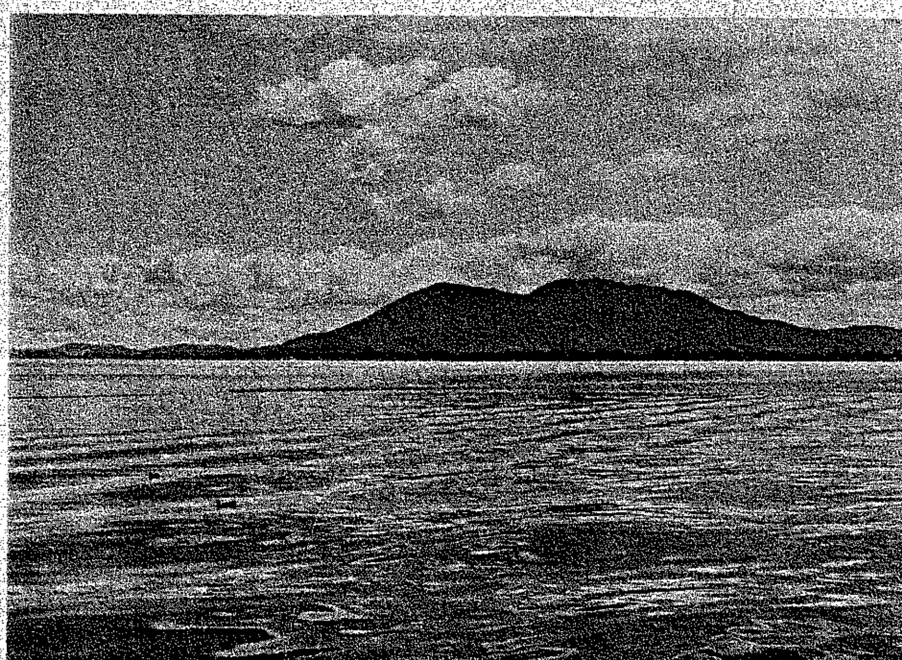
STORM DRAINAGE MASTER PLAN

CITY OF LAKEPORT, CALIFORNIA



BARRETT, HARRIS & ASSOCIATES, INC.

A STORM DRAINAGE
MASTER PLAN
FOR
THE CITY OF LAKEPORT

<u>City Council</u>

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Gary Waterman, Mayor Pro Tem
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June 1980

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June 30, 1980

The Honorable Mayor and City Council
City of Lakeport
Lakeport, CA 95453

Gentlemen:

In accordance with our contract dated April 7, 1980, we submit herewith "A Storm Drainage Master Plan for the City of Lakeport". This report summarizes the results of our engineering investigations and presents a course of action for development of future storm drainage facilities. The plan developed is a conceptual guide which, when correlated with individual development proposals, will enable the City's technical staff to properly determine the suitability of the facilities proposed.

Conclusions and recommendations are presented in Chapter II.

We appreciated the cooperation and interest shown by the City Council and staff during the course of our investigations. We look forward to discussing our findings with you at your convenience.

Very truly yours,

BARRETT, HARRIS & ASSOCIATES, INC.

Frank H. Barrett, Jr.

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CHAPTER I

INTRODUCTION

Background

The City of Lakeport is located in Lake County along the west shore of Clear Lake. The community has a permanent population of approximately 4,500 people and serves local and seasonal residents as a commercial center.

Clear Lake and its tributaries have a long history of flooding. Since 1900, severe flooding has occurred 21 times. The City of Lakeport has four principal streams tributary to Clear Lake. There are also many smaller drainage areas with poorly defined stream beds which drain directly to the Lake.

The City of Lakeport is experiencing moderate growth which tends to accentuate existing drainage problems and increases the potential for damage from flooding. Presently, there is no storm drainage master plan and each new development must be reviewed as it is proposed. As a result, the City has found the need for uniform design standards and an overall storm drainage master plan to help make policy decisions.

Previous Studies

A number of studies of flooding have been made in the

Lakeport area. Only the most recent reports of relevance will be discussed herein. The largest watershed tributary to Clear Lake which passes through Lakeport is drained by Forbes Creek and the North Branch of Forbes Creek. In June, 1969, a study entitled "Watershed Investigation Report, Forbes Creek, Lake County, California" was prepared by the United States Department of Agriculture. This preliminary report indicated that there was little potential for providing a viable water supply from the watershed and the report centered upon construction of a storm retarding structure. It was found that facilities could be constructed which would eliminate flooding from a ten year flood and would minimize flood damage from a 100 year flood. While the project was found to be cost-effective at the time, there apparently was insufficient local interest to carry the project to completion. Presently, this alternative for flood damage mitigation is being re-evaluated by the City and the Department of Agriculture.

The Lake County General Plan and the City of Lakeport General Plan provided very little information on flooding or storm drainage.

The U.S. Army Corps of Engineers (Corps) performed substantial hydrologic and hydraulic calculations in 1971 and this work was expanded in 1975. In 1978, a report entitled "Flood Insurance Study, City of Lakeport and

Unincorporated Areas of Lake County, California" was prepared by the U.S. Department of Housing and Urban Development, Federal Insurance Administration. This report utilized the work performed by the Corps and updated a previous flood insurance study. The history of flooding was discussed and historical high water levels in Clear Lake were presented. The report provided water elevations and flows for 10, 50, 100, and 500 year floods. Maps were also prepared which identified floodways and areas subject to inundation from a 100 year flood. No information was provided as to flood damage mitigation except for restriction of land use and flood proofing within the areas subject to inundation.

Scope of Study

In order to develop a storm drainage master plan that will reduce potential flood damage as well as develop design standards for storm drainage facilities, Barrett, Harris & Associates, Inc. was retained by the City of Lakeport to prepare a Storm Drainage Master Plan. The scope of the study is contained in Appendix A.

CHAPTER II

CHAPTER II

CONCLUSIONS AND RECOMMENDATIONS

As a result of our comprehensive investigations, the following conclusions and recommendations are presented:

Conclusions

1. There is a long history of flooding in the Lakeport area. Those portions of the City adjacent to Clear Lake and the areas adjoining the principal water courses tributary to the lake have experienced frequent inundation.

2. Precipitation in the Lakeport area averages 28 inches per year with 40 percent occurring in December and January and 95 percent between October and April.

3. Topography within Lakeport is relatively gentle with slopes ranging from 0.5 to 15 percent. The watershed beyond the City limits becomes more rugged.

4. Soils in the area consist of loams and clays and generally have a low permeability. The hazard of erosion is moderate.

5. Two groundwater basins are adjacent to Lakeport.

Scotts Valley to the west and Big Valley to the south. High groundwater levels normally range from 5 to 40 feet below the surface.

6. The projected land use for Lakeport provided by the City Planning Department indicates that the remaining lands within the City will generally develop as single family residential, although there are substantial areas planned for commercial and industrial uses.

7. The projected land use in the watershed outside the City limits is not clearly defined by County land use maps and the categories utilized are broad in range.

8. There are seven defined drainage areas which affect Lakeport. They are Hartley, Rumsey Bay, Tenth Street, Forbes Creek, Sixth and Third Streets, Pier 1900, and Todd Road. All storm drainage from Lakeport presently discharges to Clear Lake.

9. A large portion of the watersheds are outside the City with 68 percent of the land area presently under County jurisdiction.

10. The Tenth Street and Forbes Creek watersheds have the most inadequate facilities and are most in need of improvement.

11. Presently available hydrologic design methods were initially developed to analyze particular watersheds with specific conditions and were later modified to allow more general application. Two of the more important parameters are watershed size and land use. Considering these and other parameters, the rational method is suitable for hydrologic analyses of all but Forbes Creek where the Corps "unit- hydrograph" method should be used.

12. The Lake County Flood Control and Water Conservation District Hydrology Design Standards are suitable for use with the rational method when designing storm sewers in Lakeport.

13. The 100-year design event is suitable for areas larger than 100 acres while lesser events should be utilized for smaller areas. The 100-year Clear Lake water level of 1,330.6 was adopted for use with all design events.

14. Due to the large portion of the watershed area under County jurisdiction, City-County cooperation is essential for the success of a flood control program in Lakeport.

15. Existing drainage facilities vary in size from 15-inch corrugated metal pipe culverts to a 13-foot by 7-foot box culvert on Forbes Creek. Much of the

drainage is still carried in natural stream beds and open channels.

16. Portions of the existing drainage system are in good condition and incorporation of these facilities into the long range master plan can reduce the cost of new facilities required. In some cases where the existing system cannot be incorporated, it may be used to collect and convey local runoff to the new facilities.

17. Roadway culvert crossings are generally inadequate and will require replacement as the area develops.

18. The proposed Master Plan for the City of Lakeport includes:

    1) Drainage facilities within Lakeport sized to serve future growth outside the area tributary to the existing drainage system.

    2) Improvements to increase the capacity of of existing drainage faciilities, and

    3) Improvements to relieve flooding within presently developed areas.

19. Consideration was given to incorporation of retention basins in the overall storm drainage master plan. Use of retention basins can serve to reduce

peak flows thereby minimizing the size of conveyance facilities required and reducing the overall cost of storm drainage facilities. Retention basins are not feasible within the Lakeport city limits due to the topography and existing development. They may, however, be provided in the larger watersheds upstream of Lakeport in the presently undeveloped lands thereby reducing the effect of peak runoff caused by development.

20. The total project cost of providing facilities to 1) serve the entire watershed area, 2) alleviate problems in the existing systems, and 3) replace the present open channels with pipelines, except for portions of Forbes Creek, is estimated to be approximately $7,852,000 for projected ultimate development (this excludes the cost of in-tract storm drains installed by developers).

21. In order to provide facilities as funds become available, construction may take place in stages although construction plans for an entire reach must be prepared in order to ensure that segments will fit together when the system is completed.

22. Developer fees are a viable means of providing funds for master planning and for preparation of construction plans for storm drainage facilities. Developer fees may also be used as the local share

in using grant funds.

23. Flood control zones created under the authority of the Lake County Flood Control and Water Conservation District could serve as a means to obtain uniform application of standards and as a source of funds.

24. Assessment districts could be utilized to provide funding where necessary in fully developed areas.

25. There are a number of federal grant and loan programs which can be utilized to construct storm drainage and flood control facilities. Agencies administering these programs include: U.S Army Corps of Engineers, U.S. Department of Agriculture and the U.S. Department of Commerce. As a result of recent revisions to the Federal budget, availability of Federal assistance for drainage facilities is uncertain.

Recommendations

Based on the foregoing conclusions, it is recommended that the City of Lakeport:

1. Adopt this Storm Drainage Master Plan as a guide for construction of future drainage facilities.

2. Initiate discussions with representatives of Lake County regarding drainage facilities to serve areas

adjacent to the City as well as to adopt uniform policies and standards for design and construction of the necessary facilities. If mutually beneficial, appropriate flood control zones may be created to assist in development of flood control facilities.

3. Have construction plans prepared for each reach and undertake a staged program for construction of the proposed facilities as funds become available.

4. Explore the feasibility of obtaining grant funds for construction of storm drainage facilities.

5. Continue the City's present policy of requiring construction of storm drainage facilities at the time of development. Facilities should be in conformance with the Storm Drainage Master Plan.

CHAPTER III

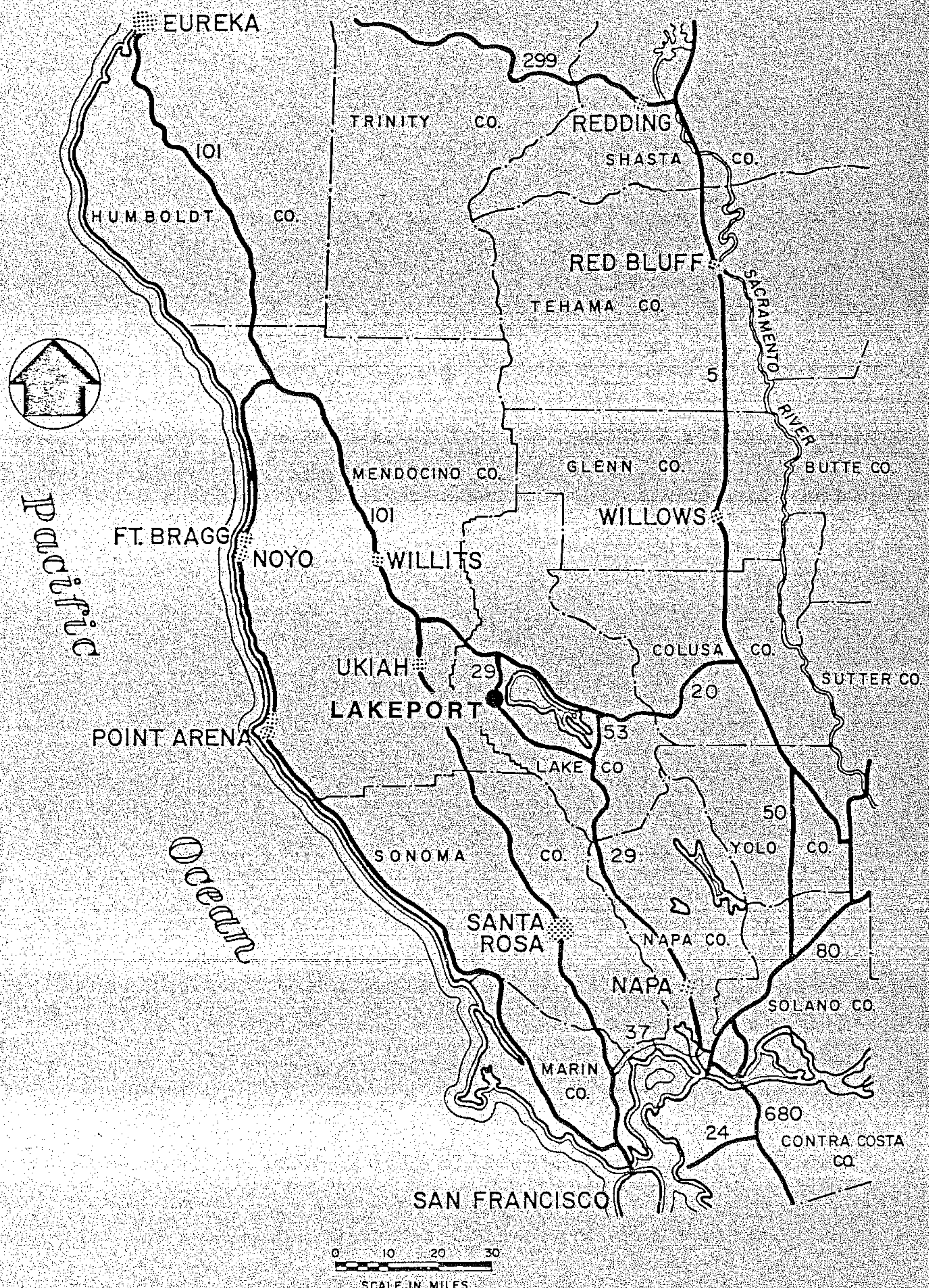


FIGURE 3-1
LOCATION MAP

CHAPTER III

THE STUDY AREA

General

The City of Lakeport is located in the center of Lake County on the western shore of Clear Lake. State Highway 29 runs along the west side of the City of Lakeport and provides access to Napa to the south and Ukiah to the west (via Highway 20). The city's location in relation to major highways and nearby communities is shown on Figure 3-1.

Lakeport has a permanent population of approximately 4,500 people. This number increases significantly during the summer tourist and recreation season. Lakeport serves as the seat for Lake County and as a commercial center for residents and tourists along the western shore of Clear Lake.

For investigation of drainage facilities, an area approximately 4,150 acres in size, was defined utilitizing watershed boundaries as shown on Figure 3-2. These boundaries were found to essentially agree with the study area utilized by the U.S. Army Corps of Engineers and by the California Department of Transportation (CalTrans) for earlier drainage investigations.

In evaluating drainage facilities and runoff character-

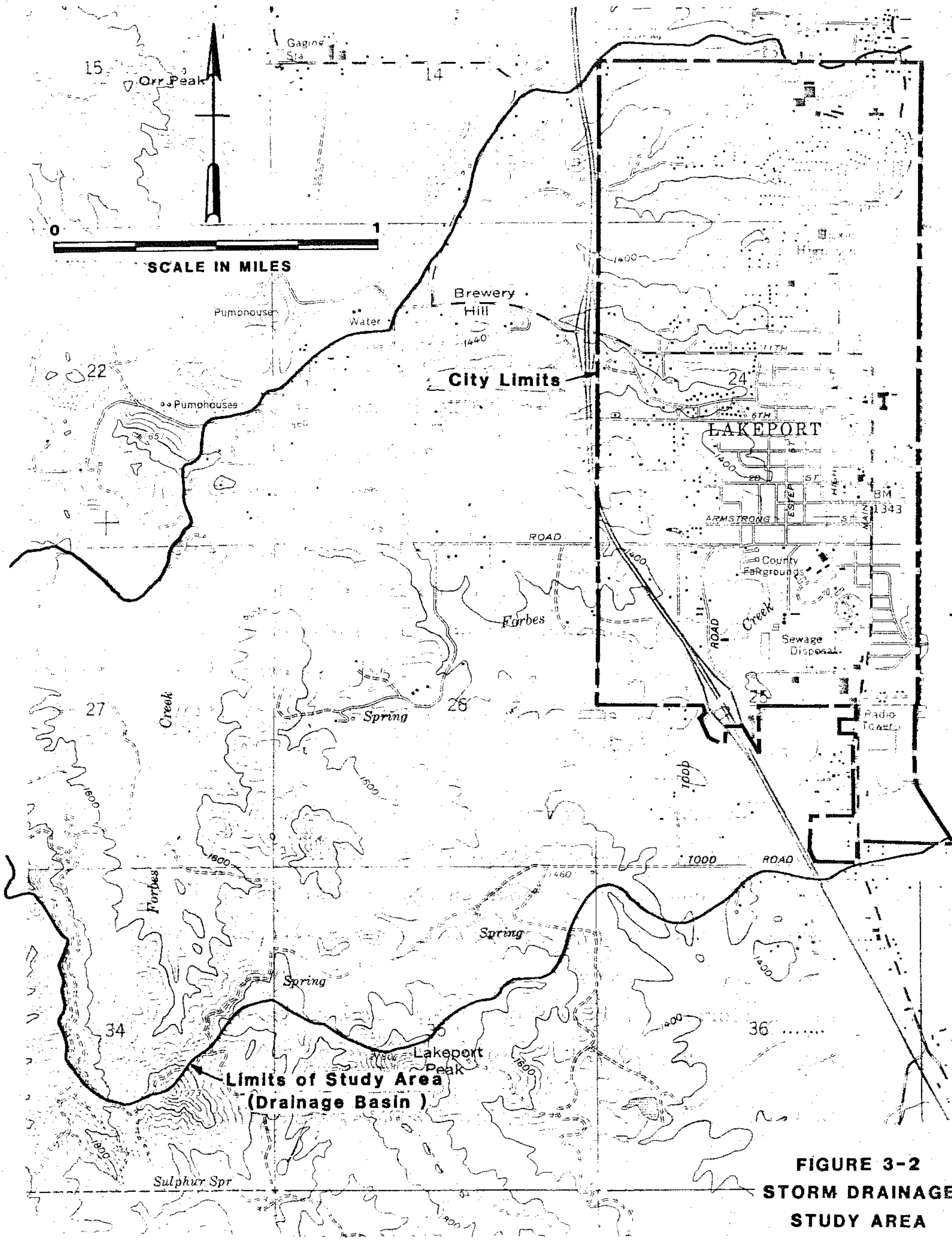


FIGURE 3-2
STORM DRAINAGE STUDY AREA

istics for an area, several aspects of the physical environment must be carefully evaluated. These include climate, topography, soil characteristics, groundwater levels, land use, and the interrelationship of these characteristics. These factors are briefly discussed in the following paragraphs.

Climate

The climate in the Lakeport study area is typical of Lake County and is classified as temperate semi-arid. This classification is characterized by dry, rainless summers with high daytime temperatures and warm nights. Lakeport generally enjoys a cool breeze caused by lake evaporation aided by a prevailing westerly wind which helps to cool the area. The mean annual high and low temperatures are 94 degress and 30 degress fahrenheit respectively. However, extremes of 109 and 12 degrees have been recorded.

Winters tend to be wet with moderate temperatures. The average annual rainfall in Lakeport is 28.31 inches. Ninety-five percent of the annual rainfall normally occurs between October and April. Rainfall during December and January accounts for more than 40 percent of the annual total. Table 3-1 presents average monthly rainfall data while Table 3-2 presents annual rainfall data and high and low lake levels for the period from 1959 to 1979. The rainfall data is for the water year July 1 through June 30. A record of lake levels from 1873 to date and annual rainfall data (also for the water year) from 1931 to date are given in Appendix B.

Topography

The elevations within the city limits of Lakeport vary from 1,326 feet at Clear Lake to 1,450 feet at the western boundary along Highway 29. The highest point in the study area is at the upper end of the Forbes Creek Watershed at 1910 feet. These elevations are based on the datum established by the United States Geological Survey (USGS). Figure 3-2 provides both topography and delineation of the overall study area.

Land slopes are relatively gentle near Clear Lake and increase fairly rapidly in a westerly direction. Slopes vary from 0.5 percent near the lake to 100 percent (1:1) in the upper reaches of the Forbes Creek watershed. Although there are a few slopes exceeding 40 percent within the City limits of Lakeport, most of the terrain has slopes of less than 15 percent.

There are five principal drainage areas with defined natural streams in the study area. The five drainage basins include Hartley, Rumsey Bay, Tenth Street, Forbes Creek and Todd Road watersheds. Sub-basins include the Third and Sixth Street watershed and the Pier 1900 drainage area. Forbes Creek has a North Branch and has the largest area of any of the drainage basins. The Todd Road

TABLE 3-1

AVERAGE PRECIPITATION

Month	Inches	Percent
January	5.95	21.0
February	4.57	16.1
March	3.17	11.2
April	2.04	7.2
May	0.70	2.5
June	0.34	1.2
July	0.02	-
August	0.08	0.3
September	0.22	0.8
October	1.71	6.1
November	3.52	12.4
December	5.99	21.2
Total	28.31	100.0

Source: Lake County Resource Management Plan, 1976.

area is almost totally outside and south of the present city limits. In addition to the naturally defined channels there are a number of smaller watersheds which drain by sheet flow or small diameter pipe directly to Clear Lake.

Soils and Groundwater

Soil mapping in Lake County is in progress and the following information is from a preliminary soil survey report prepared in June, 1979, by the Lakeport Office of the Soil Conservation Service. Approximately sixty percent of the study area has been mapped at this time. The predominant soil types, both inside and outside the city limits, are Manzanita Loam and Kimball Variant Loam.

TABLE 3-2

ANNUAL RAINFALL AND CLEAR LAKE LEVELS

Year	Annual Rainfall (Inches)	Clear Lake Water Level High	Clear Lake Water Level Low
1959-60	31.59	6.71	1.29
1960-61	20.30	7.18	1.76
1961-62	28.20	7.75	1.88
1962-63	30.87	8.20	3.17
1963-64	32.31	6.83	0.31
1964-65	28.50	9.03	2.50
1965-66	25.59	7.59	1.05
1966-67	32.07	7.92	3.02
1967-68	35.66	7.78	3.12
1968-69	40.41	8.80	1.74
1969-70	38.94	10.37	1.37
1970-71	33.14	7.84	1.60
1971-72	19.60	4.58	0.54
1972-73	38.01	7.74	1.28
1973-74	46.95	9.10	1.70
1974-75	31.62	8.89	1.68
1975-76	12.19	2.32	-0.60
1976-77	12.46	-0.30	-3.39
1977-78	45.06	8.10	1.45
1978-79	24.71	6.62	1.38
1979-80	41.81	9.61	-

Note: Annual rainfall is given for the water year July 1 through June 30. Clear Lake water levels are measured in feet on the Rumsey guage. Zero on the Rumsey guage is elevation 1,318.26 USGS datum

The Manzanita Loam is deep, well drained and occurs on terraces. It formed in old alluvium derived dominately from mixed rock sources. Generally, the surface layer consists of seven inches of brown loam. The upper 30 inches of the subsoil is brown and reddish yellow clay loam and this is underlain by red clay. The permeability of this soil is low. Runoff is medium and the hazard of water erosion is moderate. The soil has good load carrying capability when dry but is unstable when wet necessitating the provision of drainage when roads, homes, or other structures are constructed.

Kimball Variant Loam is described as a very deep, well drained soil occuring on terraces. It formed in alluvium derived dominantly from sedimentary and igneous rocks. Generally, the surface layer consists of 10 inches of brown loam. The upper layer of subsoil is generally 24 inches of brown clay underlain by 17 inches of reddish yellow clay loam and sandy clay loam. Beneath the subsoil there is a layer of light yellowish brown clay loam. Permeability of this soil is very low. Runoff is medium and the hazard of water erosion is moderate. When development occurs in areas with this soil type, the main limitations are low permeability, susceptibility to compaction, the high shrink-swell potential in the subsoil, and the hazard from erosion.

Lakeport is adjacent to two groundwater basins: Scotts Valley to the west and Big Valley to the south. These basins were identified and described in the 1976 "Lake County Resource Management Plan". The two aquifers are similar in that they contain both confined and unconfined zones of groundwater. The portion of the Scotts Valley aquifer closest to Lakeport is unconfined and is 40 to 70 feet thick. The closest portion of the Big Valley aquifer is the Western Upland subunit which is a confined aquifer

20 to 40 foot in thickness starting at depths varying from 5 to 40 feet. Both of these aquifers are being intensively utilized and the resource management plan recommends that Lakeport develop all future water supplies from Clear Lake and limit the amount taken from Scotts Valley to 700 acre feet per year.

Land Use

To provide a sound basis for predicting future storm runoff, projections must be made of future land use within the study area. The storm water facilities recommended in this report considered the Lakeport Land Use Map A, amended April 1977, the Lakeport Zoning Map, amended June 18, 1979, as well as supplemental information provided by the City Planning Department concerning probable future changes in land use and intensity of present and future development.

Lakeport's planned land use is mostly low and medium density residential in nature. Commercial development is proposed to be located primarily along Main Street and Eleventh Street with higher intensity land uses extending as far back as High Street between Martin Street and Clear Lake Avenue. There is also high density residential use proposed adjacent to the Lake County Fairgrounds. Major retail-industrial use is planned or in existence in the vicinity of State Highway 29 and Lakeport Boulevard. The resort-residential designation is located along approximtely 50 percent of the Clear Lake frontage in the City. The City land use map amended April, 1977, is shown on Figure B-1 in Appendix B.

Lake County zoning and land use plans were considered for that portion of the study area outside the City Limits of Lakeport. The County is currently working on an update of their general plan and unfortunately no information is available on the effect this update will have on land use in the vicinity of Lakeport. County policies regarding land use are important because more than 65 percent of the drainage area being studied is currently under County jurisdiction. Some guidance has been obtained verbally from County Planning although no written response has yet been received. This guidance has been considered and it is not anticipated that the revised general plan will materially affect the results of this study.

The land use element of Lake County's General Plan provides general designations with wide variations in density allowed. For this reason, definitive guidance as to future land use is not available from the map. A copy of the current Lake County zoning map was provided by the County Planning Department and indicates that most land immediately west of Lakeport is zoned for a residential density of 2.5 units per acre or less. Discussion with the County Planning Department indicated that full development of the area will probably be to the maximum density allowed, based upon availability of services and topography. The flatter land to the south of Lakeport can be expected to develop to a higher density than the lands to the west of town.

CHAPTER IV

CHAPTER IV

EXISTING DRAINAGE

General

The location of existing drainage facilities within the study area are based on reconnaissance investigations conducted during May, 1980, and information compiled from existing records and supplemented by field work performed by the City Engineering Department. Also, a review was made of information provided by CalTrans and the U.S. Army Corps of Engineers.

Within the city limits, most of the storm drainage consists of open channels with culverts used at street crossings. However, both the Hartley Road and Tenth Street drainage areas have significant lengths of conduit in place. The majority of existing facilities follow the natural stream alignments which generally run west to east in a meandering manner and terminate at Clear Lake. Presently, all drainage is provided by gravity flow and no pumping stations are utilized.

As previously decribed, there are five principal watersheds which drain through the City. They are Hartley, Rumsey Bay, Tenth Street, Forbes Creek and Todd Road. In the areas of the City adjacent to Clear Lake, drainage is often directly to the lake rather than to one of these principal channels. There are also two smaller definable areas (Third and Sixth Streets and Pier 1900) which drain by sheet flow and small diameter pipelines to Clear Lake. The drainage areas are delineated on Figure 4-1. The estimated area of each watershed is presented in Table 4-1. The existing facilities and features of each of the drainage areas are described in the following paragraphs. Where data as to the slope of pipe is unavailable, no estimated capacity has been calculated. The elevation of Clear Lake used in hydraulic calculations is 1,330.6 feet, the hundred year maximum water level as determined by the U.S. Army Corps of Engineers. The principal existing drainage facilities serving each watershed are shown on Figure 4-2 at the end of this chapter.

Hartley Drainage Basin

The Hartley drainage basin is approximately 340 acres in area. One-third of the basin is presently in the County. The upper half of the basin is only partly developed and much of the lower half is occupied by Clear Lake High School, Terrace School, and Lakeport Elementary School.

Drainage from the upper reaches of the Hartley basin comes to the State Highway in natural channel. CalTrans provided a 36-inch reinforced concrete pipe (RCP) culvert to accommodate a flow of 50 cubic feet per second (cfs) in a 100 year event. The flow then travels from the highway to Hartley Road in a natural channel which in some areas is

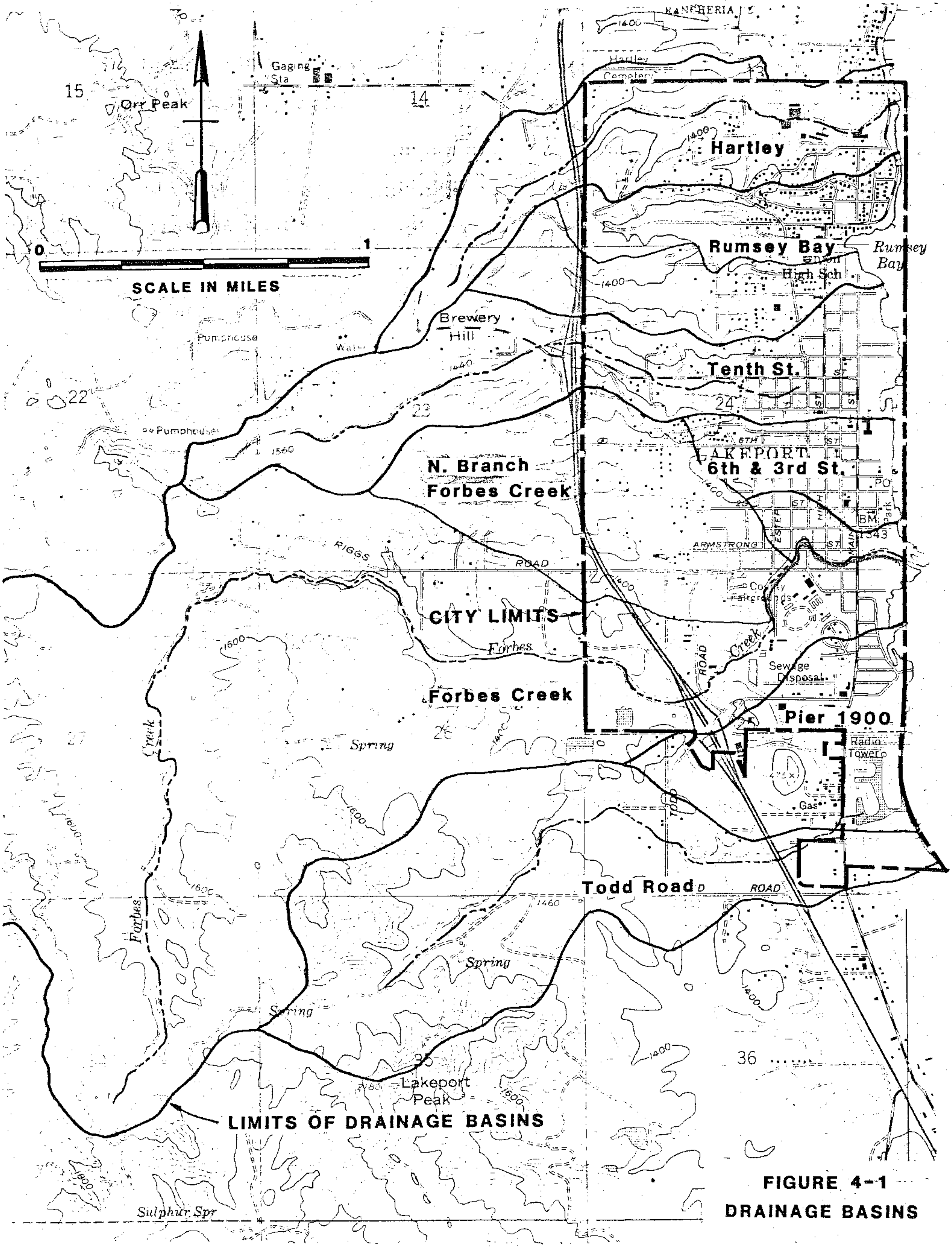


FIGURE 4-1
DRAINAGE BASINS

choked with vegetation. The California State Department of Fish and Game makes removal of growth in natural channels difficult by restricting work to ensure wildlife habitats are not adversely affected. Unfortunately, the need to provide an unrestricted channel for storm water and the maintenance of wildlife habitats are often in direct conflict with each other. In many cases, the two goals may actually be mutually exclusive in that attainment of either goal makes the other goal at least partly unattainable.

TABLE 4-1

WATERSHED AREAS

Watershed	Estimated Area (Acres)		
	City	County	Total
Hartley	205	135	340
Rumsey Bay			
Northerly Basin	135	5	140
Southerly Basin	115	40	155
Tenth Street	180	255	435
Third and Sixth Streets	100	0	100
Forbes Creek			
North Branch	200	150	350
Main Branch	235	1,570	1,805
Pier 1900	135	95	230
Todd Road	20	575	595
Total	1,325	2,825	4,150
Percent	32	68	100

The natural channel ends at Hartley Road and flow enters a 36-inch corrugated metal pipe (CMP) which carries the flow under Hartley Road to a 60-inch cast-in-place concrete pipe (CIP) which runs approximately 2,300 feet to an open channel at the end of the school property. This line appears to be in good condition and has an estimated capacity of 130 cfs. The flow is then carried in an unlined open channel to Clear Lake with the exception of a double 4-foot by 3-foot concrete box culvert (BC) crossing under Lakeshore Boulevard.

Presently, the facilities provide adequate drainage although the area along Lakeshore Boulevard has flooded due to high water in Clear Lake. The existing roadway is more than two feet below the lake high water elevation for the 100 year event. The 36-inch CMP at Hartley Road will become inadequate as development occurs upstream.

Rumsey Bay

There are two narrow watersheds which drain to Rumsey Bay as described in the following paragraphs.

Northerly Basin Rumsey Bay - The northerly basin is almost totally within the City with less than five percent of the 140 acre drainage area in the County. Presently, the upper half of this watershed is undeveloped. Single family residential development is currently taking place in the lower half of the watershed. Because of the small size of the watershed above the highway, no calculations were made and it was assumed that the 24-inch CMP under the State Highway is adequate to carry drainage from the area. CalTrans' policy requires use of either 18-inch or 24-inch pipe crossings for State Highways to drain small areas, depending upon the length of the culvert and engineering judgement. Runoff flows from the highway in a swale which becomes more clearly defined as the flow increases and nears Mellor Drive. At Mellor Drive, a 24-inch RCP, installed in conjunction with recent development, carries the water to a 36-inch RCP in Nineteenth Street which ends in an unlined open channel downstream of Hartley Road. The open channel continues to High Street where a 45-inch by 29-inch oval reinforced concrete pipe (ORCP) carries the flow under the street. A short length of unlined open channel followed by a 3.5-foot by 3-foot concrete box culvert conveys the flow to Clear Lake. Information regarding the slope of these facilities was unavailable and, therefore, the capacities of existing lines were not calculated.

Southerly Basin Rumsey Bay - The southerly basin tributary to Rumsey Bay is slightly larger than the northerly basin. The watershed area is estimated to be 195 acres with 40 percent of the area presently under County jurisdiction. The area west of Mellor Drive is very lightly developed at present whereas the area east of Mellor Drive is nearing full development in conformance with the general plan and zoning restrictions which allow single family residential, commercial, and resort-residential uses.

The drainage basin west of Highway 29 is unimproved and storm water flows to the highway in a natural swale. CalTrans installed a 30-inch RCP to carry a 100-year design flow of 27 cfs. After crossing the highway, flow continues in the natural channel to Mellor Drive where present facilities have proven inadequate and a 48-inch RCP is being proposed by the City to carry the storm water to Palm Drive. The short length of 30-inch RCP on Sixteenth Street would be replaced by the 48-inch RCP. From Palm Drive, a 36-inch by 22-inch corrugated metal pipe arch (CMPA) carries the flow under the roadway to a short length of unlined open channel along the north side of Sixteenth Street. The open channel ends at mid-block and a 36-inch RCP continues to a point approximately 150 feet east of Hartley Road. At this point, an open channel continues along the north side of Sixteenth Street to the rear property line of the properties fronting on High Street, turns north and runs along the rear property line to a point approximately 300 feet north of Seventeenth Street. Flow then enters a 36-inch RCP running east and parallel to Seventeenth Street to a point on the east side of High Street. The line turns north along High Street to Via Del Lago, runs east for approximately 350 feet on Via Del Lago, and finally turns northeasterly and discharges into Clear

Lake. Although the 36-inch RCP on Via Del Lago is laid at a slope of one percent, the effective slope from the open channel at Seventeenth Street to Clear Lake is only 0.18 percent. The estimated capacity of the 36-inch RCP is 24 cfs using the effective slope.

Tenth Street Drainage Basin

The Tenth Street drainage basin is approximately 395 acres in area and is almost equally divided between City (46%) and County (54%). The basin is long and narrow with a length to width ratio of approximately 8:1. While present development west of Highway 29 is minimal, it is estimated that more than 85 percent of the land east of Highway 29 is developed or currently being developed. A large portion of the land south of Eleventh Street and west of Pool Street is being developed as a shopping center. The remainder of the drainage basin is single family residential except in the vicinity of Main Street where commercial and multi-family residential uses predominate.

Storm drainage improvements start at Highway 29 where the main conduit crossing the highway is a 42-inch RCP designed to carry a 100-year storm of 76 cfs. In addition, a second parallel RCP, 24-inches in diameter, is designed to carry 13 cfs during a 100-year storm. Runoff flows from the Highway to Eleventh Street in a trapezoidal earthen channel. A 30-inch RCP culvert carries the flow under Eleventh Street to an open channel on the south side of

Eleventh Street. The open channel continues approximately 250 feet to the westerly end of the shopping center presently being developed. At this point, the flow enters a 60-inch RCP which continues to the easterly end of the new development where flow again enters the natural channel and is carried to Pool Street.

Flow is carried under Pool Street in a 30-inch RCP and flows easterly from Pool Street in an open channel meandering under a house and arriving at Manzanita Street where flow enters a 3.5-foot by 3-foot box culvert. The culvert extends approximately 100 feet passing under a house. Flow then resumes in an open channel to a point 100 feet east of Brush Street except for a 30-inch RCP culvert crossing of Estep Street and 36-inch culvert crossings of Tenth, Tunis, and Brush Streets. At the end of the open channel, flow enters a 5-foot by 3-foot concrete box culvert. The top of the culvert also serves as a sidewalk along the north side of Tenth Street. The original box culvert had no bottom concrete slab and no bottom has been added to this section. A 36-inch CMP is used to cross High Street and after crossing the street, the 5-foot by 3-foot concrete box culvert resumes although in this reach, a concrete floor has been added to the structure.

At Forbes Street, the box culvert changes to 4-feet by 3-feet in size and there is no bottom. The culvert crosses Forbes Street diagonally to a point midway between Tenth and Eleventh Streets where the size changes to 5-foot by 5-foot with a bottom slab. At this point, the culvert changes directions and continues to Clear Lake running parallel to and midway between Tenth and Eleventh Streets. The size changes to 5-foot by 4.5-foot crossing Main Street and this section has no bottom. East of Main Street, the conduit changes to a 5.5-foot by 5-foot open channel.

The concrete box culvert west of Forbes Street is generally in poor condition. All of the sections without a concrete bottom slab are subject to scour and in some areas, the bottom has scoured out and the box culvert and surrounding ground has settled substantially.

The open channel along Tenth Street presents a potential hazard to motorists. The flow passes under houses in several places which is also highly undesirable. All of the pipe culverts west of Forbes Street and east of Highway 29 are grossly undersized. The box culvert sections vary in capacity from an estimated 90 cfs to 180 cfs and the concrete lined open channel east of Main Street has an estimated capacity of 260 cfs. These estimated capacities do not provide for any freeboard and since the top of much of the conduit is at the ground surface, storm water would be unable to enter these conduits at these flows and might even exit at catch basins. A reduction in flow below these capacities would be required in order to provide the necessary freeboard to drain the areas east of

Brush Street.

Third and Sixth Streets Drainage Basin

This watershed is actually comprised of two drainage areas. The largest area drains to Sixth Street and the smaller drains to Third Street. The total area is estimated to include 100 acres and all of this area is within the City of Lakeport. Presently, the basins are almost fully developed although redevelopment could occur in some areas and result in increased density.

The Sixth Street watershed begins just west of Harrie Street and extends to Clear Lake. Flow is carried under Sixth Street at Estep Street to a 24-inch by 16-inch box culvert running along the south side of Sixth Street to Forbes Street. The flow is carried under Forbes Street by a 36-inch RCP and the the 36-inch RCP continues to Clear Lake. The smaller basin, draining Third Street, starts at Brush Street and extends easterly to Clear Lake. Some portion of the flow is concentrated on Third Street and carried in a 24-inch RCP from Park Street to the lake. A portion of the basin drains by sheet flow directly to Clear Lake.

Forbes Creek Drainage Basin

The drainage area contributing to Forbes Creek consists of more than 2,100 acres and is more than three times as large as the next largest area draining through Lakeport. It comprises more than half of the total watershed area being studied. There are two main channels draining this basin, Forbes Creek and the North Branch of Forbes Creek.

North Branch Forbes Creek - The North Branch drains an area of approximately 350 acres of which 43 percent is under County jurisdiction and 57 percent is under City jurisdiction. Development in the County area is sparse whereas within the City, it is estimated that development has occurred on two-thirds of the land available within the North Branch watershed. The upper reaches of the North Branch drain to the highway in a series of natural swales. To drain the area, CalTrans has provided four CMP culverts under Highway 29 ranging in size from 24-inches to 48-inches in diameter with 100-year design flows varying from 17 to 29 cfs. The total 100-year design flow for the four culverts is 96 cfs.

Flow travels overland from the three northerly culverts and joins at a point west of Russell Street on Spurr Street to form the main segment of the North Branch of Forbes Creek. Flow from the southerly highway crossing runs along Martin Street to the main channel of Forbes Creek just east of Estep Street. Only the main segment and southerly segment of the North Branch have significant facilities. Flow in the main segment is carried under the freeway by a 30-inch RCP and then flows in the natural streambed to a 3-foot by 2-foot box culvert with no bottom, crossing under Spurr

Street where an open channel carries the flow to Compton Street. The flow is carried in a culvert under Compton Street to an open channel along the south side of Compton. The open channel turns at Russell Street and runs along the west side under Second Street to a point midway between First and Second Streets. At this point, the channel turns east, passes under Russell Street and flows in an open channel to Starr Street. A 60-inch by 33-inch oval RCP carries the flow diagonally across Starr Street in a southeasterly direction. The open channel continues until intercepted by a 4-foot by 3-foot box culvert with no bottom which carries the flow to a short stretch of open channel just before Armstrong and Polk Streets. The flow crosses under Armstrong Street and flows along the rear of the properties on the east side of Polk Street to Martin Street. The channel turns east paralleling Martin Street and is carried in a 30-inch RCP along the north side of Martin Street to Estep Street, where a 36-inch RCP carries the flow under Estep Street to the main channel of Forbes Creek. The existing facilities along the main segment of the north branch of Forbes Creek are grossly inadequate.

The southerly segment of the North Branch is brought under Highway 29 by a 30-inch RCP and then flows in an open channel along Martin Street where this segment joins the main channel of Forbes Creek. Three culverts convey flow under streets. The lower portion of this open channel is inadequate and flooding has occurred from Russell Street along Martin Street to the main channel of Forbes Creek.

<u>Forbes Creek (Main Branch)</u> - The main branch of Forbes Creek drains more than 1,800 acres in addition to the area drained by the North Branch . Lake County presently has jurisdiction over 87 percent of this watershed while only 13 percent of the basin is within the city limits. The area within the County is sparsely developed and utilized mainly for agricultural purposes. The upper reaches of the drainage basin are quite steep and it is unlikely that significant development will occur in this area. There is potential, however, for development along Riggs Road. This area is zoned, for the most part, for a minimum lot size of 2.5 acres. It is likely that the areas closer to Highway 29 where the land is not as steep will develop at a higher density when utilities become available.

Flow from the western hills is carried to the highway by a well defined natural channel extending approximately 3 miles west of Highway 29. To cross the highway, CalTrans constructed a double 8-foot by 5-foot box culvert under Highway 29 which was designed to accommodate a 100-year design flow of 539 cfs in Forbes Creek. The Creek follows a meandering path to Clear Lake as shown on Figure 4-2. With the exception of culverts at road crossings, the creek consists of an earthen open channel. The culverts vary greatly in size and capacity. The crossing under Martin

Street is a double, 10.5-foot by 4-foot box culvert. The two crossings at Armstrong Street are single, 12-foot by 4.5-foot box culverts with no bottom. High Street is crossed by an 11-foot by 5.5-foot box with no bottom. Forbes Street is crossed by a double, 6-foot by 6-foot box culvert with no bottom and Main Street is crossed by a 13-foot by 7.5-foot box culvert with no bottom. Past flooding indicates that the capacity of the existing channel and culverts are grossly inadequate.

Pier 1900 Drainage Basin

This drainage basin, named for the Pier 1900 trailer park, is comprised of a number of small watersheds which drain to Clear Lake. The total area involved is 230 acres, with 40 percent in the County and 60 percent in the City. Most of the area within the City is developed whereas the County area is just beginning to develop. Existing development generally consists of light commercial use and trailer parks.

The largest watershed within the Pier 1900 drainage basin is located in the southern portion of the basin. The others are all considerably smaller in area and drain directly to the Lake. An earthen swale drains the southern watershed, beginning just east of Todd Road and flowing overland in a southeasterly direction to State Highway 29. A 43-inch by 27-inch CMP arch brings the flow under the highway. An open channel running almost due east transports flow to a point approximately 150 feet west of South Main Street where the channel then turns north for approximately 200 feet. At this point, a 42-inch CMP takes the flow in a northeasterly direction to South Main Street. There is a 30-inch RCP under South Main Street and a 42-inch RCP from the roadway to Clear Lake.

Todd Road Drainage Basin

This watershed drains an estimated 595 acres. Almost all of the basin is outside of the existing City limits. Most of the watershed is presently used for agricultural endeavors. Ground slopes within the basin are gentle and the potential for more intensive land use is significant. The designated use for the lands west of Highway 29 is low density residential while light commercial use is proposed for the land east of the highway.

The upper reaches of the drainage basin are fairly steep. A well defined stream bed brings the runoff to Todd Road. The flow is carried under Todd Road by two 48-inch RCP's and then proceeds to South Main Street in an open channel parallel to and approximately 150 feet south of Industrial Avenue. The culvert under South Main Street consists of two 48-inch RCP's and these connect to a 6-foot by 4-foot box culvert which carries the flow to Clear Lake.

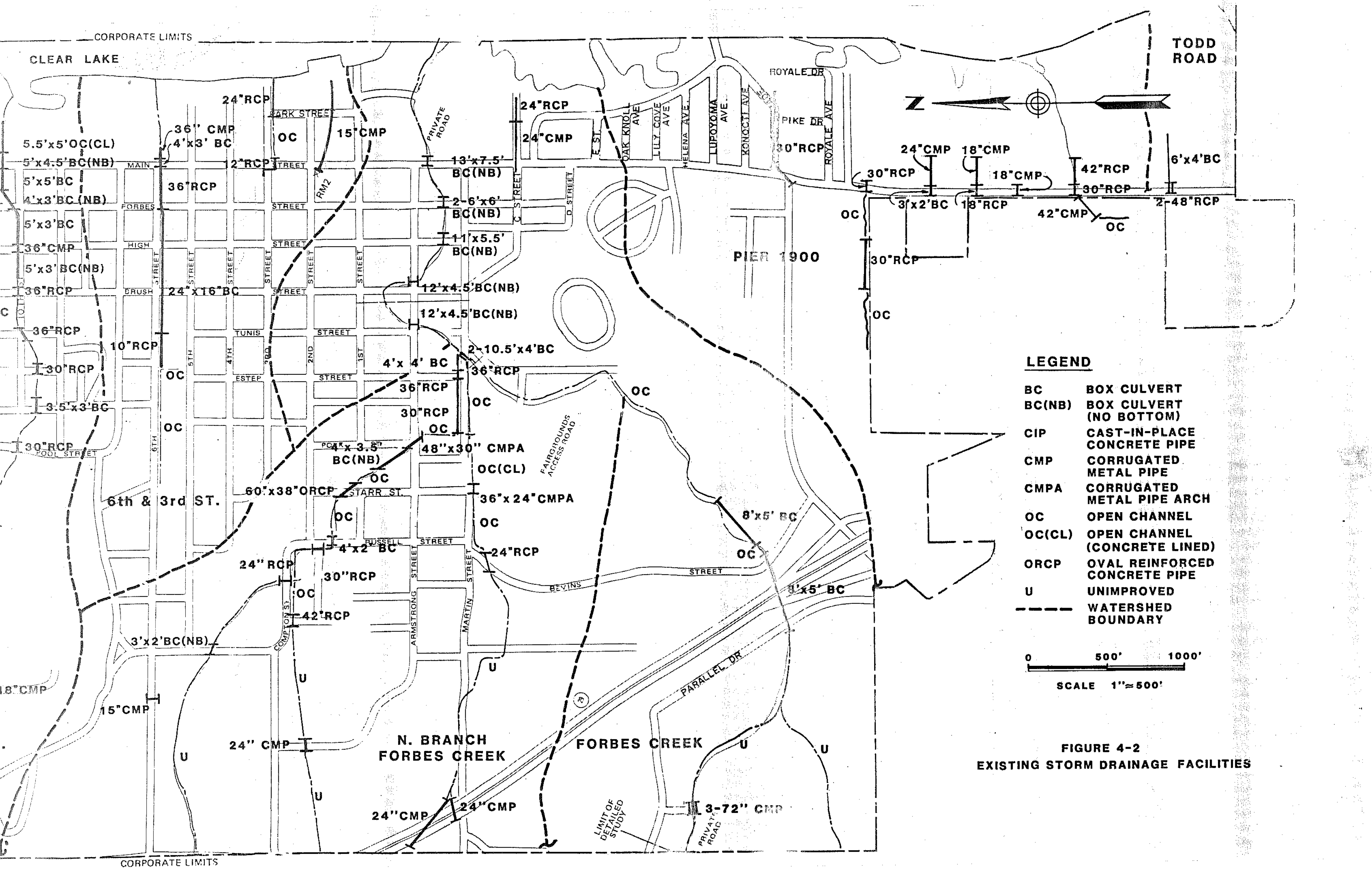
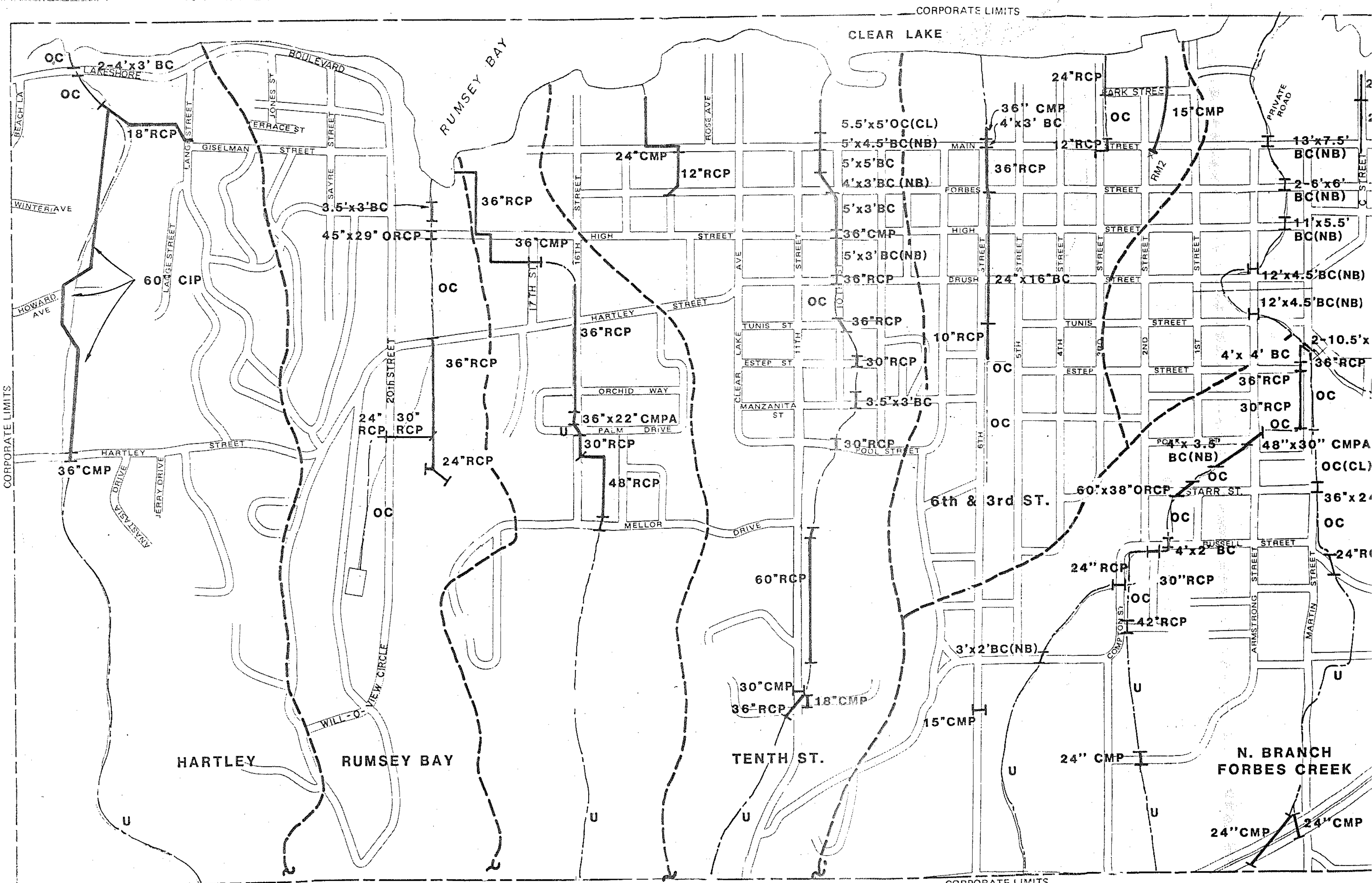


FIGURE 4-2
EXISTING STORM DRAINAGE FACILITIES



CORPORATE LIMITS
CLEAR LAKE
RUMSEY BAY
OC
2-4'x3' BC
LAKESHORE
BOULEVARD
OC
18"RCP
BEACH LA
JONES ST
TERRACE ST
LANG STREET
GISELMAN STREET
SAYRE
STREET
WINTER AVE
3.5'x3'BC
45"x29" ORCP
36"RCP
36"CMP
LANGE STREET
60" CIP
HOWARD AVE
OC
17TH ST
16TH STREET
HIGH STREET
HARTLEY STREET
36"RCP
36"RCP
20th STREET
24" RCP
30" RCP
ORCHID WAY
36"x22" CMPA
U
PALM DRIVE
30"RCP
24"RCP
HARTLEY STREET
36"CMP
DRIVE
ANASTASIA
JERRY DRIVE
48"RCP
OC
MELLOR DRIVE
ROSE AVE
24"CMP
12"RCP
5.5'x5'OC(CL)
5'x4.5'BC(NB)
5'x5'BC
4'x3'BC (NB)
5'x3'BC
36"CMP
5'x3' BC(NB)
36"RCP
36"RCP
30"RCP
3.5'x3'BC
30"RCP
POOL STREET
AVE
STREET
10TH ST
OC
TUNIS ST
ESTEP ST
11TH
LAKE
CLEAR
MANZANITA ST
60"RCP
30"CMP
36"RCP
18"CMP
36" CMP
4'x3' BC
MAIN
FORBES
36"RCP
HIGH
DRUSH
24"x16"BC
10"RCP
OC
OC
6TH
5TH
4TH
3RD
2ND
1ST
6th & 3rd ST.
3'x2'BC(NB)
15"CMP
24"RCP
PARK STREET
OC
12"RCP
STREET
15"CMP
RM2
STREET
STREET
STREET
TUNIS
ESTEP
STREET
STREET
PRIVATE ROAD
13'x7.5' BC(NB)
2-6'x6' BC(NB)
11'x5.5' BC(NB)
12'x4.5'BC(NB)
12'x4.5'BC(NB)
2-10.5'x
4'x 4' BC
36"RCP
36"RCP
30"RCP
OC
OC
48"x30" CMPA
OC(CL)
4'x 3.5' BC(NB)
OC
60"x38"ORCP
STARR ST.
36"x2
OC
OC
RUSSELL STREET
4'x2' BC
24"RCP
30"RCP
OC
42"RCP
COMPTON ST.
ARMSTRONG STREET
MARTIN STREET
24"R
C STREET
U
U
U
24" CMP
U
U
U
U
U
24"CMP
24"CMP
HARTLEY
RUMSEY BAY
WILL-O-VIEW CIRCLE
TENTH ST.
N. BRANCH FORBES CREEK
CORPORATE LIMITS

CHAPTER V

CHAPTER V

DESIGN CRITERIA

General

An area-wide study of drainage facilities consists of the layout and analysis of a network of trunk drainage conduits, evaluation of existing outfall conduits such as drains and laterals, and consideration of facilities such as retention basins and pumping stations. Provision for drainage from local streets and future subdivisions, consisting of storm water inlets and drainage laterals, involves local considerations which are best dealt with by the City Department of Public Works staff and consulting engineers representing developers. Although recommended design criteria and standards will be developed and provided for reference in designing local facilities, facilities considered in this report are those which serve relatively large tributary sub-areas. The areal extent of the drainage sub-areas given detailed attention within the City varies from about 40 to 80 acres, depending upon location, routing of storm drainage water for ultimate disposal, potential near-future development, ground slope, and presence of existing drainage problems requiring attention.

All storm drainage facilities proposed herein are planned to serve ultimate development of the tributary area. This required the use of runoff coefficients and times of concentration anticipated in the future. Although the recommended system provides for ultimate development, facilities need not be constructed until an area develops. Staged construction may be undertaken based on the rate of growth in an area. Storm drainage plans will have to be developed for each watershed in order to ensure that the segments to be constructed will be compatible with the previously completed improvements. Most of the land in the lower reaches of each watershed has already been developed. Unfortunately, many of the storm drainage facilities have proven inadequate and flooding has occurred. In order to correct these existing deficiencies, additional facilities will be required in the lower reaches of many of the watersheds.

In many cases, construction of additional facilities may be deferred until sufficient development occurs upstream. "Ultimate development" refers to the watershed as fully developed in accordance with present land use planning. A summary of design criteria is presented in Table 5-4 following Page . The following sections provide further detail and explanations.

Alternative Design Methods

In order to design stormwater facilities, the sciences of hydrology and hydraulics are employed. The end result is a system sized to accommodate a design flow based on some return period for a rainfall or runoff event. There are a number of different approaches available for use in the design of drainage facilities. Each method has advantages and limitations. The following paragraphs will discuss methods employed by three agencies who have designed facilities and performed studies of flood hazards in the Lakeport area. The agencies are the U.S. Army Corps of Engineers, CalTrans, and Lake County.

U. S. Army Corps of Engineers - In the early 1970's, the Corps performed an extensive hydrologic study of the watersheds affecting Lakeport. Computer modeling programs developed by the Corps at Davis, California, were employed in the study. Models used were the "HEC-1 Flood Hydrograph Package" and "HEC-2, Water Surface Profiles".

The HEC-1 program provides a relatively sophisticated model of single storm events. There is no direct provision to account for preceeding periods of precipitation although loss rates may be adjusted and storms may be combined to better model actual event sequences. Construction of unit hydrographs may be done using either Snyder's or Clark's method and routing can be accomplished using any of six different methods including the Muskingum method. These modeling techniques work best when used to analyze rural or undeveloped watersheds although with care they can give adequate results in the analysis of urban watersheds.

HEC-2 calculates water surface profiles in open channels. The basic approach used is similar to Method 1, Backwater Curves on River Channels, Engineering Manual 1110-2-1409. This method applies Bernoulli's Theorem for the total energy at each cross section. Other losses may be calculated using different methods. The critical water surface elevation corresponding to the minimum specific energy is computed using an iterative process.

The Corp's study used these two programs to derive peak flows for the 10, 25, 100, and 500-year floods. Subsequently, 50-year peak flows were derived using the original calculations. In conformance with Federal policy at that time (1971), calculations were based on existing development. However, "existing development" in Lakeport (in 1971) was substantially less than it is today, as indicated in the following quote from the report entitled "Lakeport Flood Insurance Hydrology":

> "The urban areas of Lakeport are very sparsely populated, storm drains are inadequate and drainage courses are not very well defined."

Present Corps policy allows consideration of development expected to occur within the next five years. Since development of land increases runoff quantity and also the peak discharge unless mitigation measures are employed, the peak flow values developed by the Corps will be substantially less than the actual runoff when the land is fully developed.

While it is true that an analysis using the Corps' method and procedures would yield higher peak flows if based on ultimate land use within each basin, the unit hydrograph method and design parameters used tend to yield a conservative peak flow when this approach is applied to smaller watersheds such as those in Lakeport. The results are usually even more conservative than when applied to larger watersheds. This means that an engineer using less conservative methods and design parameters could arrive at peak flows based on ultimate development which were no higher and might even be lower than those flows calculated by the Corps based on 1971 development.

CalTrans - CalTrans calculated 10 and 100-year design flows to use in the selection of culverts to carry stormwaters underneath the Highway. CalTrans presently lists five design methods in the California Department of Transportation Highway Design manual to be used alone or in combination to size highway culverts. The five methods are the rational method, statistical methods, hydrograph methods, regional analysis, and field review. The Department selects the most appropriate method of calculation based upon the existing conditions, data available, and potential for flood damage.

The culverts in Highway 29 adjacent to Lakeport were sized using the rational method. The rational method is widely used to estimate peak flows because of the ease of calculation and the minimum amount of data required. Although mainly utilized to analyze urban watersheds, with care, the method can be used in rural or undeveloped watersheds. The design flows are based on the area of the drainage basin, rainfall intensity, and the runoff coefficient. The rainfall intensity is determined using rainfall duration curves or formulas. The duration utilized is equal to the time of concentration flow to the point of interest. The time of concentration is determined by calculating the overland flow time from the top of the basin and adding the flow time in any channels or pipe used to carry stormwaters to the point of concentration. Then a rainfall intensity is selected and a rainfall duration chart prepared for the vicinty under consideration. The rainfall intensity curves give lower intensities for longer times of concentration. The drainage area is calculated and a composite runoff coefficient determined by using the proper coefficients for each type of surface and obtaining a weighted average. Finally, the rainfall intensity, area, and runoff coefficient are multiplied and the result is a design flow at the point of concentration for the design selected. The formula is usually written:

$$Q=AIC$$

Where Q=runoff in cubic feet per second
A=area in acres
I=rainfall intensity in inches
C=runoff coefficient

The State tends to be conservative in design of culverts since the cost of damage caused by undersized drains can be far greater than the construction cost of slighly oversized culverts. Care is also taken to ensure that no damage is caused by upstream ponding or downstream erosion as a result of providing culverts. CalTrans, in sizing the culverts under Highway 29, gave consideration to future urbanization where deemed likely.

Lake County - The Lake County Flood Control and Water Conservation District has developed "Hydrology Design Standards" for the design of "Minor Waterways". "Minor Waterways" are defined as having a tributary drainage area less than one square mile and a design frequency of re-occurrence of once in 10 years.

The next larger classification is "Secondary Waterways" which are defined as having a tributary drainage area of between one and four square miles and required a design frequency of re-occurrence of once in 25 years. The rational method is used to calculate the design flows as described above except for an additional factor to adjust rainfall intensity based upon mean annual rainfall. This additional factor is needed because one set of rainfall intensity-duration curves is used for the entire County. Variations are related to the mean annual rainfall in the watershed under consideration and this additional factor provides the necessary adjustment.

Included in the standards are runoff coefficients for the average clay soils most frequently encountered in Lake

County. Adjustments are made when sandy or porous volcanic soils are encountered. Curves are provided which give the runoff coefficient based on the intensity of development and slope of the land. A map giving mean seasonal precipitation in inches is included which covers all of Lake County. Mean seasonal precipitation in the Lakeport basins range between 28-inches and 30-inches per year.

TABLE 5-1

COMPARISON OF ESTIMATED 100 YEAR DESIGN FLOWS AT STATE HIGHWAY 29

Drainage Basin	U.S. Army Corps of Engineers	CalTrans	Lake County
Hartley	220	62 (105)*	117
Rumsey Bay	-	27	62
Tenth Street	250	89	218
Forbes Creek	800	539 (800)*	641

Notes:
1. Flow in cubic feet per second.
2. (xxx) indicates capacity of facilities constructed at probable headwater depth.
3. * denotes sum of two culverts

Rainfall intensity-duration curves are given for 10, 25 and 100-year storms and a graph for determination of the factor to adjust the variations in mean seasonal precipitation as described above is also included. A copy of these Hydrology Design Standards is provided in Appendix C. The comparison of design runoff for areas upstream of Highway 29 presented in Table 5-1 indicates the wide variation in design flows obtained when different hydrologic methods and design criteria are utilized. The area contributary to each of these basins was determined using the USGS Lakeport quadrangle map and the areas were essentially the same. Since the storm re-occurrence period is identical, the differences result from the choice of method (unit hydrograph or rational method), choice of runoff coefficients, and the rainfall duration-intensity curves utilized. The unit hydrograph method appears to provide design flows that are much too conservative for the smaller basins. The design flow for Forbes Creek, however, appears to be somewhat more realistic. For the City of Lakeport, it is proposed that the rational method be used for design of all facilities in the smaller basins and that the unit hydrograph as developed by the U.S. Army Corps of Engineers be employed for the design of facilities on Forbes Creek.

Design Event

The "design event", "design storm", "design period", or "design frequency of re-occurrence" represents the estimated highest probable "quantity" to occur within the period selected. The "quantity" may be inches of rainfall or cubic feet per second of runoff depending on the method of calculation chosen. The larger the period selected, the higher the quantity of the chosen parameter. The choice of the period reflects the estimated relative protection provided by the particular facility under consideration. The decision as to the length of the design period to be chosen is based upon the consequences of failure. Failure is usually evaluated in economic terms and the costs of providing a given level of protection are compared to the estimated costs of repairing damage caused by flooding over the design life of the planned facilities. Cost estimates of providing a chosen protection level are relatively easy to determine, whereas the estimated costs of repairing damages, given that protection level, are much more difficult to calculate. For this reason, the level of protection to be provided is usually selected on the basis of the land use and area served. Larger areas and higher value land uses generally justify longer design periods.

The storm water basins which drain through Lakeport are all relatively small. The only exception is the Forbes Creek watershed. Based on County criteria, a design re-occurrence interval of ten years is indicated. The Federal Flood Insurance Program usually evaluates insurance needs on the "standard storm" which is the 100 year flood. As previously noted, wide variations in estimated peak flows occur when using the Corps' and County methods. Comparison of the design flow using the County standards shows little variation between the 100 year and 25 year events and only a little more than 20 percent reduction in flow if the 10 year event is used. As a result, there would be little, if any, cost savings in using a design period of 25 years rather than 100 years.

The majority of the upstream watershed areas are presently undeveloped. There is also some uncertainty as to the nature of the ultimate development which may be expected to occur in the lower areas of the watershed, where damage is more likely to occur and development is projected to be more intense. For these reasons, it is proposed that the 100 year event be used in the design of facilities serving 100 acres or more and that a 25 year and 10 year design period be used in the design of facilities serving 50 to 100 acres and less than 50 acres respectively.

Clear Lake Water Levels

In addition to the designation of a design storm, a water level for Clear Lake must be selected in order to design storm drainage facilities in Lakeport. High and low water levels were presented in Table 3-2 and in Appendix B. The Corps analyzed available records and determined the levels presented in Table 5-2 for the return periods indicated. The results of the Corps' analysis were reviewed and are believed to be suitable for use in this study. Five times during the period of record (1873-1980) the 100 year value has been exceeded. Apparently, due to stream conditions below the dam, lake levels have risen or remained high for long periods of time. For this reason, it is recommended that the 100 year event, a lake level of 1,330.6 feet be used for design of all facilities, including those designed using lesser storm events such as 10 and 25 years.

TABLE 5-2

CLEAR LAKE WATER LEVELS

Return Period (Years)	Water Level (feet)
10	1,328.3
50	1,330.0
100	1,330.6
500	1,332.1

Source: Flood Insurance Study, City of Lakeport and the Incorporated areas of Lake County, California, April 1978.

Design Parameters

In order to provide a consistent level of protection from flooding, design parameters must be well defined and uniformly applied. In the past, the rational method has been used by the Lake County Flood Control and Water Conservation District to compute storm runoff and the Hydrology Design Standards have been the source for the design parameters used. The actual conditions affecting the watersheds in the vicinity of Lakeport were studied and the applicability of the Lake County standards was confirmed. The Hydrology Design Standards were developed to allow design of facilities throughout the County and only those variations suitable for use in the Lakeport area have been selected.

A mean annual rainfall for Lakeport of 30-inches per year has been selected. The "K factor" utilized in the County version of the rational formula of 0.85 has been incorporated in the rainfall intensity duration curves and should not be included in the rational formula when these curves are used. Figure 5-1 provides these adjusted rainfall intensity curves for the 10, 25, and 100-year events.

In order to determine a rainfall intensity for use in the rational formula, a time of concentration is required. Discussions with the County staff indicated that the following formula has been used to calculate the overland flow time of concentration:

$$T = 60 \left(\frac{11.9\ L^3}{H}\right)^{0.385} + 10$$

Where T = Time of concentration in minutes
L = Distance flow travels in miles
H = Difference in elevation in feet between farthest point and point of concentration

The formula gives a minimum time of concentration of 10 minutes which conforms with the County minimum time of concentration for a residental area with lot sizes of less than one-half acre. The County standard of 15 minutes minimum time of concentration for residential areas with lot sizes greater than one half acre may not be met and in those cases, the 15 minute time of concentration should be utilized. The flow time of storm water in any conveyance facilities such as gutters or pipes should be calculated in accordance with standard hydraulic methods and added to the overland flow time where applicable. The total time of concentration is then used to select the proper rainfall intensity from the rainfall intensity duration curves described above.

The runoff coefficients given in Plate No. 1 of the County Hydrology Design Standards are directly applicable for the design of minimum facilities using the 10-year design period. Lakeport soils meet the clay classification and no adjustment for sandy or porous volcanic soils should be made. The runoff coefficient increases as soils and surfaces become saturated. For this reason, these values should be modified for use with 25 and 100 year design periods by increasing the coefficients determined for the 10 year design period by 5 and 10 percent respectively. These increases in runoff coefficients are necessary to account for the likelihood of prolonged rainstorms being preceded by minor storms causing saturated soils and surfaces and thereby increasing runoff coefficients. The contributary area is determined and a weighted average for the runoff coefficient is calculated using the values from Plate No. 1 adjusted if necessary for use with 25 and 100-year design events. Only Plate No. 1 of the County standards is necessary because Figure 5-1 provides rainfall intensity duration curves replacing the need to use Plates 2, 3, and 4.

Facilities Standards

Application of the rational method using the design parameters described in the previous section requires

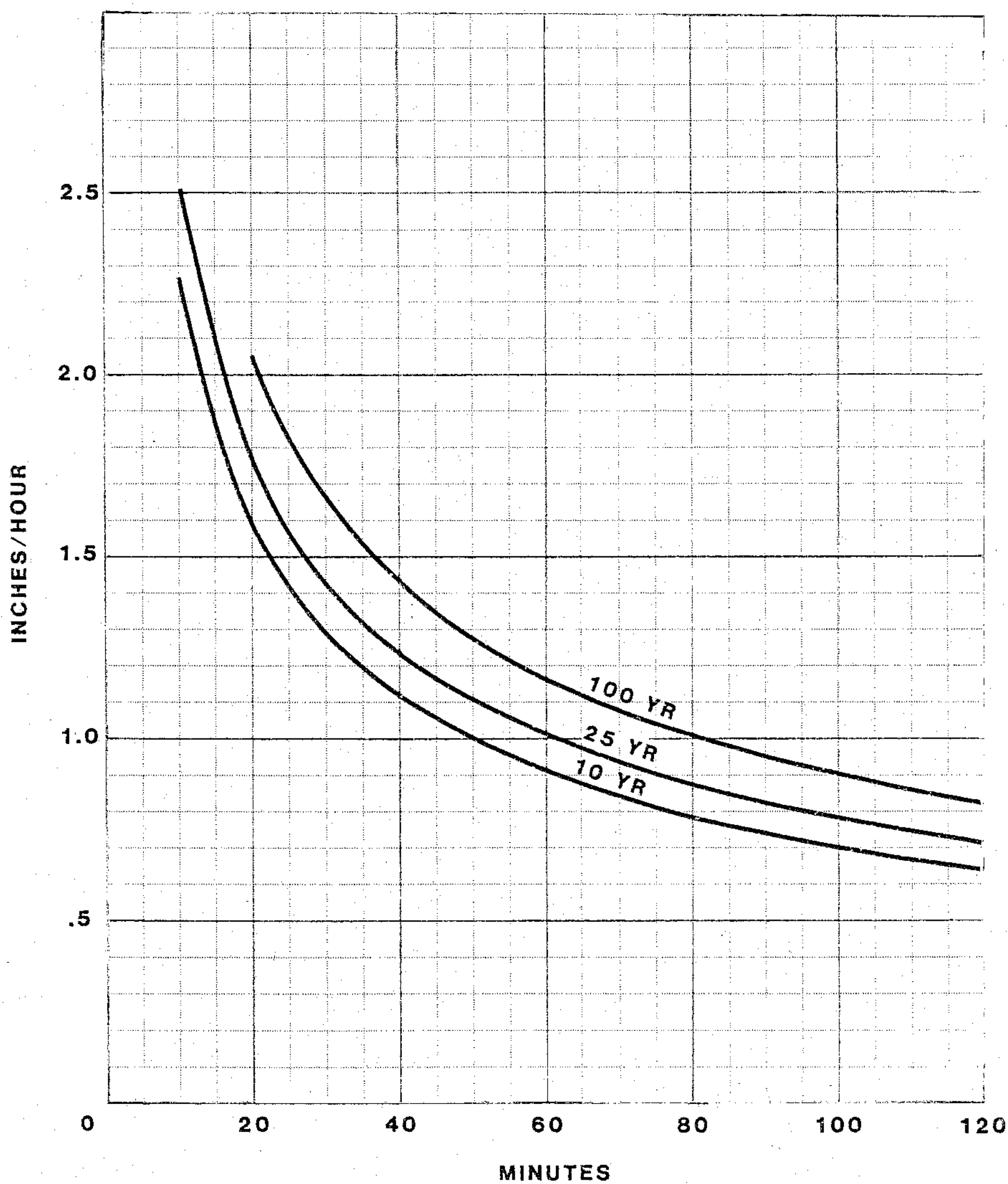


FIGURE 5-1
CITY OF LAKEPORT
RAINFALL INTENSITY
DURATION CURVES

certain facilities standards in order to provide consistent results. These facilities standards must include requirements for all of the conveyance system components and any flood peaking mitigation measures utilized.

The conveyance system consists of natural stream beds and man made channels, culverts, and pipelines. Mannings equation is a standard method used to calculate velocity and capacity of open channels and conduits used to carry stormwater flows. In order to provide comparable results, the friction factors utilid in the formula for various materials must be consistent. Table XIV, Values of Effective Absolute Roughness and Friction Formula Coefficients in ASCE Manual 37, "Design and Construction of Sanitary and Storm Sewers" 1970, provides friction factors for use in the Manning equation. Table 5-3 gives recommended values for material typically used in storm drain conduits. These factors fall within the range of values given in Table XIV and are based on engineering judgement as to the probable construction standards and maintainable conditions of a conduit in service. Table 5-3 presents coefficents for three different materials, asbestos cement, corrugated metal, and concrete. Plastic and fiberglass pipe are not yet readily available in the larger diameter needed for storm drains. For this reason, these materials were not included in Table 5-3.

TABLE 5-3

RECOMMENDED VALUES OF MANNINGS FRICTION FACTOR

Materials	Factor
Asbestos Cement Pipe	0.012
Reinforced Concrete Pipe	0.015
Corrugated Metal Pipe	
Unlined	0.024
Paved invert	0.019
Fully paved	0.015
Concrete Box Culverts	0.015
Concrete Lined Channels	0.015

Asbestos cement is not readily available in sizes larger than 3-inches. Corrugated metal pipe is available in a full range of diameters. In addition, arch shapes of corrugated metal are also available. Corrugated metal pipe is relatively easy to install and has the ability to deform under loading without damage. Unfortunately, the pipe is subject to corrosion and even when fully asphalt coated the expected life is not as long as concrete or asbestos cement. Concrete is available both as precast pipe and cast-in-place pipe throughout the range of sizes required for drainage in Lakeport. The long life, low maintenance, high strength and ready availability of concrete make it the most desirable of the materials available for storm drain construction. Corrugated metal may be used for temporary drains and may also be the most economical choice if large roadway culverts are required along Forbes Creek. A replacement fund may be necessary to ensure availability of monies when the culverts require replacement.

The velocity of flow provided in storm sewers should be in the range of 2.5 feet per second to 10 feet per second for facilities designed to accommodate the 10-year storms. The energy grade line should be kept three feet below the gutter for these facilities. The standards for facilities designed to accommodate the 25 and 100-year storms should meet the minimum velocity standards of 2.5 feet per second. Due to the infrequency of use at design flows, the maximum velocity can be as high as 20 feet per second although 15 feet per second is more desirable. The energy grade line should be kept two feet below the gutter for facilities designed using the 25-year event and one foot below the gutter for facilities using the 100- year event. Open channels should provide a minimum one foot of freeboard at the design flow. Where velocities are high, a greater freeboard should be provided and backwater depth determined to ensure containment of the flow within the channel. Velocities in concrete lined open channels should be kept below 15 feet per second and unlined channels will require lower velocities to avoid erosion. Design criteria are summarized in Table 5-4.

Retention Basins

After review of existing development and conditions and discussions with City staff, it was determined that the use of detention or retention basins as such was not feasible within the City. Most of the drainage basins are relatively small and available slopes are adequate to keep pipe sizes to a minimum reducing the cost-effectiveness of detention basins. However, there is the potential for use of detention facilities in the Forbes Creek basin and the Todd Road watershed. These areas are presently under County jurisdiction. Construction of facilities in these areas will require the cooperation and support of the County. The potential benefits of common standards and goals justifies the effort necessary to obtain agreement on goals and standards. No standard for retention basins are provided at this time. Such standards will require approval by the County. It is suggested that the goal of not increasing the flow presently reaching Highway 29 is desirable and that a joint effort of the City and County be undertaken to accomplish this result.

The clay soil in the vicinity of Lakeport makes use of percolation basins uneconomical and the terrain eliminates the need for storm water pump stations. Current ordinances require flood proofing of properties subject to potential flooding by the 100-year event. These requirements should be maintained and will result in substantial reductions in flood damage as new improvements are constructed meeting these standards. Dikes may be used to protect areas adjacent to Clear Lake which are below the elevation of 1,330.6, the level of a 100-year event. If such dikes are constructed, small private pumping systems to discharge on-site storm water over the dikes may be necessary.

TABLE 5-4

SUMMARY OF DESIGN CRITERIA

Design Event

Area (acres)	Return Period (Years)
Greater than 100	100
50 to 100	25
Less than 100	10

Clear Lake Water Level - 1,330.6 feet (USGS datum)

Time of Concentration - $T = \left[(11.9\ L^3)^{0.385}/H\right] + 10$

Where T = Time of concentration (minutes)
L = Distance flow travels (miles)
H = Difference in elevation (feet) between farthest point and point of concentration

This equation is for overland flow, for 10 and 25 year event use minimum of 30 minutes

Design Flow (cfs) - Q = AIC

Where Q = Runoff in cubic feet per seconds
A = Area (acres) - All acres tributary to point of concentration
I = Rainfall Intensity (inches) - from Figure 5-1 for the selected design period
C = Runoff Coefficient - based upon ultimate development. Use Lake County parameters for clay soils in Appendix B. For return periods of 25 and 100 years, multiply composite run-off coefficients by 1.05 and 1.1 respectively.

Friction Factors - Use Mannings friction factors given in Table 5-3.

Velocity and Energy Gradeline - $EGL = 1.5\ V^2/2g$

Where EGL = Energy guideline
V = Velocity in feet per second
g = Acceleration of gravity 32.2 feet per second^2

Calculate the velocity using Mannings equation. Maintain the following clearances between the gutter elevation and the energy gradeline and maintain the velocity within the ranges given below:

Design Event (yrs)	Minimum Clearance (ft.)	Maximum Velocity (fps)	Minimum Velocity (fps)
10	3.0	10	2.5
25	2.0	10	2.5
100	1.0	15*	2.5

* In designing open channels, a lesser velocity may be desirable for safety or to prevent erosiion.

CHAPTER VI

PROPOSED STORM DRAINAGE MASTER PLAN

General

As discussed in earlier chapters of this report, the development of a drainage plan was undertaken in two phases, namely the investigation of 1) outlying areas within the study area but outside the city limits, and 2) the area tributary to the existing drainage system within the city limits with particular emphasis on alleviating present problem areas. In addition, the U.S. Army Corps of Engineers and CalTrans drainage calculations were considered in establishing a recommended drainage plan.

Major emphasis was placed on developing a plan that would minimize the total cost of improvements. Existing facilities were utilized as part of the overall system wherever feasible. Because this plan is intended as a guide for development of future drainage facilities, it does not attempt to present detailed drainage designs for individual areas. Rather, it is intended to indicate flow patterns and peak runoff characteristics from an area and the size of pipelines and culverts that can serve the tributary area. Technical guidelines and data are provided to facilitate City staff review as development occurs in different sectors of the study area. Detailed design and construction plans of each trunkline will have to be accomplished prior to constructing individual segments. This is necessary to ensure a fully functioning system upon completion of improvements. Particular care will be required when designing transitions between existing and new drainage facilities to avoid operational problems. It will be the responsibility of the City staff to evaluate development proposals in light of the overall needs presented herein and to make changes as necessary to achieve the overall goal of adequate storm drainage for the least cost.

Estimated Costs

In order to determine the overall economic feasibility of the proposed drainage plan, it was necessary to prepare preliminary cost estimates for the proposed improvements. Cost estimates are based on the premise that all construction will be accomplished by competitively bid contracts.

Construction Cost Trends - Because of the wide diver- sity of costs of various components which enter into the construction of drainage facilities, it is necessary to establish a basis for cost estimates which will measure the effects of wage rates and material prices at a particular location and point in time.

The Engineering News-Record magazine (ENR), a weekly publication for the construction industry, publishes certain index numbers which reflect a compilation of changes in construction costs. These indices are based on a weighted average of costs of certain key construction materials and labor on national and regional levels. The index shown on Figure 6-2 reflects the nationwide trend of continually increasing construction costs. The regional construction cost index for San Francisco has also been plotted to show the relationship of the Pacific coast to the nationwide average.

In the past 24 months, inflationary pressures have resulted in more than a 15 percent increase for each of the indices. While the cost of construction is not expected to continue to increase at this rate, costs will continue to escalate. For the purpose of comparison of various alternatives, the year 1980 has been chosen as a base. To ensure that all costs are comparable, an ENR index figure of 325 has been used and is believed to be representative of conditions expected to prevail in 1980 for the Lakeport area. Estimates may be updated in future years by adjustment of the costs to conform to the then-current index value.

Storm Drains - Storm drain costs were developed from bid tabulations of previous jobs, recent estimates by developers, and other published data. All costs were adjusted to reflect a cost level expected to prevail in the summer of 1980. These costs include furnishing,

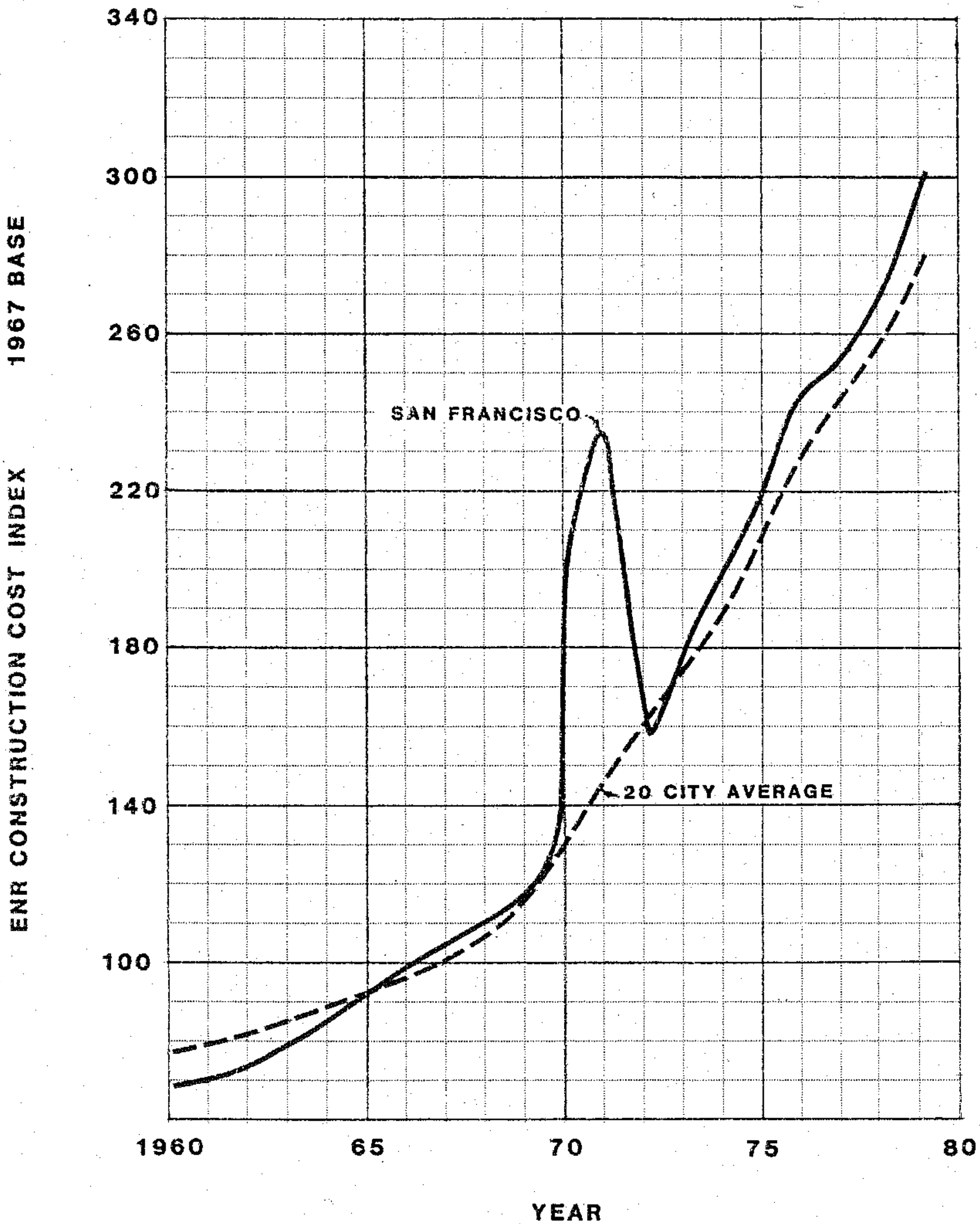


FIGURE 6-2

CONSTRUCTION COST INDEX

laying, and jointing of reinforced concrete pipe, excavation and backfill, bedding material, manholes, connections to existing pipes, pavement replacement, some interference with existing utilities, and contractors overhead and profit. See upper curve on Figure 6-3.

Since significant lengths of storm drain will be constructed through open and undeveloped areas, a separate cost curve was developed which does not include an allowance for paving and utility interference. The lower curve on Figure 6-3 is based on these assumptions.

In developing costs for storm drains, an allowance was made for land costs where proposed facilities are to be constructed across private property in developed areas. In undeveloped areas no allowance was made since nearly all pipelines will be constructed within easements or roadways to be dedicated by developers. Estimated right-of-way costs are presented in Table 6-2 at the end of this chapter.

Contingencies and Engineering

In preliminary engineering studies, it is not possible to go into the detail necessary to define the exact location or conditions which may have a substantial bearing on the cost of the proposed work. To allow for unforeseen difficulties or variations from study plans, a percentage of the preliminary estimate is often added. This same

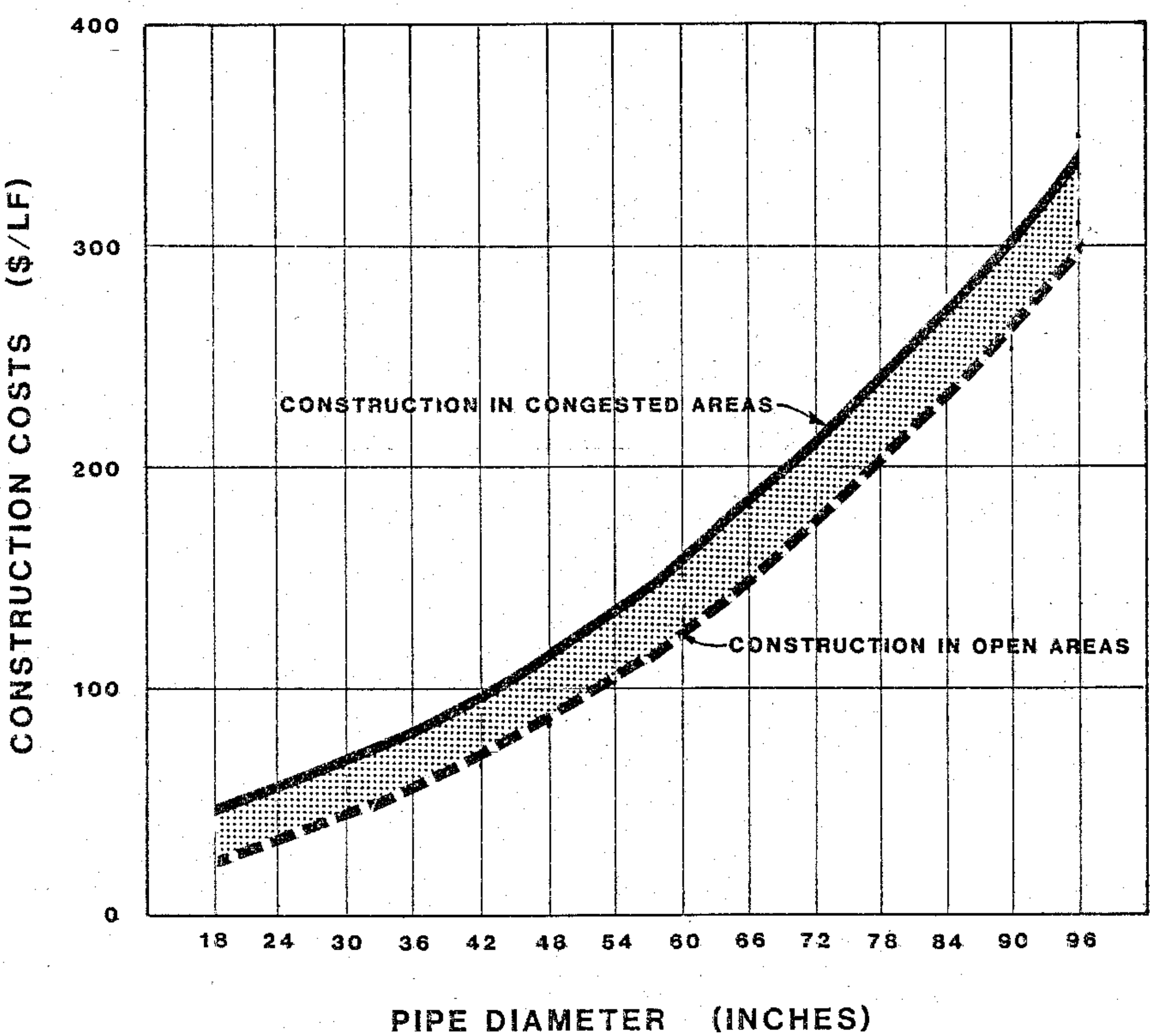


FIGURE 6-3

STORM DRAINS

CONSTRUCTION COSTS

procedure is also used to cover the cost of engineeing design and supervision of construction. While the larger the project the lower the percentage is likely to be, a 25 percent allowance has been used for planning purposes.

Areas Outside City Limits

As previously discussed, the storm drainage study area defined by the existing topography includes substantial areas outside of present city limits. Six of the seven drainage basins have contributary areas outside the city boundaries. Although drainage facilities were not designed to serve these areas, consideration was given to the impact which would occur in the downstream portion of each watershed upon development and installation of storm drainage facilities upstream. The watershed area, average ground slope, and projected land use in each of these County areas are presented in Table 6-1.

Except for the Rumsey Bay and Sixth and Third Street watersheds, the area under County jurisdiction comprises 40 percent or more of the total area in each watershed. The potential impact of development and storm drainage in these areas on the downstream area within Lakeport cannot be overemphasized. The potential impact of development in the areas under County jurisdiction indicates a strong need for City-County cooperation. This cooperation should include overall storm drainage plans and consistent development requirements.

TABLE 6-1

LAND USE DISTRIBUTION BY DRAINAGE BASIN

Drainage Basin	County Area (Acres)	% of Watershed	Average Slope (%)	Projected Land Use
Hartley	135	40	8	Residential
Rumsey Bay				
North	5	4	8	Residential
South	40	26	8	Residential
Tenth Street	255	59	12	Residential & Agricultural
Forbes Creek				
North Branch	150	43	10	Residential &
Main Channel	1570	87	15/3	Agricultural
Pier 1900	93	41	12	Residential & Agricultural
Todd Road	575	97	14/3	Residential & Agricultural

Note: Where two average slopes are given (15/3), the first average refers to the upper portion of the watershed and the second to the lower portion

Source: Lake County Land Use Element of the General Plan

Where possible, design standards in the City and County should be identical. Contributions to the City of Lakeport by the County and developers in the County should be made to pay for drainage conveyance facilities. Otherwise, facilities required to transport storm water from upstream areas through the City to Clear Lake should be provided.

Proposed Drainage Facilities

Engineering criteria used for design of the proposed facilities was outlined in Chapter V. In general, the rational method was used to determine design flows with parameters developed for Lake County. Land use outside the City Limits was based on the Lake County General Plan as shown in Table 6-1. The projected land use given in the table was used with the assumption that residential density would increase as land slopes decreased, Downstream facilities were designed for the estimated ultimate upstream land use. A check was made to confirm the adequacy of proposed facilities to meet existing conditions. Land use in the City was based on the City General Plan land use map (see Appendix B). After initial sizing of pipelines, consideration was given to the incorporation of existing facilities into the overall drainage plan. The new facilities needed to serve ultimate development are shown on Figure 6-1 at the end of this chapter. Table 6-2, also at the end of this chapter, summarizes estimated costs of the individual watershed improvements described in the following paragraphs.

Hartley Drainage Basin - The watershed area under County jurisdiction is presently undeveloped and approximately 40 percent of the available land within the City is undeveloped. Future development is expected to be residential in nature. Lesser densities are anticipated west of Highway 29.

The proposed facilities start at Highway 29 with a 48-inch RCP. The 48-inch RCP connects to a 60-inch RCP approximately 1,050 feet west of Hartley Road. The 60-inch RCP runs from this point easterly to the east side of Hartley Road where it is connected to the 60-inch CIP running across the school property. The 60-inch CIP is supplemented by a parallel 54-inch RCP. (The existing 60-inch CIP is adequate to carry the 50-year event with present development and the proposed parallel line may be deferred until development occurs west of the school property.) From the end of the existing 60-inch CIP a 78-inch RCP carries the flow to Lakeshore Boulevard. The 78-inch RCP connects to an 84-inch RCP which runs under Lakeshore Boulevard to Clear Lake.

Rumsey Bay Drainage Basin - The northerly basin is almost totally within the City and 80 percent of the area is presently developed. Development generally consists of single family residences. The facilities sized in this report start at the southwest side of Will-O-View Circle although minor facilities will be required beyond this point to collect local drainage. The first segment of the proposed system is a 24-inch RCP which runs from Will-O-View Circle to the facilities recently installed in Nineteenth Street and vicinity. These facilities are not adequate to carry the 10-year event and will eventually have to be supplemented with parallel lines. It is proposed that the existing 30-inch RCP be paralleled by a 24-inch RCP and the existing 36-inch RCP in Nineteenth Street be paralleled by a 27-inch RCP to the open ditch east of Hartley Road. The open ditch will be replaced by a 54-inch RCP to High Street and a 60-inch RCP from High Street to Clear Lake. Although the existing pipeline facilities are inadequate, construction of parallel lines can be deferred until development occurs west of Mellor Drive. The first priority in this basin should be elimination of the rear lot ditch running from Hartley Road to High Street.

The southerly basin draining to Rumsey Bay is presently 50 percent developed and approximately 25 percent of the basin is west of Highway 29 under County jurisdiction. Generally, development is single family residential except along High Street where commercial and multiple family uses exist. The existing 36-inch RCP along Sixteenth Street is grossly inadequate and has not been incorporated in the ultimate system. The 36-inch RCP may still serve to carry local drainage and may be interconnected to the new facilities. The recommended facilities start at Highway 29 with a 27-inch RCP which carries the flow to a point approximately 1,400 feet west of Mellor Drive where a 33-inch RCP begins and continues to Mellor Drive. At Mellor Drive the 33-inch RCP connects to a 42-inch RCP which carries the flow down Sixteenth Street to Orchid Way.

At Orchid Way the 42-inch RCP is connected to a 66-inch RCP which continues down Sixteenth Street to High Street. At High Street the 66-inch RCP turns north and runs along High Street to Via Del Lago. At Via Del Lago a 72-inch RCP connects to the 66-inch RCP and carries the flow down Via Del Lago to Clear Lake.

Tenth Street Drainage Basin - This watershed is the third largest drainage basin in Lakeport. The basin is long and narrow with almost 60 percent of the area presently undeveloped and located west of Highway 29 in the County. The area within the City will be almost completely developed after completion of the new shopping center. Land use within the City is a mixture of commercial and high and low density residential development. The proposed facilities are sized to carry the projected development of the watershed. The new 60-inch RCP being installed with the development of the shopping center is properly sized for the 100-year event and is incorporated in the proposed storm drainage system. The facilities from Pool Street to a point approximately 150 feet east of Brush Street are grossly inadequate and have not been included in the ultimate drainage system.

The existing box culvert along the north side of Tenth Street could be incorporated in the ultimate system. However, the actual capacity of the existing facility is minimal and the cost of the transitions needed to incorporate the existing culverts in the final system would substantially offset any savings which might result. The existing improvements are in marginal condition and substantial work may be required to rehabilitate them. In addition, new facilities could only be reduced one pipe size by incorporating the existing culverts in the long-range plan. Although the use of the existing open channel from Main Street to Clear Lake could save approximately $40,000 if incorporated in the final system, the hazards presented by an open channel in fully developed areas does not appear to justify the savings. Proposed facilities include a new 84-inch RCP which could be reduced in size to a 48-inch RCP if the open channel is retained.

The proposed facilities to serve the Tenth Street basin start at Highway 29. A 60-inch RCP, running generally parallel to Eleventh Street, carries the flow from Highway 29 under the new shopping center to Pool Street. At Pool Street the 60-inch RCP is connected to a 78-inch RCP in Tenth Street. The 78-inch RCP continues east on Tenth Street to Main Street. From Main Street an 84-inch RCP is provided to carry the flow under private property to Clear Lake.

<u>Sixth Street and Third Street Drainage Basin</u> - The total area within both the Sixth Street and Third Street watersheds is only slightly more than 100 acres. The entire area is within the City and essentially fully

developed. There are existing drainage conduits in both Third and Sixth Streets. Only the drainage area contributing to Sixth Street was reviewed due to the small area contributing to Third Street (less than 50 acres). The facilities in Sixth Street are inadequate to carry the 10 year design storm from the area above Brush Street and the 25 year design storm below Brush Street. Although the 36-inch pipe can be used to carry local drainage, it should not be incorporated in the trunkline facilities serving this area.

The proposed facilities in the Sixth Street basin start at Manzanita Street where the flow is carried under Sixth Street to the south side by a 30-inch RCP. The 30-inch RCP continues east along the south side of Sixth Street to Brush Street. AT Brush Street a 54-inch RCP is provided to carry the flow the remainder of the distance to Clear Lake along the south side of Sixth Street.

Forbes Creek Drainage Basin - This watershed is by far the largest drainage basin in the study area. Total area is in excess of three square miles and 80 percent is under County jurisdiction. Present development is generally sparse west of Highway 29. The area within the City is approximately 70 percent developed. Development includes the County fairgrounds, single family residential development, and intensive commercial uses The basin is drained by two principal water courses. The Main Channel of Forbes Creek and the North Branch of Forbes Creek.

The North Branch of Forbes Creek has been realigned and culverts installed from Spurr Street southeasterly to the Main Channel. The existing improvements are inadequate and stretches of open channel run adjacent to the roadway creating a hazard to motorists. In addition, it would not be cost-effective to incorporate the existing short lengths of improvements into the proposed trunkline drainage system. The proposed storm drainage facilities are described in the following paragraphs.

A 36-inch RCP is proposed from Highway 29 to Spurr Street. From Spurr Street to Compton Street a 54-inch RCP is utilized. Both of these lines are shown following the general alignment of the existing channel. Final alignment will have to be determined when the lands are developed and the facilities designed. At Compton Street the 54-inch RCP is connected to a 78-inch RCP. The 78-inch RCP runs east on Compton Street to Russell Street where the line turns south along Russell Street to a point approximately halfway between First and Second Streets. At this point the 78-inch RCP turns east parallel to First Street and flows to Starr Street. The line turns south on Starr Street and continues to Martin Street. At Martin Street the 78-inch RCP turns east and runs along Martin Street to its outfall in the Main Channel of Forbes Creek.

Analysis of the Main Channel of Forbes Creek by the Corps indicated that the flow upstream of Highway 29 is greater than the flow generated within the City and sets the capacity requirements for the facilities required east of the highway. The proposed facilities in the Main Channel are sized to carry the peak flow from the area above Highway 29 as determined by the U.S. Army Corps of Engineers. The upstream area was assumed to be developed without increasing peak storm water discharge. This will require cooperation of the County if development more dense than the current trend of 1 unit per 2.5 acres occurs. More dense development would require onsite detention facilities or other mitigation measures to limit peak discharge.

Presently, a retention basin in the upper branches of the Forbes Creek basin is being reevaluated to determine its feasibility for reducing downstream flooding. The idea was evaluated in 1969 and found cost-effective at that time. Unfortunately, there was insufficient interest to pay for local costs and pursue federal funding and construction of facilities. The criteria used at that time were based on a 10 year event. The project would eliminate flooding in the agricultural area for the 10 year event and would reduce the flows entering the City of Lakeport. If this project is constructed, the proposed downstream facilities can be reduced somewhat in size and a savings realized in constructing the necessary channel improvements. The proposed improvements shown on Figure 6-1, consist of two

108-inch RCP's and a diversion structure on Forbes Creek at Martin Street. The two 108-inch RCPs continue east down Martin Street to Main Street and then across private property from Main Street to Clear Lake. sk. Provision is made to allow a small portion of the peak flow to travel down the existing channel in order to meet expected State Department of Fish and Game requirements. Allowing the existing creek to carry the low flows will help to maintain the existing wildlife habitat. Consideration was given to using the existing channel up to the maximum safe capacity, reducing the size of the pipes in Martin Street and thereby the overall cost of Forbes Creek improvements. Preliminary cost estimates of the diversion structure required and the improvements and acquisition of right-of-way in the existing channel made this option more costly than conveying the full flow down Martin Street.

<u>Pier 1900 Drainage Basin</u> - This watershed is relatively small and consists of a series of small areas draining directly to Clear Lake. Only the southerly most area is of a size justifying inclusion in the storm drainage master plan. The watershed is partially developed for commercial and recreational-residential uses. There are numerous existing drainage facilities under the trailer park which carrry runoff from South Main Street to Clear Lake. The existing 30-inch and 42-inch RCP are undersized and it is proposed that they be paralleled by a 54-inch and 42-inch RCP, respectively.

Todd Road - This watershed is almost totally under County jurisdiction and only the southern tip of the City is in this basin. Existing development is sparse and agricultural in nature. The potential for development is high in the lower half of this basin because of the gentle ground slopes . It is proposed that when development occurs, the existing 6-foot by 4-foot box culvert be supplemented by a parallel 72-inch RCP from South Main Street to Clear Lake.

TABLE 6-2

LAKEPORT STORM DRAINAGE

COST ESTIMATE

Basin	Pipe Size (inches)	Length (feet)	Estimated Const.Cost	Contingencies Engrg. 25%	Right-Of Way	Total Cost
Hartley						
	48	2,200*	$ 182,600			
	60	1,100*	144,100			
	54	2,300	299,000			
	84	500	135,000			
Subtotal			$ 760,700	$ 190,200		$ 950,900
Rumsey North	24	1,000*	$ 32,000			
	30	900	55,800			
	27	600	33,000			
	54	700	91,000			
	60	300	47,400			
Subtotal			$ 259,200	$ 64,800	$100,000	$ 424,000
South	27	700*	$ 26,600			
	33	1,400*	71,400			
	42	400	36,400			
	66	1,900	353,400			
	72	600	124,800			
Subtotal			$ 612,600	$ 153,200	$ 25,000	$ 790,800
Tenth Street						
	60	2,100	$ 275,100			
	78	2,000	470,000			
	84	400	108,000			
Subtotal			$ 853,100	$ 213,300	$ 50,000	$1,116,400
Sixth Street						
	30	800	$ 49,600			
	54	1,300	169,000			
Subtotal			$ 218,600	$ 54,700	$ 65,000	$ 338,300

TABLE 6-2

LAKEPORT STORM DRAINAGE

COST ESTIMATE

(Continued)

Basin	Pipe Size (inches)	Length (feet)	Estimated Const. Cost	Contingencies Engrg. 25%	Right-of Way	Total Cost
Forbes Street						
North Branch	36	1,400	$ 81,200			
	54	700	91,000			
	78	2,400	564,000			
Subtotal			$ 736,200	$ 184,100	$ 85,000	$1,005,300
Main Branch	108	4,200	$2,100,000			
	Diversion Structure		200,000			
Subtotal			$2,300,000	$ 575,000	$150,000	$3,025,000
Pier 1900						
	36	100	$ 7,900			
	54	200	26,000			
Subtotal			$ 33,900	$ 8,500	$ 25,000	$ 67,400
Todd Road						
	72	400	$ 83,200	$ 20,800	$ 30,000	$ 134,000
TOTAL COST			$5,857,500	$1,464,600	$530,000	$7,852,100

Note:

* These facilities will be constructed in presently undeveloped areas and it is assumed there will be no cost for paving or relocation of utilities.

CHAPTER VI

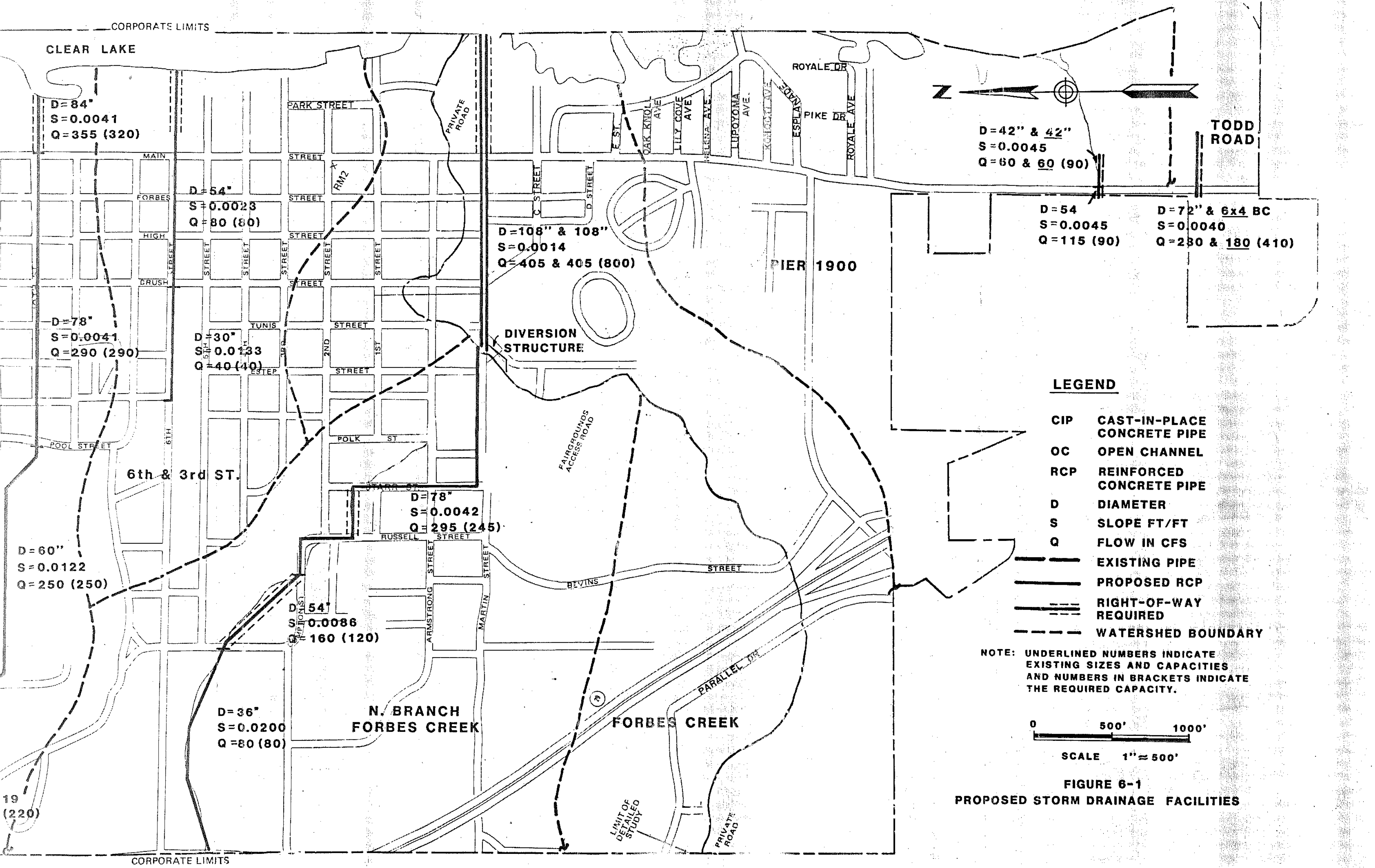
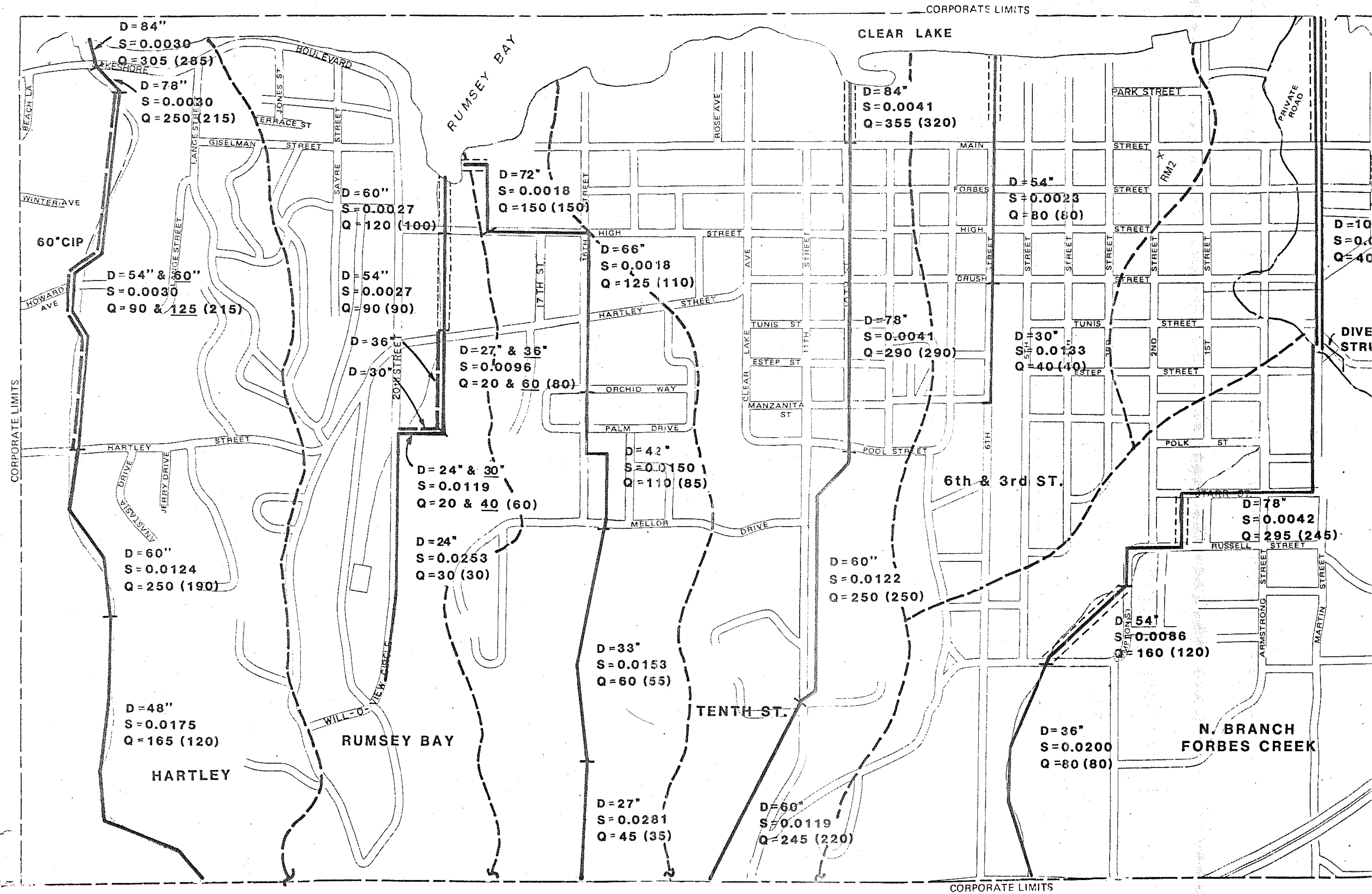


FIGURE 6-1
PROPOSED STORM DRAINAGE FACILITIES


CORPORATE LIMITS
CLEAR LAKE
RUMSEY BAY
D=84"
S=0.0030
Q=305 (285)
D=78"
S=0.0030
Q=250 (215)
60"CIP
D=54" & 60"
S=0.0030
Q=90 & 125 (215)
D=60"
S=0.0027
Q=120 (100)
D=54"
S=0.0027
Q=90 (90)
D=36"
D=30"
D=72"
S=0.0018
Q=150 (150)
D=66"
S=0.0018
Q=125 (110)
D=27" & 36"
S=0.0096
Q=20 & 60 (80)
D=24" & 30"
S=0.0119
Q=20 & 40 (60)
D=24"
S=0.0253
Q=30 (30)
D=42"
S=0.0150
Q=110 (85)
D=84"
S=0.0041
Q=355 (320)
D=78"
S=0.0041
Q=290 (290)
D=54"
S=0.0023
Q=80 (80)
D=30"
S=0.0133
Q=40 (40)
6th & 3rd ST.
D=78"
S=0.0042
Q=295 (245)
D=60"
S=0.0124
Q=250 (190)
D=48"
S=0.0175
Q=165 (120)
HARTLEY
RUMSEY BAY
D=33"
S=0.0153
Q=60 (55)
TENTH ST.
D=27"
S=0.0281
Q=45 (35)
D=60"
S=0.0122
Q=250 (250)
D=60"
S=0.0119
Q=245 (220)
D=54"
S=0.0086
Q=160 (120)
D=36"
S=0.0200
Q=80 (80)
N. BRANCH
FORBES CREEK
BOULEVARD
LAKESHORE
BEACH LA
JONES ST
TERRACE ST
GISELMAN STREET
LANGE STREET
SAYRE STREET
WINTER AVE
HOWARD AVE
HARTLEY STREET
ANASTASIA DRIVE
JERRY DRIVE
20TH STREET
17TH ST.
16TH STREET
WILL-O-VIEW CIRCLE
HIGH STREET
HARTLEY STREET
ORCHID WAY
PALM DRIVE
MELLOR DRIVE
ROSE AVE
CLEAR LAKE AVE
TUNIS ST
ESTEP ST
MANZANITA ST
11TH STREET
POOL STREET
MAIN STREET
FORBES STREET
CRUSH STREET
PARK STREET
PRIVATE ROAD
RM2
TUNIS STREET
ESTEP
POLK ST
STARR ST
RUSSELL STREET
ARMSTRONG STREET
MARTIN STREET
6TH
5TH
3RD
2ND
1ST
DIVE
STRU
D=10
S=0.
Q=40

CHAPTER VII

CHAPTER VII

PRIORITIES AND FINANCING

General

As indicated in Chapter VI, the total cost of a completed storm drainage system to protect Lakeport is substantial. The staging of improvements in accordance with established priorities is desirable in order to ensure that maximum benefits are achieved for the monies spent. Even with staged improvements, a number of different methods of financing will be necessary in order to ultimately provide a complete storm drainage system. Community support is required and City-County cooperation is essential to successfully implement a comprehensive storm drainage program for Lakeport. The following paragraphs present priority criteria, suggested priorities, and methods of financing.

Priority Criteria

The central purpose and therefore the primary criteria for installation of flood protection facilities is the minimizing of potential flood damage. In developed areas, costs of damage can be measured in terms of repair and replacement of damaged facilities and economic loss due to disruption of businesses and services. Where no development exists, costs of flood damage are minimal and improvements can usually be deferred.

In Lakeport, most development has occurred adjacent to Clear Lake where the potential for flooding is highest. Protection of this existing development is of major importance and a high priority for improvements to protect this area is justified. Of the developed areas adjacent to Clear Lake, those at the lower end of the larger watersheds and those with the least adequate existing facilities have a higher flood damage potential and should therefore be placed before those areas where existing facilities are nearly adequate.

Additional factors considered in setting priorities included cost effectiveness, the relationship of the storm drainage facilities to other improvements, and funds available. Cost effectiveness of storm drainage facilities is evaluated by comparing the potential savings realized from avoidance of flood damage to the cost of the components necessary to provide that level of protection. The various projects to be constructed should be compared to each other and those providing the greatest protection for the least cost should receive the highest priority.

When land is subdivided or developed, all storm drainage facilities needed to serve the land being improved should be designed and constructed. This avoids having to tear up existing improvements at a later date to install storm drainage facilities. Improvements downstream of new developments may also be required in order to prevent flooding caused by increased storm runoff and higher peak flows. Often it is advantageous to install storm drainage facilities in conjunction with other improvements such as streets, curbs, gutters, and sidewalks in order to avoid later disruption of these improvements.

Available funds may also affect the selection of projects for construction. Often a long length of pipe is required in order to make a project functional. Constructing short lengths may necessitate temporary transition facilities or the creation of new hazards may occur as a result of higher water levels during peak runoff periods.

Priority of Improvements

Based upon the criteria developed in the previous section, certain priorities may be established. All of the facilities upstream of existing development may be deferred until development occurs. The existing facilities in the Hartley Basin are acceptable for present development, although flooding of Lakeshore Boulevard will continue to cause inconvenience when high lake levels occur. The Rumsey Bay watersheds have existing facilities which although not fully adequate do provide some measure of protection. The open channel sections in developed areas should be replaced with pipe as funds become available.

The facilities in Tenth Street basin below Pool Street should be replaced. The open channel sections are the most critical, especially where the channel parallels the street creating a hazard to traffic. The North Branch of Forbes Creek from Spruce Street to Forbes Creek should be improved. First priority should be given to the open channels adjacent to the roadway. Forbes Creek should be improved from Martin Street to Clear Lake by modifying the existing channel to allow the maximum uniform flow within the existing channel. This would involve clearing, bank protection, and replacement of inadequate culverts. When funds become available, a diversion structure and relief lines to carry the flows in excess of the open channel capacity should be installed in Martin Street from the existing structure between Estep and Tunis Streets to Clear Lake.

Methods of Financing

There are a number of methods available to finance storm drainage facilities for Lakeport. One of the main differences between methods is the number of people involved in payment of costs. The extremes range from an individual developer improving a piece of property, to a local assessment district, to the people of the United States who through taxes finance numerous grant programs. The developer usually passes his costs on to the buyer. Where Federal grants are available, the direct costs to local residents are minimized and local funds may be utilized to fund other needed projects.

Development Fees - Ordinance 588 was approved by the voters in the April 8, 1980 general election. A copy of Ordinance 588 is provided in Appendix D. This ordinance establishes a special tax of $0.20 per square foot of structure and related impermeable areas. Based on estimates of impermeable areas provided by the City, estimated revenues were calculated. Table 7-1 presents the estimated future revenues to be collected under the provisions of the present City Ordinance. The total estimated revenue figure represents the maximum potential revenue if every lot in Lakeport is developed to its full potential under existing planning and zoning regulations. This is highly unlikely and, especially during the short term, the revenue received will probably be much less than the total possible revenue.

It should be noted that even the total possible revenue is much less than that required to construct all of the needed storm drainage facilities in Lakeport. No funds are available from this tax to provide for reimbursement of developer expenses. The purpose of this special tax was to provide monies to perform storm drainage studies and prepare plans to ensure a complete and fully functioning storm drainage system when constructed. If funds beyond those required to provide the necessary plans become available, the intent is to use them as a portion of the local share in grant programs and to correct the most hazardous storm drainage problems in the existing system.

A similar ordinance is under consideration by Lake County. If enacted, the ordinance will provide funds for use in the County to complete their storm drainage and flood control planning. Funding would also be available for development of joint City-County standards and plans for storm drainage improvements. The County should be encouraged to adopt this ordinance to ensure availability of funds for facilities necessitated by development within the County.

<u>Flood Control Zones</u> - The Lake County Flood Control and Water Conservation District Act, Act 4145, established the District in 1951. Under this Act, the District has the power to create flood control zones and to levy taxes to construct and maintain storm drainage facilities. The creation of a flood control zone or zones including the entire study area watershed would (1) provide a means of raising local funds, (2) coordinate construction of improvements, and (3) provide equal treatment of landowners throughout the drainage basin. Proposition 13 and subsequent legislation has had some adverse impact on taxation powers, although legislation is now being put forth by various districts to mitigate the impacts of Proposition 13. One example is Assembly Bill 549 which allows special taxing if approved by the majority of the voters.

TABLE 7-1

ESTIMATED DEVELOPMENT FEE REVENUE

Drainage Basin	Potential* Impermeable Area (Sq.Ft.)	Estimated Revenue
Hartley	850,000	$170,000
Rumsey Bay North	390,000	$ 78,000
South	440,000	$ 88,000
Tenth Street	270,000	$ 54,000
Sixth Street & Third Street	60,000	$ 12,000
Forbes Creek North Branch	760,000	$152,000
Main Channel	990,000	$198,000
Pier 1900	540,000	$108,000
	4,300,000	$860,000

*Source: City of Lakeport

Assessment Districts - Current State law provides a number of different assessment district acts which allow construction of drainage facilities. The most frequently used acts are the Improvement Act of 1911 and the Municipal Improvement Act of 1913. Improvement bonds may be sold under either of these acts or by use of the Improvement Bond Act of 1915. Each act has advantages and disadvantages. The 1911 act requires the contractor to sell the bonds and an assessment is made at the end of the project. The 1913 act requires assessments to be levied at the start of work and the contractor does not have to obtain the financing. Support of those to be assessed is essential for any of these proceedings to succeed.

Grants and Loans - There are a number of federal programs which provide grants and loans to construct drainage and flood control projects. Under the Department of Agriculture, both the Farmers Home Administration and the Soil Conservation Service administer programs which provide monies for flood control and drainage facilities. Under the Department of Defense, the U.S. Army Corps of Engineers administers programs as does the Economic Development Agency under the Department of Commerce.

The Farmers Home Administration provides monies for drainage and flood control under the following programs: 1) Irrigation, Drainage and other Soil and Water Conservation Loans; 2) Water and Waste Disposal Systems for Rural Communities; and 3) Watershed Protection and Flood Prevention Loans. The first program has a maximum loan amount of $1,000,000. The average loan amount is $250,000 and $7,400,000 is estimated to be available nationally in 1980. The second program mainly provides money for water and sewerage projects although collection of storm water is eligible for funding. The amount of grant money is determined by the community income level. Grants average $270,000 and loans $500,000. The estimated funding in

1980 is $300,675,000 for grants and $700,000,000 for loans.

The third program, Watershed Protection and Flood Prevention, provides funding for flood protection, irrigation, drainage, water quality management, sedimentation control, fish and wildlife development, public water basin recreation, and water storage and related costs. The broad range of watershed improvements allow flexibility in projects and would provide funding if measures are required by the State Department of Fish and Game as well as needed flood control measures. The maximum allowable loan in any single watershed is $10,000,000. The average loan is $320,000 and the maximum to date is $5,450,000. The estimated funding level nationwide in 1980 is $26,000,000.

The Soil Conservation Service has two programs which could be used to fund flood protection facilities in Lakeport. The programs are "Resource Conservation and Development" and "Watershed Protection and Flood Prevention". The first program is limited to "Resource Conservation and Development" areas authorized for assistance. If eligible, the program will provide technical and financial assistance for a wide range of watershed improvements including flood protection. Past grants have ranged from $2,000 to $250,000 with the average grant being $50,000. The 1980 estimate of funds available nationally is

$34,000,000. Although flood protection can be 100 percent grant eligible, land or easement costs are generally a local expenditure and a local contribution to the flood protection works may be required.

The second program administered by the SCS is also known as the Small Watershed program or the PL-566 Program. This program is similar to the Farmers Home Administration Watershed Protection and Flood Prevention Loan program. Average financial assistance is $2,000,000 and an estimated $11,100,000 will be available in 1980 (nationwide).

The Department of Commerce, Economic Development Administration, provides funding through the "Economic Development - Grant and Loans for Public Works and Develoment Facilities" program. The main thrust of this program is to encourage long-term economic growth in areas where growth is lagging behind the rest of the nation. Storm drainage and flood protection improvements may be installed in conjunction with facilities to improve opportunities for the successful establishment of industrial or commercial facilities. In those areas where the general plan and zoning allow such development, public improvements could be installed to encourage private enterprise. This program could be used in conjunction with other programs to provide the necessary flood protection facilities within a watershed. There is no specific minimum or maximum project amount. Past assistance has ranged from $5,000 to $7,100,000 and the average is $580,000. It is estimated that $248,500,000 will be available in grant funding in 1980.

The U.S. Army Corps of Engineers administers the "Flood Control Projects" or "Small Flood Control Projects" program. The program is designed to reduce flood damage through projects not specifically authorized by Congress. The Corps usually designs and constructs the project. Each project must be feasible, complete within itself, and economically justified. The funding limit is $2,000,000 and any lands or easements required must be obtained without use of federal funds. Estimated national funding in 1980 is $21,000,000.

Each of the programs described above may be suitable for use by Lakeport to solve flooding problems. Present fiscal constraint by the Federal government may make obtaining funds more difficult. Also, it should be noted that programs frequently have small nationwide appropriations. Creative and unified community support will be necessary to compete for these limited funds. Most of these programs require a substantial lead time. Combining of programs should be considered where possible. Where loan programs are used the terms are usually generous, typically five percent interest and a 40-year term. Care must be taken to explore all possibilities before proceeding. The Corps' Small Flood Control Projects program may be ideal for Forbes Creek, possibly in conjunction with the Department of Agriculture improvements upstream as recommended in the 1969 report. However, cost-effectiveness for Corps improvements must be shown and reduction in potential flooding by an upstream dam may reduce the flood hazard below a point which justifies Corps participation.

APPENDIX A

APPENDIX A

SCOPE OF WORK
STORM DRAINAGE MASTER PLAN
CITY OF LAKEPORT, CA

I. ORIENTATION/MOBILIZATION

A. Preliminary discussions regarding project, meet with:

1. City Staff
2. City Advisory Committee/City Council (if approriate)
3. Lake County Representatives

B. Refine Project Approach

1. Prepare detailed work schedule (PERT diagram) for undertaking the project
2. Refine responsibilities of City, County, and Consultant.

II. DATA COLLECTION AND REVIEW

A. Engineering Information Required (Data to be collected by Owner and submitted to Engineer within 14 days of issuance of Notice to Proceed)

1. Climatology - This information is available from the National Oceanic and Atmospheric Administration (NOAA) as well as the flood insurance study undertaken by HUD for the City of Lakeport and Lake County.
2. Topography - Aerial maps presently available from the City with a scale of 1" = 200' and a contour interval of 5'.
3. Existing drainage system - While a comprehensive drainage master plan is unavailable, plans of various storm drainage structures, including location of pipelines, are available from the City. Much of this information can be obtained from subdivision maps.
4. Soils and groundwater information - Soil Conservation Service has reportedly completed soil mapping of the study area.
5. Clear Lake historical data on water levels - Meetings will be held with representatives of Yolo County to determine policies determining maximum water levels of Clear Lake.

6. Pertinent engineering reports - Available engineering reports prepared for the City may be helpful in developing a storm drainage system.
7. History of problem areas - Information on pipe sizes, types, and slopes of pipes and culverts will be required. Information on drainage problems can be obtained from field discussions with local residents regarding historical flooding problems.
8. Peak storm runoff - Much of this information is included in the Flood Insurance Study prepared by HUD.
9. Ordinances, codes and related legal documents - The City of Lakeport Flood Plain Management Ordinance, the Land Use/Zoning Ordinance, and Storm Drainage Fee Ordinance will be extremely important in establishing future drainage requirements.
10. Design criteria for existing facilities - While much of this will have to be determined in the field, available data will be helpful.
11. Similar information will also be required for a portion of the upstream drainage area within Lake County - Much of this information can be obtained from Hank Porter, Flood Control Engineer for Lake County.

B. Planning and Economics information required (data to be collected by Owner and submitted to Engineer within 14 days of issuance of Notice to Proceed.

1. Zoning and land-use maps.
2. Proposed planning programs.
3. Environmental documents prepared for the study area.
4. Any similar information available for the portions of Lake County within the upstream drainage basin.

C. Review Existing Reports, Documents, and Storm Drainage Plans

III. PRELIMINARY STUDIES

A. Engineering

1. Evaluate climatological data
   a. Determine precipitation - amount, intensity, frequency
   b. Study effect of other weather conditions on runoff

c. Review rainfall intensity - duration curves for storms of varying frequency
d. Review creek runoff data contained in Flood Insurance Study for Lakeport area

2. Topographic data
   a. Review existing topographic maps available from City
   b. Define drainage basins, determine drainage patterns
3. Soils and groundwater information
   a. Analyze available Soil Conservation Servation Service soils maps and available information
   b. Evaluate percolation and runoff capacity of soils based on available data
   c. Determine the effect of groundwater level on storm runoff
4. Existing drainage facilities
   a. Review existing data on drainage facilities
   b. Collect field information on drainage system in order to verify existing conditions; City of Lakeport to provide staff assistance
   c. Evaluate condition and life expectancy from field investigations
   d. Determine hydraulic capacity of existing structures
5. Lake County drainage facilities
   a. Review available data on upstream facilities located in Lake County's portion of drainage basin
   b. Estimate hydraulic capacity of existing facilities
   c. Meet with representatives of Lake County to determine future plans for drainage facilities to serve upstream areas

B. Planning and Economics

1. Review land use projections prepared by City Planning Department
2. Study land use and economic trends
3. Consider relationship between residential, commercial, and agricultural and undeveloped land
4. Discuss future land use projections with representatives of the Planning Department
5. Meet with representatives of Lake County to discuss land use goals for upstream drainage basin

C. Review preliminary conclusions and estimates with City staff and the City Advisory Committee if appropriate.

IV. DETAILED DRAINAGE STUDIES

A. Review existing City design criteria for drainage facilities as well as design criteria for computing peak runoff as proposed in HUD flood insurance study.

B. Conduct study of existing drainage to:

1. Determine capacity of pipelines, structures, and channels
2. Isolate problem areas; meet with local residents to discuss historic flooding problems and water levels during wet weather periods

C. From hydrologic data contained in the Flood Insurance Study and developed as part of this study, determine:

1. Runoff coefficient and concentration times for individual drainage basins based on:
   a. Soils analysis
   b. Topography
   c. Projected land usage
2. Storm frequency to be used in computing runoff will be based on projected economic valuations of drainage basins
3. Compare existing criteria with data developed
4. Meet with City staff and Advisory Committeee to discuss proposed design criteria and adopt design criteria for master planning purposes
5. Compute runoff for each drainage basin

D. Evaluate existing storm drainage facilities within the study area and the ability of individual components to carry projected runoff based on future development

V. PREPARE PRELIMINARY LAYOUT OF FACILITIES REQUIRED TO COMPLETE MASTER DRAINAGE SYSTEM

A. Consider alternate plans, if applicable

B. Prepare preliminary design of system including size and slope of conduits and/or channels, location and description of appurtenant facilities including bridges, culverts, etc.

C. Based on projected area growth and critical existing needs, determine construction priorities for proposed facilities

D. Review proposed layouts with City staff and/or Advisory Committee

VI. PREPARE FINANCING PROGRAM

A. Develop preliminary construction cost estimates; estimates to be presented in terms of individual lines as well as by drainage basins or subareas

B. Based on the construction cost estimates and the priority program defined in Section V, prepare a capital improvement program which defines incremental improvements needed to meet the long-range growth projections of the study area.

VII PREPARE STORM DRAINAGE MASTER PLAN; REPORT TO INCLUDE:

A. Description of all work performed

B. Results of field reconnaissance surveys

C. Basic design criteria

D. Proposed drainage systems including size, location, capacity of all major facilities

E. Preliminary construction cost estimate for all segments of the work

F. An incremental construction program which defines project priorities

G. All necessary plates, maps and figures needed to define plan

H. Two draft copies of the storm drainage master plan to be submitted to City staff for review

I. Upon receipt of City approval, finalize drainage master plan and submit fifteen copies of the final master plan report

J. Attend one City Council meeting to present storm drainage master plan.

APPENDIX B

APPENDIX B

LAKE COUNTY CHAMBER OF COMMERCE

P.O. Box 517

Lakeport, California 95453

LEVELS OF CLEAR LAKE

Engineers of Lake County have figured out that about every six years Clear Lake goes over the 10-foot level. They point out that this does no come at such regular intervals, but usually flood years bunch up as do dr years.

The level of Clear Lake is measured at 7.56 feet on the Rumsey Gauge as the high water mark and Zero as low water mark or 1,318.65 feet above sea level. The Rumsey Gauge is an established reference plane used since 1873. Captain Rumsey lived near the north end of Main Street, Lakeport, and took the rim of the lake where the water ceased to run out or over th Grigsby Riffle in Cache Creek, as his Zero mark.

The level of Clear Lake is now controlled by an impounding dam constructed on Cache Creek outlet in 1915 and operated under a court decree known as the Gopcevic Decree which allows the lake to fluctuate between the Zero mark and 7.56 feet, a mark that was established as an average of high water levels over about a 50 year period.

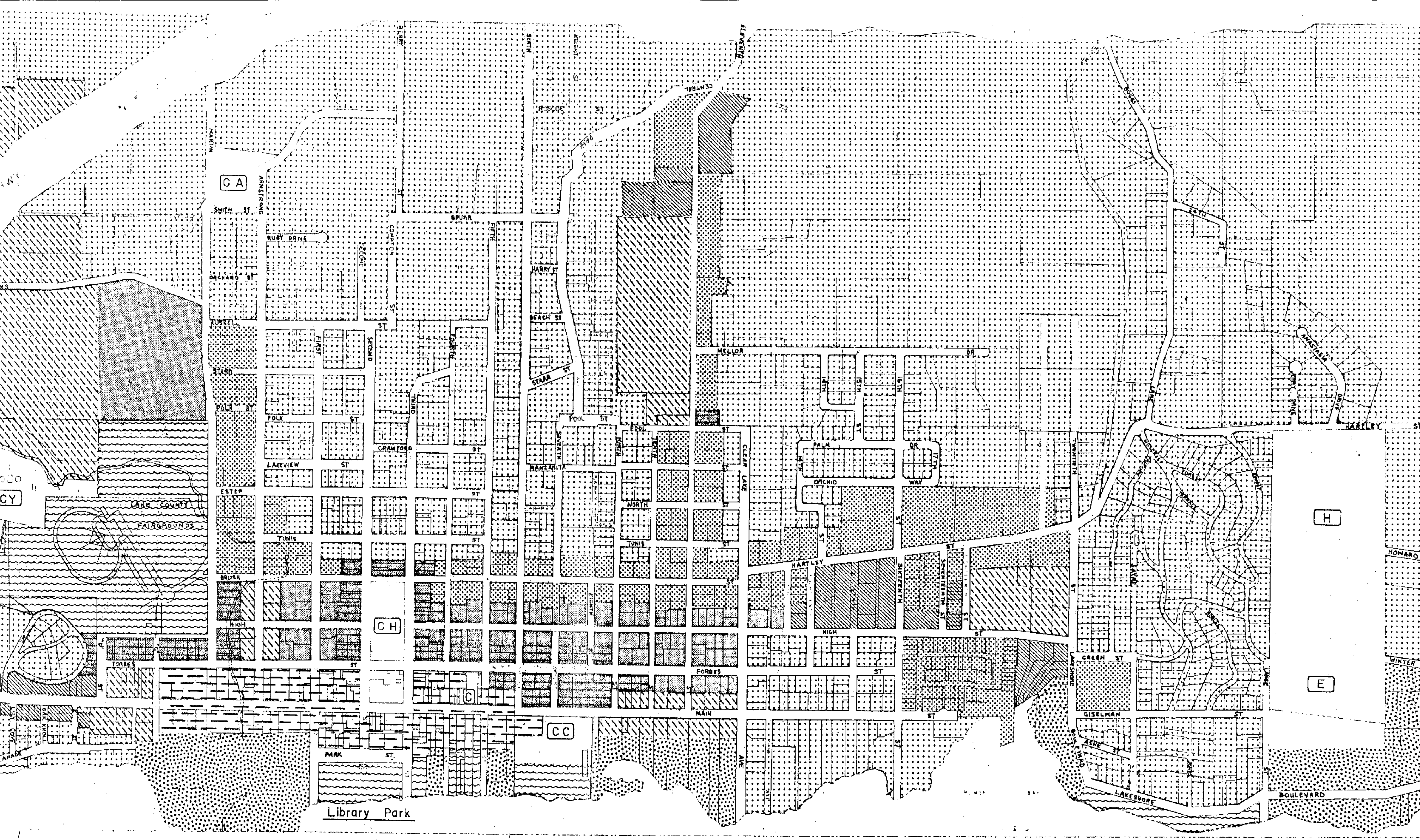
The Gopcevic Decree, established in 1920 by Mendocino County Superior Court, is a consent decree and sets forth details for raising and lowering the lake to a common level of 7.56, excepting for a 10 day period when unforseen storms might raise the level faster than the water could be drawn off.

The natural level of the lake was controlled by a natural barrier in Cache Creek outlet called the Grigsby Riffle, which now is approximately three and a half feet below Zero on the Rumsey Gauge. This riffle was altered to its present height about 1915.

DATE	MONTH	HIGH	MONTH	LOW
1873	---	---	Nov.	1.08
1874	Mar.	8.62	Oct.	3.41
1875	Feb.	6.60	Nov.	1.75
1876	Mar.	12.37	Jan.	3.71
1877	Mar.	5.64	Oct.	1.77
1878	Mar.	12.39	Jan.	1.95
1879	Mar.	8.31	Nov.	3.56
1880	Apr.	10.08	Nov.	3.83
1881	Feb.	10.25	Nov.	3.08
1882	Mar.	6.16	Nov.	2.39
1883	May	4.12	Nov.	1.47
1884	Apr.	5.58	Dec.	1.41
1885	Jan.	6.02	Oct.	1.41
1886	Jan.	8.94	Dec.	3.08
1887	Mar.	5.42	Dec.	1.82
1888	Mar.	4.86	Nov.	1.56
1889	Apr.	5.88	Oct.	2.88
1890	Jan.	13.66	Nov.	3.25

DATE	MONTH	HIGH	MONTH	LOW	TOTAL RAINFALL
1891	Apr.	6.47	Nov.	2.35	
1892	May	5.08	Nov.	1.75	
1893	Mar.	9.70	Nov.	2.83	
1894	Mar.	8.66	Nov.	2.50	
1895	Jan.	12.25	Nov.	2.58	
1896	Feb.	7.75	Nov.	2.91	
1897	Apr.	8.16	Nov.	2.25	
1898	Mar.	3.41	Nov.	.08	
1899	Apr.	3.08	Oct.	.25	
1900	Mar.	5.66			
1901	Feb.-Mar.	~~8.13~~	Nov.	1.92	
1902	Mar.	9.98	Oct.-Nov.	2.77	
1903	Mar.	7.81	Oct.-Nov.	1.67	
1904	Apr.	11.91	Nov.	2.67	
1905	Apr.	8.68	Nov.	1.72	
1906	Apr.	9.66	Dec.	2.17	
1907	Mar.	11.64	Nov.	2.42	
1908	Mar.	~~7.53~~	Oct.-Nov.	1.37	
1909	Feb.	13.38	Nov.	2.42	
1910	Apr.	6.95	Nov.-Dec.	1.27	
1911	Mar.	9.09	Jan.	1.27	
1912	Mar.	3.78			
1913	Jan.-Feb.	4.6	Oct.	.62	[CL DAM]
1914	Jan.	11.12	Nov.-Dec.	2.78	
1915	Feb.	10.68	Nov.	2.48	
1916	Feb.	8.53	Nov.	1.37	
1917	Apr.	6.60	Dec.	.61	
1918	Apr.	3.03	Oct.	-2.00	
1919	Apr.	4.42	Nov.-Dec.	-1.50	
1920	Apr.-May	-0.50	Sept.	-3.50	
1921	Mar.-Apr.	7.20	Nov.	1.75	
1922	Apr.	6.50	Oct.	1.18	
1923	Apr.	5.70	Dec.	.70	
1924	Feb.	1.80	Oct.	-1.53	
1925	May	6.90	Nov.	2.00	
1926	Apr.	7.47	Nov.	1.90	
1927	Feb.	9.00	Oct.-Nov.	1.30	
1928	Apr.	7.35	Oct.-Nov.	1.70	
1929	Mar.-Apr.	3.30	Dec.	-0.32	
1930	Apr.	6.00	Dec.	1.25	14.29
1931	Mar.-Apr.	2.20	Dec.	-0.85 [92]	13.55
1932	Mar.-Apr.	3.78 [4/16.61]	Nov.-Dec.	-0.10	22.35
1933	Apr.	2.60			21.02
1934	Mar.-Apr.	~~3.60~~	Oct.	.07	26.82
1935	Apr.	7.28	Nov.-Dec.	2.78	26.91
1936	Feb.	8.20	Dec.	1.85	40.42
1937	Apr.	7.05	Nov.	1.10	33.54
1938	Feb.	10.25	Dec.	2.10	15.01
1939	Apr.	3.75	Dec.	-0.36	46.64
1940	Mar.	8.33	Oct.	2.55	45.71
1941	Apr.	8.90	Nov.	3.05	36.62
1942	Feb.	9.60	Nov.	2.32	21.24
1943	Apr.	7.72	Dec.	1.30	

DATE	MONTH	HIGH	MONTH	LOW	TOTAL RAINFALL
1944	Apr.	5.03	Oct.	.45	28.91
1945	Apr.	5.82	Sept.	.10	34.91
1946	Apr.	7.23	Nov.	.08	16.03
1947	Apr.	3.41	Dec.	-.00	19.11
1948	May	4.62	Dec.	.55	27.00
1949	Apr.	5.95	Nov.	.13	16.09
1950	Apr.	4.65	Oct.	-.135	36.75
1951	Mar.-Apr.	7.38	Nov.	1.56	33.31
1952	Feb.	8.08	Nov.	1.45	35.00
1953	Jan.	7.81	Nov.	2.41	22.39
1954	Apr.	7.67	Nov.	1.58	30.37
1955	Mar.	4.71	Nov.	-.12	28.68
1956	Feb.	9.53	Dec.	2.35	23.10
1957	Apr.	7.06	Sept.	2.69	35.18
1958	Feb.	10.86	Dec.	3.32	37.98
1959	Apr.	7.48	Dec.	1.18	21.57
1960	Apr.	6.71	Jan.	1.29	31.59
1961	Apr.	7.18	Nov.	1.76	20.30
1962	Mar.	7.75	Oct.	1.88	28.20
1963	Apr.	8.20	Oct.	3.17	30.87
1964	Dec.	6.83	Oct.	0.31	32.31
1965	Jan.	9.03	Nov.	2.50	28.50
1966	Mar.	7.59	Oct.	1.05	25.59
1967	Mar.	7.92	Nov.	3.02	32.07
1968	Mar.	7.78	Oct.	3.12	35.66
1969	Feb.	8.80	Dec.	1.74	40.41
1970	Jan.	10.37	Oct.	1.37	38.94
1971	Mar.	7.84	Oct.	1.60	33.14
1972	Apr.	4.58	Oct.	0.54	19.60
1972/1973	Feb.	7.74	NOV.	1.28	38.01
1974	APR.	9.10	NOV.	1.70	46.95
1975	MAR.	8.90	OCT.	1.68	31.62
1976	APR.	2.32	NOV.	-0.60	12.19
1977	FEB.	-0.30	NOV.	-3.39	
1978	MAR.	8.10	DEC	1.45	
1979	MAY	6.62	OCT	1.38	
1980	FEB.	9.61			



LAKEPORT

0 200 500 750 1000 1500 2000 2500 3000

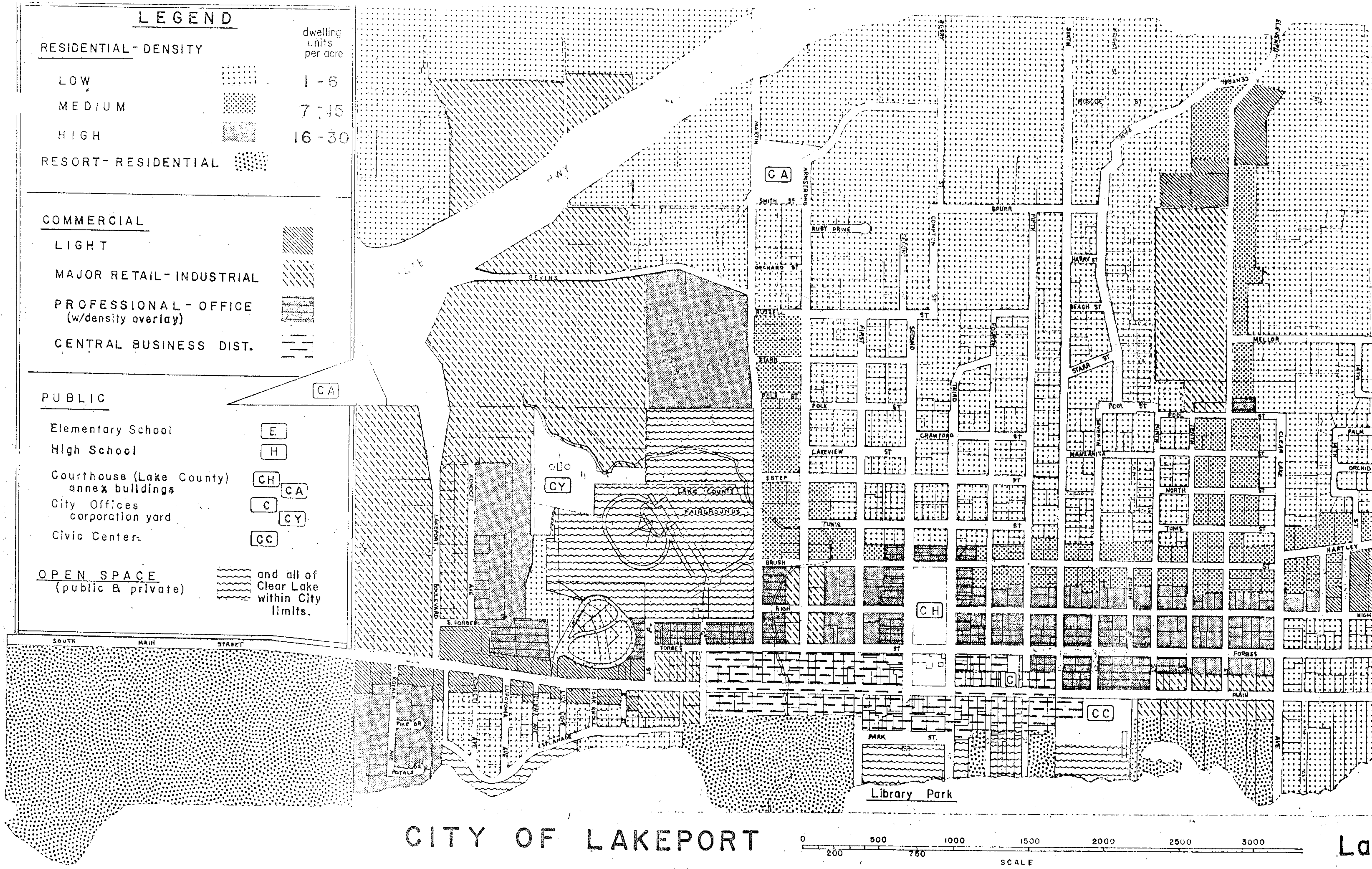
SCALE

Land Use Plan Map A

(amended 4/77)

P.T.

FIGURE B-1
LAND USE


LEGEND
RESIDENTIAL - DENSITY
dwelling units per acre
LOW 1 - 6
MEDIUM 7 - 15
HIGH 16 - 30
RESORT - RESIDENTIAL
COMMERCIAL
LIGHT
MAJOR RETAIL - INDUSTRIAL
PROFESSIONAL - OFFICE (w/density overlay)
CENTRAL BUSINESS DIST.
PUBLIC
Elementary School E
High School H
Courthouse (Lake County) CH
annex buildings CA
City Offices C
corporation yard CY
Civic Center CC
OPEN SPACE (public & private)
and all of Clear Lake within City limits.
Library Park
LAKE COUNTY FAIRGROUNDS
CITY OF LAKEPORT
0 200 500 750 1000 1500 2000 2500 3000
SCALE

APPENDIX C

APPENDIX C

H Y D R O L O G Y

D E S I G N

S T A N D A R D S

Lake County

Flood Control and Water Conservation District

Lakeport, California

REVISED 3/20/70

GENERAL

The Design Standards contained herein have been adopted by the Lake County Flood Control and Water Conservation District for use in the design of flood control projects within the District.

These standards are based upon information obtained from the U. S. Soil Conservation Service, U. S. Weather Bureau, the State of California Departmen of Water Resources, and from prior experience in the field.

The format of these standards has been adapted from the Sonoma County Flood Control and Water Conservation District "Flood Control Design Standards", the permission for the use of which we gratefully acknowledge. The use of this established format should provide a continuity of design methods with which local area engineers are familiar.

The precipitation intensity curves contained herein represent the culmination of an extensive study of precipitation records obtained from the above mentioned agencies. The curves are considered to be reasonably complete and to accurately represent all areas of the county. These curves are, however, subject to change and refinement as more precipitation data becomes available in the future.

The intent of the material provided herein is expressly for use in the design of flood control systems for Minor Waterways, as defined herein, which have a time of concentration less than two hours. It is recommended that the engineer contact the Lake County Flood Control and Water Conservation Distric office for design criteria to be used for larger areas and/or longer times of concentration.

It is anticipated that in the future these Design Standards will be expanded to include Major Waterways and Secondary Waterways, if the demand warrants such expansion.

DEFINITION OF WATERWAYS

A 'waterway' is defined as being a natural or artifical channel or depression in the surface of the earth or an underground conduit system which provides a course for water flowing as a consequence of storm water runoff.

For the purposes of design criteria contained herein, waterways are divided into three classifications:

1. Major Waterways - having a tributary drainage area of four square miles or more; shall require a design frequency of re-occurrence of once in 100 years. This frequency would only apply to subdivision design and not, for instance, agricultural channel design.

2. Secondary Waterways - having a tributary drainage area of between one and four square miles; shall require a design frequency of re-occurrence of once in 25 years.

3. Minor Waterways - having a tributary drainage area less than one square mile; shall require a design frequency of re-occurrence of once in 10 years.

HYDROLOGIC DESIGN

The design of all flood control facilities shall be founded on the assumption that all upstream areas are fully developed to the highest possible level consistent with existing zoning at the time of approval of the project by the District.

Watershed design discharge shall be determined by the use of the rational formula:

$$Q = C\ I\ A\ K$$

in which:

Q = design discharge in cubic feet per second

C = runoff co-efficient from Plate I in the appendix based on full development

I = intensity of rainfall in inches per hour from Plate 2 in the appendix

A = tributary watershed area in acres

K = co-efficient of intensity from Plates 3 and 4 in the appendix

Initial lot to street time of concentration (Tc) shall be a minimum of 10 minutes for residential areas of less than one half acre, and 15 minutes for residential or other areas greater than one half acre.

Sub-areas shall be established within each watershed area where zoning, slope of the land, or other characteristics which effect runoff change significantly.

Each area or sub-area shall be computed seperately and shall be combined progressively proceeding downstream from the area or sub-area of highest elevation, properly accumulating the parameters.

EXPLANATION AND USE OF TABLES

I. Runoff Co-efficients (Plate No. 1)

A. Definitions

Ap = Area paved (includes Building roof area)
At = Total Area
Av = Area Planted or vegetated
Cp = Co-efficient of runoff of paved area
Ct = Co-efficient adjusted for vegetated area
Cv = Co-efficient of runoff for planted or vegetated areas

B. For commercial, manufacturing, multiple residential, and extensive fully paved areas use Cp = 0.9

When planted and vegetated areas are combined with the above zones in excess of 20% of the total area, use Cv curve (see Plate No 1) to reduce Cp by the formula:

$$Ct = Cv \frac{Av}{At} + Cp \frac{Ap}{At}$$

C. All curves on Plate 1 represent average clay soils native to Lake County. Reduce C obtained from any curve by a value of 15% for areas of predominantly sandy soil and a value of 25% for areas of predominantly porous volcanic type soils.

II. Rainfall Intensity (Plate No. 2)

Use minimum time of concentration as stated previously under "Hydrologic Design". For areas greater than five acres or with a distance from the furthest upstream point to the point of concentration greater than 1000 feet determine a reasonable overland flow velocity for the physical conditions of the area. Use To = 10 minutes and add the time of overland flow to obtain total time of concentration (Tc). Using Tc obtained read intensity (I) from the appropriate curve.

III. Mean Seasonal Precipitation (Plate No. 3) and K factor (Plate No. 4)

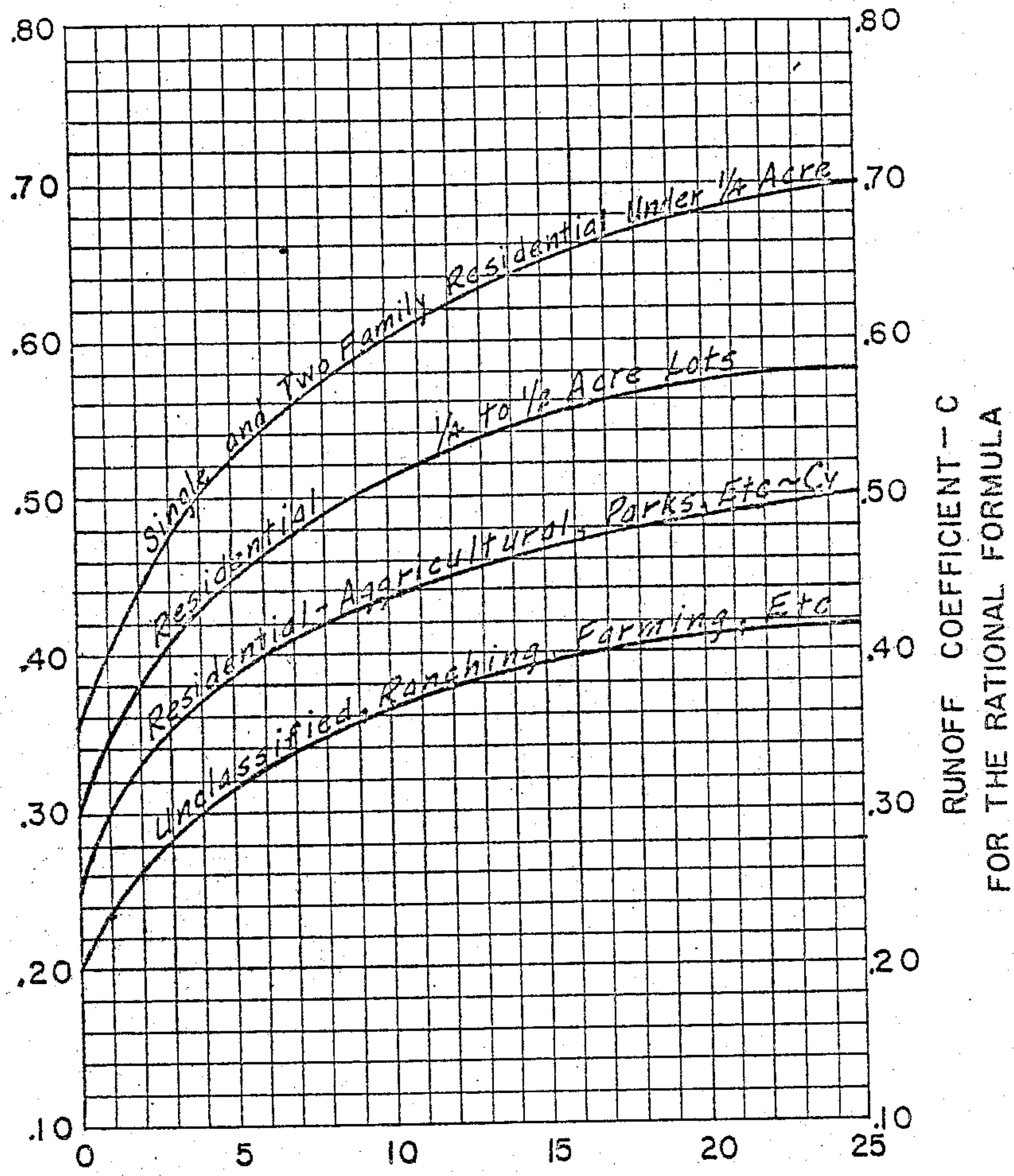
Locate on Plate No 3 the approximate site in question. Pick the nearest isohyetal line and record the mean seasonal precipitation for the site.

On Plate No. 4 locate the intersection of the index line with the line of mean seasonal precipitation. Read the value of the K factor at the left.

EXAMPLE:

Site in Middletown (southern Lake County)
Plate No 3, Mean seasonal precipitation at Middletown = 45 inches
Plate No 4, for mean seasonal precipitation = 45
K factor = 1.3

NOTE: See Text Of HYDROLOGY STANDARDS For Modification Conditions And Proceedures For Values From C Curves



-RUNOFF COEFFICIENTS-
LAKE COUNTY FLOOD CONTROL
& WATER CONSERVATION DISTRICT

PLATE No. 1

LAKE COUNTY

RAINFALL INTENSITY

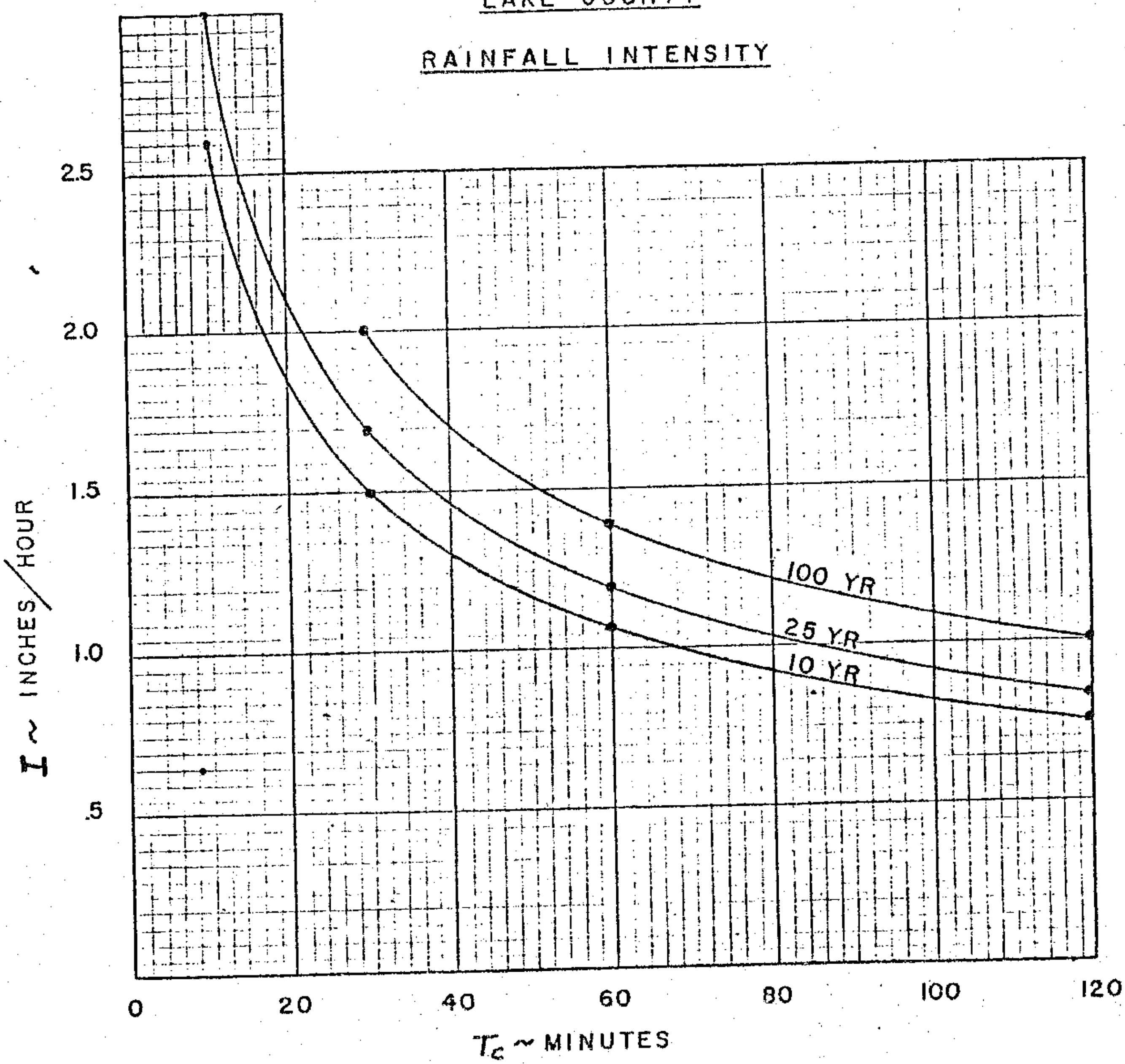
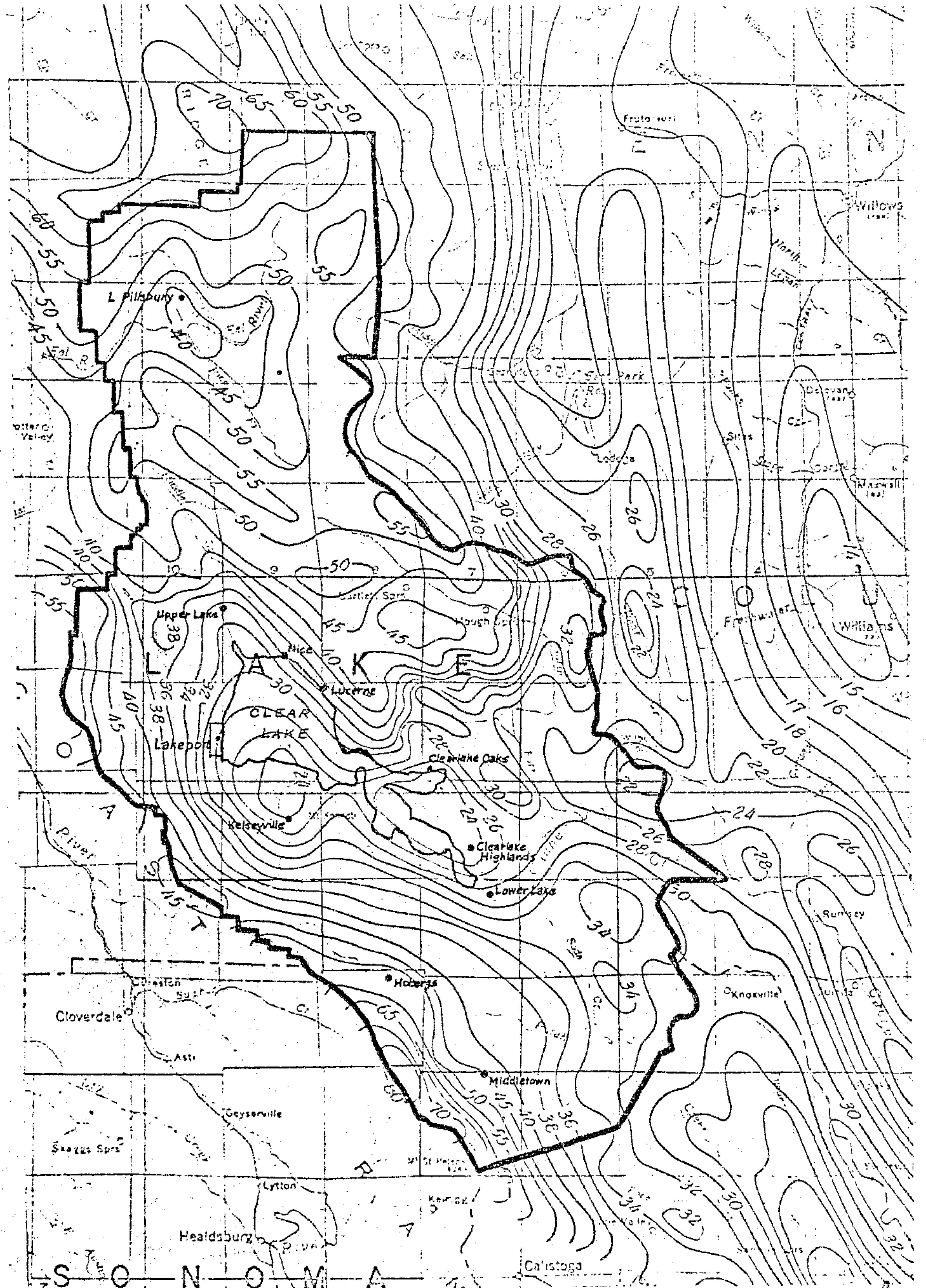


PLATE N°2



MEAN SEASONAL PRECIPITATION IN INCHES

PLATE

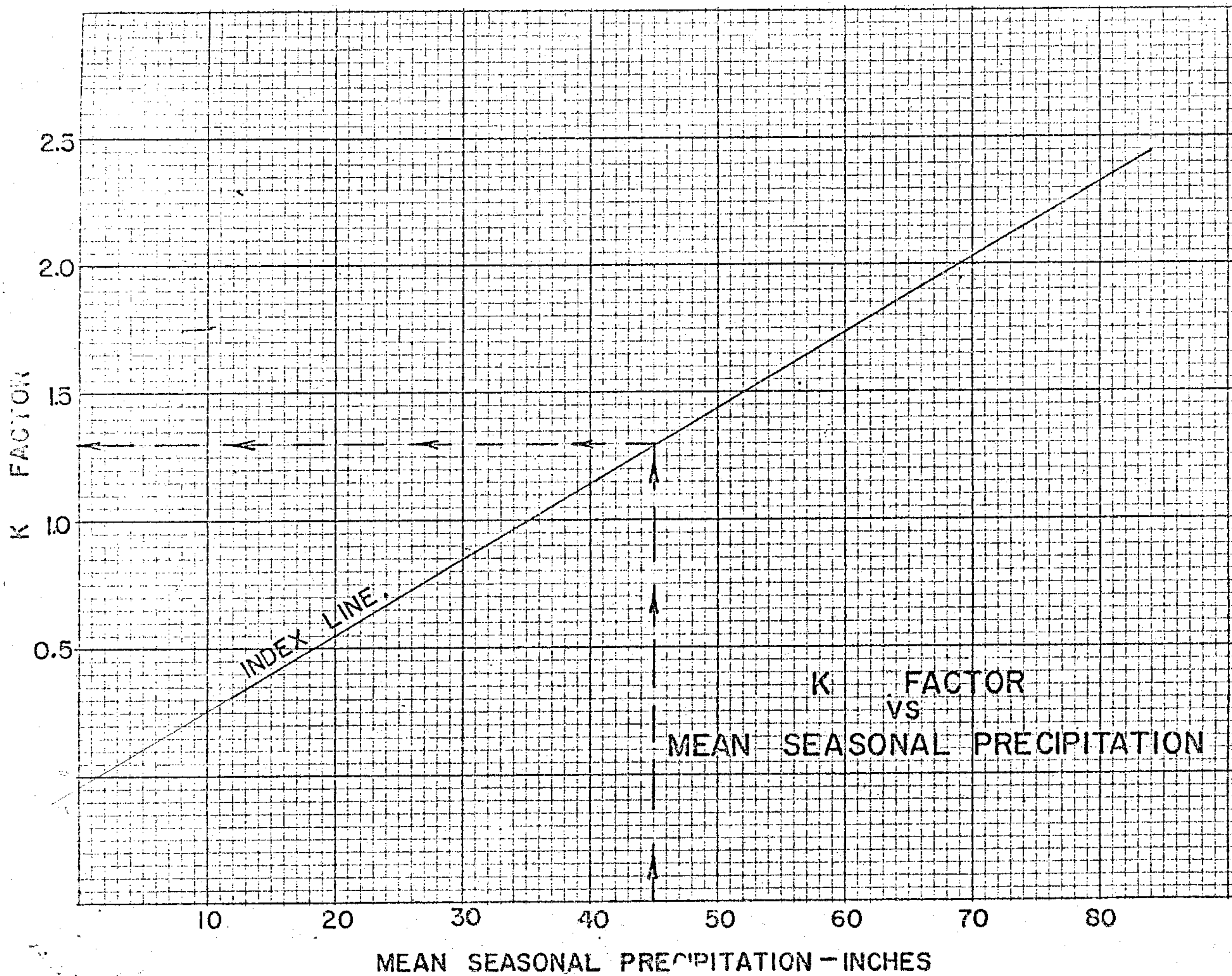

K FACTOR
2.5
2.0
1.5
1.0
0.5
INDEX LINE
K FACTOR
VS
MEAN SEASONAL PRECIPITATION
10
20
30
40
50
60
70
80
MEAN SEASONAL PRECIPITATION - INCHES

PLATE NO.

APPENDIX D

APPENDIX D

ORDINANCE NO. 588 (80)

AN ORDINANCE ESTABLISHING A SPECIAL TAX ON NEW CONSTRUCTION FOR FLOOD CONTROL PURPOSES; SETTING THE MATTER FOR APPROVAL BY THE VOTERS, AND PROVIDING FOR AN INCREASE IN THE CITY OF LAKEPORT'S APPROPRIATION LIMIT.

THE CITY COUNCIL OF THE CITY OF LAKEPORT DOES ORDIAN AS FOLLOWS:

Section 1. There is hereby levied upon all new structures and related impermeable surfaces within the City of Lakeport a special tax for flood control and storm drainage improvements. No existing structure or related impermeable surface shall be subject to said special tax.

Section 2. The amount of the special tax for storm drainage improvements shall be set at a rate of $0.20 per square foot of area covered by the new structure and related impermeable surface.

Section 3. The special tax shall be levied and collected at the time the building permit or grading permit shall be issued. New structures not requiring a building or grading permit shall not be required to pay said tax.

Section 4. No building permit or grading permit shall be issued until the tax has been paid.

Section 5. The enactment of this tax shall be set for confirmation of voters of the City of Lakeport at the April 8, 1980 general election.

Section 6. The voters of the City of Lakeport shall also confirm or reject an increase in the City of Lakeport's appropriations limit at the April 8, 1980 general election. Confirmation of this ordinance shall authorize an increase in the appropriations limit in an amount equal to the funds raised by this tax plus any grant funds obtained by the City. This authorization for an increase in the appropriations limit shall be effective for four (4) years from the date it is confirmed by the voters.

<u>Section 7.</u> This ordinance shall become effective upon receiving the necessary confirmation from the voters of the City of Lakeport.

This ordinance was passed by the City Council of the City of Lakeport on the _____ day of January, 1980, by the following vote:

AYES:

NOES:

ABSENT:

ABSTAINING:

____
ALDEN H. JONES
Mayor

ATTEST:

____
Bernice M. Hudson
City Clerk