Improvement - Option 3
**(Kimberley Lane from Sam Houston Tollway Frontage Road to West Bough Lane)**

| Item Description | Unit | 2009 Unit Cost | Quantity | 2009 Subtotal |
|---|---|---|---|---|
| Mobilization (10%) | LS | | 1 | $55,324 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Flagmen | LS | $10,000 | 1 | $10,000 |
| Con Pvmnt - Remove & Replace | SY | $62 | 1385 | $85,856 |
| Cement Stabilized Base | SY | $20.00 | 1385 | $27,696 |
| Curb - Remove and Replace | LF | $14.67 | 612 | $8,972 |
| Trench Safety System | LF | $1 | 1,133 | $1,133 |
| SWPPP | LS | $15,000 | 1 | $15,000 |
| Utility Relocation | LF | $75 | 650 | $48,750 |
| 5' x 3' Concrete Box Culvert | LF | $210 | 1133 | $237,930 |
| CSB for Culvert | LF | $27 | 1133 | $30,591 |
| Excavation | CY | $12 | 2526.59 | $30,319 |
| Dewatering | LF | $30 | 567 | $16,995 |
| Manholes | Ea | $4,500 | 6 | $27,000 |

| | |
|---|---|
| Sub Total | $608,566 |
| Contingency - 25% | $152,142 |
| Total | $760,708 |
| | |
| Construction | **$800,000** |
| Engineering Design (COH Fee Curves - 9.737%) | $78,000 |
| Surveying ($5.00 per LF) | $5,665 |
| Geotechnical | $10,000 |
| Total | **$839,665** |

## Future Costs Associated with Kimberley Reconstruction

| Item Description | Unit | 2009 Unit Cost | Quantity | 2009 Subtotal |
|---|---|---|---|---|
| Mobilization (10%) | LS | | 1 | $81,380 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Flagmen | LS | $10,000 | 1 | $10,000 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Con Pvmnt - Remove & Replace | SY | $62.00 | 5922 | $367,164 |
| Cement Stabilized Base | SY | $20.00 | 6500 | $130,000 |
| Inlet & Grate Removal | Ea | $750 | 6 | $4,500 |
| Curb - Remove and Replace | LF | $15 | 2600 | $38,133 |
| SWPPP | LS | $15,000 | 1 | $15,000 |
| Utility Relocation | LF | $75 | 1300 | $97,500 |
| Temporary Signal | LS | $75,000 | 1 | $75,000 |
| Barricades | MO | $2,500 | 9 | $22,500 |
| Pavement Markings | LS | $10,000.00 | 1 | $10,000 |
| Inlets | EA | $3,000.00 | 6 | $18,000 |

| | |
|---|---|
| Sub Total | $895,177 |
| Contingency - 25% | $223,794 |
| Total | $1,118,971 |
| | |
| Construction | **$1,100,000** |
| Engineering Design (COH Fee Curves - 9.737%) | $107,000 |
| Engineering Additional Services - 3.0% | $33,000 |
| Surveying ($5.00 per LF) | $6,500 |
| Total | **$1,246,500** |

## Kimberley Lane
## Storm Sewer Improvement - Option 4 - 25-Year Level of Service
**(Kimberley Lane from Sam Houston Tollway Frontage Road to West Bough Lane)**

| Item Description | Unit | 2009 Unit Cost | Quantity | 2009 Subtotal |
|---|---|---|---|---|
| Mobilization (10%) | LS | | 1 | $65,282 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Flagmen | LS | $10,000 | 1 | $10,000 |
| Con Pvmnt - Remove & Replace | SY | $62 | 1259 | $78,051 |
| Cement Stabilized Base | SY | $20.00 | 1259 | $25,178 |
| Curb - Remove and Replace | LF | $14.67 | 612 | $8,972 |
| Trench Safety System | LF | $1 | 1,133 | $1,133 |
| SWPPP | LS | $15,000 | 1 | $15,000 |
| Utility Relocation | LF | $75 | 650 | $48,750 |
| 6' x 3' Concrete Box Culvert | LF | $307 | 1133 | $347,831 |
| CSB for Culvert | LF | $27 | 1133 | $30,591 |
| Excavation | CY | $12 | 2526.59 | $30,319 |
| Dewatering | LF | $30 | 567 | $16,995 |
| Manholes | Ea | $4,500 | 6 | $27,000 |

| | |
|---|---|
| Sub Total | $718,102 |
| Contingency - 25% | $179,526 |
| Total | $897,628 |
| | |
| Construction | **$900,000** |
| Engineering Design (COH Fee Curves - 9.737%) | $88,000 |
| Surveying ($5.00 per LF) | $5,665 |
| Geotechnical | $10,000 |
| Total | **$1,003,665** |

## Future Costs Associated with Kimberley Reconstruction

| Item Description | Unit | 2009 Unit Cost | Quantity | 2009 Subtotal |
|---|---|---|---|---|
| Mobilization (10%) | LS | | 1 | $81,380 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Flagmen | LS | $10,000 | 1 | $10,000 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Con Pvmnt - Remove & Replace | SY | $62.00 | 5922 | $367,164 |
| Cement Stabilized Base | SY | $20.00 | 6500 | $130,000 |
| Inlet & Grate Removal | Ea | $750 | 6 | $4,500 |
| Curb - Remove and Replace | LF | $15 | 2600 | $38,133 |
| SWPPP | LS | $15,000 | 1 | $15,000 |
| Utility Relocation | LF | $75 | 1300 | $97,500 |
| Temporary Signal | LS | $75,000 | 1 | $75,000 |
| Barricades | MO | $2,500 | 9 | $22,500 |
| Pavement Markings | LS | $10,000.00 | 1 | $10,000 |
| Inlets | EA | $3,000.00 | 6 | $18,000 |

| | |
|---|---|
| Sub Total | $895,177 |
| Contingency - 25% | $223,794 |
| Total | $1,118,971 |
| | |
| Construction | **$1,100,000** |
| Engineering Design (COH Fee Curves - 9.737%) | $107,000 |
| Engineering Additional Services - 3.0% | $33,000 |
| Surveying ($5.00 per LF) | $6,500 |
| Total | **$1,246,500** |

## Kimberley Lane
## Storm Sewer Improvement - Option 4 - 100-Year Level of Service
**(Kimberley Lane from Sam Houston Tollway Frontage Road to West Bough Lane)**

| Item Description | Unit | 2009 Unit Cost | Quantity | 2009 Subtotal |
|---|---|---|---|---|
| Mobilization (10%) | LS | | 1 | $84,883 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Flagmen | LS | $10,000 | 1 | $10,000 |
| Con Pvmnt - Remove & Replace | SY | $62 | 1259 | $78,051 |
| Cement Stabilized Base | SY | $20.00 | 1259 | $25,178 |
| Curb - Remove and Replace | LF | $14.67 | 612 | $8,972 |
| Trench Safety System | LF | $1 | 1,133 | $1,133 |
| SWPPP | LS | $15,000 | 1 | $15,000 |
| Utility Relocation | LF | $75 | 650 | $48,750 |
| 2 - 5' x 3' Concrete Box Culvert | LF | $480 | 1133 | $543,840 |
| CSB for Culvert | LF | $27 | 1133 | $30,591 |
| Excavation | CY | $12 | 2526.59 | $30,319 |
| Dewatering | LF | $30 | 567 | $16,995 |
| Manholes | Ea | $4,500 | 6 | $27,000 |

| | |
|---|---|
| Sub Total | $933,712 |
| Contingency - 25% | $233,428 |
| Total | $1,167,140 |
| | |
| Construction | **$1,200,000** |
| Engineering Design (COH Fee Curves - 9.737%) | $117,000 |
| Surveying ($5.00 per LF) | $5,665 |
| Geotechnical | $10,000 |
| Total | **$1,332,665** |

### Future Costs Associated with Kimberley Reconstruction

| Item Description | Unit | 2009 Unit Cost | Quantity | 2009 Subtotal |
|---|---|---|---|---|
| Mobilization (10%) | LS | | 1 | $81,380 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Flagmen | LS | $10,000 | 1 | $10,000 |
| Traffic Control | LS | $13,000 | 1 | $13,000 |
| Con Pvmnt - Remove & Replace | SY | $62.00 | 5922 | $367,164 |
| Cement Stabilized Base | SY | $20.00 | 6500 | $130,000 |
| Inlet & Grate Removal | Ea | $750 | 6 | $4,500 |
| Curb - Remove and Replace | LF | $15 | 2600 | $38,133 |
| SWPPP | LS | $15,000 | 1 | $15,000 |
| Utility Relocation | LF | $75 | 1300 | $97,500 |
| Temporary Signal | LS | $75,000 | 1 | $75,000 |
| Barricades | MO | $2,500 | 9 | $22,500 |
| Pavement Markings | LS | $10,000.00 | 1 | $10,000 |
| Inlets | EA | $3,000.00 | 6 | $18,000 |

| | |
|---|---|
| Sub Total | $895,177 |
| Contingency - 25% | $223,794 |
| Total | $1,118,971 |
| | |
| Construction | **$1,100,000** |
| Engineering Design (COH Fee Curves - 9.737%) | $107,000 |
| Engineering Additional Services - 3.0% | $33,000 |
| Surveying ($5.00 per LF) | $6,500 |
| Total | **$1,246,500** |