# Sonoma County
## Final Villa Grande Drainage Study
## December 2022

Job # SONO.01

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# List of Abbreviations

| | |
|---|---|
| CCTV | Closed Circuit Television |
| CIP | Capital Improvement Project |
| CMP | Corrugated Metal Pipe |
| CN | Curve Number |
| FEMA | Federal Emergency Management Agency |
| FHWA | Federal Highway Administration (FHWA) |
| FMDM | (Sonoma County) Flood Management Design Manual |
| GIS | Geographic Information System |
| HEC-22 | Hydraulic Engineering Circular No. 22 (Urban Drainage Design Manual) |
| HGL | Hydraulic Grade Line |
| LiDAR | Light Detection and Ranging |
| NOAA | National Oceanic and Atmospheric Administration |
| RCP | Reinforced Concrete Pipe |
| SFHA | Special Flood Hazard Area |
| SUHM | Synthetic Unit Hydrograph Method |
| USDA | United States Department of Agriculture |
| WSEL | Water Surface Elevation |

# 1 Executive Summary

This storm drainage study provides an analysis of the capacity and function of the existing stormwater collection system and recommendations for capital improvements within the Villa Grande community in Sonoma County.

## 1.1 Study Objective

The basic objective of this study is to identify capacity issues as well as project alternatives to mitigate them.

The tasks we completed as part of this study include:

- Collection of field data to supplement GIS data for building an existing conditions model of the storm drainage network;
- Assessment of the condition of the existing system;
- Delineation of drainage areas affecting the Villa Grande storm drain network;
- Assessment of the performance of existing storm drainage systems;
- Identification of capital improvement alternatives to reduce flood risk;
- Identification of projects to reduce maintenance;
- Estimation of project costs for the Capital Improvement Program (CIP)

The adoption of this document is exempt from the requirements to prepare Environmental Impact Reports [EIR] or Negative Declarations [ND]. However, CEQA must be satisfied for any capital improvement project described in this report that may be implemented by the County in the future through the preparation of an appropriate EIR, ND, or determined to be categorically excluded.

## 1.2 Work Products

This study is intended to function as a multipurpose storm drain system resource guide for the County's staff and residents. It will provide sufficient background information and data to County engineers responsible for storm drainage Capital Improvement Program [CIP] implementation and/or modification. However, it will also provide a summary of system deficiencies and potential solutions to the Villa Grande community.

The appendices of this report include planning level cost estimates for the alternatives presented in the report.

## 1.3 Background

The Villa Grande storm drain system is a relatively small network consisting of open channel conveyance (e.g. ditches), inlet structures, and storm drain pipes with outlets to the Russian River. There are two, separate, contiguous systems that handle stormwater runoff from the area. Most of the system has capacity for the 10-year event; however, portions of the system lack the capacity necessary to meet the 10-year standard.

County staff and residents identified some known, recurring problems or deficiencies:

- High water in the Russian River causes surcharge in the system.
- Runoff from the hillsides above Moscow Road sometimes concentrates too heavily on West Street
- The system surcharges or lacks capacity near the Post Office on West Street

## 1.4 Evaluation

We developed a MIKE URBAN rainfall-runoff model for Villa Grande that contains the storm drainage pipe and channel system providing essential conveyance capacity for storm runoff. This was used to evaluate existing and required capacity for the system.

Detailed review, field investigations, analysis, and modeling of the area's storm drainage system led to several conclusions. We used these conclusions to recommend improvements to the system intended to reduce flood risk within the Villa Grande Community.

The recommended improvements are preliminary in nature and based on currently available information. Detailed project designs will ultimately require more data, including utility locations, which remain to be obtained.

We evaluated the current physical condition of the drainage system using pole-mounted camera topside observations, as well as targeted CCTV inspection of portions of the system that were difficult to reach on foot or potentially damaged to the point of losing design capacity.

Most of the observed system is in good condition. However, there are reaches with heavy debris and sediment accumulation and failure. Improvements for the condition related projects are detailed in this report.

## 1.5 Capital Improvement Recommendations

Schaaf & Wheeler developed a Capital Improvement Program based on model results and suggested improvements. We recommend between $50,000 and $2,200,000 worth of improvements to address the capacity and condition deficiencies identified in this analysis. The large range of potential costs is attributed to the identification of several separate projects and alternatives. The actual value of the improvements will ultimately depend upon the combination of projects and alternatives selected to carry through design, permitting, and construction.

Recommended improvements are intended for public rights-of-way and other County-owned property or easements, not privately owned facilities.

The cost of the alternatives explored in this report are summarized broadly (rounded to two significant figures) in Table 1-1.

**Table 1-1: Approximate Cost Ranges by Project Type**

| Improvement Type | Description | Approximate Cost Range |
|---|---|---|
| Non-Return (Backwater Prevention) | Mitigate issues related to the occurrence of backwater from high water levels in the Russian River | $120,000 - $170,000 |
| City System Capacity | Mitigate interior flooding issues related to pipe and/or inlet capacity deficiency | $250,000 - $850,000 |
| Willow Way Culvert Capacity | Mitigate interior flooding issues related to the capacity of the existing 32" culvert at Willow Way and Russian River Ave | $230,000 -$480,000 |
| Center Street Drainage | Mitigate issues with ponding where no closed conveyance currently exists | $100,000 - $310,000 |
| System Condition/ Maintenance | Mitigate system condition issues that may cause flooding now or in the future | $50,000 - $290,000 |

## 1.6 Conclusion

This storm drain system analysis provides a tool for Sonoma County to use in their efforts to reduce both nuisance flooding and the likelihood of more serious storm water related hazards to private and/or public property in the Villa Grande community. This study and capital improvement alternatives are merely the conceptual starting point.

We anticipate that the County and/or their consultants will perform more detailed studies and alternatives analyses to identify the most affordable and effective capacity and condition improvement projects with information gathered as part of the design process, including more detailed topography, utility conflicts, available easements and rights-of-way, construction impacts, permitting needs, and long-term operation and maintenance. This report ventures to consider these factors in developing an alternatives analysis for various improvement strategies. However, more detailed information will always provide the best tool in making informed decisions.

# 2 Introduction

## 2.1 Overview

This document provides a capacity analysis and condition assessment of existing storm drain collection systems, a discussion of drainage design standards, and recommended improvement projects to reduce the risk of flooding with estimated costs within Villa Grande. Its primary focus is on the County-owned drainage facilities.

This analysis should be used to guide the County in planning, financing, engineering, and maintaining its own infrastructure. Each chapter of this report is intended to help the County identify problems, manage resources, and provide cost-effective and comprehensive solutions.

This chapter provides a general discussion of drainage and flood management systems and issues currently affecting the community. It also describes the objectives of this analysis, explains the criteria used to evaluate storm drain system performance, and presents a summary of the data collected to support this effort.

## 2.2 Setting

Villa Grande an unincorporated community situated in Sonoma County, adjacent to the Russian River. The community is situated approximately 2 miles southwest of Guerneville and 5.5 miles east of Jenner and the Pacific Ocean.

The community rests on a plateau on the left bank of the Russian River and on the adjacent hillside. The low-lying portion of the community sits in the FEMA-defined Zone AE Special Flood Hazard Area (SFHA). The SFHA in the vicinity of the Villa Grande community is shown in Figure 2-1. A profile through the community, from the hillside through the Russian River is shown in Figure 2-2.

The storm drainage system manages stormwater from the plateau as well as the hillside above, which drains across Moscow Road into a ditch, and finally to the storm drainage system below. The plateau is primarily deep, well-drained alluvium.

Villa Grande is predominantly forested with rural residential development and unpaved roads and ranges in elevation from 30 to approximately 400 feet on the 1988 North American Vertical Datum [NAVD88]. The study area, defined primarily by the drainage area to the existing stormwater conveyance system in Villa Grande, covers an area of approximately 0.7 square miles (Figure 2-3 shows the study area).

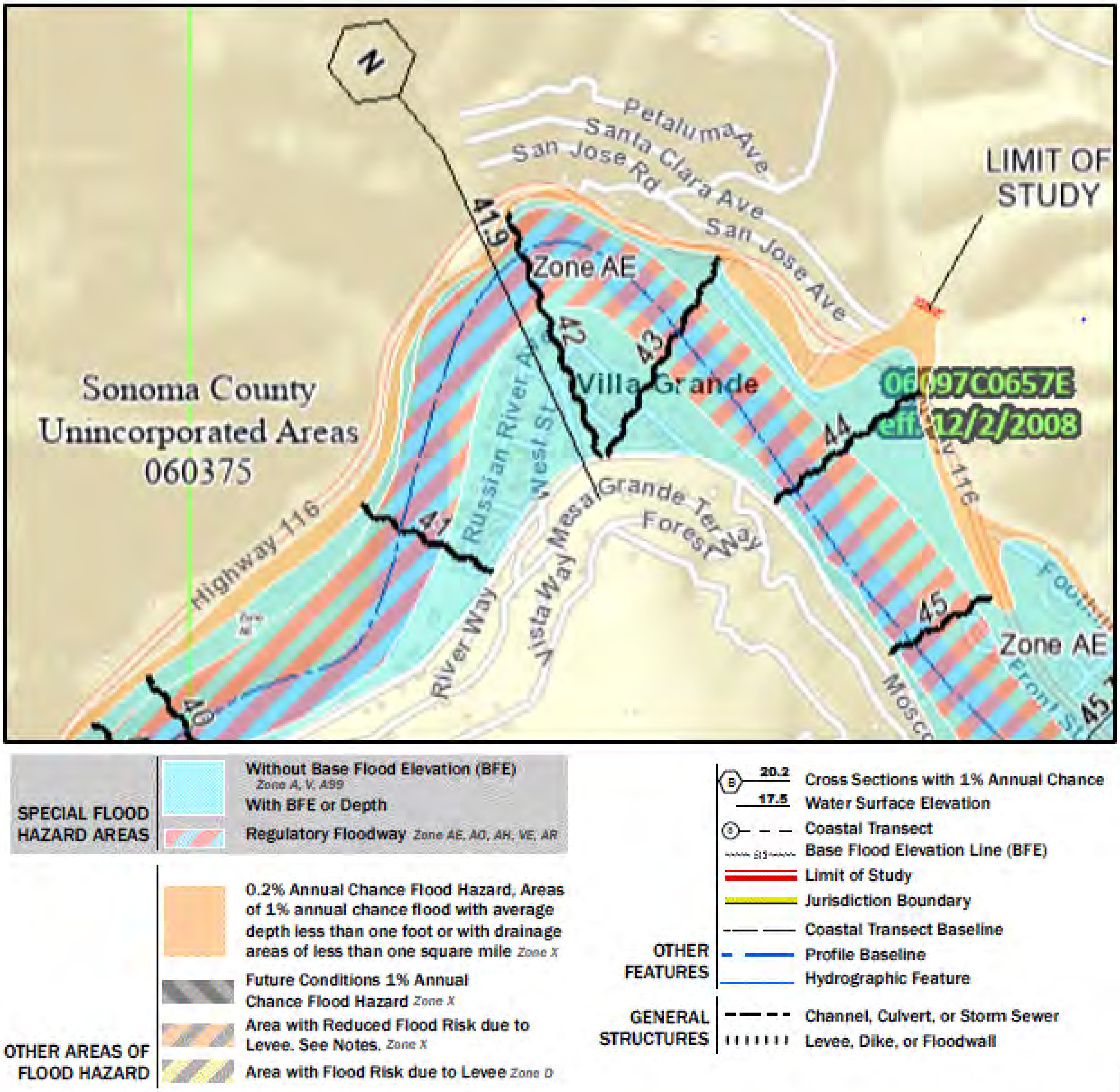



**Figure 2-1: FEMA Special Flood Hazard Areas in the Vicinity of Villa Grande.**

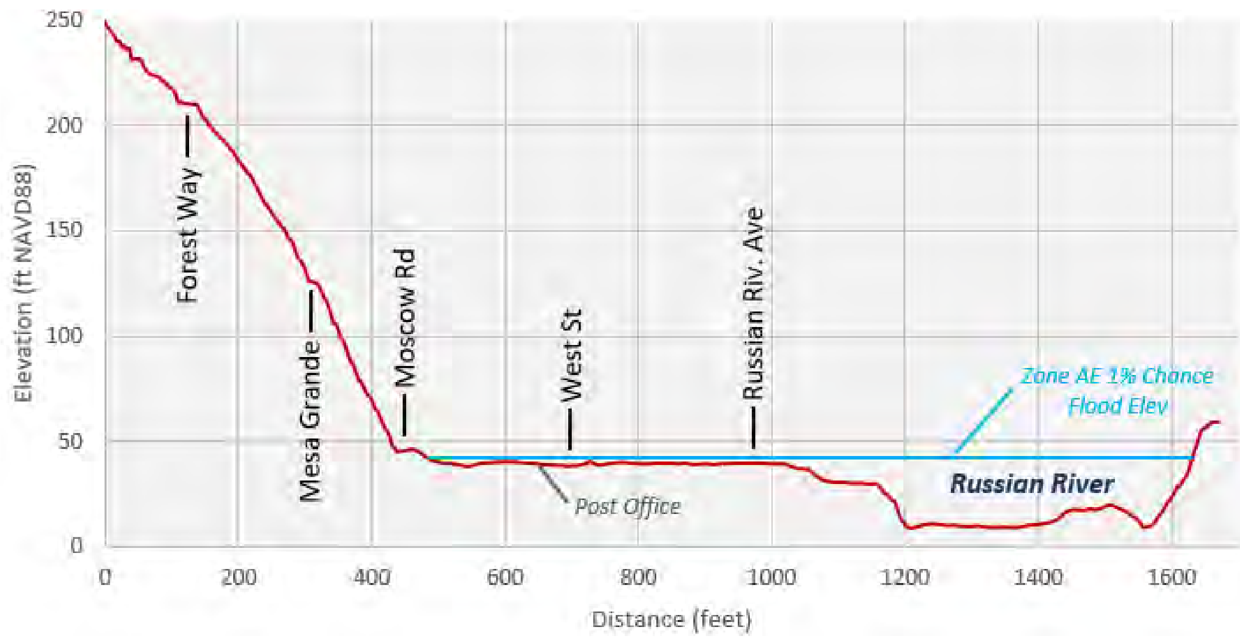



**Figure 2-2: Ground Surface Profile Through Villa Grande, to the Russian River**

## 2.3 Climate

Study area has a climate consisting of Summary of climate. The average annual high temperature is 73°F, and the average annual low temperature is 42°F. While mean annual precipitation varies throughout the Study area, the city-wide average is about 45 inches per year. Most of the rainfall occurs during Fall and Winter months (November through March).

## 2.4 Existing System

Runoff generated by precipitation within the Villa Grande community and surrounding area is conveyed through various conveyance systems. The majority of runoff captured by the storm drain networks discharges through gravity outlets into the Russian River. The study area and existing stormwater conveyance system are shown in Figure 2-3.

Aside from various culverts crossing Moscow Road, the system consists of contiguous sub-systems of pipe and ditch that drain to three outfalls:

1. A northern system draining to an outfall in alignment with 4$^{th}$ Street

2. A southern system draining to an outfall in alignment with 6$^{th}$ Street (this system drains West Street near the post office)

3. Two additional culverts at the intersection of Willow Road and Russian River Ave that drain a large area of hillside to the south.

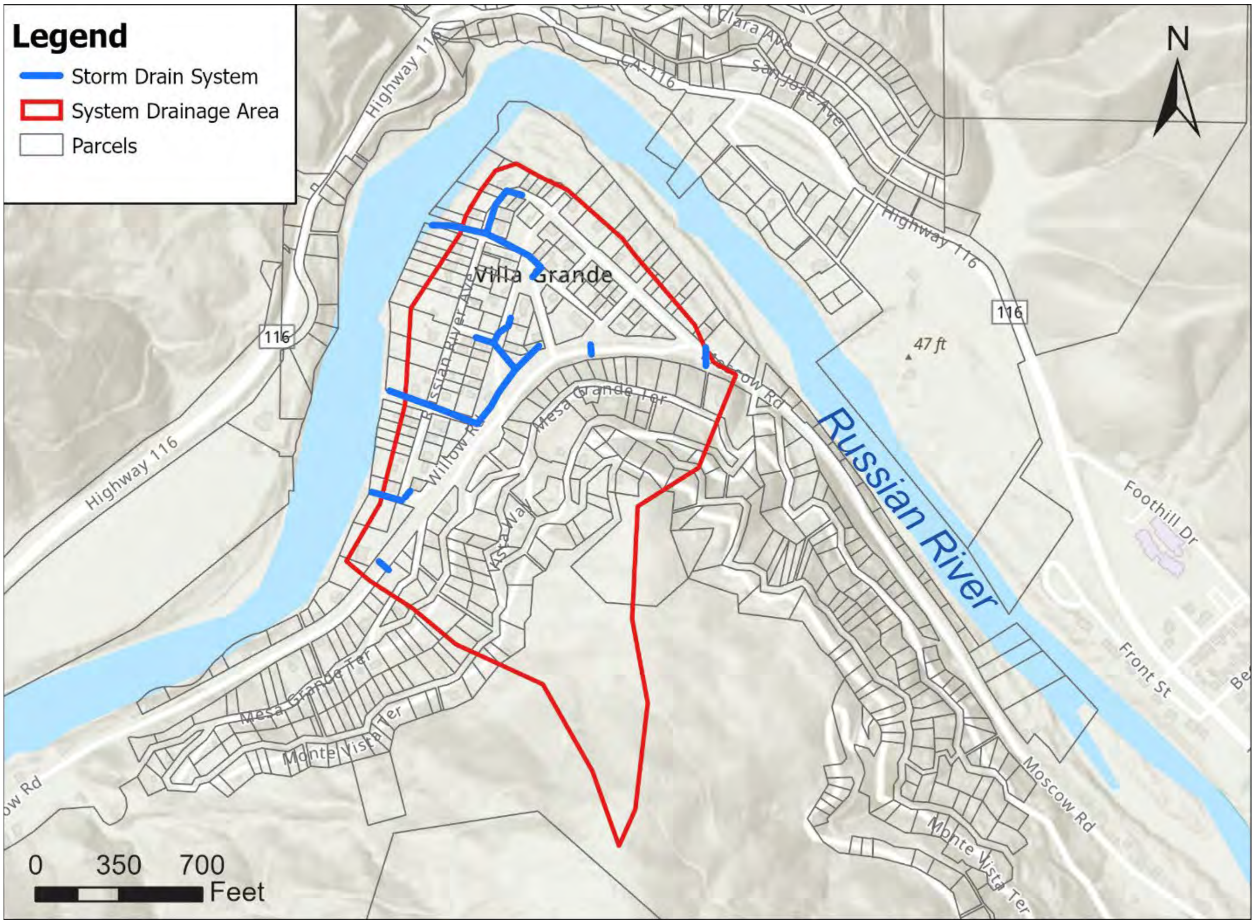



Figure 2-3: Existing Storm Drainage System and Drainage Area

# 3 Data

## 3.1 Data Sources

Schaaf & Wheeler reviewed and used readily available land use, topographic, geological, geographical, and storm drain system data within the study area. Available data, while mostly complete, had some missing or incorrect information. We improved and added to the collective data when possible.

We also used assumptions and engineering judgment to complete remaining data gaps. This chapter summarizes the findings and data acquired as part of this storm drainage study. It also summarizes data limitations, assumptions, and impacts.

### *3.1.1 Topography and Aerial Imagery*

All project data and results are in vertical datum NAVD88 (feet) and the State Plane California Zone II coordinate system.

Schaaf & Wheeler created an integrated citywide digital elevation model from available Sonoma County 2017 LiDAR data (Figure 3-1) to aid in developing the hydrologic and hydraulic models for the system analysis. Higher accuracy topographic survey of the roadways and stormwater system were also used to create a more accurate hydraulic model. We also used aerial imagery available in ArcGIS to obtain related data such as road networks, land use, and water bodies.

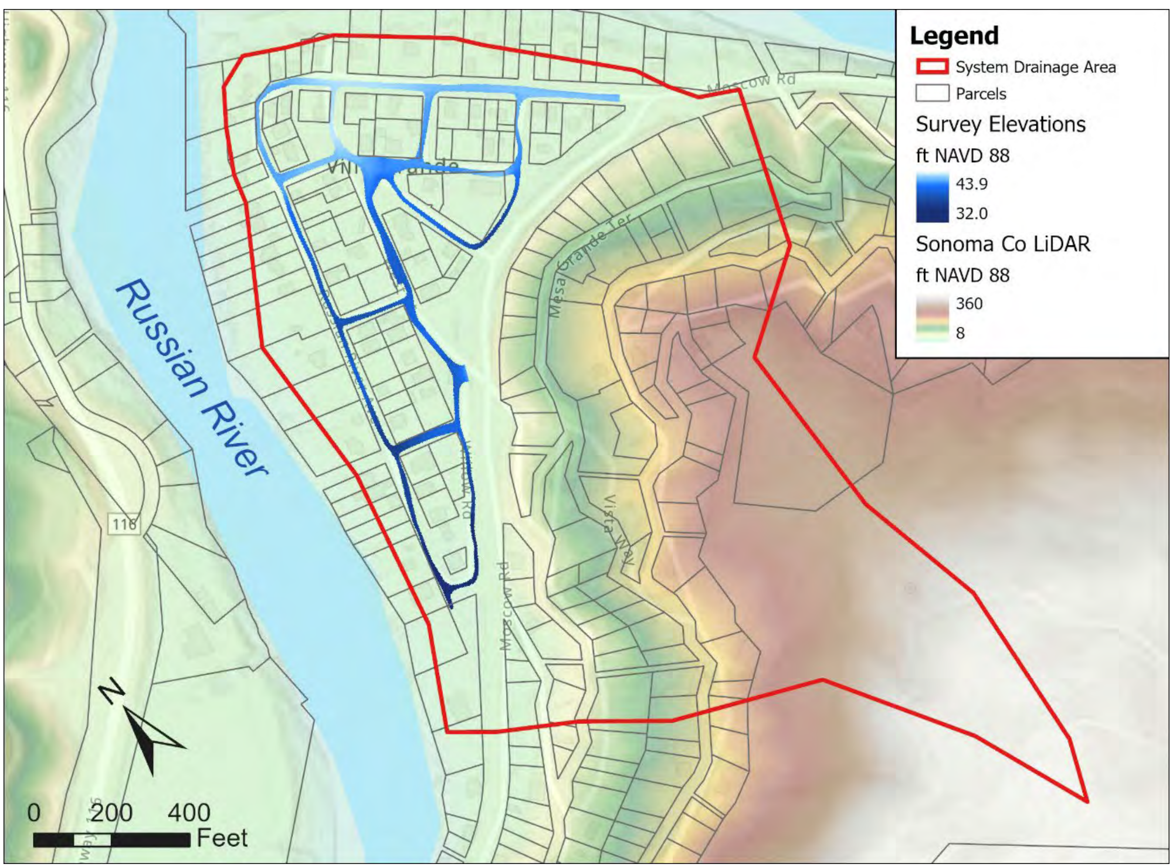



**Figure 3-1: Villa Grande Topographic Data**

### *3.1.2 Storm Drain System Data*

Sonoma County provided available GIS data representing storm drain nodes (e.g. inlets and outfalls) and storm drain pipes to Schaaf & Wheeler in a geodatabase format (.gdb). Initial data included:

- Pipe locations and lengths;
- Node types (Drain Inlet - DI, Catch Basin - CB, Outfall - O);
- Elevation of two outfalls; and
- Sizes for all pipes

Schaaf & Wheeler identified missing data as well as items in need of verification. Information needed to create the model needed for analysis included:

- Verification of pipe diameters; and
- Node depth and rim elevations

The storm network elements were placed in GIS. Nodes were assigned ground and invert elevations based on field visits and topographic survey information. Schaaf and Wheeler conducted a field visit on July 19, 2022. Topographic survey including node rims and depth was collected by Cinquini & Passarino, Inc. on July 19, 2022. The system is shown in Figure 3-2.

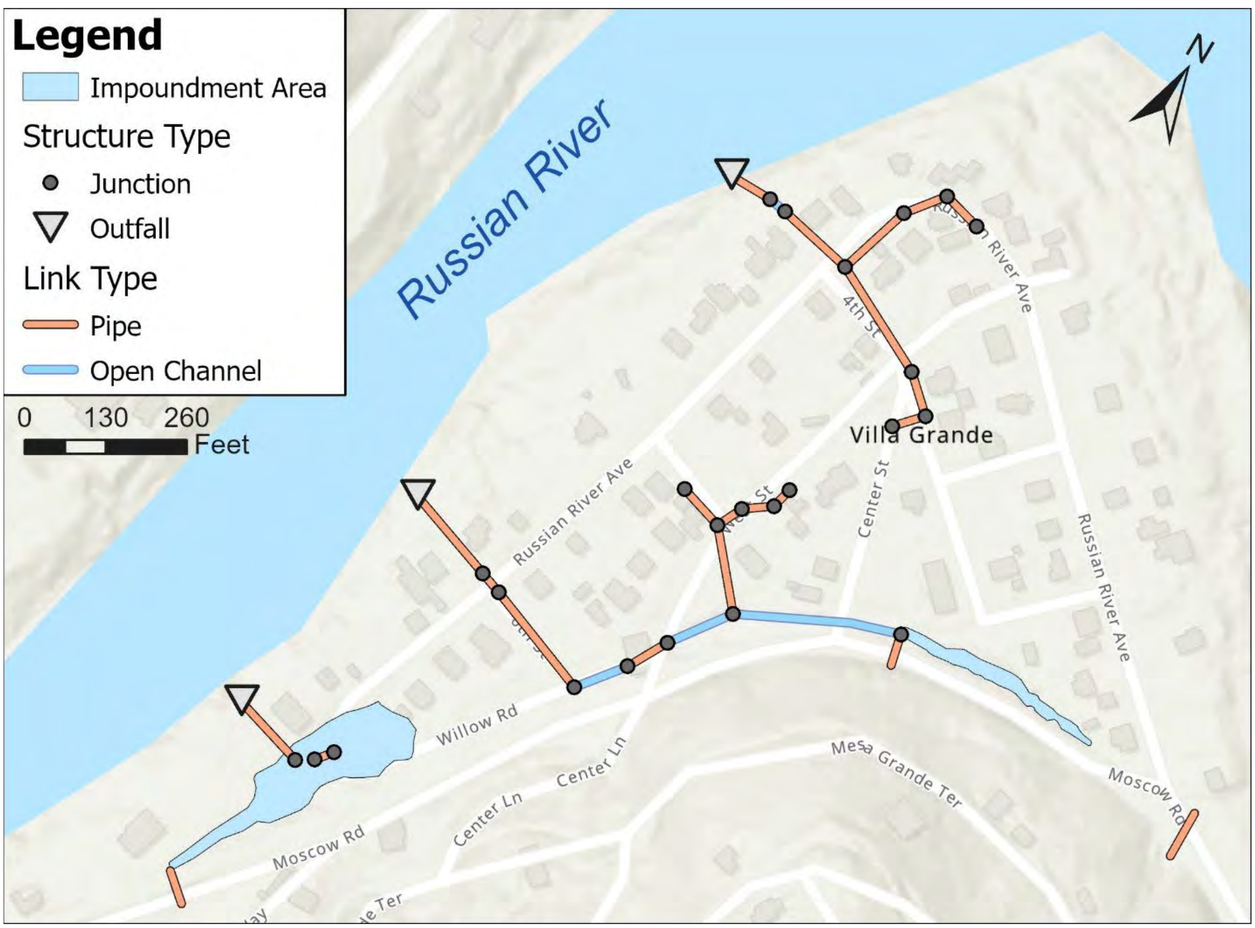



**Figure 3-2: Villa Grande Storm Drainage Network**

Certain culverts crossing Moscow Road are not included in the model. In general, known drainage issues occur on the north side of Moscow Road. No known issues were identified with the capacity of these culverts. It's also likely that drainage will cross Moscow Road whether it fits in the culverts or not, ultimately flowing into the systems where drainage issues have been identified. The most conservative approach to evaluating the systems that most directly affect the community is to ignore the small amount attenuation that these culverts might cause. The culverts are inventoried and shown nonetheless for reference.

In some areas, ditches have been added to the system to convey water from hillsides and between closed system elements. There are also certain areas where ponding is a known issue. These are also shown in Figure 3-2 as "Impoundment Areas". Impoundment at Willow Way and Russian River Ave is modeled using basin elements with geometric properties to properly evaluate culvert hydraulics

### *3.1.3 Land Cover and Soil Characteristics*

Land cover and soil characteristics are essential factors in development of a hydrologic model. Soils information was acquired from the United States Department of Agriculture (USDA) Web Soil Survey system. Land use data was defined based on a combination of aerial imagery, Sonoma County parcel information, and the National Land Cover Database (NLCD) to reflect conditions affecting hydrology as accurately as possible.

Zoning for County parcels is shown in Figure 3-3.

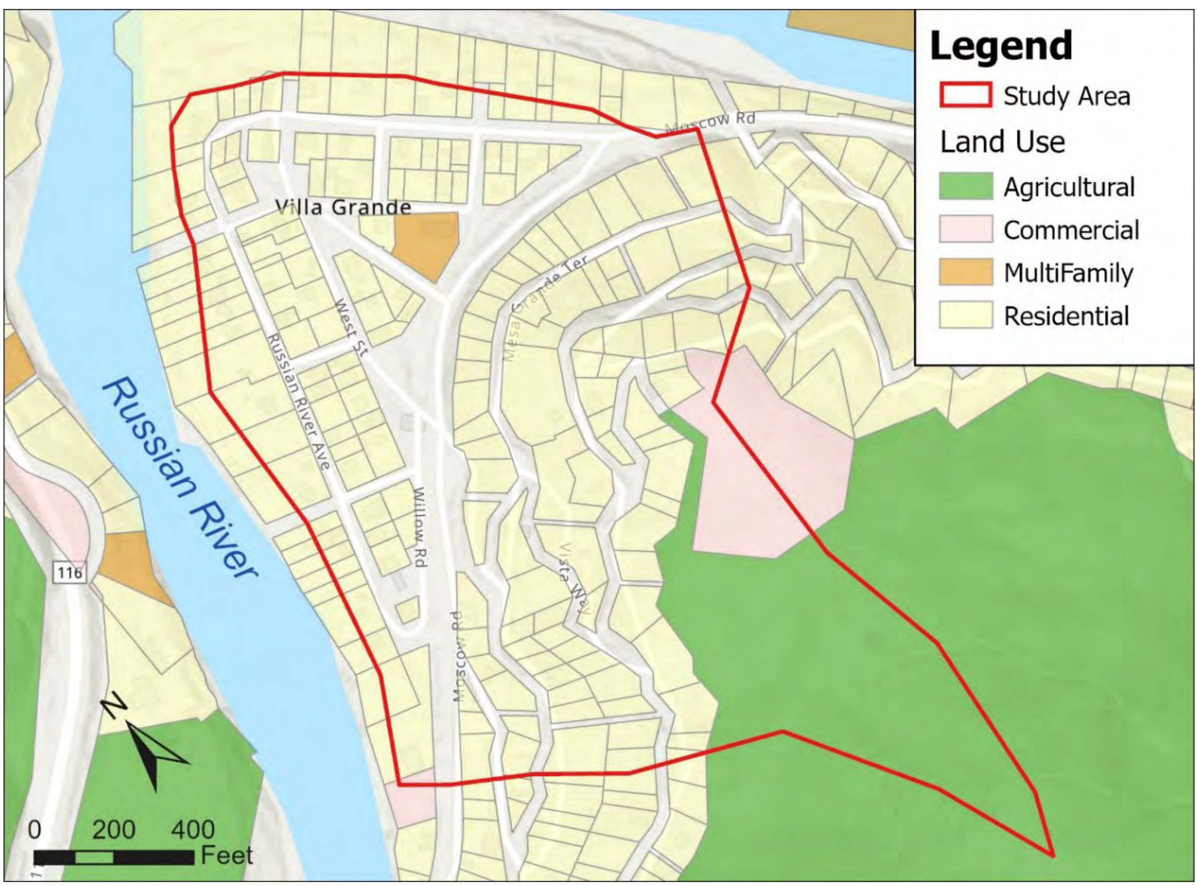



**Figure 3-3: Land Use Information Used in the Development of the Hydrologic Model**

### *3.1.4 Curve Numbers*

The NRCS Curve Number (CN) methodology is applied to aid in estimating runoff from catchments based on soil and land cover characteristics. Curve Numbers vary from 0 to 100, with 0 representing no runoff and 100 meaning that all precipitation will run off. A summary of select Curve Numbers suggested by the Sonoma County Water Agency Flood Management Design Manual (FMDM) is provided in Table 3-1

**Table 3-1: Curve Number Summary by Land Use and Soil Type**

| | Hydrologic Soil Group | | | |
|---|---|---|---|---|
| **Description** | **A** | **B** | **C** | **D** |
| **Bare Soil** | 77 | 86 | 91 | 94 |
| **Forest** | 30 | 55 | 70 | 77 |
| **Residential 2 acre** | 46 | 65 | 77 | 82 |
| **Residential 1 acre** | 53 | 70 | 80 | 84 |
| **Residential 1/2 acre** | 58 | 73 | 82 | 86 |
| **Residential 1/4 acre** | 68 | 79 | 86 | 89 |
| **Residential 1/8 acre or Less** | 81 | 87 | 91 | 93 |

Some engineering judgement must be applied to use of these curve numbers. Generally speaking, Residential CN values in this table are representative of more typical urbanized areas. Villa Grande is unique in that the density of tree canopy on residential properties exceeds that of a typical residential neighborhood, to the point where the National Land Cover Database (NLCD) describes this area as “Developed Open Space” based on classification of satellite imagery. Additionally, most of the roads in Villa Grande are not paved and may be better represented by a Bare Soil cover type.

# 4 Methodology

## 4.1 Overview

The criteria used to evaluate storm drain system performance must be technically sound and simple to understand and apply. Ideally, the same methodology used to analyze system performance for this report will continue to be used for future infrastructure design.

Schaaf & Wheeler applied methodology presented in the FMDM to estimate stormwater runoff based on land cover and soil types present in the study area.

Additionally, we used MIKE+ storm drain modeling software by DHI to evaluate system performance, identify deficiencies, and evaluate and recommend necessary improvements. We also performed a spreadsheet analysis of inlet capacity. Physical parameters used in the analysis are based on information detailed in Chapter 3 – Data.

Schaaf & Wheeler discussed and agreed upon evaluation criteria described in the following section with the County.

## 4.2 Evaluation Criteria

The FMDM sets various performance criteria for drainage systems that must be considered. These include:

- Minimum pipe sizes of 18 inches for open-ended inlets, with other inlets sized to carry calculated inflows (Section 4.3.2.2). Pipe sizes must also not increase in the downstream direction.
- Design flow rates set by waterway type (Section 3.3.4), where:
    - "Minor Waterways" of 1 square mile or less must be sized with a design flow rate of the 10-year peak;
    - "Secondary Waterways" with drainage areas between 1 and 4 square miles must be sized with a design flow rate of the 25-year peak;
    - "Major Waterways" with drainage areas greater than 4 square miles must be sized with a design flow rate of the 100-year peak.
- Hydraulic and Energy Grade Line requirements specifying that the HGL depth in pipes be no greater than 80% of the pipe diameter, if downstream receiving waters allow (Section 4.3.2.4).
- Minimum pipe cover of two feet between the top of the conduit and the ground surface (Section 4.3.2.7).
- Manholes should be placed at a maximum interval of 500 feet along closed conduit systems, with acceptable access points placed at all junctions, reductions in slope, bends, or other points where access is critical (Section 4.3.2.8).

Drainage areas for waterways and pipe systems in this study fall below 1 square mile, meaning that a design event for the systems is a 10-year peak flow. Schaaf & Wheeler created hydrologic analysis and one-dimensional hydraulic models for the 10-year event and applied the event as the level-of-service standard in accordance with the FMDM.

While ideally a project would meet all of the criteria set by the FMDM, it may be more practical to define an alternative level of service for the system. The FMDM, for example, notes that the HGL depth requirements are subject to downstream receiving waters. For these systems, the 10-year water surface in the Russian River (discussed in greater detail in Section 5.2.3) does create a tailwater condition that inundates large segments of the system. Additionally, the existing system is very shallow in certain areas, particularly near the post office. Meeting the cover requirement of two feet or more where projects are recommended on West Street would be impossible without replacing nearly the entire system downstream to Russian River Avenue at 6$^{th}$ Street. A CIP of that nature would likely cost roughly

We recommend that in order to make improvements practical, the performance criteria be set to reduce the 10-year hydraulic grade to no higher than the rim elevation at any location in the pipe network and to mitigate nuisance flooding issues identified throughout the community. Given the lack of curb and gutter throughout the community that would provide some conveyance and containment of stormwater runoff above ground, this standard minimizes the risk of property damage.

## 4.3 Modeling Software

Schaaf & Wheeler selected the Danish Hydraulic Institute [DHI] MIKE+ software to model the Site/system. MIKE+ is a package of software programs designed by DHI for the analysis, design, and management of urban drainage systems, including storm water sewers and sanitary sewers.

The model can simulate runoff, open channel flow, pipe flow, water quality, sediment transport, and two-dimensional surface flow.

The Villa Grande modeling package consists of two interrelated products:

1. MIKE-1D is a group of hydrologic, hydraulic, water quality and sediment transport modeling modules that can be used together or independently.

   The modules used in the Villa Grande storm drain model include the Surface Runoff Module, which computes surface runoff using one of five computational methods, and the Hydrodynamic Pipe Flow Module, which calculates an implicit finite-difference numerical solution of the St. Venant flow equations for the modeled pipe network.

2. MIKE+ is a GIS-based program that includes tools specifically designed to develop urban drainage models. MIKE+ provides a graphical user interface for data input and editing. It serves as a bridge between GIS data inputs and the hydrology and 1-D pipe flow module.

   Capabilities of the software include import and export of model data, network editing and gap-filling, catchment delineation, and network simplification. MIKE+ can also be used to present results including plan, longitudinal, and cross-section views; animation of results;

presentation of flooding including water depth and pressure; and overlay of results on background graphics such as maps or aerial photos).

## 4.4 Model Operation

MIKE+ performs two separate calculations for the Villa Grande model. First, a runoff calculation [hydrologic analysis] estimates the amount of water entering the storm drain system during a design rainfall event. Second, a network flow calculation [hydraulic modeling] replicates how the storm drain system will convey flows to outlet locations. Flows resulting from the runoff calculation are used as inflows for the subsequent network flow calculation.

The MIKE+ runoff model offers a choice of infiltration methods. The Villa Grande storm drain models use the synthetic unit hydrograph method (SUHM) to calculate surface runoff with a peaking factor of 0.75, as required by the FMDM. A simulation can be started at any point during the chosen design storm to assess surface runoff for any period of the design storm, with computations made based on a user-specified time step.

### *4.4.1 Input and Output*

Surface runoff calculations require two types of input data: boundary data and catchment data. Boundary data for the run-off computation consists of an input rainfall time series representing the design storm event for the model.

Catchment data includes the pipe network and boundaries of each drainage catchment, along with relevant physical and hydrologic parameters including surface area and parameters used to calculate basin lag time. Drainage catchments for the study area are shown in Figure 4-1.

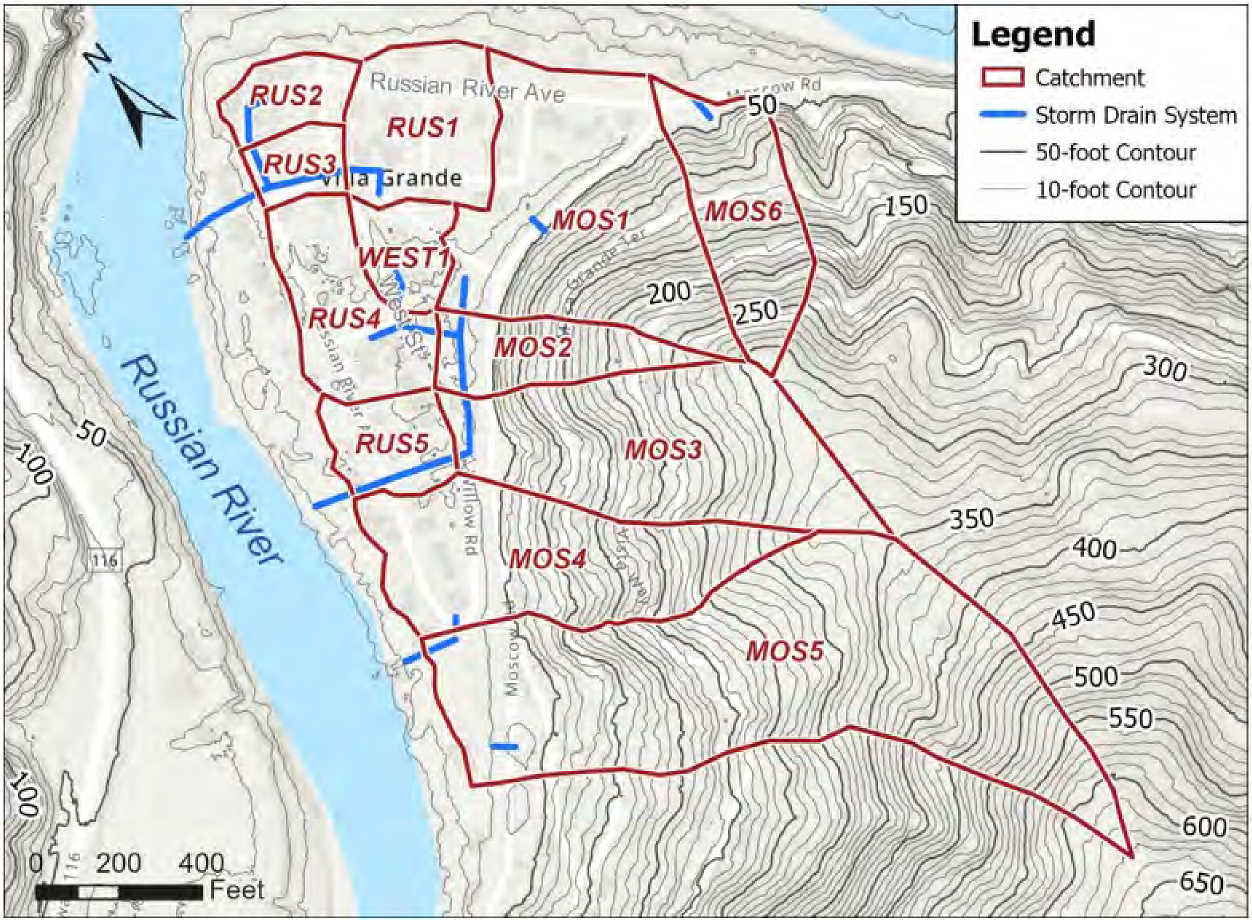



**Figure 4-1: Villa Grande Storm Drain System Catchments**

While the flat, low-lying areas drain predominantly into inlet structures connecting to the pipe system, the hillside above the Russian River floodplain drains onto Moscow Road. Runoff to the roadway either enters the adjacent ditches to the north, or is directed along asphalt berms or curbs to West Street, where it tends to pond until it starts to enter the ditches or pipe system.

A summary of typical model input and output is provided in Table 4-1.

**Table 4-1: Summary of Model Input and Output**

| Model | Inputs | Outputs |
|---|---|---|
| **Runoff** | *Boundary Data*<br>• Rainfall time series<br>*Urban Catchment Data*<br>• Drainage catchments<br>• Lag time<br>• Curve number | Runoff hydrographs for each individual catchment |
| **Pipe Flow** | *Storm Drain Network*<br>• Nodes (catch basins, manholes, outlets, etc.)<br>• Links (pipes, culverts, open channels)<br>• Operational Data<br>• Catchment connections<br>• Junction Losses<br>• Boundary Data (e.g. Water Surfaces at Outfalls)<br>• Catchment runoff hydrographs<br>• Water surface elevation time series | Water level at each node<br>Water level in network links<br>Velocity in network links<br>Water volume in the system<br>Discharges |

## 4.5 Rainfall Depth and Pattern

As recommended by the FMDM, we used a balanced, 24-hour, synthetic hyetograph with a five-minute time step based on NOAA ATLAS 14 precipitation-frequency information. This information was obtained from NOAA's online precipitation-frequency map and input into a spreadsheet. The 10-year storm is shown in Figure 4-2. The synthetic storm is centered approximately in the middle of the 24-hour period, as suggested by the FMDM. The 10-year, 24-hour storm rainfall depth at this location is 8.07 inches.

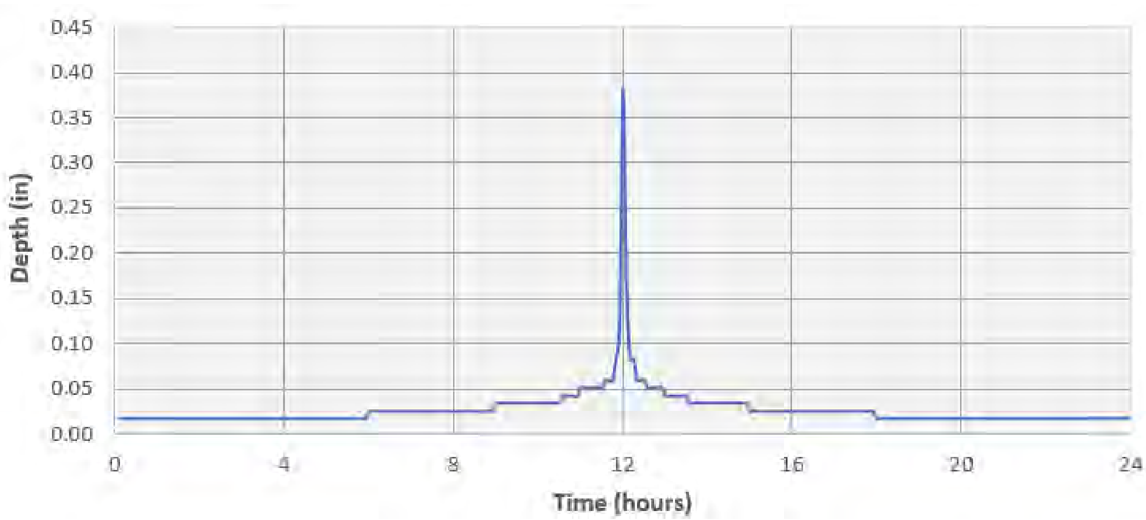



**Figure 4-2: 24-hour, 10-year Storm for Villa Grande**

## 4.6 Catchment Data

### *4.6.1 Curve Numbers*

The FMDM recommends the use of the SUHM method for runoff estimation. The unit hydrograph is a numerical representation of the time response of catchment runoff caused by rainfall applied uniformly over a unit of time. Catchments were overlain with land use and soils information in GIS to estimate curve numbers for each.

### *4.6.2 Lag Time*

The SUHM also requires the definition of lag time for the catchments. The FMDM prescribes a standard lag equation for basins. Lag is a function of the longest flow path, measured from the catchment outlet to the most remote point in the catchment, the centroidal flow path, and the average slope along the principal flow path.

The lag time equation suggested by the FMDM is:

$$t_l = 1.56 * \left(\frac{L * L_c}{\sqrt{S_0}}\right)^{0.38}$$

Where: $L$ = Longest flow path (mi)

$L_c$ = The Centroidal flow path length (distance from the outlet to a point orthogonal to the catchment centroid) (mi)

$S_0$ = The average slope of the longest flow path (ft/mi)

Flow paths were estimated in GIS based on LiDAR topographic data and elevations were extracted at the top and bottom of the flow paths to estimate slopes.

In general, this method is more suited to larger basins than those represented in this model. Given the dominance of residential land cover, buildings in small catchments present some difficulty in simply using lag calculated by this method. The effect of manmade structures such as buildings and fences are also difficult to quantify in these catchments. Villa Grande is also a unique community, with denser tree canopy than would typically be associated with residential land covers.

In order to account for the relatively small size and mild slopes in some of these basins, as well as the dominance of residential land cover and the density of tree canopy, a minimum lag time of 5 minutes is used, even if the calculated lags are less.

### 4.6.3 Hydrologic Model Inputs

The parameters estimated for each catchment, including area, time of concentration, and curve number were used as inputs to the MIKE+ model. These parameters are summarized in Table 4-2.

**Table 4-2: Catchment Characteristics and Model Inputs**

| Catchment | Area (Acre) | Curve Number | Longest Flow Path (ft) | Centroid Flow Path (ft) | Slope (%) | Calculated Lag Time (min) | Model Lag Time (min) |
|---|---|---|---|---|---|---|---|
| MOS1 | 7.58 | 76 | 1,183 | 388 | 22.6 | 5.1 | 5.1 |
| MOS2 | 2.01 | 76 | 772 | 318 | 31.5 | 3.8 | 5.0 |
| MOS3 | 6.88 | 68 | 1,071 | 457 | 28.5 | 5.0 | 5.0 |
| MOS4 | 5.81 | 76 | 910 | 247 | 33.0 | 3.6 | 5.0 |
| MOS5 | 14.3 | 76 | 2,000 | 965 | 30.0 | 8.4 | 8.4 |
| MOS6 | 3.27 | 76 | 700 | 262 | 38.0 | 3.3 | 5.0 |
| RUS1 | 3.01 | 74 | 495 | 226 | 0.39 | 6.5 | 6.5 |
| RUS2 | 1.18 | 75 | 226 | 37 | 0.53 | 2.3 | 5.0 |
| RUS3 | 0.86 | 80 | 284 | 134 | 0.43 | 4.2 | 5.0 |
| RUS4 | 2.82 | 74 | 477 | 182 | 0.64 | 5.4 | 5.4 |
| RUS5 | 1.52 | 73 | 255 | 68 | 0.54 | 3.0 | 5.0 |
| WEST1 | 1.23 | 76 | 221 | 53 | 1.37 | 2.2 | 5.0 |

## 4.7 Inlet Capacity Analysis

While sufficient pipe capacity is a requirement to meet performance standards, system inlets must also have sufficient capacity to move runoff from the surface into the pipe system. Because Villa Grande streets generally lack curb and gutter, even a few inches of ponded depth can become problematic.

The capacity of a storm drain inlet depends upon its geometry as well as characteristics of the flow entering the inlet. Most of Villa Grande's system relies on area inlets. These inlets generally operate as weirs for depths up to approximately 3-5 inches, beyond which they begin to operate as orifices. Assuming that the inlets are generally situated at low points in their drainage areas, two equations can be applied to estimate a depth of water around the inlets for each drainage area, depending upon whether a weir or orifice flow condition occurs.

Weir flow can be described with the following equation:

$$Q = 3.33L(H)^{3/2}$$

Where: $L =$ The effective perimeter of the grate where flow is present

$H =$ The depth of water around the grate (in feet)

Orifice flow can be described with the following equation:

$$Q = CA\sqrt{2dg}$$

Where: $A =$ Open area of grate (in square inches)

$d =$ Depth of water overt the grate (inches)

$C =$ Orifice coefficient

Existing grates were analyzed by simply splitting the peak 10-year flow across the number of inlets present in each catchment. Certain assumptions have been applied to this analysis:

- Grates are 2' x 2' square, as observed in the field
- Grates have approximately 50% open area
- Grates are 50% blocked, representing leaves and debris that sit on the grate surface during a storm

These equations were applied broadly to the drainage areas to identify drainage areas that may require additional inlet capacity. This approximate analysis is summarized in full in Appendix B. This simply assumes that peak flow in each drainage area is split evenly across the inlets, with the purpose of identifying areas that need greater inlet capacity.

In reality, each inlet has its own distinctive drainage area and inlet rim elevation. Inlets are also situated on either a continuous grade, where flow might bypass the inlet, or at a sag point where water can pond over the inlet. For the recommended alternative and preliminary design, more detailed Federal Highway Administration methodology from the HEC-22 document was applied to ensure that drainage systems meet desired level of service criteria.

# 5 Evaluation of Storm Drain Systems

## 5.1 Overview

A performance evaluation of the Villa Grande storm drain system is the primary focus of this analysis. This chapter describes Villa Grande's storm drain facilities and discusses potential capacity deficiencies and other drainage issues in the system.

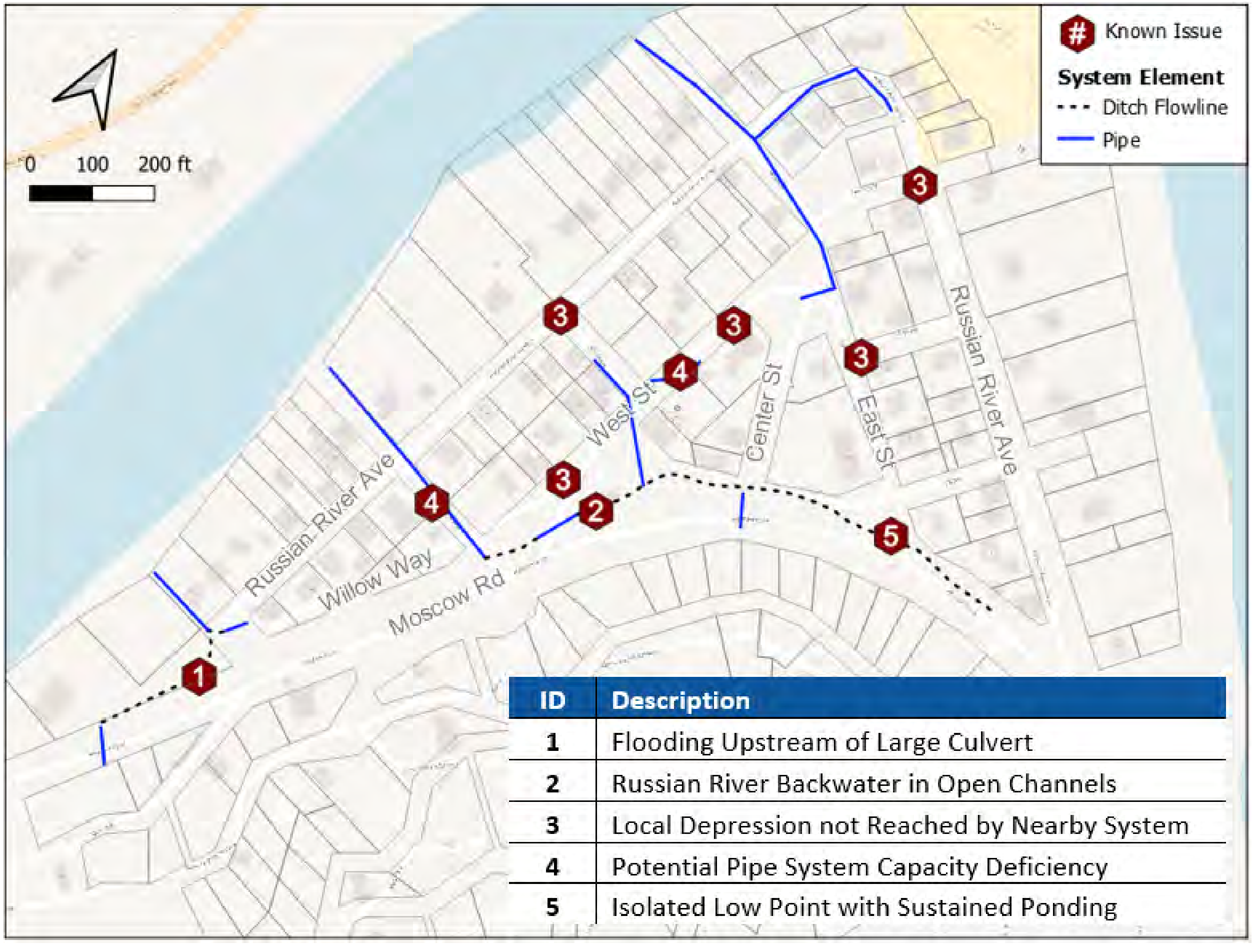
The system consists of about 1,530 linear feet of pipe, 14 drain inlets, two catch basins, and two outfalls to the Russian River. Evaluation of the system is based on containing a 10-year event in the pipe system. This is expected to provide a reasonable level of protection against property damage.

Input from residents highlights various concerns about the function of this system. And provides a means of verifying model results, field observations, County staff knowledge, and other calculations. This is even more important in this community as model calibration is difficult in a drainage area this size, with little data available in the vicinity with which to calibrate.

Information obtained from the members of the Villla Grande community includes:

- Certain elements in the system don't appear to be functioning, whether due to blockages, failures, or simply undersized pipe. Specific locations include:
    - Pipes and inlets near the Post Office
    - Culvert(s) at the south end of Willow Way
    - The system along 6$^{th}$ Street that carries runoff from Willow Way to the River
    - Large area of ponding on the north side of Moscow Road, east of the bend in Center Street
- There are spots that tend to remain ponded after even small storms for extended periods of time
- There may be issues with backwater from the Russian River affecting the system. Backwater has been observed in the ditches parallel to Moscow Road.

A map of the locations of these various known or suspected drainage issues is shown in Figure 5-1.




| ID | Description |
|---|---|
| 1 | Flooding Upstream of Large Culvert |
| 2 | Russian River Backwater in Open Channels |
| 3 | Local Depression not Reached by Nearby System |
| 4 | Potential Pipe System Capacity Deficiency |
| 5 | Isolated Low Point with Sustained Ponding |

**Figure 5-1: Map of Drainage Issues Identified by the Community, County Staff, and Others.**

The community has also voiced concern over how solutions to these drainage issues might impact large, mature trees in the area. Any solution to these issues must be designed around minimizing these impacts and, if carried through the design and construction process, may require the opinion of an arborist.

## 5.2 Existing System Evaluation

### *5.2.1 Pipe System Capacity*

The pipe system model has been used to identify areas where overflow occurs due to a lack of available conveyance capacity. MIKE+ highlights system nodes where the hydraulic grade line rises above ground level. These areas are shown in Figure 5-2.

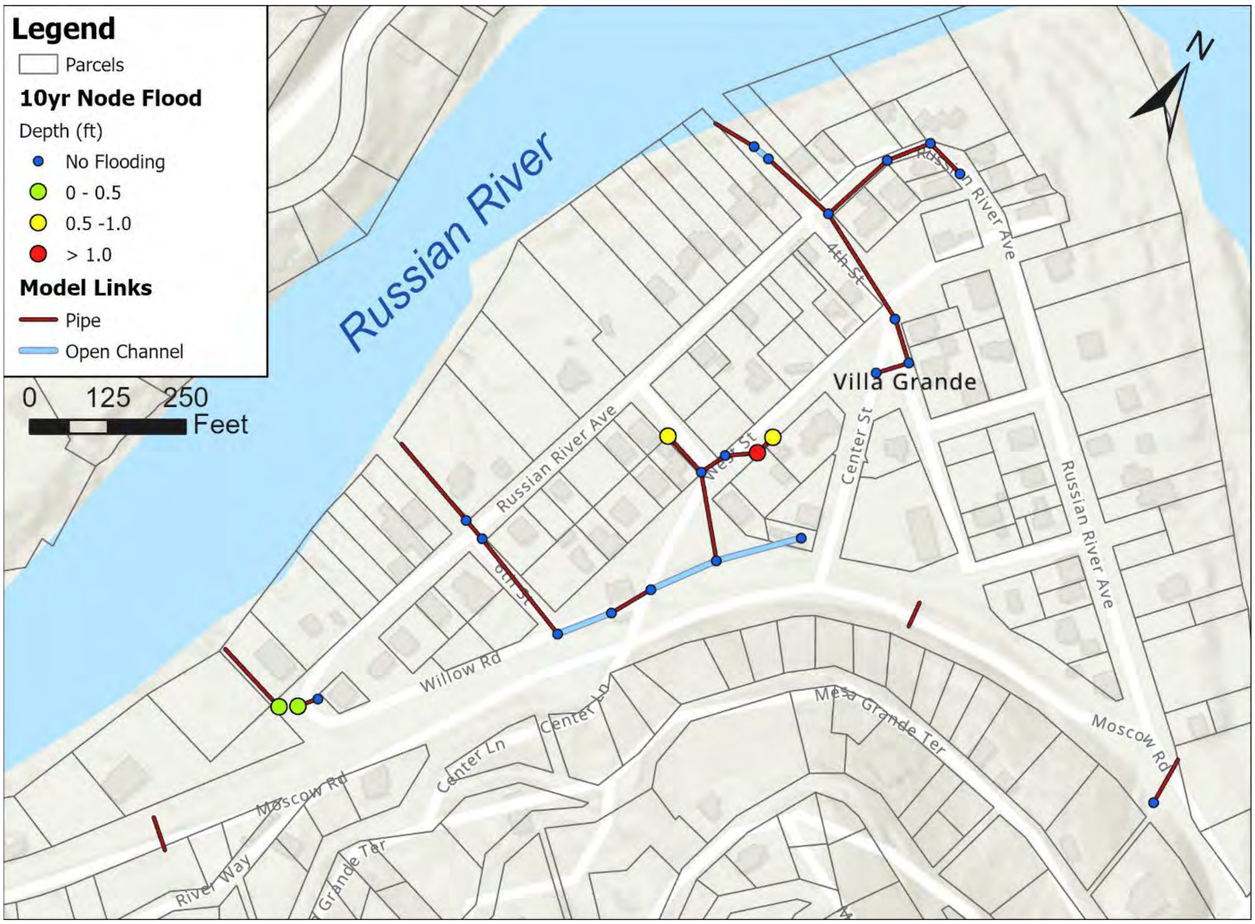



**Figure 5-2: Existing System 10-year Node Flood Result from MIKE+**

While the northern system appears to have no conveyance capacity issues in the 10-year event, the southern system lacks capacity in its upper reaches, near the post office on West Street and along 5$^{th}$ Street. The two culverts at the south end of Willow Way also appear to surcharge significantly

System profiles produced by the model have also been used to establish the likely reason for surcharge at these locations. Near the post office, the existing 6" pipe is undersized and simply can't carry runoff from West Street and the surrounding area. With large drainage areas to the existing 32" culvert to the south, an inlet controlled condition occurs, meaning that the pipe opening at the upstream end is not large enough to get incoming drainage into the culvert.

### *5.2.2 Inlet Capacity*

System inlets (e.g. catch basins) were identified in each catchment area where grated inlet structures exist. The ten-year peak was taken for each catchment from the hydrologic model and divided across the inlets in each catchment. The full analysis is presented in Appendix B. A summary for existing conditions with 50% clogging at inlets is shown in Table 5-1

**Table 5-1: Expected Depth at Grates During a 10-year Peak (Existing Inlets)**

| Catchment | 10-year Peak (cfs) | # Inlets (Existing) | Flow per Grate (10-yr) | Depth (in) |
|---|---|---|---|---|
| RUS1 | 4.2 | 3 | 1.4 | 3.2 |
| RUS2 | 1.9 | 3 | 0.65 | 1.9 |
| RUS3 | 1.6 | 1 | 1.6 | 3.5 |
| RUS4 | 4.2 | 2 | 2.1 | 3.7 |
| RUS5 | 2.2 | 2 | 1.1 | 2.8 |
| WEST1 | 2.0 | 2 | 1.0 | 2.6 |

The same analysis can be applied to evaluate the benefit of additional inlets, as shown in Table 5-2.

**Table 5-2: Expected Depth at Grates During a 10-year Peak with Additional Inlets**

| Catchment | 10-year Peak (cfs) | # Inlets (Existing) | Flow per Grate (10-yr) | Depth (in) |
|---|---|---|---|---|
| RUS1 | 4.2 | 4 | 1.0 | 2.7 |
| RUS2 | 1.9 | 3 | 0.63 | 1.9 |
| RUS3 | 1.6 | 2 | 0.8 | 2.2 |
| RUS4 | 4.2 | 4 | 1.1 | 2.7 |
| RUS5 | 2.2 | 4 | 0.55 | 1.8 |
| WEST1 | 2.0 | 4 | 0.50 | 1.6 |

It's clear that additional inlet grates are beneficial across nearly the entire community. Consideration must be given to where these grates may be beneficial. While one option to address this is to add inlet capacity at the same location as existing inlets, topographic survey identified three locations where low points exist without a grate (shown in Figure 5-4):

- The intersection of Russian River Ave and 5$^{th}$ Street
- The intersection of 2$^{nd}$ Street and East Street
- West Street between the Post Office and East Street


**Figure 5-3: Ponded Water at Russian River Ave & 5$^{th}$ Street**


**Figure 5-4: Ponded Water at East Street and 2$^{nd}$ Street**


**Figure 5-5: Ponded Water and Sediment Buildup on West Street (Between Post Office and East St)**

The County identified another location where an additional inlet would be beneficial, on West Street near Willow Road. This is where runoff from Moscow Road tends to run down West Street and pond before entering the ditch system. This is shown in Figure 5-6.


**Figure 5-6: Low Point at Willow Road where Runoff from Moscow Road Accumulates**

With recommended improvements, it's important to consider how the system might be extended to reach these underserved areas, or how other strategies might be implemented to carry drainage to the conveyance system more effectively. Proposed conditions models have also been developed to evaluate the required pipe sizes for potential system extensions.

### *5.2.3 Russian River Outfalls*

One or more Villa Grande residents have indicated that high levels in the Russian River may cause surcharge in the community's storm drain system. This could cause some flooding, particularly in the lower reaches of the two pipe systems.

These issues can be addressed by the addition of non-return valves to prevent backwater from the River from entering the system where necessary. An analysis of the topography in Villa Grande and the effective FEMA flood profiles is the most useful way to determine where non-return valves are likely useful.

Based on effective maps, 10-year levels vary from about 36 ft NAVD88 near the intersection of Willow and Russian River Ave to roughly 38 ft NAVD88 near the intersection of Russian River Ave and Moscow Road. 100-year levels vary from about 41 to 43.5.

Most importantly, near the three outfalls, effective Russian River levels are summarized in Table 5-3.

**Table 5-3: Russian River Water Levels at System Outfalls**

| Outfall | 10-yr WSEL | 100-yr WSEL | Lowest Inlet Grate Elevation |
|---|---|---|---|
| 4th Street | 36.8 | 41.7 | 41.8 |
| 6th Street | 36.25 | 41.25 | 35.39 |
| Willow (Culvert) | 36.0 | 41.0 | 29.33* |

**Culvert Flowline*

Based on topographic information available to us, it appears that high ground near the river would protect most of the community from a 10-year water surface in the River. However, the 6th Street system has inlets with ground surfaces at roughly 35.4 and 36.3. The culvert crossing West Street at the entrance to the community (which also drains to the 6$^{th}$ Street outfall) has a flow line at roughly elevation 35, allowing river water as far back as Moscow Road at a 10-year peak WSEL. A 10-year profile through the 6$^{th}$ Street system is shown in Figure 5-7.

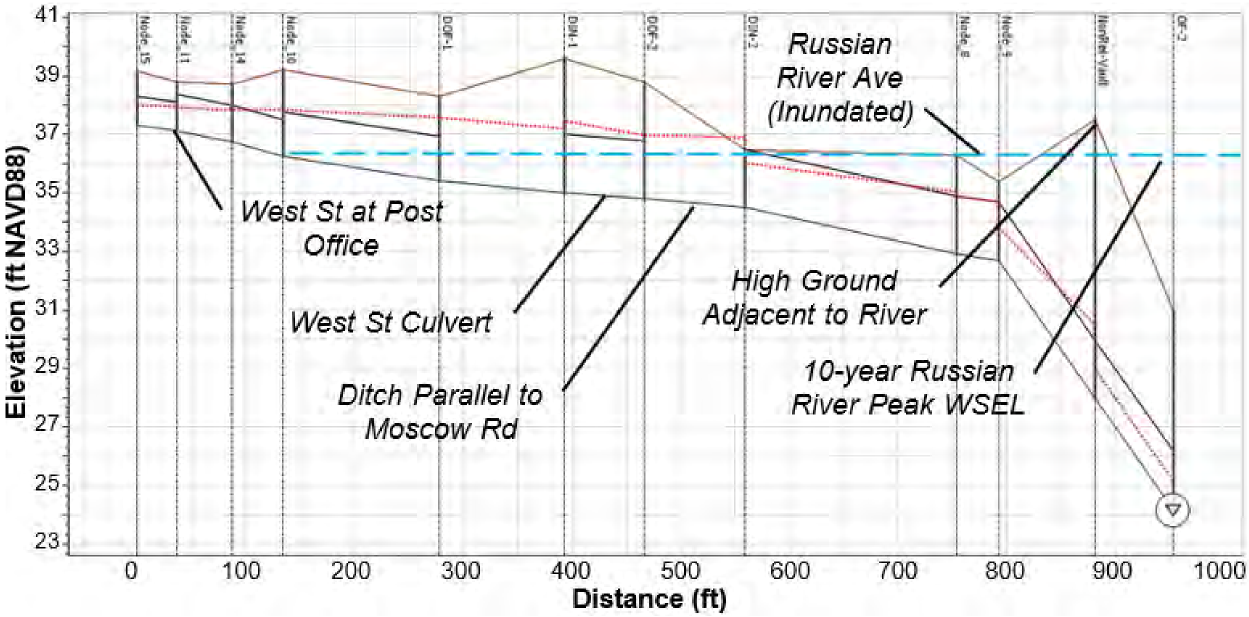



**Figure 5-7: System Profile from West Street to 6th Street Outfall.**

Existing culverts at the intersection of Willow Street and Russian River Ave have flow lines around elevation 30. However, high ground near the river at this point would likely allow river water over the bank regardless at a 10-year level. Backflow prevention is far less likely to provide benefit to this particular area.

Backflow prevention may also be less essential to the northern system (discharging to the River via the 4th Street outfall) in the context of a 10-year event. It would likely only provide benefit at greater return periods and that benefit is likely minimal.

### *5.2.4 Other Drainage Issues*

The community also identified an issue with drainage adjacent to Moscow Road near Center Street that is more difficult to evaluate with a model or calculation. This instead requires a more holistic approach to identifying the cause of the issue. Residents noted that after storms, sheet flow from Moscow Road enters the ditch to the north, adjacent to private properties, where it ponds and does not appear able to drain. The first step in evaluating this problem is examining the topography in the area. While survey isn't available across the entire community, 2017 Sonoma County LiDAR topography is available and can be used here. This is shown in Figure 5-8.

The model simply assumes all of the drainage that accumulates at this location makes it further downstream to the West St Culvert and 6th Street outfall. This is an important modeling assumption to ensure that the system downstream has adequate capacity to convey this drainage. Solutions to this issue are explored separately from other pipe system capacity improvements that would allow this impounded runoff to drain more freely.

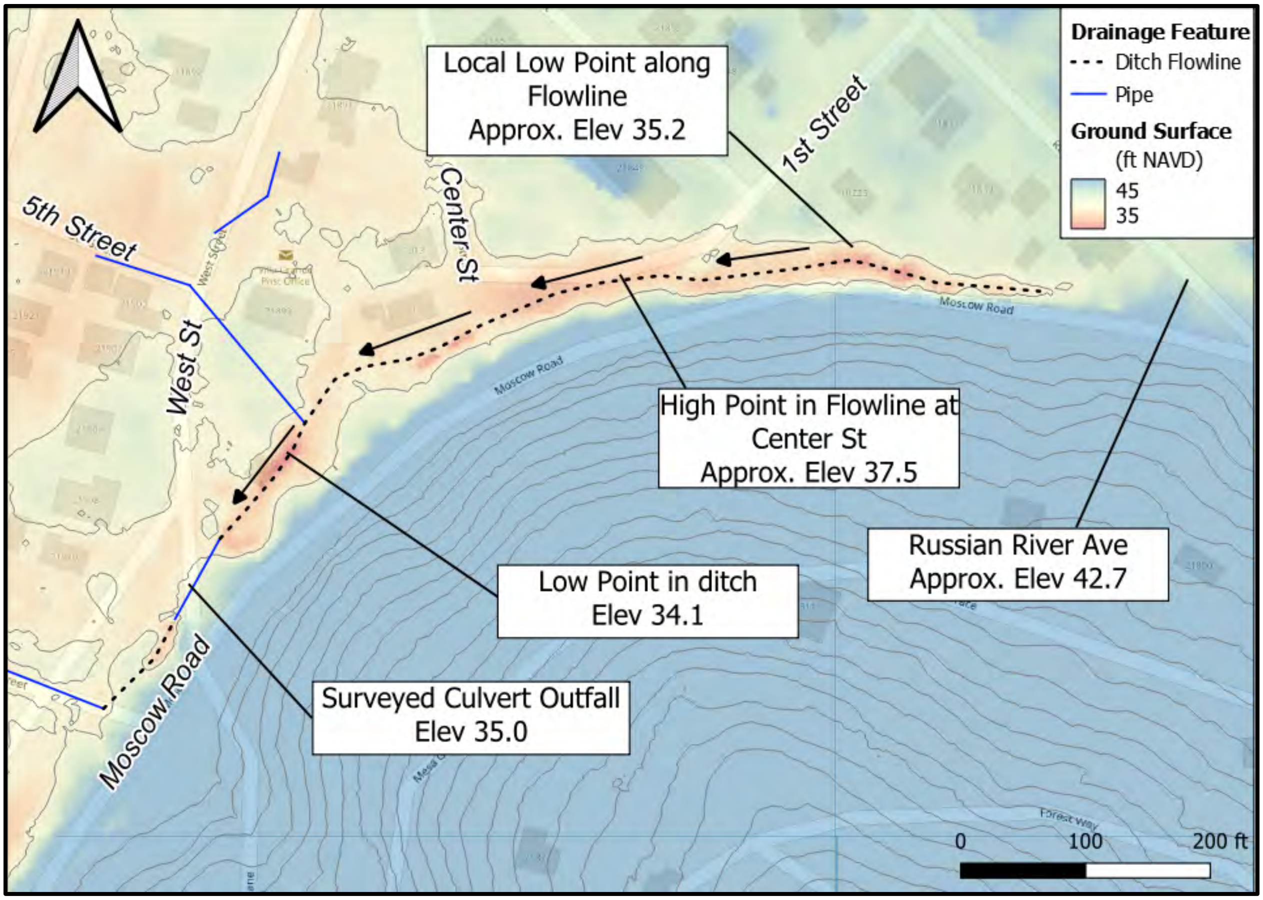



**Figure 5-8: Ditch Flowline Between 6th Street and Russian River Ave, Parallel to Moscow Road.**

An approximate profile of the flowline is shown in Figure 5-9.

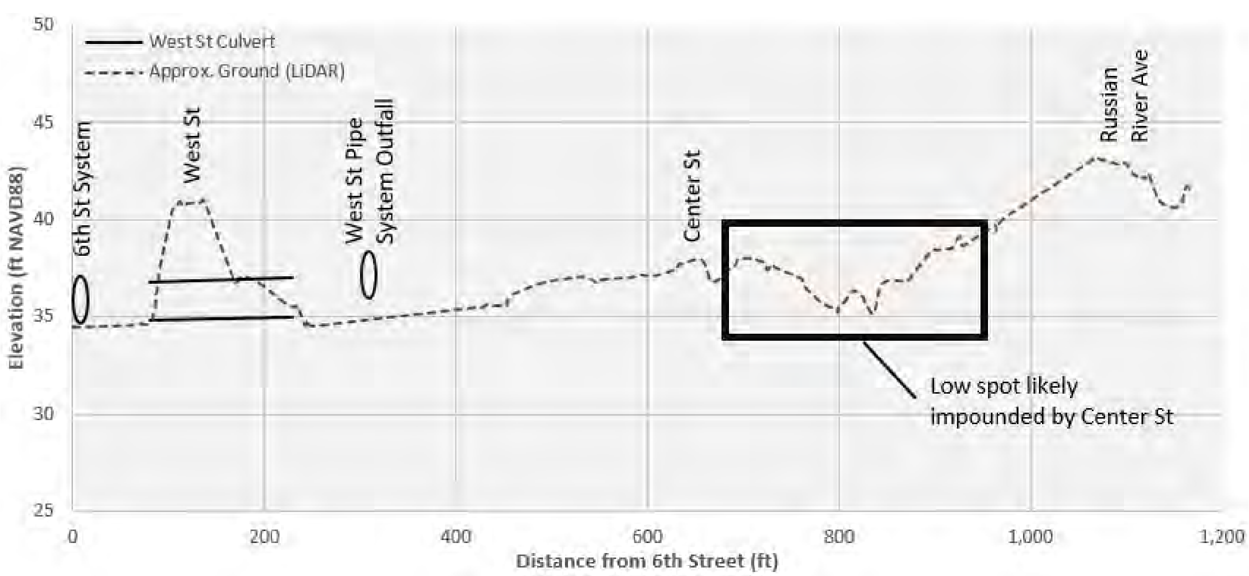



**Figure 5-9: Drainage Profile Parallel to Moscow Road**

## 5.3 Capital Improvement Alternatives

Recommendations for capital improvements to the Villa Grande system are broken into two parts. One deals with the issue of backwater from the Russian River. The second deals with actual system capacity (pipe, inlets, and surface conveyance) in the absence of high tailwater in the River.

### *5.3.1 Russian River Outfalls*

Outfalls to the Russian River are currently open pipe outfalls. The southern outfall is pictured in Figure 5-10.

**Figure 5-10: Southern Pipe System Outfall (From 6$^{th}$ Street).**

There are a multitude of options for placing non-return type valves on these systems:

1. Tideflex type valves fitted over the end of the pipes
2. Weighted swing check (flap gate) valves at the end of the existing outfall pipes
3. Weighted swing check (flap gate) valve located in a structure upstream of the outfall
4. In-line rubber check valve pipe inserts

Tideflex valves are less expensive than check valves. However, as shown in Figure 5-10, these outfalls are susceptible to debris accumulation. If enough debris accumulates on either type of valve, they may not fully open during a storm to let water out of the pipe system. This may cause backwater into the system and result in flooding in Villa Grande. Mitigating for debris accumulation would require some form of debris rack, which would likely entail building a concrete structure at the end of the pipe.

Examples of traditional pipe-end non-return valve installations are shown in Figure 5-11.

**Figure 5-11: Tideflex (Left) and Flap Gate (Right) Non-Return Valves on Outfall Ends**

Alternatively, traditional valves could be used by placing a new structure along the pipes upstream of the outfall and attaching a flap gate valve inside of the structure. Issues with debris accumulation and construction on the banks of the Russian River could be mitigated and this type of installation could improve access to the valve for maintenance.

The final option for a non-return valve is the simplest to implement but has a greater impact on head loss in the system. Inline rubber check valve inserts exist that can be slid into pipes and fastened to structures (catch basins or vaults). These could be easily installed in storm structures by County staff. The function and installation of one such valve (the WaPro Wastop valve) is shown in Figure 5-12.

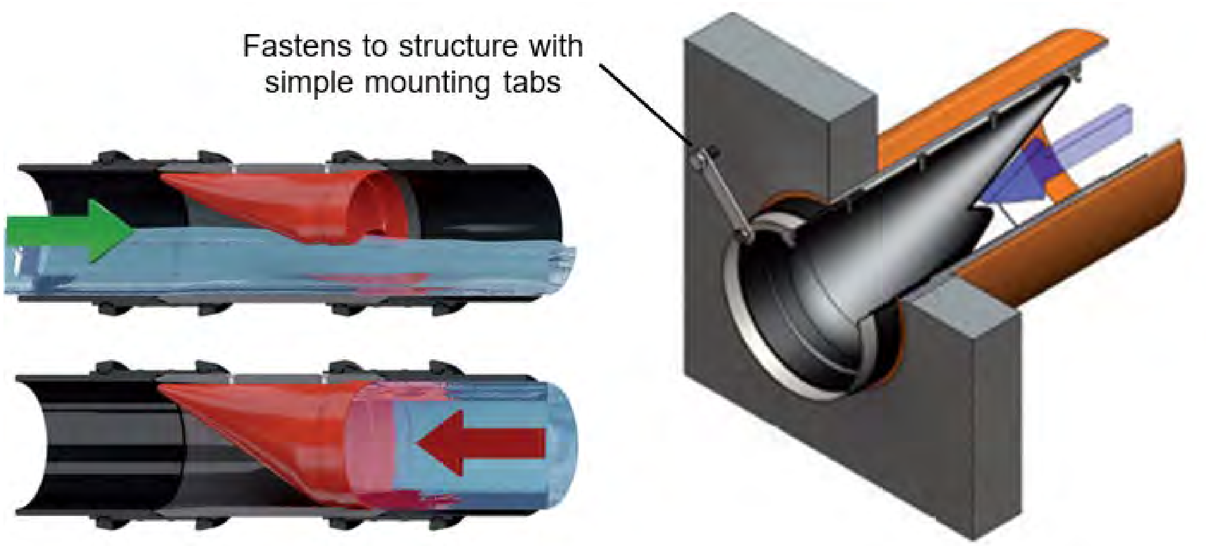



**Figure 5-12: Inline Check Valve Operation (Left) and Installation in Existing Structure (Right)**

The model was used to evaluate the impact of head loss due to placement of the non-return valves. Should a non-return valve be placed on the northern system, higher head loss required for the in-line valve (2.5-3 feet) does not negatively impact the system.

In the shallower system to the south, however, placement of an in-line non-return valve has the potential to cause flooding at the intersection with 6$^{th}$ Street and even further upstream. It's recommended that backflow prevention be placed further to the west, where it can be installed at greater depth. An in-line valve, requiring approximately 4 feet of head loss for a 10-year peak flow, will cause backwater and flooding regardless of valve siting. A flap gate with lower unseating head requirements must be used at this location, even if an in-line valve is installed on the system to the north.

Alternatives for installing non-return valves on the system are summarized in Table 5-4.

**Table 5-4: Capital Improvement Alternatives Summary (Non-Return Valves)**

| Alternative | Description | Analysis |
|---|---|---|
| O-1 | Mitigate Russian River backwater into the 6$^{th}$/West Street system by adding a non-return gate or Tideflex type valve at the existing outfall | • Highest cost option<br>• Requires debris mitigation<br>• Requires more extensive environmental permitting<br>• Requires additional erosion & sediment control measures during construction on the banks of the River<br>• Requires more regular inspection and debris removal |
| O-2 | Mitigate Russian River backwater into the 6$^{th}$/West Street system by adding a non-return gate valve in a concrete vault upstream of the existing outfall point | • Moderate cost option<br>• Does not require working within Russian River ordinary high-water mark (easier to permit)<br>• Requires placement of both valves in an enclosed space with an access hatch<br>• Structures must be large enough to accommodate the full range of motion of the valves<br>• Design will require attention to maintenance access within existing property boundaries |
| O-3 | Mitigate Russian River backwater into the system by:<br>• Adding an inline non-return rubber check valve insert along Russian River Ave at 4$^{th}$ Street<br>• Adding a flap gate on the outfall pipe west of Russian River Ave and 6$^{th}$ Street | • Lowest cost to implement<br>• Does not require working within Russian River ordinary high-water mark<br>• The In-line valve requires only a catch basin at Russian River Ave, rather than a vault or large concrete headwall structure, but has the greatest impact on HGL upstream<br>• The in-line valve can be used at 4$^{th}$ Street, but a lower loss flap gate must be used on the 6$^{th}$ Street system to avoid upstream impact |

### 5.3.2 Pipe System Capacity

Various alternatives have been identified to achieve the standard of containing the 10-year storm event below ground. These are summarized in Table 5-5. Generally speaking, these could be constructed separately from the outfall non-return project alternatives (with the exception of O-3, which would require a catch basin proposed in certain pipe system capacity alternatives)

**Table 5-5: Capital Improvement Alternatives Summary (Pipe System Capacity and/or Extension)**

| Alternative | Description | Analysis |
|---|---|---|
| S-1 | Mitigate capacity deficiency by upsizing the existing system without extension | • Lowest cost<br>• Addresses most immediate needs at the community core<br>• Does not solve all drainage problems |
| S-2 | Improve system function by a combination of:<br>• Upsizing as necessary<br>• Extending system to reach underserved areas | • Moderate cost<br>• Addresses underserved areas |
| S-3 | Optimize system function by a combination of:<br>• Upsizing existing pipes<br>• Providing an improved distribution of inlets, and<br>• Adding additional pipe where necessary | • Highest cost<br>• Addresses underserved areas<br>• Improves system function more widely |
| S-4 | Improve system function by a combination of:<br>• Upsizing existing pipes<br>• Grading roadways and providing asphalt berm/curb or valley gutter to reach inlets more efficiently<br>• Extending the system to reach underserved areas, but to a lesser extent than Alt S-2 based on improved surface conveyance | • Moderate cost<br>• Addresses underserved areas<br>• Surface grading can happen in conjunction with an already planned paving project |

This section also discusses the scope of these alternatives in greater detail. The pipe system on Russian River Ave north of 4th Street is also discussed. There appears to be existing infrastructure that requires rehabilitation, which is discussed separately from actual capacity improvements.

#### 5.3.2.1 Alternative S-1

Alternative S-1 would minimize the extent of pipe replacement and address the most urgent needs in the system. Improvements would be focused on eliminating flooding identified near the Post Office and on 5th Street. This would also add inlet capacity in the areas with the greatest need. The alternative is illustrated in Figure 5-13. Pipe capacity improvements are summarized in Table 5-6 (Non-return valves are shown in these figures, but are not part of the pipe system alternatives).

This alternative reduces flooding identified by the model along West Street and 5th Street by simply upsizing the existing system and adding inlet capacity where it's needed most based on the analysis of existing inlet capacity. In addition to pipe capacity improvements, this alternative would add six grate inlets to the system to enhance the flow of runoff into the pipes and reduce nuisance flooding.

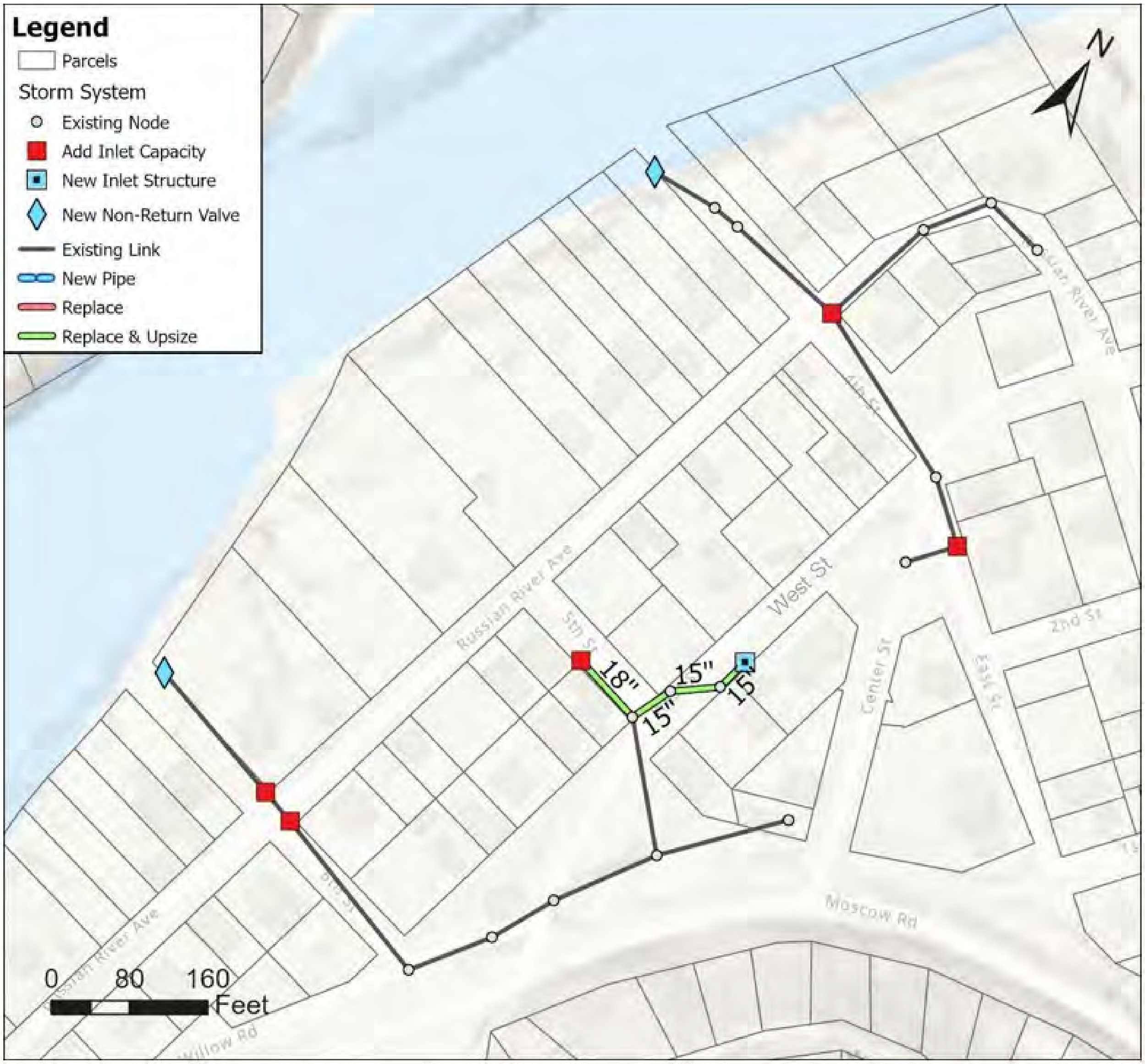



**Figure 5-13: Villa Grande Pipe Conveyance Capital Improvement Alternative S-1 Map**

**Table 5-6: Villa Grande Capital Improvement Alternative S-1 Pipe Capacity Summary**

| Ex. Pipe Diameter (in) | New Pipe Diameter (in) | Approx. Length (ft) |
|---|---|---|
| 6 | 15 | 87 |
| 12 | 15 | 47 |
| 12 | 18 | 78 |

#### *5.3.2.2 Alternative S-2*

Alternative S-2 would both address flooding issues and extend the system to reach the three underserved areas of the system, adding inlets throughout the system to reduce nuisance flooding and provide resiliency even with clogged inlets.

Two inlets are added at the low point of Russian River Ave, and one is added at the low point at 2nd Street and East Street, capturing smaller sub-catchment areas and mitigating ponding. An inlet is also added where Willow Road meets West Street to capture runoff from the hillside that currently ponds there until it can reach the ditches.

In order to reach the low point at the intersection of Russian River Ave and 5th Street, the existing system must be deepened. This would require replacement of the 18” pipe draining the system southward to the ditch, even though the pipe is already sufficiently sized.

In addition to pipe capacity improvements, this alternative would add up to 11 grate inlets to the system to enhance the flow of runoff into the pipes and reduce nuisance flooding.

This alternative is illustrated in Figure 5-14. Pipe capacity improvements are summarized in Table 5-7.


**Figure 5-14: Villa Grande Pipe Conveyance Capital Improvement Alternative S-2 Map**

**Table 5-7: Villa Grande Capital Improvement Alternative S-2 Pipe Capacity Summary**

| Ex. Pipe Diameter (in) | New Pipe Diameter (in) | Approx. Length (ft) |
|---|---|---|
| N/A (New) | 12 | 98 |
| N/A (New) | 15 | 97 |
| N/A (New) | 18 | 105 |
| 6 | 15 | 87 |
| 12 | 15 | 47 |
| 12 | 18 | 78 |
| 18 | 18 | 144 |

#### *5.3.2.1 Alternative S-3*

Alternative S-3 would address flooding issues, extend the system to reach the three underserved areas of the system, and further improve resilience with the addition of a 24” pipe along Russian River Ave. The goal of this alternative is to provide capacity to drain the West Street system, even if the West Street culvert near Moscow Road becomes clogged and causes backwater.

Inlets are added throughout the system similar to Alternative S-2. However, two additional inlets are added along a reach of new 24” pipe on Russian River Ave, reducing the volume of runoff that must flow along the road to existing inlets. An additional inlet is also added with further system extension to improve the level of service on West Street.

An additional benefit of this alternative is that it does not require replacement of the 18” pipe draining the West Street system southward to the ditch as Alternative 2 would. This instead allows drainage from the ‘WEST1’ catchment (including the post office) to flow either northward along 5$^{th}$ Street into the new 24” pipe, or southward to the ditch. Backwater from the West Street culvert can also cause water from the ditch to drain into the 24” pipe, preventing potential flooding issues that could be caused by more extreme culvert blockage.

In addition to pipe capacity improvements, this alternative would add 11 grate inlets to the system to enhance the flow of runoff into the pipes and reduce nuisance flooding.

This alternative is illustrated in Figure 5-15. Pipe capacity improvements are summarized in Table 5-8.


**Figure 5-15: Villa Grande Pipe Conveyance Capital Improvement Alternative S-3 Map**

**Table 5-8: Villa Grande Capital Improvement Alternative S-3 Pipe Capacity Summary**

| Ex. Pipe Diameter (in) | New Pipe Diameter (in) | Approx. Length (ft) |
|---|---|---|
| N/A (New) | 12 | 190 |
| N/A (New) | 15 | 97 |
| N/A (New) | 18 | 105 |
| N/A (New) | 24 | 333 |
| 6 | 15 | 87 |
| 12 | 15 | 47 |
| 12 | 18 | 78 |

#### *5.3.2.2 Alternative S-4*

While modifications to the pipe system can't be avoided as a means of addressing certain drainage issues identified in Villa Grande, a near-term paving project does provide some opportunity to improve conveyance of stormwater on the surface. By performing grading work in certain areas where stormwater concentrates and travels to the pipe system, modification to the pipe systems may be minimized. Grading has essentially been utilized in conjunction with pipe system modifications to develop a modified version of Alternative S-2.

AutoCAD Civil3D has been utilized to verify where such grading work is possible. Gutter spread and depth calculations have also been performed in Excel based on the FHWA HEC-22 document to evaluate inlet sizing and the need for multiple inlets at various locations.

An overview of this alternative is shown in Figure 5-16, with pipe system improvements summarized in Table 5-9.

This will still require the installation of 12 new 2'x3' (minimum) drain inlets distributed throughout the area to more efficiently capture drainage from the surface and reduce ponding depth and spread in roadways and properties during a storm. In certain areas where runoff concentrates heavily, inlets would be dual, side-by-side inlets to remove water from the surface more quickly.

This alternative also does not increase the size of certain existing pipes. The system extension shown in Alternative S-2 recommends 18" pipe on 5$^{th}$ Street. In order to install 18" pipe, however, replacement of the system downstream all the way to the ditch would be required. The preferred alternative instead balances system extension with utilizing existing capacity on 5$^{th}$ Street. Short duration system surcharge is generally tolerable and isn't likely to cause property damage. This project simply extends the 12" pipe to a new low point graded on 5$^{th}$ Street.

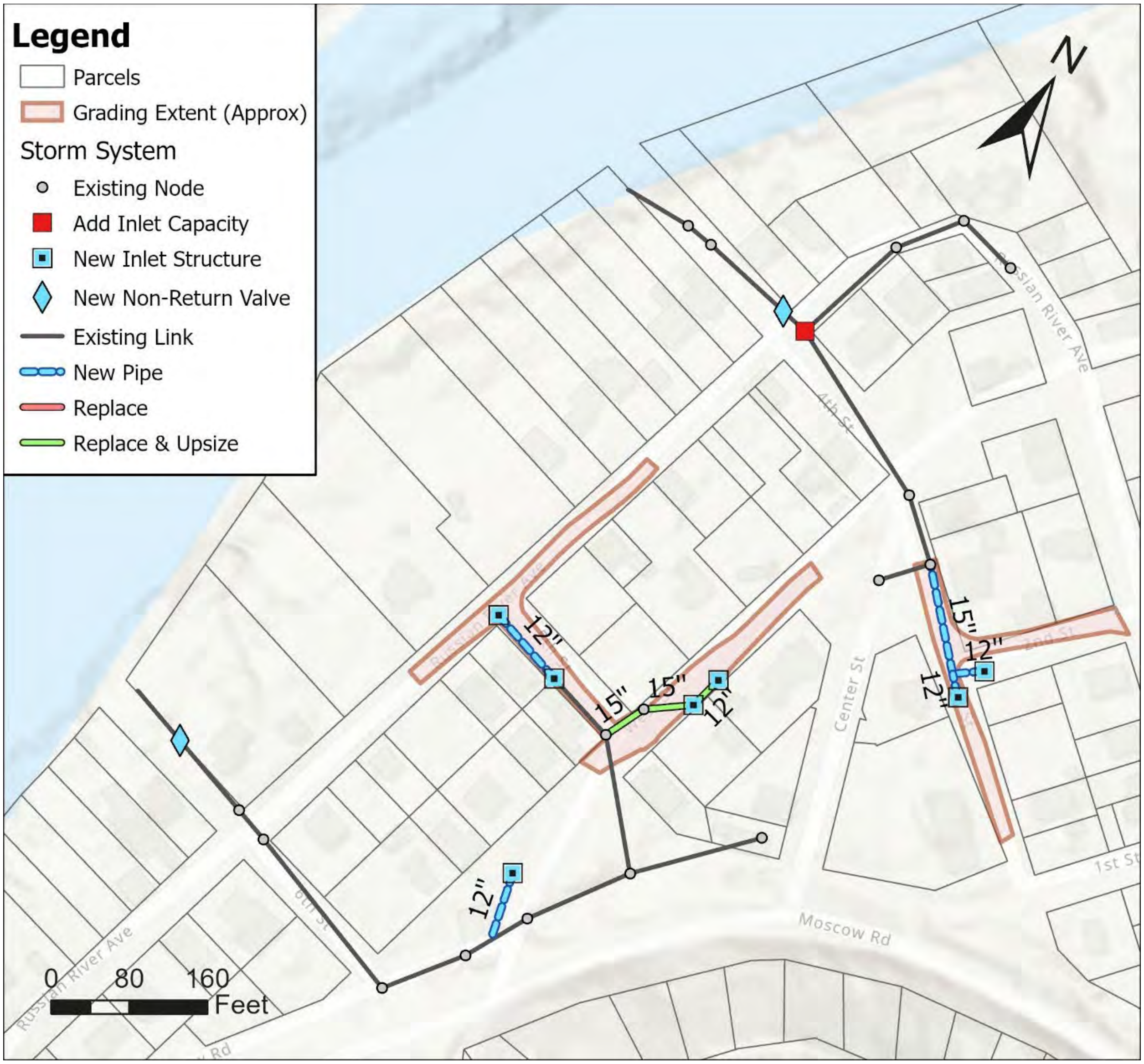



**Figure 5-16: Villa Grande Pipe Conveyance Capital Improvement Alternative S-4 Map**

**Table 5-9: Villa Grande Capital Improvement Preferred Alternative Pipe Capacity Summary**

| Ex. Pipe Diameter (in) | New Pipe Diameter (in) | Approx. Length (ft) |
|---|---|---|
| N/A (New) | 12 | 170 |
| N/A (New) | 15 | 92 |
| 6 | 12 | 36 |
| 6 | 15 | 43 |
| 12 | 15 | 52 |

### *5.3.2.3 Upper 4th Street System*

Residents have pointed out that some ponding occurs at Russian River Ave and 3rd Street. Survey of the pipe systems draining to the 4th Street outfall appears to show an 18-inch pipe extending further east along Russian River Ave from the last inlet located by the survey crew. However, there were no other inlets located. While system extension could be recommended at this location, it's possible that an inlet exists but does not function properly. Over time, this inlet could have been covered or damaged.

The approximate location of the 18-inch pipe, which is apparent at the furthest upstream grate on Russian River Ave is illustrated in Figure 5-17.

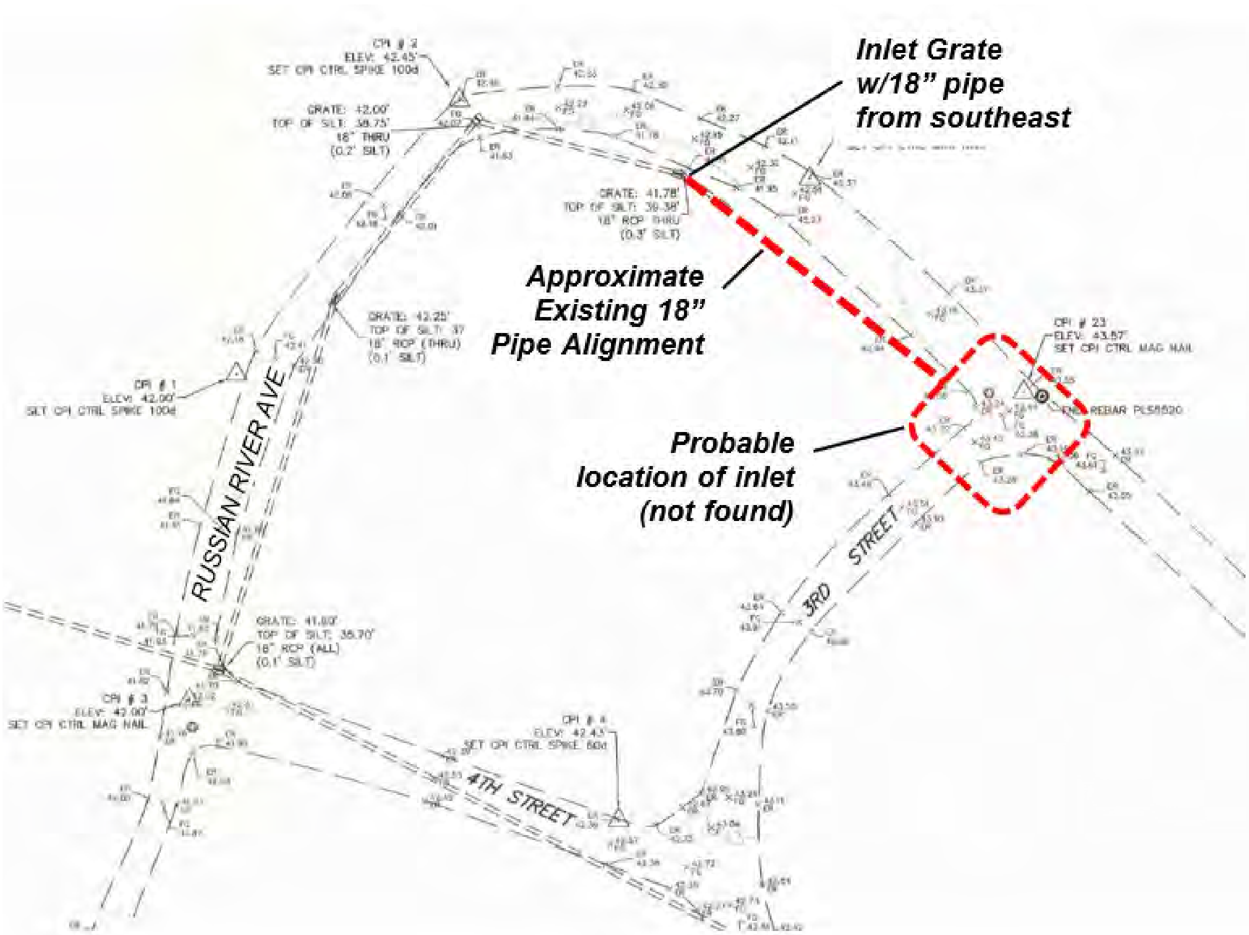



**Figure 5-17: Surveyed System Around 3rd Street Annotated with Probable Missing Inlet Location.**

Attempts to inspect this system and locate the inlet were not successful, as the grates appear to be rusted in place. It's recommended that the catch basins along Russian River Ave be repaired so that grates can be removed, then CCTV be performed on the system. If an inlet can be located, a smaller project should be undertaken that restores it or relocates to a position where it might be more effective at capturing local runoff and conveying it to the 4th Street outfall in the existing pipe system, which has adequate capacity available.

### *5.3.3 Willow Way Culvert Capacity*

Residents' observations of flooding around the Willow Way culverts have been confirmed by the models. The apparent cause is an undersized existing 32" culvert discharging to the Russian River. While this is still a pipe system capacity deficiency, it's treated separately from the issues explored in the previous section, as it's more isolated from the larger pipe networks serving the community to the north.

There are a few alternatives for providing additional capacity to evacuate runoff from this area more efficiently. They are summarized in Table 5-10.

**Table 5-10: Capital Improvement Alternatives Summary (Willow Way)**

| Alternative | Description | Analysis |
|---|---|---|
| W-1 | Install a parallel culvert with the same capacity as the existing 32" CMP, effectively doubling conveyance | • Likely lowest cost<br>• Less efficient hydraulically than other alternatives<br>• Utilizes existing culvert capacity<br>• Requires confirmation that existing easement could fit both pipes |
| W-2 | Remove the existing culvert and replace it with a larger circular culvert (48" diameter). | • Moderate cost<br>• Likely needs to be installed at greater depth than the existing culvert<br>• Hydraulic efficiency is still limited by a circular section |
| W-3 | Remove the existing culvert and replace it with a 3' wide by 2.5' tall box culvert | • Highest Cost<br>• Upstream invert could remain the same as existing<br>• Greatest hydraulic efficiency and fastest drawdown of ponding after a storm |

The approximate location of this culvert and conceptual footprints of improvement alternatives is shown in Figure 5-18. It's likely that before choosing an alternative to proceed with, more detailed topographic and boundary survey will be required. Access to the outfall of this culvert appears to be provided by a 12-foot easement, based on assessor maps (shown in Figure 5-19). However, upon superimposing the surveyed culvert inlet and the approximate location of the outfall on the GIS parcel data, it appears the existing culvert may not be located within the easement at all. This would place the existing pipe entirely on private property.

The actual placement of a new or parallel pipe will most likely depend upon the actual size and location of existing easements. Without boundary survey, this is difficult to predict beyond superimposing GIS parcel data.

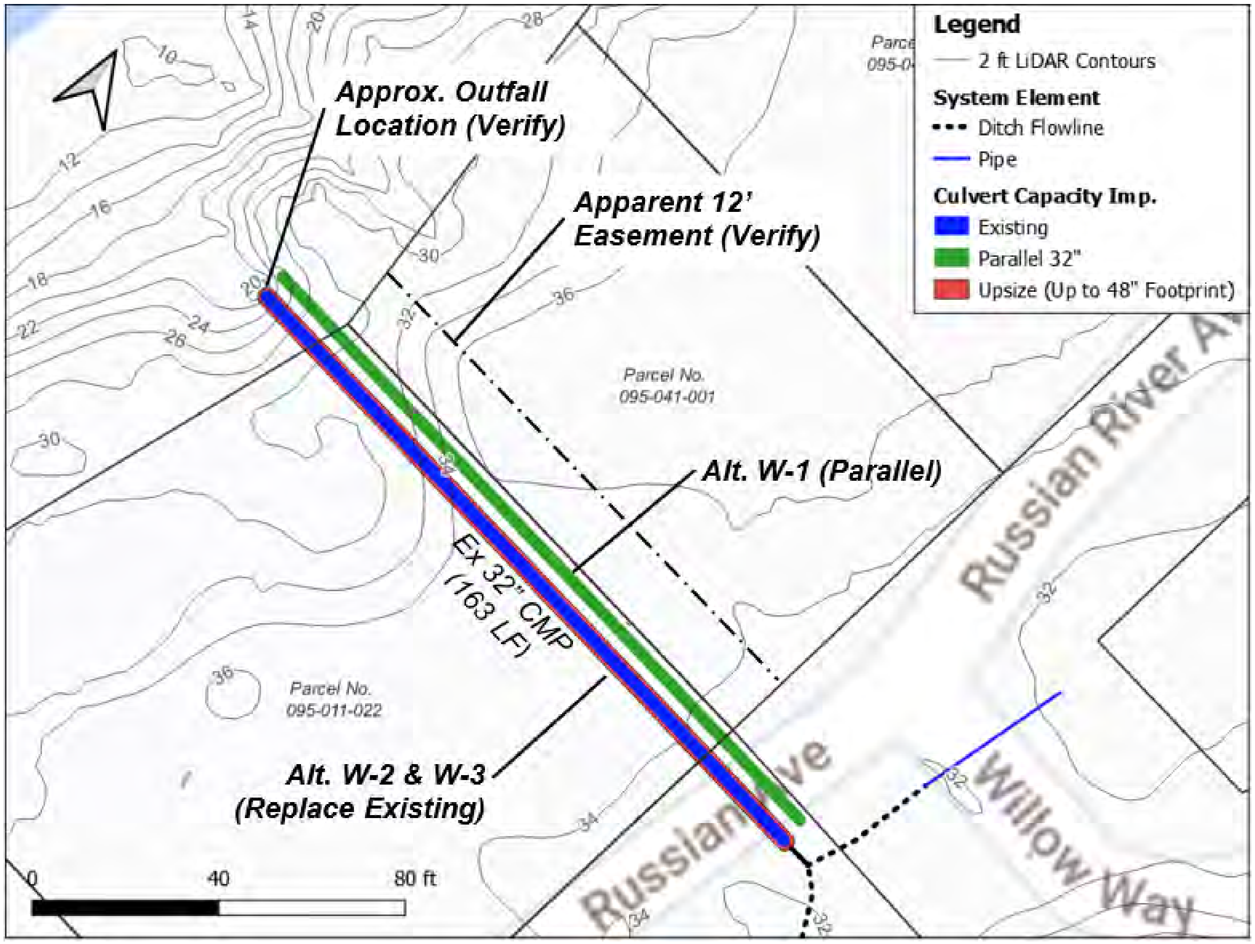



Figure 5-18: Willow Way Culvert Improvement Alternative Footprint Comparison.

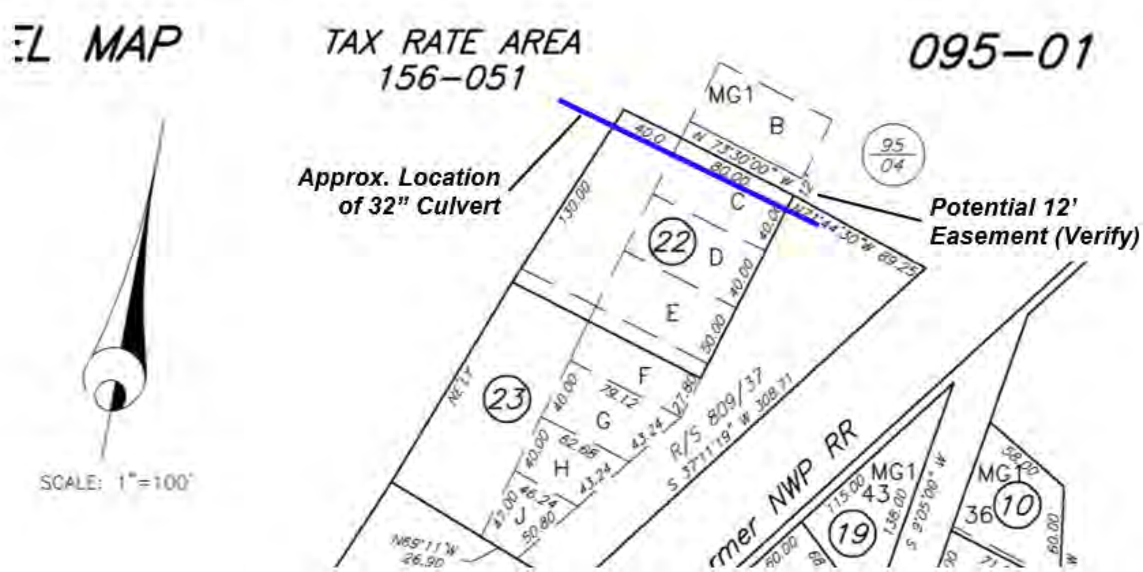



Figure 5-19: Annotated County Assessor's Map for Parcel 095-011-022

### *5.3.4 Center Street Conveyance Capacity*

Resident concerns regarding flooding near Center Street warrant consideration separately from the previously discussed system improvements. These issues largely appear to be a consequence of topography, rather than undersized or under-maintained pipe system infrastructure.

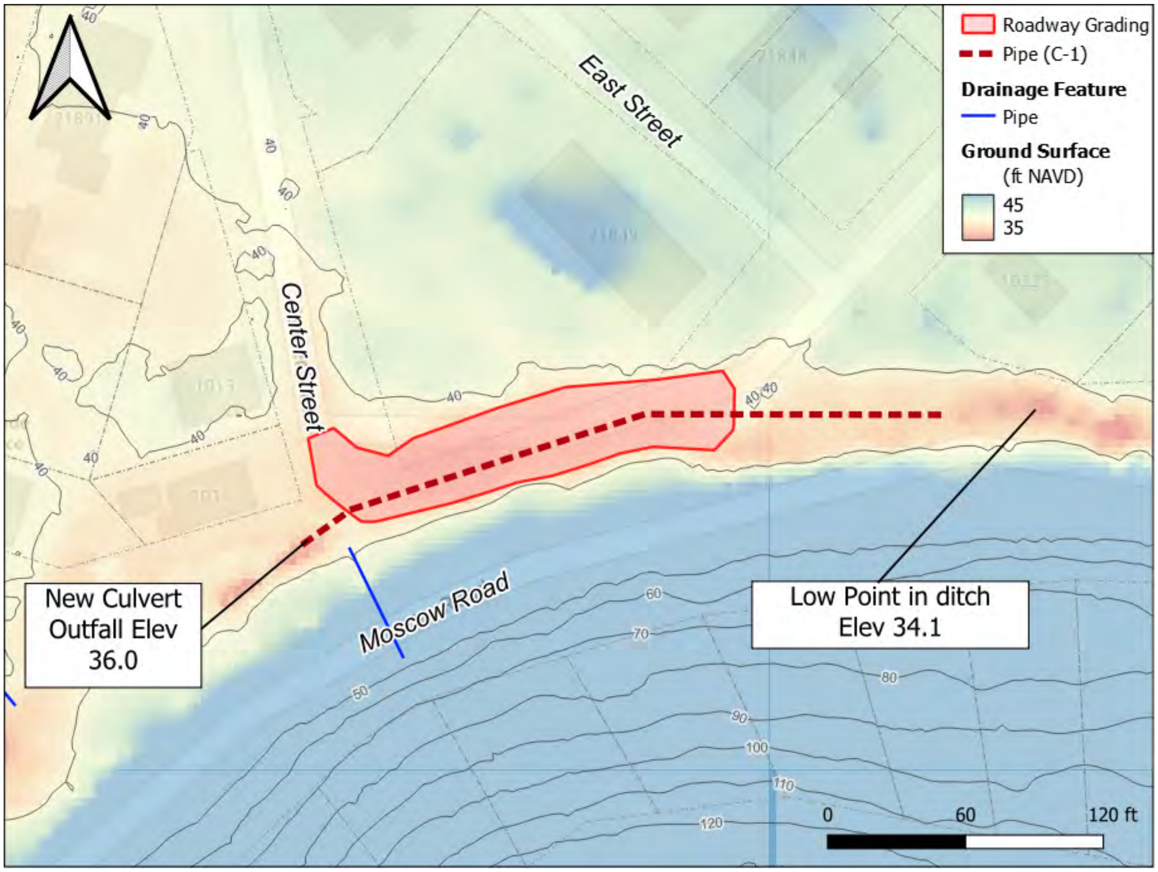
This section examines potential alternatives for dealing with the ponding issues near Center Street. Alternatives explored for this CIP are summarized in Table 5-11.

**Table 5-11: Capital Improvement Alternatives Summary (Center Street)**

| Alternative | Description | Analysis |
|---|---|---|
| C-1 | Raise Center Street and Construct a Culvert connecting the problematic low area to the ditch to the west | • Moderate Cost (highly dependent on the length of pipe required to fully drain ponding)<br>• Protects mature trees along Center St by avoiding cut |
| C-2 | Continue to allow flow to run across Center Street, but grade the roadway down so that the low area drains more easily | • Highest Cost<br>• No pipe required<br>• Assumes that retaining wall is required at the Moscow Road embankment. May require retaining walls on both sides<br>• Most likely to impact tree roots, with cut depth along Center Street up to about 1.5 feet |
| C-3 | Fill in the low area and construct a shallow ditch that meets the existing flow line elevations at Center Street | • Likely lowest cost<br>• No pipe required<br>• May have impacts on adjacent properties, as this could allow runoff from Moscow and hillsides to spread more |
| C-4 | Raise Center Street a moderate amount, place a culvert, and place some fill in the low area to eliminate remaining ponding as required | • Moderate cost<br>• Ensures drainage<br>• Protects properties<br>• Less pipe than C-1<br>• Protects trees |

If a lower level of ponding is tolerable, Alternative C-4 may be achievable without placing fill in the low area. Placement of a culvert would simply allow the area to drain more freely and leave a reduced ponding area compared with existing conditions. This is especially important if placing fill in that area would disturb or harm trees and other vegetation.

Alternative C-1 is shown schematically in plan and approximate profile in Figure 5-20. This alternative requires a moderate amount of fill material and the greatest amount of new pipe to maintain drainage. Cost estimates for this alternative assume that the roadway must be filled approximately one foot on average in order to provide cover for a 12-inch pipe, extending from the low point east of the road to the ditch line to the west.



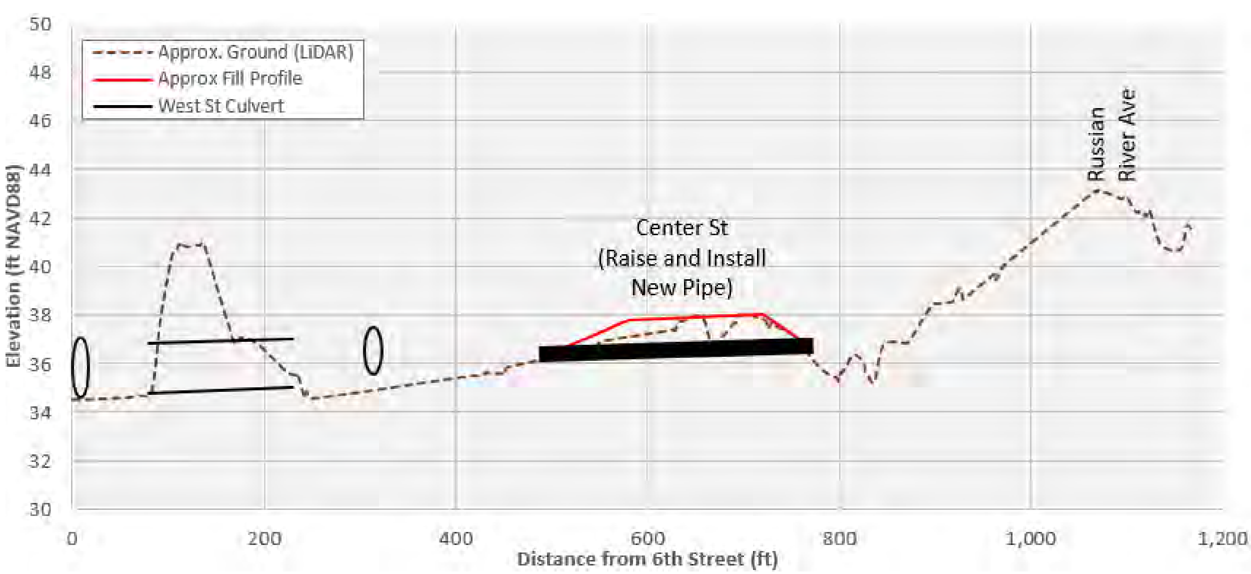




**Figure 5-20: Alternative C-1 Plan (Top) and Approximate Profile (Bottom)**

Alternative C-2 is shown schematically in Figure 5-21.

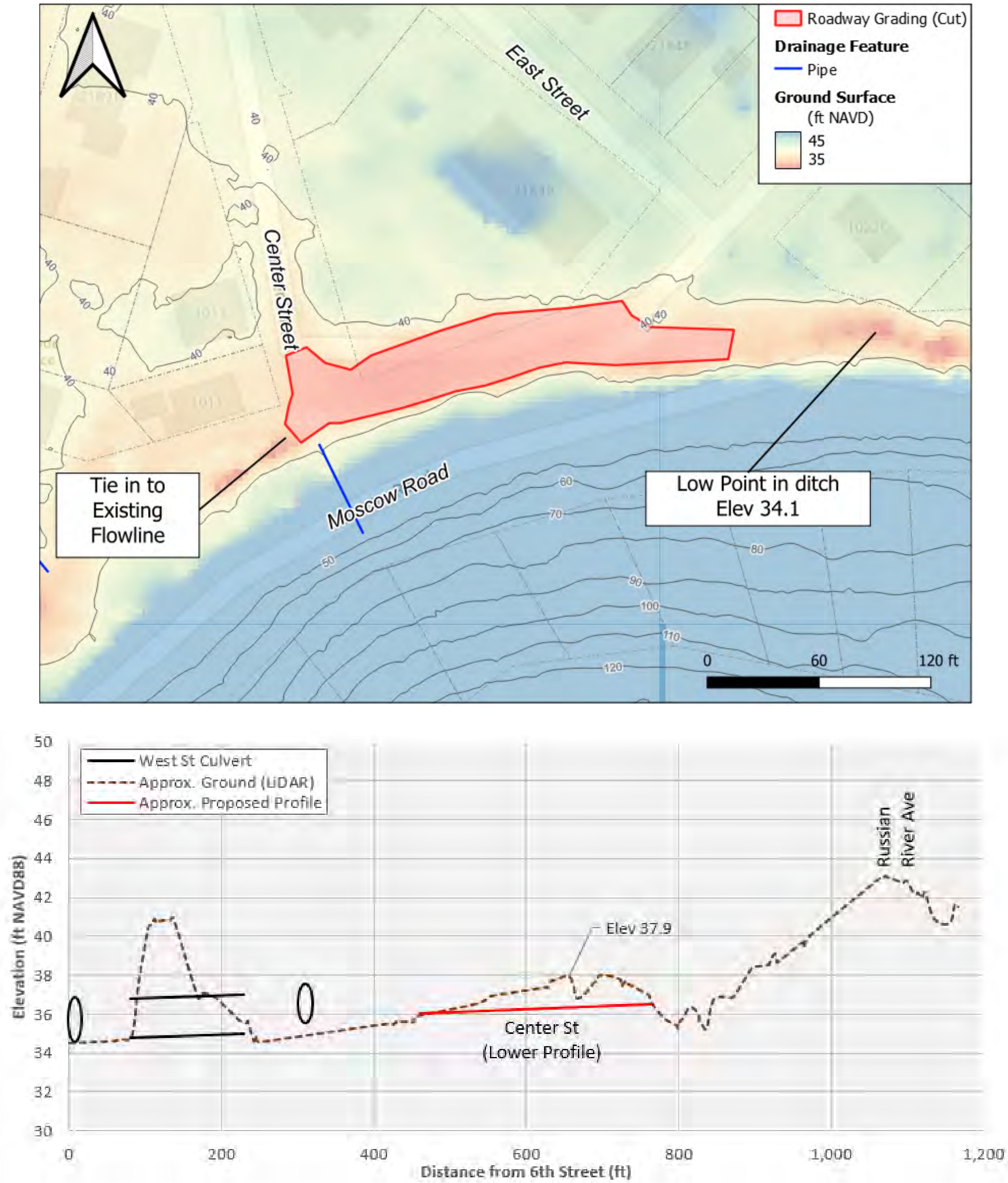



**Figure 5-21: Alternative C-2 Plan (Top) and Approximate Profile (Bottom)**

The full scope and cost of this alternative is subject to several factors. Grading may either extend onto private property or require retaining walls on either side of the roadway. On one side, the embankment adjacent to Moscow Road constrains grading and would most likely require a retaining wall to remain stable. On the north side of Center Street, private property appears to be relatively close to the roadway and would either require a construction easement to daylight grading or a retaining wall to stay out of the property.

This option would also most likely have the greatest impact on the large trees between Center Street and Moscow Road. The community has voiced their concern about maintaining the health of trees throughout the area, so this may not be the most favorable solution.

This analysis assumes that the roadway must be cut approximately one foot on average and up to 1.5 foot maximum.

Alternative C-3 is shown schematically in Figure 5-22. This is likely the cheapest alternative to address drainage issues near Center Street. Modeling indicates that a rock-lined v-ditch 1.75 feet in depth with 4:1 side slopes would convey a 10-year event with approximately 0.75 foot of freeboard. A sample section through the low area showing fill and the v-ditch is shown in Figure 5-23.

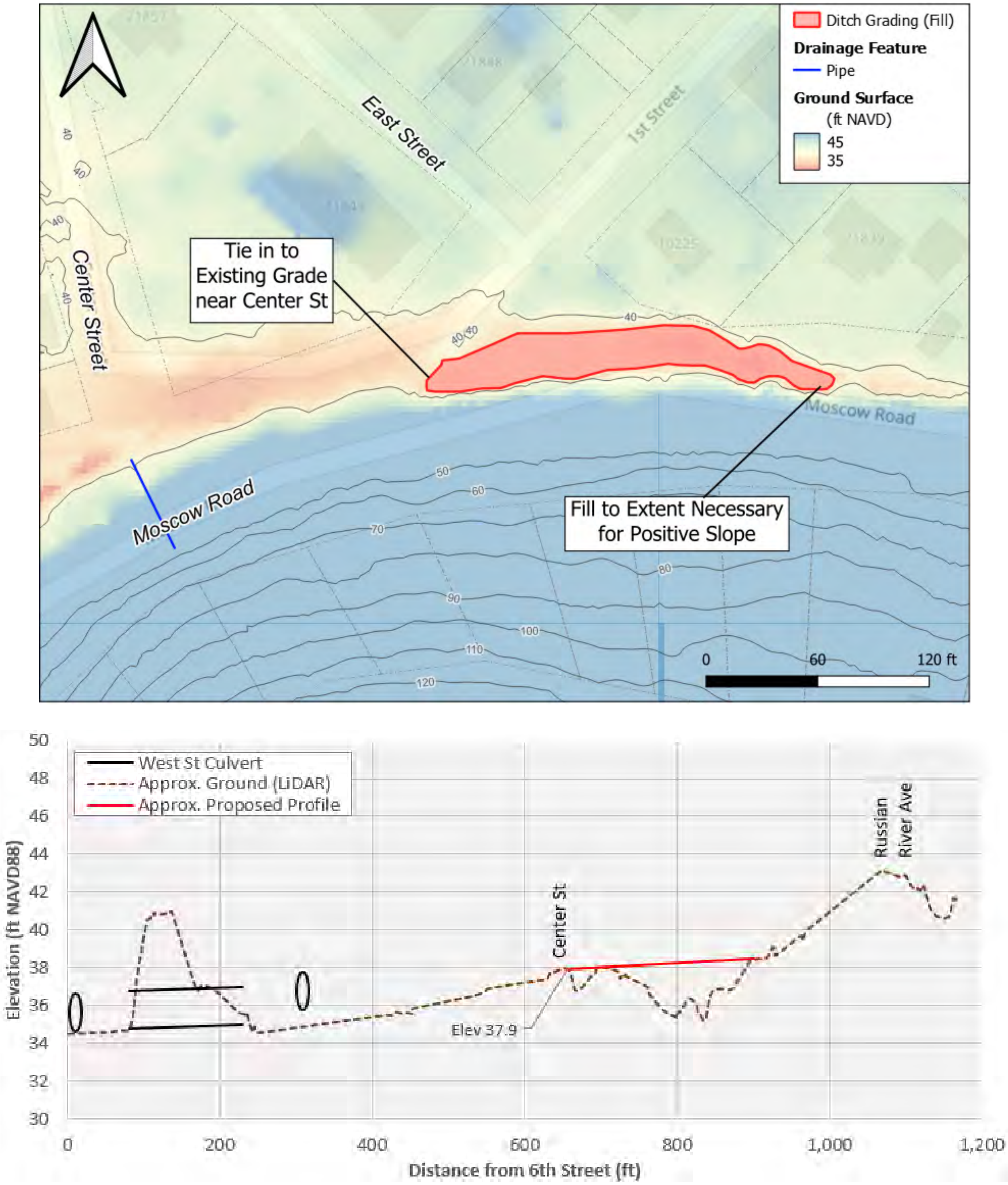



**Figure 5-22: Alternative C-3 Plan (Top) and Approximate Profile (Bottom)**

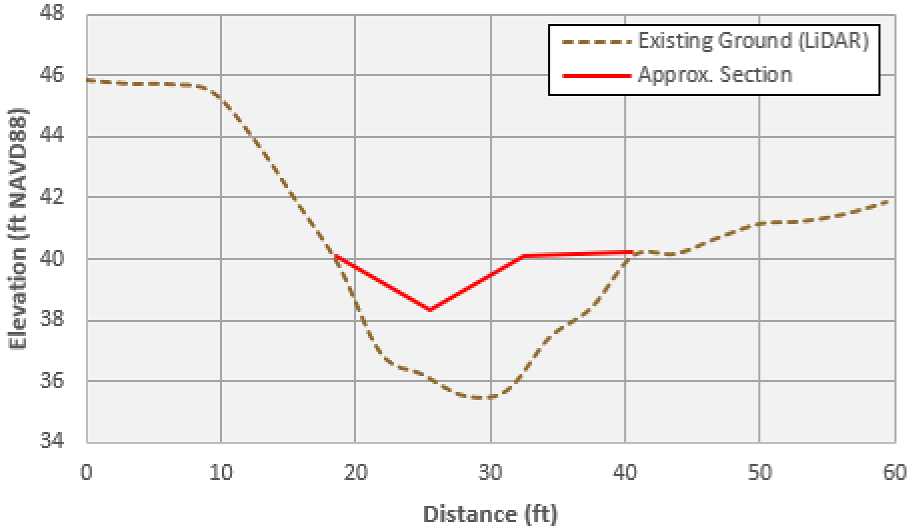
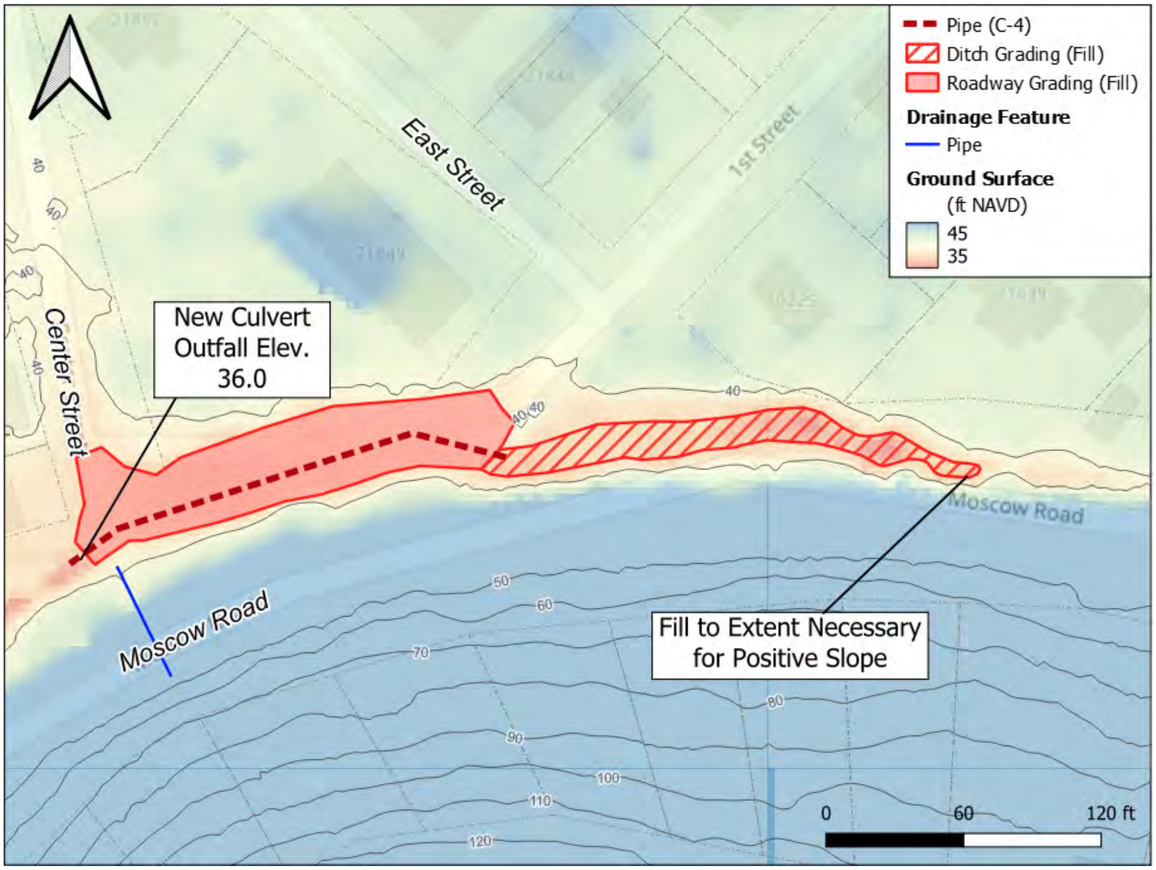



**Figure 5-23: Approximate V-Ditch Section for Alternative C-3**

Based on GIS parcel boundaries and available LiDAR, it appears that grading required for this alternative may remain completely outside of private properties. However, this alternative must be carefully evaluated during later design phases with additional survey available to ensure that this approach is feasible without creating additional shallow flooding on properties to the north.

This alternative also involves placement of about three feet of fill in certain locations. An arborist should be consulted to determine whether this volume of fill might have an impact on root systems of trees around the area where water ponds. Constructing a lined conveyance channel may also require removal of some trees to provide conveyance

Alternative C-4 is shown schematically in Figure 5-24. This alternative is likely more costly than simply filling the low spot but keeps fill more concentrated to the roadway. Fill in the low-lying area would be only to the extent necessary to prevent ponding below the elevation of a new pipe system and may not be necessary if some ponding is acceptable. The pipe system for this alternative would be shorter than that required for Alternative C-1. This still requires verification of property lines and evaluation of the need for construction easement or retaining walls.



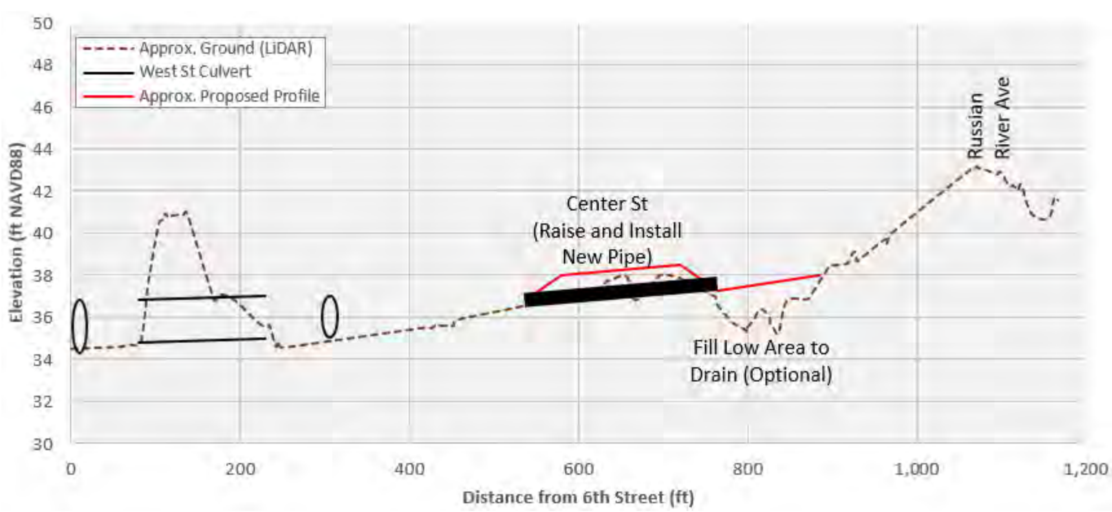




**Figure 5-24: Alternative C-4 Plan (Top) and Approximate Profile (Bottom)**

### *5.3.5 System Condition*

Pipe inspection performed on September 20, 2022 targeted portions of the Villa Grande stormwater system where information was missing after performing prior field visits and survey, or it was suspected that the condition of the system might be having an impact on performance. While the focus of other capital improvement projects focuses on building or improving capacity, this CIP focuses on fully utilizing existing capacity or restoring design capacity.

The 4th Street system was inspected west of Russian River Ave (Figure 5-25). The 24-inch RCP pipe appears to be in good condition but requires some removal of built-up sediment and debris in order to maintain its capacity (Figure 5-26). Downstream, however, the pipe transitions to a 32-inch CMP with a corroded bottom (Figure 5-27). It's not likely that this will cause flooding in its current condition, as there is a significant drop in invert elevation to the outfall. However, this should be monitored closely for further failure and prioritized for replacement.

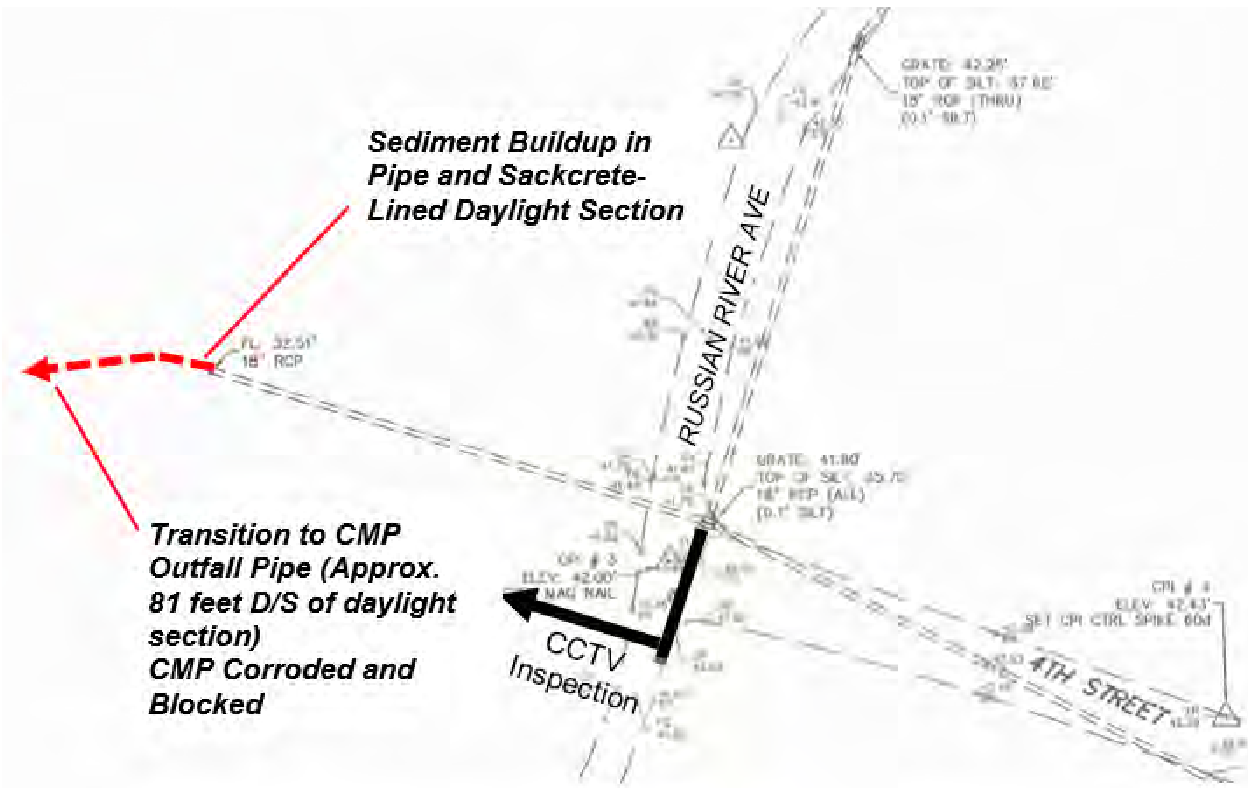



**Figure 5-25: 4th Street Outfall System**

**Figure 5-26: 4th Street Outfall Daylight Section Sediment Buildup**


**Figure 5-27: Corroded CMP and Outfall Blockage (4th Street Outfall)**

The pipe system along 6th Street was inspected in its entirety. Potential problems identified on this system that were of interest include:

- A 12” CMP was found entering one of the catch basins at Russian River Ave, but no upstream structure was found
- Residents indicated that some flooding or system overflow occurs here
- There is a 24” RCP leaving the last catch basin on Russian River Ave, but the outfall appears to be a 32” CMP

A plan view of identified issues in this system is shown in Figure 5-28. The inspection identified that some capacity has been lost to sediment deposition and overgrowth at the upstream end, along Willow Way. The pipe is in good condition at this location, but the system appears to need some maintenance to operate at full capacity. Further downstream, the missing catch basin was found approximately 32 feet to the south and is evidently buried under soil, vegetation, or debris. The pipe and structure seem to be in good condition but clearing is required to utilize the capacity of the system. Finally, the change in pipe material and diameter was located approximately 91 feet downstream of the most downstream catch basin. At this transition, the bottom of the CMP has completely corroded. It’s very unlikely that this has any impact on capacity in its current state, as the CMP is a much larger pipe than the RCP upstream. However, if the pipe continues to corrode and fail more extensively, it may eventually cause a loss of capacity. This should be monitored occasionally if it’s not replaced soon.

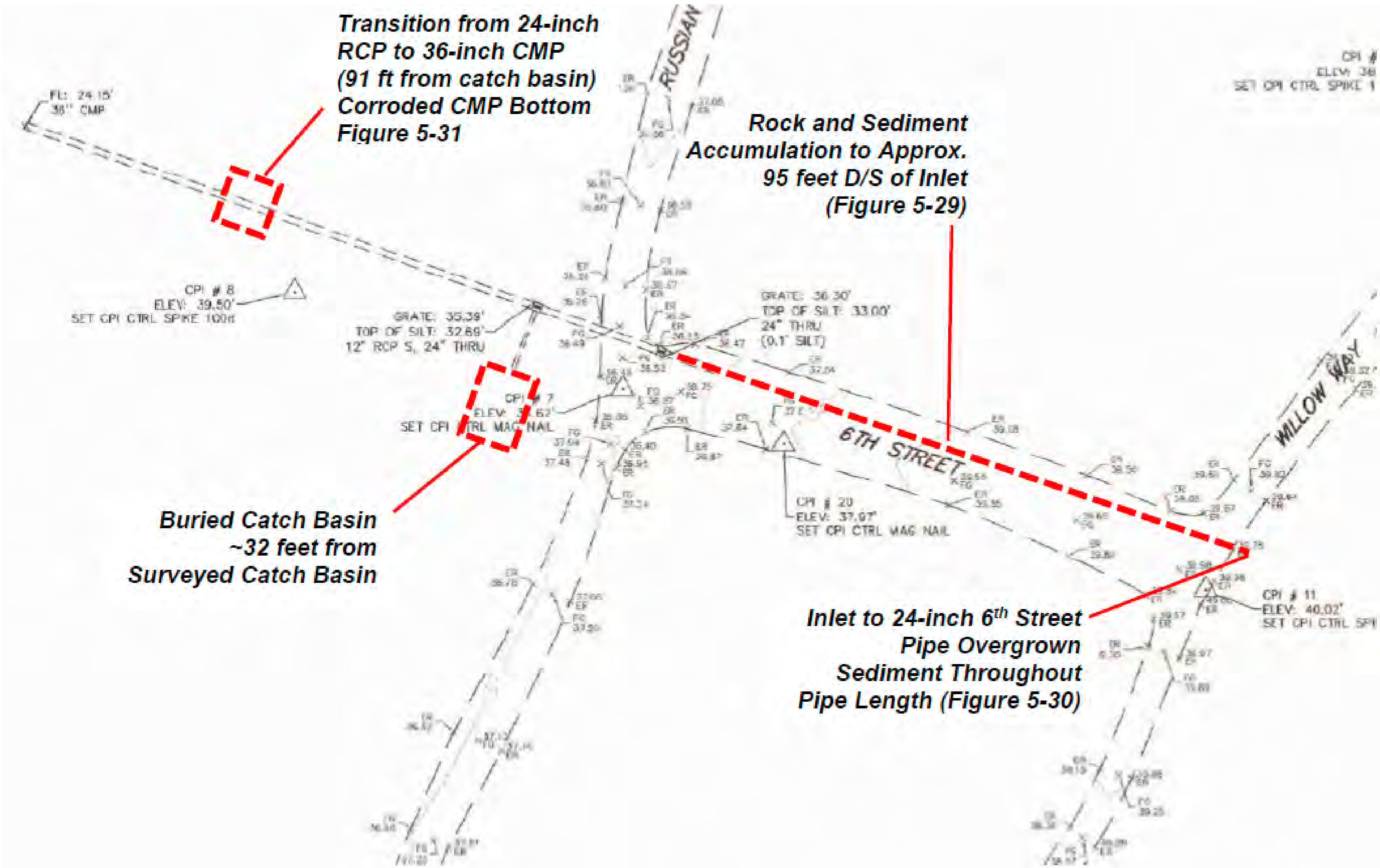



**Figure 5-28: 6th Street System Condition**

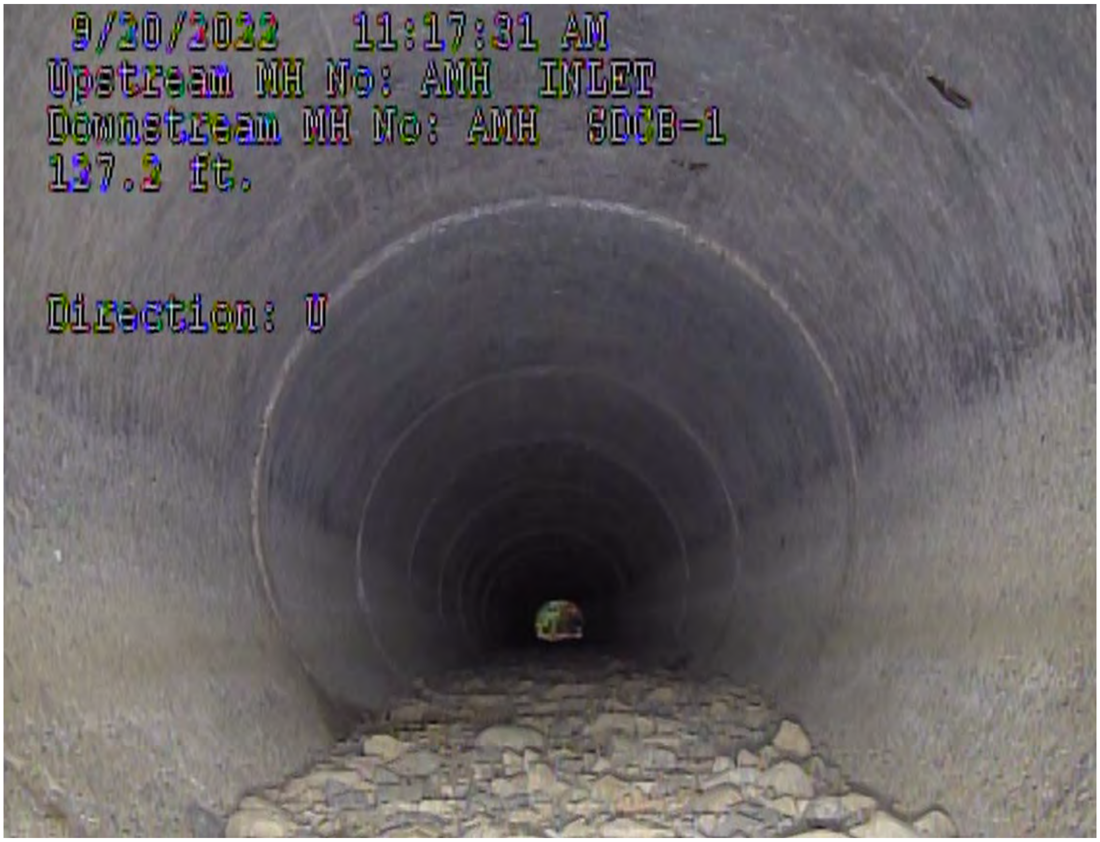



**Figure 5-29: Rock and Sediment Accumulation in 6th Street RCP**


**Figure 5-30: Overgrowth and Sediment Accumulation at Upstream end of 6th Street (24-inch RCP)**


**Figure 5-31: Corroded CMP Bottom at Transition from RCP to CMP (6th Street Outfall)**

Further south at Willow Way and Russian River Ave, both existing culverts were inspected. Residents indicated that this area floods during storms. Capacity deficiency has been identified by the hydraulic model for the 32-inch culvert to the Russian River. However, the inspection of this system also showed that the downstream end of the 18-inch CMP culvert crossing Willow Way is nearly completely collapsed and embedded in sediment. This represents a near complete loss of capacity for the conveyance of runoff crossing Willow Way from the north. This is shown in Figure 5-32 and Figure 5-33. This culvert is also experiencing corrosion throughout its length from its invert to approximately halfway up its profile, and there is evidence of potential failure underneath the roadway, approximately 20 feet from its upstream end (Figure 5-34).

The full length of the 32-inch CMP was inspected. It is generally clear of blockage and in fair condition. This culvert transitions to a 36-inch HDPE approximately 20 feet from its upstream end. There is some corrosion along the invert of the CMP. This culvert has been identified as undersized and is already part of the Willow Way capacity CIP.

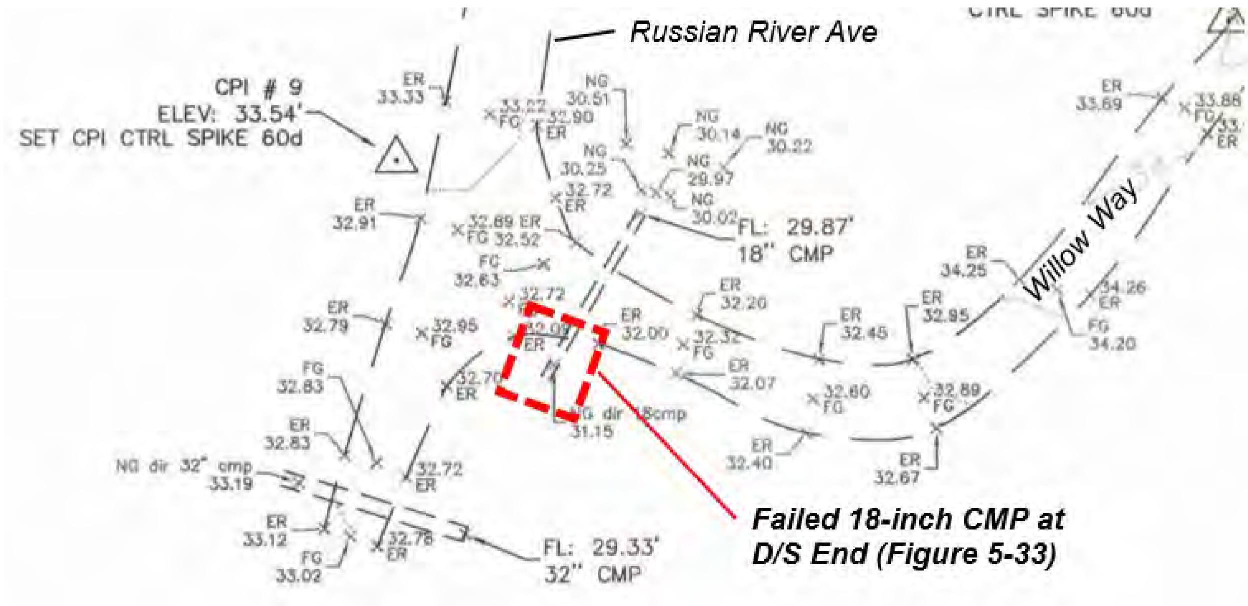



Figure 5-32: Willow Way Culverts


Figure 5-33: Failed 18-inch CMP Culvert at Willow Way (Downstream End)

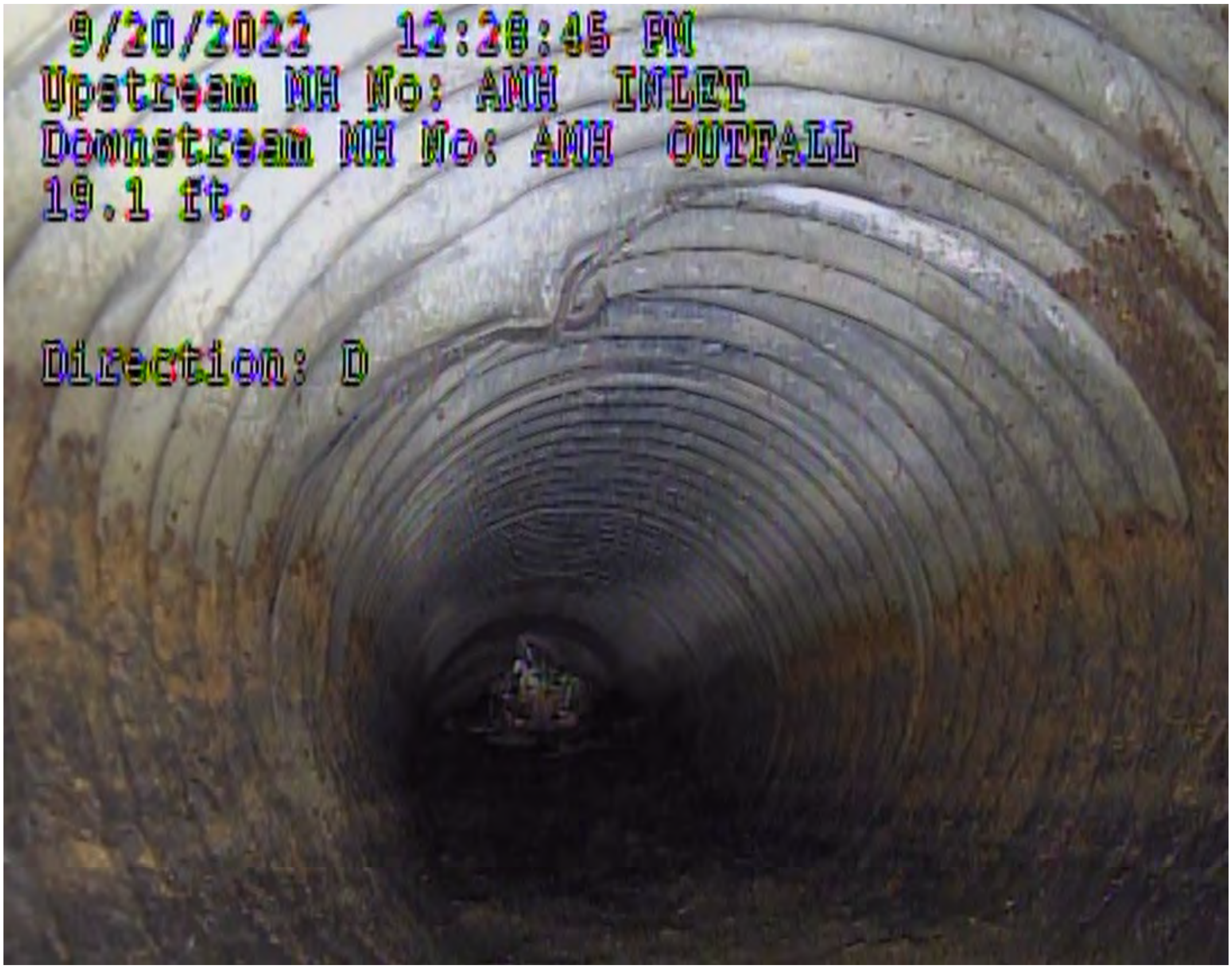



**Figure 5-34: Creasing/Flexure and Corrosion in 18-inch CMP Crossing Willow Way.**

A summary of condition-driven projects is provided in Table 5-12

**Table 5-12: Maintenance and Capital Improvement Project Summary for Condition-related Issues.**

| System | Project ID | Projects | Project Type/Description |
|---|---|---|---|
| 4th Street | M-1 | 4th Street Sediment Management | Maintenance – Remove blockage |
| | M-2 | Outfall Replacement | CIP – Remove failed 32-inch CMP and extend 24-in RCP to outfall |
| 6th Street | M-3 | Sediment Management and Ditch Clearing | Maintenance – Remove blockage |
| | M-4 | Outfall Replacement | CIP – Slip line existing 32-inch CMP, if feasible |
| Willow Way | M-5 | 18-inch Willow Way Culvert Repair | CIP – Replace existing 18-inch failing CMP |

The change in material along the 6th Street outfall pipe happens to coincide with the approximate location chosen for a backflow prevention device. CIP M-4 could be designed and constructed along with CIP O-2. Replacement of an outfall may require additional permitting that would delay the construction of the backflow prevention device. However, it's possible that this pipe could be slip-lined to simplify the project and greatly reduce cost and permitting effort

It's more difficult to determine whether the 4th Street system is a candidate for the simplified approach of slip-lining the existing CMP, given the degree of failure and blockage in the pipe. It's possible that the blockage could be removed to make room for a lining, but this should be investigated further.

### *5.3.6 Preferred Alternatives*

Ideally, the alternatives selected for design and construction will address all known drainage issues within Villa Grande during events up to the 10-year return period and improve conditions for storms of greater return periods. In order to accomplish those ends most efficiently, projects must be chosen that leverage planned projects to minimize disruption, improve the function of the pipe system, and remove the threat of issues created by Russian River backwater into the system in the absence of overbank flooding.

For those projects where alternatives are explored by this report, the alternatives are compared and the most favorable of them identified in Table 5-13. This selection is based solely on available information. It's entirely possible that detailed design information (utilities, property boundaries, topography, etc) drives the selection of a different alternative to design, permit, and construct.

**Table 5-13: Preferred Alternative/Project Selection Matrix**

| Recommended Project/ Alternative | | Summary |
|---|---|---|
| Backflow Prevention | O-2 | • Environmental permitting associated with Alternative O-1 greatly increases cost and extends the project timeline. This alone means that it should be avoided unless other alternatives are not feasible.<br>• Alternative O-3 includes an in-line non-return valve on the northern system as well. This could provide some protection from backwater flooding at East Street and $2^{nd}$ Street during very high river events (beyond a 25-year level, but not as high as a 100-year). This second valve would only be effective under very specific circumstances and ultimately is not likely worth the cost of installing.<br>• A traditional flap gate valve installed as part of Alternative O-2 requires a large, concrete structure that allows for full range of motion to operate properly. However, it provides favorable hydraulics and protects against backwater impacting Russian River Ave and the low-lying areas parallel to Moscow Road. **Alternative O-2** is therefore the preferred approach to addressing river backwater where it is most likely to have an impact. |
| Pipe System Capacity Imp. | S-4 | • Alternative S-1 is the least costly pipe system improvement but does not address all the drainage issues at the core of the community.<br>• Alternative S-2 better improves drainage but does not leverage other projects and focuses purely on the drainage system.<br>• Alternative S-3 provides the greatest benefit to reducing drainage issues and building a resilient system; however, it is the costliest by a wide margin and trenching along Russian River Ave is likely to have a greater impact on tree root systems.<br>• **Alternative S-4** goes beyond addressing the most immediate existing pipe system capacity deficiency, and balances extending the pipe system with leveraging a planned paving project to provide more efficient surface drainage. It is therefore the preferred system improvement alternative. |
| | Upper $4^{th}$ St | • Locating existing infrastructure and rehabilitating or replacing as necessary can be done independently from the alternatives for system capacity improvements |
| Willow Way Culvert Cap. | W-3 | • At Willow Way, Alternatives W-1 and W-2 simply don't provide the same level of efficiency in reducing flood depth and duration as a new 3' x 2.5' box.<br>• **Alternative W-3** is recommended as it provides the greatest benefit to the southern area of Villa Grande in solving a chronic flooding problem.<br>• This recommendation is based entirely on hydraulic analysis. Feasibility of any alternative will be subject to determining boundary and easement locations. If the existing pipe is entirely on private property, it may be most cost effective to install a parallel 32-inch pipe (Alternative W-1) or equivalent box section within the existing easement (if the easement allows for it). |
| Center Street Drainage Imp. | C-4 | • At Center Street, **Alternative C-4** provides the most balanced approach to protecting trees, minimizing flooding, and effectively draining the area.<br>• Though it is difficult to predict the exact constraints that will dictate a final design, the balanced approach is recommended.<br>• It's possible that the final design could focus on improving drainage east of Center Street without filling the low area. Some ponding would remain, but this would minimize disturbance of existing vegetation and impact to the community.<br>• Floodplain ordinance must be considered. If net fill has an impact, Alternative C-2 may be the only viable option for mitigating the ponding issue at Center Street. |
| System Condition | All M-1 to M-5 | • All condition-related projects are recommended, though some may be lower priority than others where capacity is not impacted or the condition of the system is not a likely cause of the community's current interior flooding issues. |

A preliminary, 30% design for certain system improvements is provided in Appendix C. FHWA inlet calculations for the preliminary design based on peak 10-year flows from the MIKE+ model are provided in Appendix D. These drawings do not currently include the rehabilitation of the upper 4th Street system along Russian River Ave. More detailed survey or investigation is required to provide further design detail at that locations, beyond that provided in Figure 5-18. Willow Way and Center Street drainage improvements are also shown with relatively limited detail, as limited topographic and property boundary information is available.

Grading and placement of inlet structures has been developed at a preliminary level with various criteria in mind:

- Minimize impact to tree roots by concentrating fill (rather than cut) near existing trees, placing inlets as far from trees as possible while still capturing drainage
- Remain as near existing grades as possible throughout, while also eliminating existing low points where ponding is problematic (2nd Street at East Street, West Street between the Post Office and East Street, and Russian River Ave at 5th Street)
    - The vast majority of proposed grading cut isn't expected to extend more than three inches below existing grade
    - Proposed grading would tie into existing grades (daylight) at the edges of existing right-of-way in most spots, so the grading depths should be even less near trees
    - Grading at the ponding on Russian River Ave at 5th Street is mitigated by fill (rather than cut) immediately adjacent to three large trees.
- Use simple asphalt curbs to aid in providing surface conveyance, especially where grading would be challenging or highly impactful to property or vegetation outside of the right-of-way
- Minimize loss of parking by using valley gutters instead of asphalt curb

It's been noted that Villa Grande is within the FEMA Zone AE SFHA, where any project must comply with local floodplain ordinance. Proposed preliminary grading for Alternative S-4 has been developed with net cut across the project. Center Street, however, will be difficult to construct without placing net fill in the floodplain, even if combined with other projects. Any alternative for this CIP is extremely constrained. The only Center Street alternative that would not propose net fill would be alternative C-2. As project selection and design proceeds, floodplain analysis of pre- and post-development conditions could be necessary to support a design that does not impact flood storage capacity.

This is a preliminary evaluation of the feasibility of constructing these alternatives based on available information. In order to fully consider all these criteria and other constraints, detailed survey and utility information will be required to support further design work.

# 6 Capital Improvement Costs

## 6.1 Overview

Chapter 5 discusses Villa Grande's storm drainage system condition, capacity, and known and modeled deficiencies. It further lays out an alternatives analysis for addressing various issues and improving overall system performance and level of service to the community.

This chapter provides an analysis of cost for the proposed alternatives.

## 6.2 Cost Basis

Costs have been estimated based on a variety of available information, including:

- Cost estimation guides (e.g. RSMeans)
- Inflation indices, published by the Engineering News Record (ENR)
- Actual cost and bid data from recent projects
- Engineering judgement

The ENR Construction Cost Index (CCI) for San Francisco as of July 2022 is 15,640, compared with a 20-city average of 13,171. Schaaf and Wheeler performed a detailed unit cost analysis in 2015 for storm drain pipe and structures. This information has also been used with adjustment based on the ENR CCI from 2015 to 2022. All cost estimates are further inflated to 2025 dollars, assuming that it takes up to three years to fund, design, and construct these projects.

## 6.3 Project Alternative and Recommended Improvement Costs

Cost estimates for pipe system improvements are broken into five distinctive categories:

1. Adding non-return valves to the outfalls
2. Improving storm drain system capacity
3. Improving Willow Way culvert capacity
4. Improving drainage around Center Street
5. Addressing Problems related to the condition of the System

Costs for these projects are summarized in Table 6-1. More detailed estimates are provided in Appendix A for CIPs that are not primarily Maintenance issues. Construction costs include 30% contingency and 20% administration cost. Design services are estimated to be 20% of construction cost. For alternative O-1 and project M-2, environmental permitting is estimated as 25% of construction cost. Project M-4 includes reduced environmental permitting cost, estimated as 10% of construction cost due to the relative lack of grading and disturbance required to complete the project.

**Table 6-1: Pipe System Project Alternative Cost Estimate Summary**

| Category | Project/ Alternative | | Summary | Estimated Cost |
|---|---|---|---|---|
| 1 | Backflow Prevention | O-1 | Traditional non-return valves on existing 6th Street outfall | $170,000 |
| | | ***O-2**** | Traditional non-return flap gate on 6th Street System | $120,000 |
| | | O-3 | Mix of traditional (6th St) and in-line (4th St) non-return valves | $140,000 |
| 2 | Pipe System Capacity Imp. | S-1 | Upsize system to mitigate capacity deficiency | $250,000 |
| | | S-2 | Upsize system and extend to underserved areas | $590,000 |
| | | S-3 | Upsize, extend, and add redundancy to the system | $850,000 |
| | | ***S-4**** | Upsize and extend pipe system and improve surface conveyance | $550,000 |
| | ***Upper 4th St**** | | Locate existing infrastructure and rehabilitate or replace as necessary | Up to $120,000 |
| 3 | Willow Way Culvert Cap. | W-1 | Install a parallel 32" culvert (verify existing easement) | $230,000 |
| | | W-2 | Replace 32" culvert with a 48" diameter culvert | $340,000 |
| | | ***W-3**** | Replace 32" culvert with a 3' x 2.5' box culvert | $480,000 |
| 4 | Center Street Drainage Imp. | C-1 | Raise Center St and construct new pipe conveyance for drainage | $250,000 |
| | | C-2 | Lower Center St and allow drainage across the surface | $310,000 |
| | | C-3 | Fill the low area and grade stable open conveyance (ditch) | $100,000 |
| | | ***C-4**** | Raise Center St, construct a shorter pipe run, and place some fill in the low area | $160,000 |
| 5 | System Condition | ***M-1**** | Remove sediment and debris from 4th Street System | --† |
| | | ***M-2**** | Replace failing CMP outfall pipe (~25 LF) | $90,000 |
| | | ***M-3**** | Remove sediment and debris from 6th Street System; Manage vegetation in the ditch along Moscow Road | --† |
| | | ***M-4**** | Line failing CMP outfall pipe (~75 LF) | $140,000 |
| | | ***M-5**** | Replace failing 18-inch CMP culvert | $50,000 |

**Recommended Project or Alternative*
†*Maintenance project by County operations staff, or line jetting – no construction required*

While it's entirely possible to reduce flooding purely by improving the existing pipe system, grading to provide adequate surface conveyance helps reduce the need for extensive pipe system improvement and appears to be a more cost-effective approach. Grading may also be required to address certain ponding issues near Center Street. A paving project is already planned for the area that could be augmented to include grading and system improvement work at some additional cost.

The cost estimates presented here do not include roadway paving. Instead, the estimates include additional grading, asphalt curbs, and valley gutters, which are beyond the scope of the paving project but are an integral part of accomplishing positive surface drainage throughout the community.

Projects identified to replace failing systems may also be combined with other CIPs. CIP M-4, for example, could be most easily combined with CIP O-2, as the preliminary design proposes a new structure at the transition from RCP to corroding CMP identified for replacement.

The total, combined cost of the preferred capital improvement project alternatives (O-2, S-4, C-4, and W-3) plus rehabilitation of the northern branch of the 4th Street system (assuming replacement of the structure and 18-inch pipe is required) and all of the condition CIPs (M-2, M-4, and M-5) is approximately $1,700,000. The two maintenance-oriented projects (M-1 and M-3) are not included in this estimate, as no construction is proposed.

# Appendix A

## Planning Level Project Cost Estimates

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: River Backwater**

**Project: Non-Return Valve Alternative O-1**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 7,800 | $ 7,800 |
| ***Demo*** | | | | | |
| 2 | Clearing and Grubbing | 1 | LS | $ 5,000 | $ 5,000 |
| 3 | Grading & Excavation | 1 | LS | $ 5,000 | $ 5,000 |
| 4 | Cut Back Existing Pipe | 1 | EA | $ 2,500 | $ 2,500 |
| ***Storm Drainage*** | | | | | |
| 5 | Steel Debris Rack | 1 | LS | $ 12,000 | $ 12,000 |
| 6 | Concrete Outfall Structure | 1 | LS | $ 30,000 | $ 30,000 |
| 7 | Non-Return Valve (24") | 1 | EA | $ 16,000 | $ 16,000 |
| | | | | **Construction Subtotal** | **$ 78,000** |
| | | | | *Contingency (30%)* | *$ 23,000* |
| | | | | *Construction Admin (20%)* | *$ 16,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 117,000** |
| | | | | *Environmental Permitting (25%)* | *$ 29,000* |
| | | | | *Design (20%)* | *$ 23,000* |
| | | | | **Total** | **$ 169,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: River Backwater**

**Project: Non-Return Valve Alternative O-2**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 6,600 | $ 6,600 |
| ***Demo*** | | | | | |
| 2 | Clearing and Grubbing | 1 | LS | $ 5,000 | $ 5,000 |
| 3 | Grading & Excavation | 1 | LS | $ 2,500 | $ 2,500 |
| 4 | Cut and Remove Existing Pipe | 1 | LS | $ 5,000 | $ 5,000 |
| ***Storm Drainage*** | | | | | |
| 5 | 4' x 4' Concrete Structure | 1 | EA | $ 12,200 | $ 12,200 |
| 6 | Access Hatch | 1 | EA | $ 10,000 | $ 10,000 |
| 7 | 24" RCP | 10 | LF | $ 420 | $ 4,200 |
| 8 | 24" Flap Gate | 1 | EA | $ 16,000 | $ 16,000 |
| 9 | Connect to Existing | 1 | EA | $ 5,000 | $ 5,000 |
| | | | | **Construction Subtotal** | **$ 67,000** |
| | | | | *Contingency (30%)* | *$ 20,100* |
| | | | | *Construction Admin (20%)* | *$ 13,400* |
| | | | | **Construction Subtotal w/Contingency** | **$ 100,500** |
| | | | | *Design (20%)* | *$ 20,000* |
| | | | | **Total** | **$ 120,500** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: River Backwater**

**Project: Non-Return Valve Alternative O-3**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 7,900 | $ 7,900 |
| ***Demo*** | | | | | |
| 4 | Cut and Remove Existing Pipe | 1 | LS | $ 5,000 | $ 5,000 |
| 5 | Grading & Excavation | 1 | LS | $ 1,500 | $ 1,500 |
| 6 | Cut and Remove Existing Pipe | 1 | LS | $ 2,500 | $ 2,500 |
| ***Storm Drainage*** | | | | | |
| 7 | 4' x 4' Concrete Structure w/Solid Lid | 1 | EA | $ 12,000 | $ 12,000 |
| 8 | Access Hatch | 1 | EA | $ 10,000 | $ 10,000 |
| 9 | 24" RCP | 10 | LF | $ 390 | $ 3,900 |
| 10 | 21" In-line Check Valve Insert | 1 | EA | $ 15,000 | $ 15,000 |
| 11 | 24" Flap Gate | 1 | EA | $ 16,000 | $ 16,000 |
| 12 | Connect to Existing | 1 | EA | $ 5,000 | $ 5,000 |
| | | | | **Construction Subtotal** | **$ 79,000** |
| | | | | *Contingency (30%)* | *$ 24,000* |
| | | | | *Construction Admin (20%)* | *$ 16,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 119,000** |
| | | | | *Design (20%)* | *$ 24,000* |
| | | | | **Total** | **$ 143,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

Only one vault structure is included in this cost. It's assumed that the check valve (at 4th Street) will be installed in a catch basin to be installed as part of other storm system improvements

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Pipe System Capacity**

**Project: Pipe System Improvement Alternative S-1**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 14,000 | $ 14,000 |
| ***Demo*** | | | | | |
| 2 | Pipe Removal/Disposal (12" and Under) | 212 | LF | $ 40 | $ 8,500 |
| 3 | Existing Inlet Structure Demo | 2 | EA | $ 2,000 | $ 4,000 |
| ***Storm Drainage*** | | | | | |
| 4 | 15" RCP | 134 | LF | $ 313 | $ 41,900 |
| 5 | 18" RCP | 78 | LF | $ 344 | $ 26,800 |
| 6 | New Grate Inlet | 8 | EA | $ 5,000 | $ 40,000 |
| 7 | Connect to Existing | 1 | LS | $ 5,000 | $ 5,000 |
| | | | | **Construction Subtotal** | **$ 140,000** |
| | | | | *Contingency (30%)* | *$ 42,000* |
| | | | | *Construction Admin (20%)* | *$ 28,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 210,000** |
| | | | | *Design (20%)* | *$ 42,000* |
| | | | | **Total** | **$ 252,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Pipe System Capacity**

**Project: Pipe System Improvement Alternative S-2**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 32,700 | $ 32,700 |
| ***Demo*** | | | | | |
| 2 | Pipe Removal/Disposal (12" and Under) | 212 | LF | $ 40 | $ 8,480 |
| 3 | Pipe Removal/Disposal (18") | 144 | LF | $ 45 | $ 6,480 |
| 4 | Existing Inlet Structure Demo | 3 | EA | $ 2,000 | $ 6,000 |
| ***Storm Drainage*** | | | | | |
| 4 | 12" RCP | 98 | LF | $ 277 | $ 27,150 |
| 5 | 15" RCP | 231 | LF | $ 313 | $ 72,300 |
| 6 | 18" RCP | 327 | LF | $ 344 | $ 112,490 |
| 7 | Grate Inlet | 11 | EA | $ 5,000 | $ 55,000 |
| 8 | Connect to Existing | 1 | LS | $ 5,000 | $ 5,000 |
| 9 | Outfall Protection | 1 | LS | $ 2,000 | $ 2,000 |
| | | | | **Construction Subtotal** | **$ 328,000** |
| | | | | *Contingency (30%)* | *$ 98,000* |
| | | | | *Construction Admin (20%)* | *$ 66,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 492,000** |
| | | | | *Design (20%)* | *$ 98,000* |
| | | | | **Total** | **$ 590,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Pipe System Capacity**

**Project: Pipe System Improvement Alternative S-3**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 46,900 | $ 46,900 |
| ***Demo*** | | | | | |
| 2 | Pipe Removal/Disposal (12" and Under) | 212 | LF | $ 40 | $ 8,480 |
| 3 | Pipe Removal/Disposal (18") | 144 | LF | $ 45 | $ 6,480 |
| 4 | Existing Inlet Structure Demo | 3 | EA | $ 2,000 | $ 6,000 |
| ***Storm Drainage*** | | | | | |
| 4 | 12" RCP | 190 | LF | $ 277 | $ 52,630 |
| 5 | 15" RCP | 231 | LF | $ 313 | $ 72,300 |
| 6 | 18" RCP | 183 | LF | $ 344 | $ 62,950 |
| 7 | 24" RCP | 333 | LF | $ 425 | $ 141,530 |
| 8 | Grate Inlet (Including replaced structures) | 11 | EA | $ 5,000 | $ 55,000 |
| 9 | Connect to Existing | 3 | LS | $ 5,000 | $ 15,000 |
| 10 | Outfall Protection | 1 | LS | $ 2,000 | $ 2,000 |
| | | | | **Construction Subtotal** | **$ 469,000** |
| | | | | *Contingency (30%)* | *$ 141,000* |
| | | | | *Construction Admin (20%)* | *$ 94,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 704,000** |
| | | | | *Design (20%)* | *$ 141,000* |
| | | | | **Total** | **$ 845,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Pipe System Capacity**

**Project: Pipe System Improvement Alternative S-4**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 30,700 | $ 30,700 |
| ***Demo*** | | | | | |
| 2 | Pipe Removal/Disposal (12" and Under) | 123 | LF | $ 40 | $ 4,900 |
| 3 | Existing Inlet Structure Demo | 2 | EA | $ 2,000 | $ 4,000 |
| ***Storm Drainage*** | | | | | |
| 4 | 12" RCP | 205 | LF | $ 277 | $ 56,800 |
| 5 | 15" RCP | 187 | LF | $ 313 | $ 58,500 |
| 6 | 21" RCP | 5 | LF | $ 390 | $ 2,000 |
| 7 | Grate Inlet (2'x3') | 11 | EA | $ 5,000 | $ 55,000 |
| 8 | SD Structure w/Solid Lid | 1 | EA | $ 5,000 | $ 5,000 |
| 9 | Connect to Existing | 2 | LS | $ 5,000 | $ 10,000 |
| ***Grading/Pavement*** | | | | | |
| 9 | Cut (Incl. Haul, and Disposal) | 60 | CY | $ 200 | $ 12,000 |
| 10 | Fill | 60 | CY | $ 100 | $ 6,000 |
| 11 | Asphalt Curb | 650 | LF | $ 40 | $ 26,000 |
| 12 | Valley Gutter | 450 | LF | $ 80 | $ 36,000 |
| | | | | **Construction Subtotal** | **$ 307,000** |
| | | | | *Contingency (30%)* | *$ 92,000* |
| | | | | *Construction Admin (20%)* | *$ 61,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 460,000** |
| | | | | *Design (20%)* | *$ 92,000* |
| | | | | **Total** | **$ 552,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

Cost does not include roadway pavement. Grading and asphalt curb/valley gutter represent additional work required beyond the scope of rodway pavement to provide improved drainage

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Pipe System Capacity**

**Project: Upper 4th Street System Rehab**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 6,400 | $ 6,400 |
| ***Demo*** | | | | | |
| 2 | Pipe Removal/Disposal (18") | 120 | LF | $ 40 | $ 4,800 |
| 3 | Existing Inlet Structure Demo | 1 | EA | $ 2,000 | $ 2,000 |
| ***Storm Drainage*** | | | | | |
| 4 | 12" RCP | 120 | LF | $ 344 | $ 41,300 |
| 5 | Grate Inlet (2'x3') | 1 | EA | $ 5,000 | $ 5,000 |
| 6 | Connect to Existing | 1 | LS | $ 5,000 | $ 5,000 |
| | | | | **Construction Subtotal** | **$ 65,000** |
| | | | | *Contingency (30%)* | *$ 20,000* |
| | | | | *Construction Admin (20%)* | *$ 13,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 98,000** |
| | | | | *Design (20%)* | *$ 20,000* |
| | | | | **Total** | **$ 118,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

This cost assumes full replacement of a segment of pipe and inlet structure. This may be more extensive scope than required to simply restore the system by rehabilitating an existing inlet and/or short segment of existing pipe

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Center Street Drainage**

**Project: Center Street Drainage Improvement Alternative C-1**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 14,000 | $ 14,000 |
| ***Storm Drainage*** | | | | | |
| 2 | 12" RCP | 350 | LF | $ 277 | $ 97,000 |
| 3 | Grate Inlet (2'x3') | 1 | EA | $ 5,000 | $ 5,000 |
| 4 | SD Structure w/Solid Lid | 1 | EA | $ 5,000 | $ 5,000 |
| 5 | Connect to Existing | 2 | LS | $ 5,000 | $ 10,000 |
| ***Grading*** | | | | | |
| 6 | Fill (Center St) | 55 | CY | $ 100 | $ 5,500 |
| | | | | **Construction Subtotal** | **$ 137,000** |
| | | | | *Contingency (30%)* | *$ 41,000* |
| | | | | *Construction Admin (20%)* | *$ 27,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 205,000** |
| | | | | *Design (20%)* | *$ 41,000* |
| | | | | **Total** | **$ 246,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

Cost does not include roadway pavement. Grading and asphalt curb/valley gutter represent additional work required beyond the scope of rodway pavement to provide improved drainage

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Center Street Drainage**

**Project: Center Street Drainage Improvement Alternative C-2**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 17,000 | $ 17,000 |
| ***Storm Drainage*** | | | | | |
| 2 | 12" RCP | 350 | LF | $ 277 | $ 97,000 |
| 3 | Grate Inlet (2'x3') | 1 | EA | $ 5,000 | $ 5,000 |
| 4 | SD Structure w/Solid Lid | 1 | EA | $ 5,000 | $ 5,000 |
| 5 | Connect to Existing | 2 | LS | $ 5,000 | $ 10,000 |
| ***Grading*** | | | | | |
| 6 | Cut (Center St) | 75 | CY | $ 100 | $ 7,500 |
| 7 | Wall | 180 | SF | $ 150 | $ 27,000 |
| | | | | **Construction Subtotal** | **$ 169,000** |
| | | | | *Contingency (30%)* | *$ 51,000* |
| | | | | *Construction Admin (20%)* | *$ 34,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 254,000** |
| | | | | *Design (20%)* | *$ 51,000* |
| | | | | **Total** | **$ 305,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

Cost does not include roadway pavement. Grading and asphalt curb/valley gutter represent additional work required beyond the scope of rodway pavement to provide improved drainage

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Center Street Drainage**

**Project: Center Street Drainage Improvement Alternative C-3**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 6,000 | $ 6,000 |
| ***Grading*** | | | | | |
| 2 | Fill (Low-Lying Area) | 90 | CY | $ 100 | $ 9,000 |
| 3 | Rock Lined Ditch | 160 | CY | $ 200 | $ 32,000 |
| 4 | Restore Vegetation | 1 | LS | $ 10,000 | $ 10,000 |
| | | | | **Construction Subtotal** | **$ 57,000** |
| | | | | *Contingency (30%)* | *$ 17,000* |
| | | | | *Construction Admin (20%)* | *$ 11,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 85,000** |
| | | | | *Design (20%)* | *$ 17,000* |
| | | | | **Total** | **$ 102,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

Cost does not include roadway pavement. Grading and asphalt curb/valley gutter represent additional work required beyond the scope of rodway pavement to provide improved drainage

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Center Street Drainage**

**Project: Center Street Drainage Improvement Alternative C-4**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 9,000 | $ 9,000 |
| ***Storm Drainage*** | | | | | |
| 2 | 12" RCP | 200 | LF | $ 277 | $ 55,400 |
| 3 | Grate Inlet (2'x3') | 1 | EA | $ 5,000 | $ 5,000 |
| 4 | SD Structure w/Solid Lid | 1 | EA | $ 5,000 | $ 5,000 |
| ***Grading*** | | | | | |
| 5 | Fill (Center St) | 100 | CY | $ 100 | $ 10,000 |
| 6 | Fill (Low-Lying Area) | 20 | CY | $ 100 | $ 2,000 |
| 7 | Restore Vegetation | 1 | LS | $ 5,000 | $ 5,000 |
| | | | | **Construction Subtotal** | **$ 91,000** |
| | | | | *Contingency (30%)* | *$ 27,000* |
| | | | | *Construction Admin (20%)* | *$ 18,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 136,000** |
| | | | | *Design (20%)* | *$ 27,000* |
| | | | | **Total** | **$ 163,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

Cost does not include roadway pavement.

Cost also assumes an additional Grate Inlet is required to provide inlet capacity on the north side of Center

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Willow Way Culvert Capacity**

**Project: Willow Way Culvert Improvement Alternative W-1**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 12,000 | $ 12,000 |
| ***Storm Drainage*** | | | | | |
| 2 | 32" RCP | 165 | LF | $ 590 | $ 97,000 |
| ***Grading*** | | | | | |
| 3 | Regrade Culvert Inlet/Outlet | 1 | LS | $ 5,000 | $ 5,000 |
| 4 | Outlet Protection | 1 | LS | $ 5,000 | $ 5,000 |
| 5 | Restore Vegetation | 1 | LS | $ 5,000 | $ 5,000 |
| | | | | **Construction Subtotal** | **$ 124,000** |
| | | | | *Contingency (30%)* | *$ 37,000* |
| | | | | *Construction Admin (20%)* | *$ 25,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 186,000** |
| | | | | Easement Acquisition* | $ 10,000 |
| | | | | *Design (20%)* | *$ 37,000* |
| | | | | **Total** | **$ 233,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

Easement acquisition approximate, if required. Based on 120 ft by 5 ft additional easement to fit additional parallel line. Actual need for easement requires assessment with boundary survey

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Willow Way Culvert Capacity**

**Project: Willow Way Culvert Improvement Alternative W-2**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 18,000 | $ 18,000 |
| ***Demolition*** | | | | | |
| 2 | 32" RCP Demolition and Disposal | 165 | LF | $ 70 | $ 12,000 |
| ***Storm Drainage*** | | | | | |
| 3 | 48" RCP | 165 | LF | $ 870 | $ 144,000 |
| ***Grading*** | | | | | |
| 4 | Regrade Culvert Inlet/Outlet | 1 | LS | $ 5,000 | $ 5,000 |
| 5 | Outlet Protection | 1 | LS | $ 5,000 | $ 5,000 |
| 6 | Restore Vegetation | 1 | LS | $ 5,000 | $ 5,000 |
| | | | | **Construction Subtotal** | **$ 189,000** |
| | | | | *Contingency (30%)* | *$ 57,000* |
| | | | | *Construction Admin (20%)* | *$ 38,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 284,000** |
| | | | | *Design (20%)* | *$ 57,000* |
| | | | | **Total** | **$ 341,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Willow Way Culvert Capacity**

**Project: Willow Way Culvert Improvement Alternative W-3**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 26,000 | $ 26,000 |
| ***Demolition*** | | | | | |
| 2 | 32" RCP Demolition and Disposal | 165 | LF | $ 70 | $ 12,000 |
| ***Storm Drainage*** | | | | | |
| 3 | 3'x2.5' Box | 165 | LF | $ 1,305 | $ 215,000 |
| ***Grading*** | | | | | |
| 4 | Regrade Culvert Inlet/Outlet | 1 | LS | $ 5,000 | $ 5,000 |
| 5 | Outlet Protection | 1 | LS | $ 5,000 | $ 5,000 |
| 6 | Restore Vegetation | 1 | LS | $ 5,000 | $ 5,000 |
| | | | | **Construction Subtotal** | **$ 268,000** |
| | | | | *Contingency (30%)* | *$ 80,000* |
| | | | | *Construction Admin (20%)* | *$ 54,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 402,000** |
| | | | | *Design (20%)* | *$ 80,000* |
| | | | | **Total** | **$ 482,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Maintenance/Condition**

**Project: M-2 - Replace Failing 32" Outfall (4th Street System)**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 4,000 | $ 4,000 |
| ***Demolition*** | | | | | |
| 2 | 32" CMP Demolition and Disposal | 25 | LF | $ 70 | $ 2,000 |
| ***Storm Drainage*** | | | | | |
| 3 | 24" RCP | 25 | LF | $ 645 | $ 16,000 |
| 4 | Connect to Existing RCP | 1 | LS | $ 5,000 | $ 5,000 |
| ***Grading*** | | | | | |
| 4 | Outlet Protection | 1 | LS | $ 5,000 | $ 5,000 |
| 5 | Restore Vegetation | 1 | LS | $ 10,000 | $ 10,000 |
| | | | | **Construction Subtotal** | **$ 42,000** |
| | | | | *Contingency (30%)* | *$ 13,000* |
| | | | | *Construction Admin (20%)* | *$ 8,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 63,000** |
| | | | | *Environmental Permitting (25%)* | *$ 16,000* |
| | | | | *Design (20%)* | *$ 13,000* |
| | | | | **Total** | **$ 92,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Maintenance/Condition**

**Project: M-4 - Slip-Line Failing 32" Outfall (6th Street System)**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 7,000 | $ 7,000 |
| ***Storm Drainage*** | | | | | |
| 2 | 24" RCP | 75 | LF | $ 645 | $ 48,000 |
| 3 | Connect to Existing System | 1 | LS | $ 5,000 | $ 5,000 |
| 4 | Annular Grouting for Slip-lining | 1 | LS | $ 10,000 | $ 10,000 |
| | | | | **Construction Subtotal** | **$ 70,000** |
| | | | | *Contingency (30%)* | *$ 21,000* |
| | | | | *Construction Admin (20%)* | *$ 14,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 105,000** |
| | | | | *Environmental Permitting (10%)* | *$ 11,000* |
| | | | | *Design (20%)* | *$ 21,000* |
| | | | | **Total** | **$ 137,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Villa Grande Storm Drain System CIP

**Sonoma County, CA**

**Category: Maintenance/Condition**

**Project: M-5 - Replace Failing 18" CMP Culvert (Willow Way)**

**Cost Estimate**

| Item No. | Description of Work | Est. Qty. | Unit | Unit Price | Total Cost |
|---|---|---|---|---|---|
| 1 | Mobilization/Demobilization (10% Project Cost) | 1 | LS | $ 3,000 | $ 3,000 |
| ***Demolition*** | | | | | |
| 2 | 18" CMP Demolition and Disposal | 25 | LF | $ 40 | $ 1,000 |
| ***Storm Drainage*** | | | | | |
| 3 | 18" RCP | 25 | LF | $ 525 | $ 13,000 |
| ***Grading*** | | | | | |
| 4 | Outlet Protection and Ditch Grading | 1 | LS | $ 5,000 | $ 5,000 |
| 5 | Restore Vegetation | 1 | LS | $ 5,000 | $ 5,000 |
| | | | | **Construction Subtotal** | **$ 27,000** |
| | | | | *Contingency (30%)* | *$ 8,000* |
| | | | | *Construction Admin (20%)* | *$ 5,000* |
| | | | | **Construction Subtotal w/Contingency** | **$ 40,000** |
| | | | | *Design (20%)* | *$ 8,000* |
| | | | | **Total** | **$ 48,000** |

**NOTES:**

Costs presented are planning-level, with subtotal/total values rounded to the nearest $1,000

# Appendix B

## Approximate Inlet Capacity Analysis

**Existing Grates - Approximate Capacity (No Clogging)**

| Catchment | 10-year Peak (cfs) | 100-year (cfs) | # Inlets | Orifice Capacity (cfs) at 4" Depth | 10-yr Condition | Flow per Grate (10-yr) | Depth (in) |
|---|---|---|---|---|---|---|---|
| RUS1 | 4.2 | 10.7 | 3 | 18.7 | Weir | 1.4 | 2.0 |
| RUS2 | 1.9 | 5.6 | 3 | 18.7 | Weir | 0.6 | 1.2 |
| RUS3 | 1.6 | 3.5 | 1 | 6.2 | Weir | 1.6 | 2.2 |
| RUS4 | 4.2 | 10.7 | 2 | 12.4 | Weir | 2.1 | 2.7 |
| RUS5 | 2.3 | 6.9 | 2 | 12.4 | Weir | 1.1 | 1.8 |
| WEST | 2.0 | 6.0 | 2 | 12.4 | Weir | 1.0 | 1.6 |

**Existing Grates - Approximate Capacity (Clogged - 50%)**

| Catchment | 10-year Peak (cfs) | 100-year (cfs) | # Inlets | Orifice Capacity (cfs) at 4" Depth | 10-yr Condition | Flow per Grate (10-yr) | Depth (in) |
|---|---|---|---|---|---|---|---|
| RUS1 | 4.2 | 10.7 | 3 | 9.3 | Weir | 1.4 | 3.2 |
| RUS2 | 1.9 | 5.6 | 3 | 9.3 | Weir | 0.6 | 1.9 |
| RUS3 | 1.6 | 3.5 | 1 | 3.1 | Weir | 1.6 | 3.5 |
| RUS4 | 4.2 | 10.7 | 2 | 6.2 | Weir | 2.1 | 3.7 |
| RUS5 | 2.3 | 6.9 | 2 | 6.2 | Weir | 1.1 | 2.8 |
| WEST | 2.0 | 6.0 | 2 | 6.2 | Weir | 1.0 | 2.6 |

**Additional Inlet Grates - Approximate Capacity (Clogged - 50%)**

| Catchment | 10-year Peak (cfs) | 100-year (cfs) | # Inlets | Orifice Capacity (cfs) at 4" Depth | 10-yr Condition | Flow per Grate (10-yr) | Depth (in) |
|---|---|---|---|---|---|---|---|
| **RUS1** | 4.2 | 10.7 | **4** | 12.4 | Weir | 1.0 | **2.6** |
| RUS2 | 1.9 | 5.6 | 3 | 9.3 | Weir | 0.6 | 1.9 |
| **RUS3** | 1.6 | 3.5 | **2** | 6.2 | Weir | 0.8 | **2.2** |
| **RUS4** | 4.2 | 10.7 | **4** | 12.4 | Weir | 1.1 | **2.7** |
| **RUS5** | 2.3 | 6.9 | **4** | 12.4 | Weir | 0.6 | **1.8** |
| **WEST** | 2.0 | 6.0 | **4** | 12.4 | Weir | 0.5 | **1.6** |

**Single 2' x 2' grate weir capacity**

| Depth (in) | Full Capacity (cfs) | Capacity - 50% Clogged (cfs) |
|---|---|---|
| 1 | 0.48 | 0.24 |
| 2 | 1.4 | 0.7 |
| 3 | 2.5 | 1.2 |
| 3.5 | 3.1 | 1.6 |

**Single 2' x 2' grate orifice capacity**

| Depth (in) | Full Capacity (cfs) | Capacity - 50% Clogged (cfs) |
|---|---|---|
| 4 | 6.2 | 3.1 |
| 5 | 7.0 | 3.5 |
| 6 | 7.6 | 3.8 |
| 7 | 8.2 | 4.1 |
| 8 | 8.8 | 4.4 |
| 9 | 9.3 | 4.7 |
| 10 | 9.8 | 4.9 |

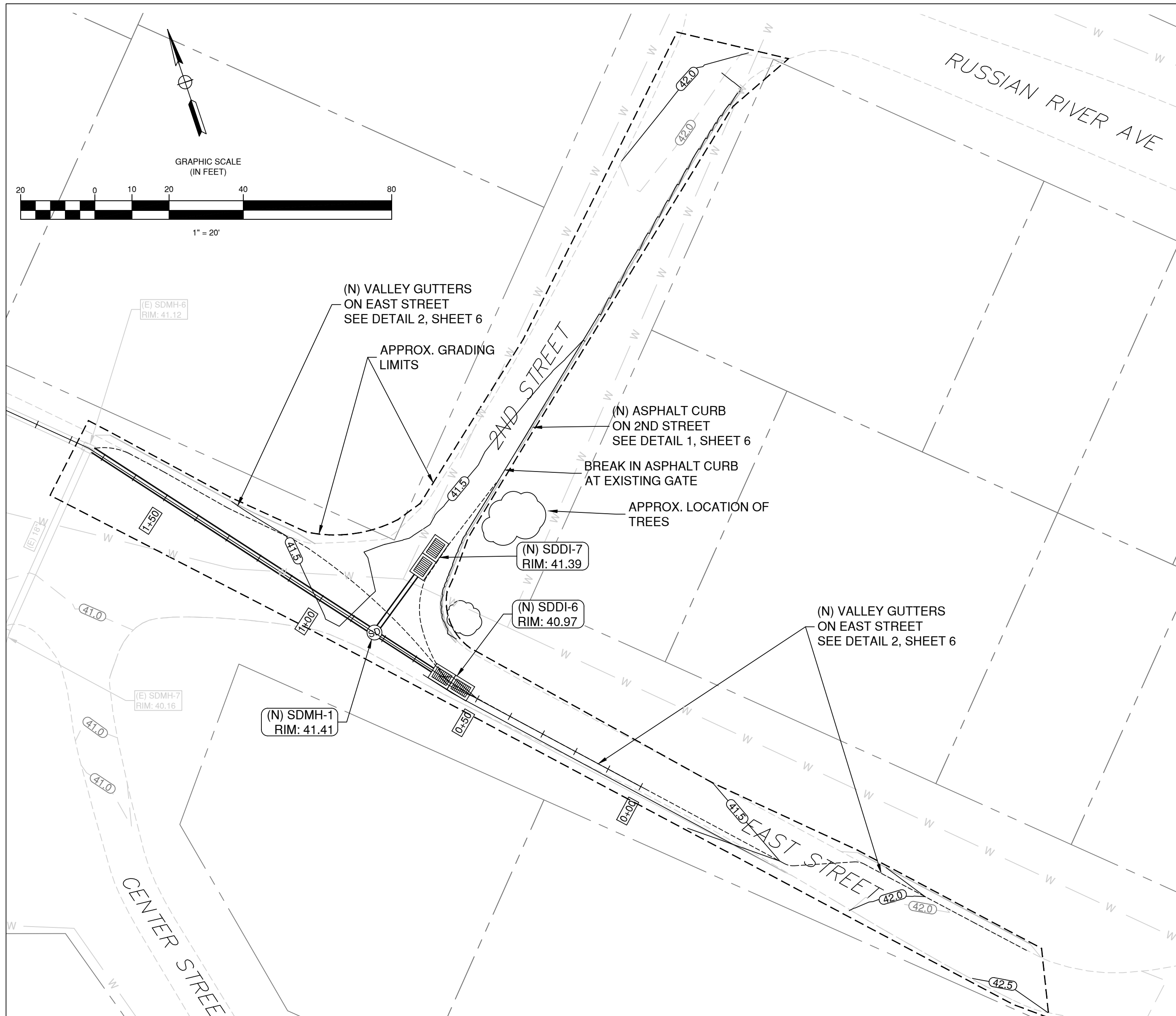
**Grate Open Area:** 288

# Appendix C

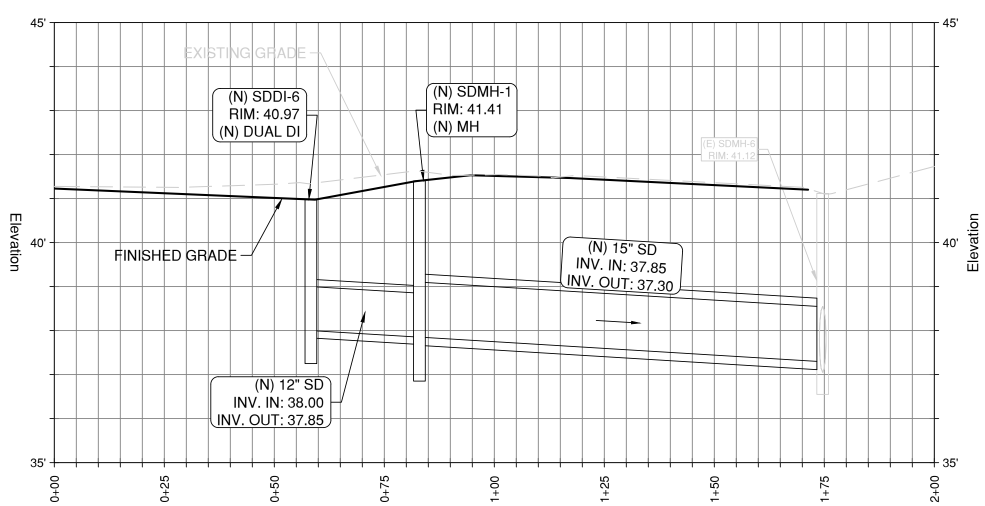
## Preliminary Design

GENERAL NOTES:

1. PROPERTY BOUNDARIES FROM GIS ARE APPROXIMATE. NO PROPERTY BOUNDARY SURVEY HAS BEEN PERFORMED.
2. EXISTING UTILITIES GEOREFERENCED FROM UTILITY MAPS. LOCATIONS SHOWN ARE APPROXIMATE. FINAL DESIGN WILL REQUIRE UTILITY SURVEY AND/OR POTHOLING
3. APPROXIMATE GROUND SURFACE ELEVATIONS SHOWN OUTSIDE OF ROADWAYS IN PROFILE BASED ON SONOMA COUNTY 2017 LIDAR.
4. GRADING LIMITS IN THESE PLANS ARE APPROXIMATE. FINAL DESIGN WILL REQUIRE DETAILED TOPOGRAPHIC SURVEY.
5. SOME KNOWN LOCATIONS OF EXISTING TREES ARE SHOWN. THESE DRAWINGS ARE NOT INTENDED TO INCLUDE ALL TREES. TREES SHOULD BE SURVEYED PRIOR TO FINAL DESIGN AND PROTECTED TO THE MAXIMUM EXTENT FEASIBLE.

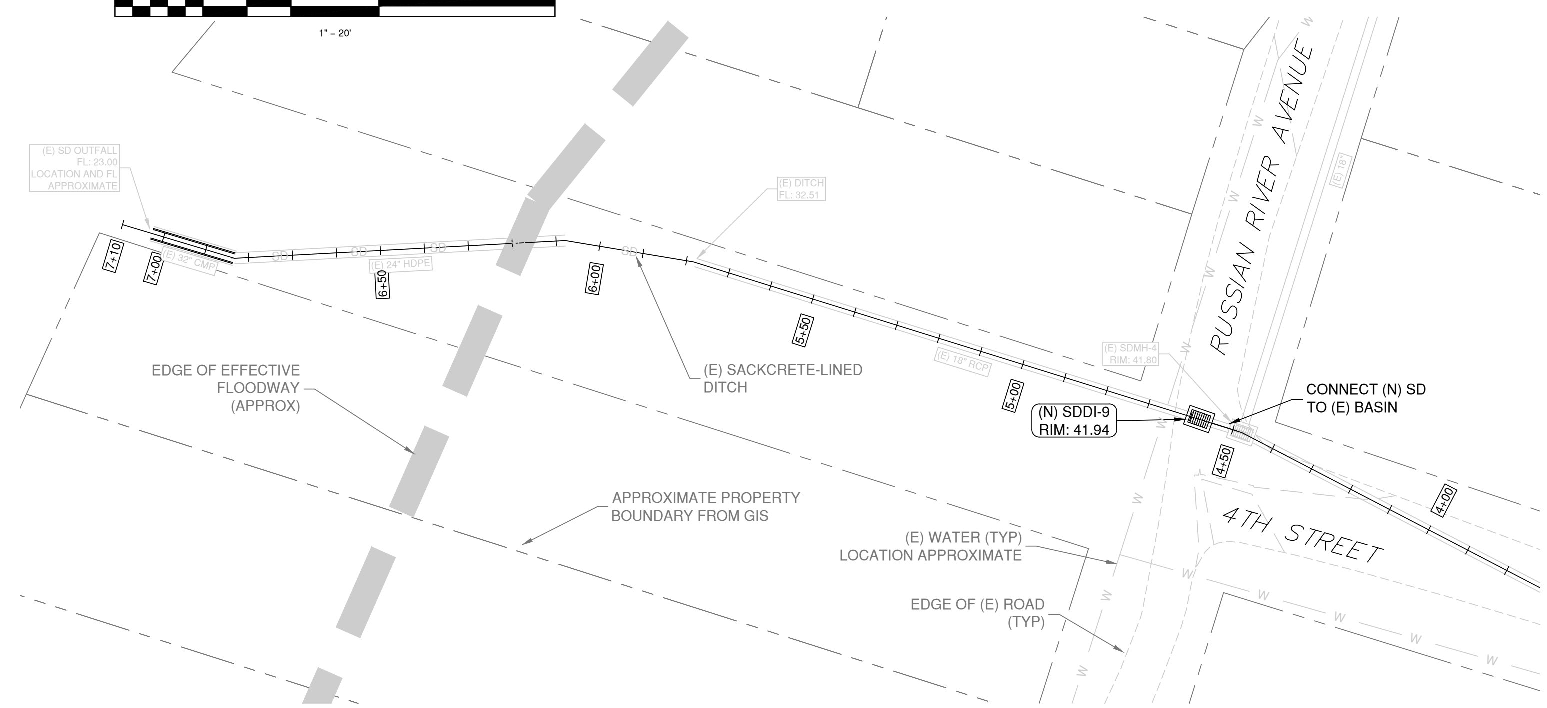



EAST STREET STORM SYSTEM IMPROVEMENT PLAN

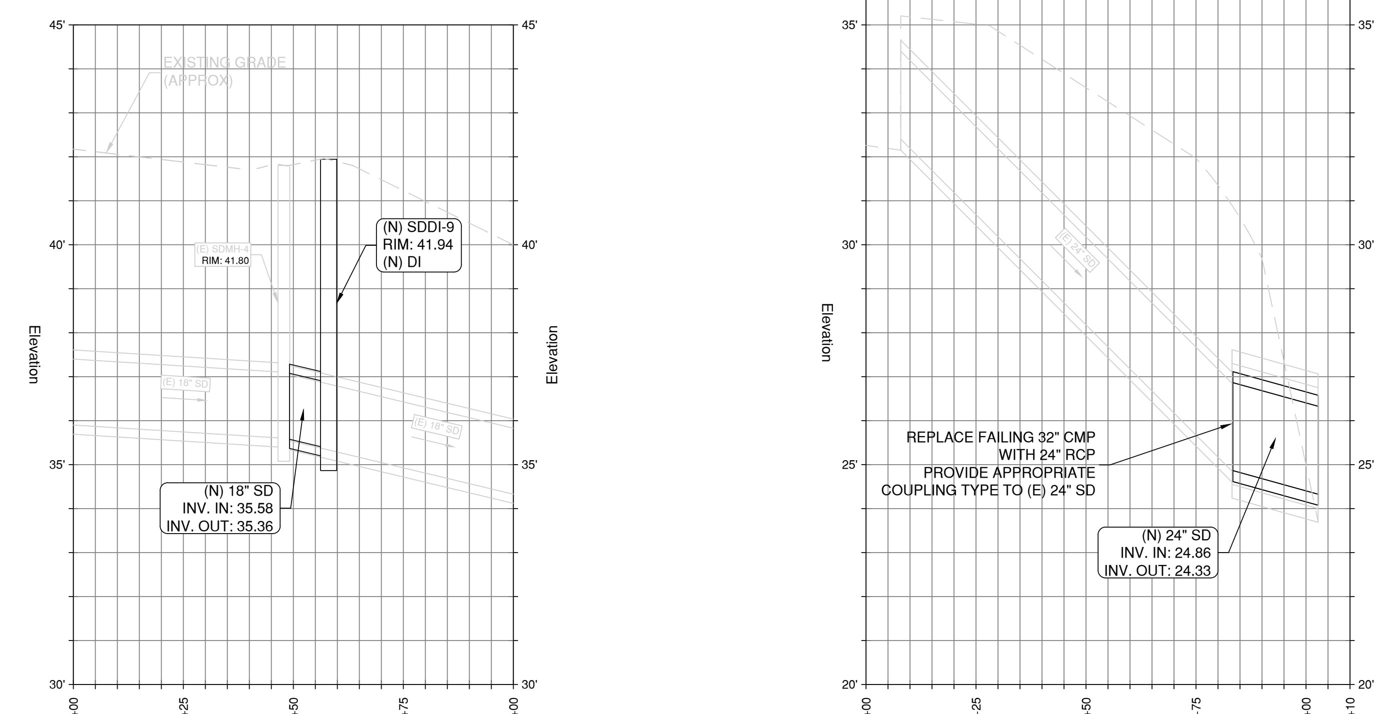



EAST STREET STORM SYSTEM IMPROVEMENT PROFILE

HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 10'




4TH STREET OUTFALL IMPROVEMENT PLAN




4TH STREET OUTFALL IMPROVEMENT PROFILE

HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 10'

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SANTA CLARA, CA 95054
(408) 246-4848

PRELIMINARY NOT FOR CONSTRUCTION

DATE:

| MARK | REVISIONS | APPR. | DATE. |
|---|---|---|---|

DESIGNED BY: JM DRAWN BY: FM CHECKED BY: JM

VILLA GRANDE - COUNTY OF SONOMA, CALIFORNIA

APPROVED BY | BY | DATE | APPROVED BY

CITY ENGINEER

DATE:

SONO-01 VILLA GRANDE

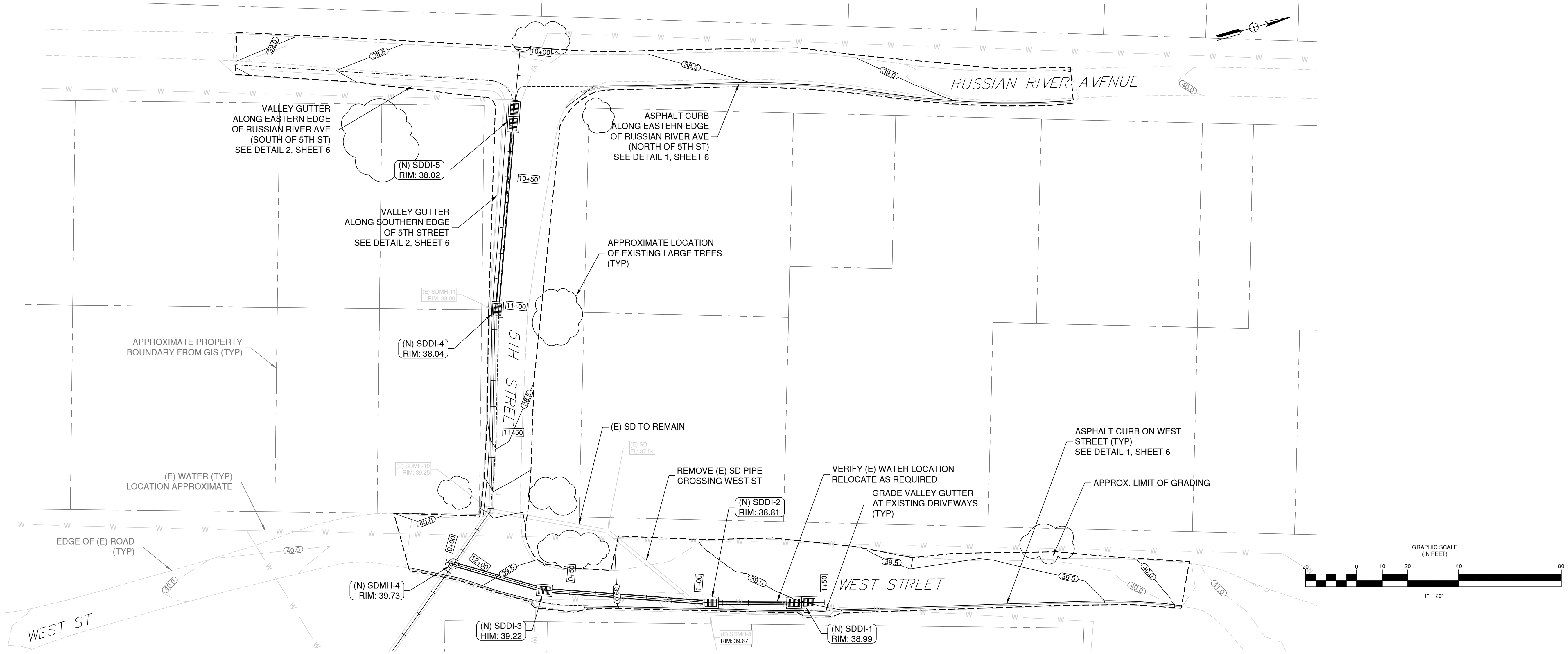
VILLA GRANDE
STORMWATER IMPROVEMENTS
EAST STREET SYSTEM PLAN & PROFILE

SCALE: AS SHOWN

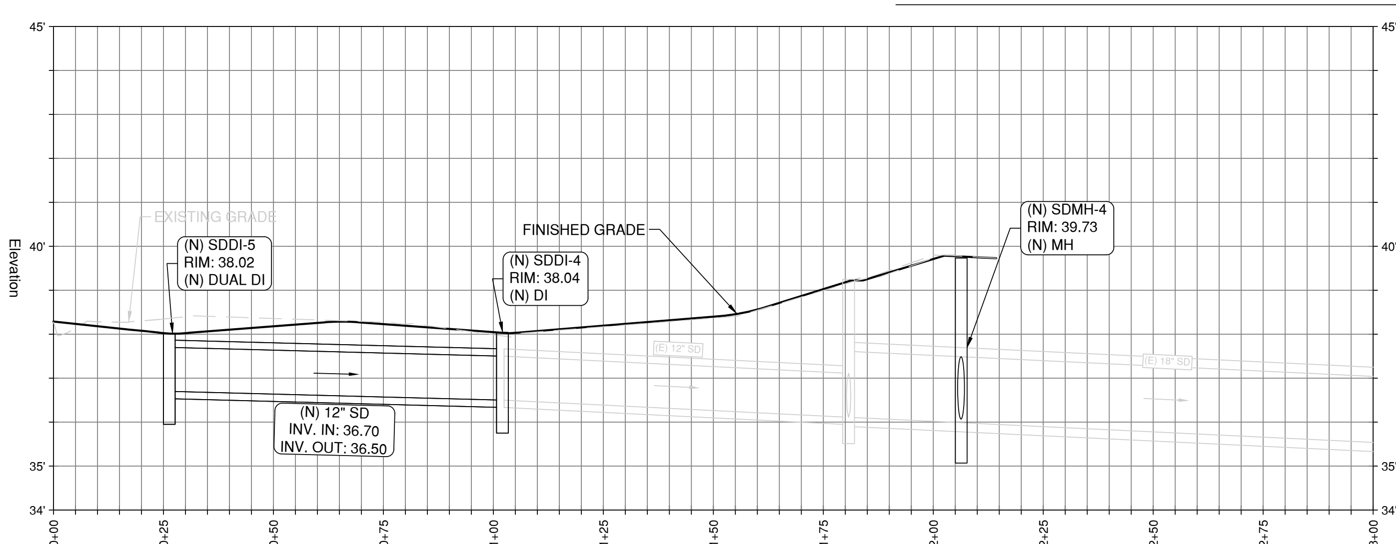
C1

SHEET 1 OF 6

30% PLANS - NOT FOR CONSTRUCTION




## WEST STREET& 5TH STREET STORM SYSTEM IMPROVEMENT PLAN




## 5TH STREET STORM SYSTEM IMPROVEMENT PROFILE

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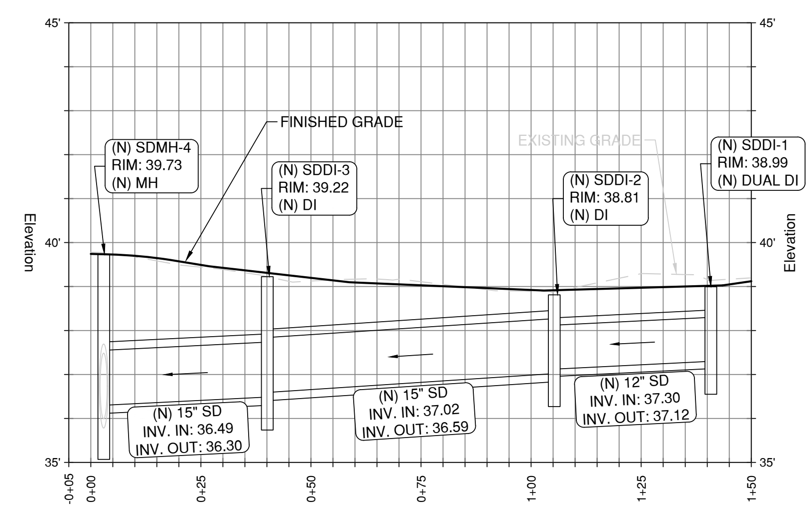
VERTICAL SCALE: 1" = 10'




## WEST STREET STORM SYSTEM IMPROVEMENT PROFILE

HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 10'

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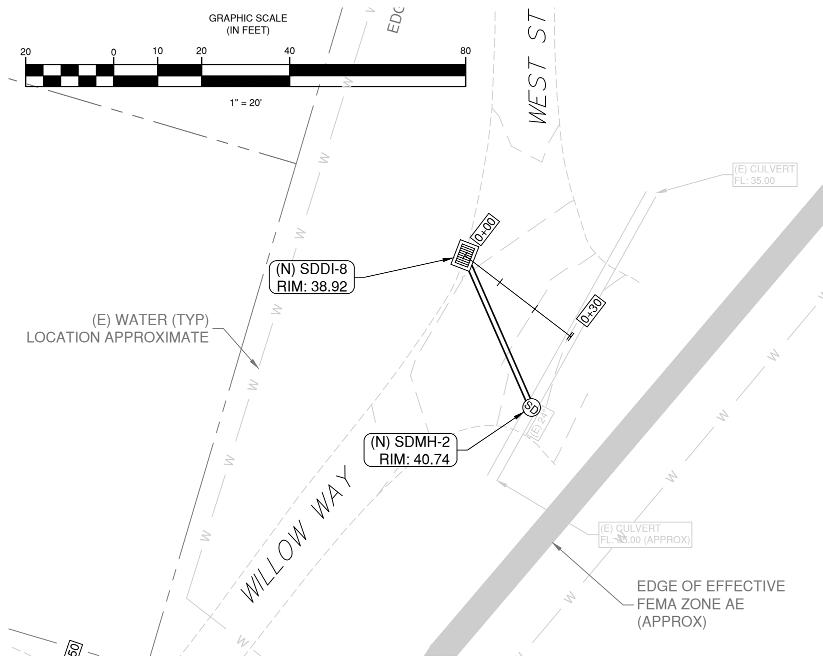
VILLA GRANDE
STORMWATER IMPROVEMENTS
WEST ST SYSTEM PLAN & PROFILE

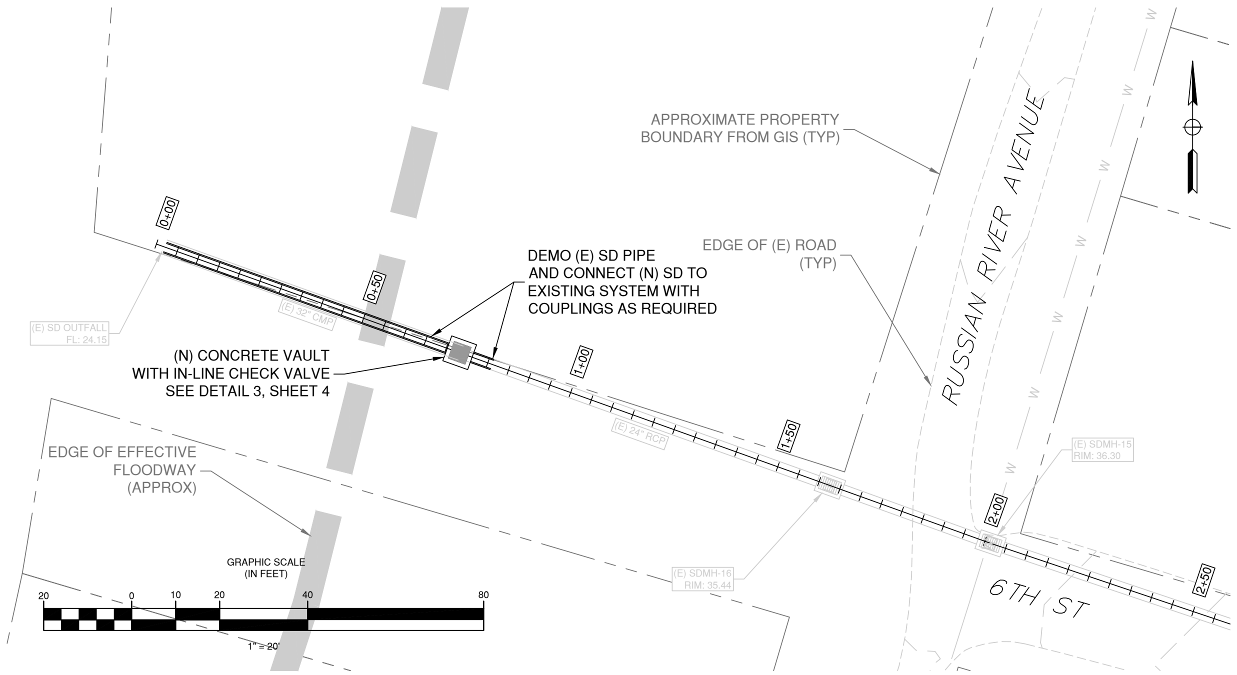
SCALE: AS SHOWN

C2

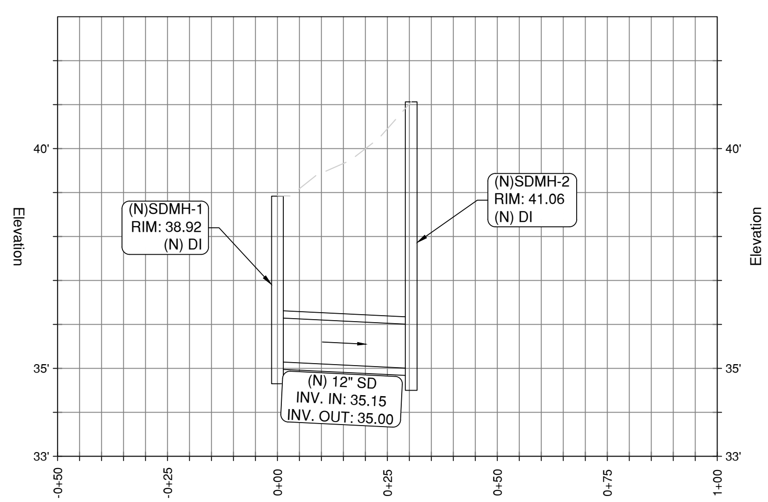
SHEET 2 OF 6




WILLOW WAY STORM SYSTEM IMPROVEMENT PLAN

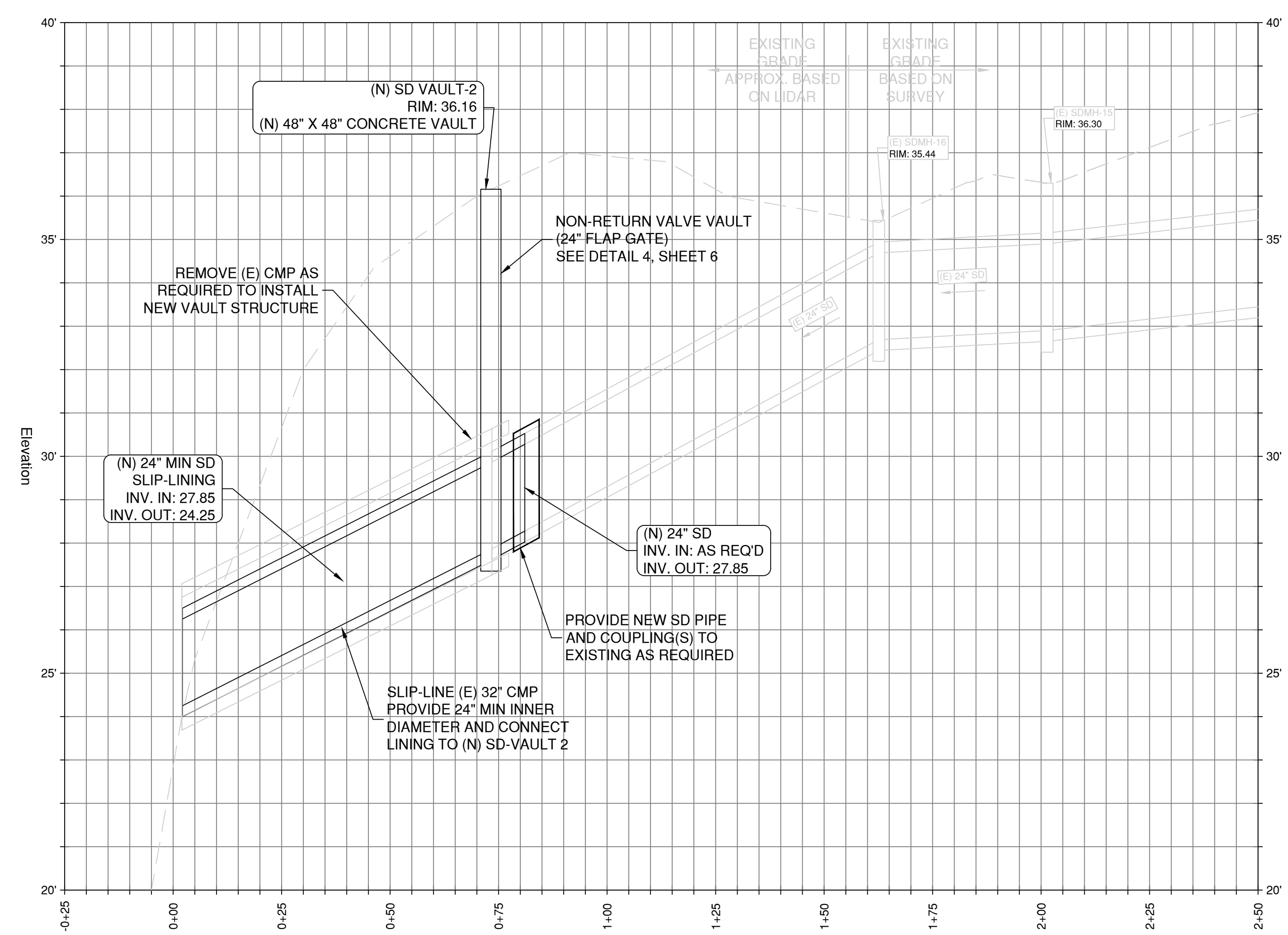



6TH STREET OUTFALL PIPE NON-RETURN PLAN




WILLOW WAY STORM SYSTEM IMPROVEMENT PROFILE

HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 10'




6TH STREET OUTFALL PIPE NON-RETURN PROFILE

HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 10'

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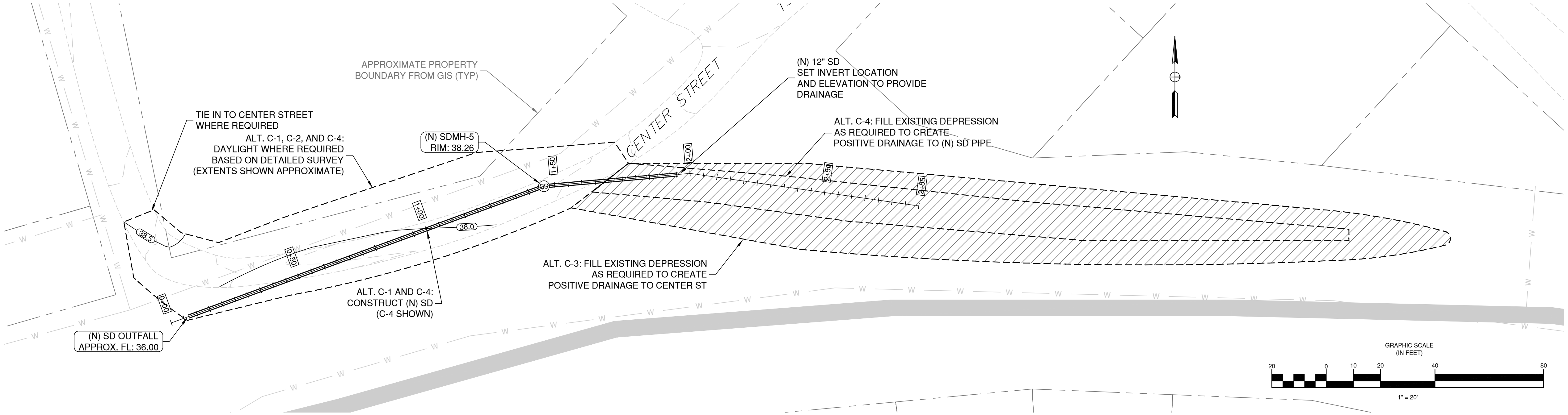
WILLOW & 6TH PLAN & PROFILE

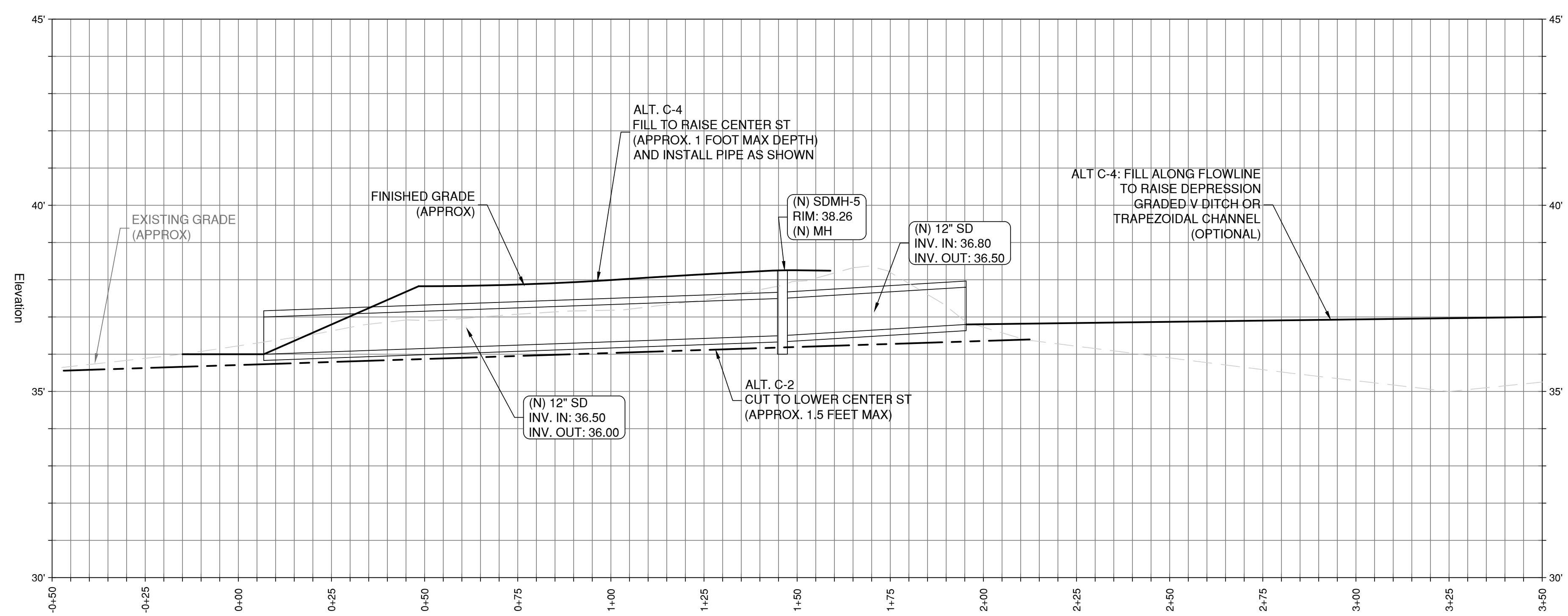
SCALE: AS SHOWN

C3

SHEET 3 OF 6




## CENTER STREET DRAINAGE CONCEPTUAL PLAN




## CENTER STREET DRAINAGE CONCEPTUAL PROFILE

HORIZONTAL SCALE: 1" = 20'
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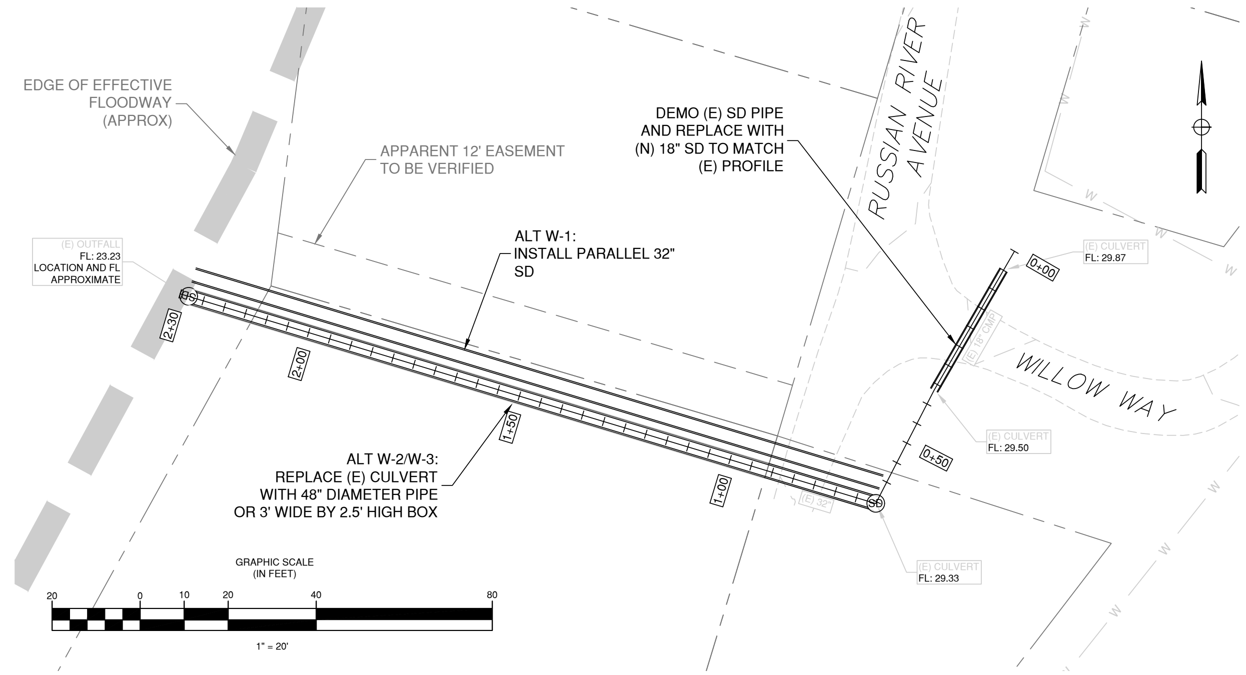
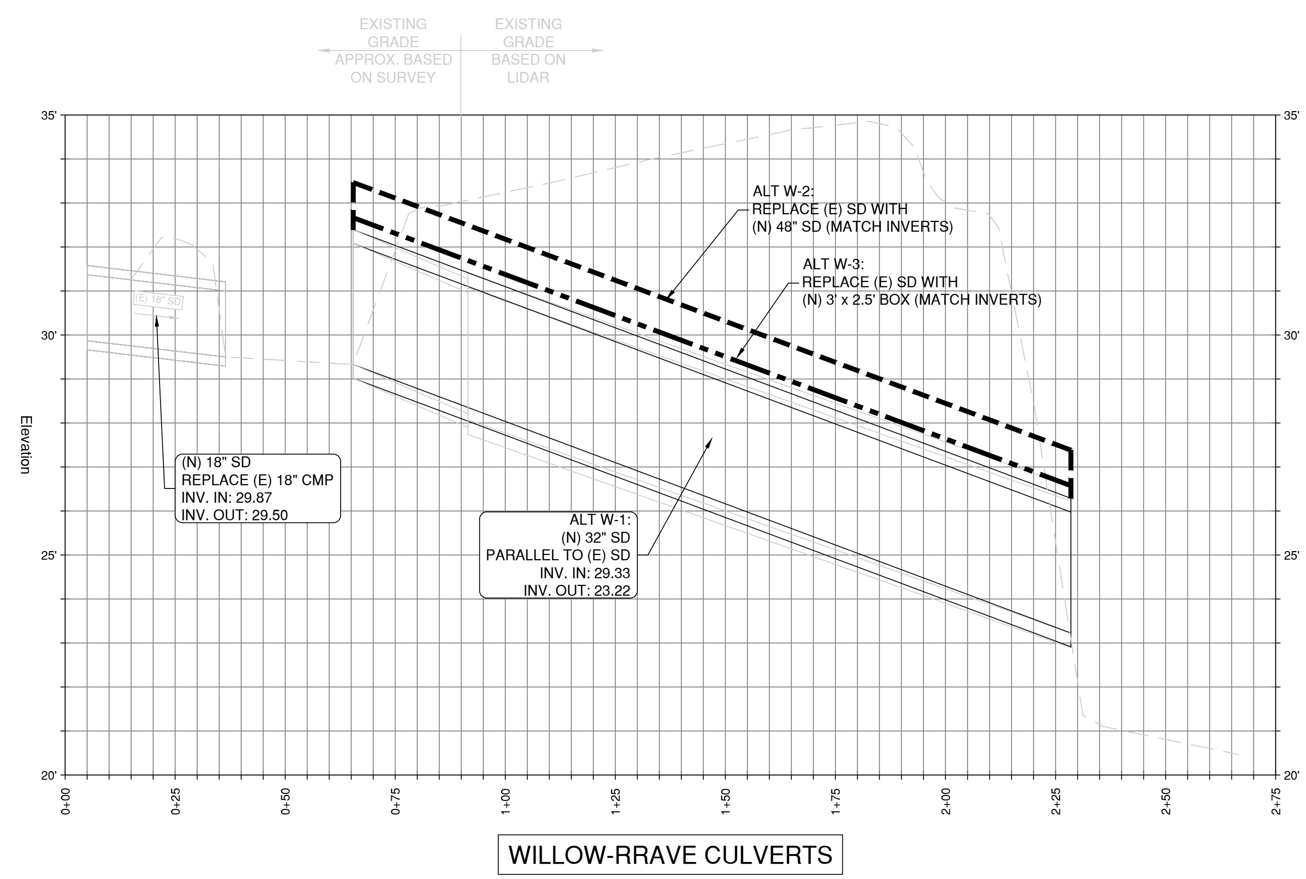
CENTER STREET PLAN & PROFILE

SCALE: AS SHOWN

C4




## WILLOW WAY OUTFALL PLAN




## WILLOW WAY OUTFALL PROFILE

HORIZONTAL SCALE: 1" = 20'
VERTICAL SCALE: 1" = 10'

30% PLANS - NOT FOR CONSTRUCTION

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DATE:

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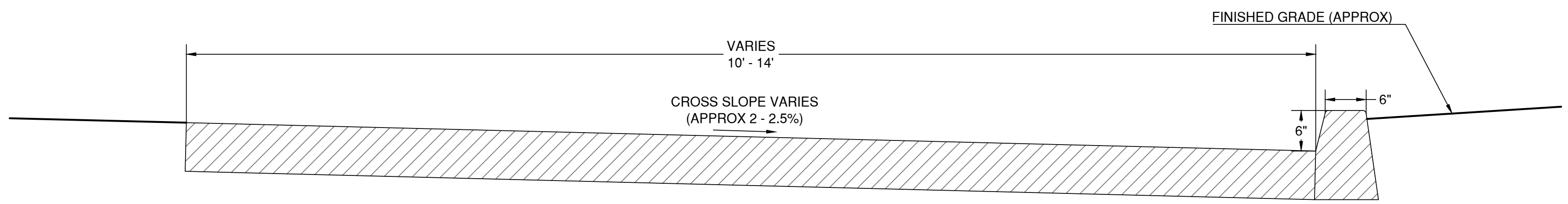
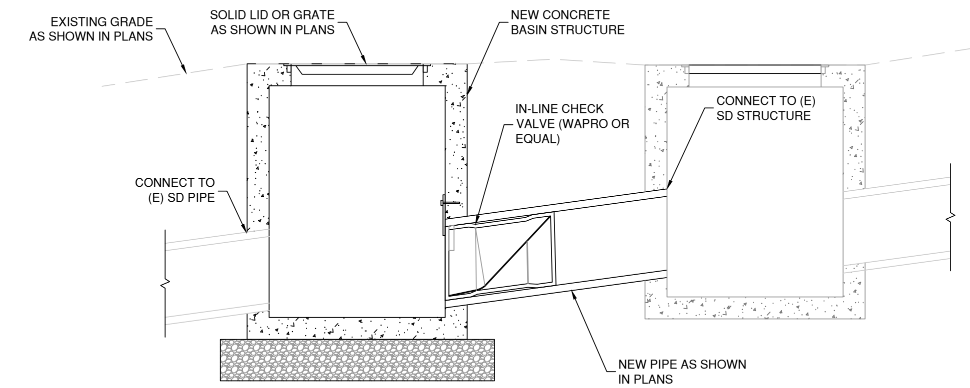
VILLA GRANDE
STORMWATER IMPROVEMENTS
WILLOW WAY OUTFALL

SCALE: AS SHOWN

C5

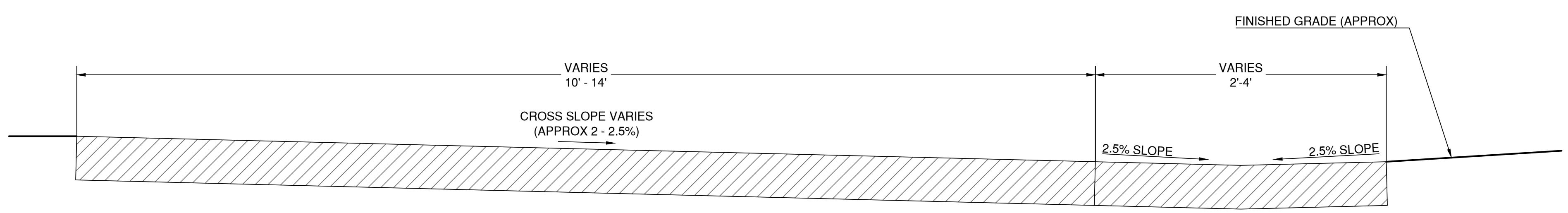



1/4 TYPICAL ROAD SECTION W/CURB
NTS

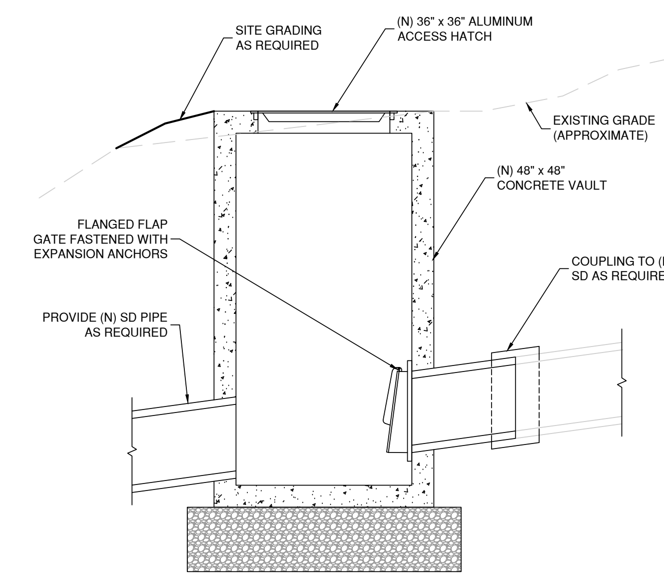



NOTES:
1. PROVIDE WAPRO VALVE SIZE TO FIT PIPE AT EACH SITE
2. BOLT VALVE TO CONCRETE STRUCTURE IN ACCORDANCE WITH MANUFACTURER INSTALLATION INSTRUCTIONS
3. FINAL SITING AND ANY REQUIRED GRADING TO BE DETERMINED BASED ON DETAILED TOPOGRAPHIC SURVEY.

3/4 TYPICAL IN-LINE CHECK VALVE DETAIL
NTS




2/4 TYPICAL ROAD SECTION W/VALLEY GUTTER
NTS




NOTES:
1. FINAL DESIGN TO PROVIDE SUFFICIENT STRUCTURE DEPTH FOR FLAP GATE TO ACHIEVE FULL RANGE OF MOTION.
2. BOLT VALVE TO CONCRETE STRUCTURE IN ACCORDANCE WITH MANUFACTURER INSTALLATION INSTRUCTIONS
3. FINAL SITING AND ANY REQUIRED GRADING TO BE DETERMINED BASED ON DETAILED TOPOGRAPHIC SURVEY.

4/4 TYPICAL FLAP GATE NON-RETURN DETAIL
NTS

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VILLA GRANDE
STORMWATER IMPROVEMENTS
DETAILS
SCALE: AS SHOWN

C6
SHEET 6 OF 6

# Appendix D

## Preferred Alternative HEC-22 Inlet Capacity and Surface Flow Analysis

# VILLA GRANDE INLET CAPACITY AND SURFACE FLOW ANALYSIS (PREFERRED ALTERNATIVES)

| Structure ID | Station | Location | Bypass To | Δ Q cfs (cfs) | Σ Q (cfs) | Slope L (ft/ft) | Super T (ft/ft) | Effective Grate Width (ft) | Effective Grate Length (ft) | Calculated Spread (ft) | Depth of Flow at Face of Curb, d (inches) | Manning's n for Street and Pavement Gutter | Velocity for Gutter Flow (ft/sec) | Ratio of Frontal Flow to Total Gutter Flow $E_o$ | Splash-Over Velocity $V_o$ (ft/sec) | Ratio of Frontal Flow Intercepted to Full Frontal Flow $R_f$ | Ratio of Side Flow Intercepted to Total Side Flow $R_s$ | Effiency of Grate E | $Q_i$ (cfs) | $Q_{bp}$ (cfs) | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WEST STREET** | | | | | | | | | | | | | | | | | | | | | |
| ---------- | *43+10.00* | *West St near East St* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *High Point* |
| SDDI-1 | 41+55.00 | West St at Post Office | SDDI-2 | 1.20 | 1.20 | 0.004 | 0.020 | 1.50 | 5.40 | 9.21 | 2.21 | 0.016 | 1.41 | 0.38 | 4.60 | 1.00 | 0.78 | 0.86 | 1.03 | 0.17 | 4x4 inlet to catch as much as possible just upstream of post office/sag point |
| **SDDI-2** | **41+18.00** | **West St at Post Office** | **N/A (Sag)** | **0.00** | **0.87** | **--** | **0.020** | **1.50** | **2.70** | **6.85** | **1.64** | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | **Sag inlet. Captures flow from southwest and bypass from SDDI-1** |
| ---------- | 40+80.00 | West St at 5th | SDDI-2 | 0.70 | 0.70 | 0.006 | 0.020 | ------------ | ------------ | 6.97 | 1.67 | 0.016 | 1.44 | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | Calcs for approximate gutter flow between high point and CB |
| Ex DI-5th | 40+20.00 | West St at 5th | SDDI-4 | 1.10 | 1.10 | 0.080 | 0.030 | 1.50 | 1.80 | 6.00 | 2.16 | 0.016 | 6.22 | 0.54 | 0.00 | 0.44 | 0.03 | 0.25 | 0.27 | 0.83 | Inlet at Intersection w/5th Ave. Bypass to 5th Ave System |
| **RUSSIAN RIVER AVENUE AND 5TH AVE** | | | | | | | | | | | | | | | | | | | | | |
| ---------- | *6+74.00* | *RR Ave High Point* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *High Point* |
| ---------- | 7+50.00 | RR Ave | SDDI-5 | 0.75 | 0.75 | 0.008 | 0.020 | ------------ | ------------ | 6.78 | 1.63 | 0.016 | 1.63 | ------------ | 1.60 | ------------ | ------------ | ------------ | ------------ | ------------ | Calcs for approximate gutter flow between high point and CB |
| **SDDI-5** | **8+00.00** | **RR Ave at 5th** | **SDDI-5** | **0.10** | **3.15** | **--** | **0.025** | **1.50** | **5.40** | **11.40** | **3.42** | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | **Sag DI on 5th Street (Drainage primarily comes from RR Ave). Provide dual inlet** |
| ---------- | 8+20.00 | RR Ave (Graded) | SDDI-5 | 0.30 | 2.30 | 0.015 | 0.020 | ------------ | ------------ | 9.17 | 2.20 | 0.016 | 2.73 | ------------ | 1.60 | ------------ | ------------ | ------------ | ------------ | ------------ | Calcs for approximate gutter flow between high point and CB |
| ---------- | 10+00.00 | RR Ave | SDDI-5 | 2.00 | 2.00 | 0.006 | 0.020 | ------------ | ------------ | 10.27 | 2.47 | 0.016 | 1.89 | ------------ | 1.60 | ------------ | ------------ | ------------ | ------------ | ------------ | Calcs for approximate gutter flow between high point and CB |
| ---------- | *11+63.00* | *RR Ave High Point* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *High Point* |
| ---------- | *30+75.00* | *5th Ave at RR Ave* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *RR Ave intersection - Start of 5th Street* |
| **SDDI-5** | **30+37.00** | **RR Ave at 5th** | **N/A (Sag)** | **3.15** | **3.15** | **--** | **0.025** | **1.50** | **5.40** | **11.40** | **3.42** | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | **Sag DI on 5th Street (Drainage primarily comes from RR Ave). Same as Above** |
| ---------- | *30+75.00* | *5th Ave High Point* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *High Point* |
| **SDDI-4** | **31+14.00** | **RR Ave Midpoint** | **N/A (Sag)** | **0.50** | **1.33** | **--** | **0.020** | **1.50** | **2.70** | **11.15** | **2.68** | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | **Sag DI on 5th Street (Drainage primarily comes from 5th and West).** |
| ---------- | *32+07.00* | *5th Ave at West St* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *West St intersection - Start of 5th Street* |
| **EAST STREET AND 2ND STREET** | | | | | | | | | | | | | | | | | | | | | |
| ---------- | *62+00.00* | *2nd St at RR Ave* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *Start of 2nd Street - Recieves drainage from Russian River Ave to the northeast* |
| SDDI-7 | 60+00.00 | 2nd St at East St | SDDI-6 | 2.49 | 2.49 | 0.003 | 0.022 | 1.50 | 5.40 | 12.04 | 3.18 | 0.016 | 1.56 | 0.30 | 4.60 | 1.00 | 0.76 | 0.83 | 2.07 | 0.42 | Add inlet to capture some runoff before it reaches East St |
| ---------- | *50+47.00* | *Start East St* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *Start of East Street - Recieves drainage from Russian River Ave to the north* |
| **SDDI-9** | **50+72.00** | **East St at RR Ave** | **N/A (Sag)** | **1.52** | **1.52** | **--** | **0.020** | **1.50** | **4.50** | **9.62** | **2.31** | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | **Sag point - One inlet exists here already. Adding inlet to reduce depth** |
| ---------- | *49+70.00* | *East St at 4th St* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *High Point* |
| ---------- | 50+00.00 | ---------- | Ex DI-East | 0.53 | 0.53 | 0.010 | 0.020 | ------------ | ------------ | 5.69 | 1.37 | 0.016 | 1.62 | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | Calcs for approximate gutter flow between high point and CB |
| **Ex DI-East** | **50+72.00** | **East St at West St** | **N/A (Sag)** | **1.05** | **1.05** | **--** | **0.020** | **1.50** | **3.60** | **8.38** | **2.01** | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | **Sag point - Two inlets exist here already on either side of the road** |
| ---------- | 51+00.00 | ---------- | Ex DI-East | 0.53 | 0.53 | 0.006 | 0.020 | ------------ | ------------ | 6.26 | 1.50 | 0.016 | 1.34 | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | Calcs for approximate gutter flow between high point and CB |
| ---------- | *51+50.00* | *East St High Point* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *High Point* |
| ---------- | 51+80.00 | ---------- | SDDI-6 | 0.16 | 0.16 | 0.012 | 0.020 | ------------ | ------------ | 3.54 | 0.85 | 0.016 | 1.29 | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | Calcs for approximate gutter flow between high point and CB |
| **SDDI-6** | **52+00.00** | **East St at 2nd St** | **N/A (Sag)** | **1.23** | **1.23** | **--** | **0.020** | **1.50** | **5.40** | **7.60** | **1.83** | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | **Sag inlet - 4x4 Inlet** |
| ---------- | 53+50.00 | ---------- | SDDI-6 | 0.65 | 0.65 | 0.005 | 0.020 | ------------ | ------------ | 7.15 | 1.72 | 0.016 | 1.26 | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | Calcs for approximate gutter flow between high point and CB |
| ---------- | *54+00.00* | *East St at 1st St* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | *High Point* |
| **WILLOW WAY AT WEST STREET** | | | | | | | | | | | | | | | | | | | | | |
| ---------- | *N/A* | *High Point on Willow* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | |
| **SDDI-8** | **Not Stationed** | **West St at Willow** | **N/A (Sag)** | **1.60** | **1.60** | **--** | **0.050** | **1.50** | **2.70** | **5.05** | **3.03** | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | **Sag Point - Assumes 50% of flow from MOS2 Drainage Area** |
| ---------- | *N/A* | *High Point on West St* | ---------- | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | ------------ | |

**LEGEND:**

| Formatting | | | | Description |
|---|---|---|---|---|
| [Structure] | XX+XX.XX | [Description] | [Structure] | Rows Highlighted in gray represent inlets on continuous grade. Bypass is calculated to next inlet |
| **[Structure]** | **XX+XX.XX** | **[Description]** | **N/A (Sag)** | Sag Inlet. Flow can come from both directions |
| ---------- | XX+XX.XX | [Description] | ---------- | Rows Highlighted in blue represent gutter spread and depth calculations only (no inlets) |
| ---------- | *XX+XX.XX* | *[Description]* | ---------- | Rows with stations but no calculation represent the start station of calculation (high point or start of road) |

**NOTES:**

1. Flow rates in this spreadsheet have been estimated from 10-year MIKE+ hydrology model peaks
2. Sag inlet spread and depth are calculated assuming inlets are 50% clogged
3. Sag inlet perimeters for calculation of depth and spread are based on perimeter exposed to flow. At the Post Office, inlets will be against a curb and only three sides exposed, while at other locations inlets will be in valley gutters and weir flow will occur around all four sides.
4. Due to its location, SDDI-3 is not analyzed. Runoff primarily goes to SDDI-1 and SDDI-2. Modifications to the West Street system require a deeper system at SDDI-3, which will require a structure
5. Effective Grate dimensions calculated based on percent open area on a bar grate (assumes 75% on the short side, 90% on the long side)