2005 Storm Drainage Master Plan

City of Fortuna California

July 2005

Prepared for:

City of Fortuna
621 - 11th St.
Fortuna, CA 95540

Prepared by:

WINZLER & KELLY
CONSULTING ENGINEERS
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CHAPTER 1 – SUMMARY

1.1 Purpose

This 2005 Storm Drainage Master Plan has been prepared as an update to the City of Fortuna's (City) 1982 Storm Drainage Master Plan. Its purpose is to provide a detailed overview of the adequacy of the major storm drainage facilities serving the City. The 2005 Storm Drainage Master Plan provides the following review and update of the hydrology and hydraulics of the City's storm drainage system:

- A comprehensive description and mapping of the City's storm drain system and facilities;
- Update of the City's Utility Map that shows the locations of existing public storm drains and facilities, size of pipelines, and pipe material in electronic format;
- An assessment of the capacity of the existing creeks, channels, culverts and closed conduits having diameters 12 inches and larger;
- Identification of existing and future system deficiencies;
- Recommendations on upgrades required;
- Opinion of the probable cost of these upgrades, and financing options;
- A detention basin, creek, and channel maintenance program.

1.2 Methodology

This 2005 Storm Drainage Master Plan began with an updated identification of the study area and drainage boundaries defined in the 1982 Storm Drainage Master Plan, as well as the development of critical hydrology parameters, such as design storms and land use patterns. Included in this study were the waterways that flow through or adjacent to the City. The study area was defined as the City Limits and that area which drains into the City Limits.

Land use mapping was obtained from the City of Fortuna. The design storms used in the study were established based upon the intensity-duration-frequency (IDF) curves for Fortuna, which were also used in the 1982 Storm Drainage Master Plan. These study area characteristics are described in Chapter 3.

Hydrologic modeling was performed using the Rational Method, which provided the design flows for this Master Plan update. The 1982 analysis was updated to reflect the changes in land use as identified by the current land use map, and a conservative, yet more realistic approach to modeling runoff was used. Hydraulic modeling of major open channels was performed using HEC-RAS. Closed-conduits and drainage structures were modeled using Haestad Methods' StormCAD and FlowMaster. Detention ponds were modeled using Haestad Method's POND-2. Chapter 4 is devoted to a description of the design criteria used in the hydrologic and hydraulic study, and Chapter 5 contains a detailed discussion of hydraulic results.

1.3 Proposed Improvements

The analysis indicates that 79 drainage structures within the City of Fortuna are undersized for the 25-year design flow. These deficiencies were combined into 55 recommended improvement projects. The specific recommendations, including figures and opinion of probable costs, are discussed in detail in Chapter 5. Winzler & Kelly's opinion of the probable cost of the top 25 priority projects is approximately $9,013,000. Winzler & Kelly's opinion of the probable cost of all 55 improvement projects is approximately $14,787,000. It should be noted that, where appropriate, alternatives for the proposed improvements are also included and reflected in the total cost. The reason for the alternatives is to achieve the same purpose of relieving the existing system and increasing the capacity to contain the 25-year flow, but at less cost. Rather than replacing an undersized pipe with a larger one, the alternatives achieve design capacity by installing new storm conduits parallel to existing undersized conduits. Chapter 5 provides a prioritization of these improvements.

1.4 Recommendations

It is recommended that this Storm Drainage Master Plan be adopted as a guide for construction of future drainage improvements. The Capital Improvement Program, outlined in Chapter 5, provides a prioritized ranking of the recommended projects, and outlines the components of each project, and the total project cost for all projects. Due to the importance of some projects over others, it is suggested that projects are completed in the order recommended in the Capital Improvement Program. Methods of financing the proposed projects are discussed in Chapter 6.

It should be noted that the recommended drainage facilities are based on the City's current 5-Year Capital Improvements Program, along with suggestions from the City staff. Should future development be planned that will significantly change the land use, appropriate measures should be taken to design and size those drainage facilities that may be affected. They must have the capacity needed for the modified land uses, without causing or increasing existing drainage problems for downstream property and the existing storm drain system.

Winzler & Kelly Consulting Engineers (Winzler & Kelly) recommends a channel and detention basin maintenance program to maintain the capacity of the City's detention basins, drainage ditches and channels. The channel maintenance program is discussed in more detail in Chapter 5.

1.5 Acknowledgement

The input and feedback from Mr. Wayne Yazzolino, Superintendent of Streets, Water, and Storm Drains, Mr. Bruce Gehrke, Superintendent of Water and Sewer, Mr. Jedd Short, Engineering Technician, Ms. Evelyn Plessinger, Engineering Technician, and Mr. Christian Engelhardt, Engineering Technician, was extremely valuable in completing this document. Thank you all for your assistance.

CHAPTER 2 – INTRODUCTION

2.1 Project Background and Purpose

2.1.1 Background

The City of Fortuna is located on the California North Coast, 225 miles north of San Francisco. The City is located adjacent to the Eel River, which lies to the west, and encompasses approximately 3,060 acres. A location map of the City is shown in Figure 2-1. The dominant physiographic features of Fortuna are the Eel River flood plain bounding the southern and western edges of the study area, and rising hills and mountains on the northern and eastern boundaries of the study area. There are a number of natural streams that traverse the study area. The majority of these top their banks during periods of heavy runoff. Most of the City lies between Rohnerville Road to the east and U.S. Highway 101 to the west. The City is largely rural in character with a central downtown commercial and business district surrounded largely by residential lands.

The City of Fortuna's downtown storm drainage system consists primarily of reinforced concrete pipe (RCP) and corrugated metal pipe (CMP) with diameters ranging from 8" to 54". There are also older box culverts and cross drains at intersections. Since the mid-1980's, several subdivisions have been constructed with storm drains consisting of RCP, corrugated metal pipe (CMP), and N-12 high-density polyethylene (N-12) pipe with diameters ranging from 12 to 48 inches.

The primary natural waterways in Fortuna are Rohner Creek, Hillside Creek, Strongs Creek, Jameson Creek, and Mill Creek. These creeks are primarily in their natural, unchannelized state, and all join Strongs Creek before flowing into the Eel River. In the rural areas surrounding the City, the storm drainage system consists largely of roadside ditches and culverts. The City's stormwater flows by gravity to the above-mentioned creeks before discharging to the Eel River. The North Fortuna area discharges directly to the Eel River (refer to Figures 5-2 through 5-21 for discharge locations).

2.1.2 History

Historically, the City of Fortuna has experienced flooding problems in central downtown area during somewhat minor storms due to an undersized storm drainage system, the City's proximity to the Eel River, and the level of flow in the Eel River. In November 1974 at the request of the City of Fortuna, the Humboldt County Board of Supervisors, acting upon recommendations of the Humboldt County Flood Control District Subzone 1-1 Technical Committee authorized an engineering study directed towards the development of a master drainage plan for District 1-1.

The report was divided into two separate studies and completed in January 1976. Part A consisted of a master drainage plan for the Rohner Creek and Hillside Creek drainages. Part B consisted of a master drainage plan for the Strongs Creek and Jameson Creek drainages. Potential runoff flows for 10-year and 100-year storms were determined at certain nodal points and existing problems were identified. Solutions to the problems were proposed and cost estimates for these solutions were calculated.

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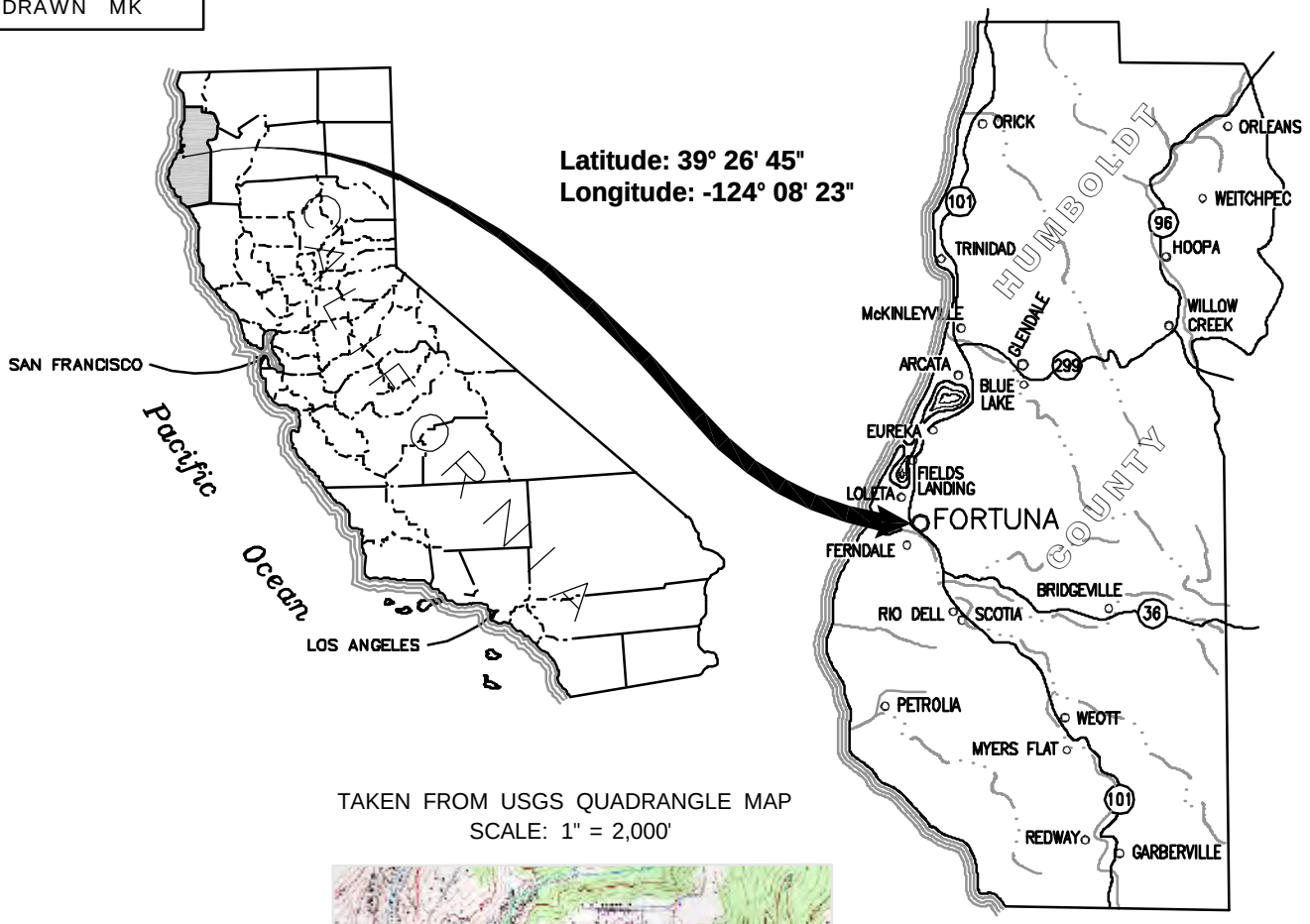

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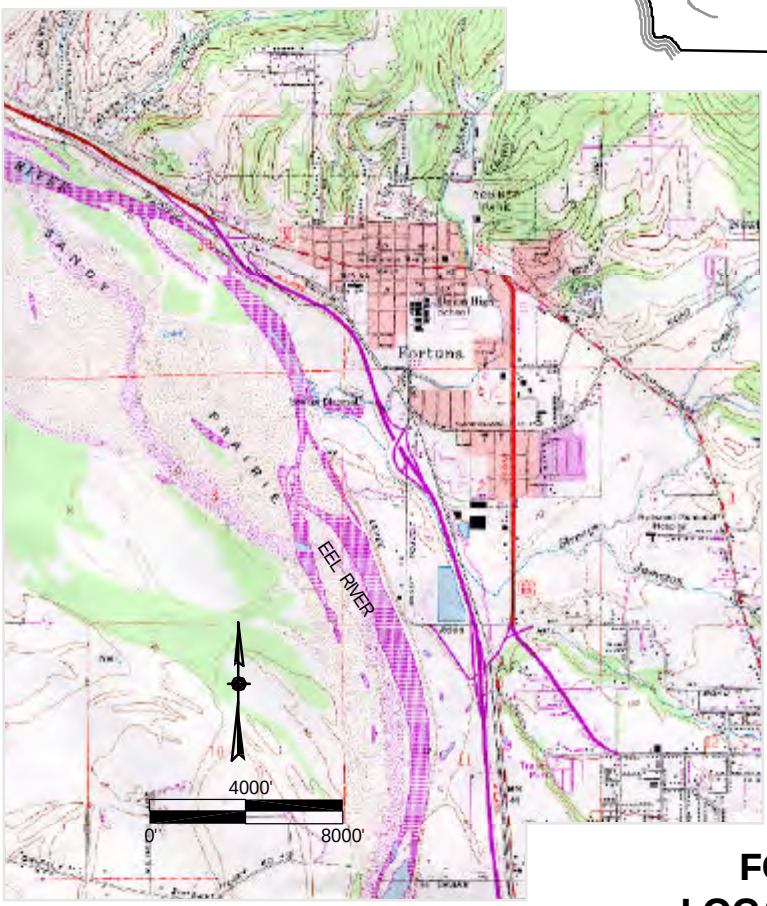


CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN

FORTUNA LOCATION MAP

FIGURE 2-1

WINZLER & KELLY

A General Plan for the City of Fortuna was completed in 1978, which included a proposed land use plan.

In 1982 Winzler & Kelly completed a Storm Drainage Master Plan to aid the City in solving the existing stormwater drainage problems and to plan for expanded growth within the City and outlying areas. This plan included the updating of the two existing drainage plans for subzone 1-1, and took into account the proposed land use as well as the existing and proposed zoning in developing the storm water runoff calculations.

In 2005 the City will begin the process of updating its General Plan. The current General Plan contains only two elements. In the updated General Plan the City intends to explore opportunities for future annexations, compose guidelines for commercial and residential development, and rezone some existing areas within the City.

The City would like to solve the remaining stormwater drainage problems as well as plan for continued growth within the City and expanded growth in the City's outlying areas. To accomplish this, the City of Fortuna has contracted with Winzler & Kelly to develop a Storm Drainage Master Plan update with a Capital Improvement Program.

2.1.3 Purpose

This drainage plan takes into account the land use element of the current General Plan as well as the existing and proposed zoning and the study area in developing the stormwater runoff calculations. The objectives of this Storm Drain Master Plan are to:

- Provide a comprehensive description and mapping of the City's storm drain system including creeks, channels and ditches;
- Update the City's Utility Map that shows locations of public storm drains and facilities, size of pipelines, pipe material and flow directions;
- Create a computerized hydraulic model of critical elements of the storm drain system that has the City's Utility Map as its base;
- Evaluate the storm drain and channel systems in order to identify existing and future deficiencies;
- Evaluate deficiencies in the channel and detention basin maintenance program;
- Prepare engineering cost estimates for up to 25 identified improvement projects.

2.1.4 Scope of Work

The Scope of Work for the 2005 Storm Drainage Master Plan included the following tasks:

Review of Existing Data/Establish Critical Parameters: Winzler & Kelly gathered and reviewed existing information, determined critical factors that were expected to influence the hydrology and hydraulic modeling analyses, and identified local conditions that may impact the ability of the storm drainage system to alleviate flooding. Previous reports, as-built records, construction reports and O&M data were reviewed, as available. Historical rainfall information,

channel flow capacities, and stream flow records were also obtained. Based upon the findings of the data review, Winzler & Kelly performed a preliminary delineation of subwatersheds and defined the critical modeling parameters.

Mapping and Field Verifications: Winzler & Kelly conducted field investigations to verify existing storm drain systems, typical cross-sections of waterway channels, roadside ditches and culverts, and evaluated the condition of major drainage structures. Flow directions of pipelines and overland runoff were verified where the existing data was questionable. To maximize the value of work already completed by the City, the AutoCAD Utility Map prepared by City staff was used to develop the base map required for this study. The Utility Map contains the following:

- City Land Use Designations from the 1978 General Plan;
- Locations of public storm drains and facilities, size of lines and pipe material;
- Locations of creeks, stormwater channels, and detention basins;
- Elevations of selected facilities and structures, as surveyed by City staff, or obtained from as-built records.

Hydrologic and Hydraulic Modeling: Winzler & Kelly used the hydrologic analysis completed as part of the 1982 Storm Drainage Master Plan to provide design flows for this Master Plan update. The original hydrologic analysis was revisited to verify where runoff may have changed based on anticipated changes in land use and where flooding currently occurs as identified by the City staff. Additional modeling and calculations were performed to develop solutions and validate the City's 2005-2009 CIP planned drainage projects.

The City's storm drain system was modeled using Haestad Methods' StormCAD and FlowMaster for closed-conduit segments and drainage structures, the Hydrologic Engineering Center's (HEC's) HEC-RAS for open-channel segments, and Haestad Methods POND-2 for detention ponds. The following data served as input to the hydraulic models:

- City topographic data was used to estimate water channel invert elevations and slopes;
- As-built records and the City Utility Map were used to obtain manhole rim elevations, drop inlet grate elevations, and invert elevations;
- Elevations for select manholes and drop inlets were collected by City staff;
- Channel and roadside ditch cross-section measurements were obtained during the field investigations.

Identification of System Deficiencies: Hydraulic structures are sized to convey the maximum anticipated runoff of an area, which occurs when the building density of upstream areas reach "build-out conditions", the maximum development allowable within the zoning designation. In this study, the design flow calculations were based upon the assumption that the upstream drainage area has reached build-out conditions. Hydraulic capacity was modeled using StormCAD, FlowMaster or HEC-RAS. From the modeling efforts hydraulic deficiencies within the storm drain system were identified. Each deficiency was evaluated to determine if the model result was realistic. For drainage facilities identified as undersized, the drainage area upstream of the structure was evaluated to determine whether build-out capacity has been attained. We also

used the model to validate the proposed projects identified by the City in the 2005-2009 CIP. Undersized structures that are located in areas that have reached build-out capacity were given a higher priority for improvement than those located in areas where more development is anticipated.

Prepare Capital Improvement Program: Winzler & Kelly prepared a Capital Improvement Program (CIP) based on recommended system improvements identified during field investigations and hydraulic modeling efforts and incorporating the projects in the City's 2005-2009 CIP. The CIP identified storm system replacement projects and growth-related projects, and included a prioritized listing of each of the projects. Replacement projects are considered those located in areas with little or no anticipated future development. Growth-related projects are considered those resulting from the increased runoff associated with future development. The CIP should become a tool that is used by the City to plan subsequent work, and includes the following key elements:

- Accurate identification of all required improvement projects;
- Prioritization of projects according to an established set of criteria that is acceptable to City staff;
- Our opinion of probable construction costs, based on real-world data obtained from similar public works projects;
- Recognition of potential future regulatory changes that impact management of the storm drainage system.

Financing Plan: Winzler & Kelly presented the City with a wide range of options for funding the improvements. In addition to fees, assessments, and bonds some of the funding sources that were evaluated include Rural Development loan/grant combinations, Community Development Block Grants, Economic Development Administrative Grants, and State Revolving Fund loans.

Phase II Stormwater Best Management Practices (BMP): Fortuna is subject to the requirements of the NPDES Phase II regulations as a State-designated municipal separate storm sewer system (MS4). The City of Fortuna is currently working with the Region I – North Coast Region office of the SRWQCB on implementing a Phase II NPDES stormwater program, which contains the NPDES General Permit, recommended Best Management Practices (BMPs), and six required Minimum Control Measures.

Prepare Storm Drainage Master Plan Update: Winzler & Kelly gathered the evaluations, analyses and recommendations performed in the previous tasks and document them in a Draft 2005 Storm Drainage Master Plan. After review by the City staff and then by the City Council the 2005 Storm Drain Master Plan Update Report was finalized and adopted by the City.

CHAPTER 3 – STUDY AREA CHARACTERISTICS

3.1 Introduction

The purpose of this chapter is to describe pertinent physical, demographic, environmental, and economic characteristics of the study area to provide a basis for the update of this 2005 Storm Drainage Master Plan. This chapter defines the study area and drainage boundaries needed for the hydrologic analysis. It also develops the land use information used to calculate runoff coefficients, and it outlines the hydrologic patterns that form the basis for the selection of intensity-duration-frequency curves. Included are descriptions of the geographical setting, economic activity, population, environmental setting, and institutions within the study area. In addition, this chapter includes a description of the significant changes in land use within the study area since the 1982 Storm Drainage Master Plan.

3.2 Study Area Boundaries and Composition

The project study area is the area located between the Rohner Creek and Mill Creek drainages in Humboldt County, as shown in Figure 3-1. The project study area is that area which is within the City Limits and drains into the City Limits. The project study area encompasses approximately 11,350 acres including the City of Fortuna and outlying areas within the drainage boundaries that affect the City.

The City of Fortuna is divided into 6 drainage basins. The drainage basin names and assigned primary node numbers are listed below.

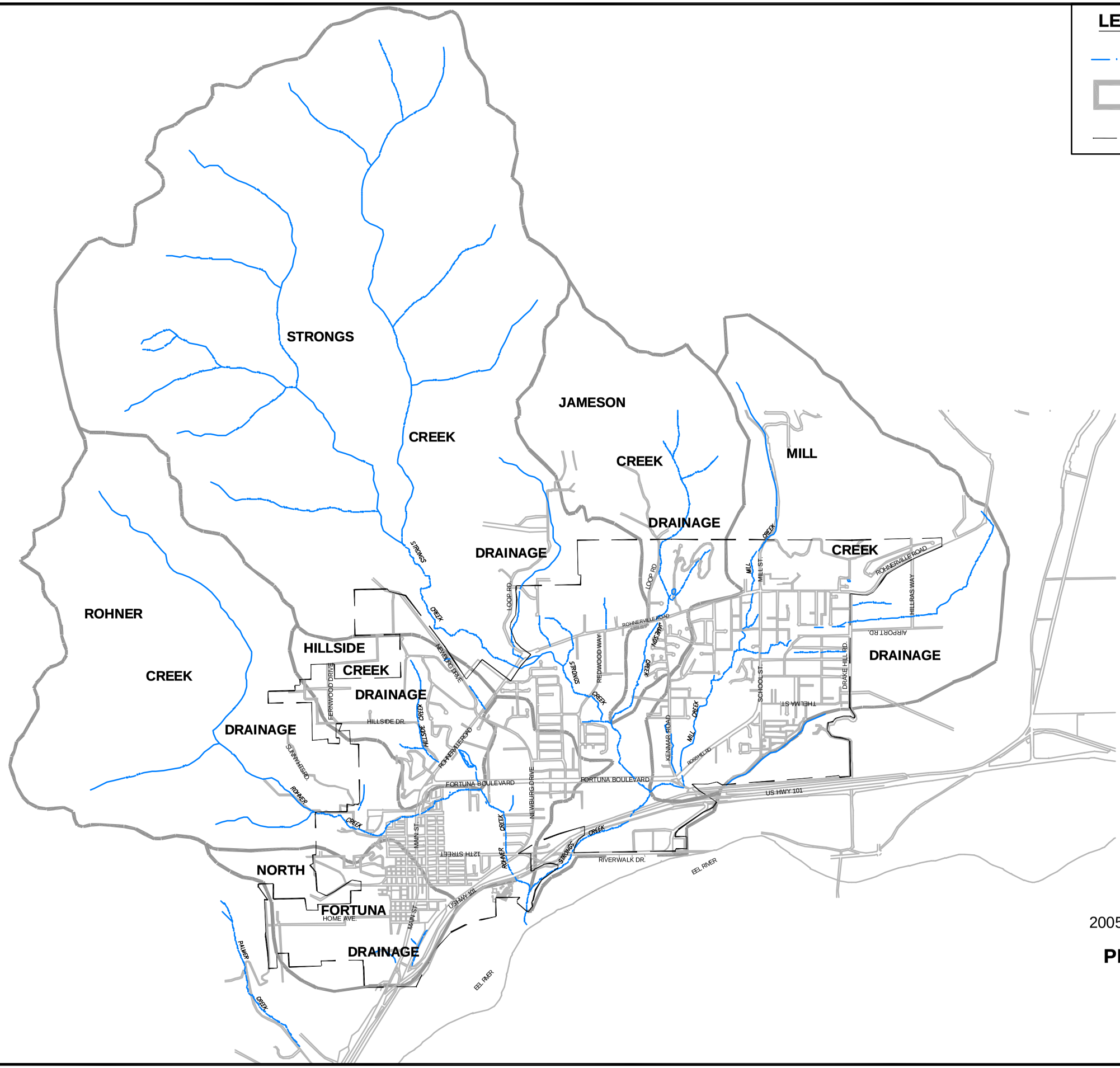
1. North Fortuna Drainage
2. Rohner Creek Drainage
3. Hillside Creek Drainage
4. Strongs Creek Drainage
5. Jameson Creek Drainage
6. Mill Creek Drainage

The drainage basin boundaries are shown in Figure 3-1. Each drainage basin drains to the designated creek, with the exception of the North Fortuna Drainage, which drains directly into the Eel River. All drainages ultimately flow to the Eel River.

3.3 Geographical Setting

3.3.1 Topography and Drainage

The elevation of the study area varies from approximately 20 feet mean sea level (MSL) at Rohner Creek's confluence with the Eel River, to over 1,700 feet (MSL) to the east in the Rohner Creek and Strongs Creek watersheds. The majority of the City is located on a relatively flat terrace ranging between 40 feet and 75 feet in the north and central portions of the City, to approximately 350 feet in the Forest Hills Subdivision and Upper Hillras Road areas.



LEGEND

CREEKS AND STREAMS

DRAINAGE BASIN BOUNDARY

CITY LIMITS

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0 3000' 6000'

SCALE 1"= 3000'

CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN

PROJECT STUDY AREA AND DRAINAGE BASINS

FIGURE 3-1

WINZLER & KELLY
633 THIRD ST., EUREKA, CA

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The major natural drainages in the study area from north to south are Rohner Creek, Hillside Creek, Strongs Creek, Jameson Creek, and Mill Creek. To the north and just outside of the study area is Palmer Creek.

Strongs Creek is the largest natural drainage in Fortuna. The other creeks are all tributaries to it. Strongs Creek generally flows from east to west through the central low lying plain of Fortuna and somewhat south of the urban core.

Rohner Creek and its tributary Hillside Creek flow from the north and east through the City core area before joining with Strongs Creek west of U.S. Highway 101 just upstream of Strongs Creek's confluence with the Eel River. Rohner Creek is known to flood its banks during periods of high runoff, particularly in the area between Main Street and Newburg Drive.

Jameson Creek is a tributary to Strongs Creek, paralleling Loop Road and flowing into Strongs Creek approximately 2,700 feet west of Rohnerville Road.

The southern most drainage system in the study area is Mill Creek. It is a relatively small drainage that closely parallels Mill Street east of Rohnerville Road. It crosses Rohnerville Road approximately 200 feet north of the School Road-Mill Street intersection. It continues northwest crossing Fortuna Boulevard at the Kenmar Road-Ross Hill Road intersection, and flows into Strongs Creek just east of U.S. Highway 101 and north of Kenmar Road.

Flows from the Campton Heights area and south of Drake Hill Road travel north in a series of natural channels and storm drains. The majority of these discharge into Mill Creek north of School Road.

The Eel River borders the western edge of the study area, and is susceptible to frequent flooding as a result of a number of factors, including high precipitation and surface runoff in its upper reaches, the presence of low, broad alluvial flats in the lower reaches, and a reduction in channel capacity due to upstream erosion and sedimentation. As a result of major flooding events in the past 75 years damage to the City of Fortuna has been extensive. Much of U.S. Highway 101 and portions of downtown Fortuna have been flooded. Levees were constructed along the river by the Corps of Engineers to an elevation above the 1955 high water mark. These levees were overtopped by the 1964 flood, and have not been reconstructed to the 1964 high water mark.

3.3.2 Soils

The soil in the study area is predominantly fine to coarse sandy loam in the north to silty clay loam in the south, but it includes some fine river washed sand and some gravel.

3.3.3 Vegetation

A woodland prairie vegetative community characterizes the major portion of the undeveloped property in Fortuna at present. The immediate hills are generally grassy with redwood and Douglas fir timber.

The plateau area south of the Fortuna core area is in a state of development. It is generally characterized by pasture land with riparian woodlands and dense berry thickets and brush along the creeks.

Several species of anadromous fish are present in the various creeks in the study area. Coho salmon and steelhead have been reported in Rohner Creek, Strongs Creek, and Mill Creek. The California Department of Fish and Game monitors these creeks for the presence of anadromous fish.

3.4 Climate

The climate is moderate with the predominant weather factor being the moist air masses from the Pacific Ocean. Average annual rainfall in Scotia, 10 miles south of Fortuna is approximately 48.5 inches, with the major portion falling between October and April (Table 3-1).

TABLE 3-1 AVERAGE MONTHLY CLIMATE[1]

Month	Precipitation (inches)	Maximum Temperature (F)	Minimum Temperature (F)	Average Temperature (F)
January	8.96	55.2	40.1	47.6
February	7.54	57.3	41.4	49.1
March	6.68	58.3	42.3	49.9
April	3.43	60.2	44.2	52.0
May	1.70	63.2	47.6	55.1
June	0.60	66.3	50.9	58.1
July	0.07	69.0	52.6	60.6
August	0.24	70.2	53.0	61.3
September	0.62	70.9	50.8	60.1
October	2.99	67.2	47.7	56.3
November	6.36	60.5	44.0	50.9
December	9.29	55.6	41.0	47.1

[1]Period of record (1/ 9/1931 to 12/31/2004); from the Western Region Climate Center, National Climatic Data Center Station Historical Listing for National Weather Service Cooperative Network, Scotia, California, Department of Commerce, NOAA, 2005.

The daily temperature extremes range from the low-twenties to the high nineties, with an annual mean temperature of 54.6°F.

3.5 Hydrology

Stormwater master planning and the design of drainage facilities are highly dependent on the selection of the "design storm." This storm, typically expressed in terms of its expected *recurrence interval* (e.g., 10 years), is used to determine rainfall intensity. The recurrence interval, also called a *return period* or *event frequency*, is the length of time expected to elapse between rainfall events of equal or greater magnitude. For example, a 10-year recurrence interval represents a storm event that is expected to occur once every 10 years, on average. This does not imply that two storm events of that same size will not occur in the same year, nor does it mean

that the next storm event of that size will not occur for another 10 years. Rather, a 10-percent chance of occurrence exists in any given year. The length of the design storm also affects storm flows and runoff. In this study intensity-duration-frequency (IDF) curves are used to determine rainfall intensities for expected recurrence intervals and durations.

3.6 Land Use and Planning

Land use patterns also affect stormwater master planning efforts because the rate at which stormwater runs off, as opposed to the amount that percolates into the soil, is proportional to the amount of impervious area in a watershed. For long-term planning efforts, it is important to look not only at current development, but also at ultimate land use according to the City's 1978 General Plan. Storm drain infrastructure is intended to provide service for 50 to 100 years, and facilities must be designed to accommodate future development in a watershed.

3.6.1 Land Use

Land uses within the project study area are representative of a growing urban center surrounded by a rural community with some light industry and residential shopping.

The City of Fortuna 1978 General Plan establishes policies for all land within the Fortuna City limits. The main goal of the 1978 General Plan was to address the development of a residential community and shopping center for southern Humboldt County with potential for light industrial expansion. The current 2002 Zoning Map, shown as Figure 3-2, delineates a high density and commercial core in the downtown area with medium and low density residential areas to the northeast and south and industrial development to the west. While not within City Limits, the area south of Drake Hill Road in the Rohnerville Airport area is designated as agricultural with the potential for industrial development. Discussions with the City planning staff indicated that long-range rezoning may occur in specific areas, such as the area south of Drake Hill Road and the Pacific Lumber Fortuna mill site, and will be addressed in the City's planned update of its General Plan in 2005/2006. One of the most significant policy changes that will be addressed in the General Plan update is the reclassification of the Pacific Lumber industrial lands east of U.S. Highway 101. These lands, which were classified in the 1978 General Plan as Heavy Industrial, may be reclassified to allow for commercial and residential development. Any improvements of the Pacific Lumber site and areas south of Drake Hill Road need to be evaluated in the context of its effect on storm drainage (refer to Section 5.6).

Discussions with the City staff indicate increased growth in the areas east of Rohnerville Road and south of Drake Hill Road. Development in these areas is beginning to affect drainage within the City. This growth, and additional future growth, is taken into account when developing projected stormwater flows.

3.6.2 Economic Activity

Historically, unemployment in Humboldt County has averaged about 7.6 percent since 1990, which is about 0.7 percent higher than the state average, and is presently 0.9 percent higher than the state average. Much of the economic activity in Humboldt County shows seasonal trends.

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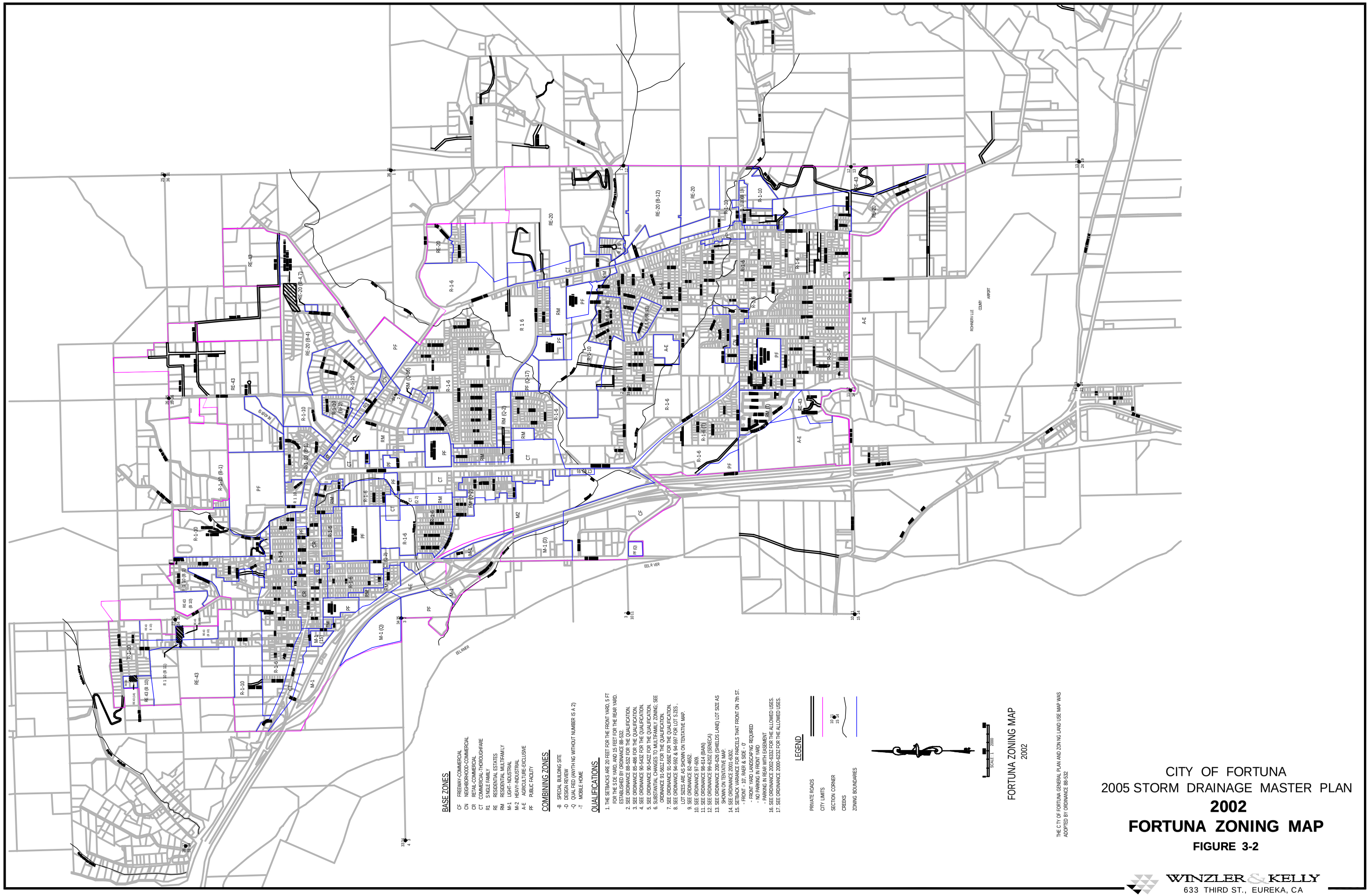


CITY OF FORTUNA

2005 STORM DRAINAGE MASTER PLAN

2002

FORTUNA ZONING MAP

FIGURE 3-2

WINZLER & KELLY

633 THIRD ST., EUREKA, CA

Logging and tourism are greatly reduced during the rainy season, and the secondary sector is affected as a result. Timber, agriculture, tourism and government form the economic backbone of the area. However, with the closing of the Pacific Lumber Fortuna mill in June 2005 and new timber restrictions, the economic influence of the timber industry is dwindling, and its future is uncertain.

In spite of a shifting economic base, the City serves as the commercial, educational, medical and professional service center for much of the surrounding area. Tourism is steadily becoming an increasingly important part of Fortuna's economic base, and according to state employment projections, services, retail trade, and tourism will have the largest growth during the forecast period.

3.6.3 Population and Population Characteristics

3.6.3.1 General

According to U.S. Census Bureau estimates, Humboldt County has a current population of approximately 130,000 (based on 2000 U.S. Census Bureau data). Approximately 8.5 percent of the County resides within the Fortuna City limits, totaling 11,100 people. The population within the study area is somewhat higher due to development outside the City limits.

3.6.3.2 Growth and Population Projections

According to the U.S. Census Bureau, the estimated annual growth rate for Humboldt County is about 1-2 percent per year. Much of the population growth is attributed to in-migration, especially of people from the larger metropolitan areas located to the south.

Based on the State of California, Department of Finance "*Population Projections by Race/Ethnicity, Gender and Age for California and Its Counties 2000-2050,"* Sacramento, California, May 2004, the estimated population growth for Fortuna through the year 2050 is given in Table 3-2. The population decrease at 2040 results from model projections of low birth and migration rates in Humboldt County. These estimates are scaled from population projections for Humboldt County, and assume approximately 9.5 percent of the county lives in Fortuna.

TABLE 3-2 POPULATION PROJECTIONS WITHIN THE INCORPORATED AREA OF FORTUNA

Year	Estimated Population
1990	8,788
2000	10,500
2005	11,100
2010	12,650
2020	13,250
2030	13,530
2040	13,420
2050	13,270

3.6.4 Institutions within the Project Study Area

3.6.4.1 Municipalities

The study area consists of the City of Fortuna and surrounding outlying areas. Urban services within the project service area are divided between two agencies: the City of Fortuna Department of Public Works and the Humboldt County Department of Public Works. The City of Fortuna Department of Public Works provides sewer and water services for the majority of the developed area within the developed area of the City. The City of Fortuna is also responsible for the storm drainage system, street maintenance, and street lighting.

3.6.4.2 Planning Agencies

Planning within the service area is provided by the following agencies:

- City of Fortuna Planning Department within City limits.
- Humboldt County Planning Department outside the City limits.
- California Coastal Commission.

The City of Fortuna is responsible for establishing current zoning within the majority of the study area.

The Coastal Zone boundary parallels U.S. Highway 101 to the west at the north edge of the City limits. It runs south and parallels the eastern edge of the Eel River along the levee, coming back to U.S. Highway 101 at the Kenmar Road exit. Little if any of the study area is within the Coastal Zone. Any work done within the Coastal Zone will likely require prior approval from the California Coastal Commission.

CHAPTER 4 – STUDY METHODOLOGY

4.1 Introduction

One of the primary purposes of this study is to develop and update criteria applicable to the design of the drainage facilities. This chapter reviews existing data including previous design and construction reports, improvements completed since the 1982 Storm Drainage Master Plan, mapping and planning documents, and establishes pertinent design criteria. Chapter 5 discusses the hydraulic modeling results and highlights deficient drainage systems. Chapter 5 also presents the recommended storm drainage improvements and the Capital Improvement Program (CIP).

4.2 Land Use Classifications

4.2.1 Existing Land Use

The existing land use within the study area is characteristic of a developing urban center surrounded by residential development (refer to Figure 3-2). Areas to the south and east are in a developing state.

The most densely populated area occurs between Main Street and Newburg Road west of Fortuna Boulevard. There is substantial commercial development within this core area, which serves as the major shopping center for southern Humboldt County. Radiating outwards from this core area, development moderates to medium density and finally light density. Development density is increasing in southern and eastern Fortuna.

The Pacific Lumber Company currently owns the area bounded by Newburg Drive, Fortuna Boulevard, Kenmar Drive and U.S. Highway 101. Pacific Lumber maintains their own drainage facilities; therefore, the drainage facilities for this area will not be considered in this study. It should be noted that Pacific Lumber intends to sell this property in the near future. Any plan to develop this property should include a drainage facilities plan that can incorporate the results of this report as directed by the City.

4.2.2 Future Land Use

Future land use should follow the existing land use plan with a trend toward increasing densities as development warrants (refer to Figure 3-2).

4.3 Drainage Basin Delineation

Drainage basins provide the basis for all hydrologic calculations in this study. The drainage basins that were delineated in the 1982 Storm Drainage Master Plan are also used in this 2005 Storm Drainage Master Plan update. The basin boundaries were adjusted prior to performing any analyses so they reflect current drainage conditions and include any new areas impacting the existing and future drainage. Basin areas for this 2005 Master Plan were adjusted using information obtained from field investigations and topography based on the USGS 1:24,000 series Quadrangle maps for the Fortuna area (40-foot contour intervals).

4.4 Data Review

The 1982 Storm Drainage Master Plan and the City Utility Map were used as a starting point for analyzing the existing drainage facilities. Previous drainage studies and as-built plans for improvements made to the storm drain system since 1982 were obtained from City staff. Drainage facilities and their contributory watersheds in the County land were identified from USGS mapping.

4.5 Field Investigations

Once the map and data review was complete, the identified drainage facilities and their contributory watersheds were verified in the field and through conversations with City staff. The maps presented in Chapter 5 of this 2005 Master Plan reflect the results of this effort.

Several of the drainage channels were photographed during the field investigations. The dimensions of the channels were obtained from the 1982 Drainage Study, and also measured at critical areas. This information was compiled for use in developing Manning's "n" values for the subsequent modeling effort.

4.6 Design Criteria

Prior to the 1982 Storm Drainage Master Plan, the City had a policy to design the majority of storm drainage facilities to pass the flow from a 10-year storm event with no surcharging of pipes. In the 1982 Storm Drainage Master Plan the City requested the design of the stormwater facilities to be such that they will pass the 25-year storm with no surcharge or overtopping of stream banks. The system must also pass the 100-year storm while maintaining all flows in the streets, resulting in no major flooding damage. The 25-year design storm has a minimum average recurrence interval of twenty-five years, or a four percent chance (on average) of occurring in any given year. This design criterion is also used in this updated 2005 Storm Drainage Master Plan.

4.7 Flood Zones

The Federal Emergency Management Agency (FEMA) requires the City to set the minimum standards for development in the 100-year floodplain. No development is allowed in the actual floodway, which is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment in order that a 100-year flood may be carried without substantial increases in flood height. In addition, any development in the floodway fringes cannot cause more than a one foot rise in flood heights, and any such development requires that the "habitable floor" of any structure be at least one foot above the 100-year peak flood elevations. The majority of the City is situated above the 100-year floodplain.

4.8 Hydrology Model

The hydrology model predicts the volume of flow generated at any point in the watershed from the defined rainfall event. Nodes were located at critical drainage facilities. A node represents a location where runoff rates were calculated. The City of Fortuna is divided into 6 drainage basins. The drainage basin names and assigned primary node numbers are listed below.

1. North Fortuna Drainage Basin
2. Rohner Creek Drainage Basin
3. Hillside Creek Drainage Basin
4. Strongs Creek Drainage Basin
5. Jameson Creek Drainage Basin
6. Mill Creek Drainage Basin

All nodes were designated based on the drainage basin tributary to them. For example, Node 1.1 is in the North Fortuna Drainage Basin, and node 4.11.2 is in the Strongs Creek Drainage Basin. Each drainage basin in the study area was divided at nodes into sub-basins. The drainage basin boundaries were presented in Figure 3-1.

4.8.1 Rational Method

The Rational Method is the most widely used method in the U.S. for computing quantities of stormwater runoff. It allows consideration of local conditions and relates runoff directly to rainfall by the following equation:

$$Q = C \cdot i \cdot A$$

where: Q = peak runoff rate in cubic feet per second.

C = runoff coefficient, the ratio of the peak runoff rate for particular surface types and permeabilities to the average rainfall rate for a period known as the time of concentration.

i = average rainfall intensity in inches per hour for a period equal to the time of concentration.

A = drainage area in acres.

The Rational Method makes the following assumptions:

1. The rainfall intensity is uniform over the entire drainage area during the entire storm duration.
2. The maximum runoff rate occurs when the rainfall lasts as long or longer than the time of concentration.
3. The time of concentration is the time required for the runoff from the most remote part of the watershed to reach the drainage outlet or point under design.

4.8.2 Runoff Coefficient

Because runoff is directly proportional to the value assigned to "C", the proper selection of this value is critical for stormwater runoff calculations. Care should be exercised in selecting its value as it incorporates all of the hydrologic extractions, surface imperviousness and antecedent conditions.

As development increases, the amount of runoff also increases. Runoff coefficient "C" values selected for this report are based on those used in the 1982 Storm Drainage Master Plan and the land use designations described in the City of Fortuna 2002 Zoning Map (see Figure 3-2), and are listed in Table 4-1. The values of the runoff coefficients "C" for each land use type have been updated to reflect the most recently approved land use zoning.

The values for "C" listed in Table 4-1 are somewhat conservative because they assume maximum build-out in the associated zone. Substantial portions of rural and low-density areas may or may not develop to full potential. However, it is difficult to determine where growth will or will not occur. Because the costs of stormwater drainage systems are very expensive, it is generally preferable to size the system for the maximum development rather than upsizing later at additional cost. Less than maximum development, for example to a level of 80-percent, would have a relatively minor effect in overall storm flows. As an example, it can be expected that the case of 80-percent development could result in up to a one pipe size reduction for that area.

TABLE 4-1 RUNOFF COEFFICIENTS "C"

Land Use Designation	Runoff Coefficient "C"
Residential	
RE-43—Residential Estates (1 acre min.)	0.35
RE-20—Residential Estates (1/2 acre min)	0.40
R-1-10—Residential Single Family (10,000 ft^2 min.)	0.45
R-1-6— Residential Single Family (6,000 ft^2 min.)	0.55
RM—Multi-Family Residential, Restricted (6,000 ft^2 min.)	0.65
Commercial	
CR—Retail-Commercial	0.85
CN—Neighborhood-Commercial	0.85
CF—Freeway-Commercial	0.85
CT—Commercial-Thoroughfare	0.85
Industrial	
M-1—Light Industrial	0.85
M-2—Heavy Industrial	0.90
Other	
A-E—Agricultural Exclusive (2-1/2 acre min.)	0.30
PF—Public Facilities	0.85
Open Space—Forest and Watershed	0.20

The land use zoning used in this study is assumed to be the most dense that could occur in the future under the current land use plan. It is important that during the actual design stage, the current land use zoning for the specific site in question be re-evaluated if it has changed since this study.

4.8.3 Rainfall Intensity and Duration

An accurate measure of rainfall intensity and its duration for an expected recurrence interval is necessary to determine stormwater flows for a particular area. Long-term precipitation data for Scotia, 10 miles south of Fortuna, are available from the Western Region Climate Center (refer to Table 3-1). The rainfall intensity-duration-frequency (IDF) curves used in the 1982 Drainage Study from the California Department of Water Resources were again used in this study. The IDF curves are generated for the 10-year, 25-year and 100-year events from precipitation data for the City of Fortuna. These curves are shown in Figure 4-1.

For detention basin sizing, the 25-year 24-hour precipitation total was used. For the City of Fortuna, this event corresponds to a precipitation depth of approximately 5.8 inches. Isopluvials of 25-year 24 hour precipitation for the Fortuna area are shown in Figure 4-2. Detention basins are discussed later in this section.

4.8.4 Time of Concentration

The time of concentration, "t_c", is defined as the flow time required for water to flow overland from the most remote point in the drainage area to the point in question, or the inlet point of the drain in question. For this reason, time of concentration is often referred to as the inlet time. Inlet time was determined from estimated velocities for overland flow or pipe flow. Pipe velocities were calculated using Manning's equation for a fully flowing pipe:

$$V = \frac{1.49}{n} R^{2/3} S^{1/2}$$

where: V = Velocity (ft/s)

n = Friction Factor (also known as Manning's "n")

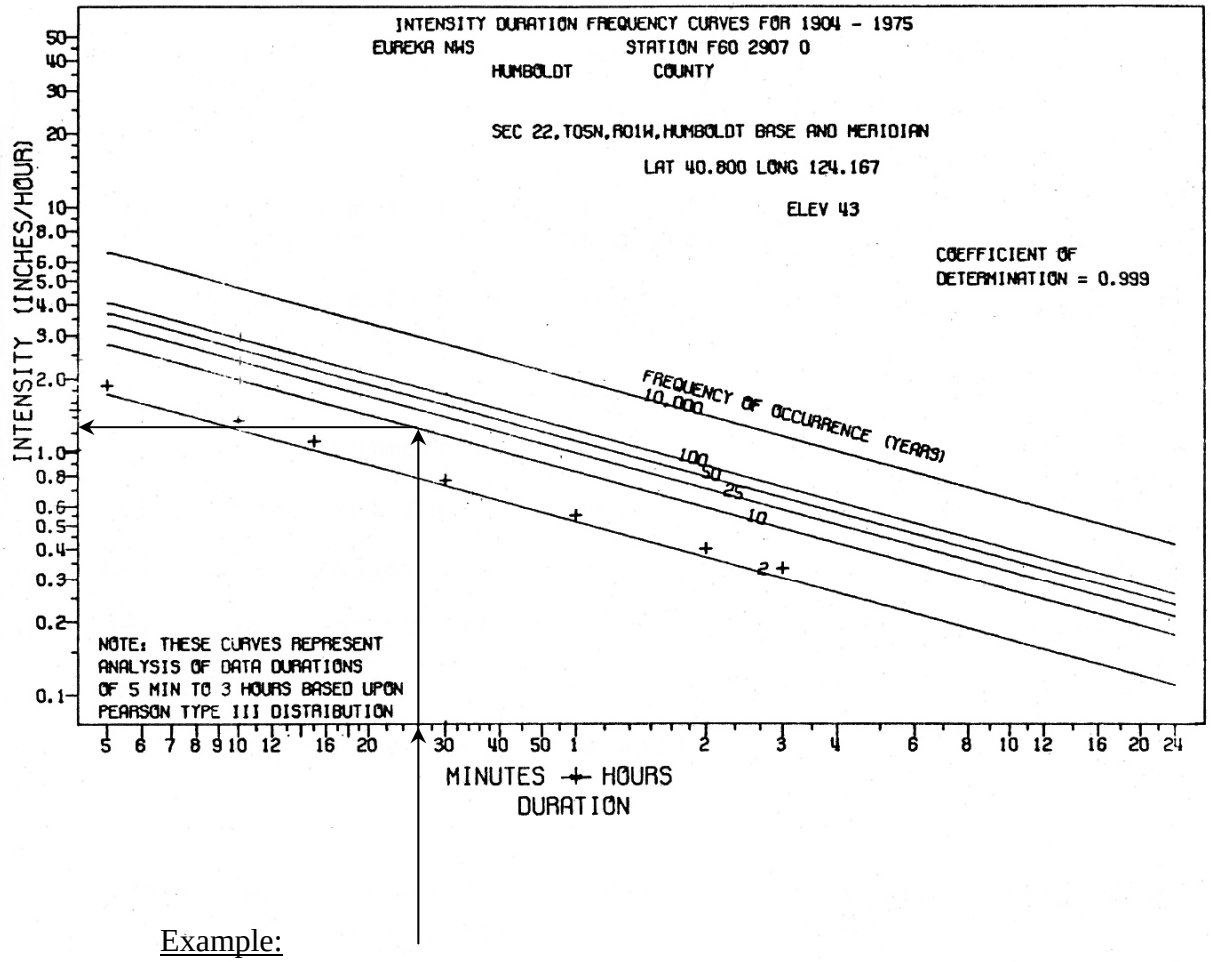
R = Hydraulic Radius (ft)

S = Channel Slope (ft/ft)

Overland flow velocities were computed using the following equation for channel flow in a natural waterway:

$$V = 5.46 \cdot S^{0\ 486} \cdot Q^{0\ 3287}$$

where: Q = Estimated Flow Rate (cfs)



Example:

- Calculated t_c = 26 minutes
- 10-year recurrence interval intensity:
  1.27 inch/hour

FIGURE 4-1 PRECIPITATION INTENSITY-DURATION-FREQUENCY CURVES

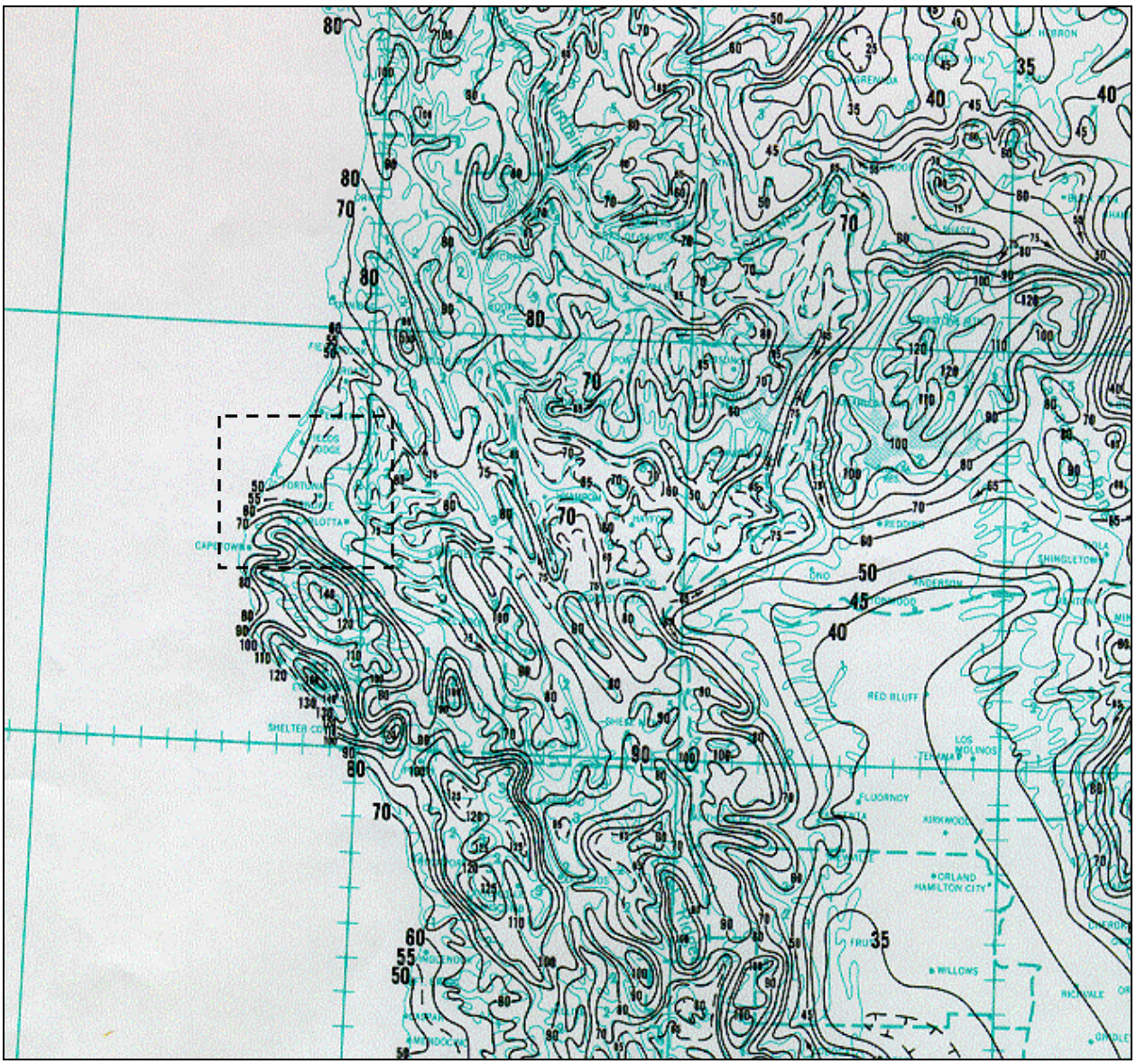


FIGURE 4-2 ISOPLUVIALS OF 25-YEAR 24-HOUR PRECIPITATION IN TENTHS OF AN INCH

Source: NOAA Atlas 2, Volume XI. Prepared by U.S. Department of Commerce National Oceanic and Atmospheric Administration, National Weather Service, Office of Hydrology. Prepared for U.S. Department of Agriculture Soil Conservation Service, Engineering Division.

The flow rate was estimated by assuming 1 cubic feet per second (cfs) of runoff from each contributing acre in the drainage area. Watershed slopes and pipe slopes were determined from topographic maps and known drainage elevation data. With the velocity and length known, the inlet time was calculated (t_c = distance/velocity). In drainage basins with more than one contributing area, the time of concentration increases as water flows downstream toward the watershed outlet. At each point of concentration the time required for water to travel from the upstream point of concentration to the downstream point of concentration is added to the previous inlet time to obtain the new inlet time for that area. The highest inlet time is always carried through to the next downstream area. This cumulative inlet time is the time of concentration for the entire upstream area contributing to the flow at that point of concentration. The known inlet times for each point of concentration were used to determine the 10-year, 25-year and 100-year precipitation intensities from the IDF curves. Flows at each point of concentration were then calculated using the precipitation intensity from Figure 4-1, cumulative runoff coefficient, and area ($Q = C \cdot i \cdot A$). This method of calculating hydrology flows is a modification of the method used in the 1982 Storm Drainage Master Plan, where flows were computed for each contributing area and summed downstream. This new method results in moderately less conservative yet more realistic flow estimates. An example calculation using this method is included in Appendix B of this report.

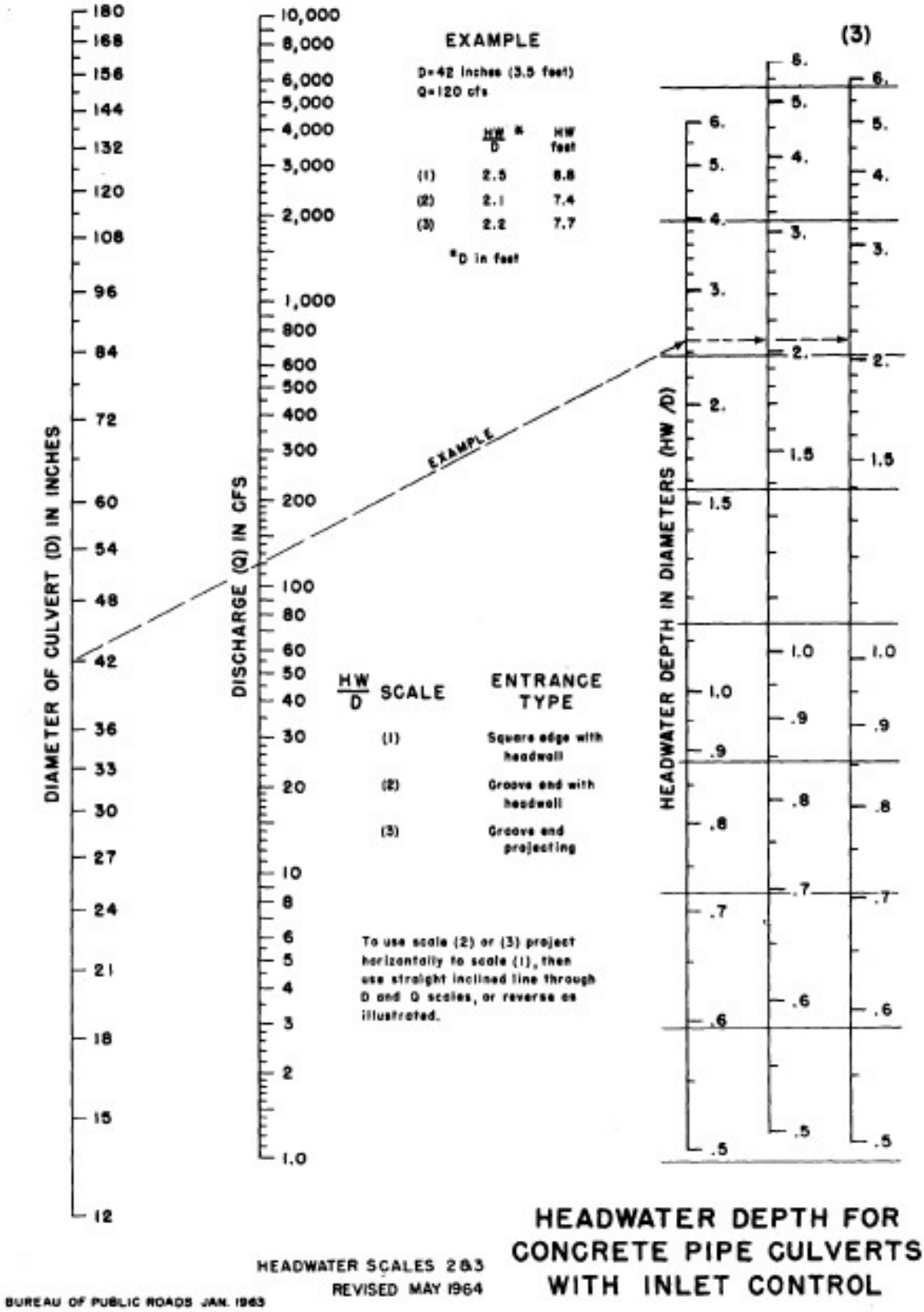
Inlet time for improved areas can vary widely and accurate values are difficult to obtain. Values between 5 and 30 minutes are used for developed areas with steep slopes or closely spaced inlets. 10 to 15 minute periods are common for similar areas with flatter slopes, and for areas with widely spaced inlets or very gentle slopes inlet times of 20 to 30 minutes are normally used. A minimum inlet time of 10 minutes was used in the 1982 Storm Drainage Master Plan, and is also used for all areas in this study.

4.9 Hydraulic Models

The purpose of the hydraulic analysis was to evaluate the adequacy of the existing storm drainage system, and to determine design options for inadequately sized conduits and channels. Select creeks, channels, and storm drain trunks 12 inches in diameter and larger were simulated using the flow data generated with the hydrology model. Storm drains were simulated using Haestad Method's StormCAD and FlowMaster, or Inlet Control Nomographs (see Figure 4-3), and open channels were simulated using HEC-RAS or Manning's equation. Where Inlet Control Nomographs were used to calculate pipe capacity, the headwater depth, the actual depth of the water entering the pipe, is assumed to be 1.5 times the pipe diameter. Allowing head to build up in manholes and at inlets increases the capacity of the pipes. The Inlet Control Nomograph used in this study was obtained from the Federal Highway Administration's publication on the Hydraulic Design of Highway Culverts.

4.9.1 Hydraulic Analysis Methods

The hydraulic models utilize Manning's equation to relate depth of flow in the waterway to the flow rate (Q), cross sectional area of the drainage structure (A), slope of the structure (S), and roughness of the structure (Manning's roughness coefficient "n").



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

FIGURE 4-3

4.9.1.1 Flow Rates

In the hydrology model, runoff flow rates were computed at each node for the appropriate design storms. Runoff is assumed to enter the drainage ditches, channels, and closed conduits at node locations. Drop inlets serving closed conduits are assumed to have 100 percent capture efficiency. Within the hydraulic model, the flow that enters at each node location is assumed to be flowing through the entire upstream length of pipe, that is, the pipe between that node and the next upstream node. An example of this method is included in Appendix B of this report.

4.9.1.2 Closed Conduit Systems

The City of Fortuna provided maps and survey data showing the locations and dimensions of storm drain structures. These data sources show the locations of manholes and inlets, as well as pertinent invert and rim elevation data.

During field investigations Fortuna City staff verified invert elevations at key nodal locations, and obtained invert elevations where only rim elevations were known. Invert elevations were obtained by measuring from the rim of each structure to the flowline of storm drain pipelines. Pipe sizes and materials were verified as accurately as possible from the surface without confined space entry. This data was then incorporated into the hydraulic models. Where no data was available, the slope of storm drains was assumed to approximate the ground slope.

4.9.1.3 Open Channels

The cross-sectional areas and ground slopes for drainage ditches and open channels from the 1982 Drainage Study were used in this study, or measured from USGS 1:24,000 series Quadrangle map for Fortuna with 40-foot contour intervals. Measurements were also taken during field investigations by Fortuna staff.

For this study, the following Manning's roughness coefficients "n" were used:

- Reinforced concrete pipe (RCP) 0.013
- Corrugated metal pipe (CMP) 0.024
- N-12 High density polyethylene pipe (N-12) 0.012
- Earth channels 0.025
- Grassed channels 0.035
- Natural waterways 0.050

4.9.1.4 Stormwater Detention

Detention facilities may be ponds, basins, depression or underground containers that provide storage capacity during periods of high flows to detain excess runoff for the purpose of reducing downstream flooding. Detention differs from retention in that retention involves capturing runoff without release. Detention involves temporary storage and release. Above ground detention facilities usually consist of a depression or excavated area with or without an earthen dam or berm. Underground facilities can be as simple as a series of appropriately sized pipes or detention chambers manufactured for underground detention. Underground facilities are

typically used for large parking lots and other locations with large impervious surface areas. Flow out of a detention basin is generally limited by restricting the outlet size. It is very important that a safety bypass system be designed into the outlet structure should flows exceed the capacity of the storage facility and it overflows.

The amount of peak flow reduction is dependent on the volume of the detention basin, the outlet size, and the timing of the peak reduction. The amount of storage required for an area requires the development of three relationships: an inflow hydrograph, a depth-storage curve, and a depth-outflow curve. The timing of the outlet peak is a very important factor to consider when designing detention facility. Because detention ponds affect the timing characteristics of runoff hydrographs, the combined hydrograph from all detention facilities may not be effective in reducing the overall peak flow rate. Studies have shown that detention basins located near the drainage basin outfall may in some cases increase the peak flow rate as a whole because it can delay the peak from the site to coincide more closely with the overall watershed peak.

This report uses the same method as the 1982 Storm Drainage Master Plan, which is the T.R. No. 55 from the Soil Conservation Service. This method is programmed into the POND-2 Version 5.21 software package by Haestad Methods, which was used to simulate the inflow hydrograph and generate the depth-storage and depth-outflow relationships. Hydrographs were developed and detention basins were sized for the 25-year 24-hour precipitation event. Isopluvials of 25-year 24 hour precipitation for the Fortuna area are shown in Figure 4-2. Detention basin projects proposed in this report are discussed in Chapter 5.

If designed and constructed, it is important to determine who is ultimately responsible for the maintenance of the detention basin system. Detention basins generally require more maintenance than a typical storm water conduit system. Depending on the characteristics of the upstream drainage area, the detention basin may require silt and trash removal, and other periodic maintenance. The potential safety hazard posed by a detention basin may necessitate the need for perimeter fencing.

As the City of Fortuna continues to develop, it is recommended that the Community Development Department require planners, developers and owners to incorporate onsite and regional stormwater detention into their development plans. These facilities will help in reducing the amount of runoff that enters the existing storm drainage system, and may help postpone or eliminate the need for some of the storm drainage projects proposed in this report. *It is also recommended that the Community Development Department require that new development not increase the existing estimated 25-year peak runoff volume from a site. Any increase in runoff beyond the peak 25-year event resulting from new development should be retained or detained on site.*

4.9.1.5 Boundary Conditions

For hydraulic analyses, a downstream and upstream water surface condition is required as input. For 25-year design storms, a uniform flow condition was assumed (i.e., discharge and cross-sectional area are constant throughout the length of the pipe or channel). For open channels the depth of flow is assumed to be constant, so the hydraulic grade line is parallel to the channel slope.

CHAPTER 5 – HYDRAULIC CAPACITY, RECOMMENDATIONS, AND OPINION OF PROBABLE COSTS

5.1 General

The study area has been divided into six separate drainage areas which delineate each creek's drainage basin and the north Fortuna area, as shown in Figure 5-1. The hydraulic capacities of the drainage facilities were calculated with the hydraulic models discussed in Chapter 4 using the 25-year design storm. This chapter presents and discusses the capacities of existing drainage facilities, the hydraulically deficient drainage facilities, 10-year, 25-year and 100-year flows, and problem areas for each drainage basin. Hydraulically deficient facilities are those that are undersized for the 25-year design flow and/or backwatered pipes which are causing or have the potential to cause flooding problems. Estimated peak flows generated from a 25-year storm event at maximum build-out were used as a basis for sizing drainage facilities. Alternative flow routing for controlling flooding and a list of proposed improvements has been developed, along with our opinion of the probable cost for the top 25 priority drainage projects.

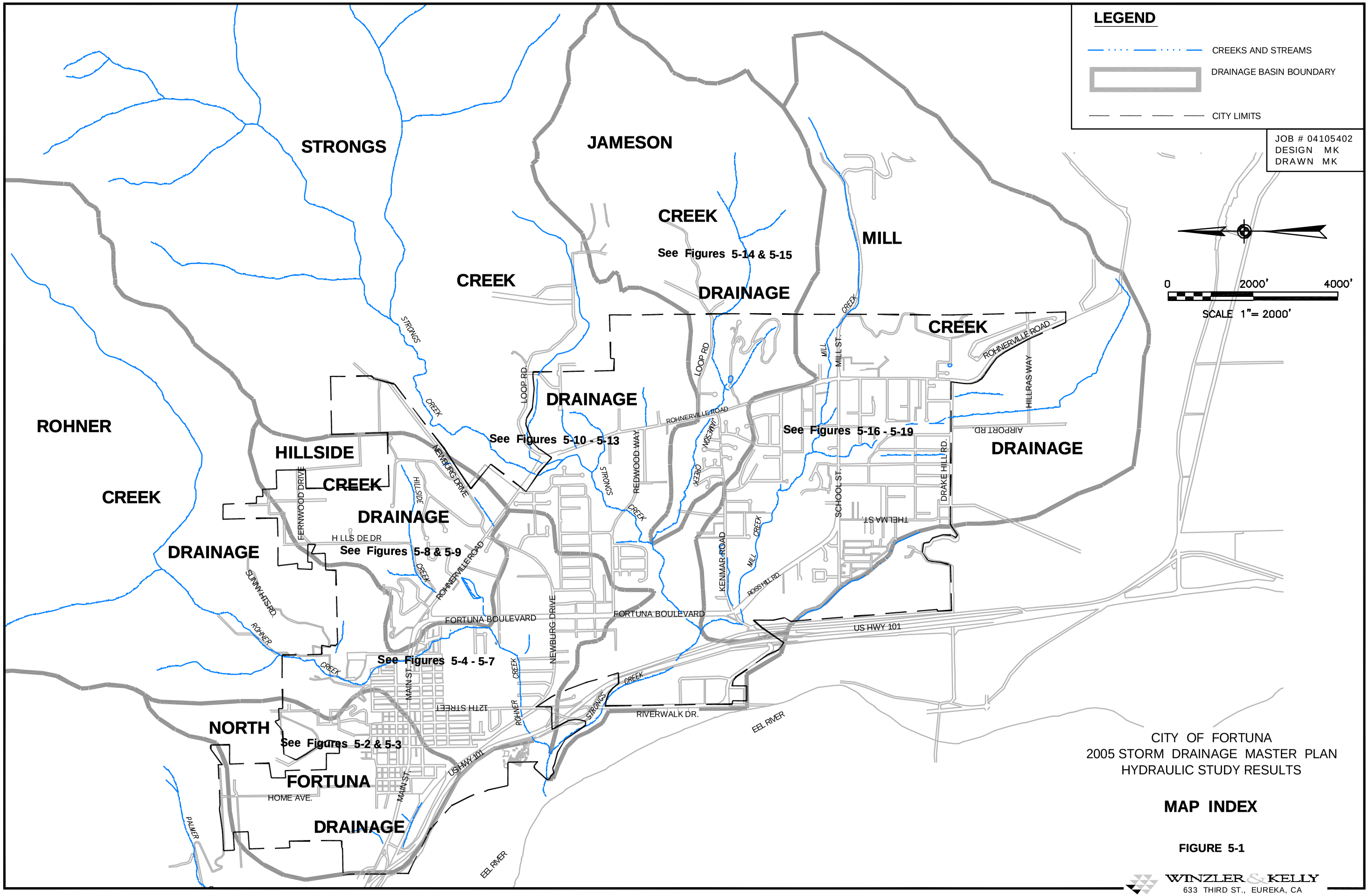
A major emphasis was placed on developing a plan that would minimize costs and solve all known existing drainage problems. Recommendations have also been made for the replacement or upgrade of existing facilities that the hydraulic models indicate are undersized for the design condition.

Because this plan is intended as a guide for the development of future drainage facilities and it is somewhat uncertain how future development will proceed, it does not attempt to present detailed drainage designs for individual areas. Rather, it determines peak flows for individual drainage systems and sizes lines to serve these areas. It should be noted that detailed designs and construction plans would be required before individual proposed projects are constructed.

5.2 Capacity of Existing Drainage Facilities

The existing stormwater drainage system contains several "problem areas" identified by City staff and hydraulic modeling efforts. Approximately one-third of the improvements recommended in the 1982 Storm Drainage Master Plan have been partially or fully completed. Many improvements not recommended in the 1982 Storm Drain Master Plan have also been completed to meet the drainage requirements of new developments, improve existing facilities and facility capacity, and reduce erosion caused by drainage outfalls. Much of the City still has undersized storm drains and culverts, and development in southern and eastern areas is increasing runoff to the City's drainage systems resulting in some areas of localized flooding. Improvement projects were recommended to correct the identified undersized storm drain conduits in the City limits.

In the discussion of each drainage basin is a list of the capacity of each facility. Winzler & Kelly established the following capacity criteria for identifying hydraulically deficient storm drainage systems:



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- Channels and creeks shall accommodate the 25-year design storm flows with a 1-foot freeboard. 100-year design flows will be allowed above the defined banks provided that the water surface does not exceed finished grade elevations within lots or areas of improvements.
- The hydraulic capacity of closed conduit systems under 25-year design flows is a full-pipe condition.
- Where backwater conditions impede the conveyance of water under design flows, surcharging of manholes and drop inlets will be tolerated with depths up to 1.5 times the pipe diameter.

5.3 Recommended Improvement Projects

In addition to the hydraulic deficiencies, Winzler & Kelly also recommends improvement projects where stormwater facilities and outfalls that no longer have adequate hydraulic capacity causing backwater in pipes and/or flooding problems, or have physically degraded creating traffic and safety hazards or serious erosion. Hydraulic deficiencies are identified with an “H”, and safety deficiencies are identified with an “S”. A preliminary design was conducted for improvement projects to correct each identified deficiency. The projects include new or modified closed conduit systems and culvert replacements.

5.3.1 Improvement Projects

For closed conduits, the design consists of proposed pipe locations and dimensions, and numbers of manholes and drop inlets. The following criteria were used for the design of the majority of closed conduit systems. (Exceptions to these criteria are noted in the project descriptions.):

- Minimum capacity of a 25-year storm.
- Preferred minimum slope of 2%; minimum allowable slope of 0.5% per circumstances to meet a self-cleaning velocity of 2.5 ft/s.
- Manholes shall be placed at a maximum of 350 feet on center and at changes in pipe diameter.
- Standard manholes shall be 48 inches in diameter.
- Minimum pipe cover of 2 feet in roadways.
- Pipe material: N-12 high-density polyethylene pipe (N-12).
- New storm drain systems shall be sized to convey the design storm without surcharging.
- Modifications to existing storm drain systems shall not increase downstream surcharging or backwater effects.
- Closed conduits shall be located within the public right-of-way or drainage easement.

The City of Fortuna prefers the use of N-12 high-density polyethylene (N-12) pipe for all new storm drain conduits, as opposed to reinforced concrete pipe (RCP), but the design must fit the material. N-12 pipe has a smooth interior wall and corrugated exterior wall, which offers exceptional hydraulics and strength. For the same diameter pipe, N-12 has greater than 50 percent higher hydraulic capacity than CMP and 5 percent higher capacity than RCP due to a

lower Manning's roughness factor. It is also generally less expensive in initial material cost than RCP. The real savings, however, are realized in installed costs. Due to the lightweight, longer lay lengths, and ease of handling, the installed cost savings of N-12 ranges from 10% to 30% when compared with RCP. Corrugated metal pipe (CMP) is not recommended for use in storm drainage improvements due to its short life span.

5.3.2 Project Design Methods

The proposed projects were hydraulically analyzed through computer simulations to confirm that the hydraulic criteria were met. Closed conduit systems and culverts were modeled using StormCAD and FlowMaster. Open channels were modeled using HEC-RAS. Detention ponds were modeled using POND-2. These models were subjected to the flow rates generated during the hydrology analysis.

5.3.3 Development of Opinion of Probable Cost

Our opinion of the probable cost for the top 25 proposed projects within individual drainage basins has been provided. Our opinion is based on the premise that all construction will be accomplished by competitively bid contracts. Our opinions of the probable cost were developed using *Means Construction Cost Data*, recent experience on bids received in Northern California for similar improvements, and costs obtained directly from suppliers. The following items are added to the subtotal amount:

- General Conditions (32.25%)
  - Mobilization/Demobilization (5%)
  - Contractor's Bond and Insurance (5%)
  - General Contractor's Overhead and Profit (15%)
  - Sales Tax (7.25%)
- Legal, Administration and Engineering (25%)
- Contingency (20%)
- Bonding (15%)

The general conditions are the sum of mobilization/demobilization, contractor's bond and insurance, contractor's overhead and profit, and sales tax, and are added to the construction subtotal. The legal, administration and engineering costs and contingencies are a percent of the total construction cost, and are added to the construction cost total to obtain the total project cost. A 20% contingency is also included. If the City of Fortuna funds the drainage improvements using bonds, an additional 15% is added to the total project cost to obtain the final opinion of probable cost. This 15% is to cover the bond costs, interest during construction, and provide reserve funds.

It should be noted that all costs are given in June 2005 dollars, with an Engineering News-Record (ENR) Construction Cost Index equal to 7,415.

5.3.4 Project Priority Analysis

The proposed drainage improvements will require a number of years to complete. The proposed improvement projects were ranked with the assistance of City staff according to priority for

construction. Priority rankings of low, medium, or high were attributed to each project based upon the criteria established below.

High Priority was attributed to projects that met all of the following criteria:

- Existing drainage facilities are significantly undersized for current levels of development.
- Maximum development has occurred in the project area.
- Maximum anticipated runoff conditions currently exist.
- Flooding of structures or severe erosion is known to occur.

Medium Priority was attributed to projects that met all of the following criteria:

- Existing drainage facilities are significantly undersized for anticipated levels of development.
- Existing drainage facilities are undersized for current levels of development but do not currently flood during the design storm.
- Structures or improvements exist in the anticipated 100-year flood area.
- Further development is anticipated in the project area.
- Runoff rates are expected to increase due to anticipated future development.

Low Priority was attributed to projects that met all of the following criteria:

- Existing drainage facilities are undersized for current levels of development but do not currently flood during the design storm.
- Further development is not anticipated in the project area.
- Structures or improvements exist in the anticipated 100-year flood area.

5.3.5 Development-Driven Projects

The existing land use surrounding proposed improvements was compared to build-out conditions as designated in the current zoning plans. Development was expected in areas where current land use density was significantly less than the current zoning allows. Development-driven projects were considered to be those located in areas where the existing land use was significantly less dense than build-out conditions. Storm drainage systems within new developments are typically paid for by the owner/builder in addition to fees for connecting the new system to the existing City-owned storm drainage system. Whenever permanent off site storm drainage facilities are required by the City to be constructed and installed as a part of a development, an amount of $0.32 per square foot of developed land is charged to the owner/builder of the new development to facilitate in funding future storm drainage developments in the City. *It is recommended that the City Community Development Department require development methods that incorporate onsite stormwater detention and infiltration for all new developments to minimize the amount of runoff entering the drainage system. Some methods include detention basins, vegetated swales, buffer strips, and other bioretention methods. It is also recommended that the Community Development Department require that new development not increase the existing estimated 25-year peak runoff volume from a site. Any increase in runoff beyond the peak 25-year event resulting from new development should be retained or detained on site.*

5.4 Comparison to 1982 Storm Drainage Master Plan

The hydrology analysis used in this updated 2005 Storm Drainage Master Plan resulted in less conservative (10 – 30 %) yet more realistic flows than those estimated in the 1982 Storm Drainage Master Plan. This outcome is a result of the method used to calculate the times of concentration, precipitation intensities, and resulting flow estimates. The effect of a cumulative time of concentration is a lower precipitation intensity. Combining this intensity with the total upstream area gives the updated flow estimate. This method differs from that used in the 1982 Storm Drainage Master Plan, where inlet times, precipitation intensities and resulting flows were computed for each contributing area, and then summed downstream. The new hydrology model, when used to combine and route small watersheds downstream, tends to result in conservative estimates. Improvement projects were recommended to correct the identified undersized storm drain conduits in the City limits.

5.5 Existing and Recommended Storm Drainage Facilities by Drainage Basin

A description of the existing and undersized facilities for each drainage basin is provided in this section, followed by a list of proposed improvements with cost estimates. Drainage facilities having capacity equal to or in excess of the 25-year design flows are considered adequately sized, and are shown in normal type. Undersized facilities are shown in **bold blue** type. The capacities of the existing storm drain system, and the estimated 10-year, 25-year and 100-year flows at specific nodal points are shown for each drainage basin on Figures 5-2, 5-4, 5-6, 5-8, 5-10, 5-12, 5-14, 5-16 and 5-18. On each figure, capacities and flows for undersized facilities are in **bold blue**. The existing drainage facilities and recommended improvements for each drainage basin are shown on Figures 5-3, 5-5, 5-7, 5-9, 5-11, 5-13, 5-15, 5-17 and 5-19. Tables 5-1 through 5-6 describe the existing and recommended facilities with reference to the figures. In Tables 5-1 through 5-6, undersized facilities are shown in **bold blue**, hydraulic deficiencies are identified with an “H”, and safety deficiencies are identified with an “S”. Table 5-7 summarizes the proposed drainage projects.

5.5.1 North Fortuna Drainage Basin

This area is mainly commercial and residential, is located in the northwest section of the City, and encompasses approximately 500 acres including Fortuna Elementary School. It is, essentially, bounded by Garland Avenue and Holman Way to the north, Vancil Street and 13th Street to the east, the Eel River to the south and 3rd Street and Main Street to the west. The general flow direction is to the southwest toward the Eel River.

The drainage facilities in the North Fortuna Basin are generally acceptable and in good condition, but there are several areas where frequent flooding occurs during relatively minor storm events. A few of the improvements recommended in the 1982 Storm Drainage Master Plan have been completed, but many remain. Table 5-1 summarizes the capacities and design flows for the existing drainage facilities in North Fortuna. Figure 5-2 shows the location of facilities, their existing capacities, and the estimated 10-year, 25-year and 100-year flows at specific nodal points. Undersized facilities are shown in **bold blue**. Results of the hydraulic modeling efforts indicate that a number of the drainage facilities are undersized for the 25-year rainfall event. Discussions with City staff also suggested there are significant flooding problems in this area.

Table 5-1 and Figure 5-3 summarize the undersized existing facilities, and describe their deficiencies and the recommended improvements.

Hydraulic analyses indicate that the 35" RCP culvert that runs under U.S. Highway 101 and discharges into the Eel River is just slightly undersized for the 25-year event (see Node 0.0 on Figure 5-2). Since there have not been any drainage or flooding problems reported at this culvert or in the area served by this culvert, it is probably sufficiently sized and does not require any improvements. The 42" N-12 storm drain that runs up 8th Street between Main Street and N Street, and on N Street between 8th Street and 9th Street was determined by the hydraulic model as being slightly undersized for the 25-year design flow (see Node 1.6 on Figure 5-2). Because this is a new section of pipe, and the City has not indicated any drainage problems associated with this storm drain, it is probably sufficiently sized and does not require any improvements at this time.

5.5.1.1 Culvert Replacement: Main Street Project No. 1

Hydraulic analyses of the 24" CMP culvert crossing Main Street west of 3rd Street is undersized for the 25-year flow (see Node 0.1 on Figure 5-3). *Replacing the existing culvert with a 36" N-12 culvert is recommended to allow for complete passage of the design flow.* This project is assigned a *low priority* ranking because the existing structure does not cause any known flooding problems during the design storm and further development is not anticipated in this area. This project is not development-driven. Our opinion of the probable cost of this project is $40,000.

5.5.1.2 Culvert Replacement: U.S. Highway 101 Project

A new culvert crossing under U.S. Highway 101 is recommended to replace or parallel the existing 48" RCP culvert to provide sufficient capacity for the 25-year flow (see Node 1.0 on Figure 5-3). Hydraulic analyses indicate that replacing the existing 48" RCP culvert with a 54" N-12 culvert or adding a parallel 48" N-12 culvert will provide sufficient capacity for the 25-year flow. This project is assigned a *low priority* ranking because the existing structure does not have any known flooding problems during the design storm and further development is not anticipated in this area. This project is not development-driven. Our opinion of the probable cost of this project is $61,000.

5.5.1.3 Drainage Channel Improvements: Quail Hollow Project (City Project No. 9813)

Runoff from Quail Hollow and the upper north side of Home Avenue flows down a drainage ditch and then gathers and meanders through the thicket area behind Parlotto's Restaurant (see Node 1.0.2 on Figure 5-3). The City has documented flooding of the parking lot area of Parlotto's Restaurant during periods of high runoff. This problem has only been seen a few times over the last 20 years. It is believed that the 36" RCP culvert which conveys this runoff under Main Street becomes overwhelmed at the downstream end causing a backwater effect and resulting in flooding problems. Hydraulic analysis of the 36" RCP storm drain indicates that it is properly sized. *It is recommended that the drainage ditch in the thicket area be cleared and increased in size to increase its capacity and improve the inlet hydraulics.* This project is assigned a *high priority* ranking because there still exists upstream development potential, and flooding is known to occur. This project is not development-driven. Our opinion of the probable cost of the project is $30,000.

5.5.1.4 Culvert Replacement: 3rd Street and Railroad Xing Project (City Project No. 9702)

An analysis of the culverts that runs under 3rd Street and the railroad tracks indicates that they are undersized and have geometric problems (see Node 1.1 and on Figure 5-3). Flow from the majority of the North Fortuna Drainage travels in the drainage channel that runs parallel to the railroad tracks, makes a sharp 90 degree turn and passes through a 36" CMP culvert. It then makes another 90 degree turn as it enters a small section of drainage channel, then passes through one more 36" CMP culvert (Node 1.1). At this location the existing 36" RCP culvert, which crosses Main Street and drains the majority of the area north of Home Avenue, also discharges (Node 1.0.1). Flow then passes into a small basin and drainage ditch before the U.S. Highway 101 crossing at Node 1.0. Hydraulic analyses indicate that the two 36" CMP culverts at Node 1.1 are undersized for the 25-year flow. During periods of high runoff, the small drainage basin also becomes overwhelmed from the combined flow of these two areas causing a backwater effect resulting in flooding of the basin, freeway off-ramp, and adjacent stockyard. *It is recommended that the 36" CMP culverts at Node 1.1 be upsized to 54", and that the first culvert be installed with a smaller angle to improve the inlet flow hydraulics and eliminate the sharp 90 degree bends which flow must currently make. It is also recommended that the small drainage basin and ditch into which these culverts discharge be cleared and maintained to improve the capacity and allow flow to travel through unimpeded.* This project is assigned a *high priority* ranking because the existing culverts are undersized, development is at or near maximum levels, and flooding occurs creating a safety hazard. This project was recommended in the previous Storm Drainage Master Plan, and is not development driven. Our opinion of the probable cost of the project is $93,000.

5.5.1.5 Storm Drain Replacement: South 6th Street Project

Hydraulic analyses of the 18" CMP storm drain at the south end of 6th Street show this pipe is undersized for the 25-year storm event (see Node 1.2.1 on Figure 5-3). *While no flooding currently occurs, increasing the size of this storm drain to 24" is recommended to provide sufficient capacity.* This project was recommended in the 1982 Storm Drainage Master Plan. Should flooding occur along this section of 6th Street, excess flows will travel toward the railroad tracks and enter the drainage channel. This project is assigned a *low priority* ranking because the existing drainage facilities are undersized for current levels of development but do not currently flood during the design storm. This project is not development-driven. Our opinion of the probable cost of this project is $165,000.

5.5.1.6 Storm Drain Replacement: Main Street Project No. 2

Hydraulic analyses of the 48" RCP storm drain on Main Street between 7th Street and the outlet point west of 6th Street indicate that this storm drain is slightly undersized for the estimated 25-year design flow (see Nodes 1.3 and 1.4 on Figure 5-3). This is part of the primary storm drain for the North Fortuna Drainage into which the majority of the runoff from this basin flows. *The recommended Main Street Project No. 2 consists of installing 54" N-12 storm drain along Main Street between 7th Street and the outlet point west of 6th Street with a minimum slope of 0.5%. A new manhole at the intersection of Main Street and 6th Street is also recommended.* This project has been assigned a *low priority* ranking because existing drainage facilities are undersized for the design flow, but do not currently flood during the 25-year storm event, and additional

development is not anticipated in the project area. This project is not development driven. Our opinion of the probable cost of this project is $387,000.

5.5.1.7 Storm Drain Replacement: Home Avenue Project (City Project No. 9801)

The City of Fortuna Public Works Department has identified the 2'x2' box culvert on Home Avenue between P Street and the "S" turn as in need of replacement (see Node 1.4.2 on Figure 5-3). This old box culvert is so old that no one with the City knows when or how it was built. Old forming lumbers continually fall off the inside of the culvert and flows down where they get jammed in the new junction box at the intersection of Home Avenue and P Street. The culvert is located just under the sidewalk for the entire length below the "S" turn on Home Avenue, and there is concern that it could collapse and possibly cause injury. *Replacement of this culvert with a 24" storm drain is recommended to eliminate the maintenance and hazard issues. It is also recommended that two additional drop inlets and two manholes be installed along this new section of storm drain.* A variation of this project was recommended in the 1982 Storm Drainage Master Plan. This project is assigned a *high priority* ranking because of the ongoing maintenance issues and because this culvert is a safety hazard. This project is not development driven. Our opinion of the probable cost of the project is $326,000.

5.5.1.8 Storm Drain Replacement: 11th Street and N Street Project (City Project No. 9504)

The City of Fortuna Public Works Department has identified the sections of storm drain which runs down the alley between P Street and O Street, then down the alley between 10th Street and 11th Street, then down 10th Street to N Street and from N Street to 9th Street as in need of replacement (see Nodes 1.6.1 and 1.6.2 on Figure 5-3). These old RCP storm drains, which range in size from 14" to 18", were poorly designed in the 1920's or 1930's, are undersized for the 25-year flow, and have repeated flooding problems. *The proposed project would replace the existing storm drains by rerouting the system in this area down 11th Street from P Street to N Street in a 24" pipe, and down N Street from 11th Street to 9th Street in a 30" pipe. New drop inlets and manholes are also recommended.* This project is assigned a *high priority* ranking because the existing drainage facilities are significantly undersized for current levels of development and flooding of the existing drainage facilities is known to occur. This project is not development driven. Our opinion of the probable cost of the project is $331,000.

5.5.1.9 Storm Drain Replacement: 9th Street Project No. 1 (City Project No. 9506)

The City of Fortuna Public Works Department has identified the 3'x3' concrete box culvert on 9th Street between P Street and N Street as in need of replacement (see Node 1.7 on Figure 5-3). Hydraulic analyses of this section of storm drain indicate that it has sufficient capacity for the 25-year flow, however the existing box culvert is extremely old and the concrete is disintegrating. Sewer lines and laterals also run through the culvert creating a possible contamination risk. If a sewer line or lateral were to break or begin leaking, raw wastewater would enter the storm drainage system and be discharged to the Eel River. *It is recommended that the City first install new sewer laterals to all affected residences (the sewer main along this section of 9th Street is approximately 7 – 9 feet deep), and then install a new 36" storm drain above the sewer laterals.* This will reduce the risk of raw wastewater entering the storm drainage system. This project is assigned a *high priority* ranking because of the ongoing maintenance issues, because this culvert is a safety hazard, and because of the pollution risk. This project is

not development driven. Our opinion of the probable cost of the storm drainage portion of this project is $176,000.

5.5.1.10 Storm Drain Replacement: 9th Street Project No. 2

Hydraulic analyses of the 18" RCP storm drain on 9th Street between P Street and Christian Ridge Road indicate that it is undersized for the 25-year storm event (see Node 1.8 on Figure 5-3). *This area of the City still has development potential, and replacement of this pipe with a 30" storm drain or installation of a parallel 30" storm drain is recommended to ensure that this section of the drainage system has sufficient capacity to meet future build-out conditions. New drop inlets and manholes are also recommended.* This project is assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and anticipated levels of development, but do not currently flood during the 25-year storm, and runoff rates are expected to increase due to future development. This project is development driven. Our opinion of the probable cost of this project is $489,000.

TABLE 5-1 EXISTING CONDITIONS AND PROPOSED DRAINAGE FACILITIES IN NORTH FORTUNA DRAINAGE

Node ID	Location	Existing Condition	Existing Capacity (cfs)	Estimated Flows (cfs)			Recommended Improvement	Deficiency H=Hydraulic S=Safety
				10-Year	25-Year	100-Year		
0.0	**U.S. 101 Underpass**	**36" RCP**	**35**	**32**	**38**	**46**	**None[1]**	**H**
0.1	**Main St.**	**24" CMP**	**13**	**30**	**35**	**43**	**36" N-12**	**H**
1.0	**U.S. 101/RR Tracks**	**48" RCP**	**80**	**180**	**220**	**280**	**54" N-12**	**H**
1.0.1	3rd St./Main St.	36" RCP	72	38	45	56	None	None
1.0.2	**Quail Hollow**	**Channel**	**--**	**38**	**45**	**56**	**Improve Channel**	**H/S**
1.1	**3rd St./RR Tracks**	**36" CMP**	**44**	**155**	**190**	**240**	**54" N-12**	**H/S**
1.2	Near RR Tracks	Drainage Channel	--	155	190	240	None	None
1.2.1	**6th St. @ RR Tracks**	**18" CMP**	**11**	**18**	**21**	**26**	**24" N-12**	**H**
1.3	**Main St.**	**48" RCP**	**104**	**125**	**150**	**190**	**54" N-12**	**H/S**
1.3.1	6th St.	24" RCP	53	6	8	10	None	None
1.4	**Main St.**	**48" RCP**	**113**	**120**	**140**	**190**	**54" N-12**	**H/S**
1.4.1	7th St.	30" RCP	104	39	47	57	None	None
1.4.2	**Home Ave.**	**2'x2' Box Culvert**	**77**	**32**	**40**	**48**	**24" N-12**	**S**
1.4.3	Home Ave.	18" RCP	26	18	22	27	None	None
1.5	Main St.	48" RCP	140	110	130	160	None	None
1.5.1	Main St.	48" RCP	305	12	15	18	None	None
1.6	**8th St.**	**42" N-12**	**114**	**100**	**120**	**150**	**None[1]**	**H**
1.6.1	**N St.**	**16" RCP**	**9**	**25**	**30**	**36**	**30" N-12**	**H/S**
1.6.2	**11th St./12th St.**	**18" RCP**	**24**	**13**	**16**	**20**	**24" N-12**	**H/S**
1.7	**9th St.**	**3'x3' Box Culvert**	**126**	**84**	**99**	**125**	**36" N-12**	**S**
1.7.1	P St.	30" RCP	104	7	8	10	None	None
1.8	**9th St.**	**18" RCP**	**19**	**71**	**83**	**100**	**30" N-12**	**H**
1.9	Christian Ridge Rd.	18" RCP	31	17	21	25	None	None

[1]See text for discussion.

*Note: Undersized facilities shown in **bold blue type**.

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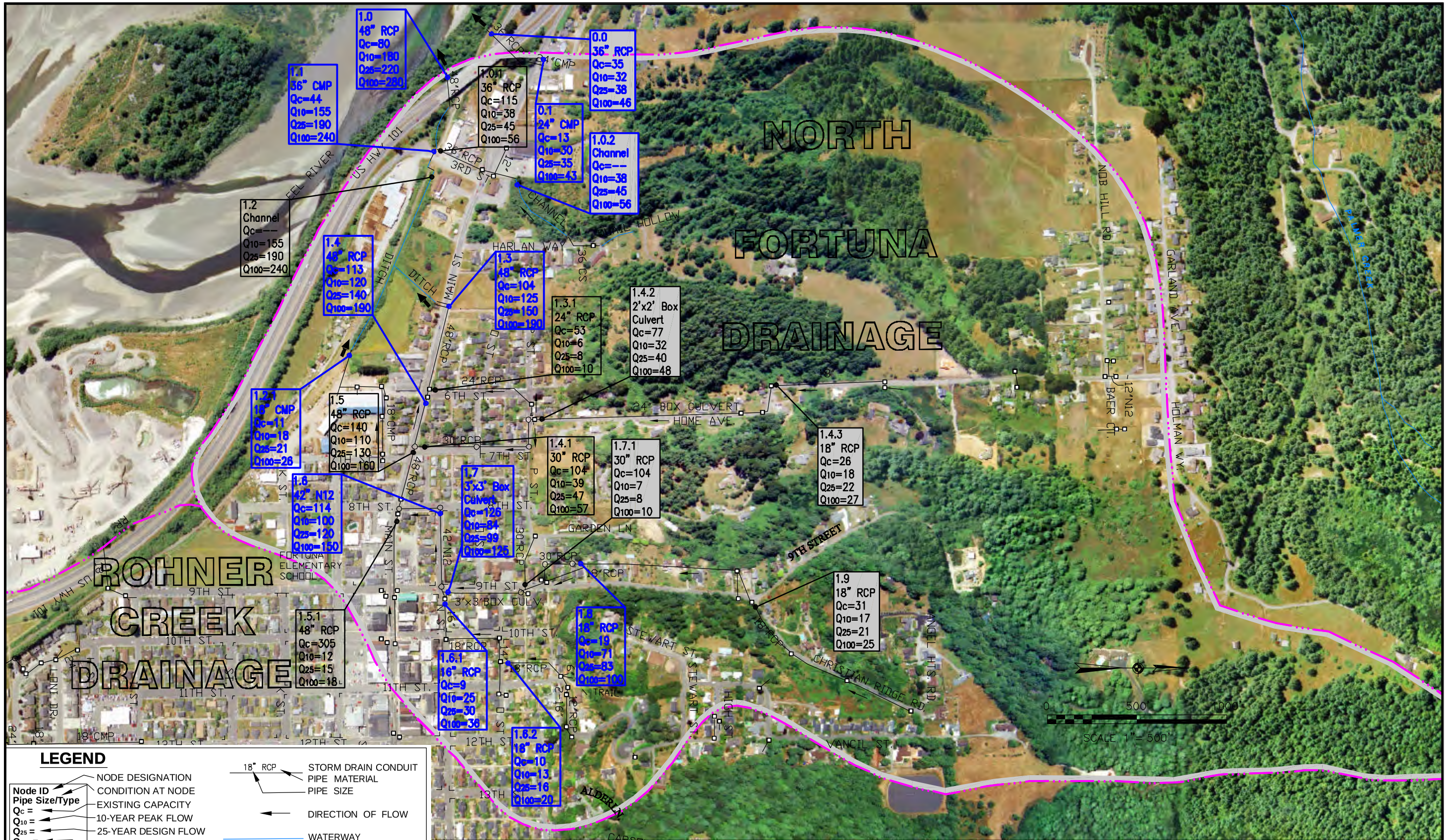

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DRAWN MK

CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN
EXISTING CAPACITIES AND ESTIMATED FLOWS

NORTH FORTUNA DRAINAGE

FIGURE 5-2

WINZLER & KELLY

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CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN
PROPOSED IMROVEMENTS

NORTH FORTUNA DRAINAGE

FIGURE 5-3

WINZLER & KELLY

5.5.2 Rohner Creek Drainage Basin

This drainage basin is the Rohner Creek watershed. It is located in the northern portion of the City and is bordered by the North Fortuna Drainage Basin to the west and the Hillside Creek and Strongs Creek watersheds to the east. It encompasses approximately 2,700 acres. The majority of this drainage basin lies within undeveloped areas, and only the lower southern portion of it is in developed areas in the City. Hillside Creek is a tributary of Rohner Creek, and meets Rohner Creek near the Fortuna Boulevard/Alder Drive intersection. Rohner Creek is the largest tributary of Strongs Creek, and joins Strongs Creek just before it discharges into the Eel River.

Rohner Creek has more potential than any other creek in Fortuna to cause serious flooding damage. It meanders through residential and urban development for much of its length, and is characterized by relatively steep erodable banks. Bank erosion, as well as the growth of heavy brush and willows, contributes to a serious reduction in channel capacity. Since the last Storm Drainage Master Plan was completed, Rohner Creek has overtopped its banks several times, mainly in the area between Main Street and Alder Drive near Fortuna Boulevard. When the creek overtops its banks, streets and residences along Stillman Way, Ash Street, Beech Street, Rohnerville Road and Fortuna Boulevard become flooded.

The remainder of the storm drainage system that drains to Rohner Creek is generally in good condition. Several of the improvement projects recommended in the 1982 Storm Drainage Master plan have been completed, although the major project addressing the Rohner Creek flooding problems has not yet been completed. Table 5-2 summarizes the capacities and design flows for the existing drainage facilities in the Rohner Creek Drainage Basin. Figures 5-4 & 5-6 show the locations of drainage facilities, their existing capacities and the estimated 10-year, 25-year and 100-year flows at specific nodal points. Undersized facilities are shown in **bold blue**. Results of the hydraulic modeling efforts indicate that a number of the drainage facilities are undersized for the 25-year rainfall event. Table 5-2 and Figures 5-5 and 5-7 summarize the undersized facilities, and describe their deficiency and the recommended improvement.

Hydraulic analysis using an inlet control nomograph indicates that the 48” RCP storm drain that parallels the railroad tracks near 12th Street is undersized for the estimated 25-year runoff event (see Node 2.1.1 on Figure 5-6). The City is not currently experiencing any flooding or drainage problems in this area, therefore it is probably of sufficient size and slope and does not require any improvements. *The City Community Development Department may want to require development methods that incorporate onsite stormwater detention in this area to minimize the amount of runoff entering the drainage system. It is also recommended that the Community Development Department require that new development not increase the existing estimated 25-year peak runoff volume from a site. Any increase in runoff beyond the peak 25-year event resulting from new development should be retained or detained on site.*

Hydraulic analyses using an inlet control nomograph also show that the two 18” storm drains at the east end of Newburg Drive, one RCP and one N-12, are slightly undersized for the 25-year storm event (see Node 2.1.4 on Figure 5-6). The N-12 storm drain was recently installed to serve the Newburg Subdivision. Provided these storm drains have a slope of at least 2 percent, no improvements should be necessary.

5.5.2.1 Storm Drain Replacement: 10th Street Project

Hydraulic analyses of the 24" CMP storm drain system that begins at the south end of 10th Street and discharges into Rohner Creek near the railroad tracks show that this storm drain is undersized for the 25-year design flow (see Node 2.1.0 on Figure 5-7). *Replacing the existing storm drain with 30" N-12 is recommended to provide sufficient capacity for this flow.* The 1982 Storm Drainage Master Plan also recommended that this section of storm drain be upsized to 30". This project is assigned a *low priority* ranking because the existing drainage facilities are undersized for current levels of development but do not currently flood during the design storm, and future development in this area is not anticipated. This project is not development driven. Our opinion of the probable cost of this project is $390,000.

5.5.2.2 New Storm Drain: Spring Street Project (City Project No. 9810)

The City of Fortuna Public Works Department has identified the section of storm drain on Spring Street as in need of improvement (see Nodes 2.1.1.1 and 2.1.1.2 on Figure 5-7). The existing 12" storm drain runs from Newburg Drive to 1st Avenue. Stormwater from private property and the Pacific Lumber property travels as gutter flow from 3rd Avenue north to 1st Avenue where it enters the storm drain to Newburg Drive. *Replacing the existing 12" pipe with a 24" N-12 storm drain from Newburg Drive to 1st Avenue and installing 18" N-12 storm drainpipe from 3rd Avenue to 1st Avenue is recommended to help with the drainage in this area. It is also recommended that additional drop inlets and manholes be installed. An alternative to this project would be to install 18" N-12 from 3rd Avenue to 2nd Avenue, and from 2nd Avenue to Fortuna Boulevard where it would tie in to the proposed new 36" storm drain.* This project is assigned a *medium priority* ranking because existing drainage facilities are significantly undersized for current levels of development, and existing drainage problems are known to exist. This project is not development driven. Our opinion of the probable cost of the project is $298,000.

5.5.2.3 Storm Drain Replacement: Newburg Drive Project No. 1

Hydraulic modeling of the storm drains on Newburg Drive east of the Fortuna Boulevard intersection show that they are undersized for the 25-year storm event (see Nodes 2.1.2 and 2.1.3 on Figure 5-7). The 1982 Storm Drainage Master Plan shows that this section of Newburg Drive had 18" RCP storm drains, and that as development occurred newer 24" and 18" N-12 storm drains were installed as parallel lines. Because slopes in this area are gentle, these storm drains have reduced capacity. *Replacing the 24" RCP pipe across the Newburg Drive/Fortuna Boulevard intersection with 42" N-12, and the 24" RCP pipe from Fortuna Boulevard to the location just past Orchard Lane with 36" N-12, as shown on Figure 5-7, is recommended to provide sufficient capacity for the 25-year storm event.* This project is assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and anticipated levels of development, but do not currently flood during the 25-year storm, and runoff rates are expected to increase due to future development. This project is development driven. Our opinion of the probable cost of this project is $384,000.

5.5.2.4 Storm Drain Replacement: Fortuna Boulevard Project No. 1

Hydraulic analyses of the storm drains on Fortuna Boulevard between Newburg Drive and Redwood Way indicate that they are undersized for the 25-year design event (see Nodes 2.1.2.1 and 2.1.2.2 on Figure 5-7). The existing storm drain system consists of parallel 12" and 18" RCP from Newburg Drive to 2nd Avenue, and two parallel 12" RCP pipes from 2nd Avenue to Redwood Way. *Replacing these older parallel pipes with 36" and 30" N-12 storm drains is recommended to provide enough capacity for the 25-year design flow.* This project is assigned a *low priority* ranking because the existing drainage facilities are undersized for current levels of development but do not currently flood during the design storm, and future development in this area is not anticipated. This project is not development driven. Our opinion of the probable cost of this project is $370,000.

5.5.2.5 Creek Widening: Rohner Creek Widening Project (City Project No. 9600)

The 1982 Storm Drainage Master Plan recommended that Rohner Creek be widened between 12th Street and South 15th Street to increase the capacity of the channel. The City of Fortuna Public Works Department has also identified this section of Rohner Creek as in need of increased hydraulic capacity. Updated hydraulic analyses of this section of Rohner Creek indicate that it has just enough capacity for the estimated 25-year flow. Between 12th Street and 15th Street development occurs within only 20 feet of the bank. *It is again recommended in this Storm Drainage Master Plan that this section of Rohner Creek be widened (see Node 2.3 on Figure 5-7). The channel design proposed in the 1982 Drainage Study is suggested, which calls for a benched parallel bank just above the flow line.* This project is assigned a *high priority* ranking because of current upstream flooding problems. It is important to note that because Rohner Creek is an anadromous fish bearing stream California Department of Fish and Game (DFG) and Army Corps of Engineers (ACOE) permits will be required, and any design will have to meet DFG and NOAA Fisheries standards for fish passage. It is recommended that this project be completed in conjunction with the Rohner Creek Bypass Project (City Project No. 9601). This project is not development driven. Our opinion of the probable cost of the project is $323,000.

5.5.2.6 Creek Rerouting: Rohner Creek Bypass Project (City Project No. 9601 & City Project No. 9704)

Since the 1982 Storm Drainage Master Plan was completed, Rohner Creek has overtopped its banks several times, mainly in the area between Main Street and Alder Drive near Fortuna Boulevard. When the creek overtops its banks, streets and residences along Stillman Way, Ash Street, Beech Street, Rohnerville Road and Fortuna Boulevard become flooded. The 1982 Storm Drainage Master Plan provided three alternatives for increasing the hydraulic capacity of Rohner Creek between Main Street and South 15th Street. These alternatives were:

1. Clean and widen the existing channel from Main Street to south 15th Street;
2. Reroute the channel from Main Street to just above 12th Street, fill the existing channel downstream to its confluence with Hillside Creek, and widen and clear the remaining channel to South 15th Street; and
3. Reroute a winter bypass channel and maintain the existing channel for normal flows.

The City Public Works Department has begun to purse winter bypass options related to the third alternative. This project would involve construction of a winter bypass channel beginning at Main Street downstream from the entrance of Rohner Park, and cross behind Fortuna High School and over to South 15th Street. The bypass would consist of open channels and weirs, and possibly sections of buried storm drainpipe. The project would take excess flows from Rohner Creek before it reaches a bank-full stage and reroute them into the bypass channel, thereby eliminating the overflow problem. The City has also proposed the idea of installing a detention basin at the end of Alder Drive where there is an existing drainage channel to help reduce the bypass hydrograph peak. This property is owned by the City, and is currently part of Fortuna High School.

Winzler & Kelly concurs with the pursuit of this project (see Nodes 2.4, 2.5, 2.6 & 2.7 on Figure 5-7). *It is recommended that the bypass channel be designed and located in accordance with Alternative 3, which was recommended in the 1982 Storm Drainage Plan. The use of a detention pond at the end of Alder Drive may help reduce the bypass hydrograph peak, however, due to a high groundwater table in this area, particularly during winter months, its capacity may be limited. It is also recommended that the east bank of Rohner Creek along Stillman Way be stabilized using riprap or a stem wall to help retain the creek within its banks and prevent flooding in this area.*

This project will require significant hydraulic design to ensure adequate channel slopes and hydraulic capacities. Some storm drainage pipe may be required in the area between Main Street and J Street due to the proximity of existing residences to the proposed project area. It is important to note that because Rohner Creek is an anadromous fish bearing stream California Department of Fish and Game (DFG) and Army Corps of Engineers (ACOE) permits will be required, and any design will have to meet DFG and NOAA Fisheries standards for fish passage.

This project is assigned a *high priority* ranking because the existing creek channel does not have sufficient capacity for existing and anticipated future levels of development and the expected 25-year storm event, and flooding of streets and residences already occurs during storms with 5-year to 10-year return periods. It is not development driven. Our opinion of the probable cost of the bypass and bank stabilization portions of this project is $2,926,000. Our opinion of the probable cost of the detention basin portion of this project is $346,000.

5.5.2.7 Storm Drain Replacement: South 15th Street Project

Hydraulic analyses of the storm drains that discharge into Rohner Creek near South 15th Street indicates that they are not sufficiently sized for the 25-year design flow (see Nodes 2.4.1 and 2.4.2 on Figure 5-7). Runoff from Orchard Lane and Fortuna Boulevard flows into a drainage ditch before entering a 12” CMP culvert and discharging into Rohner Creek. Flow from Smith Lane travels down Fortuna Boulevard in storm drains increasing in size from 18” to 48” before entering a 30” storm drain and discharging to Rohner Creek. *Increasing the 12” CMP culvert to 42” N-12 and the 30” storm drain to 36” N-12 is recommended to provide sufficient capacity to pass the estimated flows.* This project is assigned a *medium priority* ranking because the existing drainage facilities are undersized for current levels of development but do not currently flood during the design storm, and further development is anticipated. This project is development driven. Our opinion of the probable cost of this project is $197,000.

5.5.2.8 Storm Drain Replacement: Carson Woods Road Project

Hydraulic analyses of the 30" storm drain on Carson Woods Road show that it has insufficient capacity for the estimated 25-year flow (see Node 2.9.1 on Figure 5-5). *Replacing this storm drain with 42" N-12 is recommended to provide sufficient capacity for the design flow at anticipated future development in the Sunny Heights Road and Carson Woods Road area. An alternative to this project is to install a 24" N-12 storm drain parallel to the existing 30"*. This project is assigned a *medium priority* ranking because the existing drainage facilities are undersized for current levels of development but do not currently flood during the design storm, and future development in this area is anticipated. This project is development driven. Our opinion of the probable cost of this project is $109,000. Our opinion of the probable cost of the alternative project is $82,000.

TABLE 5-2 EXISTING CONDITIONS AND PROPOSED DRAINAGE FACILITIES IN ROHNER CREEK DRAINAGE

Node ID	Location	Existing Condition	Existing Capacity (cfs)	Estimated Flows (cfs)			Recommended Improvement	Deficiency H=Hydraulic S=Safety
				10-Year	25-Year	100-Year		
2.0	Near WWTP	Creek Channel	--	710	830	1,100	None	None
2.1	RR Tracks	3 – 5'x10' RCB	2,240	700	820	1,090	None	None
2.1.0	**10th St./RR Tracks**	**24" CMP**	**13**	**14**	**17**	**21**	**30" N-12**	**H**
2.1.1	**RR Tracks**	**48" RCP**	**70**	**91**	**110**	**135**	**None[1]**	**H**
2.1.1.1	**Spring St.**	**12" RCP**	**4**	**11**	**13**	**16**	**24" N-12**	**H**
2.1.1.2	**Spring St.**	**Gutter Flow**	**--**	**7**	**9**	**11**	**18" N-12**	**H**
2.1.2	**Newburg Dr.**	**2x24" RCP**	**45**	**91**	**110**	**130**	**42" N-12**	**H**
2.1.2.1	**Fortuna Blvd.**	**12" & 18" RCP**	**10**	**24**	**28**	**34**	**36" N-12**	**H**
2.1.2.2	**Fortuna Blvd.**	**2x12" RCP**	**13**	**16**	**19**	**24**	**30" N-12**	**H**
2.1.3	**Newburg Dr.**	**24" RCP & N-12**	**43**	**73**	**87**	**110**	**36" N-12**	**H**
2.1.4	**Newburg Dr.**	**18" RCP & N-12**	**22**	**27**	**33**	**41**	**None[1]**	**H**
2.2	12th St.	3 – 5'x10' RCB	2,240	650	750	1,000	None	None
2.2.1	12th St.	30" & 42" RCP	72	48	57	70	None	None
2.3	**12th St.**	**Creek Channel**	**775**	**630**	**740**	**990**	**Widen Channel**	**H**
2.4	**South 15th St.**	**Creek Channel**	**1300**	**630**	**730**	**980**	**Bypass Channel**	**H/S**
2.4.1	**South 15th St.**	**12" CMP**	**3**	**33**	**40**	**49**	**42" N-12**	**H**
2.4.2	**South 15th St.**	**30" CMP**	**22**	**24**	**30**	**36**	**36" N-12**	**H**
2.5	**Smith Ln.**	**Creek Channel**	**1,300**	**595**	**700**	**940**	**Detention Basin**	**H/S**
2.6	**Smith Ln.**	**Creek Channel**	**300**	**580**	**680**	**920**	**Bypass Channel**	**H/S**
2.7	**Alder Dr.**	**Creek Channel**	**300**	**440**	**520**	**700**	**Bypass Channel**	**H/S**
2.8	Main St.	Creek Channel	1,130	445	540	700	None	None
2.8.1	Park St.	3'x3' Box Culvert	73	29	35	43	None	None
2.9	Carson Woods Rd.	Channel	1,130	440	530	680	None	None
2.9.1	**Carson Woods Rd.**	**30" RCP**	**29**	**43**	**51**	**62**	**42" N-12**	**H**
2.10	Carson Woods Rd.	Creek Channel	--	410	500	635	None	None
2.10.1	Carson Woods Rd.	Creek Channel	--	23	27	33	None	None
2.11	Carson Woods Rd.	Creek Channel	--	390	475	610	None	None

[1]See text for discussion.

*Note: Undersized facilities shown in **bold blue type**.

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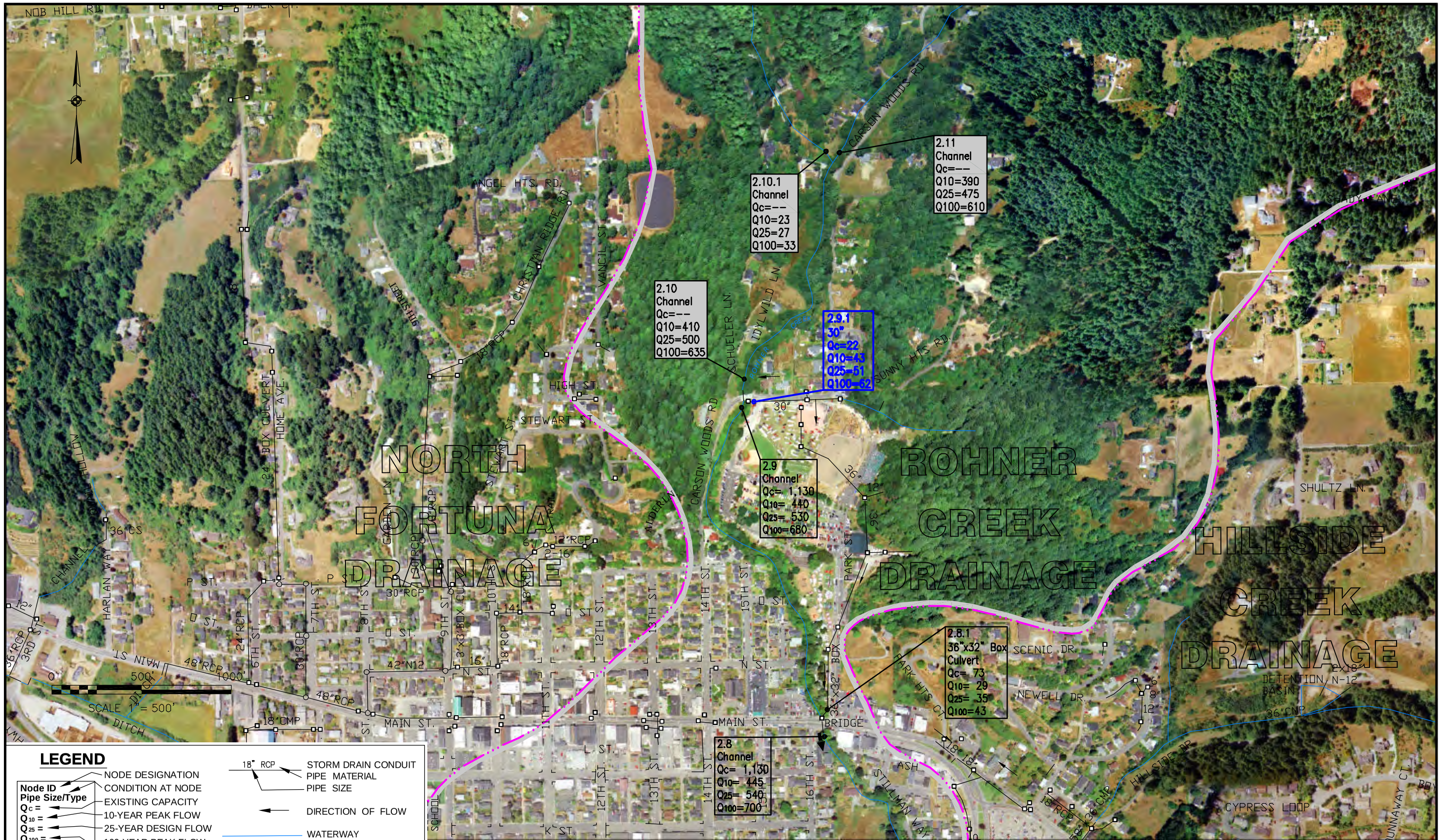

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2005 STORM DRAINAGE MASTER PLAN
EXISTING CAPACITIES AND ESTIMATED FLOWS

UPPER ROHNER CREEK DRAINAGE

FIGURE 5-4

WINZLER & KELLY

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CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN
PROPOSED IMPROVEMENTS

UPPER ROHNER CREEK DRAINAGE

FIGURE 5-5

WINZLER & KELLY

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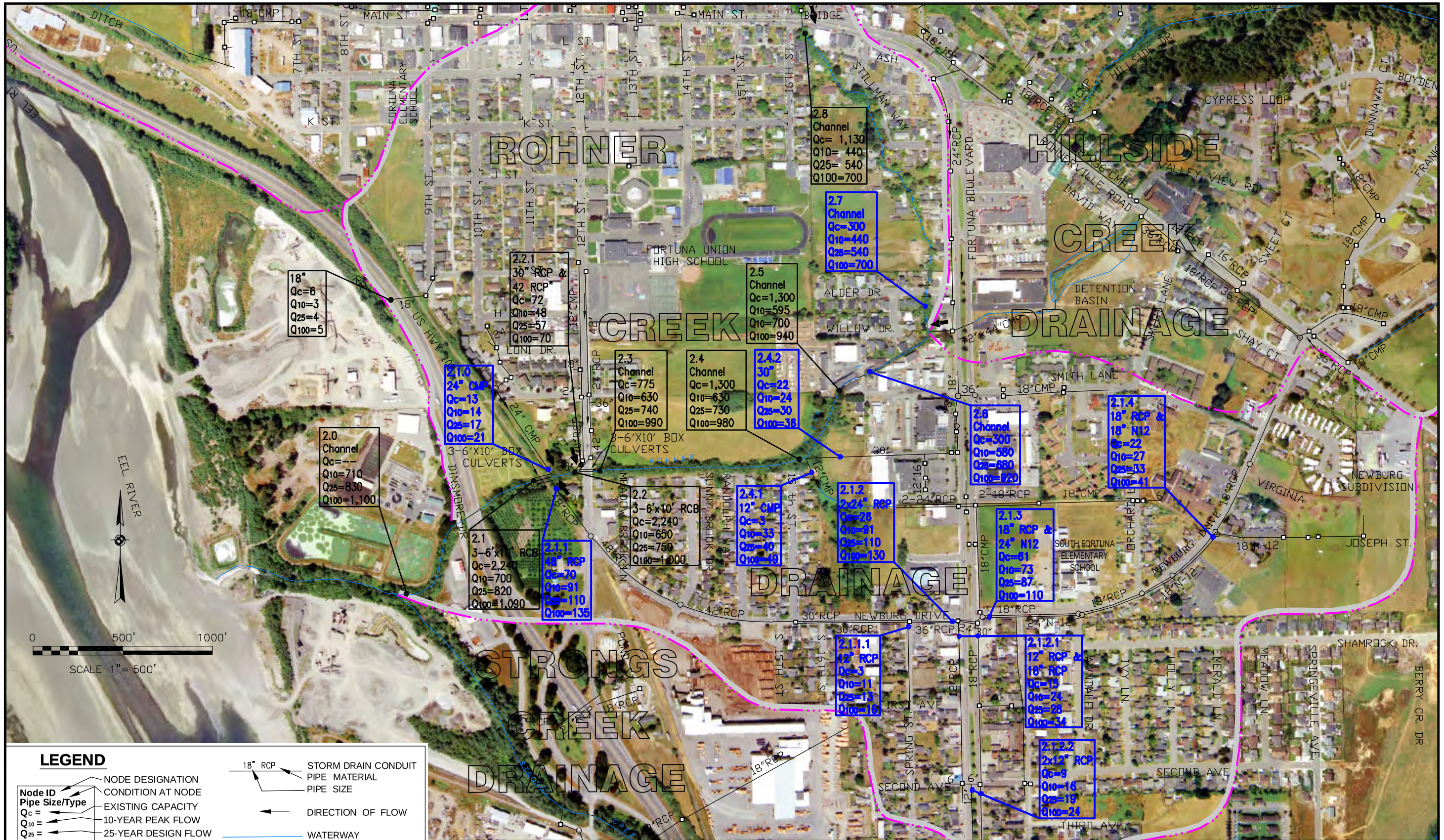

LEGEND

- Node ID — NODE DESIGNATION
- Pipe Size/Type — CONDITION AT NODE
- Q_C = EXISTING CAPACITY
- Q_{10} = 10-YEAR PEAK FLOW
- Q_{25} = 25-YEAR DESIGN FLOW
- Q_{100} = 100-YEAR PEAK FLOW
- 18" RCP — STORM DRAIN CONDUIT, PIPE MATERIAL, PIPE SIZE
- DIRECTION OF FLOW
- WATERWAY
- DRAINAGE BASIN BOUNDARY
- OUTFALL
- NODE
- MANHOLE
- DROP INLET

BOLD BLUE = UNDERSIZED
NORMAL TEXT = ADEQUATE

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DESIGN MK
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CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN
EXISTING CAPACITIES AND ESTIMATED FLOWS

LOWER ROHNER CREEK DRAINAGE

FIGURE 5-6

WINZLER & KELLY

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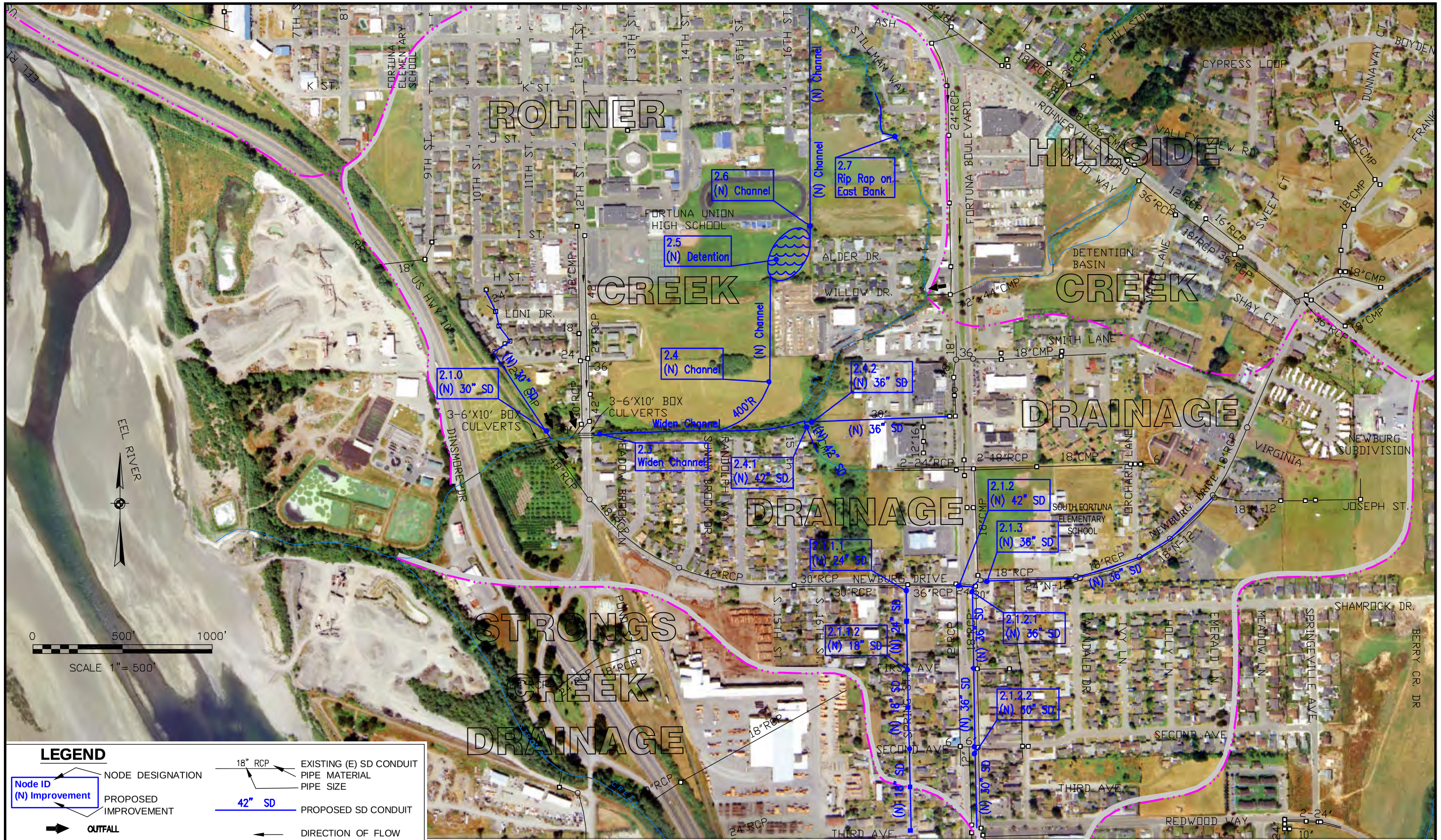

LEGEND

Node ID / (N) Improvement	NODE DESIGNATION / PROPOSED IMPROVEMENT
OUTFALL	
EXISTING / NEW	
○ / ●	MANHOLE
□ / ■	DROP INLET
18" RCP	EXISTING (E) SD CONDUIT, PIPE MATERIAL, PIPE SIZE
42" SD	PROPOSED SD CONDUIT
	DIRECTION OF FLOW
	WATERWAY
	DRAINAGE BASIN BOUNDARY

JOB # 04105402
DESIGN MK
DRAWN MK

CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN
PROPOSED IMPROVEMENTS

LOWER ROHNER CREEK DRAINAGE

FIGURE 5-7

WINZLER & KELLY

5.5.3 Hillside Creek Drainage Basin

Hillside Creek is a relative minor ephemeral watershed, which encompasses approximately 420 acres. It begins in the foothills to the east of Hillside Drive and has its confluence with Rohner Creek just west of Fortuna Boulevard near Alder Drive and Willow Drive. Near Rohnerville Road the Creek enters a series of storm drains but daylights again near Valley View where it enters a detention basin. It then enters a short section of storm drain passing under Fortuna Boulevard before discharging to Rohner Creek.

Hydraulic analyses of the Hillside Creek storm drainage system shows that the majority of facilities are undersized for the 25-year design flow. A number of improvement alternatives were recommended in the 1982 Storm Drainage Master Plan, however none have been successfully implemented. Table 5-3 summarizes the capacities and design flows for the existing drainage facilities in the Hillside Creek Drainage Basin. Figure 5-8 shows the location of drainage facilities, their existing capacities and the estimated 10-year, 25-year and 100-year flows at specific nodal points. Undersized facilities are shown in **bold blue**. Table 5-3 and Figure 5-9 summarize the undersized facilities, and describe their deficiency and the recommended improvement.

The main channel of Hillside Creek between Rohnerville Road and the 36” CMP culvert crossing on Hillside Road is estimated to have a slightly lower capacity than the estimated 25-year design flow. *Rather than a costly project to increase the capacity of the channel, it is recommended that the City maintain the channel to keep brush, willows and weeds from becoming thick and inhibiting flow through this area.*

5.5.3.1 Storm Drain Replacement: Hillside Creek Outflow Project

A new storm drain is recommended to parallel the existing 77”x44” CMP storm drain through which Hillside Creek flows into Rohner Creek (see Node 3.0 on Figure 5-9). *The proposed project involves the installation of a 36” N-12 storm drain pipe parallel to the existing 77”x44” CMP storm drain. This additional pipe is recommended to provide enough capacity to pass the estimated 25-year flow unimpeded.* This project is a variation of a similar project recommended in the 1982 Storm Drainage Master Plan. This project is assigned a *high priority* ranking because the existing facility is inadequate for existing conditions, currently flood during the design storm, and further development is anticipated in the project area. It is a development driven project. Our opinion of the probable cost of the project is $84,000.

5.5.3.2 Storm Drain Replacement: Fortuna Boulevard Project No. 2

A new storm drain is recommended to parallel the existing 24” RCP on Fortuna Boulevard running from Willow Drive to Rohnerville Road (see Nodes 3.0.1 and 3.0.2 on Figure 5-9). *The existing 24” RCP storm drain does not have sufficient capacity to pass the estimated 25-year design flow, and installation of a parallel 24” N-12 storm drain system that is cross-connected with the existing system is recommended to provide sufficient capacity to contain the design flow in both the new and existing pipes without surcharging. Additional drainage facilities along Fortuna Boulevard may also help to alleviate flooding which may occur as a result of Rohner*

Creek overtopping its banks. This project has been given a *medium priority* ranking because the existing facility is inadequate for existing conditions but does not currently flood during the design storm. This project is not considered development-driven because no significant growth is anticipated in the area. Our opinion of the probable cost of this project is $367,000.

5.5.3.3 Detention Basin Repair: Stockton Property Detention Basin Project (City Project No. 9701)

The existing detention basin on the Stockton property between Fortuna Boulevard and Rohnerville Road has silted in as a result of the settlement of upstream eroded soils and currently provides very little stormwater detention during peak flow periods (see Node 3.1 on Figure 5-9). Silts have also washed through into Rohner Creek reducing its capacity. The City created this drainage basin based on recommendations made in the 1982 Storm Drainage Master Plan. If this drainage basin were repaired such that its volume is increased it may help reduce the peak runoff entering Rohnerville Creek from Hillside Creek. *It is recommended that the City make the existing detention basin wider and deeper, and perform maintenance on the basin during summer months to ensure its capacity is not reduced.* This project is assigned a *high priority* ranking because of the potential the basin has to alleviate flooding on Rohner Creek, the current maintenance needs, and the expected future development in the area that drains to the detention basin. This project is not development driven. Our opinion of the probable cost of the project is $635,000.

5.5.3.4 Storm Drain Replacement: Rohnerville Road Project No. 1

The existing 58”x36” CMP storm drain in which Hillside Creek flows from Hillside Drive, down Rohnerville Road and discharging into the detention basin on the Stockton property lacks the capacity to handle the 25-year design flow, and is in need of replacement (see Nodes 3.2, 3.3 and 3.4 on Figure 5-9). Over the years upstream sediments have eroded and filled in a good portion of this pipe, and at the detention pond outlet the 36” CMP pipe is about two-thirds full of silt. *It is recommended that the 58”x36” CMP storm drain and 36” CMP outlet pipe be replaced with 60” N-12 storm drain. It is also recommended that upstream sediment sources be identified and stabilized to the greatest extent possible to prevent capacity reduction in downstream drainage facilities through erosion and sedimentation.* This project is a variation of a project recommended in the 1982 Storm Drainage Master Plan. It is assigned a *high priority* ranking because of the current sedimentation issue, the storm drains are inadequate for existing conditions and the expected future development in the area that drains to the detention basin. This project is not development driven. Our opinion of the probable cost of the project is $550,000.

5.5.3.5 Storm Drain Replacement: Rohnerville Road Project No. 2

Hydraulic analyses indicate that the existing 36”, 18”, 16” and 12” storm drains on Rohnerville Road have insufficient hydraulic capacity for the 25-year design event (see Nodes 3.2.1, 3.2.2 and 3.2.2.1 on Figure 5-9). *It is recommended that a storm drain consisting of 24” and 18” N-12 be installed parallel to the existing storm drain in order to pass the estimated future flows.* This project is assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and anticipated levels of development, but do not currently flood during

the 25-year storm, and runoff rates are expected to increase due to future development in the Hillside Creek Drainage Basin. This project is development driven. Our opinion of the probable cost of this project is $278,000.

5.5.3.6 Storm Drain Replacement: Newburg Drive Project No. 2

Hydraulic analyses indicate that the existing 18" CMP storm drain on Newburg Drive east of Rohnerville Road is undersized for the 25-year flow (see Node 3.2.3 on Figure 5-9). As development in the Hillside Creek Drainage continues, runoff to this drainage system will increase beyond the current capacity. *It is recommended that an 18" N-12 storm drain be installed parallel to the existing 18" CMP storm drain to provide sufficient capacity for the expected future runoff.* This project is assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and anticipated levels of development, but do not currently flood during the 25-year storm, and runoff rates are expected to increase due to future development in the Hillside Creek Drainage Basin. This project is development driven. Our opinion of the probable cost of this project is $80,000.

5.5.3.7 Storm Drain Replacement: Hillside Creek Culvert Replacement Project

There is an existing 36" CMP culvert where Hillside Creek passes under Hillside Drive and drains upper Hillside Creek and a detention basin area (see Node 3.6 on Figure 5-9). This culvert is undersized for the estimated 25-year design flow. *It is recommended that this culvert be replaced with a 48" N-12 culvert, or install a parallel 42" culvert. If the City improves the existing detention basin at this location, an outlet structure that discharges to the new culvert should also be installed.* This project is assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and anticipated levels of development, but do not currently flood during the 25-year storm, and runoff rates are expected to increase due to future development in the Hillside Creek Drainage Basin. This project is development driven. Our opinion of the probable cost of this project is $51,000.

5.5.3.8 Improve Detention Basin: Hillside Drive Detention Basin Project

A detention basin was created in the area just east of the existing 36" CMP culvert under Hillside Drive as part of the Buena Vista Subdivision development (see Node 3.7 on Figure 5-9). The basin has silted in and has a steep slope toward the 36" culvert. *It should be excavated to improve the storage. An improved outlet structure is also recommended.* Enhancement of this drainage basin may help reduce the peak runoff entering Rohnerville Creek from Hillside Creek. *It is recommended that the City pursue efforts to improve this detention basin*. This project is assigned a *medium priority* ranking because of the potential the basin has to alleviate flooding on Rohner Creek, and the expected future development in upper Hillside Creek Drainage flows to the detention basin. This project is not development driven. Our opinion of the probable cost of this project is $203,000.

TABLE 5-3 EXISTING CONDITIONS AND PROPOSED DRAINAGE FACILITIES IN HILLSIDE CREEK DRAINAGE

Node ID	Location	Existing Condition	Existing Capacity (cfs)	Estimated Flows (cfs)			Recommended Improvement	Deficiency H=Hydraulic S=Safety
				10-Year	25-Year	100-Year		
3.0	**Near Willow Dr.**	**72”x44” CMP**	**140**	**170**	**210**	**270**	**36” N-12**	**H**
3.0.1	**Fortuna Blvd.**	**24” RCP**	**13**	**33**	**38**	**45**	**24” N-12**	**H**
3.0.2	**Fortuna Blvd.**	**24” RCP**	**13**	**23**	**28**	**34**	**24” N-12**	**H**
3.1	**Near Fortuna Blvd.**	**Channel/Detention**	**--**	**150**	**180**	**230**	**Improve Basin**	**H**
3.2	**Rohnerville Rd.**	**36” CMP**	**35**	**145**	**170**	**220**	**60” N-12**	**H**
3.2.1	**Rohnerville Rd.**	**36” & 18” RCP**	**52**	**47**	**56**	**70**	**Parallel 24” N-12**	**H**
3.2.2	**Rohnerville Rd.**	**36” RCP**	**32**	**39**	**46**	**57**	**Parallel 18” N-12**	**H**
3.2.2.1	**Rohnerville Rd.**	**18” CMP**	**6**	**10**	**11**	**14**	**Parallel 18” N-12**	**H**
3.2.3	**Newburg Dr.**	**18” CMP**	**6**	**29**	**34**	**42**	**Parallel 18” N-12**	**H**
3.3	**Rohnerville Rd.**	**58”x36” CMP**	**80**	**105**	**125**	**160**	**60” N-12**	**H**
3.4	**Rohnerville Rd.**	**58”x36” CMP**	**80**	**105**	**125**	**155**	**60” N-12**	**H**
3.5	**Hillside Dr.**	**Creek Channel**	**100**	**100**	**120**	**155**	**Maintenance[1]**	**H**
3.5.1	Near Newell Dr.	Creek Channel	--	20	25	30	None	None
3.6	**Hillside Dr.**	**36” CMP Culvert**	**35**	**91**	**110**	**135**	**Parallel 42” N-12**	**H**
3.7	**Hillside Dr.**	**Creek Channel**	**--**	**91**	**110**	**135**	**Detention Basin**	**H**

[1]See text for discussion.
*Note: Undersized facilities shown in **bold blue type**.

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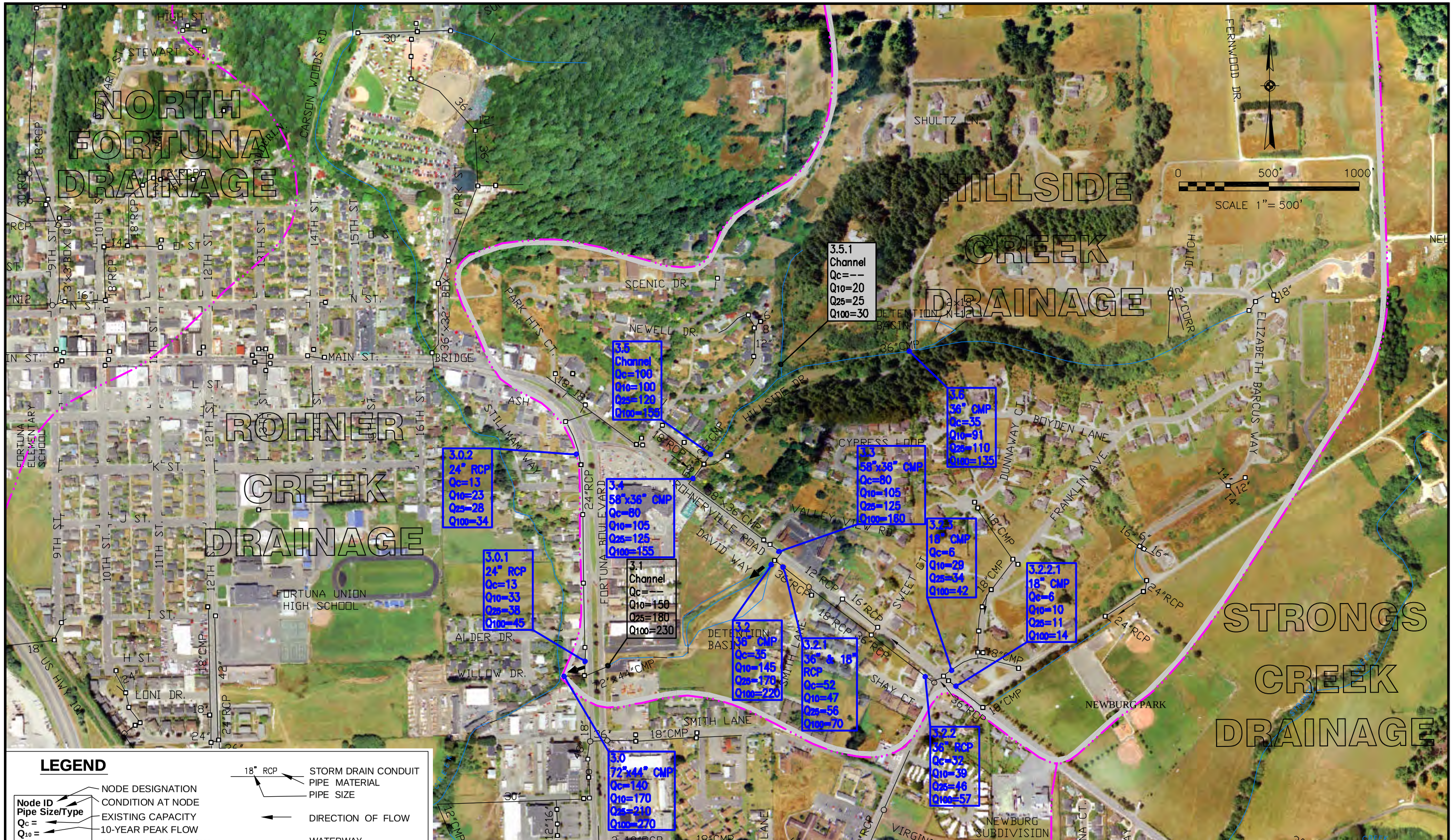

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EXISTING CAPACITIES AND ESTIMATED FLOWS

HILLSIDE CREEK DRAINAGE

FIGURE 5-8

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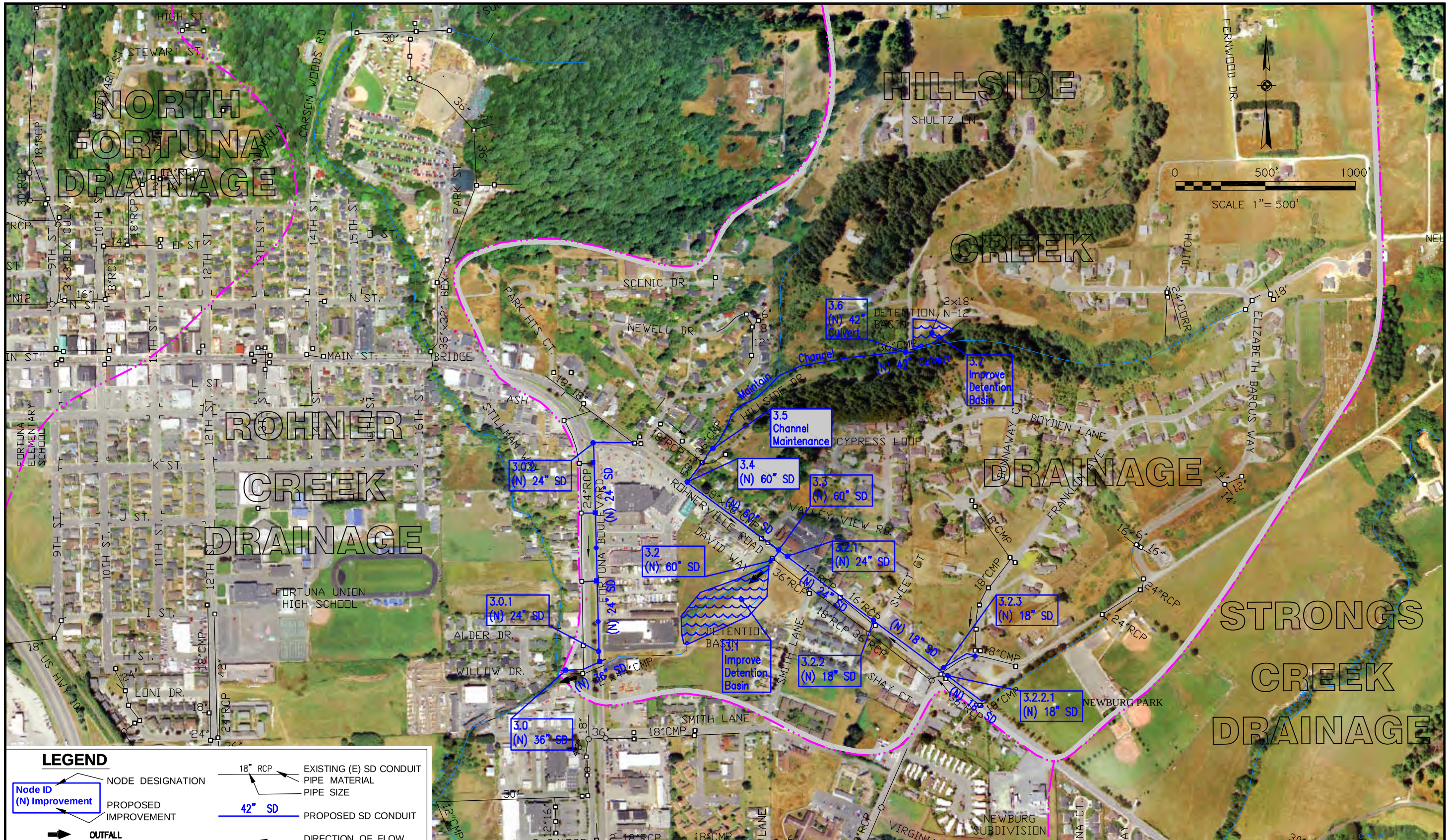

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PROPOSED IMPROVEMENTS

HILLSIDE CREEK DRAINAGE

FIGURE 5-9

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5.5.4 Strongs Creek Drainage Basin

The Strongs Creek Drainage Basin is the largest drainage area in the Fortuna Area, encompassing over 5,200 acres without including its tributaries. Tributaries to Strongs Creek are Jameson Creek, Mill Creek and Rohner Creek. With these tributaries, the Strongs Creek watershed is nearly 10,700 acres. The creek begins in the hills east of Fortuna where the majority of the drainage area is characterized by relatively steep, forested and sparsely populated slopes.

At the eastern edge of the Fortuna City Limits, Strongs Creek meanders in a southwesterly direction through open pastureland. Jameson Creek joins Strongs Creek west of Redwood Memorial Hospital. Mill Creek has its confluence with Strongs Creek just west of Fortuna Boulevard. Rohner Creek does not join Strongs Creek until approximately 1,000 feet upstream of the Eel River confluence.

The 1982 Storm Drainage Master Plan recommended that development along Strongs Creek be conducted using building setbacks corresponding to the calculated 100-year flood plain. Inspection of the latest aerial photograph of Fortuna indicates that development has progressed according to this recommendation. The 1982 Storm Drainage Master Plan also stated that it should be recognized that during extreme floods the Eel River will cause flooding in the lower reaches of Strongs Creek. This important statement is reiterated in this report.

Hydraulic analyses of the Strongs Creek storm drainage system show a number of the drainage facilities are undersized for the 25-year design flow. Several of the improvement alternatives recommended in the 1982 Storm Drainage Master Plan have been completed. Table 5-4 summarizes the capacities and design flows for the existing drainage facilities in the Strongs Creek Drainage Basin. Figures 5-10 and 5-12 show the location of drainage facilities, their existing capacities and the estimated 10-year, 25-year and 100-year flows at specific nodal points. Undersized facilities are shown in **bold blue**. Table 5-4 and Figures 5-11 and 5-13 summarize the undersized facilities, and describe their deficiency and the recommended improvement.

Hydraulic analysis of the 30” storm drain that discharges from Alamar Way into Strongs Creek indicates it is slightly undersized for the estimated 25-year runoff event (see Node 4.3.1 on Figure 5-12). The City is not currently experiencing any flooding or drainage problems related to this storm drain, therefore it is probably of sufficient size and slope and does not require any improvements.

5.5.4.1 Storm Drain Replacement: Riverwalk Drive Project

The 24” storm drain that runs north on Riverwalk Drive and discharges into Strongs Creek has been identified through hydraulic analysis as being undersized for the 25-year design flow (see Nodes 4.2.1 on Figure 5-13). This storm drain system was installed in 2002. *Replacing this storm drain system with 36” N-12 or installing a parallel 24” N-12 storm drain is recommended to provide enough capacity to contain the estimated flows for this area.* This project has been given a *low priority* ranking. This project is considered development-driven. Our opinion of the probable cost of this project is $209,000. Our opinion of the probable cost of the alternative project is $190,000.

5.5.4.2 Storm Drain Replacement: Alamar Way Project

Hydraulic analyses of the storm drain system on Alamar Way indicate that it is undersized for the 25-year design flow (see Nodes 4.3.1.1, 4.3.2 and 4.3.3 on Figure 5-13). As a result of low pipe slopes, the existing 30" and 18" pipes do not have enough capacity for the estimated runoff in this area at full build-out. *Installing new 36" N-12 storm drains parallel to the existing storm drains will provide the necessary capacity to contain the 25-year flow.* This project has been given a *medium priority* ranking because the existing facilities are inadequate for anticipated future conditions but do not currently flood during the design storm, and further development is anticipated in the project area. This project is considered development-driven. Our opinion of the probable cost of this project is $512,000.

5.5.4.3 Storm Drain Replacement: Fortuna Boulevard Project No. 3

City of Fortuna Public Works staff have identified the 12" CMP storm drain on Fortuna Boulevard between Redwood Way and Strongs Creek as undersized and in need of replacement (see Node 4.5.1 on Figure 5-13). Manhole covers on this section of storm drain pipe are known to lift off their manholes as water under pressure is forced out of the pipe. Hydraulic analysis of the storm drain system confirms this condition. *It is recommended that the existing 12" CMP pipe be replaced with 24" N-12 to provide the necessary capacity to contain the 25-year flow.* This project has been given a *high priority* ranking because the existing pipe is significantly undersized for current and future flows, and annual flooding is known to occur. This project is not considered development-driven. Our opinion of the probable cost of the project is $324,000.

5.5.4.4 Stream Bank Protection: Maxwell Lane Slope Stabilization Project (City Project No. 9700)

During the last 10 years, high flow events on Strongs Creek have eroded a considerable amount of stream bank in the vicinity of Maxwell Lane just upstream of Strongs Creek's confluence with Jameson Creek (see Node 4.8 on Figure 5-11). At this location, Strongs Creek flows into a sharp turn, which has forced the flow toward the bank causing it to erode. This natural process of stream meandering is common in low-lying alluvial streams. The extent of the bank erosion has reached the point of property loss and a threat of home loss. The City of Fortuna Public Works Department has identified this section of stream bank as in need of stabilization. *It is recommended that rock slope protection, or some other method of bank and channel armoring, be used to stabilize this bank and help dissipate energy in the stream. Weirs, large boulders, or other in-stream structures may also be used to help dissipate energy in this area.* This project has been assigned a *high priority* ranking because of the continuing loss of property and the threat of home loss. This project is not considered development driven. Our opinion of the probable cost of the project is $160,000.

5.5.4.5 Storm Drain Replacement: Shamrock Drive to Redwood Way Project (City Project No. 9703)

The City of Fortuna Public Works Department has identified the storm drain system at the intersection of Springville Avenue and Redwood Way as in need of improvement. Runoff from the Lawndale Subdivision travels from Shamrock Drive to Redwood Way entirely as surface flow to the drop inlets and storm drains located at the intersection of Springville Avenue and

Redwood Way. From here it travels through dual 24" N-12 drain pipe and discharges into a drainage ditch. Survey data and hydraulic analyses indicate that the storm drains crossing Redwood Way to the drainage ditch have adverse slopes and inadequate capacity for the estimated 25-year design flow. It is believed that the adverse slopes may be causing the current flooding problems at this intersection. *In order to alleviate the flooding problems in this intersection, it is recommended that the storm drain pipes crossing Redwood Way be reconstructed with positive slopes of at least 1 percent. It is also recommended that additional 24" N-12 storm drains and drop inlets be installed from the intersection of Springville Avenue and Redwood Way to the intersection of Springville Avenue and Shamrock Drive with slopes no less than 0.7 percent (see Nodes 4.8.2, 4.8.3 and 4.8.4 on Figure 5-11). Due to existing low ground slopes in this area, the new storm drains should be no smaller than 24" in diameter to provide the necessary capacity for the 25-year flow*. This project has been given a *high priority* ranking because the existing drainage facilities are inadequately designed for current levels of development and flooding of the existing drainage facilities is known to occur. This project is not development driven. Our opinion of the probable cost of the project is $346,000.

5.5.4.6 Storm Drain Replacement: Rohnerville Road Project No. 3

Hydraulic analyses of the drainage facilities on Rohnerville Road that drain into the stream near Brazil Lane indicate that they are undersized for the 25-year design flow (see Nodes 4.11.2 and 4.11.2.1 on Figure 5-11). These drainage pipes are older CMP, and do not have the capacity needed to contain the anticipated runoff for this area at the full build-out level. *It is recommended that the 36" CMP pipe under Rohnerville Road be replaced with 42" N-12, and the 18" CMP pipe be replaced with 30" N-12.* This project has been assigned a *medium priority* ranking because the existing drainage facilities are significantly undersized for current levels of development but do not currently flood during the design storm, and further development is anticipated. This project is development driven. Our opinion of the probable cost of this project is $125,000.

5.5.4.7 Storm Drain Replacement: Rohnerville Road Project No. 4

The 18" CMP culvert which discharges runoff from Hilltop Drive across Rohnerville Road was determined to be undersized for the estimated 25-year design flow (see Node 4.12.1 on Figure 5-11). *It is recommended that the existing culvert be replaced with a 30" N-12 culvert.* This project is a variation of a project recommended in the 1982 Storm Drainage Master Plan. This project has been assigned a *medium priority* ranking because the existing drainage facilities are significantly undersized for current levels of development but do not currently flood during the design storm, and further development is anticipated. This project is development driven. Our opinion of the probable cost of this project is $126,000.

5.5.4.8 Storm Drain Replacement: Rohnerville Road Project No. 5

There is a 54" RCP culvert under Rohnerville Road which drains the small creek that flows adjacent to Loop Road. This culvert was determined to be hydraulically deficient for the 25-year design flow. *In order to provide the necessary capacity, it is recommended that a 42" N-12 culvert is installed parallel to the existing 54" RCP culvert (see Node 4.13.1a on Figure 5-11).* This project is a variation of a recommendation in the 1982 Storm Drainage Master Plan. This

project has been assigned a *medium priority* ranking because the existing drainage facilities are significantly undersized for current levels of development but do not currently flood during the design storm, and further development is anticipated. This project is development driven. Our opinion of the probable cost of this project is $61,000.

5.5.4.9 New Detention Basin: Loop Road Detention Basin Project (City Project No. 9603)

The City of Fortuna Public Works Department has identified the area north of and between Rohnerville Road and Loop Road as a potential site for a future detention basin (see Node 4.13.1b on Figure 5-11). As the development of properties accessed by Loop Road continues, runoff into the creek adjacent to Loop Road is expected to increase. The detention of flows in this area will help alleviate downstream flooding along Strongs Creek. The property at this site is privately owned, therefore the City of Fortuna would have to purchase it or acquire an easement in order to construct the detention basin. *To maintain flows in this creek at the discharge side of the detention basin at or below the 25-year flow for a 100-year flow event, the basin should have a volume of 1.5 to 2.0 acre-feet of storage. Because this area is so flat, the majority of the basin would have to be excavated. A basin 75-100 feet wide would require about 0.25 to 0.5 acres of land.* This project is development driven, and has been assigned a *medium priority* ranking because of the potential for future development in this area. Our opinion of the probable cost of this project is $142,000.

5.5.4.10 Storm Drain Replacement: Loop Road Project

There is a 30” CMP culvert under Loop Road which drains this small tributary of Strongs Creek. This culvert was determined to be hydraulically deficient for the 25-year design flow. *In order to provide the necessary capacity, it is recommended that a 60” N-12 culvert is installed parallel to the existing 30” CMP culvert (see Node 4.13.2 on Figure 5-11).* This project has been assigned a *medium priority* ranking because the existing drainage facilities are significantly undersized for current levels of development but do not currently flood during the design storm, and further development is anticipated. This project is development driven. Our opinion of the probable cost of this project is $30,000.

TABLE 5-4 EXISTING CONDITIONS AND PROPOSED DRAINAGE FACILITIES IN STRONGS CREEK DRAINAGE

Node ID	Location	Existing Condition	Existing Capacity (cfs)	Estimated Flows (cfs)			Recommended Improvement	Deficiency H=Hydraulic S=Safety
				10-Year	25-Year	100-Year		
4.0	Eel R. Confluence	Creek Channel	--	2,630	3,090	3,800	None	None
4.1	Near WWTP	Creek Channel	--	2,150	2,450	3,260	None	None
4.2	Dinsmore Dr.	Creek Channel	--	2,150	2,440	3,250	None	None
4.2.1	**Riverwalk Dr.**	**24”**	**13**	**28**	**35**	**42**	**36” N-12**	**H**
4.3	U.S. HWY 101	24’x13’ RCB	7,600	2,130	2,430	3,230	None	None
4.3.1	**Alamar Way**	**30”**	**65**	**62**	**72**	**89**	**None[1]**	**H**
4.3.1.1	**Alamar Way**	**30”**	**22**	**27**	**34**	**41**	**36” N-12**	**H**
4.3.2	**Alamar Way**	**18”**	**6**	**38**	**44**	**55**	**36” N-12**	**H**
4.3.3	**Riverwalk Dr.**	**18”**	**6**	**25**	**31**	**38**	**36” N-12**	**H**
4.4	**Railroad Tracks**	**Creek Channel**	**1,350**	**2,080**	**2,400**	**3,200**	**Maintain Creek**	**H**
4.5	Fortuna Blvd.	24’x13’ RCB	7,600	1,280	1,480	1,990	None	None
4.5.1	**Fortuna Blvd.**	**12” CMP**	**3**	**30**	**36**	**44**	**24” N-12**	**H/S**
4.6	Fortuna Blvd. Up	Channel	2,000	1,270	1,470	1,980	None	None
4.6.1	Maxwell Lane	24”	22	16	20	24	None	None
4.7	At Jameson Crk.	Creek Channel	1,500	1,260	1,460	1,960	None	None
4.8	**Near Jameson Crk.**	**Creek Channel**	**1,500**	**1,090**	**1,270**	**1,710**	**Install Rip Rap**	**S**
4.8.1	Near Redwood Way	Drainage Ditch	75	17	20	26	None	None
4.8.2	**Redwood Way**	**2x24”**	**0[1]**	**17**	**20**	**25**	**Positive Slope**	**H/S**
4.8.3	**Springville Ln.**	**Gutter Flow**	**--**	**17**	**20**	**25**	**24” N-12**	**H/S**
4.8.4	**Springville Ln.**	**Gutter Flow**	**--**	**10**	**12**	**14**	**24” N-12**	**H/S**
4.9	Redwood Way	Bridge	--	1,080	1,260	1,700	None	None
4.9.1	Redwood Way	36” RCP	35	26	31	38	None	None
4.10	Near 2nd Ave.	Creek Channel	--	1,070	1,250	1,680	None	None
4.10.1	2nd Ave.	24”	13	19	22	28	None	None
4.10.1.1	2nd Ave.	24”	13	11	13	16	None	None

[1]See text for discussion.

*Note: Undersized facilities shown in **bold blue type**.

TABLE 5-4 EXISTING CONDITIONS AND PROPOSED DRAINAGE FACILITIES IN STRONGS CREEK DRAINAGE
(continued)

Node ID	Location	Existing Condition	Existing Capacity (cfs)	Estimated Flows (cfs)			Recommended Improvement	Deficiency H=Hydraulic S=Safety
				10-Year	25-Year	100-Year		
4.10.2	Senestraro Way	24”	25	9	11	13	None	None
4.11	Near Francisco Place	Creek Channel	--	1,060	1,240	1,670	None	None
4.11.1	Near Francisco Place	Creek Channel	200	104	120	155	None	None
4.11.2	**Rohnerville Rd.**	**36” CMP**	**40**	**100**	**115**	**145**	**42” N-12**	**H**
4.11.2.1	**Rohnerville Rd.**	**18” CMP**	**6**	**33**	**38**	**47**	**30” N-12**	**H**
4.11.3	Rohnerville Rd.	36” N-12	100	76	90	110	None	None
4.11.4	Rohnerville Rd.	36” N-12	106	65	76	94	None	None
4.12	Near Francisco Place	Creek Channel	--	1,000	1,090	1,570	None	None
4.12.1	**Rohnerville Rd.**	**18” CMP**	**6**	**14**	**17**	**21**	**30” N-12**	**H**
4.13	Rohnerville Rd.	Creek Channel	--	1,000	1,090	1,570	None	None
4.13.1	**Rohnerville Rd.**	**54” RCP**	**95**	**115**	**140**	**170**	**Parallel 42” N-12**	**H**
4.13.1	**Loop Rd.**	**Stream Channel**	**--**	**115**	**140**	**170**	**Detention Basin**	**None**
4.13.2	**Loop Rd.**	**30” CMP**	**22**	**115**	**140**	**170**	**Parallel 60” N-12**	**H**
4.14	Rohnerville Rd.	Bridge	--	920	1,110	1,450	None	None

*Note: Undersized facilities shown in **bold blue type**.

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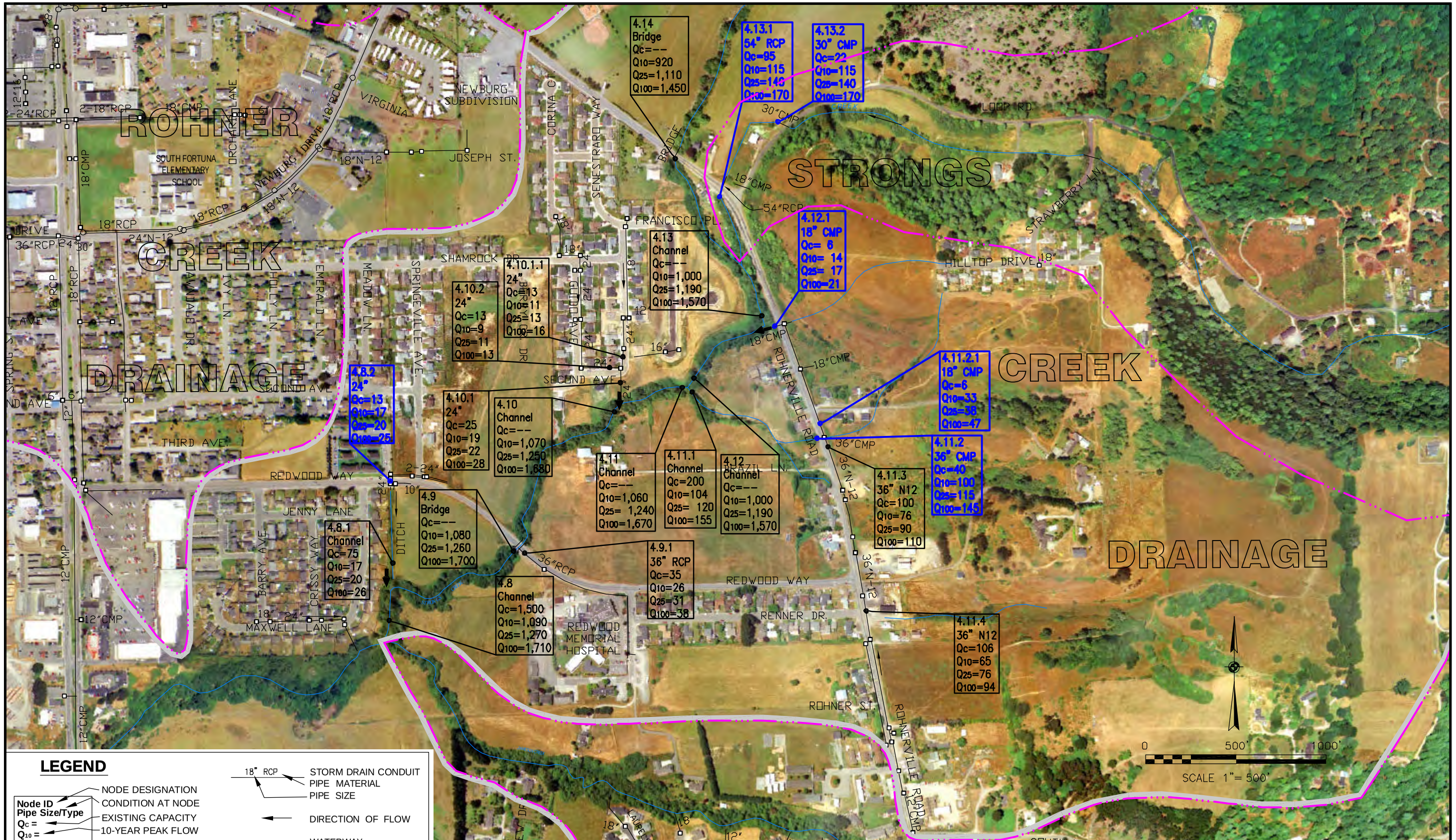

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EXISTING CAPACITIES AND ESTIMATED FLOWS

UPPER STRONGS CREEK DRAINAGE

FIGURE 5-10

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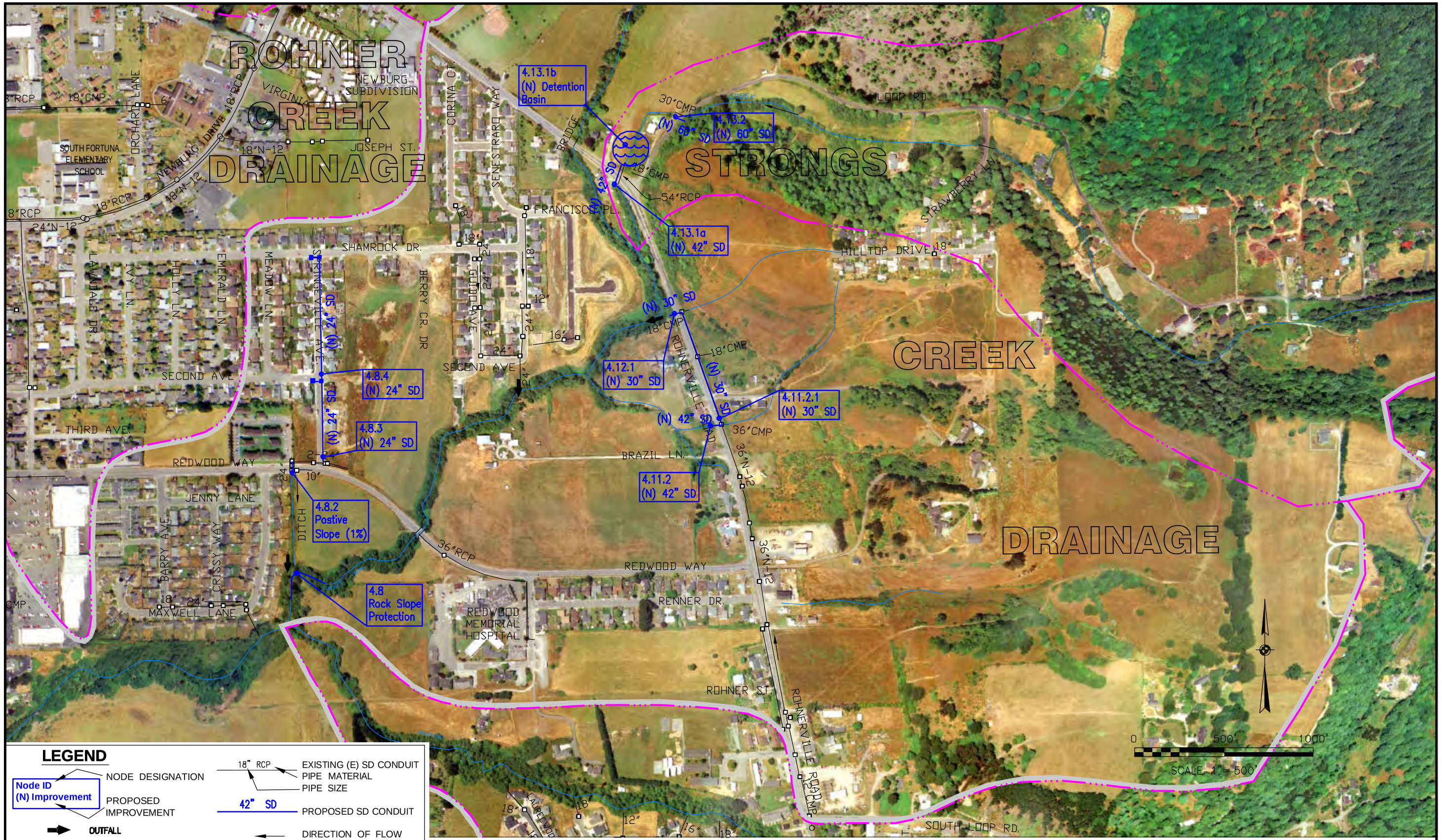

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PROPOSED IMPROVEMENTS

UPPER STRONGS CREEK DRAINAGE

FIGURE 5-11

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EXISTING CAPACITIES AND ESTIMATED FLOWS

LOWER STRONGS CREEK DRAINAGE

FIGURE 5-12

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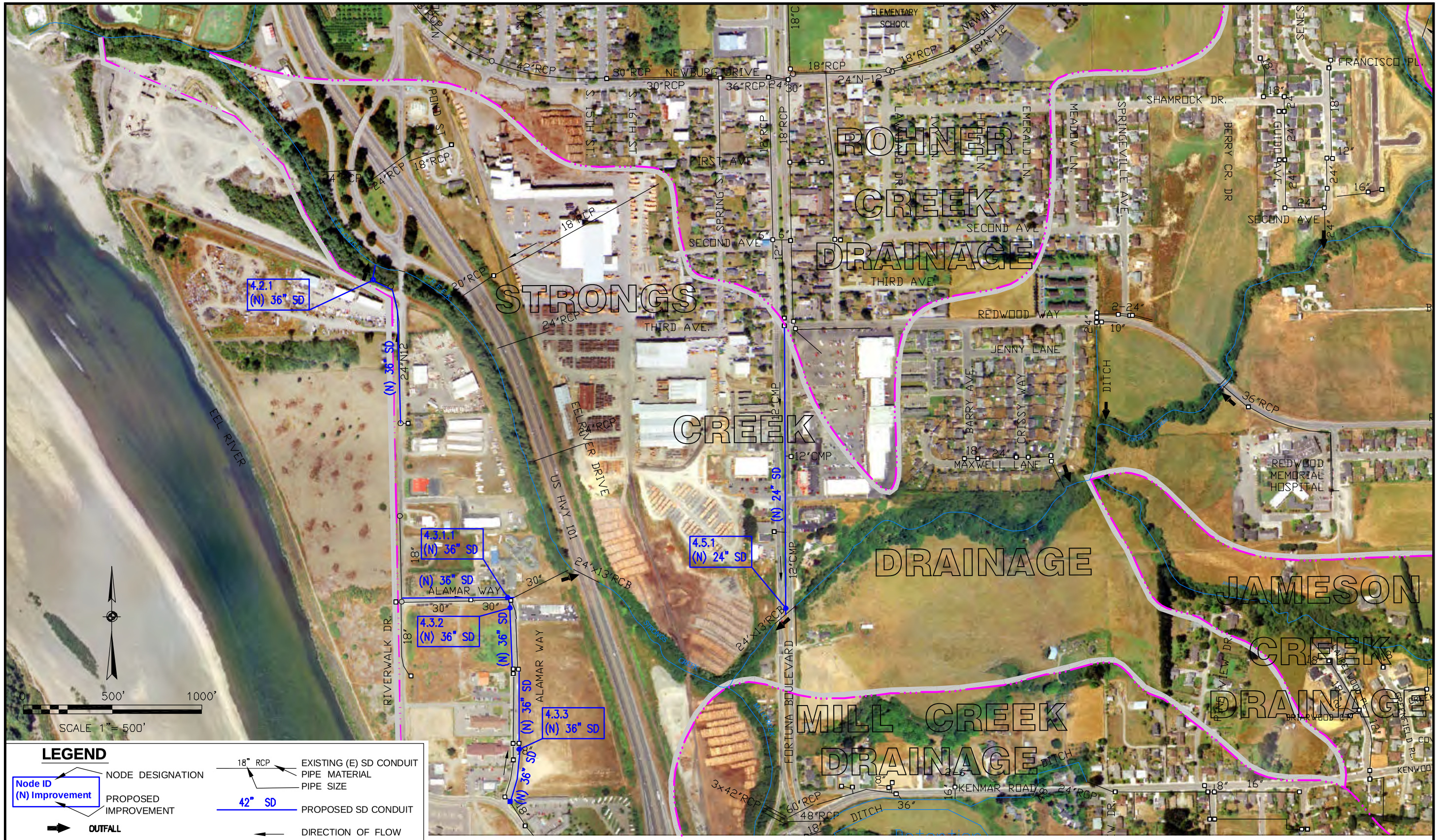

LEGEND

Node ID (N) Improvement	NODE DESIGNATION / PROPOSED IMPROVEMENT
18" RCP	EXISTING (E) SD CONDUIT PIPE MATERIAL / PIPE SIZE
42" SD	PROPOSED SD CONDUIT
OUTFALL	
	DIRECTION OF FLOW
	WATERWAY
	DRAINAGE BASIN BOUNDARY
EXISTING / NEW	MANHOLE
EXISTING / NEW	DROP INLET

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2005 STORM DRAINAGE MASTER PLAN
PROPOSED IMPROVEMENTS

LOWER STRONGS CREEK DRAINAGE

FIGURE 5-13

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5.5.5 Jameson Creek Drainage Basin

Jameson Creek, a major tributary of Strongs Creek, has its origin in the hills east of Fortuna and drains an area of about 950 acres. It parallels South Loop Road in a steep well-defined channel. Jameson Creek crosses Rohnerville Road in a 72" CMP culvert which, although is undersized, has resulted in little if any flooding due to the storage capacity of the stream's relatively deep channel.

Throughout its length, the channel is generally congested and overgrown with brush and willows. Historically, the only flooding that has occurred in the Jameson Creek watershed has been at its confluence with Strongs Creek. Little if any damage to residences or property has resulted from this flooding due to a lack of development in this area.

Significant development has occurred in the Jameson Creek Drainage Basin since the completion of the 1982 Storm Drainage Master Plan. Most of the development has occurred adjacent to Kenwood Drive, with several homes built within 60 – 70 feet of the creek channel. The Forest Hills Subdivision, located in the Seneca Gulch area east of Rohnerville Road, is currently in a state of development. A detention pond has been built off Huffman Lane to detain the anticipated increase in runoff resulting from this development. Increasing levels of development have the potential to cause bank erosion which can result in mass wasting. City of Fortuna staff has identified erosion sources, some of which have been extensive. Increases in sediment deposition within stream channels reduce their capacity and may increase downstream flooding potential in Jameson Creek and Strongs Creek. *Because of continuing development and increases in erosion within the Jameson Creek drainage, it is recommended that best management practices be used during construction, and mitigation measures be implemented that reduce the potential for increased sedimentation in Jameson Creek and Strongs Creek.* Table 5-5 and Figure 5-14 summarize the capacities and design flows for the existing drainage facilities at specific nodal points in the Jameson Creek Drainage Basin. Undersized facilities are shown in **bold blue**.

Only two improvement projects were recommended in the 1982 Storm Drainage Master Plan for the Jameson Creek Drainage Basin. These were to keep the Jameson Creek channel clear of brush and debris to ensure sufficient capacity, and to replace the existing 72" CMP culvert crossing under Rohnerville Road with a 102" RCP culvert when upstream development warrants. The hydraulic capacity of this culvert was determined to be 200 cfs using an inlet control nomograph. This is a conservative estimate. Assuming an average slope of 1 percent in this culvert, the capacity is approximately 230 cfs. *The recommendation to replace this culvert if it fails or as development warrants is restated in this report. At a 1 percent slope, a 60" N-12 culvert will provide sufficient capacity for all future flows.* The only storm drainage improvements that have been completed since the 1982 Drainage Study have been development related. These improvements are shown on Figure 5-15. Table 5-5 and Figure 5-15 summarize the undersized facilities, and describe their deficiencies and the recommended improvements.

TABLE 5-5 EXISTING CONDITIONS AND PROPOSED DRAINAGE FACILITIES IN JAMESON CREEK DRAINAGE

Node ID	Location	Existing Condition	Existing Capacity (cfs)	Estimated Flows (cfs)			Recommended Improvement	Deficiency H=Hydraulic S=Safety
				10-Year	25-Year	100-Year		
5.0	Strongs Creek	Creek Channel	--	215	265	335	None	None
5.1	Laurelwood Pl.	Creek Channel	--	215	260	330	None	None
5.1.1	Laurelwood Pl.	18” N-12	15	7	9	11	None	None
5.2	Justice Ct.	Creek Channel	--	205	250	320	None	None
5.3	**Rohnerville Rd.**	**72” CMP Culvert**	**200**	**195**	**235**	**300**	**60” N-12 Culvert**	**H**

[1]See text for discussion.
*Note: Undersized facilities shown in **bold blue type**.

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LEGEND

- Node ID / Pipe Size/Type — NODE DESIGNATION
- CONDITION AT NODE
- Q_C = EXISTING CAPACITY
- Q_{10} = 10-YEAR PEAK FLOW
- Q_{25} = 25-YEAR DESIGN FLOW
- Q_{100} = 100-YEAR PEAK FLOW
- 18" RCP — STORM DRAIN CONDUIT, PIPE MATERIAL, PIPE SIZE
- DIRECTION OF FLOW
- WATERWAY
- DRAINAGE BASIN BOUNDARY
- OUTFALL
- NODE
- MANHOLE
- DROP INLET

BOLD BLUE = UNDERSIZED
NORMAL TEXT = ADEQUATE

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EXISTING CAPACITIES AND ESTIMATED FLOWS

JAMESON CREEK DRAINAGE

FIGURE 5-14

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PROPOSED IMPROVEMENTS

JAMESON CREEK DRAINAGE

FIGURE 5-15

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5.5.6 Mill Creek Drainage Basin

The Mill Creek Drainage Basin is located in the southern most part of the City of Fortuna and study area. It encompasses an area greater than 1,700 acres, and has several branches which meet and form the main stem of the creek. The main channel of Mill Creek downstream of Rohnerville Road is relatively deep and well defined. There are three undersized stream crossings at Mill Street (two 42" RCP culverts), Webber Street (3'x3' box culvert), and Ross Hill Road (72" CMP culvert).

The area south of Drake Hill Road and near the Rohnerville Airport is currently pastured and agricultural land. Discussions with City of Fortuna Community Development Department indicate that the City may pursue options in the near future to annex lands south of Drake Hill Road with possible industrial zoning. This zoning type may greatly affect the amount of runoff that is generated from this area. Because storm drain infrastructure is intended to provide service for 50 to 100 years, recommended improvements in the Mill Creek Drainage Basin assume the future industrialization of this area. In the hydrology calculations, it is assumed that half of the area south of Drake Hill Road that drains to Mill Creek is industrialized and the remaining half remains as pasture and agricultural land. Table 5-6 and Figures 5-16 and 5-18 summarize the capacities and design flows for the existing drainage facilities at specific nodal points in the Mill Creek Drainage Basin. Undersized facilities are shown in **bold blue**.

Significant development has occurred in the Mill Creek Drainage Basin since the completion of the 1982 Storm Drainage Master Plan. Most of the development has been south of School Road and east of Rohnerville Road. Many of the recommendations made in the 1982 Drainage Plan have been implemented, although most storm drains installed have been downsized from those recommended. A new storm drain system was also installed on Rohnerville Road draining north toward the drainage systems on Bartlett Drive and Tami Drive, and also toward Mill Creek. Currently, significant development is occurring east of Rohnerville Road in the Osprey Terrace and Hillras Way areas. Field observations and reports from City staff suggest that drainage in the Upper Hillras Way and Sunset View Drive area is impaired and in need of development. A detention basin was constructed near Merlin Court and Osprey Terrace to help reduce the runoff peak resulting from this area's developments. City staff has observed a significant increase in the amount of runoff entering the Mill Creek drainage system as a result of recent developments in the Mill Creek Drainage Basin. Table 5-6 and Figures 5-17 and 5-19 summarize the undersized facilities, and describe their deficiencies and the recommended improvements.

Hydraulic analyses of the 15" N-12 storm drain system on Maggie Lane that discharges into Mill Creek indicate that it is just slightly undersized for the 25-year storm (see Node 6.3.4 on Figure 5-18). Due to the uncertainty in predicting runoff flow rates and the unknown pipe slope, it is our opinion that this storm drain is properly sized and sloped, and that no replacement is necessary.

Hydraulic analyses of the 15" N-12 storm drain system on Trinity Avenue that discharges into Mill Creek also indicate that it is just slightly undersized for the 25-year storm (see Node 6.7.1 on Figure 5-18). Due to the uncertainty in predicting runoff flow rates and the unknown pipe slope, it is our opinion that this storm drain is properly sized and sloped, and that no replacement is necessary.

5.5.6.1 Storm Drain Replacement: Kenmar Road Project

A new storm drain system is proposed to replace the existing undersized conduit on Kenmar Road near Crestview Drive. The Kenmar Road Project consists of the installation of new 36" and 24" storm drain conduits (see Node 6.1.3 on Figure 5-19). *It is recommended that the 24" RCP at Crestview Drive be replaced with 36" N-12. It is also recommended that the 18" RCP between Crestview Drive and Mill Creek Way be replaced with 24" N-12.* The proposed project has been assigned a *low priority* because existing drainage facilities are undersized for current levels of development, but do not currently flood, and the area is near maximum development. This project is considered development-driven. Our opinion of the probable cost of this project is $186,000.

5.5.6.2 Storm Drain Replacement: Ross Hill Road Culvert Replacement Project

The area immediately upstream of the 72" CMP culvert through which Mill Creek flows under Ross Hill Road acts as detention during high flow periods (see Node 6.3 on Figure 5-19). The 1982 Storm Drainage Master Plan identified this culvert as undersized for the estimated 25-year design flow and in need of replacement. *Hydraulic analyses performed as part of this project confirm this condition. In order to provide the hydraulic capacity needed to pass the 25-year flow at this location while still maintaining the detention area, it is recommended that two 60" N-12 culverts be installed parallel to and above the existing culvert.* These culverts will serve as a bypass once the detention area becomes full. This project is assigned a *medium priority* ranking because the existing drainage facilities are significantly undersized for current levels of development but do not currently flood during the design storm, and further development is anticipated. This project is development driven. Our opinion of the probable cost of this project is $215,000.

5.5.6.3 Storm Drain Replacement: Webber Street Culvert Replacement Project

Hydraulic analyses of the 3'x3' RCB culvert at Webber Street indicate that it has insufficient hydraulic capacity for the estimated 25-year flood event (see Node 6.4.2 on Figure 5-19). *It is recommended that a 36" N-12 culvert is installed parallel to the existing box culvert to provide the additional capacity necessary to maintain the 25-year storm event within the creek.* This project is a variation of a project proposed in the 1982 Storm Drainage Master Plan. This project is assigned a *medium priority* ranking because the existing drainage facilities are significantly undersized for current levels of development, and flooding does not currently occur during the design storm. This project is development driven because further development in this drainage area is anticipated. Our opinion of the probable cost of this project is $34,000.

5.5.6.4 Storm Drain Replacement: School Street Project No. 1

Hydraulic analyses of the 14" CMP storm drain crossing School Street between Webber Street and Rohnerville Road indicate that it is significantly undersized for the estimated 25-year design event (see Node 6.4.2.1 on Figure 5-19). *Replacing the section of 14" CMP from Trinity Avenue to School Street with 24" N-12 and installing an additional drop inlet on School Street is recommended to provide the capacity necessary for the 25-year storm event at the area's ultimate level of build out.* This project is a modification of a project proposed in the 1982 Storm Drainage Master Plan. It has been assigned a *medium priority* ranking because while the existing drainage facilities are significantly undersized for current levels of development, flooding does

not currently occur during the design storm. This project is development driven because further development in this drainage area is anticipated. Our opinion of the probable cost of this project is $147,000.

5.5.6.5 New Storm Drain and Detention Basin: Jones Street Project (City Project No. 9809)

A significant amount of runoff from above the Jones Street and View Street area travels as surface flow through the Jones Street and Jones Court area. The City has been aware of this issue for some time, but recent development in this area has exacerbated the problem. *The Department of Public Works has studied several possible solutions to this problem, the most cost effective of which is to install an 18" N-12 storm drain with drop inlets on Jones Street from View Street down and across Mill Street where it would discharge to Mill Creek (see Node 6.4.3.1a on Figure 5-17). The City has also considered plans to construct a small detention basin on the north side of Mill Street into which the new storm drain would discharge. The detention basin would help reduce the impact this additional flow would have on downstream areas of Mill Creek. If a detention basin was constructed in this area, its volume would have to be between 1.0 and 1.25 acre-feet (see Node 6.4.3.1b on Figure 5-17).* The storm drain portion of this project has been assigned a *high priority* ranking due to the current runoff and flooding problems in this area, and the potential for additional runoff as development up the hill continues. Construction of the detention basin has been assigned a *medium priority* ranking because while several downstream drainage structures on Mill Creek are undersized for the estimated 25-year design flow they do not currently flood. The City may also wish to consider the option of increasing the capacity of downstream drainage structures on Mill Creek rather than construct this detention basin because a greater overall benefit may be gained by increasing the size of downstream culverts. These projects are development driven. Our opinion of the probable cost of the storm drain portion of this project is $137,000. Our opinion of the probable cost of the detention basin portion of this project is $72,000.

5.5.6.6 Culvert Replacement: Mill Street Project

In the 1982 Storm Drainage Master Plan it was recommended that an additional culvert be installed paralleling the dual 42" RCP culverts through which Mill Creek flows under Mill Street. Hydraulic analyses performed as part of this project confirm this recommendation. *It is recommended that an additional 42" N-12 culvert be installed in parallel with the existing culverts to provide the capacity necessary to contain the 25-year flow event (see Node 6.4.4 on Figure 5-19).* This project is a modification of a project proposed in the 1982 Storm Drainage Master Plan. It has been assigned a *medium priority* ranking because while the existing drainage facilities are undersized for current and future levels of development, flooding does not currently occur during the design storm. This project is not development driven. Our opinion of the probable cost of this project is $54,000.

5.5.6.7 Culvert Replacement: School Street Project No. 2

In 1998 a 30" pipe was installed as a slip lining in the existing 3'x3' RCB at School Street near Ronald Avenue, and a 48" N-12 culvert was installed above the slip lined box culvert to provide additional capacity. The area upstream serves as detention if the 30" culvert becomes overwhelmed, and the 48" culvert acts as an emergency bypass if the backwater becomes too

high. Hydraulic analyses of the 30" and 48" N-12 culverts at School Street near Ronald Avenue indicate that combined capacity is less than the estimated 25-year design flow (see Node 6.6 on Figure 5-17). *In order to provide the necessary hydraulic capacity for the emergency bypass, it is recommended that an additional 48" N-12 culvert is installed parallel to the existing 48" culvert.* This project is a modification of a project proposed in the original drainage study. It has been assigned a *low priority* ranking because the existing drainage facilities are undersized for future levels of development, and flooding does not currently occur during the 25-year storm. This project is development driven. Our opinion of the probable cost of this project is $56,000.

5.5.6.8 Storm Drain Replacement: West School Street Project

Hydraulic analyses of the storm drainage system on West School Street between Wood Street and the mobile home park indicate that it is undersized for the 25-year design flow (see Nodes 6.6.2, 6.6.3, 6.6.4 and 6.6.5 on Figure 5-17). The reduced capacity of these pipes is due to low slopes. *To provide the necessary hydraulic capacity for the 25-year design flow under future build-out conditions for this area, it is recommended that a 30" N-12 storm drain pipe be installed parallel to the existing 36" RCP pipe between Wood Street and Thelma Street, a 24" N-12 pipe be installed parallel to the existing 24" RCP pipe between Thelma Street and the mobile home park, and an 18" N-12 pipe be installed parallel to the existing 18" RCP pipe adjacent to the mobile home park. Additional drop inlets are also recommended. The new system should be cross-connected with the existing system.* The capacity afforded by this project will also allow for the connection of future storm drains to this system. This project is assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and future levels of development, but flooding does not currently occur during the 25-year storm. This project is development driven. Our opinion of the probable cost of this project is $527,000.

5.5.6.9 New Storm Drain: Thomas Street Project (City Project No. 9806)

A new storm drainage system is proposed for the Thomas Street area near Toddy Thomas Elementary School (see Node 6.6.3.1 on Figure 5-17). The City of Fortuna Public Works Department has identified this site as in need of storm drainage improvements based on a historic problem with water flooding residents on Thomas Street and several private lanes off Thelma Street near School Street. The runoff originates in the area near the Rohnerville Airport and flows into the Campton Heights area in various areas on the plateau. *Based on the plans proposed by the Public Works Department, and hydraulic calculations made as part of this study, it recommended that a new 18" N-12 storm drain system with new drop inlets be installed on Thomas Street west to Thelma Street and then north where it should be connected to the existing 36" storm drain system on West School Street.* This project is assigned a *high priority* ranking due to the current runoff and flooding problems in the Thomas Street area, and the potential for additional runoff as development south of Drake Hill Road continues. It is not development driven. Our opinion of the probable cost of the project is $134,000.

5.5.6.10 Culvert Replacement: Campton Heights Drive Project (City Project No. 9805)

Anticipated industrialized development south of Drake Hill Road is expected to increase storm water flows in the system of storm drains and drainage ditches between Ronald Avenue and Clara Avenue. The existing 18" CMP culvert located on Campton Heights Drive which drains

into the drainage ditch between Ronald Avenue and Clara Avenue was identified by the City as in need of replacement because it is significantly undersized for the 25-year design flow and floods during periods of high runoff (see Node 6.7.3 on Figure 5-17). This culvert was identified in the 1982 Storm Drainage Master Plan as in need of improvement. *It is recommended that the existing culvert be replaced with a 48" N-12 culvert to provide the capacity for the 25-year storm event.* This project has been assigned a *high priority* ranking because the existing drainage facilities are significantly undersized for current and future levels of development, and flooding currently occurs on Campton Heights Drive during heavy precipitation events. This project is not development driven. Our opinion of the probable cost of the project is $90,000.

5.5.6.11 Culvert Replacement: Drake Hill Road Project No. 1

Hydraulic analyses of the two 24" CMP culverts crossing Drake Hill Road between Ronald Avenue and Clara Avenue indicate that they have inadequate capacity for the estimated 25-year storm event considering the future industrialization of lands south of Drake Hill Road (see Node 6.7.4 on Figure 5-17). *Installing a 36" N-12 culvert parallel to the existing culverts is recommended to provide sufficient hydraulic capacity to pass the design storm flows. An alternative to this project is to replace the existing culverts with a single 42" N-12 culvert.* This project is a modification of a project proposed in the 1982 Storm Drainage Master Plan. It has been assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and future levels of development, but flooding does not currently occur during the 25-year storm. This project is development driven. Our opinion of the probable cost of this project is $34,000.

5.5.6.12 Storm Drain Replacement: Cecil Avenue Project No. 1

Hydraulic analyses of the 60" RCP storm drain crossing Cecil Avenue and discharging into the West Branch of Mill Creek indicate that it has approximately half the hydraulic capacity necessary to contain the estimated 25-year design flow at the future build-out level assuming the industrialization of lands south of Drake Hill Road (see Node 6.8 on Figure 5-17). *To provide the capacity necessary for this future flow, it is recommended that a 52" N-12 storm drain be installed parallel to the existing 60" RCP and connected to the storm drain system on Cecil Avenue and on Tami Drive.* This project is a variation of a proposed project in the 1982 Storm Drainage Master Plan. It has been assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and future levels of development, but flooding does not currently occur during the 25-year storm. This project is development driven. Our opinion of the probable cost of this project is $182,000.

5.5.6.13 Storm Drain Replacement: Bridle Creek Avenue Project

The existing 36" N-12 storm drain system that was installed on Bridle Creek Avenue between Bartlett Drive and Rohnerville Road has sufficient capacity for area assuming land use south of Drake Hill Road remains in its current state. Should industrial development occur on these lands in the future, this storm drain system may need to be upsized to handle the estimated 25-year flow (see Node 6.8.1 on Figure 5-17). *It is recommended that the storm drain system between Bartlett Drive and the new development at the north end of Bridle Creek Avenue is increased to 42" N-12 if runoff increases beyond the existing storm drain's design capacity as a result of*

industrialized development south of Drake Hill Road. An alternative to this project would be to install a 24" N-12 storm drain parallel to the existing 36" pipe. This project has been assigned a *low priority* ranking because the existing drainage facilities are undersized for anticipated future levels of development but do not currently flood during the design storm. This project is development-driven. Our opinion of the probable cost of this project is $91,000. Our opinion of the probable cost of the alternative project is $79,000.

5.5.6.14 Storm Drain Replacement: Bartlett Drive and Rohnerville Road Project

Hydraulic analyses of the 36" RCP storm drains on Rohnerville Road and Bartlett Drive indicate that they are undersized for the 25-year design flow (see Nodes 6.8.2 and 6.8.2.1a on Figure 5-17). The 1982 Storm Drainage Master Plan recommended installing 42" storm drains at these locations. *In order to meet the drainage requirements for the 25-year storm, it is recommended that a 36" N-12 storm drain is installed parallel to the existing system in these locations, along with additional drop inlets, as shown on Figure 5-17. The new storm drain should also be cross connected to the existing storm drain.* This project has been assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and future levels of development, but flooding does not currently occur during the 25-year storm. This project is development driven. Our opinion of the probable cost of this project is $416,000.

5.5.6.15 New Detention Basin: Osprey Terrace Project (City Project No. 9804)

The City of Fortuna Public Works Department has identified the area just east of Rohnerville Road and Tony Street as a potential site for a new storm water detention basin (see Node 6.8.2.1b on Figure 5-17). With the continuing development of the area east of Rohnerville Road between Osprey Terrace and Mountain View Road, storm runoff is becoming more of a problem. *At the proposed site there is an existing depression that could be developed to create a detention basin to help reduce the runoff peak which enters the 36" RCP storm drain on Rohnerville Road. Preliminary estimates show that this basin should have a volume between 1.25 and 1.75 acre-feet.* This project has been assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and future levels of development, but flooding does not currently occur during the 25-year storm. This project is development driven. The City may wish to make this project the responsibility of the developer(s) as a mitigation requirement related to the downstream effects of increased runoff from development in this area. Our opinion of the probable cost of this project is $89,000.

5.5.6.16 Storm Drain Replacement: Cecil Avenue Project No. 2 (City Project No. 9405)

The City of Fortuna Public Works Department has identified the drainage channel and culverts behind Cecil Avenue as in need of improvements (see Node 6.9 on Figure 5-17). This section of the storm drainage system consists of open channel between two sections of storm drain pipe (36" and 48", respectively). The Public Works Department also has a problem keeping the grate at the inlet of the 48" pipe free of debris from people using the drainage channel for refuse disposal. *It is recommended that the City completely enclose the drainage channel in storm drain pipe from Drake Hill Road to Bartlett Drive with 48" N-12, replacing the existing 36" section. It is also recommended that a parallel 48" N-12 storm drain be installed in order to provide the capacity necessary for the estimated 25-year flow. New drop inlets should also be installed.* This

project is assigned a *medium priority* ranking because the existing drainage facilities are undersized for current and future levels of development, but flooding does not currently occur during the 25-year storm. This project is development driven. Our opinion of the probable cost of this project is $538,000.

5.5.6.17 Storm Drain Replacement: Drake Hill Road Project No. 2

Hydraulic analyses of the culverts crossing Drake Hill Road near Airport Road indicate that they are undersized for the 25-year design flow (see Node 6.10 on Figure 5-17). *To safely drain the area south of Drake Hill Road, it is recommended that two 36" N-12 culverts be installed parallel to the existing 24" and 30" CMP culverts.* This project is assigned a *high priority* ranking because the existing drainage facilities are undersized for current and future levels of development, and flooding on Drake Hill Road currently occurs during heavy precipitation events. This project is development driven. Our opinion of the probable cost of the project is $76,000.

TABLE 5-6 EXISTING CONDITIONS AND PROPOSED DRAINAGE FACILITIES IN MILL CREEK DRAINAGE

Node ID	Location	Existing Condition	Existing Capacity (cfs)	Estimated Flows (cfs)			Recommended Improvement	Deficiency H=Hydraulic S=Safety
				10-Year	25-Year	100-Year		
6.0	Strongs Creek	Creek Channel	--	850	980	1,320	None	None
6.1	Fortuna Blvd.	3x42" RCP	150	37	46	58	None	None
6.1.1	Kenmar Rd.	Drainage Channel	61	37	46	58	None	None
6.1.2	Kenmar Rd.	48" RCP	77	31	37	48	None	None
6.1.3	**Kenmar Rd.**	**24" RCP**	**13**	**27**	**32**	**41**	**36" & 18" N-12**	**H**
6.2	S. Fortuna Blvd.	10'x5' RCB	740	550	650	860	None	H
6.3	**Ross Hill Rd.**	**72" CMP**	**280**	**550**	**650**	**860**	**2 x 60" N-12**	**H**
6.3.1	Kenmar Rd.	30" RCP	200	32	39	48	None	None
6.3.2	Kenmar Rd.	30" RCP	50	32	39	48	None	None
6.3.3	Kenmar Rd.	18" RCP	13	11	13	16	None	None
6.3.4	**Maggie Ln.**	**15" N-12**	**12**	**11**	**13**	**16**	**None[1]**	**H**
6.4	Church St.	Creek Channel	--	495	605	770	None	None
6.4.1	Church St.	Creek Channel	--	160	195	250	None	None
6.4.2	**Webber St.**	**3'x3' RCB**	**145**	**160**	**190**	**250**	**Parallel 36" N-12**	**H**
6.4.2.1	**School St.**	**14" CMP**	**4**	**11**	**14**	**17**	**24" N-12**	**H**
6.4.2.2	Trinity Ave.	18" CMP	6	4	5	6	None	None
6.4.3	Rohnerville Rd.	72" RCP	200	160	190	240	None	None
6.4.3.1a	**View St.**	**Surface Runoff**	**--**	**12**	**14**	**18**	**18" N-12**	**H**
6.4.3.1b	**View St.**	**Surface Runoff**	**--**	**12**	**14**	**18**	**Detention Basin**	**H**
6.4.4	**Mill St.**	**2x42" RCP**	**100**	**150**	**180**	**220**	**Parallel 42" N-12**	**H**
6.5	Near Maggie Ln.	Creek Channel	--	350	415	530	None	None
6.6	**School St.**	**30" & 48" N-12**	**280**	**350**	**415**	**530**	**Parallel 48" N-12**	**H**
6.6.1	West School St.	36" RCP	112	61	75	95	None	None
6.6.2	**West School St.**	**36" RCP**	**49**	**59**	**71**	**91**	**Parallel 30" N-12**	**H**
6.6.2.1	Wood St.	24" RCP	42	29	34	42	None	None

[1]See text for discussion.

*Note: Undersized facilities shown in **bold blue type**.

TABLE 5-6 EXISTING CONDITIONS AND PROPOSED DRAINAGE FACILITIES IN MILL CREEK DRAINAGE
(continued)

Node ID	Location	Existing Condition	Existing Capacity (cfs)	Estimated Flows (cfs)			Recommended Improvement	Deficiency H=Hydraulic S=Safety
				10-Year	25-Year	100-Year		
6.6.3	**West School St.**	**36" RCP**	**30**	**30**	**35**	**44**	**Parallel 30" N-12**	**H**
6.6.3.1	**Thomas St.**	**Surface Runoff**	**--**	**5**	**7**	**8**	**18" N-12**	**H/S**
6.6.4	**West School St.**	**24" RCP**	**10**	**28**	**33**	**42**	**Parallel 24" N-12**	**H**
6.6.5	**West School St.**	**18" RCP**	**10**	**22**	**26**	**32**	**Parallel 18" N-12**	**H**
6.7	Trinity Ave.	Creek Channel	--	350	410	515	None	None
6.7.1	**Trinity Ave.**	**24" RCP**	**13**	**11**	**14**	**17**	**None[1]**	**H**
6.7.2	College St.	48" N-12	155	78	93	115	None	None
6.7.3	**Campton Heights Dr.**	**18" CMP**	**6**	**67**	**82**	**100**	**48" N-12**	**H/S**
6.7.4	**Drake Hill Rd.**	**2x24" CMP**	**26**	**56**	**70**	**85**	**Parallel 36" N-12**	**H**
6.8	**Cecil Ave.**	**60" RCP**	**180**	**300**	**360**	**440**	**Parallel 52" N-12**	**H**
6.8.1	**Bridle Creek Ave.**	**36" N-12**	**51**	**58**	**69**	**85**	**42" N-12**	**H**
6.8.2	**Bartlett Dr.**	**36" RCP**	**47**	**95**	**110**	**140**	**Parallel 36" N-12**	**H**
6.8.2.1a	**Rohnerville Rd.**	**36" RCP**	**47**	**72**	**85**	**105**	**Parallel 36" N-12**	**H**
6.8.2.1b	**Rohnerville Rd.**	**Surface Flow**	**--**				**Detention Pond**	**H**
6.8.2.2	Sunset View Dr.	36" N-12	310	60	71	87	None	None
6.9	**Cecil Ave.**	**36" & 48" N-12 & Ditch**	**50-100**	**180**	**220**	**270**	**Parallel 48" N-12**	**H**
6.10	**Drake Hill Rd.**	**2x24" CMP & 2x30" CMP**	**70**	**140**	**170**	**210**	**Parallel 26" N-12**	**H/S**

[1]See text for discussion.
*Note: Undersized facilities shown in **bold blue type**.

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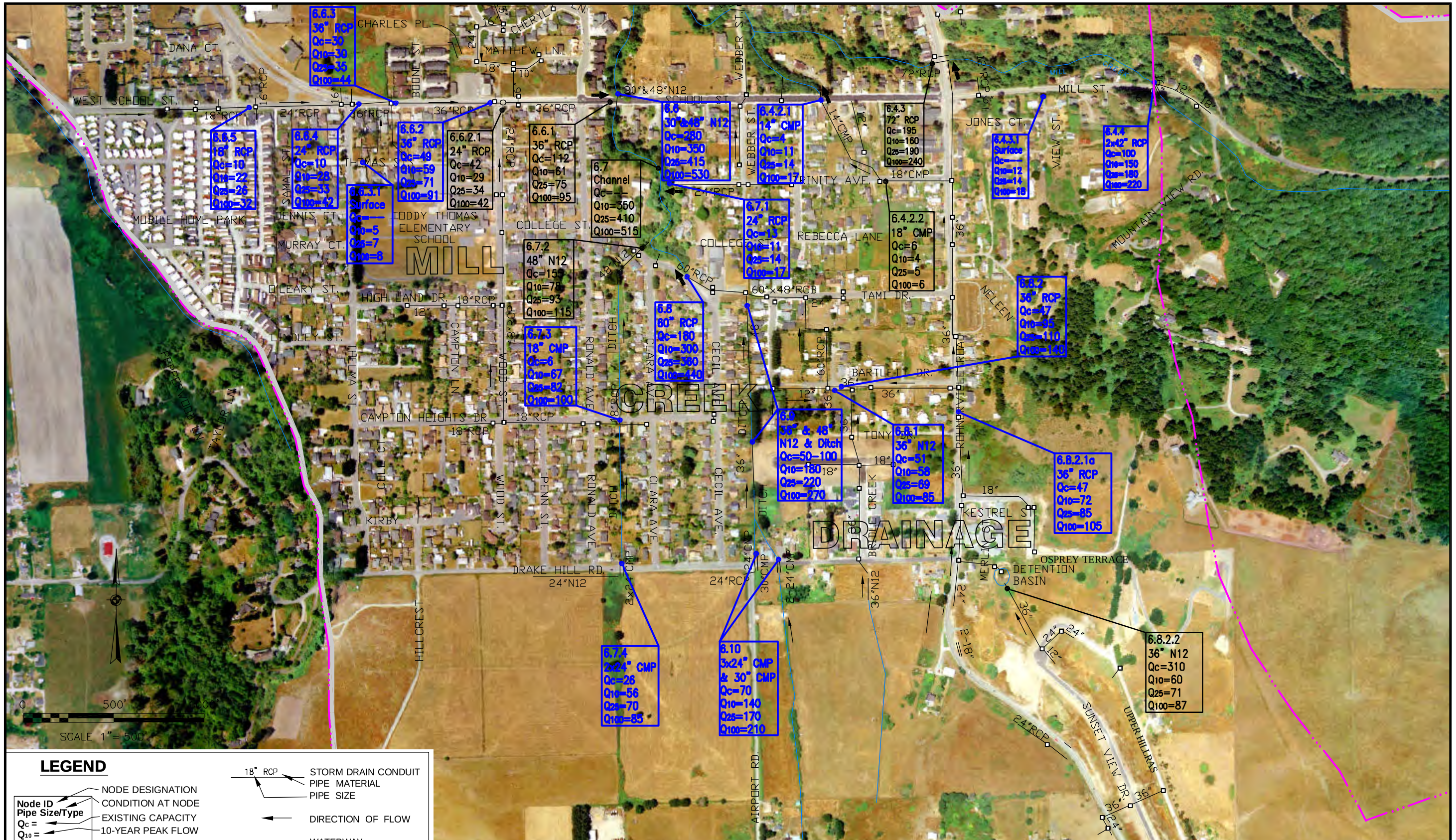

JOB # 04105402
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DRAWN MK

CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN
EXISTING CAPACITIES AND ESTIMATED FLOWS

UPPER MILL CREEK DRAINAGE

FIGURE 5-16

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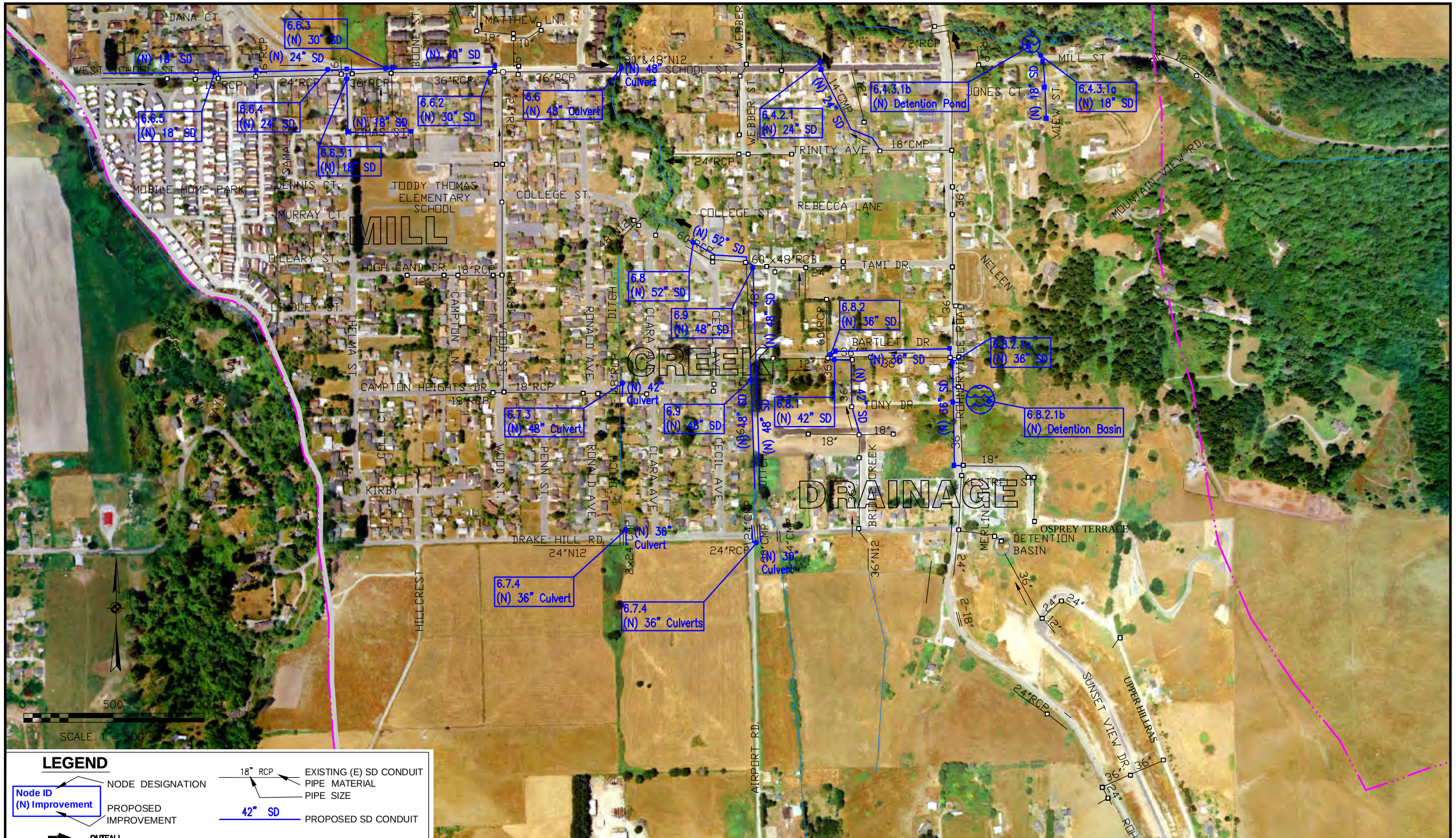

LEGEND

Node ID (N) Improvement	NODE DESIGNATION / PROPOSED IMPROVEMENT
OUTFALL	
EXISTING / NEW: MANHOLE	
EXISTING / NEW: DROP INLET	
18" RCP	EXISTING (E) SD CONDUIT, PIPE MATERIAL, PIPE SIZE
42" SD	PROPOSED SD CONDUIT
	DIRECTION OF FLOW
	WATERWAY
	DRAINAGE BASIN BOUNDARY

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DESIGN MK
DRAWN MK

CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN
PROPOSED IMPROVEMENTS

UPPER MILL CREEK DRAINAGE

FIGURE 5-17

WINZLER & KELLY

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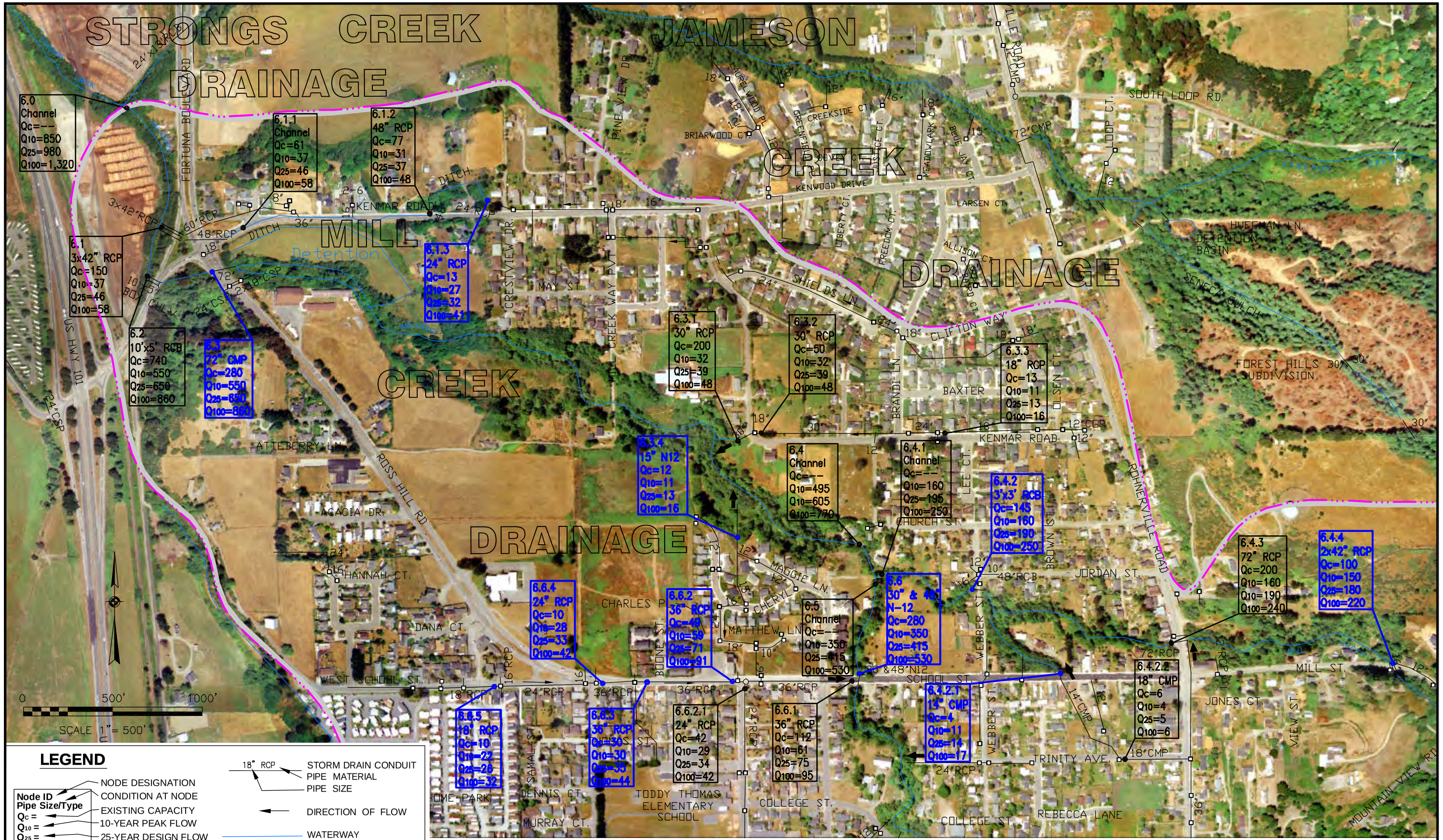

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DRAWN MK

CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN
EXISTING CAPACITIES AND ESTIMATED FLOWS

LOWER MILL CREEK DRAINAGE

FIGURE 5-18

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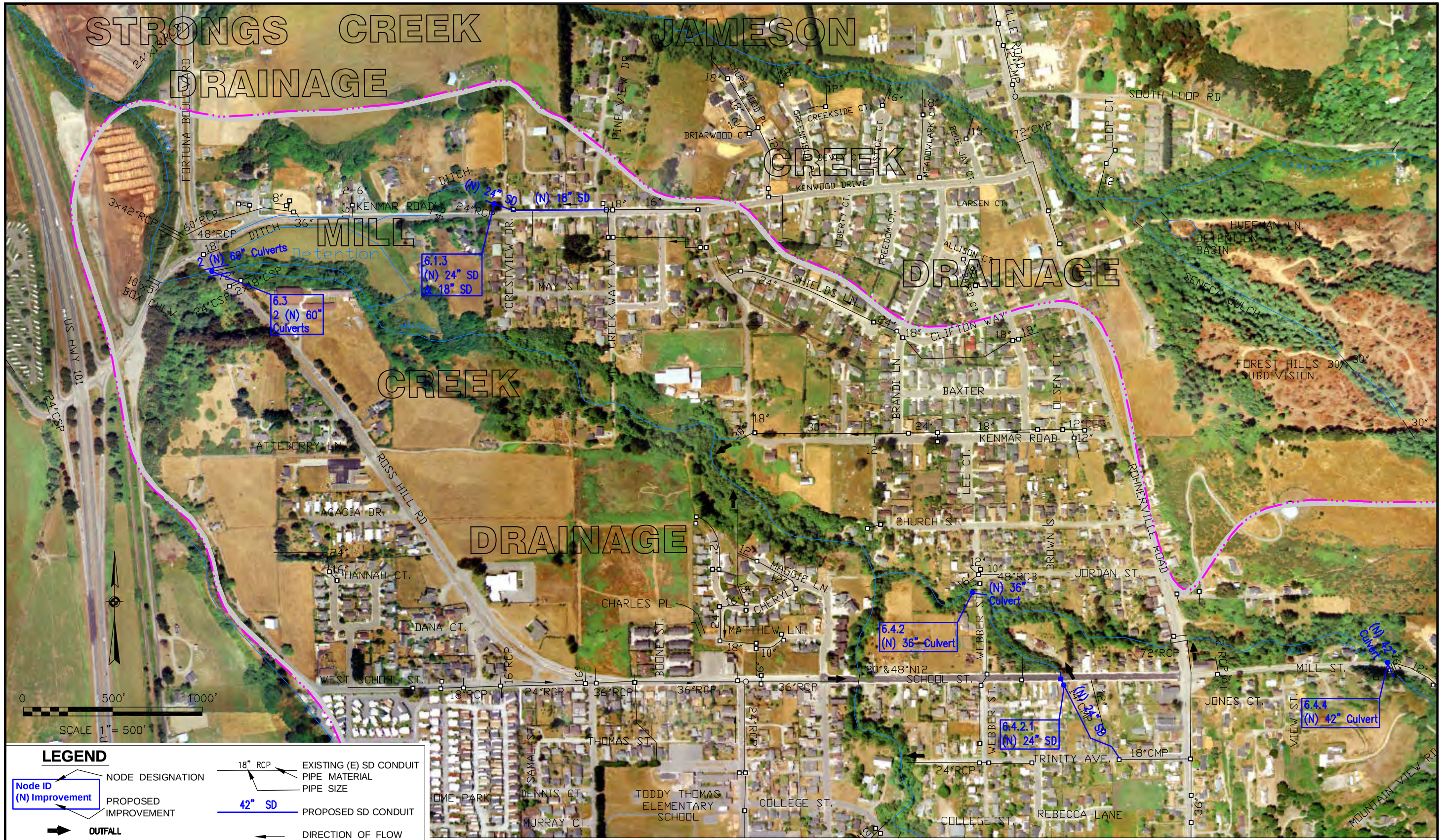

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CITY OF FORTUNA
2005 STORM DRAINAGE MASTER PLAN
PROPOSED IMPROVEMENTS

LOWER MILL CREEK DRAINAGE

FIGURE 5-19

WINZLER & KELLY

5.6 Pacific Lumber Fortuna Mill Site

The Pacific Lumber mill site is located in western Fortuna between Newburg Drive, Fortuna Boulevard and U.S. Highway 101, and encompasses an area of approximately 75 acres. The mill, which had been one of the cornerstones of the area's economy, permanently closed operations in June 2005. Tentative plans are currently in place to redevelop this area as a "super store" or central shopping center. Zoning for this area, City of Fortuna General Plan amendments, and design review still await the potential development, which is at least three years off. With regard to storm drainage, it is important that development plans address the potential impacts redevelopment of this area may have on the City's stormwater system. *It is recommended that in developing this site, onsite underground stormwater detention basins be utilized to detain runoff prior to entering the City's storm drainage systems on Newburg Avenue, Fortuna Boulevard, and/or Strongs Creek.* A high level of impervious area at this site could have significant implications on the City's drainage system in this area, much of which is undersized for current and future levels of development.

5.7 Capital Improvement Program

The purpose of the Capital Improvement Program (CIP) is to be a hands-on tool that is used by the City to plan subsequent work. The CIP prioritizes the 55 recommended and proposed drainage projects based on the following set of critical factors:

- Current flooding potential
- Long-term impacts on public safety
- Potential to reduce flooding or erosion
- Correction of structural deficiencies
- Cost-effectiveness
- Inclusion of BMPs
- Short-term construction impacts
- Impacts on operation and maintenance
- Potential to influence development, business growth, or create jobs

This method of assessing the relative value of the improvement projects is in adherence with the guidelines of the Government Accounting Standards Board Statement 34 (GASB-34). Adherence with these guidelines is an important step in protecting the City's bond rating.

The California Department of Transportation (Caltrans) is responsible for the drainage facilities within their right-of-way along the State Highway 101 corridor, which passes through the Fortuna City Limits. If Caltrans proposes a project in Fortuna that is within the State's right-of-way and includes drainage facility improvements similar to those proposed in this Storm Drainage Master Plan, it may be possible to negotiate with them to either contribute funds to or construct part of the proposed improvement.

The drainage projects described in this chapter are summarized in Table 5-7. Figures 5-3, 5-5, 5-7, 5-9, 5-11, 5-13, 5-15, 5-17 and 5-19 show the locations of the proposed improvements. Using the above set of critical factors, the proposed projects for each drainage area were assigned a high, medium or low priority ranking. In addition to these rankings, the table shows a

recommended grouping of projects, and the order in which they should be completed. It is important to note that this priority ranking may change as conditions within each drainage basin change and as future development occurs. Also, developers typically fund development-driven projects in part or in full.

5.8 Recommended Channel and Detention Basin Maintenance Program

A channel and detention basin maintenance program is important for maintaining the design capacity of flood control channels, ditches, and basins. Channels should be designed with 1-foot of freeboard at the estimated 25-year flow. Once a channel is created, the hydraulic capacity of a channel is a function of the roughness of the channel. Debris and vegetation increase the roughness of the section and decrease the channel's hydraulic capacity.

Winzler & Kelly recommends the following channel and basin maintenance program to ensure that drainage channels and ditches function as designed:

Biannual Maintenance

- Flood control channels, ditches and basins: Trees and thick vegetation such as grasses, cattails and blackberry bushes should be removed within the banks. Floor and banks should be mown. Debris should be removed. Outlet structure functionality maintained.
- Natural creeks and channels: Trees should be pruned such that the leaves are above the bank level. Thick vegetation such as grasses, cattails and blackberry bushes should be removed within the banks. Debris should be removed.

Five-Year Maintenance

- Flood control channels, ditches, and basins: Remove excess sediment to restore original channel or basin dimensions.

Table 5-8 summarizes the primary channels and drainage ditches with recommended maintenance under the Channel Maintenance Program.

5.9 Strongs Creek

Strongs Creek, and its tributaries Rohner Creek and Mill Creek, are classified as an anadromous fish bearing streams. In the past, the Fortuna Creeks Project, in cooperation with various other fisheries and stream restoration groups, have volunteered to clean and help restore Strongs Creek and its tributaries with the goals of improving the water quality and habitat of the stream, and restoring the creek channel capacity while enhancing salmonid habitat. Activities include the removal of non-native vegetation and urban refuse to increase flood protection, and the revegetation of sparsely vegetated sections along the bankfull zone and upper creek terraces with native plants. Rohner and Strongs Creeks are cleaned of trash twice a year by the project. It is important to note that because Strongs Creek and its tributaries are anadromous fish bearing streams California Department of Fish and Game (DFG) and Army Corps of Engineers (ACOE) permits will be required, and any design will have to meet DFG and NOAA Fisheries standards for fish passage.

TABLE 5-7 PROPOSED IMPROVEMENT PROJECTS FOR THE FORTUNA STORM DRAIN MASTER PLAN

Ranking H = High M = Medium L = Low Numbers indicate project order	**Node ID**	**Location**	**Existing Storm Drain Description**	**Improvement**	**Development Driven?**	**Opinion of Probable Cost**
H-1	1.6.1	11th St./Alley	14” – 18” RCP	Replace w/30” N-12	NO	$331,000
H-1	1.6.2	Alley/P St.	18” RCP	Replace w/24” N-12	NO	See Node 1.6.1
H-2	1.7	9th St.	3’x3’ Box Culvert	Replace w/36” N-12	NO	$176,000
H-3	2.3	Rohner Creek	Creek Channel	Widen Channel	NO	$323,000
H-4	1.4.2	Home Ave.	2’x2’ Box Culvert	Replace w/24” N-12	NO	$326,000
H-5	4.8	Strongs Creek	Creek Channel	Bank Stabilization	NO	$160,000
H-6	3.1	Rohnerville Rd.	Detention Basin	Improve Basin	NO	$635,000
H-7	6.4.3.1a	Jones St.	Surface Flow	Install 18” N-12	YES	$137,000
H-8	2.4	Rohner Creek	Creek Channel	New Bypass Channel	NO	$2,926,000
H-8	2.5	Rohner Creek	Creek Channel	Detention Basin	NO	$346,000
H-8	2.6	Rohner Creek	Creek Channel	New Bypass Channel	NO	See Node 2.4
H-8	2.7	Rohner Creek	Creek Channel	Rock Slope Protection	NO	See Node 2.4
H-9	4.8.2	Redwood Way	2x24” N-12	Make Slope Positive	NO	$346,000
H-9	4.8.3	Springville Ave.	Gutter Flow	Install 24” N-12	NO	See Node 4.8.2
H-9	4.8.4	Springville Ave.	Gutter Flow	Install 24” N-12	NO	See Node 4.8.2
H-10	1.1	3rd St.	36” CMP Culvert	Replace w/54” N-12	NO	$93,000
H-11	6.7.3	Campton Heights Dr.	18” CMP Culvert	Install 48” N-12	NO	$90,000
H-12	6.6.3.1	Thomas St.	Gutter Flow	Install 18” N-12	NO	$134,000
H-13	1.0.2	Quail Hollow	Channel	Improve Channel	NO	$30,000
H-14	3.0	Fortuna Blvd.	77”x44” CMP	Install 36” N-12	NO	$84,000
H-15	3.2	Rohnerville Rd.	36 CMP	Replace w/60” N-12	NO	$550,000
H-15	3.3	Rohnerville Rd.	58”x36 CMP	Replace w/60” N-12	NO	See Node 3.2
H-15	3.4	Rohnerville Rd.	58”x36 CMP	Replace w/60” N-12	NO	See Node 3.2
H-16	4.5.1	Fortuna Blvd.	12” CMP	Replace w/24” N-12	NO	$324,000

Note: The developer typically funds development-driven project in part or in full.

TABLE 5-7 PROPOSED IMPROVEMENT PROJECTS FOR THE FORTUNA STORM DRAIN MASTER PLAN
(continued)

Ranking H = High M = Medium L = Low Numbers indicate project order	**Node ID**	**Location**	**Existing Storm Drain Description**	**Improvement**	**Development Driven?**	**Opinion of Probable Cost**
H-17	6.10	Drake Hill Rd.	24” & 30” CMP	Install 2x36” N-12	YES	$76,000
M-18	4.13.1b	Loop Rd.	Creek Channel	New Detention Basin	YES	$142,000
M-19	6.9	Cecil Ave.	Channel & 36” &48” SD	Install 48” N-12	YES	$538,000
M-20	6.8.2.1b	Osprey Terrace	None	New Detention Basin	YES	$89,000
M-21	2.1.1.1	Spring St.	12” SD	Replace w/24” N-12	NO	$298,000
M-21	2.1.1.2	Spring St.	Gutter Flow	Install 18” N-12	NO	See Node 2.1.1.1
M-22	6.4.3.1b	Jones St.	None	New Detention Basin	YES	$72,000
M-23	2.4.1	South 15th St.	12” CMP	Replace w/42” N-12	YES	$197,000
M-23	2.4.2	South 15th St.	36” SD	Replace w/36” N-12	YES	See Node 2.4.1
M-24	3.7	Hillside Dr.	Detention Basin	Improve Basin	NO	$203,000
M-25	1.3	Main St.	48” RCP	Replace w/54” N-12	NO	$387,000
M-25	1.4	Main St.	48” RCP	Replace w/54” N-12	NO	See Node 1.3
M-25	1.5	Main St.	36” RCP SD	Replace w/54” N-12	NO	See Node 1.3
M-26	1.8	9th St.	18” RCP	Install 30” N-12	YES	$489,000
M-27	2.1.2	Newburg Ave.	24” RCP & N-12	Replace w/42” N-12	YES	$384,000
M-27	2.1.3	Newburg Ave.	24” RCP & 18” N-12	Replace w/36” N-12	YES	See Node 2.1.2
M-28	2.9.1	Carson Woods Rd.	30” SD	Replace w/42” N-12	YES	$109,000
M-29	3.0.1	Fortuna Blvd.	24” RCP	Install 24” N-12	NO	$367,000
M-29	3.0.2	Fortuna Blvd.	24” RCP	Install 24” N-12	NO	See Node 3.0.1
M-30	3.2.1	Rohnerville Rd.	12”, 16”, 18” & 36” RCP	Install 24” N-12	YES	$278,000

Note: The developer typically funds development-driven project in part or in full.

TABLE 5-7 PROPOSED IMPROVEMENT PROJECTS FOR THE FORTUNA STORM DRAIN MASTER PLAN
(continued)

Ranking H = High M = Medium L = Low Numbers indicate project order	**Node ID**	**Location**	**Existing Storm Drain Description**	**Improvement**	**Development Driven?**	**Opinion of Probable Cost**
M-30	3.2.2	Rohnerville Rd.	36” RCP	Install 18” N-12	YES	See Node 3.2.1
M-30	3.2.2.1	Rohnerville Rd.	18” CMP	Install 18” N-12	YES	See Node 3.2.1
M-31	3.2.3	Newburg Dr.	18” CMP	Install 18” N-12	YES	$80,000
M-32	3.6	Hillside Dr.	36” CMP	Replace w/48” N-12	YES	$51,000
M-33	4.11.2	Rohnerville Rd.	36” CMP	Replace w/42” N-12	YES	$125,000
M-33	4.11.2.1	Rohnerville Rd.	18” CMP	Replace w/30” N-12	YES	See Node 4.11.2.1
M-34	4.12.1	Rohnerville Rd.	18” CMP	Replace w/30” N-12	YES	$126,000
M-35	4.13.1a	Rohnerville Rd.	54” RCP Culvert	Install 42” N-12	YES	$61,000
M-36	4.13.2	Loop Rd.	30” CMP Culvert	Install 60” N-12	YES	$30,000
M-37	6.3	Ross Hill Rd.	72” CMP Culvert	Install 2x60” N-12	YES	$215,000
M-48	6.4.2	Webber St.	3’x3’ RCB	Install 36” N-12	YES	$34,000
M-39	6.4.2.1	School St.	14” CMP	Install 24” N-12	YES	$147,000
M-40	6.4.4	Mill St.	2x42” RCP	Install 42” N-12	YES	$54,000
M-41	6.6.2	West School St.	36” RCP	Parallel 30” N-12	YES	$527,000
M-41	6.6.3	West School St.	36” RCP	Parallel 30” N-12	YES	See Node 6.6.2
M-41	6.6.4	West School St.	24” RCP	Parallel 24” N-12	YES	See Node 6.6.2
M-41	6.6.5	West School St.	18” RCP	Parallel 18” N-12	YES	See Node 6.6.2
M-42	6.7.4	Drake Hill Rd.	2x24” CMP	Install 36” N-12	YES	$34,000
M-43	6.8	Cecil Ave.	60” RCP	Install 52” N-12	YES	$182,000
M-44	6.8.2	Bartlet Dr.	36” RCP	Install 36” N-12	YES	$416,000
M-44	6.8.2.1a	Rohnerville Rd.	36” RCP	Install 36” N-12	YES	See Node 6.8.2.1a
M-45	4.3.1.1	Alamar Way	30” SD	Install 36” N-12	YES	$512,000
M-45	4.3.2	Alamar Way	30” SD	Install 36” N-12	YES	See Node 4.3.1.1

Note: The developer typically funds development-driven project in part or in full.

TABLE 5-7 PROPOSED IMPROVEMENT PROJECTS FOR THE FORTUNA STORM DRAIN MASTER PLAN
(continued)

Ranking H = High M = Medium L = Low Numbers indicate project order	**Node ID**	**Location**	**Existing Storm Drain Description**	**Improvement**	**Development Driven?**	**Opinion of Probable Cost**
M-45	4.3.3	Alamar Way	18” SD	Install 36” N-12	YES	See Node 4.3.1.1
L-46	0.1	Main St.	24” CMP Culvert	Replace w/36” N-12	NO	$40,000
L-47	1.0	U.S. HWY 101	48” RCP	Install 48” N-12	NO	$61,000
L-48	1.2.1	South 6th St.	18” CMP	Install 24” N-12	NO	$165,000
L-49	4.2.1	Riverwalk Dr.	24” SD	Replace w/36” N-12	YES	$209,000
L-50	2.1.0	10th St.	24” CMP	Replace w/30” N-12	NO	$390,000
L-51	2.1.2.1	Fortuna Blvd.	12” & 18” RCP	Replace w/36” N-12	NO	$370,000
L-51	2.1.2.2	Fortuna Blvd.	2x12” RCP	Replace w/30” N-12	NO	See Node 2.1.2.1
L-52	5.3	Rohnerville Rd.	72” CMP Culvert	Replace w/60” N-12	YES	N/A
L-53	6.1.3	Kenmar Rd.	24” & 18” RCP	Replace w/36” & 24” N-12	YES	$186,000
L-54	6.6	School St.	30” & 48” N-12	48” N-12 Culvert	YES	$56,000
L-55	6.8.1	Bridle Creek Ave.	36” N-12	Replace w/42” N-12	YES	$91,000

Note: The developer typically funds development-driven project in part or in full.

Abbreviations:
CMP = Corrugated Metal Pipe
N-12 = Smooth Interior High-Density Polyethylene Pipe
RCP = Reinforced Concrete Pipe
RCB = Reinforced Concrete Bridge
SD = Storm Drain (Unknown Type)

TABLE 5-8 CHANNELS MAINTAINED UNDER MAINTENANCE PROGRAM

Node ID	Figure Reference	Description	Design Capacity[1] (cfs)	Estimated Flow (cfs)		
				10-year	25-year	100-year
1.0.2	Figure 5-2	Natural Channel	--	38	45	56
1.2	Figure 5-2	Drainage Channel	--	155	190	240
2.0	Figure 5-6	Rohner Creek	--	710	830	1,100
2.3	Figure 5-6	Rohner Creek	775	630	740	990
2.4	Figure 5-6	Rohner Creek	1,300	630	730	980
2.5	Figure 5-6	Rohner Creek	1,300	595	700	940
2.6	**Figure 5-6**	**Rohner Creek**	**300**	**580**	**880**	**920**
2.7	**Figure 5-6**	**Rohner Creek**	**300**	**440**	**540**	**700**
2.8	Figure 5-4	Rohner Creek	1,130	445	540	700
2.9	Figure 5-4	Rohner Creek	1,130	440	530	680
2.10	Figure 5-4	Rohner Creek	--	410	500	635
2.10.1	Figure 5-4	Rohner Creek Tributary	--	23	27	33
2.11	Figure 5-4	Rohner Creek	--	390	475	610
3.1	Figure 5-8	Stockton Property Detention Basin	--	150	180	230
3.2.2.1	Figure 5-8	Newburg Road Drainage Ditch	--	10	11	14
3.5	**Figure 5-8**	**Hillside Creek**	**100**	**100**	**120**	**155**
3.5.1	Figure 5-8	Hillside Creek Tributary	--	20	25	30
3.6	Figure 5-8	Hillside Dr. Detention Basin	--	91	110	135
4.0	Figure 5-12	Strongs Creek	--	2,630	3,090	3,800
4.1	Figure 5-12	Strongs Creek	--	2,150	2,450	3,260
4.2	Figure 5-12	Strongs Creek	--	2,150	2,440	3,250
4.4	**Figure 5-12**	**Strongs Creek**	**1,350**	**2,080**	**2,400**	**3,200**
4.6	Figure 5-12	Strongs Creek	2,000	1,270	1,470	1,980
4.7	Figure 5-12	Strongs Creek	1,500	1,260	1,460	1,960
4.8	Figure 5-12	Strongs Creek	1,500	1,090	1,270	1,710

Undersized facilities shown in **bold blue type**.
[1]Design capacity or capacity in maintained state. Estimated capacity was not determined for all drainage channels.

TABLE 5-8 CHANNELS MAINTAINED UNDER MAINTENANCE PROGRAM
(continued)

Node ID	Figure Reference	Description	Design Capacity[1] (cfs)	Estimated Flow (cfs)		
				10-year	25-year	100-year
4.10	Figure 5-10	Strongs Creek	--	1,070	1,250	1,680
4.11.1	Figure 5-10	Strongs Creek Tributary	200	104	120	155
4.12	Figure 5-10	Strongs Creek	--	1,000	1,190	1,570
4.13	Figure 5-10	Strongs Creek	--	1,000	1,190	1,570
5.0	Figure 5-14	Jameson Creek	--	215	265	335
5.1	Figure 5-14	Jameson Creek	--	215	260	330
5.2	Figure 5-14	Jameson Creek	--	205	250	320
5.3	**Figure 5-14**	**Jameson Creek**	**200**	**195**	**235**	**300**
6.0	Figure 5-18	Mill Creek	--	850	980	1,320
6.4	Figure 5-18	Mill Creek	--	495	605	770
6.4.1	Figure 5-18	Mill Creek	--	160	195	205
6.5	Figure 5-18	Mill Creek Tributary	--	350	415	530
6.7	Figure 5-16	Mill Creek Tributary	--	350	410	515
6.7.2	Figure 5-16	Drainage Channel	--	78	93	115
6.7.3	Figure 5-16	Drainage Channel	--	67	82	100
6.8.2.2	Figure 5-16	Osprey Terrace Detention Basin	--	60	71	87
6.9	Figure 5-16	Drainage Channel	--	180	220	270

Undersized facilities shown in **bold blue type**.
[1]Design capacity or capacity in maintained state. Estimated capacity was not determined for all drainage channels.