City of Citrus Heights Neighborhoods 8, 9, and 10

Storm Drainage Master Plan Study

Prepared for

City of Citrus Heights

February 2016

WEST YOST ASSOCIATES 25 YEARS 1990–2015

396-00-12-02

WEST YOST ASSOCIATES

consulting engineers

WATER WASTEWATER STORMWATER

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REGISTERED PROFESSIONAL ENGINEER
MARK O. KUBIK
No. 50963
Exp. 9-30-17
CIVIL
STATE OF CALIFORNIA

Mark Kubik

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The City of Citrus Heights (City) incorporated in 1997. However, until 2010 the storm drainage facilities that serve the City were owned by the City and maintained by the County of Sacramento. The City has now taken over full responsibility for the drainage system and is in the process of developing a comprehensive drainage Capital Improvement Program to reduce or eliminate flooding and drainage problems. The City retained West Yost Associates (West Yost) to perform a drainage study for City Neighborhoods 8, 9, and 10. This study represents another step in the City's effort towards the development of the drainage Capital Improvement Program. A drainage study was completed by West Yost for Neighborhoods 6 and 7 in March 2012.

ES.1.1 Study Objectives

The main objectives of the study are as follows:

- Gain an understanding of the facilities that comprise the existing drainage system in the study area.
- Determine the flood control performance of the key elements of the existing drainage system.
- Identify local drainage and flooding problems and develop solutions to eliminate the problems.
- Develop a Capital Improvement Plan (CIP) that includes a list of the proposed drainage and flooding solutions, the associated costs, and an implementation schedule.

ES.1.2 Study Area

Neighborhoods 8, 9, and 10 are located in the central and eastern portions of the City (see Figure ES-1). These neighborhoods are comprised of rolling terrain that drains to one of the three major creeks in the area: Cripple Creek, Arcade Creek, or San Juan Creek (see Figure ES-2). Although the three creeks present a flood threat to portions of the study area, this study was focused on local flooding issues separate from the creek flooding. The creek flooding is considered a regional flooding issue that needs to be resolved in coordination with Sacramento County.

ES.1.3 Study Approach

The general approach to the study was as follows:

- Define the Existing Storm Drainage System – The first step of the study was to gain an understanding of the existing drainage system. To do so, we collected the available information on the drainage system and performed a field inventory of selected portions of the system.

- Identify Problems – The existing drainage and flooding problems were identified by the following activities:
  - Hydraulic analyses of trunk storm drains
  - Review of service call records
  - Input from City staff
  - Input from residents
- Develop Solutions for Problem – The identified problems were evaluated and recommended solutions were developed.
- Develop a CIP – A drainage CIP was developed that includes a prioritized list of recommended improvements. The CIP also includes estimated implementation costs and an implementation schedule.

Each of the tasks listed above is described in more detail below.

ES.2 EXISTING STORM DRAINAGE SYSTEM

To gain an understanding of the existing drainage system in the study area, West Yost gathered the existing available data that had already been prepared by others. We also performed a field inventory for selected portions of the drainage system.

ES.2.1 Data Collection

The data collected for this study generally fits into one of the following categories:

- Previous Studies Prepared by Others – This included the Flood Insurance Study prepared by FEMA.
- As-built Design Drawings – This included a number of construction drawings for the major storm drain pipes in the study area.
- Mapping Data – This included aerial topographic mapping, aerial photographs, and Geographic Information System (GIS) based storm drain system mapping.
- Field Evaluations Performed by West Yost Staff – This included a field review of key portions of the drainage system to verify the existence of and the approximate horizontal location of the facilities included in the City's GIS storm drainage facility mapping, to confirm that the information included on as-built plans is reasonably accurate, to fill in data gaps on important facilities, and to gain a general understanding of the drainage patterns in the study area.
- Service Calls and Public Input – Input was solicited from City residents at a public meeting and a list of past service calls received by the City and Sacramento County was obtained.

ES.3 IDENTIFICATION OF PROBLEMS

Drainage and flooding problems in the study area were identified by the following activities:

- Hydraulic analyses of trunk storm drains
- Review of service call records
- Input from City staff
- Input from residents

ES.3.1 Hydraulic Analyses of Trunk Storm Drains

Existing trunk storm drain pipes with diameters 36-inches or larger were analyzed to determine whether they have adequate capacity to carry runoff from storms (see Figure ES-2). All but one of the trunk pipe systems were found to have adequate capacity to meet the City's drainage criteria. The pipe system that was found to be inadequate is labeled as SD6 on Figure ES-2. This pipeline was identified as Problem Location 10 and improvements to the system were recommended as described later in this report.

ES.3.2 Review of Service Call Records

City staff provided a list of service calls that document problems reported by residents during prior storm events. This list included service calls recorded primarily by Sacramento County and to a lesser extent the City. This list was reviewed and used to prepare a preliminary list of problem areas within the study area.

ES.3.3 Input from City Staff

City staff have significant knowledge of the drainage issues in the study area based on prior discussions with residents and visual observations during storm events. West Yost met with City staff at the outset of the project to obtain input on known problem locations.

ES.3.4 Input from Residents

A public meeting was held in March 2012, to solicit input from residents on flooding and drainage problems in the area. Descriptions of potential problems were provided by the residents. A follow-up public meeting was held to provide interested residents with a status report and a description of preliminary solutions that had been developed for the problems.

Based on the above activities, a total of 12 flooding and drainage problems were identified. Figure ES-2 presents the general locations the problems.

ES.4 SOLUTIONS TO PROBLEMS

Each flooding and drainage problem location was evaluated and a recommended solution identified. In many cases, the proposed solutions affect more than one problem; therefore, multiple problems were grouped together for evaluation. The problem locations and recommended solutions are shown on Figures ES-3 through ES-12. Table ES-1 provides a summary of the problem locations and the recommended solutions.

ES.5 CAPITAL IMPROVEMENT PROGRAM

The CIP provides a prioritized list of the recommended improvements along with estimated implementation costs and an implementation schedule. The recommended improvements have been separated into three categories: high priority; medium priority; and low priority. The criteria used to define the priority of a given set of improvements are as follows:

- High Priority Improvements – The high priority improvements include those that address potential structure flooding, threats to health and safety, serious traffic hazards, and those that have a very high benefit to cost ratio. The benefit-cost ratios were determined qualitatively; formal determinations of damages and benefits were not performed.
- Medium Priority Improvements – Medium priority improvements include those that address potential flooding of lesser structures (e.g., garages, outbuildings), chronic ponding over large areas, and problems that require excessive maintenance.
- Low Priority Improvements – Low priority improvements include those that address minor or occasional ponding and nuisance drainage issues.

Table ES-1 lists the recommended projects along with the associated priority, estimated schedule for implementation, and estimated implementation cost. The estimated costs include the cost of construction as well as costs for planning, design, construction management, environmental permitting, and program management. The cost estimates are master planning level estimates suitable for decision making and budgeting purposes. More detailed cost estimates should be prepared to a greater level of accuracy as the projects advance to the design stage and more detailed information is developed. Also, the cost estimates were prepared based on the assumption that small projects will be bundled with large projects at the time of implementation to achieve better cost efficiency. The schedules for the project are based on input from City staff.

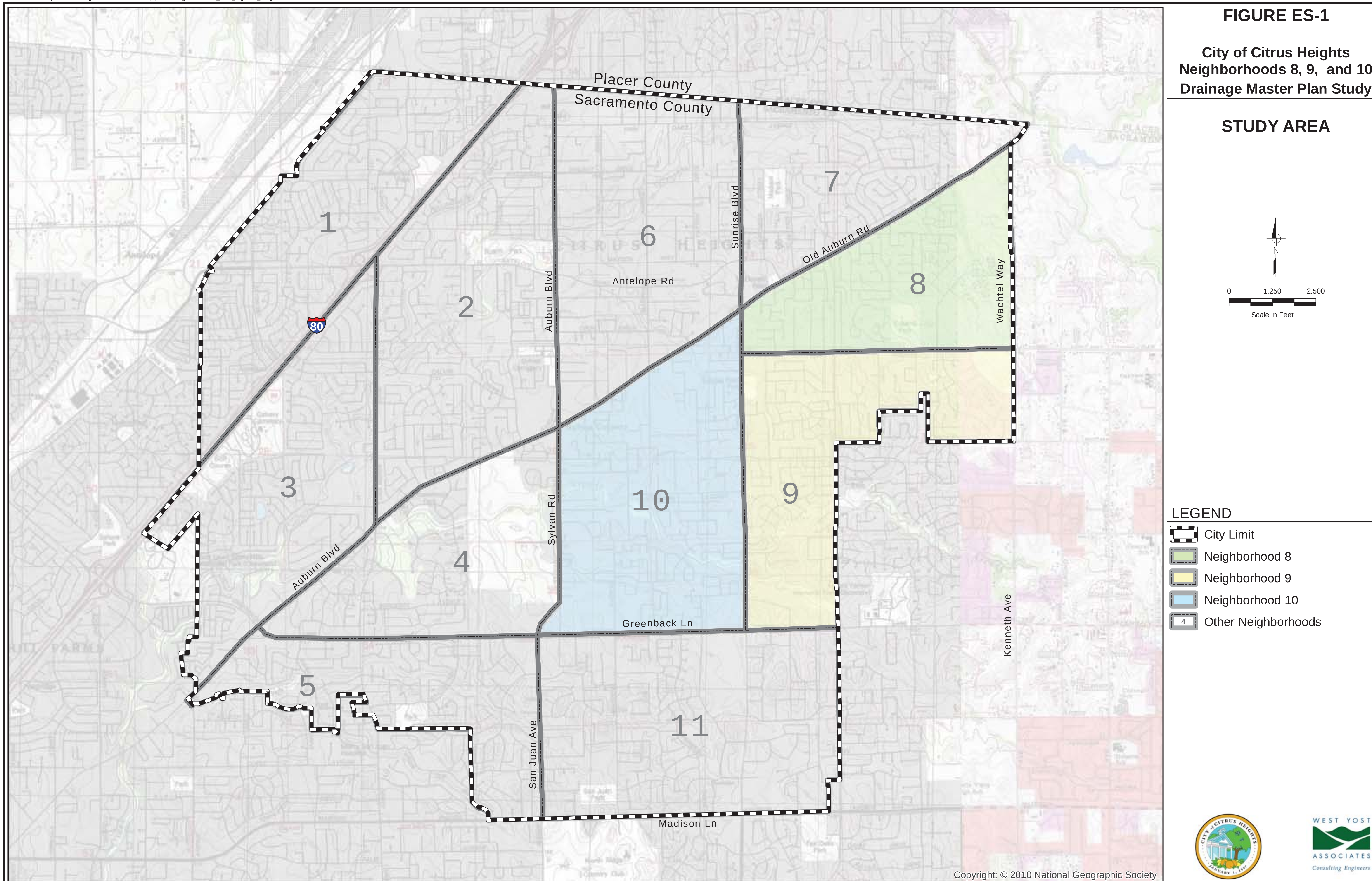

FIGURE ES-1

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

STUDY AREA

WEST YOST ASSOCIATES

Consulting Engineers

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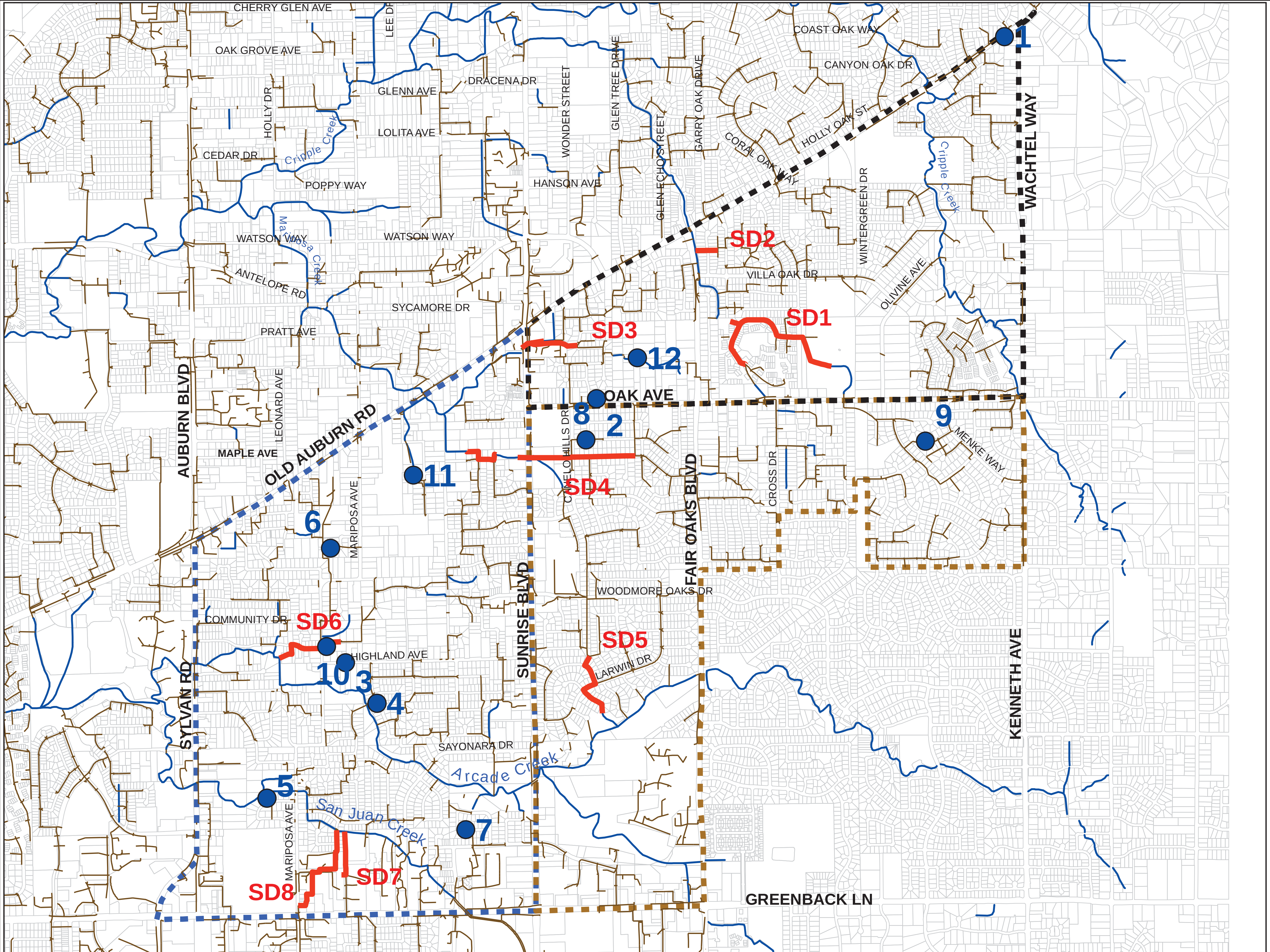
FIGURE ES-2

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

TRUNK PIPES AND PROBLEM LOCATIONS



N

0 750 1,500

Scale in Feet

LEGEND

- Problem Location
- Trunk Pipe (36" and Larger)
- Drainage Pipe
- Stream or Channel
- Neighborhood 8
- Neighborhood 9
- Neighborhood 10

WEST YOST ASSOCIATES
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Figure ES-3

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

Problem Location 1 and Proposed Solution

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LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)
- Proposed Pipeline or Drain

N

0 20 40

Scale in Feet

Figure ES-4

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

Problem Location 2 and Proposed Solution

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Consulting Engineers

Figure ES-5

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Locations 3 and 4 Proposed Solution

0 75 150
Scale in Feet

LEGEND

- Problem Location
- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Proposed Inlet
- Proposed Outfall
- Proposed Manhole
- Elevation Contour (NAVD88)
- Proposed Pipeline or Drain
- Proposed Pipeline or Drain for Problem Location 10
- Proposed Ditch Replacement
- Proposed Overland Release

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LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)
- Proposed Pipeline or Drain

0 50 100
Scale in Feet

Figure ES-6

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

Problem Location 5 and Proposed Solution

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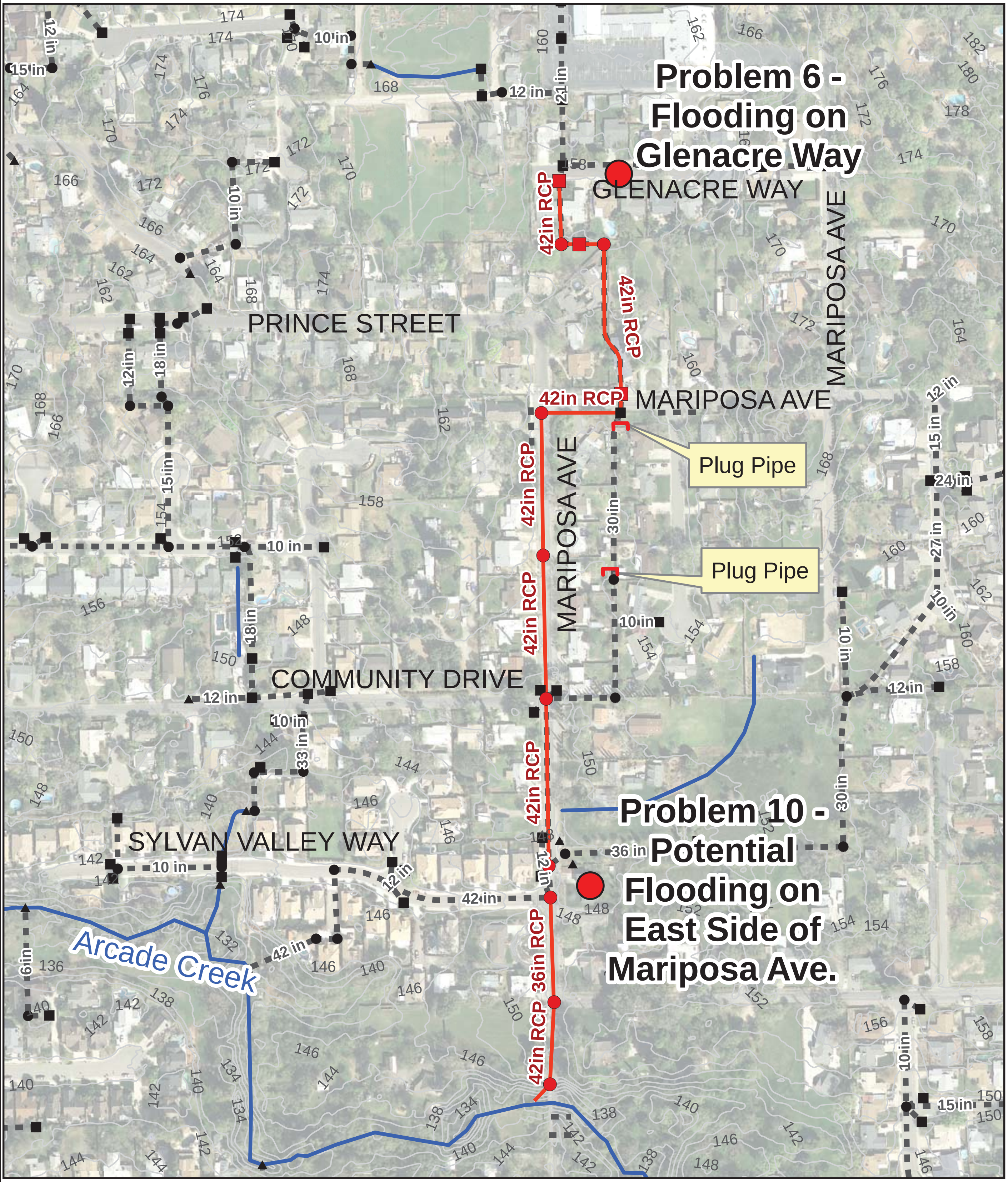

LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Proposed Pipeline or Drain
- Proposed Inlet
- Proposed Outfall
- Proposed Manhole
- Elevation Contour (NAVD88)

N

0 150 300

Scale in Feet

Figure ES-7

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Locations 6 and 10
Proposed Solution

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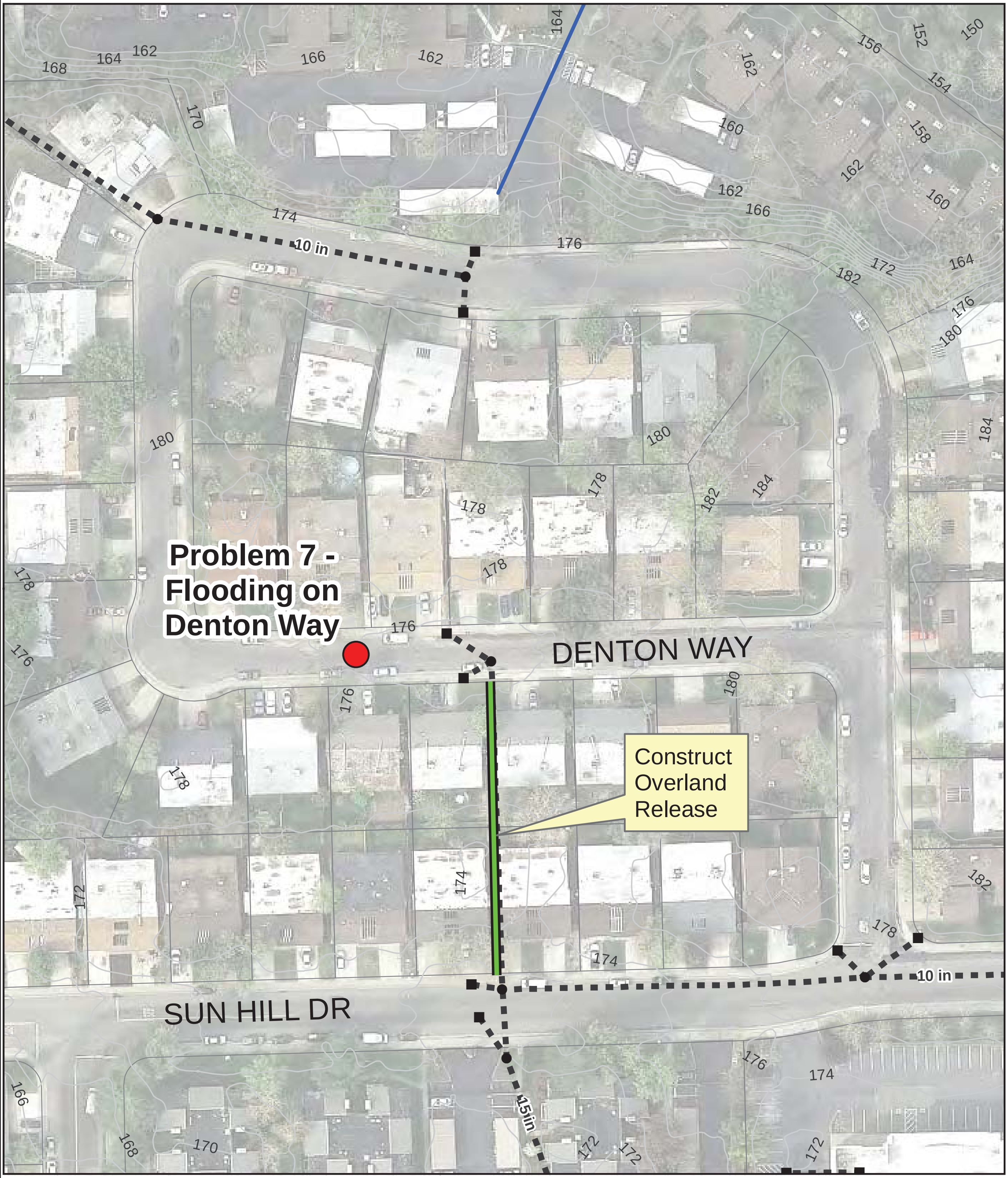

LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)
- Proposed Overland Release

N

0 50 100

Scale in Feet

Figure ES-8

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 7
Proposed Solution

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LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)
- Proposed Pipeline or Drain

N

0 50 100

Scale in Feet

Figure ES-9

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 8
Proposed Solution

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Consulting Engineers

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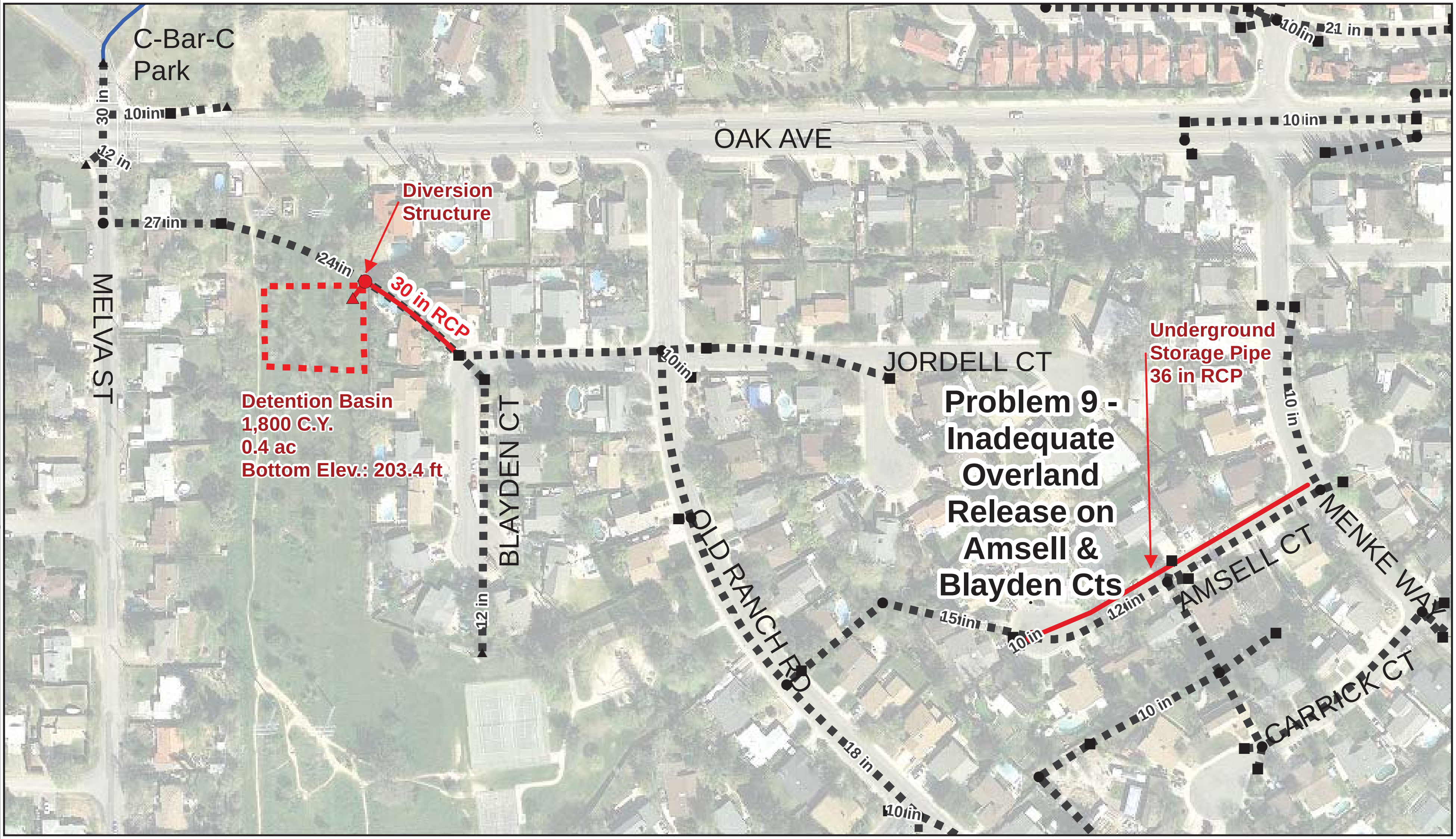

LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Proposed Pipe or Drain
- Proposed Detention Basin
- Elevation Contour (NAV88)

N

0 100 200

Scale in Feet

Figure ES-10

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 9
Proposed Solution

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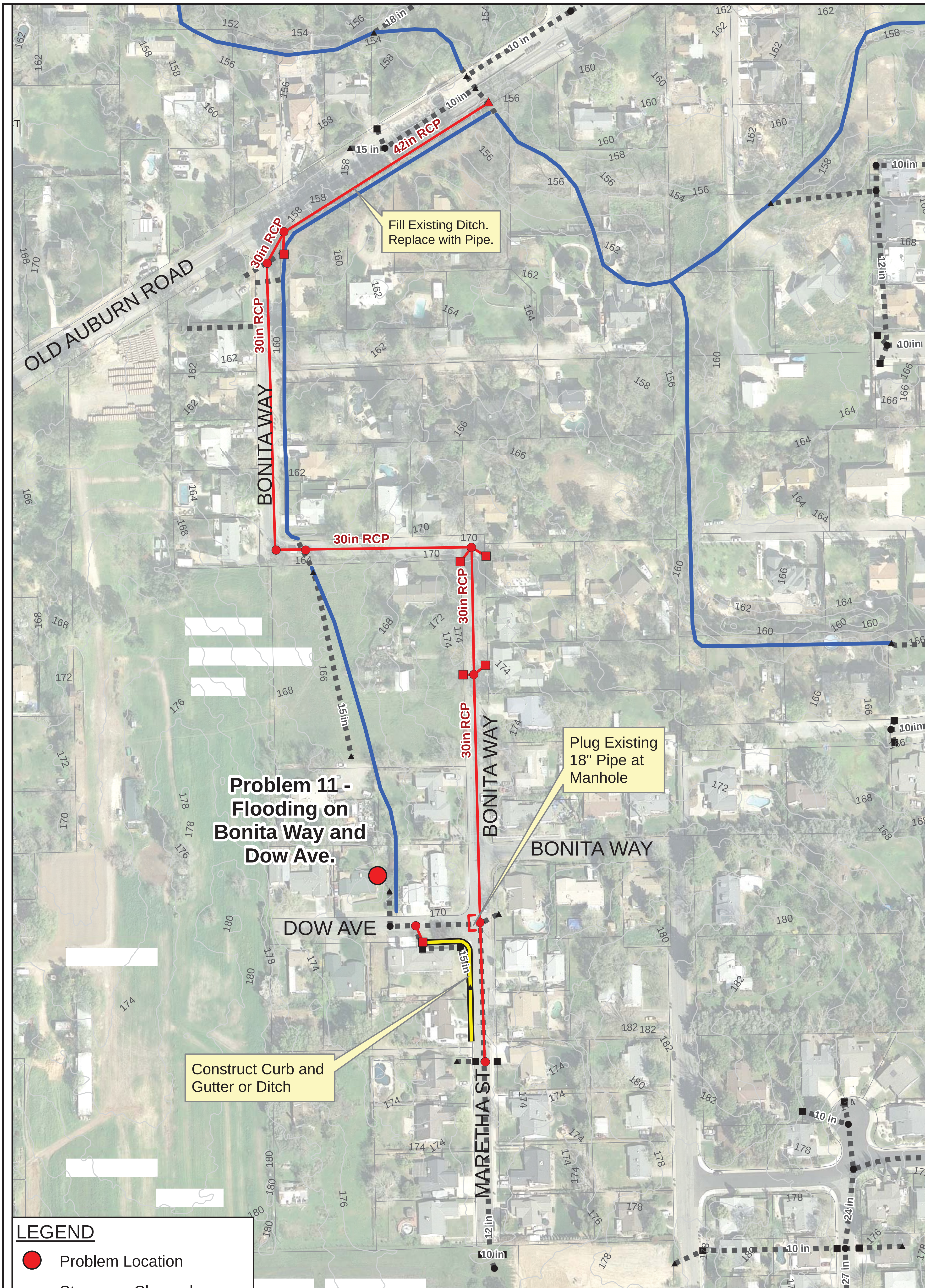

LEGEND

- Problem Location
- Stream or Channel
- Existing Pipe
- Proposed Pipeline or Drain
- Proposed Inlet
- Proposed Outfall
- Proposed Manhole
- Proposed Ditch

N

0 75 150
Scale in Feet

FIGURE ES-11

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 11
and Proposed Solution

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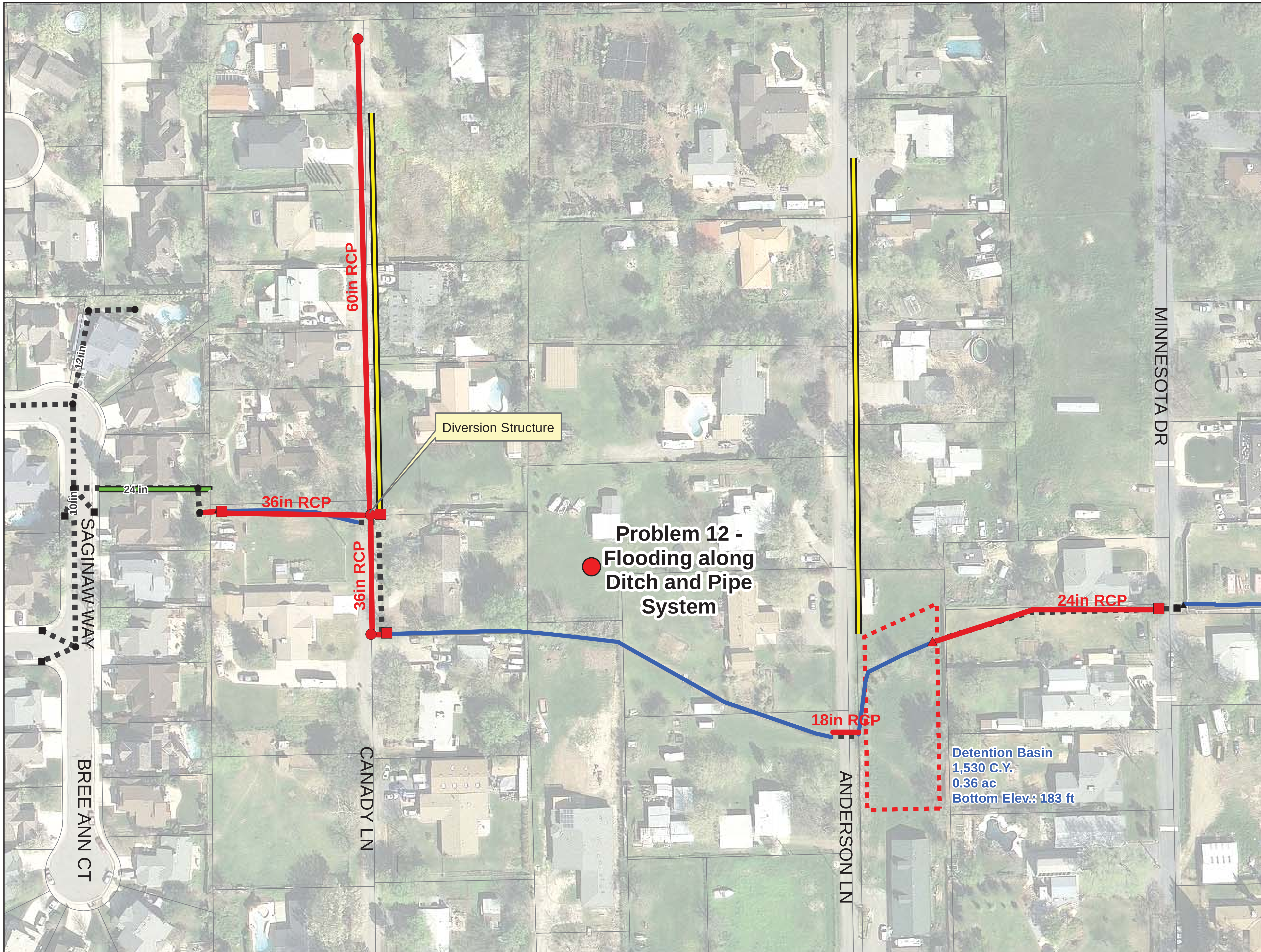

Figure ES-12

**City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study**

**Problem Location 12
and Proposed Solution**

0 50 100
Scale in Feet

LEGEND

- Elevation Contour (NAVD88)
- Stream or Channel
- Existing Drain Pipe
- Proposed Pipe or Drain
- Proposed Detention Basin
- Proposed Overland Release
- Proposed Ditch or Gutter
- Proposed Inlet
- Proposed Outfall
- Proposed Manhole

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CHAPTER 1
Introduction

The City of Citrus Heights (City) is located in northern Sacramento County just south of the Placer County line. The City incorporated in 1997 and until 2010, the storm drainage facilities that serve the City were owned by the City and maintained by the County of Sacramento. The City has taken over responsibility for the drainage system and has retained West Yost Associates (West Yost) to perform a drainage study for City Neighborhoods 8, 9, and 10. This study represents a comprehensive effort towards the development of a drainage Capital Improvement Program (CIP) for Neighborhoods 8, 9, and 10, and ultimately the entire City.

1.1 STUDY OBJECTIVES

The main objectives of the study are as follows:

- Provide an inventory and condition assessment of key portions of the existing drainage system in the study area;
- Assess the flood control performance of the key elements of the existing drainage system;
- Recommend improvements to eliminate or reduce recurring local flooding and drainage problems; and
- Develop a CIP to help guide the City in implementing future drainage projects.

1.2 STUDY AREA

This study is focused on three of the City's 11 neighborhoods – Neighborhoods 8, 9, and 10. As shown on Figure 1-1, Neighborhoods 8, 9, and 10 are located in the central and eastern portions of the City. A drainage master plan study for Neighborhoods 6 and 7 was completed in March 2012.

The study area is comprised of rolling terrain that drains to one of the three major creeks traversing the area: Cripple Creek, Arcade Creek, and San Juan Creek (see Figure 1-2). Cripple Creek enters the study area at the intersection of Kenneth Avenue and Oak Avenue. The creek generally conveys runoff north through Neighborhood 8 before exiting the study area at Old Auburn Road. Arcade Creek enters the study area at Fair Oaks Boulevard in the southwest portion of Neighborhood 9. It conveys storm runoff west through Neighborhoods 9 and 10 before exiting the study area at Sylvan Road. San Juan Creek flows through the southern portion of Neighborhood 10 and joins Arcade Creek just downstream of Sylvan Road. All three creeks have the potential to overflow their banks during large storm events. The Federal Emergency Management Agency (FEMA) has prepared flood maps that show the floodplain along the two creeks. The floodplain defined by FEMA is presented on Figure 1-2. Although the three creeks present a flood threat to portions of the study area, this study was focused on local flooding issues separate from the creek flooding. The creek flooding is considered a regional flooding issue that needs to be resolved in coordination with Sacramento County. Sacramento County is currently preparing an updated flood study along the Arcade and Cripple Creek that could provide the basis for identifying and evaluating flood solutions along the creeks.

The emphasis of this study was the local drainage systems that serve the three neighborhoods. These systems include approximately 49 miles of pipes and culverts, 8 miles of streams and channels, 850 manholes, and hundreds more inlets and catch basins.

1.3 STUDY APPROACH

The general approach to the study was as follows:

- A data collection effort was performed to obtain available information related to the drainage systems within the study area. This included gathering previously prepared reports, floodplain studies, as-built drawings, topographic mapping, storm drainage facilities mapping, and any other relevant data. The data collection effort is described in more detail in Chapter 2.
- A drainage system inventory was performed to verify the locations and existence of the drainage system facilities contained in the City's Geographic Information System (GIS) database and to provide an assessment of the facility conditions. For this effort field crews visually inspected the drainage system from the surface and, in some cases, pulled manhole covers to view the subsurface conditions of the system. This effort was focused on key portions of the existing drainage system inventory as described in more detail in Chapter 3.
- The City's drainage system GIS database was updated to include the information developed during this study. This included updated information on the existing drainage system as determined during the field inventory and other new information developed during this study. A detailed description of the GIS database update is provided in Chapter 4.
- Hydrologic and hydraulic studies were performed to assess the capacities of the critical existing drainage systems and to define recommended improvements to improve conveyance capacity. This included analyses of the existing trunk pipes in the study area and evaluations of known problem areas. These analyses are described in Chapters 5 through 7.
- A storm drainage CIP was developed that defines the recommended improvements, provides estimated implementation costs, and prioritizes the improvements. The CIP is presented in Chapter 8.

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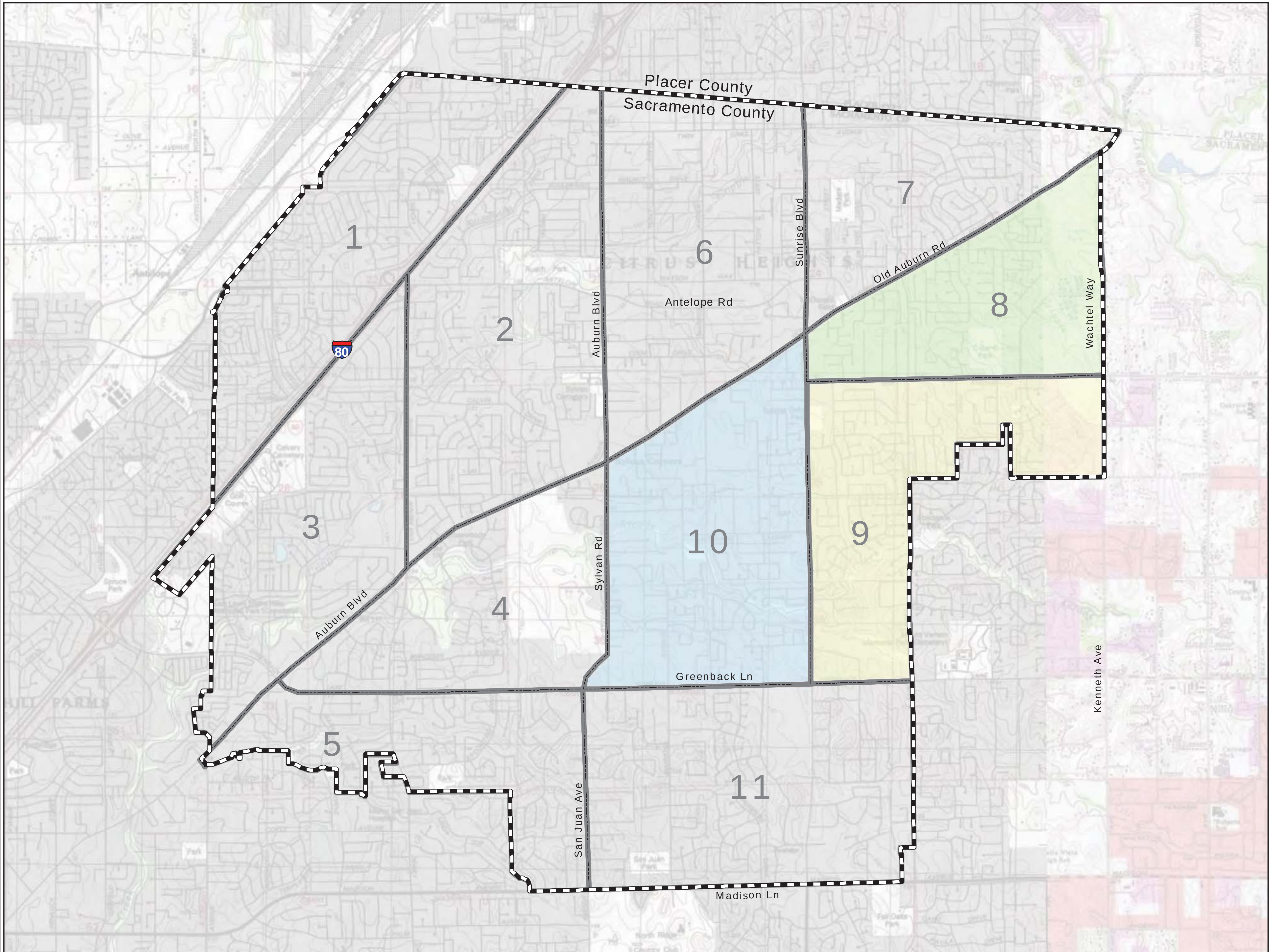

FIGURE 1-1

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

STUDY AREA

0 1,250 2,500

Scale in Feet

LEGEND

- City Limit
- Neighborhood 8
- Neighborhood 9
- Neighborhood 10
- 4 Other Neighborhoods

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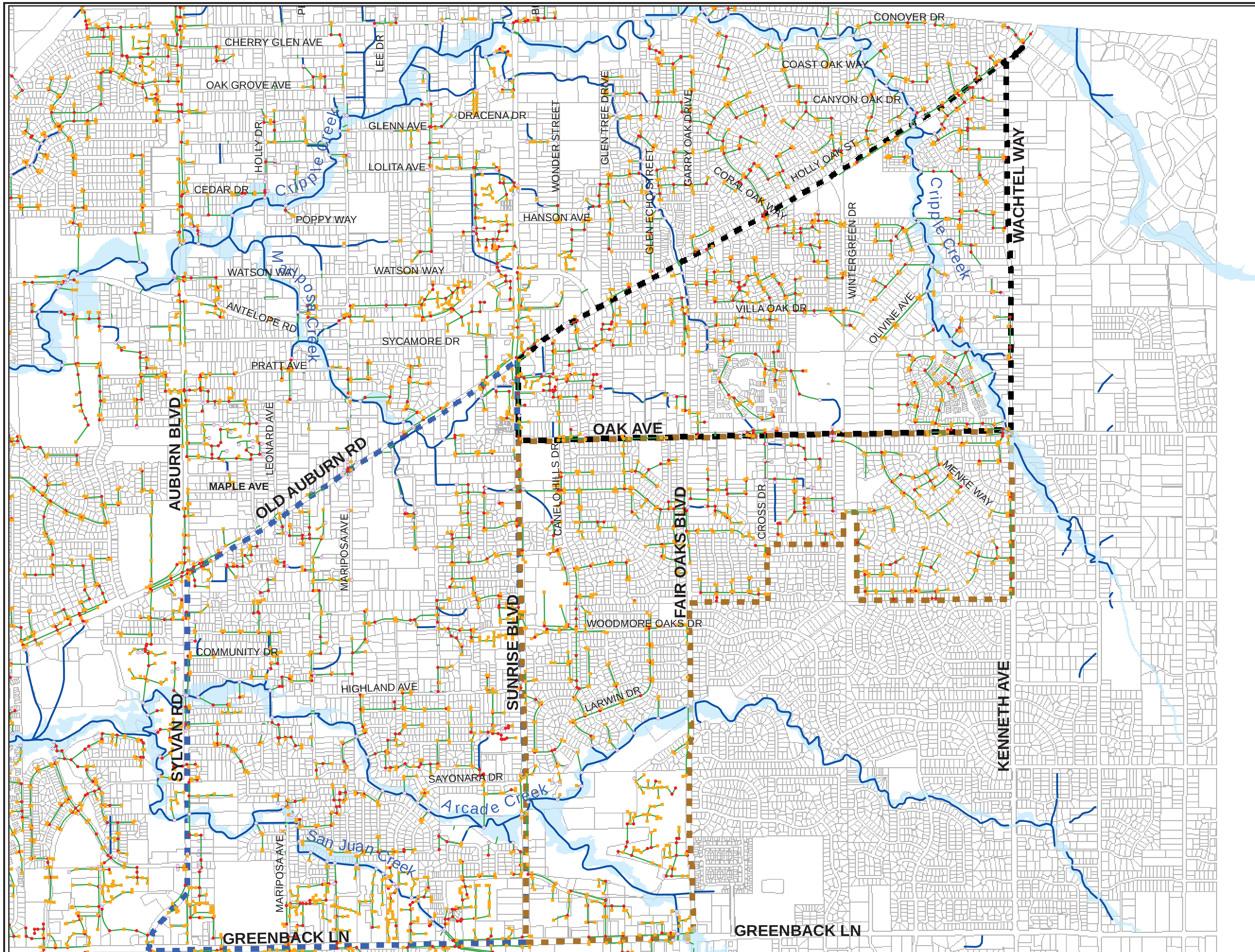

FIGURE 1-2

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

STUDY AREA AND EXISTING DRAINAGE FACILITIES

LEGEND

- Inlet
- Outfall
- Manhole
- Drainage Pipe
- Stream or Channel
- FEMA Flood Zone
- Neighborhood 8
- Neighborhood 9
- Neighborhood 10

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CHAPTER 2
Data Collection

This chapter presents a summary of the data collected for use with the Storm Drainage Master Plan Study for Neighborhoods 8, 9, and 10. The data generally fits into one of five categories as follows:

- Previous Studies Prepared by Others
- As-built Design Drawings
- Mapping Data
- Field Evaluations Performed by West Yost Staff
- Service Calls and Public Input

For each category, the specific data collected is described below.

2.1 PREVIOUS STUDIES PREPARED BY OTHERS

Flood Insurance Study, Sacramento County, California, August 2012 – This flood study prepared by the FEMA defines the flood risk along the major waterways within Sacramento County, including the three major waterways that pass through the study area: Cripple Creek, Arcade Creek, and San Juan Creek. The flood study includes floodplain maps that present the limits of the 100-year and 500-year floodplains; and flood profiles for the 10-year, 50-year, 100-year, and 500-year storm events. For this study, the FEMA data was used to establish the downstream water surface elevations for the hydraulic analysis of storm drain systems that discharge to the creeks. Table 2-1 provides a listing of the FEMA floodplain map numbers and flood profile numbers that cover the study area.

Table 2-1. FEMA Floodplain Data for Study Area

Item	Map or Profile Numbers from the 2012 Flood Insurance Study
Floodplain Maps	06067C0083H, 06067C0084H, 06067C0091H, 06067C0092H, 06067C0103H
Flood Profiles	Arcade Creek – 19P, 20P Cripple Creek – 49P San Juan Creek – 132P

2.2 AS-BUILT DESIGN DRAWINGS

As-built plans were gathered from Sacramento County archives and, where available, were used to help define the sizes, lengths, slopes and invert elevations of the trunk storm drain pipes within the study area. Table 2-2 provides a list of the drawings that were gathered and the associated storm drain system. The trunk storm drain evaluations are described in detail in Chapter 6 and a figure showing the trunk drain locations is provided as Figure 6-1. For some trunk drains, there was no as-built data available. In other cases, the as-built data provided information on only a part of the trunk drain. For those systems, additional information was gathered through field evaluations as summarized below and as described in detail in Chapter 3.

Table 2-2. List of Trunk Storm Drains and Associated As-Built Plans	
Storm Drain ID	Associated As-Built Plan Set
SD1	Oak Crest Village
SD2	Woodside Oaks Unit No. 2
SD3	Lost Oaks, Chevron Station 7551 Sunrise Blvd.
SD4	Casa Grande Unit No. 3, Sunrise Estates
SD5	Tempo Unit No. 1, Tempo Unit No. 6
SD6	None
SD7	None
SD8	Park Wood Racket Club, 6244 Mariposa Avenue

2.3 MAPPING DATA

Mapping data used for the study include aerial topographic mapping, field survey data, aerial orthophotos, and GIS based storm drain system mapping. These items are described below.

- Aerial Topographic Mapping – LiDAR topographic mapping prepared for Sacramento County in 2004 was used to define watershed boundaries and general drainage patterns. This topographic data is based on the North American Vertical Datum of 1988. The coordinate system for the topographic mapping is the California State Plane Zone II NAD83.
- A field survey was performed along Highland Avenue between Mariposa Avenue and Rinconada Drive and a topographic map was also prepared. This survey and mapping was prepared in 2010 by Doucet & Associates, Inc. + Surveyors Group, Inc.
- Aerial Orthophotos – The aerial photographs used for this study were created in 2008 for the State of California Central Valley Flood Plain Evaluation and Delineation project. The coordinate system for the aerial photos is UTM Zone 10, NAD83.
- Storm Drainage Facility Maps – The City provided storm drainage facility mapping in GIS format. This mapping provides approximate locations of drainage pipes, manholes, inlets, outlets, streams, and other storm drainage facilities as well as pipe size data. The information is based on the County's CAD based storm drainage facilities maps and is considered approximate.

2.4 FIELD EVALUATIONS

West Yost performed field evaluations to verify the existence of and approximate horizontal location of the facilities included in the City's GIS storm drainage facility mapping, to confirm that the information included on as-built plans is reasonably accurate, to fill in data gaps on important facilities, and to gain a general understanding of the drainage patterns in the study area. This effort was focused on key portions of the existing drainage system inventory as described in more detail in Chapter 3.

2.5 PUBLIC INPUT

A public meeting was held on April 10, 2012. This meeting was well attended by residents within the study area and descriptions of potential problem areas were provided by the residents both verbally and in writing. City staff prepared a summary table that provides descriptions of each problem, the location of the problem, the name and address of the resident that reported the problem, and a problem category (i.e. flooding, drainage system, maintenance). This summary table is provided as Table 2-3. For this report, the names, addresses and phone numbers have been removed from the table. Each problem was assigned a Workshop Item No., which is simply the order the problem was recorded in the workshop. They were also given an Assigned Problem No. for the Master Plan, which corresponds to the problem identification number that is used later in this report (see Chapter 7). In some cases, problem identification numbers were not assigned to a reported problem because the problem was simply a maintenance issue to be addressed by City staff. Although these problems were not evaluated with the master plan study, City staff is addressing them or has already addressed them separate from this study. In other cases, the problems were related to flooding along one the major creeks. Creek flooding issues are not being addressed by this study, but may be considered at a future time after the County of Sacramento finalizes their updated hydrologic and hydraulic study for the Arcade Creek watershed.

2.6 SERVICE CALLS

To further assist with defining potential problem areas, City staff provided a list of service calls that document problems reported by residents during prior storm events. This list included service calls recorded by Sacramento County and the City. This list was reviewed and used to identify additional problems to be evaluated during this study.

Table 2-3. City of Citrus Heights - Neighborhoods 8, 9, and 10 Storm Drainage Master Plan Study
Citizen Feedback
Public Workshop - April 10, 2012

Workshop Item No.	Assigned Problem No. for Master Plan Study	First	Last	Address 1	Address 2	Phone Number	Citizen Comments, Edited	Category (D, F, CC)	City staff Understanding of Issue
1	n/a, maintenance issue				Smoke Tree Ct.		Outfall pipe to Arcade Creek has not been cleaned for over 10 years. Overrun by blackberries. Also, Tempo Park Remodel.	CC	The vegetation is overgrown and the outfall pipe was not visible. Sunrise Park & Recreation project in progress.
2	n/a, City staff coordinating response				Mica Way		I would like a visit to discuss a better solution to install pipe and cover with rock to match other side of drain and removed safety issue and filling with mud. I would even be willing to submit plans or info. Sac Sewer didn't repair dig out properly.	D	
3	1				Old Auburn Rd.		No open drainage out to the street. Neighbor in the back drains into our yard. Then neighbor raised the gravel driveway preventing the drainage from escaping.		
4	n/a, needed advice for private drainage issue				Quailwood Way		Who can I consult with regarding flooding on my residential property?		
5	n/a, leak unrelated to storm drainage system				Poulson St.		On my street there has been an underground leak for as long as I have lived there for 35 years. It runs all year.	D	Problems with ground water along Poulson Street.
6	n/a, private property issue already resolved				Cranford Way		We have a drainage situation at our home. Water comes from street and next door neighbor and drains down to our neighbor on Kenneth Ave. Recently, we replaced the pipes in our back yard as the pipes were filled with dirt and roots. Its draining beautifully but into our neighbor's yard. Our neighbor's house is on Kenneth and property sits downhill 10 feet below our home. We also have a drainage issue in our front yard. The pipes that lead to another home on Kenneth that sits behind us is blocked and puddles in front of the garage. If we fix the pipes (replace them) our other neighbors will receive the overflow of water and will flood. Water from our neighbor also drains into our yard. Water also drains in our next door neighbor's house as we both sit down from the street.	D	Issue is located on private property. Resident resolved issue. No further action needed.
7	3				Highland Ave.		Highland Ave. floods in heavy rains in the areas indicated. There are a number of students who walk to and from San Juan High School and the First Apostolic Church. The narrowness of Highland is a hazard. It is escalated when it is raining.	D,F	
8	3				Beam Dr.		Ditch that separates two private streets does not have enough capacity.	D,F	The ditch is shallow and doesn't have enough capacity. Private street. Adding ditch capacity will require changing receiving inlet.
9	2				Foxhills Dr.		Water runs off from the neighbors property when it rains or the sprinklers are left on for a long while.	D	Property to the east slopes gently towards his fence. Appears like multiple properties contribute to the runoff.

Table 2-3. City of Citrus Heights - Neighborhoods 8, 9, and 10 Storm Drainage Master Plan Study
Citizen Feedback
Public Workshop - April 10, 2012

Workshop Item No.	Assigned Problem No. for Master Plan Study	First	Last	Address 1	Address 2	Phone Number	Citizen Comments, Edited	Category (D, F, CC)	City staff Understanding of Issue
10	4				Rinconada Dr.		Inlets do not have enough capacity. More inlets needed.	D,F	The inlets are small and seem inadequate. Replacement and addition of inlets may solve issue.
11	3				Highland Ave.		The west end of Highland is very narrow and needs the ditch covered with a curb for the safety of students walking to or from school. It is a hazard to the motorists too.	D,F	Water fills the ditch along the north side and overflows between 7689 & 7677. The entire street needs to be redesigned.
12	n/a, private property issue, advice provided by City staff				Community Dr.		County project made a huge mess. City cleaned pipes. Theirs and their neighbor's driveway flood. There are only 2 clean-outs for 3 houses.	D	The issue is on private property. Possible solutions provided to the property owner. No further action needed.

Category Codes:
D= Drainage issue (the system is not working right or there is no system)
F= Flooding (issue is causing flooding repeatedly)
CC= Conservation Corp (issue can be solve by the crews, maintenance)

CHAPTER 3
Drainage System Inventory

3.1 INTRODUCTION

The purpose of the drainage system inventory was to verify the locations and existence of the drainage system facilities contained in the City's GIS database and to provide an assessment of the facility conditions. The drainage system within the study area contains more than 49 miles of pipeline, over 850 manholes, and hundreds more inlets and catch basins. Detailed verification and assessment of every facility in the study area would have been time consuming and costly and was not necessary to achieve the objectives of the study. Therefore, the system inventory was performed only for key portions of the study area as shown on Figure 3-1. These areas represent the trunk drainage systems and known problem areas. A detailed description of the approach used to perform the drainage system inventory is provided below along with the key findings.

3.2 APPROACH AND CRITERIA

The specific approach and criteria for conducting the drainage system inventory are presented below.

3.2.1 Facility Types

The drainage inventory was focused on the following facility types:

- Manholes
- Drop Inlets/Catch Basins
- Pipe Inlets and Outfalls
- Culverts
- Drainage Ditches

3.2.2 Assessment Type

Two types of assessments were performed during the drainage system inventory:

1. Surface Assessment – A surface assessment was performed for all the storm drain facilities included in the City's GIS drainage database within the areas shown on Figure 3-1. This step included a visual observation of drainage facilities visible from the surface. The assessment was performed from the public right-of-way; private property was not entered. The size, material, and condition of the facilities were observed and recorded where possible.
2. Subsurface Assessment – Targeted subsurface assessments were performed at key locations along major storm drain systems with pipe diameters 36-inches or greater. At key locations, manhole lids were opened to obtain the following information:
   a) Pipe shape
   b) Pipe size
   c) Pipe material
   d) Depth of pipe invert from surface
   e) Conditions of pipe invert as visible from surface

The data collected for the subsurface assessment were used to prepare hydraulic modeling as described in Chapter 5. In some cases, the data were used to verify the information included on the available as-built plans. In other cases, no as-built data was available and the field data collected during this task represented the key data source for preparing hydraulic models.

3.2.3 Facility Conditions

When the conditions of the existing facilities were assessed, the conditions were categorized with the codes used by the City's maintenance staff as follows:

- Physical Condition
  1. Facility appears in excellent condition (new looking, no rust or deformation).
  2. Facility appears in good condition with typical wear and tear (minimal rusting).
  3. Facility appears in fair condition (typical rusting, slight joint separation, minor root intrusion).
  4. Facility is unserviceable and needs replacement (severe rusting, collapse pipe, major joint separation, severe root intrusion).
- Cleanliness
  1. Facility is clean. Flow is not restricted.
  2. Facility has minor sediment and debris. Flow is not significantly restricted (blocked depth is less than 5 percent of the pipe diameter).
  3. Facility has moderate sediment and debris. Flow is moderately restricted (blocked depth is between 5 percent and 10 percent of the pipe diameter).
  4. Facility has excessive sediment and debris. Flow is significantly restricted (blocked depth is greater than 10 percent of the pipe diameter).

3.3 RESULTS

Data collected in the field were recorded on Drainage System Inventory Workmaps, which are included as Appendix A. Field staff recorded data on field assessment forms, and this data is provided in Table 3-1. Table 3-1 is organized by Storm Drain or Problem Area and contains field data which corresponds to the notations on the Workmaps. Descriptions of the key fields are provided below:

1. Item Type – Facility type (i.e., manhole, pipe, ditch, etc.).
2. ID No. – Corresponds to structure IDs designated in the GIS database. If a structure was not included in the GIS database, no ID No. is listed and a description of the facility is included in the Notes field.

Table 3-1. Field Data and Photo Index

Drainage System Inventory Workmap No.	Date	Item Type	ID No.	Size, in	Shape	Depth to Invert, feet	Material	Photo No.	Condition Code		Notes
									Physical	Cleanliness	
Storm Drain1	9/11/2012	MH	376-209-M47		Circ.	6.83	RC	IMG_4493	B	1	
Storm Drain1	9/11/2012	Pipe	376-209-M48:M47	12	Circ.		RCP		B	1	Small pipe coming in from south on Heritage Meadow, invert is above invert in manhole
Storm Drain1	9/11/2012	Pipe	376-209-T01:M47	36	Circ.	6.83	RCP		B	1	Large diameter pipe from creek to south
Storm Drain1	9/11/2012	Pipe	376-209-M47:T02	36	Circ.	6.83	RCP		B	1	Large diameter pipe flowing toward outfall to north
Storm Drain1	9/11/2012	MH	378-209-M52		Circ.	7.75	RC	IMG_4494	B	2	Manhole near NW outfall, some standing water at invert
Storm Drain1	9/11/2012	Pipe	378-209-453:M52								Piping from DI to manhole shown in GIS, connection not found in manhole
Storm Drain1	9/11/2012	Pipe	378-209-T01:M52	42	Circ.	5.70	RCP		B	1	Upstream pipe to west (size based on as-builts, field data not certain)
Storm Drain1	9/11/2012	Pipe	378-209-T01:M52	48	Circ.	6.00	RCP		B	1	Upstream pipe to east (size based on as-builts, field data not certain)
Storm Drain1	9/11/2012	Pipe	378-209-M52:C25	66	Circ.	7.75	RCP		B	2	Downstream pipe leading to outfall (size based on as-builts, field data not certain)
Storm Drain1	9/11/2012	MH	378-212-M27	48	Circ.	6.95	RC		B	1	Manhole on Quail Vista Lane
Storm Drain1	9/11/2012	Pipe	378-212-T02:M27	48	Circ.	6.95	RCP		B	1	Upstream of Quail Vista
Storm Drain1	9/11/2012	Pipe	378-212-M27:T03	48	Circ.	6.95	RCP		B	1	Downstream of Quail Vista
Storm Drain1	9/11/2012	Pipe	378-212-M41:M27	12	Circ.		Steel		B	1	South on Quail Vista, inverts are above invert of manhole
Storm Drain1	9/11/2012	Pipe	378-212-M43:M27	10	Circ.		Steel		B	1	North on Quail Vista, inverts are above invert of manhole
Storm Drain1	9/11/2012	Pipe	378-212-468:M27								Piping from DI to manhole shown in GIS, connection not found in manhole
Storm Drain 2	9/11/2012	MH	378-209-M35		Circ.	5.15	RC	IMG_4503, IMG_4504	B	1	On Ziebell Ct
Storm Drain 2	9/11/2012	Pipe	378-209-M60:M35	36	Circ.	5.15	RCP		B	2	Upstream of manhole (east)
Storm Drain 2	9/11/2012	Pipe	378-209-M35:C06	36	Circ.	5.15	RCP		B	2	Downstream of manhole (west)
Storm Drain 2	9/11/2012	Pipe	378-209-441:M35	10	Circ.	3.75	RCP		B	1	Connects to east side of street
Storm Drain 2	9/11/2012	Pipe	378-209-440:M35	10	Circ.	3.75	RCP		B	1	Connects to west side of street
Storm Drain 2	9/11/2012	Outfall	378-209-C06					IMG_4505, IMG_4506			Inaccessible, not located
Strom Drain 3	9/10/2012	MH	378-206-M31		Circ.	6.00	RC	IMG_4471	C	1	Corner of Saginaw Way
Strom Drain 3	9/10/2012	Pipe	378-206-427:M31	10	Circ.	4.10	RCP		C	2	Upstream pipe from north leg of Saginaw Way
Strom Drain 3	9/10/2012	Pipe	378-206-M32:M31	30	Circ.	5.50	RCP		C	2	Upstream pipe from eastern leg of Saginaw Way
Strom Drain 3	9/10/2012	Pipe	378-206-M31:542	36	Circ.	6.00	RCP		C	2	Downstream pipe from Saginaw to Sunrise Oaks Apts.
Strom Drain 3	9/10/2012	Overland Channel		24x64	Rect.	At street surface	RC	IMG_4472	C	2	Connects Saginaw Way and Sunrise Oaks Apts between yards, Downstream end has 2 openings (3'Wx24"H and 3'Wx15"H)
Strom Drain 3	9/10/2012	MH	378-206-M36				RC		C	2	Manhole at eastern end of Sunrise Oaks Apts, grate cover
Strom Drain 3	9/10/2012	Pipe	378-206-T03:M36	42	Circ.	5.15	RCP	IMG_4474	C	2	Upstream pipe from east, size estimated
Strom Drain 3	9/10/2012	Pipe	378-206-M36:M68	42	Circ.	5.15	RCP		C	2	Downstream pipe toward Sunrise, size estimated
Strom Drain 3	9/10/2012	Pipe	378-206-M37:M36	24	Circ.	5.15	RCP		C	2	Upstream pipe from south, sized estimated
Strom Drain 3	9/10/2012	MH	378-206-M43				RC		C	2	Manhole in west end of Sunrise Oaks Apts, grate cover 36" is shown connecting in GIS, not found in field (may be 48" inch connecting to manhole to north)
Strom Drain 3	9/10/2012	Pipe	378-206-M42:M43	42	Circ.	5.50	RCP		C	2	Upstream pipe to east from Sunrise Oaks parking lot
Strom Drain 3	9/10/2012	Pipe		42	Circ.	5.50	RCP		C	2	Downstream pipe heading west across Sunrise Blvd., May not be shown correctly in GIS, size estimated (not found in as-builts),
Strom Drain 3	9/10/2012	MH					RC		C	2	Manhole in grass between Sunrise Oaks Apts. and Valero. Not shown in GIS
Strom Drain 3	9/10/2012	Pipe		58x36	Rect.	5.20	RCP		C	2	Size based on as built plans, downstream pipe to west (not surveyed), Not shown correctly in GIS.
Strom Drain 3	9/10/2012	Pipe		36	Circ.	5.20	RCP		C	2	Size based on as built plans (field data not certain), downstream pipe to west. Not shown correctly in GIS
Strom Drain 3	9/10/2012	Pipe		48	Circ.	5.20	RCP		C	2	Size estimated, not found in as-builts, upstream pipe entering from east. Not shown correctly in GIS
Strom Drain 3	9/10/2012	Pipe		12	Circ.	5.20	RCP		C	2	Collector from north .Not shown correctly in GIS
Strom Drain 3	9/10/2012	Pipe		12	Circ.	5.20	RCP		C	2	Collector from north. Not shown correctly in GIS
Strom Drain 4	9/10/2012	MH	376-206-M32			7.25	RC		C	2	Corner of Meadowriver Way and Casa Bella Way
Storm Drain 4	9/10/2012	Pipe	376-206-M35:M32	12	Circ.	7.25	CMP		C	2	Collector that flows from west end of Meadowriver Way, not seen in manhole 376-206-M32, likely connects without manhole. Size is based on inspection of manhole at west end of Meadowriver Way
Storm Drain 4	9/10/2012	Pipe	376-206-M33:M32	36	Circ.	7.25	RCP		C	2	Flows north on Casa Bella Way to corner of Casa Bella Way and Meadowriver Way
Storm Drain 4	9/10/2012	Pipe	376-206-M29:M32	60	Circ.	7.25	RCP		C	2	Flows west on Meadowriver Way from Geowood Way to Casa Bella Way, Upstream end not clearly identified in MH 376-206-M29, but appears to connect a few feet south of structure
Storm Drain 4	9/10/2012	Pipe	376-206-M32M31	66							This pipe not located in MH 376-206-M32, flows found in manhole indicated that pipe was connected somewhere to the west without a manhole. Invert likely matching 376-206-M32
Storm Drain 4	9/10/2012	MH	376-206-M29			6.79	RC	IMG_4478	C	2	Corner of Geowood Way and Meadowriver Way, (connections shown in GIS not completely verifiable in field. Connections appears to happen a few feet to the south of structure).
Storm Drain 4	9/10/2012	Pipe	376-206-M30:M29	60	Circ.	6.79	CMP		C	2	Large diameter pipe from yard to north, connects to 48" inlet pipe that picks up about 10 feet to east
Storm Drain 4	9/10/2012	Pipe	376-206-452:M29	12	Circ.		CMP		C	2	To DI in intersection
Storm Drain 4	9/10/2012	Pipe	376-206-440:M29	12	Circ.		CMP		C	2	To DI in intersection
Storm Drain 4	9/10/2012	Pipe	376-206-M28:M29								Not clearly located, (pipe should connect to other pipes local to MH 376-206-M29, actual connections appear to happen a few feet south of manhole structure, pipe is assumed to exist but could not be physically verified).
Storm Drain 4	9/10/2012	Pipe	376-206-479:M30	48	Circ.		CMP	IMG_4479, IMG_4480	C	2	Outfall connection from creek to east to 60" that flows south to MH376206-
Storm Drain 4	9/10/2012	channel	376-206-39F02	60Wx48H	Rect.		Earthen		C	3	Lots of vegetation, small trees
Storm Drain 4	9/10/2012	MH	376-206-M21			6.75			C	2	Corner of San Cosme Dr and Canelo Hills Dr
Storm Drain 4	9/10/2012	Pipe	376-209-M11:M21	36	Circ.	6.75	RCP		C	2	Flows west from San Cosme Dr
Storm Drain 4	9/10/2012	Pipe	376-206-M21-M42	48	Circ.	6.75	RCP		C	2	Flows east from Canelo Hills Dr toward Sunrise
Storm Drain 4	9/10/2012	Pipe	376-206-M48:M21	12	Circ.				C	2	Flows south down Canelo Hills Dr
Storm Drain 4	9/10/2012	Pipe	376-206-M22:M21	12	Circ.				C	2	Flows north down Canelo Hills Drive
Storm Drain 4	9/10/2012	Pipe	376-206-434:M21	10	Circ.				C	2	From DI at NE corner
Storm Drain 4	9/10/2012	Pipe	376-206-435:M21	10	Circ.				C	2	From DI at SE corner
Storm Drain 4	9/10/2012	Pipe	376-206-436:M21	10"	Circ.				C	2	From DI at SW
Storm Drain 4	9/10/2012	MH	376-209-M09						C	2	On San Cosme Dr west of Alma Mesa Way
Storm Drain 4	9/10/2012	Pipe	376-209-M14:M09	36					C	2	From east
Storm Drain 4	9/10/2012	Pipe	376-209-479:M09	30					C	2	From north
Storm Drain 4	9/10/2012	Pipe	376-209-M09:M10	36					C	2	To west
Storm Drain 5	9/10/2012	MH	376-209-M08		Circ.	6.54	RC	IMG_4481	B	2	On Sugar Maple Way
Storm Drain 5	9/10/2012	Pipe	372-209-T01:M08	36	Circ.	6.54	RCP		B	2	From yard to northeast
Storm Drain 5	9/10/2012	Pipe	372-209-M08:M10	36	Circ.	6.54	RCP		B	2	To south on Sugar Maple Way
Storm Drain 5	9/10/2012	MH	372-209-M12				RC		B	2	End of Sweet Gum Ct

Table 3-1. Field Data and Photo Index

Drainage System Inventory Workmap No.	Date	Item Type	ID No.	Size, in	Shape	Depth to Invert, feet	Material	Photo No.	Condition Code		Notes
									Physical	Cleanliness	
Storm Drain 5	9/10/2012	Pipe	372-209-M09:M12	42	Circ.	6.35	RCP		B	2	From north on Sweet Gum Ct
Storm Drain 5	9/10/2012	Pipe	372-209-M12:C02	42	Circ.	6.35	RCP		B	2	To south toward creek on Sweet Gum Ct
Storm Drain 5	9/10/2012	Pipe	372-209-412:M12	10	Circ.		RCP		B	2	From DI on South Gum Ct
Storm Drain 5	9/10/2012	creek/outfall	372-209-11H10				earthen	IMG_4482, IMG_4483	B	2	In creek to south of Sweet Gum Ct
Storm Drain 6	9/10/2012	MH	372-203-M19		Circ.	5.00	RC	IMG_4493	C	2	Manhole at upstream end of west branch of SD6 model
Storm Drain 6	9/10/2012	Pipe	372-203-M22:M19	36	Circ.	5.00	RCP		C	2	From dirt driveway to east
Storm Drain 6	9/10/2012	Pipe	372-203-M19:M18	36	Circ.	5.00	RCP		C	2	Down Mariposa toward Sylvan Valley Way
Storm Drain 6	9/10/2012	Pipe	372-203-443:M19	12	Circ.				C	2	From DI to north
Storm Drain 6	9/10/2012	Pipe	372-203-449:M19	12	Circ.				C	2	From DI to south
Storm Drain 6	9/10/2012	MH	368-203-M40		Circ.	7.25	RCP		C	2	
Storm Drain 6	9/10/2012	Pipe	372-203-M16:M37	42	Circ.	7.25	RCP		C	2	Upstream Pipe from east. Size is based on city block maps (not determined in field)
Storm Drain 6	9/10/2012	Pipe	372-203-M37:M38	42	Circ.	7.25	RCP		C	2	Downstream Pipe to South. Size based on city block maps (not determined in field)
Storm Drain 7	9/10/2012	MH	368-203-M40		Circ.	9.25	RC		C	2	Manhole at upstream end of SD7, on Burich
Storm Drain 7	9/10/2012	Pipe	368-203-485:M40	36	Circ.	9.25	RC		C	2	
Storm Drain 7	9/10/2012	Pipe	368-203-M41-M40	24	Circ.	5.17	RC		C	2	
Storm Drain 7	9/10/2012	Pipe	368-203-426:M40	18	Circ.		RC		C	2	
Storm Drain 7	9/10/2012	Pipe	368-203-M40:T01	48	Circ.	9.25	RC		C	2	
Storm Drain 7	9/10/2012	Pipe	368-203-425:M40								Not found in field
Storm Drain 7	9/10/2012	MH	370-203-M08								Not found in field
Storm Drain 7	9/10/2012	Outfall	370-203-C35	48							Access restricted
Storm Drain 8	9/10/2012	MH	372-203-M08		Circ.	7.40	RC		C	2	Manhole at upstream end of SD8 model
Storm Drain 8	9/10/2012	Pipe	368-203-M07:M08	30	Circ.	4.90	RCP		C	2	Pipe upstream of 372-203-M08
Storm Drain 8	9/10/2012	Pipe	368-203-M08:M09	36	Circ.	7.40	RCP		C	2	Pipe downstream of 372-203-M08
Storm Drain 8	9/10/2012	MH	368-203-M39		Circ.	13.75	RC		C	2	Located in back parking lot of apartment complex
Storm Drain 8	9/10/2012	Pipe	368-203-T09:M39	48	Circ.	13.75	RCP				Size based on GIS (field data no certain)
Storm Drain 8	9/10/2012	Pipe	368-203-M39:Y09	48	Circ.	13.75	RCP				Size based on GIS (field data no certain)
Storm Drain 8	9/10/2012	MH	370-203-M07		Circ.	4.92	RC				Depth is to top of deck, Deck was ~48" above grade
Storm Drain 8	9/10/2012	Outfall	370-203-C32	48							Access restricted
Problem Area 1	9/11/2012	Ditch			trapezoidal	varies	earthen	IMG_4508, IMG_4509, IMG_4510, IMG_4511, IMG_4512, IMG_4513	C, F	3, 4	South side of Old Auburn Road, west of Wachtel Way, ditch is in various state of repair with more problematic parts near upstream end. Problems vary from cleaning needs to overgrowth. Some driveway culverts are present as well, a few of which are plugged or partially plugged with sediment.
Problem Area 1	9/11/2012	Ditch			trapezoidal	varies	earthen	IMG_4514, IMG_4515, IMG_4516, IMG_4517	C, F	3, 4	North side of Old Auburn Road, west of Wachtel Way, ditch is in various state of repair with more problematic parts near upstream end. Problems vary from cleaning needs to overgrowth. Some driveway culverts are present as well, a few of which are plugged or partially plugged with sediment.
Problem Area 2	9/11/2012	Outfall	376-209-484								Not able to locate in field, possibly in backyard
Problem Area 2	9/11/2012	MH	376-209-M03		Circular	4.00	RC	IMG_4498	B	2	Located on Oak Ave, east of Fox Hills Pipe to north has been plugged with concrete
Problem Area 2	9/11/2012	Pipe	376-209-405:M03	8	Circular	3.25	DIP		B	2	
Problem Area 2	9/11/2012	Pipe	376-209-484:M03								Pipe has been plugged with concrete
Problem Area 2	9/11/2012	Pipe	376-209-M03:M19	12	Circular	4.00	RCP		B	2	
Problem Area 2	9/11/2012	DI	376-209-404		Rect.	1.83	RC	IMG_4499	B	2	Corner of Oak Ave and Fox Hills Dr
Problem Area 2	9/11/2012	Pipe	376-209-404:431	10	Circular	1.83	PVC		B	2	
Problem Area 2	9/11/2012	DI	376-206-431		Rect.	1.83	RC		B	2	On Oak Ave, west of Fox Hills Dr
Problem Area 2	9/11/2012	Pipe	376-206-M46:431	10	Circular	0.83	PVC		B	2	

Table 3-1. Field Data and Photo Index

Drainage System Inventory Workmap No.	Date	Item Type	ID No.	Size, in	Shape	Depth to Invert, feet	Material	Photo No.	Condition Code Physical	Condition Code Cleanliness	Notes
Problem Area 2	9/11/2012	Pipe	376-206-431:428	10	Circular	0.83	PVC		B	2	
Problem Area 2	9/11/2012	MH	376-206-M19						C	4	Corner of Canelo Hills Drive and Oak Ave, Southeast side of street, Severe sedimentation, not draining
Problem Area 2	9/11/2012	Pipe	376-206-430:M19	10			PVC		B	2	
Problem Area 2	9/11/2012	Pipe	376-206-429:M19	12					B	2	
Problem Area 2	9/11/2012	Pipe	376-206-M19:428	Unknown					F	4	Filled with sediment, not draining
Problem Area 2	9/11/2012	DI	376-206-427			4.00	RC		B	2	Corner of Canelo Hills Drive and Oak, Northwest side of street,
Problem Area 2	9/11/2012	Pipe	376-206-428:427	12	Circular	4.00			B	2	
Problem Area 2	9/11/2012	Pipe	376-206-427:482	12	Circular	4.00			B	2	
Problem Area 3	9/10/2012	Ditch			trapezoidal	1.0 to 1.5	earthen	IMG_4491, IMG_4492	B, C	2, 3	South side of Highland Ave, between Rinconada and Mariposa. At upstream end near Rinconanda ditch is not present, but ground to south slopes away from street toward creek. 10" Culverts under driveways
Problem Area 4	9/10/2012	MH	372-203-M27		Circ.	6.75	RC		B	2	Manhole on Rinconada near Aptos Cir
Problem Area 4	9/10/2012	DI	372-203-431	12x18	Rect.	Unknown	RC	IMG_4489	C	2	DI connected to 372-203-M27, 6" outlet pipe likely too small for overland flow
Problem Area 4	9/10/2012	DI	372-203-430	12x18	Rect.	Unknown	RC	IMG_4490	C	2	DI connected to 372-203-M27, 6" likely too small for overland flow
Problem Area 4	9/10/2012	Pipe	372-203-M27:C18	24	Circ.	6.75	RC		B	2	Pipe between 372-203-M27 to outfall
Problem Area 4	9/10/2012	Pipe	372-203-M26:M27	24	Circ.	6.75	RC		B	2	Pipe upstream of 372-203-M27
Problem Area 4	9/10/2012	MH	372-203-M24		Circ.	5.50	RC		B	2	MH at Rinconada and Highland
Problem Area 4	9/10/2012	Pipe	372-203-M24:M25	12	Circ.	5.50	RC		B	2	Pipe south of 372-203-M24
Problem Area 5	10/30/2012	MH	370-203-M06		Circ.	4.41	RC	DSCN9289, DSCN9290	B	2	Manhole on North leg of Chula Vista
Problem Area 5	10/30/2012	Pipe	370-203-476:437	12	Circ.	4.41	RC		B	2	Connecting pipe from south
Problem Area 5	10/30/2012	Pipe	370-203-438:C04	15	Circ.	4.41	RC		B	2	Connecting pipe from north
Problem Area 5	10/30/2012	Outfall	370-203-C04	15	Circ.		RC	DSCN9291, DSCN9292	B	2	Outfall to creek
Problem Area 9	10/30/2012	MH	376-212-445				RC		B	2	Manhole on Blayden Ct
Problem Area 9	10/30/2012	Pipe	376-212-445:446	24		4.1	RC		B	2	Downstream pipe on Blayden
Problem Area 9	10/30/2012	Pipe	376-212-M35:445	18		4.1	RC		B	2	Upstream pipe on Blayden
Problem Area 9	10/30/2012	MH	376-212-M33				RC		B	2	Manhole on Old Ranch downstream from Amsell
Problem Area 9	10/30/2012	Pipe	376-212-M33:M34	18		4.4	RC		B	2	Downstream pipe on Old Ranch
Problem Area 9	10/30/2012	Pipe	376-212-439:M33	15		4.4	RC		B	2	Upstream pipe from Old Ranch to Amsell

3. Size – The size of a pipe measured during a subsurface investigation.
4. Shape – Shape of pipe or channel.
5. Depth to Invert – Depth from the ground/street surface to the invert of the pipe. Multiple pipe depths were listed with directional indicator (N, W, SE, etc.) to identify specific pipe depths.
6. Material – The facility material type code based on City's standard codes.
7. Photo No. – The file name of the digital photograph taken of the referenced facility. The digital photographs that are listed on Table 3-1 are provided as Appendix B which is included on the CD with this report.
8. Condition Code – Code identifications as described in Facility Conditions section, above.

3.3.1 General Observations

The project area contains a wide variety of facilities including drainage ditches, culverts, and channels, some located within private property. There are also some areas with more traditional curb and gutter systems that drain to an underground pipe system. All facilities ultimately drain to one of the three major creeks: Cripple Creek, Arcade Creek, or San Juan Creek. Examples of the types of facilities found in the study area are shown in Photos 3-1, 3-2, 3-3, and 3-4.

In general, field staff found that the majority of the existing drainage facilities in the study area are represented with reasonable accuracy in the City's GIS database. Field staff did find a few miscellaneous drainage facilities that were not included in the GIS database. In a one case, a significant portions of an existing drainage system was missing from the GIS database (i.e., portions of SD3 described in the next section).

Photo 3-1. Roadside Ditches and Driveway Culverts – Looking Northeast on Old Auburn Road toward Oakwood Hills Circle

Photo 3-2. Drainage Channel Outlet to Arcade Creek – Near Sweet Gum Court

Photo 3-3. No Roadside Ditches or Driveway Culverts – Heritage Meadow Lane near Black Tree Lane

Photo 3-4. Curb, Gutter and Inlet – Rinconada Way

3.3.2 Specific Findings

Major findings are summarized as follows:

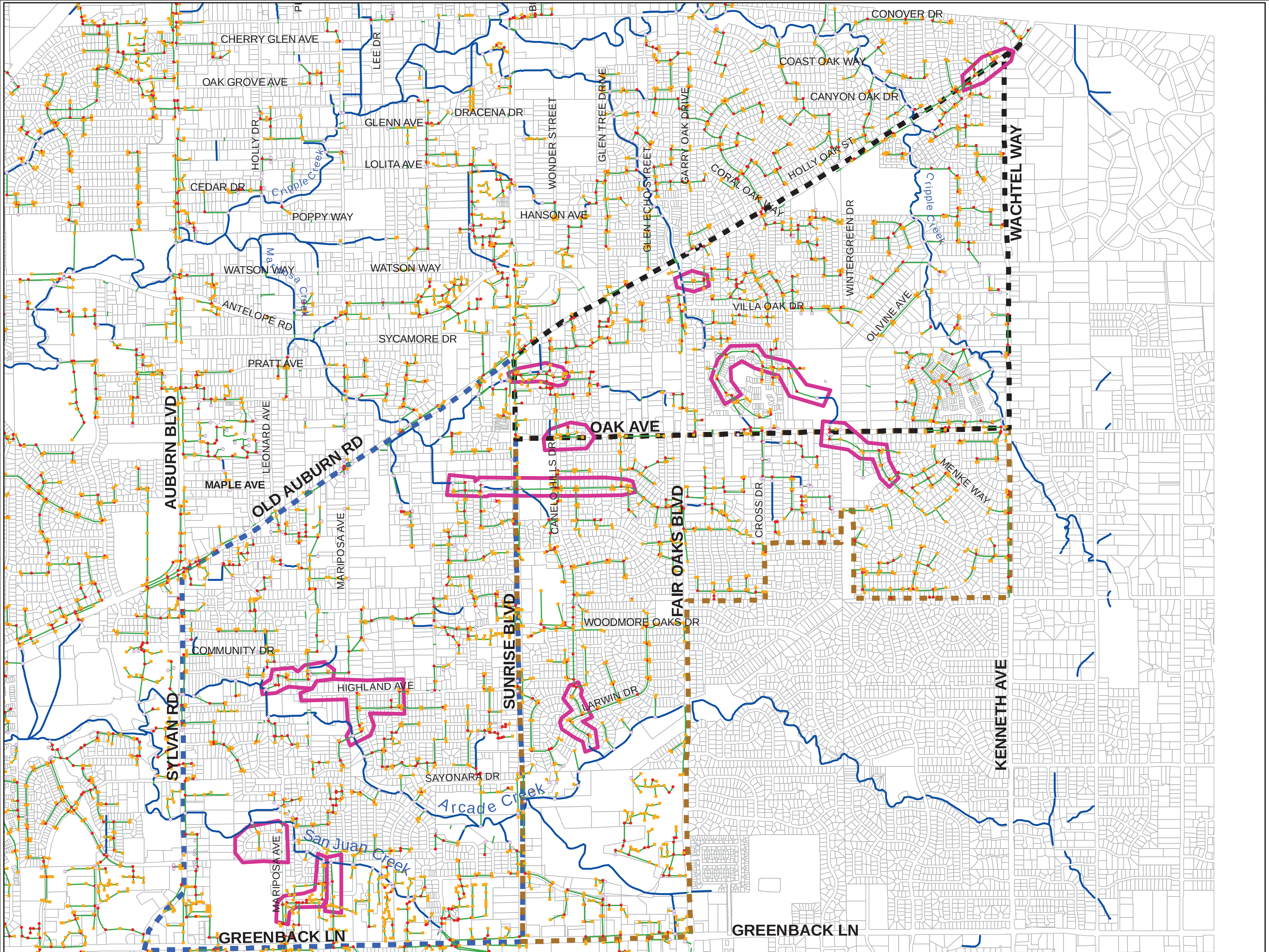
- Piped Drainage Systems: The field observation noted the following discrepancies in the City's GIS database related to piped drainage systems:
  - Trunk Drain SD3 in Sunrise Blvd. south of Old Auburn Road – Connections shown for the single manhole shown in the driveway at 2522 Sunrise Boulevard in the GIS database are not accurately represented. An additional manhole and parallel pipe system were observed at this location.
  - 6235 Burich Avenue – A manhole in an apartment complex parking area was not found in the field. This facility may have been paved over by the owner.
  - 6316 Mariposa Avenue – A manhole along the south boundary of an apartment complex was not located, and may not be accurately delineated in the GIS database.

- Physical Condition of Facilities – The existing drainage facilities that were observed in the field appear to be in reasonably good condition with a few exceptions:
  - Oak Avenue near Fox Hills Drive – In a manhole on the south side of Oak Avenue, west of Fox Hills Drive, we observed a large amount of sediment in the outflowing pipe and, as a result, there was standing water in the manhole. Another manhole east of Fox Hills Drive on the same drainage system contained a concrete plug that was not shown in the GIS database.
  - Rinconada Drive near Aptos Circle – Two inlets on Rinconada Drive, although not in poor physical condition, appear to be undersized and may be restricting flow into the pipe system. These inlets would be good candidates for wet weather observations.

It should be noted that there are limitations to the inventory work that was performed for this study. To keep the cost of the inventory to a reasonable level, many of the drainage facilities were only reviewed from surface. In those areas, if the facilities observed on the surface matched the information in the GIS database, it was assumed that the underground system in that area was also consistent with the GIS database. Without additional subsurface investigation, it is not possible to confirm this. Also, in some instances there were small drainage channels and storm drains that were in private property which field staff could not verify.

The information collected during the field inventory was used to update and correct the City's GIS database. This is described in more detail in Chapter 4.

N:\Clients\396 City of Citrus Heights\00-12-02 SDMP 8,9,10\GIS\Figures\SDMP_8-10_Fig3-1_Field_Assessment_Areas.mxd 10/31/2012



DRAFT **FIGURE 3-1**

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

FIELD ASSESSMENT AREAS

N

0 750 1,500
Scale in Feet

LEGEND

- Inlet
- Outfall
- Manhole
- Drainage Pipe
- Stream or Channel
- Field Assesment Area
- Neighborhood 8
- Neighborhood 9
- Neighborhood 10

WEST YOST ASSOCIATES
Consulting Engineers

CHAPTER 4
GIS Database Development

The City maintains a GIS database that includes data representing the existing drainage facilities in the City. For this study, West Yost obtained two shapefiles from the City: one that represents the point drainage facilities such as inlets, manholes, and outfalls; and one that represents line drainage facilities such as pipes, culverts, ditches, and creeks. These shapefiles were updated during this study to include corrected information related to the existing data or to include new information generated during the study.

4.1 GIS REVISIONS DEVELOPED FROM THE FIELD INVENTORY

West Yost performed a field inventory of the existing drainage facilities in the study area as described in Chapter 3. This task included verifying the existence and location of drainage facilities included in the City's GIS system. For some facilities, additional information was collected such as the facility condition, size, depth, etc. The findings from the drainage system inventory were used to update the City's GIS database. The approach to making these updates is described below.

1. Missing Facilities: Some drainage facilities were located during the field investigations that are not included in the City's original GIS database. The locations of these facilities were established in the field based on adjacent property lines or with a GPS unit. These facilities were added to the appropriate layer of the City's GIS database. Fields such as the X and Y coordinates and depth in the existing GIS database were filled in, as appropriate. The following additional fields were added to track the changes:
    - DATE_UPDAT – populated with mmyyyy (e.g., 092012)
    - UPDATE_BY – filled in with WEST YOST
    - LOC_Meth – includes a notation of either APPROX or GPS
    - NOTES – in the shapefile representing the point data, this field includes miscellaneous notes from the field and also an ID No. that corresponds to the ID No. on Table 3-1. For the shapefile representing the line data, this field may also include information on pipe size and condition.
2. Verified or Unverified Facilities: Facilities that were located in the field and found to be generally consistent with the existing mapping were tracked in the City's GIS database. New X and Y coordinates were provided for facilities that appeared to be located incorrectly in the original GIS database. Facilities that were accessible from the public right-of-way but could not be found were identified. Also, facilities that could not be assessed due to access limitations (e.g., private property) were identified. The verification status was included with "Verified – Found" (the facility was found), "Not Found" (the facility was not found), or "Not Verified – Private Property or Inaccessible" (the facility is on private property and its existence could not be verified). The date of verification corresponds to "DATE_UPDAT" field previously described.

The updated GIS shapefiles were renamed as follows:

- CH_RoadsideDrainage_update2012.shp
- CH_DrainageLinesMerge_update2012.shp
- CH_DrainagePointsMerge_update2012.shp

4.2 OTHER GIS DATA DEVELOPED DURING THE STUDY

In addition to the revisions described above, new drainage data was developed during the study and new shapefiles were created. The following data was developed during the study:

1. Watershed Boundaries for Trunk Pipes – As described in Chapter 6, hydrologic and hydraulic analyses were performed for the major trunk pipe systems within the study area. This included delineation of the watersheds draining to the pipe system. The watershed boundaries are represented in a new shapefile (trunk_pipe_sheds.shp).
2. Recommended Improvements – As described in Chapter 7, improvements were recommended to solve the flooding and drainage problems in the study area. The proposed improvements are schematically represented in the following shapefiles:
    - A shapefile representing proposed point facilities (Proposed Drain Point Solutions.shp)
    - A shapefile representing proposed pipe facilities (Proposed Pipeline Solutions.shp)
    - A shapefile representing proposed improvements to existing ditches (Proposed Ditch Solutions.shp)

CHAPTER 5
Hydrologic and Hydraulic Modeling Approach

West Yost performed hydrologic and hydraulic analyses of major storm drainage systems within the study area to assess their capacities, to determine deficiencies, and to define recommended new facilities. Descriptions of the types of facilities that were evaluated, the approach for the hydrologic and hydraulic analyses, and the criteria used to evaluate the performance of the facilities are provided below. Specific results from the analyses for the storm drains and problem areas are provided in Chapters 6 and 7.

5.1 FACILITIES EVALUATED DURING STUDY

Within the study area (see Figure 1-2), hydrologic and hydraulic analyses were performed to assess the performance of existing trunk drainage pipes that are 36-inches in diameter and larger. Significant flooding problems are less likely to occur in areas served by smaller pipe sizes because the small tributary watersheds typically served by these pipes tend to produce limited volumes of water. Even during large storms, the excess runoff from small watersheds can usually be conveyed or stored on the ground surface without causing property damage. Therefore, limiting the evaluation to the larger pipes was considered appropriate and allowed the level of effort for the study to be kept to a reasonable level. Descriptions of the specific trunk pipes analyzed during this study and the results of the analyses are provided in Chapter 6.

In addition to the trunk pipe systems, modeling was also performed for other areas that are known to have drainage or flooding problems. These areas were identified based on input from area residents, review of service calls compiled by the City and Sacramento County, and input from City staff. These known problem areas are served by a variety of drainage system types including pipes, roadside ditches, and channels. Descriptions of the specific problem areas and the results of the analyses are provided in Chapter 7. For most of the problem areas, hydrologic and hydraulic analyses were performed to size recommended facilities to eliminate or reduce the problems. Relatively complex problems were assessed using hydrologic and hydraulic modeling. Less complex problems were evaluated with spreadsheet calculations or normal depth analyses. For the simplest problems with relatively straightforward solutions, City staff directed that only qualitative analyses be performed. For those problems, general solutions were recommended without engineering calculations being performed.

As discussed previously, modeling was not performed for the major creeks in the area including Cripple Creek, Arcade Creek, and San Juan Creek. Although there are known flooding problems along these creeks, these problems represent regional flooding issues that need to be resolved in coordination with Sacramento County.

5.2 HYDROLOGIC ANALYSES

Peak flood flows were determined based on the methods in the County of Sacramento Municipal Services Agency Improvement Standards (County Standards) dated October 1, 2006. In accordance with these standards, peak flows for evaluating pipe systems were based on the Nolte Method. This method has been used in Sacramento County since the 1960's and produces peak flows that have a recurrence interval from 2- to 5-years. Nolte Method flood peaks were calculated for the major storm drainage facilities using Sacramento County's SacCalc software. SacCalc is a program that was developed for Sacramento County to assist local engineers in preparing hydrologic models based on the County Standards.

Peak flows for evaluating overland flow paths were based on the 100-year storm. The 100-year peak flows were determined using the Sacramento Method charts in the County Standards.

Watershed boundaries were determined primarily from 2-foot contour LIDAR topographic mapping. In some cases as-built plans, aerial photographs, and field visits were also used to assist with the watershed boundary definitions.

The land use within each watershed was determined from high resolution aerial photographs that were produced in 2008 for the California Department of Water Resources Central Valley Flood Plain Evaluation and Delineation project. Because the study area is nearly built out, land-use densities are not expected to change significantly in the future. Therefore, flood flows were only calculated for existing land-use conditions.

5.3 HYDRAULIC ANALYSES

Hydraulic analyses were performed to evaluate the performance of major drainage facilities and to size recommended improvements to solve problems. Hydraulic calculations were performed in accordance with the County Standards. The hydraulic calculations for pipe systems were based on the Friction Loss Method 1, which neglects minor losses but uses a larger Manning's n value to compensate. Typical Manning's n values used for the study are presented in Table 5-1.

Table 5-1. Typical Manning's n Values

Item	Manning's n Value
Concrete Pipe	0.015
Corrugated Metal Pipe	0.024 - 0.028
Open Channel	0.04 - 0.06

For all trunk pipelines, and for many of the drainage systems at the known problem areas, hydraulic models were prepared using the XP-SWMM modeling software. The XP-SWMM models were configured to perform steady-state calculations using peak flows for the pipe design event (Nolte Method) and also for the 100-year storm event.

Pipe sizes, invert elevations, and materials were determined from as-built drawings when available (see Table 2-2). For pipes without as-built plans, pipe data was estimated from field measurements. Invert elevations were estimated at key locations by measuring the depth to the invert from the surface, and subtracting this value from the nearest spot elevation from the LiDAR topographic data. Typically, this was done at two or three key points along a pipe system and that information was used to estimate the invert elevations at other locations along the pipeline. Channel and ditch sizes, depths, and inverts were also estimated using field measurements, LiDAR topographic data, and photographs. Because no field surveying was performed, the elevations used in the models are considered approximate.

The method used to establish the starting water surface elevations at the downstream ends of the hydraulic models was dependent on the specific situation. For drainage systems that discharge directly to Cripple Creek, Arcade Creek, or San Juan Creek, the water surface profiles published by FEMA were used. For the Nolte pipe design event, the starting water surface elevation was set to the 10-year water surface elevation in the creek. For the 100-year event, it was set to the 100-year water surface elevation in the creek. In most other cases, the starting water surface elevations were typically set at normal depth.

5.4 PERFORMANCE CRITERIA

The performance of the drainage systems was evaluated using the following criteria:

- For pipe systems, Sacramento County Standards require that the hydraulic grade line based on the pipe design flow (Nolte Method) be a minimum of 0.5 foot below inlet grates. This criterion was used for proposed new pipe systems. However, for existing pipe systems, it was considered acceptable for the hydraulic grade line to rise up to the elevation of the inlet grates.
- For open ditches and channels, the capacity should be adequate to contain the peak flows based on the Nolte Method, at a minimum.
- Ideally, structures should be protected from the 100-year storm by limiting the hydraulic grade line during the 100-year storm to no greater than nearby building pad elevations. Pad elevations were estimated using LiDAR topographic data. The economic feasibility of providing this level of protection was considered when recommending proposed drainage facilities.

For proposed new drainage systems, the primary objective was eliminating or reducing flooding problems. However, consideration was also given to incorporating features into the improvements that would improve stormwater quality or promote infiltration of runoff.

CHAPTER 6
Analysis of Existing Trunk Pipes

6.1 INTRODUCTION

As described in Chapter 5, hydrologic and hydraulic analyses of the existing trunk storm drain pipes were performed to determine whether the major pipe systems in the study area have adequate capacity. The trunk pipes with diameters 36-inches or larger were evaluated and are shown on Figure 6-1. Eight distinct trunk pipes or pipe systems were identified for evaluation during this study. Each of the systems was given a unique identifier (SD1 through SD8).

6.2 HYDROLOGIC ANALYSIS OF EXISTING PIPES

For each of the eight trunk pipe systems that were evaluated, SacCalc models were prepared to calculate peak design flows based on the Nolte Method (see additional discussion on methodology in Chapter 5). The Nolte Method flow rates were used to assess the capacities of the pipe systems. Peak flows for the 100-year storm were determined using the Sacramento Method charts. The 100-year flows were used to assess the adequacy of the pipe system and associated overland flow paths.

The watershed boundaries for each of the trunk pipe systems are shown on Figures 6-2 through 6-4. The calculated flood flows are presented in Table 6-1.

6.3 HYDRAULIC ANALYSIS OF EXISTING PIPES

For each of the eight trunk pipe systems that were evaluated, XP-SWMM models were prepared to perform hydraulic calculations. Chapter 5 provides additional discussion on the approach used to perform these calculations. The results from the XP-SWMM models were used to determine whether each pipe system had adequate capacity to convey the pipe design flows based on the City's drainage standards. In addition, the models were used to assess the adequacy of the overland release path for the 100-year storm.

The pipe layouts for each of the trunk systems are presented on Figures 6-2 through 6-4. The input data for each pipe system are presented in Table 6-2. It should be reiterated that field surveying was not performed for this study. The pipe data listed in Table 6-2 was based on as-built plans or approximate field measurements and is considered approximate.

Table 6-1. Peak Flows for Existing Trunk Storm Drains

Contributing Watershed	Upstream Node	Downstream Node	Contributing Area, acres by Land-Use Type and Percent Impervious: Comm./Office 90%	Apts./RD-20 80%	RD-5 50%	RD-4 40%	RD-3 30%	RD-2 25%	RD-1 20%	Open 2%	Subshed Total: Area, acres	Subshed Total: % Imp.	Cumulative Total at Upstream Node: Area, acres	% Imp.	Pipe Flow, cfs: Nolte Zone 1	100-year Flow, cfs: Sac. Method Zone 3
Trunk Storm Drain SD1																
SD1A	SD1A	SD1B	-	-	-	55.1	-	-	-	16.1	71.2	31.4	71.2	31.4	27.8	96.0
SD1B	SD1B	SD1C	-	1.4	-	-	-	-	16.4	20.6	38.4	12.5	109.6	24.8	52.7	130.0
SD1C	SD1C	J1E	-	7.4	3.3	-	-	-	-	-	10.7	70.7	120.3	28.9	63.3	145.0
SD1D	SD1D	SD1E	-	-	-	-	76.1	21.0	-	-	97.1	28.9	97.1	28.9	42.7	122.0
SD1E	SD1E	J1E	-	-	-	-	-	10.6	-	-	10.6	25.0	107.7	28.5	51.1	130.0
-	J1E	SD1Out	-	-	-	-	-	-	-	-	0.0	0.0	228.0	28.7	141.1	240.0
Trunk Storm Drain SD2																
SD2A	SD2A	SD2B	-	-	9.7	47.6	-	7.3	-	-	64.6	39.8	64.6	39.8	24.7	95[(a)]
SD2B	SD2B	SD2Out	-	-	-	6.4	-	-	-	-	6.4	40.0	71.0	36.9	27.7	101.0
Trunk Storm Drain SD3																
SD3A	SD3A	J3B	-	-	-	14.3	-	32.0	-	-	46.3	29.6	46.3	29.6	15.6	68.0
SD3B	J3B	J3D	-	2.4	-	13.8	-	3.7	-	-	19.9	42.0	66.2	33.4	25.4	90.0
SD3C	SD3C	J3D	1.5	0.8	2.6	41.0	-	-	-	3.4	49.3	40.1	49.3	40.1	17.1	74.0
SD3D	J3D	SD3Out	25.5	1.0	-	5.8	-	-	-	-	32.3	80.7	147.8	45.9	93.4	190.0
Trunk Storm Drain SD4																
SD4A	SD4A	J4B	3.3	-	-	72.4	-	11.2	-	1.4	88.3	39.4	88.3	39.4	37.3	120.0
SD4B	J4B	J4C	-	-	-	18.6	-	-	-	-	18.6	40.0	106.9	39.5	50.4	140.0
SD4C	J4C	CH1	2.4	-	-	14.6	-	-	-	0.4	17.4	46.0	124.3	40.4	67.4	160.0
SD4D	CH1	J4E	13.6	-	-	5.5	-	-	-	17.7	36.8	40.2	161.1	40.3	105.6	200.0
SD4E	J4E	J4F	-	-	-	15.3	-	-	-	-	15.3	40.0	176.4	40.3	115.3	210.0
SD4F	J4F	SD4Out	4.3	-	-	38.7	-	3.9	-	-	46.9	43.3	223.3	41.0	144.0	255.0
Trunk Storm Drain SD5																
SD5A	SD5A	SD5B	12.3	-	63.3	-	-	-	-	-	75.6	56.5	75.6	56.5	31.3	117[(a)]
SD5B	SD5B	SD5Out	-	-	50.4	-	-	-	-	-	50.4	50.0	126.0	53.9	69.6	180.0
Trunk Storm Drain SD6																
SD6A	SD6A	SD6B	-	3.5	13.2	-	-	48.5	-	-	65.2	33.0	65.2	33.0	25.0	90.0
SD6B	SD6B	SD6C	6.6	-	-	-	77.0	-	-	-	83.6	34.7	148.8	34.0	92.2	165.0
Trunk Storm Drain SD7																
SD7A	SD7A	SD7Out	3.4	11.4	30.3	-	-	-	-	-	45.1	60.6	45.1	60.6	17.0	79.0
Trunk Storm Drain SD8																
SD8A	SD8A	SD8B	6.5	6.2	64.7	-	-	-	-	-	77.4	55.8	77.4	55.8	32.1	122.0
SD8B	SD8B	SD8C	-	1.7	-	12.3	-	-	-	-	14.0	44.9	91.4	54.1	39.7	135.0
SD8C	SD8C	SD8D	-	7.7	-	-	-	-	-	-	7.7	80.0	99.1	56.1	44.8	145.0
SD8D	SD8D	SD8Out	-	4.0	-	2.4	-	-	-	-	6.4	65.0	105.5	56.6	50.0	155.0

(a) Due to lack of adequate overland flow paths in the upstream watershed, the full 100-year flow cannot reach this point. See the report for a more detailed discussion.

Table 6-2. Results from Hydraulic Analysis for Trunk Storm Drains

Conduit	Conduit Type	Upstream Node	Downstream Node	Length, ft	Upstream Invert Elevation, ft[(a)]	Downstream Invert Elevation, ft[(a)]	Slope, ft/ft	Manning's n Value	Pipe Diameter, in	Avg. Ditch Bottom Width, ft	Avg. Ditch or Street Flow Depth, ft	Avg. Side Slope, (H:V)	Est. Ground or Top of Channel Elev., ft[(a)]	Est. Low Pad Elev., ft[(a)]	Upstream Pipe Design hgl, ft[(a,b)]	Upstream 100-Year hgl, ft [(a),(b)]
Trunk Storm Drain SD1																
P_1A	Pipe	SD1A	J1A	340	194.0	187.5	0.0191	0.015	36	-	-	-	197.5	n/a	195.4	198.6
P_J1A	Pipe	J1A	SD1B	392	187.5	184.1	0.0087	0.015	36	-	-	-	195.6	n/a	189.1	196.0
P_1B	Pipe	SD1B	SD1C	133	184.1	183.6	0.0038	0.015	48	-	-	-	192.3	n/a	186.6	193.1
P_1C	Pipe	SD1C	J1Ca	147	183.6	182.9	0.0048	0.015	48	-	-	-	190.5	192.2	186.2	191.7
P_1Ca	Pipe	J1Ca	J1Cb	340	182.9	181.5	0.0041	0.015	48	-	-	-	190.3	192.9	185.6	189.8
P_1Cb	Pipe	J1Cb	J1E	470	181.5	179.4	0.0045	0.015	60	-	-	-	193.6	195.7	183.8	185.3
P_1D	Pipe	SD1D	J1D	161	181.7	181.1	0.0037	0.015	36	-	-	-	189.2	190.8	185.5	189.1
P_J1D	Pipe	J1D	SD1E	225	181.1	180.4	0.0031	0.015	36	-	-	-	188.2	190.2	184.7	188.3
P_1E	Pipe	SD1E	J1E	392	180.4	179.7	0.0018	0.015	42	-	-	-	185.9	188.7	183.6	186.0
PJ1E	Pipe	J1E	SD1Out	187	177.7	175.2	0.0134	0.015	66	-	-	-	185.0	188.2	180.2	180.8
OLR_1C	Street Surface	SD1C	J1Ca	147	190.5	192.0	-0.0102	0.020	-	5	1.0	1:1	190.5	192.2	186.2	191.7
OLR_1Ca	Street Surface	J1Ca	J1Cb	340	192.0	196.0	-0.0118	0.020	-	5	1.0	1:1	190.3	192.9	185.6	189.8
OLR_1Cb	Street Surface	J1Cb	J1E	470	196.0	185.4	0.0226	0.020	-	25	1.0	10:1	193.6	195.7	183.8	185.3
OLR_1D	Street Surface	SD1D	J1D	161	188.5	187.9	0.0037	0.020	-	25	1.0	10:1	189.2	190.8	185.5	189.1
OLR_J1D	Street Surface	J1D	SD1E	225	187.9	185.6	0.0102	0.020	-	25	1.0	10:1	188.2	190.2	184.7	188.3
OLR_1E	Street Surface	SD1E	J1E	392	185.6	185.4	0.0005	0.020	-	25	1.0	10:1	185.9	188.7	183.6	186.0
OLR_1Eb	Overland Flow	SD1E	SD1Out	260	185.5	180.0	0.0212	0.040	-	0	1.0	25:1	185.9	188.7	183.6	186.0
Trunk Storm Drain SD2																
P_2A	Pipe	SD2A	J2A	145	174.0	173.1	0.0062	0.015	30	-	-	-	178.3	181.7	175.3	181.0
P_J2A	Pipe	J2A	SD2B	163	172.2	170.9	0.0080	0.015	36	-	-	-	181.7	181.7	171.2	178.1
P_2B	Pipe	SD2B	SD2Out	179	170.9	169.9	0.0056	0.015	36	-	-	-	176.7	180.1	170.2	176.8
Trunk Storm Drain SD3																
P_3A	Pipe	SD3A	J3B	293	166.3	166.0	0.0010	0.015	36	-	-	-	172.4	175.0	168.6	173.7
P_3B	Pipe	J3B	J3D	476	166.0	164.2	0.0038	0.015	36	-	-	-	171.2	173.4	168.4	172.2
P_3C	Pipe	SD3C	J3D	400	166.8	163.3	0.0088	0.015	36	-	-	-	169.7	173.4	168.2	171.1
P1_3D	Pipe	J3D	J3E	140	163.3	162.1	0.0086	0.024	36	-	-	-	168.5	171.1	167.6	169.5
P2_3D	Pipe	J3D	J3E	140	163.3	162.1	0.0086	0.024	57x36 arch	-	-	-	168.5	171.1	167.6	169.5
P_3E	Pipe	J3E	SD3Out	94	162.1	162.0	0.0016	0.015	60	-	-	-	167.5	169.2	166.4	167.6
OLR_3A	Pipe	SD3A	J3B	125	172.7	171.8	0.0072	0.015	24x63 box	-	-	-	172.4	175.0	168.6	173.7
OLR_3B	Street Flow	J3B	J3D	476	171.7	169.7	0.0042	0.020	-	25.0	0.5	20:1	171.2	173.4	168.4	172.2
OLR_3C	Street Flow	J3C	J3D	400	170.5	168.7	0.0045	0.020	-	20.0	1.0	1:1	169.7	173.4	168.2	171.1
OLR_3D	Street Flow	J3D	J3E	140	168.8	168.3	0.0036	0.020	-	1.0	0.5	70:1	168.5	171.1	167.6	169.5
OLR_3E	Street Flow	J3E	SD3Out	90	169.0	168.5	0.0056	0.020	-	1.0	0.5	50:1	167.5	169.2	166.4	167.6
Trunk Storm Drain SD4																
P_4A	Pipe	SD4A	J4B	700	174.1	170.6	0.0050	0.015	36	-	-	-	181.7	182.9	176.7	182.5
P_4B	Pipe	J4B	J4C	271	170.6	168.4	0.0081	0.015	36	-	-	-	176.3	178.5	173.9	177.6
P_4C	Pipe	J4C	J4D	680	168.4	165.3	0.0046	0.015	42	-	-	-	173.6	177.1	172.0	176.8
P_4D	Pipe	J4D	CH1	60	165.3	164.6	0.0117	0.015	42	-	-	-	171.6	175.4	167.8	170.5
SD4_Chan	Open Channel	CH1	CH2	350	164.6	161.1	0.0100	0.060	-	5.0	7.0	2:1	167.5	175.4	167.3	168.5
P_CH2	Pipe	CH2	Junc	33	161.1	160.6	0.0152	0.015	48	-	-	-	164.7	168.4	163.5	166.8
P_Junc	Pipe	Junc	J4E	50	159.6	159.3	0.0060	0.015	60	-	-	-	n/a	168.4	163.0	166.0
P_4E	Pipe	J4E	J4F	250	159.3	158.5	0.0032	0.015	60	-	-	-	165.2	168.4	162.9	165.8
P_4F	Pipe	J4F	SD4Out	328	158.0	157.0	0.0030	0.015	66	-	-	-	165.2	166.7	162.1	164.3
OLR_4A	Street Flow	SD4A	J4B	700	181.7	176.7	0.0071	0.020	-	-	1.0	30:1	181.7	182.9	176.7	182.5
OLR_4B	Street Flow	J4B	J4C	271	176.7	174.5	0.0081	0.020	-	-	1.0	30:1	176.3	178.5	173.9	177.6
OLR_4C	Street Flow	J4C	J4D	470	176.0	172.0	0.0085	0.020	-	-	1.0	30:1	173.6	177.1	172.0	176.8
OLR_4D	Overland Flow	J4D	CH1	90	171.4	170.4	0.0111	0.020	-	-	0.5	50:1	171.6	175.4	167.8	170.5
OLRCH2	Overland Flow	CH2	J4E	50	165.5	166.5	-0.0200	0.040	-	-	1.0	1:1	164.7	168.4	163.5	166.8
OLR_4E	Overland Flow	J4E	J4F	250	166.1	165.5	0.0024	0.020	-	-	0.5	50:1	165.2	168.4	162.9	165.8

Table 6-2. Results from Hydraulic Analysis for Trunk Storm Drains

Conduit	Conduit Type	Upstream Node	Downstream Node	Length, ft	Upstream Invert Elevation, ft[(a)]	Downstream Invert Elevation, ft[(a)]	Slope, ft/ft	Manning's n Value	Pipe Diameter, in	Avg. Ditch Bottom Width, ft	Avg. Ditch or Street Flow Depth, ft	Avg. Side Slope, (H:V)	Est. Ground or Top of Channel Elev., ft[(a)]	Est. Low Pad Elev., ft[(a)]	Upstream Pipe Design hgl, ft[(a,b)]	Upstream 100-Year hgl, ft [(a),(b)]
Trunk Storm Drain SD5																
PSD5AB	Pipe	SD5A	J5A	170	166.5	165.5	0.0059	0.015	36	-	-	-	176.0	177.0	168.4	173.5
PSJ5AB	Pipe	J5A	SD5B	350	165.5	163.8	0.0048	0.015	36	-	-	-	171.6	174.1	167.5	172.2
PSD5BD	Pipe	SD5B	SD5D	215	163.3	162.0	0.0062	0.015	42	-	-	-	170.4	172.4	166.0	171.0
PSD5DE	Pipe	SD5D	SD5E	344	162.0	154.7	0.0212	0.015	42	-	-	-	169.1	170.9	163.9	168.8
PSD5EF	Pipe	SD5E	SD5F	173	154.7	154.3	0.0023	0.015	42	-	-	-	160.2	162.9	158.8	162.1
OLR_J5A	Street Flow	J5A	SD5B	350	171.7	170.3	0.0040	0.020	-	0.0	1.0	40:1	171.6	174.1	167.5	172.2
CDSD5BD	Street Flow	SD5B	SD5D	215	170.3	169.0	0.0060	0.020	-	0.0	1.0	40:1	170.4	172.4	166.0	171.0
CDSD5DE	Street Flow	SD5D	SD5E	344	168.4	160.5	0.0230	0.020	-	0.0	1.0	40:1	169.1	170.9	163.9	168.8
CDSD5EF	Overland Flow	SD5E	SD5F	173	161.5	159.0	0.0145	0.020	-	5.0	2.0	1.5:1	160.2	162.9	158.8	162.1
Trunk Storm Drain SD6 - With 10-year and 100-year FEMA Tailwater																
P_6A	Pipe	SD6A	J6A	280	144.7	143.0	0.0061	0.015	36	-	-	-	149.5	n/a	149.1	150.9
P_J6A	Pipe	J6A	SD6B	69	143.0	142.3	0.0101	0.015	36	-	-	-	147.8	147.8	**148.6**	**149.4**
P_6B	Pipe	SD6B	J6B	555	142.3	136.2	0.0110	0.015	42	-	-	-	148.2	147.8	**148.5**	**149.4**
P_J6B	Pipe	J6B	SD6Out	461	136.2	131.2	0.0108	0.015	42	-	-	-	143.3	145.2	142.4	144.2
OLR_6A	Overland Flow	SD6A	J6A	280	148.3	146.8	0.0054	0.040	-	3.0	1.0	1:1	149.5	n/a	149.1	150.9
OLR_J6A	Street Flow	J6A	SD6B	69	148.3	148.0	0.0043	0.020	-	40.0	0.5	50:1	147.8	147.8	**148.6**	**149.4**
OLR_6B	Street Flow	SD6B	J6B	555	148.5	143.4	0.0092	0.020	-	0.0	1.0	25:1	148.2	147.8	**148.5**	**149.4**
OLR_J6B	Street Flow	J6B	SD6_OLROut	250	143.4	140.2	0.0128	0.020	-	0.0	1.0	25:1	143.3	145.2	142.4	144.2
Trunk Storm Drain SD6 - No Tailwater																
P_6A	Pipe	SD6A	J6A	280	144.7	143.0	0.0061	0.015	36	-	-	-	149.5	n/a	146.4	150.9
P_J6A	Pipe	J6A	SD6B	69	143.0	142.3	0.0101	0.015	36	-	-	-	147.8	147.8	145.2	**149.4**
P_6B	Pipe	SD6B	J6B	555	142.3	136.2	0.0110	0.015	42	-	-	-	148.2	147.8	145.2	**149.4**
P_J6B	Pipe	J6B	SD6Out	461	136.2	131.2	0.0108	0.015	42	-	-	-	143.3	145.2	139.1	144.0
OLR_6A	Overland Flow	SD6A	J6A	280	148.3	146.8	0.0054	0.040	-	3.0	1.0	1:1	149.5	n/a	146.4	150.9
OLR_J6A	Street Flow	J6A	SD6B	69	148.3	148.0	0.0043	0.020	-	40.0	0.5	50:1	147.8	147.8	145.2	**149.4**
OLR_6B	Street Flow	SD6B	J6B	555	148.5	143.4	0.0092	0.020	-	0.0	1.0	25:1	148.2	147.8	145.2	**149.4**
OLR_J6B	Street Flow	J6B	SD6_OLROut	250	143.4	140.2	0.0128	0.020	-	0.0	1.0	25:1	143.3	145.2	139.1	144.0
Trunk Storm Drain SD7																
P_SD7	Pipe	SD7A	SD7Out	650	148.6	145.1	0.0054	0.015	48	-	-	-	157.8	158.2	149.8	151.6
Trunk Storm Drain SD8																
P_SD8A	Pipe	SD8A	J8A	114	152.9	152.0	0.0079	0.015	36	-	-	-	160.4	161.7	154.6	161.2
P_J8A	Pipe	J8A	SD8B	620	152.0	147.4	0.0074	0.015	42	-	-	-	161.7	160.7	153.6	159.8
P_SD8B	Pipe	SD8B	SD8C	115	147.4	146.5	0.0081	0.015	42	-	-	-	156.0	156.6	149.2	**156.5**
P_SD8C	Pipe	SD8C	J8C	299	146.5	144.3	0.0073	0.015	48	-	-	-	153.3	n/a	148.4	155.6
P_J8C	Pipe	J8C	SD8D	255	144.3	143.5	0.0031	0.015	48	-	-	-	155.3	158.1	146.8	153.5
P_SD8D	Pipe	SD8D	SD8Out	358	143.5	142.5	0.0028	0.015	48	-	-	-	151.3	155.2	146.2	151.8
OLR_A	Street Flow	SD8A	OLR_AC	310	160.3	158.6	0.0055	0.020	-	0.0	1.0	30:1	160.4	161.7	154.6	161.2
OLR_AC	Overland Flow	OLR_AC	SD8C	432	158.6	154.2	0.0102	0.035	-	34.0	0.5	1:1	158.9	n/a	158.6	159.2
OLR_CD	Overland Flow	SD8C	SD8D	460	155.0	151.7	0.0072	0.020	-	15.0	0.5	1:1	153.3	n/a	148.4	155.6
OLR_8D	Street Flow	SD8D	SD8Out	358	151.0	149.5	0.0042	0.020	-	0.0	0.5	30:1	151.3	155.2	146.2	151.8

[(a)] All elevations are based on the North American Vertical Datum 1988.

[(b)] Hgl values with red and bold text indicate that the performance criteria is not met at that location.

6.4 RESULTS FROM THE ANALYSIS OF EXISTING PIPES

Calculated water surface elevations along the pipe systems are presented in Table 6-2. These water surface elevations were used to determine whether the pipe systems have adequate capacity based on the following criteria:

- The pipe design hydraulic grade line (hgl) should be below the inlet grate elevation; and
- The 100-year hgl should be below the lowest adjacent pad elevation.

At those locations where the calculated water surface (i.e., the hgl) does not meet the capacity criteria above, the water surface elevation is highlighted in Table 6-2 with a bold red font. As Table 6-2 shows, each of the pipe system meets the criteria with the exception of trunk pipe SD6. That pipeline does not meet the City's criteria for either the pipe design storm event or the 100-year storm event at Nodes J6A or SD6B, which are located near the upstream end of the pipeline at Mariposa Avenue.

For the pipe design storm event, the predicted flooding is largely the result of the high tailwater in Arcade Creek, which is approximately 2.6 feet above the top of the outfall pipe. If the tailwater is low, the pipe has sufficient capacity to convey the design flow without flooding. To illustrate this, water surface elevations for trunk pipe SD6 are presented for both the high tailwater and low tailwater conditions in Table 6-2. As shown in the table, when the tailwater is low, there is no flooding predicted during the pipe design event.

For the 100-year storm, flooding is predicted at Mariposa Avenue regardless of the tailwater conditions. One lot on the east side of the roadway sits lower than the roadway and the ground around the lot. This lot is at risk of flooding during a large storm event. This potential flooding problem was added to the list of problems that also includes problems that were identified through public outreach and a review of service call records. The evaluations of potential solutions to solve all of the identified problems are described in Chapter 7. In that chapter, the problem along trunk drain SD6 is included as Problem 10.

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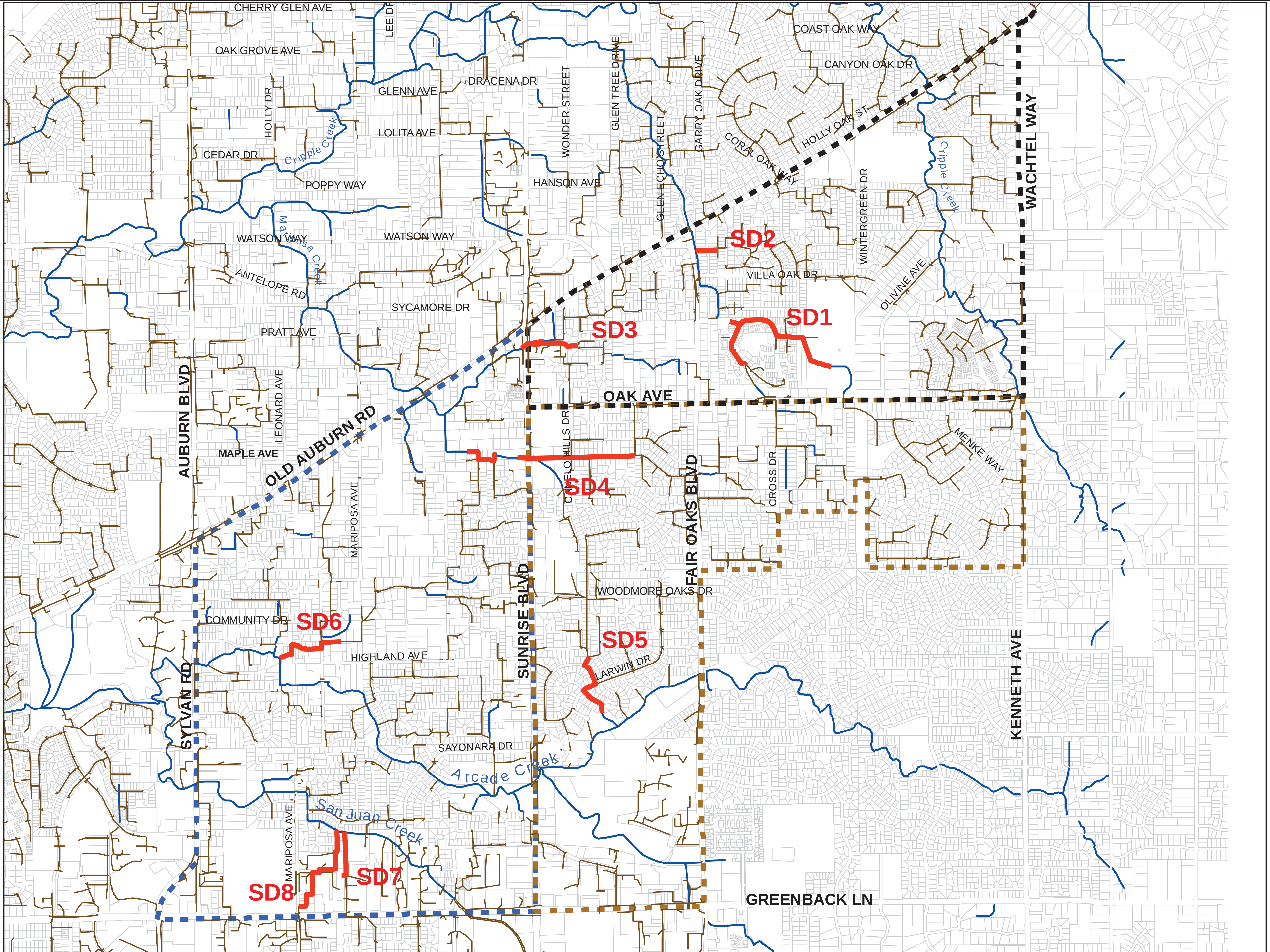

FIGURE 6-1

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

TRUNK PIPES

LEGEND

- Trunk Pipe (36" and Larger)
- Drainage Pipe
- Stream or Channel
- Neighborhood 8
- Neighborhood 9
- Neighborhood 10

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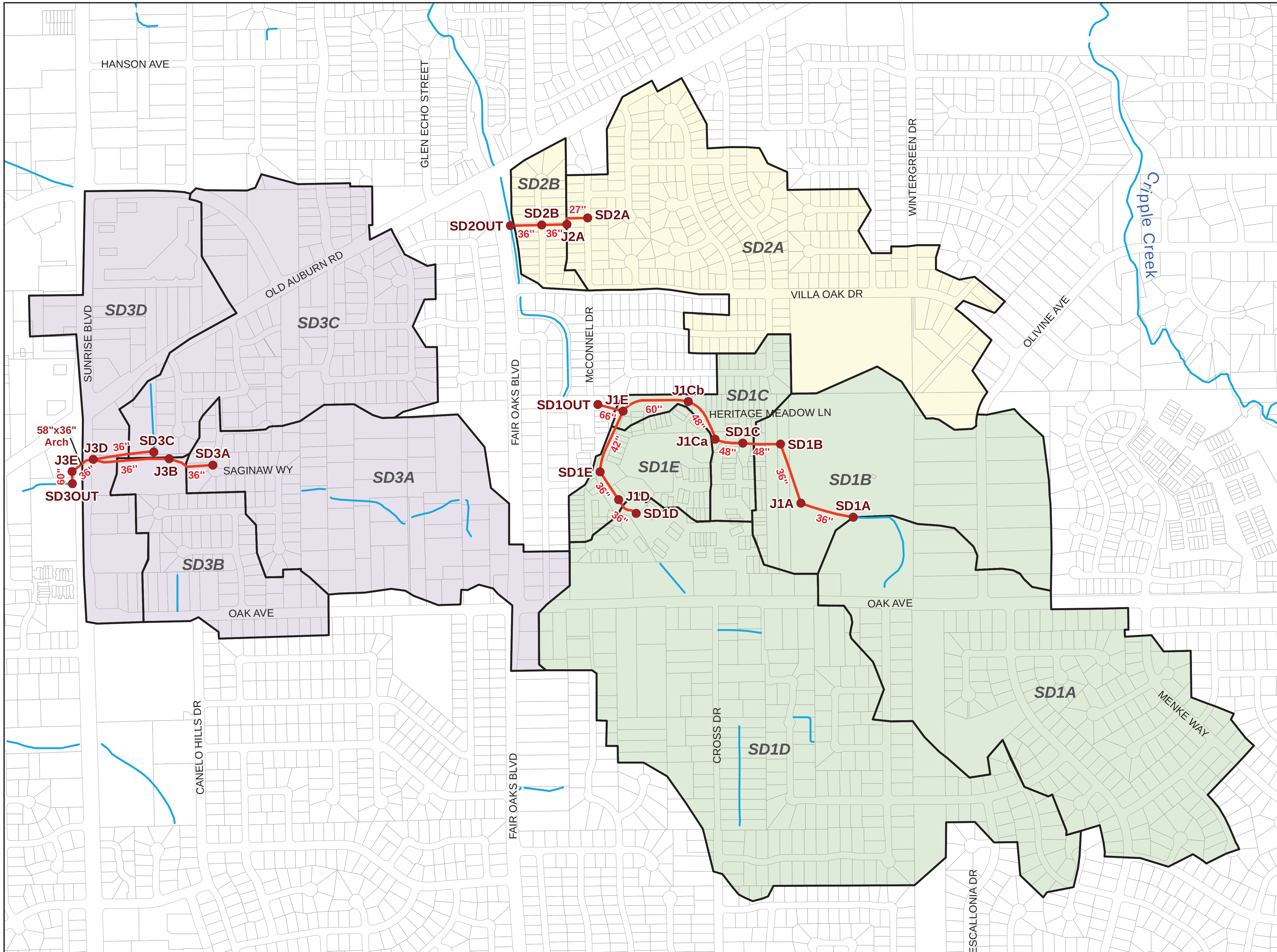
FIGURE 6-2

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

TRUNK PIPES SD1, SD2, and SD3 SUBSHEDS AND MODELED FACILITIES



N

0 300 600

Scale in Feet

LEGEND

- Modeled Node
- Modeled Trunk Pipe
- Stream or Channel
- Trunk Pipe SD1 Subshed
- Trunk Pipe SD2 Subshed
- Trunk Pipe SD3 Subshed

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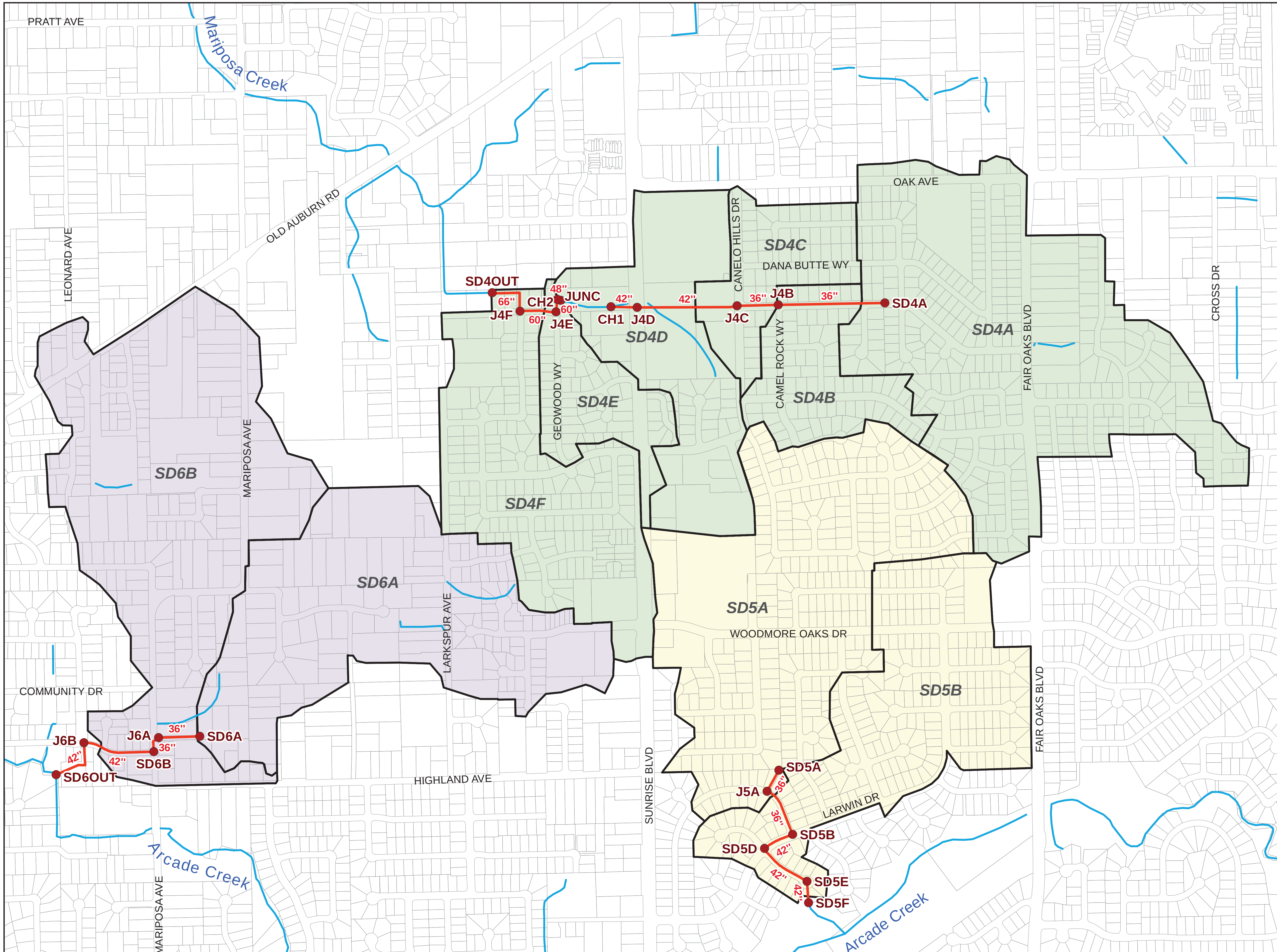
FIGURE 6-3

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

TRUNK PIPES SD4, SD5, and SD6 SUBSHEDS AND MODELED FACILITIES



0 325 650
Scale in Feet

LEGEND
- Modeled Node
- Modeled Trunk Pipe
- Stream or Channel
- Trunk Pipe SD4 Subshed
- Trunk Pipe SD5 Subshed
- Trunk Pipe SD6 Subshed

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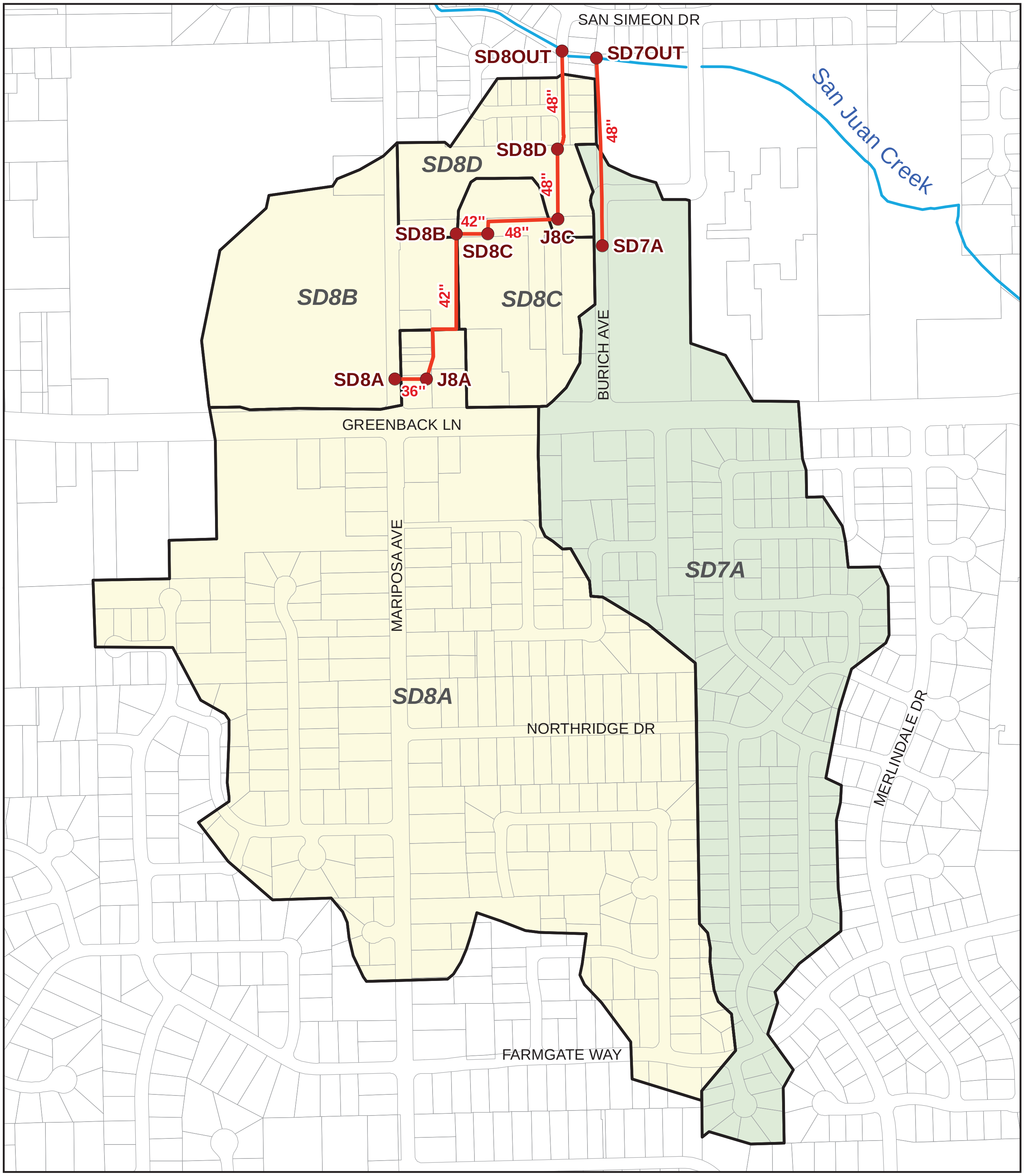

LEGEND

- Modeled Node
- Modeled Trunk Pipe
- Stream or Channel
- Trunk Pipe SD7 Subshed
- Trunk Pipe SD8 Subshed

N

0 250 500

Scale in Feet

FIGURE 6-4

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

TRUNK PIPES SD7 AND SD8 SUBSHEDS AND MODELED FACILITIES

WEST YOST ASSOCIATES Consulting Engineers

CITY OF CITRUS HEIGHTS JANUARY 1, 1997

CHAPTER 7
Analysis of Problem Locations

7.1 INTRODUCTION

One of the key objectives of this study was to identify significant drainage and flooding problems in the study area and to develop solutions to reduce or eliminate the problems. The problem locations were identified from the following activities:

- Existing Trunk Pipe Analyses – As discussed in Chapter 6, hydraulic analyses were performed for the existing trunk pipe systems within the detailed study area. One trunk pipe system, SD6, was found to have a potential flooding problem.
- Review of Service Call Records – As discussed in Chapter 2, City staff provided service call records that document problems reported by residents during prior storm events. These records were reviewed to determine potential problem locations.
- Input from City Staff – City staff have significant knowledge of the drainage issues in the study area based on prior discussions with residents and visual observations during storm events. West Yost met with City staff at the outset of the project to obtain input on known problem locations.
- Input from Public – A public meeting was held on April 10, 2012 to solicit input from area residents on potential flooding and drainage problems. Descriptions of potential problems were provided by the residents both orally and in writing. As discussed in Chapter 2, a summary table was prepared after the meeting that provides descriptions of each problem, the location of the problem, the name and address of the resident that reported the problem, and a problem category (i.e., flooding, drainage system, maintenance). This summary table was provided in Table 2-3. Additional problems were reported by residents outside of the public meeting forum.

Based on the above activities, a total of 12 flooding and drainage problems were identified for evaluation. The general locations of the problems are shown on Figure 7-1. Relatively complex problems were assessed using hydrologic and hydraulic modeling. Less complex problems were evaluated with spreadsheet calculations or normal depth analyses. For the simplest problems with relatively straightforward solutions, City staff directed that only qualitative analyses be performed. For those problems, general solutions were recommended without engineering calculations being performed.

For all problem areas where modeling or other hydraulic calculations were performed, pipe and channel sizes, depths, and inverts were estimated from limited field measurements, LiDAR topographic data, and photographs. Pad elevations, which were used to estimate flooding thresholds, were also estimated from LiDAR topographic data. As a result, the hydraulic calculations are approximate. They are considered adequate for planning purposes, but field surveying will be necessary prior to the final planning and design of the recommended improvements. The hydraulic calculations for the problem evaluations are provided in Appendix C.

Each flooding and drainage problem area is described in the following sections along with descriptions of the evaluation performed and the recommended solution. In some cases, multiple problems were grouped together for evaluation due to their proximity to one another. Therefore, some of the sections below include discussions of more than one problem.

7.2 PROBLEM LOCATION 1

7.2.1 Description of Problem Location 1

Problem Location 1 is at the northeast corner of the study area along Old Auburn Road (see Figure 7-2). Runoff from a small watershed (approximately 2.3 acres) flows to the northwest corner of a lot located near the intersection of Old Auburn Road and Wachtel Way. The runoff does not effectively drain from the lot because it is blocked by a driveway located just west of the lot along Old Auburn Road. The runoff is intended to drain into a roadside ditch along Old Auburn Road and flow under the driveway in culvert. However, the roadside ditch at that location is not well defined and the existing culvert under the adjacent driveway has been buried and no longer functions as intended.

7.2.2 Proposed Solution for Problem Location 1

The proposed solution for Problem Location 1 is shown on Figure 7-2. The solution includes re-grading the roadside ditch along Old Auburn Road in front of the problem location and construction of a new culvert underneath the adjacent driveway. The ditch should have a one-foot bottom width, 1 to 1 side slopes, and a minimum depth of 1.5 feet. A 12-inch concrete culvert should be constructed under the driveway. An XP-SWMM model was prepared for the culvert sizing. Results from the modeling can be found in Appendix C.

7.3 PROBLEM LOCATION 2

7.3.1 Description of Problem Location 2

A residential lot on Fox Hills Drive has drainage problems due to runoff entering the lot from the surrounding properties and poor drainage within the backyard (see Figure 7-3). The resident has constructed a drainage swale in the backyard, but it appears that the ditch may not have sufficient depth to effectively convey runoff.

7.3.2 Proposed Solution for Problem Location 2

The proposed solution for this problem is to provide an under sidewalk drain along the south side of the residential lot. This will provide the resident with the ability to create a deeper swale or ditch to drain the backyard (See Figure 7-3). The location of the sidewalk drain should be coordinated with the property owner prior to construction. This solution was developed qualitatively; no hydrologic or hydraulic modeling was performed.

7.4 PROBLEM LOCATIONS 3 AND 4

7.4.1 Description of Problem Location 3

Highland Avenue has a roadside ditch system that conveys runoff from the surrounding areas to the west. The ditch is small and does not provide adequate capacity to serve the area. Flooding has been reported by several residents that live along Highland Avenue west of Beam Drive. In addition, Beam Drive is drained by a small ditch between the northbound and southbound lanes. This ditch conveys runoff south to Highland Avenue. The ditch is small and shallow and does not provide adequate capacity. During large storms, overflow from the ditch produces property flooding along the west side of Beam Drive. This problem location is shown on Figure 7-4.

7.4.2 Description of Problem Location 4

Flooding has been reported along Rinconada Drive. There is a low point along the roadway south of Aptos Circle that has very small inlets that drain into a pipe system that coveys runoff east between two lots and into Arcade Creek. During large storms that exceed the capacity of the pipe system, the excess flows form a pond in the street. Because there is no overland release path to allow the excess flows to be safely conveyed to the creek, some of the lower lying homes are at risk of flooding during large storm events. A contributing factor to the flooding problem is that, during large storms, runoff that exceeds the capacity of the Highland Avenue drainage system (Problem Location 3) flows over Highland Avenue and continues south to the low point on Rinconada Drive. This problem location is shown on Figure 7-4.

7.4.3 Proposed Solution for Problem Locations 3 and 4

Two options were developed for solving the problems at Locations 3 and 4. Both options are described below and a recommended option is identified.

7.4.3.1 Proposed Solution for Problem Locations 3 and 4 – Option 1

The improvements included with Option 1 are shown on Figure 7-5A. For this option, the solution for Problem Location 3 includes an asphalt concrete v-ditch along Beam Drive that will replace the existing shallow earthen ditch. This v-ditch will have side slopes of 3:1 (H:V), and will be 1 foot deep and 6 feet wide. This ditch will convey flows up to the 10-year peak flow of 7.2 cfs. At the time of design, if it is determined that additional ditch width can be accommodated, the ditch should be widened to increase the flow capacity up to the 100-year peak flow of 11 cfs. The ditch design will need to accommodate traffic safety features since it is in the middle of the road. The v-ditch in Beam Drive will convey runoff south to a new pipe system in Highland Avenue that will convey runoff west to Mariposa Avenue. The size of the pipe varies from 21 to 24 inches in diameter. At Mariposa Avenue, the new pipe will connect to another new pipe that is proposed for Problem Location 10 (see discussion below). The new pipe in Mariposa Avenue will convey runoff south to Arcade Creek. The existing roadside ditch on the north side of Highland Drive between Beam Drive and Mariposa Avenue will be filled and replaced with a valley gutter to collect runoff and direct it to inlets connected to the pipe system.

To help reduce the flooding at Problem Location 4, runoff entering the existing inlet at the southeast corner of Highland Avenue and Rinconada Drive will be re-directed into the new Highland Avenue pipe system instead of the pipe that conveys runoff south along Rinconada Drive. The existing 10-inch pipe in Rinconada Drive will be abandoned between Highland Avenue and Spring Valley Avenue. Additional improvements to reduce the flooding risk on Rinconada Drive include enlarged drain inlets at the low point and an overland release structure, which is essentially a small rectangular concrete channel, between two lots on Rinconada Drive to allow some of the excess flow during large storms to be conveyed overland to Arcade Creek.

7.4.3.2 Proposed Solution for Problem Locations 3 and 4 – Option 2

As shown on Figure 7-5B, Option 2 includes all of the elements as Option1 plus the pipe system in Highland Avenue will be extended east to Pacheco Way. This allows more runoff to be diverted into the Highland Avenue pipe system that would otherwise flow to the problem area on Rinconada Drive. The existing pipe on Pacheco Way between Highland Avenue and Spring Valley Avenue would be plugged and abandoned. The size of the extended pipe in Highland Avenue would be 27 inches. Because this option directs more runoff into the new pipe in Highland Avenue east of Beam Street than Option 1, the size of the pipe along this reach needs to be increased to 30 inches for Option 2. The new pipe proposed in Mariposa Avenue for the solution to Problem Location 10 has adequate capacity for this option.

7.4.3.3 Recommended Solution for Problem Locations 3 and 4

Option 2 is the recommended solution for Problem Locations 3 and 4. Although Option 2 is significantly more costly than Option 1 ($878,000 versus $529,000), Option 2 provides significantly better flood protection for Problem Location 4 on Rinconada Drive. Option 2 would lower the 100-year water surface elevation on Rinconada Drive by an additional 1 foot compared to Option 1. Option 2 could provide protection against the 100-year storm event depending on the water elevations in Arcade Creek at the time of the local peak flow. Option 1 would not provide 100-year protection. Hydraulic calculations for the proposed pipe system included with Option 2 are provided in Appendix C.

7.5 PROBLEM LOCATION 5

7.5.1 Description of Problem Location 5

Chula Vista Drive and the surrounding area are drained by a roadside ditch system that delivers runoff to a 15-inch storm drain pipe that discharges to San Juan Creek (see Figure 7-6). The outfall pipe to the creek passes through a residential lot and the owner of the lot reports that the pipe may be failing and causing his driveway to sag and crack. In addition, there is not an adequate overland release path for flows that exceed the capacity of the pipe system.

7.5.2 Proposed Solution for Problem Location 5

The proposed solution for Problem Location 5 is to replace the existing 15-inch outfall pipe with a 24-inch pipe. This pipe will provide 3.5 times the capacity of the existing outfall and would be adequate to convey the 10-year flow of 16.8 cfs. The proposed solution is shown on Figure 7-6. Normal depth hydraulic calculations were performed and are summarized in Appendix C.

7.6 PROBLEM LOCATIONS 6 AND 10

Problem Locations 6 and 10 are shown on Figure 7-7 and are described below.

7.6.1 Description of Problem Location 6

Residents on Glenacre Way have reported multiple flooding instances ranging from flooded garages to flooded homes. A small storm drain collects runoff from the eastern portion of Glenacre Way and conveys it to a low point near the west end of the road. From this point, runoff is conveyed south between two residential lots in a 24-inch storm drain. A 21-inch storm drain from the north also conveys runoff to the 24-inch pipe. The 24-inch pipe drains a watershed of approximately 50 acres. The main problem is that the roadway and the homes on the south side of the road lie relatively low compared to the surrounding area. There is no overland release path for conveyance of flows in excess of the pipe system capacity. Therefore, during large storm events, runoff collects in the street. If the storm is large enough, the water can pond to a level that causes flooding.

To assist with evaluating the problem, a XP-SWMM hydraulic model was prepared for the Glenacre Way drainage system. Because Glenacre Way is tributary to trunk pipe SD6, the modeling prepared for SD6 was extended upstream to the Glenacre Way area. Model results for existing conditions indicate that five building pads on the south side of Glenacre Way could be inundated during a 100-year storm event.

7.6.2 Description of Problem Location 10

Problem Location 10 is at the intersection of Mariposa Avenue and Sylvan Valley Way. A residential lot on the east side of Mariposa Avenue sits lower than the roadway and is predicted to be at risk of flooding during a large storm that exceeds the capacity of the nearby trunk pipe system, which is trunk drain SD6. This problem was identified during the trunk drain modeling performed for trunk drain SD6 (see Chapter 6).

7.6.3 Proposed Solution for Problem Locations 6 and 10

Three options were considered for solving the problems at Locations 6 and 10. All three options were evaluated with XP-SWMM hydraulic models. These options are described below and a preferred option is recommended.

7.6.3.1 Proposed Solution for Problem Locations 6 and 10 – Option 1

For this option, the flooding at Problem Location 6 would be addressed by construction of a detention basin in the playfield of the church property to the north of Glenacre Way (see Figure 7-8A). The basin would cover 1.3 acres and would be approximately seven feet deep. Flow would be diverted from the nearby pipe system into the detention basin when the pipe system begins to surcharge but prior to flooding occurring on Glenacre Way. Hydraulic modeling indicates that the detention basin would reduce the 100-year flood elevation at Glenacre Way by 0.8 feet and would prevent three of the five at-risk pads from flooding. Two pads are still predicted to flood.

To help solve the flood potential at Problem Location 10, a pipe would be constructed in Mariposa Avenue from the intersection of Sylvan Valley Way south to Arcade Creek. The pipe would be 36-inches in diameter from Sylvan Valley Way to Highland Avenue and 42-inches from Highland Avenue to Arcade Creek. This pipe extension would reduce the 100-year water surface elevation below the pad elevation of the at-risk lot. The pipe from Highland Avenue to Arcade Creek is sized to accept flow from the new pipeline proposed to be constructed in Highland Avenue that will help to reduce the flooding at Problem Locations 3 and 4. This pipeline is not shown on Figure 7-8A, which shows the other improvements for this option, but can be seen on Figure 7-8B.

7.6.3.2 Proposed Solution for Problem Locations 6 and 10 – Option 2

For Option 2, the capacity of the pipe system that conveys runoff from Glenacre Way would be increased. As shown on Figure 7-8B, the existing pipes between Glenacre Way and Sylvan Valley Way would be increased to 42-inches in diameter. A portion of the existing pipe system that currently runs through backyards would be relocated into Mariposa Avenue. In addition, just as with Option 1, a new pipe ranging in size from 36-inches to 42-inches would be extended south along Mariposa Avenue from Sylvan Valley Way to Arcade Creek. Hydraulic modeling indicates that this option would reduce the 100-year water surface elevation at Glenacre Way (Problem Location 6) by 0.9 feet and would eliminate all pad flooding. The potential 100-year flooding at Problem Location 10 would also be eliminated.

7.6.3.3 Proposed Solution for Problem Locations 6 and 10 – Option 3

For Option 3, the houses at the at-risk lots would be raised above the predicted flood elevation. To reduce the number of houses that would be raised, underground detention storage would be also constructed in Glenacre Way (see Figure 7-8C). Approximately 450 feet of 2’x12’ box culvert would be constructed in the street to provide detention storage. A weir structure would be constructed at the existing manhole at the west end of Glenacre Way. During large storm events when the existing pipe system begins to surcharge, flow would spill over the weir into the box culvert. This alternative would reduce the 100-year water surface elevation at Glenacre Drive by approximately 0.2 feet. Three pads would remain in the floodplain and the houses at these locations would be raised above the flood elevation.

As with Options 1 and 2, a pipe would be constructed in Mariposa Avenue from the intersection of Sylvan Valley Way south to Arcade Creek (see Figure 7-8B). The pipe would range in size from 36-inches to 42-inches and would be sized to accept flow from the new pipeline proposed in Highland Avenue to help solve the flooding at Problem Locations 3 and 4.

7.6.3.4 Recommended Solution for Problem Locations 6 and 10

Option 2, which would increase the existing pipe system capacity, is the recommended solution for Problem Location 6. Option 2 provides the best flood control performance, can be constructed entirely within public easements or rights of way, and also would provide significant benefits to other areas along the pipe system. The major disadvantage of Option 2 is cost. The cost to implement Option 2 is estimated at approximately $1.43 million. Although Option 1 is estimated to be significantly less costly, it would be constructed almost entirely on private property and the feasibility of obtaining an easement is uncertain. Without the cost an easement included, Option 1 is estimated at $0.70 million. The cost of an easement is uncertain but Option 1 is still likely to be significantly less costly than Option 2 with the easement cost included. However, due to the uncertainty of being able to obtain and easement and due to the inferior flood control performance of this option, Option 2 is considered the better option. The cost for Option 3 is estimated to be $2.14 million. Because of its high cost and inferior flood control performance, and private property impacts, Option 3 is not recommended. Cost estimates for all three options are provided later in this chapter.

7.7 PROBLEM LOCATION 7

7.7.1 Description of Problem Location 7

Runoff on Denton Way flows to a low point in the street where a small storm drain collects the runoff and conveys it south through two residential lots. There is not an adequate overland release path for flows that exceed the capacity of the pipe system and flooding along the street has been reported. This problem location is shown on Figure 7-9.

7.7.2 Proposed Solution for Problem Location 7

The proposed solution for Problem Location 7 is to construct an overland release structure between Denton Way and Sun Hill Drive. The overland release structure would be constructed over the top of the existing storm drain within the existing drainage easement. A schematic of the proposed solution is shown on Figure 7-9. This solution was developed qualitatively and no hydraulic calculations were performed.

7.8 PROBLEM LOCATION 8

7.8.1 Description of Problem Location 8

Runoff is collected at a low point in Dana Butte Way at the intersection with Alma Mesa Way. A storm drain system conveys runoff west to Canelo Hills Drive. The storm drain system is too small and there have been several reports of street flooding at the low point in Dana Butte Way. This problem location is shown on Figure 7-10.

7.8.2 Proposed Solution for Problem Location 8

The recommended solution for Problem Location 8 is to replace the existing storm drains from the intersection of Dana Butte Way and Alma Mesa Way to the intersection of Canelo Hills Drive and San Cosme Drive. The existing 10-inch and 12-inch pipes will be replaced with a 15-inch pipe as shown on Figure 7-10. This solution was developed qualitatively and no hydraulic calculations were performed. Problem Location 9

7.8.3 Description of Problem Location 9

This problem location is shown on Figure 7-11. A storm drain system conveys runoff to the west end of Amsell Court where it continues through residential lots to Old Ranch Road. The storm drain continues north along Old Ranch Road, then west on Blayden Court and then between two lots at the turn on Blayden Court. From there it continues to the northwest to C-Bar-C Park. There is not an adequate overland release path at the west end of Amsell Court for flows that exceed the capacity of the pipe system. As a result, flooding has been reported at this location. The same problem occurs at the turn of Blayden Court and flooding has been reported there also.

7.8.4 Proposed Solution for Problem Location 9

Two options were developed for solving the problems at Location 9. A XP-SWMM model was prepared to analyze the two options. Both options are described below and a recommended option is identified.

7.8.4.1 Proposed Solution for Problem Location 9 – Option 1

For Option 1, a 24-inch pipe would be constructed from the end of Amsell Court to Old Ranch Road. This pipe would replace the existing 15-inch pipe. A 30-inch pipe would be constructed to replace the existing 24-inch pipe from the turn at Blayden Court to the existing junction/inlet located on the west side of the power line corridor. To mitigate for the potential increase in flows downstream of these pipe improvements, a detention basin would be constructed within the power line corridor west of Blayden Court. The detention basin would cover approximately 0.60 acres and would store a volume of approximately 1.2 acre-feet at the peak of the 100-year storm. Hydraulic modeling indicates that this option would eliminate the predicted 100-year pad flooding at both Amsell Court and Blayden Court without increasing flood flows downstream. This option is shown on Figure 7-12A.

7.8.4.2 Proposed Solution for Problem Location 9 – Option 2

For Option 2, underground detention storage would be constructed in Amsell Court in the form of 400 feet of 36-inch pipe. A weir structure would be constructed at the existing manhole at the end of the court. During large storm events when the existing pipe system begins to surcharge, flows would spill over the weir into the 36-inch pipe. A flapgate on the end of the 36-inch pipe would prevent flows from entering the pipe except from over the weir, but would allow the pipe to empty when the storm recedes.

A 30-inch pipe would be constructed to replace the existing 24-inch pipe from the turn at Blayden Court to the east side of the power line corridor. To mitigate for the potential increase in flows downstream of these pipe improvements, a detention basin would be constructed within the power line corridor. Because of the underground storage constructed in Amsell Court, the size of this detention basin is reduced for Option 2. The detention basin would cover approximately 0.4 acres and would store a volume of approximately 0.9 acre-feet at the peak of the 100-year storm.

Hydraulic modeling indicates that this option would eliminate the predicted 100-year pad flooding at both Amsell Court and Blayden Court without increasing flood flows downstream. This option is shown on Figure 7-12B.

7.8.4.3 Recommended Solution for Problem Location 9

It is recommended that Option 2 be implemented to solve the problem at location 9. Both options would provide adequate flood protection, but Option 2 is less costly. The estimated implementation costs for Options 1 and 2 are $495,000 and $417,000, respectively, without the cost of an easement for the detention basin. Because Option 2 requires less land for the detention basin, the cost differential will be even larger when the cost of an easement is included.

7.9 PROBLEM LOCATION 11

7.9.1 Description of Problem Location 11

This problem location is shown on Figure 7-13. The storm drainage system at this problem location consists of a combination of underground pipes, channels, and roadside ditches. The existing system is inadequately sized and property flooding has been reported on Bonita Way and Dow Avenue during large storms.

7.9.2 Proposed Solution for Problem Location 11

As shown on Figure 7-13, the recommended solution for Problem Location 11 is to construct a new 30-inch storm drain along Maretha Street and Bonita Way, and a 42-inch storm drain along Old Auburn Road. On Maretha Street, the new 30-inch pipe will replace an existing 15-inch drain. The existing pipe that drains west along Dow Avenue will be plugged at the new manhole at the intersection of Maretha Street and Dow Avenue. On the west side of Maretha Street the existing curb will be extended north to Dow Avenue and along Dow Avenue to a new inlet and 12-inch pipe that will collect runoff and convey it to the existing drain in Dow Avenue. Alternatively, a ditch could be constructed. The purpose of the curb and gutter or ditch is to convey flow that exceed the pipe capacity in Maretha Street into the Dow Avenue Storm Drain without flowing across the property at the southwest corner of the intersection. The existing roadside ditch along Bonita Way will remain and will be used to collect runoff from the adjacent lots and to convey flows in excess of the pipe capacity during very large storm events. On Old Auburn Road, the 42-inch pipe will replace the existing ditch that is currently eroding and is planned to be filled by the City.

7.10 PROBLEM LOCATION 12

7.10.1 Description of Problem Location 12

This problem location is shown on Figure 7-14. An existing 15-inch pipe collects runoff at Minnesota Drive and coveys it west to a ditch system near Anderson Lane. The pipe is inadequately sized for large storm events and the overland release path is inadequate to convey flows in excess of the pipe capacity. The ditch system that begins near Anderson Lane conveys runoff west to a pipe system that begins just west of Canady Lane. The ditch system also lacks capacity for larger storm events and structure flooding has occurred at several locations. In addition, both Anderson Lane and Canady Lane receive runoff from adjacent properties. Because there are inadequate conveyance facilities along these roads (e.g., curb and gutter or road side ditch), during large storm events, runoff crosses the road and flows through properties on the opposite side of the road causing property flooding.

7.10.2 Proposed Solution for Problem Location 12

As shown on Figure 7-14, the proposed solution for this problem location includes a 24-inch pipe that will convey runoff from Minnesota Drive to the west. This pipe will replace the existing 15-inch pipe and is sized to convey the 100-year peak flow without causing overland flow through the adjacent properties. The 24-inch pipe will discharge to a new detention basin to be constructed on the east side of Anderson Lane. The detention basin would cover approximately 0.36 acres and would store a volume of approximately 1.0 acre-foot at the peak of the 100-year storm. Runoff will be discharged from the detention basin through the existing 18-inch culvert under Anderson Lane plus a new 18-inch culvert. At Canady Lane, flow in the ditch will be directed to a new 36-inch drain that will convey runoff to the north along the road before turning west. The 36-inch pipe will connect to an existing storm drain manhole located in the backyard of a property on Saginaw Way. To help reduce the peak flows discharged to the existing storm drain system, a 60-inch pipe will be constructed in Canady Lane. A diversion structure will prevent flow from the 36-inch pipe from entering the 60-inch pipe until the 36-inch pipe begins to surcharge during larger storm events. Then flows will be diverted into the pipe, which will act as an underground detention basin to reduce the peak flows continuing to the west from Canady Lane. During very large storm events, some overland flow is expected along the existing pipe system that passes along the side yard of a lot on Saginaw Way. Therefore, an overland release structure is proposed along the side yard of this lot. Finally, it is proposed that curb and gutter or roadside ditches be constructed along at least one side of Anderson and Canady Lanes to prevent runoff from crossing the road and flooding adjacent properties.

7.11 COST ESTIMATES FOR PROPOSED SOLUTIONS

Implementation cost estimates were prepared for the drainage improvements discussed above. Implementation costs include estimates of construction, contingencies, and other project costs. The cost estimates presented in this chapter are master planning level accuracy and are for decision making and budgeting purposes only. As projects advance through preliminary design and preparation of plans and specifications, estimates can be made in more detail to greater accuracy. The major assumptions used to estimate costs for the drainage improvements are listed below.

- Unit costs are based on current construction costs. (July 2015 ENR 20 Cities CCI of 10037).
- The unit costs used to determine construction costs were based on cost data from recently constructed projects, manufacturer quotes, estimating guides, engineering judgment, and input from City staff.
- For pipelines proposed within existing streets, costs include repairing the pavement. For estimating these costs, it was assumed that the width of the trench would be equal to the inside diameter of the pipe plus two feet.
- The cost of raising homes (Problem Location 6 – Option 3) was based on the costs per square foot used for the Benefit/Cost Analysis for Raising Residential Structures in the Beach Stone Lakes Area, Ensign & Buckley, June 1996 escalated to current cost levels. The costs in that report were based on the average cost to raise 16 structures along Dry Creek in Sacramento County in the 1990s. Actual costs can vary significantly based on site specific conditions.
- Land acquisition costs were not included. These costs will require negotiation between the property owner and the City and it may not be desirable to publish an assumed land value prior to negotiations.
- A contractor's mobilization/demobilization cost of 5 percent was included as part of the construction cost.
- A construction contingency of 20 percent was included to account for the planning level uncertainties (e.g., utility relocations, etc.) and construction cost uncertainties associated with the estimates.
- The following mark-ups were added to the total construction cost to obtain the estimated total project implementation cost or capital cost.
  - Planning & Design at 10 percent
  - Construction Management at 10 percent
  - Environmental Permits and Mitigation at 5 percent
  - Program Management at 5 percent

The soft cost percentages above may not be appropriate for small projects. For this study, it is assumed that small projects will be bundled with larger ones during the design and construction phases to achieve better cost efficiency.

A summary of the estimated costs for the proposed solutions for each problem location are presented on Table 7-1. Detailed cost estimates for each of the proposed solutions are provided on Table 7-2.

Table 7-1. Summary of Capital Cost Estimates for Proposed Solutions

Item	Estimated Total Project Capital Cost, dollars
Problem Location 1 Solution	8,000
Problem Location 2 Solution	9,000
Problem Locations 3 and 4 Solution (Option 2)	878,000
Problem Location 5 Solution	90,000
Problem Locations 6 and 10 Solution (Option 2)	1,425,000
Problem Location 7 Solution	70,000
Problem Location 8 Solution	117,000
Problem Location 9 Solution (Option 2)	417,000
Problem Location 11 Solution	1,060,000
Problem Location 12 Solution	871,000
Total Estimated Cost of all Solutions	**$4,945,000**

Table 7-2. Cost Estimates for Proposed Solutions

Item	Quantity	Unit of Measure	Unit Cost, dollars	Item Cost, dollars
Problem Location 1 Solution				
12-Inch Storm Drain	32	ft	84	2,688
Ditch Grading	1	lump sum	2,200	2,200
Mobilization/demobilization (at 5 percent)				200
Construction Contingency (at 20 percent)				1,000
Estimated Construction Cost				6,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				2,000
Estimated Capital Cost				**8,000**
Problem Location 2 Solution				
Install Under Sidewalk Drain	1	lump sum	5,500	5,500
Mobilization/demobilization (at 5 percent)				300
Construction Contingency (at 20 percent)				1,000
Estimated Construction Cost				7,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				2,000
Estimated Capital Cost				**9,000**
Problem Locations 3 and 4 Solution - Option 1				
12-Inch Storm Drain	96	ft	84	8,064
15-Inch Storm Drain	30	ft	105	3,150
21-Inch Storm Drain	462	ft	147	67,914
24-Inch Storm Drain	580	ft	168	97,440
Valley Gutter	1,090	ft	33	36,115
Drain Inlets	7	each	4,600	32,200
Maintenance Holes	3	each	5,500	16,500
Outfall Structure	1	each	5,700	5,700
Existing Pavement Repair	4,400	sf	9	39,600
Overland Flow Structure	110	ft	177	19,470
Mobilization/demobilization (at 5 percent)				16,000
Construction Contingency (at 20 percent)				65,000
Estimated Construction Cost				407,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				122,000
Estimated Capital Cost				**529,000**
Problem Locations 3 and 4 Solution - Option 2				
12-Inch Storm Drain	96	ft	84	8,064
15-Inch Storm Drain	30	ft	105	3,150
21-Inch Storm Drain	86	ft	147	12,642
27-Inch Storm Drain	670	ft	189	126,630
30-Inch Storm Drain	956	ft	210	200,760
AC Ditch	1,090	ft	30	32,700
Drain Inlets	7	each	4,600	32,200
Maintenance Holes	5	each	5,500	27,500
Outfall Structure	1	each	5,700	5,700
Existing Pavement Repair	7,900	sf	9	71,100
Overland Release Structure	110	ft	177	19,470
Mobilization/demobilization (at 5 percent)				27,000
Construction Contingency (at 20 percent)				108,000
Estimated Construction Cost				675,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				203,000
Estimated Capital Cost				**878,000**
Problem Location 5 Solution				
24-Inch Storm Drain	194	ft	168	32,592
Drain Inlets	1	each	4,600	4,600
Maintenance Holes	1	each	5,500	5,500
Outfall Structure	1	each	5,700	5,700
Existing Pavement Repair	75	sf	9	675
Miscellaneous Items (related to private property impacts)	1	lump sum	5,500	5,500
Mobilization/demobilization (at 5 percent)				3,000
Construction Contingency (at 20 percent)				11,000
Estimated Construction Cost				69,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				21,000
Estimated Capital Cost				**90,000**
Problem Locations 6 and 10 Solution - Option 1				
18-Inch Storm Drain	363	ft	126	45,738
21-Inch Storm Drain	102	ft	147	14,994
36-Inch Storm Drain	410	ft	252	103,320
Maintenance Holes	5	each	5,500	27,500
Outfall Structure	1	each	5,700	5,700
Diversion Structure and Inlet/Outlet	1	each	11,000	11,000
Existing Pipe Disposal	690	lf	10	6,900
Existing Pavement Repair	380	sf	9	3,420
Excavation & Disposal	10,500	cy	15	157,500
Turf Replacement	56,600	sf	0.38	21,508
Irrigation Replacement	1.3	acre	25,000	32,500
Mobilization/demobilization (at 5 percent)				22,000
Construction Contingency (at 20 percent)				86,000
Estimated Construction Cost				538,000
Land/Easement	1.3	acre	TBD	TBD
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				161,000
Estimated Capital Cost				**699,000**

Table 7-2. Cost Estimates for Proposed Solutions

Item	Quantity	Unit of Measure	Unit Cost, dollars	Item Cost, dollars
Problem Locations 6 and 10 Solution - Option 2				
36-Inch Storm Drain	220	ft	252	55,440
42-Inch Storm Drain	1,975	ft	294	580,650
Drain Inlets	4	each	4,200	16,800
Maintenance Holes	9	each	5,500	49,500
Outfall Structure	1	each	5,700	5,700
Existing Pipe Disposal	1,419	lf	10	14,190
Existing Pavement Repair	8,870	sf	9	79,830
Utility Relocation	1	lump sum	75,000	75,000
Mobilization/demobilization (at 5 percent)				44,000
Construction Contingency (at 20 percent)				175,000
Estimated Construction Cost				1,096,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				329,000
Estimated Capital Cost				**1,425,000**
Problem Locations 6 and 10 Solution - Option 3				
36-Inch Storm Drain	410	ft	252	103,320
2'x12' Box	450	ft	800	360,000
Maintenance Holes	4	each	5,500	22,000
Outfall Structure	1	each	5,700	5,700
Weir Box Structure	1	each	8,800	8,800
Existing Pavement Repair	8,350	sf	9	75,150
Raise Homes	13,740	sf	54	741,960
Mobilization/demobilization (at 5 percent)				66,000
Construction Contingency (at 20 percent)				263,000
Estimated Construction Cost				1,646,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				494,000
Estimated Capital Cost				**2,140,000**
Problem Location 7 Solution				
Overland Release Structure	210	ft	177	37,170
Miscellaneous Items (related to private property impacts)	1	lump sum	5,500	5,500
Mobilization/demobilization (at 5 percent)				2,000
Construction Contingency (at 20 percent)				9,000
Estimated Construction Cost				54,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				16,000
Estimated Capital Cost				**70,000**
Problem Location 8 Solution				
15-Inch Storm Drain	535	ft	105	56,175
Existing Pavement Repair	1,750	sf	9	15,750
Mobilization/demobilization (at 5 percent)				4,000
Construction Contingency (at 20 percent)				14,000
Estimated Construction Cost				90,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				27,000
Estimated Capital Cost				**117,000**
Problem Location 9 Solution - Option 1				
24-Inch Storm Drain	390	ft	168	65,520
30-Inch Storm Drain	548	ft	210	115,080
Drain Inlets	2	each	4,600	9,200
Maintenance Holes	2	each	5,500	11,000
Inlet/Outlet Structure	1	each	5,700	5,700
Fence Removal/Replacement	40	ft	22	880
Existing Pipe Disposal	938	ft	10	9,380
Existing Pavement Repair	200	sf	9	1,800
Overland Release Reconstruction	140	ft	200	28,000
Miscellaneous Items (related to private property impacts)	1	lump sum	5,500	5,500
Excavation & Disposal	3,300	cy	15	49,500
Hydroseeding	0.6	acre	5,500	3,300
Mobilization/demobilization (at 5 percent)				15,000
Construction Contingency (at 20 percent)				61,000
Estimated Construction Cost				381,000
Land/Easement	0.6	acre	TBD	TBD
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				114,000
Estimated Capital Cost				**495,000**
Problem Location 9 Solution - Option 2				
30-Inch Storm Drain	180	ft	210	37,800
36-Inch Storm Drain	400	ft	252	100,800
Drain Inlets	1	each	4,600	4,600
Maintenance Holes	3	each	5,500	16,500
Weir Box Structure	1	each	8,800	8,800
Inlet/Outlet Structure	1	each	5,700	5,700
Fence Removal/Replacement	20	ft	20	400
Existing Pipe Disposal	180	ft	10	1,800
Existing Pavement Repair	2,000	sf	9	18,000
Overland Release Reconstruction	140	ft	200	28,000
Miscellaneous Items (related to private property impacts)	1	lump sum	5,500	5,500
Excavation & Disposal	1,800	cy	15	27,000
Hydroseeding	0.4	acre	5,500	2,035
Mobilization/demobilization (at 5 percent)				13,000
Construction Contingency (at 20 percent)				51,000
Estimated Construction Cost				321,000
Land/Easement	0.6	acre	TBD	TBD
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				96,000
Estimated Capital Cost				**417,000**

Table 7-2. Cost Estimates for Proposed Solutions

Item	Quantity	Unit of Measure	Unit Cost, dollars	Item Cost, dollars
Problem Location 11 Solution				
12-Inch Storm Drain	130	ft	84	10,920
30-Inch Storm Drain	1,725	ft	210	362,250
42-Inch Storm Drain	400	ft	294	117,600
Drain Inlets	6	each	4,600	27,600
Maintenance Holes	8	each	5,500	44,000
Inlet/Outlet Structure	1	each	5,700	5,700
Existing Pipe Disposal	222	ft	10	2,220
Existing Pavement Repair	7,605	sf	9	68,445
Curb and Gutter	233	lf	55	12,815
Mobilization/demobilization (at 5 percent)				33,000
Construction Contingency (at 20 percent)				130,000
Estimated Construction Cost				815,000
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				245,000
Estimated Capital Cost				**1,060,000**
Problem Location 12 Solution				
18-Inch Storm Drain	30	ft	126	3,780
24-Inch Storm Drain	244	ft	168	40,992
36-Inch Storm Drain	300	ft	252	75,600
60-Inch Storm Drain	500	ft	420	210,000
Drain Inlets	4	each	4,600	18,400
Maintenance Holes	2	each	5,500	11,000
Diversion Structure and Inlet/Outlet	1	each	11,000	11,000
Existing Pipe Disposal	370	ft	10	3,700
Existing Pavement Repair	6,700	sf	9	60,300
Curb and Gutter	925	lf	55	50,875
Overland Release Structure	115	ft	177	20,355
Miscellaneous Items (related to private property impacts)	1	lump sum	5,500	5,500
Excavation & Disposal	1,530	cy	15	22,950
Hydroseeding	0.4	acre	5,500	1,980
Mobilization/demobilization (at 5 percent)				27,000
Construction Contingency (at 20 percent)				107,000
Estimated Construction Cost				670,000
Land/Easement	0.4	acre	TBD	TBD
Engineering, CM/Insp, CEQA, City Admin (At 30 percent, see Note 1)				201,000
Estimated Capital Cost				**871,000**

Notes:

1) Soft costs include and allowance of 30 percent comprised of the following:
   - Planning and design at 10 percent of the construction cost
   - Construction management at 10 percent of the construction cost
   - Environmental permits and mitigation at 5 percent of the construction cost
   - Program management (City administration during design and construction) at 5 percent

2) The unit costs and soft cost percentages are based on the assumption that small projects will be bundled with larger projects to achieve better cost efficiency.

3) Costs are for July 2015 ENRCCI 20 City Average 10,037.

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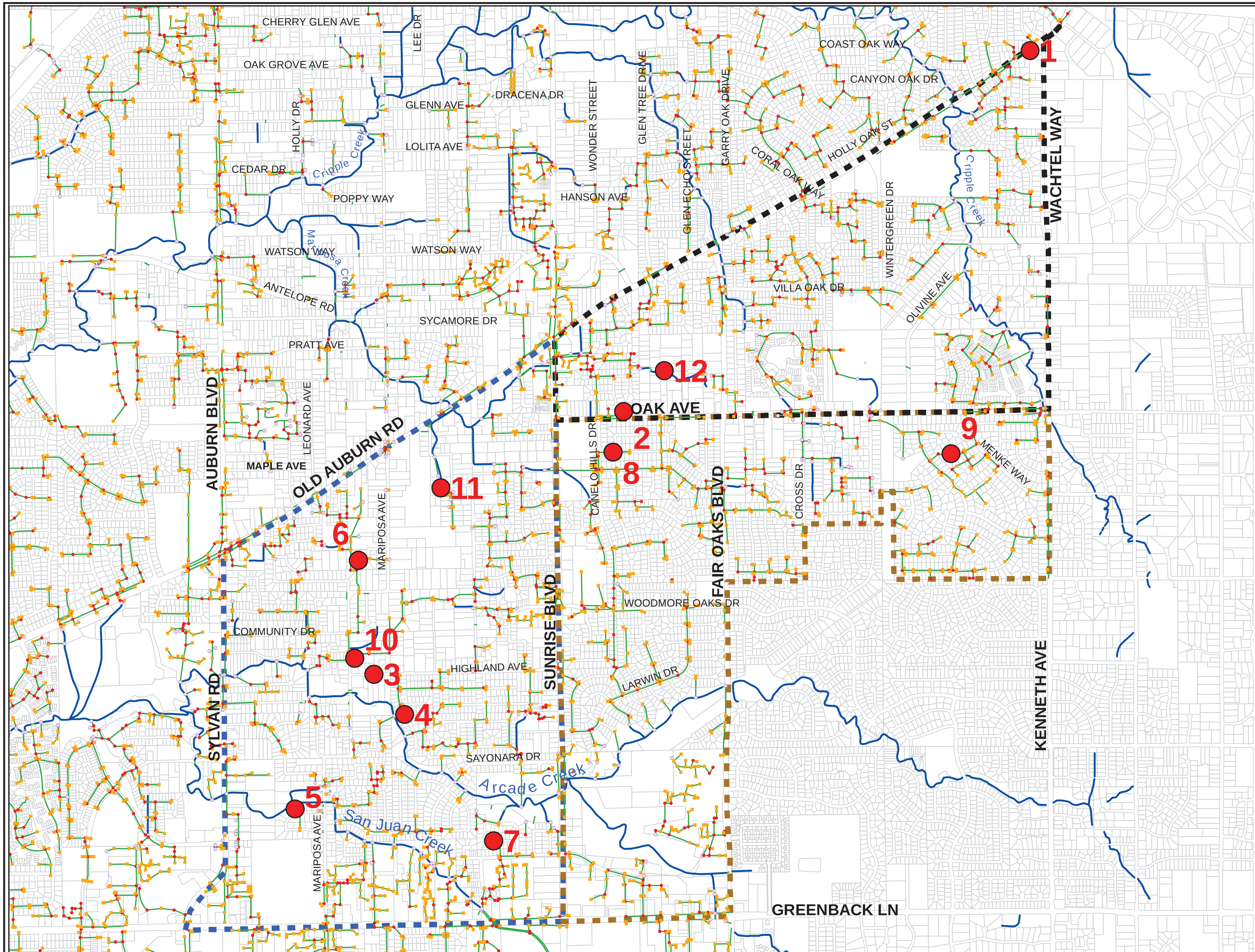

FIGURE 7-1

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

FLOODING/DRAINAGE PROBLEM LOCATIONS

N

0 750 1,500
Scale in Feet

LEGEND

- Problem Location
- Inlet
- Outfall
- Manhole
- Drainage Pipe
- Stream or Channel
- Neighborhood 8
- Neighborhood 9
- Neighborhood 10

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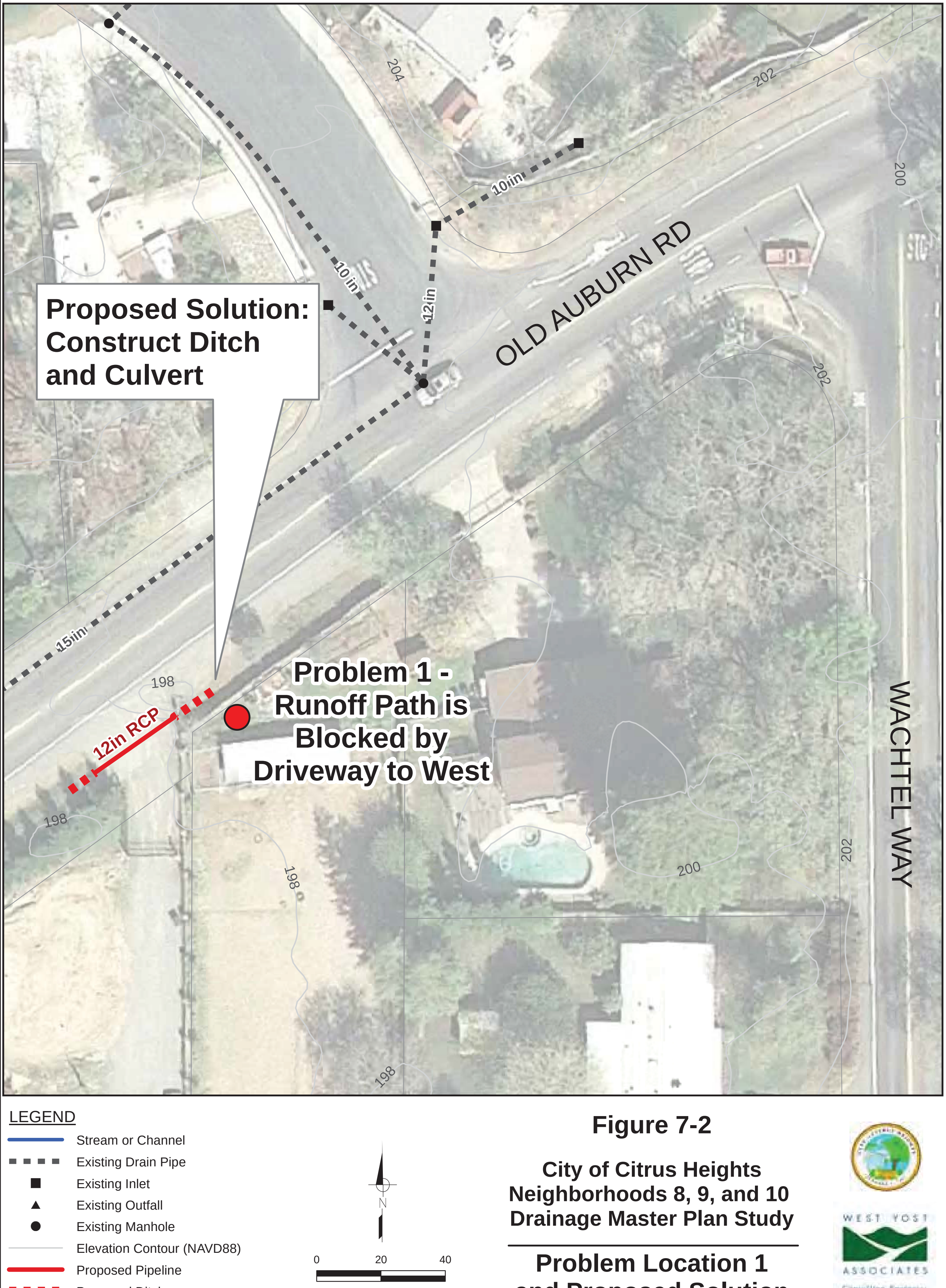

Figure 7-2

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 1
and Proposed Solution

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LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)
- Proposed Pipeline or Drain

N

0 20 40

Scale in Feet

Figure 7-3

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

Problem Location 2 and Proposed Solution

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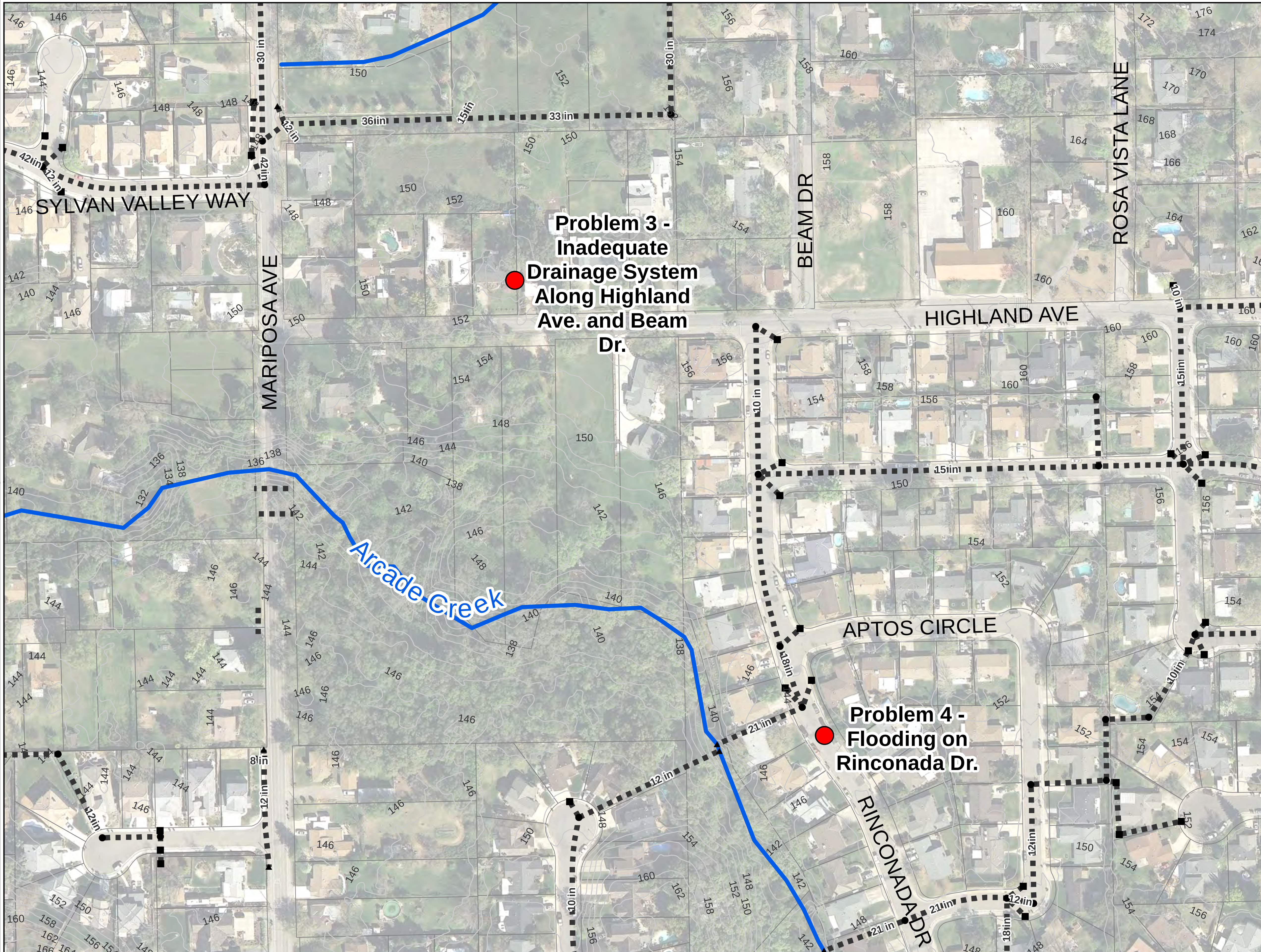

Figure 7-4

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Locations 3 and 4

N

0 75 150
Scale in Feet

LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)

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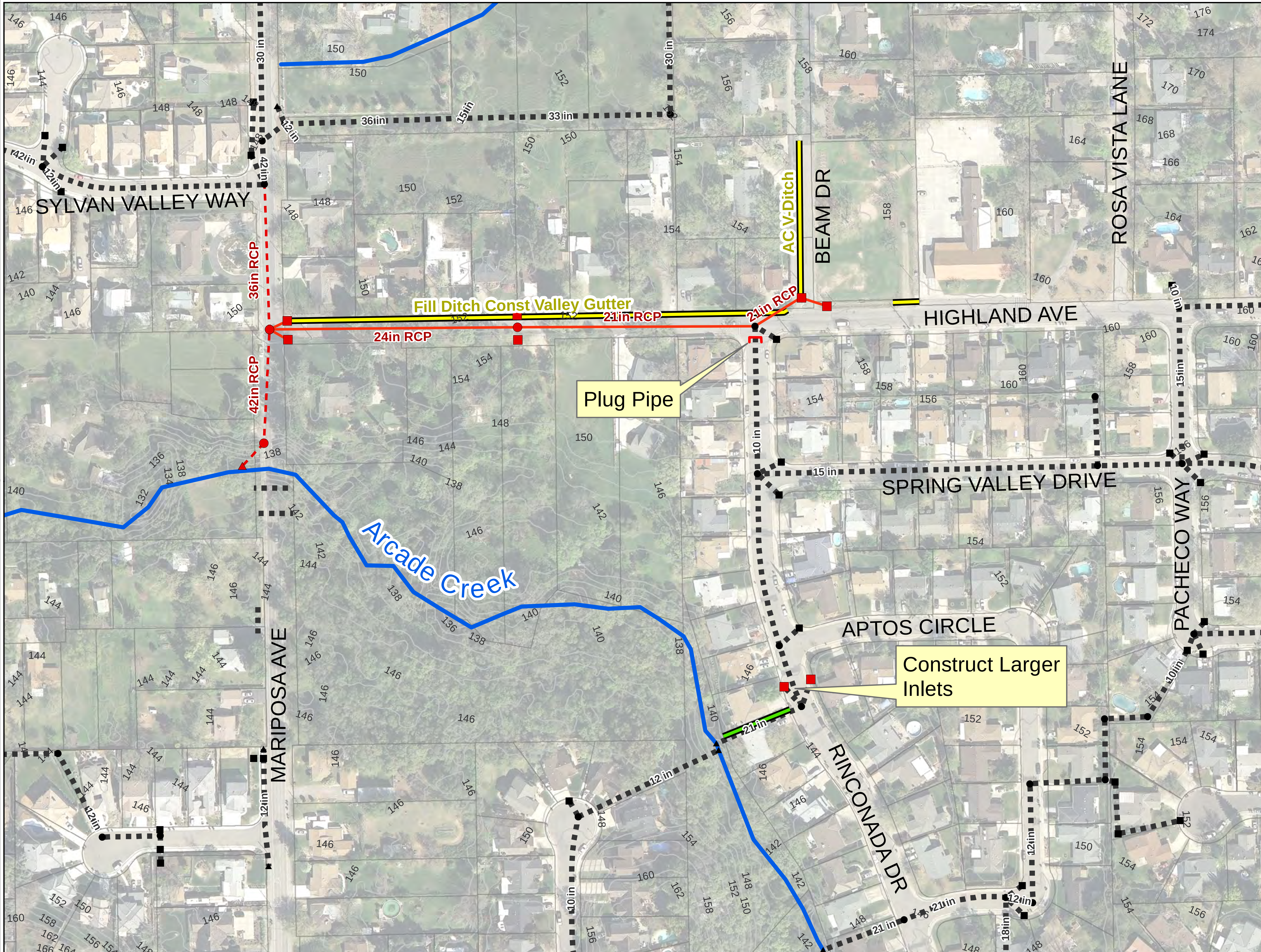
Figure 7-5A

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Locations 3 and 4
Proposed Solution
Option 1



0 75 150
Scale in Feet

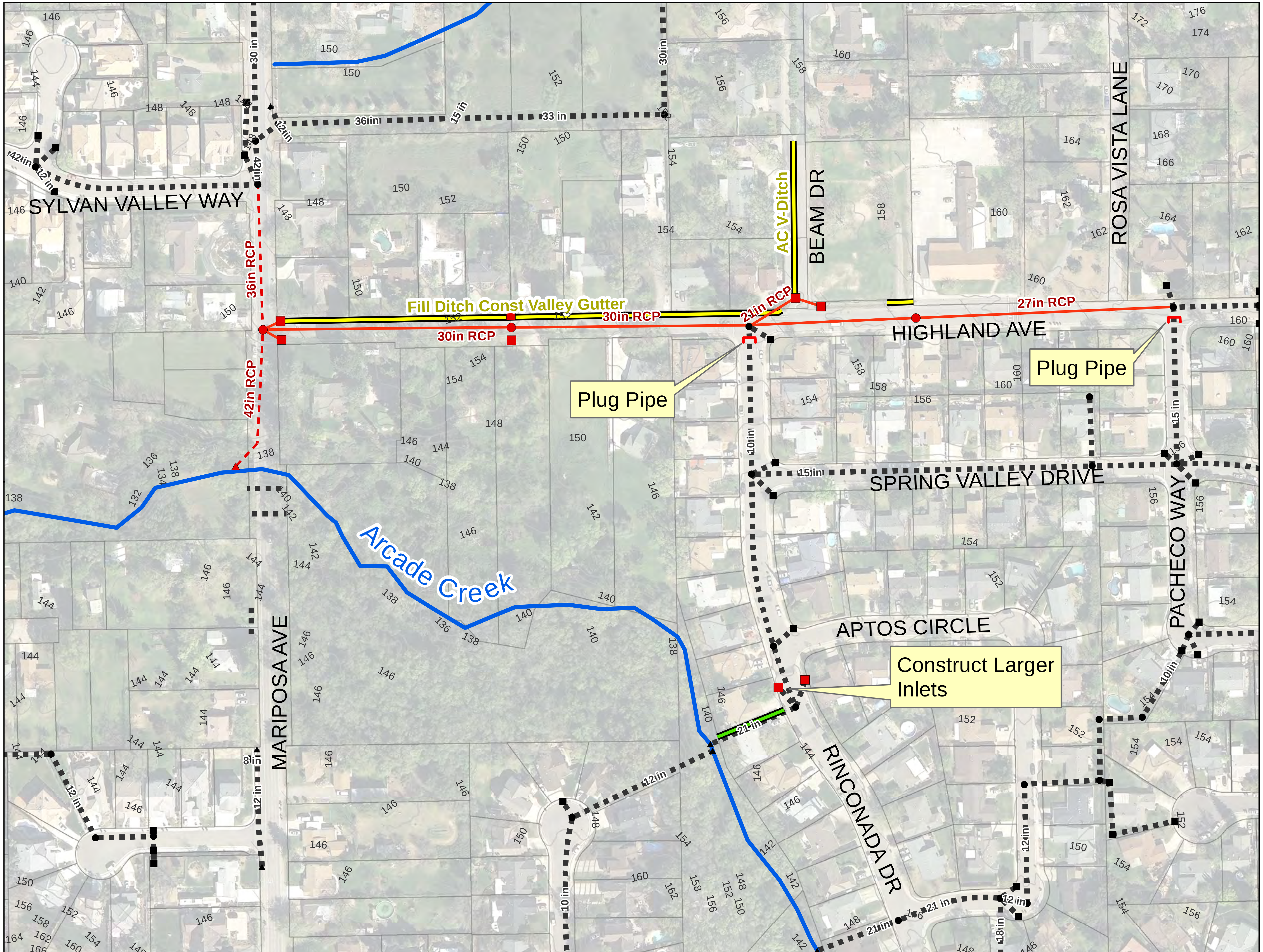
LEGEND

- Stream or Channel
- Proposed Inlet
- Proposed Outfall
- Proposed Manhole
- Elevation Contour (NAVD88)
- Proposed Pipeline or Drain
- Proposed Pipeline or Drain for Problem Location 10
- Proposed Ditch Replacement
- Proposed Overland Release

Figure 7-5B

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

Problem Locations 3 and 4 Proposed Solution



0 75 150
Scale in Feet

LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Proposed Inlet
- Proposed Outfall
- Proposed Manhole
- Elevation Contour (NAVD88)
- Proposed Pipeline or Drain
- Proposed Pipeline or Drain for Problem Location 10
- Proposed Ditch Replacement
- Proposed Overland Release

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LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)
- Proposed Pipeline or Drain

N

0 50 100

Scale in Feet

Figure 7-6

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

Problem Location 5 and Proposed Solution

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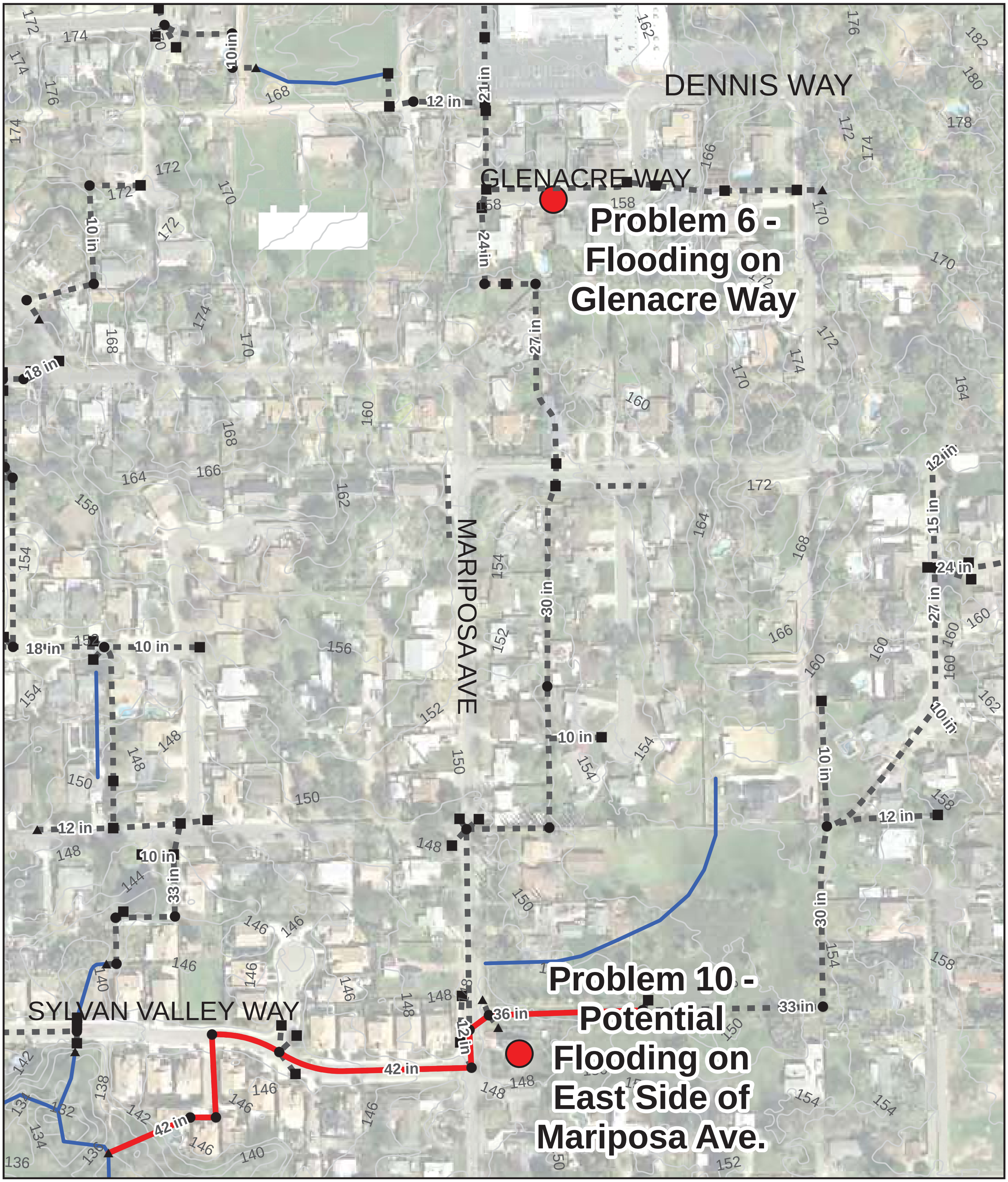

LEGEND

- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)
- Stream or Channel
- Trunk Pipe SD6

0 125 250

Scale in Feet

Figure 7-7

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Locations 6 and 10

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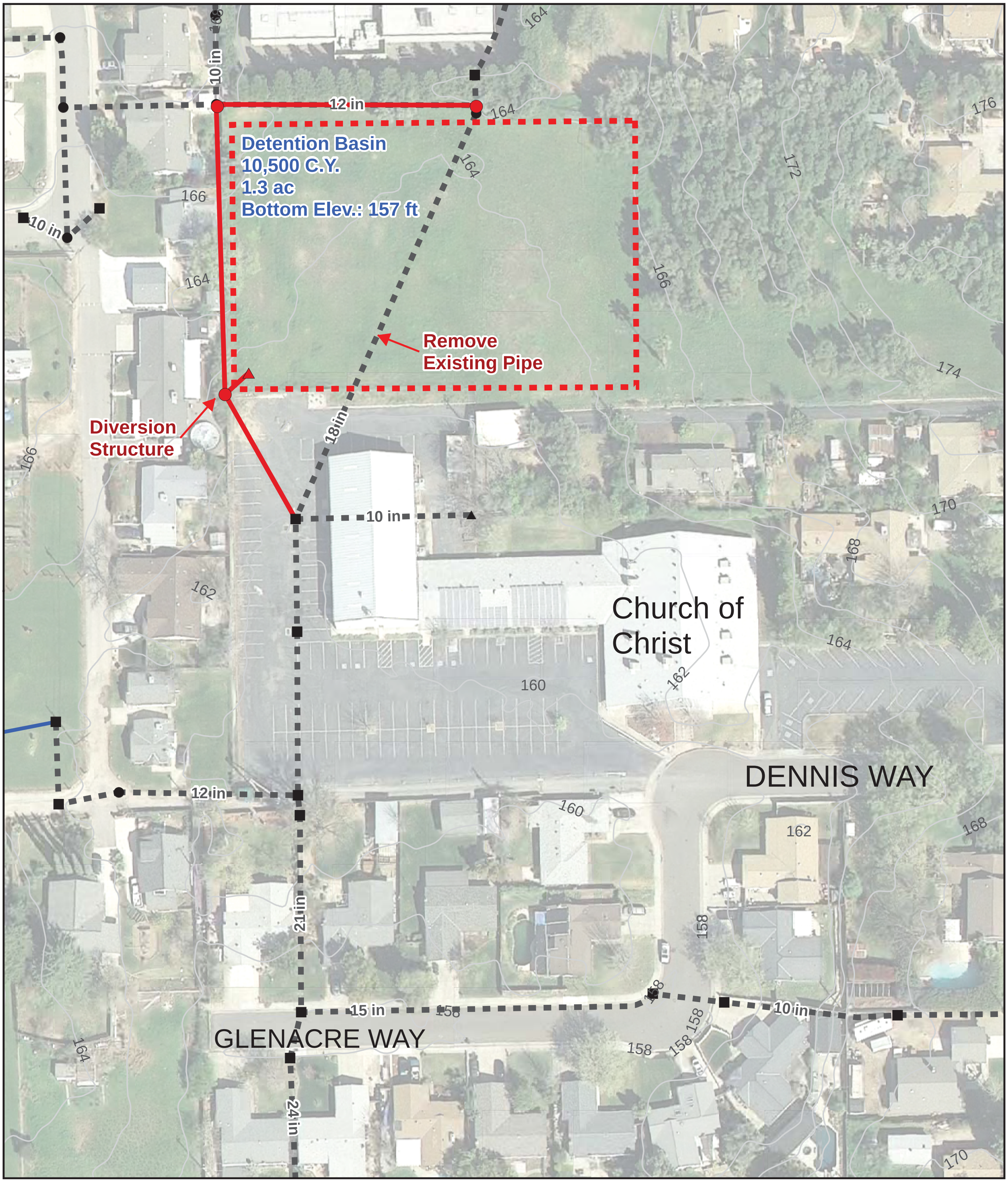

LEGEND

- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Proposed Pipeline or Drain
- Proposed Manhole
- Proposed Outfall
- Proposed Detention Basin
- Elevation Contour (NAVD88)

N

0 50 100

Scale in Feet

Figure 7-8A

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 6
Proposed Solution - Option 1

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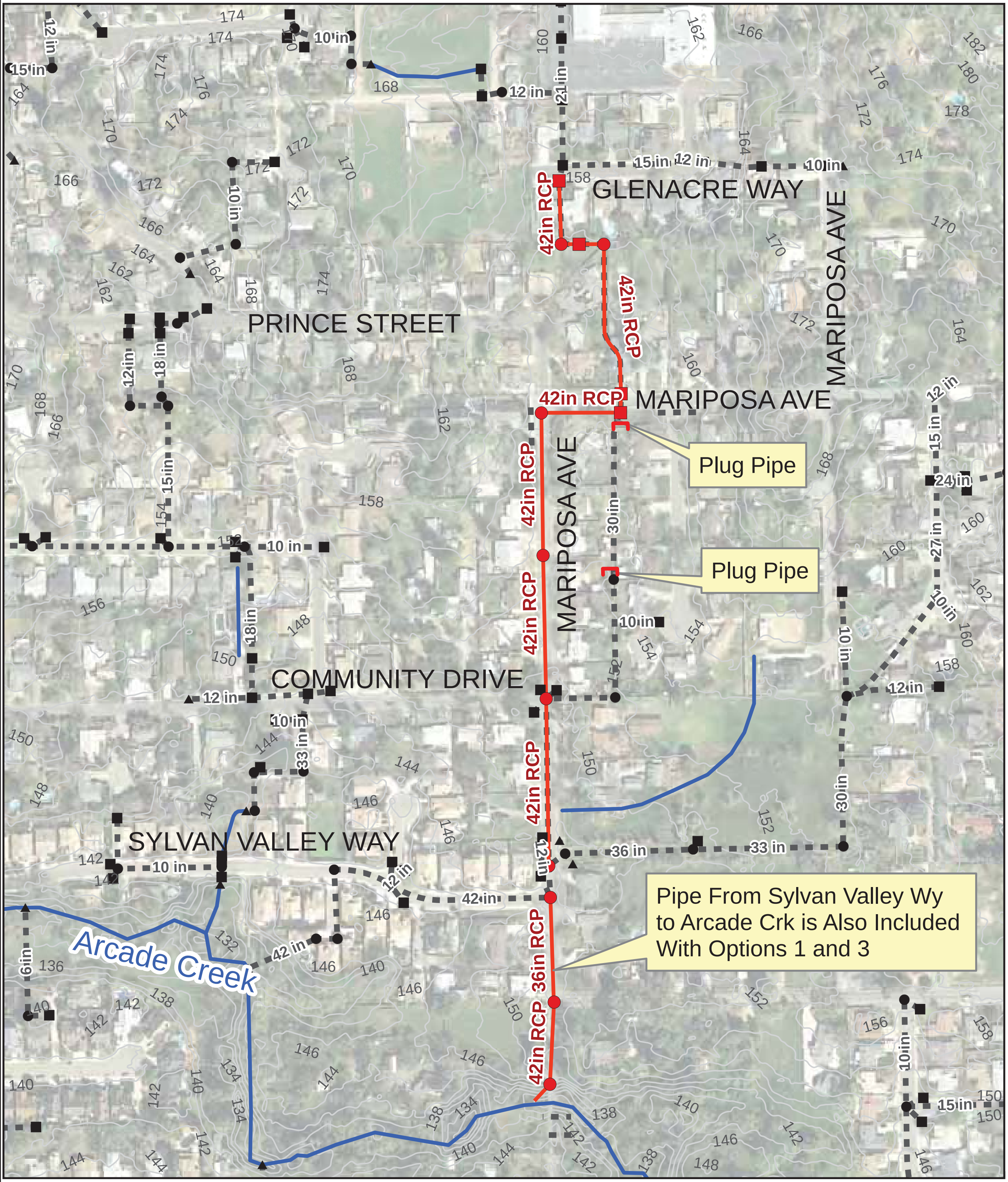

LEGEND
- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Proposed Pipeline or Drain
- Proposed Inlet
- Proposed Outfall
- Proposed Manhole
- Elevation Contour (NAVD88)

N

0 150 300
Scale in Feet

Figure 7-8B

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Locations 6 and 10
Proposed Solution - Option 2

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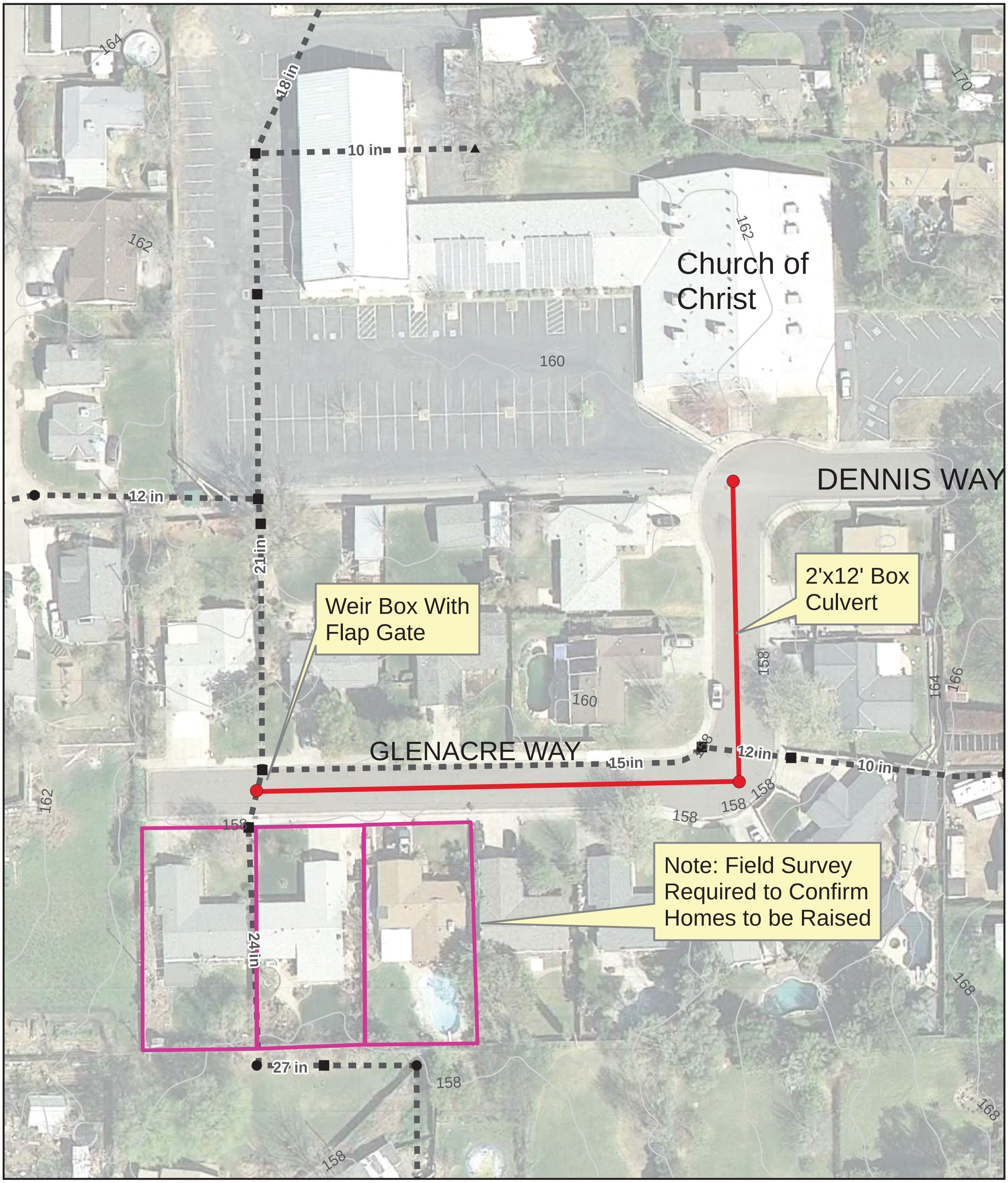

LEGEND
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Proposed Manhole
- Proposed Outfall
- Elevation Contour (NAVD88)
- Raise Homes

N

0 50 100
Scale in Feet

Figure 7-8C

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Locations 6 and 10
Proposed Solution - Option 3

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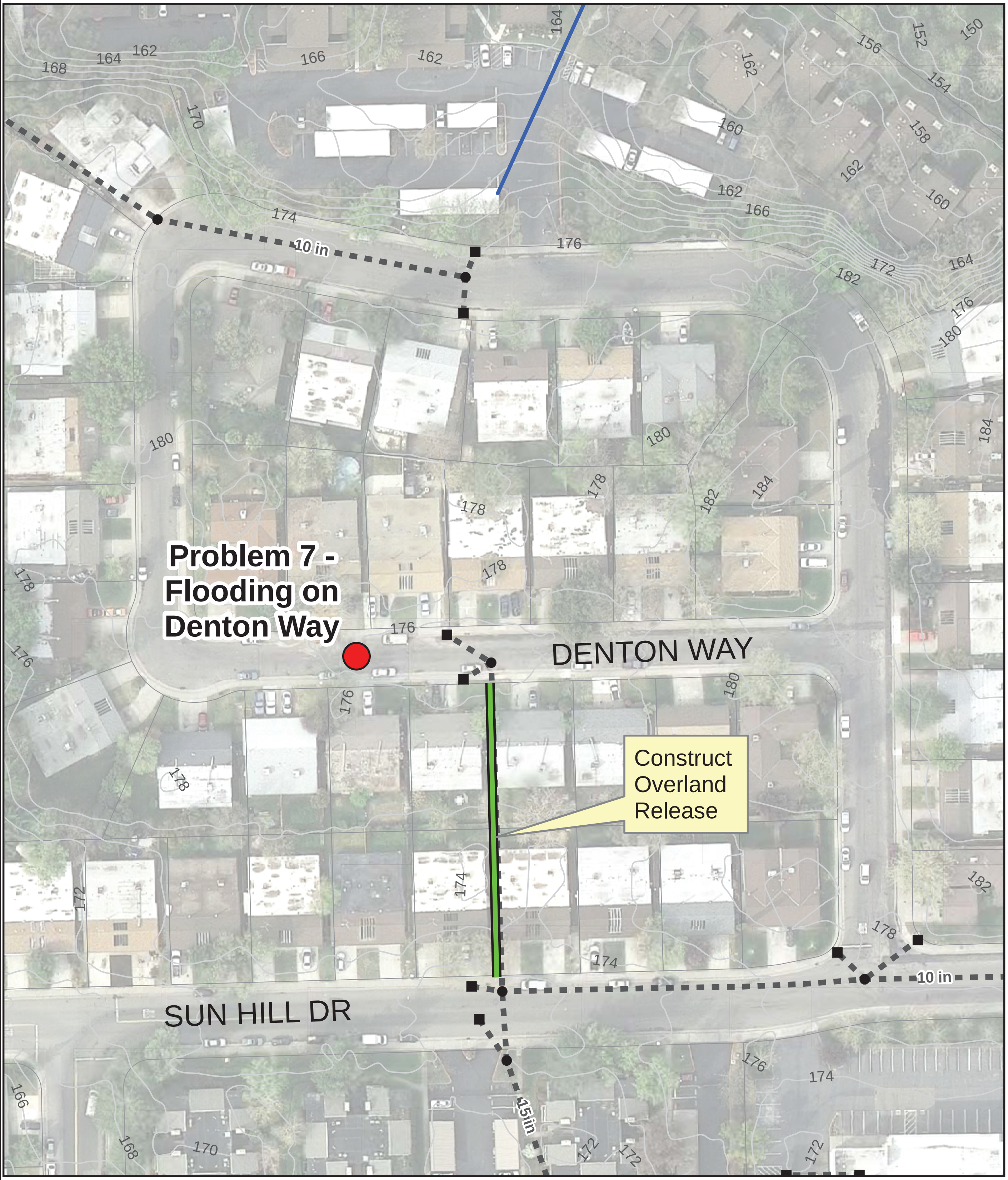

LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)
- Proposed Overland Release

N

0 50 100

Scale in Feet

Figure 7-9

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 7
Proposed Solution

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LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAVD88)
- Proposed Pipeline or Drain

N

0 50 100

Scale in Feet

Figure 7-10

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 8
Proposed Solution

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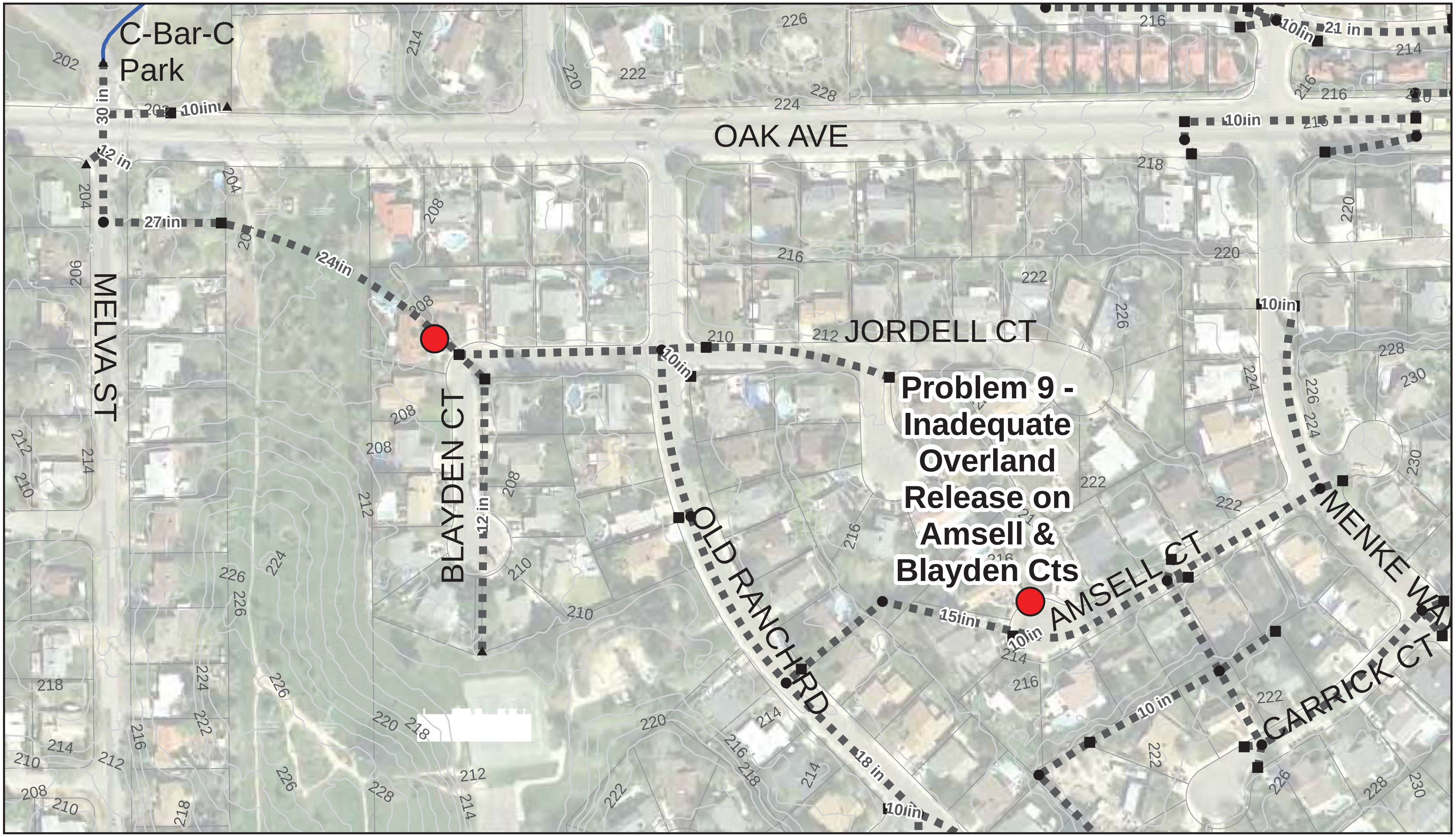

LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Elevation Contour (NAV88)

N

0 100 200

Scale in Feet

Figure 7-11

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 9

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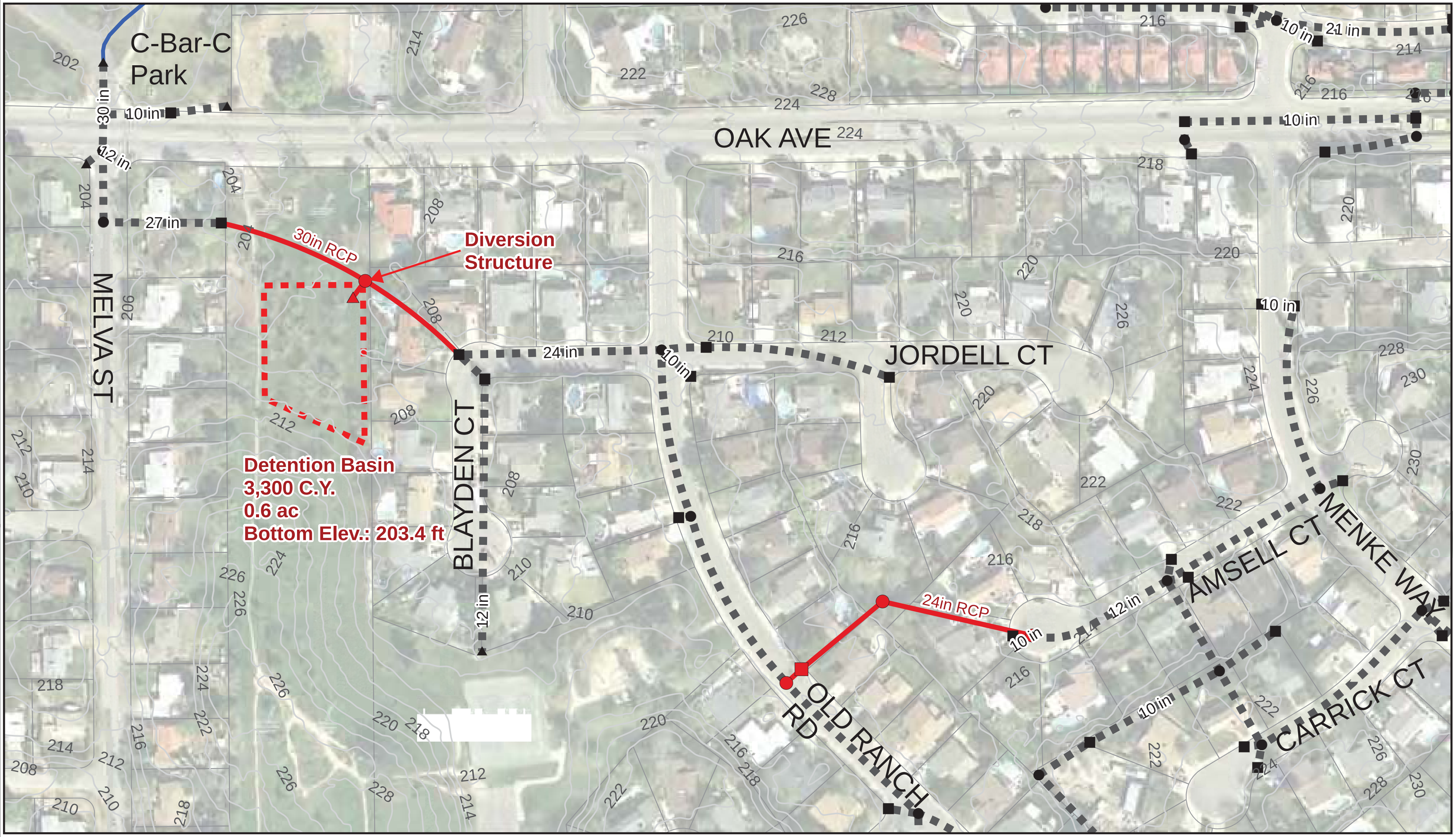

LEGEND
Stream or Channel
Existing Drain Pipe
Existing Inlet
Existing Outfall
Existing Manhole
Proposed Pipe or Drain
Proposed Inlet
Proposed Manhole
Proposed Outfall
Proposed Detention Basin
Elevation Contour (NAV88)

0 100 200
Scale in Feet

Figure 7-12A

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 9
Proposed Solution - Option 1

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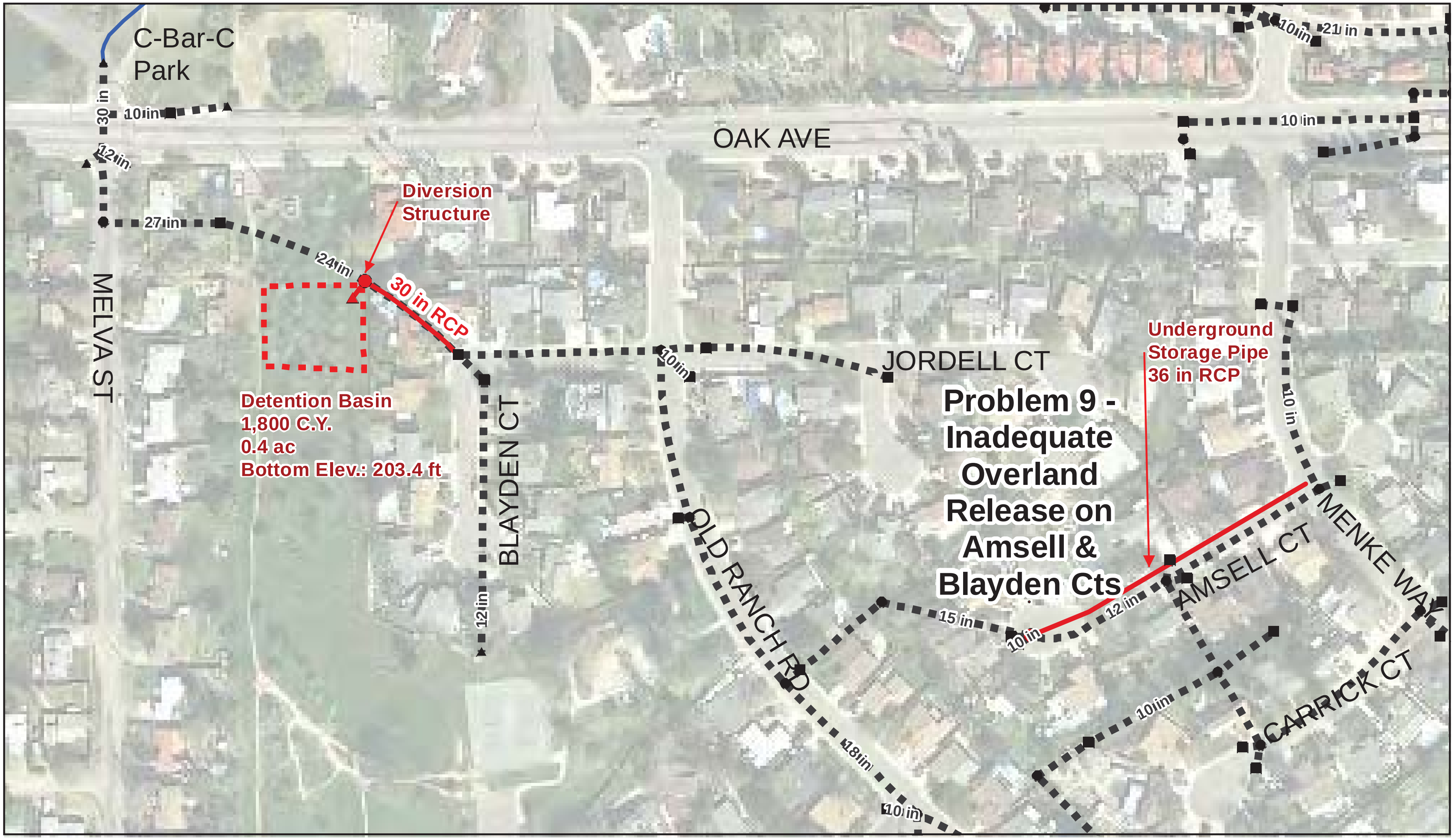

LEGEND

- Stream or Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole
- Proposed Pipe or Drain
- Proposed Detention Basin
- Elevation Contour (NAV88)

N

0 100 200

Scale in Feet

Figure 7-12B

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 9
Proposed Solution - Option 2

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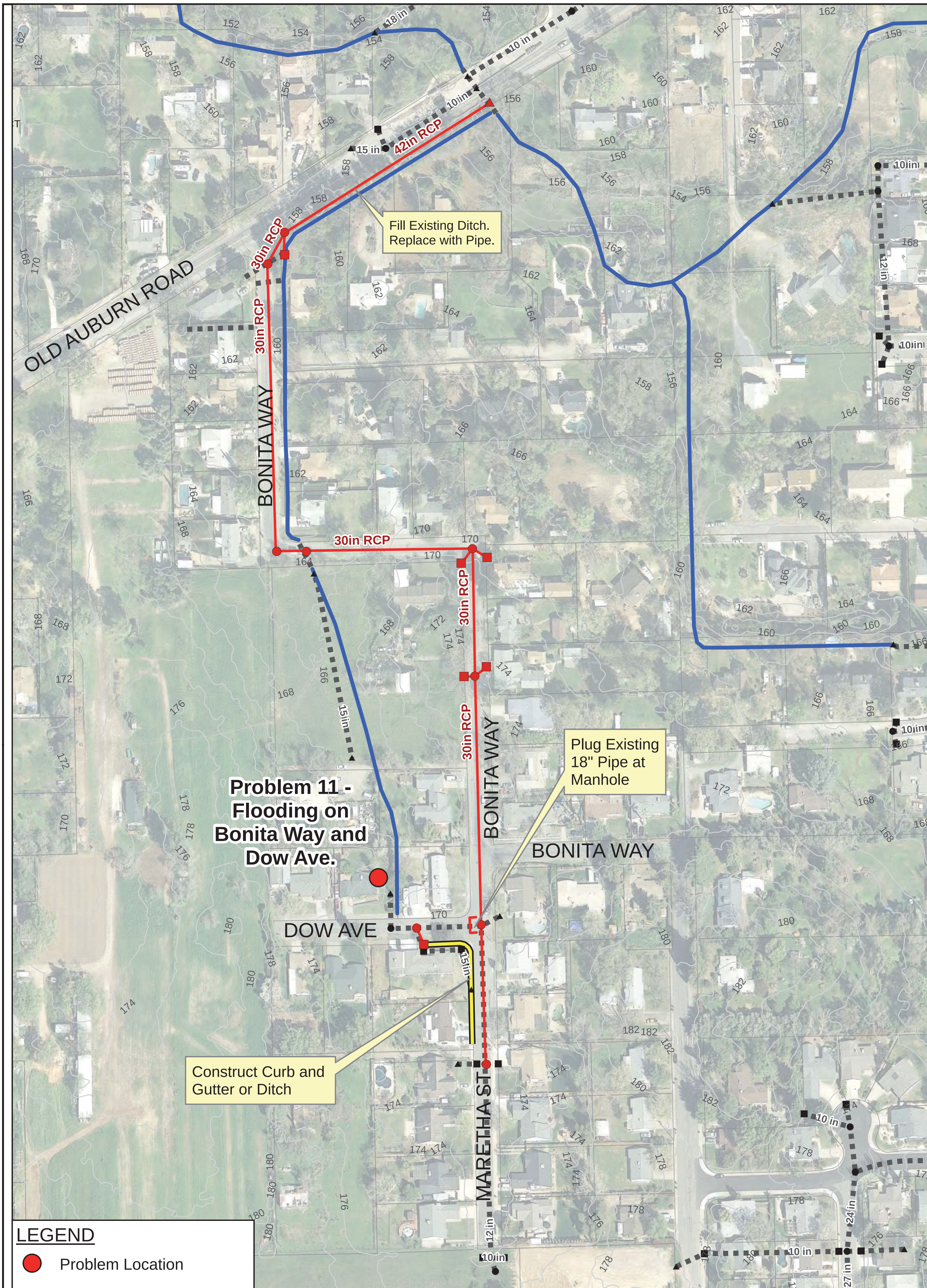

LEGEND

- Problem Location
- Stream or Channel
- Existing Pipe
- Proposed Pipeline or Drain
- Proposed Inlet
- Proposed Outfall
- Proposed Manhole
- Proposed Ditch

0 75 150
Scale in Feet

DRAFT **FIGURE 7-13**

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 11
and Proposed Solution

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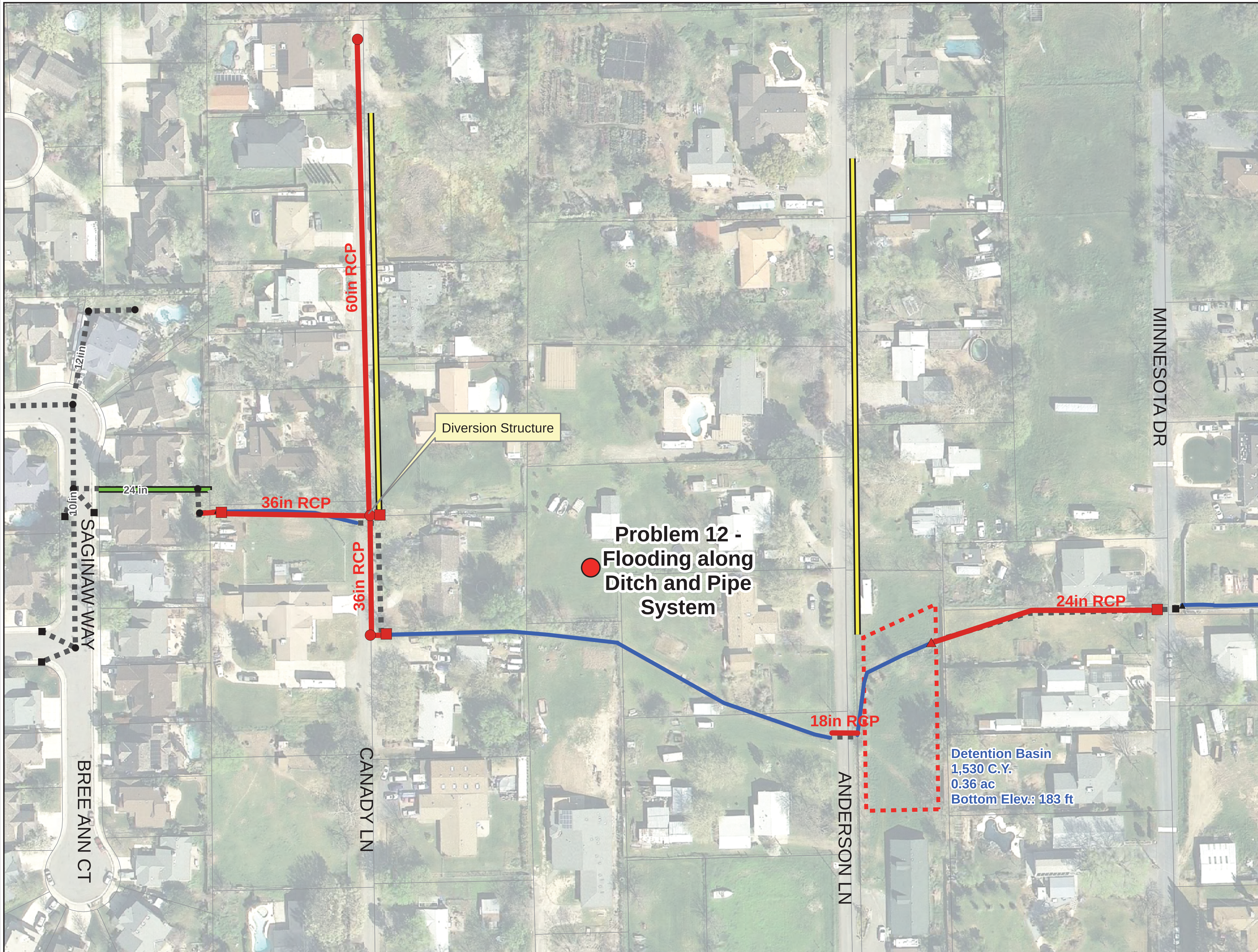
DRAFT **Figure 7-14**

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

Problem Location 12 and Proposed Solution



N

0 50 100

Scale in Feet

LEGEND

- Elevation Contour (NAVD88)
- Stream or Channel
- Existing Drain Pipe
- Proposed Pipe or Drain
- Proposed Detention Basin
- Proposed Overland Release
- Proposed Ditch or Gutter
- Proposed Inlet
- Proposed Outfall
- Proposed Manhole

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CHAPTER 8
Capital Improvement Program

The flooding and drainage problems and recommended solutions have been described in previous chapters. This chapter provides a summary of the recommended capital improvements, the cost of the improvements, and the priorities for the implementation of the improvements based on the criteria described below.

8.1 PRIORITIZATION CRITERIA

The recommended capital improvements have been separated into three categories: high priority; medium priority; and low priority. The criteria used to define the priority of a given set of improvements are as follows:

8.1.1 High Priority Improvements

The high priority improvements include those that address potential structure flooding, threats to health and safety, serious traffic hazards, and those that have a very high benefit to cost ratio. The benefit-cost ratios were determined qualitatively; formal determinations of damages and benefits were not performed.

8.1.2 Medium Priority Improvements

Medium priority improvements include those that address potential flooding of lesser structures (e.g., garages, outbuildings), chronic ponding over significant areas, and problems that require excessive maintenance.

8.1.3 Low Priority Improvements

Low priority improvements include those that address minor or occasional ponding and nuisance drainage issues.

8.2 CAPITAL IMPROVEMENT PROGRAM

Costs for recommended capital improvements within each priority classification are presented in Table 8-1. Also shown in the table are the estimated implementation dates for the improvements. As indicated previously in this report, the cost estimates presented in the table are master planning level estimates suitable for decision making and budgeting purposes only. More detailed cost estimates need to be prepared to a greater level of accuracy as the projects advance to the design stage and more detailed information is developed.

Table 8-1. Summary of Implementation Dates and Costs for Proposed Solutions

Problem Location Number	Solution Description	Figure Showing Proposed Improvements	Target Implementation Date	Total Estimated Improvements Cost, dollars[a]
High Priority				
3 and 4	Highland Avenue Pipe System and Rinconada Overland Release (Option 2)	7-5b	Spring 2017	878,000
6 and 10	Pipe Improvements along Mariposa Ave. from Glenacre Way to Arcade Creek (Option 2)	7-8b	Spring 2019	1,425,000
7	Overland Release Structure from Denton Way to Sun Hill Drive	7-9	Spring 2019	70,000
9	Underground Storage at Amsell Ct., Pipe Improvements at Blayden Ct., and Detention Basin in Power Line Corridor (Option 2)	7-12b	Spring 2018	417,000
11	Pipe Improvements along Maretha St., Bonita Way, and Old Auburn Rd. Curb and Gutter on Maretha St. and Dow Ave.	7-13	Spring 2018	1,060,000
12	Pipe Improvements between Minnesota Dr. and Anderson Ln. and near Canady Ln. Detention Basin near Anderson Ln. Underground Storage Pipe in Canady Ln. Overland Release Structure near Saginaw Way	7-14	Spring 2017	871,000
	Total Estimated Cost of High Priority Improvements			**4,721,000**
Medium Priority				
1	Ditch and Driveway Culvert on Auburn Blvd.	7-2	Summer 2016	8,000
5	Upsize Outfall on Chula Vista Drive	7-6	>Summer 2017	90,000
8	Upsize Pipe on Dana Butte Way and Canelo Hills Drive	7-11	Spring 2017	117,000
	Total Estimated Cost of Medium Priority Improvements			**215,000**
Low Priority				
2	Under Sidewalk Drain on Oak Ave.	7-3	Summer 2016	9,000
	Total Estimated Cost of Low Priority Improvements			**9,000**
	Total Estimated Cost of All Improvements			**4,945,000**

[a] The estimated costs for Problem Locations 9 and 12 solutions do not include the cost of easement acquisition.

APPENDIX A

Master Field Notes

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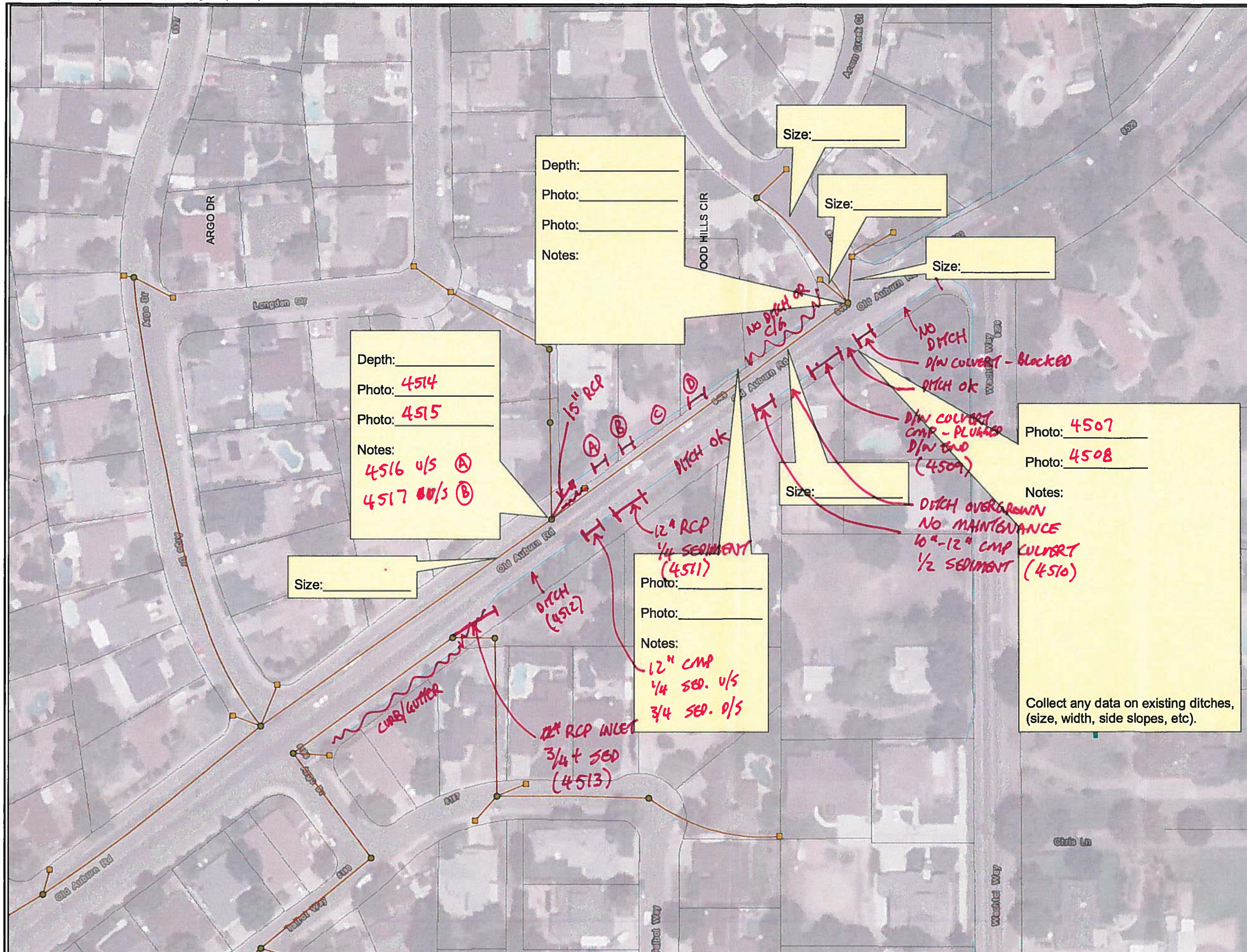

FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10

Drainage Master Plan Study

PROBLEM AREA 1

Notes:

(A) D/S OPEN, U/S BURIED IN VEG. 12" RCP

(B) RCP - FULL SEDIMENT

NO DEFINED DITCH BTWN (A) & (B)

(C) NO DEFINED DITCH

(D) CMP PLUGGED, NO DITCH U/S (4518)

LEGEND

- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

N

0 50 100

Scale in Feet

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SEDIMENT (SEVERE) OUTLET PIPE 3/4. EAST PIPE 1/2 OTHERS ABOVE WATER LEVEL

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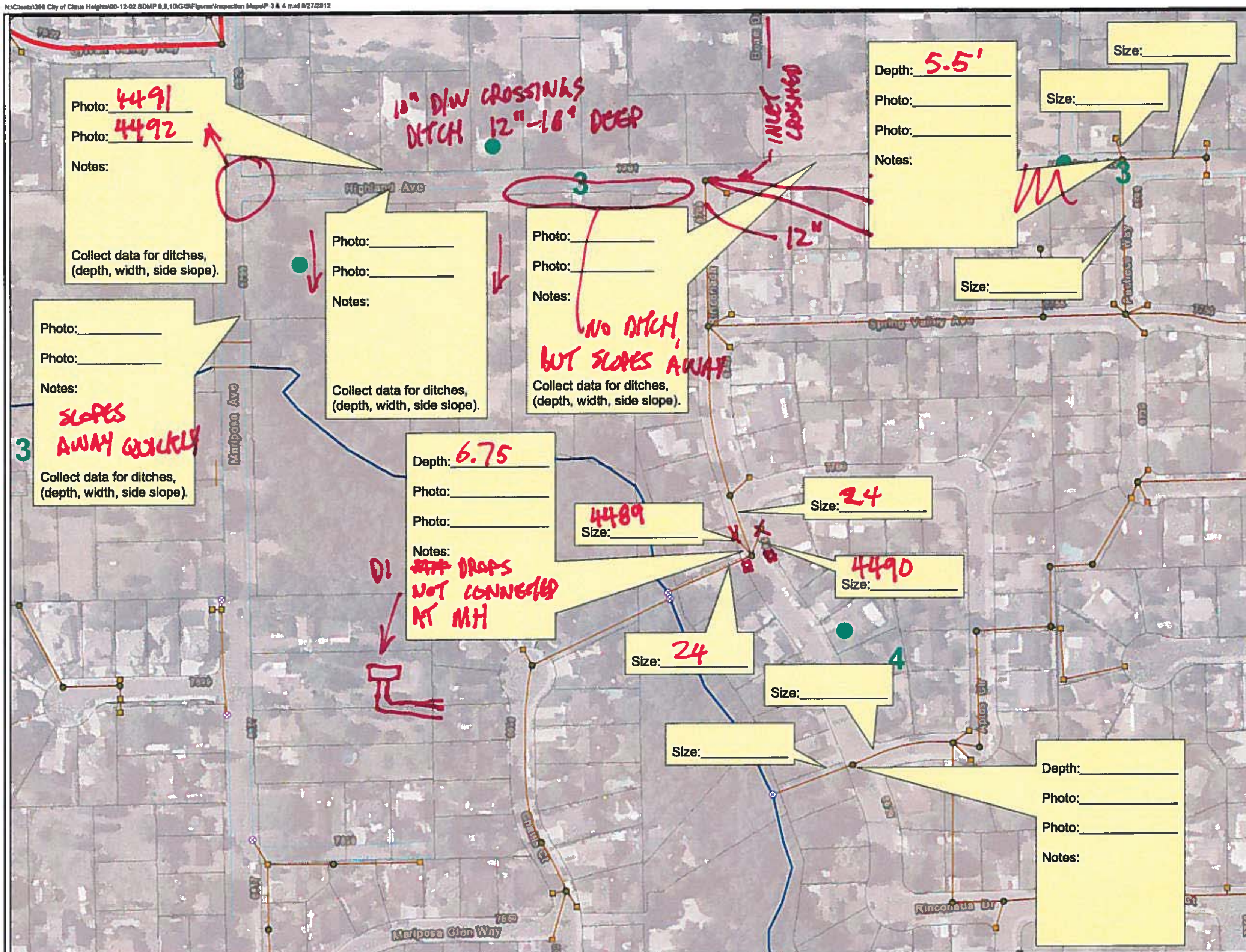

FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

PROBLEM AREAS 3 AND 4

Notes:

INLETS TOO SMALL

LEGEND

- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

0 75 150
Scale in Feet

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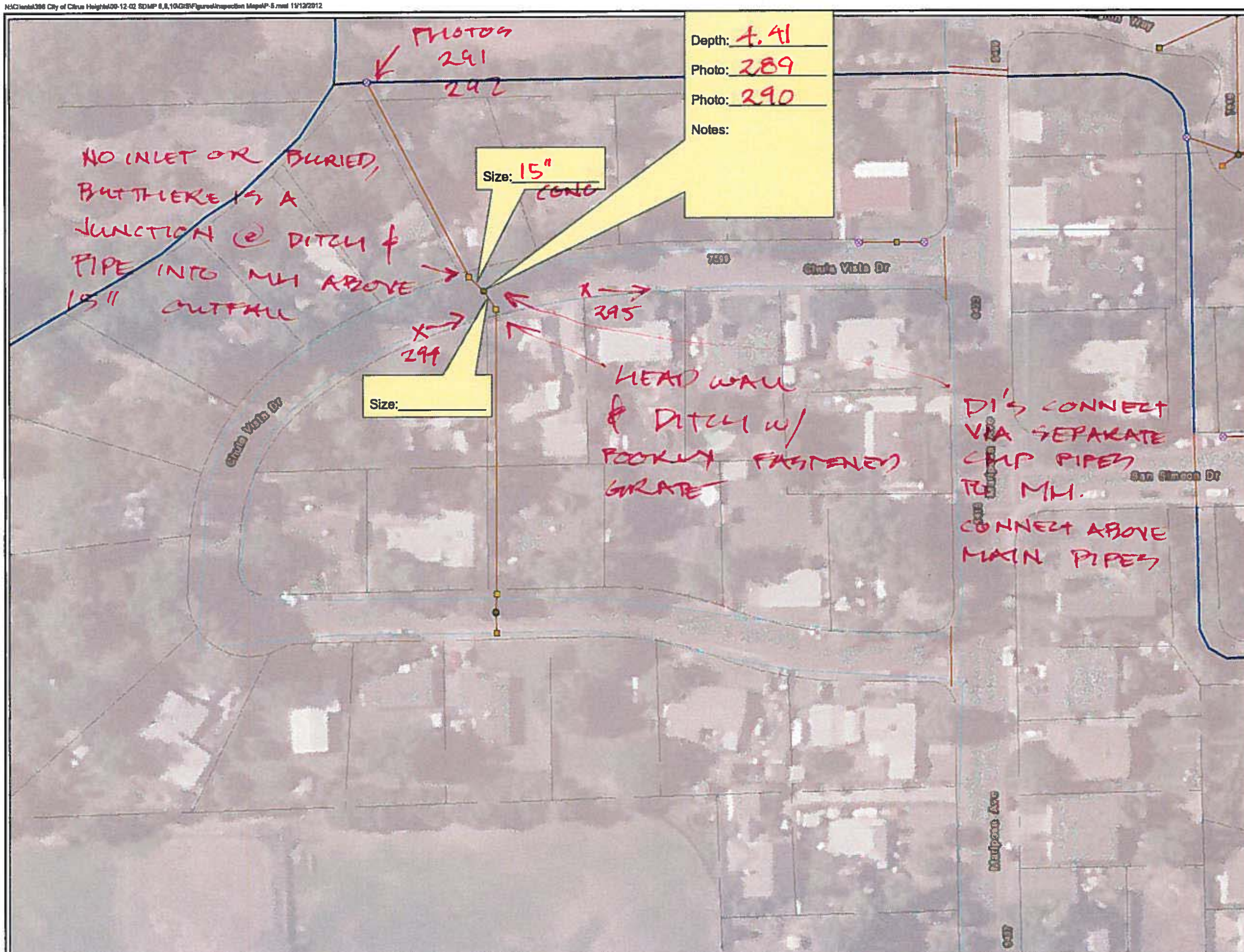

FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

PROBLEM AREA 5

Notes:

LEGEND

- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

0 75 150
Scale in Feet

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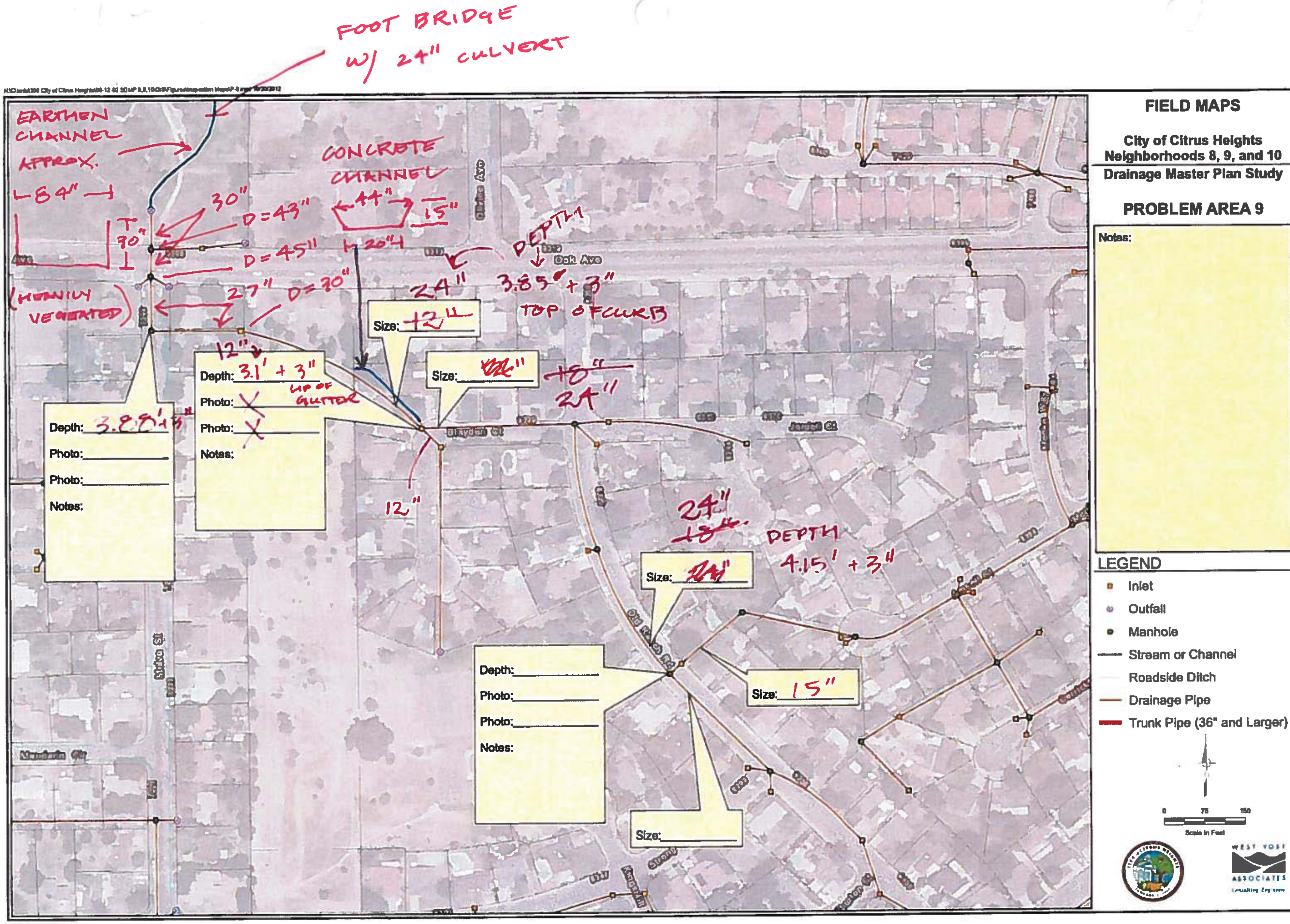
FOOT BRIDGE
W/ 24" CULVERT
EARTHEN CHANNEL APPROX.
84"
30"
30"
D=43"
D=45"
CONCRETE CHANNEL
44"
15"
20"
(HEAVILY VEGETATED)
27"
D=30"
24"
DEPTH
3.85' + 3"
TOP OF CURB
Oak Ave
Size: 12"
12"
Depth: 3.1' + 3"
LIP OF GUTTER
Photo: X
Photo: X
Notes:
Size:
18"
24"
Depth: 3.88' + 3"
Photo:
Photo:
Notes:
12"
Jardell Ct
24"
18"
DEPTH
4.15' + 3"
Size:
Size: 15"
Depth:
Photo:
Photo:
Notes:
Size:
Mandarin Cir
FIELD MAPS
City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study
PROBLEM AREA 9
Notes:
LEGEND
Inlet
Outfall
Manhole
Stream or Channel
Roadside Ditch
Drainage Pipe
Trunk Pipe (36" and Larger)
0
75
150
Scale in Feet
WEST YOST ASSOCIATES
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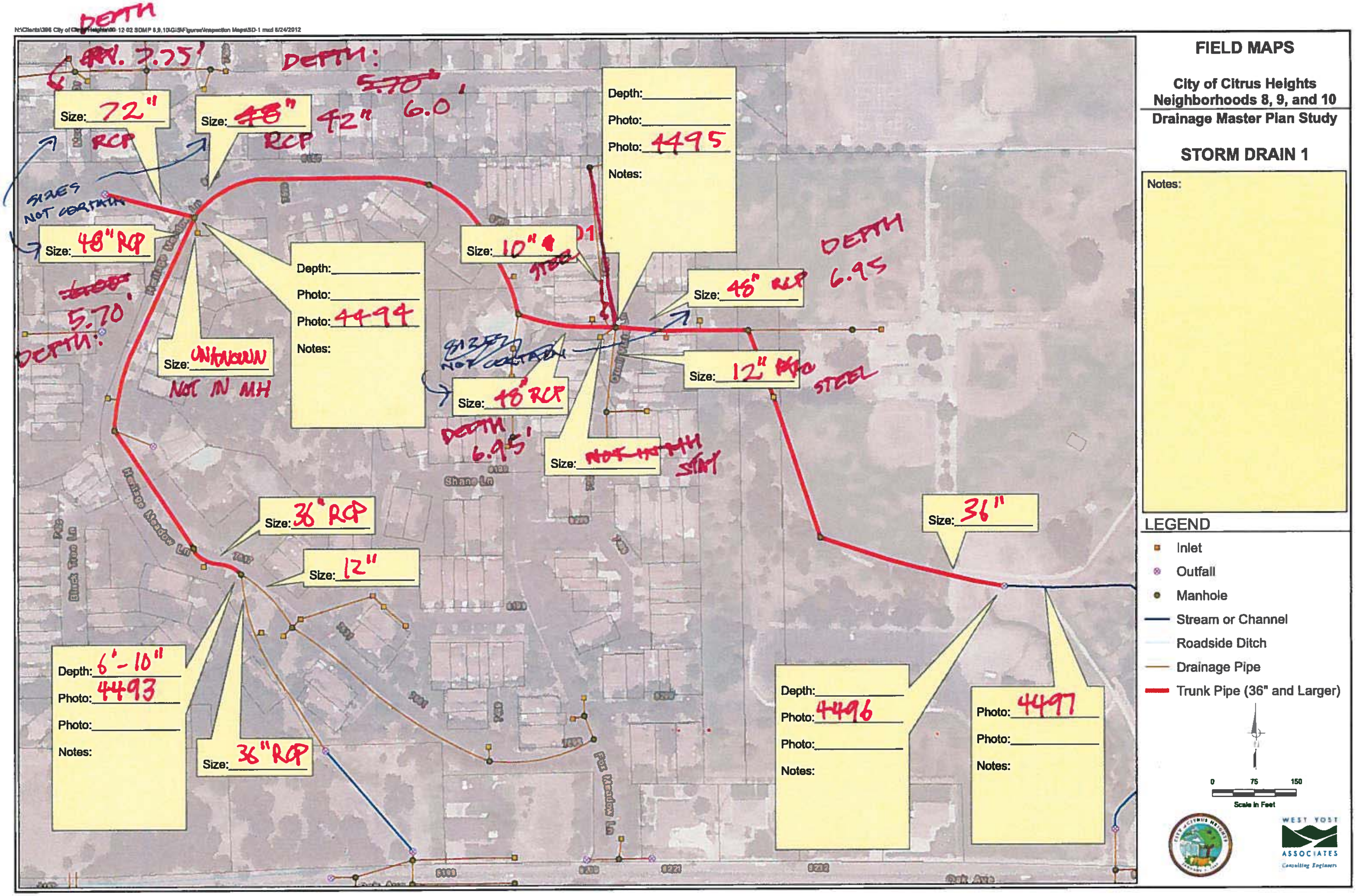
FIELD MAPS
City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study
STORM DRAIN 1
Notes:
LEGEND
Inlet
Outfall
Manhole
Stream or Channel
Roadside Ditch
Drainage Pipe
Trunk Pipe (36" and Larger)
0 75 150
Scale in Feet
WEST YOST ASSOCIATES
Consulting Engineers
DEPTH
Size: 72" RCP
Size: 48" 42" RCP
DEPTH: 6.0'
SIZES NOT CERTAIN
Size: 48" RCP
DEPTH: 5.70'
Size: UNKNOWN NOT IN MH
Depth:
Photo:
Photo: 4494
Notes:
Size: 10" STEEL
Depth:
Photo:
Photo: 4495
Notes:
Size: 48" RCP
DEPTH 6.95
SIZES NOT CERTAIN
Size: 48" RCP
DEPTH 6.95'
Size: 12" STEEL
Size: STAY
Shane Ln
Heritage Meadow Ln
Size: 36" RCP
Size: 12"
Size: 36"
Depth: 6'-10"
Photo: 4493
Photo:
Notes:
Size: 36" RCP
Fair Meadow Ln
Depth:
Photo: 4496
Photo:
Notes:
Photo: 4497
Photo:
Notes:
Oak Ave

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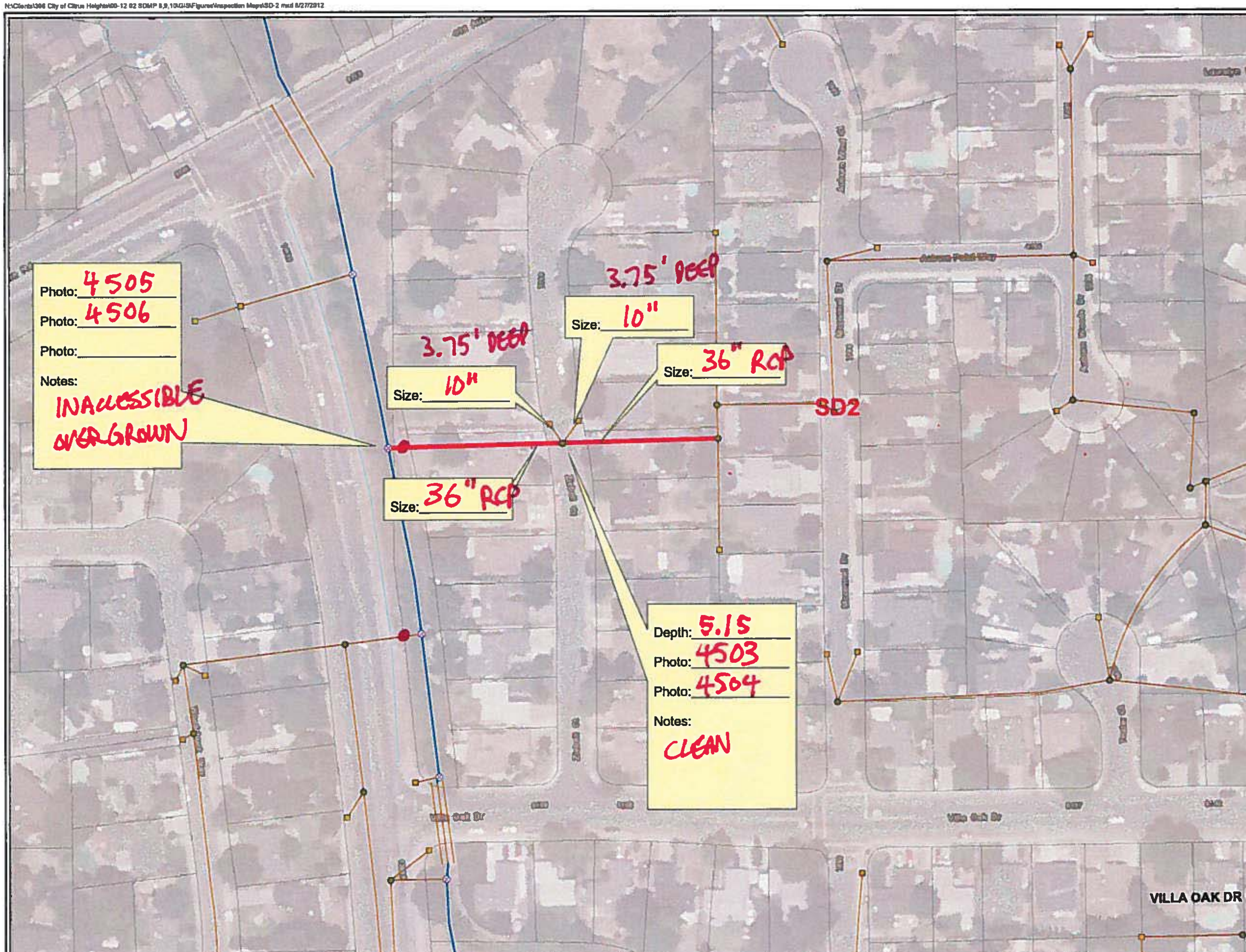

FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

STORM DRAIN 2

Notes:

LEGEND

- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

0 50 100
Scale in Feet

WEST YOST ASSOCIATES
Consulting Engineers

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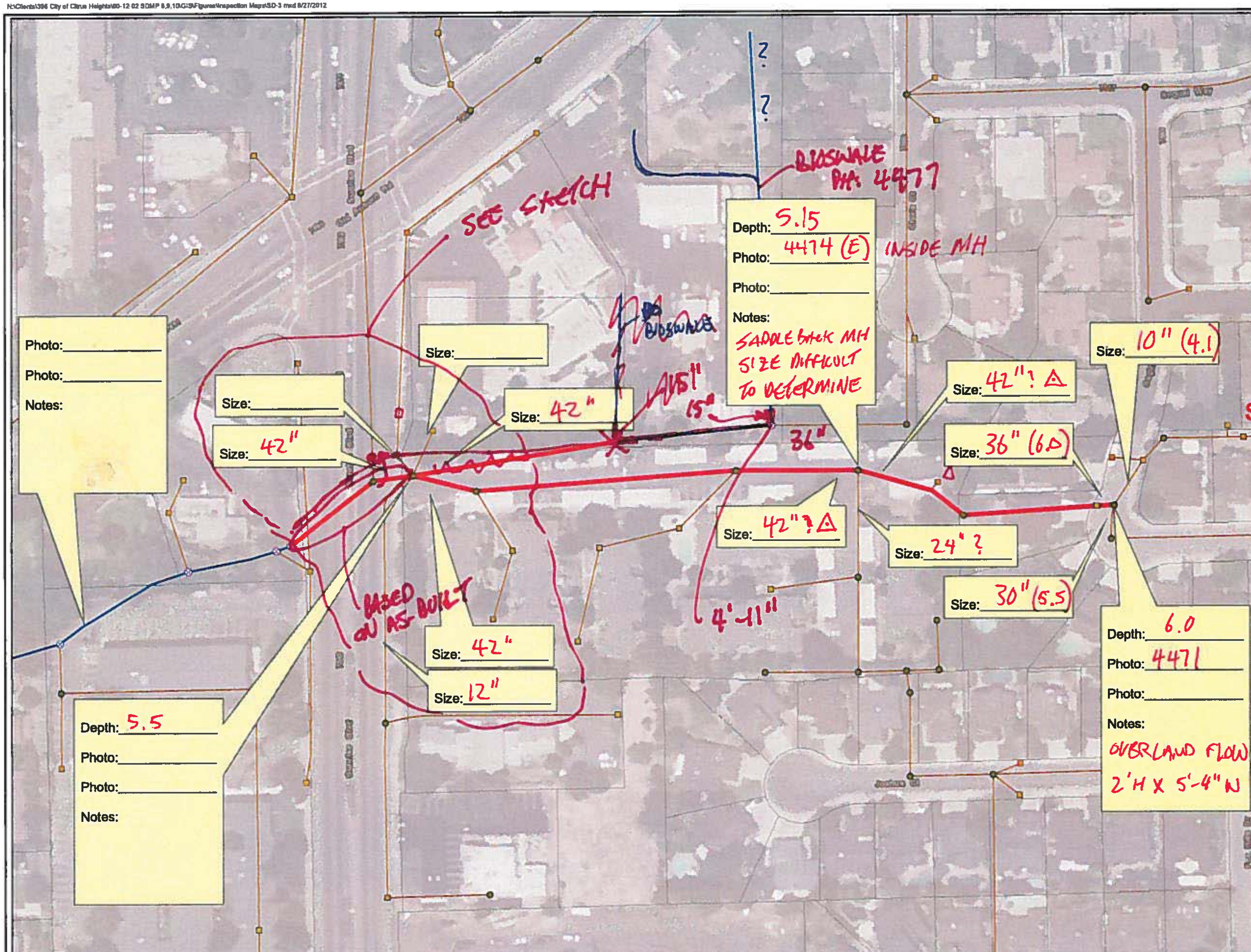


FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

STORM DRAIN 3

Notes:
△ OVERLAND OPENING
2 - 3'W x 24"H
~~15"W X~~
3'W x 15"H
PHOTO: 4472
△ ESTIMATED SIZE BASED ON MH DEPTH

LEGEND
- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

0 50 100
Scale in Feet

WEST YOST ASSOCIATES
Consulting Engineers

Project

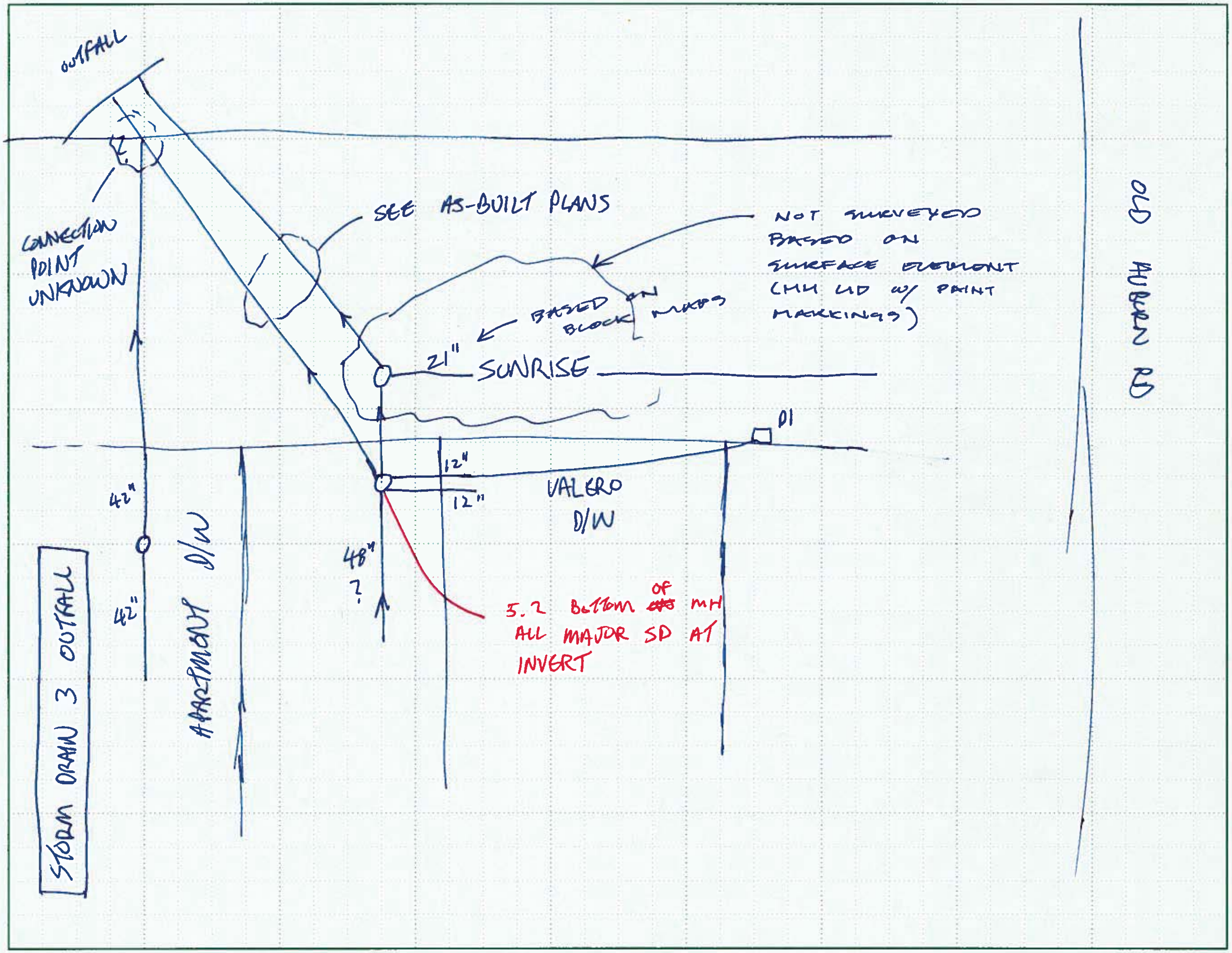
Job No.

Date

Calc. By

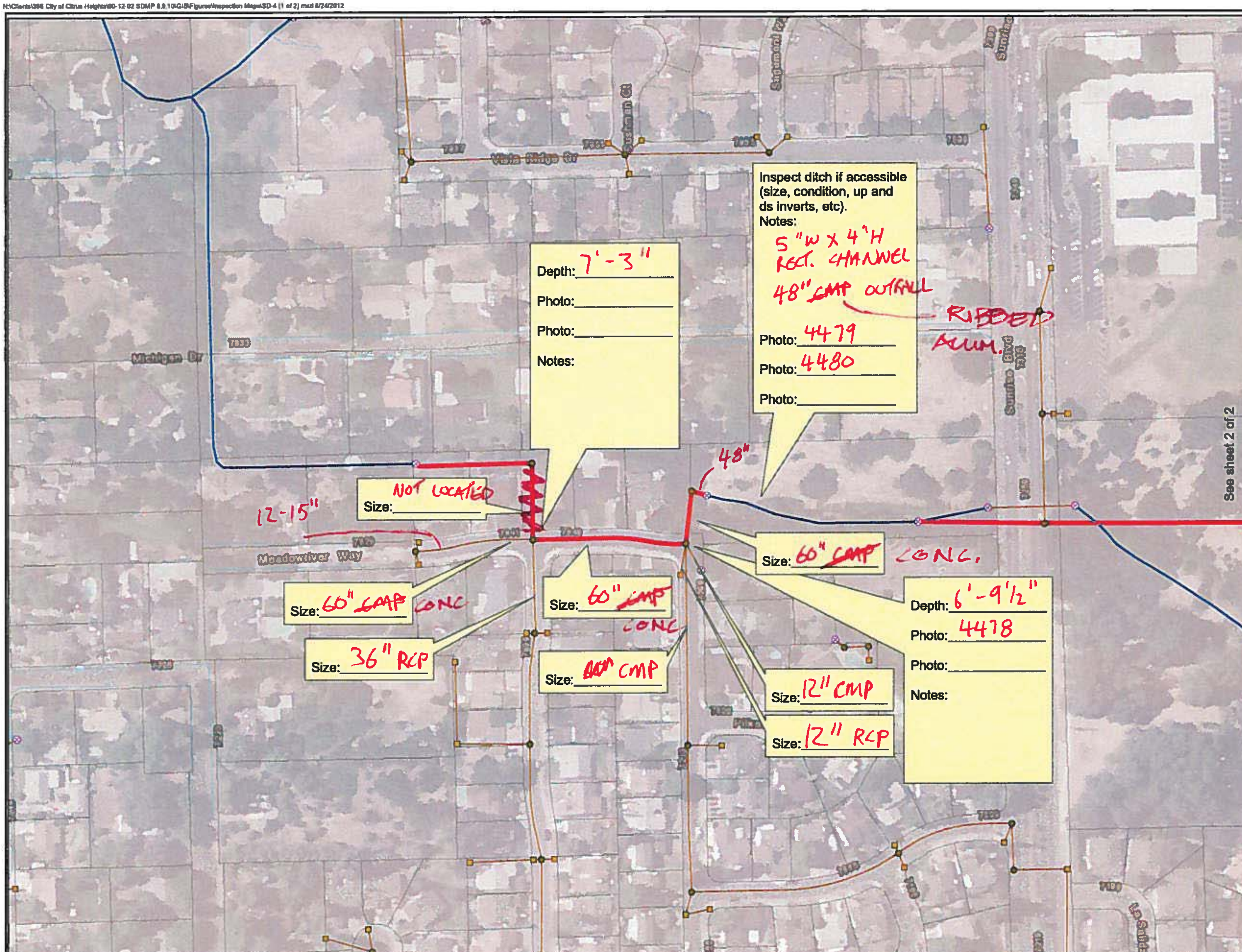
Ckd. By

of



WEST YOST ASSOCIATES

Consulting Engineers



FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10

Drainage Master Plan Study
STORM DRAIN 4
(Part 1 of 2)

Notes:

LEGEND

- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

0 75 150
Scale in Feet

WEST YOST ASSOCIATES
Consulting Engineers

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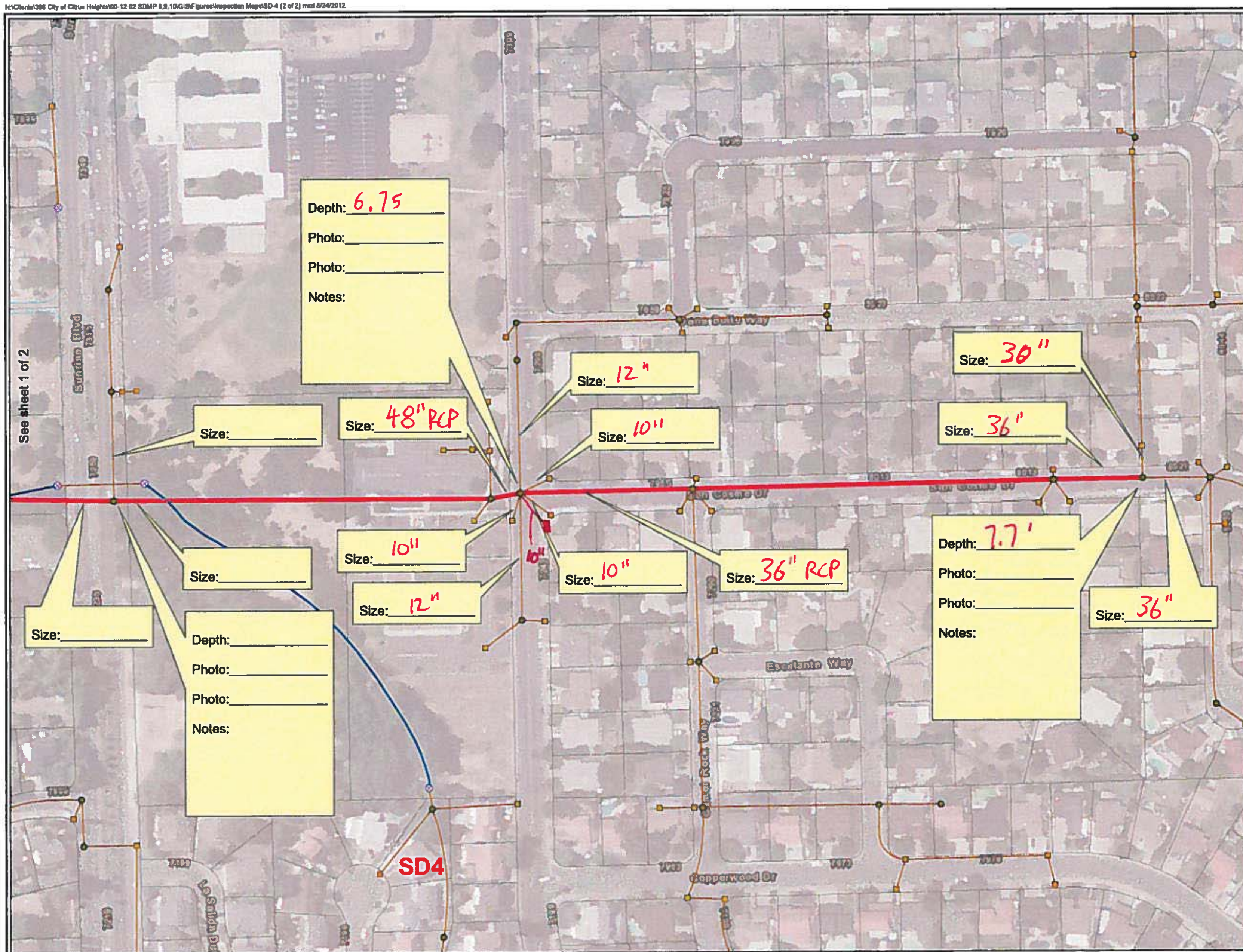

FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study
STORM DRAIN 4
(Part 2 of 2)

Notes:

LEGEND

- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

0 75 150
Scale in Feet

WEST YOST ASSOCIATES
Consulting Engineers

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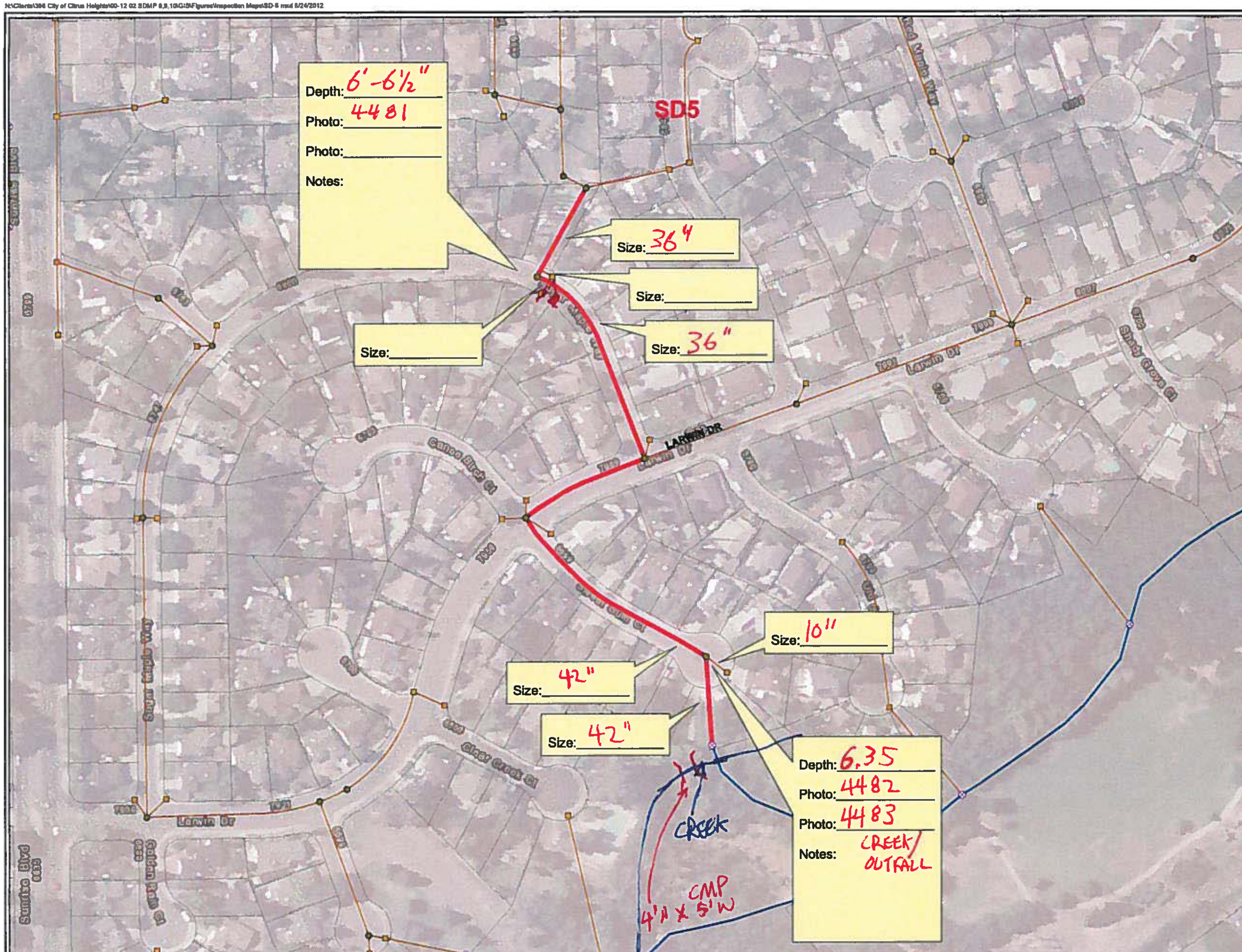

FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

STORM DRAIN 5

Notes:

LEGEND

- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

0 75 150
Scale in Feet

WEST YOST ASSOCIATES
Consulting Engineers

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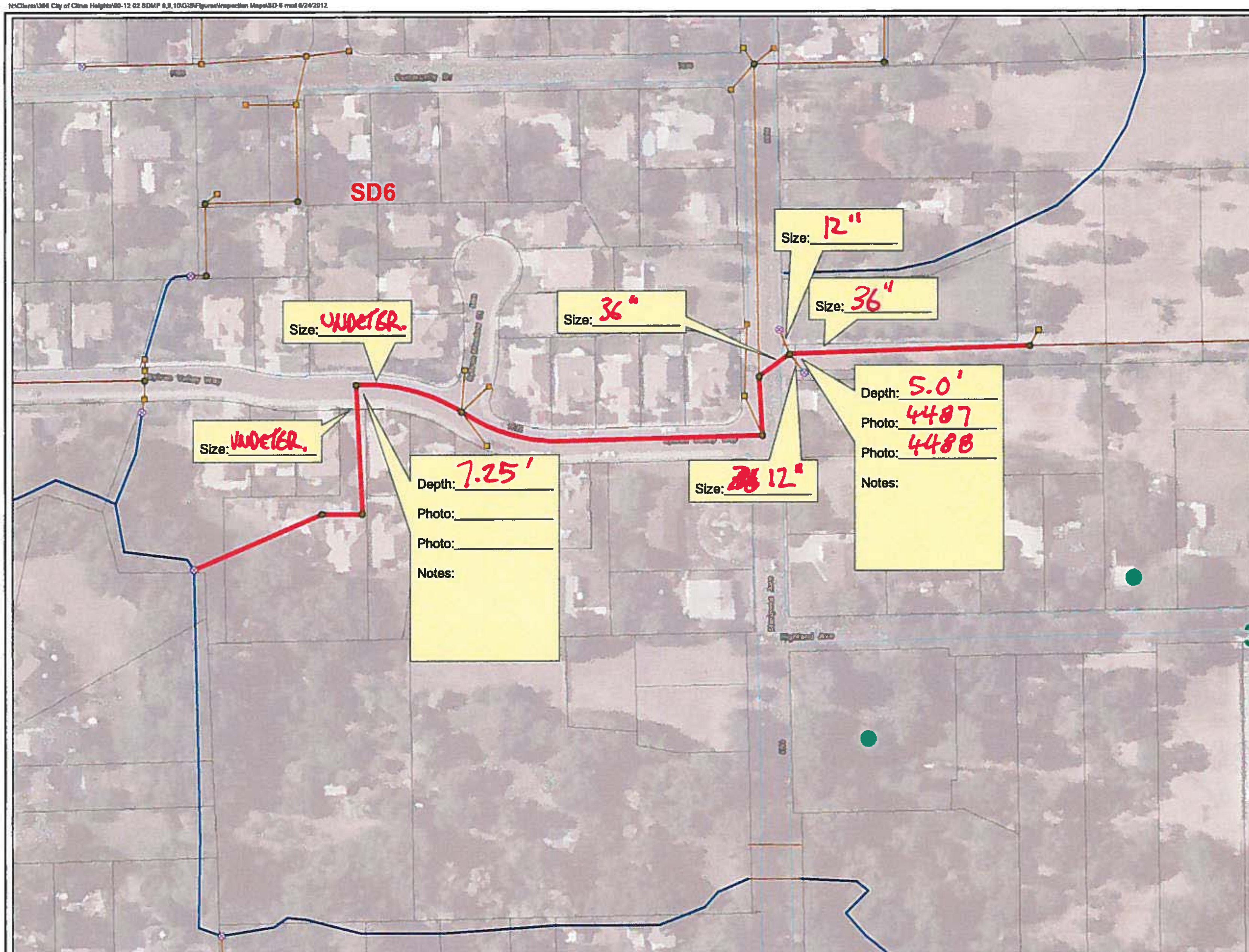

FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

STORM DRAIN 6

Notes:

LEGEND

- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

0 75 150
Scale in Feet

WEST YOST ASSOCIATES
Consulting Engineers

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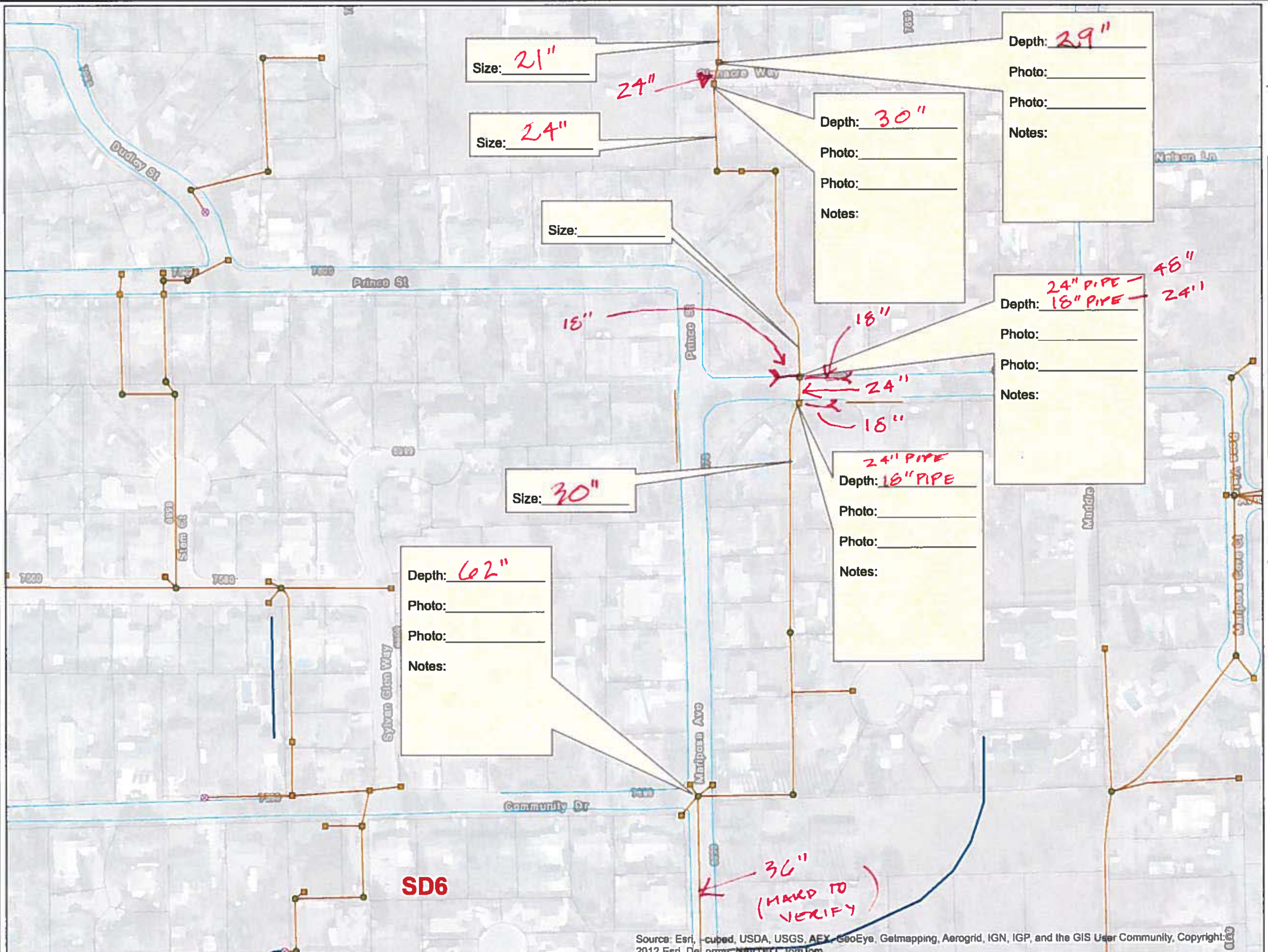


FIELD MAPS

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

STORM DRAIN 6

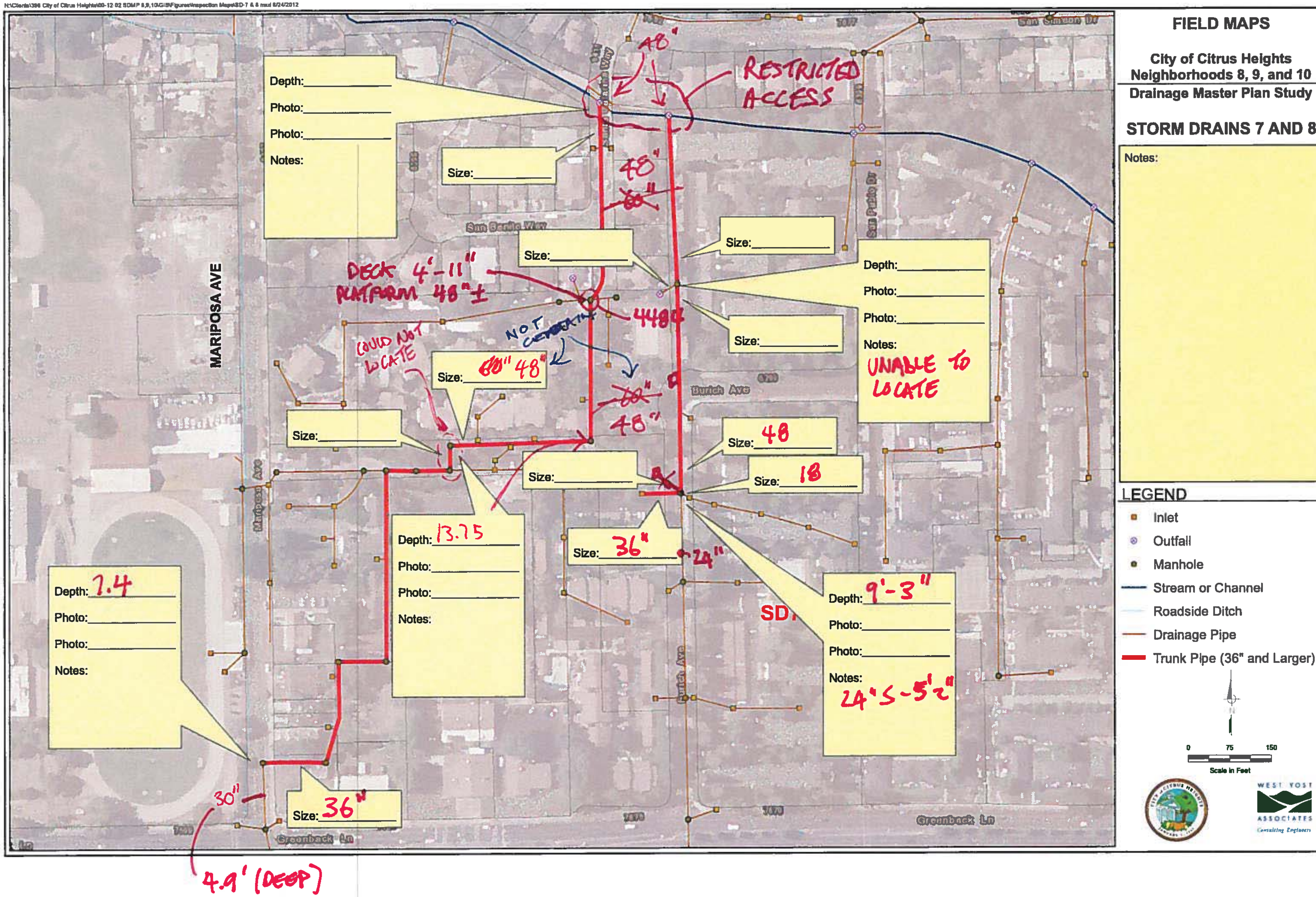
Notes: PART II

LEGEND

- Inlet
- Outfall
- Manhole
- Stream or Channel
- Roadside Ditch
- Drainage Pipe
- Trunk Pipe (36" and Larger)

0 75 150
Scale in Feet

WEST YOST ASSOCIATES


FIELD MAPS
City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study
STORM DRAINS 7 AND 8
Notes:
LEGEND
Inlet
Outfall
Manhole
Stream or Channel
Roadside Ditch
Drainage Pipe
Trunk Pipe (36" and Larger)
0 75 150
Scale in Feet
WEST YOST ASSOCIATES
Consulting Engineers
MARIPOSA AVE
Mariposa Ave
San Benito Way
San Pablo Dr
San Simeon Dr
Burich Ave
Greenback Ln
RESTRICTED ACCESS
48"
Depth:
Photo:
Photo:
Notes:
Size:
DECK 4'-11"
PLATFORM 48" ±
COULD NOT LOCATE
NOT
Size: 48"
UNABLE TO LOCATE
Size: 48
Size: 18
Depth: 13.75
Size: 36"
24"
Depth: 9'-3"
Notes: 24"S-5'2"
SD
Depth: 7.4
30"
Size: 36"
4.9' (DEEP)

APPENDIX B

Photos on CD

APPENDIX C

Hydraulic Calculations for Proposed Solutions

Table C-1. Peak Flows for Problem Locations

Contributing Subshed	Upstream Node	Downstream Node	Contributing Area (acres) by Land-Use Type and/or Percent Impervious: Comm./Office 90%	Apts./RD-20 80%	RD-5 50%	RD-4 40%	RD-3 30%	RD-2 25%	RD-1 20%	Open Space 2%	Subshed Total: Area (acres)	Subshed Total: % Imp.	Cumulative Total at Node: Area (acres)	Cumulative Total at Node: % Imp.	Pipe Flow (cfs) Nolte Zone 1	10-Year Flow (cfs) Sac. Method Zone 3	100-Year Flow (cfs) Sac. Method Zone 3
Problem Location 1																	
P1A	P1A	P1B	-	-	-	-	-	2.3	-	-	2.3	25.0	2.3	25.0	0.6	n/a	4.2
Problem Location 2 - Qualitative Solution Defined, No Hydrologic Calculations Performed																	
Problem Location 3 - Option 1																	
P3A	P3A	J3B	-	-	-	3.6	-	-	-	-	3.6	40.0	3.6	40.0	1.0	6.2	9.0
P3B	P3B	J3B	-	-	-	-	4.6	-	-	-	4.6	30.0	4.6	30.0	1.3	7.2	11.0
-	J3B	P3C	-	-	-	-	-	-	-	-	0.0	0.0	8.2	34.4	2.3	12.3	18.0
P3C	P3C	P3D	-	-	-	1.1	-	-	-	-	1.1	40.0	9.3	35.1	2.6	13.2	19.5
P3D	P3D	P3E	-	-	-	-	1.4	-	-	-	1.4	30.0	10.7	34.4	3.0	15.0	22.5
P3E	P3E	P3Out	-	-	-	-	0.9	-	-	-	0.9	30.0	11.6	34.1	3.3	16.0	23.0
Problem Location 3 - Option 2																	
P3	P3	J3B	-	-	0.6	-	8.5	-	6.9	-	16.0	26.4	16.0	26.4		20.0	
P3A	P3A	J3B	-	-	-	3.6	-	-	-	-	3.6	40.0	3.6	40.0		6.2	
P3B	P3B	J3B	-	-	-	-	4.6	-	-	-	4.6	30.0	4.6	30.0		7.2	11.0
-	J3B	P3C	-	-	-	-	-	-	-	-	0.0	0.0	8.2	34.4		12.3	
P3C	P3C	P3D	-	-	-	1.1	-	-	-	-	1.1	40.0	25.3	29.6		29.0	
P3D	P3D	P3E	-	-	-	-	1.4	-	-	-	1.4	30.0	26.7	29.6		30.0	
P3E	P3E	P3Out	-	-	-	-	0.9	-	-	-	0.9	30.0	27.6	29.6		31.5	
Problem Location 4 - Existing																	
P4A	P4A	P4AOut	-	-	-	25.5	-	3.1	7.0	-	35.6	34.8	35.6	34.8	11.1	40.0	57.0
Problem Location 4 - Option 1																	
P4A	P4A	P4AOut	-	-	-	24.4	-	3.1	7.0	-	34.5	34.6	34.5	34.6	10.6	39.0	56.0
Problem Location 4 - Option 2																	
P4A	P4A	P4AOut	-	-	-	18.5	-	-	-	-	18.5	40.0	18.5	40.0	5.4	24.0	35.0
Problem Location 5																	
P5A	P5A	P5B	1.4	-	-	-	6.6	-	-	5.1	13.1	25.5	13.1	25.5	3.7	16.8	
Problem Locations 6 and 10 - Unsteady Calculations Performed (See Table A-2)																	
Problem Locations 7 & 8 - Qualitative Solution Defined, No Hydrologic Calculations Performed																	
Problem Location 9 - Unsteady Calculations Performed (See Table A-2)																	
Problem Location 11																	
P11A	P11A	P11B	-	-	-	-	3.6	-	7.7	-	11.3	23.2	11.3	23.2	3.2	14.2	20.5
P11B	P11B	P11C	-	-	-	-	3.8	-	-	-	3.8	30.0	15.1	24.9	4.3	18.5	26.7
P11C	P11C	P11D	-	-	-	-	1.6	-	-	-	1.6	30.0	16.7	25.4	4.8	20.3	29.2
P11D	P11D	P11D2	-	-	-	-	2.1	-	-	-	2.1	30.0	18.8	25.9	5.4	22.6	32.4
P11E	P11E	P11E2	-	-	-	-	-	-	3.3	1.9	5.2	13.4	24.0	23.2	7.1	27.3	39.1
P11F	P11F	P11F2	-	-	-	-	2.3	-	-	-	2.3	30.0	26.3	23.8	7.8	29.6	42.3
P11G	P11G	P11G2	-	-	-	-	4.2	-	-	1.7	5.9	21.9	32.2	23.5	9.8	34.9	49.6
Problem Location 12 - Unsteady Calculations Performed (See Table A-2)																	

Table C-2. Hydrologic Model Parameters for Unsteady Flow Calculations - Problem Locations 4, 6, 9, 10, and 12

Subbasin	Area (acres)	Mean Elevation (ft, NAVD)	Basin Length (ft)	Basin Centroid Length (ft)	Basin Slope (ft/ft)	Land-Use (acres) and Percent Imperviousness								Average % Imp.
						Comm./ Office	Apts./ RD-20	RD-5	RD-4	RD-3	RD-2	RD-1	Open Space	
						90%	80%	50%	40%	30%	25%	20%	2%	
Problem 4 (Option 2)														
P4A1	18.5	154	2360	1000	0.0186	-	-	-	18.5	-	-	-	-	40.0
P4B1	12.8	162	1680	840	0.0142	-	-	-	12.8	-	-	-	-	40.0
P4B2	5.4	158	930	450	0.0180	-	-	-	5.4	-	-	-	-	40.0
P4B3	3.3	154	680	340	0.0120	-	-	-	3.3	-	-	-	-	40.0
P4B4	6.8	148	770	300	0.0100	-	-	-	6.8	-	-	-	-	40.0
Problems 6 & 10														
6A1	5.1	181	830	440	0.0217	-	-	-	5.1	-	-	-	-	40.0
6A2	12.4	192	1210	680	0.0264	-	3.5	-	8.2	-	-	-	0.7	49.1
6A3	19.6	172	1380	800	0.0167	-	-	-	-	-	-	19.6	-	20.0
6A4	16.0	170	1410	650	0.0156	-	-	-	-	-	-	16.0	-	20.0
6A5	12.2	160	1290	650	0.0155	-	-	-	-	-	12.2	-	-	25.0
6B1	8.0	170	1080	520	0.0111	-	-	-	-	8.0	-	-	-	30.0
6B2	14.7	168	1000	470	0.0080	3.9	-	-	-	10.8	-	-	-	45.9
6B3	13.5	169	960	480	0.0188	2.7	-	-	-	7.9	-	-	2.9	36.0
6B4	14.6	168	1350	670	0.0178	-	-	-	4.6	-	-	10.0	-	26.3
6B5	9.2	164	1000	490	0.0160	-	-	-	3.2	-	6.0	-	-	30.2
6B6	10.3	160	1250	650	0.0168	-	-	-	-	10.3	-	-	-	30.0
6B7	6.3	150	740	320	0.0108	-	-	-	-	-	6.3	-	-	25.0
6B7J	3.3	146	570	220	0.0123	-	-	-	3.3	-	-	-	-	40.0
6B8	27.5	162	2720	1600	0.0132	1.2	-	0.6	1.2	8.4	9.2	6.9	-	29.3
Problem 9														
P9A	5.6	228	870	460	0.0069	-	-	-	5.6	-	-	-	-	86.3
P9B	5.7	223	780	300	0.0103	-	-	-	5.7	-	-	-	-	86.9
P9C	2.5	214	360	100	0.0167	-	-	-	2.5	-	-	-	-	87.5
P9D	16.2	220	1800	600	0.0200	-	-	-	16.2	-	-	-	-	87.0
P9E	10.1	213	750	380	0.0187	-	-	-	9.4	-	-	-	0.7	86.0
P9F	9.2	210	800	300	0.0125	-	-	-	5.1	-	-	-	4.1	86.6
P9H	1.8	210	500	250	0.0400	-	-	-	-	-	-	-	1.8	86.5
P9I	10.0	210	1050	500	0.0240	-	-	-	9.6	-	-	-	0.4	86.3
Problem 12														
SD3A1a	5.5	200	1,400	695	0.0114	-	-	-	3.4	-	2.1	-	-	34.3
SD3A1b	5.0	194	605	300	0.0198	-	-	-	0	-	5.0	-	-	25.0
SD3A2	9.2	192	750	320	0.0160	-	-	-	0	-	9.2	-	-	25.0
SD3A3	12.7	190	770	390	0.0156	-	-	-	0	-	12.7	-	-	25.0
SD3A4	3.7	184	550	225	0.0145	-	-	-	0.7	-	3.0	-	-	27.8
SD3A5	3.6	180	600	300	0.0150	-	-	-	3.6	-	-	-	-	40.0
SD3A6	6.6	178	725	300	0.0110	-	-	-	6.6	-	-	-	-	40.0
SD3B	19.9	180	2,080	800	0.0087	-	2.4	-	13.8	-	3.7	-	-	42.0
SD3C	49.3	188	2,970	1,810	0.0061	1.5	0.8	2.6	41.0	-	-	-	3.4	40.1
SD3D	32.3	182	1,800	960	0.0133	25.5	1.0	-	5.8	-	-	-	-	80.7

Table C-3. Problem Location 1 XPSWMM Node Data and Results

Node Name	Proposed Solution			
	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	Nolte Water Surface Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)
P1A	198.80	196.80	197.14	197.73
P1B	198.40	196.50	196.79	197.42
P1C	197.70	196.10	196.36	196.87
P1D	196.60	194.70	194.96	195.47

Table C-4. Problem Location 1 XPSWMM Link Data and Results

Name	Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max Nolte Flow cfs	Max Nolte Velocity ft/s	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
Proposed Solution													
P1A_Ditch	Link1	P1A	P1B	Trapezoidal	1.00	33	196.80	196.50	0.040	0.6	1.3	4.2	2.3
P1B_Culv	Link2	P1B	P1C	Circular	1.00	32	196.50	196.10	0.015	0.6	3.3	4.2	5.6
P1C_Ditch	Link3	P1C	P1D	Trapezoidal	1.00	65	196.10	194.70	0.040	0.6	1.8	4.2	3.1

Table C-5. Problem Location 3 Hydraulic Data for Proposed Solution									
Reach No.	Upstream Node	Downstream Node	Design Flow - 10-Year (cfs)	Pipe Diameter (in.)	Manning's Roughness	Length (ft)	Approximate Slope (ft/ft)	Flow Depth (ft)	Flow Velocity (ft/s)
1	P3	P3C	20.0	27	0.015	670	0.0056	1.8	5.8
2	P3A	J3B	6.2	15	0.015	30	0.0123	1.0	5.8
3	P3B	J3B	7.2	V-Ditch[1]	0.015	250	0.0045	0.9	2.9
4	J3B	P3C	12.3	21	0.015	86	0.0080	1.4	5.8
5	P3C	P3D	29.0	30	0.015	376	0.0067	2.0	6.8
6	P3D	P3E	30.0	30	0.015	390	0.0072	2.0	7.0

Notes: 1. V-ditch is 1 foot deep with 3:1 side slopes.

Table C-6. Problem Location 4 XPSWMM Node Data and Results

Node Name	Proposed Solution (Option 2)			
	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	10-Year Water Surface Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)
P4A1	146.00	138.30	144.69	145.43
P4A_Out	146.00	138.00	141.60	144.30
P4B1	150.50	146.50	150.47	150.47
P4B1b	148.00	142.50	147.16	147.26
P4B2	154.00	150.00	154.76	154.79
P4B3	154.00	149.00	153.27	153.29
P4B4	148.00	141.80	147.67	148.08
P4B4b	148.00	141.30	144.94	146.16
P4B_Out	148.00	141.00	142.75	144.90
PB4_23	152.00	147.80	151.69	151.97

Table C-7. Problem Location 4 XPSWMM Link Data and Results												
Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 10-Year Flow cfs	Max 10-Year Velocity ft/s	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
Option 2												
P_4A1	P4A1	P4A_Out	Circular	1.75	146	138.30	138.00	0.015	20.2	8.3	12.3	5.0
OLR_4A1	P4A1	P4A_Out	Rectangular	1.50	146	144.00	143.60	0.015	2.8	2.8	7.9	3.9
P_4B2	P4B2	PB4_23	Circular	0.83	314	150.00	148.00	0.015	2.6	4.7	2.5	4.5
P_PB4-23	PB4_23	P4B4	Circular	1.00	414	147.80	142.60	0.015	4.0	5.0	3.6	4.5
P_4B4	P4B4	P4B4b	Circular	1.75	167	141.80	141.30	0.015	17.8	7.3	15.5	6.3
P_4B4b	P4B4b	P4B_Out	Circular	1.75	136	141.30	141.00	0.015	17.5	7.2	13.3	5.5
OLR_4b-4a	P4B4b	P4A1	Trapezoidal	0.50	370	145.80	143.80	0.020	0.0	0.0	8.1	0.6
P_4B1	P4B1	P4B1b	Circular	1.25	140	146.50	142.70	0.015	9.4	7.6	9.1	7.3
OLR_B1-B1b	P4B1	P4B1b	Trapezoidal	0.50	812	150.00	145.80	0.020	16.1	1.6	15.8	1.4
P_4B1b	P4B1b	P4B4	Circular	1.50	444	142.50	141.80	0.015	6.2	3.5	-5.1	2.2
OLR_B1b	P4B1b	P4B4b	Trapezoidal	0.50	250	146.80	145.80	0.020	5.9	1.4	11.4	1.6
P_4B3	P4B3	PB4_23	Circular	0.83	198	149.00	148.00	0.015	1.8	3.3	1.7	3.0

Table C-8. Problem Location 5 Hydraulic Data for Proposed Solution

Reach No.	Upstream Node	Downstream Node	Design Flow - 10-Year (cfs)	Pipe Diameter (in.)	Manning's Roughness	Length (ft)	Approximate Energy Slope (ft/ft)	Flow Depth (ft)	Flow Velocity (ft/s)
1	P5A	P5B	16.8	24	0.015	151	0.0073	Full Pipe	5.35

Table C-9. Problem Locations 6 & 10 XPSWMM Node Data and Results

Node Name	Existing Conditions				Proposed Solution (Option 2)				Change in Water Surface Elevation	
	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	10-Year Water Surface Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	10-Year Water Surface Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)	10-Year	100-Year
SD6B1	166.00	162.50	165.74	165.82	166.00	162.50	165.74	165.82	0.00	0.00
SD6B2	164.50	160.50	164.37	164.46	164.50	160.50	164.37	164.46	0.00	0.00
J6B2	160.50	156.20	160.46	160.57	160.50	156.20	160.46	160.57	0.00	0.00
SD6B3	160.00	155.40	159.56	159.76	160.00	155.40	159.50	159.71	-0.05	-0.04
J6B3	158.50	157.70	159.09	159.74	158.50	157.70	158.52	158.86	-0.58	-0.89
SD6B4	159.00	154.80	159.09	159.74	159.00	153.30	156.41	158.78	-2.68	-0.96
J6B4	157.80	153.60	157.26	157.90	157.80	152.00	155.84	157.88	-1.42	-0.02
SD6B5	156.10	151.60	155.23	155.85	156.10	151.10	154.01	155.53	-1.22	-0.33
Mar_OLR	154.90	154.40	154.40	154.59	154.90	154.40	154.40	154.56	0.00	-0.04
SD6B6	150.00	144.10	149.82	149.92	150.00	144.10	149.75	149.87	-0.08	-0.06
6B6b_Out	146.20	145.70	146.12	146.22	146.20	145.70	146.05	146.17	-0.08	-0.06
SD6B7	149.50	142.30	148.41	149.10	149.50	142.30	147.56	147.41	-0.86	-1.69
SD6A1	174.10	171.50	173.94	174.03	174.10	171.50	173.94	174.03	0.00	0.00
SD6A2	174.20	170.70	174.14	174.77	174.20	170.70	174.14	174.77	0.00	0.00
J6A2a	173.40	170.00	171.08	171.14	173.40	170.00	171.08	171.14	0.00	0.00
J6A2b	167.40	163.00	167.78	167.97	167.40	163.00	167.78	167.97	0.00	0.00
J6A2c	167.50	162.50	167.23	167.44	167.50	162.50	167.23	167.44	0.00	0.00
SD6A3	165.30	160.80	164.55	164.68	165.30	160.80	164.55	164.68	0.00	0.00
SD6A4	160.30	155.70	160.26	160.47	160.30	155.70	160.26	160.46	0.00	0.00
J6A4a	159.20	154.70	159.68	160.33	159.20	154.70	159.68	160.33	-0.01	0.00
J6A4b	155.00	150.50	155.01	155.41	155.00	150.50	154.99	155.41	-0.02	0.00
J6A4c	153.20	147.50	151.53	152.81	153.20	147.50	151.30	152.78	-0.23	-0.03
SD6A5	149.50	144.70	149.71	150.47	149.50	144.70	149.48	150.20	-0.23	-0.27
J6A5	148.80	143.00	148.56	149.11	148.80	143.00	148.08	148.38	-0.49	-0.73
J6B7	144.40	136.20	142.15	143.90	144.40	136.20	143.32	142.75	1.17	-1.15
SD6Out	140.00	131.20	139.60	141.00	140.00	131.20	139.60	141.00	0.00	0.00
SD6_OLROut	141.20	140.20	140.20	141.00	141.20	140.20	140.20	141.00	0.00	0.00
SD6B8	N/A	N/A	N/A	N/A	149.70	141.10	144.34	145.06	N/A	N/A
SD6MOut	N/A	N/A	N/A	N/A	146.60	139.50	142.74	143.60	N/A	N/A

Table C-10. Problem Locations 6 & 10 XPSWMM Link Data and Results

Name	Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 10-Year Flow cfs	Max 10-Year Velocity ft/s	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
Existing Conditions													
ORL_6B1	ORL_6B1	SD6B1	J6B2	Trapezoidal	0.50	300	165.50	160.00	0.035	10.6	2.0	17.0	2.4
P_6B2	C_6B2	SD6B2	J6B2	Circular	1.50	324	160.50	156.20	0.015	10.3	6.0	10.2	5.9
OLR_6B2	C_6B2	SD6B2	J6B2	Trapezoidal	0.50	324	164.00	160.00	0.035	16.1	1.6	28.6	1.8
P_6B1	C_6B1	SD6B1	SD6B2	Circular	1.00	302	162.50	161.00	0.015	3.1	3.9	3.2	4.1
P_J6B2	C_J6B2	J6B2	SD6B3	Circular	1.75	216	156.20	155.40	0.015	9.7	4.0	9.6	4.0
PLR_J6B2	C_J6B2	J6B2	SD6B3	Trapezoidal	0.50	216	160.00	158.80	0.020	24.7	1.9	43.4	2.1
P_6B3	C_6B3	SD6B3	SD6B4	Circular	1.75	143	155.40	154.80	0.015	14.3	5.9	14.2	5.9
OLR_6B3a	OLR6B3a	SD6B3	J6B3	Trapezoidal	0.70	425	158.90	157.80	0.020	38.8	1.8	68.4	2.0
OLR_6B3b	OLR6B3b	J6B3	SD6B4	Trapezoidal	0.50	280	157.80	157.70	0.020	17.3	0.6	27.0	0.7
P_6B4	C_6B4	SD6B4	J6B4	Circular	2.00	173	154.80	153.60	0.015	22.8	7.2	24.0	7.6
P_J6B4	C_J6B4	J6B4	SD6B5	Circular	2.25	471	153.60	151.60	0.015	22.8	5.8	24.0	6.1
P_6B5	C_6B5	SD6B5	SD6B6	Circular	2.50	776	151.60	144.10	0.015	29.8	6.9	31.2	7.0
Mar1_OLR	C_Mar1_OLR	SD6B5	Mar_OLR	Trapezoidal	0.50	140	155.60	154.40	0.020	0.0	0.0	3.9	1.5
Mar2_OLR	C_Mar2_OLR	Mar_OLR	SD6B6	Trapezoidal	0.50	650	154.40	149.40	0.020	0.0	0.0	2.3	0.9
OLR_6b6b.1	OLR_6B6b	SD6B6	6B6b_Out	Trapezoidal	0.50	505	149.40	145.70	0.020	13.5	2.3	23.3	2.7
P_6B6	C_6B6	SD6B6	SD6B7	Circular	2.50	434	144.10	143.30	0.015	35.0	7.2	35.3	7.2
OLR_6B6	C_6B6	SD6B6	SD6B7	Trapezoidal	0.50	434	149.40	148.50	0.020	6.0	1.1	12.0	1.4
P_SD6A1	C_SD6A1	SD6A1	J6A2c	Circular	0.83	399	171.50	163.70	0.015	2.9	5.5	2.8	5.5
OLR_6A1	C_SD6A1	SD6A1	J6A2c	Trapezoidal	0.50	399	173.60	167.00	0.035	5.5	1.5	10.7	1.9
P_SD6A2	C_SD6A2	SD6A2	J6A2a	Circular	2.00	197	170.70	170.00	0.015	21.2	7.0	23.8	7.9
CH_J6A2a	C_J6A2a	J6A2a	J6A2b	Trapezoidal	1.00	320	170.00	165.50	0.035	21.1	3.3	23.8	3.3
P_J6A2b	C_J6A2b	J6A2b	J6A2c	Circular	1.50	86	163.00	162.50	0.015	11.2	6.3	11.3	6.3
OLR_6A2b	C_J6A2b	J6A2b	J6A2c	Trapezoidal	0.16	86	167.20	167.00	0.035	7.1	1.1	15.9	1.3
P_J6A2c	C_J6A2c	J6A2c	SD6A3	Circular	1.50	67	162.50	161.30	0.015	18.4	10.3	18.8	10.5
OLR_6A2c	C_J6A2c	J6A2c	SD6A3	Trapezoidal	0.50	67	167.00	164.80	0.035	2.5	1.9	12.3	2.9
P_SD6A3	C_SD6A3	SD6A3	SD6A4	Circular	2.00	735	160.80	156.00	0.015	16.8	5.6	16.9	5.6
OLR_6A3	C_SD6A3	SD6A3	SD6A4	Trapezoidal	0.50	735	164.00	159.60	0.020	30.7	2.4	54.2	2.7
P_SD6A4	C_SD6A4	SD6A4	J6A4a	Circular	2.25	255	155.70	154.70	0.015	30.4	7.7	30.4	7.7
OLR_6A4	C_SD6A4	SD6A4	J6A4a	Trapezoidal	0.70	255	159.60	158.40	0.020	45.3	2.3	82.1	2.5
P_J6A4a	C_J6A4a	J6A4a	J6A4b	Circular	2.25	297	154.70	150.80	0.015	37.1	9.3	37.3	9.4
OLR_6A4a	C_J6A4a	J6A4a	J6A4b	Trapezoidal	0.50	297	158.70	154.50	0.060	13.2	2.0	35.3	2.8
P_JA64b	C_J6A4b	J6A4b	J6A4c	Circular	2.50	329	150.50	147.80	0.015	38.8	7.8	38.2	7.7
OLR_A64b	C_J6A4b	J6A4b	J6A4c	Trapezoidal	0.50	329	154.50	152.50	0.035	9.4	1.3	37.4	1.9
P_J6A4c	C_J6A4c	J6A4c	SD6A5	Circular	2.75	181	147.50	145.00	0.015	46.1	8.5	53.9	9.0

Table C-10. Problem Locations 6 & 10 XPSWMM Link Data and Results

Name	Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 10-Year Flow cfs	Max 10-Year Velocity ft/s	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
OLR_6A4c	C_J6A4c	J6A4c	SD6A5	Trapezoidal	0.70	181	152.50	148.30	0.035	0.0	0.0	16.0	0.4
P_6A	C_SD6A5	SD6A5	J6A5	Circular	3.00	280	144.70	143.00	0.015	43.0	7.0	40.5	6.7
OLR_6A	C_SD6A5	SD6A5	J6A5	Trapezoidal	1.00	280	148.30	146.80	0.040	14.8	2.3	33.8	3.0
P_J6A	C_J6A	J6A5	SD6B7	Circular	3.00	69	143.00	142.30	0.015	53.3	7.5	44.4	6.3
OLR_J6A	C_J6A	J6A5	SD6B7	Trapezoidal	0.50	69	148.30	148.00	0.020	21.3	1.5	67.2	1.4
P_6B	C_6B7	SD6B7	J6B7	Circular	3.50	555	142.30	136.20	0.015	93.7	10.1	89.5	9.3
OLR_6B	C_6B7	SD6B7	J6B7	Trapezoidal	1.00	555	148.50	143.40	0.020	0.0	0.0	29.0	3.2
P_J6B	C_J6B	J6B7	SD6Out	Circular	3.50	461	136.20	131.20	0.015	93.7	9.7	96.5	10.0
OLR_J6B	C_J6B7	J6B7	SD6_OLROut	Trapezoidal	1.00	250	143.40	140.20	0.020	0.0	0.0	20.7	3.3
Proposed Solution													
ORL_6B1	ORL_6B1	SD6B1	J6B2	Trapezoidal	0.50	300	165.50	160.00	0.035	10.6	2.0	17.0	2.5
P_6B2	C_6B2	SD6B2	J6B2	Circular	1.50	324	160.50	156.20	0.015	10.3	6.1	10.2	6.0
OLR_6B2	C_6B2	SD6B2	J6B2	Trapezoidal	0.50	324	164.00	160.00	0.035	16.2	1.6	28.6	1.8
P_6B1	C_6B1	SD6B1	SD6B2	Circular	1.00	302	162.50	161.00	0.015	3.2	4.1	3.5	4.4
P_J6B2	C_J6B2	J6B2	SD6B3	Circular	1.75	216	156.20	155.40	0.015	11.3	4.7	11.3	4.7
PLR_J6B2	C_J6B2	J6B2	SD6B3	Trapezoidal	0.50	216	160.00	158.80	0.020	24.4	1.9	43.3	2.2
P_6B3	C_6B3	SD6B3	SD6B4	Circular	1.75	143	155.40	154.80	0.015	20.5	8.5	20.7	8.6
OLR_6B3a	OLR6B3a	SD6B3	J6B3	Trapezoidal	0.70	425	158.90	157.80	0.020	31.0	1.8	65.8	2.1
OLR_6B3b	OLR6B3b	J6B3	SD6B4	Trapezoidal	0.50	280	157.80	157.70	0.020	21.5	1.1	50.8	1.3
P_6B4	C_6B4	SD6B4	J6B4	Circular	3.50	173	153.30	152.00	0.015	56.0	6.8	66.5	6.9
P_J6B4	C_J6B4	J6B4	SD6B5	Circular	3.50	471	152.00	151.10	0.015	55.7	5.7	65.9	6.8
P_6B5	C_6B5	SD6B5	SD6B6	Circular	3.50	776	151.10	144.10	0.015	65.5	7.8	74.8	7.9
OLR_6B5	C_6B5	SD6B5	SD6B6	Trapezoidal	0.50	810	155.60	149.40	0.020	0.0	0.0	0.0	0.0
Mar1_OLR	C_Mar1_OLR	SD6B5	Mar_OLR	Trapezoidal	0.50	140	155.30	154.40	0.020	0.0	0.0	2.5	1.2
Mar2_OLR	C_Mar2_OLR	Mar_OLR	SD6B6	Trapezoidal	0.50	650	154.40	149.40	0.020	0.0	0.0	1.4	0.7
OLR_6b6b.1	OLR_6B6b	SD6B6	6B6b_Out	Trapezoidal	0.50	505	149.40	145.70	0.020	8.0	2.0	17.1	2.5
P_6B6	C_6B6	SD6B6	SD6B7	Circular	3.50	434	144.10	143.30	0.015	63.4	6.6	74.6	7.8
OLR_6B6	C_6B6	SD6B6	SD6B7	Trapezoidal	0.50	434	149.40	148.50	0.020	3.5	0.9	7.6	1.2
P_SD6A1	C_SD6A1	SD6A1	J6A2c	Circular	0.83	399	171.50	163.70	0.015	2.9	5.5	2.8	5.5
OLR_6A1	C_SD6A1	SD6A1	J6A2c	Trapezoidal	0.50	399	173.60	167.00	0.035	5.5	1.5	10.7	1.9
P_SD6A2	C_SD6A2	SD6A2	J6A2a	Circular	2.00	197	170.70	170.00	0.015	21.2	7.0	23.8	7.9
CH_J6A2a	C_J6A2a	J6A2a	J6A2b	Trapezoidal	1.00	320	170.00	165.50	0.035	21.1	3.3	23.8	3.3
P_J6A2b	C_J6A2b	J6A2b	J6A2c	Circular	1.50	86	163.00	162.50	0.015	11.2	6.3	11.3	6.3
OLR_6A2b	C_J6A2b	J6A2b	J6A2c	Trapezoidal	0.16	86	167.20	167.00	0.035	7.1	1.1	15.9	1.3
P_J6A2c	C_J6A2c	J6A2c	SD6A3	Circular	1.50	67	162.50	161.30	0.015	18.4	10.3	18.8	10.5

Table C-10. Problem Locations 6 & 10 XPSWMM Link Data and Results

Name	Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 10-Year Flow cfs	Max 10-Year Velocity ft/s	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
OLR_6A2c	C_J6A2c	J6A2c	SD6A3	Trapezoidal	0.50	67	167.00	164.80	0.035	2.5	1.9	12.3	2.9
P_SD6A3	C_SD6A3	SD6A3	SD6A4	Circular	2.00	735	160.80	156.00	0.015	16.8	5.6	16.9	5.6
OLR_6A3	C_SD6A3	SD6A3	SD6A4	Trapezoidal	0.50	735	164.00	159.60	0.020	30.7	2.4	54.2	2.7
P_SD6A4	C_SD6A4	SD6A4	J6A4a	Circular	2.25	255	155.70	154.70	0.015	30.4	7.7	30.4	7.7
OLR_6A4	C_SD6A4	SD6A4	J6A4a	Trapezoidal	0.70	255	159.60	158.40	0.020	45.2	2.4	82.1	2.5
P_J6A4a	C_J6A4a	J6A4a	J6A4b	Circular	2.25	297	154.70	150.80	0.015	37.4	9.4	37.4	9.4
OLR_6A4a	C_J6A4a	J6A4a	J6A4b	Trapezoidal	0.50	297	158.70	154.50	0.060	13.1	2.0	35.2	2.8
P_JA64b	C_J6A4b	J6A4b	J6A4c	Circular	2.50	329	150.50	147.80	0.015	42.7	8.7	42.2	8.6
OLR_A64b	C_J6A4b	J6A4b	J6A4c	Trapezoidal	0.50	329	154.50	152.50	0.035	8.4	1.2	37.0	1.9
P_J6A4c	C_J6A4c	J6A4c	SD6A5	Circular	2.75	181	147.50	145.00	0.015	47.4	9.5	56.7	9.5
OLR_6A4c	C_J6A4c	J6A4c	SD6A5	Trapezoidal	0.70	181	152.50	148.30	0.035	0.0	0.0	12.9	0.4
P_6A	C_SD6A5	SD6A5	J6A5	Circular	3.00	280	144.70	143.00	0.015	54.6	7.7	60.1	8.4
OLR_6A	C_SD6A5	SD6A5	J6A5	Trapezoidal	1.00	280	148.30	146.80	0.040	11.3	2.3	26.4	2.9
P_J6A	C_J6A	J6A5	SD6B7	Circular	3.00	69	143.00	142.30	0.015	57.8	8.2	75.8	10.7
OLR_J6A	C_J6A	J6A5	SD6B7	Trapezoidal	0.50	69	148.30	148.00	0.020	0.0	0.0	2.4	0.7
P_6B	C_6B7	SD6B7	J6B7	Circular	3.50	555	142.30	136.20	0.015	76.6	8.0	81.6	9.1
OLR_6B	C_6B7	SD6B7	J6B7	Trapezoidal	1.00	555	148.50	143.40	0.020	0.0	0.0	0.0	0.0
P_J6B	C_J6B	J6B7	SD6Out	Circular	3.50	461	136.20	131.20	0.015	78.9	8.2	86.0	8.9
OLR_J6B	C_J6B7	J6B7	SD6_OLROut	Trapezoidal	1.00	250	143.40	140.20	0.020	0.0	0.0	0.0	0.0
P_6B72	C_6B72	SD6B7	SD6B8	Circular	3.00	220	143.50	141.60	0.015	44.7	9.1	68.6	9.7
OLR_6B72	C_6B72	SD6B7	SD6B8	Trapezoidal	0.50	220	148.00	149.20	0.020	0.0	0.0	0.0	0.0
P_6B8	C_6B8	SD6B8	SD6MOut	Circular	3.50	190	141.10	139.50	0.015	56.8	8.6	104.1	10.4
OLR_6B8	C_6B8	SD6B8	SD6MOut	Trapezoidal	0.50	190	149.20	146.10	0.020	0.0	0.0	0.0	0.0

Table C-11. Problem Location 9 XPSWMM Node Data and Results

Node Name	Existing Conditions			Proposed Solution (Option 2)			Change in Water Surface Elevation
	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)	
P9A	222.60	218.20	222.64	222.60	218.20	222.64	0.00
P9B	215.90	211.10	215.82	215.90	211.10	215.82	0.00
Node18	N/A	N/A	N/A	217.00	209.00	209.00	N/A
Node19	N/A	N/A	N/A	212.50	208.95	213.91	N/A
P9C	212.50	208.90	214.61	212.50	208.90	213.91	-0.70
P9D	209.80	205.40	209.88	209.80	205.40	209.88	-0.01
P9E	208.60	203.70	208.87	208.60	203.70	208.84	-0.03
P9F	209.00	202.70	208.26	209.00	202.70	207.79	-0.48
P9G	207.00	201.90	206.45	207.00	201.40	206.53	0.08
PFb	208.70	207.00	207.25	208.70	207.00	207.15	-0.09
P9H	205.00	201.00	204.38	205.00	201.00	204.34	-0.05
P9I	204.20	200.30	203.65	204.20	200.30	203.37	-0.28
P9Hb	204.60	203.30	204.09	204.60	203.30	204.05	-0.04
P9J	203.60	198.90	201.56	203.60	198.90	201.16	-0.41
P9K	201.40	189.40	198.95	201.40	189.40	198.87	-0.08
P9L	200.00	194.00	196.55	200.00	194.00	196.47	-0.08

Table C-12. Problem Location 9 XPSWMM Link Data and Results

Name	Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
Existing Conditions											
PAB	LnkAB	P9A	P9B	Circular	1.00	264	218.20	211.10	0.015	5.1	6.4
PBC	LnkBC	P9B	P9C	Circular	1.00	211	211.10	209.00	0.015	4.8	6.0
ChBC	LnkBC	P9B	P9C	Trapezoidal	0.50	211	215.40	212.00	0.020	18.0	1.8
PCD	LnkCD	P9C	P9D	Circular	1.25	390	208.90	206.20	0.015	7.4	6.0
PDE	LnkDE	P9D	P9E	Circular	2.00	507	205.40	203.70	0.015	11.0	4.0
ChDE	LnkDE	P9D	P9E	Trapezoidal	0.50	507	209.30	208.10	0.020	21.6	1.5
PEF	LnkEF	P9E	P9F	Circular	2.00	282	203.70	202.70	0.015	15.9	5.0
ChEF	LnkEF	P9E	P9F	Trapezoidal	0.50	282	208.10	207.50	0.020	29.9	1.8
PFG	LinkFH	P9F	P9G	Circular	2.00	180	202.70	201.90	0.015	20.5	6.5
OLRFFb	LinkFFb	P9F	PFb	Trapezoidal	1.50	180	206.50	207.00	0.020	17.5	3.8
PGH	LinkGH	P9G	P9H	Circular	2.00	204	201.90	201.00	0.015	20.5	6.5
OLRHI	LinkFbHb	PFb	P9H	Trapezoidal	1.00	210	207.00	204.00	0.040	17.5	1.6
PHI	LinkHI	P9H	P9I	Circular	2.25	164	201.00	200.30	0.015	29.8	7.5
OLRHHb	LinkHHb	P9H	P9Hb	Trapezoidal	1.00	80	204.00	203.30	0.040	12.7	1.2
PIJ	LinkIJ	P9I	P9J	Circular	2.25	100	200.30	198.90	0.015	42.8	10.7
OLRHbJ	LinkHbJ	P9Hb	P9J	Trapezoidal	0.50	180	203.60	202.60	0.020	12.6	2.0
PJK	LinkJK	P9J	P9K	Circular	2.50	170	198.90	196.40	0.015	45.0	9.4
CHKL	LinkKL	P9K	P9L	Trapezoidal	4.00	500	196.40	194.00	0.080	45.0	1.8
Proposed Solution											
PAB	LnkAB	P9A	P9B	Circular	1.00	264	218.20	211.10	0.015	5.1	6.4
PBC	LnkBC	P9B	P9C	Circular	1.00	211	211.10	209.00	0.015	4.9	6.1
ChBC	LnkBC	P9B	P9C	Trapezoidal	0.50	211	215.40	212.00	0.020	17.7	2.4
P_Stor	Link18	Node18	Node19	Circular	3.00	400	209.00	208.95	0.015	0.0	0.0
Weir	Link18	Node18	Node19	Circular	3.00	400	209.00	208.95	0.015	0.0	0.0
Weir_conn	Link19	Node19	P9C	Circular	3.00	33	208.95	208.90	0.015	-10.7	0.0
Weir.1	Link19	Node19	P9C	Circular	3.00	33	208.95	208.90	0.015	-10.7	0.0

Table C-12. Problem Location 9 XPSWMM Link Data and Results

Name	Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
PCD	LnkCD	P9C	P9D	Circular	1.25	390	208.90	206.20	0.015	7.0	5.7
PDE	LnkDE	P9D	P9E	Circular	2.00	507	205.40	203.70	0.015	11.4	3.9
ChDE	LnkDE	P9D	P9E	Trapezoidal	0.50	507	209.30	208.10	0.020	21.0	1.5
PEF	LnkEF	P9E	P9F	Circular	2.00	282	203.70	202.70	0.015	20.3	6.4
ChEF	LnkEF	P9E	P9F	Trapezoidal	0.50	282	208.10	207.50	0.020	26.1	1.7
PFG	LinkFH	P9F	P9G	Circular	2.50	180	202.70	201.40	0.015	34.5	7.0
OLRFFb	LinkFFb	P9F	PFb	Trapezoidal	1.50	180	206.50	207.00	0.020	7.7	2.6
PGH	LinkGH	P9G	P9H	Circular	2.00	204	201.40	201.00	0.015	24.0	7.6
OLRDB	LinkGH	P9G	P9H	Trapezoidal	0.30	100	206.40	204.00	0.040	10.3	1.2
OLRHI	LinkFbHb	PFb	P9H	Trapezoidal	1.00	210	207.00	204.00	0.040	7.7	1.2
PHI	LinkHI	P9H	P9I	Circular	2.25	164	201.00	200.30	0.015	29.8	7.5
OLRHHb	LinkHHb	P9H	P9Hb	Trapezoidal	1.00	80	204.00	203.30	0.040	10.2	1.1
PIJ	LinkIJ	P9I	P9J	Circular	2.25	100	200.30	198.90	0.015	41.6	10.5
OLRHbJ	LinkHbJ	P9Hb	P9J	Trapezoidal	0.50	180	203.60	202.60	0.020	10.2	1.9
PJK	LinkJK	P9J	P9K	Circular	2.50	170	198.90	196.40	0.015	42.6	9.4
CHKL	LinkKL	P9K	P9L	Trapezoidal	4.00	500	196.40	194.00	0.080	42.5	1.8

Table C-13. Problem Location 11 XPSWMM Node Data and Results

Node Name	Existing Conditions			Proposed Solution (Option 2)			Change in Water Surface Elevation
	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)	
P11A	171.90	168.20	171.88	171.90	167.00	171.63	-0.24
P11B	171.30	167.20	171.28	171.30	166.70	171.09	-0.19
P11C	170.80	166.90	169.41	170.80	166.90	167.99	-1.42
P11D	168.30	166.30	168.17	168.30	166.30	167.85	-0.32
P11D2	168.20	166.10	168.11	168.20	166.10	167.84	-0.27
P11E	166.90	164.00	166.80	166.90	164.00	166.43	-0.37
P11E2	165.10	162.10	164.85	165.10	159.50	163.22	-1.63
P11E3	164.80	161.30	163.80	164.80	161.30	162.53	-1.27
P11E4	164.00	161.10	163.74	164.00	161.10	162.51	-1.23
P11E5	163.70	160.90	163.31	163.70	160.90	162.33	-0.99
P11E6	162.80	160.00	162.66	162.80	160.00	162.23	-0.43
P11F	162.20	159.60	162.15	162.20	159.60	161.34	-0.81
P11F2	161.50	158.90	161.44	161.50	158.90	161.22	-0.22
P11F3	161.10	158.30	161.00	161.10	158.30	160.66	-0.35
P11F4	161.00	157.80	160.98	161.00	157.80	160.65	-0.33
P11G	161.10	156.90	159.54	161.10	157.50	158.87	-0.67

Table C-14. Problem Location 11 XPSWMM Link Data and Results

Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
Existing Conditions										
P_11A	P11A	P11B	Circular	1.25	222	168.2	167.2	0.015	2.9	2.4
P_11B	P11B	P11C	Circular	1.5	132	167.2	166.9	0.015	10.9	6.1
C_11C	P11C	P11D	Rectangular	2	112	166.9	166.3	0.025	29.2	4.6
CH_11D	P11D	P11D2	Trapezoidal	1	130	166.3	166.1	0.015	32.4	2.4
P_11D2	P11D2	P11E	Circular	1	180	166.1	164	0.015	2.7	3.4
P_11E	P11E	P11E2	Circular	1.5	160	164	162.1	0.015	10.1	5.7
P_11E2	P11E2	P11E3	Circular	1.5	35	162.1	161.3	0.024	8.9	5.0
C_11E3	P11E3	P11E4	Trapezoidal	2	33	161.3	161.1	0.035	39.1	2.6
P_11E4	P11E4	P11E5	Rectangular	1.25	33	161.1	160.9	0.015	9.9	3.5
C_11E5	P11E5	P11E6	Trapezoidal	2	93	160.9	160	0.035	39.1	4.1
P_11E6	P11E6	P11F	Circular	1.5	45	160	159.6	0.024	4.9	2.8
C_11F	P11F	P11F2	Trapezoidal	2	72	159.6	158.9	0.04	42.3	4.2
P_11F2	P11F2	P11F3	Circular	1.25	60	158.9	158.3	0.024	2.6	2.1
C_11F3	P11F3	P11F4	Trapezoidal	2	53	158.3	157.8	0.035	42.3	1.7
P_11F4	P11F4	P11G	Circular	1.25	33	157.8	159.6	0.024	-2.4	-3.6
C_11G	P11G	P11G2	Trapezoidal	1.3	274	157.5	155.4	0.035	49.6	2.0
P_11G2	P11G2	P11G3	Circular	1.5	33	155.4	155.4	0.015	10.2	5.7
C_11G3	P11G3	P11G4	Trapezoidal	2.3	33	155.4	155.9	0.04	-10.2	-0.6
P_11G4	P11G4	P11G5	Circular	1.67	33	155.9	155.4	0.015	10.2	4.6
C_11G5	P11G5	P11_Out	Trapezoidal	3.3	185	155.4	152.7	0.04	10.2	0.7
OLR_11A	P11A	P11B	Trapezoidal	0.5	222	171.4	170.5	0.02	17.6	1.6
OLR_11B	P11B	P11C	Trapezoidal	0.5	132	170.8	170.3	0.02	15.8	1.7
OLR_11D2	P11D2	P11E	Trapezoidal	0.7	160	167.5	166.2	0.04	29.7	1.7
OLR_11E	P11E	P11E2	Trapezoidal	0.5	160	166.2	164.4	0.04	29.0	1.8
OLR_11E2	P11E2	P11E3	Trapezoidal	0.5	35	164.6	164.3	0.02	30.2	2.3
OLR_11E4	P11E4	P11E5	Trapezoidal	0.6	33	163.3	163.1	0.02	29.2	2.4
OLR_11E6	P11E6	P11F	Trapezoidal	0.5	45	162.3	161.7	0.02	34.2	2.8
OLR_11F2	P11F2	P11F3	Trapezoidal	0.5	60	161	160.6	0.02	39.7	2.2
OLR_11F4	P11F4	P11G	Trapezoidal	0.5	33	160.5	160	0.02	39.9	3.8
OLR_11G2	P11G2	P11_Out	Trapezoidal	0.5	260	159	158.9	0.02	1.0	0.4
OldAubOLR.	P11G2	P11_Out2	Trapezoidal	0.5	100	159	158.5	0.02	38.4	1.7
Proposed Solution										
P_11A	P11A	P11B	Circular	2.5	222	167	166.7	0.015	17.7	3.6
P_11B_New	P11B	P11B_New	Circular	2.5	425	166.7	164.3	0.015	22.8	4.6

Table C-14. Problem Location 11 XPSWMM Link Data and Results

Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
P_11B_New2	P11B_New	P11E2	Circular	2	463	164.3	159.5	0.015	22.8	7.2
C_11C	P11C	P11D	Rectangular	2	112	166.9	166.3	0.025	6.4	1.8
CH_11D	P11D	P11D2	Trapezoidal	1	130	166.3	166.1	0.015	9.6	1.0
P_11D2	P11D2	P11E	Circular	1	180	166.1	164	0.015	2.7	3.5
P_11E	P11E	P11E2	Circular	1.5	160	164	162.1	0.015	12.6	7.1
P_11E2	P11E2	P11E3	Circular	1.5	35	162.1	161.3	0.024	6.5	4.6
P_Bonita_N	P11E2	P11G2a	Circular	2.5	535	159.5	155.4	0.015	32.6	6.6
C_11E3	P11E3	P11E4	Trapezoidal	2	33	161.3	161.1	0.035	6.5	1.1
P_11E4	P11E4	P11E5	Rectangular	1.25	33	161.1	160.9	0.015	6.5	2.3
C_11E5	P11E5	P11E6	Trapezoidal	2	93	160.9	160	0.035	6.5	1.4
P_11E6	P11E6	P11F	Circular	1.5	45	160	159.6	0.024	6.5	3.7
C_11F	P11F	P11F2	Trapezoidal	2	72	159.6	158.9	0.04	9.7	1.6
P_11F2	P11F2	P11F3	Circular	1.25	60	158.9	158.3	0.024	3.0	2.4
C_11F3	P11F3	P11F4	Trapezoidal	2	53	158.3	157.8	0.035	9.7	0.5
P_11F4	P11F4	P11G	Circular	1.25	33	157.8	157.5	0.024	6.6	5.3
C_11G	P11G	P11G2a	Trapezoidal	1.5	79	157.5	155.9	0.04	17.0	2.1
P_11G2	P11G2a	P11G2	Circular	3.5	195	154.5	153.18	0.015	49.6	5.0
OLR_11A	P11A	P11B	Trapezoidal	0.5	222	171.4	170.5	0.02	2.8	0.8
OLR_11B	P11B	P11C	Trapezoidal	0.5	132	170.8	170.3	0.02	3.9	1.2
OLR_11D2	P11D2	P11E	Trapezoidal	0.7	180	167.5	166.2	0.04	6.9	1.0
OLR_11E	P11E	P11E2	Trapezoidal	0.5	160	166.2	164.4	0.04	3.7	1.0
OLR_11E2	P11E2	P11E3	Trapezoidal	0.5	35	164.6	164.3	0.02	0.0	0.0
OLR_11E4	P11E4	P11E5	Trapezoidal	0.6	33	163.3	163.1	0.02	0.0	0.0
OLR_11E6	P11E6	P11F	Trapezoidal	0.5	45	162.3	161.7	0.02	0.0	0.0
OLR_11F2	P11F2	P11F3	Trapezoidal	0.5	60	161	160.6	0.02	6.7	1.4
OLR_11F4	P11F4	P11G	Trapezoidal	0.5	33	160.5	160	0.02	3.1	2.0
OLR_11G2	P11G2	P11_Out	Trapezoidal	0.5	251	159	158.9	0.02	0.0	0.0
OldAubOLR.	P11G2	P11_Out2	Trapezoidal	0.5	100	159	158.5	0.02	0.0	0.0

Table C-15. Problem Location 12 XPSWMM Node Data and Results							
	Existing Conditions			Proposed Solution (Option 2)			
Node Name	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)	Modeled Ground Elevation (ft, NAVD)	Modeled Invert Elevation (ft, NAVD)	100-Year Water Surface Elevation (ft, NAVD)	Change in Water Surface Elevation
SD3A1a	194.00	190.40	192.52	194.00	190.40	192.80	0.28
SD3J1a	190.00	188.50	189.49	190.00	188.50	189.35	-0.15
SD3J1b	188.90	186.70	189.24	188.90	186.70	188.64	-0.60
SD3A1b	189.30	186.50	189.24	189.30	185.70	187.79	-1.46
SD3A1c	188.00	184.60	186.13	188.00	183.20	184.92	-1.21
SD3A2	186.30	177.04	186.05	186.30	182.50	184.92	-1.13
SD3A2b	186.30	176.85	184.25	186.30	176.85	183.93	-0.31
SD3A3	180.70	177.70	180.92	180.70	176.00	180.32	-0.60
SD3A3b	180.60	177.50	180.87	180.60	175.50	180.00	-0.86
SD3A3c	180.50	177.00	180.87	180.50	172.65	179.25	-1.62
SD3A4	180.00	176.00	180.84	179.00	172.55	178.85	-2.00
SD3A4b	179.10	172.50	179.30	179.10	172.50	178.66	-0.64
SD3A5	176.50	171.00	177.71	177.50	171.00	177.67	-0.04
J3A5b	177.80	170.30	177.15	177.80	170.30	177.10	-0.06
SD3A5c	173.20	167.00	173.08	173.20	167.00	172.93	-0.14
SD3A6	174.70	166.30	172.89	174.70	166.30	172.85	-0.04

Table C-16. Problem Location 12 XPSWMM Link Data and Results

Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
Existing Conditions										
C_3A1a	SD3A1a	SD3J1a	Circular	1.5	151	190.4	188.5	0.015	12.2	7.1
C_3Ja	SD3J1a	SD3J1b	Trapezoidal	1.5	153	188.5	186.7	0.04	12.1	1.5
C_3J1b	SD3J1b	SD3A1b	Circular	1.5	33	186.7	186.5	0.024	5.3	2.9
C_3A1b	SD3A1b	SD3A1c	Circular	1.67	230	186.5	184.6	0.024	8.9	4.1
C_3A1c	SD3A1c	SD3A2	Trapezoidal	2	160	184.6	182.5	0.04	19.4	1.3
C_3A2	SD3A2	SD3A2b	Circular	1.67	33	182.5	182.4	0.024	14.2	6.5
C_3A2b	SD3A2b	SD3A3	Trapezoidal	2	500	182.4	177.7	0.04	38.4	3.2
C_3A3	SD3A3	SD3A3b	Circular	2	70	177.7	177.5	0.024	12.4	4.0
C_3A3b	SD3A3b	SD3A3c	Circular	2	33	177.5	177	0.015	20.5	6.5
C_3A3c	SD3A3c	SD3A4	Trapezoidal	1.8	148	177	176.5	0.04	66.2	2.7
C_3A4	SD3A4	SD3A4b	Circular	2.25	33	176	172.5	0.024	30.8	9.9
C_3A4b	SD3A4b	SD3A5	Circular	2	167	172.5	171	0.015	20.9	6.6
C_3A5	SD3A5	J3A5b	Circular	2	81	171	170.3	0.015	25.5	8.0
C_3A5b	J3A5b	SD3A5c	Circular	2	410	170.3	167.5	0.015	27.0	8.5
C_3A5c	SD3A5c	SD3A6	Circular	2.5	52	167	166.8	0.015	37.7	7.6
C_3A6	SD3A6	SD3B	Circular	3	293	166.3	166	0.015	39.8	5.6
C_3B	SD3B	SD3D	Circular	3	476	166	164.2	0.015	48.8	6.9
C_3C	SD3C	SD3D	Circular	3	400	166.8	163.3	0.015	40.0	6.3
C_3Da	SD3D	J3E	Circular	3	140	163.3	162.1	0.024	42.7	6.0
C_3Db	SD3D	J3E	Special	3	140	163.3	162.1	0.024	77.8	6.8
C_3E	J3E	SD3Out	Circular	5	94	162.1	161.95	0.015	200.3	9.8
OLR_3A1b	SD3A1b	SD3A1c	Trapezoidal	0.5	230	188.8	187.5	0.04	10.4	0.9
OLR_3A2	SD3A2	SD3A2b	Trapezoidal	0.5	33	185.8	185.7	0.02	25.4	1.1
OLR_3A3	SD3A3	SD3A3b	Trapezoidal	0.5	70	180.2	180.1	0.035	60.2	1.9
OLR_3A3b	SD3A3b	SD3A3c	Trapezoidal	0.5	33	180.1	179.9	0.014	62.2	3.2
OLR_3A5	SD3A5	J3A5b	Trapezoidal	0.5	81	175.5	177.3	0.02	15.9	0.6
OLR_3A5b	J3A5b	SD3A5c	Trapezoidal	0.5	410	176.8	172.7	0.02	12.7	2.4
OLR_3A5c	SD3A5c	SD3A6	Trapezoidal	0.5	52	172.7	172.4	0.02	10.8	1.7
OLR_3A6	SD3A6	SD3B	Rectangular	2	125	172.7	171.8	0.02	1.9	1.8
OLR_3B	SD3B	SD3D	Trapezoidal	0.5	476	171.7	169.7	0.02	30.3	2.1
OLR_3C	SD3C	SD3D	Trapezoidal	1	400	170.5	168.7	0.02	41.2	3.3
OLR_3D	SD3D	J3E	Trapezoidal	0.5	140	168.8	168.3	0.02	82.7	2.2
OLR_3E	J3E	SD3Out	Trapezoidal	0.5	90	169	168.5	0.02	0.0	0.0
OLR_3J1b	SD3J1b	SD3A1b	Trapezoidal	0.5	33	188.4	188.3	0.02	10.9	1.0
Proposed Solution										
C_3A1a	SD3A1a	SD3J1a	Circular	1.5	151	190.4	188.5	0.015	7.2	12.2
C_3Ja	SD3J1a	SD3J1b	Trapezoidal	1.5	153	188.5	186.7	0.04	2.1	12.2

Table C-16. Problem Location 12 XPSWMM Link Data and Results

Link Name	Upstream Node Name	Downstream Node Name	Shape	Diameter (Height) ft	Length ft	Upstream Invert Elevation (ft, NAVD)	Downstream Invert Elevation (ft, NAVD)	Manning's Roughness	Max 100-Year Flow cfs	Max 100-Year Velocity ft/s
C_3J1b	SD3J1b	SD3A1b	Circular	1.5	33	186.7	186.5	0.024	5.5	9.7
C_3A1b	SD3A1b	SD3A1c	Circular	2	230	185.7	183.2	0.015	7.6	22.6
C_3A1c	SD3A1c	SD3A2	Trapezoidal	2	33	183.2	182.5	0.04	3.2	22.3
C_3A2	SD3A2	SD3A2b	Circular	1.67	33	182.5	182.4	0.024	4.5	9.8
C_3A2b	SD3A2b	SD3A3	Trapezoidal	2	500	182.4	177.7	0.04	2.9	25.6
C_3A3	SD3A3	SD3A3b	Circular	3	70	176	175.5	0.015	6.7	49.4
C_3A3b	SD3A3b	SD3A3c	Circular	3	33	175.5	175	0.015	6.8	49.3
C_3A3c	SD3A3c	SD3A4	Circular	3	148	172.65	172.55	0.015	6.2	43.7
C_3A4	SD3A4	SD3A4b	Circular	2.5	33	172.55	172.5	0.015	4.5	21.1
C_3A4b	SD3A4b	SD3A5	Circular	2	167	172.5	171	0.015	6.7	21.1
C_3A5	SD3A5	J3A5b	Circular	2	81	171	170.3	0.015	8.0	25.5
C_3A5b	J3A5b	SD3A5c	Circular	2	410	170.3	167.5	0.015	8.5	27.0
C_3A5c	SD3A5c	SD3A6	Circular	2.5	52	167	166.8	0.015	6.5	32.1
C_3A6	SD3A6	SD3B	Circular	3	293	166.3	166	0.015	4.9	34.5
C_3B	SD3B	SD3D	Circular	3	476	166	164.2	0.015	6.4	45.6
C_3C	SD3C	SD3D	Circular	3	400	166.8	163.3	0.015	6.4	41.2
C_3Da	SD3D	J3E	Circular	3	140	163.3	162.1	0.024	6.0	42.7
C_3Db	SD3D	J3E	Special	3	140	163.3	162.1	0.024	6.8	77.8
C_3E	J3E	SD3Out	Circular	5	94	162.1	161.95	0.015	9.8	199.3
OLR_3A1b	SD3A1b	SD3A1c	Trapezoidal	0.5	230	188.8	187.5	0.04	0.0	0.0
OLR_3A2	SD3A2	SD3A2b	Trapezoidal	0.5	33	185.8	185.7	0.02	0.0	0.0
OLR_3A3	SD3A3	SD3A3b	Trapezoidal	0.5	70	180.2	180.1	0.035	0.4	1.7
OLR_3A3b	SD3A3b	SD3A3c	Trapezoidal	0.5	33	180.1	179.9	0.014	0.0	0.0
OLR_3A5	SD3A5	J3A5b	Trapezoidal	0.5	81	175.5	177.3	0.02	0.5	12.4
OLR_3A5b	J3A5b	SD3A5c	Trapezoidal	0.5	410	176.8	172.7	0.02	2.1	7.9
OLR_3A5c	SD3A5c	SD3A6	Trapezoidal	0.5	52	172.7	172.4	0.02	1.0	2.9
OLR_3A6	SD3A6	SD3B	Rectangular	2	125	172.7	171.8	0.02	1.5	1.3
OLR_3B	SD3B	SD3D	Trapezoidal	0.5	476	171.7	169.7	0.02	2.1	29.3
OLR_3C	SD3C	SD3D	Trapezoidal	1	400	170.5	168.7	0.02	3.3	41.1
OLR_3D	SD3D	J3E	Trapezoidal	0.5	140	168.8	168.3	0.02	2.2	81.6
OLR_3E	J3E	SD3Out	Trapezoidal	0.5	90	169	168.5	0.02	0.0	0.0
OLR_3J1b	SD3J1b	SD3A1b	Trapezoidal	0.5	33	188.4	188.3	0.02	1.1	2.5

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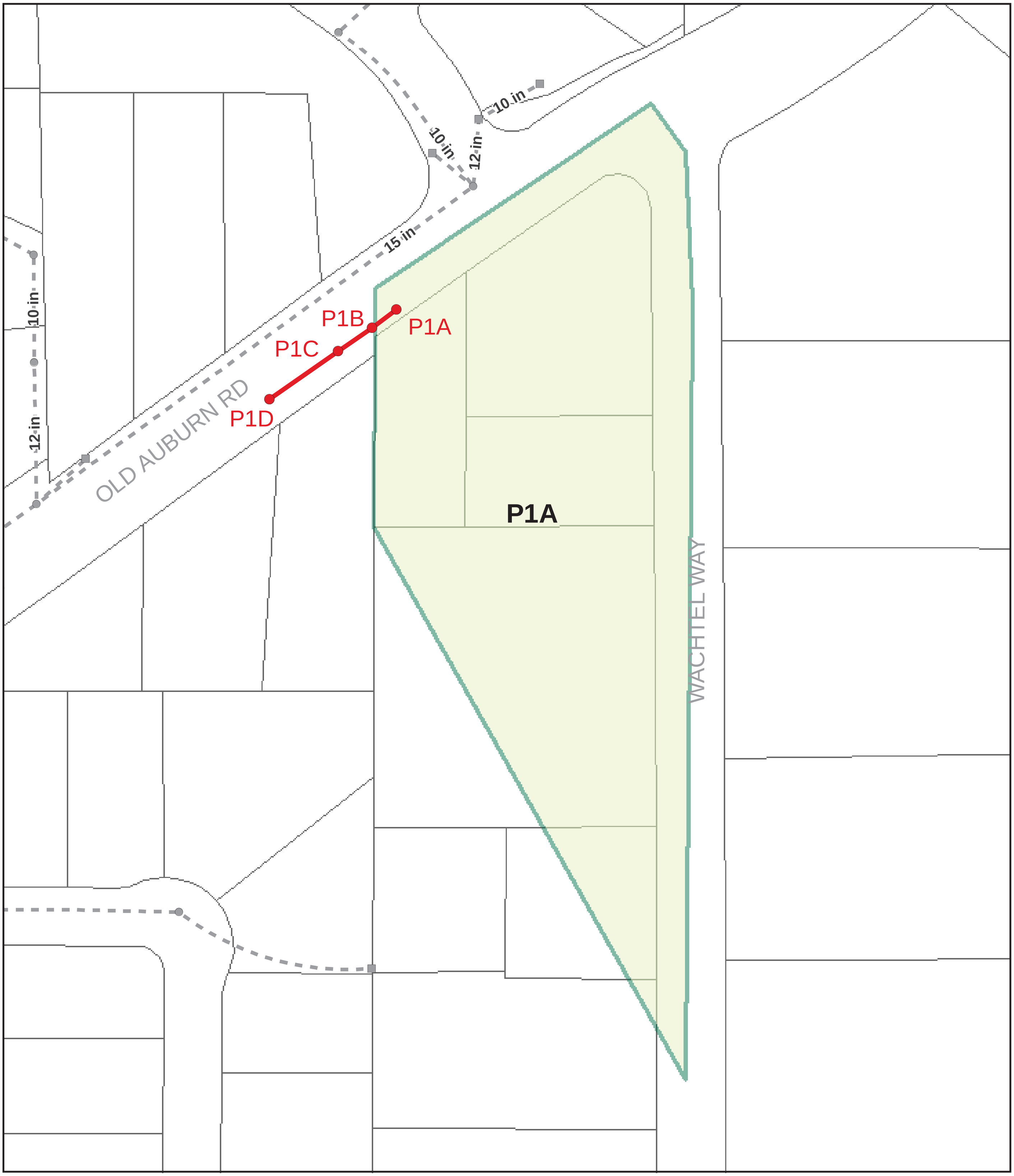


LEGEND

- P1 Shed
- P1 XPSWMM Modeled Links
- P1 XPSWMM Modeled Nodes
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole

N

0 50 100

Scale in Feet

Figure C1
City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 1
Subshed and XPSWMM
Model Layout

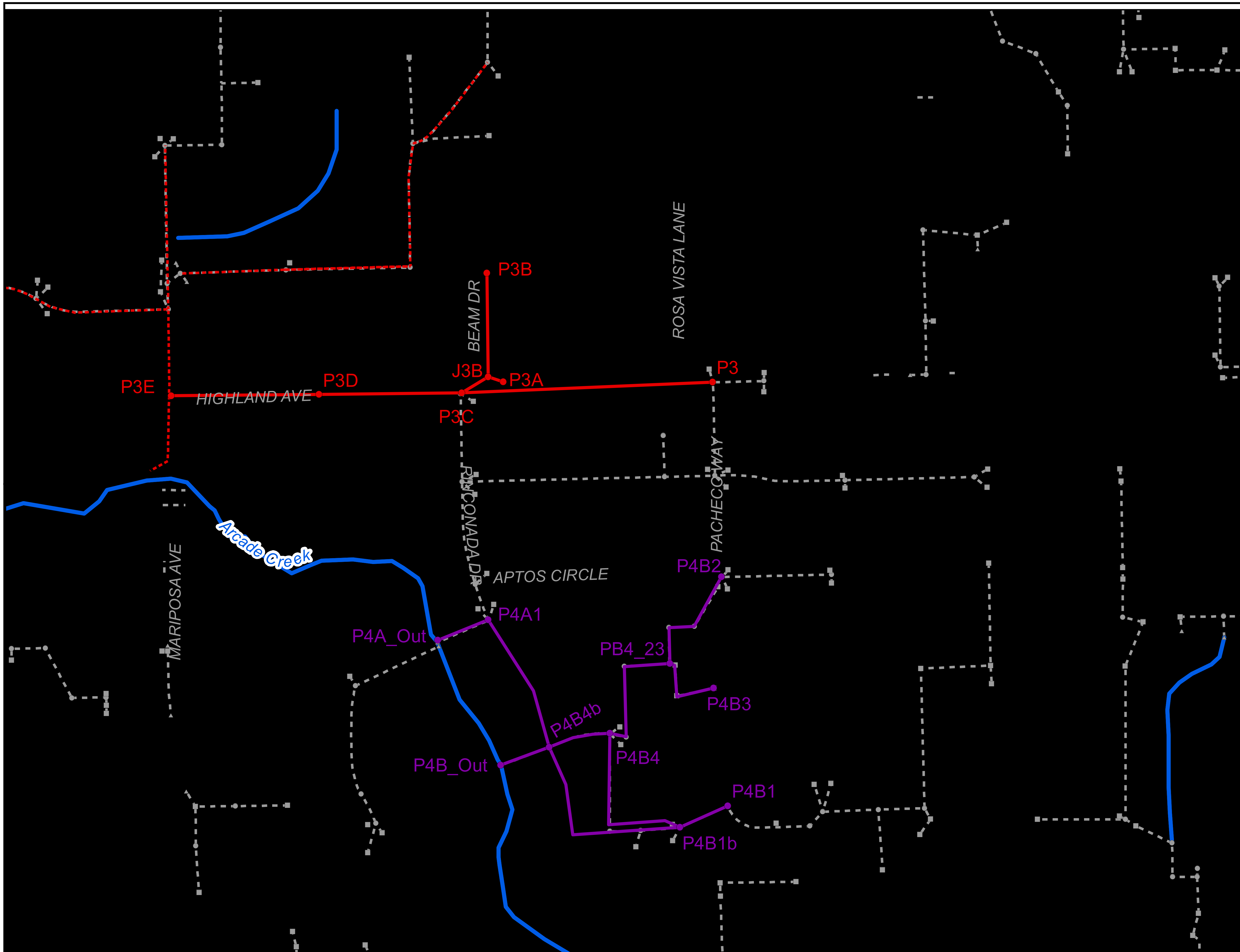
WEST YOST ASSOCIATES

Consulting Engineers

Figure C2

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Locations 3 and 4 Option 2 Subsheds and Model Layouts



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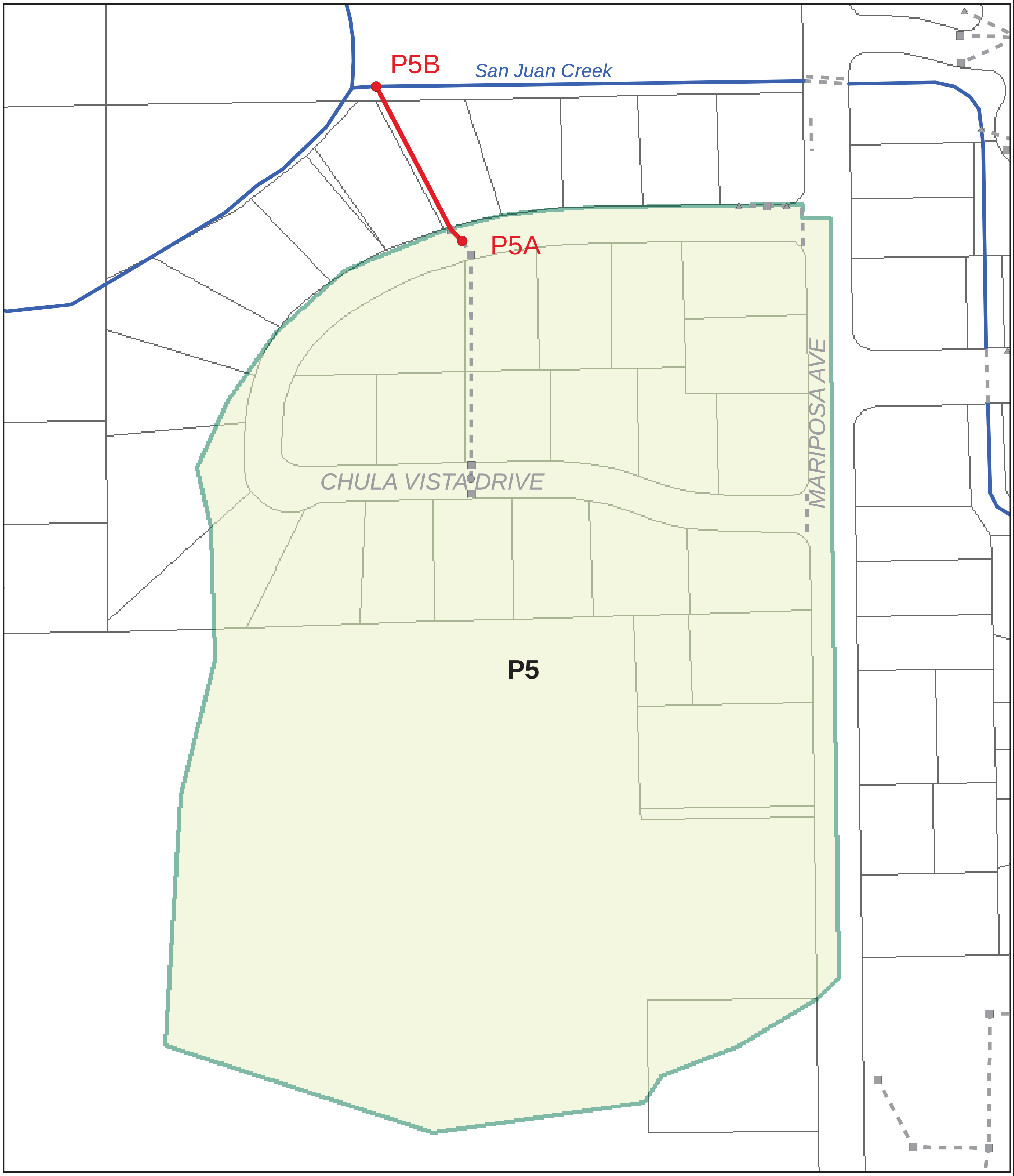
0 125 250
Scale in Feet

LEGEND

- P3 Sheds
- P4 Sheds
- P3 Calculation Links
- P4 XPSWMM Modeled Links
- P3 Calculation Nodes
- P4 XPSWMM Modeled Nodes
- P6 Modeled Links (see Fig. A4)
- Open Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole



LEGEND

- P5 Shed
- P5 Calculation Links
- P5 Calculation Nodes
- Open Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole

N

0 75 150

Scale in Feet

Figure C3
City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 5
Subshed and Hydraulic
Calculations Layout

WEST YOST ASSOCIATES

Consulting Engineers

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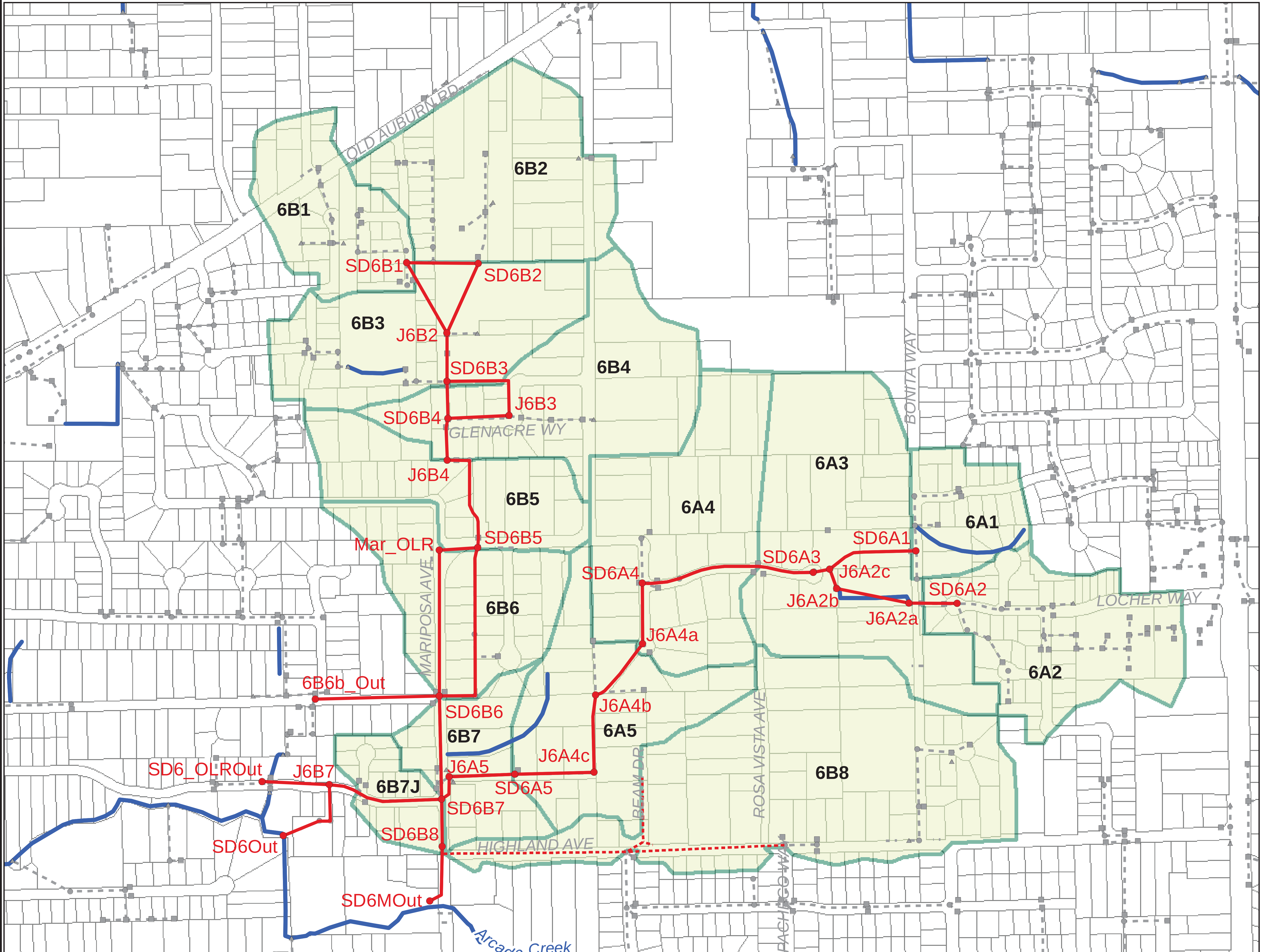

Figure C4

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Locations 6 & 10 Option 2 Subsheds and Model Layout

N

0 200 400
Scale in Feet

LEGEND

- P6 & P10 Sheds
- P6 & P10 XPSWMM Modeled Links
- P6 & P10 XPSWMM Modeled Nodes
- P2 Calculation Links (see Fig. A2)
- Open Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole

WEST YOST ASSOCIATES
Consulting Engineers

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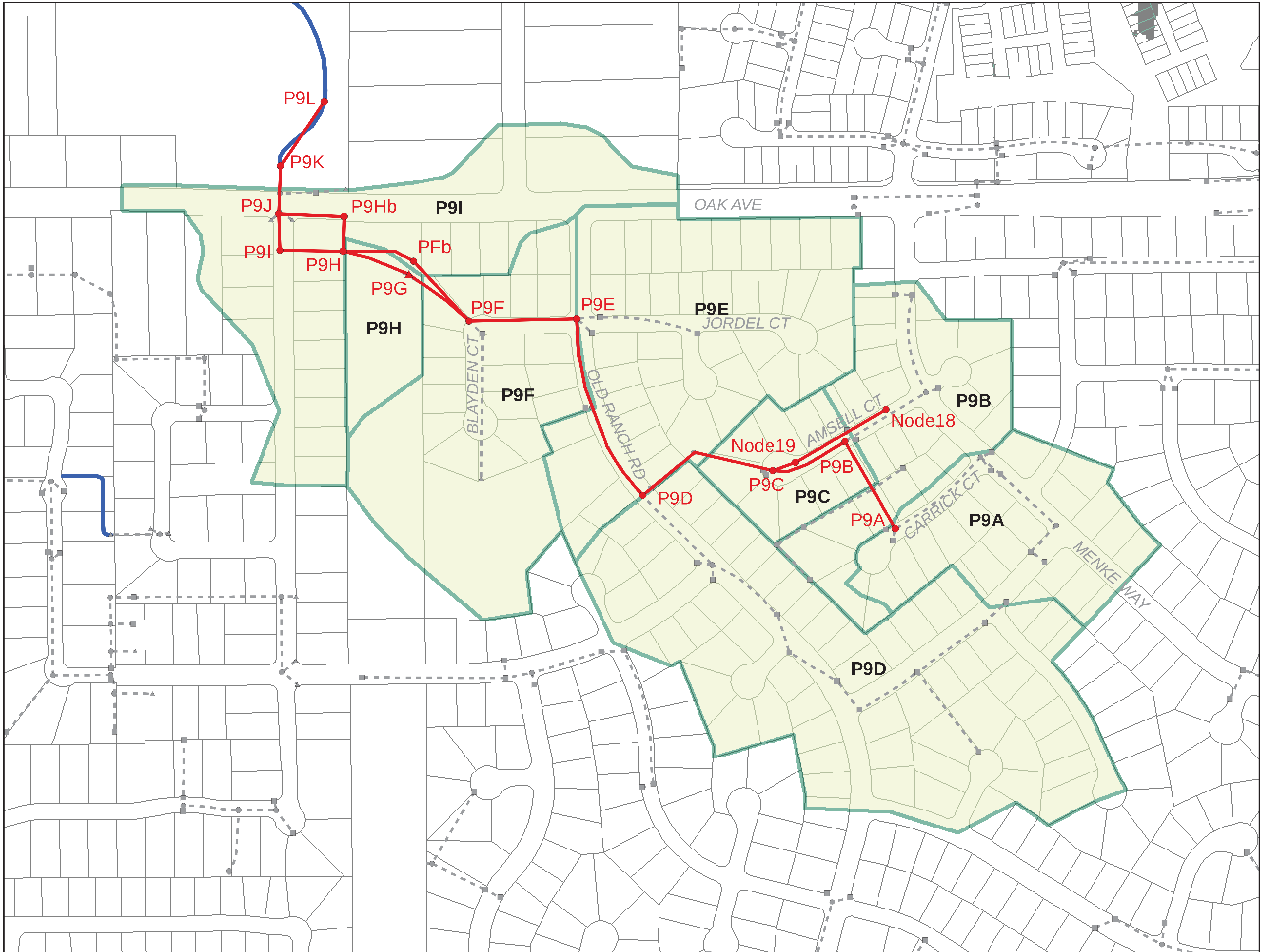

Figure C5

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 9
Option 2 Subsheds and XPSWMM Model Layout

N

0 125 250
Scale in Feet

LEGEND

- P9 Sheds
- P9 XPSWMM Modeled Links
- P9 XPSWMM Modeled Nodes
- P9 XPSWMM Modeled Storage Node
- Open Channel
- Existing Drain Pipe
- Existing Inlet
- Existing Outfall
- Existing Manhole

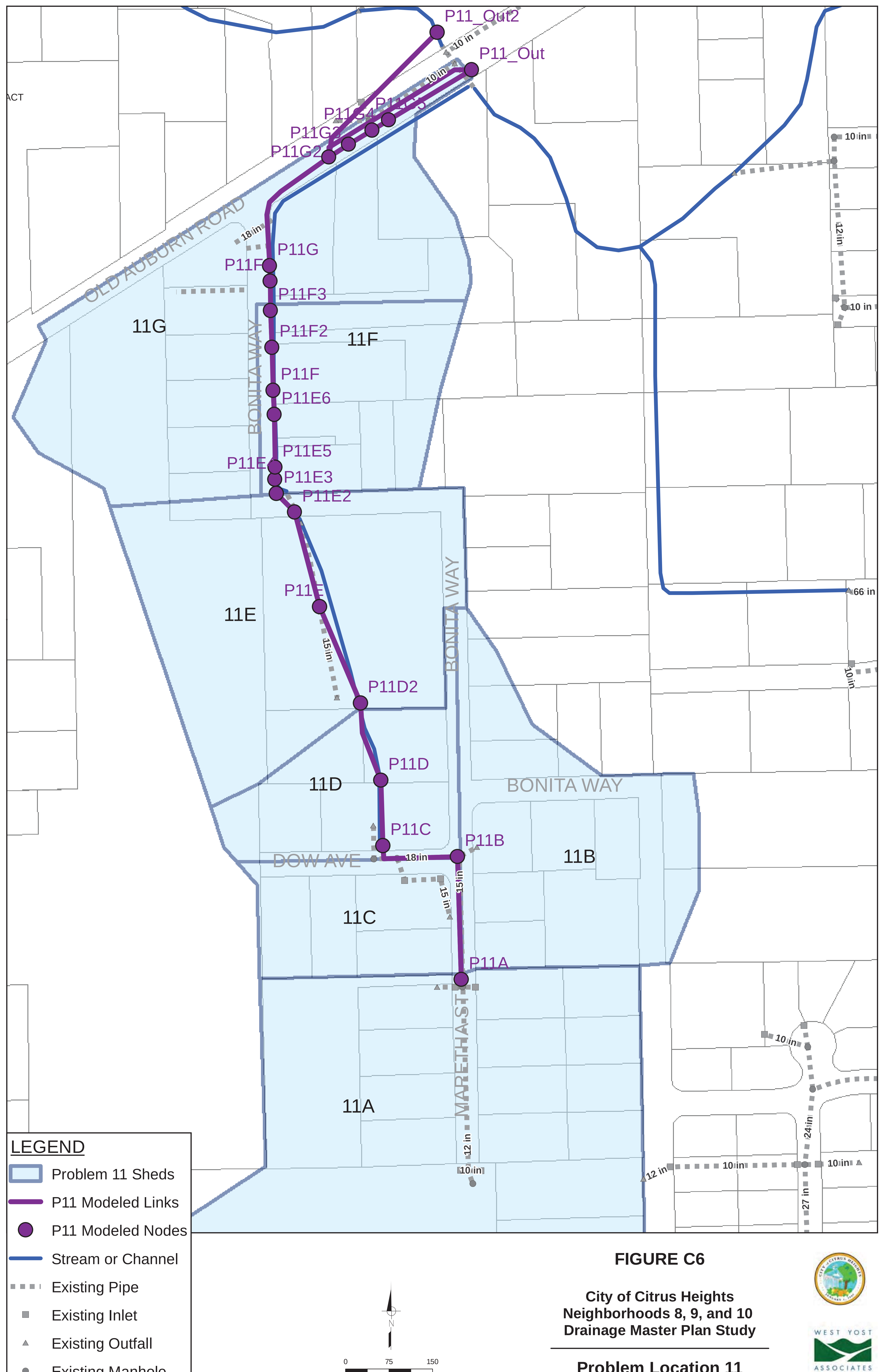

FIGURE C6

City of Citrus Heights
Neighborhoods 8, 9, and 10
Drainage Master Plan Study

Problem Location 11
Subsheds and Model Layout

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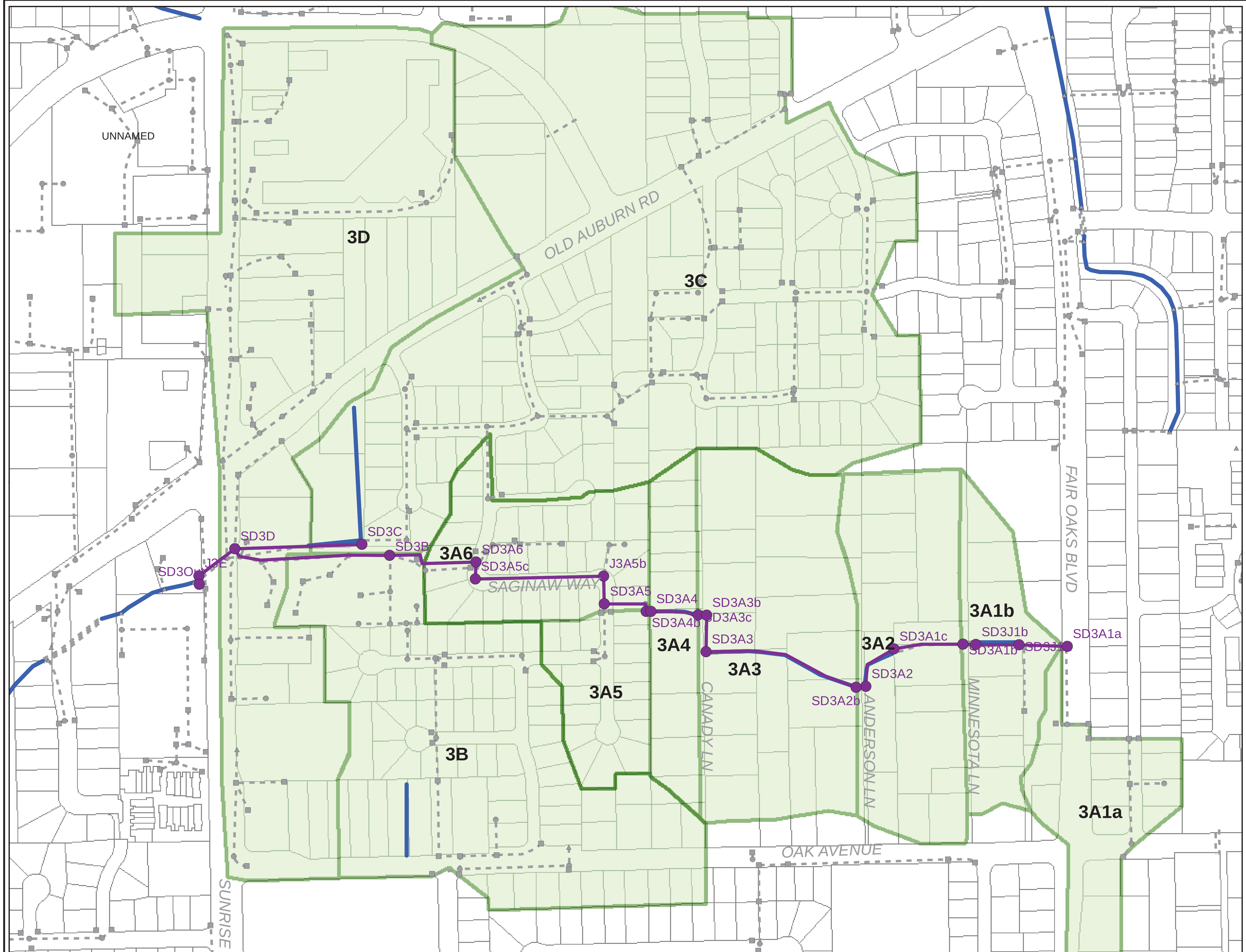

Figure C7

City of Citrus Heights Neighborhoods 8, 9, and 10 Drainage Master Plan Study

Problem Location 12 Subsheds and Model Layout