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PETALUMA RIVER WATERSHED

MASTER DRAINAGE PLAN

JUNE 2003

FINAL

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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

THIS MASTER PLAN OF DRAINAGE FOR THE

PETALUMA RIVER WATERSHED HAS BEEN PREPARED FOR

PETALUMA BASIN FLOOD CONTROL ZONE 2A

BY THE

SONOMA COUNTY WATER AGENCY

AT THE REQUEST OF THE

CITY OF PETALUMA

MARCH 1986

UPDATED: JUNE 2003

SONOMA COUNTY WATER AGENCY

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"The season of 1849-50 was extremely wet...

...the whole of Santa Rosa and Petaluma plains were flooded."

"In 1852-53 there were very heavy rains, and the whole of Petaluma and Santa Rosa valleys were under water..."

(Thompson's Historical Atlas, 1877)

FOREWORD

In the mid-1800s, excess storm water runoff which drained to the Petaluma River and its tributaries often overtopped the existing channels and spread across the valley until it could return to the waterways and complete its flow to San Pablo Bay. In the ensuing century, with settlement of the town of Petaluma and the surrounding areas, and the accelerated urbanization of the region since the 1950s, such overflow could no longer be tolerated and flooding became a "problem". Measures were implemented to improve drainage and control the flooding – public projects were constructed, standards were adopted for private development, flood plain zoning was instituted. All of these helped to solve many of the problems but, as was most dramatically evident during the storms of January 1982 and February 1986, many problems still exist. The most serious of these, of course, is the flooding that occurs along the Petaluma River itself. This waterway, which once spread itself across the entire valley, now flows through the most heavily urbanized area of the City of Petaluma and causes untold damage when storm runoff from its tributary area exceeds its capacity.

The 1986 Master Plan of Drainage was prepared by the staff of the Sonoma County Water Agency (SCWA) at the request of the City of Petaluma and recommendation of the Zone 2A Advisory Committee to identify the most significant areas of flooding along the river and its tributaries and to identify projects that might be implemented to alleviate such flooding. Preparation of the Master Plan was funded through the Agency's Petaluma Basin Flood Control Zone 2A, with financial assistance from the City of Petaluma.

In 2003, the Master Plan was updated to reflect a more environmentally sensitive approach to flood control projects. Uncompleted projects from the 1986 Master Plan were reanalyzed in 2003, and in some cases, modified or eliminated. Preparation of the 2003 Master Plan Update was funded through the Agency's Flood Control Zone 2A.

CITY OF PETALUMA, 1983

WINZLER & KELLY CONSULTING ENGINEERS

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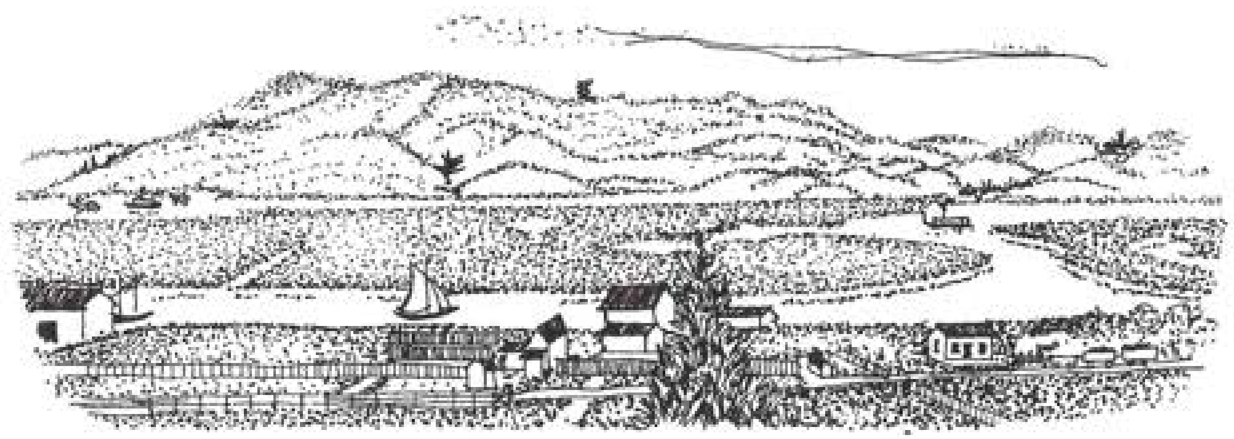


SECTION 1
INTRODUCTION

INTRODUCTION

The Agency...

The **Sonoma County Water Agency,** formerly the Sonoma County Flood Control and Water Conservation District, was created by an act of the State Legislature (Statutes of 1949, Chapter 994, as amended). One of the general powers granted to the Sonoma County Water Agency by these statutes is the authority to provide for the control and disposition of flood, storm and other waters. Specifically, the Agency is empowered...

> "...to control flood and storm waters within the Agency and the flood and storm waters of streams outside of the Agency which flow into the Agency; to construct any and all necessary drains or any other works and do any and every lawful act necessary to be done that the lands and other property within the Agency may be drained and protected from the effects of water; to maintain, repair, improve or protect any drains or other works which are deemed necessary; to do any and all works necessary for the drainage of the lands of the agency; to locate and acquire land needed for rights-of-way, including drains, canals, sloughs, water gates, embankments and watercourses; and to construct works necessary to provide drains, canals, sloughs, water gates, embankments and watercourses and to provide the materials for said construction;"

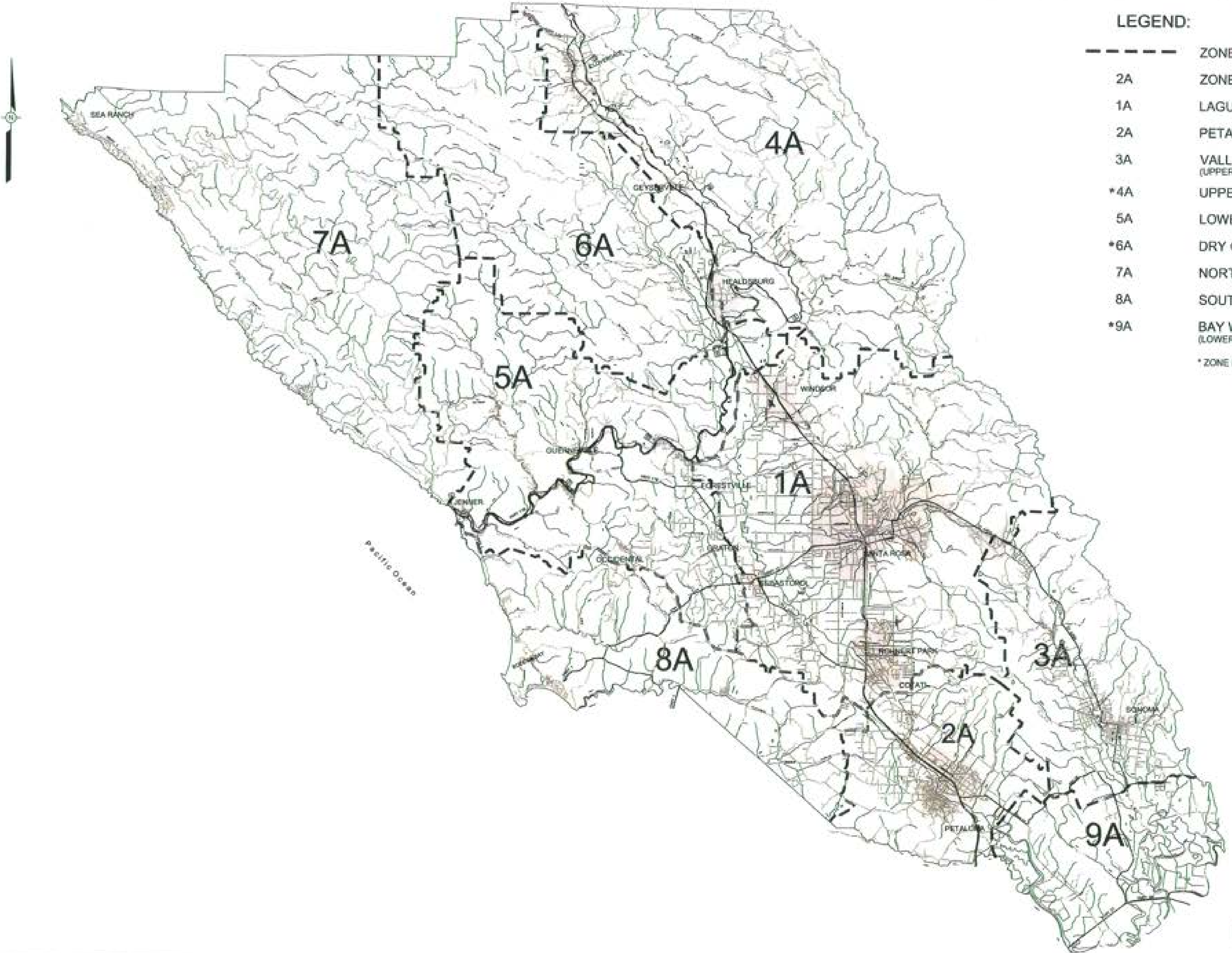
The Zone...

Section 13.1 of the Agency's enabling act provides for the establishment of zones to undertake projects or works of improvement. By resolution in 1956 and again by Resolution No. 2048 on April 21, 1958, the Petaluma City Council requested that the Agency investigate the need for the formation of a flood control zone comprising the City of Petaluma, Petaluma Creek, and its tributaries.

An Engineer's Report for the creation of eight flood control zones within the Agency's boundaries was issued on November 16, 1958. Six of the eight zones, including the Petaluma Basin Zone 2A, were established in 1959 (see Figure 1A, page 1-2). A ninth zone (Bay Zone 9A) was proposed in September 1967 to cover the lower portions of Sonoma Creek and the Petaluma River, however, due to local opposition, proceedings for its establishment were terminated in December of that year.

The **Petaluma Basin Zone 2A,** as established, encompasses 87 square miles of land bounded by San Antonio Creek on the south; Browns Lane and Stage Gulch Road on the southwest; the Sonoma Mountains ridgeline on the east and northeast; Railroad Avenue, Roberts Road and Lichau Road on the north; and Laguna Road, Lake Street and Two Rock Road on the west. In general, the Zone includes all tributary drainage reaching the Petaluma River north of the mouth of San Antonio Creek.

There is a 7-member Zone 2A Advisory Committee consisting of citizens who reside within the Zone area. Six members are appointed by the Board of Directors of the Agency, and one member is appointed by the City of Petaluma. The Committee meets at least once a year to recommend budget priorities to the Board of Directors for inclusion in the following fiscal year's zone budget. Other meetings are held from time to time to discuss specific items or review the status of projects.



LEGEND:

– – – –	ZONE BOUNDARIES
2A	ZONE DESIGNATIONS
1A	LAGUNA-MARK WEST WATERSHED
2A	PETALUMA CREEK WATERSHED
3A	VALLEY OF THE MOON WATERSHED (UPPER SONOMA CREEK)
*4A	UPPER RUSSIAN RIVER WATERSHED
5A	LOWER RUSSIAN RIVER WATERSHED
*6A	DRY CREEK WATERSHED
7A	NORTH COASTAL WATERSHED
8A	SOUTH COASTAL WATERSHED
*9A	BAY WATERSHED (LOWER PETALUMA RIVER & LOWER SONOMA CREEK)

* ZONE NOT FORMED

SONOMA COUNTY WATER AGENCY FLOOD CONTROL ZONES FIGURE 1A

WINZLER & KELLY CONSULTING ENGINEERS

z:\02\224301\CAD\Flood Control Zones.dwg 7-7-03

Flood control and drainage projects constructed by Petaluma Basin Zone 2A to date are as follows:

Project Name	Year Completed	Contract Cost
McDowell Creek Drainage Project	1965	$97,666.20
Fending of Washington Creek	1969	5,244.00
Western Avenue Conduit	1969	160,890.00
Washington Creek Channel Improvements	1970	68,605.75
Shasta Avenue Conduit	1971	32,694.50
Capri Creek Channel Improvements	1972	222,430.95
Cherry-Magnolia Conduit	1972	280,448.37
Washington/Lynch Creek Bypass	1977	357,525.40
Thompson/Kelly Creek Bypass	1981	873,973.62
Lakeville Street Conduit	1982	295,345.85
"H" Street Conduit	1983	283,035.75
North Corona Creek Conduit	1983	339,099.82
Sunnyslope Avenue Conduit	1984	140,098.27
Magnolia Avenue Conduit	1984	449,167.00
Mountain View Conduit	1984	88,079.30
Wilson/Lakeville Street Project	1985	$1,315,000
West Street Conduit	1991	$169,000
Wilson/Lakeville Street Project – Phase 2	1991	$137,000
Laurel Street Conduit	1992	$175,000
Wilson/Lakeville Street Project – Phase 3	1994	$53,000
Mt. View Avenue Conduit – Phase 2	1995	$524,000
'B' Street/El Rose Drive Conduits	1995	$330,000
Petaluma River Channel Improvements – Payran Street Bridge	1997	$1,678,000
Petaluma River Channel Improvements – "U" Shaped Channel	1998	$1,320,000
Skillman Lane Conduit – Phase 1	1999	$237,000
Lindberg Lane Conduit	1999	$75,000
Madison Street/Vallejo Street Conduits and Pump Station	2000	$722,000
Petaluma River Channel Improvements – Trapezoid Shaped Channel	2001	$3,000,000
'C' Street Conduit	2002	$430,000
		$13,859,304.78

It should be noted that the above reflects construction contract costs only and have not been adjusted for inflation. Design, right-of-way and inspection costs are not included.

The Plan...

A drainage master plan is a report regarding storm water runoff in a watershed or several related watersheds. The report provides basic information on areas of flooding and drainage problems and also identifies structural solutions to those problems. That information is used by public agencies, planning and engineering consultants, land developers and individuals to better understand the flood hazard to certain land and to plan for the drainage improvements to mitigate those hazards.

The engineering analysis and design is done in accord with the Agency's Flood Control Design Criteria. This practice promotes ultimate construction of drainage systems that are designed to function properly with existing or future downstream or upstream systems. Plan review, however, is conducted by multiple agencies. The Agency conducts plan review for drainage projects built by private entities within the Petaluma city limits and some City of Petaluma public projects. Drainage projects constructed in County areas are reviewed by the Sonoma Count Permit and Resource Management Department.

Master plan design is less specific than design for a construction contract. However, the design is based on the same engineering principles. Upon a decision to construct any element of a master plan, final design based on the current location of utilities and other constraints is necessary.

Master plans are used by the county and cities in their capital improvement planning and construction, and in review and approval of land developments. They can also provide a valuable tool for consulting engineers by alerting them to the approximate scope of the drainage improvements needed for land development.

Master plans are also used by the flood control zone advisory committees, such as the Petaluma Basin Zone 2A Committee, to select projects for construction using Agency funds. Master plans are used by the Agency as resource information to respond to questions from the public.

In general, the report format of a master plan has three basic elements. The watershed is described as to size, location, land use and other significant information. The flooding and drainage problems of the watershed are described. Structural solutions are described, including anticipated changed conditions or environmental effects. The report includes maps to identify the area studied and also the flood hazard and drainage problem areas. It includes drawings to show the location, size and type of drainage improvements that, if constructed, would alleviate or eliminate the problem.

In this report, Section 2 contains the general description of the watershed and its environmental setting. Due to the significance of flooding problems along the Petaluma River, a separate section (Section 3) has been devoted specifically to this element of the master plan, while Section 4 contains information on the waterways tributary to the river.

Section 5 includes a discussion of both the historic and possible future alternative means of financing flood control projects, such as those contained in the Master Plan.

Section 6 contains an environmental assessment covering in general terms the impacts associated with the various types of projects discussed in the report. It is intended that this assessment serve only as a base for the more specific environmental evaluation that would be performed by the lead agency prior to implementation of any project described in the Master Plan.

The identification of a structural solution to a drainage problem in the master plan should not be construed as a recommendation that it be constructed. While the identified structural solutions are considered the best structural alternatives, based on the information developed in the master planning process, no investigation of the economic viability or financial feasibility is made and no project-specific environmental analysis is done. Also, generally, no comparison is made with non-structural alternatives or the "no action" alternative.

SECTION 2
DESCRIPTION OF WATERSHED

DESCRIPTION OF WATERSHED

Location

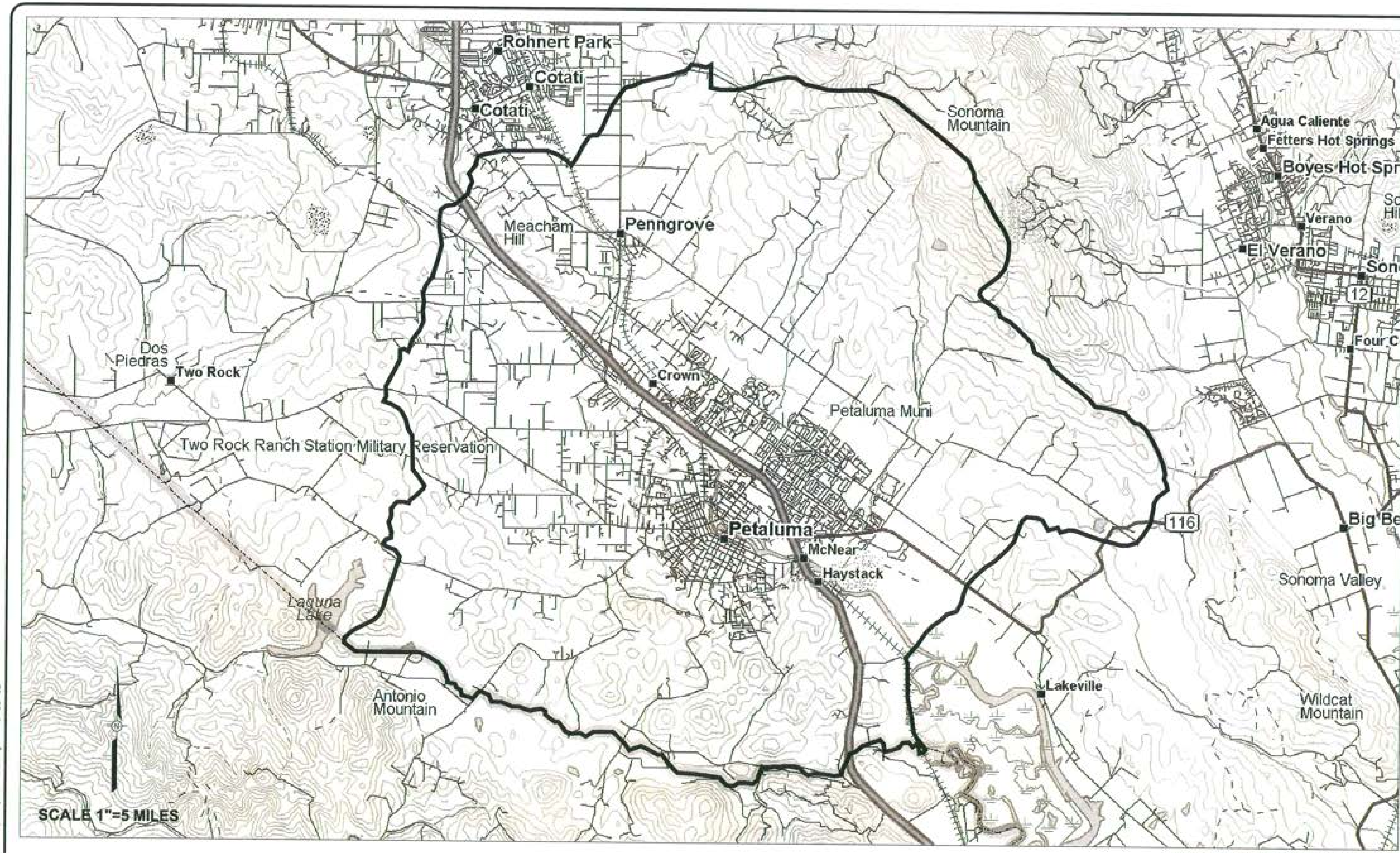
The Petaluma River Basin is situated in Sonoma and Marin Counties, California on the northwestern shore of San Pablo Bay. The Petaluma River and its tributaries drain an area of about 146 square miles, of which 113 square miles (77%) are in Sonoma County and 33 square miles (23%) are in Marin County. The basin is pear-shaped and has a length of about 19 miles, oriented in a northwest-southeast direction, and a maximum width of about 13 miles. The City of Petaluma, located near the center of the basin, lies about 35 miles north-northwest of San Francisco. Petaluma River, from its source at the confluence of Liberty Creek and Willow Brook in the northwest portion of the basin, flows generally in a southeasterly direction through the middle of the basin for about 18 miles, passing through Petaluma, and emptying into San Pablo Bay.

The area covered by this Master Plan of Drainage, as delineated on Figure 2A, page 2-2, includes that portion of the Petaluma River Basin within Sonoma County northerly of San Antonio Creek. This is essentially the same as the 87-square-mile area encompassed by the Agency's Petaluma Basin Zone 2A.

Topography

The Petaluma River basin is composed of a hilly and mountainous headwater section, a central valley section and a tidelands section near the bay. Elevations range from sea level at the mouth of Petaluma River to about 2,000 feet above sea level along the ridges and peaks of the mountainous northern boundary. [Corps, 1975]

About 56 percent of the basin area consists of mountainous and hilly headwater land, 33 percent of the basin is included in a central valley section, and the remaining 11 percent of the area consists of a salt marsh section abutting the lower 11-mile reach of Petaluma River and San Pablo Bay. At least one third of the marshlands have been reclaimed by a system of levees, drainage ditches, tide gates and pumps. The highest point on the divide outlining the basin is Sonoma Mountain, located in the northeast corner, with a summit elevation of 2,295 feet above mean sea level. Elevations of the divides generally range from 700 to 2,200 feet along the northeast side of the basin, from 100 to 300 feet along the northwest side, and from 600 to 1,400 feet along the southwest side of the basin. The southeast side of the basin opens to San Pablo Bay at sea level. In general, the hilly section of the basin lies above the 100-foot contour. The elevation of the marshlands, before reclamation, ranged from about mean sea level to 3 feet above mean sea level. The ground surface has settled two to four feet over much of the reclaimed area, mainly because of the loss of water from and the consolidation of the soil resulting from drainage and cultivation. [Corps, 1972]



PETALUMA RIVER WATERSHED
STUDY LIMITS
FIGURE 2A

WINZLER & KELLY CONSULTING ENGINEERS

Geology

The Petaluma River Watershed is located within the southern portion of the northern Coast Ranges of California. Jurassic-Cretaceous Franciscan basement assemblages are overlain by thick, discontinuous sequences of Tertiary and Quaternary deposits. Prior to the general rise in sea level that occurred in recent geologic time, Petaluma Valley was filled with older alluvium consisting of gravels, sands and clays that were deposited by aggradation along stream courses traversing the area and by sheet wash and other colluvial processes in interstream areas. Boring well logs indicate these deposits are fairly thin in the upper Petaluma Valley but thicken to over 300 feet near the bay. The rise in sea level and the subsequent encroachment of the waters of San Pablo Bay resulted in the filling of the lower portion of the valley, extending inland as far as the City of Petaluma, with younger alluvium and soft marine silts and clays which are known as Bay Mud. Folding and faulting, which occurred in the basin during the late Pliocene and Quaternary periods, produced the main structural and topographic features of the area. These processes have continued into recent time. [Corps, 1975] Information on the geologic units in the Petaluma Valley and their characteristics is contained in the State Department of Water Resources' (DWR) Evaluation of Ground Water Resources in Petaluma Valley (Volume 3, Bulletin 118-4) published in June 1982. The Rodgers Creek fault zone, which has been linked by some to the active Hayward fault, runs along the easterly ridge of the watershed. The Tolay fault extends along the valley easterly of the City of Petaluma, while the Bloomfield fault is located on the westerly side.

Climate

The climate of the Petaluma River Basin is generally characterized as a marine west-coast-type climate with cool, wet winters and warm, dry summers with some fog and wind. Localized climatic conditions are strongly affected by the topography, and it is not unusual to have a wide variation in climate at locations separated by only a few miles.

Temperature means for the year are 70.6 degrees F maximum and 44.7 degrees F minimum, resulting in an average annual temperature of 57.7 degrees F. Extreme recorded temperatures are 17 degrees F and 109 degrees F. Average annual rainfall over the basin ranges from about 20 inches at the mouth of the Petaluma River to about 50 inches at the highest elevations in the drainage basin.

Rainfall and its resultant runoff is, of course, the most significant factor which must be considered in the design of flood control and drainage facilities. Such design is based on extremes of rainfall rather than on annual averages, i.e. on predictions of the return period, the intensity and duration of storms. These predictions, in turn, are developed from historical records of rainfall.

The collection of rainfall data has undergone a great deal of refinement in the past century. In the mid-1800s, rainfall "records" were often the result of guesswork, as reflected in the following quote from Thompson's 1877 Atlas of Sonoma County:

> "The season of 1849-50 was extremely wet; **there was no rain gauge in this county,** but not less than 45 inches of rain fell; the whole of Santa Rosa and Petaluma plains were flooded…"
>
> "In 1852-53 there were very heavy rains, and the whole of Petaluma and Santa Rosa valleys were under water; there was a fall of not less than 42 inches, **estimating the average of one-fourth more rain here than in San Francisco,** where a fall of 33.5 inches is reported." [Thompson, 1877]

Tabulations of monthly and annual amounts of rainfall at the Petaluma Fire Station No. 2 begin in November of 1872. [DWR, July 1981] The following table shows the mean monthly precipitation (in inches) recorded at that location in the periods indicated.

Table 2.1 – Mean Monthly Precipitation, Petaluma, CA

Month	1941-1970[1]	1872-1980[1]	1961-1990[2]
January	5.71	5.38	5.03
February	3.90	4.13	2.85
March	3.00	2.91	3.27
April	1.98	1.70	1.10
May	0.43	0.59	0.13
June	0.23	0.21	0.01
July	0.01	0.02	0.00
August	0.06	0.04	0.00
September	0.15	0.23	0.08
October	1.34	1.18	0.97
November	3.10	2.73	3.23
December	4.78	4.69	3.90
Annual	**24.69**	**23.77**	**23.11**

It can be seen that over 90% of the annual precipitation falls during the six months of November through April. Beginning in February 1913, daily records of rainfall at the Petaluma Fire Station #2 were also available and by 1944, measurements were being made in short-duration increments from 15 minutes to 24 hours. This provides a means of actually comparing the most damaging storms of recent times at this location. The following table compares the maximum precipitation (in inches) recorded during the indicated time intervals for the years listed:

Table 2.2 – Maximum Precipitation (Petaluma Fire Station #2 and #3)[3]

Year	1-hr.	2-hr.	3-hr.	6-hr.	12-hr.	24-hr.	Annual
1945	.42	1.02	1.10	1.98	2.50	3.14	29.54
1954	.31	.60	.70	1.05	1.78	3.10	24.91
1955	.52	.80	1.04	1.99	2.14	2.34	27.15
1962	.57	.78	.90	1.28	1.92	3.48	23.72
1964	.38	.71	1.02	1.37	1.77	1.98	19.33
1967	.49	.78	1.02	1.49	2.08	3.87	29.07
1970	.75	1.15	1.80	2.63	3.11	3.88	33.54
1982	.70	1.30	1.80	3.10	4.90	6.40	35.96
1986	N/A	N/A	N/A	N/A	N/A	N/A	33.00
1994	.30	.60	.80	1.50	2.40	4.00	21.29
1995	.60	.90	1.20	1.80	3.00	4.10	42.34

[1] Petaluma Fire Station #2.

[2] National Oceanic and Atmospheric Administration (NOAA) (1992), Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1961-1990, California, Petaluma Fire Station #3.

[3] NOAA, Hourly Precipitation Data, California, various months. The NOAA rain gauge was relocated from Fire Station #3 to Fire Station #2 in January 1982.

The State Department of Water Resources, Division of Planning, [1980] based on its short duration precipitation records at Petaluma Fire Station #2, estimated the maximum precipitation for each interval for the return periods listed as follows:

Table 2.3 – Maximum Precipitation for Estimated Return Periods

Return Period in Years	Maximum Precipitation For Indicated Duration						
	1-hr.	2-hr.	3-hr.	6-hr.	12-hr.	24-hr.	Annual
2	.40	.62	.80	1.16	1.54	2.04	22.31
5	.57	.87	1.12	1.64	2.17	2.88	29.10
10	.68	1.04	1.34	1.96	2.59	3.44	33.02
20	.78	1.20	1.55	2.26	2.98	3.96	36.45
25	.81	1.25	1.61	2.35	3.11	4.13	37.49
40	.88	1.35	1.75	2.55	3.36	4.47	39.58
50	.91	1.40	1.81	2.64	3.48	4.63	40.54
100	1.01	1.55	2.00	2.92	3.85	5.12	43.39
200	1.10	1.69	2.19	3.19	4.21	5.60	46.10
1000	1.32	2.02	2.61	3.81	5.03	6.69	51.96
10000	1.61	2.48	3.20	4.67	6.17	8.20	59.66

Comparing the maximum precipitation shown in Table 2.2 against the estimated return period in Table 2.3 gives an indication of the "frequency of occurrence" of a storm. For example, the 3.11 inches of rain experienced in a 12-hour period in 1970 would equal the State's estimate of a 25-year frequency storm for that interval of time, however, the 1.80 inches of rain which fell in only 3 hours in the same year would equate to an estimated 50-year event.

Applying the same comparisons to the 1982 storm, it can readily be seen why the news media labeled this storm as "the biggest of all time" and "the worst storm ever to hit the Bay Area". For the 1-, 2- and 3-hour periods, the storm crept up from a 10 to 25 and then 50-year event, respectively. At the end of 6 hours, it was a 100-year storm, and by the end of 12-hours, it had exceeded the estimate for a 200-year storm by nearly 3/4 of an inch and was only .13 less than a 1,000-year storm! Although estimates of return periods can change as periods of record become longer, it is still evident that the 1982 storm was one of unusual magnitude in the Petaluma area.

As of 2003, the January 1982 storm remains the storm of record for the region. Since that time, however, several years have had above normal rainfall. As shown in Table 2-2, the years of 1994 and 1995 had 24-hour storms in excess of a 20-year event. Rainfall data for the El Nino winter of 1997 and 1998 was not recorded by NOAA, but 39.17 inches of rain fell between November 1997 and February 1998.

Hydrology

A hydrological analysis of the study area is essential to the development of a Master Plan of Drainage. The hydrologic cycle includes the following major elements:

(a) Precipitation – snow, rain, hail, etc.

(b) Infiltration – passage of water through the soil surface into the ground.

(c) Surface runoff – residual of precipitation that drains from the land after prior demands have been met, i.e. infiltration, transpiration and depression storage.

(d) Transpiration – process by which plants absorb water from the soil through their root systems and discharge the water into the atmosphere through their leaves.

(e) Evaporation – process by which water as a liquid is changed into water vapor by heat.

(f) Groundwater – water that passes beneath the ground surface (infiltration) and reaches a zone of saturation, being stored for short or long periods, then being passed on to the next stage in the hydrologic cycle. [Naydo, 1982]

In the design of drainage facilities, the most important product of the hydrological analysis is the determination of peak flow rates of surface runoff resulting from storms of varying intensities. The peak flow rate of storm runoff is affected by several factors.

Climatic factors include: the intensity, duration and distribution of rainfall on the drainage basin; the direction of storm movement; and climatic conditions that affect evaporation and transpiration.

Topographic factors that influence runoff include: land use; type of soil; the size, shape, elevation, slope and orientation of the drainage area; and the existing drainage system (natural and constructed).

Antecedent watershed conditions also influence the rate of storm runoff. A short time between storms will cause increased runoff, as the soils in the watershed will still retain water from the last storm, thus decreasing the subsurface storage available through infiltration.

An equation to determine runoff or rate of runoff for the various climatic and topographic factors is difficult to derive. With the present state of the art, runoff predictions are made by one or a combination of the following procedures, which consider the previously listed factors to a greater or lesser degree:

1. Empirical formula method
2. Statistical method
3. Hydrograph method
4. Rational method

Empirical formulas were derived and used extensively in computing the rate of runoff near the end of the 19th century and in the early 20th century. Most formulas of this type do not specifically consider rainfall intensity and duration, which are important variables. Such formulas are not reliable and are rarely used today.

The statistical approach predicts the future stream runoff based on its past performance. This procedure possesses fundamental merit provided that data over a sufficiently long period of record are available to assure establishment of a reliable statistical trend and provided that the stream has not changed regime of flow significantly during or subsequent to the period of record. The reliability of an estimate of flow by this method is related to a large extent to the length of time for which the data are available.

The hydrograph method is usually preferred by engineers planning water resource facilities in large watersheds. In its most elementary forms, the hydrograph graphically describes the runoff characteristics of the watershed. A hydrograph is applicable to the particular watershed for which it is developed. Its reliability is predicated upon accurate rainfall and runoff observations for the area for which it is established. The hydrograph is well suited for studies where flows in addition to the peak flows are needed. [Portland, 1964]

The rational method, the method described in the Agency's Flood Control Design Criteria, is the most widely used technique for estimating peak runoff. Although it uses an empirical equation, certain modifications based on scientific knowledge provide a direct and feasible method of predicting flood peaks for drainage system design. This method is particularly applicable when sufficient stream flow data over a long period of time is not available.

For the 1986 Master Plan, the rational method was used to develop hydrology for the designs included in Section 4, Tributary Creeks and Urban Drainage Systems. As further discussed in Section 3, analysis of projects on the Petaluma River itself combined the techniques of both the hydrograph method and the rational method.

The determination of values for the variables in the rational formula was based on methods outlined in the Sonoma County Water Agency's Flood Control Design Criteria. The determination of land use, necessary to choose a runoff coefficient, C, was based on the general and specific plans applicable to the study area that were current in 1986.

For the 2003 Master Plan Update, the 1986 hydrological analysis was used without modification because land use classifications had not changed significantly between the 1978-1988 and 1989-2005 County General Plan and 1980-1986 and 1987-2005 City of Petaluma General Plan. Even though significant development has occurred within the watershed since 1986, because the 1986 hydrologic analysis assumed full buildout of the General Plan, the peak flow rates that were developed in 1986 are still valid.

Flood Plain Delineation

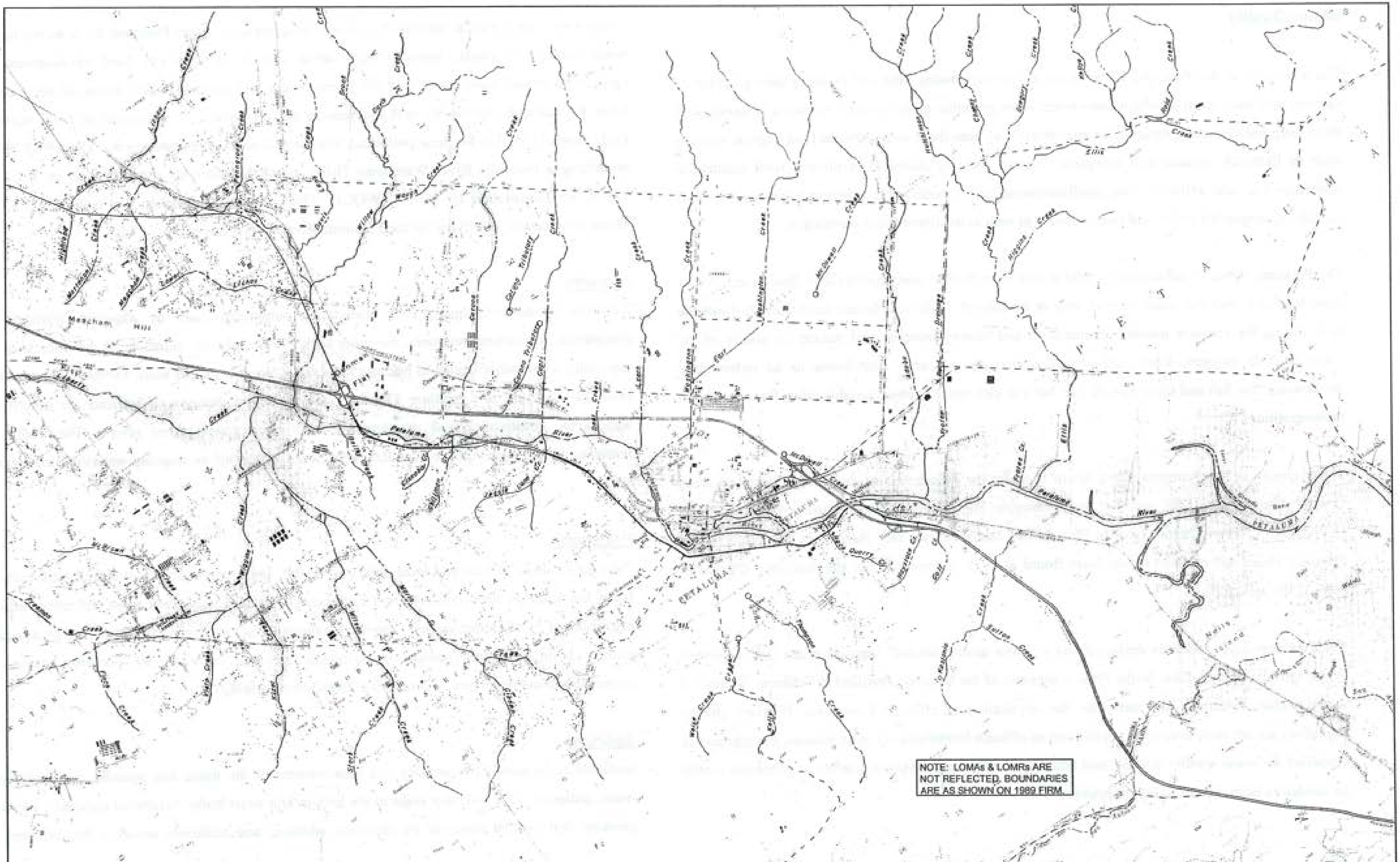
Following the hydrological study, additional analysis was performed for the 1986 Master Plan to determine the extent of flooding along the Petaluma River and its tributaries during a design storm.

Flood damage reports, survey notes, newspaper articles and eyewitness accounts were reviewed to identify areas of historical detrimental flooding. Topographical data, including capacities of existing waterways, was compiled from surveys, field investigations and aerial topographic mapping.

Utilizing the topographic information and the peak flows derived from the hydrological study, a water surface profile study was performed by computer analysis and the areas of flooding for the 100-year frequency event were mapped. These areas of flooding are delineated on Figure 2B.

The delineated areas approximate closely the base (100-year) flood elevation lines developed by the U.S. Army Corps of Engineers for the National Insurance Administration, Federal Emergency Management Agency's Flood Insurance Rate Maps for the City of Petaluma and Sonoma County.

The term "100-year flood" is often used inconsistently and is misunderstood by many people. It's misuse can lead individuals to believe that if a 100-year flood occurs in any one year, then it cannot occur for another 100 years. This belief is false because it implies that floods occur deterministically rather than randomly. Because floods occur randomly, there is a finite probability that the 100-year flood could occur in any year, i.e. if a storm has a statistical average return period of 100 years, it has an exceedance probability of 0.01 or a 1-percent chance of occurring in any year.



NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 4,000' 8,000'
1" = 4,000'

SONOMA COUNTY WATER AGENCY

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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

AREAS OF FLOODING 100-YEAR FREQUENCY

FIGURE 2B

JOB NO. 02224301

Water Quality

The tributaries of the Petaluma River begin in the surrounding hills and meander through areas of varying land uses, each of which contributes some pollution to the stream. Sediment is transported from steep erosive areas, agricultural operations may contribute contaminants from organic sources such as livestock manure and inorganic sources such as chemical fertilizers, rural residential properties can add effluent from malfunctioning septic tanks, and urbanized areas add runoff containing suspended solids and heavy metals as well as treatment plant discharges.

The Petaluma River is influenced by tidal action from the Bay and receives little fresh water inflow from May to November when there is little or no rainfall. With insufficient fresh water to flush the river during the summer months, temperature and salinity increase and reduce the ability of the water to hold oxygen. Inadequate dissolved oxygen not only contributes to an unfavorable environment for fish and other aquatic life, but can also result in objectionable odors from anaerobic decomposition.

Water quality in the Petaluma River Basin is under the jurisdiction of the State Water Resources Control Board (SWRCB) and its San Francisco Bay Region Water Quality Control Board (RWQCB). A Water Quality Control Plan for the San Francisco Bay Basin was developed by the Regional Board and adopted by the State Board in 1975. Amendments to the plan were adopted in 1982, 1986 and 1995.

The Petaluma River has been designated as a "water quality limited" segment in the 1982 amended Water Quality Control Plan. In the Plan, a segment of the basin is classified as "effluent limited" if water quality objectives are met after the application of effluent limitations. If water quality objectives are not met, even after application of effluent limitations on point sources, the segment is classified as "water quality limited" and additional control of non-point sources of pollutants would be needed to meet water quality objectives.

Additionally, the SWRCB identified a 22-mile-long segment of the Petaluma River as not meeting water quality standards. Impacts from urban runoff, construction, land development, and agricultural runoff have resulted in the Clean Water Act Section 303(d) listing of the Petaluma River for nutrients, pathogens, and sediment in the jurisdiction. Development of Total Maximum Daily Loads (TMDLs) for these pollutants were identified as a medium priority. The RWQCB plans to develop a Petaluma River Watershed TMDL report for nutrients and pathogens by 2003, with TMDL implementation by 2005 [RWQCB, 2002]. Recently, diazinon was added to the Clean Water Act Section 303(d) list for the Petaluma River, with a low priority TMDL.

Nutrients

Nutrients consist of algae-growth stimulating substances such as ammonia, nitrogen, and phosphorus. Unionized ammonia, the more toxic portion of total ammonia, is detrimental to fish, especially when water begins to become more basic, around 7.8 pH units. For the Petaluma River, nutrients are listed as a medium TMDL priority pollutant. Sources of nutrients are described as agriculture, construction/land development, and urban runoff/storm sewers. The TMDL for nutrients will be developed by the Regional Board as part of an ongoing watershed management effort.

Pathogens

Pathogens consist of total and fecal coliform, E. coli, and Enterococci. Most recently, the pathogen focus has been on fecal coliform and Enterococci, the less costly and more definitive indicator organisms of fecal contamination. For the Petaluma River, pathogens are also listed as a medium priority pollutant. The sources of pathogens are the same as for nutrients: agriculture, construction/land development, and urban runoff/storm sewers.

Sediment

Sediment is measured by turbidity – a measurement of the more fine particles or cloudiness of water, sediment – the soils that sinks to the bottom of a water body, suspended material – the larger particles that can be removed by chemical addition, and settleable matter – the particles that eventually settle to the bottom of a water body. Sediment is also considered a medium priority pollutant by the Regional Board.

The causes of sedimentation can be separated into those attributable to the natural background sediment load of the streams and those attributable to the additional loads created by urban development, construction, and agricultural runoff.

The effects of sedimentation appear to be aggravated and magnified by past construction of levees and land fills in the tidal areas. Confinement of the natural waterway by levees has accelerated sediment buildup in the remaining un-leveed area. As a result, the flood-carrying capacity of the remaining waterway area is gradually diminished by sedimentation and soon the levees begin to lose their effectiveness.

Sediment from erosion in the upper tributaries of the watershed decreases the capacity of downstream and tidal waterways. As further discussed in Section 3, the Corps of Engineers in 1933 removed over half a million cubic yards of sediment from the Petaluma River to improve its navigability. Since 1937, the Corps has had to dredge over three million cubic yards of deposited material from the river to maintain the navigable channel.

Some tributaries to the Petaluma River northwest of Petaluma are over 50 percent filled with sediment, believed to be primarily from natural sources. Although adoption of erosion control ordinances, such as the City of Petaluma's Ordinance 1576, helps to limit sedimentation produced from man's activities, public funds have been and will continue to be used to remove this material from critical reaches of the waterway.

Diazinon

Diazinon is listed as a low priority pollutant in the Petaluma River watershed. Diazinon is a commonly used pesticide, and is listed as a pollutant that impairs the Petaluma River in both the upper reaches as well as in the tidal portion of the river. Diazinon is linked to harmful effects on aquatic life and has been detected in concentrations exceeding water quality standards. [Winzler & Kelly, 2003]

Wastewater Disposal

The City of Petaluma wastewater treatment facilities provide secondary treatment and are currently subject to the following order of the State Board:

> "The discharge of wastewater to the Petaluma River is prohibited from May 1 through October 20 of each year. The Executive Officer may authorize discharge prior to October 20 or subsequent to May 1 based upon a demonstration that rainfall has produced adequate flushing flow in the Petaluma River."

During the summer months, when discharge to the Petaluma River is not allowed, reclaimed effluent is used for irrigation.

Previous Water Quality Studies

In the mid 1970's and 1993, the RWQCB collected water samples and measured water quality parameters such as nutrients, dissolved oxygen and coliform bacteria. In the upper watershed, tests showed levels of nutrients and coliform counts above maximum standards and dissolved oxygen levels below minimum standards. In the lower reaches, unacceptable levels of dissolved oxygen, turbidity, sedimentation, ammonia, coliform, algal blooms, eutrophication, and foul odors were noted. [Questa Engineering Inc., 1992]

Additional field biological studies were conducted by Anatec Laboratories in 1977 and 1978 and a subsequent report was issued by Brown and Caldwell in April 1981 in conjunction with the City of Petaluma's wastewater management plan. In 1982, SWRCB reported "Dissolved oxygen and nutrient problems persist [in the Petaluma River] producing seasonal fish kills." [Whitsel, 1984]

Ongoing Water Quality Studies

The California Department of Fish and Game (CDFG) has been involved with monitoring stations in the Petaluma River Watershed since 1971, but not systematically until 1991 when they developed the Marin-Sonoma Counties Agricultural Runoff Influence Investigation (MSCARII). During this time, the CDFG has monitored 8 stations in the San Antonio Creek subwatershed and more recently they have begun monitoring 2 sites within the Ellis Creek subwatershed, and 2 sites on Wiggin's creek near King Road. At these sites, they have regularly (biweekly) measured pH, temperature, ammonia, percent saturation, electrical conductivity, dissolved oxygen, biochemical oxygen demand, and total dissolved solids. Data for the MSCARII monitoring is available for the last 10 years, and shows that levels of toxic ammonia in San Antonio and Ellis Creeks have reached maximum levels within the last year of 0.059 and 0.108 mg/L, respectively, both of which are well above the 0.25 mg/L criteria. [Rugg et al, 2002]

The City is currently monitoring discharge effluent on a monthly basis from May 1 to October 20. There are 4-8 sampling sites, which are within 2,000 feet upstream and downstream of the effluent discharge into Ellis Creek. Parameter include total suspended solids, conductivity, temperature, dissolved oxygen, pH, bacteria and biochemical oxygen demand. In addition, pesticides and metals are occasionally tested. There have been two sampling runs in the lower Petaluma River, where antidegradation studies were conducted, but no sediment studies have been conducted to date. [St. George, 2002]

The San Francisco Estuary Regional Monitoring Program monitors a site at the mouth of the Petaluma River. This site has exhibited high levels of trace elements and trace organics [SFEI, 1994-2000]. It is unknown whether these high levels are due to the circulation of particulate associated contaminants through San Pablo Bay and deposition and accumulation near the Petaluma River mouth, or if they are primarily coming from the Petaluma River watershed itself.

Since 1983, students from Casa Grande High School have monitored stream conditions for seven tributaries within the watershed. In addition to monitoring, they have been involved in a variety of successful stream restoration projects.

Students from Grant Elementary School are working with AmeriCorps members to develop a monitoring program for Thompson Creek. Students are monitoring for pH, temperature, ammonia, and dissolved oxygen.

The Sonoma and Marin County Farm Bureaus have developed a water quality monitoring program. This program includes monitoring at four sites within the watershed for parameters such as pH, temperature, ammonia and DO. [RWQCB, 2002]

Groundwater

To provide a basis for the evaluation of any potential impacts of proposed flood control measures on groundwater in the Petaluma River basin, a brief general overview of this resource is included here. A comprehensive report of the geology and groundwater in the Petaluma Valley area was published by the U.S. Geological Survey in 1958 [Cardwell, Water Supply Paper 1427] and, more recently, by the State Department of Water Resources in 1982 (Volume 3, Bulletin 118-4). The 1982 report is part of an ongoing cooperative study being conducted by the State Department of Water Resources and the Sonoma County Water Agency to estimate the volume of ground water in storage and the recharge potential of the major ground water basins in Sonoma County. Much of the information contained in this section has been excerpted from that report.

Several physical factors control natural recharge of groundwater in an area, including:

- Slope of the land surface - for significant recharge to take place in an area, the slope of the land surface should be less than 15 percent.

- Permeability of the soils - the infiltration rate of the soil profile should exceed 0.6 inch per hour.

- Subsurface geology - good aquifer continuity between the area of recharge and the area of extraction is necessary.

- Amount of available storage space in the aquifer - the availability or the lack of storage space in the aquifer determines whether or not recharge can take place.

The largest concentration of suitable soils is northwest of the City of Petaluma. These soils have formed on the sandy Merced Formation and cover 28 percent of the land surface in this area. Many soils in this area not classified as recharge areas were excluded because land slope exceeded 15 percent. The Merced Formation in this area is essentially one continuous aquifer averaging 450 feet in thickness. Because few creeks cross the recharge areas, the major source of natural recharge to the Merced Formation appears to be from rain falling on suitable soils.

Other recharge areas dot the western uplands and are scattered on the western flank of the Sonoma Mountains. In these areas too, most recharge is from rainfall because few streams flow across the recharge areas.

Soils suitable for recharge underlie portions of the City of Petaluma, having formed on top of a thin deposit of alluvium and, to a lesser extent, alluvial fan deposits and the Tolay Volcanics. The Petaluma River flows across some of these recharge areas, however, because there is little storage available in aquifers beneath these recharge areas, the loss of surface water to the ground water body is probably small. Because the Petaluma River is tidal and brackish at the City of Petaluma, an increase in river recharge in this area would not be desirable.

Ground water levels near the City of Petaluma dropped from the mid-1950s until the early 1960s, allowing greater intrusion of salt water into the aquifers along the lower Petaluma River. Delivery of Russian River Project water to the City of Petaluma began in 1962 with completion of the Agency's Petaluma Aqueduct. This allowed reduction in the volume of municipal groundwater pumpage and recovery of ground water levels. Ground water levels have remained relatively steady since that time except during the drought of 1976-77, and no appreciable change appears to have occurred in the last 20 years in the volume of ground water affected by seawater intrusion. As long as ground water pumpage near the tidal portion of the Petaluma River does not substantially increase, the volume of affected ground water should not increase.

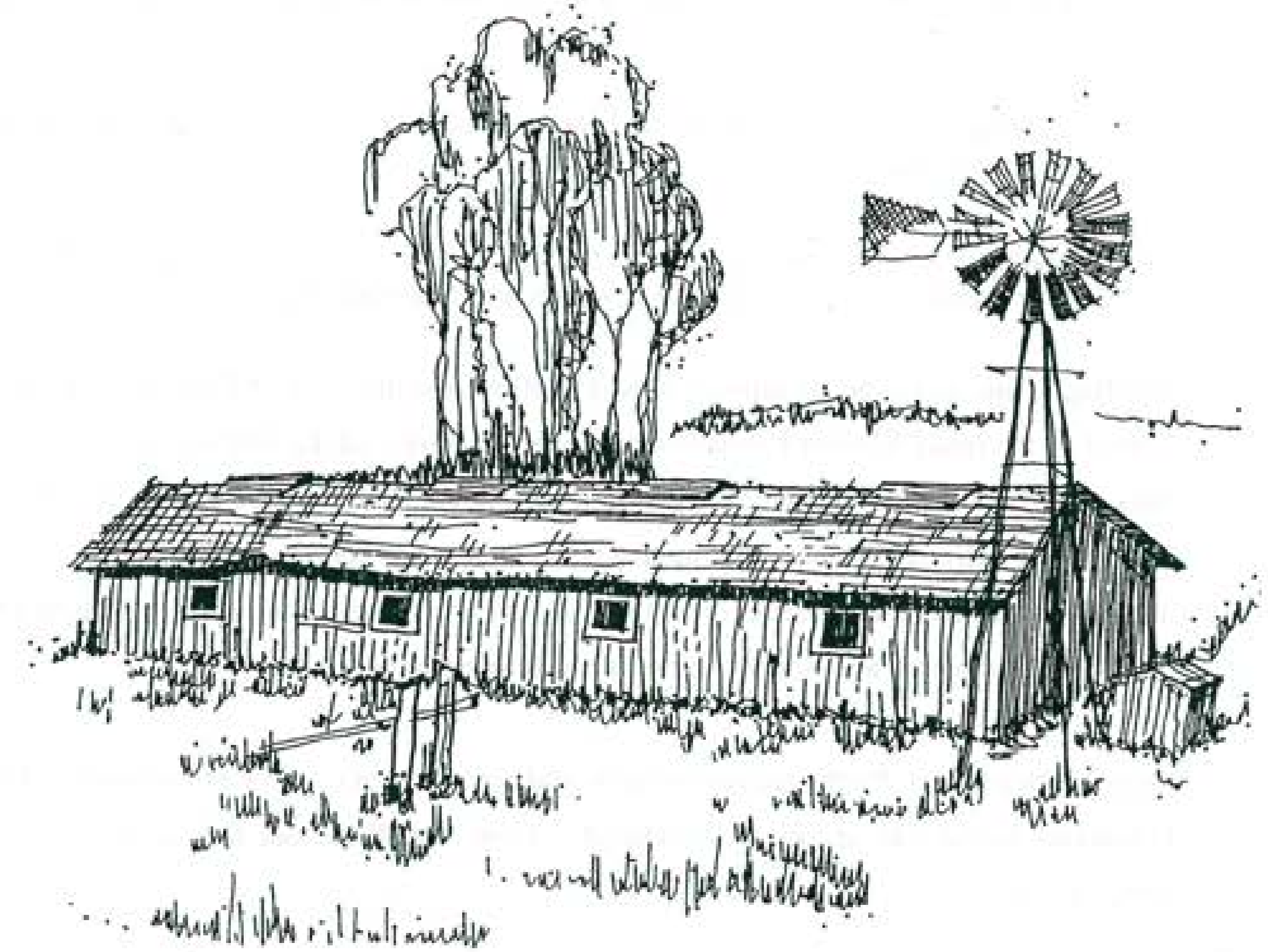
State Department of Water Resources' computer analysis indicates that the total groundwater storage capacity of the Petaluma Valley is 1,697,000 acre-feet. Based on fall 1980 ground water levels, total water in storage was 1,420,000 acre feet – about 84 percent of the total capacity. This figure includes water of all quality types, including brackish water caused by seawater intrusion. The report states that natural topographic constraints prevent the Petaluma Valley ground water basin from filling more than the 84 percent indicated by the DWR's computer program. If the basins are more than the 84 percent full, the additional ground water begins to leak out along road cuts and into streams as "rejected recharge". The report concludes, "The Petaluma Valley basin is therefore, in effect, completely filled at the present time." [DWR, June 1982]

Land Use

As previously noted in the hydrology section, land use is an important topographic factor influencing surface runoff of storm waters. Land use determinations in the Petaluma River watershed were made on the basis of existing County and City General Plans and on adopted specific land use plans for the Penngrove, Sonoma Mountain and West Petaluma areas. The Penngrove, Sonoma Mountain and West Petaluma Specific Plans are all part of the Sonoma County General Plan, which covers all lands within the watershed other than those under the jurisdiction of the City of Petaluma. In cases where such plans overlap, the runoff coefficient has been based on the highest use indicated. Proposed developments on file with the Agency have also been superimposed on the land use plans.

The watershed encompasses a wide variety of land uses. In general, an urban environment exists within the City of Petaluma and, on a smaller scale, within the community of Penngrove. These urban areas are surrounded by a mixture of industrial, commercial, residential and agricultural uses that also extend along the Highway 101 corridor. The outlying areas consist of agricultural and undeveloped lands interspersed with areas of rural residential development. The primary agricultural use in the valley section of the watershed is dairying, with other portions devoted to hay forage, grain, fruit, vegetable, ornamental crops and vineyards. Forage crops, grain and grain-hay are also the principal products of the reclaimed marshlands. The mountainous areas are covered with grass, shrubs and clumps of oak and pepperwood. The hilly section of the watershed is used for grazing and pasturage with tracts of cultivated lands scattered throughout.

The City of Petaluma, with an estimated 2000 population of 54,548, is the only incorporated city in the Petaluma River Watershed. The Petaluma Area General Plan covers a 94-square-mile area, including the City of Petaluma and adjoining land in the County from Meacham Hill to Hog Island and from the Sonoma Mountains to the County line.



The City of Petaluma Land Use and circulation map utilized during the 1986 hydrology analysis is shown on Figure 2C. The current Land Use Map, adopted by the City on March 30, 1987, and most recently modified on October 15, 2001, is shown on Figure 2D.

Since the 1986 version of this Master Plan, land use designations within the City of Petaluma have not significantly changed. Land use changes within the City of Petaluma include newly annexed land north of the airport and south of Sunny Slope Avenue. All of the land north of the airport was designated as an urban separator land use, whereas the southern annexed area has been given mostly suburban and urban land use designations with an urban separator boundary.

Significant development has occurred since 1986 within the City limits. Major subdivisions have been constructed in several areas: in the northeastern portion of the City near Sonoma Mountain Parkway, North Redwood Highway and Lakeville Highway; in the foothills of the southern part of the City near Sunny Slope Road and Sunny Slope Avenue; to the west near Magnolia Avenue; and as general infill throughout the City.

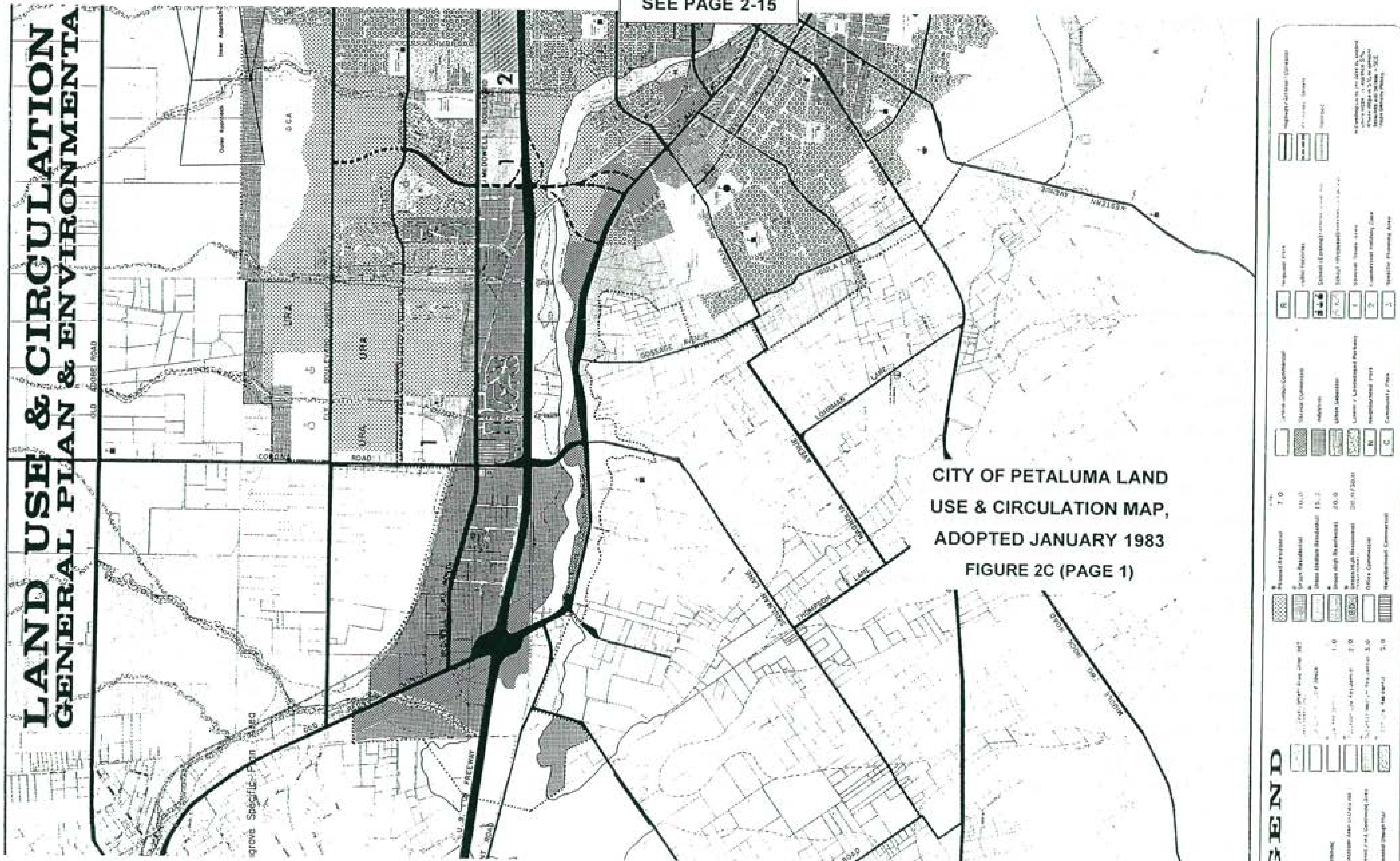
In the County portions of the watershed, new development has occurred largely in rural residential areas near Penngrove and at the outskirts of the Petaluma city limits.

The small rural community of Penngrove is located in the northerly portion of the watershed, between Petaluma and the Cities of Rohnert Park and Cotati. Existing development in the Penngrove study area consists of small commercial establishments along both sides of Petaluma Hill Road (Main Street) surrounded predominantly by single-family residences. The area along the east side of old Redwood Highway and Lichau Creek is developed with commercial and light industrial uses, as well as a 40-unit mobile home park. The majority of the community is developed with single-family residences located on rural lots ranging in size from one-half to two acres, with a few residential lots as small as 6,000 square feet. The Penngrove Specific Plan, adopted by the County Planning Commission on April 10, 1984, covers an area of 2,748 acres with approximately 1,640 residents (1983 estimate). The adopted Land Use Plan for the Penngrove area is shown on Figure 2E. As of 2003, the Penngrove Specific Plan has not been updated. The 2003 population of the Penngrove sewer district is estimated as 1,100 residents.

The Sonoma Mountain Specific Plan covers a 65 square mile area stretching along the 18-mile reach from Crane Canyon Road on the north to Highway 37 on the south. At the time of the study in 1978, the area had an exceptionally low density of residential development (approximately one dwelling unit per ninety-five acres) and 40% of the land was in agricultural preserves. The 1978 Land Use Plan is shown on Figure 2F. Since that time, this plan has not been updated, but portions of the area have been annexed to the City of Petaluma and several large high-density residential developments have been constructed south of Adobe Road.

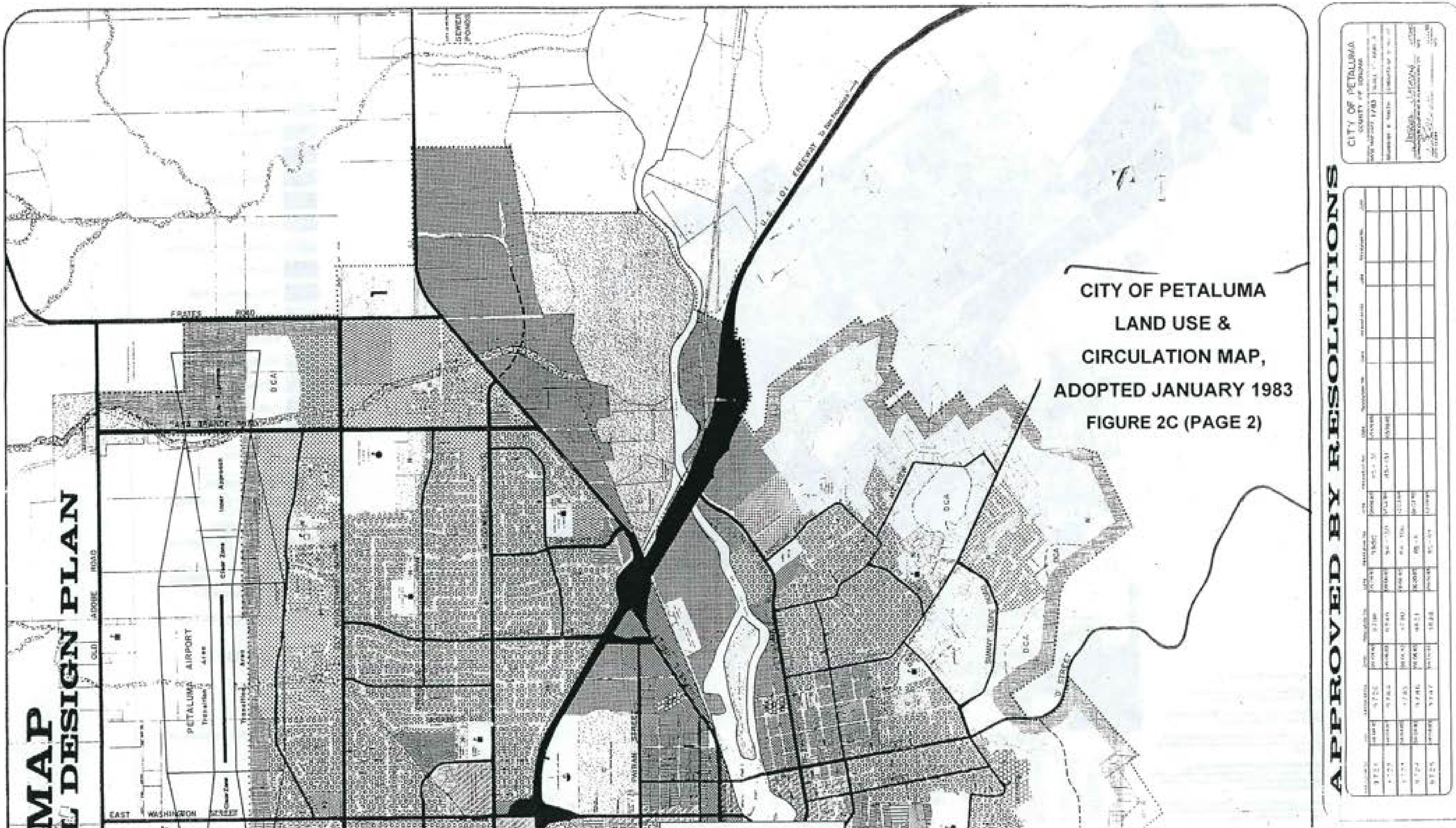
The West Petaluma Specific Plan, adopted by the County Board of Supervisors in August 1981, encompasses a 17-square-mile area extending westerly and northerly from the City of Petaluma. The 1980 census indicated a population of 7,457 in the study area. The West Petaluma area is dominated by open lands and small valleys with scattered hedgerows of eucalyptus, and sometimes cypress. Poultry raising and egg production was the dominant activity in West Petaluma until World War II, when rural residential development began to be noticeable. The 1981 Specific Plan noted that horse ranches seemed to be an emerging agricultural use in the area, as well as specialty agriculture such as tree and mushroom farms, nurseries, vineyards and pheasant breeding. Overall, however, agricultural diversity waned and rural development increased. The northern and central portions of the specific plan area have become almost exclusively rural residential, with the highest densities (averaging more than one unit per 2 acres) concentrating south of Skillman Lane and east of Thompson Lane. The West Petaluma Specific Plan is shown on Figure 2G. Since 1981, this plan has not been updated.

SEE PAGE 2-15



CITY OF PETALUMA LAND USE & CIRCULATION MAP, ADOPTED JANUARY 1983

FIGURE 2C (PAGE 1)



CITY OF PETALUMA LAND USE & CIRCULATION MAP, ADOPTED JANUARY 1983
FIGURE 2C (PAGE 2)

SEE PAGE 2-14

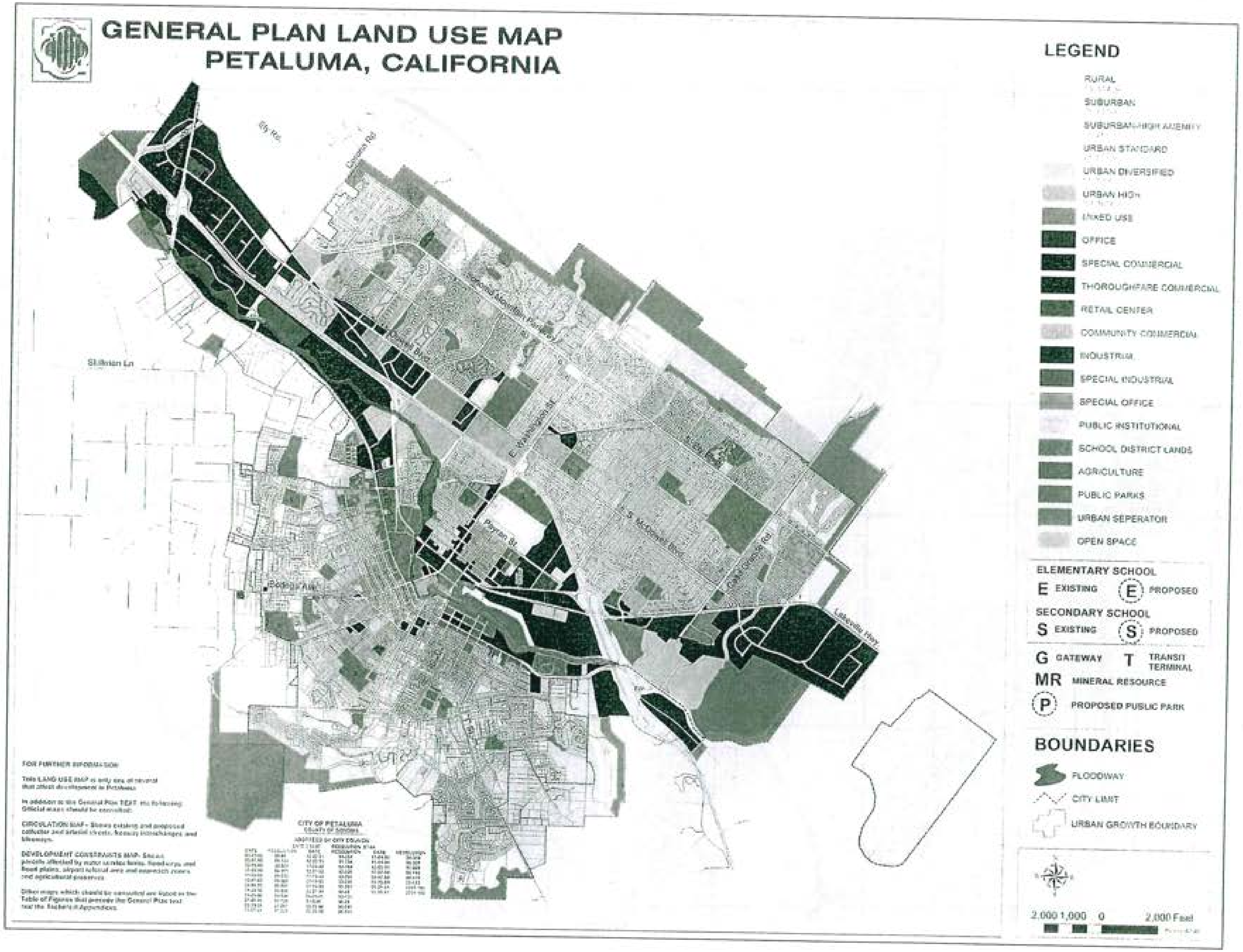


FIGURE 2D

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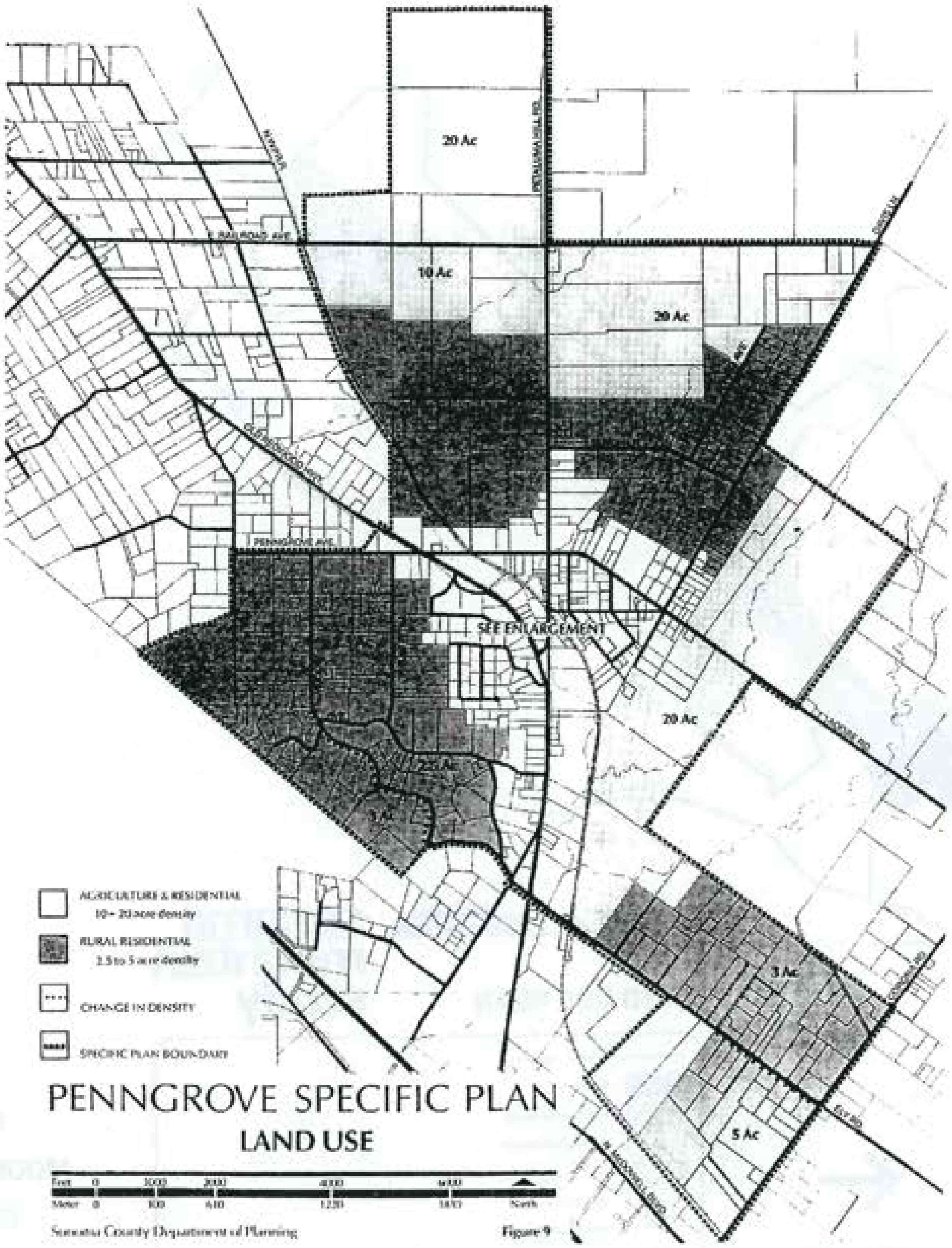
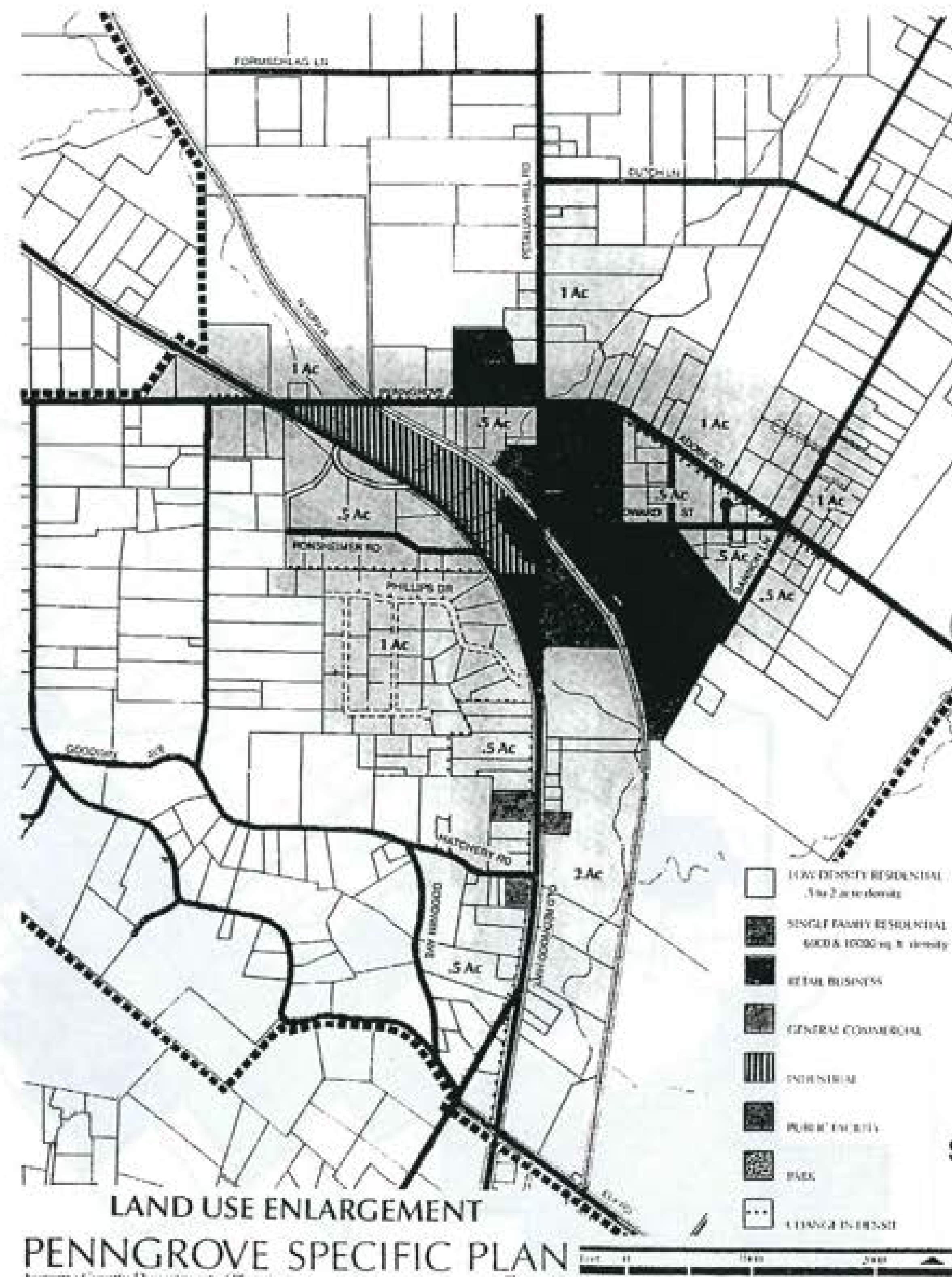
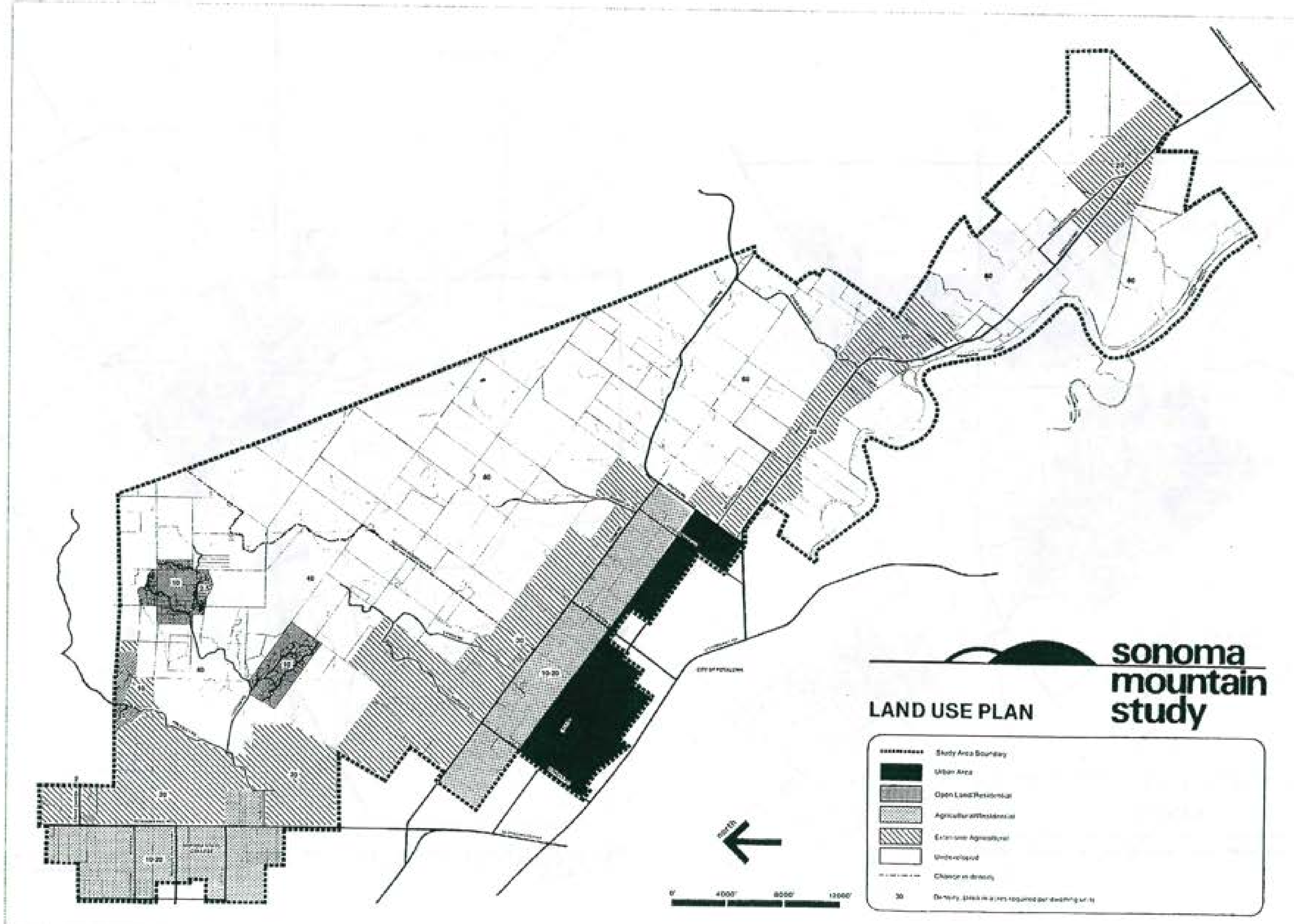
CONSULTING ENGINEERS

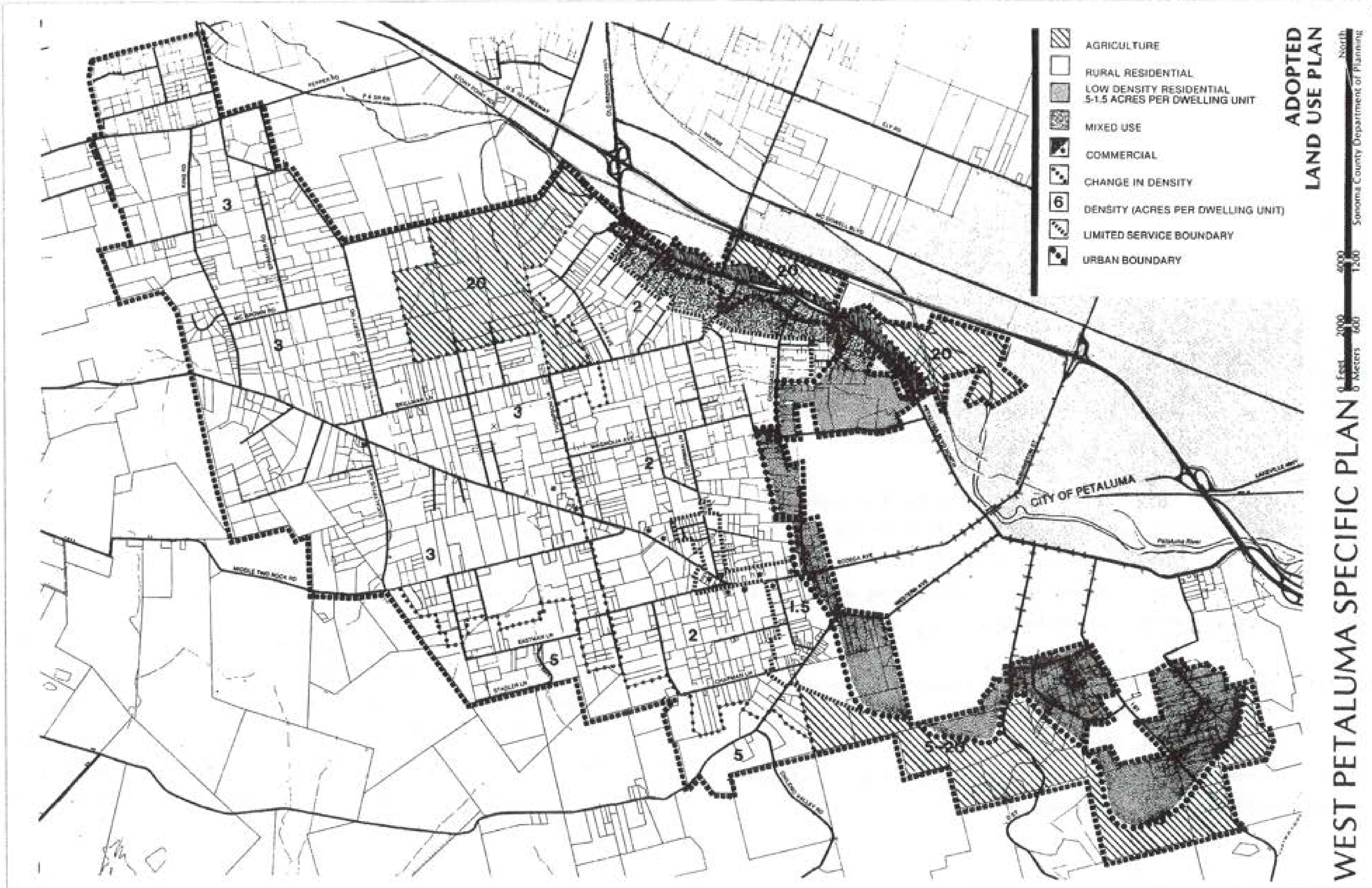




PENNGROVE SPECIFIC PLAN FIGURE 2E



SONOMA
MOUNTAIN STUDY
FIGURE 2F



WEST PETALUMA
SPECIFIC PLAN
FIGURE 2G

Biotic Resources

The most significant biotic resource within the Petaluma River watershed is the marshland (shown on Figure 2H), which surrounds the mouth and parallels the banks of the Petaluma River. Approximately 1,950 acres of this land is included in the State-owned Petaluma Marsh Wildlife area. This area, located approximately six miles southeast of the City of Petaluma, is bordered by the Petaluma River on the east, by San Antonio Creek on the south, by private property (Neil's Island) on the west and by Schultz Slough on the north. Nearly all of the area is subject to tidal action.

Pickleweed (Salicornia pacifica) is now the dominant plant species, comprising over 90 percent of the groundcover. Cordgrass (Spartina foliosa) is found along the sloughs and banks of the southern portion of the Petaluma River, while alkali bulrush (Scirpus robustos) is common along the northern reaches. Vegetation found along the old levees and berms of the area include coyote bush (Baccharis pilularis), gumplant (Grindelia cunifolia) and a variety of annual grasses.

The Petaluma Marsh system historically graded from a freshwater marsh at the upper reaches through a brackish condition, and finally into a salt marsh at the mouth near San Pablo Bay. Alterations of the watershed have permitted the typical salt marsh vegetation (Salicornia) to encroach upriver, lessening habitat diversity. At the same time, decreased planting of crops such as winter wheat in the surrounding area has made the region less attractive for waterfowl.

The marshlands have historically supported abundant bird life. Year-round residents included most of the herons, egrets, gulls and shorebirds common to the Bay Area and a number of "land" birds such as blackbirds and sparrows. During the fall and winter seasons, the area provides food and shelter for millions of shorebirds and hundreds of thousands of water foul, with diving ducks such as scaup, canvasback and ruddy ducks being the most common.

The Petaluma watershed provides habitat for a number of federally listed species. The California Clapper Rail, the California Black Rail and the Salt Marsh Harvest Mouse are completely dependent on marshes. The California Clapper Rail and the Salt Marsh Harvest Mouse are both dependent on tidal marshlands while the California Balck Rail lives in freshwater and saltwater marshlands. Table 2.4 identifies all federal listed species of concern located in the watershed.

Table 2.4

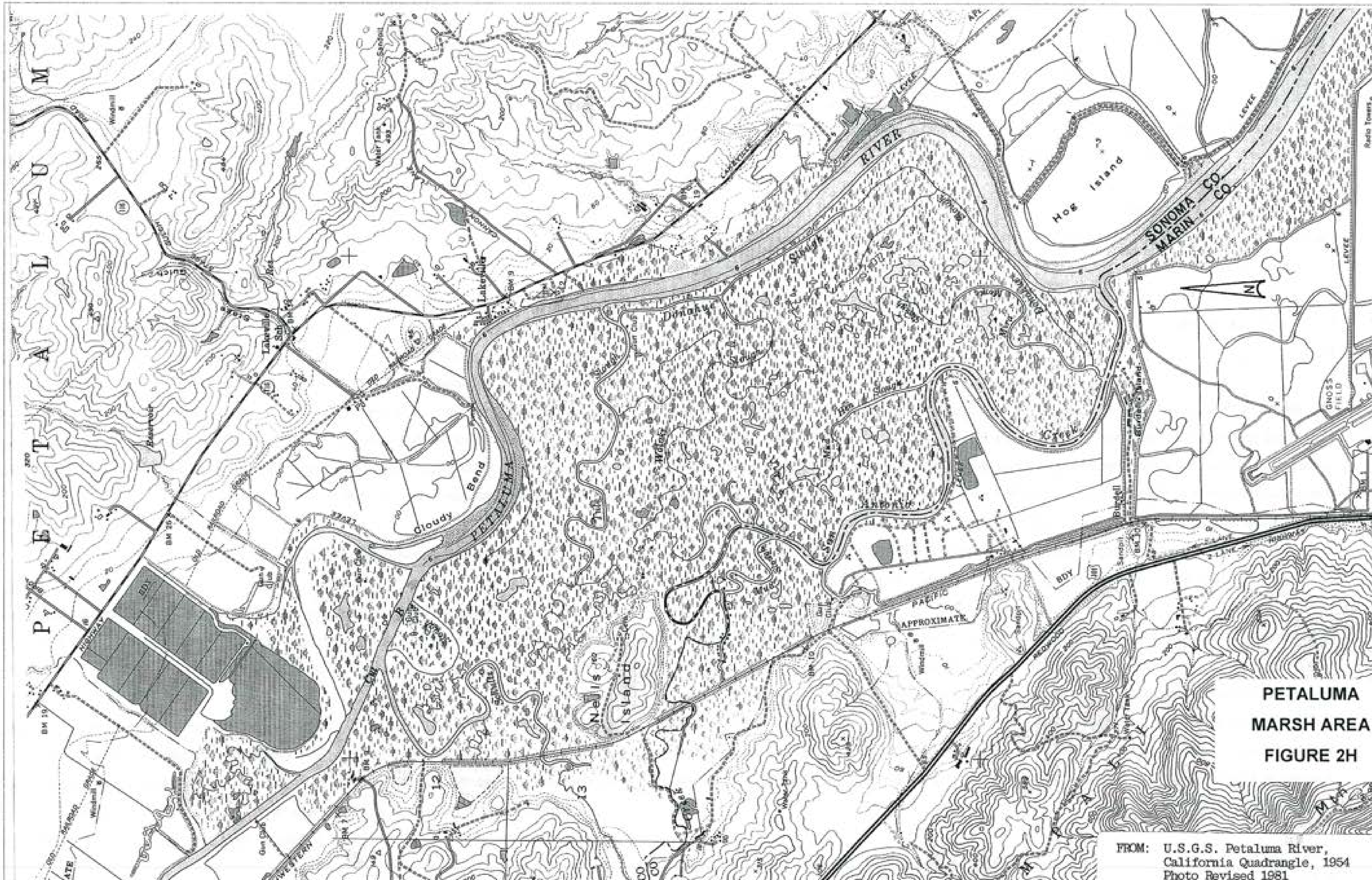
Federally Threatened and Endangered Species in the Petaluma River Watershed[4]

Listed Species – Threatened (T) and Endangered (E)

Mammals	Salt marsh harvest mouse, *Reitrodontomys raviventris* (E)
Birds	American Peregrine Falcon, *Falco peregrinus anatum* (E) California Clapper Rail, *Rallus longirostris obsoletus* (E) Western Snowy Plover, *Charadrius alexandrinus nivosus* (T) Bald Eagle, *Haliaeetus leucoccophalus)* (T)
Amphibians	California Red-Legged Frog, *Rana aurora draytonii* (T)
Fish	Winter-Run Chinook Salmon, *Oncorhynchus tshawytscha* (T) Delta Smelt, *Hypomesus transpacificus* (T) Central California Steelhead, *Oncorhynchus mykiss* (T) Sacramento Splittail, *Pogonichthys macrolepidotus* (T)
Plants	Soft Bird's-Beak, *Cordylanthus mollis ssp. mollis* (E) Baker's Stickyseed, *Blennosperma bakeri* (E) Burke's Goldfields, *Lasthenia burkei* (E) Showy Indian Clover, *Trifolium amoenum* (E) Sebastopol Meadowfoam, *Limnanthes vinculans* (E)

In 1993, the U.S. Fish and Wildlife Service (USFWS) conducted a fishery survey in the watershed. Fish were collected from two stations, one at the confluence of Lynch and Washington Creeks and the other at the Northwestern Pacific Railroad crossing next to the Lakeville Avenue bridge. The twenty-five species collected included marine, estuarine, and freshwater fish. The most numerous species (totaling 75% of the fish) included the inland silverside and Pacific staghorn sculpin. Of the species caught for this study, twelve are native to California. These included bay pipefish,

[4] Petaluma Watershed Enhancement Plan (1999).



PETALUMA MARSH AREA

FIGURE 2H

FROM: U.S.G.S. Petaluma River, California Quadrangle, 1954 Photo Revised 1981

California roach, Chinook salmon, Pacific herring, Pacific staghorn sculpin, prickly sculpin, Sacramento splittail, Shiner surfperch, steelhead, threespine stickleback, and tule perch. The introduced species included American shad, black crappie, brown bullhead, chameleon goby, yellowfin goby, common carp, *Gambusia*, goldfish, inland silverside, largemouth bass, *Lepomis* spp., rainwater killifish, and striped bass. [SSCRCD, 1999]

Stream survey records for 1968 from the California Department of Fish and Game (CDFG) indicate that Lichau, Lynch, Adobe, and San Antonio Creeks should be managed as steelhead streams. The records also identify habitat limitations, which include lack of summer flows and large amounts of sand and silt in Lichau Creek, lack of stream flow in Lynch Creek, fish passage barriers in Adobe Creek, and lack of summer flow, a high percentage of sand, and water pollution in San Antonio Creek.

The steelhead that spawn and rear in the Petaluma River watershed are wild, not hatchery, stock. Watershed residents have observed fish in Lichau, Adobe, and San Antonio Creeks. Since 1985, surveys of salmonids and their spawning and rearing habitat have been conducted by the United Anglers of Casa Grande High School. The students have observed steelhead in Adobe Creek, redds (the salmonid fish egg nests) in Willow Brook Creek just above the Highway 101 crossing, and fish at several other locations, including in the reach from the Payran Street bridge to the Lynch Creek confluence and from Washington Street Creek to the confluence of Lynch Creek.

According to CDFG and the National Marine Fisheries Service (NMFS), the Petaluma River is a low gradient stream that would not have historically supported coho or chinook salmon. Chinook salmon are found in much bigger river systems, such as the Sacramento River. The chinook salmon found today are believed to be hatchery strays entering San Pablo Bay that become "lost" on their way to the Sacramento River. Chinook are seen in the main stem of the Petaluma River. The United Anglers of Casa Grande High School have seen chinook at the turning basin and near the Lynch Creek confluence. [SSCRCD, 1999]

In an attempt to restore the diversity of habitat, the CDFG implemented a management plan for some of the ponds that exist throughout the area. Many of these ponds did not receive adequate flushing action to encourage waterfoul. Three ponds in the upper reach of the marsh were deepened, a water control structure was installed, and a channel in the vicinity of Lakeville (near the downstream end of Cloudy Bend) was constructed to direct wintertime fresh water flows from the Petaluma River into the ponds. With the ability to control water levels in a deepened pond, it was anticipated water quality would improve and vegetation favored by waterfowl could be encouraged. [Botti, 1984]

As of 2003, Fred Botti of CDFG stated that their agency's approach to restoration projects has changed since the implementation of the project near Cloudy Bend. Where the above-mentioned project attempted to convert tidal salt marsh to freshwater ponds, a system requiring operation of gates and continual management, CDFG now supports projects that enhance or restore natural steady-state conditions. Botti mentioned two more recent restoration projects that involved the breaching of levees to restore full tidal action to historic tidal marsh. One of these projects was implemented at the Green Point Unit Marsh between 1985-1986 and the second was located at Carl's Marsh and completed in the late 1990's.

Historic and Archaeological Resources

The Petaluma River and its tributaries have played an integral part in the recorded history of the area. Much of the region's historic development has been directly attributable to and influenced by the Petaluma River, known until 1958 as Petaluma Creek.

The Petaluma River watershed is part of the territory once inhabited by the Coast Miwok Indians. The settlement of Olompolli and its outposts were located on San Antonio Creek. Petaluma Creek, from the head of tidewater up, also drew to it a number of little towns, of which Petaluma and Likatiut were perhaps the principal. Other villages were located on or near running streams. The Coast Miwok are the third body of California Indians to have been encountered by white men and the first to be encountered by English-speaking people. In 1579, Francis Drake spent five weeks in a bay on the California coast repairing the "Golden Hind", and was in close contact with the natives. Although the evidence is too scant to be conclusive, it is believed that Drake's native friends were Coast Miwok. [Kroeber, 1953]

It has been asserted that the name Petaluma came from the Indian vernacular, meaning, "duck ponds", and also that it was a compound word signifying "little hills". [Thompson, 1877] Both expressions are apropos, being descriptive of either the topography or of the marsh areas that historically attracted greater numbers of waterfowl than are now present.

San Pablo Bay, the northern extremity of the bay of San Francisco, was once known as the bay of Sonoma. Thompson's 1877 atlas indicates that "each of the valleys fronting on San Pablo Bay have an estuary leading inland, navigable for steamers of considerable size. One, called Sonoma Creek or estuary leads into Sonoma Valley; another known as Petaluma Creek is navigable for eighteen miles inland." This navigability was to lead to the exploration and subsequent settlement of the Petaluma Valley.

The first inland expedition was in 1776, the year after the discovery of Bodega. Captain Fernando Quiros, in a small boat from the Spanish ship San Carlos, voyaged up Petaluma Creek for the purpose of finding out if there was a connection between the waters of San Francisco and Bodega Bay.

On June 25, 1823, Padre Jose Altimira, traveling by water, left San Rafael with a military escort on an expedition to select a proper site for a new mission. The following day he passed the point called Chocuali by the Indians, where Petaluma now stands, and camped near the old adobe house on the Petaluma plain. The road over the mountain to the Sonoma Valley passed the former Lake Tolay, of which Padre Altimira said:

> "We found on said hillock, a little further on, the large lake of Tolay – so-called after the chief of the Indians, who in former times settled there. Its width at some parts is, with little difference, one hundred and fifty varas [A vara is 33-1/3 inches] – at others, two hundred varas, and at one point one-fourth of a league, which is also its length."

Thompson's atlas (1877) states "this lake, from which Lakeville was named, was drained by its present owner…and is now a potato patch." The mission of Sonoma was founded in July 1823, but no settlement was made in Petaluma valley.

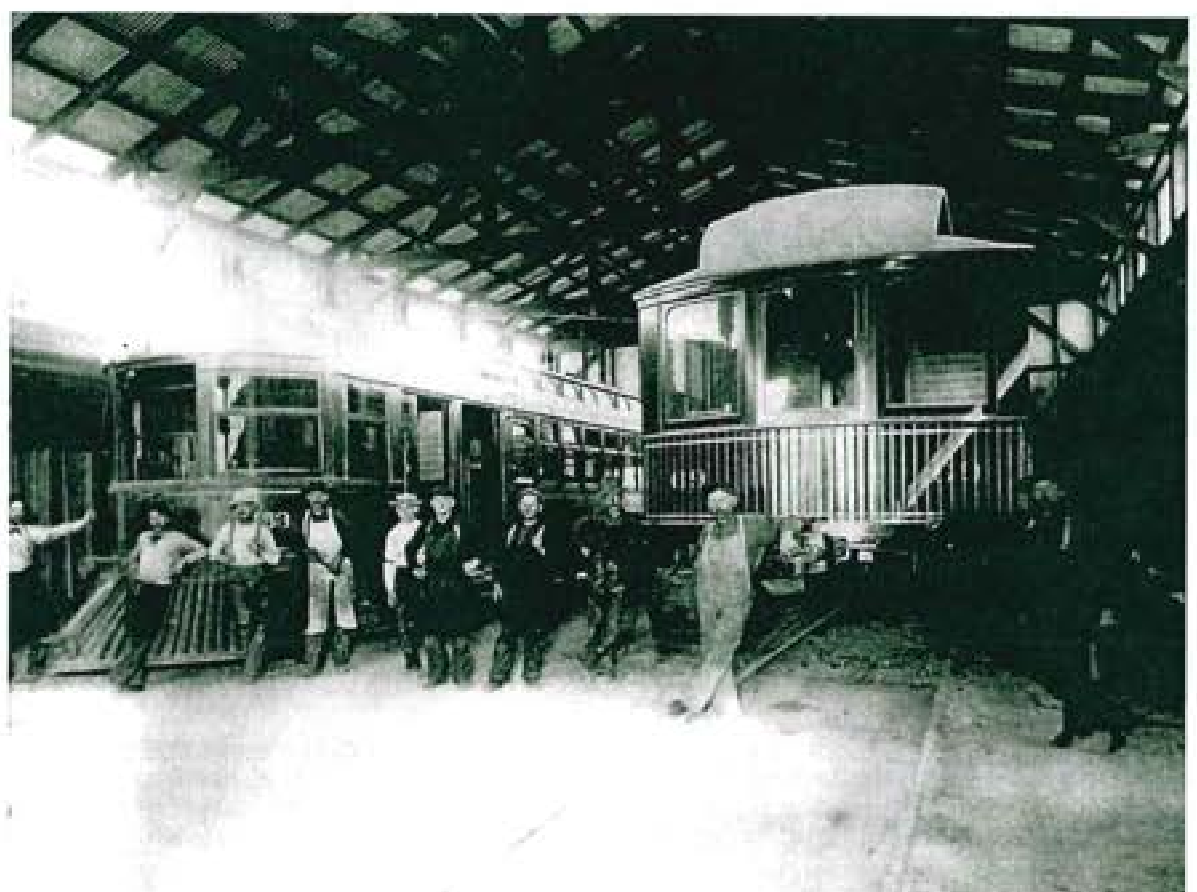
After the secularization of the mission property, General Vallejo received a grant of all the land lying between Sonoma Creek on the east, the waters of the bay on the south, and Petaluma River on the west. That portion of the city known as East Petaluma now stands on part of this tract. [SCEDB 1970] The Petaluma Adobe, located at the intersection of Casa Grande and old Adobe Roads, was built in 1836 by General Vallejo as the ranch house and central quarters for the 66,000-acre grant known as Rancho Petaluma. The adobe site is now operated by the California Department of Parks and Recreation.

The land on the west side of the river was claimed under a Mexican grant by Juan Miranda, who settled there in 1838. He built the first house on the west side of the river, about two miles from the present City of Petaluma. [SCEDB, 1970]

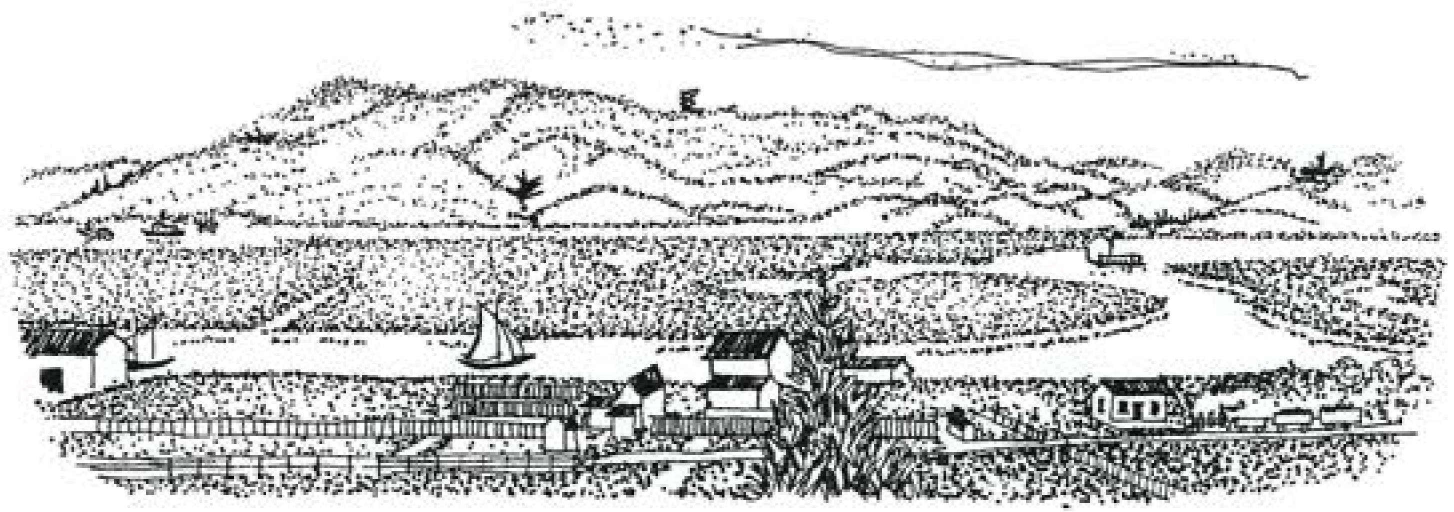
In 1850, hunters traveled up the river, attracted by reports of the abundance of game. Camping on the banks of the river, they shipped their kill to the San Francisco market. Other settlers soon followed, and by 1852, businesses were established and the town site was surveyed. Steamboat navigation on the Petaluma River became the convenient means of transportation between the town of Petaluma and other Bay Area settlements.

Between 1853 and 1855, the town of Petaluma grew rapidly; the valleys north and south of it were settled and many acres of land were brought under cultivation. The town of Petaluma was incorporated at the session of the legislature of 1857-58 and the first municipal election was held on April 19, 1858. The new City soon ranked as one of the most flourishing agricultural towns in the state and became the general shipping point for the produce of Sonoma and Mendocino Counties. The Petaluma River once ranked third in the amount of traffic carried along the State's water highways with steamboats, including paddlewheelers, carrying much of the tonnage.

In the 1870s, two events occurred of historical significance. A railway station was located at Penn's Grove when the San Francisco and North Pacific Railroad was extended from Petaluma to Santa Rosa, providing a nucleus for the formation of a community some 50 years later. Petaluma in that period gained an important new resident – a Canadian named Lyman C. Byce, who laid the foundation for the later fame of the City as a poultry and egg production center. [Scott, 1959] By 1880, Petaluma had a population of 3,326 residents and was on its way to becoming the principal trading and shopping center for Southern Sonoma County and the major residential community that it is today.



Courtesy of Petaluma Historical Library/Museum Archives



SECTION 3
THE PETALUMA RIVER

THE PETALUMA RIVER

Previous Studies

The navigability of the Petaluma River and its importance in the exploration, settlement and development of the watershed has been mentioned in the previous section of this report. Flooding along the banks of the river and siltation of the streambed, affecting both navigation and water-carrying capacity, have also been increasingly serious problems for more than a century. This is perhaps best illustrated by the following summarization of a number of reports prepared by the Corps of Engineers and others on navigation improvements and flood control.

Corps of Engineers Reports

Navigation Reports	Recommendations
December 1879	Proposed a channel 50 feet wide, 3 feet deep, and the making of three cutoffs in Petaluma River.
January 1897	Proposed straightening of the channel was unfavorable because costs were greater than benefits.
December 1905	A channel 50 feet wide and 6 feet deep from the mouth of the river to McNears, then 50 feet wide and 4 feet deep to Washington Street bridge.
April 1913	Maintenance of a channel not less than 100 feet wide and 8 feet deep across the flats in San Pablo Bay.
October 1917	A channel 200 feet wide and 8 feet deep across the mud flats in San Pablo Bay, 4 cutoffs, and a turning basin in Petaluma.
January 1923	Provide and maintain a channel above Washington Street, Petaluma, 40 feet wide, 4 feet deep, and 935 feet long.
January 1927	Provide a channel 200 feet wide and 8 feet deep across the flats in San Pablo Bay to the mouth of river; then 8 feet deep and 100 feet wide to Western Avenue in Petaluma, including a depth of 8 feet in the turning basin; then 4 feet deep and 50 feet wide to the Washington Street Bridge; then 4 feet deep and 40 feet wide to the head of navigation, 935 feet above Washington Street.
July 1966 (Unpublished report)	Authorized federal participation in construction of a small-craft harbor in Petaluma River. (Project was subsequently cancelled due to lack of local support.)

Flood Control Reports

August 1942 (unpublished) — *Preliminary Examination Report for Flood Control, Petaluma Creek Basin, California.*

Report concluded that a plan could be developed to alleviate flooding and channel erosion on Petaluma River and its tributaries by construction of levees, channels, interceptor ditches and drop structures, along with implementation of proper grazing and land-use practices. Recommended authorization of a survey.

January 1960 (unpublished) — *Reconnaissance Report for Flood Control on Petaluma River, Sonoma and Marin Counties, California - Public Law 685.*

Study of four potential dam and reservoir projects for flood control. It was determined that construction of the four dams would control only about one-half the runoff above Petaluma and, therefore, channel improvement would be required to control flooding along the reach above the City. Report recommended that, in view of unfavorable cost-benefit ratio and the controversial nature of channel improvements above Petaluma, no further studies under Public Law 685 be made at that time.

March 1972 — *Survey Report for Flood Control and Allied Purposes, Petaluma River Basin, Sonoma and Marin Counties, California.*

Study considered resolution of flood problem by structural measures, including levees, channel improvements, dams and reservoirs. No type of structural measure was found to be economically justified at that time. This conclusion was reconfirmed by the Corps in May 1983 following re-evaluation of the cost/benefit analysis.

November 1994 — *Petaluma River, California, Detailed Project Report for Flood Control, Basis of Design*

Report presented the engineering studies carried out to determine the recommended plan and its baseline cost estimate. The engineering studies included for 10-Year Plan and 40-Year Plan. 10-Year Plan was the NED plan and provided 15-year level of protection under present conditions and 10-year level of protection under future conditions. 40-Year Plan was the locally preferred plan and provided 100-year level of protection under present conditions and 40-year level of protection under future conditions.

March 1995 — *Petaluma River, California Detailed Project Report for Flood Control, Final EIS/EIR.*

Report evaluated alternative plans for addressing flooding problems along the Petaluma River within the City of Petaluma in this Environmental Impact Statement/Environmental Impact Report (EIS/EIR). The three alternatives were: no action, National Economic Developments Plan, and a Recommended Plan. Each of the project alternatives required construction of a trapezoidal shaped channel.

Other Reports

1896 — California Department of Public Works, *Two Plans for Protecting the City Of Petaluma from Overflow Water and for Improving Navigation of Petaluma Creek*

This 1896 report emphasized the importance of the Petaluma River as a transportation corridor by citing that in the year ending May 31, 1894, vessels on the river carried 12,126 passengers and goods valued at over $11,000,000. The report recommended, as one alternate, that, "the water... should be taken into a canal at the crossing of the S.F.& N.P.R.R., and conducted thence down Bayles Street to its intersection with Petaluma Creek..." The proposed 100-foot-wide canal was found insufficient to provide full flood control, however, since it was estimated to be able to carry only "...one half the discharge of Petaluma Creek...", a further suggestion was made that Lynch Creek and Washington Creek could "...be diverted so as to discharge their waters onto the salt marsh east of the town of Petaluma." The report also concluded that these two creeks "...discharge a large percentage of the sediment to be cared for in Petaluma Creek..."

June 1970 — Hudis, M., *Flood Plain Report for the Petaluma River, Sonoma County, California*

In February of 1968, the Agency contracted with Milton Hudis, Consulting Civil Engineer, for development of a flood plain information report for the Petaluma River. This study was to "...determine hydrology and extent of flooding along the Petaluma River from the mouth of the river at San Pablo Bay upstream to the area commonly referred to as Denman Flats which lies northeast and southwest of Stony Point Road around the confluence of Petaluma River and Willowbrook."

October 1983 — Mackay & Somps, *Preliminary Petaluma River Study (Payran Street Area)*

This report was prepared for the City of Petaluma to develop alternate solutions for different levels of protection against flooding in the Payran Street area along the Petaluma River. Alternates included removal or replacement of bridge structures, channelization, relocation of homes and berming to elevation 14 feet.

November 1988 — Western Ecological Services Company, Inc. (WESCO), *Summary of Interim Reports and Advisory Statements on the Proposed Petaluma River Watershed Master Drainage Plan*

WESCO was retained by the City to provide an independent review of the SCWA's *Petaluma River Watershed Master Drainage Plan.* The interim reports include a hydrologic and hydraulic analysis by Philip Williams & Associates (PWA) and a fairly in-depth report on biological resources prepared by WESCO. PWA concluded that the Denman dam by itself would result in only a 4% decrease in peak flows at the Payran ranch. The bypass channel, as proposed by the SCWA, would reduce the peak discharge at the Payran reach by 24%, and extension of the bypass to include Willow Brook Creek would decrease the Payran discharge by 40%.

May 1996 — *Petaluma River Access and Enhancement Plan*

Plan describes the community's vision for the Petaluma River, including its riverfront uses, activities, and developments. Described in this plan are various means of enhancing the river, encouraging compatible developments along the river frontage, creating and maintaining a system of river-related public trails and direct riverfront access, and other methods of achieving goals of the Petaluma General Plan. A conceptual plan was developed for a 6.5-mile reach of the Petaluma River between Old Redwood Highway at Willow Brook Creek to the Petaluma Marina.

July 1996 *Restoration Design and Management, Guidelines for the Petaluma River Watershed Volume I, Restoration and Revegetation Design*

Report provides an inventory and assessment of biological resources within the Petaluma River Watershed, including native vegetation and wildlife living in riparian, marsh, wetland, and other environments. The report provides guidelines for restoring and revegetating creeks and riparian environments, including a recommended design approach, and design concepts for channel systems and revegetation.

July 1996 *Restoration Design and Management, Guidelines for the Petaluma River Watershed, Volume II, Management for Stream Corridors*

Report provides guidelines for managing channel systems including recommended approaches to thinning and stocking procedures, long-term vegetation management, streambank stabilization, sediment control, herbicide and pesticide management and use, and hydraulic structure maintenance.

July 1999 *Petaluma Watershed Enhancement Plan*

Plan was developed by an advisory committee of agriculturists and rural landowners to state a set of goals, objectives and recommended actions to: improve water quality and ground water recharge in the Petaluma Watershed, support the viability of agriculture in the community, and conserve and enhance existing wildlife habitat. Technical appendices in this document include studies of land use, groundwater quality, erosion and sedimentation, riparian plant community enhancement, fisheries enhancement, water quality monitoring guidelines, and flood control impacts.

August 1999 *City of Petaluma: Interim Detention Feasibility Study*

Study examined the interim feasibility of detention across the entire Petaluma River watershed for the next two to four years. It was prepared to help the City understand the differences between those locations where detention is either feasible or unfeasible. The document's goal was to guide the development of an interim flood management policy until a more comprehensive long-term plan for managing the watershed's surface water resources can be developed. The recommendations made in the study apply to both short- and long-term detention siting and are compatible with the City of Petaluma's future flood management goals and objectives.

October 2001 *City of Petaluma Floodplain Management Plan*

Plan establishes goals and management activities for the City of Petaluma to minimize threat to life and property from flooding.

Recommended management activities include the preservation of open space, the zero net-fill policy, maintenance of freeboard requirements, drainage system maintenance, and storm water regulations.

It is quite evident from a comparison of Figures 3A and 3B that some of the early recommendations for straightening the alignment of the Petaluma River through the City were subsequently implemented. The river today is no longer the "tortuous watercourse" described by Thompson in 1877 as "...winding through the green marsh, sometimes doubling back upon its course, [and] making in a distance of eight miles a direct progress of but two." But the problems of siltation and flooding recognized over a century ago still exist.

Courtesy of Petaluma Historical Library/Museum Archives

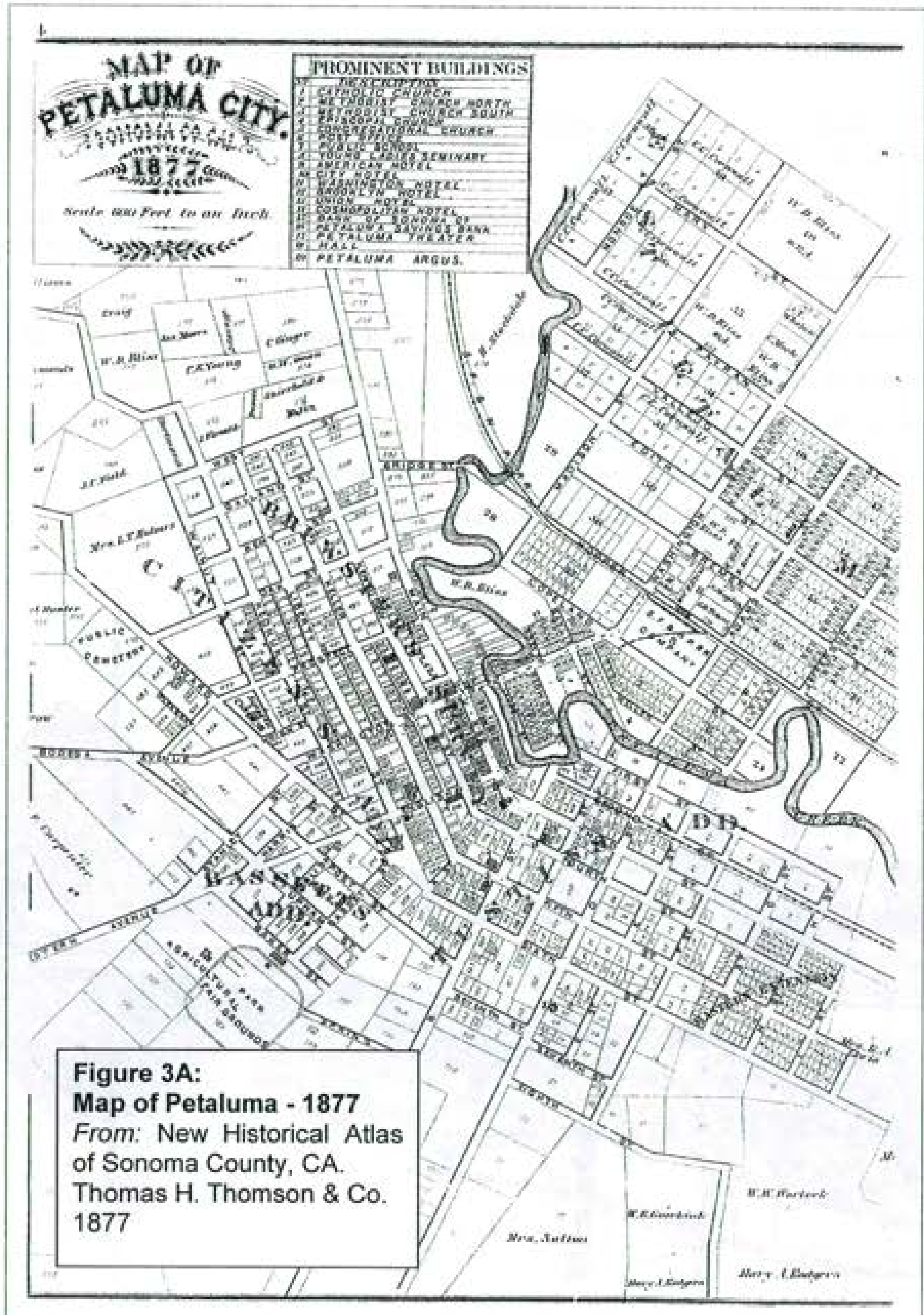


Figure 3A:
Map of Petaluma - 1877
From: New Historical Atlas of Sonoma County, CA. Thomas H. Thomson & Co. 1877

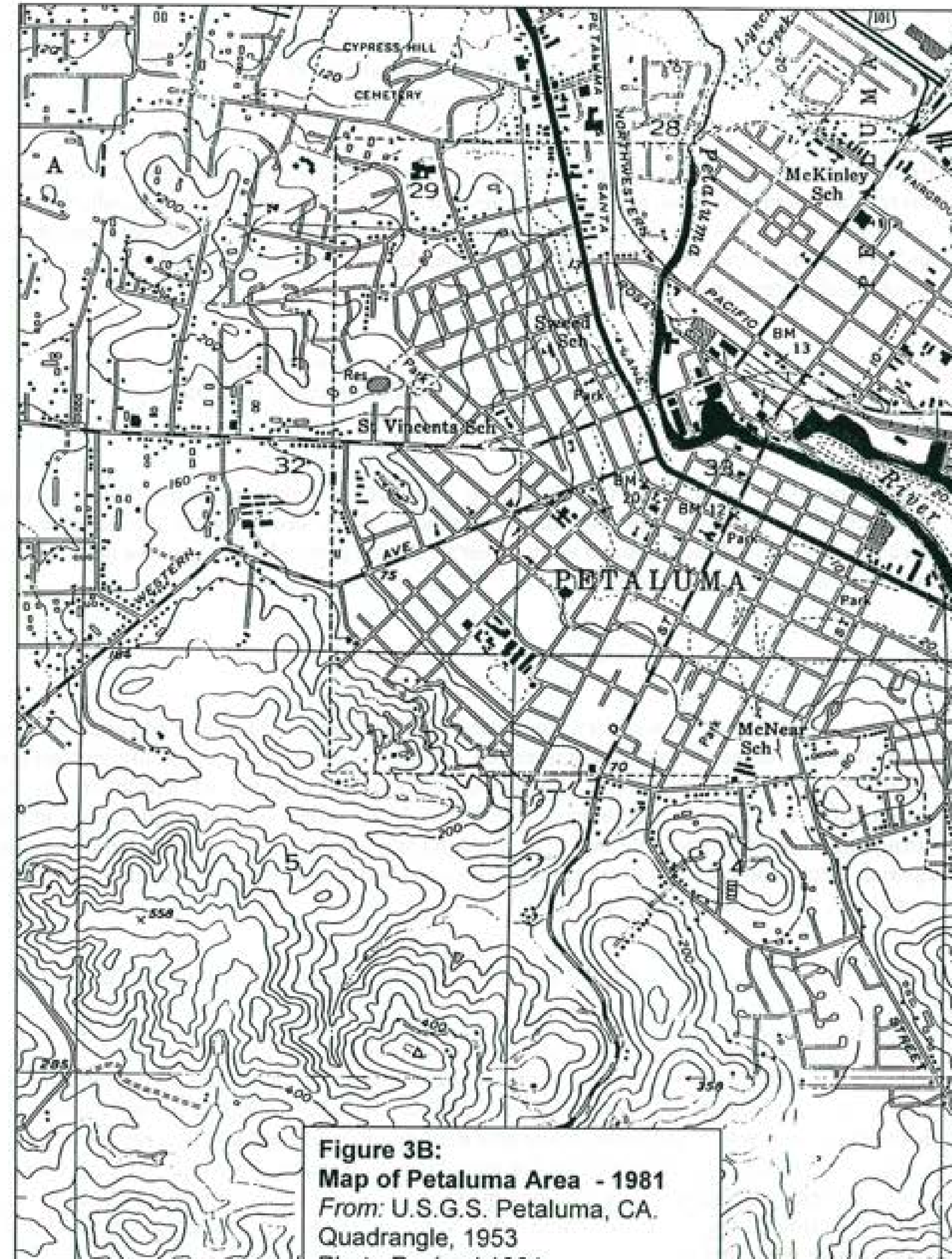


Figure 3B:
Map of Petaluma Area - 1981
From: U.S.G.S. Petaluma, CA. Quadrangle, 1953
Photo Revised 1981

Related Projects

Corps of Engineers Dredging

The Corps of Engineers has improved and maintained the Petaluma River for navigation since 1880. The existing project for the Petaluma River, essentially as recommended in the January 1927 Corps' report, was authorized under the Rivers and Harbors Act of 1930. The project, completed in 1933, provides for a 200-foot-wide, 8-foot-deep channel for 33,000 feet across the mudflats in San Pablo Bay to the mouth of the Petaluma River. For the next 69,000 feet upstream to Western Avenue in the City of Petaluma, the channel is 100 feet wide and 8 feet deep. Included in this part of the project is a 300- by 400-foot turning basin, 8 feet deep. From Western Avenue upstream to the Washington Street Bridge, the channel is 50 feet wide and 4 feet deep. The project is a continuing project and under present scheduling, the San Francisco District of the Corps of Engineers maintains the San Pablo Bay Channel on a 144-month cycle and the Upper River Channel on a 48-month cycle.

Maintenance in the upper river channel, which extends from about 8,000 feet southerly of the Northwestern Pacific Railroad crossing of Petaluma River (nearly opposite Browns Lane) upstream to Western Avenue, includes hydraulic dredging to a depth of -8 feet MLLW. The section between Western Avenue and the Washington Street Bridge is dredged to a depth of -4 feet MLLW.

Maintenance dredging performed by the Corps of Engineers in this upper river channel since completion of the project in 1933 is tabulated below.

Table 3.1

Corps of Engineers' Dredging Projects

Fiscal Year	Amount Dredged (cubic yards)	Contract Cost (dollars)
1937	275,193	$ 51,102
1938	31,800	11,000
1939	30,820	9,045
1941	172,305	36,414
1942	67,322	30,641
1943	25,398	14,451
1945	113,313	59,867
1947	144,516	48,514
1952/53	352,918	177,195
1956/57	51,698	54,212
1959/60	293,600	203,446
1964/65	267,305	228,405
1969	266,039	249,229
1975	444,000	442,476
1980	204,307	780,072
1983/84	262,000	1,225,000,
1988	170,925	NA
1992	108,684	NA
1996	164,700	NA
Total	**3,002,534**	**$3,621,069.00**

NA=Not Available

The Agency's hydraulic analysis of the Petaluma River has assumed that the Corps of Engineers will continue to maintain the dredged channel sections.

The Corps' dredging experience was also used as the basis for evaluating any impacts a proposed project might have on silt deposition in the Petaluma River. Based on the Corps' experience over the past 50 years, it appears that an average of 60,000 cubic yards of material is deposited in the river each year. To perform the evaluation, each major tributary watershed was rated on its probable per-acre contribution to this total annual sediment deposition. To date, no definitive studies have been performed of erosion and silt transport in the Petaluma River Watershed. The Agency, therefore, based on personal contacts, field experience and review of the available literature, devised a method of rating the tributary watershed. The rating method was based on factors such as topography, erosiveness of the soils, land use and the existing channel transport system (to determine how much of the silt is deposited in the tributary watershed and how much is actually carried to the Petaluma River). This rating was then multiplied by the total acreage in the tributary watershed and the product used to establish the percentage contribution of that watershed to the total sediment carried to the river each year.

Voluntary Home Relocation Program

Following the disastrous 1982 flooding, the City of Petaluma initiated several programs to reduce future flooding potential and to resolve existing flooding problems.

One of the major remedial actions planned was a home relocation program. The program was conceived as a phased project to assist some or all of approximately 65 property owners with homes in the floodway in the Linda del Mar and Madison Square Subdivisions to relocate their homes out of floodway areas in order to:

1) Provide ongoing protection and security to the property owners whose homes are relocated out of the floodway;

2) Secure right-of-way for eventual widening and channelization of the Petaluma River in this vicinity; and

3) Provide long-term protection to properties in the remainder of the Linda del Mar and Madison square neighborhoods.

On March 15, 1982, the Petaluma City Council authorized a request for Federal Community Development Block Grant funding to initiate the program, and on April 2, 1984, the Voluntary Home Relocation Program was adopted. Figure 3C shows the designated floodway zone and the phasing plan for the Home Relocation Program.

As of 2003, the Voluntary Home Relocation Program is no longer active.

Figure 3C – Petaluma Home Relocation Program

Cooperative Flood Warning System

A cooperative flood warning system, while it cannot prevent flooding, can provide the necessary time so that action to save life and property can be taken by local residents and agencies. Owing to the brief time period before heavy upstream rains generate damaging downstream flows, the maximum time advantage can be gained by real-time monitoring of upstream precipitation gages, evaluating the expected duration and amount of rain from meteorological conditions and available information, and then using hydrologic analysis techniques to assess the runoff threat.

Wilson Street at East Court, Petaluma
December 22, 1955

The basic components of an automated flood warning system include:

1. Automated precipitation and river gages;
2. Automated data collection and processing equipment;
3. Computerized hydrologic and meteorologic analysis techniques, and
4. The warning distribution.

In cooperation with the California-Nevada River Forecast Center of the National Weather Service, located in Sacramento, the City of Petaluma in 1983 and 1984 installed such a flood warning system for the Petaluma River.

This automated system includes eight rain gages in the upper watershed, six river gages at Stony Point Road, Payran Street, Holly Lane, Old Redwood Highway at Willow Creek, Penngrove Fire Station, Rainsville Road at Wiggins Creek, and at La Cresta tank site. There is a combination rain and river flow-monitoring gage at the end of Corona Road and a river gage and weather station at the "D" Street Bridge. Data from these gages is automatically relayed via repeater at Mount St. Helena to the base stations in Petaluma, the National Weather Service Forecast Offices in Monterey and Sacramento, and to the California-Nevada River Forecast Office in Sacramento.

The collected data is used by the River Forecast Center as input for a stream flow simulation model. An advisory of peak stream flow volumes based on various possible rainfall amounts is then prepared and transmitted to Petaluma for incorporation in the local flood warning and preparedness plan.

The intent of the monitoring system is to enable personnel to study the cumulative impact, in real time, of inclement weather on various areas of the City. In general, when a rainfall rate of ½ inch per hour continues for more than one hour, emergency personnel begin continuous monitoring of river levels. Weather records are kept on file to document flood events and flood related claims.

As certain water elevations are registered on these gauges, various City procedures are activated. The first of these procedures is the activation of the City's Emergency Operations Center (EOC). Once activated, City staff begins to execute standard management operation plans.

Five evacuation plans exist for the Payran area, which has been flooded most frequently over the past 20 years. These plans are labeled and prioritized, with the lowest topographical areas designated as most at risk for flooding. Once the evacuation order is given, field personnel go door-to-door to notify residents that they must leave. Once the Payran Reach Project, discussed later in this section, is completed, flooding will be reduced in the Payran area.

When stream gauge readings reflect a pre-determined level, the National Weather Service Alert System is activated, and a flash flood warning is automatically announced to the National Oceanic and Atmospheric Administration. These warnings are relayed as standard radio and TV broadcasts. In addition, the Sonoma County EOC releases warnings to the media; however, it is up to the media to distribute the information at their discretion. As of 2003, the cooperative flood warning system is still active.

Petaluma River Analysis

The Petaluma River was not hydrologically or hydraulically reanalyzed for the 2003 Master Plan Update. Currently, the City of Petaluma is developing a detailed hydrologic and hydraulic model of the Petaluma River Basin above the Petaluma downstream city limits. This model will be calibrated using the City's rainfall and stream gage data.

The hydraulic model developed for the 1986 Master Plan and used to design the flood control projects in the Petaluma River is no longer representative of current conditions, as the Payran channel and other improvements have been constructed that have altered the hydraulics. Therefore, a new or updated hydraulic model will need to be used as the basis of future designs. As of 2003, only the Payran Reach project from the 1986 Master Plan has been constructed in the Petaluma River. Several of the remaining projects are now considered infeasible due to the significant adverse environmental impacts that are likely to occur and the potential conflicts with City of Petaluma's watershed goals and objectives. The anticipated feasibility of the remaining 1986 projects are discussed in the "Analysis of Alternatives" subsection on page 3-15.

In order for future flood control projects for the Petaluma River to be effective, constructible, and permittable, they must be developed from a regional perspective with consideration of:

- City of Petaluma General Plan, River Plan, and other applicable plans,
- CEQA, FEMA and other regulatory requirements,

Therefore, the Petaluma River Analysis subsection in this master plan describes the analysis work done for the 1986 Master Plan and the proposed solutions to mitigate flooding along the Petaluma River. The current status of these proposed projects is also discussed, including their current feasibility.

In the 1986 Master Plan, the Petaluma River was analyzed from the U.S. Highway 101 crossing up to the confluence of Willow Brook and Liberty Creek. It encompassed the section of the river included in the Corps of Engineers' reports and dredging project previously described.

The Petaluma River is classed as a "major waterway" under the Agency's Flood Control Design Criteria. Major waterways have a drainage area of four square miles or more and can carry flood flows with an average recurrence interval of 100 years.

To determine the extent of flooding in the river during a design storm, two studies were performed in 1986: a hydrology study of the entire watershed, and a water surface profile study of the existing river.

Hydrology

A general discussion of hydrology is contained in Section 2. As stated, the Rational Method was used to estimate peak runoff from the Petaluma River watershed. Additional discussion regarding the use of this and other methods in the development of the 1986 hydrographs for the Petaluma River is included later in this section.

Water Surface Profiles

The behavior of flowing water continues to elude rigorous mathematical analysis. Even a slight change in a dimension or rate of flow may result in a radical change in behavior. [Garstka] Hydraulic models, such as the Corps of Engineers' HEC-2 computer program, have been developed to produce the most probable flood flow behavior and was used to analyze existing natural waterways and proposed projects.

The HEC-2 program was developed in the Corps' Hydrologic Engineering Center at Davis, California and has become an internationally recognized method of developing water surface profiles of waterways of any shape or condition, including the modeling of obstructions such as bridges and levees. The model requires the following data to perform computation of water surface elevations at locations of interest for actual or estimated flood flow:

1. Starting elevation. The initial water surface elevation was determined by using the Mean Higher High Water (MHHW) at the entrance to the Petaluma River in San Pablo Bay of 3.4 NGVD. [Corps, 1984]

2. Discharge. Flows derived from the rational method hydrology study were used.

3. Loss coefficients. Several types of loss coefficients are utilized by the program to evaluate head losses:

   (a) Manning's 'n' values for friction loss, with the coefficient of roughness 'n' dependent on such factors as type and amount of vegetation, channel configuration and stage
   (b) Contraction and expansion coefficients to evaluate transition (shock) losses (contraction or expansion of flow due to changes in the channel cross section is a common cause of energy losses within a reach)
   (c) Bridge loss coefficients to evaluate losses related to the effects of various obstructions such as bridges, culverts, weirs and structures in the flood plain

4. Cross section geometry. Cross sections are located at intervals along a stream to characterize the flow carrying capability of the stream and its adjacent flood plains. They are required at representative locations throughout a stream reach and at locations where changes occur in discharge, slope, shape or roughness; at locations where levees begin or end; and at bridges or control structures such as weirs.

5. Reach lengths. The measured distances between cross sections are referred to as reach lengths. Reach lengths for the left overbank, right overbank and the channel (typically measured along the thalweg, being the extreme low flow path) are used in the computations.

For the 1986 Master Plan, information regarding river topography and existing structures for the various backwater program parameters was obtained from: (1) Agency field surveys; (2) a preliminary study of the Payran Street area of the Petaluma River prepared by Mackay and Somps for the City of Petaluma, dated October 10, 1983; (3) HEC-2 input data developed by the U. S. Army Corps of Engineers, including 1984 dredging soundings; (4) the City of Petaluma's report on the Petaluma River dredging spoils disposal area and dike construction dated August 1979; and (5) HEC-2 input data developed by Water Resources Engineers, Inc., Walnut Creek, CA, in February 1976.

Identification of Problem Areas

The capacity of a watercourse is the maximum flow rate that the watercourse will carry without floodwaters leaving the confines of the channel. Development of water surface profiles for the 100-year flow rate provides information needed to determine inadequate portions of the channel, i.e. those areas where the water surface elevation exceeds the top of the channel banks.

Several locations within the Petaluma River study area experience flooding during the 100-year design storm as shown on Figure 2B (Page 2-7). Some of these locations, however, are in agricultural or other low-density use where flood damage is minimal. The following two reaches along the river, and another reach along Willow Brook, experience flooding during the design storm that causes serious damage to improved properties and structures:

1. The **Payran Reach** begins downstream at the turning basin and ends upstream at the confluence with Lynch Creek. Land use is a combination of industrial, commercial and residential. Flooding along this reach occurs within the area shown on Figure 2B and reaches depths of 5 feet or more, with the greatest depth being in the Payran Street area. Velocities of the overbank flow are estimated to be relatively slow (one foot per second or less) except in public roadways, which are parallel to the river and public road crossings. Army Corps of Engineers estimations of peak flow rates at Payran Street in the Petaluma River for the 100-year design storm significantly exceed Agency estimations. As of 2003, the Payran Reach Project is nearly complete, which should greatly reduce flooding in this region.

2. The **Denman Reach** begins downstream at Corona Road and ends upstream at the confluence of Liberty Creek and Willow Brook. Land use in this area is a combination of commercial, agricultural and mobile homes. Flooding along this reach due to inadequate capacity within the Petaluma River occurs within the area shown on Figure 2B and is estimated to reach depths of 5 feet or more. Velocities of the overbank flow are generally two feet per second or less except at public road crossings.

3 The **Willow Brook Reach** begins at its junction with the river and Liberty Creek just west of Stony Point Road and extends upstream through Highway 101 and Old Redwood Highway North to Ely Road. Land use is mostly commercial and industrial with some residential such as the Leisure Lake Mobile Home Park. This entire reach is not adequate to carry the 100-year flood. The floodwater that escapes from Willow Brook flows into the adjacent industrial and commercial areas and also becomes lost water flowing into adjacent watersheds such as Corona Creek. This lost water also floods the industrial area east of Highway 101 and north of Corona Road. Flood depths vary up to about 3 feet with much of the flooding being sheet-flow over the relatively flat land.

Leisure Lake Area, 1986 – Doug Brown Argus-Courier

Investigation of flood mitigation measures for the Petaluma River in the 1986 Master Plan focused on the above three reaches.

Flood Mitigation Measures

Solutions to flooding problems fall into two categories: "structural" and "non-structural". Non-structural measures are primarily oriented to the control of damage by regulatory control of development within a flood plain, while structural measures are generally oriented to the control of floodwaters by constructing dams, diversions or larger channels. A brief explanation of the common types of projects under each category, including those already implemented, is given below.

A. Non-Structural Measures:

1. **Flood Plain Management** – the regulating of land use in a floodplain to ensure an unimpeded flow of water and minimal flood damage.

The Sonoma County Zoning Ordinance includes designations for Primary Flood Plain Districts (F-1) and Secondary Flood Plain Districts (F-2) to provide land use regulations for properties situated in floodways and along creeks and streams where such Districts have been implemented by specific action of the County. The Petaluma River downstream of Petaluma is the only reach of the river currently in the F-1 and -F-2 Districts.

The National Flood Insurance Program requires that flood plain management regulations be established and enforced by a community in order to retain its eligibility for coverage under the program. Both the County of Sonoma and the City of Petaluma have established the required regulations for flood-prone areas within the Petaluma River Watershed.

Land use zoning can prevent the building of structures in areas where they would be subject to flood damage. It is not an independently viable alternative once those areas have developed to the density of use, which exists along the three problem reaches of the Petaluma River studied for the 1986 Master Plan.

2. **Purchase of Land and Improvements** - involves public acquisition in fee or easement of open, flood-prone lands to avoid future flood problems associated with development of those lands. Land purchase, accompanied by relocation of structures to higher ground, may also be considered for developed areas in the flood plain. An example of this mitigation measure is the City of Petaluma's Voluntary Home Relocation Program described previously.

B. Structural Measures

1. **Channel Improvements** - the modifying of an existing channel to increase its capacity. Modifications may include excavation to deepen and/or widen the channel, channel lining to increase bank stability (and decrease its coefficient of roughness), removal of obstructions and channel straightening.

2. **Dam/Detention Basin Structures** - the impounding of storm water flows in a basin or reservoir by obstructing the flow in a channel with a dam or other barrier. A further discussion of this measure is contained in Section C below.

3. **Bypass Systems** - the routing of storm flows around a particular flood-prone area by use of channels or storm drains.

4. **Diversion Systems** - the diversion of storm flows into a basin or different watershed.

5. **Levees** - the confinement of flows to a watercourse or floodplain area by use of embankments built up around the watercourse.

The use of any one or combinations of two or more of these measures depend on the type of flooding problem and what structural method would most effectively and feasibly provide a solution. Changes in the HEC-2 computer program data input are made to allow simulation of a selected structural channel solution, allowing the design engineer to test the effectiveness of a candidate solution in lowering the water surface profile. Other hydraulic analysis methods are used to evaluate dams and detention basins. In the 1986 Master Plan, these processes were performed to screen possible alternative flood mitigation measures for the Petaluma River.

C. Detention Reservoirs

The function and effect of detention reservoirs is often misunderstood. In the case of "retention" reservoirs, such as Coyote Dam and Warm Springs Dam, control gates are physically closed and water is "retained", i.e. kept in the reservoir until the gates are opened to allow a controlled release after downstream flood danger has passed. A "detention" basin on the other hand is a reservoir without adjustable control gates. It ordinarily has a restricted fixed-size outlet control opening to release water from the basin so that inflows that exceed the capacity of the outlet are temporarily "detained" or delayed within the detention basin. Storage of water under the "detention" concept is commonly used to contain excess runoff due to new development, holding the outflow rate down to pre-development flow. By restricting the discharge rate from the detention basin to the pre-development condition, the impact of the increased runoff from the development on peak flow within the local watershed is mitigated. It must, however, be remembered that a "detention" basin is designed to be free draining, i.e. the pond will gradually and continuously empty in the period after the end of the design storm. The total amount of runoff from the local watershed, including the increase due to land development, will eventually be discharged; the detention basin merely discharges at a restricted rate over a longer period of time.

A detention basin can beneficially reduce peak flows in one watershed, but it can harmfully increase peak flood flow in a downstream watershed. A detention basin will usually perform its intended flood reduction action in its immediate watershed. This is because it stores part of the peak flow runoff from its watershed and slowly releases that stored water gradually after the flood peak has passed and the downstream drainage system of that particular watershed can safely carry the temporarily stored water.

There is an unintended negative effect in other downstream channels into which the temporarily stored water flows. When it leaves its watershed, joining larger downstream waterways that normally develop peak flow later in time than the smaller watershed, it contributes flow to the peak flow of the larger watershed. That flow is then larger than it would normally be as it includes water that was delayed in the detention pond. In the downstream channels, this delayed water adds to the flood problems instead of reducing flood problems as it did in its own watershed.

Detention ponds in small watersheds store and release small amounts of water in comparison to the flows in large downstream watersheds. There is usually only a small incremental, often insignificant, increase to peak flood flow downstream. However, many such small increases can accumulate to become a significant flooding increase. In general, any delay of flood runoff from small watersheds in the vicinity of Petaluma will result in some of that water being added to the normally expected flood peak in the Petaluma River.

One way to better understand this detention pond problem is to compare it to automobiles and roads used to get workers to San Francisco. If workers in Sonoma and Marin Counties were to begin their trip to San Francisco in the same way as floodwater begins its trip to San Francisco Bay, they would all leave their homes, get in their cars and begin driving to the City at about the same time, just as rainwater would begin flowing into all streams at about the same time. For example, if all the commuters, no matter where they lived, began their trip at 6:30 a.m., then most of the Marin County workers would have driven to the freeway and onto San Francisco before the Sonoma County workers got to the freeway through Marin County. That would be wonderful indeed.

That is not the way it really works. Some of the workers in Marin County leave early, but many of them detain themselves by sleeping later than their Sonoma County commuters. These late sleepers then join the peak commute from Sonoma County, adding to the peak flow of vehicles, thereby further exceeding the capacity of the freeway.

The similarity between moving floodwater or moving commuters, although not precisely the same, is this: the efficiency of a flood channel or a highway is increased by getting downstream floodwater or down-system commuters into the channel or onto the freeway early while there is spare capacity available. If floodwater or commuters are detained and added at the time of peak flow, then such detention is adding to the downstream flooding or commute problem. The decision to use a detention basin should be made only after careful consideration, so as not to create or increase unacceptable downstream flooding.

Development of Hydrographs

The hydrograph is a graphic representation of the flow of floodwater at any time past a specific location along a stream. In the 1986 Master Plan, the Payran Street crossing of the Petaluma River was selected as the point of greatest interest for hydrographs. The hydrographs show the rate of flow in cubic feet per second that would occur at that point at any time during the several hour time span of the hydrographs. The rise or fall of the hydrograph represents the increase or decrease of flood flow at Payran Street.

The flood event hydrology of the Petaluma River was analyzed in several different ways in the 1986 Master Plan. The primary method of determining the peak flood flows was through the modified rational method described in the Agency's Flood Control Design Criteria. The resultant hydrographs depicted in this report are a combination of the rational method hydrology, the Muskingum flood routing procedures and observations of actual flood peaks at the Payran Street Bridge. The peak flow and the time of peak flow were computed by the rational method. The general shape of the hydrograph and the relative relationship of the hydrograph peak flows were developed by flood routing and by observation of actual flood events.

Verification of the general shape and time to reach peak flow was further examined by use of the Corps of Engineers Hydrologic Engineer Center's hydrology program package called HEC 1. The kinematic wave method in that program package was used for the analysis. Similar hydrograph shapes and time relationships between peak flow of the major tributaries were found supporting the general interpretation and application of the hydrology method described above.

In the 1986 Master Plan, the hydrographs were used to assess the relative merits of the various alternates that were considered to alleviate flooding along the Petaluma River. The modification of the hydrograph shape and peak flow change that would result from implementation of a proposed alternate is an indication of the effectiveness of that alternate for flood reduction. The hydrographs also serve to explain in a general sense to the non-technical public and decision makers the flood event as it occurs in the City of Petaluma, particularity in the vicinity of Payran Street. They also depict the flood reduction that can be realized by implementation of flood reduction alternates.

The hydrographs presented in this report depict the quantity of water flowing past the Payran Street Bridge at any time during a 100-year frequency flood, as determined in the 1986 Master Plan.

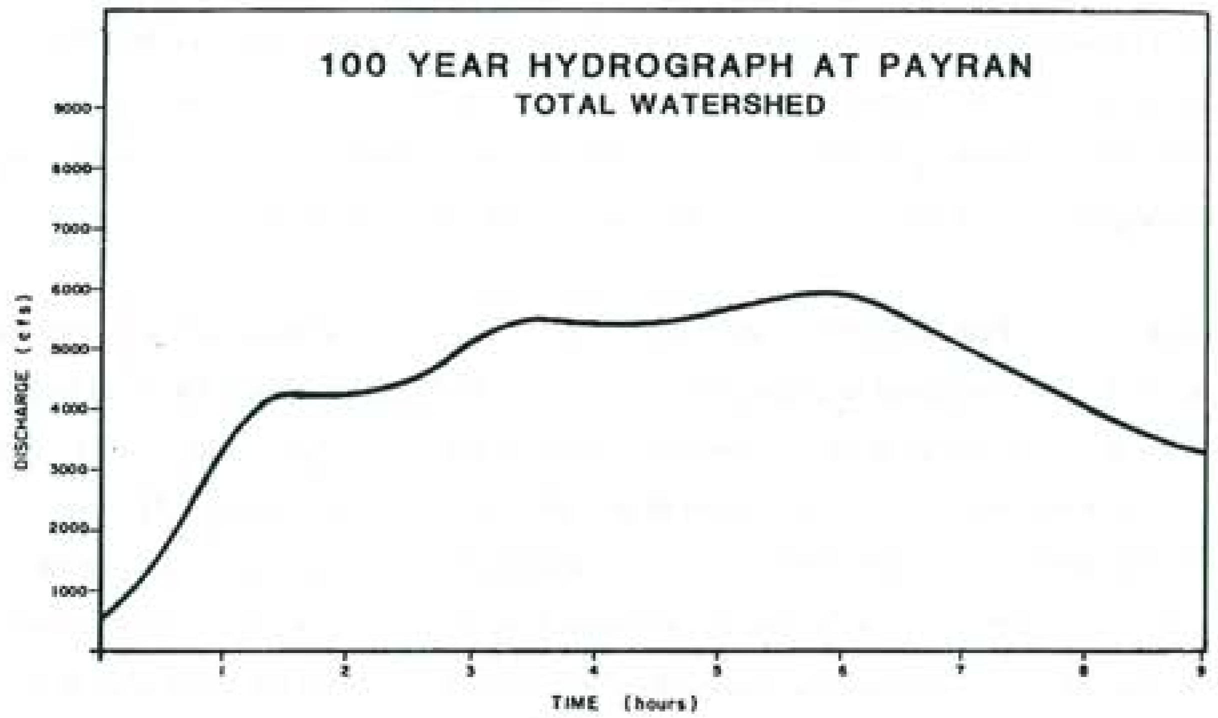


Figure 3D

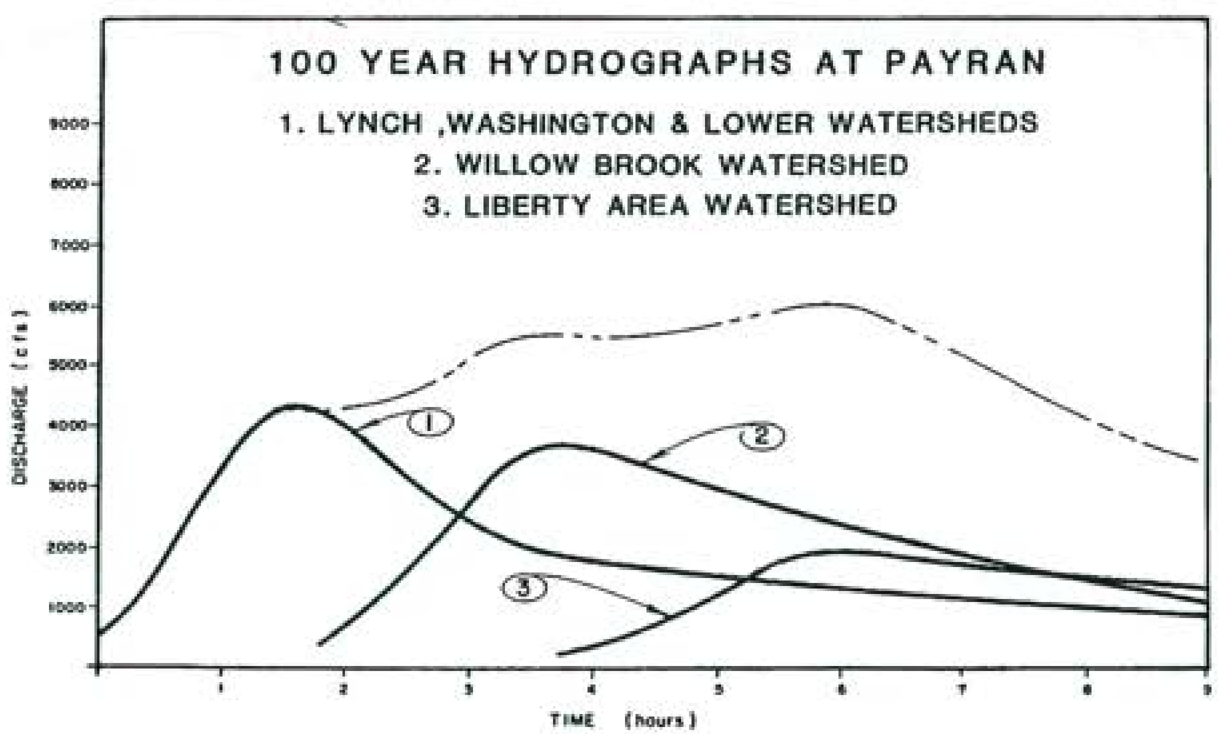
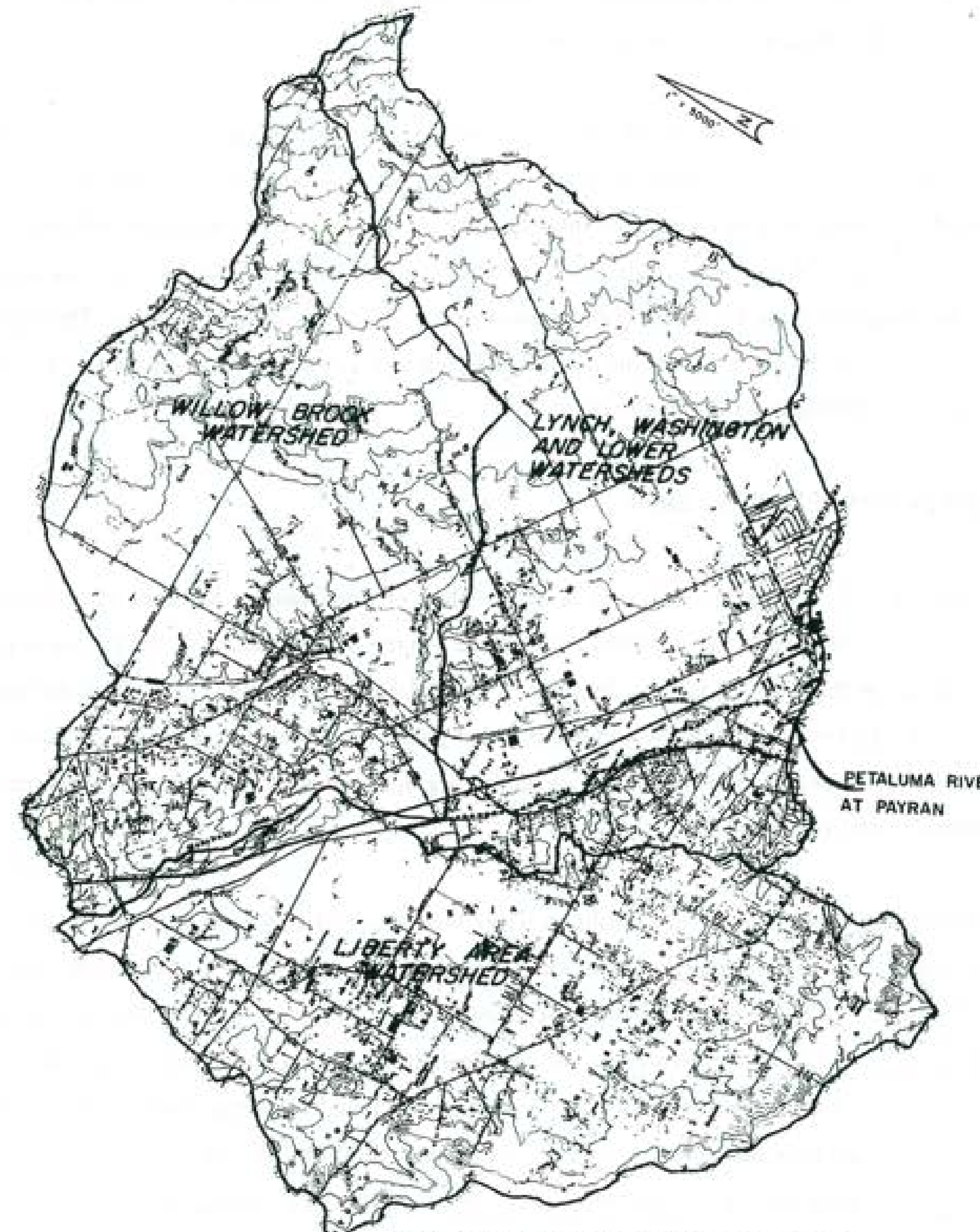


Figure 3E



HYDROGRAPH WATERSHED AREAS

Figure 3F

Any watershed will have a hydrograph shape unique to that watershed. The natural hydrograph for the Petaluma River at Payran Street in 1986, shown on Figure 3D, shows points of peak flow separated in time by about three hours. The origin of these three peaks is evident from the separate hydrographs shown on Figure 3E. The first peak is caused by flood flow from the Lynch Creek and Washington Creek watersheds. The intermediate and last peaks are caused by the flood flow from the upper Petaluma River watershed. Since flows from the separate watersheds are cumulative, this difference in time to peak from the upper and lower watershed areas is fortunate. If flood flow from these areas arrived at Payran Street together, the natural flood peak would be substantially higher.

However, this time displacement complicates finding a solution for flooding problems. Reduction of the Lynch Creek and Washington Creek peak flow makes only a small reduction at the time of the upper river peak flow and reduction of the upper river peak flow makes very little reduction at the time of the Lynch/Washington watershed peak flow.

Solution of Petaluma River flooding in the City of Petaluma cannot be fully achieved unless both peak flows are reduced to the capacity of the river or the river is enlarged and/or modified to carry the highest peak flows produced by the selected alternate. The alternates (and combinations of alternates) presented in this report for the Petaluma River demonstrate flood reduction solutions developed in the 1986 Master Plan. One reduces flood flow down to the existing capacity of the river. The other increases river flood-carrying capacity up to the peak flow created when all reaches are enlarged to carry all the floodwater.

Analysis of Alternates

In the 1986 Master Plan, several alternate ways of controlling Petaluma River floodwater were investigated. These alternates are categorized below into the two flood control methods mentioned above. One method diverts or stores floodwater so that the river channel could safely carry the remaining flow and the other method enlarges and modifies the river channel and upstream channels so as to be capable of keeping the floodwater in the river.

Payran at Jess Street
Doug Brown Argus-Courier

In the 1986 Master Plan, both of the structural methods described provided 100-year flood protection to areas near the Petaluma River from "D" Street to Denman Flat and along Willow Brook to Ely Road (identified in the previous description of problem areas as the Payran, Denman and Willow Brook reaches).

Floodwater Diversion and Storage

In the 1986 Master Plan, control of Petaluma River flooding by means of floodwater diversion and storage included the following three main structural elements:

1. The **Petaluma Bypass**, an underground conduit diversion of Capri Creek, flowing into an open earth channel diversion of Lynch Creek and Washington Creek around the east side of Petaluma and entering the river near the wastewater treatment plant. The Petaluma Bypass Project is no longer considered a feasible project by SCWA due to anticipated environmental impacts.

   The 1988 WESCO report indicates that the Petaluma Bypass Project could have far reaching biological impacts. The bypass could substantially reduce in size 14 acres of coastal salt marsh at the mouth of Ellis Creek. This area is the uppermost extent of the Petaluma Marsh and provides suitable habitat for California clapper rail, California black rail, salt marsh yellowthroat, and other species of concern. Pool habitat in the reaches of the creeks cut off by the bypass would be reduced or eliminated. Salmonid passage would be profoundly affected, as would instream habitat for rearing salmonids and resident fish. Changes in the volume and timing of stream flow would also impact the health and species composition of riparian plants. The channel modification alternatives proposed in 1986 would impact riparian habitat and fish passage, particularly during construction [SSCRCD, 1999].

2. The **Denman Dam and Reservoir**, a floodwater detention facility in a portion of Denman Flat. Denman Dam and Reservoir is no longer considered a feasible project by SCWA due to probable environmental impacts and public opposition.

3. The **Willow Brook Diversion**, a floodwater diversion of Willow Brook into the Denman Reservoir. The Willow Brook Diversion project is no longer considered a feasible project by SCWA due to probable environmental impacts associated with this and the Denman Dam project. According to the 1988 WESCO Report, construction of the Willow Brook Diversion will impact passage of steelhead trout to and from Willow Brook Creek.

Description of Structural Elements

The following is a description of the structural elements, as proposed in the 1986 Master Plan.

1. Petaluma Bypass

As shown on Figure 3M (Page 3-26), the project would begin upstream at Capri Creek, diverting its flow into a 54-inch diameter concrete pipe extending approximately 4,000 feet to Lynch Creek. Additional flows would be diverted from Lynch Creek into an open bypass channel. The bypass channel would be constructed to simulate a natural creek and would extend for a distance of about 5.3 miles along an alignment roughly paralleling Highway 101. Flows from Washington and East Washington Creeks and from minor drainage areas between Capri Creek and Casa Grande Road would also be diverted into the bypass channel along its route. At the Adobe Creek crossing, flows could be redirected, allowing Adobe Creek to carry those within its capacity, while the remainder of the flow continued downstream through the bypass to its outlet into the Petaluma River at Ellis Creek, just upstream of the City of Petaluma's Wastewater Treatment Plant ponds.

A siltation basin would be provided along the bypass upstream of the outlet into Petaluma River to trap sediment before it reaches the river. The silt basin would be on City-owned property adjacent to the City's wastewater treatment site at the edge of the tidal area of the Petaluma River at Ellis Creek.

The top width of the bypass channel would vary between 100 to 180 feet with depths ranging from 6.5 to 12.5 feet and bottom widths between 10 and 30 feet. Side slopes would be varied from 2.5:1 to 6:1 to simulate a natural stream. Flow velocities would range from 6.5 to 8.5 feet per second.

Ellis Creek would be added and enlarged to become part of the bypass channel from South Ely Road downstream to the Petaluma River outlet. The siltation basin to be constructed about 2,000 feet below Lakeville Highway would be approximately 350 feet wide, 8.5 feet in depth and about 1,800 feet in length.

Bridge or box culvert road crossings would be required at East Washington Street, Casa Grande Road, Frates Road and Lakeville Highway.

A 200-foot-wide right-of-way would be required for the open channel portion of the bypass. A 15-foot-wide right-of-way would be needed for the underground conduit section. The total length of the project is about 32,000 lineal feet (just over 6 miles) and the total estimated project cost in 1986 was $11.07 million.

2. Denman Dam and Reservoir

This project is located in the Denman Flat area; the actual dam site is located immediately downstream of the confluence of Liberty and Marin Creeks. The area of inundation is outlined on Figure 3M.

As shown on Figure 3M, the dam site is located 500 to 1,000 feet west of Stony Point Road between Rainsville and Liberty Roads. Intercepted flows would include those from the Wiggins, Wilson and Marin Creek watersheds, as well as those in Petaluma River above the dam site. The area inundated by the impounded floodwaters would be the lands upstream of the dam lying below elevation 37 feet above mean sea level (MSL). These lands under existing conditions are inundated to an elevation of 36 feet MSL during a 100-year storm.

The dam would be 2,500 feet in length, 86 feet in width at the base and 14 feet wide at the top, with 3:1 side slopes and a height of 12 to 15 feet. It would be constructed of local material with an impervious core, and would have a principal spillway and an emergency spillway.

The dam would be operated so that flows are impounded for a short time during peak flow conditions, creating a temporary lake over an area of about 240 acres during a 100-year frequency event. A lesser area would be inundated by impoundments during smaller storms of greater frequency.

Total right-of-way required for the dam and reservoir would be 300 acres. The project cost was estimated to be $2.82 million in 1986, with an annual operation cost of $10,000 for the detention basin area.

3. Willow Brook Diversion

The purpose of this project is to reduce the peak flood flows and amount of sedimentation in the Petaluma River and the lower reach of Willow Brook. The Denman Dam and Reservoir Project would have to be constructed before the Willow Brook diversion.

The Willow Brook diversion would divert floodwater in an open channel from Willow Brook at Ely Road to discharge into Denman Reservoir, a distance of about 6,200 lineal feet, as shown on Figure 3M. Approximately 75% of the peak flow and the majority of the sediment load from Willow Brook would be diverted into Denman Reservoir. Surface area of the temporary lake created during a 100-year frequency event would be about 280 acres at elevation 38 feet MSL. The diverted and stored floodwater would then be discharged at a reduced rate to the Petaluma River. The peak flow from the reservoir would be low enough to be contained within the natural channel of the Petaluma River.

The diversion would require installation of underground conduit at U. S. Highway 101 and at the crossings of Stony Point Road, Orchard Lane, Baker Lane, Denman Road and Old Redwood Highway.

The estimated cost of the project was $6.82 million in 1986; the combined cost of Denman Dam and the diversion was about $9.6 million.

Impact on Flooding

In the 1986 Master Plan, the effectiveness of the floodwater diversion and storage method of flood control was assessed by comparing the impact of each single structural element on the amount and height of floodwater at the Payran Street Bridge and then assessing the cumulative impact of the combined elements. Impact on the quantity of runoff reaching Payran Street is graphically depicted by comparing the "after project" hydrograph with the existing or "base" condition.

1. Petaluma Bypass

The first element in the 1986 Master Plan, the Petaluma Bypass, would reduce the flooding caused by the first flood peak to reach Payran Street in Petaluma by bypassing flood flows from the major tributaries around the inadequate Payran reach of the river.

In addition to diverting floodwater, the bypass system would intercept a large amount of silt that now enters the river through Lynch Creek and Washington Creek and divert the silt past the City for discharge into a silt basin at the end of the bypass. The diversion of silt from the tidal reaches of the river in the City was considered a significant additional benefit by lengthening the time between dredging of the river.

As illustrated on the Figure 3G hydrograph, the Petaluma Bypass project would reduce peak flow at the Payran Street Bridge about 19% and the beginning of flooding would be delayed about 1.5 hours. The water surface elevation would be reduced approximately 1.4 feet. The amount of sediment carried to the river would be reduced about 65%.

2. Denman Dam and Reservoir

The Denman Dam and Reservoir element from the 1986 Master Drainage Plan would replace the uncontrolled natural floodwater detention in the Denman Flat area with controlled detention and regulated spillway discharge. The reservoir would also be capable of storing the flood peak from the Willow Brook watershed diverted by the Willow Brook Diversion Project.

Construction of the Denman Dam and Reservoir element would reduce peak runoff in the Petaluma River, particularly in the reach from the confluence with Willow Brook to downtown Petaluma, by impounding flood flows in Denman Reservoir during peak flow conditions.

The peak flow at Rainsville Road (near the upper end of the Denman Reach) would be reduced by approximately 18% with a reduction in water surface elevation of about 0.4 foot. As illustrated on the Figure 3H hydrograph, peak flow at the Payran Street Bridge would be reduced about 7%, lowering the water surface elevation approximately 0.3 foot. No significant decrease in siltation is anticipated in the downtown area.

The impact of Denman Dam alone on flood flows is relatively small since the Denman Flat area already stores substantial floodwater under existing conditions, as is indicated by the flooded area shown on Figure 2B.

3. Combined Willow Brook Diversion and Denman Dam

The purpose of the Willow Brook Diversion in the 1986 Master Plan was to reduce the peak flows and amount of sedimentation realized in the Petaluma River and the lower reach of Willow Brook. This element is dependent on prior or concurrent construction of the Denman Dam.

As shown on Table 3.2 and on the Figure 3I hydrograph, this combined project would reduce the water surface elevation at the Payran Street Bridge by 2 feet and the peak flow by about 27%. The water surface elevation at Rainsville Road would be lowered 2.5 feet and the peak flow reduced by about 75%.

This combination of the second and third elements would reduce the second flood peak to reach the Payran Street Bridge. If only the second and third elements were constructed, there would be some flood peak reduction by lowering the second flood peak and also the time of flooding would be reduced. However, without the Petaluma Bypass, the first flood peak would still occur, as it would be only slightly reduced.

4. **Combined Petaluma Bypass and Denman Reservoir**

As illustrated on the Figure 3J hydrograph, construction of this combination would reduce peak flood flow at the Payran Street Bridge by 32% and would reduce the water surface elevation by 2.5 feet.

There would be no additional reduction in peak flow or water surface elevation in the Denman Reach over the 18% and 0.4 foot, respectively, achieved by construction of the Denman Dam Project alone.

This combination would not be fully effective unless the Willow Brook Diversion was also constructed.

5. **Combined Petaluma Bypass, Denman Reservoir and Willow Brook Diversion**

This combination of elements would reduce peak flood flow to a rate that can be carried by the river channel without modification of the channel or the bridges and structures along the river. The peak flows would be either diverted around the problem area or diverted to detention storage.

At Rainsville Road, the reduction of flood flows derived from construction of the combined Willow Brook Diversion and Denman Dam Project would also be realized under this combination of diversion and storage projects.

As shown on the Figure 3K hydrograph, the peak flood flow at the Payran Street Bridge would be reduced to 2,635 cfs, a reduction of 56%. The water surface elevation would be lowered to 9.5 feet MSL, a reduction of 4.2 feet. The 100-year flood would stay in the channel of the river and there would be no flooding of adjacent land.

This combination of flood mitigation measures was also thought to have a substantial beneficial impact on siltation in the Petaluma River, reducing the amount of silt reaching the river by 90%.

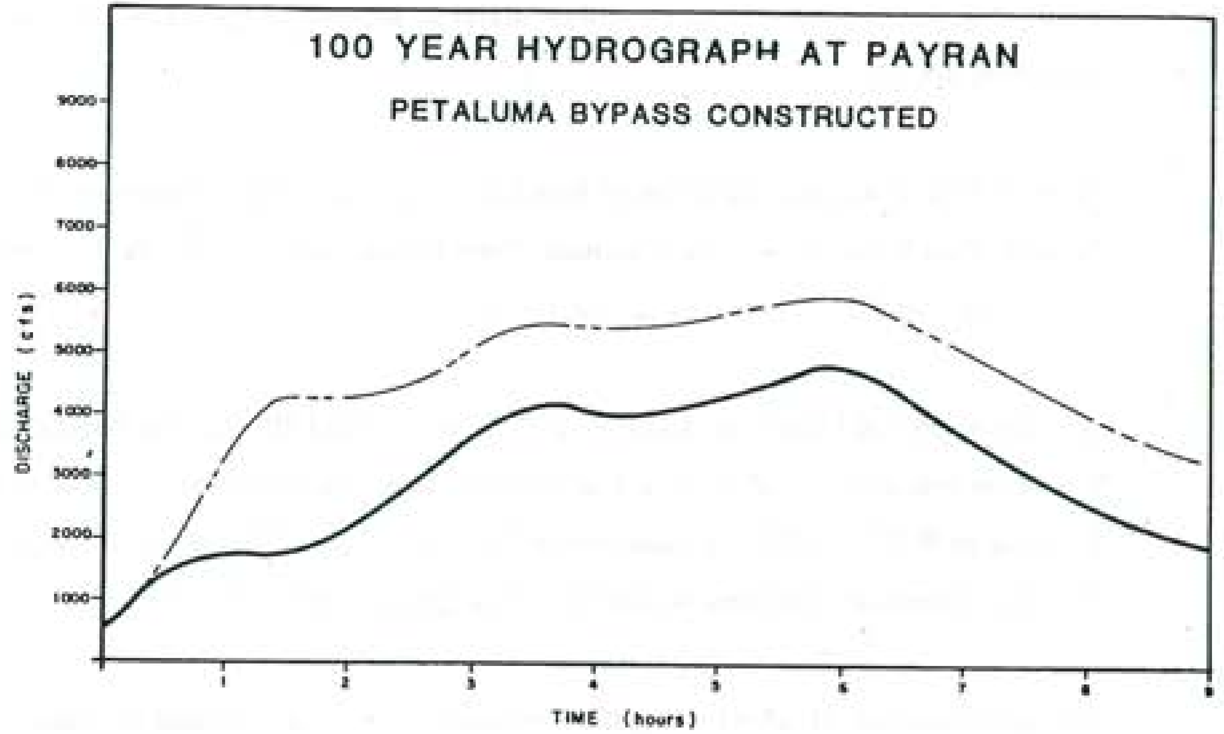


Figure 3G

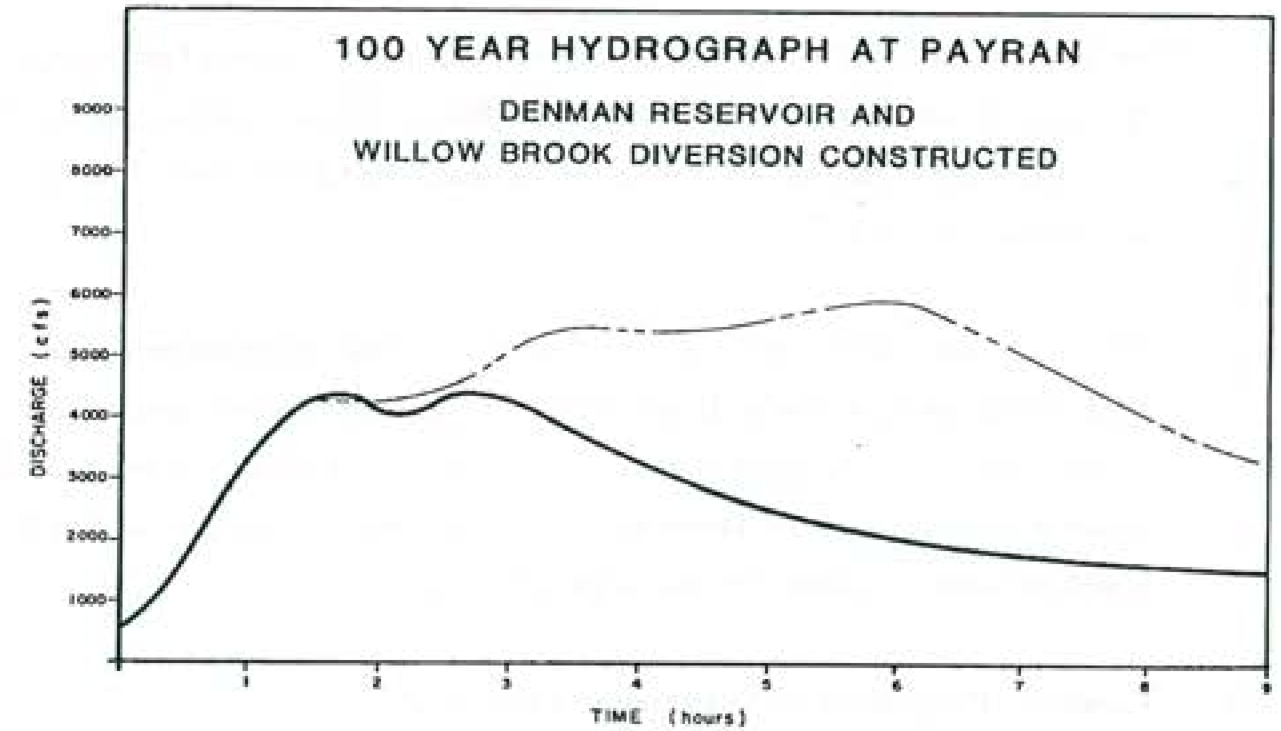


Figure 3I

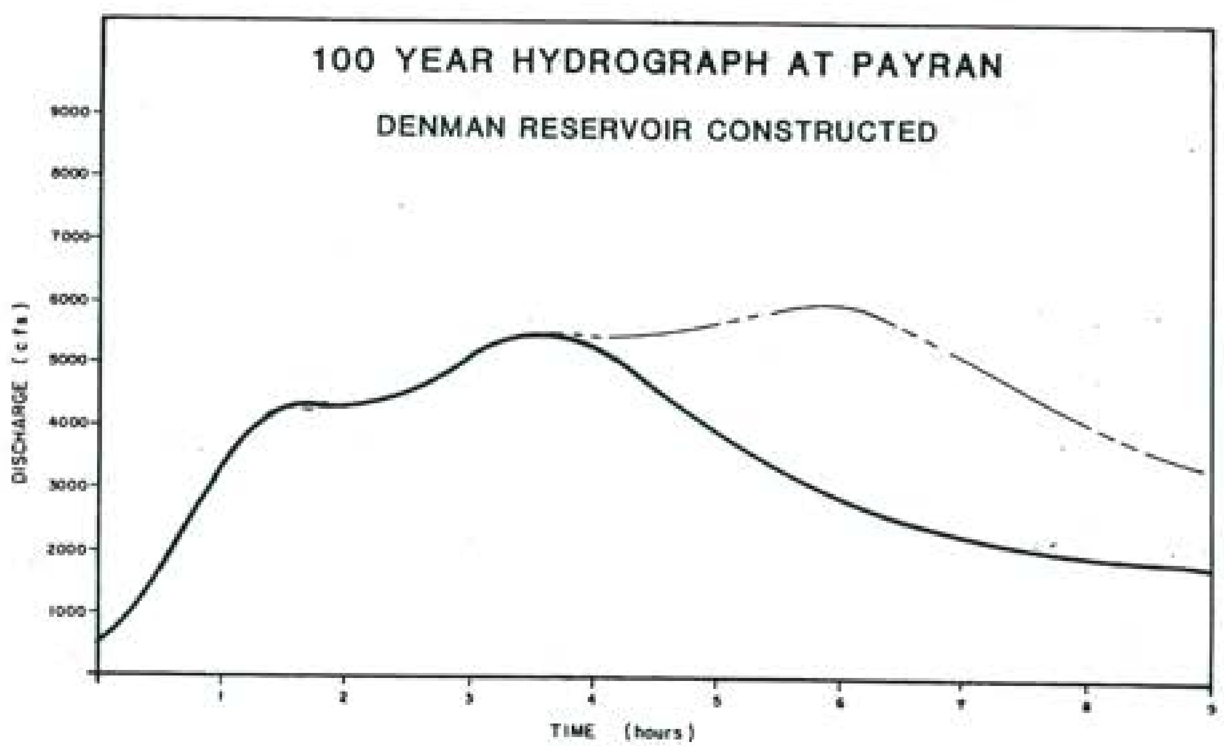


Figure 3H

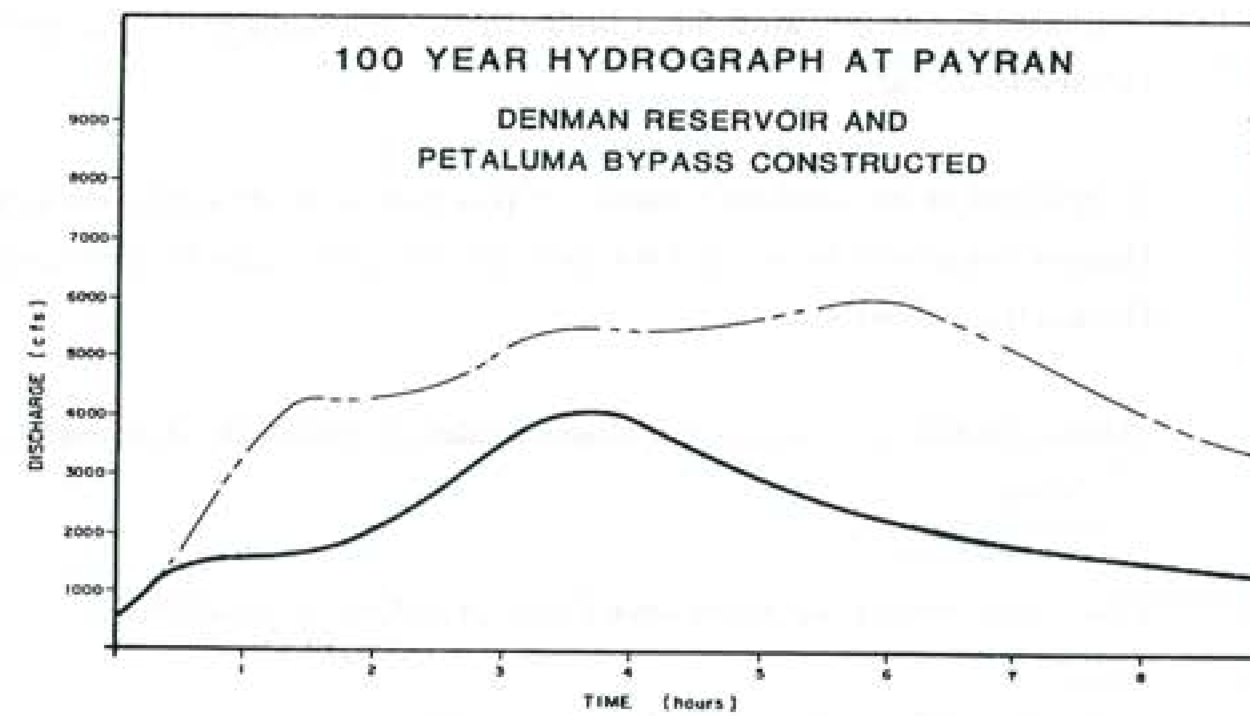


Figure 3J

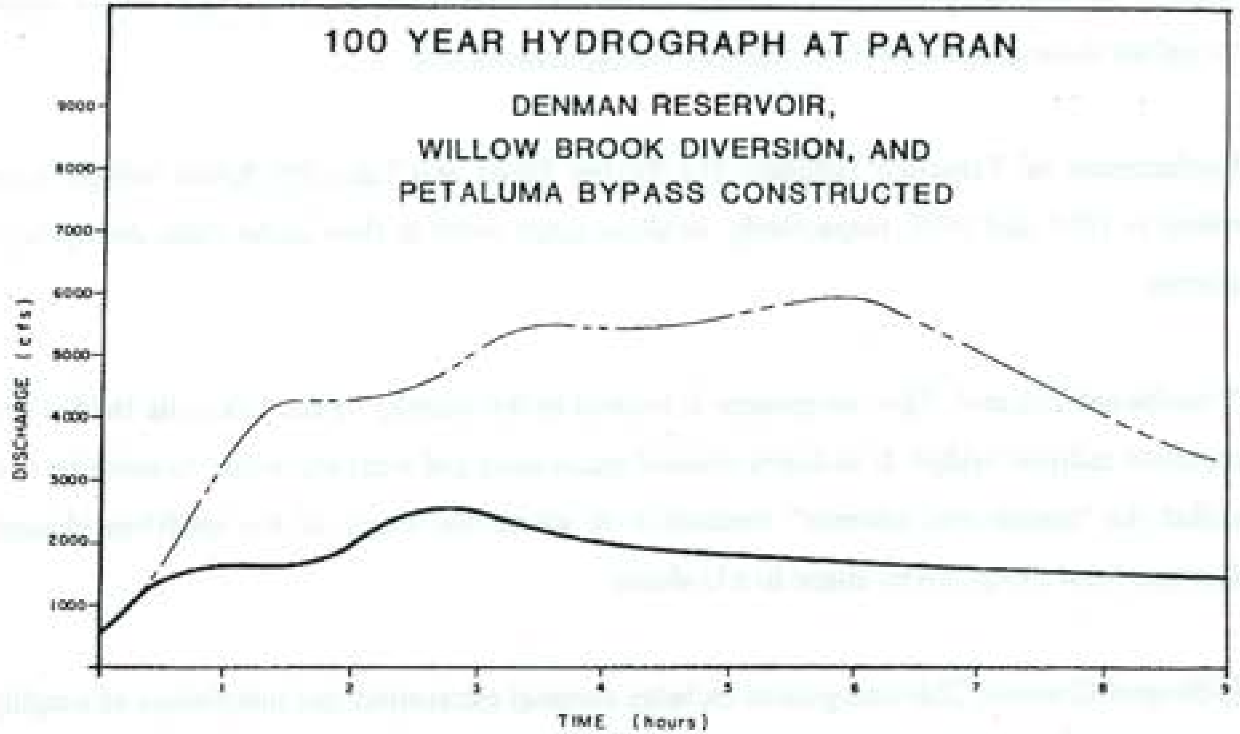


Figure 3K

Channel Enlargement and Modification

In the 1986 Master Drainage Plan, control of flooding through this method included enlargement and modification of the following three channel reaches:

1. The **Payran Reach** would be an open earth channel following the existing river from just upstream of Lynch creek near Payran Street to D Street.

2. The **Denman Reach** would be an open earth channel following the existing river from Willow Brook to just downstream of Corona Road.

3. The **Willow Brook Reach** would be an open earth channel following the existing channel of Willow Brook from Ely Road to the Petaluma River at Stony Point Road.

Description of Structural Elements

The following is a description of the structural elements as proposed in the 1986 Master Plan, and the current status of flood control projects in these reaches. For ease of reading, they have been separated under headings that clearly delineate the alternates as proposed in 1986 and the current state of the flood control projects in these areas.

1. Payran Reach

1986 Master Plan

The purpose of this alternate was to lower the water surface elevation along the Petaluma River in the Payran Street Bridge area by structural enlargement and modification within the river.

Construction of the alternate would require increasing the capacity of the river channel through residential and commercial areas of the City from just above Lynch Creek downstream through "D" Street. The channel would have an earth bottom and banks. Stress areas at transitions and bridges would require bank protection.

The Lakeville Street Bridge, Payran Street Bridge, and two railroad bridges (upstream and downstream of Lakeville Street) would be replaced. Public utilities that cross the river, such as water, sewer, gas and phone conduits would be reconstructed and relocated out of the channel.

The channel widening would require purchase of additional rights-of-way to a total width of about 185 feet. It was anticipated that the City's program of removal of homes from the flood plain of the river, described previously, would decrease the right-of-way cost in the vicinity of Payran Street.

If the Payran Reach were the only flood mitigation measure constructed, the channel would have a bottom width of 100 feet and be 15 feet deep with 2 to 1 side slopes. Estimated cost for this project was $10.17 million in 1986.

If the Payran Reach were constructed in conjunction with improvement of the Willow Brook and Denman Reaches (described in 2 and 3 below), the channel would still have a bottom width of 100 feet and 2:1 side slopes, but the depth would be increased to 17.5 feet to provide the additional capacity needed to accommodate the greater peak flow being passed through the improved upstream reaches. The estimated cost of the Payran Reach under this condition was approximately $11.25 million in 1986.

A third combination is also possible, i.e. construction of the Payran Reach after or concurrently with construction of the Denman Dam and Willow Brook Diversion. In this case, upstream flows have been diverted and stored, and size of the Payran Reach channel could be reduced to a bottom width of 80 feet, with 2:1 side slopes and a depth of 15 feet. The cost of the Payran Reach under this combination was estimated at $8.75 million in 1986.

2003 Master Plan Update

The Payran Reach project was designed to reduce flooding in the Payran neighborhood. As of 2003, the project is nearing completion. The project includes 3,600 lineal feet of channel widening and floodwalls, two new pump stations, two vehicular bridge replacements, and two railroad bridge replacements. In order to build the project as quickly as possible, it was divided into five major components, each which can be funded and built separately. Starting at the upstream end of the project, each major component is described below.

1. Trapezoidal Channel: This is the largest component of the project. It extends between Lynch Creek and the vicinity of the mainline railroad bridge near Lakeville Street. This component includes channel widening; steel sheet-pile floodwalls along Washington Creek and both sides of the Petaluma River; a concrete weir (a small dam with a V-shaped opening that controls the velocity of the water); two new pump stations; and the planting of native plants to replace those plants that were removed during construction.

2. Replacement of Vehicular Bridges: The Payran Street and Lakeville Street bridges were raised in 1997 and 1998, respectively, to allow more water to flow under them during large storms.

3. Transitional Channel: This component is located in the vicinity of the Lakeville Bridge and mainline railroad bridge. It includes channel excavation and steel sheet-pile floodwalls. It is called the "transitional channel" because it is where the shape of the modified channel changes from a trapezoidal shape to a U-shape.

4. U-Shaped Channel: This component includes channel excavation and installation of roughly 600 lineal feet of sheet-pile floodwall along both sides of the river channel between the Lakeville Street Bridge and the spurline railroad bridge south of the Lakeville Bridge.

5. Replacement of Railroad Bridges: The mainline and spurline railroad bridges to the north and south of Lakeville Street have to be raised to allow more water to flow under them during large storms.

The Payran Reach project will help the river contain the water associated with a "100-year flood" event under Petaluma's General Plan build-out (Year 2005) conditions. The future effectiveness of the project depends on whether or not the conditions in the floodplain change significantly in the future.

The Corps of Engineers' hydrologic and hydraulic analysis that was completed in 1990 assumed maximum development and channelization upstream. Based on those conservative assumptions, the Corps estimated the future level of protection at that point in time would be for a "40-year flood".

The Corps analysis did not account for any ordinances that the City of Petaluma is currently considering or may be considered in the future. Such ordinances could limit development (or limit the impacts of development) within the floodplain and preserve the project's effectiveness.

2. Denman Reach

1986 Master Plan

The purpose of this alternate was to provide flood protection by lowering the water surface elevation in the Petaluma River in the reach adjacent to Stony Point Road.

This project would provide for enlarging the Petaluma River channel to 100-year flood carrying capacity in the reach from Corona Road upstream to the confluence with Willow Brook. The Leisure Lake Mobile Home Park and the commercial area and public roads at and near Petaluma Boulevard North and Stony Point Road would be protected from flooding.

This reach would be open earth channel with bank protection at transitions, stress areas and bridges. The channel would have a bottom 70 feet wide, a depth of 12.5 feet, and side slopes of 2 to 1. This 7,500-foot-long channel reach would require a right-of-way 145 feet wide, or a total of 25 acres.

The bridges at Petaluma Boulevard North and the Corona Road Bridge have adequate capacity for the peak flow, although excavation and abutment modifications would be required beneath the Petaluma Boulevard bridges.

The estimated cost of the project was about $1.14 million in 1986.

2003 Master Plan Update

The Denman Reach Project may be implemented, but probably not as described. The City of Petaluma adopted the Petaluma River Access and Enhancement Plan in 1996. This plan developed a conceptual design for widening of this reach, which recommends a wide flood control channel having a low flow channel, flood terrace restoration zone, riverbank restoration zone, and buffer zones. The Denman Reach is the first portion of the Access Plan that the City has begun to implement. In 2003, the City of Petaluma has acquired funding to purchase three riverside properties and fund preliminary engineering design. Hydraulic modeling will be conducted to ensure that City flood control policies are met.

3. Willow Brook Reach

1986 Master Plan

This project would capture floodwater that now escapes from Willow Brook between Ely Road and old Redwood Highway and flows over public roads and through the industrial lands north of Corona Road. The floodwater would be carried to the Petaluma River in a 100-year capacity channel.

The improved channel would be open earth, lined with bank protection at transitions, stress areas and bridges. The channel would have a bottom width of 50 feet, a depth of 10 feet and side slopes of 2.5 to 1. This reach would require rights-of-way 138 feet wide for a length of 5,500 feet, totaling 17 acres. The bridges at Stony Point Road and Highway 101 are adequate. The bridge at old Redwood Highway would need to be replaced.

The estimated cost of this channel reach is $1.63 million in 1986.

As of 2003, a portion of this reach has been widened, but not as described above. Between Old Redwood Highway and U.S. 101, Willow Brook Creek was widened and low-lying wetland areas were constructed. The lower portion of Willow Brook Creek between Stony Point and U.S. 101 is recommended for widening in Section 4 of this Plan in Willow Brook Creek Alternative 1. This channel improvement will reduce, but not prevent, flooding due to backwater from the Petaluma River.

Impact on Flooding

As was done for the floodwater diversion and storage projects, the effectiveness of the channel enlargement and modification projects was also assessed for the single and combined elements by comparison with the pre-project flow and height of floodwaters at the Payran Street Bridge and at Rainsville Road. The results of these comparisons from the 1986 Master Drainage Plan are shown in the hydrograph (Figure 3L) and are described below.

1. Payran Reach

If the Payran Reach project proposed in the 1986 Master Plan was constructed, the water surface elevation at the Payran Street Bridge would be reduced 4.2 feet. Flooding conditions at Rainsville Road in the Denman Reach, however, would remain unchanged. The amount of sedimentation in the river would also remain the same.

If the Denman and Willow Brook reaches are also improved, the Payran Reach would need to have greater capacity since peak flow at the Payran Street Bridge would be increased 36% by improvement of the upstream reaches. If the Payran Reach was constructed in combination with upstream diversion and storage projects, the channel size could be reduced. Analyses of the Payran Reach in combination with these other projects are presented in separate sections below.

2. Denman Reach

Construction of the Denman Reach would reduce the water surface elevation at the confluence of the Petaluma River and Willow Brook. However, improvement of the Petaluma River upstream of Petaluma will decrease the amount of overbank storage available for excess flows and would increase the amount of flooding experienced along the Payran Reach under the 1986 river conditions. The adverse impact on flooding within the City of Petaluma makes it an infeasible alternative except in combination with other channel reaches.

3. Willow Brook Reach

After construction of the Willow Brook reach, the floodwater that escapes over the south bank of Willow Brook will be contained within the enlarged channel and carried to the Petaluma River. This project would provide flood protection to the lands south of the constructed channel and east of Highway 101. This flood protection is achieved by keeping floodwater in a channel that follows the existing route of Willow Brook. This is a re-diversion of the water to its natural point of discharge into the Denman Reach of the Petaluma River. Therefore, that reach of the river must be enlarged before this project can be constructed.

4. Combined Denman and Willow Brook Reaches

This combination of channel improvement projects would reduce the water surface elevation at Rainsville Road by 4 feet. With this reduction to elevation 31.8 at Rainesville Road, the 100-year peak flow would be contained within the channel banks through the Willow Brook and Denman Reaches. This project would increase the flow at Payran Street by 36% and raise the water surface elevation by 1.4 feet at that location. Without improvement of the Payran Reach, this combination would, therefore, be infeasible.

5. Combined Payran, Denman and Willow Brook Reaches

The impact of a combination of all three channel improvement projects on the peak flow at the Payran Street Bridge is compared on the Figure 3L hydrograph with the existing or base condition. Although the hydrograph shows an initial increase in flow due to the greater flood-carrying capacity of the upstream improved reaches, it must be remembered that this increased flow would not result in adverse flooding conditions. With construction of the three proposed channel enlargement and modification projects, the capacity of the waterway would be increased sufficiently to carry the greater flow without flooding.

Water surface elevation at both Rainsville Road and the Payran Street Bridge is reduced sufficiently so that the 100-year peak flow would remain within the channel through all three reaches.

There would be no reduction in sedimentation from construction of the channel enlargement projects.

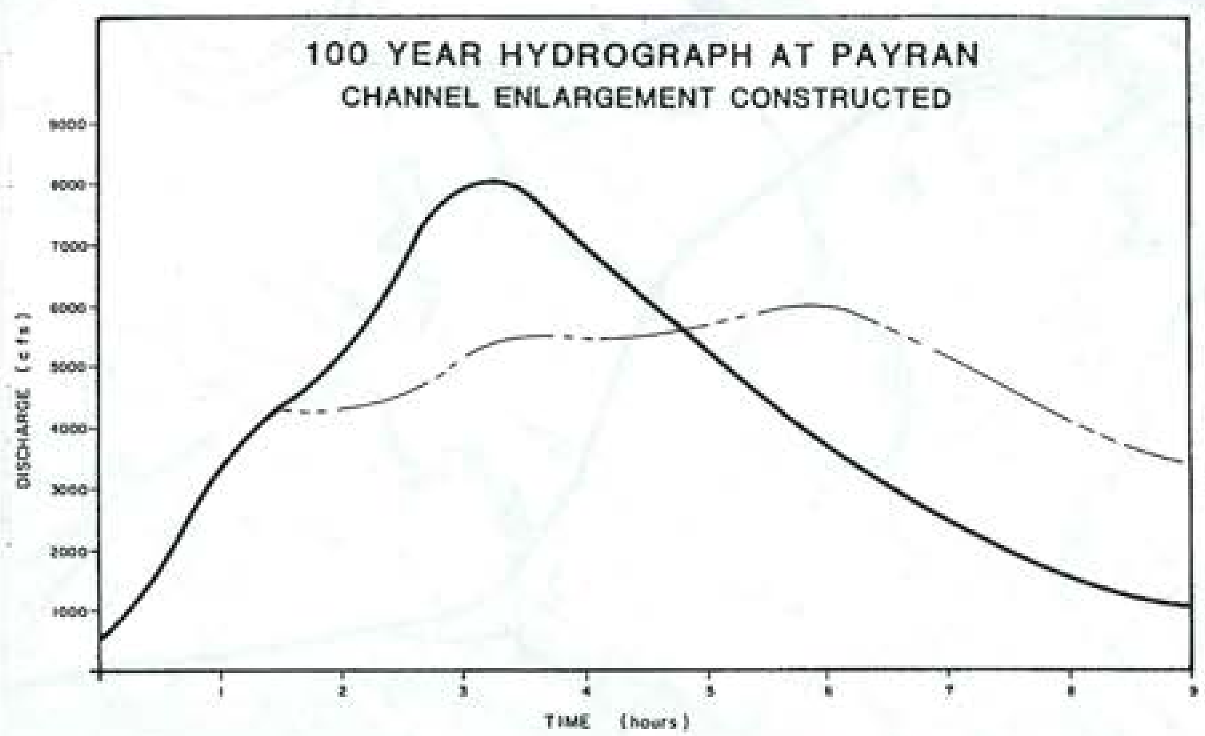


Figure 3L

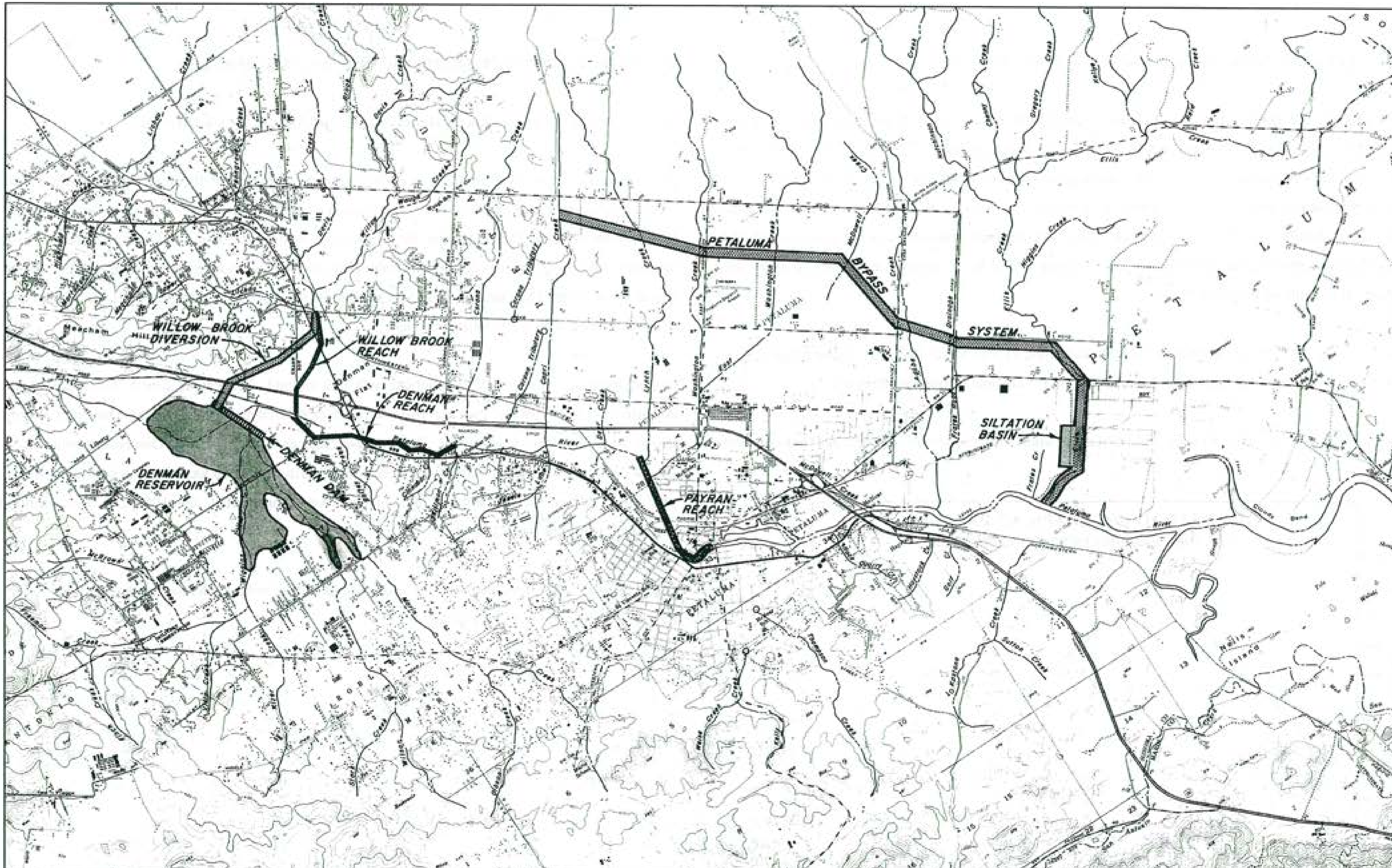
Combined Channel Enlargement with Diversion and Storage

1. Combined Payran Reach, Denman Dam and Willow Brook Diversion

This method of providing flood protection combines elements of the first two methods. There would be channel enlargement of the Payran Reach of the Petaluma River combined with storage in the Denman Dam and Reservoir and the diversion of Willow Brook to the Denman Reservoir. The upstream diversion and storage would reduce the amount of enlargement needed in the Payran Reach of the river. The Denman Dam and Willow Brook Diversion elements would be the same as when combined with the Petaluma Bypass.

Staged construction is the most practical with this method. The Payran Reach would have to be constructed first. It would provide 16-year flood protection until the Denman Dam and Willow Brook Diversion were constructed. The Denman Dam and Willow Brook Diversion could also be staged. With the dam constructed first, there would again be a flood hazard protection up to the 22-year flood. When all elements of this method were constructed, the 100-year level of flood protection would be provided.

Construction of the three elements of this method would reduce siltation in the tidal part of the Payran Reach of the river by about 25%.



NOTE:
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VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
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SCALE
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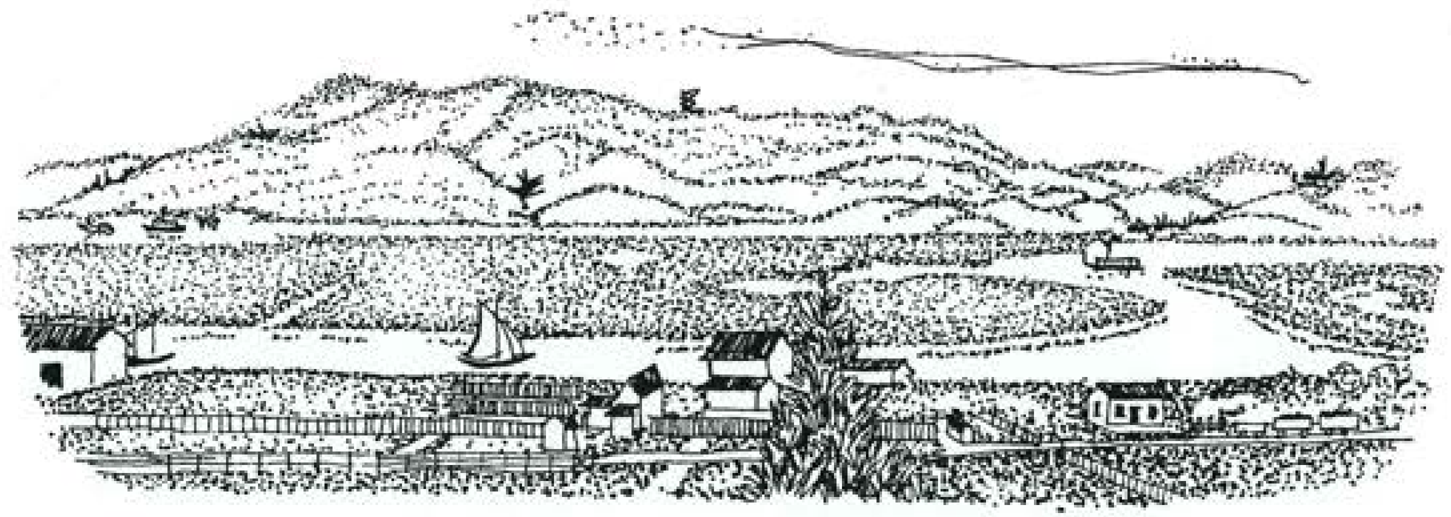
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
PETALUMA RIVER 1986
FLOOD MITIGATION ALTERNATIVES

MAP NO. 3M
JOB NO. 02284301



SECTION 4
TRIBUTARY CREEKS AND URBAN DRAINAGE SYSTEMS

TRIBUTARY CREEKS AND URBAN DRAINAGE SYSTEMS

Scope of Study

Over the past 50 years, the Sonoma County Water Agency has performed various studies of the adequacy of many of the tributary creeks and urban drainage systems within the Petaluma River Watershed. These studies were primarily focused on developing flood control and drainage projects in response to public petition or City request to solve flooding problems within the developed areas of the watershed. The scope of these previous studies was not broad enough to provide a complete general drainage plan for all of the tributary creeks and urban drainage systems within the area covered by this report.

The scope of the original 1986 study and the 2003 update was broadened to cover both developed and undeveloped areas of the watershed where flooding occurs, even though such flooding may not now cause damage to structures and improvements. It is the intent that this Master Plan be used not only to identify presently developed areas where drainage improvements are needed, but also to indicate areas where known flood hazard exists and where drainage improvements should be constructed when development occurs.

The reader is cautioned that the drainage improvement concepts identified in this report are based on the general survey and topographic information currently available. The exact sizing and location of required drainage facilities must be based on specific field survey and topographic information available at the time of construction.

Problem Identification

Floodwater flows in well-defined ravines and channels in the upper hilly part of the watershed with no chance of escaping from the stream. As the waterway emerges from the hills, the stream channel often becomes smaller and smaller as the land becomes flatter and the amount of water to be carried becomes greater. This condition increases the risk of flooding over the banks of the stream before it reaches a constructed waterway downstream. Once the floodwater leaves the natural stream, it may flow over land as sheet flow until it returns to its channel or becomes lost and enters an entirely different stream.

As urbanization or other intensification of land use creeps across the flat land toward the hills, there is danger from such lost water. Correction of waterway inadequacies must, therefore, extend upstream to a point where the natural waterway contains and controls all the floodwater. For that reason, the user of this report may see drainage systems extended upstream through open space lands and agricultural areas to the point where all the floodwater can be contained and carried safely downstream. This provides a level of protection often overlooked when lands are evaluated for flood hazard.

Street and property flooding are typical problems in the urban areas. Some structure flooding and damage also occurs in the tributary watersheds. Such problems are typically site specific and are usually caused by incorrect lot and road grading or other poor drainage construction practices on the site or on adjacent properties and roadways. The specific cause of these problems is often difficult to identify as the topographic or structural changes that create the problem are relatively small and will not normally be recorded by area-wide aerial photography and topography.

For preparation of both the 1986 Master Plan and the 2003 Update, existing drainage system size, location and elevation were identified by field inspection and measurement, by aerial topography, and from as-built construction plans. The existing drainage systems were then analyzed to determine their capacity for carrying floodwater with the adjacent watershed developed to the densities shown in the applicable General Plan. If the system could not carry the design flood, alternate ways of improving the carrying capacity of the drainage system were investigated.

Structural Solutions

1986 Master Plan

Several means were identified to increase drainage system capacity, such as replacement or enlargement of the existing system, diversion of flood flows and construction of parallel facilities to augment existing systems.

Most small inadequate drainageway problems can be corrected by installing underground storm drains. Correction of such problems can also be accomplished by excavating a larger ditch or channel. Generally, such excavation will destroy any natural values of the small waterway. It will also require the purchase of right-of-way and it must closely follow the path of the natural stream.

Using an underground pipe allows -

(1) Leaving the natural waterway mostly undisturbed;
(2) Use of less right-of-way;
(3) Avoidance of land severance by aligning the right-of-way with existing property lines; and
(4) Elimination of the high maintenance cost of open channels.

Underground conduits and open channel improvements proposed in areas not designated for urban types of land use in the General Plan are shown to indicate the type of drainage facility needed if the community finds that flooding in the non-urban area is found to be intolerable.

In many cases, it is anticipated that the existing or future flooding problems in such areas can be tolerated by avoiding the flooded areas or by only installing corrective facilities at roads or other severely affected areas. The designation of an underground conduit in such areas should not be construed as an indication of future more intense land use. It is only an indication to the user of this report of one way of correcting drainage problems that would be effective and easy to maintain in the future.

The identified flood control facilities would provide a solution for most of the problems in the tributary watersheds. There would be some remaining site-specific problems that would need the attention of the individual property owner. In general, the identified facilities have been extended upstream to a point where runoff can be captured and directed into the drainage system. Some drainage system extension beyond that shown could be required if lands within the upper watershed develop.

2003 Master Plan Update

Current environmental regulations and a new Agency approach to flood control management discourages the filling and installation of underground storm drains in creeks and drainages. Under CEQA, construction within a natural waterway poses significant and often immitigable environmental impacts. Additionally, the Department of Fish and Game opposes such projects for reasons including:

- Loss of riparian and aquatic habitat
- Loss of access to water for wildlife
- Loss of wildlife corridors
- Loss of local biotic diversity

For the 2003 Master Plan Update, a new approach to flood control management was undertaken and the need for flood protection improvements were reevaluated and based on the following criteria. Waterways within the city limits were considered undersized if design flows escaped the banks and/or the 100-year storm caused flooding of structures or improvements.

Waterways in low-density areas of the County and in City parks and golf courses were considered undersized if design flows escaped the designated natural riparian area and/or the 100-year storm caused flooding of structures or improvements. With the goal of maintaining the natural qualities of drainages and creeks while reducing the risk of flood damage to manmade improvements, the Agency considered the following improvement alternatives for undersized waterways:

- Creek Bypass
- Detention Basins
- Creek Widening with Revegetation
- No Project

Table 4-1 shows the flood problems identified and the proposed solutions from the 1986 Master Plan and the 2003 Master Plan Update.

Table 4-1 Flood Problems and Project Alternatives

Flood Problem	Recommended Projects in 1986 Report	Recommended Projects in 2003 Update
Creeks undersized for design flows	Widen or channelize Creek	Bypass peak flows in parallel storm drain.
		Design upstream detention basin to reduce peak flows to existing creek capacity.
		Widen and revegetate creek if little or no habitat value exists.
	Route creek through storm drain	In upper reaches, consider no improvements.
Storm drains undersized for design flows	Upsize storm drain or install new parallel storm drain	Upsize storm drain or install new parallel storm drain
Roadside ditches undersized for design flows	Install new storm drain	Install new storm drain

The project alternatives are described below.

Creek Bypass Alternative Design

Creek bypass projects were designed to divert flood flows in excess of a creek's capacity around the undersized reach in a storm drain pipe or box culvert.

The flow rates used for design were those developed in the 1986 hydrology study as shown on the maps of Section 4. Agency creek models in HEC-2 were used to evaluate the existing creek's capacity. Field investigations were conducted at each site to verify culvert dimensions at road crossings, verify that model cross-sections and Manning's roughness factors were representative of existing conditions, and identify potential alignments for a buried bypass culvert.

A creek's capacity was determined by incrementally removing flows from the hydraulic model of the undersized segments until Agency design criteria for open channels was met. The removed quantity of flow was subsequently modeled in a box or circular culvert located in an adjacent road or right-of-way. The size of the bypass culvert was determined by the flow, the slope between the diversion and the combination point and a minimum one-foot depth of cover. Bypass alignments were located in roads where possible and avoided existing riparian areas.

Detention Basin Alternative Design

Detention basins were considered a solution for long reaches of natural undersized creeks where suitable upgradient open land was available. Detention basins were selected to provide flood protection for the immediate watershed and did not consider impacts to downstream watersheds on the Petaluma River.

The suitability of land for a detention basin was evaluated by reviewing the land use designations of the upstream area. Viable areas for detention included existing or proposed parks, large recreation areas, soccer and football fields, and large privately owned parcels.

Detention basin projects were developed to detain flood flows in excess of downstream creek capacity. An undersized creek's capacity was determined by incrementally removing flows from the Agency's creek hydraulic model until Agency design criteria for open channels was met. The quantity of flow in excess of capacity was detained.

Field investigations were conducted to confirm that undeveloped land was available for detention and that the terrain was conducive to construction of a basin.

The Modified Rational Method was used to estimate the storage requirements for the detention basin. A hydrograph was estimated based upon the design storm (per Agency design criteria), time of concentration, maximum time of duration (24 hours), rainfall intensity, watershed roughness coefficient and watershed area. Most of these values were available from the Agency hydrology study. The maximum volume of detained flows was calculated using Haestad Methods' Pond-Pack modeling programs.

Assumptions for detention basin design included a minimum of one foot freeboard, 2:1 internal side slopes, and 3:1 external side slopes. The required land area consists of the detention basin area and a minimum 20-foot offset for a buffer zone and access road.

As discussed in Section 3, detention basins often have a positive impact on flooding in the immediate watershed but can exacerbate flooding in downstream watersheds. The hydraulic effects of the proposed detention basin projects in Section 4 were evaluated in the tributary only. Until a regional hydraulic analysis of all contributing watersheds is conducted for the Petaluma River, the proposed detention basins for Lichau Creek and Willow Brook Creek should be considered preliminary.

Creek Widening and Revegetation

For environmentally degraded drainages and creeks, such as in over-grazed pasturelands or eroded swales or ravines where little or no habitat value exists, creek widening and revegetation was considered a project alternative.

In most cases, Agency hydraulic models did not exist for these areas. Field investigations were conducted at all sites identified for creek widening. Typical cross-sections were measured and Manning's roughness factors were estimated. Distances to manmade improvements needing flood protection were taken.

Using the flow rates from the 1986 hydrology study as shown on the maps in Section 4 and slopes measured from the topography, widened channel sections were designed using Manning's equation and Agency design criteria for open channels. One and a half feet of freeboard was provided for the design storm and the water surface must be below top of banks for the 100-year storm event.

The typical approach for channel widening was to maintain the existing flow line and one side of the existing natural bank. The other bank was widened to provide a flat bench approximately 0.5 – 2 feet above the flow line of the existing channel. The new banks were provided a 2:1 slope. The Manning's roughness factor used for the remaining natural channel was that estimated during the field investigations. Widened portions of the creek were given a Manning's roughness factor of 0.60 to account for revegetated banks and benches.

No Improvement Alternative

The no improvement alternative was considered in low-density land use areas as summarized in Table 4-1. If Agency hydraulic models exist for the reach, the floodwater surface elevation and the extent of flooding in terms of area of land was estimated.

Impact on Petaluma River Flooding

Each of the projects presented in this section would in most cases have little individual impact on flood flows in the Petaluma River. The exceptions to this are the proposed detention basins on Lichau Creek and Willow Brook Creek. Cumulatively, construction of projects upstream of Corona Creek could add significantly to peak flows from the upper watersheds. On the other hand, projects downstream of Corona Creek could prove of benefit in that they would allow runoff to drain more rapidly to the Petaluma River. As discussed in Section 3, this flow would then enter the river and be on its way downstream before peak flows from the other watersheds arrived.

A regional flood management plan for the Petaluma River would evaluate the cumulative impacts to peak flows and flooding on the Petaluma River.

Organization of Section

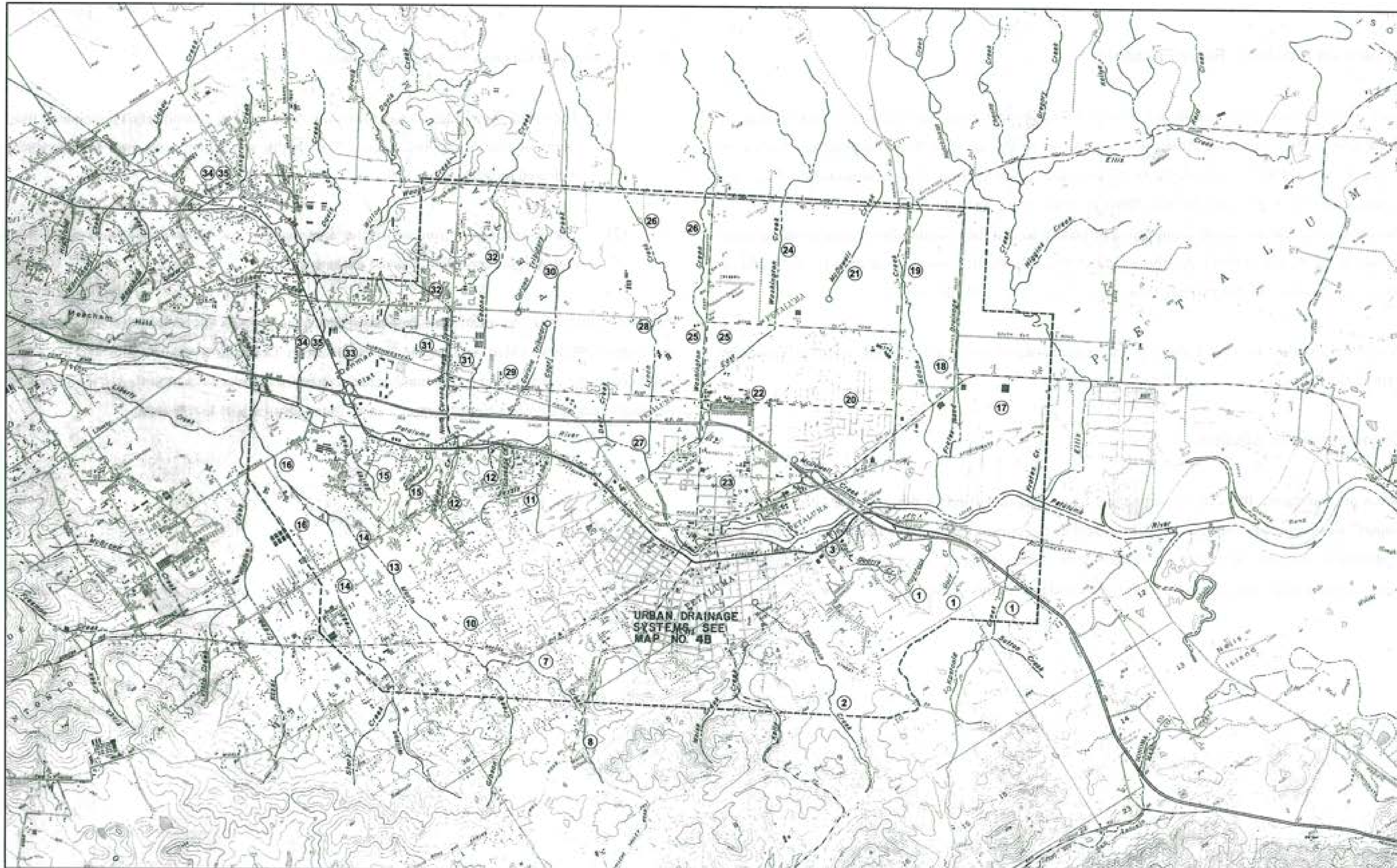
When an inadequate tributary or drainage system was identified in this study, a "Project Needs Report" was prepared. The report briefly describes the project location, the identified problem, and a structural solution, including estimated costs. These Project Needs Reports, together with accompanying maps and drawings, comprise the balance of this section.

The "Q's" shown on the maps indicate the following:

(1) The upper figure indicates the flow (in cubic feet per second [cfs]) anticipated from a storm of the designated frequency with the watershed developed to the densities indicated in the General Plan;

(2) The lower figure represents the anticipated flow after taking into account any indicated diversions into or out of the system.

For ease of reference, the location of each of the proposed projects has been indicated by number on the Index to Creeks (Map 4A) or the Index to Urban Drainage Systems (Map 4B). The index numbers on these maps refer to the number of the map for each individual project. These maps, and the accompanying Project Needs Report, can be found sequentially in this section.



LEGEND

ⓧ = MAP NUMBER

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SCALE
0 4,000' 8,000'
1" = 4,000'

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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

INDEX TO CREEKS

MAP NO.
4A
JOB NO. 03054001

LEGEND

ⓧ = MAP NUMBER

NOTE:
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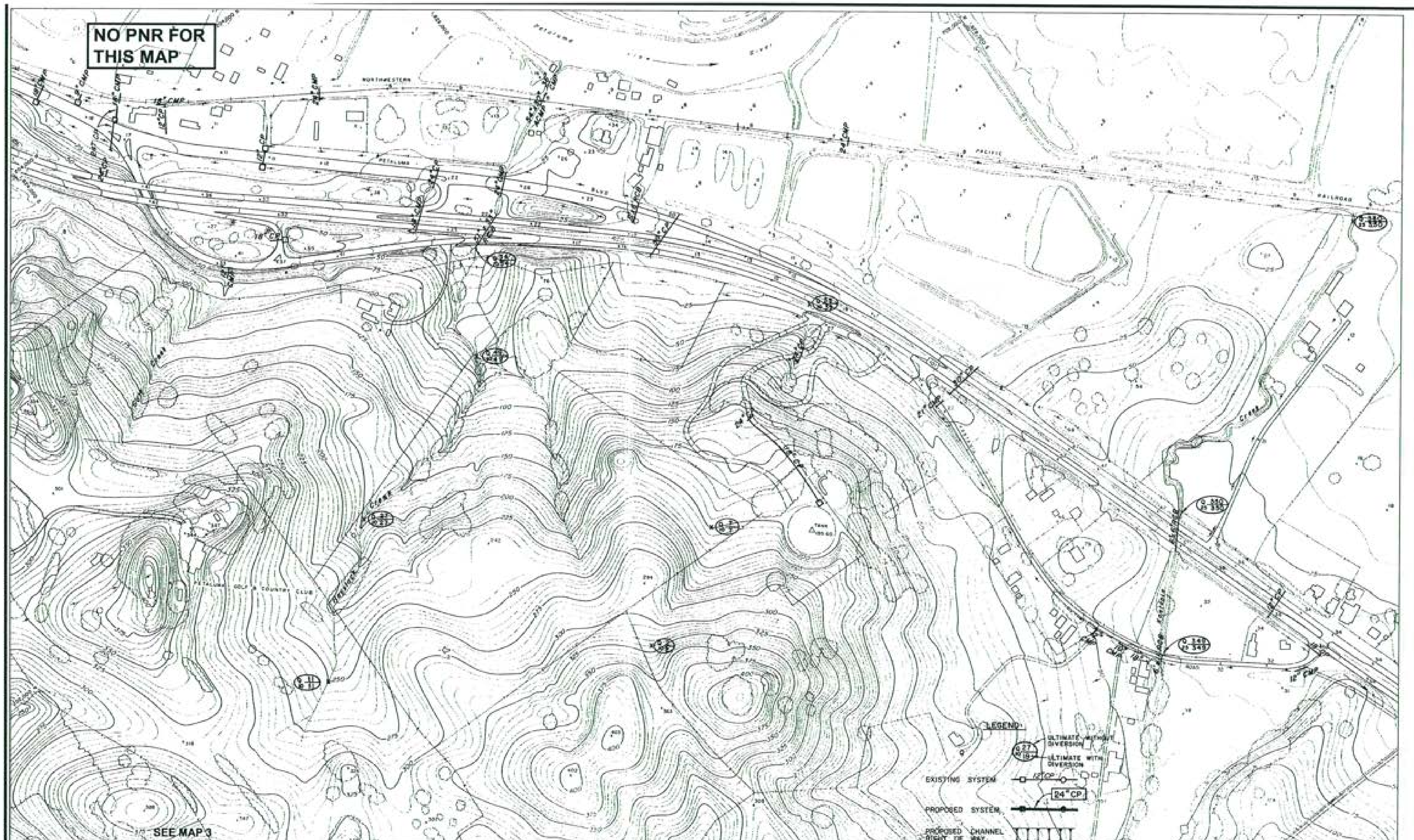
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

INDEX TO URBAN DRAINAGE SYSTEMS

MAP NO.
4B
JOB NO. 02224301



SUBDIVISION BOUNDARY - - - - - -

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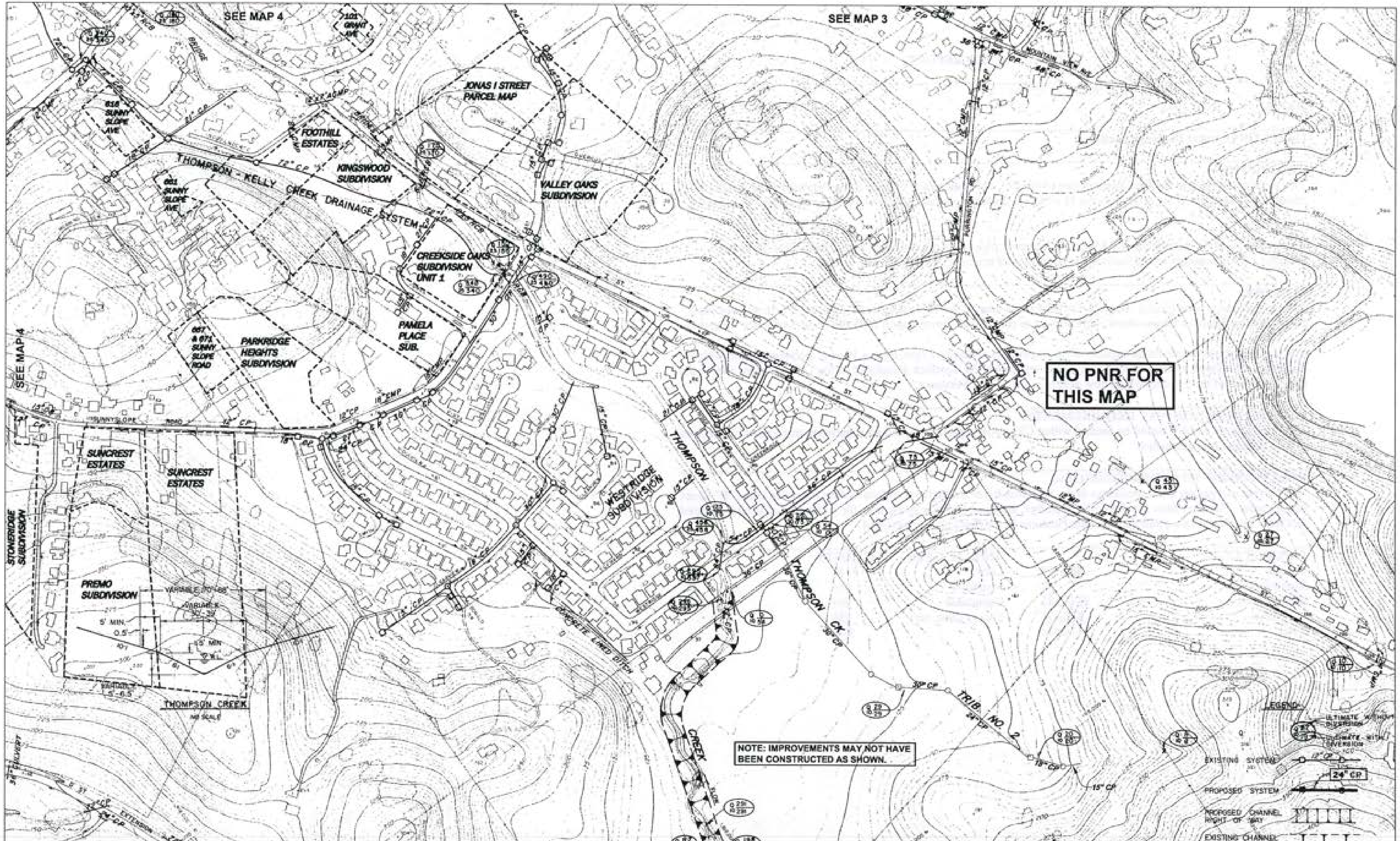
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
KASTANIA, GOLF AND HAYSTACK CREEKS

MAP NO.
1
JOB NO. 02224301



SUBDIVISION BOUNDARY - - - - - -

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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

THOMPSON CREEK & TRIBUTARY NO. 2 DRAINAGE SYSTEM

MAP NO. 2

PROJECT NEEDS REPORT

TITLE: **"E" STREET DRAINAGE SYSTEM**
DATE: **June 2003**

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located in the southwestern part of the City of Petaluma and extends along Petaluma Blvd. South, "E" Street and First Street to the existing outlet of a 14-foot diameter pipe into the Petaluma River (See Map 4 on page 4-15).

The project involves installation of 1,840 feet of concrete pipe storm drain ranging in size from 15 to 30-inch diameter. Appurtenances would include a headwall outlet structure, 4 manholes and 12 inlets.

PURPOSE:
The only existing underground drainage facility in this area is the 12-inch concrete pipe in "E" Street between 2nd Street and the Petaluma River, which is insufficient to collect and convey runoff from the 13-acre tributary watershed.

The completed project would be capable of conveying the anticipated flow from a 10-year frequency storm with the watershed developed to the Service Commercial and Industrial densities designated in the General Plan, and would alleviate much of the flooding which now occurs in this area of Petaluma.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
The underground conduit would be located within City street right-of-way and no acquisition of rights-of-way across private properties is anticipated.

RELATIONSHIP TO OTHER PROJECTS:
The 10-year and greater flood elevations in the Petaluma River are higher than land surface elevation in the "E" Street project area. Flooding from the river will, therefore, continue to occur in the area for a distance of several hundred feet from the river until a project to alleviate Petaluma River flooding is constructed.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$88,596	Labor	$197
Right-of-Way	0.	Materials	$16
Construction	$354,385	Equipment	$61
Inspection	$35,439	Energy (elec, etc)	$50
Total	$478,420		$324

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PROJECT NEEDS REPORT

TITLE: "H" STREET DRAINAGE SYSTEM
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located along Fifth, Sixth, and "H" Streets in the southwest portion of the City of Petaluma and would connect to an existing 30-inch storm drain, which is part of an adequate system extending to the Petaluma River (See Map 4 on page 4-15).

The project consists of the installation of approximately 2,500 lineal feet of concrete pipe storm drain, ranging in size from 15 to 30-inch diameter. Appurtenances include 3 manholes and 12 inlets.

PURPOSE:
No storm drain currently exists within this residential area of Petaluma. The streets are inadequate to handle flows from a 10-year frequency storm. The proposed conduits would be capable of conveying the runoff anticipated from such a storm with the 71-acre watershed developed to the various Urban Residential densities designated in the General Plan, thereby alleviating the frequent flooding which now occurs.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
The underground conduit would be located within City street right-of-way and no acquisition of rights-of-way across private properties is anticipated.

RELATIONSHIP TO OTHER PROJECTS:
This project constitutes the second phase of the Agency's "H" Street Conduit project. The first phase, from Fifth Street to the Petaluma River, was constructed in 1983. An Initial Study of Environmental Impact and Negative Declaration for the total project was prepared by the Agency in January 1983 and a Notice of Determination under the California Environmental Quality Act was filed on March 1, 1983 for both phases of the project.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$123,473	Labor	$290
Right-of-Way	0.	Materials	$24
Construction	$493,892	Equipment	$89
Inspection	$49,389	Energy (elec, etc)	$64
Total	$666,754		$467

PROJECT NEEDS REPORT

TITLE: THOMPSON CREEK TRIBUTARY 5 DRAINAGE SYSTEM
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located on the west side of the City of Petaluma and extends along "D", Fourth, and "F" Streets from Sixth Street northerly to an existing 14-foot diameter arch pipe on the northerly side of Petaluma Blvd. South (See Map 4 on page 4-15).

The project consists of the installation of approximately 2,890 lineal feet of concrete pipe storm drain, ranging in size from 12 to 42-inch diameter. Appurtenances include 7 manholes and 12 inlets.

PURPOSE:
There is no underground drainage system in "D" Street within the project area, and existing storm drains in Fourth and "F" Streets are not of adequate size to contain flows from a 10-year frequency storm, causing frequent flooding in this residential area of Petaluma.

The completed project will be capable of conveying the anticipated flow from a 10-year frequency storm with the 54-acre watershed developed to the Urban Residential and Service Commercial densities designated in the General Plan, and will alleviate flooding by carrying the runoff directly to the existing 14-foot diameter pipe which outlets into the Petaluma River.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
The proposed project would be located within existing street right-of-way and no acquisition of rights-of-way across private properties is anticipated.

RELATIONSHIP TO OTHER PROJECTS:
Some existing facilities will be utilized in the proposed system, which connects to an existing adequate 14-foot diameter concrete pipe that discharges into the Petaluma River. This 14-foot diameter arch pipe was constructed in 1937 to carry the lower reach of Thompson Creek.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$165,768	Labor	$399
Right-of-Way	0.	Materials	$32
Construction	$663,073	Equipment	$123
Inspection	$66,307	Energy (elec, etc)	$109
Total	$895,149		$664

SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 3
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
'E', AND 'H' STREETS AND THOMPSON CREEK TRIBUTARY NO. 5 DRAINAGE SYSTEMS

MAP NO. 4
JOB NO. 02234301

TITLE: **"B" STREET DRAINAGE SYSTEM**
DATE: **June 2003**

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located on the west side of the City of Petaluma and extends from the Petaluma River southerly along "B" Street to Post, and then within Post and Bassett Streets to Tenth Street (See Map 5 on page 4-17). Branch conduits from Douglas, Bassett, Fair and English Streets and from LA Cresta and Haven Drives, and the vicinity of Petaluma High School would connect to the storm drain system in Post and "B" Streets.

The project involves installation of 9,160 lineal feet of concrete pipe storm drain ranging in size from 15 to 54-inch diameter. Appurtenances would include 17 manholes, 40 inlets and a concrete headwall outlet at the river's edge.

PURPOSE:
The capacity of the existing 60-inch storm drain within Post and "B" Streets has been impaired by the installation of a 12-inch diameter ACP in the invert. This system must, therefore, be augmented by the installation of a parallel pipe ranging from 36 – 54-inch in diameter.

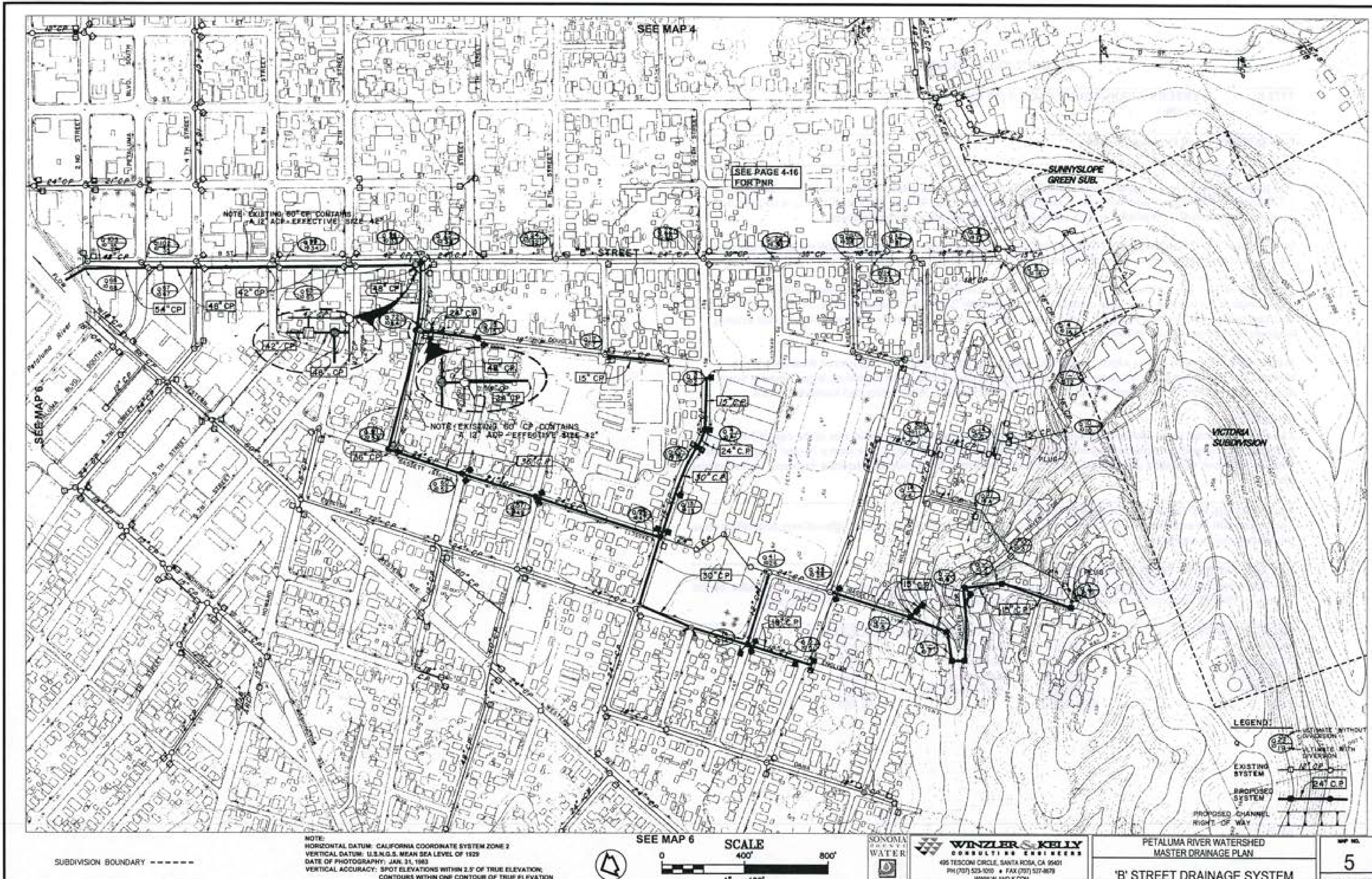
In the upper watershed, some of the existing underground storm drains pass between or even under houses. In those instances where it will be infeasible or impossible to follow the existing alignment, the drainage system has been rerouted.

The completed project will alleviate flooding by providing an enlarged and extended system capable of conveying the anticipated flow from a 10-year frequency storm with the 208-acre watershed developed to various Commercial, Residential and Industrial densities indicated in the general plan.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
Most improvements would be located within Petaluma City street right-of-way. A 15-foot wide permanent drainage right-of-way will be required from 2nd Street to the outlet at the Petaluma River.

RELATIONSHIP TO OTHER PROJECTS:
The various elements of this project would modify, enlarge and extend existing underground storm drains within this urban residential section of the City of Petaluma and connect them into an integrated drainage system outletting into the Petaluma River.

PROJECT COST		**ANNUAL OPERATING COSTS**	
Design	$588,340	Labor	$1,488
Right-of-Way	$1,500	Materials	$121
Construction	$2,353,359	Equipment	$459
Inspection	$235,336	Energy (elec, etc)	$396
Total	$3,178,535		$2,464


SEE MAP 4
SEE PAGE 4-16 FOR PNR
SUNNYSLOPE GREEN SUB.
VICTORIA SUBDIVISION
'B' STREET
NOTE: EXISTING 60" CP CONTAINS A 12" ACP - EFFECTIVE SIZE 42"
SEE MAP 6
LEGEND:
EXISTING SYSTEM
PROPOSED SYSTEM
PROPOSED CHANNEL RIGHT OF WAY
SUBDIVISION BOUNDARY
NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION
SCALE
0 400' 800'
1" = 400'
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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
'B' STREET DRAINAGE SYSTEM
MAP NO. 5
JOB NO. 02224301

PROJECT NEEDS REPORT

TITLE: WESTERN AVENUE DRAINAGE SYSTEM
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located in the westerly portion of the City of Petaluma and consists of the installation of approximately 7,720 lineal feet of concrete pipe storm drain ranging in size from 12 to 42-inch diameter (See Map 6 on page 4-19). Appurtenances include 17 manholes and 25 inlets. Included in this project are the following:

Installation of 24 – 36-inch conduit in Bodega Avenue from Baker Street to Bantam Way will replace the existing unconnected series of driveway culverts and will carry runoff to the existing adequate 48" storm drain in Baker Street.

Installation of 18 – 42-inch diameter storm drain in Western Avenue westerly from Baker Street will include replacement of the existing inadequate conduits in North Webster Street and Western Avenue, extension of the system upstream to the vicinity of the Petaluma Junior High School, and connection at the downstream end to the existing adequate 60-inch storm drain in Baker Street.

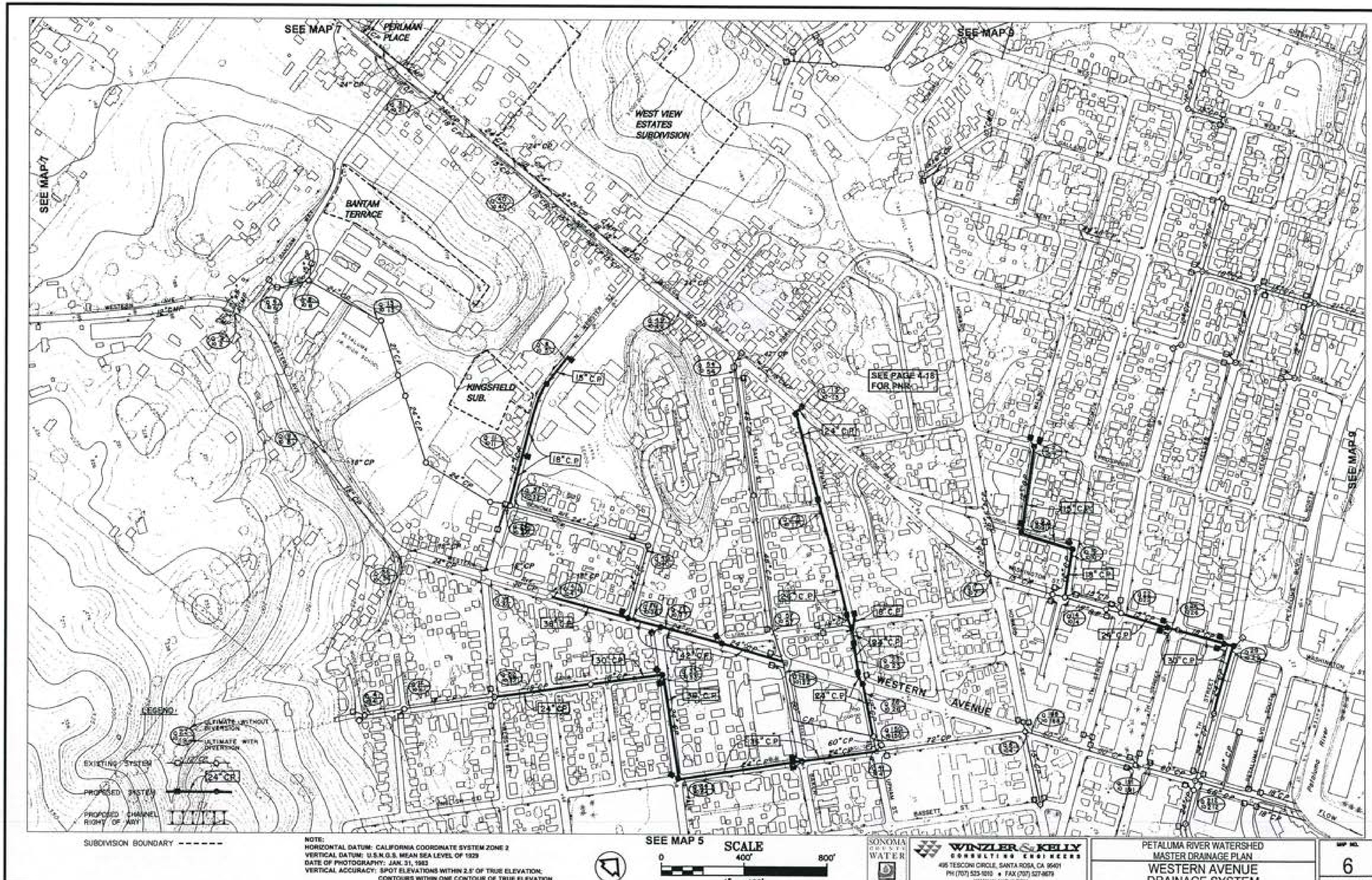
Inadequately sized storm drains within Dana, Fair, English and Upham (between English and Western) will be replaced and the system extended along Upham to Bodega Avenue. In the lower watershed, larger capacity storm drains will be installed within short reaches of Walnut, Union, Keokuk, Washington, and Kentucky Streets.

PURPOSE:
The completed project will alleviate flooding in this urban residential and commercial area of the city of Petaluma by providing an enlarged and extended system capable of conveying the anticipated flow form a 10-year frequency storm with the 434-acre watershed developed to the various commercial and residential densities indicated in the general plan.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
The project will be constructed within the City of Petaluma street right-of-way and no rights-of-way acquisition from private property is anticipated.

RELATIONSHIP TO OTHER PROJECTS:
The lower portion of the Western Avenue storm drain outletting into the Petaluma River was constructed by the Agency in 1968/69 and provides adequate outlet for the proposed enlarged and extended drainage system.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$455,297	Labor	$1,121
Right-of-Way	0	Materials	$90
Construction	$1,821,187	Equipment	$346
Inspection	$182,664	Energy (elec, etc)	$323
Total	$2,458,602		$1,880


SEE MAP 7
PERLMAN PLACE
SEE MAP 9
WEST VIEW ESTATES SUBDIVISION
SEE MAP 7
BANTAM TERRACE
KINGSFIELD SUB.
SEE PAGE 4-18 FOR PNR
SEE MAP 9
WESTERN AVENUE
LEGEND
ULTIMATE WITHOUT DIVERSION
ULTIMATE WITH DIVERSION
EXISTING SYSTEM
PROPOSED SYSTEM
PROPOSED CHANNEL RIGHT OF WAY
SUBDIVISION BOUNDARY
NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION
SEE MAP 5
SCALE
0
400'
800'
1" = 400'
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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
WESTERN AVENUE
DRAINAGE SYSTEM
MAP NO.
6
JOB NO. 02224301

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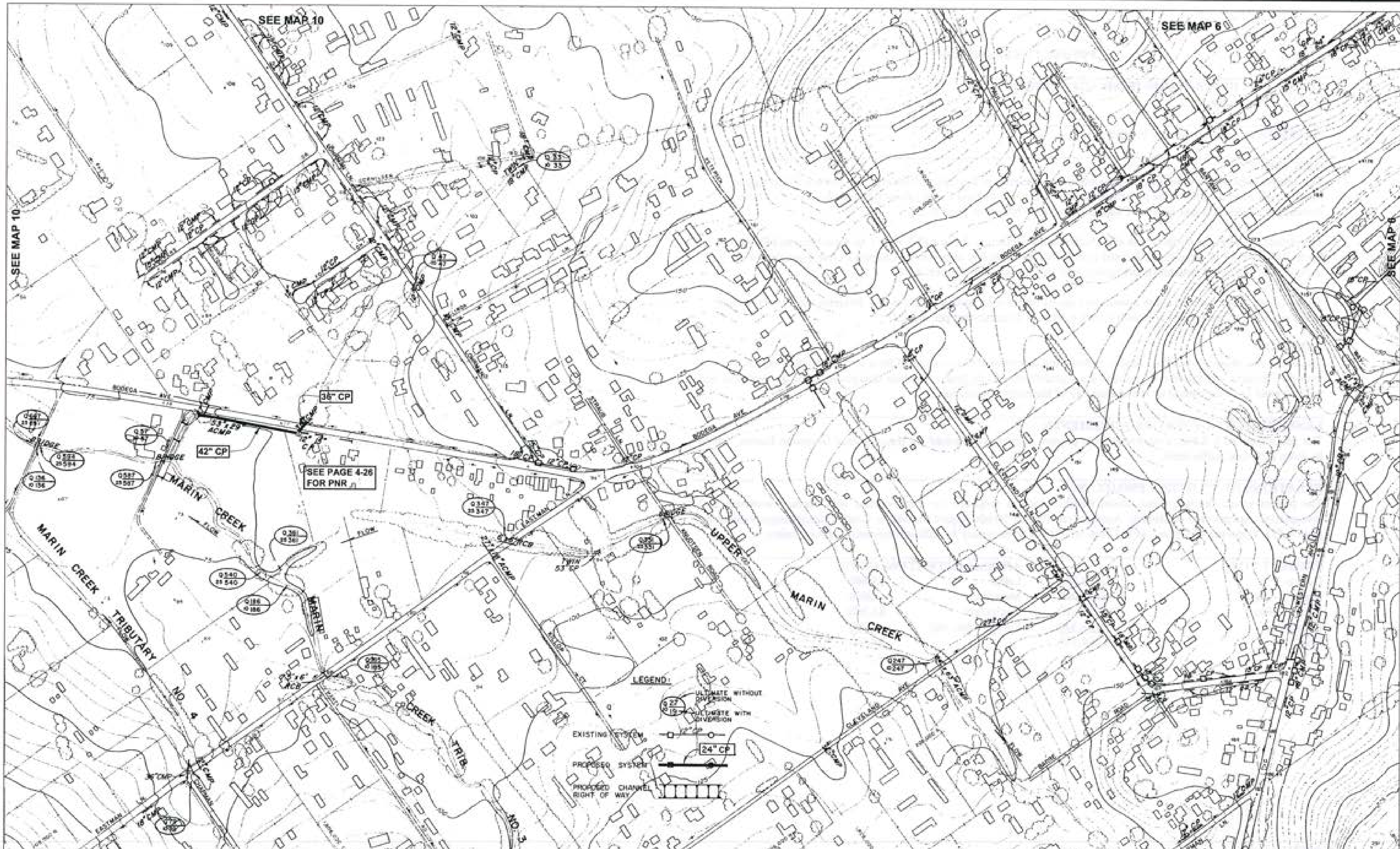

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION;
CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

MARIN CREEK & TRIBUTARIES
NO. 3 & 4 DRAINAGE SYSTEM

MAP NO.
7

JOB NO. 02224301

PROJECT NEEDS REPORT

TITLE: **UPPER MARIN DRAINAGE SYSTEM**
DATE: **June 2003**

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located within the unincorporated area westerly of the City of Petaluma and extends along Upper Marin Creek from the end of the proposed modified channel of Marin Creek (about 650 feet south west of Bodega Avenue) to a point 125 feet north of Chapman Lane (See Map 8 on page 4-23).

The project involves the construction and installation of Detention Basin 1 (5.7 Acre / 16 Acre-Feet) and Detention Basin 2 (4.1 Acre / 12 Acre-Feet), located approximately 2,000 feet upstream of Chapman Lane. Appurtenances include inlet and outlet structures, emergency overflow structure and access road.

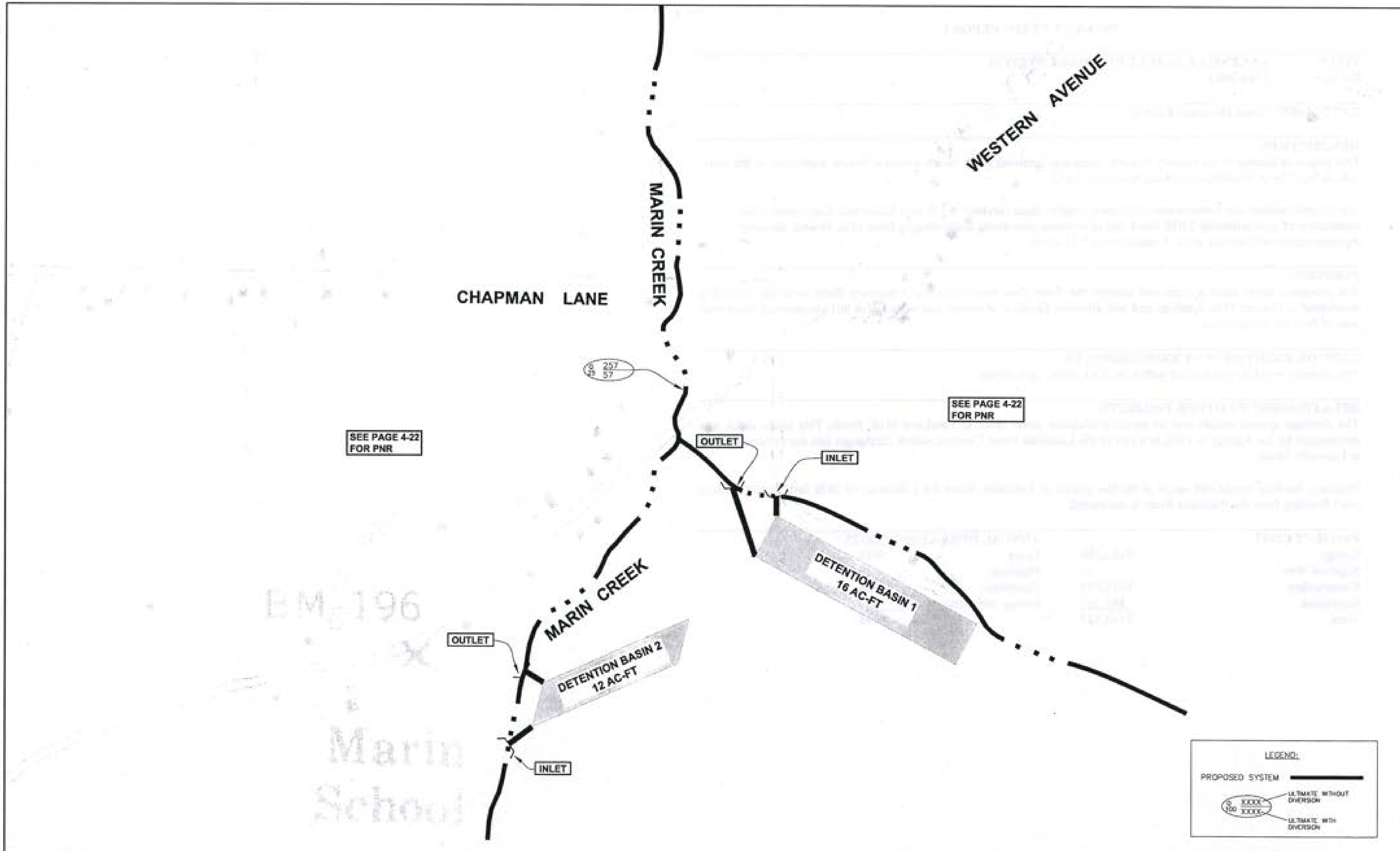
The proposed project would allow unmodified use of the existing natural waterway by detaining the 25-year design storm upstream of the project area with a peak release of 57 cubic-feet per second.

PURPOSE:
The completed project would be capable of detaining a portion of the anticipated flow from a 25-year frequency storm with the 786-acre watershed developed to the Agricultural / Open Space densities designated in the general plan and will alleviate flooding caused by the inadequacy of the existing waterway.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
The acquisition of a 9.8-acre easement from private property is required for the proposed Detention Basins, which includes a 20-foot buffer zone.

RELATIONSHIP TO OTHER PROJECTS:
The project would discharge into Marin Creek, which is proposed for improvement with channel widening and revegetation downstream of Bodega Avenue (see Project Needs Report for Marin Creek Channel improvement on page 4-32). Widening of Upper Marin Creek would not be necessary for efficient operation of this project.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$328,582	Labor	$3,840
Right-of-Way	$490,000	Materials	$600
Construction	$1,314,329	Equipment	$1,200
Inspection	$131,433	Energy (elec, etc)	$200
Total	$2,264,345		$5,840



NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
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SCALE
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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

UPPER MARIN CREEK

MAP NO. 8

JOB NO. 02224301

PROJECT NEEDS REPORT

TITLE: **LAKEVILLE STREET DRAINAGE SYSTEM**
DATE: **June 2003**

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located in the vicinity of Kent Street and Petaluma Blvd. North within a 74-acre watershed on the west side on the City of Petaluma (See Map 9 on page 4-25).

The project involves the replacement of existing smaller-sized conduits in Liberty, Keller and Kent streets with installation of approximately 2,030 lineal feet of concrete pipe storm drain ranging from 12 to 36-inch diameter. Appurtenances will include about 5 manholes and 11 inlets.

PURPOSE:
The proposed storm drain system will convey the flood flow from a 10-year frequency flood with the watershed developed to General Plan densities and will alleviate flooding of streets and property in this commercial/residential area of the City of Petaluma.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
This project would be constructed within the City street right-of-way.

RELATIONSHIP TO OTHER PROJECTS:
The drainage system outlets into an existing adequate storm drain in Petaluma blvd. North. This storm drain was constructed by the Agency in 1982 as a part of the Lakeville Street Conduit, which discharges into the Petaluma River at Lakeville Street.

Frequent flooding would still occur at the low points on Lakeville Street for a distance of 1050 feet form the River until flooding from the Petaluma River is controlled.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$103,356	Labor	$271
Right-of-Way	0.	Materials	$22
Construction	$413,424	Equipment	$84
Inspection	$41,342	Energy (elec, etc)	$71
Total	$558,122		$448

SEE MAP 6

SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

CHERRY-MAGNOLIA & LAKEVILLE STREET DRAINAGE SYSTEMS

MAP NO. 9

TITLE: CHERRY MAGNOLIA DRAINAGE SYSTEM
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located within a 457-acre watershed on the west side of Petaluma in the vicinity of Magnolia Avenue and Cherry Street (See Maps 9 and 10 on pages 4-25 and -27). The project involves the installation of 1,030 lineal feet of concrete pipe storm drain ranging in size from 15 to 30-inch diameter, along with 2,000 lineal feet of widening and revegetation of a natural waterway near Magnolia Avenue at the upstream end of the Cherry-Magnolia Drainage (Map 10). A connection between Cherry Street and Vanessa Way to existing systems is required. Portions of the existing drainage systems from Shuman Lane and Elm Drive, Antone Way and Paula Avenue, Amber Way and Howard Street, will be enlarged or extended. Appurtenances will include 1 junction box and 3 manholes. The upstream end of the Magnolia Avenue drainage follows the existing natural waterway. Alignment in this reach can be adjusted at the time of construction as necessary to protect riparian habitat, avoid property improvements and follow property lines.

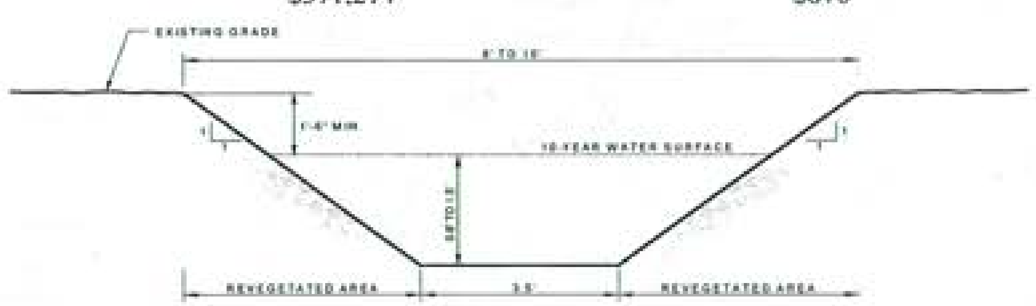
PURPOSE:
The completed project would be capable of conveying the anticipated flow from a 10-year frequency storm with the 786-acre watershed developed to the Agricultural / Open Space densities designated in the general plan and will alleviate flooding caused by the inadequacy of the existing waterway.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
Some of the storm drains would be located within the City of Petaluma street rights-of-way. Where the conduit crosses private property, a fifteen-foot wide permanent drainage right-of-way would be needed, together with an adjacent temporary 25-foot right-of-way for construction purposes. A 25-foot wide permanent drainage right-of-way would be needed for the widened channel and buffer zone/access road.

RELATIONSHIP TO OTHER PROJECTS:
The 84-inch diameter downstream portion of the Cherry-Magnolia Conduit outletting into the Petaluma River was constructed by the Agency in 1972; the 72-inch and 60-inch portions just upstream to Liberty Street were constructed by private developers, and provide adequate outlet for the proposed system.

The 42-inch diameter Magnolia Avenue Conduit from Gossage to Keokuk was constructed by the Agency in 1984.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$58,558	Labor	$602
Right-of-Way	$55,000	Materials	$41
Construction	$234,233	Equipment	$179
Inspection	$23,423	Energy (elec, etc)	$48
Total	$371,214		$870



CHERRY MAGNOLIA
NOT TO SCALE

TITLE: MARIN CREEK TRIBUTARY-5 DRAINAGE SYSTEM
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located in the unincorporated area at the westerly limits of the City of Petaluma and extends westerly across Bodega Avenue to Marin Creek (See Maps 7 and 10 on pages 4-21 and 4-27).

The project involves the installation of 50 lineal feet of 36-inch concrete pipe under Bodega Avenue, 500 lineal feet of 42-inch concrete pipe storm drain along Bodega Avenue and 250 lineal feet of bank widening and revegetation of a natural waterway from Bodega Avenue to an outlet structure at Marin Creek. Appurtenances will include a headwall outlet, winged headwall inlet and drop inlet.

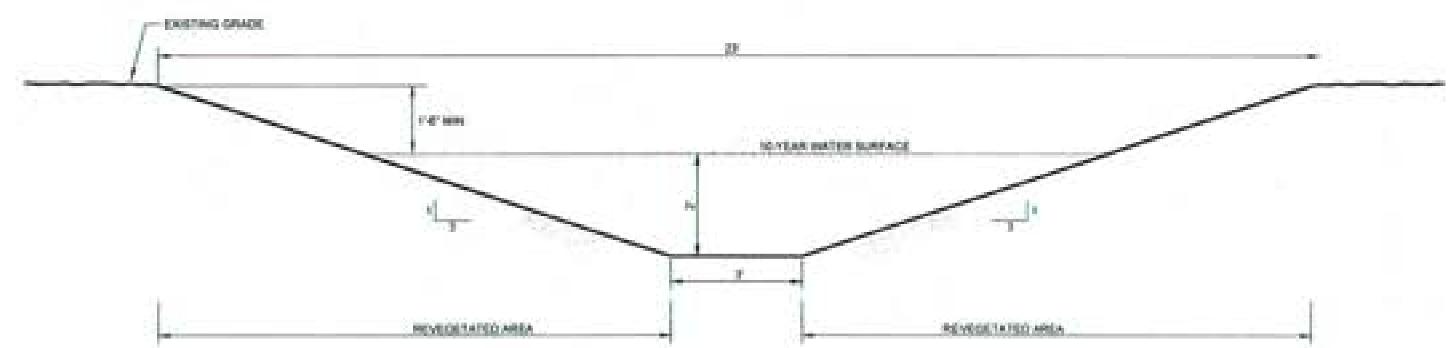
The widened section follows the path of the existing natural waterway. Alignment in this reach can be adjusted at the time of construction as necessary to protect riparian habitat, avoid property improvements and follow property lines.

PURPOSE:
The proposed project would alleviate flooding by providing a drainage system capable of conveying the runoff anticipated from a 10-year frequency storm with the 124-acre watershed developed to the Agricultural/Open Space densities indicated in the General Plan.

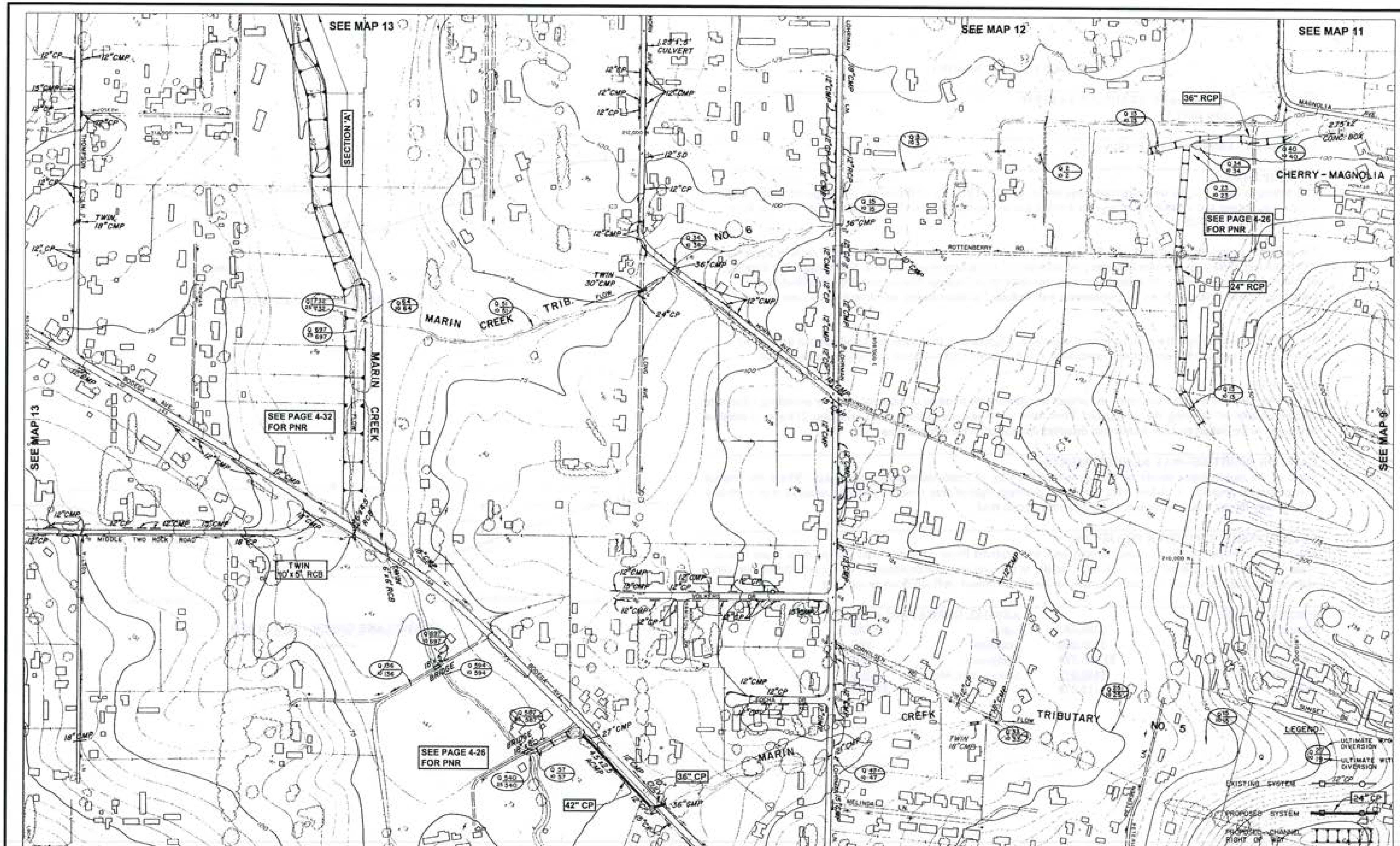
LAND OR RIGHT-OF-WAY REQUIREMENTS:
The storm drains would be located within the City of Petaluma street rights-of-way. Where the channel widening and revegetation crosses private property, a 40-foot wide permanent drainage right-of-way would be needed for the channel and buffer zone/access road.

RELATIONSHIP TO OTHER PROJECTS:
This project would discharge to Marin Creek, which is proposed for improvement as an open earth channel, however, Marin Creek has no flooding effect on this tributary and the project would function properly without the downstream channel improvements.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$40,649	Labor	$173
Right-of-Way	$10,000	Materials	$12
Construction	$162,596	Equipment	$52
Inspection	$16,260	Energy (elec, etc)	$31
Total	$229,505		$268



MARIN CREEK TRIBUTARY 5
NOT TO SCALE



SUBDIVISION BOUNDARY - - - - - -

NOTE:
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SCALE
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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
CHERRY-MAGNOLIA
MARIN CREEK & TRIBUTARY NO. 5
DRAINAGE SYSTEMS

MAP NO. 10
JOB NO. 02294301

PROJECT NEEDS REPORT

TITLE: **JESSIE LANE DRAINAGE SYSTEM**
DATE: **June 2003**

CATEGORY: Local Drainage Facility

DESCRIPTION:

This project is located in the unincorporated area northwesterly of the City of Petaluma. The proposed system begins at Gossage Avenue and extends easterly under Jessie Lane and across Petaluma Blvd. North to the Petaluma River (See Map 11 on page 4-29).

The project involves the installation of 1,500 lineal feet of 4' x 2' reinforced concrete box storm drain in Jessie Lane, 280 lineal feet of 60-inch diameter concrete pipe upstream of and across Petaluma blvd. North, and 2,050 lineal feet of widening and revegetating the natural waterway downstream of Gossage Avenue and Petaluma Blvd. North, outletting into the Petaluma River. Appurtenances will include 2 junction boxes, one drop inlet and one headwall outlet.

Most of the project follows the existing natural waterway. Alignment in this reach can be adjusted at the time of construction as necessary to protect riparian habitat, avoid property improvements and follow property lines.

PURPOSE:

At the time of future land development, the project would alleviate flooding of adjacent lands by providing a drainage system capable of carrying the anticipated flow from a 10-year frequency storm with the 214-acre watershed developed to the Suburban Low Residential densities designated in the General Plan.

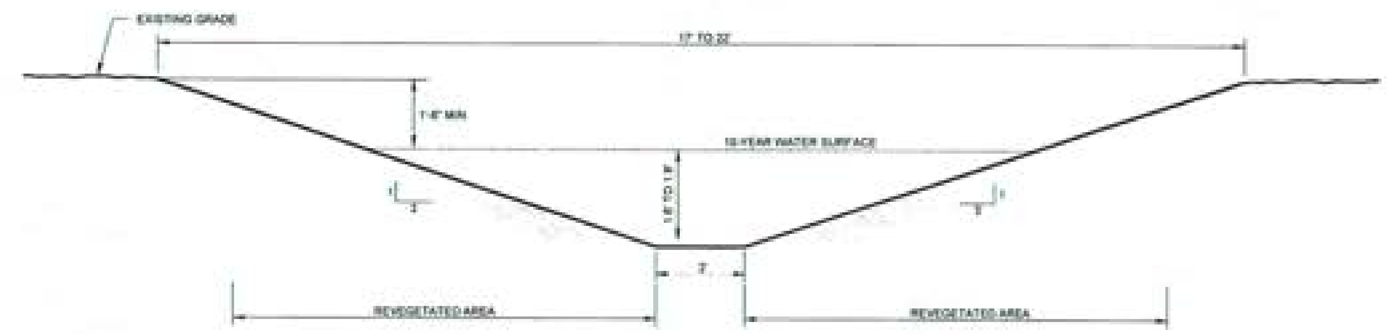
LAND OR RIGHT-OF-WAY REQUIREMENTS:

Some of the storm drains would be located within the City of Petaluma street rights-of-way. Where the conduit crosses private property, a 15-foot wide permanent drainage right-of-way would be needed, together with a 40-foot right-of-way for the widened channel and buffer zone/access road.

RELATIONSHIP TO OTHER PROJECTS:

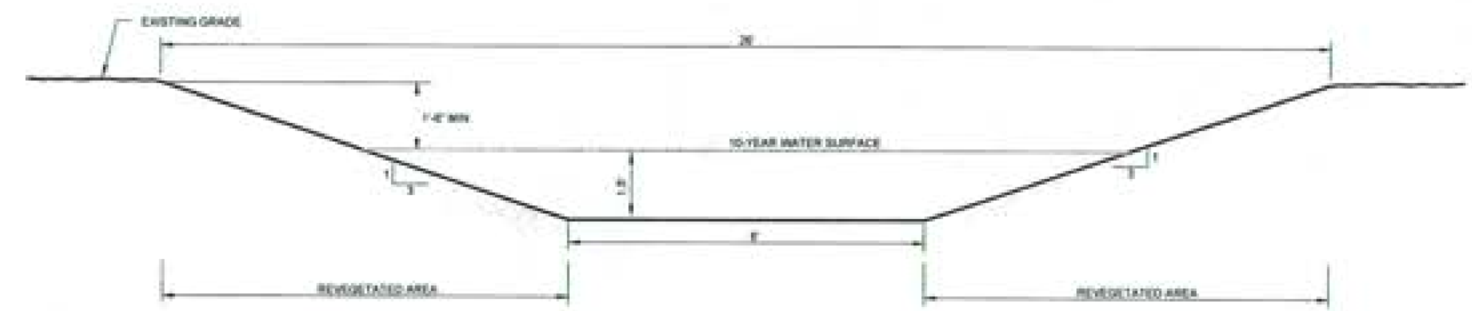
The proposed project would discharge directly into the Petaluma River downstream of Corona road. Since it would allow runoff from this watershed to drain more rapidly to the river and pass downstream before peak flows from other upstream watersheds arrived, it could have a minor beneficial impact on flood flows in the river.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$366,681	Labor	$942
Right-of-Way	$135,000	Materials	$62
Construction	$1,466,725	Equipment	$279
Inspection	$146,672	Energy (elec, etc)	$100
Total	$2,115,078		$1,383



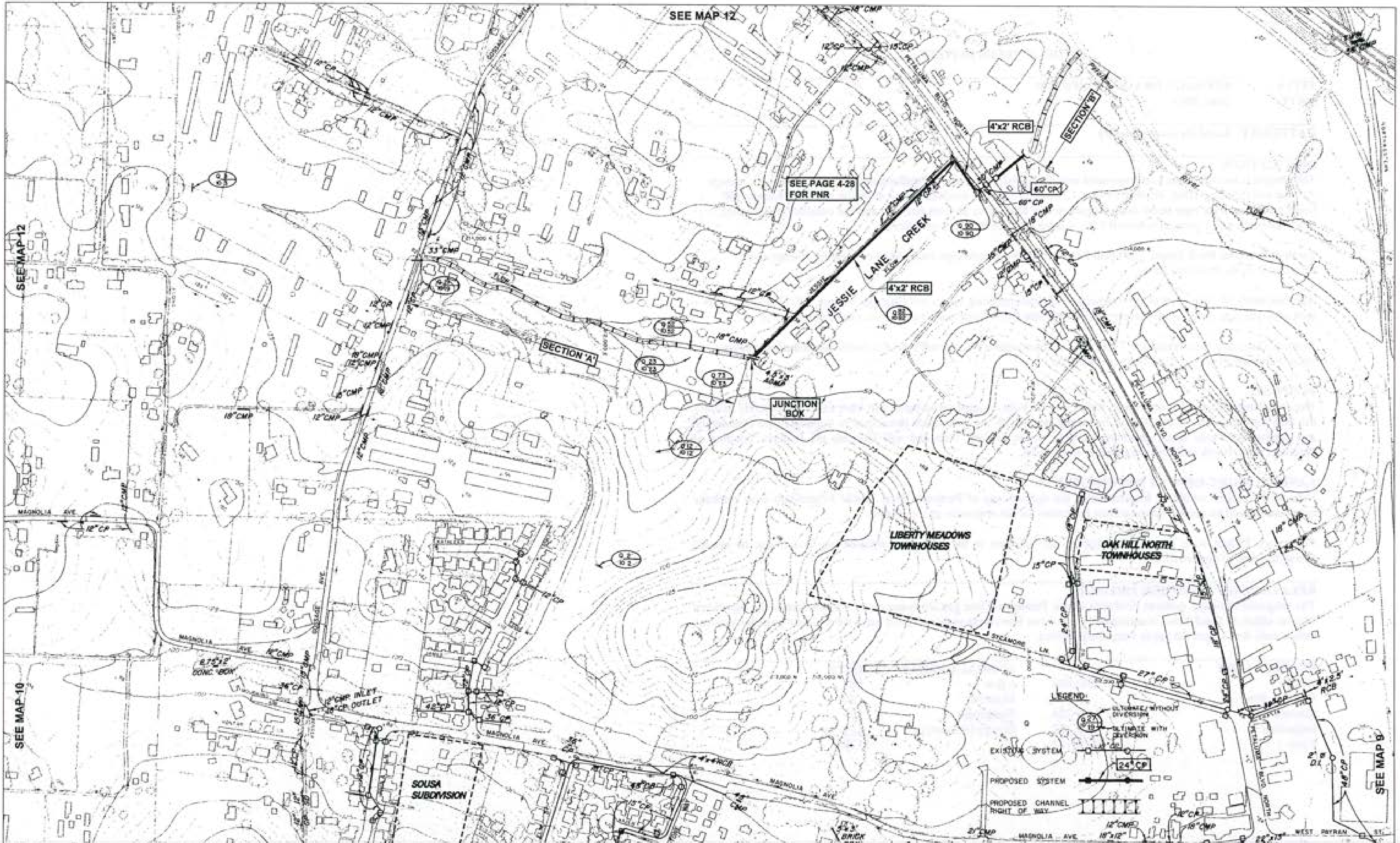
JESSIE LANE CREEK - SECTION A

NOT TO SCALE



JESSIE LANE CREEK - SECTION B

NOT TO SCALE



SUBDIVISION BOUNDARY ------

NOTE:
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VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
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SEE MAP 9

SCALE
0 400' 800'
1" = 400'

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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
JESSIE LANE CREEK
DRAINAGE SYSTEM

MAP NO. 11

PROJECT NEEDS REPORT

TITLE: **GOSSAGE DRAINAGE SYSTEM**
DATE: **June 2003**

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located in the unincorporated area northwesterly of city of Petaluma near the intersection of Gossage Avenue and Petaluma Blvd. North (See Map 12 on page 4-31). It involves the construction of approximately 760 lineal feet of concrete pipe storm drain ranging in size from 15 to 36-inch diameter and the installation of 4 inlets, 1 headwall outlet and 1 winged headwall inlet, at three separate locations as follows:

South of Petaluma Blvd. North, 120 lineal feet of 15-inch concrete pipe storm drain conveying drainage from Tributary 1 to the Petaluma River.

Approximately 600 feet west of the intersection of Petaluma Blvd. North and Gossage Avenue, 140 lineal feet of 36-inch concrete pipe storm drain crossing under Petaluma Blvd. North and draining into the Petaluma River.

North of Oak Lane, the drainage of Tributary 2 is approximately 620 lineal feet of concrete storm drain conveying under Petaluma Blvd. North to the Petaluma River.

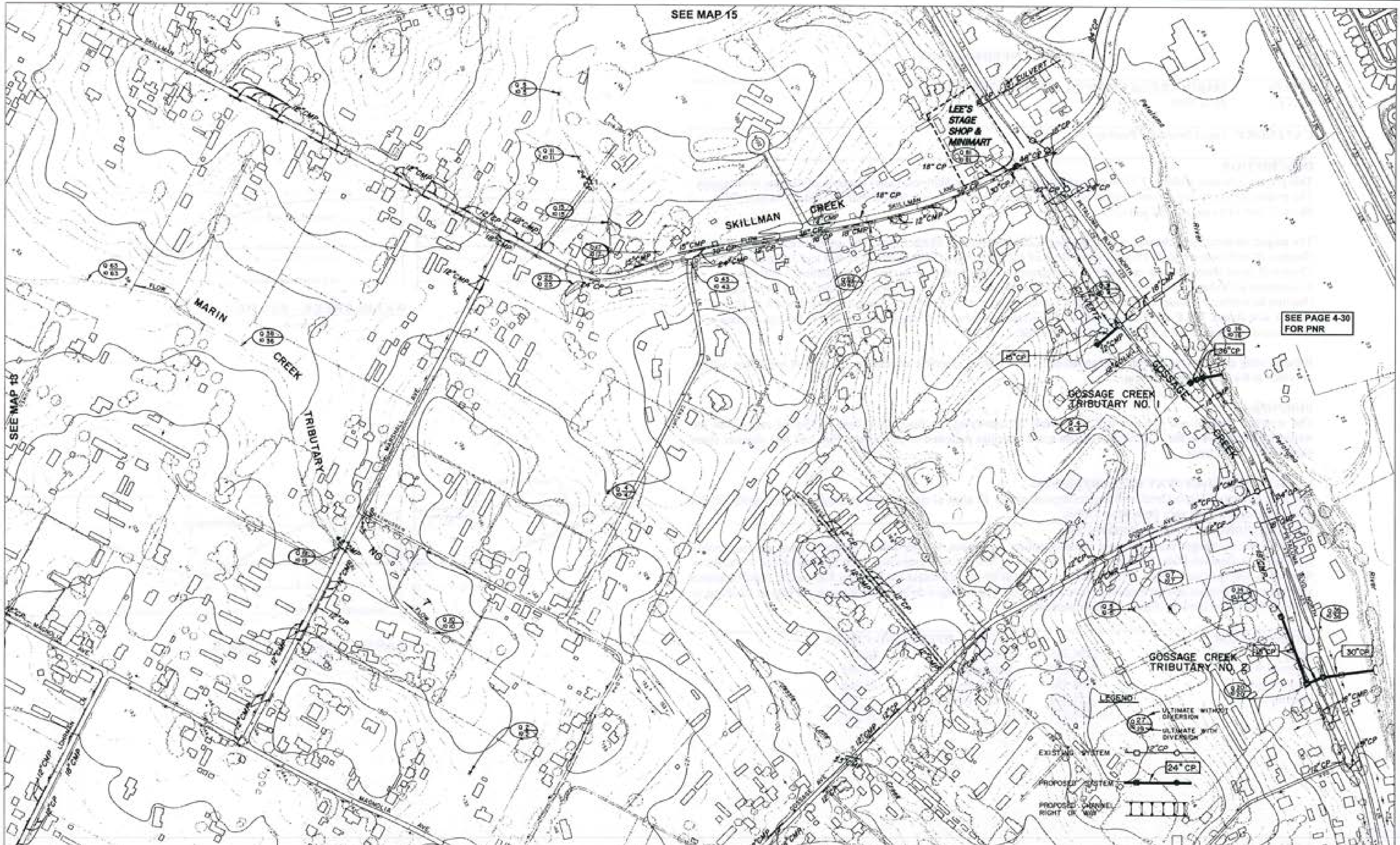
PURPOSE:
The completed portions of the project, which may be built as separate projects, will have sufficient capacity to carry the flow anticipated from the 10-year frequency storm with the watersheds developed to Suburban Low Residential and Agricultural/Open space densities indicated in the General Plan and will alleviate the frequent flooding of Petaluma Blvd. North and adjacent property in this area.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
Parts of the project would be located within the right-of-way of Petaluma Blvd. North. Fifteen-foot wide drainage easements would be needed across private properties for the remainder of the project.

Temporary 25-foot wide construction right-of-way adjacent to the permanent right-of-way would also be needed during the time of construction.

RELATIONSHIP TO OTHER PROJECTS:
The proposed drainage systems discharge to the Petaluma River just downstream of Corona Road. No significant adverse effect on flood flows is anticipated since flows from these systems would enter the river and pass downstream before peak flows from the upper watersheds arrived.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$42,806	Labor	$82
Right-of-Way	$5,000	Materials	$7
Construction	$171,224	Equipment	$25
Inspection	$17,122	Energy (elec, etc)	$16
Total	$236,152		$130



SEE MAP 10

SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SEE MAP 11

SONOMA COUNTY WATER AGENCY

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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

GOSSAGE CREEK DRAINAGE SYSTEM

MAP NO. 12

JOB NO. 02224301

PROJECT NEEDS REPORT

TITLE: MARIN CREEK CHANNEL IMPROVEMENT
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located within a 7,376-acre watershed (2,386 acres at Skillman Lane) westerly of the City of Petaluma. The project starts 200 feet downstream of Skillman Lane and extends to just downstream of Bodega Avenue (See Maps 13 and 14 on pages 4-33 and -35).

The project includes open channel widening along 5,200 lineal feet of Marin Creek. The upper reaches of the channel (Section A) will have a typical 25-year storm depth of 3.1 feet, a top of bank width of 79 feet and 2:1 side slopes. There will be no improvements necessary to the segment of natural channel starting approximately 1,900-feet downstream of Bodega Avenue and extending 600 feet downstream. The remaining 3,270 feet of the lower section (Section B) will have a widened channel with a typical 25-year storm depth of 4.2 feet, a top bank width of 73 feet and 2:1 side slopes. The 8' x 4.5' dual reinforced concrete box culverts at Magnolia Avenue and Bodega Avenue will be replaced with a dual 10' x 5' reinforced concrete box.

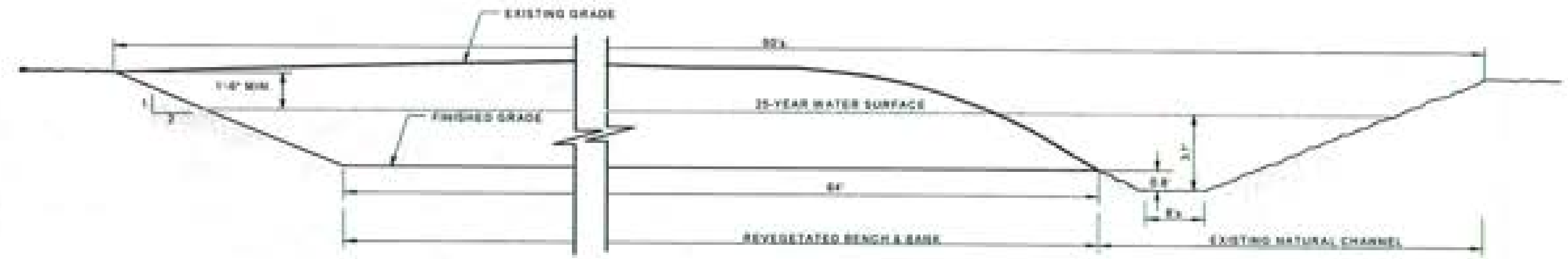
If the existing creek has significant riparian habitat, which will be adversely affected by the project, mitigation will be provided at the time of construction.

PURPOSE:
The enlarged channel and culverts will be capable of conveying the flood flow from a 25-year storm with the watershed developed to the Agricultural / Open space densities indicated in the General Plan and will alleviate flood hazard of adjacent lands

LAND OR RIGHT-OF-WAY REQUIREMENTS:
The enlargement of Marin Creek will require approximately 10 acres of right-of-way through private property. Width of the right-of-way will vary from 90 to 95 feet.

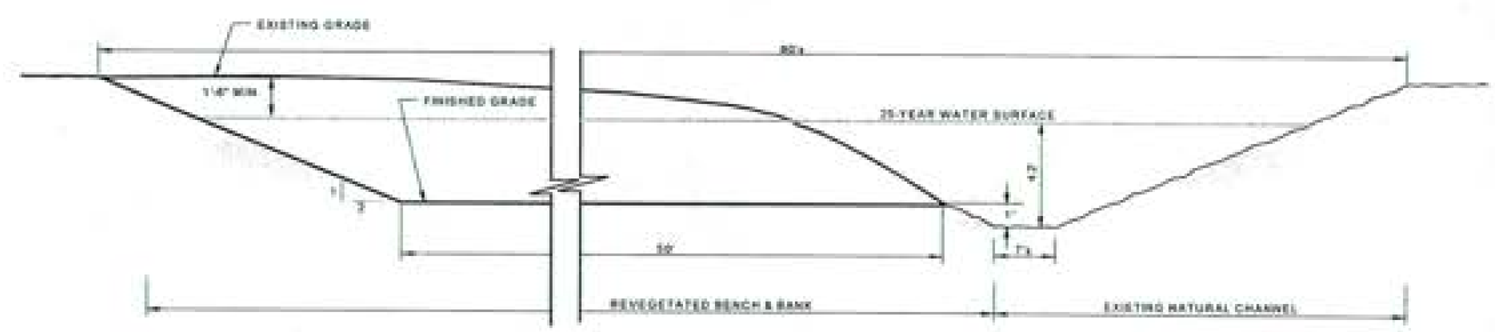
RELATIONSHIP TO OTHER PROJECTS:
Marin Creek discharges into a natural flood-detention depression located below Skillman Lane and commonly referred to as Denman Flats. Enlargement of the reach of Marin Creek extending from the confluence of Petaluma river up to 200 feet downstream of Skillman Lane will not be needed unless the Denman Flat natural flood detention area were to be drained and the Petaluma River were to be fully enlarged downstream through the City of Petaluma to carry all flood flow from the Petaluma River watershed.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$224,235	Labor	$4,703
Right-of-Way	$555,000	Materials	$285
Construction	$896,942	Equipment	$1,368
Inspection	$89,694	Energy (elec, etc)	$71
Total	$1,765,872		$6,427



MARIN CREEK - SECTION A

NOT TO SCALE



MARIN CREEK - SECTION B

NOT TO SCALE

SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SEE MAP 10

SCALE
0 400' 800'
1" = 400'

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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

MARIN CREEK & WILSON CREEK

MAP NO. 13

JOB NO. 02234301

PROJECT NEEDS REPORT

TITLE: WILSON CREEK CHANNEL IMPROVEMENT
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located within an 1,135-acre watershed west of Petaluma and extends along Wilson Creek from approximately 1,150 feet north of Skillman Lane to 670 feet north of Middle Two Rock Road (See Maps 13 and 14 on pages 4-33 and -35).

The project includes a 6,100 lineal feet widened and revegetated section of Wilson Creek. Starting upstream, the upper 3,700 feet of the channel (Section A) will have a typical 25-year storm depth of 4 feet with a top of bank width of 47 feet and 2:1 side slopes. Section B will have a typical 25-year storm depth of 2.2 feet, a top of bank width of 82 feet and 2:1 side slopes. The 1,100-feet of the lower widened reach (Section C) will have a typical 25-year storm depth of 3.1 feet, a top of bank width of 58 feet and 2:1 side slopes.

If the existing creek has significant riparian habitat, which will be adversely affected by the project, mitigation will be provided at the time of construction.

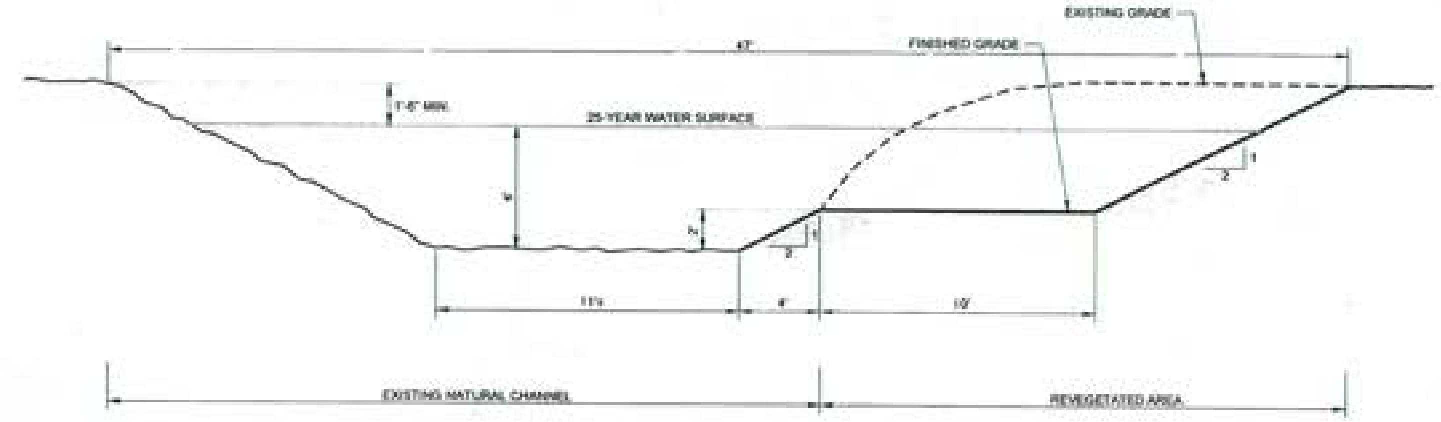
PURPOSE:
The purpose of this project is to provide flood protection by increasing the inadequate capacity of Wilson Creek which cause frequent flooding of rural residential property, and agricultural property.

The improved channel and culverts will be capable of conveying the flow anticipated from the 25-year frequency storm with the watershed developed to the Agricultural / Open Space land use densities designated in the General Plan.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
The enlargement of Wilson Creek will require approximately 10.9-acres of right-of-way through private property. Width of the right-of-way will vary from 60 to 95 feet, which includes the channel bottom and a buffer zone / access road along the channel.

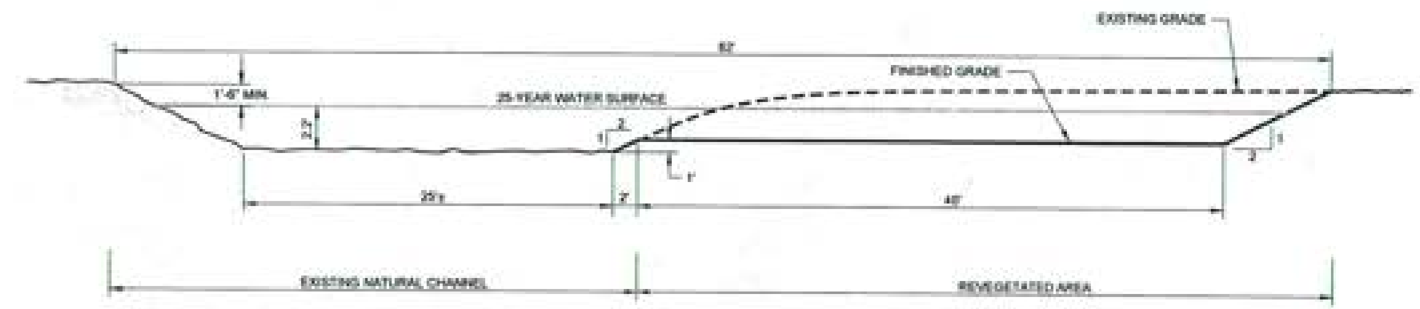
RELATIONSHIP TO OTHER PROJECTS:
Wilson Creek discharges into Marin Creek which outlets into the Denman Flat natural flood detention area (see Project Needs Report for Marin Creek Channel Improvement).

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$188,649	Labor	$8,993
Right-of-Way	$545,000	Materials	$545
Construction	$754,595	Equipment	$2,616
Inspection	$75,459	Energy (elec, etc)	$136
Total	$1,563,703		$12,290



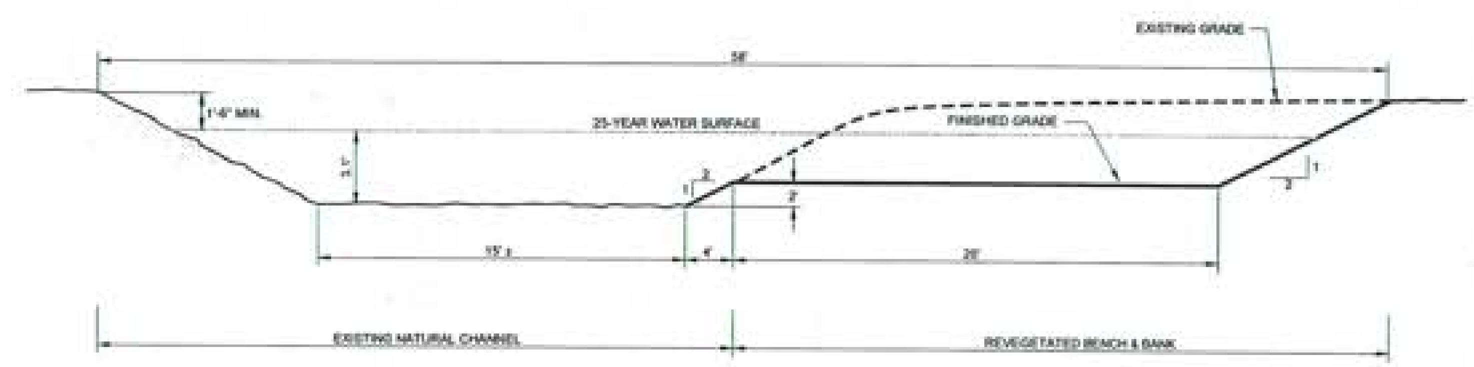
WILSON CREEK - SECTION A

NOT TO SCALE



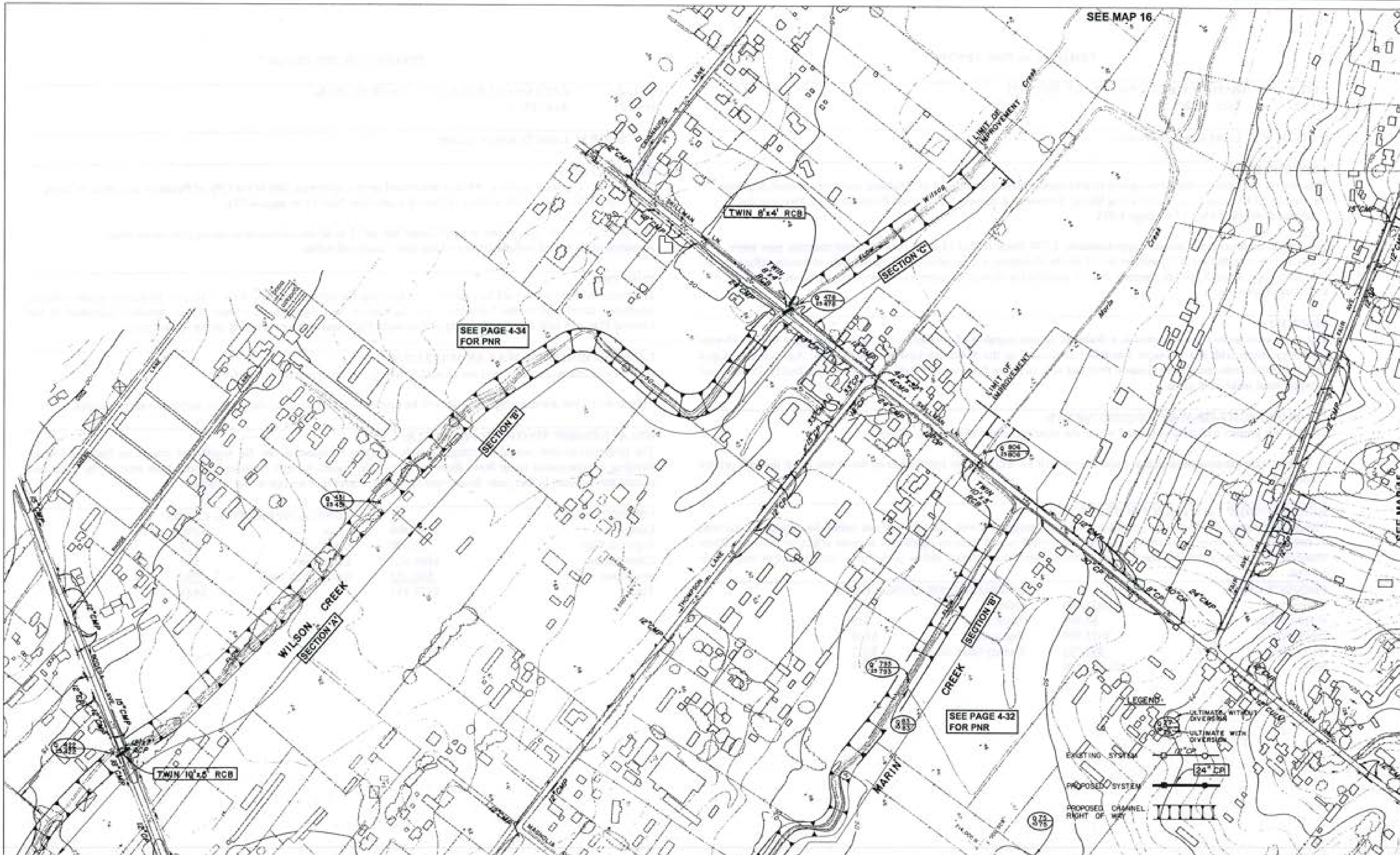
WILSON CREEK - SECTION B

NOT TO SCALE



WILSON CREEK - SECTION C

NOT TO SCALE



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SEE MAP 13

SCALE
0 400' 800'
1" = 400'

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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

MARIN CREEK & WILSON CREEK

MAP NO.
14
JOB NO. 02224301

PROJECT NEEDS REPORT

TITLE: BAILEY CREEK DRAINAGE SYSTEM
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located in the unincorporated area northwesterly of the City of Petaluma and extends northerly from the vicinity of Pacheco Lane to and along Bailey Avenue and Joerger Way, across Petaluma Blvd. North to the Petaluma River (See Map 15 on page 4-37).

The project involves installation of approximately 2,790 lineal feet of 18 to 60-inch diameter concrete pipe storm drain, and the installation of 1 junction box, 2 headwall outlets, 9 drop inlets and 1 storm drain manhole. Alignment of the storm drain through private property may be modified at time of construction to avoid property improvements or to follow property lines.

PURPOSE:
The completed project would provide a drainage system capable of conveying the flow anticipated from a 10-year frequency storm with the 145-acre watershed developed to the Suburban Low Residential and Agricultural / Open Space densities indicated in the General Plan and will alleviate flooding of Petaluma Blvd. North, Bailey Avenue, and adjacent rural residential areas.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
Most of this project will be constructed within the existing public street rights-of-way.

A 15-foot wide permanent drainage right-of-way will be required for installation of the storm drain through private properties.

RELATIONSHIP TO OTHER PROJECTS:
The proposed project will discharge directly into the Petaluma River. Specific analysis would be required at the time of construction, however, it is anticipated that the project would have no significant adverse affect on Petaluma River flooding since flows from this conduit would have passed downstream before peak flows from the upper watersheds arrived.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$238,990	Labor	$430
Right-of-Way	$1,500	Materials	$35
Construction	$955,960	Equipment	$133
Inspection	$95,596	Energy (elec, etc)	$131
Total	$1,292,046		$728

PROJECT NEEDS REPORT

TITLE: CINNABAR CREEK DRAINAGE SYSTEM
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located within an 89-acre watershed on the northwest side of the City of Petaluma and extends along Petaluma Blvd. North in the vicinity of Troudy Lane (See Map 15 on page 4-37).

The project involves installation of 1,900 lineal feet of 15 to 60-inch diameter concrete pipe storm drain. Appurtenances would include 10 drop inlets and 1 headwall outlet.

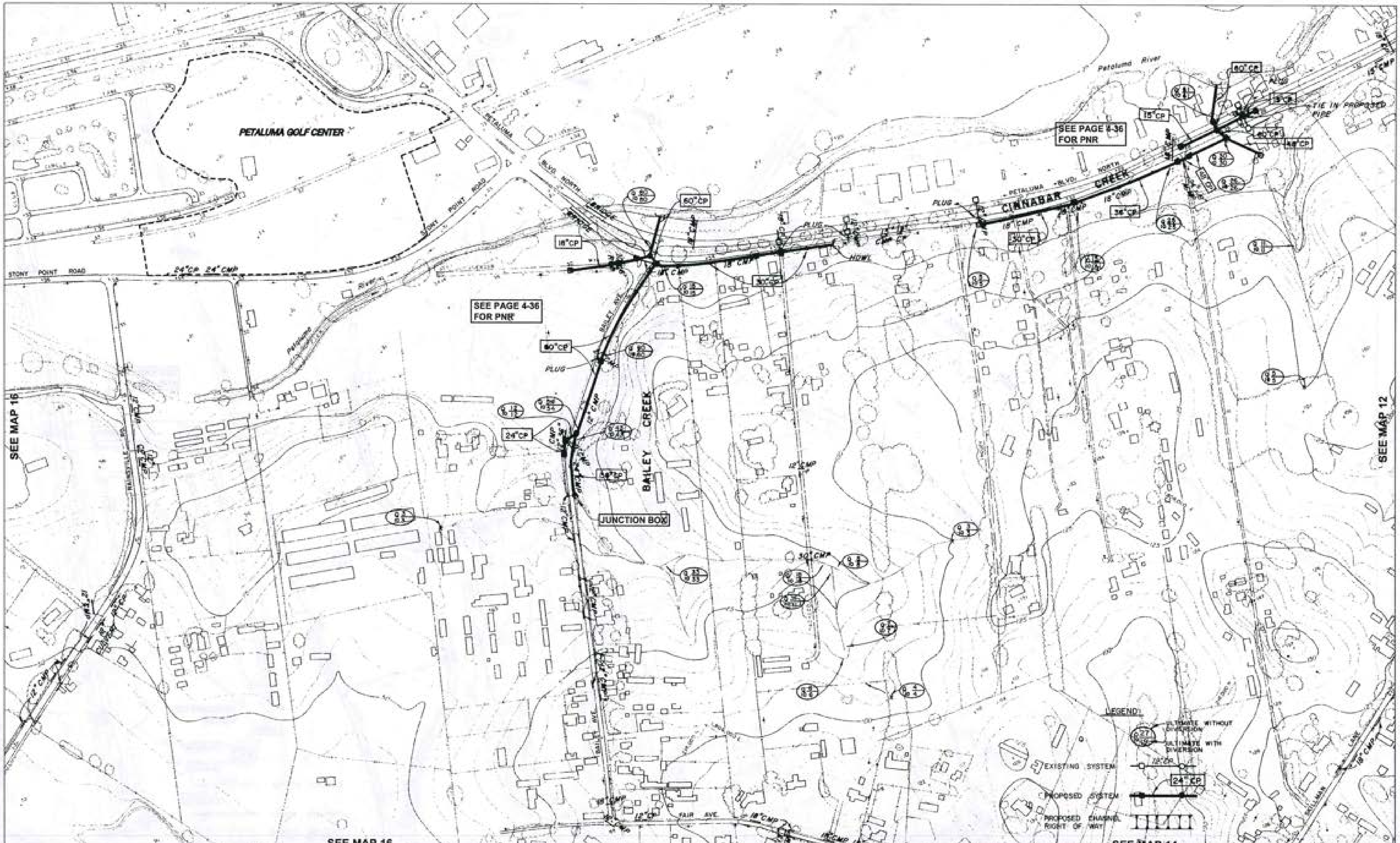
PURPOSE:
The completed project would be capable of conveying the anticipated flow from a 10-year frequency storm with the watershed developed to the Suburban Low Residential and Agricultural / Open Space densities indicated in the General Plan and will alleviate flooding of Petaluma Blvd. and adjacent property in the project area.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
A portion of the project facilities are located within the existing public rights-of-way.

Fifteen-foot wide drainage right-of-way will be needed for installation of the conduit across private properties.

RELATIONSHIP TO OTHER PROJECTS:
The proposed system would discharge directly into the Petaluma River. No significant impact on Petaluma River flooding is anticipated since flows from the proposed project, in most instances, would have entered the river and passed downstream before peak flows from the upper watersheds arrived at this location.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$150,406	Labor	$291
Right-of-Way	$5,000	Materials	$23
Construction	$601,623	Equipment	$90
Inspection	$60,162	Energy (elec, etc)	$88
Total	$817,191		$493



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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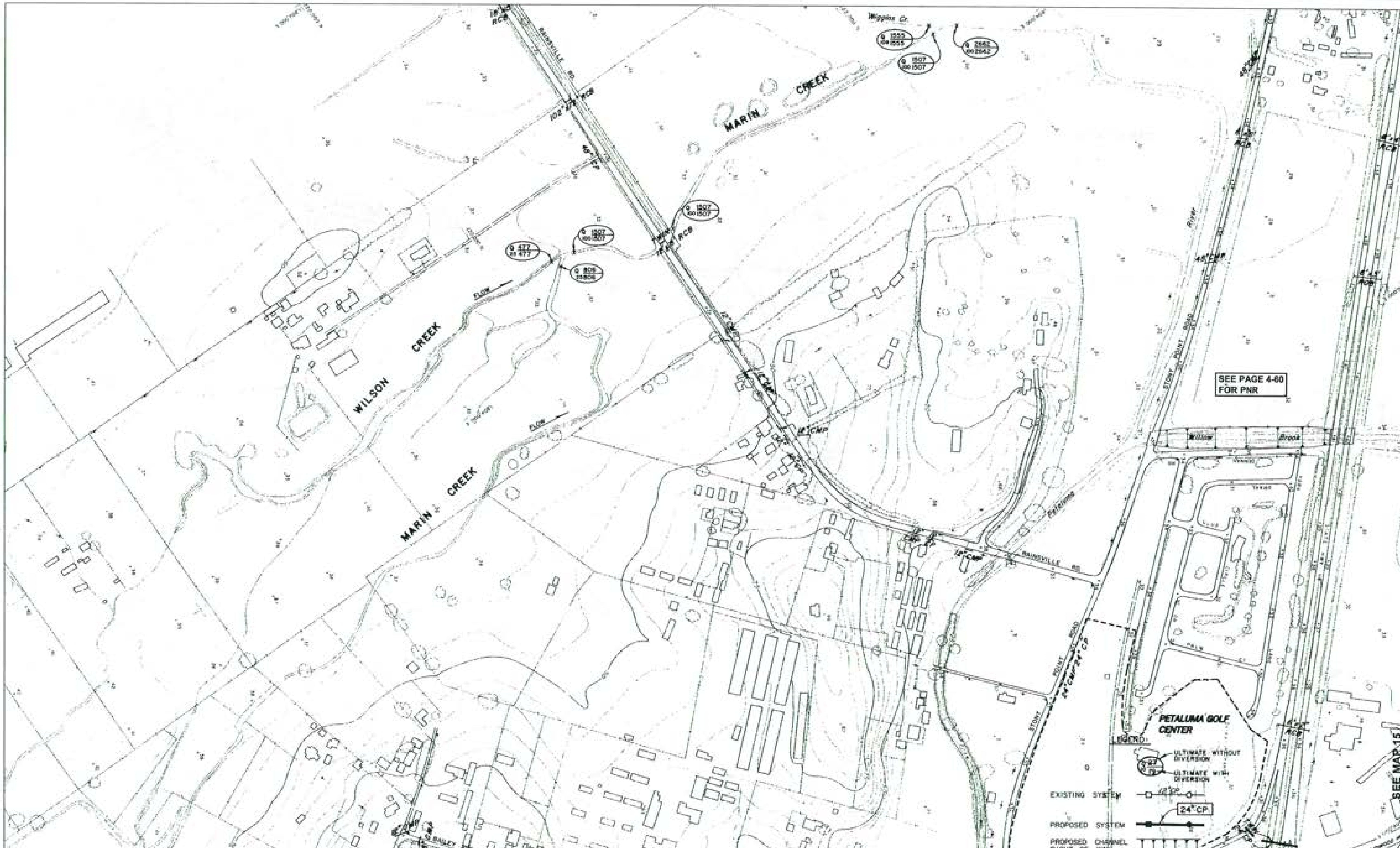
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
BAILEY CREEK & CINNABAR CREEK DRAINAGE SYSTEMS

MAP NO. 15
JOB NO. 02224301



SEE MAP 14

SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION;
CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SEE MAP 15

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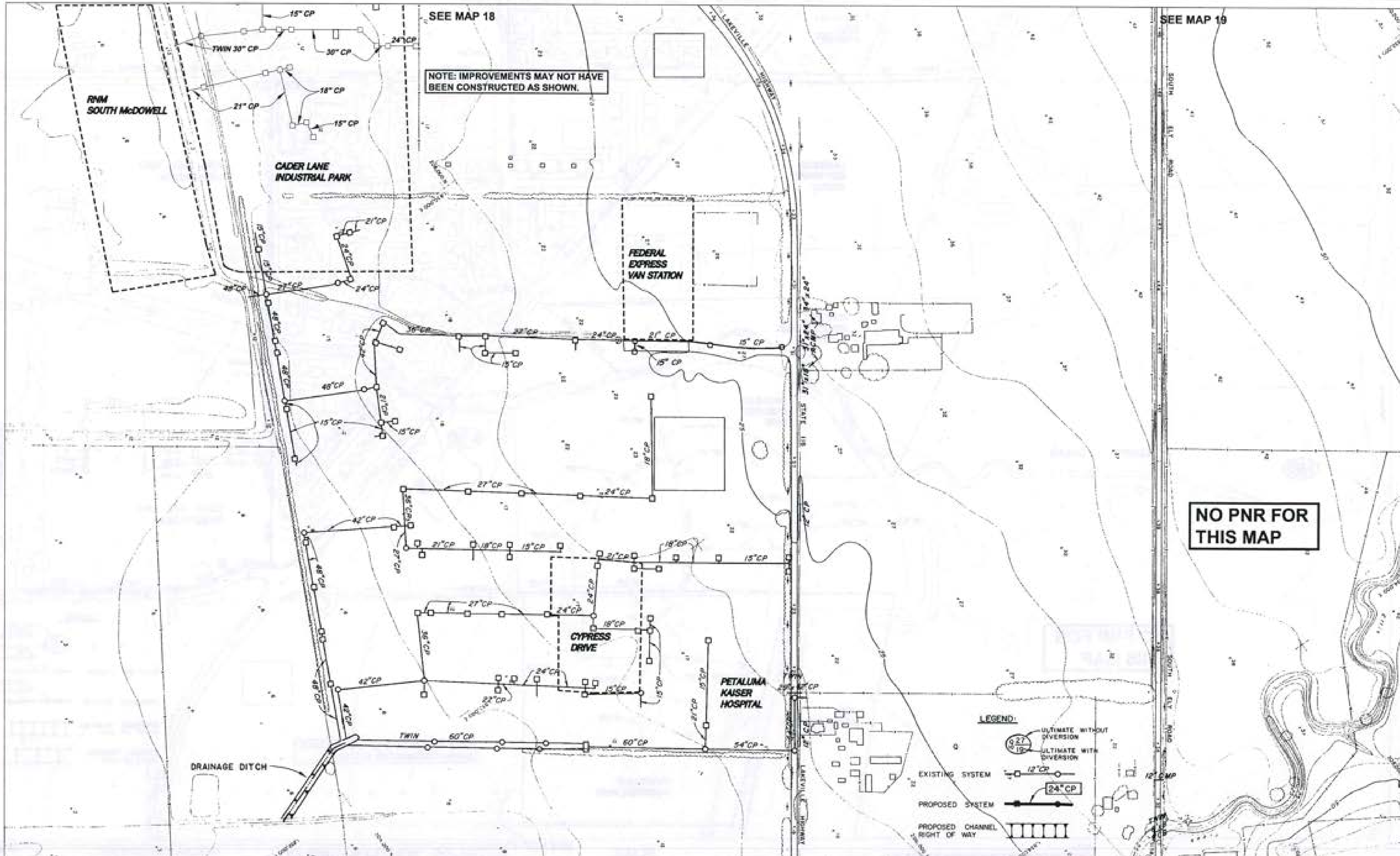
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

MARIN CREEK AND WILSON CREEK

MAP NO. 16

JOB NO. 02224301



NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE 0 400' 800'
1" = 400'

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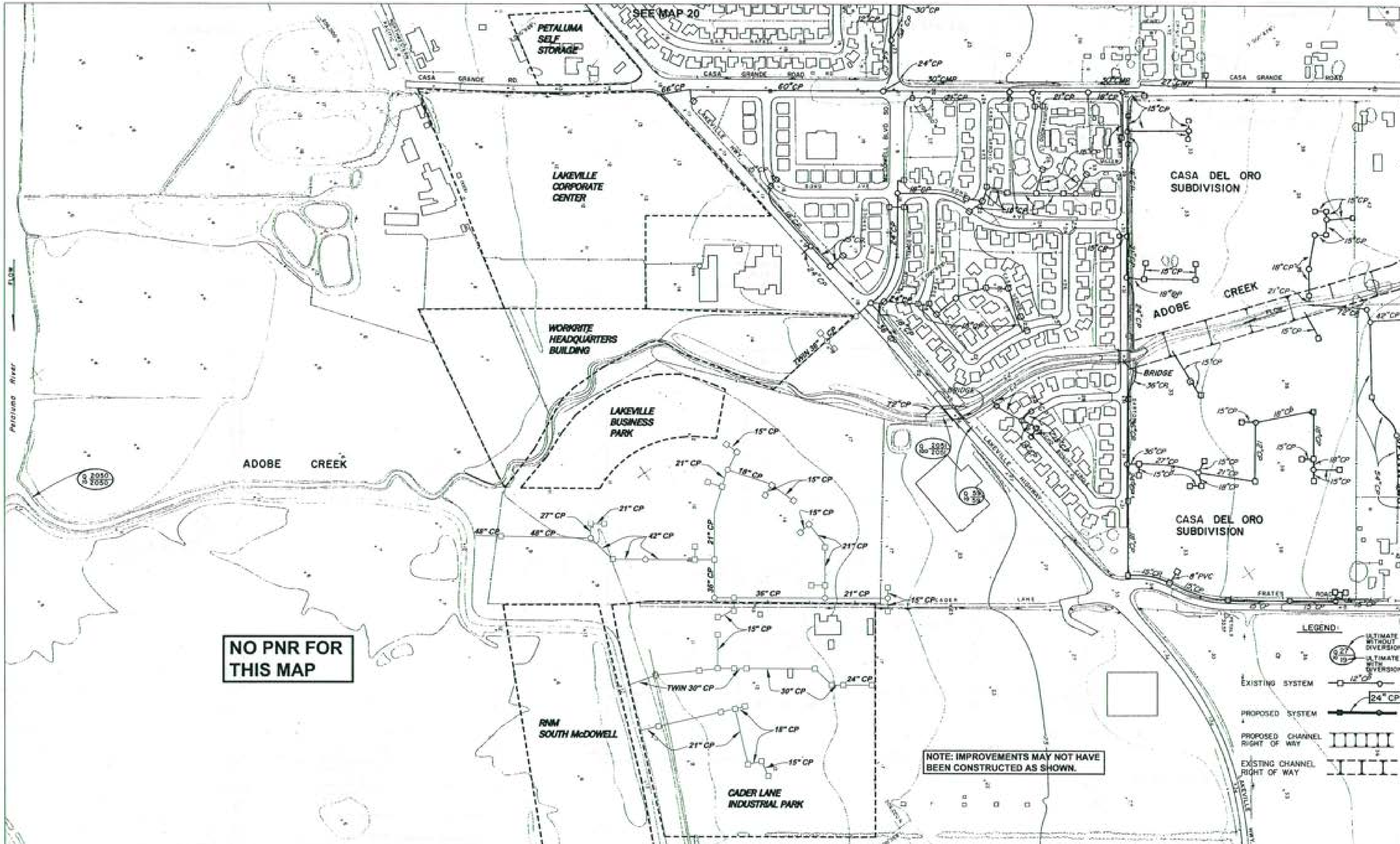
PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

LAKEVILLE HIGHWAY AREA SYSTEMS

MAP NO. 17

JOB NO. 02224301



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION;
CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SEE MAP 17

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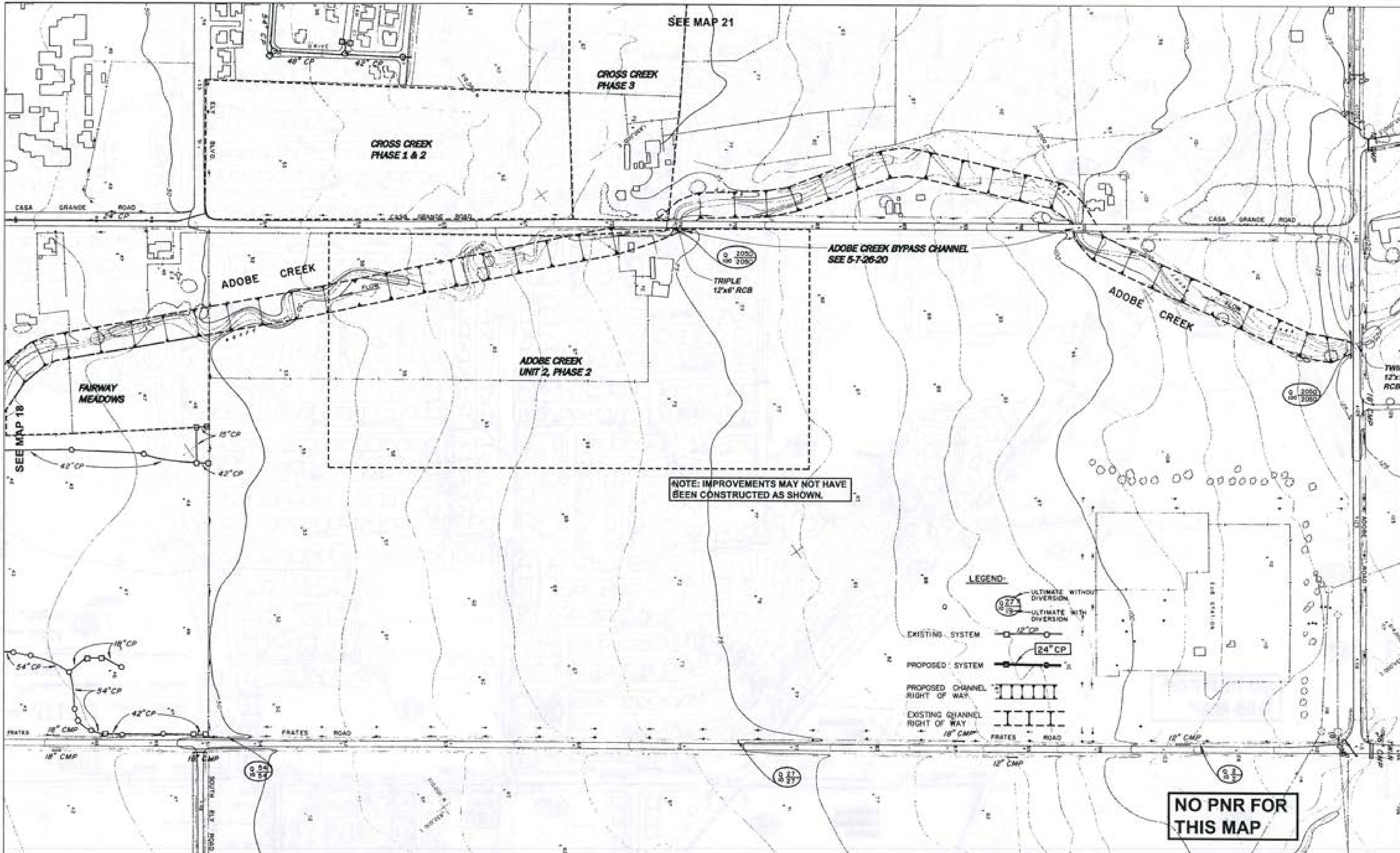
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

ADOBE CREEK

MAP NO. 18

JOB NO. 03224301



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

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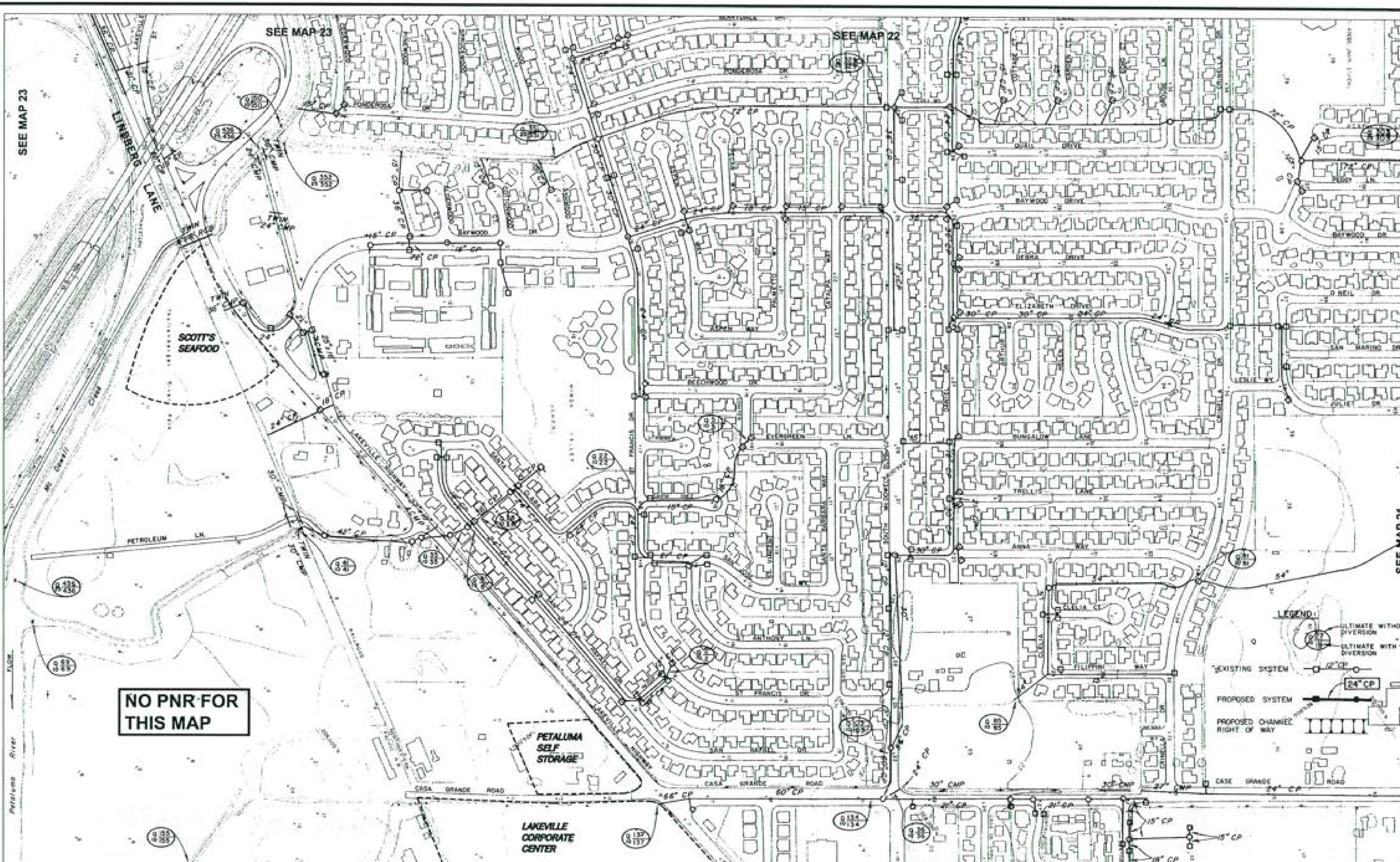
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

ADOBE CREEK

MAP NO. 19



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

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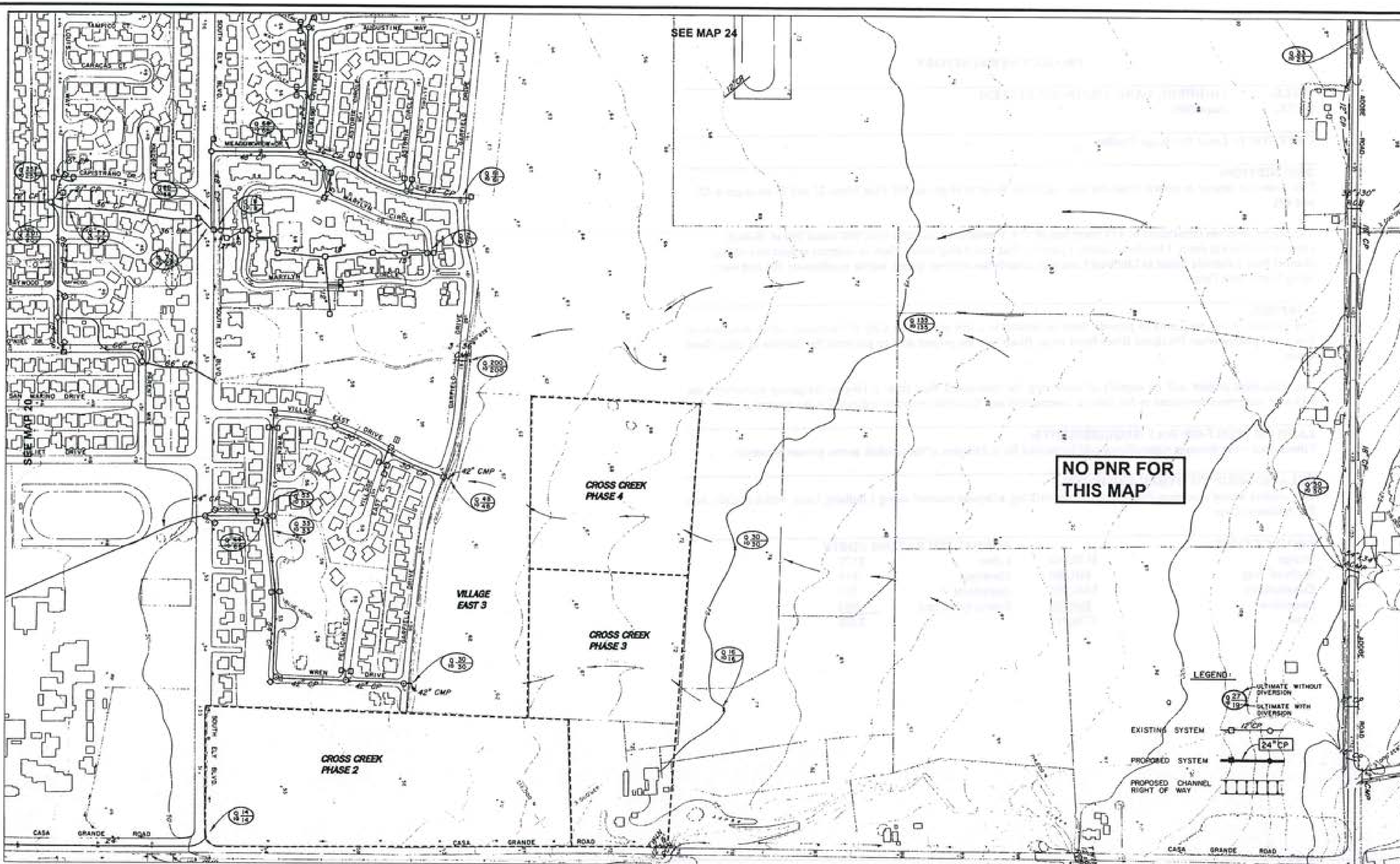
PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

McDOWELL DRAINAGE SYSTEMS & LINDBERG LANE DRAINAGE SYSTEM

MAP NO. 20

JOB NO. 02294301



SEE MAP 19

SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

McDOWELL DRAINAGE SYSTEMS

MAP NO. 21

JOB NO. 02224301

PROJECT NEEDS REPORT

TITLE: LINDBERG LANE DRAINAGE SYSTEM
DATE: June 2003

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located in central Petaluma near Lakeville Street at Highway 101 (See Maps 22 and 23 on pages 4-45 and 47).

The project involves installation of 430 lineal feet of 5' x 3' reinforced concrete box, 600 lineal feet of 36-inch concrete pipe storm drain, 1 headwall outlet, 1 junction box and 3 drop inlets. Flow is diverted around an existing channel from Lakeville Street to Lindberg Lane and extends the existing system beside southbound 101 and west along Kenilworth Drive.

PURPOSE:
The purpose of this project is to provide flood protection to a low area of the City of Petaluma, which is subject to frequent flooding when Petaluma River flood water flows into the project area or prevents the outflow of local flood water.

The completed project will be capable of conveying the anticipated flow from a 10-year frequency storm with the 123-acre watershed developed to the Service Commercial and Industrial densities indicated in the general plan.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
Fifteen-foot wide drainage right-of-way will be needed for installation of the conduit across private properties.

RELATIONSHIP TO OTHER PROJECTS:
This project would discharge flood water to the existing adequate channel along Lindberg Lane, which outfalls into the Petaluma River.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$135,262	Labor	$170
Right-of-Way	$10,000	Materials	$14
Construction	$541,050	Equipment	$53
Inspection	$54,105	Energy (elec, etc)	$55
Total	$740,417		$292

SUBDIVISION BOUNDARY ------

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SEE MAP 20

SCALE 0 400' 800'
1" = 400'

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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

LINDBERG LANE DRAINAGE SYSTEM

MAP NO. 22

JOB NO. 02224301

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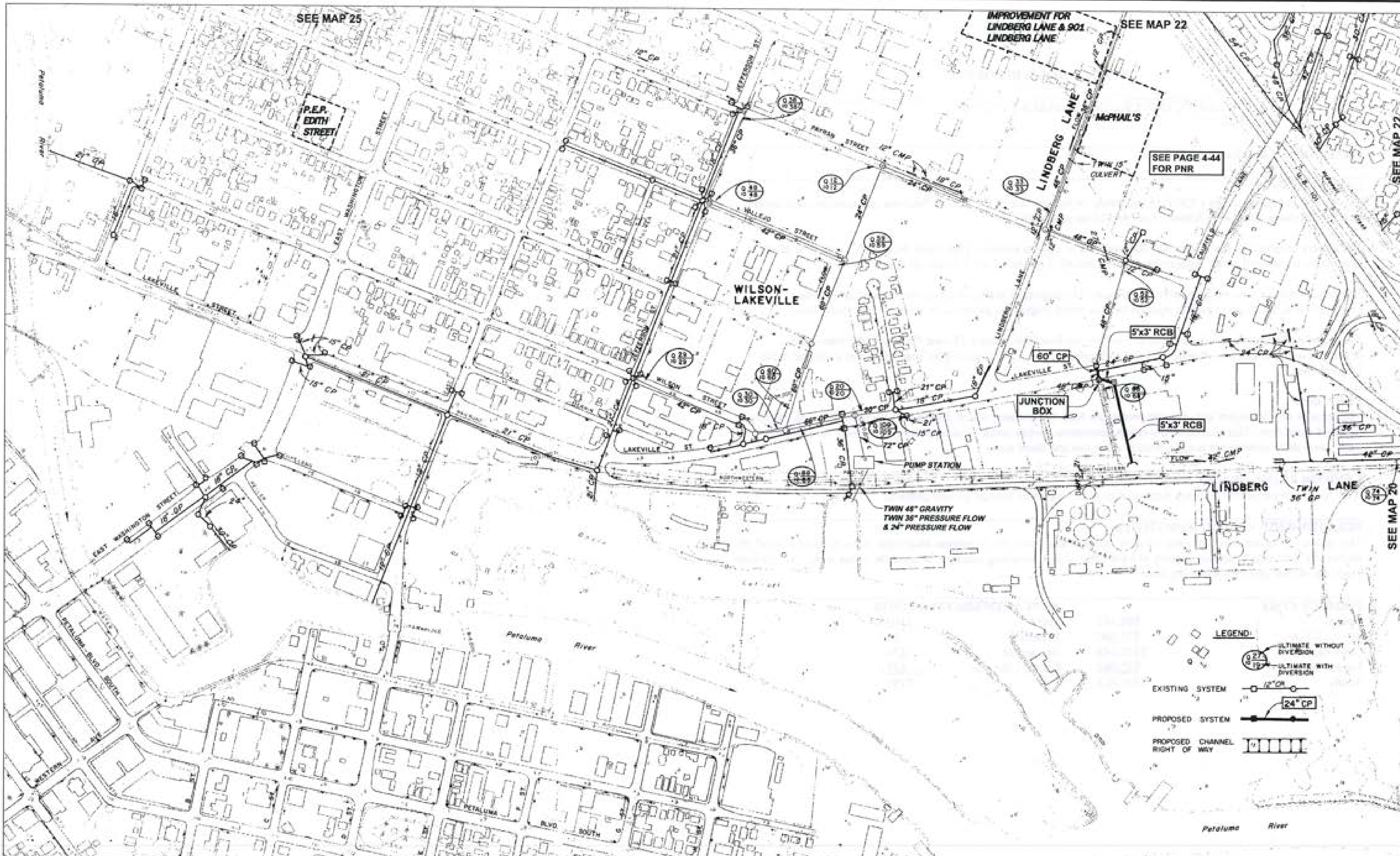

SUBDIVISION BOUNDARY - - - - - -

NOTE:
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VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
LINDBERG LANE
DRAINAGE SYSTEM

MAP NO. 23
JOB NO. 02224301

PROJECT NEEDS REPORT

TITLE: **EAST WASHINGTON CREEK DRAINAGE SYSTEM**
DATE: **June 2003**

CATEGORY: Local Drainage Facility

DESCRIPTION:
This project is located within a 930-acre watershed on the east side of the City of Petaluma and extends northeasterly near the Petaluma Sky Ranch Airport (See Map 24 on page 4-49).

The project involves the installation of 550 lineal feet of 66-inch concrete pipe storm drain and the removal of an existing twin headwall outlet. Appurtenances will include 3 manholes and 1 headwall outlet.

The project bypasses the existing natural waterway. The alignment in this reach can be adjusted at the time of construction as necessary to protect riparian habitat, avoid property improvements and follow property lines.

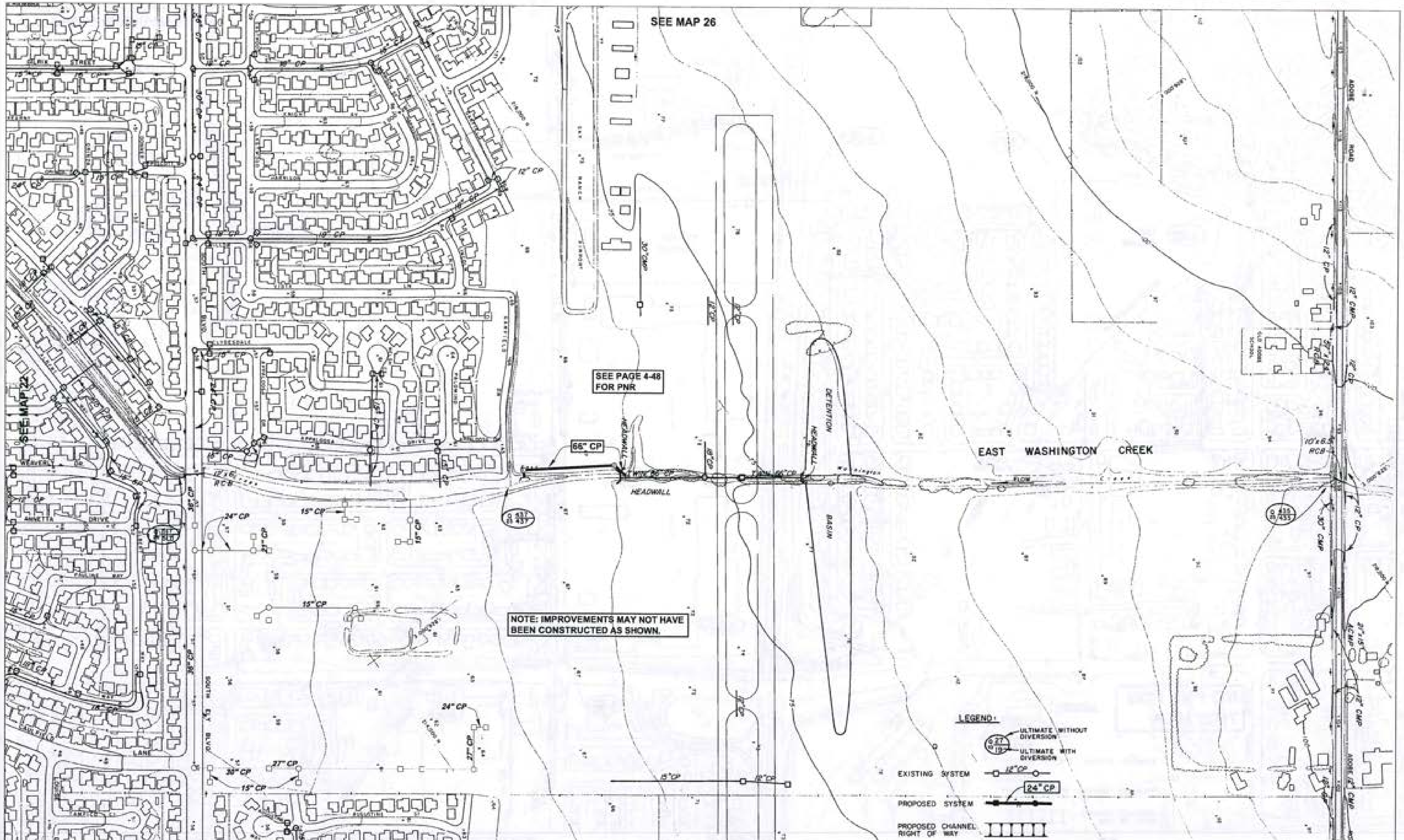
The completed project would be capable of carrying the flood flow from a 25-year flood with the watershed developed to the Urban Low Residential, Urban Separator, and Agricultural Open Space densities indicated in the General Plan.

PURPOSE:
The purpose of this project is to provide protection from flood water, which now leaves the existing creek, becoming overland sheet flow. This overland flow enters downstream urban areas, causing street and property flooding since the local storm drain systems are not designed to carry this lost flood water.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
A 15-foot wide permanent drainage right-of-way will be required through private property.

RELATIONSHIP TO OTHER PROJECTS:
This project is an extension of twin 66-inch storm drains under the Petaluma Municipal Airport. Upstream of the airport is a detention basin that appears to have little, if any, detaining qualities because the outlet is the twin 66-inch pipes that do not constrain incoming flow.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$82,412	Labor	$109
Right-of-Way	$10,000	Materials	$9
Construction	$329,648	Equipment	$34
Inspection	$32,965	Energy (elec, etc)	$35
Total	$455,025		$186



SUBDIVISION BOUNDARY ------

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

WINZLER & KELLY
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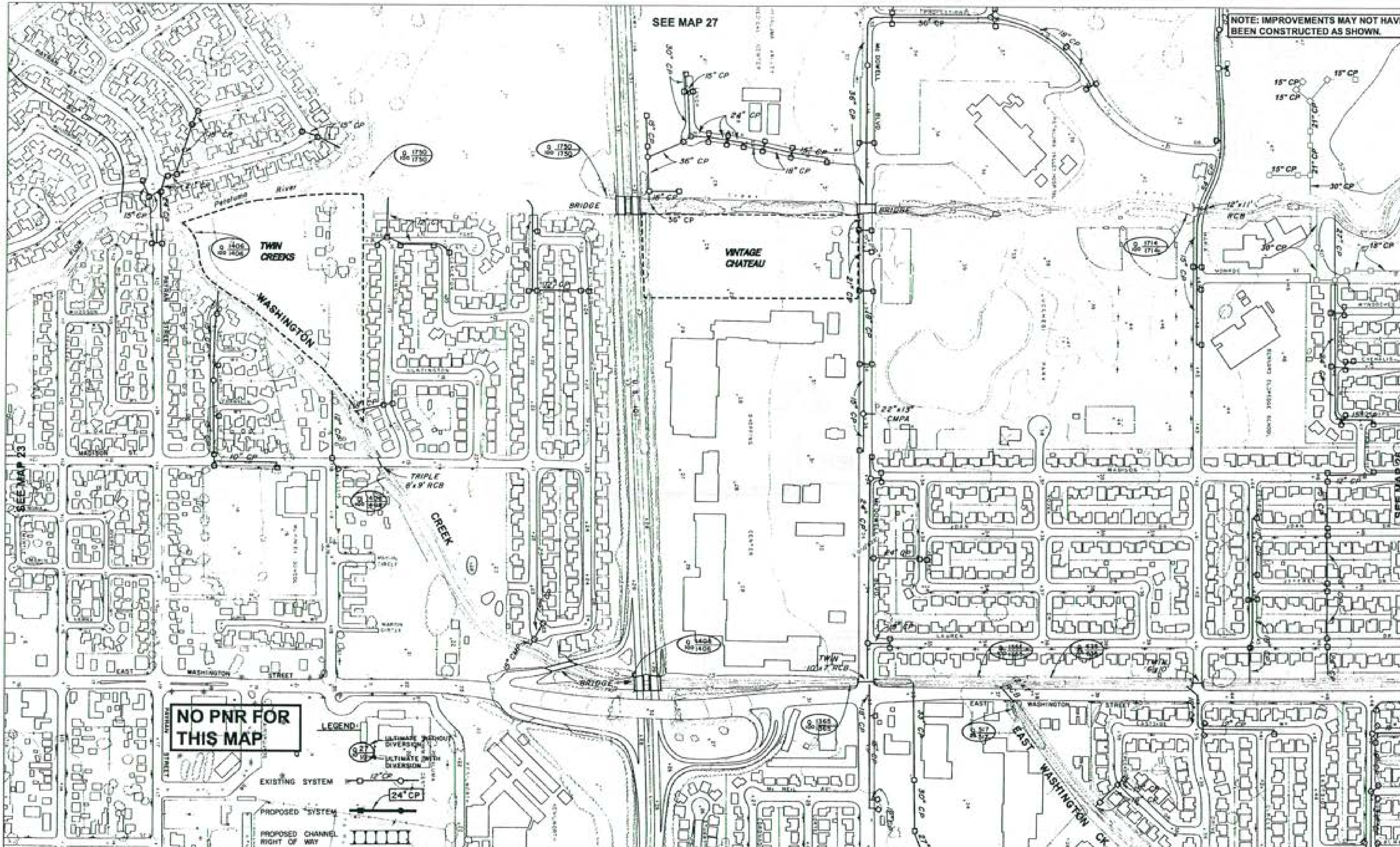
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

EAST WASHINGTON CREEK

MAP NO.
24

JOB NO. 02254301



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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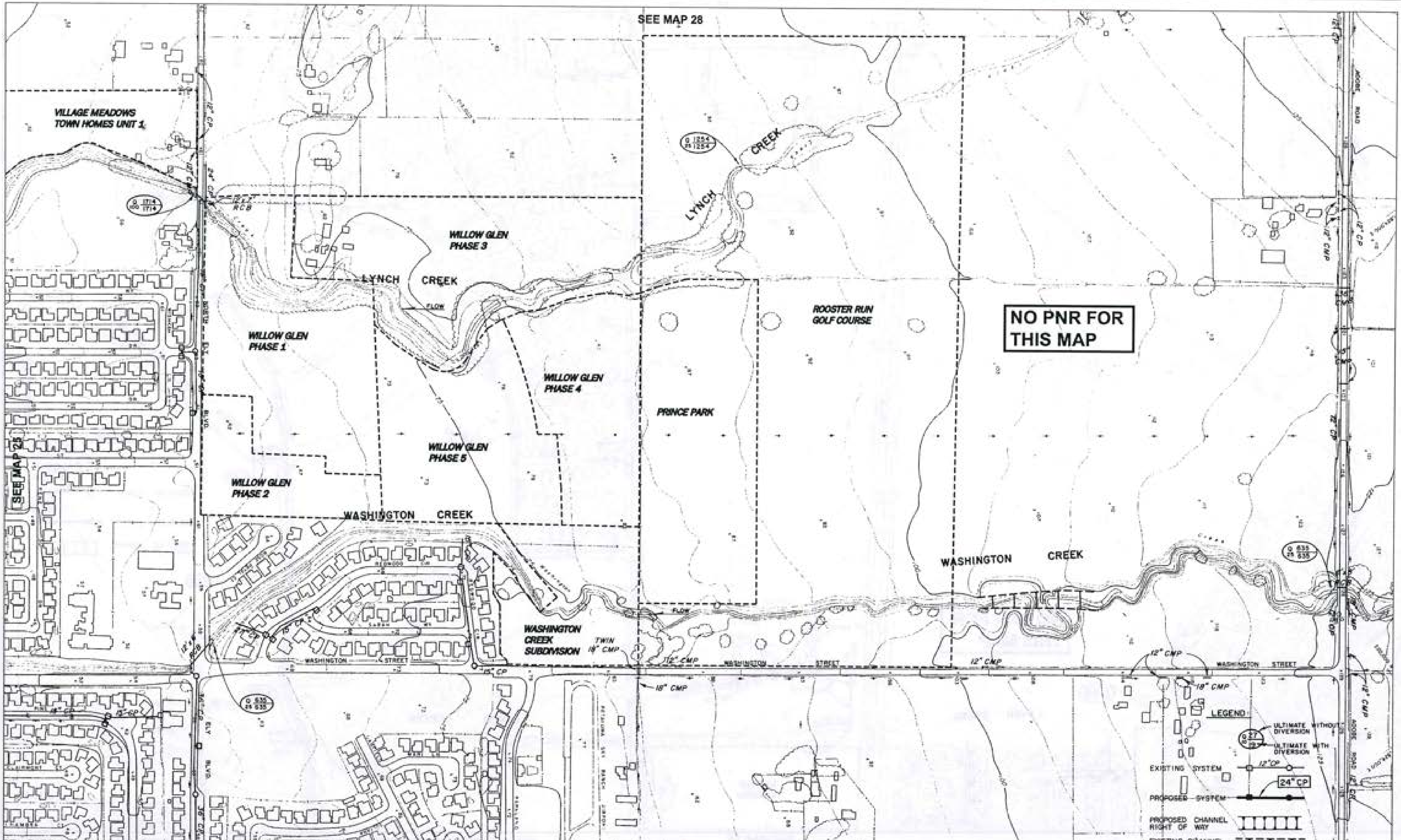
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
EAST WASHINGTON CREEK
& WASHINGTON CREEK

MAP NO.
25



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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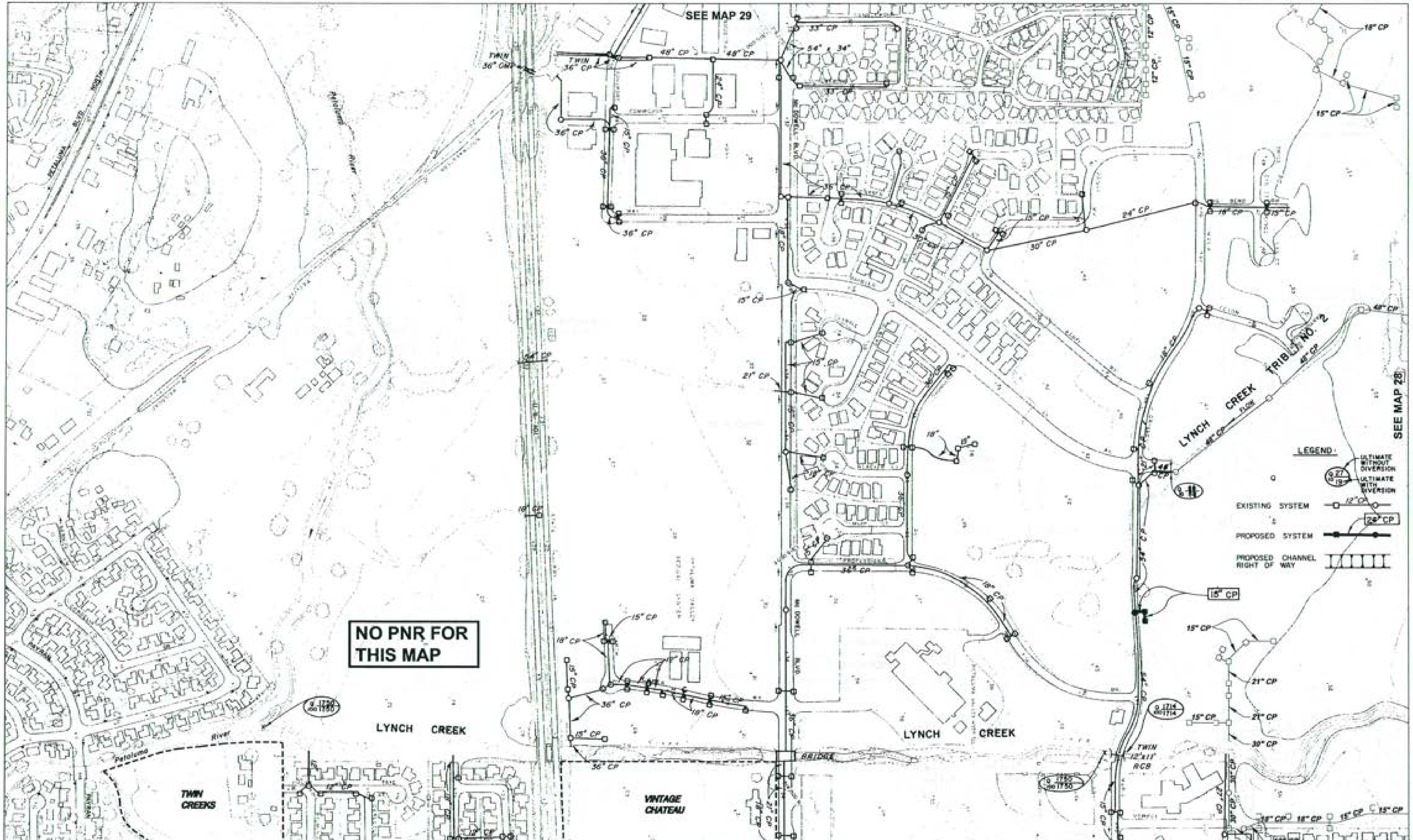
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
WASHINGTON CREEK & LYNCH CREEK

MAP NO. 26

JOB NO. 02224301



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
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1" = 400'

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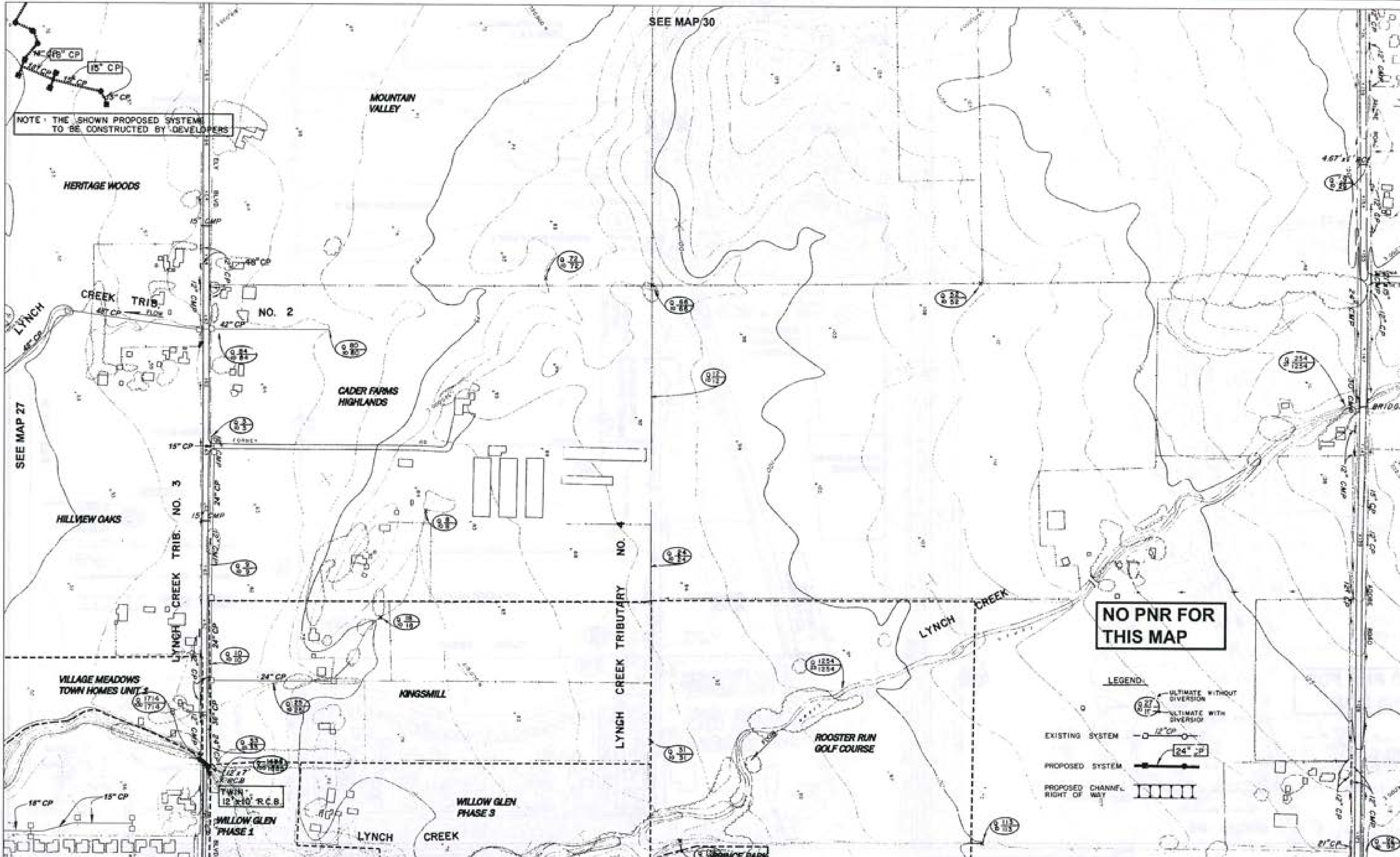
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
LYNCH CREEK &
LYNCH CREEK TRIBUTARY NO. 2

MAP NO. 27
JOB NO. 02234301



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1963
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SEE MAP 26

SCALE 0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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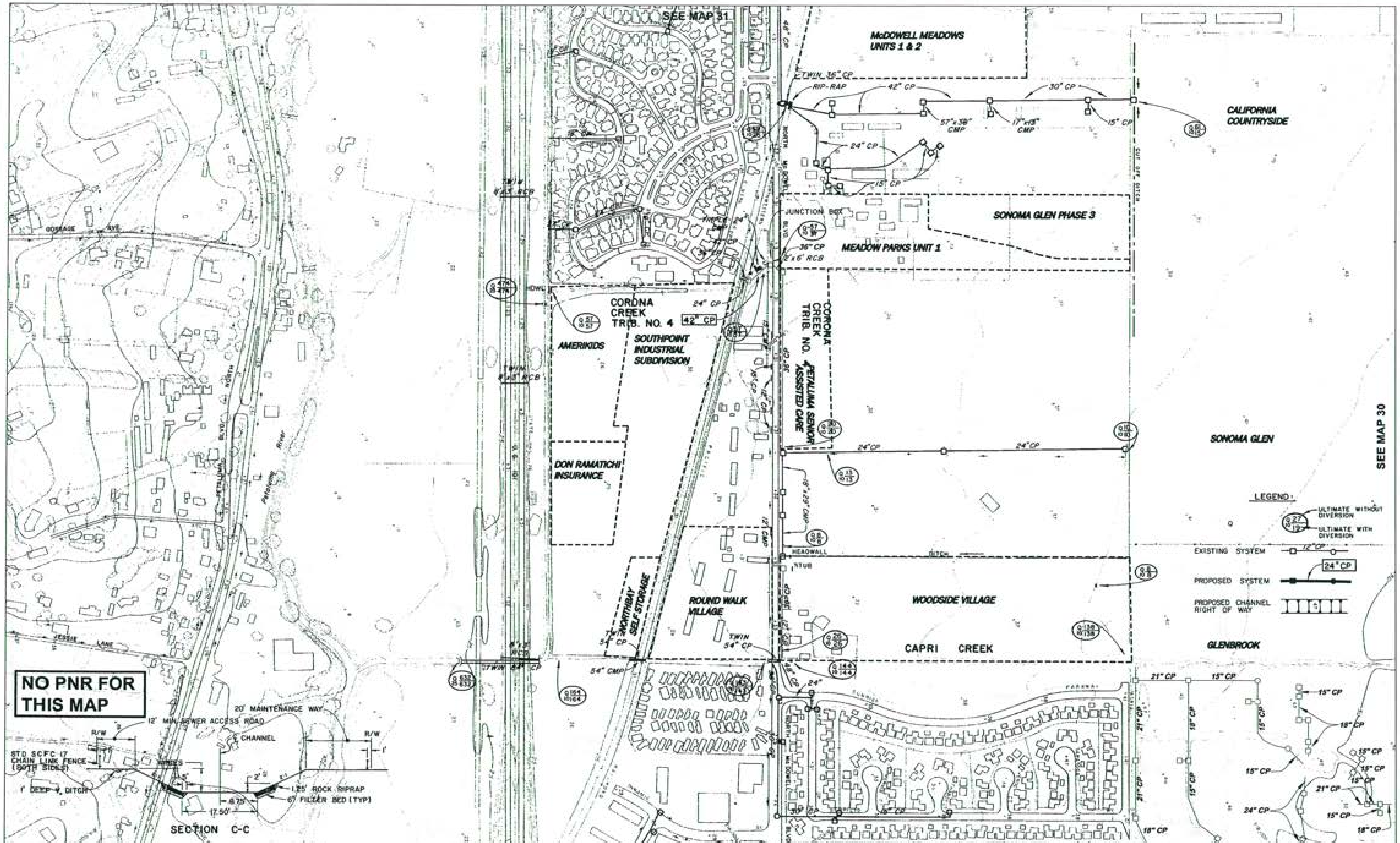
PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN

LYNCH CREEK TRIBUTARY NO. 4

MAP NO. 28



SUBDIVISION BOUNDARY - - - - - -

NOTE:
HORIZONTAL DATUM: CALIFORNIA COORDINATE SYSTEM ZONE 2
VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SEE MAP 27

SCALE 0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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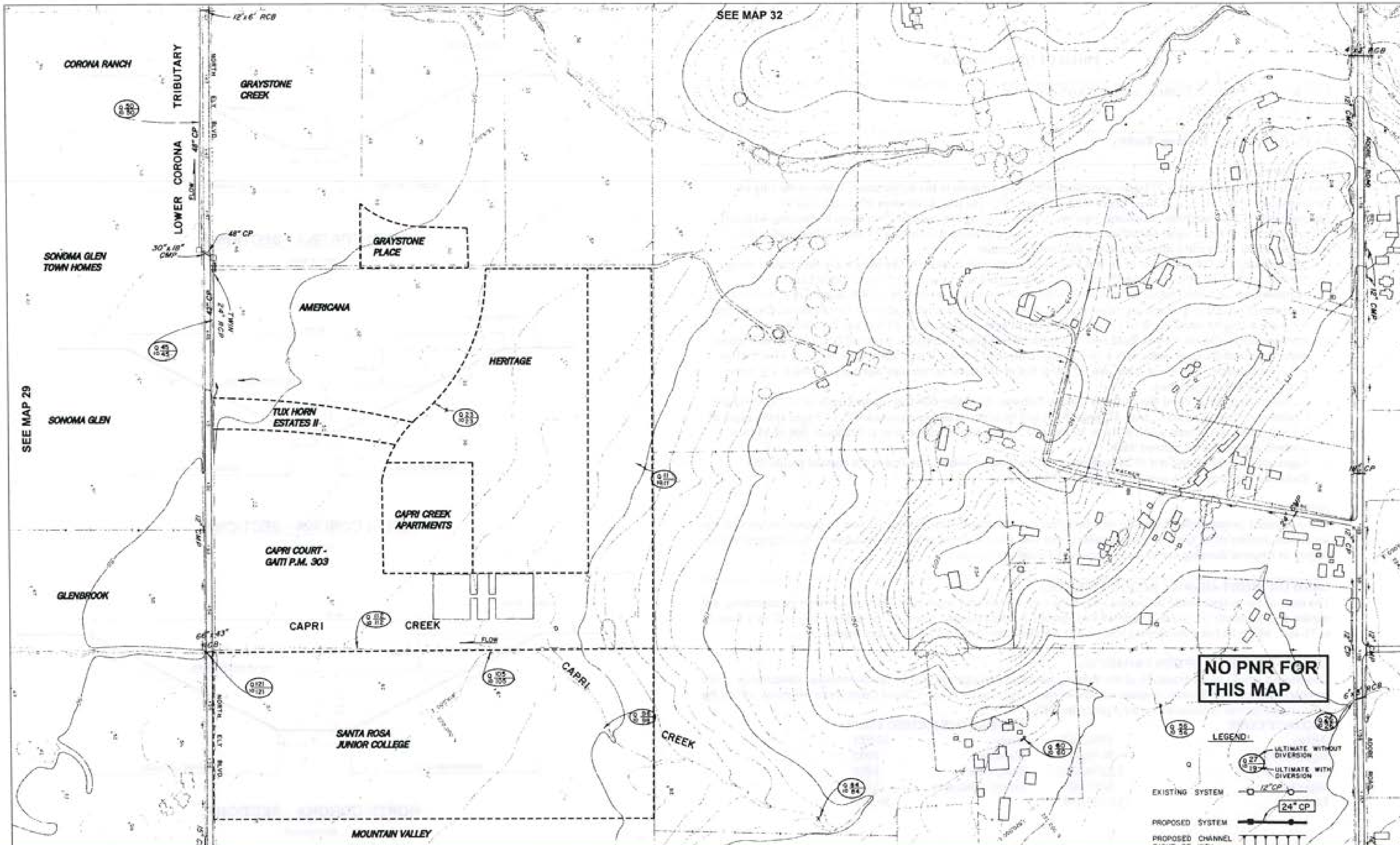
PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN
CAPRI CREEK & CORONA CREEK TRIBUTARY NO. 4

MAP NO. 29



SUBDIVISION BOUNDARY - - - - - -

NOTE:
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VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
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1" = 400'

SONOMA COUNTY WATER AGENCY

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PETALUMA RIVER WATERSHED MASTER DRAINAGE PLAN
CAPRI CREEK & LOWER CORONA TRIBUTARY

MAP NO. 30
JOB NO. 02234301

PROJECT NEEDS REPORT

TITLE: **NORTH CORONA DRAINAGE SYSTEM**
DATE: **June 2003**

CATEGORY: Local Drainage Facility

DESCRIPTION:

This project is located within a 573-acre watershed within and adjacent to the northeasterly limits of the City of Petaluma (See Maps 31, 32 and 33 on pages 4-57, -58, and -59). The project involves the installation of approximately 6,110 lineal feet of concrete pipe storm drain, ranging in size from 24 to 54-inch diameter, widening and revegetation of 4,610 lineal feet of natural channel and appurtenances including 14 inlets, 3 headwall outlets, 4 winged headwall inlets and 2 manholes, at the following locations:

- Approximately 5,110 lineal feet of 36 and 54-inch concrete pipe conduit will be installed in the channel along North Corona Road from North McDowell Blvd. to an upstream headwall inlet near Ormsby Lane.
- Northwesterly of North Corona Road near Ormsby Lane (Section B, page 4-58), 1,870 lineal feet of widened and revegetated natural swale directing flows into the new winged headwall inlet at North Corona Road. The channel will have a 10-year storm depth of 1.9 to 2.8 feet, top of bank width of 16 to 19 feet and 2:1 side slopes.
- Northwesterly of North Corona Road near North McDowell Blvd. (Section A, page 4-57), 1,140 feet of widened and revegetated drainage swale with a 10-year storm depth of 1.5 to 2.0 feet, top of bank width of 14 to 16 feet and 2:1 side slopes. The swale inlets into 80 lineal feet of 36-inch concrete pipe storm drain, which will carry flows under the railroad track.
- Approximately 1,600 lineal feet of North Corona Tributary-1 starting 600 feet southwesterly of N. Ely Road and Christensen Road (Section C, Map 33, page 4-59) will be widened and revegetated with a 10-year storm depth of 2.2 to 2.5 feet, top of bank width of 18 to 19 feet and 2:1 side slopes, connection to 100 lineal feet of 54-inch concrete pipe under the railroad track.
- Approximately 620 lineal feet of 24-inch concrete pipe conduit will be installed in the channel beside Old Redwood Highway North near Willow Brook Bridge.

PURPOSE:

The completed project will be capable of conveying the anticipated flow from a 10-year frequency storm with the watershed developed to General plan densities, and will provide flood protection to adjacent low-lying areas that subject to frequent flooding due to inadequacy of the existing systems.

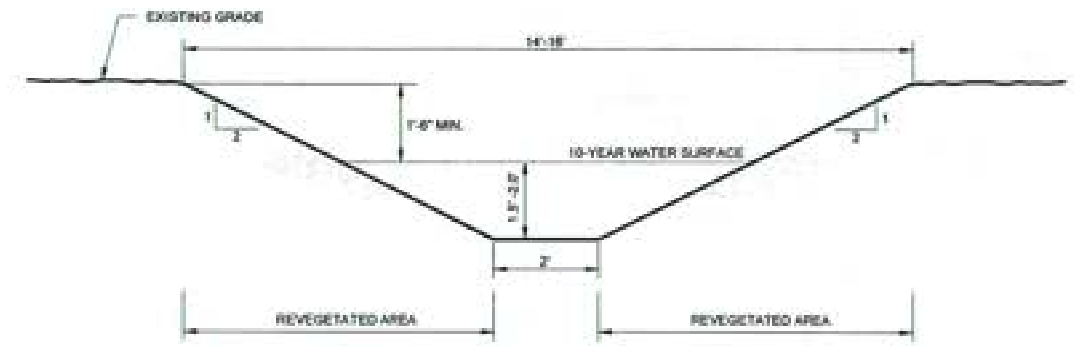
LAND OR RIGHT-OF-WAY REQUIREMENTS:

The most of the project would be located within the City of Petaluma street rights-of-way. Channel enlargements will require approximately 5.2-acres of right-of-way through private property. Width of the right-of-way will vary from 30 to 35-feet, which includes the channel bottom and a buffer zone / access road along the channel.

RELATIONSHIP TO OTHER PROJECTS:

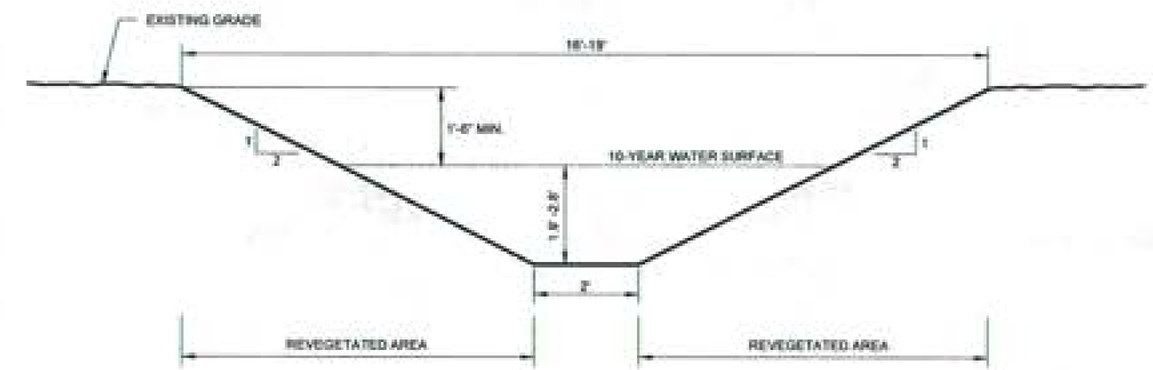
This project would be an extension of the existing adequate drainage systems in developed areas downstream of the proposed project. The 84-inch diameter concrete pipe, which carries North Corona Creek under Highway 101 to the Petaluma River was constructed by the Agency in 1983.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$592,507	Labor	$2,989
Right-of-Way	$190,000	Materials	$200
Construction	$2,370,028	Equipment	$888
Inspection	$237,003	Energy (elec, etc)	$356
Total	$3,389,538		$4,433



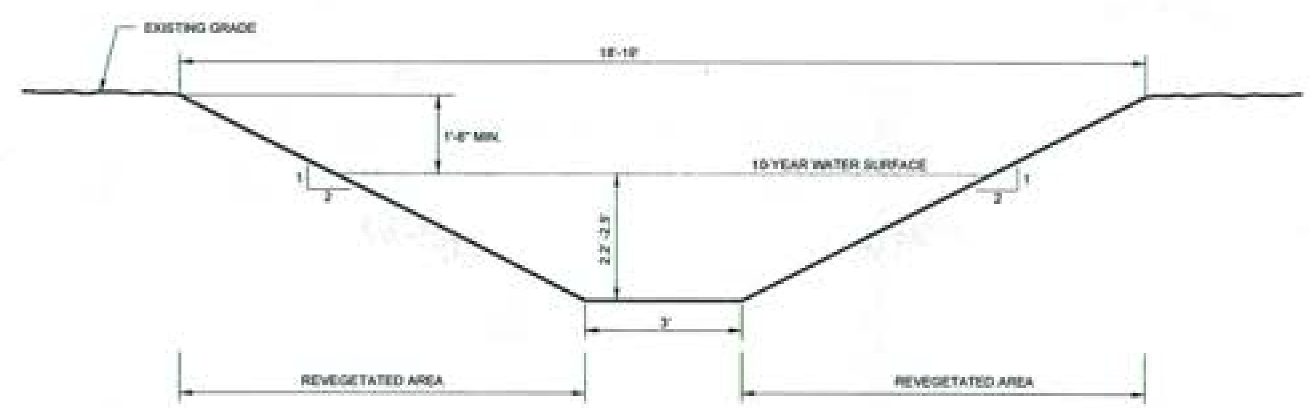
NORTH CORONA - SECTION A

NOT TO SCALE



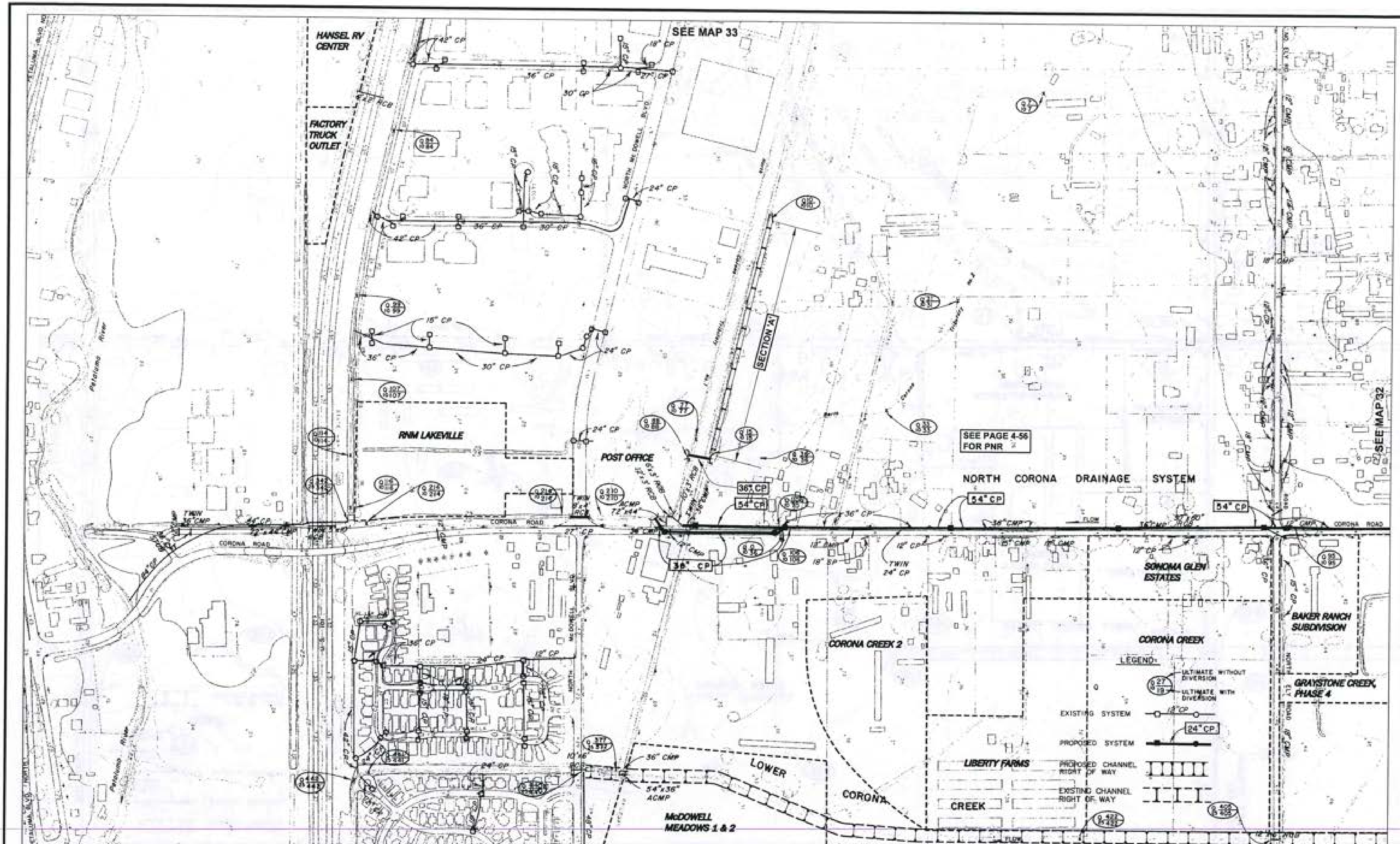
NORTH CORONA - SECTION B

NOT TO SCALE



NORTH CORONA - SECTION C

NOT TO SCALE



SUBDIVISION BOUNDARY - - - - - -

NOTE:
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VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SEE MAP 29

SCALE
0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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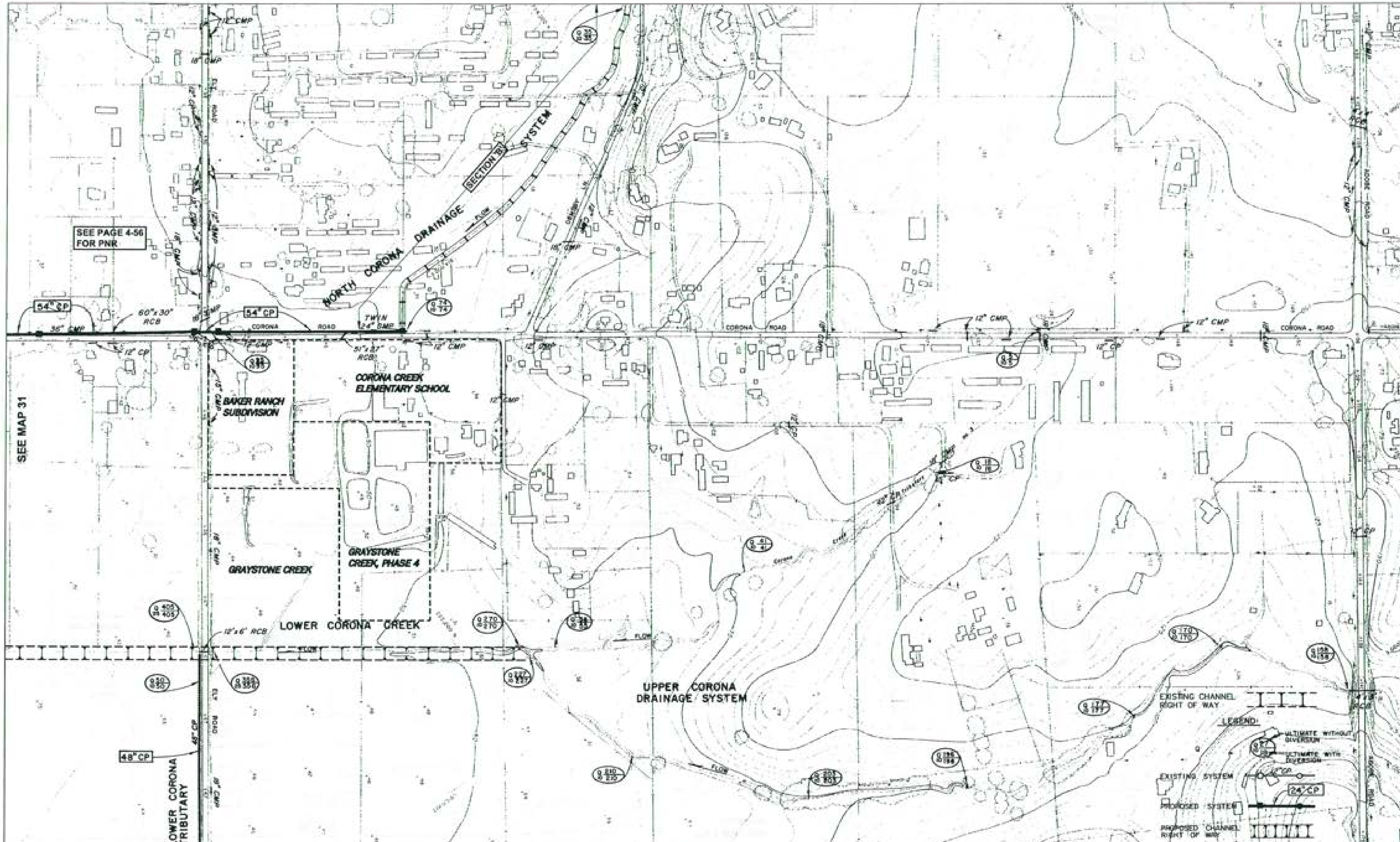
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

NORTH CORONA DRAINAGE SYSTEM

MAP NO. 31



SEE MAP 30

SUBDIVISION BOUNDARY - - - - - -

NOTE:
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DATE OF PHOTOGRAPHY: JAN. 31, 1983
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SCALE
0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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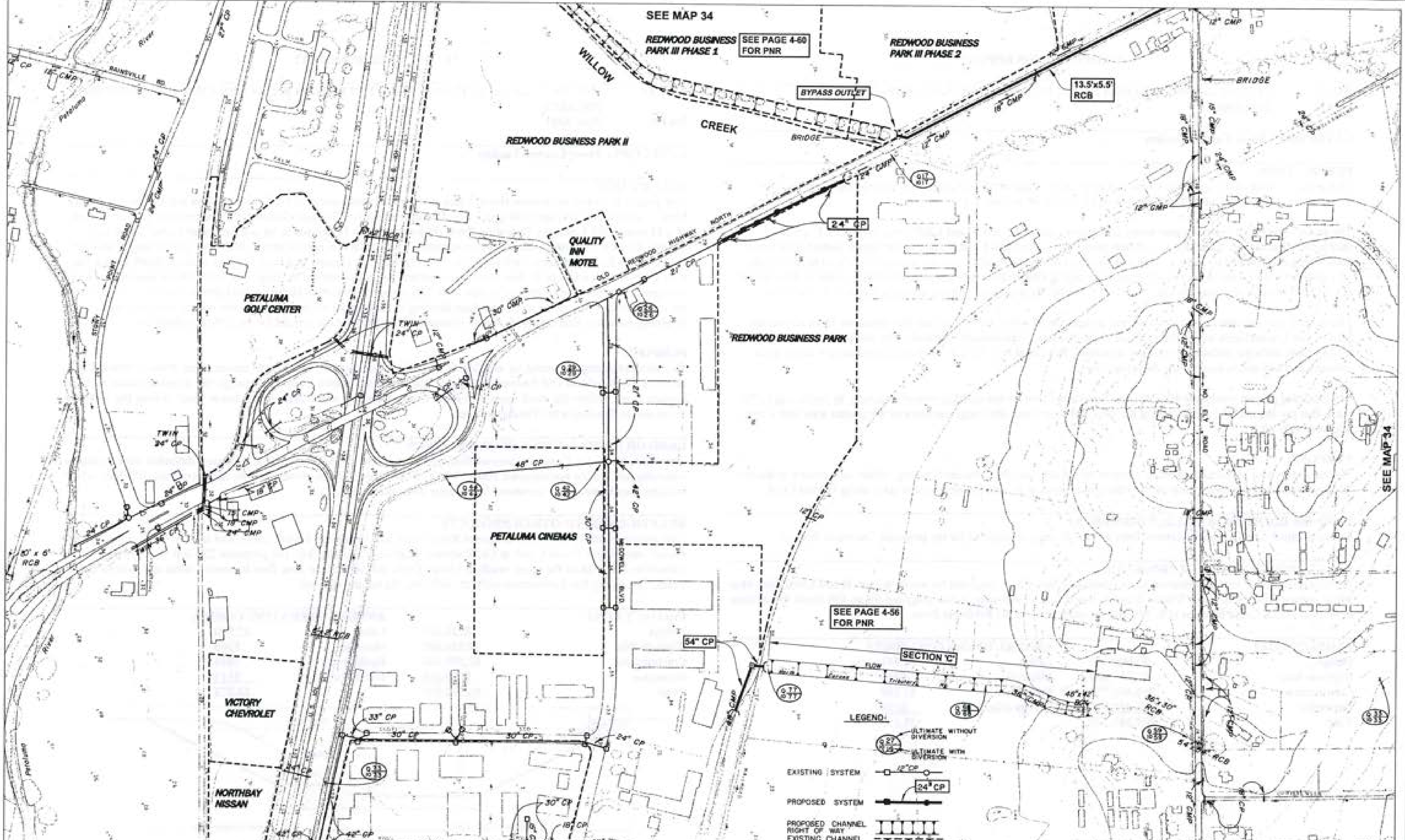
PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

NORTH CORONA DRAINAGE SYSTEM

MAP NO. 32



SUBDIVISION BOUNDARY - - - - - -

NOTE:
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VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
VERTICAL ACCURACY: SPOT ELEVATIONS WITHIN 2.5' OF TRUE ELEVATION; CONTOURS WITHIN ONE CONTOUR OF TRUE ELEVATION

SCALE
0 400' 800'
1" = 400'

SONOMA COUNTY WATER AGENCY

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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN
NORTH CORONA &
NORTH CORONA TRIBUTARY NO. 1
DRAINAGE SYSTEMS

MAP NO.
33
JOB NO. 02224301

TITLE: LICHAU CREEK ALTERNATIVE 1: DETENTION BASIN & BYPASS PROJECT
DATE: June 2003

CATEGORY: Flood Control Facility

DESCRIPTION:
This project is located along Lichau Creek and extends from just north of Adobe Road through the community of Penngrove to the confluence with Willow Brook (See Map 34 on page 4-61).

The project involves a culvert bypass using 2,590 lineal feet of 10' x 5.5' and 6,020 lineal feet of 13.5' x 5.5' reinforced concrete box storm drain, with two inlets; one at the Main Street Bridge in Penngrove (which bypasses 400 cubic-feet per second [cfs]) and the other just upstream of Adobe Road (which bypasses 700 cfs for a total of 1,100 cfs bypassed from Lichau creek). The bypass is located in Old Redwood Highway and discharges into Willow Brook at the Old Redwood Highway Bridge. A parallel 10' x 10' RCB culvert crossing at Adobe Road is also required.

This project also includes the construction and installation of a 48.6 acre / 238 acre-foot detention basin (Detention Basin 2) on Lichau Creek near Roberts Creek. Appurtenances will include headwall outlet and inlet structure(s) for the bypasses and inlet, outlet and overflow structures, 964-lineal foot 23' x 5' reinforced concrete box storm drain inlet channel and access road for the detention basin.

The proposed project would provide 100-year flood protection for the existing natural waterway by bypassing 1,100 cubic-feet per second (cfs) and detaining the 100-year storm peak discharge upstream of the project area with a peak release of 509 cfs.

PURPOSE:
The culvert bypass and detention basin projects would alleviate the frequent flooding, which now occurs in the low-lying residential and business areas of the Penngrove community, and the agricultural lands along Lichau Creek.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
The acquisition of a 48.6-acre easement from private property is required for the proposed Detention Basin 2.

RELATIONSHIP TO OTHER PROJECTS:
An additional 202.5 Acre-ft. detention basin (Detention Basin 1) is proposed for lower Willow Brook Creek (See Map 34) to reduce flooding in lower Willow Brook Creek. Channel widening is also proposed for an 800 lineal foot section of Willow Brook Creek between U.S. 101 and the confluence of the Petaluma River.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$3,600,693	Labor	$3,341
Right-of-Way	$2,445,000	Materials	$414
Construction	$14,402,772	Equipment	$1,039
Inspection	$1,440,742	Energy (elec, etc)	$558
Total	$21,889,207		$5,352

TITLE: WILLOW BROOK ALTERNATIVE 1: DETENTION BASIN AND CHANNEL WIDENING PROJECT
DATE: June 2003

CATEGORY: Flood Control Facility

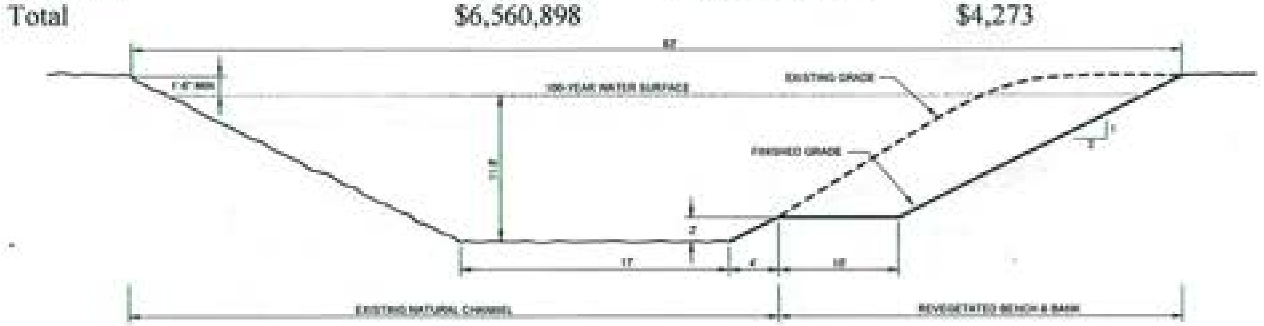
DESCRIPTION:
This project is located on Willow Brook Creek between the confluences of the Petaluma River and Lichau Creek (See Map 16 and Map 34 on page 4-38 and 4-61). The project involves 2 major elements: the construction and installation of a 51-Acre / 202.5 Acre-Ft. Detention Basin (Detention Basin 1), located at the confluence of Lichau Creek with Willow Brook Creek and a widened and revegetated channel section approximately 800 lineal feet in length between the Petaluma River confluence and Highway 101. The widened channel will have a 100-year storm depth of 11.6 feet with a top of bank width of 83 feet and 2:1 side slopes. Appurtenances of the detention basin will include inlet, outlet, emergency overflow structures and access road. The proposed Detention Basin 1 would reduce the water surface in the downstream widened section and reduce flooding in most of the existing downstream natural waterway by detaining the storm discharge with a peak release of 421 cubic-feet per second for the 100-year storm event.

PURPOSE:
The completed project would be capable of reducing flood waters, which now escape from Willow Brook Creek between Ely Road and Old Redwood Highway and flow over public roads and through the industrial lands north of Corona Road. Below the confluence of Lichau Creek, flooding will remain in the lower reach during the 100-year storm due to flooding in the Petaluma River.

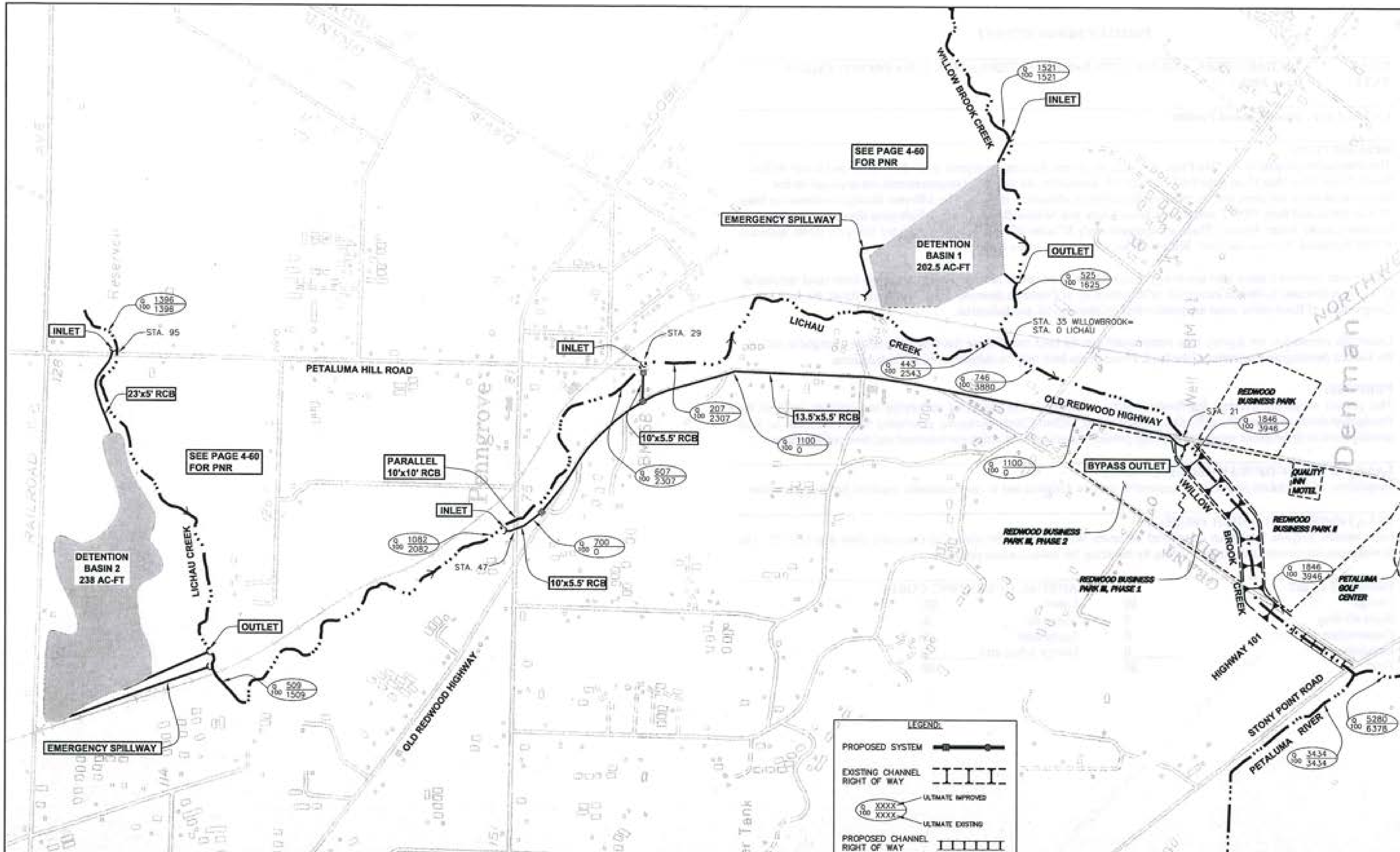
LAND OR RIGHT-OF-WAY REQUIREMENTS:
The acquisition of a 53-acre easement from private property is required for the proposed detention basin, channel widening and related maintenance roads. Width of the channel right-of-way will be approximately 100 feet, which includes the channel and a combined buffer zone with access road.

RELATIONSHIP TO OTHER PROJECTS:
This project is downstream of a proposed 8,610 lineal feet bypass on Lichau Creek that outlets 1,100 cubic-feet per second into Willow Brook Creek at Old Redwood Highway (See Map 34). The proposed 238 acre-feet detention basin (Detention Basin 2) on the upper reach of Lichau Creek will reduce the peak flow in lower Lichau and Willow Brook Creeks, providing flood protection without modifying the natural channel.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$724,240	Labor	$2,910
Right-of-Way	$2,650,000	Materials	$360
Construction	$2,898,962	Equipment	$888
Inspection	$289,696	Energy (elec, etc)	$115
Total	$6,560,898		$4,273



WILLOW BROOK CREEK CHANNEL SECTION
NOT TO SCALE



* REFER TO TECH MEMO DATED 7-02-03 IN DESIGN NOTEBOOK FOR ANALYSIS OF DETENTION BASINS AND CHANNEL FLOW ROUTINGS

SUBDIVISION BOUNDARY - - - - - -

NOTE:
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VERTICAL DATUM: U.S.N.G.S. MEAN SEA LEVEL OF 1929
DATE OF PHOTOGRAPHY: JAN. 31, 1983
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SCALE
0 1000' 2000'
1" = 1000'

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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

LICHAU CREEK & WILLOW BROOK
ALTERNATIVE 1

MAP NO. 34

PROJECT NEEDS REPORT

TITLE: LICHAU CREEK AND WILLOW BROOK ALTERNATIVE 2: NO IMPROVEMENT
DATE: June 2003

CATEGORY: Flood Control Facility

DESCRIPTION:
This alternative consists of the "No Project" option to address flooding problems on Lichau Creek and lower Willow Brook Creek (See Map 35 on page 4-63). Under this alternative, no structural improvements are imposed on the natural sections of the creek and the existing floodplain is allowed to remain. The 100-year floodplain shown on Map 35 was delineated from HEC-2 models of Lichau Creek and Willow Brook Creek, which were developed by the Sonoma County Water Agency. There are approximately 57 acres of land flooded during the 100-year storm upstream of Old Redwood Highway on lower Willow Brook Creek and Lichau Creek.

The current Sonoma County land use designations for the flood-prone areas in Penngrove range from rural residential (2-3 acre minimum) to limited industrial. Within the City of Petaluma downstream of North Ely Road, the land use designations of flood-prone areas are predominately commercial and industrial.

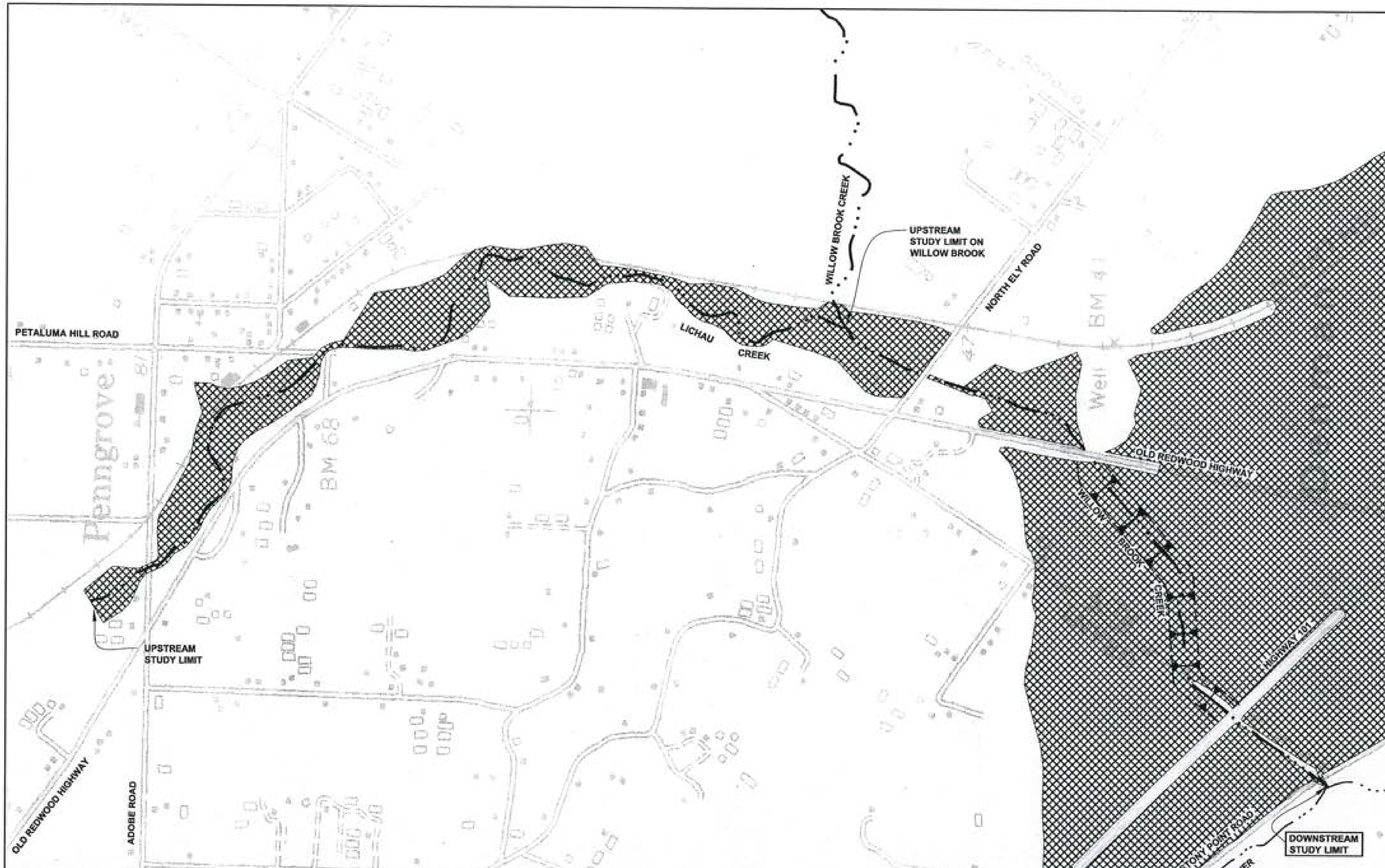
Under this alternative, the Agency may recommend that the land use of these flood-prone areas be changed to reflect the limited development potential of the land. Flood-prone land may be subject to FEMA regulations.

PURPOSE:
This project would not alleviate the flooding that now occurs in the low-lying residential and business areas of the Penngrove community and the agricultural lands along Lichau Creek. However, provisions would be made to limit development in flood-prone areas and possibly provide an enhanced riparian environment and new public access.

LAND OR RIGHT-OF-WAY REQUIREMENTS:
Acquisition of floodplain properties or easements may be desirable but is not necessarily required for this alternative.

RELATIONSHIP TO OTHER PROJECTS:
Improvement projects have been completed on lower Willow Brook between Old Redwood Hwy and US 101. The downstream improvements reduce flooding by lowering the water surface upstream.

PROJECT COST		ANNUAL OPERATING COSTS	
Design	$0	Labor	$0.
Right-of-Way	0	Materials	0.
Construction	0	Equipment	0.
Inspection	0	Energy (elec, etc)	0.
Total	$0		$0.



LEGEND:

EXISTING CHANNEL RIGHT OF WAY

ESTIMATED 100-YEAR FLOOD PLAIN

SCALE
0 700' 1400'
1" = 700'

SONOMA COUNTY WATER AGENCY

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PETALUMA RIVER WATERSHED
MASTER DRAINAGE PLAN

LICHAU CREEK & WILLOW BROOK
ALTERNATIVE 2 (NO STRUCTURAL IMPROVEMENTS)

MAP NO.
35
JOB NO.

SECTION 5
FLOOD CONTROL FINANCING

FLOOD CONTROL FINANCING

The agency collects revenues in the form of property taxes, flat charges, interest on holdings, and intergovernmental revenues. The Agency has the power to levy taxes within the Zone 2A boundaries. The Agency formerly funded its activities from property taxes. Prior to the passage of Proposition 13, the Agency could levy a tax of up to $0.25 per $100 of assessed valuation. After the damaging floods of 1986, Zone 2A voters approved a 10-year, $15/unit assessment to fund flood control activities. In 1996, this assessment was extended for an additional 10 years, through 2006, at a rate of $10/unit. The Agency currently levies this assessment and also receives a portion of County taxes. These monies fund ongoing Zone 2A operating costs and capital expenditures. After 2006, the approximately $330,000 that Zone 2A receives annually in flat charges will be eliminated if the assessment is not renewed. The Agency's revenues and expenses are summarized in Table 5-1.

The Agency's current funding plan is based on a "pay as you go" philosophy. Under this system, a capital project is paid for in cash after a sufficient amount of revenue has been accumulated to fully fund the project. Large capital projects may be saved for by funding a low level of capital projects over the preceding years. As a result, the Agency's annual cash flows can vary dramatically, as shown in Table 5-1.

Table 5-1. Petaluma River Watershed Zone 2A Summary of Revenues and Expenses

	FY 97/98	FY98/99	FY99/00	FY00/01	FY01/02
Revenues					
Property Taxes	622,124	661,195	727,449	792,350	1,052,524
Flat Charges	487,810	160,582	335,591	337,716	350,984
Other Taxes/Admin	(15,446)	(18,067)	(16,081)	(15,338)	(178,074)
Interest	311,715	363,308	354,821	260,106	204,488
Intergovernmental	14,825	15,058	15,627	15,884	16,706
Other	0	0	221,973	0	0
Total Revenues:	**1,421,028**	**1,182,076**	**1,639,380**	**1,390,718**	**1,446,628**
Expenses					
Operating	342,455	106,463	121,697	150,917	292,213
Capital	17,857	76,195	4,870,489	116,775	1,235,528
Other	11,090	8,480	0	0	0
Total Expenses	**371,402**	**191,138**	**4,992,186**	**267,692**	**1,527,741**
Net Cash Flow	**1,049,626**	**990,938**	**(3,352,806)**	**1,123,026**	**(81,113)**

The assessment unit referenced above is a measure of the amount of runoff flowing from a given parcel. A runoff factor is calculated based on area of permeable and impermeable surfaces on a parcel. Examples of permeable surfaces include landscaping and agriculture, while improved land with roofed buildings and pavement is impermeable. Based on the runoff factor and the acreage of the parcel, a benefit assessment unit is calculated. The metric is indexed such that a typical residential lot of area 0.22 acres and with a runoff factor of 0.23 produces a benefit assessment unit of 1.00.

Funding Sources

Several funding sources are available to the Agency in creating a feasible financing plan for the capital program outlined above. This discussion begins with a brief history of funding for flood control facilities in California and a discussion of Proposition 218, now Articles 13 C and D of the California Constitution, the most recent legislative action to impact flood control funding.

History of Flood Control Facilities Funding

Historically storm or flood control and sanitary sewer facilities were combined both physically and operationally. In many large and older cities they are still combined. These combined systems were usually funded from property tax revenues. In the more recent past, with the passage in 1972 of PL 92-500, separate sanitary sewer enterprises were organized by cities to obtain state and federal grants. The grant program was intended mainly for wastewater treatment and service charges were required to qualify for grants. A public enterprise is essentially a self-supporting service.

California's Proposition 13 in 1978 effectively eliminated property taxes as a revenue source for city services. Without an alternative revenue source, property tax revenues were limited and cities and other public agencies reserved property tax support for their general services. Storm sewer or flood control operations generally continued with general fund support. Some cities, however, did create separate flood control enterprises funded by user charges. In addition, public agencies that were responsible for both flood control and sanitary sewer functions continued with a combined enterprise.

Proposition 218 and Storm or Flood Control Charges

In November 1996, California voters passed Proposition 218 "The Right to Vote on Taxes Initiative". While the initiative was aimed at assessment districts, it also included ambiguous language on user charges. The original Proposition 218 language is now a part of the California Constitution in Articles 13 C and D. While clean-up language has addressed some ambiguity, the problems of storm or floodwater have yet to be fully clarified.

Under Proposition 218, a property related fee is required to reflect the cost of service. Additional procedural requirements for property related fees include a public hearing and a 45-day notification period prior to the change or imposition of a property related fee. The voting requirements dictate voter approval to establish or increase a property related fee. Local governments must hold a hearing at least 45 days after the mailing of notification of the establishment or increase of a property related fee. If a majority of affected property owners presents written protests to the proposed fee, it is rejected. If a majority does not protest, then the local government must hold an election to be decided by a majority of property owners or two-thirds of the electorate.

Proposition 218 significantly impacted the ability of public agencies to levy charges for storm or floodwater management purposes. Under Proposition 218, charges for storm water are generally considered "property-related" fees, which must be approved through a mailed ballot procedure. Approval requires a two-thirds majority.

Existing charges that are not being increased are not covered under Proposition 218. Most storm water charges currently in effect have not been increased since Proposition 218. Certain public agencies that have increased their charges believe that they can defend their charge either as a sewer charge under the Prop 218 exclusion or as simply being non-property related. At this time, we know of no organized efforts to lobby the legislature for relief or clarification of storm water's position under Proposition 218. The League of Cities believes that such an effort would be best led by the cities, agencies, and other groups who backed the Clean Water Act.

Options for Flood Control Funding Grants

A variety of state and federal agencies provide grants and other assistance to local agencies for the purposes of construction and maintenance of flood control facilities. Each of these entities is listed here, with a brief description of the program or programs that provide relevant assistance. In considering the possibility of funding flood control programs through state or federal assistance programs, it should be noted that the pool of grant money is often severely limited and competition is intense. Therefore, grants or other such assistance from these agencies should not be counted on in supporting a capital improvements program, and rather should be viewed as a possible supplement to an already complete and adequate funding program.

U.S. Natural Resources Conservation Service

The US Natural Resources Conservation Service (NRCS) maintains several programs to assist agencies in flood control activities. The Petaluma Service Center of the NRCS can be reached at (707) 664-8593. The Service offers both financial and technical assistance in the surveying, planning, and construction stages of a project through the following programs:

- Watershed Rehabilitation Program: The Small Watershed Rehabilitation Amendments of 2000 authorizes the NRCS to work with local community leaders and watershed project sponsors to address public health and safety concerns and environmental impacts of aging dams. This program provides 65% federal cost-share for activities that extend the service life of the dam, but may include associated projects to reduce the hazard level of the dam.

- Emergency Watershed Protection: The purpose of the Emergency Watershed Protection program is to undertake emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed. Up to 75% cost sharing is available.

- Small Watershed Program, Flood Prevention Program, and Watershed Surveys and Planning Program: The purpose of the Small Watershed Program, including River Basin operations, is to assist agencies in protecting watersheds from damage caused by erosion, floodwater, and sediment, to conserve and develop water and land resources, and solve natural resource and related economic problems on a watershed basis. Types of surveys and plans include watershed plans, river basin surveys and studies, flood hazard analyses, and flood plain management assistance. The focus of these plans is to identify solutions that use land treatment and nonstructural measures to solve resource problems. After approval, technical and financial assistance can be provided for installation of works of improvement specified in the plans. Projects of up to $5 million can be approved administratively; these programs have together funded over 1,600 projects.

U.S. Department of Housing and Urban Development

The U.S. Department of Housing and Urban Development (HUD) provides assistance under three separate programs for which certain flood control projects may qualify. Local HUD contacts are Patricia Fruiht at (707) 543-3023 (City of Santa Rosa) and Janie Walsh at (707) 565-7504 (County of Sonoma). The three relevant programs administered by the HUD are:

- The HUD's Community Planning and Development department provides Neighborhood Initiatives Grants for neighborhood revitalization and grant money for a wide variety of community and housing activities, specifically including improvement of distressed areas.

- The Community Development Block Grant program awards grants to community grantees to carry out a wide range of community development activities directed toward revitalizing neighborhoods, economic development, and providing improved community facilities and services.

- The Rural Housing and Economic Development program allows for grant money to be spent on capacity building or support for innovative housing and economic development activities. Construction of infrastructure is allowed

U.S. Army Corps of Engineers

The Army Corps of Engineers builds projects and advises communities on mitigating the effects of floods. Currently, the Corps is involved in two projects in the Petaluma River Watershed: maintenance dredging of San Pablo Bay and the Petaluma River, scheduled for FY 2003-05, and several improvements of a 3,500 foot stretch of the Petaluma River including bridges and channels, and is being cost-shared 65% with the Corps and 35% with the local sponsor. The San Francisco district, of which the County of Sonoma is a part, can be contacted through Frank Conway, CESPN-IM-I, at (415) 977-8601.

California Department of Water Resources

The California Department of Water Resources' Flood Control Project Subvention Program provides funding assistance for flood control projects initiated through a federal agency. The state will reimburse 50% to 70% of local costs associated with a federal flood control project. In addition, approximately $30 million remains available from proposition 13 funds to be distributed through the Flood Protection Corridor Program (FPCP), primarily for nonstructural flood management programs that include wildlife habitat enhancement and/or agricultural land preservation. The Department also manages the Urban Streams Restoration Program, which assists communities in reducing the risks of flooding while restoring the environmental and aesthetic values of streams. This program is funded through propositions 13 and 40. The FPCP has a grant cap of $5 million per project, and expresses a preference for smaller projects with greater financial participation of the local agency.

Voted Options

Formation of a Flood Control Assessments

Benefit assessment districts and assessment districts can be used to fund flood control operation and maintenance and capital projects. The voting and public hearing requirements of Proposition 218 have made the differences between a benefit assessment district and assessment district essentially negligible. Under Proposition 218, assessments can only be levied for special benefit, which must be demonstrated in an engineer's report. Other specific requirements are detailed in the Articles 13 C and D of the California Constitution.

If special benefit can be demonstrated, a special benefit assessment can be approved unless there is a 50 percent majority voter protest, weighted based on a property's assessment. Assessment bonds for capital costs would be sold based on the revenues from an assessment.

The Agency's current assessment was approved in 1996, prior to the implementation of Proposition 218. The current assessment expires in 2006 and can only be extended with voter approval.

Because of the difficulty of separating general benefit from special benefit (general enhancement of property value does not constitute special benefit under Proposition 218), assessments are not in common use as a new funding source.

Proposition 218 Storm Water Property Fee, Special Tax

In order to impose a storm water property fee or special tax under Proposition 218, an agency would hold a hearing at least 45 days after the mailing of notification of the establishment of the fee or tax. If a majority of affected property owners submitted written protests to the proposed fee, it would be rejected. If a majority did not protest, then the agency would hold an election on the imposition of the fee or tax to be decided by a majority of property owners or two-thirds of the electorate. A property fee or tax would be required to reflect the cost of the service provided.

Sales Tax Funding

Funding via a sales tax similar to Napa County's Measure "N" passed in 1998 is another voted option. Napa County passed a one-half of one percent transactions and use tax titled the "Flood Protection Sales Tax." The County established a Flood Protection and Watershed Improvement Expenditure Plan describing the projects authorized to be funded with the proceeds of the Flood Protection Sales Tax. Authorization of a sales tax surcharge requires a two-thirds voter approval.

Creation of a Flood Control Funding Charge That Builds in Beneficiaries

This option would be a voted charge or assessment which creates consensus for a positive vote by building a block of beneficiaries over whom costs can be levied and or support can be gained including: environmental concerns, habitat restoration, recreation facilities, streets, and bike paths. This effort would require a complex, coordinated effort to build consensus between different advocacy groups on the elements of such a plan. This is not so much a solution in itself but rather an option for helping to implement the three voted options discussed above.

General Obligation (GO) Bond

A 20 or 30 year GO bond could be voted to pay for some or all of the capital improvements recommended in the flood control master plan. This would require a two-thirds vote of the public (meets requirements of Prop 218). A GO bond could only be used to fund capital costs. Only projects whose lives are greater than the term of the financing can be funded using bonds.

Other voted bond options including revenue bonds would require similar voter approval. The security for non-GO bonds would be Zone 2A revenues. Any voted option would require substantial lead time in order to mount a successful public education campaign in order to secure support.

Mello-Roos Community Facilities District

The Mello-Roos Community Facilities Act of 1982 provides for the financing of a broad range of public facilities and certain specific services. The Mello-Roos Act provides for voter approval of a special tax and issuance of bonds secured by that tax. The measure to authorize a special tax and/or bonds must be approved by a two-thirds vote of the qualified (which meets requirements of Prop 218) electors in the community facilities district (CFD). Qualified electors are registered voters or, if there are fewer than 12 registered voters in the CFD, landowners based on one vote per acre. Most Mello-Roos districts are created for developers to fund improvements to serve a specific development.

Non-Voted Options

Levy of a Flood Control Impact Fee on New Development

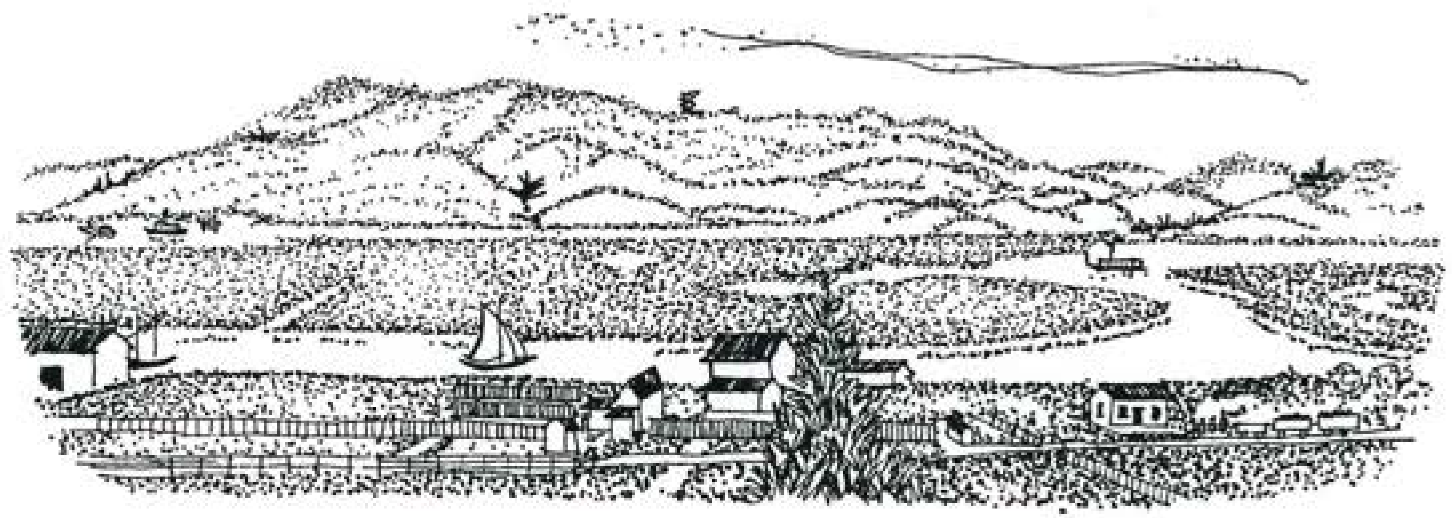
This would allow the Agency to recover the portion of the capital program allocable to new development. This would not allow the Agency to recover capital costs allocable to existing properties or on-going maintenance costs. Among other options, the Agency could adopt this type of fee under the Subdivision Map Act.

Formation of a Flood Control Utility Enterprise

This would essentially create a flood control enterprise under the sewer exclusion of Proposition 218. It is unclear whether Proposition 218 would apply to a properly crafted storm water or storm sewer enterprise fee. The California Supreme Court determined that only fees imposed directly on property or on property owners are subject to Proposition 218. (See *Apartment Assoc. of Los Angeles County, Inc. v. City of Los Angeles* (2001) 24 Cal.4th 830.) Since a storm water enterprise fee is based on each user's contribution of storm water to the storm system in excess of property in its natural state, it would seem that such fees are not imposed on property owners as property owners and therefore are not "property-related fees." However, in *Howard Jarvis Taxpayers Association v. City of Salinas* (2002) 98 Cal.App.4th 1351, a court of appeals determined that Salinas's storm drain user fee was subject to Proposition 218, because in the court's view the fee was based on the physical characteristics of property and therefore was a property-related fee. Many local-government attorneys argue that *Salinas* is inconsistent with the Supreme Court's decision in *Apartment Association* and believe that a properly crafted storm water enterprise fee could withstand a Proposition 218 challenge. Working in co-operation with the City of Petaluma may be advantageous because Zone 2A overlaps areas within the City boundaries and it would allow the Agency to pool resources in crafting the fee.

Using Bond Funding to Leverage Zone 2A Capital Funds

The Agency could sell Certificates of Participation or other non-voted debt to leverage its existing funding capabilities. For example, an annual debt service of $500,000 over 20 years, could allow the construction of approximately $6 million of capital projects. As shown in Table 5-1, Zone 2A's operating costs have been, on average, under $300,000 annually. If Zone 2A were to incur an annual debt service payment of $500,000, total annual costs of $800,000 could be met by property tax receipts alone even if the flat charge assessment were not renewed.



SECTION 6
ENVIRONMENTAL ASSESSMENT & NPDES REQUIREMENTS

Environmental Assessment & NPDES Requirements

As stated in the Foreword, this Master Plan of Drainage has been prepared to identify the most significant areas of flooding along the Petaluma River and its tributaries and to identify projects which might be implemented to alleviate such flooding. It is intended for use as a planning guideline and to provide a basis for possible future flood control and drainage projects.

The California Environmental Quality Act guidelines prescribe the following:

"15262. FEASIBILITY AND PLANNING STUDIES. A project involving only feasibility or planning studies for possible future actions which the agency, board, or commission has not approved, adopted, or funded does not require the preparation of an EIR or negative declaration but does require consideration of environmental factors…"

Accordingly, the following environmental checklist has been prepared to identify environmental factors which might be impacted by implementation of the proposals contained in this report and to identify sections of this report where environmental considerations have been discussed. This section was updated in 2003 to reflect current CEQA requirements and the new National Pollutant Discharge Elimination System (NPDES) Phase II regulations, effective March 2003.

At the time specific projects are to be considered for funding or approval, an environmental assessment and appropriate environmental document should be prepared for such project(s) under CEQA. The checklist is intended only provide a discussion of the anticipated environmental impacts of implementing the Master Drainage Plan. Project specific impacts may be vary notably from those provided in this discussion.

The 1989 Sonoma County General Plan and the 1987 Petaluma General Plan provided the basis for this analysis. Both plans are currently being updated. As such, additional impacts and policies may be identified. This could alter the discussion provided within this document.

Evaluation of Environmental Impacts

This section identifies a preliminary list of the environmental impacts that could occur with implementation of the Master Drainage Plan Update. To identify impacts, this section addresses those items listed in Appendix G of the CEQA Guidelines, the Environmental Checklist Form. The environmental issues evaluated in this section include:

- Aesthetics
- Agricultural Resources
- Air Quality
- Biological Resources
- Cultural Resources
- Geology and Soils
- Hazards and Hazardous Materials
- Hydrology and Water Quality
- Land Use Planning
- Mineral and Energy Resources
- Noise
- Population and Housing
- Public Services
- Recreation
- Transportation
- Utilities and Service Systems
- Mandatory Findings of Significance

This preliminary analysis accounts for the entire action involved, including off-site as well as on-site impacts, cumulative as well as project-level impacts, indirect as well as direct impacts and construction as well as operational impacts. Impacts are categorized as follows:

Potentially Significant Impact is appropriate if there is substantial evidence that an effect is significant, or where an established threshold has been exceeded. If there are one or more "Potentially Significant Impact" entries when the determination is made, an environmental impact report (EIR) may be required.

Less Than Significant with Mitigation Incorporated applies where the incorporation of mitigation measures would reduce an effect from Potentially Significant Impact to a Less Than Significant Impact. Mitigation measures are prescribed to reduce the effect to a less than significant level. Measures from earlier analyses may be cross-referenced.

Less Than Significant applies when the project will affect or is affected by the environment, but based on sources cited in the report, the impact will not have an adverse affect. For the purpose of this report, beneficial impacts are also identified as less than significant. The benefit is identified in Discussion of Impacts, which follows each checklist category.

A **No Impact** answer is adequately supported if the referenced information sources show that the impact simply does not apply to projects like the one involved (e.g., the project falls outside a fault rupture zone). A No Impact answer is explained where it is based on project-specific factors as well as general standards (e.g., the project will not expose sensitive receptors to pollutants, based on a project-specific screening analysis).

Earlier analyses may be used where, pursuant to the CEQA process, an effect has been adequately analyzed in an earlier EIR or negative declaration. Wherever possible, references to information sources for potential impacts (e.g., general plans, zoning ordinances) are incorporated into the analysis.

Environmental Checklist and Explanatory Notes

I. AESTHETICS - Would the project:	**Potentially Significant**	**Less Than Significant With Mitigation**	**Less Than Significant**	**No Impact**
a) Have an adverse effect on a scenic vista?	☐	☑	☐	☐
b) Damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☑	☐	☐	☐
c) Degrade the existing visual character or quality of the site and its surroundings?	☑	☐	☐	☐
d) Create a new source of light or glare that would adversely affect day or nighttime views in the area?	☐	☑	☐	☐

As shown in Figure OS-2 of the Sonoma County General Plan (1998), large portions of the Petaluma River Watershed are identified by the Open Space Element as Scenic Resource Areas. The Petaluma General Plan (1987-2005) identifies several scenic routes in Chapter 6.

In general, bypass pipelines or channel widening would not significantly affect a scenic vista. Detention basins, however, may be highly visible from certain vantage points. If properly designed and landscaped, the impact to scenic vista would not likely be considered "adverse". Both widened channels and detention could adversely affect the respective sites and surroundings. This, too, could be mitigated through design and landscaping.

The development of the detention basins could affect trees, rock outcroppings, or historic buildings. Channel widening or bypass pipelines could also affect trees. Impacts would be site-specific, and could be mitigated.

II. AGRICULTURE RESOURCES - In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:	**Potentially Significant**	**Less Than Significant With Mitigation**	**Less Than Significant**	**No Impact**
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance, as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program in the California Resources Agency, to non-agricultural use?	☑	☐	☐	☐
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☑	☐	☐	☐

II. AGRICULTURE RESOURCES - In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
c) Involve other changes in the existing environment that, due to their location or nature, could individually or cumulatively result in loss of Farmland, to non-agricultural use?	☑	☐	☐	☐

The Sonoma County General Plan includes three agricultural land use categories: Land Intensive Agriculture, Land Extensive Agriculture, and Diverse Agriculture, categorized by densities, infrastructure, access, conflicts with resource conservation, and topographic and environmental features. The Petaluma General Plan identifies all land outside its Urban Limit Boundary as agricultural, regardless of parcel size or current land use. The Petaluma River Watershed also supports Prime Farmland, Unique Farmland, and Farmland of Statewide Importance, pursuant to the Farmland Mapping and Monitoring Program (www.consrv.ca.gov).

A number of parcels that could be affected by the Master Drainage Plan Update are in Williamson Act contract, which retains an assessment based on agricultural production value, rather than highest and best use, in exchange for not developing the property. Determination of Williamson Act status would be site-specific. Williamson Act contracts could either be non-renewed or canceled if parcels were to be developed. Either the local government, or landowner, can initiate the non-renewal process. A "notice of non-renewal" starts the 9-year non-renewal period. During the non-renewal process, the annual tax assessment gradually increases. At the end of the 9-year non-renewal period, the contract is terminated. The landowner can also petition to cancel a contract. To approve a tentative contract cancellation, a county or city must make specific findings for cancellation that are supported by substantial evidence.

While bypass pipelines and channel widening would not significantly affect farmland, conversion of any farmland identified by the aforementioned agencies to detention basins may represent a significant unavoidable impact.

I. AIR QUALITY - Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☑	☐	☐
b) Violate any air quality standard or contribute to an existing or projected air quality violation?	☐	☑	☐	☐
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions that exceed quantitative thresholds for ozone precursors)?	☐	☑	☐	☐
d) Expose sensitive receptors to substantial pollutant concentrations?	☐	☑	☐	☐
e) Create objectionable odors affecting a substantial number of people?	☐	☐	☐	☑
f) Otherwise degrade the atmospheric environment?	☐	☐	☑	☐
g) Substantially alter air movement, moisture, temperature, or other aspects of climate?	☐	☐	☑	☐

The Petaluma River Watershed is within the Bay Area Air Quality Management District (BAAQMD). Within the BAAQMD, ozone is the only constituent with non-attainment status (i.e., state and/or federal maximum pollutant levels are exceeded periodically). However, the BAAQMD CEQA Guidelines for Assessing the Air Quality Impacts of Projects and Plans recommends control measures for particulate matter and other pollutants, regardless of attainment status.

In general, the Master Drainage Plan Update would not have a significant operational impact on air quality. Construction equipment and activity would create emissions, including ozone precursors and particulate matter. Construction could occur near sensitive receptors (e.g., land uses frequented by the sick, young or elderly, such as a school, retirement community or hospital). Impacts would be evaluated at a site-specific level through subsequent CEQA documentation. Implementation of the BAAQMD CEQA Guidelines would likely reduce impacts to less than significant.

IV. BIOLOGICAL RESOURCES - Would the project:	**Potentially Significant**	**Less Than Significant With Mitigation**	**Less Than Significant**	**No Impact**
a) Have an adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☑	☐	☐	☐
b) Have an adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, and regulations or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☑	☐	☐	☐
c) Have an adverse effect on Corps of Engineers jurisdictional wetlands either individually or in combination with the known or probable effects of other activities through direct removal, filling, hydrological interruption, or other means?	☑	☐	☐	☐
d) Interfere with the movement of any resident or migratory fish or wildlife species or with established resident or migratory wildlife corridors, or impede the use of wildlife nursery sites?	☑	☐	☐	☐
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☑	☐	☐	☐
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Conservation Community Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☑	☐
g) Otherwise degrade the biotic environment?	☐	☑	☐	☐

Research for this section included a search for occurrence of rare, threatened, endangered, and sensitive animals, plants, and natural communities completed by the California Natural Diversity Database (CNDDB) and consultation with California Department of Fish and Game (DFG) staff for Sonoma County.

According to the CNDDB (www.dfg.ca.gov), sensitive animal species known to currently or historically exist within the Watershed include the California red-legged frog (federal status – threatened), the foothill yellow-legged frog (federal status – species of concern), the California Black Rail (federal status – species of concern, state status – threatened), the salt-marsh common yellowthroat (federal status – threatened), steelhead trout (federal status – threatened), Townsend's western big-eared bat (federal status – species of concern), the pallid bat (no special status), the salt-marsh harvest mouse (federal and state status – endangered), the northwestern pond turtle (federal status – species of concern), the Sacramento splittail (federal status – threatened), the western pond turtle (no special status), the western yellow-billed cuckoo (state status – endangered), the northern spotted owl (federal status – threatened), the tri-colored blackbird (federal status – species of concern), California freshwater shrimp (federal and state status – endangered) rickersecker's water scavenger beetle (status – species of special concern) and the California tiger salamander (federal status – endangered).

Habitat and plant communities and plant species identified by the CNDDB include northern coastal salt marsh (no special status), coastal brackish marsh (no special status), Petaluma popcorn flower (federal status – species of concern), Napa false indigo (federal status – species of concern), alkali milk-vetch (federal status – species of concern), round-leaved filaree (no special status), Marin western flax (federal and state status – threatened), Point Reyes checkerbloom (federal status – species of concern), Tomales isopod (no special status), Sonoma spineflower (federal and state status – endangered), Marin knotweed (federal status – species of concern), baker's navarretia (federal status – species of concern), yellow larkspur (federal status – endangered, state status – rare), Point Reyes bird's beak (federal status – species of concern), soft bird's beak (federal status – endangered, state status – rare), franciscan onion (federal status – species of concern), fragrant fritillary (federal status – species of concern), northern vernal pool (no special status), showy Indian clover (federal status – endangered), Sonoma sunshine (federal and state status – endangered), dwarf downingia (no special status), legenere (federal status – species of concern), jepson's linanthus (federal status – species of concern), Sonoma ceanothus (federal status – species of concern), burke's goldsfields (federal and state status – endangered), Sebastopol meadowfoam (federal and state status – endangered), white sedge (federal and state status – endangered), Sonoma alopecurus (federal status – endangered), and north coast semaphore grass (federal status – species of concern).

Consultation with DFG indicated that some streams in Sonoma and Marin Counties currently support or historically have supported Coho salmon. Although Coho has not been identified within the Watershed, it is possible that Coho could have migrated into this area.

In general, the Master Drainage Plan Update would affect plant and animal species at the more sensitive locations. Wetlands and riparian corridors could also be affected. While migratory corridors may be affected, the infrastructure along creeks would not permanently affect movement. The detention basins would offer migratory opportunities for waterfowl, which would be considered beneficial.

Although there is the potential for significant impacts to biological resources as a result of the implementation of the Master Drainage Plan Update, impacts could be identified and mitigated through subsequent site-specific CEQA documentation.

V. CULTURAL RESOURCES - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Cause an adverse change in the significance of a historical resource, as defined in Section 15064.5?	☑	☐	☐	☐
b) Cause an adverse change in the significance of an archaeological resource, pursuant to Section 15064.5?	☑	☐	☐	☐
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☑	☐	☐	☐
d) Disturb any human remains, including those interred outside of formal cemeteries?	☑	☐	☐	☐

A complete California Historical Resources Information System records search of the Petaluma River Watershed was conducted by the Northwest Information Center at Sonoma State University in December 2002. Review of base maps, historic maps and literature indicates that the watershed area contains 142 Native American and historic-period archaeological resources listed within the system. The Northwest Information Center also has record of 352 archaeological studies within the Petaluma River Watershed. State and federal inventories list numerous historic properties within the Watershed, including the Petaluma Commercial Historic District and the Petaluma Adobe.

Native American archaeological sites in this portion of Sonoma County tend to be situated along ridge tops, mid-slope terraces, alluvial flats, near marsh margins, near ecotones, and near sources of water, including springs. The project area encompasses most of these environmental features. Native American sites within the watershed area range from sparse lithic scatters and campsites located upslope to large village sites that include burials down on the valley floor near permanent drainages. Given the environmental setting and the archaeologically sensitive nature of the general area, there is a high potential for additional Native American sites in the Watershed.

Review of historical literature and maps on file at the Northwest Information Center indicate numerous historical sites in the area. Therefore, there is a high possibility of identifying additional historic deposits in the Watershed. Other sources show the presence of historic buildings or structures. The Sonoma County landmark, for instance, lists 29 structures in the Watershed.

Because of the sensitive nature of these resources, no mapping can be provided. However, given the high possibility of encountering Native American or historic-period resources, further archival and field study by an archaeologist and architectural historian is recommended on a project-specific basis. Review for historical structures includes only those sources listed within databases available to the Center and should not be considered comprehensive. The Office of Historical Preservation has determined that buildings, structures and objects 45 years or older may be of historic value. The Watershed contains numerous "historic" properties, thus identifying the need for field and records review by an architectural historian. Although not investigated by the Center, paleontological or geological features could also be present within the Watershed. Therefore, a paleontologist should also be consulted on a project-specific basis.

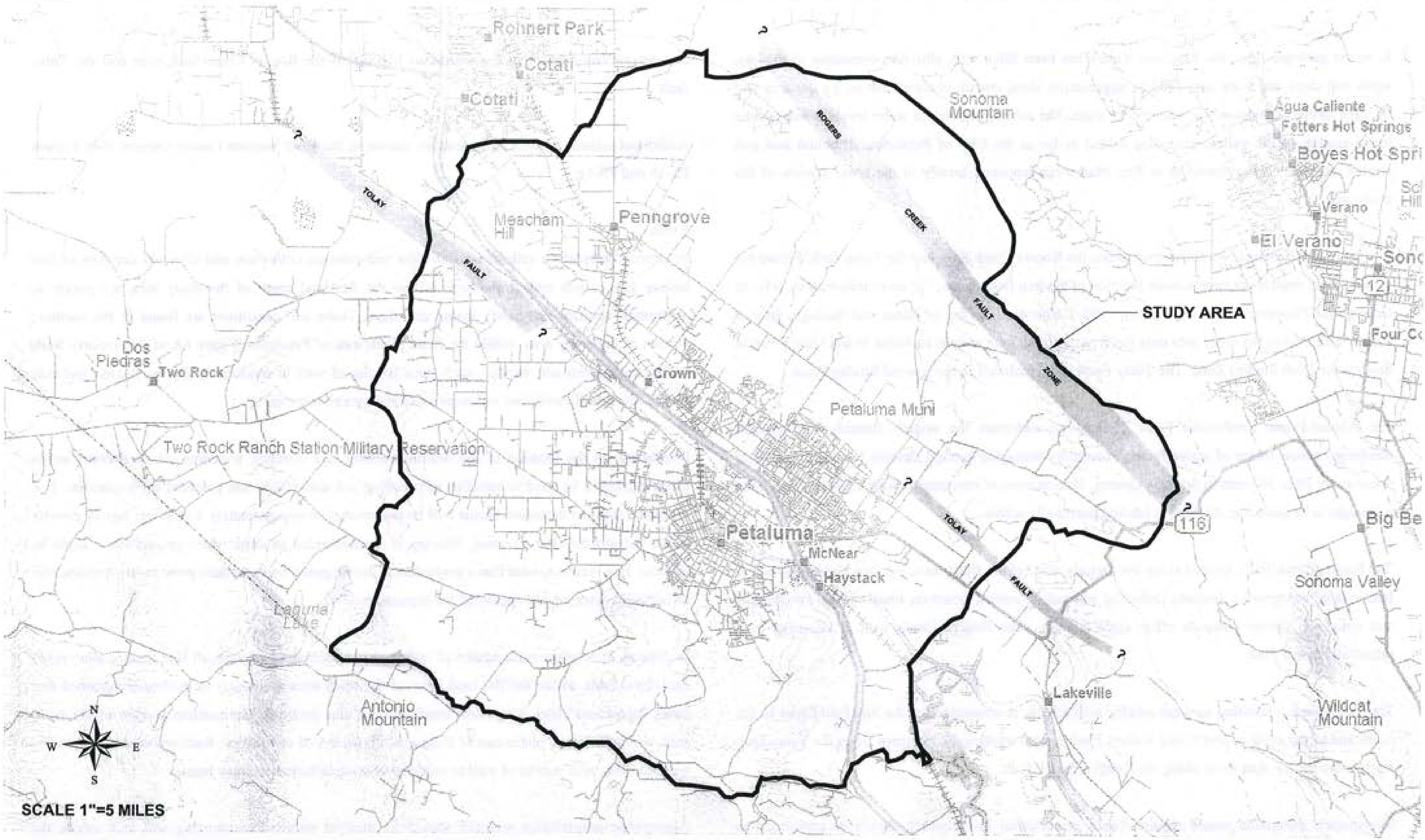
VI. GEOLOGY AND SOILS - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology, Publication 42.	☐	☐	☑	☐
Strong seismic ground shaking?	☐	☐	☑	☐
Seismic-related ground failure, including liquefaction?	☐	☑	☐	☐
Landslides?	☐	☑	☐	☐
b) Result in soil erosion or the loss of topsoil?	☐	☑	☐	☐

VI. GEOLOGY AND SOILS - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?	☐	☑	☐	☐
d) Be located on expansive soil, as defined in Table 18-1B of the Uniform Building Code (1994), creating risks to life or property?	☐	☑	☐	☐
e) Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems where sewers are not available for the disposal of wastewater?	☐	☐	☐	☑

Geologic Setting

The Petaluma River Watershed lies geographically within the northern and southern portion of the Petaluma Valley. The valley is bordered to the north by Cotati Valley, and to the east along the eastern flank of Sonoma Mountain. The southern portion of the Valley lies primarily within the Petaluma wetlands. The western extent of the Valley is bordered by hilly terrain associated with Antonio Mountain (Figure 6A of this report).

In general, the Petaluma Valley consists of Jurassic-Cretaceous age Franciscan assemblage, overlain by thick discontinuous sequences of tertiary and quaternary deposits of the Petaluma Formation and the Sonoma Volcanic Group. Overlying these formations is late quaternary fluvial and alluvium deposits located around the outer edge of the Petaluma Valley basin. Sedimentary deposits of the Wilson Grove Formation (formerly known as the Merced Formation) cover the Petaluma Valley and locally across the Cotati Valley.



Rogers Creek Fault/Alquist-Priolo Special Studies Zone Boundary (Petaluma River Quadrangle, Revised 1983; Glen Ellen Quadrangle. Revised 1983)
Tolay Fault/Potentially Active Fault Boundary
NOTE: Depicted Fault Boundaries are Approximate.

FIGURE 6A
EXISTING FAULTS
PETALUMA RIVER WATERSHED MASTER PLAN

WINZLER & KELLY

In recent geologic time, the Petaluma Valley has been filled with alluvium consisting of gravels, sands and clays that were deposited by aggradation along stream channels traversing the area and by other colluvial processes in interstream areas. The subsequent rise in water levels inundated the lower portion of the valley, extending inland as far as the City of Petaluma. Alluvium and soft marine silts and clays referred to as Bay Mud were deposited locally in the lower portion of the study area.

The study area contains two active fault zones the Rogers Creek fault and the Tolay fault. Figure 6A of this report depicts the approximate location of the two fault zones. For more information, refer to *Geology for Planning in Sonoma County 1980, California Division of Mines and Geology, Special Report 120.* Within the study area only the Rogers Creek fault zone is included in the Alquist-Priolo Earthquake Fault Studies Zone. The Tolay Fault is not included in the Special Studies Zone.

The Alquist-Priolo Earthquake Fault Zoning Act addresses the seismic hazard of subsurface conditions across traces of active faults. Potentially damaging ground shaking has the potential to occur every 20 to 30 years in Sonoma County. If recurrence of movement along a fault or fault zone is thought to be probable, the fault is labeled potentially active.

The Rogers Creek fault, located along the easterly ridge of the study area, exhibits highly distinctive fault-related topographic features including sag ponds, scarps, benches, linear ridges and troughs and numerous stream channels offset right laterally. The Rogers Creek fault is classified as a potentially active fault.

The Tolay fault, classified as a potentially active fault, is concealed by the San Pablo Bay to the south and to the north across Cotati Valley. Fault related topographic features along the Tolay fault are less distinctive than those along the Rodgers Creek fault.

Site-specific mitigation would require that a geotechnical investigation should be performed to accurately assess seismic conditions prior to the design and construction of detention basins, and channel widening on or in the immediate vicinity of the Rogers Creek fault zone and the Tolay fault.

Additional seismic hazards references are shown on the 1998 Sonoma County General Plan Figures PS-1h and PS-1g.

Soils

In general, subsurface soils consist of older and younger colluvium and alluvium deposits of fine texture silts, sands and clays. Soils within the flat land areas of the study area are poorly to moderately drained fine sandy loams and clays. These soil conditions are found in the northern portion of the study area, within the flood plains east of Petaluma (Figure 6A of this report). Soils within the eastern and western study area consist of well to moderately drained loams and clay loams. These soil conditions represent dissected marine terraces.

Depending on the location of the detention basins and channel, widening standard construction methods should be used to stabilize surrounding soil and reduce the potential for expansion. It is estimated that the detention basins will be constructed to approximately 5 to 8 feet bgs or directly above the groundwater interface. Shoring is recommended in areas where groundwater might be shallow. It is recommended that a geotechnical investigation be completed prior to any construction activities to determine the potential for expansive clays.

In general, subsurface soils consist of colluvium and alluvium deposits of fine texture silts, sands and clays. Soils within the flat land areas of the study area are poorly to moderately drained fine sandy loams and clays. These soil conditions are also found in the northern portion of the study area, within the flood plains east of Petaluma (Figure 6A of this report). Soils within the eastern and western study area consist of well to moderately drained loams and clay loams.

Appropriate construction methods should be used to stabilize surrounding soil and reduce the potential for expansion. Shoring is recommended in areas where groundwater might be shallow. It is also recommended that a geotechnical investigation be completed prior to any construction activities to determine the potential for expansive clays.

Liquefaction Potential

Liquefaction potential is classified as moderate to high within the City of Petaluma and the southern extent of the study area (Figure 6A of this report). These areas are located primarily in flat land areas, where groundwater is generally shallow. The younger Bay Mud is considered to have the highest potential for liquefaction where soils consist of younger alluvium (sands and silts). Moderate liquefaction potential is classified as areas containing unconsolidated alluvium and terrace deposits where there is a distribution of clay-free granular materials.

Prior to the design and construction of detention basins, channel widening or bypass pipelines within these areas, a geotechnical investigation should be performed to accurately assess liquefaction potential of subsurface soils.

Refer to the Sonoma County General Plan Figures PS-1h and PS-1g for specific areas subject to liquefaction potential.

Landslides and Slope Stability

Areas with high to moderate potential for landslides are primarily located within hilly terrain west-northwest of the City of Petaluma and west of the Rogers Creek fault zone (Figure 6A). These conditions exhibit unstable rock and soil units on slopes greater than 15%.

Refer to the Sonoma County General Plan (Figures PS-1h and PS-1g) for potential landslide areas.

Prior to the design and construction of detention basins and channel widening within these areas, a geotechnical investigation should be performed to accurately assess the presence or potential for landslides to occur.

Soils exposed during construction could be subject to wind and water erosion if not properly managed. Construction would occur during the dry months to minimize weather-related water erosion. Additional mitigation would include best management practices for construction such as periodic watering of construction site, covering of exposed soils, replanting, and cessation of construction activities during periods of high winds. Wind and water erosion are further discussed in III Air Quality and VIII Hydrology and Water Quality.

VII. HAZARDS AND HAZARDOUS MATERIALS - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Create a hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☐	☑
b) Create a hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☑	☐	☐
c) Have hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	☐	☑	☐	☐
d) Be located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?	☑	☐	☐	☐

VII. HAZARDS AND HAZARDOUS MATERIALS - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
e) Be located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, and consequently result in a safety hazard for people residing or working in the project area?	☑	☐	☐	☐
f) Be located within the vicinity of a private airstrip, and consequently result in a safety hazard for people residing or working in the project area?	☑	☐	☐	☐
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☑	☐
h) Expose people or structures to the risk of loss, injury, or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☑	☐

Construction and operation of the proposed drainage improvements (i.e., bypass pipelines, channel widening and/or detention basins) would not involve the routine transport, use or disposal of hazardous materials. Construction equipment would utilize gasoline and oil, which could be accidentally released into the environment. This impact could be mitigated by the immediate cleaning of any spills. Some specific project sites could be within one-quarter mile of a school. Accidental spills would not create a significant impact, as long as spills were immediately remediated. Some of the site could be included on federal, state, or local lists of hazardous materials sites; these sites could be within one-quarter mile of school. A Phase I environmental site assessment would determine whether there would be an impact to the public or construction workers, and whether impacts could be mitigated to less than significant.

Bypass pipelines and channel widening would not affect public airports or private airstrips. Detention basins may attract birds during the wet season; if they are located in the vicinity of an airport or airstrip there would be an increased risk of a bird strike. The impact and appropriate mitigation would be determined through subsequent site-specific environmental documentation.

Very little construction would occur in or adjacent to roadways, therefore there would be minimal impact to emergency response or emergency evacuation. Proper traffic control of construction sites and temporary alternative routing for evacuation or emergency response would reduce any impact to less than significant. The project would not expose people or structures to wildland fires (although there would be a minimal risk during construction in more remote areas).

VIII. HYDROLOGY AND WATER QUALITY - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Violate any applicable water quality standards or waste discharge requirements?	☐	☐	☑	☐
b) Deplete groundwater supplies or interfere with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted)?	☐	☐	☑	☐
c) Change the quality of ground waters through infiltration of reclaimed water or storm water runoff that has contacted pollutants from urban, industrial or agricultural activities?	☐	☐	☑	☐
d) Alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in erosion or siltation on- or off-site?	☑	☐	☐	☐

VIII. HYDROLOGY AND WATER QUALITY - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
e) Alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or increase the rate or amount of surface runoff in a manner that would result in flooding on- or off-site?	☐	☐	☑	☐
f) Create or contribute runoff water that would exceed the capacity of existing or planned storm water drainage systems or provide additional sources of polluted runoff?	☐	☐	☑	☐
g) Place housing within a 100-year floodplain, as mapped on a Federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☐	☑
h) Place within a 100-year floodplain structures that would impede or redirect flood flows?	☐	☐	☐	☐
i) Expose people or structures to a significant risk of loss, injury, or death involving: 1) flooding, including flooding as a result of the failure of a levee or dam or 2) inundation by seiche, tsunami, or mudflow?	☐	☐	☐	☐
j) Otherwise degrade water quality?	☐	☑	☐	☐
k) Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, turbidity or other typical storm water pollutants (e.g. sediment from construction, hydrocarbons and metals from vehicle use, nutrients and pesticides from landscape maintenance, metals and acidity from mining operations)?	☐	☑	☑	☐
l) Change the amount of surface water in a water body?	☐	☑	☑	☐
m) Change in currents or the course or direction of water movements, in marine or fresh water, or wetlands?	☐	☑	☐	☐
n) Result in the alteration of, or the reduction in the acreage of wetlands?	☐	☑	☐	☐

The Master Drainage Plan Update involves channel widening, bypass pipelines, and/or detention basins to alleviate flooding within the Petaluma River Watershed. The project will redirect existing flow. The project will affect water quality, groundwater and surface water, and will change drainage patterns. Flood flow will be redirected and some infrastructure will be built within a 100-year floodplain, but this is to correct an existing significant impact. The project will increase drainage capacity, which is also beneficial. Detention basins serve to increase the amount of surface water, and may reduce surface water elsewhere, but would be beneficial because existing surface flow is in the form of flooding. The project would not cause or be subject to seiche or tsunami. Mudflow would likely be reduced because of drainage improvements. The Master Drainage Plan Update does not include housing.

Wetlands, particularly seasonal wetlands, could be affected by the Master Drainage Plan Update. Subsequent review pursuant to CEQA will be initiated at the time that individual projects are proposed, and USACE will also be notified with regard to wetlands and disturbance to navigable waters. While avoidance of wetlands would be the preferred alternative from an environmental perspective, the proposed detention basins will provide ample opportunity to mitigate for any loss of wetlands.

Any project within the Watershed would be subject to new NPDES regulations in effect in March 2003. These regulations require that certain agencies, including the City of Petaluma and the SCWA, obtain an NPDES Phase II general permit. The NPDES Phase II general permit represents the next step in storm water pollution prevention. Where as NPDES Phase I addressed medium and large municipal separate storm sewer systems (population of 100,000 or more), Phase II addresses smaller municipal separate storm sewer systems in urbanized areas, which were specifically identified by the state Water Resources Control Board. Both Petaluma and the SCWA are in the process of obtaining their Phase II permits.

The Phase II process also requires that individual construction projects be subject to a construction permit when the area of disturbance is equal to one or more acres. The construction permit consists of filing a Notice of Intent (NOI), along with a storm water pollution prevention plan (SWPPP) to the state Water Resource Control Board. The requirement for the SWPPP would be part of construction specifications and would be the responsibility of the construction contractor.

IX. LAND USE AND PLANNING - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Physically divide an established community?	☐	☐	☑	☐
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☑	☐
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☑	☐	☐

Bypass pipeline and channel widening would not divide an established community. Detention basins would be constructed in areas that are not densely developed, most likely in rural areas. This would not have the effect of dividing an established community.

Site-specific construction projects would be subject to subsequent environmental review, which would determine consistency with existing plans, policies or regulations. Because the Master Drainage Plan Update includes some alterations to watercourses, and because detention basins would be constructed in more open areas, specific sites could be subject to formally adopted habitat and natural resource conservation plans, including *Restoration Design and Management Guidelines for the Petaluma River Watershed, Volumes 1 and 2* and the *Petaluma Watershed Enhancement Plan*. These documents would be considered in conjunction with the planning of any site-specific projects within the Watershed.

X. MINERAL AND ENERGY RESOURCES - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Result in the loss of availability of a known mineral that would be of value to the region and the residents of the state?	☐	☐	☑	☐
b) Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?	☐	☐	☑	☐
c) Result in the use of energy or non-renewable resources in a wasteful or inefficient manner?	☐	☐	☑	☐

Primary mineral resources in the Petaluma Valley consist of sand and gravel (aggregates) generated from dredging operations in the Petaluma River. The Sonoma County General Plan identifies two areas with mineral resources in the Petaluma River Watershed, one at the intersection of Lakeville Highway and Stage Gulch Road, the second at Stage Gulch Road, east of the intersection with Adobe Road. The Petaluma General Plan does not identify any mineral resources within City limits. Any impact would be identified during subsequent CEQA documentation, and could be avoided by siting projects away from mineral resources.

XI. NOISE - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Generate or expose persons to noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☑	☐	☐
b) Generate or expose persons to excessive ground-borne vibration or ground-borne noise levels?	☐	☑	☐	☐
c) Result in a permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☐	☑

XI. NOISE - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
d) A temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☑	☐	☐
e) Be located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, and consequently expose people residing or working in the project area to excessive noise levels?	☐	☐	☑	☐
f) Be within the vicinity of a private airstrip, and consequently expose people residing or working in the project area to excessive noise levels?	☐	☐	☑	☐

Construction activities can generate noise in excess of 85 dB during certain activities, such as backhoe or jack hammering. This would exceed noise levels established by both the Petaluma and Sonoma County General Plans. Refer to Figure 11-1 of the Petaluma General Plan and Table NE-2 of the Sonoma County General Plan. There would also be an increase in ground-borne noise and vibration levels. However, impacts would only be temporary; once the drainage improvement projects are completed, there would be no permanent increase in ambient noise level. Temporary impacts would be mitigated by keeping equipment in proper working order, requiring workers to wear noise attenuation headgear, and limiting hours of operation. Although some projects may occur in the vicinity of airstrips, it is not likely that construction would be allowed in direct flight paths. Although it is unlikely that air activity would significantly add to construction-related noise impacts, any impacts could be mitigated by coordinating with the Petaluma Airport to determine times when air traffic would be less active.

Individual projects would be subject to subsequent compliance with CEQA, at which point, existing conditions, specific impacts and appropriate mitigation could be determined.

XII. POPULATION AND HOUSING - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?	☐	☐	☐	☑
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☑
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☑

The Master Drainage Plan Update is to alleviate existing drainage problems, and would not affect population growth, displace a substantial number of housing units, or displace a significant number of people.

XIII. PUBLIC SERVICES - Would the project result in 1) adverse physical impacts associated with the provision of new or physically altered governmental facilities, or 2) the need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the public services:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Fire protection?	☐	☐	☑	☐
b) Police protection?	☐	☐	☑	☐
c) Schools?	☐	☐	☐	☑
d) Parks?	☐	☐	☑	☐
e) Roads?	☐	☐	☑	☐
f) Maintenance of public facilities, including roads or storm drain facilities?	☐	☐	☑	☐
g) Other public facilities?	☐	☐	☑	☐

Because additional environmental review will be performed when specific projects are proposed, fire and police departments would likely be informed of individual projects as part of traffic and emergency response control. As only small portions of roadways will be affected, it is likely that any impact would be less than significant. Furthermore, the detention basins may offer the opportunity for additional fire flow, which would be considered beneficial. School safety or attendance would not be affected. Parks and roads would be affected only in that access roads would be required to new detention basins. As noted above, there could be minor disturbance to roadways, if channel widening or bypass pipeline design were to occur within rights-of-way. The new drainage system would require some additional maintenance, but this would be offset by the decrease in emergency response and system maintenance required by flooding. There may be increased administration, at least during site-specific construction, but this would not be of the magnitude to create unacceptable service levels or objectives.

XIV. RECREATION	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☑	☐
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?	☐	☐	☑	☐

Implementation of the Master Drainage Plan Update would not increase the use of existing parks. Detention basins could be utilized for recreational purposes, and channel widening may provide additional hiking opportunities, but the construction of such facilities would occur as part of the drainage system and would not be a specific end, rather just part of an already planned project. Any site-specific impacts would be addressed through further CEQA review, and mitigation would be presented, if required.

XV. TRANSPORTATION - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Cause an increase in traffic that is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?	☐	☐	☑	☐
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?	☐	☐	☑	☐
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	☐	☐	☑	☐
d) Substantially increase hazards to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☑	☐
e) Result in inadequate emergency access?	☐	☐	☑	☐
f) Result in inadequate parking capacity?	☐	☐	☑	☐
g) Conflict with adopted policies supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	☐	☐	☑	☐
h) Adversely affect rail, waterborne, or airborne transportation?	☐	☐	☑	☐

Any impact to traffic would be construction-related, and would therefore be temporary. Projects planned for the downtown areas, and/or along existing roadways would result in the most impact. Detention basins and stream improvements (channel widening or bypass pipeline) would also have a minimal impact. Generally, though, projects are proposed in areas identified by the Petaluma General Plan as having acceptable level of services (e.g., operating free flow or stable flow). Refer to Figure 10-5 of the Petaluma General Plan. Similarly, the Sonoma County General Plan does not identify significant congestion problems in roadways in the vicinity of the areas proposed for construction of the drainage system. Refer to Figure CT-2c of the Sonoma County General Plan.

Although the general plans' data was gathered in the mid-1980s, and traffic congestion has certainly increased over the past 15 years, site-specific projects would be subject to CEQA documentation, at which time the exact impact and mitigation would be identified. In addition, a traffic control plan (TCP) would be required by the contractor as part of the construction specifications. The TCP would address emergency access, impacts to parking, traffic flow, and hazards of design. The project would not significantly affect air traffic patterns, alternative transportation, or rail, waterborne or airborne transportation.

XVI. UTILITIES AND SERVICE SYSTEMS - Would the project:	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☑	☐
b) Require or result in the construction of new facilities or expansion of existing facilities, the construction of which could cause significant environmental effects, for any of the following utilities?	☐	☑	☐	☐
Water treatment or distribution facilities?	☐	☐	☑	☐
Wastewater collection, treatment, or disposal facilities?	☐	☐	☑	☐
Storm water drainage or storm water quality control facilities?	☐	☑	☐	☐
Electric power or natural gas?	☐	☐	☑	☐
Communications systems?	☐	☐	☑	☐
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?	☐	☑	☐	☐
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☐	☑
e) Result in a determination by the wastewater treatment provider that serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☑
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☐	☐	☑	☐
g) Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☑	☐

Except for storm drainage systems, the Master Drainage Plan Update would have less than significant impacts on utilities systems. The only possibility for impact to water treatment, wastewater treatment, electricity or communications would be if these utilities were encountered during construction of the detention basins, bypass pipelines or channel widening. Engineering could avoid impacts, but if interference were to occur, proper engineering would reduce potential impact to less than significant. There is the possibility that excavated materials would be deposited into a landfill. Because design would seek to re-use excavated materials, deposits into landfill would most likely be contaminated soil. As discussed in VII Hazards and Hazardous Materials, a Phase I would identify contaminates and would make recommendations for remediation. Whether to perform the Phase I would be addressed on a site-specific basis, in conjunction with subsequent CEQA documentation.

XVII. MANDATORY FINDINGS OF SIGNIFICANCE	Potentially Significant	Less Than Significant With Mitigation	Less Than Significant	No Impact
a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☐	☑	☐	☐
b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects, as defined in Section 15130.)	☑	☐	☐	☐
c) Does the project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☑	☐	☐

Storm drainage improvements are necessary to alleviate flooding within the Watershed. However, construction has the potential to cause significant, permanent impacts to farmland, cultural resources, and biological resources. With the exception of a cumulative loss of agricultural land, which could only be mitigated by avoidance, impacts could likely be reduced to less than significant. This would be addressed by subsequent, site-specific CEQA documentation.

Other impacts addressed by this document include temporary impacts associated with construction activities (e.g., wind or water erosion, noise or traffic).

NPDES Requirements

Sonoma County Water Agency

The State Water Resources Control Board (SWRCB) administers National Pollutant Discharge Elimination System (NPDES) programs in California. On April 30, 2003 the SWRCB adopted a statewide general permit for stormwater discharges under the federal Phase II NPDES program. As required by the SWRCB, Zone 2A will submit an application for coverage under the adopted general permit in August 2003.

The application process includes the submittal of a storm water management plan that demonstrates how Zone 2A will meet the permit requirements. As of June 2003, the implementation schedule and costs of implementation are unknown. Opportunities for sharing the costs of the required programs with the City of Petaluma, the County of Sonoma, and other co-permittees conducting water quality programs within Zone 2A are anticipated, but yet unknown.

City of Petaluma

The San Francisco Bay Regional Water Quality Control Board (Regional Board) is the regulatory agency having Phase II NPDES permit oversight authority for the City of Petaluma.

Impacts from urban, construction, land development, atmospheric deposition, and agricultural runoff have resulted in the listing of the Petaluma River on the 2002 Clean Water Act's Section 303(d) list for nutrients, pathogens, sediment, diazinon, and nickel (nickel is listed for the tidal portion of the River). Section 303(d) of the federal Clean Water Act requires that states identify water bodies that do not meet water quality standards. Total Maximum Daily Loads (TMDLs) are then developed for each water body on the list, and include identifying sources of pollutants, defining how much of a pollutant a water body can tolerate while still meeting water quality standards, and specifying actions that create solutions. Nutrients, pathogens, and sediment are listed as "medium priority" pollutants, while diazinon and nickel are listed as "low priority" pollutants according to the State 303(d) list and TMDL Priority Schedule.

During the initial permit term, the City's Storm Water Management Plan (Plan) will focus efforts and resources on best management practices (BMPs) that address the reduction of nutrients, pathogens, and sediment in the City's storm water; the "medium" priority pollutants in the Petaluma River water body. The City's future storm water management program could address the low priority pollutants, diazinon and nickel, if such constituents continue to cause impairment to the River, resulting in a "medium" or "high priority" listing by the Regional Board.

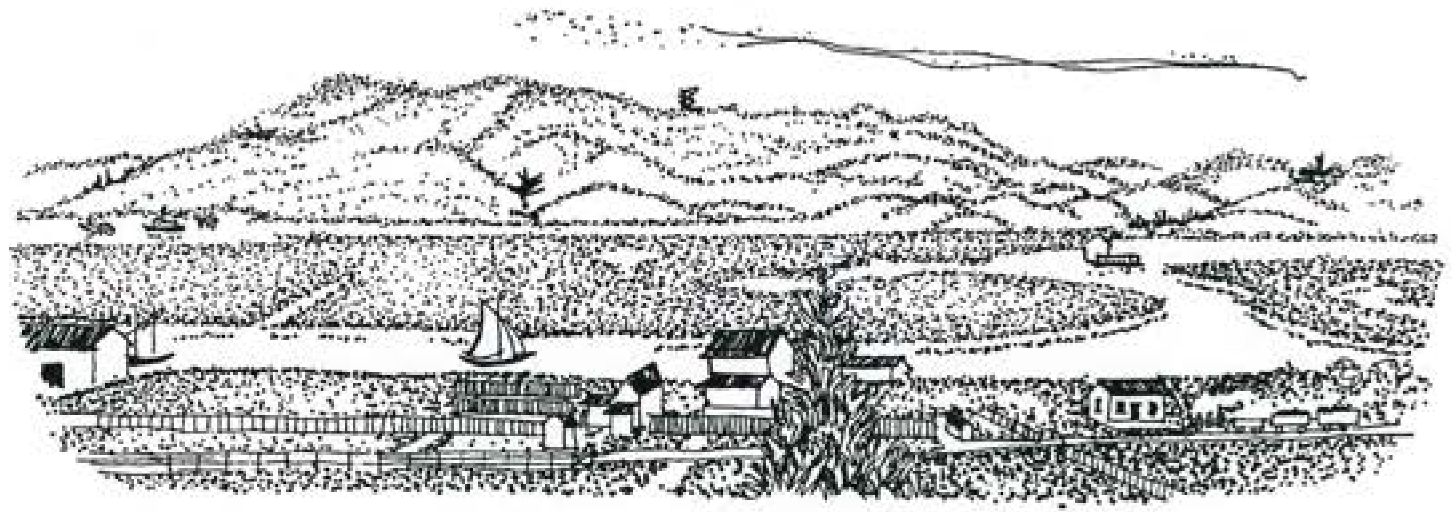
The Plan incorporates the six required Minimum Control Measures (MCMs) including:

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Storm Water Runoff Control
- Post-Construction Storm Water Management
- Pollution Prevention for Municipal Operations

Petaluma has already implemented actions to address some of the required BMPs for each of the six MCMs. These include pollution prevention, requiring construction projects to implement and maintain erosion control practices during grading activities, street sweeping, and other activities. There are several agencies and non-profit groups that Petaluma may want to establish partnerships with, such as the Sonoma County Water Agency, Sonoma Waste Management Agency, Empire Waste Management and the Southern Sonoma County Resource Conservation District. The purpose of these partnerships will be to share in the implementation of other elements of the Plan, such as public education, outreach, involvement, and participation.

As part of the Phase II regulation implementation process, new language and elements will be incorporated into existing documents such as the City's General Plan, CEQA checklist, and building and Community Development Department inspection procedures. An ordinance prohibiting non-storm water discharges will be adopted that will clarify and enforce what can and cannot be discharged to the City's storm drain system. In addition, the existing erosion control and grading ordinance will be updated for construction activities disturbing one acre or more.

The City will also develop a Standard Urban Storm Water Mitigation Plan (SUSMP) by the end of the five-year permit term. The City is subject to this requirement because it serves a population over 50,000. SUSMPs are defined as the portions of municipal storm water management programs that address storm water pollution arising from new development and redevelopment. Permittees and/or developers must adopt the requirements set forth in the SUSMPs, and must incorporate appropriate SUSMP requirements into their project plans.



SECTION 7
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Corps	U.S. Army Corps of Engineers
DWR	Department of Water Resources
SCEDB	Sonoma County Economic Development Board