STORM DRAINAGE STUDY

STRAWBERRY CREEK WATERSHED

at

UNIVERSITY OF CALIFORNIA

LAWRENCE BERKELEY LABORATORY

Prepared at the request of

LBL PLANT ENGINEERING DEPARTMENT

by

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February, 1980

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March 6, 1980

Mr. Frank E. McClure
Plant Engineer
Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

Subject: Storm Drainage Study - Strawberry Creek Watershed

Dear Mr. McClure:

Transmitted herewith are 25 copies of the final report on the subject study.

The purpose of this study has been to analyze the adequacy of the existing storm drainage facilities during a major storm of design intensity and to evaluate the impact of present and proposed future LBL developments within the watershed.

This report considers the watershed area above Gayley Road only and does not discuss the flow in the channels within the portion of Campus situated below Gayley Road.

Based on this study, we concluded that:

a) present drainage facilities are adequate with provisions as noted herein;

b) proposed additional developments will have no significant effect on drainage.

Data is summarized and tabulated on Plates I through V.

Recommendation for further improvements and maintenance procedures are included as a part of this report.

Yours very truly,

G. T. KUNTZ

bc
Enc.

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Table of Contents

STORM DRAINAGE STUDY - STRAWBERRY CREEK WATERSHED

INTRODUCTION

The purpose of this study is to analyze and assess the expected performance of the existing drainage facilities during a major storm of design intensity, and to evaluate the general impact of present and proposed future LBL developments within the watershed. This report considers the watershed area above Gayley Road only and does not discuss the flow in the channels of the campus below Gayley Road.

DESCRIPTION OF WATERSHED

This description deals with the portion of the Strawberry watershed lying generally above Gayley Road and Highland Avenue. This watershed comprises about 874 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 confluence of the two forks is at the lower end of the campus at a point about 400 feet east of the City of Berkeley's Oxford and Center Streets culvert. The entire runoff from the total watershed including the lower campus is delivered to the entrance of this culvert.

The South Fork watershed contains 733 acres comprised generally of steep-loping 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. It is largely undeveloped, with only 6.7% of the total area developed and 93.3% remaining in a natural state. Developed areas are taken as those covered by buildings, parking lots and roads.

The North Fork watershed contains 141 acres, also comprised of steep-sloping hillsides and some canyons, covered with brush and/or grass. The development in this watershed is divided thus: LBL-18.2%, University-4.6%, and Residential and Public Roads-5.7%. A total of 28.5% of the 141 acres is developed and 71.5% remains in a natural condition.

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

Plate II shows a detail summary of all the developed and undeveloped areas and their percentages of the whole area.

DISCUSSION OF THE OCTOBER, 1962, STORM

The storm of October, 1962, has been properly labeled the heaviest storm on record in the San Francisco Bay Area. It caused severe flooding and major damage at both LBL and the University, as well as much damage throughout the entire Berkeley-Oakland hills.

A brief discussion of some of the events, causes and effects of damage within the LBL and University properties is in order.

The storm produced 18 inches of rain in three days--October 11, 12 and 13. Fifteen inches of that total came in two days--the 12th and 13th.

Construction projects in the Chicken Creek and north branch of the Strawberry Creek drainage basins were in progress. New drainage facilities at the Building 77 construction site were not operable. A temporary access road to the power line construction project above Building 74 had caused stream channels to be filled with rubble and loose earth.

Chicken Creek inletted into a totally inadequate 20" diameter corrugated metal pipe at the Poultry Research Station. Chicken Creek and various branches of Strawberry Creek have steep profiles and have side slopes in the order of 1½ to 1. The sides of Chicken Creek in particular and the other streams to a lessor degree are subject to mud flows and small landslides when saturated, and thus contribute to both bed and float load when this type of erosion takes place.

The common-inlet basin for both the South Fork Bypass and the Stadium Culvert was not capable of handling the heavy bed and float loads. A trash rack at the entrance to the basin consisted of vertical pipe or bars about 4 feet high with 18-inch horizontal spacing. A wooden trash rack was located about 100 feet upstream from the basin and above the entrance of the Chicken Creek culert to the Strawberry channel.

The storm produced two peak flows, one Friday night October 12 and one Saturday noon, October 13. The effects which these two peak flows had on the above-described facilities are briefly noted here: Impounded waters on the Builing 77 construction site overtopped dykes, eroded gullies into the new cut and fill slopes and delivered heavy mud flows into Chicken Creek. Landslides occurred along the sides of both Chicken and Strawberry Creeks. Water was impounded behind the temporary road construction in the channels above Building 74. When water ran over and eroded these small fills, heavy bed load completely filled the inlet basin of the 48" storm drain at Building 74. This heavy flow 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.

In spite of the efforts of several workmen who attempted to clear the trash racks and keep the Strawberry structure open, bed and float load plugged the trash rack, filled several hundred feet of the South Fork Bypass Culvert with mud and gravel, and filled the basin to the deck level. During each of the peak flows, water

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.

The North Fork watershed was not severely damaged. Inlets were plugged, water topped the various inlet structures and generally flowed down streets. Erosion and bank sloughing occurred in the open channel between the LBL 48" culvert outfall and the inlet structure at La Loma. The extent of plugging of this city inlet structure and the flooding of the city streets below were not observed by this writer.

The above brief report is not an attempt to assess damages done, but only to point out some of the conditions that existed and some of the events that took place during the two days of heavy rainfall. We also wish to reiterate that the October 11, 12 and 13, 1962, storm was the heaviest of record.

IMPROVEMENTS TO DRAINAGE FACILITIES SINCE THE 1962 STORM

Since the October, 1962, many major improvements have been made throughout the entire Strawberry watershed. To facilitate this study, the entire drainage area has been divided into five sub-watersheds, each contributory to a particular drinage culvert or system. It is important to note the specific improvements that have been accomplished in the several sub-watersheds.

Upper Strawberry - 502 Acres

The South Fork Bypass culvert has been extended from the site of the old inlet structure approximately 1100 feet to a new retention basin which has a capacity of 1,500,00 cubic feet. A 48" x 42" hydraulically operated slide gate has been fitted to the inlet of the new pipe exterior. The purpose of this slide gate is to regulate the flow into the South Fork Bypass Culvert, force the accumulation of storage in the retention basin, and thus diminish peak flows through the culvert which discharges in Faculty Glade. The slide gate is operated from a station on Centennial Drive just above the retention dam.

A safety overflow system from the retention basin called "North Canyon Road Bypass" (Now Centennial Drive) has been constructed. It consists of an overflow flume from the basin to North Canyon 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 basis to a diversion (overflow) elevation of 594 feet, it will divert to the roadway and thus bypass the swimming pools and club house. There are wood gates in the reinforced concrete wall providing access to the recreational area. These gates must be closed to make the "North Canyon 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 occurence of a peak flow of a rate beyond the capacity of the inlet facility, and of a duration sufficient to fill the basin. This situation can happen, but with proper operation of the gate and good maintenance of the watershed, it should be very infrequent. We should note that a diversion to the North Canyon Road, although very undesirable, probably would not be a disaster, since this function has been designed to protect the Haas Recreational Area. Water thus diverted will spread across Strawberry Field and follow Rimway Drive to city streets.

The inlet basin at the 48" storm drain in the Building 74-83 area has been protected by the installation of a primary screan (trash rack) upstream from the inlet structure. Similar primary screens have been installed in several of the stream channels and have proven effective in intercepting bed and float load which would otherwise plug inlet structures.

Chicken Creek - 66 Acres

The old 20" corrugated metal pipe at the Poultry Research Station originally intended to carry the flow under the road to the Strawberry channel has been replaced with a 54" reinforced concrete pipe connecting directly into the 72" South Fork Bypass Culvert. A self-cleaning inlet structure at the west side of

the Poultry Research Building is designed to accept the peak flow from Chicken Creek. The open channel above this point has been improved and "hardened" by the addition of rock and concrete rubble groins or check dams. This channel is still subject to severe erosion during peak flows and could well be further improved.

Much of the runoff from the portion of this watershed lying above Cylotron Road now originates from developed areas, roofs, paving and landscaped slopes. This water is collected in an adequate underground storm drainage system fully protected by inlet grates and is delivered to the open channel free of bed or float load. The "design for disaster" which existed in October, 1962, has been eliminated in the portion of the watershed above Cyclotron Road. As noted above, the open channel of Chicken Creek is still subject to erosion.

Panoramic - 73 Acres

The old Stadium Culvert has been extended upstream approximately 130 feet from the site of the old inlet structure which was above Haas Clubhouse. A new inlet structure has been built with adequate capacity to handle runoff from the upper portion of the Panoramic watershed.

The problem situation which caused flooding in the International House has been corrected. Surface flow down Rimway Drive will now bypass the International House and be delivered to Piedmont Avenue.

Stadium Hill - 92 Acres

There have been few if any changes in drainage patterns in this sub-watershed since 1962. No particular problems were experienced during the big October storm other than plugging of the small culverts which diverted water to North Canyon Road. The result was that rock and rubble were washed out onto the pavement. These culverts have been replaced with larger ones and the inlet structures improved.

The 24" corrugated metal pipe carrying the flow from the area of Buildings 70 and 54 discharged at a point about 250 feet above the Greek Theatre. This 24" culvert has been extended, passes between the Greek Theatre and Stern Hall, and is tied in to the University drainage system.

North Fork - 141 Acres

Storm drain improvements in the North Fork watershed were dictated by the construction of the Lawrence Hall of Science, the Space Laboratory, and the continued growth in the LBL area. The City of Berkeley, in cooperation with the University, constructed a new 60" reinforced concrete pipe culvert with a drop-inlet structure located at the head of LeConte Avenue. This culvert follows LeConte, LaLoma, Ridge, Euclid, and discharges into the North Fork open channel just below the University North Gate. The old 4' x 5' culvert and its' inlet structure were left in place.

IMPROVEMENTS TO DRAINAGE FACILITIES SINCE THE 1962 STORM (Contd.)

The North Fork channel above the LeConte Avenue inlet has been hardened by the construction of five rock groins. These groins have several beneficial effects. They form check-dams and pools, thus flatten the slope, slow the velocity of runoff, provide some storage capacity, all contributing to increasing the time of concentration. With the stream profile thus altered, the undercutting of side slopes is decreased and the stream channel becomes more nearly stabilized. This work and similar work in the Chicken Creek channel was engineered and installed under the direction of B.F. Lennert for the University.

The LBL 48" reinforced concrete pipe culvert has been lined with steel cylinder pipe and energy dissipator structures have been constructed at the common outfall point of the 48" reinforced concrete pipe and the 30" reinforced concrete pipe culverts in Blackberry Canyon. Beginning near Building 71, a 48" reinforced concrete pipe culvert with three concrete energy dissipator structures has been installed to connect the LHS 48" corrugated metal pipe with the LBL 48" reinforced concrete pipe. The original 48" corrugated metal pipe in the LHS fill slope has been lined with a steel cylinder pipe from the first energy dissipator chamber to a point 25 feet above the elevation of that chamber. All inlets to the extensive underground drainage system in the North Fork watershed are adequate protected with bar grates. Inlet structures in the main stream channels are protected with primary screens located upstream from the inlets. This applies to both the LBL and the University drainage systems.

With the above-described improvements having been made since the October, 1962 storm, many potential hazzards have been greatly decreased or eliminated entirely. This is not to say that more improvements to channels and structures are not required. The open channels are still subject to both bed and bank erosion. It is still possible to have bed and float load carried down and to have inlet structures plugged. Hardening of channels with groins or check dams and the use of proper primary screens would go far to decrease the risk of future flooding.

EVALUATION OF RAINFALL AND RUNOFF

Data Reviewed

Studies and reviews have been made of storm drainage reports written for the University and for LBL, precipitation records in the forms of intensity-duration curves; hourly, daily, and seasonal rainfall records; precipitation depth-frequency tables, isohyetal maps of the San Francisco Bay Area and other pertinent data. (See Bibliography) No stream gauge data or official rainfall gauge data was available for the Strawberry watershed. The design criteria is therefore based on the analysis and evaluation of the published reports and weather records for the general area.

Analysis of the October, 1962, Storm

A comparison of maximum storms of record in the Bay Area indicated that the storm of October 11, 12, and 13, 1962, was the most severe storm ever recorded for

the Oakland-Berkeley-Orinda area. The maximum rainfall intensity measured at the Orinda Filter Plant was 1.75 inches per hour, with .80 inches occurring in 15 minutes at about 7:00 P.M., October 12. The daily total for October 12 was 6.49 inches. The daily total for October 13, was 8.32 inches, with a maximum hourly rate of 1.05 inches occurring about 1:00 P.M. The State of California Department of Water Resources Bulletin No. 195 Depth-Duration-Frequency table for the Orinda Filter Plant Weather Station indicates that an intensity of 8.11 inches per day statistically would recur in 200 years. Other authorities have rated this storm has being a fifty-or possibly a one-hundred year storm. The Oakland Tribune weather report of October 13, 1962, calls this storm "the heaviest in recorded history".

Isohytal maps published by the U.S. Army Corps of Engineers, the Alameda County Flood Control District, and the Contract Costa County Flood Control District (See Plate IX) indicate that the Strawberry watershed would normally receive rainfall in the order of 90% of that received at the Orinda Filter Plant. We have attempted to correlate this data using the rain gauage record from the Orinda Filter Plant and the LBL record from the "Henry Green Tipping Bucket" gauage located at Building 4. With data limited to three days, this correlation is, of course, not conclusive.

Total Daily Rainfall

Date	Orinda Filter	LBL	LBL % of Orinda Filter
Friday, 10/12/62	6.49	5.53	85%
Saturday, 10/13/62	8.32	(7.75)*	93%
Sunday, 10/14/62	.14	(.62)*	
Monday, 10/15/62	.00	8.37*	
Total	14.95	13.90	93%

*LBL rain gauge reading taken Monday morning and prorated for Saturday and Sunday as shown parenthetically.

The above tabulation has been included as a matter of interest, however, when we consider the "wringer effect" of the hills having a crest of 1700 feet elevation, we would not use a design intensity less than that for the Orinda Filter Plant area.

Design Criteria

We have used the Rational Method to calculate the rate of storm water runoff for each of the five sub-watersheds, and thus for the total Strawberry watershed under consideration.

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 runoff 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

EVALUATION OF RAINFALL AND RUNOFF (Contd.)

The rainfall intensity-duration curve developed and used as a basis of design for this report is a result of studies of all data available to us for this area, weighing their pertinence to the Oakland-Berkeley Hills, and factoring this data to relate to the known maximum intensities measured during the October, 1962, storm. We have used the Precipitation-Duration-Frequency-Depth curves developed by the Contra Costa County Flood Control and Water Conservation District. (See Plates VIII and IX) From this set of curves, we have selected the 100 year recurrence interval and mean seasonal precipitation of 40 inches. From the above data we have plotted the intensity-duration curve upon which our calculations are based. (See Plate VI)

Selecting a point on the intensity-duration curve requires that the time of of concentration T_c 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. We have assumed 10 minutes as the time for runoff to become established and have calculated that reasonable flow velocities are:

Stream flow velocity - 400'/min.
Pipe flow velocity - 800'/min.

Then T_c = 10 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 radius
n - Coefficient (King Handbook of Hydraulics)

Three of the main stream channels have been improved in selected areas by the construction of rock groins and/or check dams which tend to increase the time of concentration. Since we have not modified our Tc values to reflect this factor, our design basis therefore becomes more conservative.

We have selected "C" values higher than most handbook values for coefficient of runoff. 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:

a) almost all level areas are fully developed, that is roofed and/or paved, thus having a high percentage runoff.
b) 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.

We have used: C = .95 for developed areas (roofed or paved)
C = .60 for undeveloped areas

Tabulation of Calculations

Plate I, Map of the Strawberry Creek Watershed, which indicates the sub-watershed divisions, also shows the calculated peak flows within the culverts at the points of concentration.

An analysis of the devehoped areas, the proposed future development areas, and their percentages of each of the sub-watersheds and of the total watershed is shown on Plates II and III.

Peak flows derived from developed areas and natural areas within each sub-watershed are tabulated on Plate IV.

Incremental increases in peak flows which would be generated by the proposed future developments and the percentage increases are shown on Plate IV. The proposed future developments were taken from the LBL planning map called "Major Construction Projects--Institutional Plan, 1979".

In order to determine the adequacy of the existing individual culverts, the five separate sub-watersheds, each contributory to a particular culvert or portion of a culvert, have been analyzed and peak flows calculated separately. These peak flows and the capacities of the related culverts are shown on Plate V.

CONCLUSIONS

Performance of Existing Facilities:

We have given consideration to the extensive improvements that have been made since 1962 in the upper watersheds and to the stream channels of Chicken Creek and the North Fork; the installation of new culverts, energy dissipators, inlet structures; and the 1,500,000 cubic foot Retention Basin.

We have considered each sub-watershed separately along with its receiving culvert, and have calculated the peak runoff expected for each area and the flow capacity① of the receiving culverts. Plate V gives the results of this study.

Based on a storm of 100 year recurrence and using the intensity-duration curve for 40-inch total seasonal rainfall, we conclude that the existing drainage facilities are adequate to handle the peak 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 sufficiently to handle one-quarter of the peak flow. (See Plate VII)

b) That stream channels upstream from inlet structures are kept reasonably 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.

Impact of Proposed Future Developments

The proposed future LBL developments considered in this report are based on the "Major Construction Projects--Institutional Plan, 1979". The total additional impervious surface (roofs and paving) resulting from the developments is 1.91 acres. The detail breakdown of additional area in each watershed is shown on Plate III. The additional peak flow is due to the change in the coefficient of runoff from .60 to .95. This is 1.75 c.f.s. in the Upper Strawberry and 0.22 c.f.s. in the Chicken Creek watershed. The percentage increase in peak flow is 0.19% in the Upper Strawberry and 0.14% in the Chicken Creek watershed. This data is summarized on Plate IV.

It is safe to conclude that these small increments of increased peak flow will have negligible effect on the drainage facilities in the Strawberry Canyon watershed.

① Where culvert construction details were not available (such as the old Stadium Culvert), the capacity of that culvert has been estimated based on minimum size, minimum slope, and general configuration.

RECOMMENDATIONS AND DISCUSSIONS

Upper Strawberry Watershed

Centennial Drive is heavily used by the public as well as the LBL, the University's Botanical Gardens, Lawrence Hall of Science, and Space Science facilities. Since this road may be used as an evacuation route or for emergency vehicles, it seems prudent to avoid insofar as possible using the road as a flood channel.

We have concluded that the Retention Basin is not likely to fill and divert water down the North Canyon Road Bypass (Centennial Drive) providing that the hydraulically controlled gate is opened to pass one quarter of the peak flow, or about 225 c.f.s., and providing that the gate is not obstructed with bed and/or float load. (See Plate VII)

In the event that a major fire in this watershed is followed by a severe storm, the stage is again set for serious flooding. Erosion of the burned-over slopes would cause massive quantities of both bed and float load to move down and plug major inlet structures. Overtopping and serious downstream flooding similar to the 1962 event could happen.

The retention basin along with the North Canyon Road Bypass is designed to protect the Haas Recreation Area even though the slide gate may become completely plugged. We believe this flood diversion should be avoided if possible.

To provide better protection against the possible plugging of the retention basin slide gate, two improvements are recommended:

1. Construct a high-level overflow type inlet which will function even with the gate totally plugged and will progressively inlet water to the South Fork Bypass Culvert as the level rises in the retention basin. By proper design of the progressive inlet openings, the purpose and function of the retention basin can be maintained.
2. Construct upstream trash racks (called primary screens in this report) in all major stream channels where they do not now exist. Primary screens will afford considerable protection to culvert inlets by catching and holding both bed and float loads.

Regular clearing of the down timber and debris from channels, primary screens, and inlet grates each fall and after each major storm is not considered as a construction improvement but as an important maintenance function. It is one of our recommendations.

The hydraulically controlled slide gate at the retention basin 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.

Chicken Creek Watershed

The open channel above the Poultry Research Station and below Cyclotron Road

(a distance of about 1,000 feet) has been improved by the addition of rock and rubble installed in the form of check dams, groins, and channel hardening. In some areas, concrete was poured to bond the rubble into check dams, aprons, etc. This work was done by the University under a budget restriction and a bare minimum of work was accomplished. These additions have helped stabilize but it is generally recognized that this stream is still subject to channel cutting, bank sloughing and heavy erosion.

We recommend further hardening of this channel by the construction of rock dams to form small retention pools, flatten the profile and thus slow the erosion process. This is a general recommendation, with details of such a project being beyond the scope of this report.

One primary screen in the lower reaches of this channel is recommended.

North Fork Watershed

The two branches of the North Fork within the LBL area have primary screens protecting the inlets to culverts. There appears to be little or no danger of these two inlets being plugged. The one area that definitely needs attention is that of the inlets to the two City of Berkeley culverts at the head of LeConte Avenue. The stream channel and the inlets themselves are overgrown with vines, weeds and bushes. Moderate erosion in this channel releasing bed and float load could plug these inlets. We recommend that vines and debris be removed and the lower reaches of the channel be cleared of down wood.

General

Several of the inlets to major culverts are covered with bar grates. It is recognized that closely spaced bars can be easily plugged with either bed or float load. Some of these grates have been modified by removing every other bar. We recommend that all such structures in the total Strawberry watershed be examined for bar grate spacing and where grates have less than 10" to 12" clear opening, corrections be made to obtain say 12" minimum passage. There is never sufficient manpower available during severe storms to check and clear all inlet structures. This minor change to grates will save labor and do much to prevent local flooding.

PLATES BOUND IN REPORT

Plate I	Map of Strawberry Creek Watershed
Plate II	Development in Strawberry Watershed
Plate III	Proposed Future Additions
Plate IV	Peak Flows by Sub-Watersheds
Plate V	Peak Flows and Culvert Capacities
Plate VI	Intensity-Duration Curves
Plate VII	Flow Thru Submerged Gate
Plate VIII	Duration-Frequency-Depth Curves
Plate IX	Mean Seasonal Isohyets

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NORTH FORK

355 CFS

CHICKEN CREEK

STADIUM HILL

390 CFS

SOUTH FORK BYPASS

274 CFS

216 CFS

130 CFS

145 CFS

145 CFS

45 CFS

86 CFS

95 CFS

899 CFS

UPPER STRAWBERRY

PANORAMIC

RETENTION BASIN 1,500 000 CF

STADIUM CULVERT

MAP OF STRAWBERRY CREEK WATERSHED

LEGEND:

BOUNDARY OF WATERSHED

CREEK

PIPE

PLATE I

DEVELOPMENT IN STRAWBERRY WATERSHED

Watershed Name	Total Area	PRESENT DEVELOPMENT (Areas in Acres) LBL Bldgs. & Pavement	% of Total	Univ. Bldgs. & Pavement	% of Total	Residential & Pavement	% of Total	Total Bldgs. & Pavement	% of Total	Natural Area	% of Total
SOUTH FORK Upper Strawberry	502	3.6	0.7	2.9	0.6	3.6	0.7	10.2	2.0	491.8	98.0
Chicken Creek	66	10.3	15.6	1.7	2.6	0.2	0.3	12.0	18.2	54.0	81.8
Panoramic	73	---	---	12.9	17.7	2.5	3.4	15.4	21.1	57.6	78.9
Stadium Hill	92	7.4	8.0	3.8	4.1	0.4	0.4	11.6	12.6	80.4	87.4
Total - South Fork	733	21.3	2.9	21.3	2.91	6.7	.91	49.2	6.7	683.8	93.3
NORTH FORK	141	25.6	18.2	6.5	4.6	8.0	5.7	40.2	28.5	100.8	71.5

PLATE II

PROPOSED FUTURE ADDITIONS - based on Major Construction Projects-Institutional Plan - 1979

Watershed Name	Total Area Acres	Total Existing Bldgs. & Pavement	% of Total Area	Total Proposed Bldgs. & Pavement	% of Total Area	Total Existing & Proposed Bldgs.	% of Total Area
Upper Strawberry	502	10.2	2.0	1.7 (Note 1)	0.33	11.9	2.37
Chicken Creek	66	12.0	18.2	0.21 (Note 2)	0.32	12.21	18.5
North Fork	141	40.2	28.50	-- (Note 3)	--	40.2	28.50
Panoramic	73	15.4	21.1	--	--	15.4	21.1
Stadium Hill	92	11.6	12.6	--	--	11.6	12.6
TOTAL	874	89.4	10.2	1.91	0.2	91.31	10.44

LBL - Major Construction Projects - Institutional Plan - 1979

Note 1 - Upper Strawberry Watershed

	Acre
Chemical & Materials Science	.32
Parking Lot (Vicinity Bldg. 62)	.24
Biomedical Lab (74 Add'n.)	.22
Cell Culture Lab II) Biomedical Lab II) Other (Bldg. 83 area))	.46
Total	1.70

Note 2 - Chicken Creek Watershed

	Acre
Safety, Supply & Mat'ls. (Corp. Yard Area)	None
Chemical & Mat'ls. Science (Vicinity Bldg. 72)	.09
Parking Lot	.12
Total	.21

Note 3 - North Fork Watershed

	Acre
Energy Research Lab I) Energy Research Lab II) Support Services Bldg.) ("Old Town" Area)	No increase in impervious surface area

PLATE III

PEAK FLOWS BY SUB-WATI				PROPOSED ADDITIONS		
Watershed Name	Contributory To	Total Area Acres	pd	Additional Development Q_5	% increase $Q_5 \div Q_3$	Additional impervious Area, acres
Upper Strawbery	60" RCP Culvert at Retention Basin	502		1.75	0.19	1.7
Chicken Creek	54" RCP Culvert at Poultry Research Station	66		0.22	0.14	0.21
Chicken Creek	72" RCP South Fork Bypass Culvert	66		--	--	--
Panoramic	Old Stadium Culvert	73		--	--	--
adium Hill	South Fork Bypass Culvert	92		--	--	--
North Fork	60" RCP City Culvert at upper LeConte Avenue	141		--	--	--

Note 1: Use Tc of Upper Stra

$Q_5 = (C_1 - C_2)\ i\ A$

$(.95 - .60) \times 2.95 \times 1.7 = 1.75$

$(.95 - .60) \times 2.95 \times 0.21 = 0.22$

PLATE IV

PEAK FLOWS AND CULVERT CAPACITIES

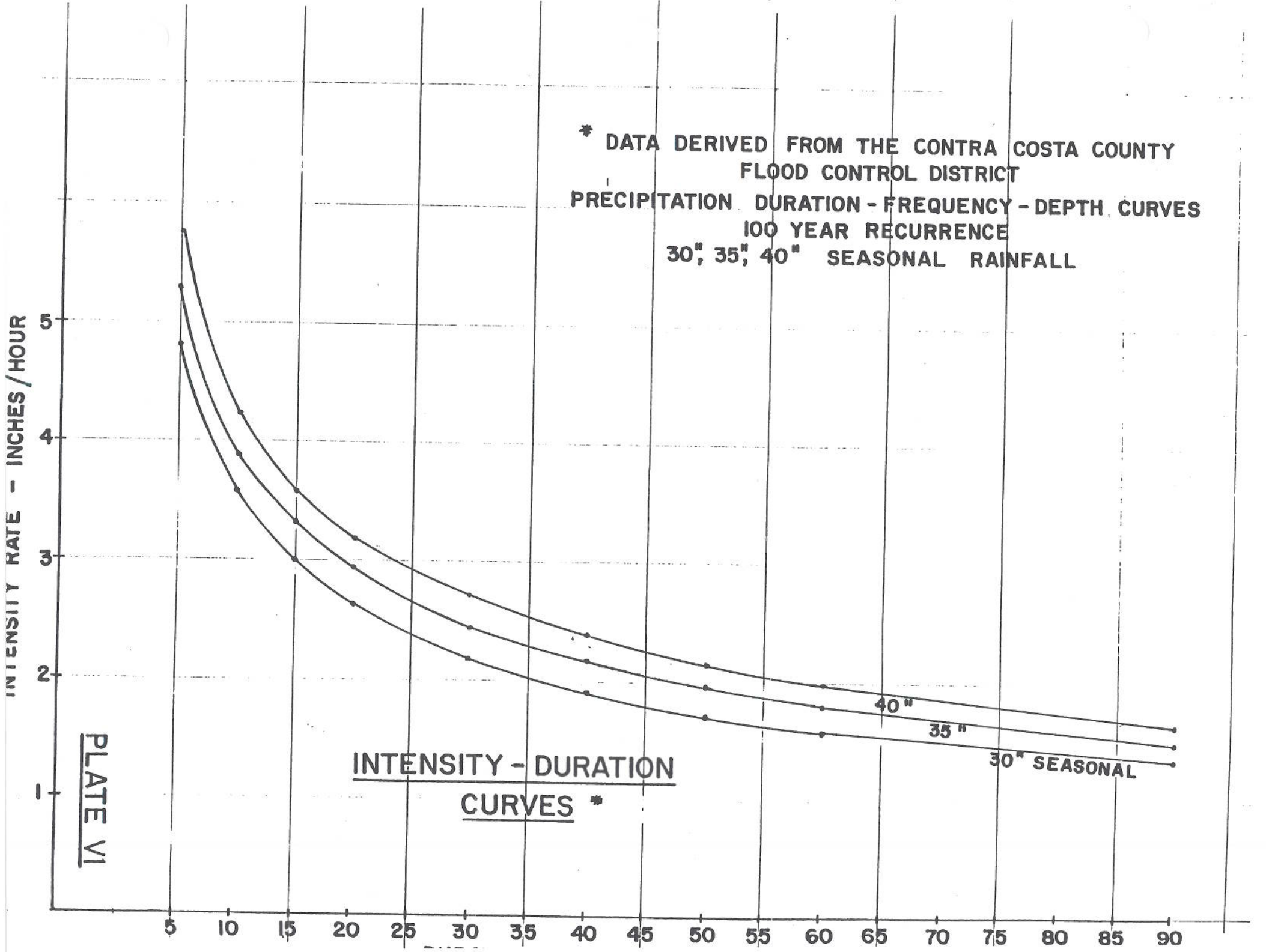
Watershed	Contributory to Culvert at Point Noted	Total Area Acres	PEAK FLOWS in cubic feet per second					CULVERT CAPACITY	
			From Watershed	South Fork Bypass Culvert Retention Basin Gate Opening 9"	24"	42" ①	Other Culverts	Q	Limiting Conditions
SOUTH FORK Upper Strawberry	60" South Fork Bypass Culvert at Retention Basin	502	899	86	230	404		404	48" x 42" slide gate
Chicken Creek	54" RCP Culvert at Poultry Research Station	66	158					500	54" RCP, slope .06
Chicken Creek	72" RCP South Fork Bypass at Junction with 54" RCP	66	130	216	360	534		500	72" RCP, slope .015
Stadium Hill	South Fork Bypass Culvert at Rimway & N.C. Road	92	174	274 (58+216) ②	418 (58+360)	592 (58+534)		600	66" RCP, slope .035
Stadium Hill	South Fork Bypass Culvert below Stadium	92	174	390 (116+274) ③	534 (116+418)	708 (116+592)		600	66" RCP, slope .035
Panoramic	36" RCP Stadium Culvert at Inlet Basin	73	145	--	--	--	45	75	36" RCP, slope .015
Panoramic	Stadium Culvert below Stadium	73	145				145	180	Equivalent to 42" RCP w/slope .04
NORTH FORK	60" RCP City of Berkeley Culvert at LeConte Ave.	141	355				355	475	60" RCP, slope .037

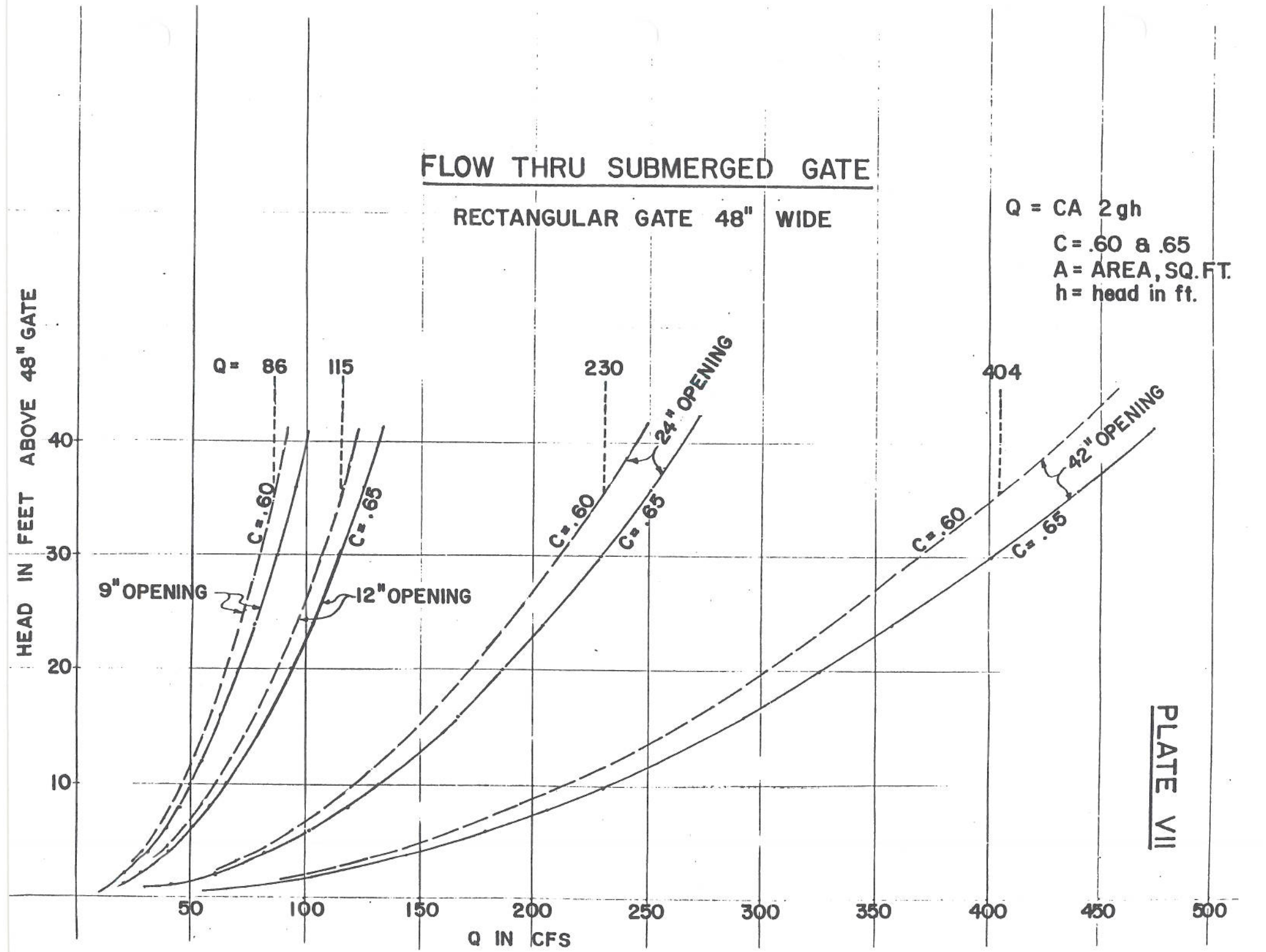
① These flow rates will occur only after retention basin has filled to overflow level thereby imposing a 36 feet static head on the slide gate.

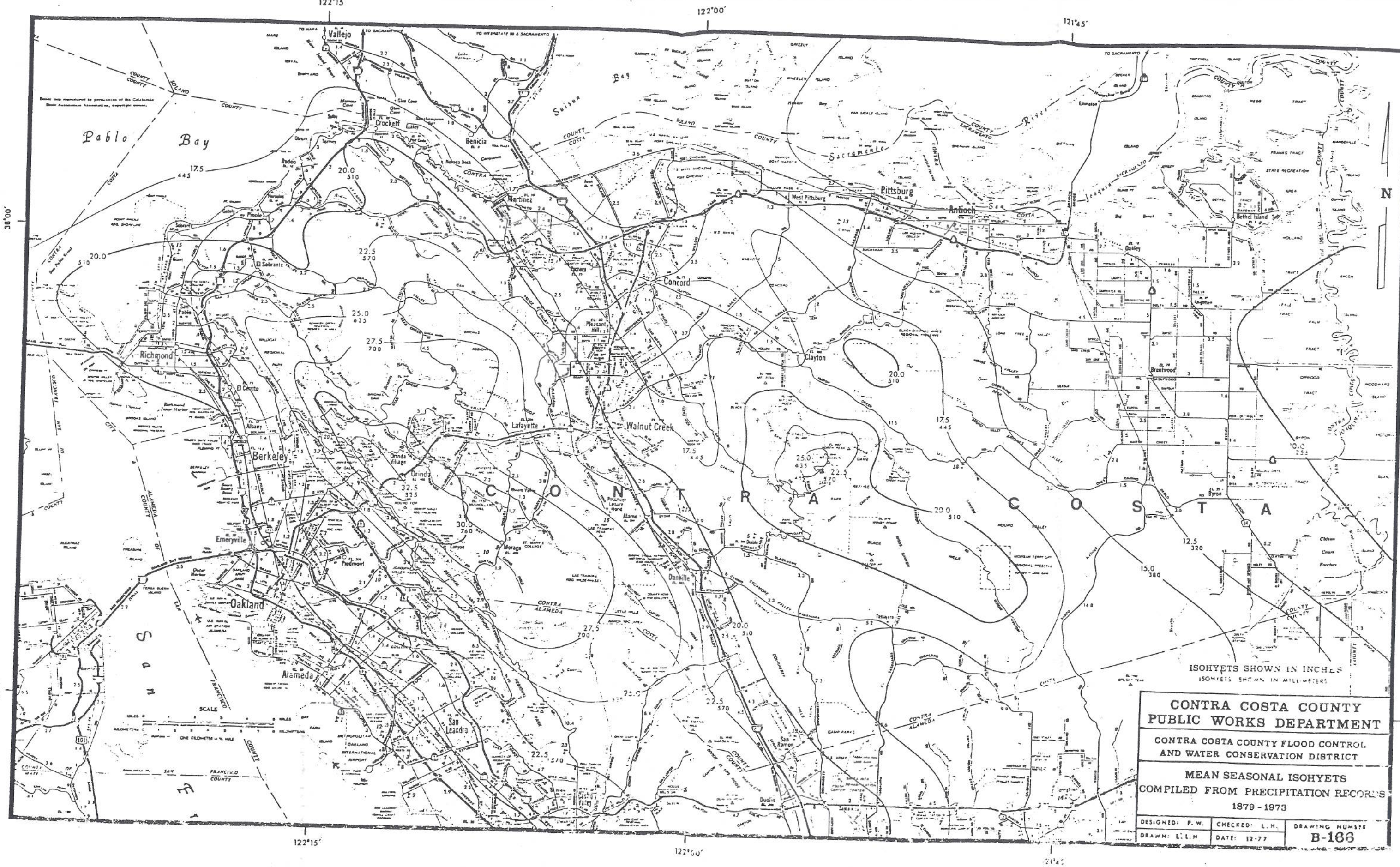
② 58 cfs is 1/3 of 174

③ 116 cfs is 2/3 of 174

PLATE V


* DATA DERIVED FROM THE CONTRA COSTA COUNTY FLOOD CONTROL DISTRICT
PRECIPITATION DURATION - FREQUENCY - DEPTH CURVES
100 YEAR RECURRENCE
30", 35", 40" SEASONAL RAINFALL
INTENSITY RATE - INCHES / HOUR
1
2
3
4
5
40"
35"
30" SEASONAL
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
INTENSITY - DURATION CURVES *
PLATE VI


FLOW THRU SUBMERGED GATE
RECTANGULAR GATE 48" WIDE
Q = CA 2gh
C = .60 & .65
A = AREA, SQ. FT.
h = head in ft.
HEAD IN FEET ABOVE 48" GATE
Q IN CFS
Q= 86
115
230
404
C=.60
C=.65
9" OPENING
12" OPENING
24" OPENING
42" OPENING
10
20
30
40
50
100
150
200
250
300
350
400
450
500
PLATE VII



CONTRA COSTA COUNTY PUBLIC WORKS DEPARTMENT

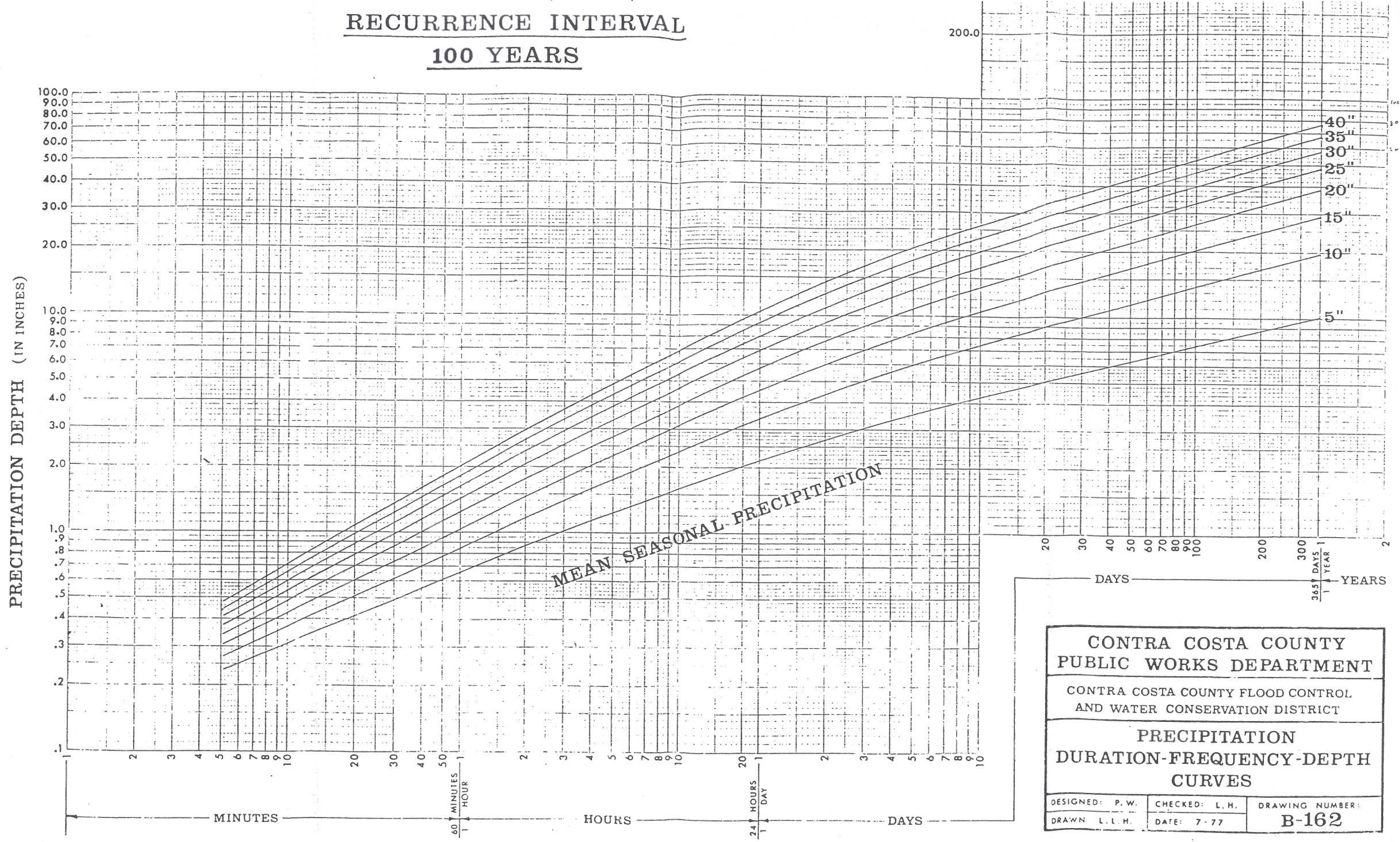
CONTRA COSTA COUNTY FLOOD CONTROL AND WATER CONSERVATION DISTRICT

MEAN SEASONAL ISOHYETS COMPILED FROM PRECIPITATION RECORDS 1879 - 1973

DESIGNED: P.W.	CHECKED: L.H.	DRAWING NUMBER
DRAWN: L.L.H.	DATE: 12-77	B-166

PLATE IX

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 VIII

CALCULATIONS
STORM DRAINAGE STUDY
STRAWBERRY CREEK WATERSHED

FOR
UNIVERSITY OF CALIFORNIA
LAWRENCE BERKELEY LABORATORY

BY
G.T. KUNTZ
CONSULTING ENGINEER
655 MONTAGUE AVE.
SAN LEANDRO, CA.

SUMMARY SHEET

(A)

AREAS WITHIN SOUTH FORK STRAWBERRY WATERSHED

	Sq. Ft.	Acres
Strawberry Watershed to Gayley Road	31,929,050	733.00
LBL Buildings	306,400	7.03
LBL Paved Parking Lots	371,700	8.53
LBL Roads	268,700	6.17
		(21.73)
UNIV. Buildings	504,790	11.59
UNIV. Paved Parking Lots	164,100	3.77
UNIV. Roads + Grizzly Peak Blvd.	367200	8.43
		(23.79)
PRIVATE RESIDENCES (including paving and Roadway)	115,000	2.54
All existing bldgs. plus parking & roads	2093,890 S.F.	48.06

Proposed Additions based on Institutional Plan April 1979

(See next sheet) for list

Total Bldg's	55,100	1.26 Ac
Total Parking	55,000	1.26 Ac.

(B)

STRAWBERRY WATERSHED

Proposed Additions based on institutinal plan, April, 1973

	Vicinity of	Bldg Area	Parking Area
Chemical & Materials Science	62/72	16,000	15,000
Biomedical	74	9,000	20,000
Cell Culture II	83	4,500	
Biomedical	83	16,000	20,000
Other	83	9,600	
Safety, Supply & Materials Handling	75	No change in impervious area	
	CHICKEN CREEK Watershed		
		55,100	55,000 S..
		1.26 Ac.	1.26 Ac

Area Strawberry Watershed to Gayley Road (1)

Area N°		Calc.	Area S.F.
1	△	1080 × 610 × ½ =	329,400
2	△	550 × 120 × ½ =	33 000
3	△	1230 × 170 × ½ =	104 550
4	▭	1870 × 90 =	168 300
5	△	650 × 170 × ½ =	55 250
6	△	1300 × 260 × ½ =	169 000
7	△	1370 × 160 × ½ =	109,600
8	△	720 × 290 × ½ =	104,400
1	▱	560 × 290 × ½ 520 × 350 × ½ }	172,200
10	△	410 × 260 × ½ =	53,300
11	△	1480 × 410 × ½ =	303 400
12	△	600 × 300 × ½ =	90,000
13	△	890 × 190 × ½ =	84 550
14	△	800 × 130 × ½ =	52 000
15	△	960 × 600 × ½ =	288,000
16	△	500 × 130 × ½ =	32 500
17	▱	1110 × 300 × ½ 780 × 140 × ½ } =	221,100
18	△	1200 × 470 × ½ =	282,000

N°		Calc	Area S.F
19	△	1110 × 380 × ½ =	210 900
20	odd	1.5 × 40,000	60,000
21	△	460 × 90 × ½ =	20,700
22	△	1830 × 90 × ½ =	82 350
23	▱	½ (2120 + 1170) × 760 =	1,250 000
24	△	400 × 90 × ½ =	18 000
25	△	1070 × 150 × ½ =	80 250
26	△	1100 × 870 × ½ =	478 500
27	△	350 × 160 × ½ =	28,000
28	△	840 × 400 × ½ =	168 000
29	odd	2.3 × 40,000	92 000
30	odd	1.85 × 40,000	74,000
31	▭	620 × 1000	620 000
32	▭	3930 × 3920	15,405,000
33	△	3720 × 1370 × ½ =	2,548.200
34	▭	2970 × 1060 =	3,148,200
35	▭	3420 × 1040 =	3,556,800
36	▭	1940 × 740 =	1 435,600

Area Strawberry Watershed 732.97 Ac

(2)

	AREA Sq. ft.	Acre		Nº Sq Ft.	Acre
1	329,400	7.56	19	210,900	4.84
2	33,000	.75	20	60,000	1,38
3	104,550	2.40	21	20,700	.47
4	168,300	3.86	22	82,350	1,89
5	55,250	1.27	23	1,250,000	28.70
6	169,000	3.88	24	18,000	.41
7	109,600	2.52	25	80,250	1,84
8	104,400	2.40	26	478,500	10.98
9	172,200	3.95	27	28,000	.64
10	53,300	1.22	28	168,000	3.86
11	303,400	6.96	29	92,000	2,11
12	90,000	2.06	30	74,000	1.70
13	84,550	1.94	31	620,000	14.23
14	52,000	1.19	32	15,405,000	353.65
15	288,000	6.61	33	2,548,200	58.50
16	32,500	.75	34	3,148,200	72.27
7	221,100	5.07	35	3,556,800	81.65
18	282,000	6.47	36	1,435,600	32.96
	2,652,550	60.89		29,276,500	672.08

AREAS - SQ. FT.

Excluding Roads (3)
Paved Areas around Bldgs including driveways and parking lots.

LBL BLOGS

10	180 x 60	10 800
70A		18 000
54	150 x 60	9 000
29	40 x 120	4 800
10	100 x 100 40 x 30	11 200
6	.9 x 40,000	36 000
37	30 x 40	1 200
14	100 x 40	4 000
4	90 x 55	4 950
5	40 x 60	2 400
45	40 x 40	1 600
15	70 x 30	2 100
25	200 x 100	20 000
25A	120 x 45	5 400
26	50 x 75	3 750
B-1	20 x 35	700
76	240 x 80	19 200
78	25 x 200	5 000
75	50 x 130	6 500
Carried Fwd.		166 600

LBL

Total A.	- Bldg. Area	= Paving Area
—	40 x 60 60 x 30	4,200
—	20 x 100 40 x 40	3,600
—		1,000
24,000	- 11,200	= 12,800
56,000	- 36,000	= 20,000
3200	- 1,200	= 2,000
—	20 x 100	= 2,000
w/Roads		
w/Roads		
16,000	—	16,000
with 45		
52,000	- 25,400	= 26,600
w/25		
w/25		
12,000	- 700	= 11,300
—		= 28,000
with 76		
80,000	- 6,500	= 73,000
Carried Fwd.		199,500

LBL BLDGS

B75B	70 x 60	4	200	w/75		—
69	60 x 220 50 x 30	14	700	w 75		—
79	50 x 80	4	000	w/77		—
77	100 x 430 240 x 50	55	000	140,000	- 59,000 =	81,000
72	70 x 50 20 x 80	4	100	—		12,000
62	100 x 150 90 x 60 50 x 30	21	900	—		28,000
73	100 x 35 40 x 50	5	500	—		2,000
73A	70 x 20	1	400	—		—
74 & 74B	70 x 60 150 x 60 100 x 70	20	200			28,000
83	100 x 60 30 x 40	7	200			1,200
41	40 x 20		800	—		—
42	40 x 20		800	—		—

LBL PARKING LOTS (+)

Blackberry Lot	8,000
Horse Shoe Lot	12 000
	172,200

	139 800
Page 3	166 600
	199,500
Total LBL Bldgs.	306 400
Total LBL Parking Lots	371,700

PROPOSED

71 Proposed	9,000
62 Proposed	14,000
72 Proposed	4,000

Proposed Lot A	10,000
Proposed Lot B	10,000
Proposed Lot C	10,000
Proposed Lot D	5,400

AREAS in SQ. FT.

LBL Roads (Parking not included)

	Lgt.	×	width	Area
yclotron Road	5600		24'	134,400
Hearst Ave	500	×	35'	17,500
Near Bldg 10	400	×	24	9 600
15 to 75	1200	×	24	28, 800
4 & 5	600	×	24	14,400
25 to 76	400	×	24	9600
W. Tank Site 1	200	×	20	4000
69	250	×	24.	6,000
72	300	×	20	6 000
77 to 72	400	×	24	9,600
62	1200.	×	20	24,000
74	200	×	24	4 800
				268,700

University Roads

Rimway Drive	2200'	×	24	52, 800	
Centennial Drive	6600	×	24	158, 400	4.84 Ac
* Grizzly Peak Blvd	6000	×	26	156, 000	3.58 A
				367, 200	8.43 A

* Public Road

AREAS in Sq. Ft.

UNIV. BLDGS

Gas Clubhouse	150 x 50 40 x 30	8,700
Poultry Research	50 x 50	2,500
Acid House	50 x 50 20 x 60	3,700
Botanical Garden		
	100 x 30	3,000
	30 x 30	900
	3 (15 x 50)	1,350
	30 x 60	1,800
	30 x 60	1,800
	50 x 50	2,500
	15 x 30	450
	25 x 50	1 250
	70 x 30	2,100
	30 x 30	900
	15 x 30	450
	Sub total	(16,500)
Animal Behavior Complex		
	70 x 40	2,800
	5 (30 x 30)	4,500
	50 x 20	1,000
	50 x 15	750
	2 (60 x 30)	3,600
	80 x 40	3200
	100 x 30	3000
	3 (90 x 20)	5400
	50 x 30	1500
	Sub total	(25,750)
Sq. Total this sheet		57,150

PARKING ETC

90 x 270 50 x 240 * 150 x 240	72,300
.1 x 40,000	4,000
.1 x 40,000	4,000
25 x 40,000 20 x 60	11,200
	91,500

* Tennis

UNIV BLDGS (continued)			PARKING	
Kleeburger Field			40 x 470 90 x 220	38,600
Bowles Hall	40 x 220 40 x 100 40 x 40	14,400		—
Stern Hall	50 x 200 30 x 220 40 x 70 40 x 70	22,200	.6 x 40,000	24,000
Greek Theater	200 x 40	8,000		—
Stadium		395,840		
Lawrence Hall of Science	60 x 120	7,200	250 x 40	= 10,000
Total, this sheet		447,640		72,600
Brought Fwd. (Sheet 6)		57,150		91,500
TOTAL UNIV.		504,790	TOTAL	164,100

Strawberry Watershed to Gayley Road 733 Ac.

	Ac.			%	
LBL Bldgs	7.03	÷ 733.	=	.903	21.04+
LBL Parking	8.53	÷ 733.	=	1.125	20.20
LBL Roads	6.17	÷ 733	=	.84	5.64+
LBL Total	21.73	÷ 733	=	2.87	Total 46.88 Ac
Univ. Bldgs	11.59	÷ 733	=	1.58	%
Univ. Parking	3.77	÷ 733	=	.51	Total 46.88 ÷ 733 = 6.3%
Univ Roads	4.84	÷ 733	=	.65	Development
	20.20	÷ 733	=	2.74	
Public Roads pan.	.83				Total proposed new
Public Road Grizzly	3.58	÷ 733	=	.48	development (Sheet B)
Private Residences	2.06	÷ 733	=	.28	
	6.46	÷ 733	=	.88	2.52 Ac / 733 = .34%

AREAS

PRIVATE RESIDENCES

Average roof area
plus paving 2,500

30 homes x 2,500 = 75,000 S.F.
1800' Road x 20 = 36,000 S.F

Total 111,000 S.F. = 2.54 Ac

Volume of Retension Basin (Revised Check)

Contour	Vert. Distance	Area	Volume
594	4	82,000	328,000
590	10	62 000	620,000
580	10	33,000	330,000
570	10	12,000	120,000

1,398,000 Cu Ft.

Area Stadium inside conc wall

40 scale 1" sq = 40' x 40' = 1600 Sq. ft. 1.0 = 1600 ft²

23.75 x 1600 = 38,000 End
23.75 x 1600 = 38000 End
120 x 168 = 32 160 Center

108,160 Sq Ft. = 2.48 Acre

Calculate watershed below Chicken Creek & Univ Tank – Panoramic Hill
Deduct from 733 acre total watershed

Deduct:

		Sq Ft.	Acres
Area 18 ✓		282 000	
19 ✓		219 900	
20 ✓		60 000	
21 ✓		20 700	
22 ✓		82 350	
23 ✓		1,250 000	
24 ✓		18 000	
25 ✓		80 250	
26 ✓		478 500	
27 ✓		28 000	
28 ✓		168 000	
36 ✓		1 435 600	
Rectangle Part of 35 ✓	1040 x 1420 =	1,476,000	
Odd balance of 35 ✓	13.2 x 40,000 =	528,000	
Odd portion of 34	27.0 x 40,000 =	1 080,000	Revised 1-24-80
		7,207,300	165. Ac

Watershed CHICKEN CREEK & U. STRAWBERRY

733 - 165 = 568 a

UPPER STRAWBERRY 568 - 66 = 502 Ac

2 Watersheds Below Chicken Creek called "PANORAMIC & STADIUM HILL"

Total Area 165 Acres

Calculate PANORAMIC only:

Odd area below Ridge line	27.	x 40,000	= 1,080,000
Area 18			282,000
19			219,900
20			60,000
21			20,700
Odd area @ Strawberry F.	24.0	x 40,000	960,000
Odd area @ Stadium	13,3	x 40,000	532,000
			3,154,600 = 73

To CLOSE calculate STADIUM HILL

Partial Rectangle			
36	1320 x 740 =		976800
23			1250,000
Less	-1.9 x 40000		[76,000]
24			18,000
25			80,000
26			478,500
27			28,000
28			168,000
		Sub Total	2922500
Add 35	26,3 x 40,000		1.052,000
			3974500

92. Ac

TOTAL BOTH 165 Ac

Calculate CHICKEN CREEK (plan.)

26.6	x 40,000			
27.6	x			
7.3	x			
10.4	x			
71.9	x 40,000	=	2,876,000	66 Ac.

Summary Of all Watersheds

UPPER STRAWBERRY	502	Acres.
CHICKEN CREEK	66	
PANORAMIC	73	
STADIUM HILL	92	
TOTAL - SOUTH FORK	733.	
NORTH FORK	140	

SUMMARY SHEET

AREAS WITHIN NORTH FORK STRAWBERRY WATERSHED

	Sq. Ft.	Acres
North Fork Watershed	6,152,300	141
LBL Buildings	429,075	9.85
LBL Paved Parking Lots	444,800	10.21
LBL Roads	242,000	5.55
		(25.61)
UNIV. Buildings	84,000	1.93
UNIV. Paved Parking Lots	100,000	2.3
Univ. Roads	99,600	2.29
		6.52
PRIVATE RESIDENCES	175,000	4.02
PUBLIC ROADS	176,000	4.04
All existing buildings, plus parking lots & roads	1,750,475	40.19

Additional Development based on LBL Institutional Plan FY'79 - FY'85 dated April 1979

	Vicinity of	
Energy Research Lab I	27	No increase in impervious surfaces.
Energy Research Lab II	7	
Support Services Bldg.	5	

Area North Fork Watershed (Blackberry)

From Lennert Sheet 4 — 140 Acres
From RE Layton Exhibit "A" — 140 Acres

Recheck by Sectional Areas

Area No°		Calculation	Sq Ft	Acre
(1)	odd	4.1 x 40,000	164,000	
(2)	▭	1130 x 660	745,800	
(3)	odd	2.4 x 40,000	96,000	
(4)	△	2750 x 800 x ½	1,100,000	
(5)	△	2100 x 700 x ½	735,000	
(6)	▭	800 x 2100	1,680,000	
(7)	odd	3.2 x 40,000	128,000	
(8)	△	1700 x 1270 x ½	1,079,500	
(9)	odd	8. x 40,000	320,000	
(10)	odd	2.6 x 40,000	104,000	
			6,152,300	141 Ac

NORTH FORK WATERSHED

(3)

BL BLDGS

Bldg Number		Area
88	.7 x 40m	28,000
90	270 x 100	27,000
65	70 x 30	2,100
55	190 x 60 100 x 30	14,400
64	50 x 300	15,000
51B	250 x 140	35 000
51	2.3 x 40m	92,000
~	.5 x 40m	20,000
50A	150 x 50 55 x 100	13,000
50B	150 x 50 75 x 100	15,000
70	.3 x 40m	12,000
46	400 x 75	30,000
47	70 x 40	2,800
58	.25 x 40m	10,000
46A	120 x 40'	4,800
'	1.0 x 40m	40,000
71A	80 x 40	3,200
Carried Fwd.		364,300

LBL Paved Areas, Driveways Parking Lots Excluding Main Roads

Total A.	- Bldg Area	=	Paved A
			8,000 20,000
			48,000
			20,000
260,000	- 55 64 51 51B 156,400	=	103,600
			20,000
with 50A			
64,000	- 46 46A 34,800	=	29,200
			16,000
72,000	- 71 40,000	=	32,000
Carried Fwd.			296,800

BLDGS. - LDL. PAVING

No		Area
1	50 x 20	1,000
17	50 x 50	2,500
27	50 x 70	3,500
53	50 x 80	4,000
7	150 x 90	13,500
9	70 x 90	6,300
12	50 x 80	4,000
80	110 x 75	8,250
52	100 x 50	5,000
-	.25 x 40m	10,000
5	80 x 40	3,200
44	15 x 35	525
Misc.	40 x 60	2,400
	30 x 20	600
		64,775
Brought Fwd.		364,300
TOTAL		429,075
		9.85 Ac

Total A - Bldg A =	Paved Area
Area of 7-17-52	68,000
	12,000
Blackberry Lot	44,000
Cafeteria Lot	24,000
	148,000
Brought Fwd.	296,800
TOTAL	444,800
	10.21 Ac.

LBL ROADS

Cyclotron Rd	28' × 2300'		64,400
88 Rd.	24' × 800'	=	19,200
50A - 70A Rd	24 × 500		12,000
Bev Cr. to 90	24' × 1200		28,800
90 to 71	24 × 1000		24,000
"Y" - 46 - 25A	24 1800		43.200
29 - 58 - 46	12 800		9,600
29 - 80	12 600		7,200
71 Back Rd	12 × 800		9,600
Blackberry Rd	24 × 1000		24,000
			242 000

5.55 Acre

NORTH FORK STRAWBERRY

UNIV. BLDGS.

LHS	1.8 x 40m	72,000
Space Science	50' x 200'	10,000
SS Trailers	(20 x 60) 2	2,400
		84,400

PARKING LOTS

20,000
44,000
36,000

100,000

UNIV. ROADS

Centennial Drive	30' x 2400'	=	72,000
LHS	24' x 400'	=	9,600
S.S.	30 x 600'	=	18,000
	TOTAL		99,600

PUBLIC ROADS

Grizzly Peak Blvd	30' x 2200'	=	66,000
Summit Rd	30 x 1000	=	30,000
Olympus + others	30 x 1600	=	48,000
Campus Dr	30 x 800	=	32,000
	TOTAL =		176,000

PRIVATE RESIDENCES

Average Area + Yard Paving 3500 ft² Ea

50 units x 3500 = 175,000 TOTAL

Jan 27, 1983

Paving & Bldgs in Upper Strawberry Watershed

LBL	s.f.	
Bldg 62	21,900	
" " parking	28,000	
Bldg 73	5,500	
parking	2,000	
Bldg 73A	1,400	
Bldgs 74 74B	20,200	
parking	28,000	
Bldg 83	7,200	
drive	1,200	
Roads 1800' x 24'	43,200	
	158,600	3.64 Ac.

UNIV.		
Acid House	3,700	
parking	4,000	
Bot. Garden	16,500	
parking	11,200	
Animal Behavior	25,000	
Univ. Roads 2600 x 24	62,400	
	127,800	2.93 Ac.

PUBLIC ROAD		
Grizzly Peak	156,000	3.58 Ac

Jan 24 '80

Paving & Buildings in Chicken Creek Watershed

LBL

	s.f.	
Bldg 72	4,100	
" " parking	12,000	
Bldg 62 parking lot	5,000	
Bldg 77	55,000	
" parking	81,000	
Bldg 79	4,000	
Bldg B-1	700	
parking	11,300	
Bldg 26	3,750	
Bldg 25	10,000	
parking	13,000	
Bldg 76	19,200	
78	5,000	
parking	28,000	
Bldg 75	6500	
B75B	4200	
pavement	73,000	
Bldg 69	14,700	
Roads 4000' x 24	96,000	
	446 450	10.25 Ac

UNIV.

Poultry Research	10,000	
Animal Behavior	4,000	
Road - Centennial Dr		
2000' x 24'	48,000	
300 x 40	12 000	
	74,000	1.7

PUBLIC ROADS

Grizzly 200 x 30' = 6,000 0.14

Jan 24, 20

Paving & Buildings in Panoramic Watershed

LBL None

UNIV.	s.f.	
Centennial Drive	19 200	
Stadium	395 840	
Kleeburger Paving	36 000	
Rimway Rd. 800 x 26	20 800	
Tennis Courts & parking	72 300	
Haas Clubhouse	8 700	
Pool paving & small bldgs	5 000	
Poultry Paving	4 000	
	561 800	= 12.89

Stadium:

Total Area − Grass Area = Conc. A.

12.6 x 40,000 − 108,160

504,000 − 108,160 = 395,840

= 9.08 Ac

PRIVATE HOMES PUBLIC ROADS		
Homes	75 000	
Roads 1800' x 20	36 000	
	111,000	= 2.54 Ac

Paving & Buildings in Stadium Hill watershed

LBL

Roads 3700 x 24	88,800	
		PUBLIC ROAD
		Hearst Ave 17,500
Horse Shoe Lot	12,000	
70	10 800	= .40 Ac.
70A 180 x 100	18,000	
Parking	4,200	
54	9,000	
parking	3,600	
29	4,800	
10	11,200	
parking	13,800	
6	36.000	
parking	20,000	
37	1,200	
paving	2.000	
14	4,000	
paving	2.000	
4	4,950	
5	2 400	
15	2 100	
45	1 600	
25	20,000	
25A	5,400	
paving 25 area	13,000	
paving 4, 14, 5 area	15,000	
paving 45-15 area	16,000	
	321,850	= 7.38 Ac

UNIV

Misc Paving & Sidewalks	10,000
Kleeburger Paving 350 x 40	14,000
Rimway Road 1500' x 24	36,000
Centennial Drive 1500 x 24	36 000
Bowles Hall	14,400
Greek Theater	8,000
Stern Hall	22,200
" " parking	24,000
	164,600 = 3.78 Ac

Strawberry Watershed above Chicken Creek

contributory to Retention Basin & 60" Stadium Bypass Culvert

Development of values for Rational Formula

T_c - Time of concentration

$$V = \sqrt{\frac{S \times 2.2082 \times r^{1/3}}{n^2}}$$

780
560
220

S = slope of stream bed
V = vel. of flow in stream
r = hyd radius $\left(\frac{a}{p}\right)$
n = coef. (King) page 267, 268.
= .035 n^2 = .0012

$$T_c = \frac{\text{distance}}{\text{vel. in ft./min}}$$

r = hyd. radius $\frac{a}{p}$

Assume  V ditch

a = 2 ft²
p = 4.46
$r = \frac{2}{4.46} = .45$

$r^{1/3} = .345$

S = slope - Hamilton Gulch .20

Strawberry Creek .20

$$V = \sqrt{\frac{.20 \times 2.2082 \times .345}{.0012}}$$ 126.2

= 11.26 '/sec. 11.26

= 676 '/min.

Chicken Creek Watershed (Lennertz Sheets 1 & 2)

Trial Analysis

110	Type	* Coef.	Area	Accumulation Time Surface flow	Channel Flow Time List	Vel.	Time
12	I	.80	10.95	Assume 10 min	600'	400'/min	1.5 min
13	II	.60	15.0				
26	I	.80	11.71				
27	I		7.67				
28	I		12.30				
29	I		5.49				
30	I		5.88				
31	II		8.38				
32	I		16.55				
33	I		3.65				
	Total		97.58				

Jan 20

Preliminary calculation of Tc for Chicken Creek

			Vel
Open channel	1000'	S = .24	400
24" CMP	1200'	S = .166	
(18" CMP	700'	S = .24)	Branch to LHS
Open channel	800	S = .30	
Surface flow	400'	S = .40	

Strawberry Watershed Ham - Gulch
5700 Creek dist to Top.

5700 x 400'/m	14.25 min
+ Accumulation	10
	25 min

North Fork Watershed 140 Acres

Calculation to determine Tc

Open Channel	700'	S = .15
39 & 36" RCP	1250'	S = .20
48" RCP	800'	S = .38 average.
42" RCP	800'	S = .125
24" RCP	200'	S = .10
18" RCP	500'	S = .03
Surface Flow	400	S = .20

Total Watershed	140 Ac
Total Bldgs, Roads, Parking Lots Includes LBL, Univ. and Private	40 Ac.
Balance of area is grassland, some trees, with average slope of .40	100 Ac

Rough Check Runoff Volumes

$Q = C\,i\,A$

Use Lennert Intensity Curve for 25 year storm

Time of Concentration:

1) North Fork to Highland 15 min.

(Layton assumes .80 C for LPL)

Lennert's Peak Flow Values (15 min)

Fig II

$Q = .8 \times 4.35 \times 140\,Ac = 487$ cfs

490 cfs

1). North Fork inlet above Highland
" Blackberry watershed 500 cfs.
140 Ac.
Toe of LHS Fill Slope 180 cfs

$Q = .8 \times 3.0 \times 97.58 = 234$ cfs
* 343 cfs

Chicken Creek @ 54" 400 cfs
Area 97.58 Ac

Fig II

$Q = .8 \times 2.3 \times 487 = 896$

585 - 98 = 487 ± ?

Retention Basin 30 min duration 10yr 525 cfs
Chicken Creek @ 54" 10yr 300
Old Stadium culvert 150 (925 tot
Input @ Basin (12" opening) 125 cfs

Old 48" Stadium Culvert 25yr 60 cfs

Fig II

$Q = .8 \times 3.0 \times 487 = 1169$ cfs

=

1795 cfs

Retention Basin 25yr (30 min)
full planned development → 1650 cfs

Entire watershed above Rec. Area 1795
full planned development

* Rod is from Lennert's Curves (Chart ...)

Retention Basin 1,500,000

Area watershed Chicken Creek and above - 585 a

$Q = C i A$

$A = 585$

Fig II $i = 3.0$ 30 min time conc. 25yr

$C = .80$ Layton - Lennert

$Q = .8 \times 3.0 \times 585$

$Q = 1404$ cfs.

Lennert's Curves CFS/Acre
Fig III & IV

Assume 30 min duration of Storm

Strawberry Watershed 733 Ac.

Runoff / Acre in cfs:		10yr Fig II		25yr Fig III	
Type I	Roofs / Pavement	2.25"		3.0"	
Type II	Grass lands	2.25	1.88	3.0"	2.45
Type III	Heavy Trees, Brush	1.50"		1.90"	

For check use entire watershed ½ Type II ½ Type III

10yr storm

Ave cfs

733a × 1.88 = 1388 Strawberry

25yr storm

Ave. cfs

733 a × 2.45 = (1795)

---

20 min duration 10yr storm

Avg. cfs

140a × 2.75" = 385

Figure II

North Fork paved & grassland

? 25yr storm

(Ave. 3.5") cfs

140a × = (490)

Figure III

Chicken Creek

98a × 3.5 = (343 cfs)

North Fork

Lennert Data
140 Acres (Layton)
15 min conc. time
500 cfs @ Le Conte inlet

$Q = C i A$

$Q = .8 \times 4.35 \times 140.$

$= 487. cfs.$

25yr storm, Upper Campus
Curves by Lennert

$i = 4.35$ inches/hr
$C = .80$ (Lennert's combined runoff coeff per Layton)

Note City San Leandro Standards:

Coef runoff "C" = Parks .2
Residential .5
Industrial-Commercial .8

T_c - Time of concentration: Time to flow from most remote point to point under consideration

i - Intensity with relation to Time of Conc.

Chabot Observatory	10yr storm	1" / hour	Duration 60 min
		1.25	30 min
		1.45	20 min
		2.20	10 min

Colma Studies Wilsey & Ham p 8

i is selected for a duration equal to the time of concentration. The peak discharge will equal the rate of rainfall falling reduced by "C" provided the duration of rain is sufficient for entire area to contribute

Rational Method $Q = C \cdot A$

∴ peak rate of runoff is direct function of average rainfall during the time of conc. to that point.

2.

3. Time of conc. is time reqd for runoff to be established and flow from the most remote part of area to point under consideration.

Area - subj to precise measurement (only one so)

Rainfall - intensity factors:
1 Frequency of occurrance
2 Intensity - duration chavactistics
3 Time of Concentration

Question: Relation of: time of concentration / duration of storm

see p 46 ASCE

Inlet time = overland flow time to point of inlet

Check Time of Concentration based on Lennart values:

(Surface Flow Vel.)	Class I (improved)	II (grass)	III (brush)
"n" =	.020	.075	.150
slope =	.05	.40	.40
surface flow vel. =	100 f/min.	75.	40.
Channel Flow Vel. "n" =	.02	.040	.040
slope =	.05	.25	.25
channel flow vel =	400 f./min	1200	1200

Hamilton Gulch

Time from most remote point of watershed

Surface flow — dist. 900'
Class III — velocity = 40 f/min = 22.5 minutes

Stream flow — dist 4000'
Class III — velocity = 1200 f/min = 3.33 minutes culvert vel

Lennerts velocity seems too high. Folder III See 1 p:

Slope of Hamilton Gulch:

	L	Rise	Slope	
	1000'	140'	.14	Average .20
	1000'	160'	.16	
Extreme upper	1000	300'	.30	

Lennert uses .25

Slope of Strawberry Creek

	L	Rise	Slope	
	1000'	140	.14	
	1000	160	.16	Average .20
	1000	210	.21	
Extreme upper	1000	300	.30	

Slope of Chicken Creek

L	Rise		
1000	240	.24	

Cap 54" culvert
slope .04 min
400 cfs @ .04
actual slope 6-8%
.06 .08

Areas from Lennerts Sheets 1 and 2

Chicken Creek Watershed

№	Type	Area	Accumulation Dist	Time		Channel Dist	Time		1/min
12	I	10.95	600'	6.00	100	2700 ←	6.75		400
13	II.	15.0	500 ←	6.67	75	2200 ←	5.50		400
27	I	7.67	300 ←	3.0	100	1730 ←	4.32		400
28	I	12.30	500	5.0	100	2650 ?	6.67		400
29	I	5.49	400	4.0	100	1550 ←	3.87		400
30	I	5.88	500	5.0	100	1650 ←	4.12		400
31	II	8.38	1100 ?	14.70	75	0 ←	0		
32	I	16.55	800	8.00	100	540	1.35		400
33	I	3.65	400	4.0	100	1100	2.75		400
26	I	11.71	400	4.00	100	1350	3.37		400
		97.58							

Attempt to Check Lennerts 400 cfs

Assume A = 97.58 25 year storm 30 min duration
C = .80 (Lennert & Layton) i = 3"/hour

Q = .8 × 3 × 97.58 = 234 cfs

Lennert includes #11 or 21 acres more

Then Q = .8 × 3 × (97.5 + 21) = 284 (118.5)

Use 20 min duration
then i = 3.7

Q = .8 × 3.7 × 118.5 = 350 cfs

30 min duration	i = 3	× 118.5 a =	355.5 cfs
20 min duration	i = 3.5	× 118.5 a =	414.7 cfs

Figure 11

11 cfs

Channel Calculations

King p 252 r, hyd radius $= \frac{a}{p}$ wetted perimeter

Bennert assumes "V" ditch 

, $r = \frac{a=2}{p=4.5} = .44$

$n = .04$

Manning formula $S = \frac{n^2 V^2}{2.2082\, r^{4/3}}$

$$V = \sqrt{\frac{S \times 2.2082\, r^{4/3}}{n^2}}$$

$S = .20$
$n = .040$

$$V = \sqrt{\frac{.2 \times 2.2082 \times .44^{4/3}}{.040^2}} \quad .335 \sqrt{\frac{0.1479}{.0016}} = \sqrt{92.46}$$

$V = 9.61$ ft. per sec

$9.61 \times 60 = 576$ ft./min

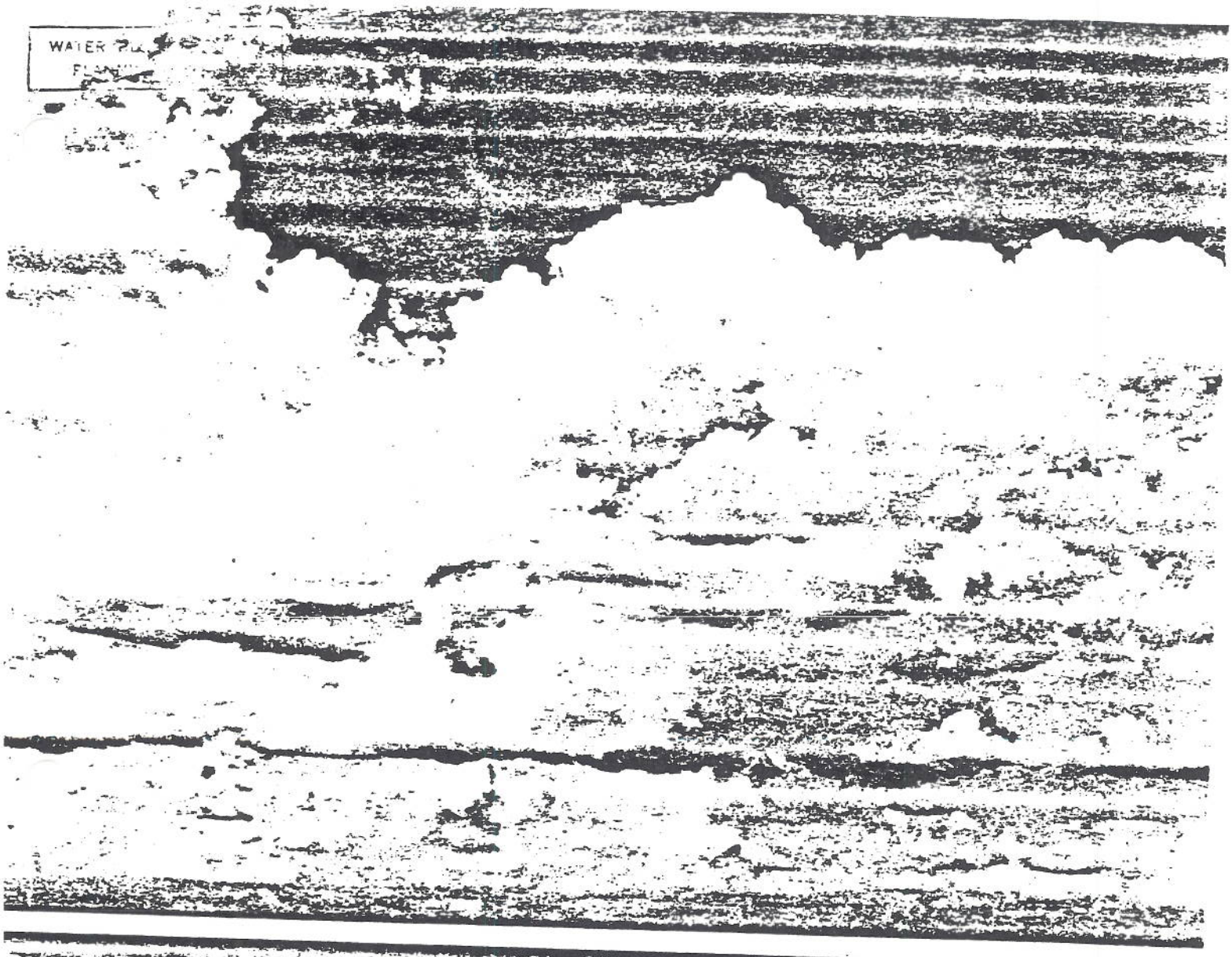
Strawberry Creek on Campus

$r = \frac{a}{p} = \frac{176}{40} = 4.4 \qquad r^{4/3} = 7.17$

$$V^2 = \frac{.027 \times 2.2082 \times 7.17}{.040^2 \quad (.0016)} = 267$$

$V =$ 16.34 ft/sec

$Q = Av = 176 \times 16.34 \quad 2875$ cfs.



State of California
The Resources Agency

Department of
Water Resources

Rainfall Analysis for Drainage Design

Volume II. Long-Duration Precipitation Frequency Data

Bulletin No. 195
October 1976

Note that the 18.19" in Oct 19 all came in FOUR day

See sheet (B)

SHEET (A)

EAST BAY MUNICIPAL UTILITY DISTRICT
PRECIPITATION RECORD
INCHES

YEAR ________

Water Resources Planning Division
Hydrographic Section

STATION: Orinda Filters COUNTY: Contra Costa STATE: Calif

ESTABLISHED: Feb. 1936 DISCONTINUED:

CLASS: U.S. Std. W.B. TIME USED: PST & PDST ELEV. FEET: 370 ±

LATITUDE: 37°53.58' LONGITUDE: 122°12.02' SECTION:

T: R: COORDINATES LAMBERT GRID SYSTEM: 511,600 N / 1,509,400 E

SEASON	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan	Feb.	Mar.	Apr.	May	June	SEASONAL	YEAR	ANNUAL
1955-56	0	0	.10	.02	2.78	20.86	8.15	5.49	.12	2.65	1.41	0	41.58	1955	35.34
1956-57*	0	0	.34	3.18	.05	.54	4.18	4.78	4.53	2.26	5.40	0	25.26	1956	21.93
1957-58	0	0	1.77	3.66	.98	4.74	8.22	11.32	9.50	4.09	.82	.19	50.29	1957	32.30
1958-59	.03	0	.05	.26	.30	1.62	5.57	7.22	.67	.58	.02	0	16.32	1958	41.40
1959-60	0	.01	2.97	0	0	2.06	6.33	5.25	3.80	1.34	1.77	0	23.53	1959	19.10
1960-61	0	0	0	.26	4.49	1.41	2.91	1.68	4.35	1.58	.80	0	17.48	1960	24.65
1961-62	0	.02	.33	.28	4.73	2.79	3.53	13.80	6.28	1.13	0	0	32.89	1961	19.47
1962-63	0	.16	.27	18.19	1.33	4.27	5.23	5.72	5.85	7.13	.52	.08	48.75	1962	48.96
1963-64	0	.02	.26	2.56	6.04	.65	6.49	.24	2.72	.47	1.05	.80	21.30	1963	34.06
1964-65	0	T	0	1.22	4.68	12.49	7.37	1.29	2.61	5.27	0	0	35.43	1964	30.66
1965-66	0	.04	T	.08	7.14	5.31	5.74	4.24	.79	1.14	.16	.08	24.62	1965	29.01
1966-67	.11	.25	.11	0	7.17	5.45	13.55	.48	7.97	7.79	.14	1.14	44.16	1966	25.24
1967-68	0	0	.02	.89	2.08	3.25	7.88	3.53	4.36	.56	.43	0	23.00	1967	37.31
1968-69	0	.58	T	1.07	3.34	6.56	13.63	9.86	2.93	3.05	0	.04	41.06	1968	28.31
1969-70	0	0	T	2.93	1.21	12.60	14.64	2.31	2.31	T	0	.47	36.47	1969	46.25
1970-71	0	0	0	1.01	9.24	11.17	2.79	.68	4.89	1.58	.07	0	31.33	1970	41.04
1971-72	0	0	.33	.07	1.80	5.74	2.13	3.94	.31	2.45	.07	.29	17.13	1971	17.95
1972-73	0	0	.91	4.08	7.87	3.70	13.88	7.11	3.86	.25	.04	0	41.70	1972	[illegible]
1973-74	0	0	1.13	2.20	11.03	6.87	4.48	2.58	10.52	4.92	.17	.03	43.95	1973	46.37
1974-75	1.28	0	0	1.09	1.94	3.15	1.66	8.95	7.59	3.76	.06	.08	29.56	1974	30.16

* P[illegible] July 1956 - Record [illegible]

[illegible]-C45 81

EAST BAY MUNIC UTILITY DISTRICT
DATA SHEE… …URLY RECORDS

Station ORINDA FILTERS
Data PRECIPITATION
SHEET (B)

OCT. 1962 — A.M. P.S.T. / P.M. P.S.T.

Date	1	2	3	4	5	6	7	8	9	10	11	Noon	1	2	3	4	5	6	7	8	9	10	11	Mid't	Sum	Mean	Date	
1																									0		1	
2																									0		2	
3																									0		3	
4																									0		4	
5																									0		5	
6																									0		6	
7																									0		7	
8						.02																			.02 *		8	
9																									0		9	
10									.05	.05	.05	.15	.45	.35	.05										1.15		10	
11	.73	.42	.45	.30	.20	.14	.05	.05	.03	.15	.02				.01				.01	.58	.75	.55	.65	.75	3.60		11	
12	.30	.25	.20	.25	.25	.30	.10									.27	.03	.20	(.75)	.65	.45	.25	.35	.20	6.45		12	5.53
13	.05	.03	.02	.01	.01	.01	.25	.25	.35	.60	.55	.75	(1.05)	.60	.45	.40	.33	.07	.20	.25	.10	.13	.42	.02	8.32		13	8.57
14							.01																		14		14	
15																									0		15	
16																									0		16	
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27																									0		27	
28																									0		28	
29																									0		29	
30																									0		30	
31																									0		31	
Sums	1.08	.70	.67	.56	.46	.47	.41	.30	.43	.80	.62	.90	1.50	.95	.51	.67	.36	.27	1.96	1.48	1.30	.93	1.42	.97	(19.72)		Sums	
Means																											Means	

* est. clock stopped

Note that 8.11 / day is considered a 200 year storm.

PRECIPITATION DEPTH-DURATION-FREQUENCY TABLE

STATION NO. BSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG	LOT	RGN	LATITUDE	LONGITUDE	COUNTY CODE
E40 6901 1	UKIAH FILTERS	378	33	01N	03W		N	39.093	122.200	07

MAXIMUM PRECIPITATION FOR INDICATED DURATION D-DAYS H-HOURS

RETURN PERIOD IN YEARS	10	20	30	40	50	60	80	100	150	200	300	600	3650
2	2.96	3.94	4.57	5.10	5.50	6.03	6.88	7.62	8.42	9.35	11.22	15.95	30.13
5	4.17	5.77	6.61	7.44	7.94	8.60	9.65	10.65	11.72	12.98	15.51	22.00	39.30
10	4.98	7.03	8.01	8.97	9.53	10.31	11.45	12.56	13.77	15.24	18.18	25.68	44.60
20	5.74	8.29	9.37	10.43	11.03	11.92	13.13	14.33	15.65	17.30	20.61	29.02	49.24
25	5.98	8.63	9.78	10.88	11.50	12.43	13.65	14.87	16.22	17.93	21.36	30.04	50.84
40	6.47	9.44	10.68	11.84	12.47	13.46	13.90	15.98	17.40	19.23	22.90	32.12	53.47
50	6.71	9.82	11.10	12.28	14.93	13.97	15.22	16.51	17.95	19.83	23.61	33.09	54.76
100	7.61	10.99	12.39	13.66	14.33	15.47	16.74	18.09	19.60	21.65	25.76	35.99	58.62
200	8.11	12.15	13.66	15.00	15.69	16.94	18.27	19.63	21.20	23.41	27.83	38.78	62.27
1000	9.69	14.88	16.56	18.07	18.79	20.24	21.55	23.05	24.75	27.32	32.45	44.96	70.20
10000	11.88	18.59	20.63	22.37	23.11	24.93	26.13	27.76	29.58	32.64	38.73	53.29	86.59
PMP	22.77	33.32	37.95	42.08	44.53	47.99	52.84	57.47	62.95	69.37	82.13	116.26	185.31
MEAN	3.232	4.472	5.094	5.728	6.099	6.616	7.390	8.157	8.995	9.932	11.912	16.825	30.988
CLOCK HR. COR.	1.140	1.070	1.040	1.020	1.010	1.010	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CALCULATED SKEW	1.617	2.249	2.968	2.338	2.077	1.748	1.468	.985	.807	.721	.445	.440	.333
REGIONAL SKEW	1.300	1.600	1.500	1.400	1.400	1.300	1.100	1.000	.900	.900	.900	.800	.500
SKEW USED	1.300	1.400	1.500	1.400	1.300	1.300	1.100	1.000	.900	.900	.900	.800	.500
KURTOSIS	6.496	10.429	15.393	10.643	8.639	7.031	5.473	3.708	3.200	2.662	2.139	2.353	2.110
N	35	35	35	31	31	31	31	35	31	31	35	31	35
RECORD YEAR	1963	1963	1963	1963	1963	1963	1963	1963	1963	1956	1956	1956	1956
RECORD MAXIMUM	6.620	12.470	17.110	18.888	18.198	18.198	18.198	18.198	18.468	18.880	22.488	29.068	58.298
NORMALIZED MAX	2.754	3.834	4.338	3.878	3.822	3.306	2.968	2.686	2.359	2.028	2.192	1.928	1.937
CALC. COEF. VAR	.381	.467	.544	.556	.567	.529	.492	.463	.456	.441	.485	.379	.322
REGN. COEF. VAR	.403	.438	.438	.423	.428	.417	.410	.403	.402	.399	.393	.394	.332
USED COEF. VAR	.403	.438	.438	.423	.428	.417	.410	.403	.402	.399	.393	.394	.332
MEAN/A	.1043	.1443	.1644	.1849	.1968	.2135	.2385	.2632	.2899	.3205	.3844	.5430	1.0000
RP10/A	.1806	.2268	.2586	.2896	.3075	.3327	.3896	.4056	.4445	.4917	.5867	.8289	1.4393
RP25/A	.1929	.2788	.3168	.3512	.3711	.4011	.4404	.4799	.5235	.5786	.6893	.9693	1.6342
RP50/A	.2164	.3168	.3583	.3964	.4173	.4508	.4912	.5324	.5792	.6400	.7618	1.0677	1.7672
RP100/A	.2393	.3546	.3998	.4407	.4624	.4993	.5402	.5839	.6325	.6947	.8312	1.1614	1.8917
RP1000/A	.3128	.4778	.5343	.5833	.6065	.6564	.6994	.7439	.7987	.8817	1.0673	1.4510	2.2652
RP10000/A	.3834	.5985	.6657	.7218	.7457	.8048	.8432	.8952	.9545	1.0531	1.2499	1.7198	2.6007
PMP/A	.7348	1.0752	1.2246	1.3578	1.4369	1.5487	1.7050	1.8545	2.0315	2.2387	2.6504	3.7519	5.9800

8.11" in 1 Day

PRECIPITATION DEPTH-DURATION-FREQUENCY TABLE

STATION NO. BSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG	LOT	RGN	LATITUDE	LONGITUDE	COUNTY CODE
E40 6931 0	PINOLE CREEK	215	36S				N	37.972	122.261	07

MAXIMUM PRECIPITATION FOR INDICATED DURATION D-DAYS H-HOURS

RETURN PERIOD IN YEARS	10	20	30	40	50	60	80	100	150	200	300	600	3650
2	2.08	2.81	3.18	3.41	3.67	4.03	4.54	4.91	5.66	6.00	7.35	10.72	19.58
5	2.93	3.78	4.49	4.90	5.25	5.76	6.46	6.86	7.87	8.33	10.17	14.78	25.54
10	3.49	4.64	5.44	5.91	6.38	6.68	7.48	8.09	9.25	9.78	11.92	17.26	28.98
20	4.03	5.40	6.36	6.87	7.29	7.96	8.71	9.23	10.51	11.11	13.51	19.50	32.00
25	4.20	5.65	6.65	7.17	7.80	8.29	9.05	9.58	10.89	11.51	14.00	20.19	32.91
40	4.54	6.18	7.26	7.80	8.24	8.99	9.22	10.30	11.66	12.35	15.01	21.59	34.76
50	4.71	6.43	7.54	8.09	8.54	9.32	10.10	10.64	12.05	12.73	15.47	22.24	35.58
100	5.20	7.19	8.41	8.99	9.46	10.32	11.10	11.66	13.16	13.90	16.88	24.19	38.09
200	5.69	7.95	9.28	9.88	10.37	11.31	12.09	12.66	14.23	15.03	18.24	26.07	40.44
1000	6.80	9.69	11.24	11.90	12.42	13.53	14.29	14.85	16.62	17.54	21.27	30.22	45.61
10000	8.34	12.14	14.01	14.73	15.27	16.63	17.33	17.87	19.86	20.95	25.39	35.82	52.37
PMP	15.98	27.81	29.77	27.71	29.42	32.02	39.05	37.09	42.27	44.54	53.83	78.15	128.41
MEAN	2.268	2.928	3.490	3.773	4.038	4.414	4.962	5.299	6.013	6.377	7.886	11.389	20.136
CLOCK HR. COR.	1.140	1.070	1.040	1.020	1.010	1.010	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CALCULATED SKEW	1.363	1.978	2.322	1.840	1.748	1.463	1.262	1.230	.779	.724	.565	.840	.667
REGIONAL SKEW	1.300	1.600	1.500	1.400	1.300	1.300	1.100	1.000	.900	.900	.900	.800	.500
SKEW USED	1.300	1.600	1.500	1.400	1.300	1.300	1.100	1.000	.900	.900	.900	.800	.500
KURTOSIS	6.816	6.866	9.773	6.893	5.958	4.986	4.744	4.647	3.283	3.011	2.832	3.188	2.456
N	25	25	25	25	25	25	25	25	25	25	25	25	25
RECORD YEAR	1940	1963	1963	1963	1963	1963	1956	1956	1956	1956	1956	1940	1956
RECORD MAXIMUM	3.978	6.826	9.938	10.378	10.378	10.378	11.448	11.848	12.388	12.818	14.478	21.748	34.218
NORMALIZED MAX	1.989	2.709	3.428	3.151	2.819	2.542	2.723	2.757	2.425	2.253	2.389	2.274	1.912
CALC. COEF. VAR	.377	.491	.547	.555	.598	.531	.490	.482	.431	.436	.370	.466	.366
REGN. COEF. VAR	.403	.438	.438	.423	.428	.417	.410	.403	.402	.399	.393	.394	.332
USED COEF. VAR	.403	.438	.438	.423	.428	.417	.410	.403	.402	.399	.393	.394	.332
MEAN/A	.1120	.1484	.1718	.1874	.2001	.2192	.2434	.2614	.2988	.3167	.3878	.5617	1.0000
RP10/A	.1734	.2295	.2703	.2933	.3127	.3416	.3773	.4019	.4594	.4899	.5918	.8576	1.4393
RP25/A	.2003	.2800	.3303	.3566	.3774	.4119	.4496	.4758	.5418	.5718	.6983	1.0027	1.6342
RP50/A	.2337	.3192	.3765	.4018	.4243	.4629	.5014	.5283	.5985	.6324	.7684	1.1048	1.7672
RP100/A	.2584	.3572	.4178	.4466	.4701	.5127	.5515	.5789	.6537	.6904	.8364	1.2016	1.8917
RP1000/A	.3376	.4812	.5584	.5912	.6167	.6722	.7999	.7375	.8254	.8712	1.0564	1.5009	2.2652
RP10000/A	.4141	.6429	.6958	.7310	.7583	.8201	.8687	.8875	.9864	1.0487	1.2668	1.7790	2.6007
PMP/A	.7930	1.0032	1.2800	1.3762	1.4618	1.5903	1.7408	1.8385	2.0994	2.2122	2.6735	3.8818	5.9800

PEARSON TYPE III DISTRIBUTION USED
PROBABLE MAXIMUM PRECIPITATION ESTIMATE BASED ON 15 STANDARD DEVIATIONS
WHERE N IS SMALL RESULTS ARE NOT DEPENDABLE

MAXIMUM ANNUAL PRECIPITATION (UNITS=INCHES)
(TO CONVERT TO MILLIMETERS MULTIPLY BY 25.4)

STATION NO. BSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG	LOT	PAR	LATITUDE	LONGITUDE	COUNTY
E40 6501 1	ORINDA FILTERS PRNG	370	33	01N	03W		R	37.893	122.200	CONTRA COSTA

M=MINUTES, H=HOURS, D=DAYS, C YR=CALENDAR YEAR, W YR=WATER YEAR, F YR=FISCAL YEAR
***** = NO DATA AVAILABLE

YEAR	DURATION 5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	F-YR
1958	*****	*****	*****	*****	0.44	0.94	1.44	2.58	2.88	3.53	50.61
1959	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	15.93
1960	0.14	0.15	0.21	0.28	0.42	0.79	1.04	1.43	1.51	1.94	22.65
1961	0.19	0.23	0.26	0.33	0.51	0.70	0.85	1.15	1.95	2.19	16.37
1962	0.18	0.21	0.28	0.47	0.70	1.20	1.40	1.87	3.37	3.95	32.83
1963	0.32	0.55	0.75	1.15	1.80	2.40	2.85	4.01	5.88	10.98	50.58
1964	0.26	0.38	0.50	0.79	1.13	1.40	1.85	2.65	3.26	3.80	29.14
1965	0.15	0.20	0.26	0.39	0.55	0.90	1.10	1.45	2.05	3.54	34.27
1966	0.21	0.32	0.38	0.44	0.60	1.00	1.48	2.30	2.78	3.97	20.64
1967	0.20	0.25	0.30	0.42	0.62	0.90	1.20	1.93	3.45	6.20	51.68
1968	0.30	0.36	0.40	0.60	0.99	1.15	1.69	2.20	3.05	3.85	25.88
1969	0.25	0.31	0.34	0.54	0.82	1.30	1.43	1.45	1.90	3.02	47.76
1970	0.28	0.50	0.65	1.04	1.48	2.05	2.55	3.75	4.08	6.08	44.64
1971	0.28	0.43	0.52	0.59	0.90	1.10	1.21	1.66	2.56	3.14	30.70
1972	0.13	0.19	0.20	0.33	0.48	0.66	0.86	1.02	1.40	2.04	16.73
1973	0.20	0.34	0.42	0.59	0.74	0.94	1.32	2.42	2.74	3.25	41.92
1975	*****	*****	0.36	0.49	0.81	1.26	1.64	2.04	2.20	2.57	29.74

Use 1.80"/h. for design
Dana Rox 5M
US CORPS ENGRS
556-0981

PRECIPITATION DEPTH-DURATION-FREQUENCY TABLE

STATION NO. BSN ORDER SUB	STATION NAME	ELEV	SEC	TWP	RNG	LOT	PAR	LATITUDE	LONGITUDE	COUNTY
E40 6501 1	ORINDA FILTERS RRNG	370	33	01N	03W		R	37.893	122.200	CONTRA COSTA

MAXIMUM PRECIPITATION (IN) FOR INDICATED DURATION D=DAYS H=HOURS M=MINUTES

RETURN PERIOD IN YEARS	5M	10M	15M	30M	1H	2H	3H	6H	12H	24H	F-YR
2	0.20	0.29	0.36	0.52	0.79	1.08	1.37	1.95	2.58	3.66	31.92
5	0.28	0.40	0.50	0.73	1.05	1.52	1.92	2.74	3.63	5.16	41.64
10	0.34	0.48	0.60	0.87	1.26	1.82	2.30	3.27	4.34	6.16	47.25
20	0.39	0.56	0.69	1.00	1.44	2.10	2.65	3.77	5.00	7.11	52.16
25	0.41	0.58	0.72	1.04	1.51	2.18	2.76	3.93	5.21	7.40	53.65
40	0.44	0.63	0.78	1.13	1.63	2.36	2.99	4.26	5.64	8.02	56.64
50	0.45	0.65	0.81	1.17	1.69	2.45	3.10	4.41	5.84	8.30	58.01
100	0.50	0.72	0.89	1.29	1.87	2.71	3.42	4.88	6.46	9.18	62.10
200	0.55	0.79	0.98	1.41	2.05	2.96	3.74	5.33	7.07	10.04	65.97
1000	0.66	0.94	1.16	1.69	2.44	3.54	4.47	6.37	8.44	12.00	74.36
10000	0.81	1.15	1.43	2.07	3.00	4.34	5.48	7.81	10.35	14.71	85.37
PMP	1.54	2.20	2.74	3.97	5.75	8.32	10.51	14.97	19.84	28.20	196.31
MEAN	0.219	0.313	0.389	0.563	0.816	1.181	1.492	2.126	2.816	4.003	32.828
CLOCK HR. COR.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
CALCULATED SKEW	0.121	0.469	1.028	1.338	1.530	1.543	1.392	1.031	1.366	2.304	0.219
REGIONAL SKEW	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	0.500
SKEW USED	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	1.300	0.500

SLOPE OF LOG INTENSITY / LOG TIME = -.465 ; INTERCEPT (TIME=1 HOUR) =0.819 ; COEFFICIENT OF DETERMINATION = 1.000
1HR INTERCEPT / MEAN YR =0.02496 ; AVERAGE CALC CV / USED CV = 0.98

KURTOSIS	2.588	3.073	4.080	4.706	5.496	5.701	5.254	4.290	6.286	9.469	2.120
N	14	14	15	15	16	16	16	16	16	16	17
RECORD YEAR	1963	1963	1963	1963	1963	1963	1963	1963	1963	1963	1967
RECORD MAXIMUM	0.320	0.550	0.750	1.150	1.800	2.400	2.850	4.010	5.880	10.980	51.480
NORMILIZED MAX	1.677	1.913	2.275	2.320	2.599	2.597	2.475	2.245	2.775	3.140	1.672
CALC. COEF. VAR	0.274	0.396	0.409	0.449	0.464	0.398	0.368	0.304	0.392	0.555	0.390
REGN. COEF. VAR	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.332
USED COEF. VAR	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.332

MEAN/A	0.0067	0.0095	0.0118	0.0172	0.0248	0.0360	0.0454	0.0648	0.0858	0.1219	1.0000
RP10/A	0.0103	0.0147	0.0182	0.0264	0.0383	0.0554	0.0700	0.0997	0.1321	0.1877	1.4393
RP25/A	0.0124	0.0176	0.0219	0.0317	0.0460	0.0665	0.0841	0.1198	0.1587	0.2255	1.6342
RP50/A	0.0139	0.0198	0.0246	0.0356	0.0515	0.0746	0.0943	0.1343	0.1780	0.2530	1.7672
RP100/A	0.0153	0.0219	0.0272	0.0394	0.0570	0.0825	0.1043	0.1485	0.1968	0.2797	1.8917
RP1000/A	0.0200	0.0286	0.0355	0.0514	0.0745	0.1078	0.1362	0.1941	0.2571	0.3655	2.2682
RP10000/A	0.0246	0.0350	0.0435	0.0631	0.0913	0.1322	0.1671	0.2380	0.3153	0.4482	2.6007
PMP/A	0.0471	0.0671	0.0834	0.1209	0.1750	0.2534	0.3202	0.4562	0.6044	0.8591	5.9800

PEARSON TYPE III DISTRIBUTION USED
PROBABLE MAXIMUM PRECIPITATION ESTIMATE BASED ON 15 STANDARD DEVIATIONS
WHERE N IS SMALL (<25) RESULTS ARE NOT DEPENDABLE

Kurtosis: The pointedness or flatness around the mode of a frequency curve.

Rainfall Records - October 1962

Date	Rainfall	Source of information
Oct 10 to 9:00 am 11th	.36	Be Gazette 10-11-62
Oct. 12 seasonal to date	3.11	@ Oak Airport Tribune 10-12-62
Oct. 13 " "	4.98	@ " " Tribune 10-13-62
	→ 1.87"	for Oct 12th
Oct 14 ———	None	
Season to date	11.5"	Be Gazette 10-14-62
Sat Oct 13 noon 12 to noon 13	4.47"	@ Oak Airport Tribune 10-13-62
Oct 12	5.53"	LBL H. Green Gauge
" 13	8.32	EBMUD Orinda Filter Plant
Oct 11-12	5.04	Orinda Oak Trib 10-12-62
Oct 15	8.37	LBL H. Green Gauge
Oct 13	4.51	Oak Tribune 10-14-62
Oct 12	2.53	Be Gazette 10-12-62
	2.77 @SFO	
Fri Oct 12	Almost 4" @ Berkeley	Be Gazette 10-12-62
Peak Oct 11-12 midnite		" " 10-12-62
Oct 11 5pm to Oct 12 11 pm	3.21"	@ San Fran.
	11.5" in 73hr	Be Daily Gazette
Thur Oct 11 to Sat 13	7.31"	
Fri 12 to Sat 13	Heaviest 24hr	in recorded history Tribune 10-13-62

Gauge location	Orinda Filter Plant		Oakland Airport	H. Green Gauge Bldg. 4			Orinda Filter Plant			San Fran Airport
Source of Info.	EBMUD	Berk. Gazette	Oakland Tribune	LBL	U.S. Army Engineers Comparison of Maximum Storms of record in the region	U.S. Army Engineers	EBMUD	Be Gazette	Oak. Tribune	
	← Rainfall per Day			→		←	Max. per hour			→
Wed. Oct. 10	1.15	.36					.45			
Thur. Oct 11	3.60					0.80 in 15 min. 1.75 max. hourly 12.3" in 72 hours	.75	11.5" in 72 hours	7.31" 11th to 13th	3.21
Fri Oct 12	6.49	2.53	1.87	5.53			1.75			
Sat Oct 13	8.32		4.47	7.75 [.62]			1.05			
Sun Oct 14	.14	11.5" to date	—	(8.37) Factor back			.05			
Mon Oct 15										

Curve "Factorea ip from CCCFCU 100 Yr

Mean seasonal @ Orinda 32.5"

1962 seasonal @ Orinda 48.75"

Max. hourly @ Orinda 1.75"

Trial #1 Use 35"/Year mean seasonal

1.8" per hr

Time	Depth	Intensity
5	.44	5.28
10	.65	3.9
15	.83	3.32
20	.98	2.94
30	1.23	2.46
40	1.45	2.18
50	1.65	2.0
60	1.80	1.8
90	2.3	1.5

Trial #2 use 40"/Year Mean seasonal

2.0"/hr.

5	.48	5.76
10	.71	4.26
15	.9	3.6
20	1.07	3.2
30	1.36	2.72
40	1.6	2.4
50	1.8	2.16
60	2.0	2.0
90	2.5	1.65

Flow thru submerged gate

$Q = CA\sqrt{2gh}$ King p 51 $C = .65$ King p 76

width 4' height 9" $A = 3\ ft^2$

$CA = .65 \times 3 = 1.95$ $2g = 64.4$

h	×	$2g$	=		$\sqrt{2gh}$	×	CA	=	Q
1		64.4		64.4	8.02		1.95		15.6
2		64.4		128.8	11.34				22.13
3		64.4							
4		64.4		257.6	16.04				31.3
5		64.4							
6		64.4		386.4	19.65				38.3
7		64.4							
8		64.4		515.2	22.7				44.2
9		64.4							
10		64.4		644	25.3				49.3
11		64.4							
12		64.4		773	27.8				54.2
14									
16		64.4		1030	32.09				62.6
18									
20		64.4		1288	35.8				70
22									
24		64.4		1545	39.3				76.6
30		64.4		1932	44				85.7
32		64.4		2060	45.4				88.5
34				2189	46.79				91.2
36		64.4		2318	48.1				93.89

Use $C = .6$ $CA = 1.8$ 86.58

W = 4 (h = 1) A = 4 ft²

.65 × 4 = 2.6

h	$\sqrt{2gh}$	CA	Q
1	8.2	2.6	21.3
2	11.34		29.48
3			
4	16.04		41.6
6	19.65		51.09
8	22.7		59.
10	25.3		65.78
16	32.09		83.43
20	35.8		93 08
24	39.3		102.2
30	44		114.4
36	48.1		125.06

(.6) × 4 = 2.4. (115.)

(h = 2) A = 8 CA = .65 · 8 = 5.

CA	Q
5.2	42
	59
	83.4
	102.2
	118.
	131.5
	166.4
	186.16
	204.4
	228.8
	250.12

(.6) 8 4.8 (230)

(h = 42") or 3.5 A = 4 × 3.5 = 14, CA = .65 × 14 = 9.1

.60 × 14 8.4

h	CA	Q	
1	9.1	74.62	
2		103.1	
4		145.96	
6		178.8	
8		206.6	
10		230.2	212
16		292.0	
20		325.78	300
24		357.6	
30		400.4	
36		437.7	

(C = .6) CA (8.4) (404)