STORM DRAINAGE STUDY OF EASTERN PORTION OF THE STRAWBERRY CREEK WATERSHED

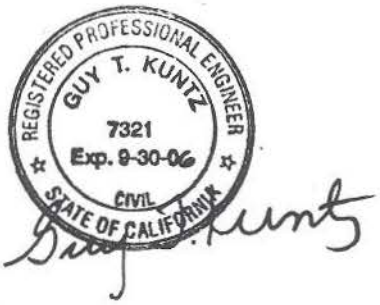
at

UNIVERSITY OF CALIFORNIA

LAWRENCE BERKELEY NATIONAL LABORATORY

Prepared at the request of

LBNL FACILITIES DEPARTMENT



By

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DESCRIPTION OF WATERSHED

The watershed considered in this report consists of the Strawberry Creek area lying generally above Gayley Road and Highland Avenue and comprises about 878 acres, approximately one-third being in the City of Berkeley and two-thirds being in the City of Oakland. Strawberry Creek has two main branches, the South Fork and the North Fork.

The South Fork watershed contains 708 acres and is comprised generally of steep-sloping canyons covered with timber and/or brush and grasslands. It is bounded by the Panoramic-Sugarloaf ridge on the south, Grizzly Peak Boulevard on the east, and the North Fork watershed to the north. The South Fork watershed is further divided into four smaller watersheds, namely Upper Strawberry, Chicken Creek, Panoramic and Stadium Hill. The Upper Strawberry watershed is unique in that its storm water runoff flows into a retention basin and the release of water to the downstream conduit is regulated by a slide gate; none of the other watersheds has a retention basin or a regulating gate. Approximately 10.7% of the total South Fork area is developed and the remaining 89.3% is in a natural state. Developed areas are taken as those covered by buildings, parking lots or roads.

The North Fork watershed contains 170 acres, also comprised of steep-sloping hillsides and some canyons, covered with brush and/or grass. Approximately 31.3% of the total area is developed and the remaining 68.7% is in a natural state.

Plate I shows the entire Strawberry Creek Watershed above Gayley Road and its division into five sub-watersheds, each contributory to a particular culvert or drainage facility.

Plate II shows a detailed summary of all the developed and undeveloped areas in the entire Strawberry Creek watershed and their percentages of the whole area.

Within the watersheds listed above, the rainfall runoff can be accommodated by the existing storm drainage facilities, as evidenced by the fact that there have been no recent significant flooding problems in the area. The current conduits and channels are large enough to accept the peak flows and pass them through downstream. With continued good maintenance of channels and inlets, it is to be expected that the storm drain system will continue to function properly.

CHANGES SINCE 1980

The changes to the drainage system since 1980 have been new pipes and ditches included as part of various building projects, new buildings, new parking lots and new roads. These changes have not altered the basic drainage pattern of the various

watersheds and serve only to redirect rainwater around the new facilities and deliver the water into the existing channels downstream. Most of the drainage changes since 1980 have been made in the area above the Building 83, 84 and 85 complex and the road leading to the new water tank. These changes are not of a magnitude that would alter the overall runoff characteristics of the watershed.

It has been the continuing practice of LBNL Facilities Department to address individual deficiencies in drainage problems as they arise and are recognized and to maintain an active maintenance program. This practice has improved the overall drainage system to where it now functions with few problems and with little or no damage from winter storms. One feature of the maintenance practices of LBNL has been the installation of trash racks upstream from inlet structures. The trash racks have proven effective in intercepting bed and float load, which would otherwise plug inlet structures.

Since 1980 new ordinances have been enacted regarding erosion and sediment control. These ordinances are designed to minimize erosion and sediment damage and require preventative measures to be followed during earthwork and grading operations and also require that cut and fill slopes created by new construction be seeded and planted to provide permanent erosion control. The temporary construction measures and permanent planting of cuts and fills virtually insure that extensive damage such as occurred during the storms of October 1962 will not be repeated at LBNL.

The storms are still the heaviest on record in this area and produced 18 inches of rain in three days—October 11, 12, and 13; fifteen inches of that total came on the 12th and 13th. Extensive earthwork operations were in progress in the Building 77 area and the rain carried tons of earth, mud and rock down onto Lawrence Road, completely blocking it. Landslides occurred along the sides of Chicken Creek. The common-inlet basin for both the South Fork Bypass and the Stadium Culvert (this structure has since been modified and the South Fork Bypass extended upstream) was not capable of handling the heavy bed and float loads. Several workmen attempted to clear the trash racks and keep the structure open; nevertheless, it was not only plugged but several hundred feet of the South Fork Bypass Culvert also was filled with mud and gravel. The water which was diverted around the inlet structure, flooded Haas Clubhouse, loaded the swimming pool with rock and silt, crossed Strawberry Field, flowed south along Rimway Drive, past and through the International House to Piedmont Avenue, and down city streets.

During the same October 1962 storms, serious damage occurred in the Building 74 area when water was impounded behind the ongoing construction in the area above Building 74. When water ran over and eroded the open earthwork, heavy bed load completely filled the inlet basin of the 48" storm drain at Building 74. Upward pressure of the trapped water lifted and destroyed the asphalt concrete paving of the road and parking lot at Building 74. Much of this flow continued down North Canyon Road toward Strawberry Field. Boulders up to 8" to 10" diameter were carried down the roadway.

Drainage improvements throughout the entire watershed, good maintenance practice and adherence to the new ordinances regarding erosion control have minimized the chances of such catastrophic storm damage occurring again.

WATERSHEDS

General

Plate III shows the calculated peak flow in each watershed and also the location of intake conduits for the various watersheds, the Q at that location and the capacity of the downstream conduit. Except for the Upper Strawberry watershed, the capacities exceed the incoming Q; for Upper Strawberry, the outflow is regulated by a slide gate and excess incoming flow is stored in the retention basin.

Upper Strawberry – 508 Acres

Since 1980, approximately 6.6 acres of additional land has been developed within this watershed. LBNL development has totaled about 4.6 acres comprised of new buildings and paving in the vicinity of Buildings 67, 83, 84 and 85, a new road to the water tank north of Building 85, and an improved access road off of Centennial drive leading to the 120kv tower. UC development has added about 2.0 acres of impervious area consisting mainly of the parking lot across Centennial Drive from the Botanical Gardens, the addition of an antenna installation south of Space Sciences building and new development in the Space Science building area.

The collection point for waters originating in the Upper Strawberry watershed is a retention basin, which has a capacity of about 1,500,000 cubic feet. This capacity has probably been reduced somewhat because of the growth of shrubs and trees within the area, and possibly by silting in the basin. Flow out of this basin is remotely controlled by a 48" x 42" hydraulically operated slide gate. The purpose of the gate is to regulate the flow into the South Fork Bypass Culvert by forcing the accumulation of storage in the retention basin, and thus diminishing peak flows through the culvert, which discharges in Faculty Glade on campus. The slide gate can be operated from a station on Centennial Drive just above the retention dam. Flow rates through the gate are shown on Plate XI . It is recommended that the gate controls and the condition of the upstream channel be checked periodically during the rainy season, and especially when heavy storms are forecast. The slide gate is inaccessible at most times during rains because it will become submerged when the water level in the retention basin is deeper than 4 or 5 feet.

A safety overflow system from the retention basin was constructed and consists of an overflow flume from the basin to Centennial Road, and a reinforced concrete wall along the southerly side of the road to a point westerly of the Haas Recreational Area. When water fills the retention basin to a diversion (overflow) elevation of 594 feet, it will divert to the roadway and thus bypass the swimming pools and clubhouse. There are two

wood gates in the wall; these gates provide access to the recreational area. The wooden gates must be closed and remain intact during the flooding to make the bypass effective. This bypass function (overflow of the retention basin) could result from one or any combination of the following three situations: a) too much throttling by operating the 48" slide gate in a nearly closed position; b) partial or total plugging of the slide gate by debris; c) the occurrence of a peak flow at a rate beyond the capacity of the inlet facility, and of a duration sufficient to fill the basin. Once during the rainy season of about 1997, the inlet gate was either plugged or shutdown too far. At that time, because of continuing rains, the retention basin filled and overflowed. The wooden gates were open at the time and muddy water which was supposed to continue down Centennial Drive instead flooded the swimming pool.

With proper operation of the slide gate and good maintenance of the watershed, any flow in the bypass system should be very infrequent but such a diversion, although undesirable, should not be a disaster if the system functions as designed. The present condition of the wooden gates should be examined to determine if the gates can withstand about 3 feet of water flowing down Centennial Drive; if not, the gates should be reinforced or replaced with ones which will seal the gate opening effectively and will withstand the water pressure.

The storm drain system in the Building 74-85 area has been modified and is protected and maintained so that the damage which occurred in the 1962 storms will not be repeated. Some flooding did occur last winter in this area when the storm drain inlet above Building 85 was blocked by debris and water flowed around it and down to Centennial Drive. The area above that intake is very heavy with brush and under growth and is particularly difficult to maintain.

Chicken Creek – 63 Acres

Since 1980, approximately 2.0 acres of additional land has been developed within this watershed. LBNL development has totaled about 0.6 acres comprised of new buildings and paving between Buildings 31 and 62, some paving at the head of Chicken Creek and some new development in the vicinity of Grizzly Substation. UC development has added about 1.4 acres of impervious area with new buildings and paving in Chicken Creek.

After the 1962 storms and prior to 1980, improvements were made by hardening the open channel portion of Chicken Creek and constructing a new inlet structure near Centennial Drive. These improvements and further subsequent improvements have made the open channel portion of Chicken Creek and the inlet structure capable of accepting the full flow from the watershed.

Panoramic – 73 Acres

Since 1980, approximately 2.0 acres of additional land has been developed within this watershed. There has been no LBNL development in the watershed during this time. UC development has added the 2 acres of impervious surface in the vicinity of the Haas Recreation area, mainly in a new parking lot.

After the 1962 storms and prior to 1980, improvements were made by extending the old Stadium Culvert upstream and constructing a new inlet structure with adequate capacity to handle runoff from the upper portion of the Panoramic watershed. Also, the conditions which caused flooding in the International House were corrected.

There have been no significant drainage problems in this watershed since the improvements made after the 1962 storm.

Stadium Hill – 92 Acres

Since 1980, approximately 4.9 acres of additional land has been developed within this watershed. LBNL development has totaled about 1.2 acres comprised of new buildings and cooling towers in the vicinity of Building 6, and the new Big C parking lot. UC development has added about 3.7 acres of impervious area with new buildings around Stern Hall and the new Hillside Parking Lot.

This watershed area experienced only minor problems in the 1962 storms. Since that time there have been no serious problems and the newly developed areas have included adequate drainage facilities

North Fork – 141 Acres

Since 1980, approximately 4.3 acres of additional land has been developed within this watershed. LBNL development has totaled about 1.8 acres comprised of the water tank area adjacent to Building 71, widening of Chamberlain and McMillan Roads, Bay View parking area and the Building 2 area. UC development has added about 2.5 acres of impervious area with developments around the Space Science building and the Lawrence Hall of Science parking lot.

Between 1962 and 1980 many storm drain improvements were made in the North Fork watershed. These improvements include: the drainage system between the Lawrence Hall of Science and Building 71, which is basically a 48" diameter pipe system with several energy dissipaters and inlets protected by trash racks; a continuation of this system through a 39" diameter conduit to an energy dissipater structure in Blackberry Canyon; hardening the North Fork channel from the energy dissipater to LeConte Avenue; and a 60" diameter reinforced concrete pipe culvert (jointly constructed by UC and the City of Berkeley) including a drop-inlet structure located at the head of LeConte Avenue.

There have been no significant drainage problems in this watershed since the improvements made between 1962 and 1980. As in the case of all watersheds, the continuing successful performance of the system is dependent upon proper maintenance.

RAINFALL AND RUNOFF

Data and Design Criteria

The basic published criteria generally used for rainfall intensity, duration, time of concentration and runoff coefficients has not changed since 1980. Therefore the criteria used in the 1980 report is being used in this report. The Rational Method of calculating rainfall runoff was used in the 1980 report and has also been used herein to calculate runoff for each of the five sub-watersheds, and thus for the total Strawberry watershed. Using the same criteria and method of calculation gives a direct comparison of the changes in Q values resulting from the addition of impervious areas in the watersheds.

The Rational Method applies the formula: $Q = C\ i\ A$ where

Q = the peak runoff rate in cubic feet per second

C = a coefficient representing the percentage of the total rainfall on a given area which will run off within the time of concentration

i = the average rainfall intensity in inches per hour for a given time of concentration

A = the drainage area in acres

The Precipitation-Duration-Frequency-Depth curves developed by the Contra Costa County Flood Control and Water Conservation District (see Plates XII and XIII) have been used to plot the intensity-duration curve upon which our calculations are based (see Plate XI).

Selecting a point on the intensity-duration curve requires that the time of concentration be determined. The time of concentration is the time for runoff to become established and flow from the most remote part of the drainage area to the point under design. Ten minutes has been used as the time for runoff to become established.

$$\text{Then } T_c = 10 \text{ min.} + \frac{\text{Length of Stream or culvert}}{\text{Velocity in feet per minute}}$$

Flow velocities were calculated using the Manning formula:

$$v = \frac{1.486}{n}\ r^{2/3}\ \ s^{1/2}$$

where: s = slope
r = hydraulic
n = coefficient (King Handbook of Hydraulics)

High "C" values have been used for coefficients of runoff because after two or three days of moderate rainfall, vegetation and soil will be approaching saturation. Surface soils in this watershed are generally clayey and have low permeability. With the watershed approaching saturation, a heavy storm will then result in a high percentage of runoff. Other factors contributing to a high runoff coefficient are: almost all level areas are fully developed, i.e., roofed and/or paved, thus having a high percentage runoff; and almost all undeveloped areas consist of steep slopes and, even though covered with grass, brush, or trees, will, when approaching saturation, provide little retention and will give a high percentage of runoff.

C = .95 for developed areas (roofed or paved)
C = .60 for undeveloped areas

PROPOSED FUTURE DEVELOPMENTS

The 2005 LDPR anticipates that LBNL will add a total of 5.2 acres of impervious area within the total Strawberry Creek Watershed. By individual watershed, these increases are to be: 3 acres in Upper Strawberry; 0.2 acres in Chicken Creek; 0 acres in Panoramic; 0.4 acres in Stadium Hill; and 1.6 acres in North Fork. Calculations on Plate X show that the total increase in storm water runoff due to these additions will be about 5.37 cfs. 3.1 cfs out of the 5.37 cfs total will be from the Upper Strawberry watershed which will flow into the retention pond and thus will not affect downstream runoff. The remainder, 2.27 cfs represents an increase of about 0.14% of the total Q within the watershed and can be considered as negligible.

CONCLUSIONS

Based on a storm of 100-year recurrence, and using the intensity-duration curve for 40-inch total seasonal rainfall, the conclusion of this report is that the existing drainage facilities in the Strawberry Creek watershed are adequate to handle the peak runoff. The 2005 LRDP increases will not measurably impact the drainage facilities because they will cause only a very small addition in rainfall runoff.

This conclusion is further based on the following provisions:

a) That the hydraulically operated slide gate at the retention basin is kept clear of debris and is set open to properly regulate the flow of water downstream into the Campus system. The flow of water to the Campus must not be too high which would cause damage to their facilities, but the rate should not be so low that the retention basin fills and overflows during normal rainfall.

b) That channels upstream from inlet structures are kept free from float load materials that could plug bar grates.

c) That all inlet bar grates and inlet basins are kept free from debris, growth of weeds and/or vines, or anything that would start a plugging action.

RECOMMENDATIONS AND DISCUSSION

Centennial Drive is used by the public as well as by the LBNL, the University's Botanical Gardens, the Lawrence Hall of Science, and the Space Science facilities. This road may be used as an evacuation route or for emergency vehicles and the use of the road as a flood channel should be avoided if possible. The retention basin is not likely to fill and divert water down Centennial Drive, providing that the hydraulically controlled gate is regulated properly, and providing that the gate is not obstructed with bed and/or float load. The exact opening for the slide gate can best be determined from operational experience. If the gate is not opened wide enough, then the retention basin may fill and cause water to be diverted down Centennial Drive; if open too wide, the rate of flow of the runoff into the lower campus may be too high. This gate is operated from a station on Centennial Drive, just above the retention dam. The need may arise to operate this gate under emergency conditions. We recommend that the operating mechanism be checked periodically and that the controls be clearly marked to define direction of gate movement.

Regular cleaning of catch basins in the developed areas, and the clearing of the down timber, brush and debris from channels, primary screens, and inlet grates, each fall and after each major storm is a positive necessity and an important maintenance function. A good maintenance program must be continued to avoid erosion of stream channels, blockage of inlets and flooding of surrounding areas.

List of Plates in This Report and Their Content

Plate I, Map of the Strawberry Creek Watershed Study Area, indicates the sub-watershed divisions, and principal drainages and storm drain pipes.

Plate II is a tabulation of developed areas in the watersheds as of 2004

Plate III shows peak flows in watersheds and shows peak flows at selected locations and the capacity of the culverts (or inlet) into which the flows discharge.

Plate IV shows property management areas within the watershed study area

Plate V shows developed areas within the Upper Strawberry Canyon Watershed

Plate VI shows developed areas within the Chicken Creek Watershed

Plate VII shows developed areas within the Panoramic Watershed

Plate VIII shows developed areas within the Stadium Hill Watershed

Plate IX shows developed areas within the North Fork Watershed

Plate X shows the current runoff and estimated runoff from proposed development under the 2005 LRDP

Plate XI shows intensity–duration curves for rainfall and shows flow rates through the slide gate at the retention basin

Plate XII shows Contra Costa County precipitation-duration-frequency-depth curves

Plate XIII shows Contra Costa County mean seasonal isohyets

LEGEND

BOUNDARY OF WATERSHED STUDY AREA

DRAINAGE

PIPE

0 100 500 1000

SCALE

NORTH FORK

CHICKEN CREEK

STADIUM HILL

UPPER STRAWBERRY

SOUTH FORK BYPASS

STADIUM

PANORAMIC

STADIUM CULVERT

SLIDE GATE

RETENTION BASIN

MAP OF STRAWBERRY CREEK WATERSHED STUDY AREA

PLATE I

DEVELOPED AREAS IN THE WATERSHEDS AS OF 2004

WATERSHED NAME	TOTAL AREA acres	LBNL DEVELOPMENT		U of C DEVELOPMENT		OTHER DEVELOPMENT	
		AREA acres	AREA % of total	AREA acres	AREA % of total	AREA Acres	AREA % of total
Upper Strawberry	508	10.85	2.1	7.77	1.5	3.6	0.7
Chicken Creek	63	12.45	19.8	4.68	7.4	0	0
Panoramic	70	0	0	16.04	22.9	2.5	3.6
Stadium Hill	67	8.17	12.2	8.98	13.4	0.4	0.6
North Fork	170	35.11	20.7	10.14	6.0	8.0	4.7
GRAND TOTAL	878	66.58	7.6	47.61	5.4	14.7	1.7

TOTAL DEVELOPED AREA = 66.58 + 47.61 + 14.70= 128.89 ACRES

PERCENTAGE OF DEVELOPED AREA = 128.89/878 = 14.68%

PLATE II

PEAK FLOW IN WATERSHEDS

NAME OF WATERSHED	Q cfs developed area	Q cfs natural area	Q cfs total area
Upper Strawberry	62	860	922
Chicken Creek	48	81	129
Panoramic	52	91	143
Stadium Hill	49	87	136
North Fork	149	207	356
TOTAL ALL WATERSHEDS	360	1,326	1,686

PEAK FLOWS AND CULVERT/INLET CAPACITIES

WATERSHED	POINT OF CONCENTRATION		CULVERT/INLET CAPACITY	
	Location	Q cfs	Q cfs	Limiting Conditions
Upper Strawberry	Slide gate in retention basin	922	404	48"x42" slide gate
Chicken Creek	54" RCP at Poultry Research (Tc = 15 minutes)	149	500	54" RCP slope = 0.06
Chicken Creek + Upper Strawberry with 9" gate opening	72" RCP South Fork Bypass at junction with 54"RCP (Tc = 25 minutes)	129 + 86= 215	500	72" RCP slope = 0.015
Chicken Creek + Upper Strawberry with 24" gate opening	72" RCP South Fork Bypass at junction with 54"RCP (Tc = 25 minutes)	129+ 230= 359	500	72" RCP slope = 0.015
2/3 of Stadium Hill + Chicken Creek + Upper Straw. with 24" gate opening	South Fork Bypass at Rimway and Centennial	91+ 359= 450	600	66" RCP slope= 0.035
Panoramic	Stadium culvert under stadium	143	180	42" RCP slope = 0.04
North Fork	60" RCP City of Berkeley culvert at LeConte Ave.	356	475	60" RCP slope = 0.037

PLATE III

PROPERTY MANAGEMENT WITHIN THE STRAWBERRY CREEK STUDY AREA WATERSHED

SOUTH FORK OF STRAWBERRY CREEK WATERSHED	TOTAL AREA IN ACRES	PROPERTY OWNER		
		UNIVERSITY OF CALIFORNIA		PUBLIC & PRIVATE LAND Area in Acres
		LBNL MANAGEMENT Area in Acres	UCB MANAGEMENT Area in Acres	
NAME OF SUB-WATERSHED				
Upper Strawberry	508	52	436	20
Chicken Creek	63	38	25	0
Panoramic	70	0	59	11
Stadium Hill	67	20	47	0
TOTAL AREA OF SOUTH FORK	708	110	567	31
NORTH FORK OF STRAWBERRY CREEK WATERSHED	170	91	54	25
TOTAL AREA SOUTH FORK PLUS NORTH FORK	878	201	621	56

PLATE IV

UPPER STRAWBERRY CANYON WATERSHED DEVELOPED AREAS

UPPER STRAWBERRY CANYON WATERSHED ROADS				
NAME	OWNER	LENGTH (feet)	WIDTH (feet)	AREA (acres)
Centennial Drive	U of C	2,546	27	1.60
Grizzly Peak Blvd	City of Oakland	6,070	26	3.62
Calvin Rd to Water Tank	LBNL	2,110	33	1.60
Lawrence Road	LBNL	720	20	0.33
Lee Road	LBNL	555	26	0.33
Road to 120kv Tower	LBNL	495	10	0.11
Animal Behavior Research Station Roads	U of C	2122	10	0.49
Road below Bldg. 62	LBNL	920	10	0.21
Botanical Gardens	U of C	3,890	10	0.89
			TOTAL	9.18

UPPER STRAWBERRY CANYON WATERSHED BUILDINGS & PAVING			
NAME	OWNER	AREA (sq.ft.)	AREA (acres)
Bldg. 67 (Molecular Foundry) and Bldg. 72 complex	LBNL	69,000	1.59
Bldg. 62 area and Bldg. 66A	LBNL	94,910	2.18
Parking along Lawrence Road	LBNL	4,390	0.10
Bldg. 74 & 84 Area including bus shelter	LBNL	87,000	2.00
Bldg 83 area including parking, kiosk, and intersection	LBNL	36,240	0.83
Bldg 85 area including road side parking	LBNL	62,400	1.43
Water tank and pavement turnouts	LBNL	6,260	0.14
Botanical Gardens East of Centennial	U of C	92,630	2.13
Botanical Gardens West of Centennial	U of C	54,960	1.26
Antenna Site	U of C	5,000	0.11
Animal Behavior Research Station	U of C	47,780	1.10
Paving & Parking at foot of Chicken Creek	U of C	8,096	0.19
	TOTAL		13.06

SUMMARY

LBNL AREA = 2.58 roads + 8.27 buildings. & paving = 10.85 acres
U C AREA = 2.98 roads + 4.79 buildings & paving = 7.77 acres
OTHER = 3.62 acres
TOTAL 22.24 acres

SAY 22.3 ACRES

PLATE V

CHICKEN CREEK WATERSHED DEVELOPED AREAS

CHICKEN CREEK WATERSHED ROADS				
NAME	OWNER	LENGTH (feet)	WIDTH (feet)	AREA (acres)
Centennial Drive	U of C	1988	33	1.51
McMillan Road	LBNL	1111	28	0.71
Glaser Road	LBNL	1535	18	0.63
Lawrence Road	LBNL	1662	21	0.80
Chicken Creek Road	LBNL	1026	10	0.24
Chicken Creek Road	U of C	1306	10	0.30
Road to 120kv Tower	LBNL	323	10	0.07
Animal Behavior Research Station Roads	U of C	228	10	0.05
Road joining McMillan Road and Glaser Road	LBNL	372	26	0.22
			TOTAL	4.53

CHICKEN CREEK WATERSHED BUILDINGS & PAVING			
NAME	OWNER	AREA (sq.ft)	AREA (acres)
Lawrence Hall of Science	U of C	40,871	0.94
Space Science & auxiliary bldg.	U of C	32,490	0.75
Bldgs. 75 & 69 Complex	LBNL	111,520	2.56
Bldgs. 76 & 78 Complex	LBNL	65,790	1.51
Bl\dgs. 77, 79, 36 & 32 plus Grizzly Substation	LBNL	142,255	3.27
Bldg. 77A and auxiliary parking	LBNL	24,303	0.56
Bldg. 31 Complex	LBNL	52,369	1.20
Chicken Creek Staging Areas	LBNL	29,660	0.68
Chicken Creek Buildings and Parking	U of C	49,251	1.13
	TOTAL		12.60

SUMMARY

LBNL AREA = 2.67 roads + 9.78 buildings. & paving = 12.45 acres
U C AREA = 1.86 roads + 2.82 buildings & paving = 4.68 acres

TOTAL 17.13 acres

SAY 17.2 ACRES

PLATE VI

PANORAMIC WATERSHED DEVELOPED AREAS

PANORAMIC WATERSHED ROADS				
NAME	OWNER	LENGTH (feet)	WIDTH (feet)	AREA (acres)
Centennial Drive	U of C	735	24	0.40
Stadium Rimway	U of C	650	28	0.42
			TOTAL	0.82

PANORAMIC WATERSHED BUILDINGS & PAVING			
NAME	OWNER	AREA (sq.ft)	AREA (acres)
Haas Pool, Building and Parking Complex	U of C	174,640	4.01
U of C Stadium	U of C	488361	11.21
Other (private residences & public roads)			2.50
	TOTAL		17.72

SUMMARY

LBNL AREA = 0 acres
U C AREA = 0.82 roads + 15.22 buildings & paving = 16.04 acres
OTHER = 2.50 acres

TOTAL 18.54 acres

SAY 18.5 ACRES

PLATE VII

STADIUM HILL WATERSHED DEVELOPED AREAS

STADIUM HILL WATERSHED ROADS				
NAME	OWNER	LENGTH (feet)	WIDTH (feet)	AREA (acres)
Cyclotron Road	U of C	899	32	0.66
Cyclotron Road	LBNL	1099	35	0.88
Lawrence Road	LBNL	1659	32	1.22
Segre Road	LBNL	370	28	0.24
N1	LBNL	301	32	0.22
Stadium Rimway	U of C	1468	24	0.81
			TOTAL	4.03

STADIUM HILL WATERSHED BUILDINGS & PAVING			
NAME	OWNER	AREA (sq.ft)	AREA (acres)
Bldg. 6 complex	LBNL	122,126	2.80
Big "C" Lot	LBNL	14,222	0.33
Horseshoe Lot	LBNL	10,186	0.23
Bldgs. 25, 58, 4, 14, 40, 45, & 48	LBNL	98,106	2.25
Hillside Parking Lot	U of C	81,913	1.88
Kleeberger Parking Lot	U of C	14,965	0.34
Between Kleeberger & Greek Theater	U of C	43,343	1.00
Greek Theater	U of C	73,934	1.70
Residence Halls adjacent to Cyclotron Road	U of C	112,795	2.59
Other (public roads)			0.40
	TOTAL		13.52

SUMMARY

LBNL AREA = 2.56 roads + 5.61 buildings & paving = 8.17 acres
U C AREA = 1.47 roads + 7.51 buildings & paving = 8.98 acres
OTHER = 0.40 acres

TOTAL 17.55 acres

SAY 17.6 ACRES

PLATE VIII

NORTH FORK WATERSHED DEVELOPED AREAS

NORTH FORK WATERSHED ROADS				
NAME	OWNER	LENGTH (feet)	WIDTH (feet)	AREA (acres)
Cyclotron Road	LBNL	954	35	0.77
Lawrence Road	LBNL	1204	28.5	0.79
McMillan Road	LBNL	1788	30.5	1.25
Seaborg Road	LBNL	422	34	0.33
Alvarez Road	LBNL	1001	25	0.57
E Road	LBNL	519	32	0.38
F2	LBNL	916	24	0.50
Chamberlain Road	LBNL	1388	28	0.89
Paved Bevatron bench	LBNL	560	8	0.10
Centennial Drive	U of C	2243	39	2.01
Space Science Lab	U of C	471	29	0.31
Grizzly Peak Blvd	Oakland/Berkeley	2141	29	1.43
Golf Course Drive	Oakland/Berkeley	266	30	0.18
Summit Road	Oakland/Berkeley	1065	17	0.42
Olympus Ave/ Wilson	Oakland/Berkeley	1098	21	0.53
Campus Drive	Oakland/Berkeley	595	21	0.29
			TOTAL	10.75

NORTH FORK WATERSHED BUILDINGS & PAVING			
NAME	OWNER	AREA (sq.ft)	AREA (acres)
Space Science	U of C	71,280	1.64
Lawrence Hall of Science	U of C	269,313	6.18
Bldg. 71 complex	LBNL	127,840	2.93
Bldg. 90 complex	LBNL	73,334	1.68
Bldgs. 55, 64, 51 complex	LBNL	315,940	7.25
Blackberry Canyon Parking Lot	LBNL	38,328	0.88
Bldg. 65	LBNL	22,668	0.52
Bldg. 88	LBNL	94,441	2.17
Bldg. 50 complex	LBNL	106,295	2.44
Bldg. 54	LBNL	31,938	0.73
Bldg. 70, 70A and parking areas	LBNL	126,743	2.91
Bldgs. 46, 47, 52, 2 and parking areas	LBNL	155,145	3.56
Bldgs. 17, 27, 5, 80, 6, 7, 52 and parking areas	LBNL	194,339	4.46
Other (private property)			5.15
		TOTAL	42.50

SUMMARY

LBNL AREA = 5.58 roads + 29.53 buildings. & paving = 35.11 acres

U C AREA = 2.32 roads + 7.82 buildings & paving = 10.14 acres

OTHER = 8.00 acres

TOTAL 53.25 acres SAY 53.2 ACRES

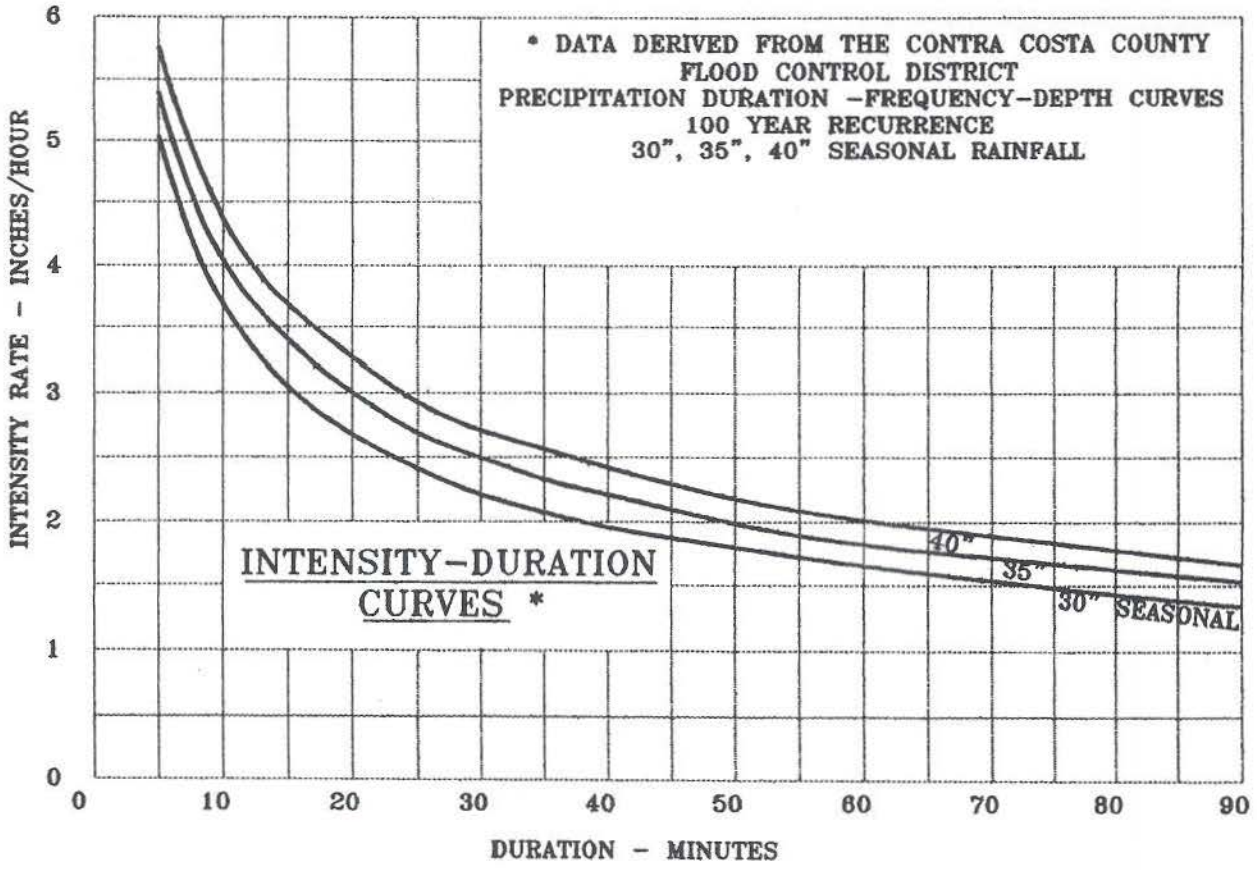
PLATE IX

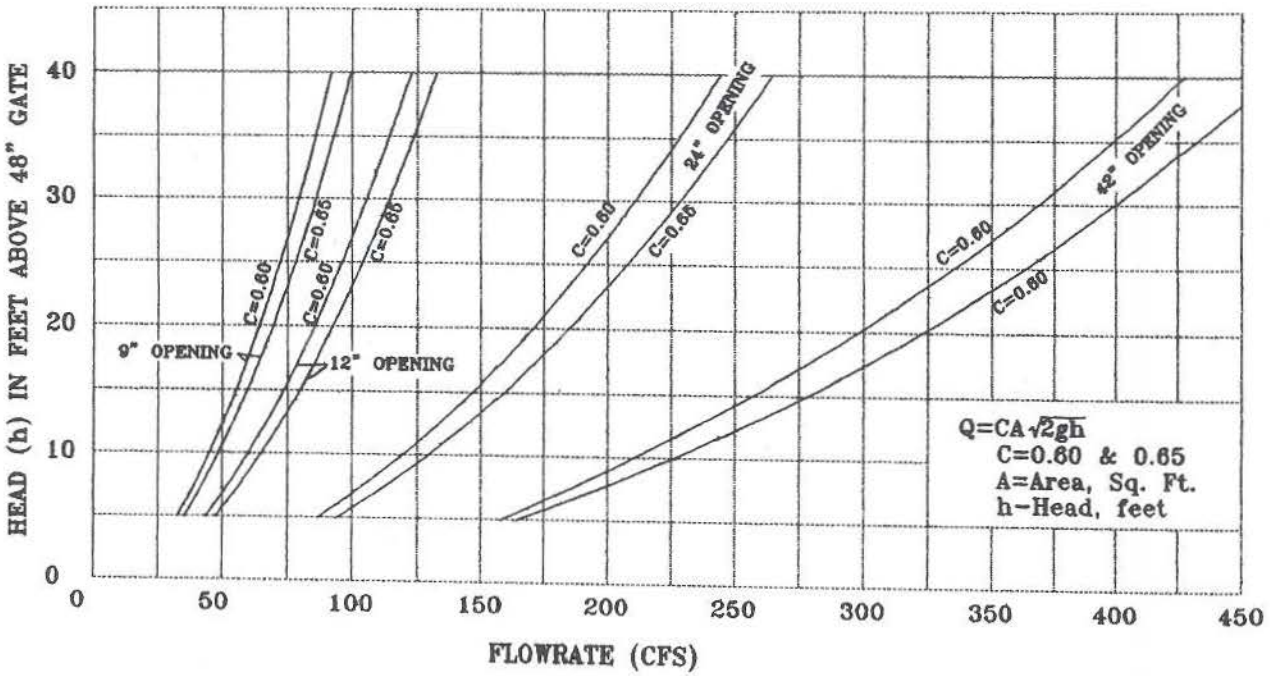
CURRENT RUNOFF AND ESTIMATED RUNOFF FROM PROPOSED DEVELOPMENT UNDER THE 2005 LRDP

Name of Watershed	2004 area acres			Coefficient of runoff "C"	Rainfall intensity "i" (in/hr)	Q (cfs)	ESTIMATED 2005 LRDP increases	
	LBNL	Non-LBNL	Total				Add area (acres)	Add Q (cfs)
Upper Strawberry								
impervious	10.9	11.4	22.3	0.95	2.95	62	3	3.10*
natural	41.1	444.6	485.7	0.6		860		
			508.0			922		
Chicken Creek								
impervious	12.5	4.7	17.2	0.95	2.95	48	0.2	0.21
natural	25.5	20.3	45.8	0.6		81		
			63 .0			129		
Panoramic								
impervious	0	18.5	18.5	0.95	2.95	52	0	0
natural	0	51.5	51.5	0.6		91		
			70.0			143		
Stadium Hill								
impervious	8.2	9.4	17.6	0.95	2.95	49	0.4	0.41
natural	11.8	37.6	49.4	0.6		87		
			67.0			136		
North Fork								
Impervious	35.1	18.1	53.2	0.95	2.95	149	1.6	1.65
natural	55.9	60.9	116.8	0.6		207		
			170.0			356		
					TOTAL	1686	5.2	5.37

*Note: The 3.1 cfs from Upper Strawberry watershed will flow into the retention basin and will not cause additional runoff. The remaining 2.27 cfs (5.37-3.10) represents an increase in runoff of 0.14% which is negligible.

PLATE X



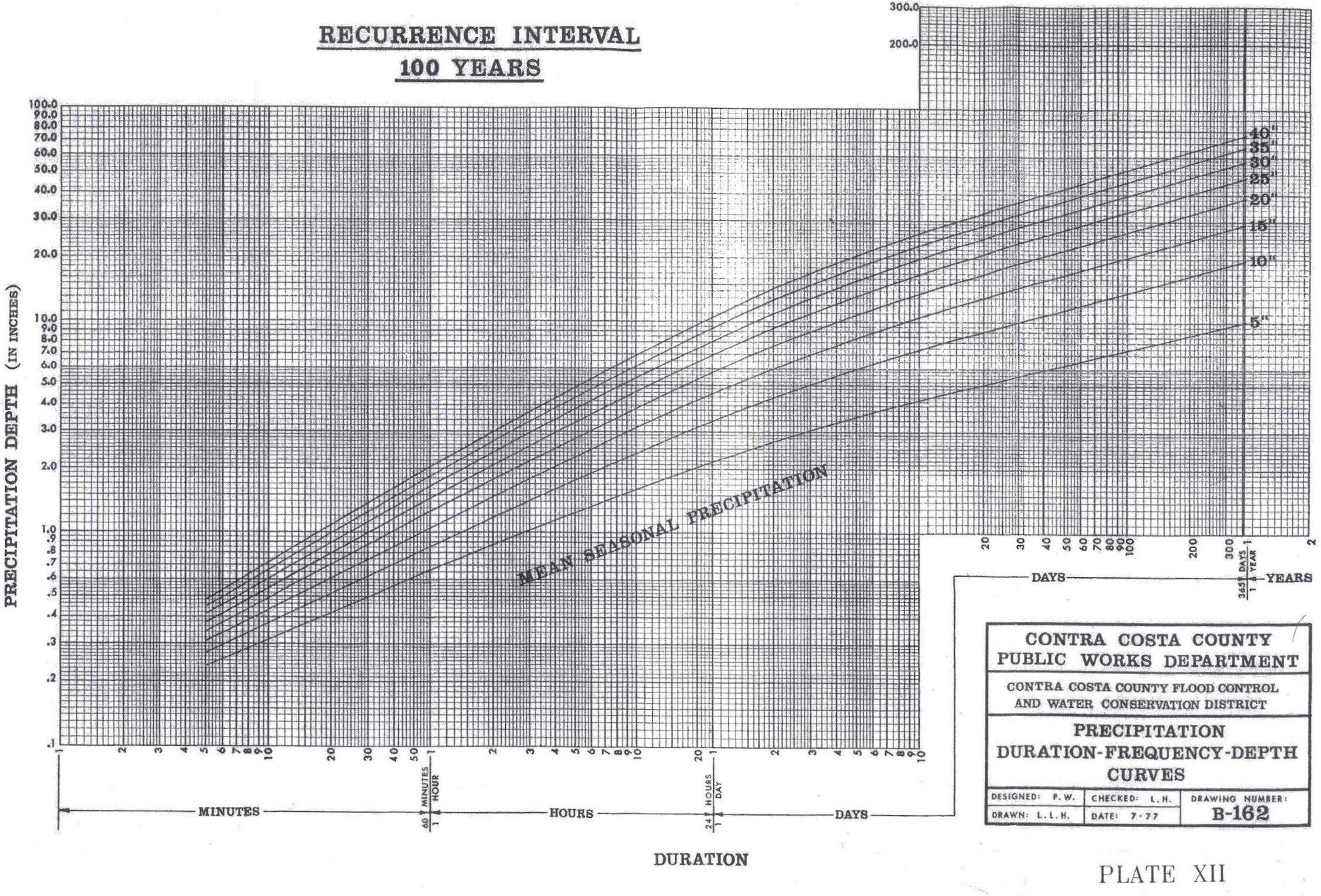


FLOW THROUGH SUBMERGED GATE

RECTANGULAR GATE 48 INCHES WIDE

PLATE XI

RECURRENCE INTERVAL
100 YEARS



CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT		
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT		
PRECIPITATION DURATION-FREQUENCY-DEPTH CURVES		
DESIGNED: P. W.	CHECKED: L. H.	DRAWING NUMBER: B-162
DRAWN: L. L. H.	DATE: 7-77	

PLATE XII

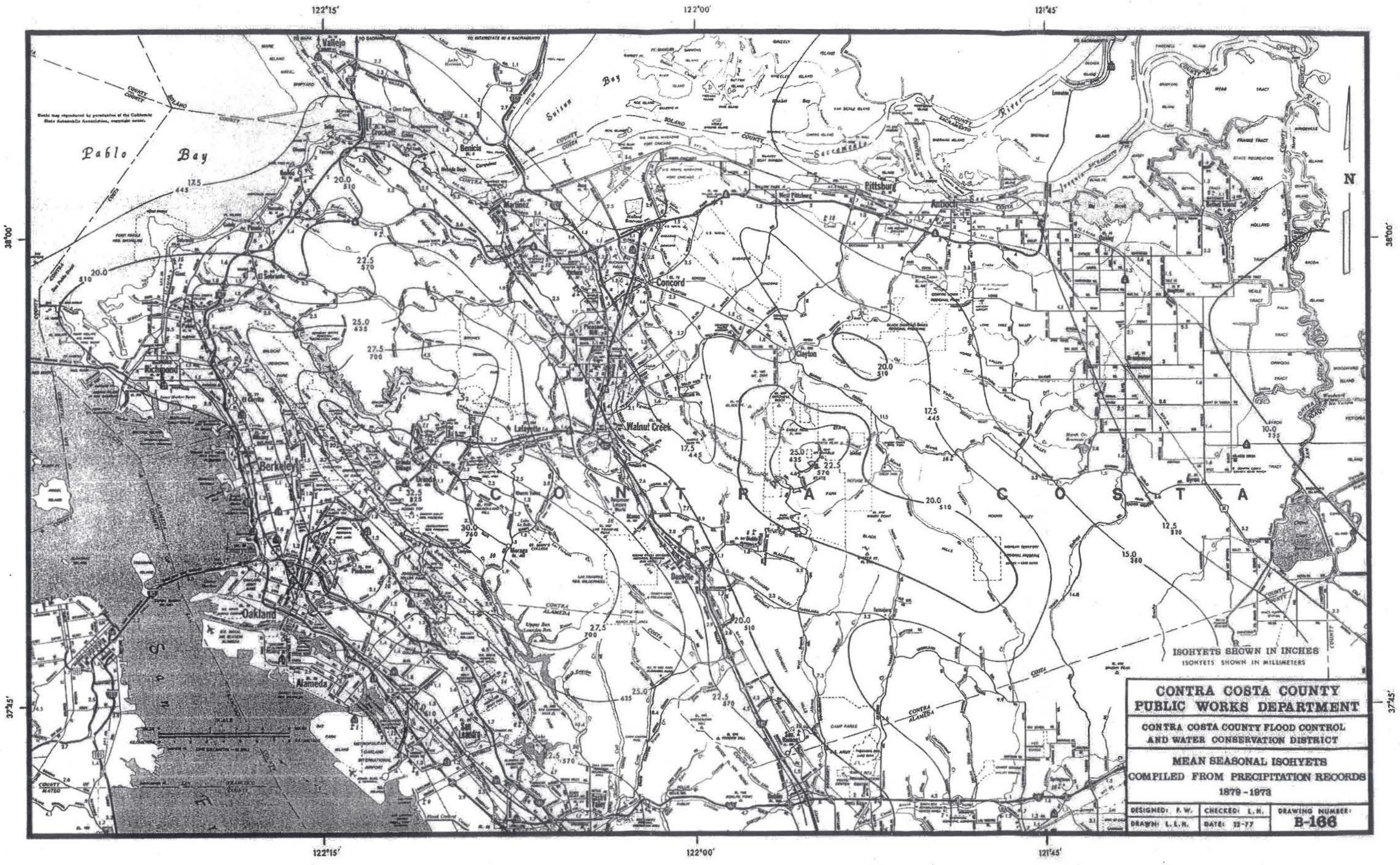

122°15'
122°00'
121°45'
38°00'
37°45'
Pablo Bay
Suisun Bay
Sacramento River
San Joaquin River
CONTRA COSTA
SAN FRANCISCO BAY
Vallejo
Crockett
Benicia
Martinez
Concord
Pittsburg
Antioch
Clayton
Walnut Creek
Lafayette
Orinda
Moraga
Danville
Berkeley
Oakland
Alameda
San Leandro
Richmond
El Cerrito
El Sobrante
Pinole
Hercules
Bethel Island
Byron
Brentwood
N
ISOHYETS SHOWN IN INCHES
ISOHYETS SHOWN IN MILLIMETERS
CONTRA COSTA COUNTY
PUBLIC WORKS DEPARTMENT
CONTRA COSTA COUNTY FLOOD CONTROL
AND WATER CONSERVATION DISTRICT
MEAN SEASONAL ISOHYETS
COMPILED FROM PRECIPITATION RECORDS
1879 - 1973
DESIGNED: F. W.
DRAWN: L. L. H.
CHECKED: L. H.
DATE: 12-77
DRAWING NUMBER:
B-166

PLATE XIII