

University of California, Berkeley  
Strawberry Creek  
Hydrology- 2006 Status Report



July 2007  
Office of Environment, Health & Safety  
University Hall, 3rd Floor  
Berkeley, CA 94720

Strawberry Creek Hydrology - 2006 Status Report, July 2007

Completed by the University of California, Berkeley Office of Environment, Health & Safety (EH&S), <http://www.ehs.berkeley.edu>, [strawberrycreek.berkeley.edu](http://strawberrycreek.berkeley.edu)

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# University of California, Berkeley Strawberry Creek Hydrology- 2006 Status Report

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# **University of California, Berkeley Strawberry Creek Hydrology- 2006 Status Report**

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## **1.0 University of California, Berkeley Strawberry Creek Management**

Strawberry Creek is a small urban creek draining the western slope of the East Bay Hills in the San Francisco Bay estuary watershed (see maps below). It is a major landscape feature of the University of California, Berkeley, and it was one of the main reasons the site was chosen in 1860 as the location for the campus. The 1163 acre (1.8 sq. mile) watershed draining the campus and upstream headwaters, is approximately 40% urbanized (residential, commercial and institutional), with the remainder consisting of undeveloped, largely natural wildlands.

Urban creeks are increasingly valued for the aesthetic, recreational and wildlife benefits they bring to a city. Strawberry Creek has been the focal point of educational activities for years. More than 3,000 university students, and many elementary and high school students from surrounding communities, use Strawberry Creek each year as an outdoor laboratory for subjects as diverse as environmental studies, biodiversity restoration, landscape design, engineering, environmental art and poetry.

The greater Strawberry Creek ecosystem, consisting of neighboring watersheds, Tilden Regional Park to the east and tidal mudflats and salt marsh at the Berkeley Marina outfall, provides important habitat for plants and wildlife in the largely urban San Francisco metropolitan area. As a source of nutrients and fresh water, Strawberry Creek supports the fisheries of the San Francisco Bay, and continued pollution prevention and restoration in the watershed contribute to the health of the fisheries.

Urban creeks also provide storm water drainage and serve as a flood control system to prevent damage to the urban environment through which they flow. Historically the creek provided sanitary sewer drainage. These uses led to historic erosion, habitat loss and water pollution. By 1987, water quality and ecosystems were degraded and the creek was considered a public health risk due to chronic sewage pollution from deteriorated sewers.

In response to campus and community concerns over the deteriorated environmental quality of Strawberry Creek, the campus Office of Environment, Health and Safety (EH&S) sponsored a comprehensive study of the creek. The results of the study completed by Robert Charbonneau were published in December 1987 as the "Strawberry Creek Management Plan" (1987 Strawberry Creek Management Plan). Implementation of the 1987 Strawberry Creek Management Plan significantly improved water quality in Strawberry Creek, as evidenced by the successful reintroduction of locally native fish species to the creek in 1989 – the first resident fish population in the creek in approximately 100 years.

This status report provides a summary of the hydrological conditions of Strawberry Creek including results of monitoring completed since the implementation of the 1987 Strawberry Creek Management Plan. This is one of a series of technical reports being issued by the EH&S to commemorate the twentieth anniversary of the restoration program.

## Strawberry Creek Watershed

### Strawberry Creek Watershed Facts

Strawberry Creek Watershed total area = 1,977 acres (CH2M Hill, 1994)

Length of Strawberry Creek = ~ 5 miles

Watershed area under jurisdiction of UC Berkeley = ~ 800 acres

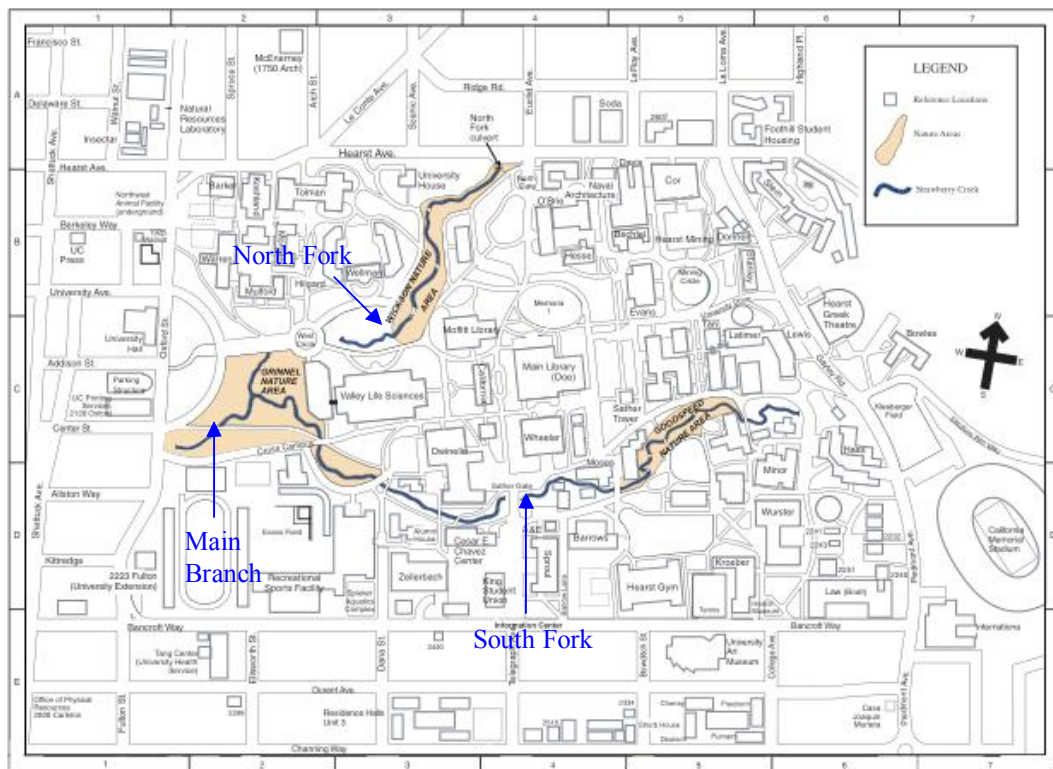
Watershed under jurisdiction of Lawrence Berkeley National Laboratory = 202 acres

Central Campus, Oxford to Gayley (base of Hill Campus) = ~ 165 acres

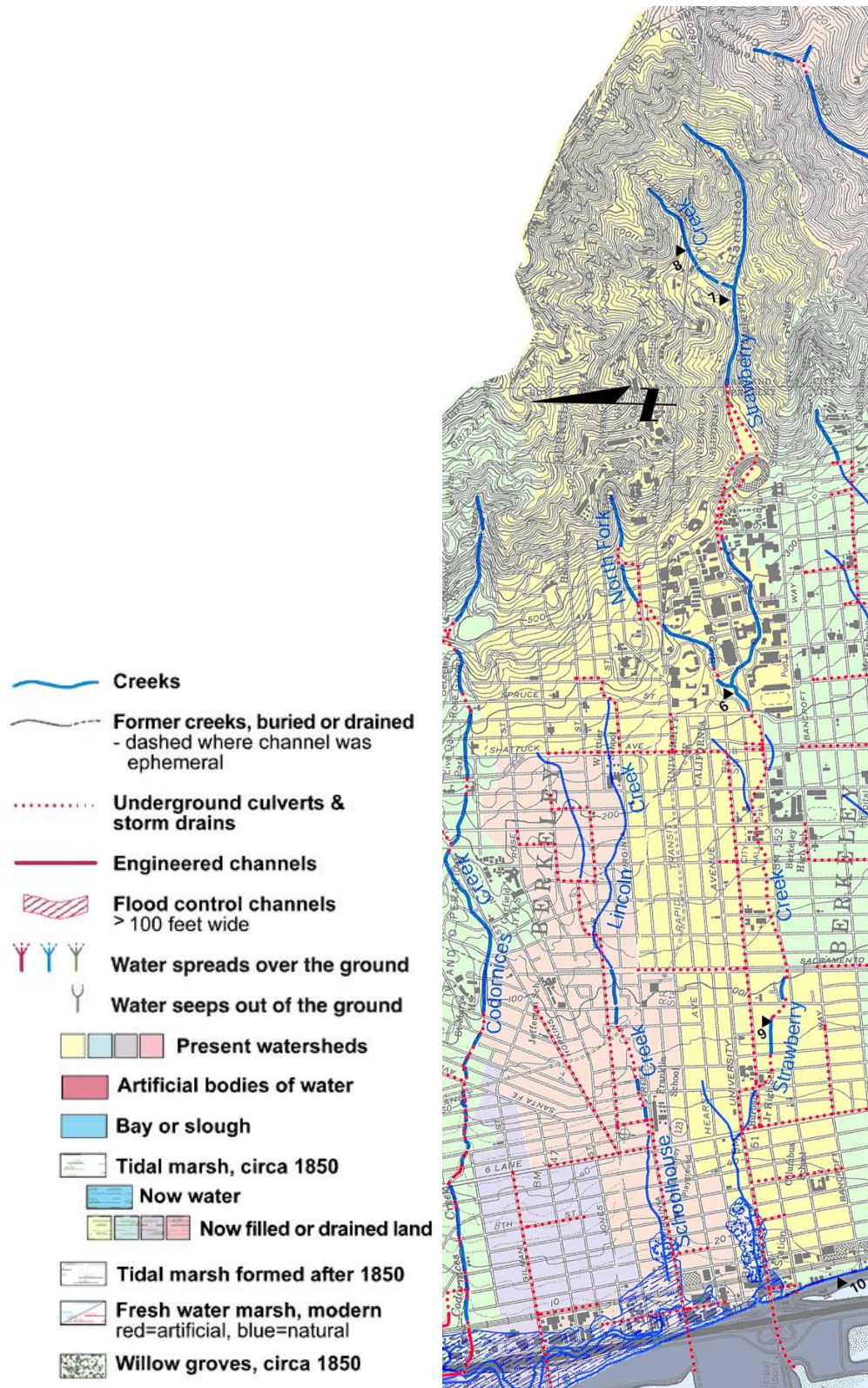
Change in elevation between headwaters and mouth (SF Bay) = 1,760 feet

Change in elevation from Grizzly Peak (1, 1760 ft) to Oxford St. (200 ft) = 1,560 ft

## Strawberry Creek on University of California Campus Park



*Strawberry Creek and Natural Areas on UC Berkeley Central Campus Park*



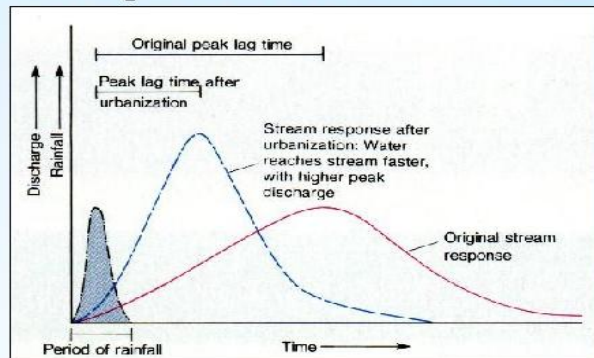
**Strawberry Creek Watershed.** *Courtesy of the Oakland Museum, [www.museumca.org](http://www.museumca.org).*

## 1.1 Strawberry Creek Hydrology Overview

Strawberry Creek's hydrology has been greatly altered by watershed urbanization which resulted in an increase in impervious surfaces. The consequences of this urbanization include increased water pollution, decreased groundwater recharge, and flash flows, characterized by higher, faster peak flows than occurred prior to urbanization. Haltiner (1988) concluded that these changes “likely resulted in significant channel downcutting by the early 1900s.” Increased peak flows also threaten to overwhelm undersized storm drains and increase the erosive power of storm flows that can damage infrastructure and ecological habitat.

Another significant consequence of urbanization’s increased impervious cover is loss of habitat quality. US Fish and Wildlife Service reports that in addition to modification of hydroperiod (cyclical changes in the amount of water in the creek), impacts in the watershed can affect habitat quality making it difficult to maintain “predevelopment stream quality when watershed development exceeds 10-15 percent impervious cover.” (US Fish and Wildlife Service, 2004)

### Hydrologic effects of urbanization



- Paving prevents water from soaking in - increases runoff
- Storm sewers move water to river faster
- Increased peak discharge, shortened lag time

*Hydrologic effects of urbanization (The Stormwater Center).*

## 1.2 Non-Storm Water Contributions to Flow

**Groundwater:** Natural springs in Strawberry Canyon feed Strawberry Creek year round, even during prolonged droughts (Charbonneau, 1987). Historical dry weather flows from this groundwater were estimated in the low hundreds of thousands of gallons per day (~100,000 gallons per day = 0.16 cfs\*, ~4,000 gallons/hr, ~70 gallons/minute) (Willey, S.H.). This is similar in magnitude to current estimated dry season Main Branch flows.

Since 1930 groundwater extraction from the Berkeley East Bay Plain aquifer has been limited to a few remaining domestic irrigation wells, hydraugers (passive drains) in the Hill Area, the Shively well at Space Sciences labs (used to dewater the foundation area for slope stability purposes), and building perimeter dewatering sumps. The groundwater basin has likely returned to pre-disturbance conditions similar to other regions of the East Bay Plain (Norfleet, 1998, executive summary).

**Municipal Sources:** The 1987 Strawberry Creek Management Plan (SCMP) estimated (page 26) that point sources (municipal discharges) on campus contributed a significant volume to the summer baseflow (dry weather flow) with North Fork point sources comprising an average of 0.14 cfs (approximately 50% of the 1987 flow) and South Fork point sources contributing 0.29 cfs (approximately 50% of the 1987 flow). Implementation of the SCMP resulted in the rerouting of most point sources, such as cooling towers, to the sanitary sewer, and other control measures eliminated the majority of non-stormwater discharges to the creek. As of 2006, non-stormwater discharges are estimated to contribute an insignificant volume to the summer baseflow.

**Irrigation runoff:** Irrigation runoff on the campus currently contributes a very small amount of overland flow in Strawberry Creek, likely not enough to affect flow itself. Excessive irrigation is controlled to prevent the discharge of wasted water and chloramines to the creek. Irrigation water use on the Campus Park has dropped in the last decade from 262,271 gallons per day in 1989 to 180,000 in 2003 (source: UC Berkeley EBMUD Wastewater Discharge Permits). This may have contributed to the reduction in dry weather flow rates since 1987. It is possible that groundwater being replenished by irrigation in the Campus Park, City of Berkeley residential areas and LBNL provides a significant contribution to low flows during dry conditions (a process known as aquifer augmentation).

\* Note: cfs = cubic feet per second, a measure of stream flow. One cfs equals 448 gallons per minute (GPM). The conversion from cfs to gallons per minute is: CFS X 448.8 = GPM



### 1.3 Climate and Rainfall

Berkeley has a Mediterranean climate, with a very dry season between April and October. Almost all rain falls during the wet season, usually in short periods of heavy intensity. Strawberry Creek therefore has a low baseflow during most of the year, with high flows of short duration only immediately after storms.

Rainfall for Berkeley varies from 18 inches at the Bay to 26 inches in the hills (CH2M HILL, 1994 page 4-7). For the City of Berkeley Storm Drainage Master Plan CH2M HILL based calculations on an annual rainfall of 26 inches for portions of the city east of Shattuck Avenue (which includes all of the campus portion of the Strawberry Creek watershed).

Rainfall intensity recurrence intervals for the Berkeley area are presented in the table Rainfall intensity for Berkeley, California as Calculated by Goodridge (1998) below.

**Rainfall intensity for Berkeley, California as Calculated by Goodridge (1998).**

All rainfall values are in inches.

<b>Return Interval (years)</b>	<b>1 Hr</b>	<b>2 Hr</b>	<b>3 Hr</b>	<b>6 Hr</b>	<b>12 Hr</b>	<b>24 Hr</b>
2	0.51	0.74	0.93	1.35	1.76	2.36
5	0.72	1.05	1.31	1.91	2.48	3.33
10	0.86	1.25	1.57	2.28	2.97	3.97
25	1.03	1.50	1.88	2.74	3.56	4.78
50	1.15	1.69	2.11	3.07	4.00	5.36
100	1.28	1.87	2.34	3.39	4.42	5.93
200	1.40	2.04	2.56	3.71	4.84	6.48
500	1.58	2.31	2.89	4.20	5.48	7.34
1,000	1.67	2.44	3.05	4.43	5.78	7.74
10,000	2.05	2.99	3.75	5.44	7.09	9.50

The one-hour, 25-year storm is more intense than the six-hour 25-year storm, and most runoff and flow calculations are based on the one-hour storm of a particular intensity. The most memorable rainstorm in the campus history is the 1962 Columbus Day storm. Eleven inches of rain fell causing widespread flooding and mud accumulation and resulting in subsequent construction of many of the flood control measures seen on the creek today. (Chronicle of the University of California, 1998) Since the Columbus Day storm in October 1962, the Berkeley campus has not experienced a storm of sufficient intensity to cause similar flooding and damage. There have been storms with near 1 in/hr intensity: 0.98, 0.93, 0.92 and 0.88 in/hr in 1969, 1986, 1993 and 2004, respectively. None of these storms exceeded the capacity of the Oxford Street culvert.

## 1.4 Low Streamflow Characterization (Dry Weather)

Strawberry Creek's flow varies greatly between summer and winter because Berkeley receives very little rain during summer and most of its rain in between October and April. Through 2006 there were no flow meters on Strawberry Creek, but numerous studies by students and others have recorded flow rates during the dry season. Low flows have been reported to be < 1.0 cfs (< ~450 gallons/minute) since 1987 and are currently estimated to be 0.1-0.2 cfs (50-100 gallons/minute) during lowest flow late in the dry season.

### Strawberry Creek Low Flow Discharge Data

[All flows are cubic feet per second\* (cfs)]

Location	Mean dry 1987 (Charonneau)	Sept. 24, 2001	October 3, 2003
South Fork above retention dam (Site #1)	0.24	0.27	NS
South Fork at Faculty Club (Site #2)	0.38	0.26	0.16**
South Fork at Eucalyptus Grove (Site #3)	0.58	0.65	NS
North Fork above Highland Avenue (Blackberry Canyon, Site #4)	0.04	0.07	NS
North Fork at North Gate (Site #5)	0.09	0.22	0.03**
North Fork at Eucalyptus Grove (Site #6)	0.28	0.13	0.15**
Main Branch above Oxford Street (Site #7)	0.89 cfs = 400 G/m = 575,000 G/d	0.53	~0.40 cfs*** = 180 Gal/min = 260,000 G/d

\*Flow measurements performed using a Pygmy current meter where possible, and using time of travel (float) or Bucket tests at all other locations.

\*\* October 2003 measurements taken by EH&S staff using bucket test (timing how long it takes to fill a bucket of known size). South Fork- flow at three locations from Sather Gate to Stephens equaled 0.16 cfs. North Fork flow from Cross Campus Culvert was 0.07 cfs. Eucalyptus Grove measurement was from the West Circle culvert. NS= not sampled.

\*\*\*Based on visual estimation. The October 2003 Main Fork was not measured directly.

## A Historical Perspective

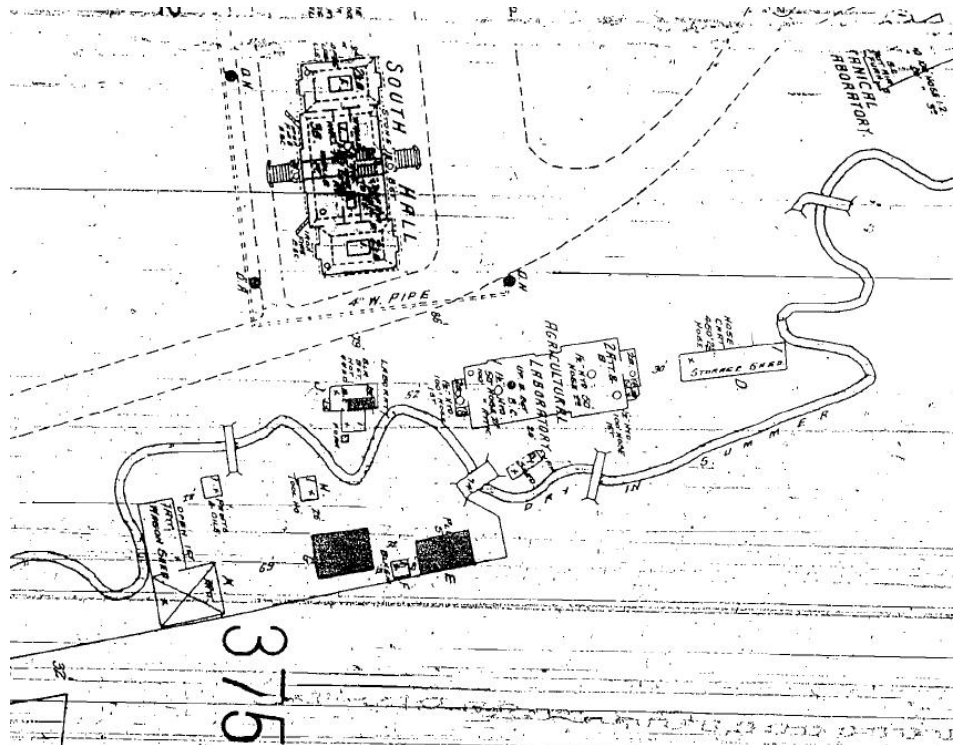
Summer low flow in Strawberry Creek appears to have decreased since 1987. The reason for this change is not completely known, but EH&S staff believe that summer base flows have decreased largely because all significant point sources of domestic water discharge (such as cooling towers) have been re-routed to the sanitary sewer system and no longer flow to the creek. Also, a reduction in irrigation has reduced aquifer augmentation of groundwater and has also reduced this as a source of overland and groundwater discharge. 1987 flow measurements were completed after six years of an extended drought, with reduced groundwater recharge and an estimated 50% contribution from point sources. 2001 and 2003 measurements occurred after six years of above average rainfall (including the record-setting 1997-98 El Nino year) that recharged groundwater.

Current low flow conditions may be equivalent to pre-disturbance conditions. In 1887 Samuel Willey summarized an engineering report completed for the College of California Trustees as they were finding a location for the new College in the 1860s, including the following description of Strawberry Creek:

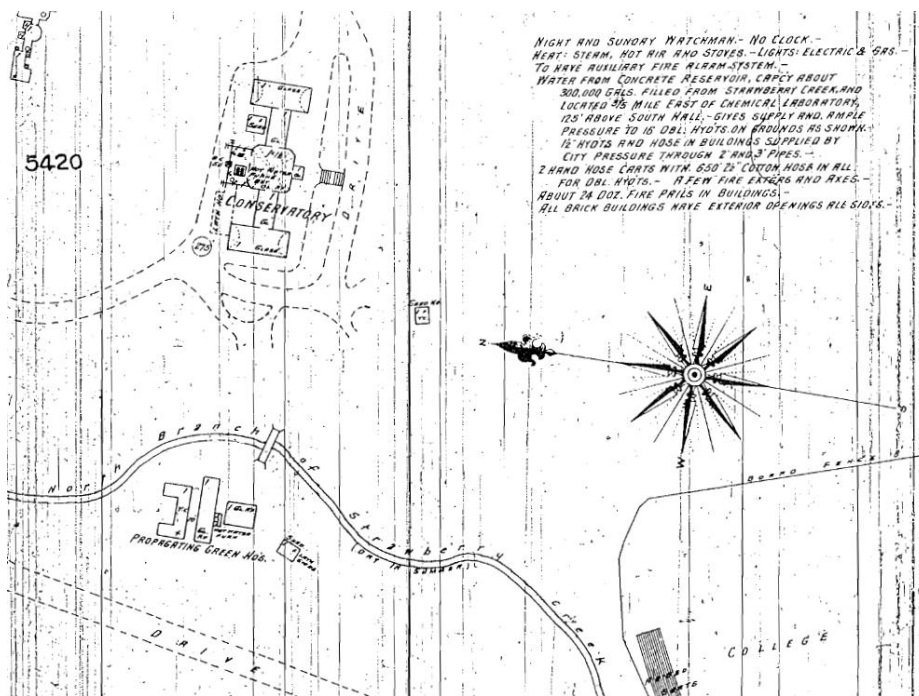
“Through these grounds runs the winding course of a stream of water. The stream flows freely the whole way during the wet season. Its sources are in the hills, where they flow the year through. Even in October, of this driest of dry years, 1864, they were yielding by actual measurement, over 100,000 gallons a day.”  
(Source: Willey, S.H. 1887. The History of the College of California)

100,000 gallons a day equals 0.15 cfs, which is comparable (within the accuracy of analytical methods) to the estimated current dry weather flow. This also seems to be a reasonably accurate basin yield in light of the Pfeiffer Springs water production from the north slope of Strawberry Canyon, which had a reported 45,900 gallons per day yield from 1909-1912 (Norfleet, 1998, page 63).

Soon after the development of the campus, water was diverted from the creek for supply water for the campus and City of Berkeley. The 1911 Sanborn Fire Insurance map describes a 300,000-gallon concrete reservoir in the canyon above the stadium that was constructed in 1898. Located 125' above South Hall, the reservoir supplied water at 50 lbs. pressure to fire hydrants on the campus. A 550,000-gallon swimming pool in Strawberry Canyon supplied by the creek was also available for fire fighting water. Diversion of water for these domestic uses likely drained the creek of summer baseflow as indicated by the Sanborn maps description of both forks (branches) of the creek as “Dry in Summer” (see maps below).

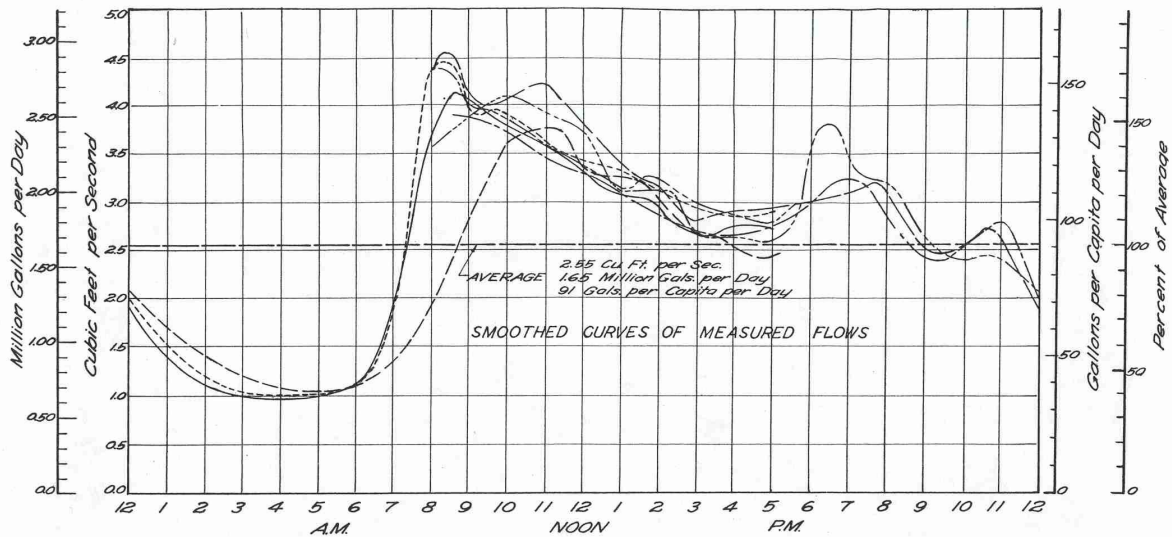


1911 Sanborn Fire Insurance Map showing South Fork (Branch) by South Hall. Note “Dry in Summer”



1911 Sanborn Fire Insurance Map showing North Fork (Branch) by South Hall. Note “Dry in Summer”

After the conversion of water supply from Strawberry Creek to the EBMUD Sierran water source in 1930, low flows in Strawberry Creek probably increased both on campus and through the City of Berkeley to the Bay with the new abundant water supply. Wastewater from homes, institutional and commercial buildings and industry was discharged into sewers that discharged into the Bay or directly to the creek until the EBMUD wastewater treatment plant was constructed in the early 1950s. When EBMUD's water pollution control plant became fully operational in May 1952 (EBMUD, 1999, page 92), most (but not all) of the wastewater was re-routed from the storm drains to the new sanitary sewer system. Between 1930 and the early 1950s, wastewater discharge to the Bay through Strawberry Creek followed a diurnal water usage pattern (see figure below), with maximum flow rates at 4th Street in West Berkeley of almost 3 million gallons per day (4.5 cfs) during mid-day peak-use periods and nighttime flow rates of 650,000 gallons per day (1.0 cfs).



FLOW DATA*					Population, 1940	18,100
Legend	Day	Date	Total Avg. Min. Rate	Max. Rate	Per Capita Sewage Flow, Gal per Day	91
			M.G.D. C.F.S.	M.G.D. C.F.S.	Per Capita Water Consumption, Gal per Day	96
					Area in Acres	1,400
					Gal. per Acre per Day, Sewage Flow	1,180
					Population Density per Acre	12.9
					Note:	
					Sewage flow in 7'-6" diameter sewer measured by a Palmer-Bowlius flume installed in the sewer at the intersection of University Avenue and 4th Street. Head measured with a plumb-bob and tape at 15 minute intervals.	
					This area includes the University of California.	
					No allowance has been made for the population increase resulting therefrom.	
					*Night flows not measured were assumed to be equal to the average of those measured.	

<b>EAST BAY CITIES</b> ALBANY BERKELEY PIEDMONT EMERYVILLE RICHMOND OAKLAND		
<b>SEWAGE DISPOSAL SURVEY</b> BOARD OF CONSULTING ENGINEERS CHARLES GILMAN HYDE A. M. RAWN HAROLD FARNSWORTH GRAY		
<b>FLOW CHART</b> UNIVERSITY AVE. & 4TH ST. BERKELEY 1940		
DRAWN BY: <i>ALB...</i> CHECKED BY: <i>H.F.G.</i> APPROVED: <i>H.F.G.</i>	DATE 6/30/41	PLATE NUMBER 56

1940 Strawberry Creek hydrograph at University Avenue and 4th Street. From "East Bay Cities Sewage Disposal Survey, Report Upon the Collection, Treatment and Disposal of Sewage and Industrial Wastes of the East Bay Cities, California" The Board of Consulting Engineers, Hyde, G.C., Gray, H.F., Rawn, A.M., June 30, 1941.

As recently as 1970, municipal water discharged to Strawberry Creek provided daily augmentation of Campus Park creek flow. EH&S estimated that dry weather flows increased from ~80 gallons per minute (GPM, 0.18 cfs) above campus to 1,500 gallons per minute (3.3 cfs) in the Main Branch [hill area North Fork = 5 - 10 GPM (0.01 – 0.02 cfs), confluence North Fork = 500 GPM (1.1 cfs), hill area South Fork = 30 - 70 GPM (0.06 – 0.13 cfs), confluence South Fork = 500- 1000 GPM (1.1 – 2.2 cfs)]. This increase was attributed primarily to lawn sprinkling [one discharge being measured as 140 GPM (0.31)]. It was also estimated that cooling towers discharged 25- 50 gallons per minute (0.05 – 0.1 cfs). (UC Berkeley EH&S, 1971).

Currently, flows on the Campus Park continue to be year-round, allowing the creek to support fish populations. Drought conditions could lead to a reduction in streamside moisture and to disconnected or drying pools.

## **1.5 High Streamflow Characterization**

Mean annual stormwater runoff in natural areas in the City of Berkeley, where human activity has had a negligible effect on runoff, is estimated to be 5 inches, or ~20% of the annual precipitation of 24 inches (Rantz, S. E.). For the entire Strawberry Creek watershed, 40% urbanization results in a mean annual runoff of over 12 inches (assuming 100% runoff from the urbanized areas).

Urban development of the watershed has had profound effects on Strawberry Creek including increased flooding potential. The SCMP presented estimates of decreased lag time from rainfall to peak flows in both forks, due to impervious surface runoff (based on Kuntz, 1980):

- The lag time in the North Fork at the entrance to the city culvert at Highland Avenue was estimated to be 15 minutes (pre-disturbance estimated to be 45 minutes);
- The lag time for the South Fork at the retention basin was calculated to be 25 minutes (pre-disturbance estimated to be 60 minutes).

Marangio and Poitros (1983) reported that the lag time between the centroids of precipitation and runoff has decreased by half from that which would have occurred under natural conditions (Haltiner, 1988). This phenomenon is caused by increased impervious surface from urbanization, which sheets water from the ground rather than absorbing it. CH2M Hill reported that the total time of concentration of flow from the upper end of the system to reach the Bay is approximately 1 hour.

There are very few direct flow measurements for runoff in the Berkeley area. Wet weather flows for various portions of the system have been calculated through standard hydrologic calculations and computer models for storm drain engineering design. The Flood Insurance Study (FIS) for the City of Berkeley performed in 1978 by the US Army Corps of Engineers generated estimated peak flows were compared to nearby USGS stream gaging station data and found modeling results to be statistically accurate (CH2M Hill, 4-13). Following are examples of runoff flow estimates from a variety of sources:

- Oxford Street culvert:
  - 10 - Year storm = 426 cfs. (CH2M Hill 1994)
  - 25- Year storm = 534 cfs. (CH2M Hill 1994)
  - 100- Year storm = 874 cfs (Haltiner, 1988)

Charbonneau measured flow in 1987 during a storm that produced 1.09 inches of rain in 24 hours. The measurements shown in the table Strawberry Creek High Flow Discharge Data below found that the flow increased six-fold between the canyon sites and the Eucalyptus Grove. The North Fork exhibited higher flows due to the highly urbanized nature of the sub-watershed. The peak flow measured during this event was approximated to be 60 cfs.

**Strawberry Creek High Flow Discharge Data (Charbonneau 1987)**

Storm Event October 27, 1987	South Fork above Retention Dam Flow (cfs)	South Fork at Faculty Club Flow (cfs)	South Fork at Eucalyptus Grove Flow (cfs)	North Fork above Highland Avenue (Blackberry Canyon) Flow (cfs)	North Fork at North Gate Flow (cfs)	North Fork at Eucalyptus Grove Flow (cfs)
	2.3 cfs	11.8 cfs	14.6 cfs	7.9 cfs	25.4 cfs	45.0 cfs

Although Strawberry Creek's streamflow is not regularly quantitatively measured, EH&S staff have made observations during large recent rainfall events that provide some insight into the flow capacity estimates presented in the few engineering reports available for the Strawberry Creek watershed. Following are high-flow observations from three recent large storms.

December 13-14, 2002: High flow on the North Fork caused the North Fork confluence check dam in the Eucalyptus Grove to collapse sometime on Friday night or Saturday morning. The storm rained 4.69 inches on campus in approximately 36 hours (based on the campus meteorological station data at the Banway Building at Bancroft and Oxford) from 2 a.m. Friday morning December 13, 2002 through Saturday afternoon December 14, 2002. The maximum 24-hour rain accumulation of 4.16" is a 13-year storm based on rainfall frequency. Despite the large rainfall, the intensity was not sufficient to flood the Oxford Street culvert, which has an estimated capacity of 426 cfs.

December 16, 2002: The December 16, 2002 storm, with a Bay Area Storm Index of 9.0 out of 10, (Null, Jan <http://ggweather.com/basi.htm>) rained 1.41 inches in a six hour

period (a 2-3 year storm), with a maximum one-hour intensity of 0.43"/hr. The North Fork flow topped the banks at the Valley Life Sciences Building bend retaining wall. The West Circle culvert overflowed, indicating that the North Fork flow exceeded the estimated capacity of the culvert of 72 cfs.

February 25, 2004: A very intense, fast-moving storm, with a Bay Area Storm Index of 8.0 out of 10 (Null, Jan <http://ggweather.com/basi.htm>), produced a rainfall maximum of 0.88 inches in a one hour period to 9:30 AM (with a maximum 15 minute intensity of 1.28 in/hr at 9:00 AM), an 11 year / one-hour storm. The runoff from this storm filled the Oxford Street culvert to almost overflowing at 9:20 AM, when the rain began to subside and the water level dropped. In 1994, CH2M Hill calculated the Oxford Street culvert capacity at 426 cfs and previous calculations have shown that the culvert capacity would be exceeded with a 25-year, one-hour intensity storm of 1.04 in/hr. This appears to be a fairly accurate assessment based on this storm, which was 85% of that rainfall rate. The West Circle culvert also overflowed. It has been estimated to have a 72 cfs capacity, which would make it undersized for a 5-year peak flow of 92 cfs resulting from a rainfall of 0.71 inches in one hour.



Flooding of Eucalyptus Grove during storm event February 25, 2004

The capacity of the Oxford Street culvert is 426 cfs, and there are no records that indicate that this flow has been exceeded since the 1962 Columbus Day storm. Unlike the Oxford Street culvert, the West Circle culvert's capacity of 92 cfs has been exceeded many occasions, approximately once every two years.



These observations show that the peak high water flows in the Main Branch are regularly in the 100- 200 cfs range, and that the potential for flooding at Oxford Street is low, even during very wet years. An example is the 1997-98 El Nino years when a record annual rainfall and intense storms occurred but the culvert did not flood. However, observations also show that at some places the creek is at capacity for storms that are less intense than the 25-year design storm and any additional increase in impervious areas will worsen the flooding potential at Oxford Street and other constricted stretches of the creek.



High water at VLSB bend (February 25, 2004)

As runoff frequency is not directly equivalent to rainfall frequency but depends on watershed soil moisture content and other climate conditions, additional climate and flow measurements may provide a better prediction of how the creek responds during rainfalls and when flood conditions may be present.

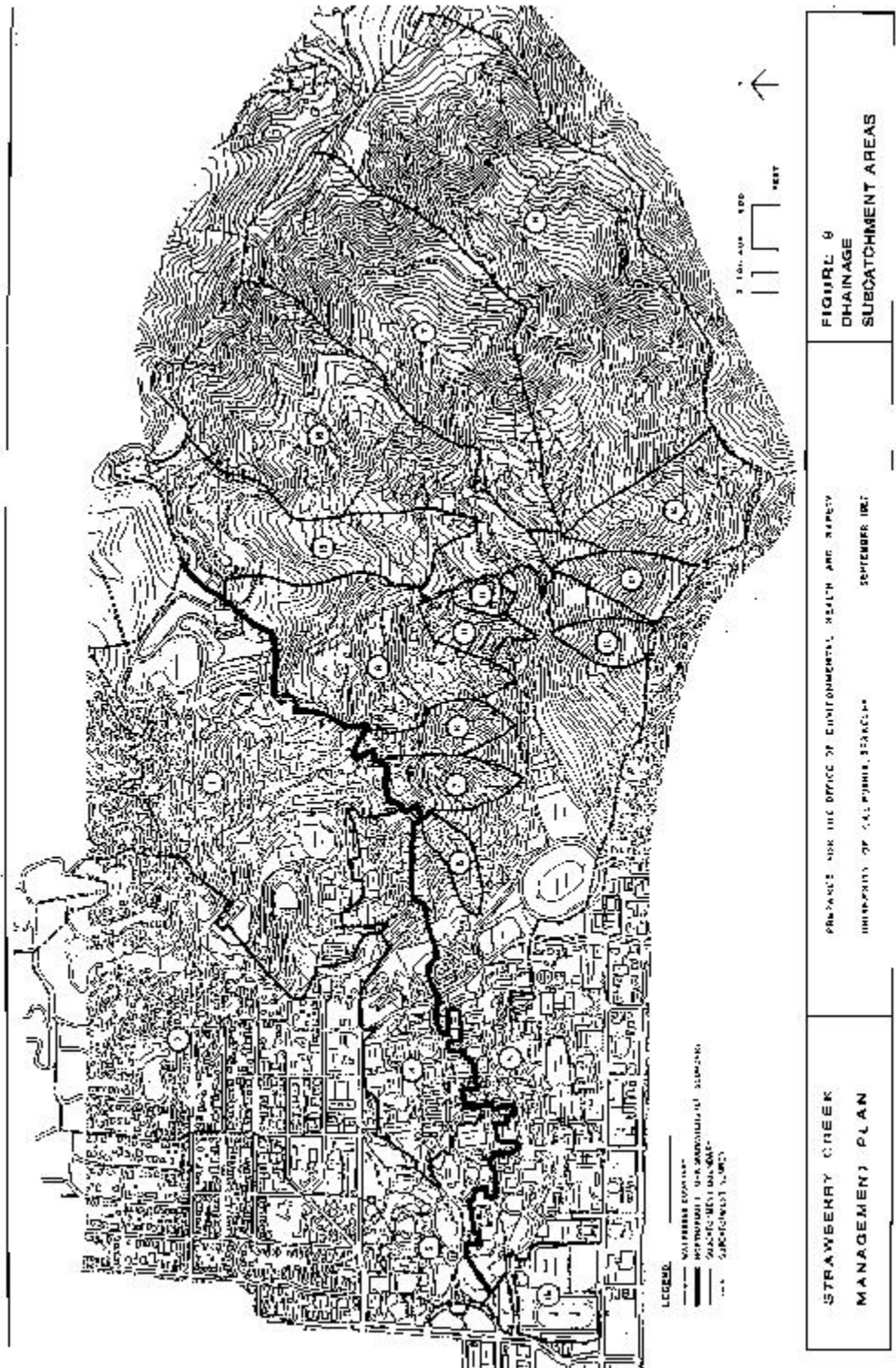
## 1.6 Drainage Basins Above Oxford Street

The Strawberry Creek watershed above the western boundary of the Campus Park at Oxford Street contains nineteen subcatchments\*. The table Strawberry Creek Drainage Subcatchments below presents the areas of these subcatchments. (See subcatchment map below for subcatchment locations.) Estimated catchment areas and storm drain culvert capacities are presented in the tables, followed by additional description of selected storm drainage system features.

**Strawberry Creek Drainage Subcatchments (SCMP Table 6)**

#	Subcatchment description	Area (acres)
1	North Fork above Highland Avenue	138.2
2	North Berkeley area	157.3
3	Central campus excluding cross campus culvert	38.2
4	Cross Campus Culvert drainage area	54.4
	<b>North Fork Total</b>	<b>388.1</b>
5	Central campus	59.5
6	Cafeteria Creek draining Stadium Hill	5.9
7	Ravine Creek	13.2
8	Ten-Inch Creek	11.8
9	Chicken Creek	57.3
10	No-Name Creek ("Poultry Creek")	8.8
11	LBNL Buildings 62 and 66	4.4
12	Ephemeral Creek left bank canyon	7.1
13	Ephemeral Creek left bank canyon	11.6
14	Ephemeral Creek left bank canyon	30.1
15	Banana Creek	51.4
16	Pineapple Creek (South Fork north of Botanical Garden)	95.6
17	South Fork of Strawberry Creek	104.4
18	Hamilton Creek	183.7
--	All other overland drainage areas into South Fork	113.9
	<b>South Fork Total</b>	<b>758.7</b>
19	Evans Field – Edwards Track Area	13.4
--	All other overland drainage into Main Branch	2.5
	<b>Main Branch Total</b>	<b>15.9</b>
	<b>Watershed Total</b>	<b>1162.7</b>

\*Notes: UC Berkeley property includes facilities to the west of Oxford Street that make up a minor percentage of the UC Berkeley owned portions of the Strawberry Creek watershed. Portions of the campus do not drain to the Strawberry Creek watershed above Oxford Street. The southern part of the Campus Park drains to Potter and Derby Creeks. The northwest corner drains to Strawberry Creek downstream of Oxford Street. Portions of the Hill Campus drain to Harwood (Claremont) Creek.



Strawberry Creek Drainage Subcatchments (SCMP Figure 9)

## 1.7 Storm Drainage System Culvert Capacities

The following table Creek and Culvert Capacities presents estimated culvert capacities for main culverts and estimated peak flows during 100-year storm events in various portions of the creek as reported in the SCMP and engineering reports.

### Culvert and Creek Capacities

Site	Drainage Area (acres)	Flow 100 year storm (cfs)	Culvert Capacity (cfs)
North Fork: Highland Bypass	138 <sup>1</sup>	500 <sup>2</sup> , 355 <sup>1</sup>	475 <sup>1</sup> , 500 <sup>2</sup>
Hearst Avenue Culvert	296 <sup>3</sup>	360 <sup>3</sup>	
Cross- Campus Culvert	54 <sup>3</sup>		87 <sup>4</sup>
Creek at Cross-Campus Culvert	369 <sup>3</sup>	430 <sup>3</sup>	
West Circle Culvert			72 <sup>6</sup>
Confluence Eucalyptus Grove	388 <sup>3</sup>	440 <sup>3</sup>	
South Fork: Earthen Retention Basin with movable hydraulic gate (maximum 42" opening)	502 <sup>1</sup>	899 <sup>1</sup>	86 (9" opening) <sup>1</sup> 230 (24" opening) <sup>1</sup> 404 (42" opening) <sup>1</sup>
Little Inch Culvert	92 <sup>3</sup>	145 <sup>1,3</sup>	
Chicken Creek drop inlet	66 <sup>1</sup>	158 <sup>1</sup>	500 <sup>1</sup>
Creek at Big-Inch Culvert	699 <sup>3</sup>	535 <sup>1,3</sup>	390 <sup>1,3</sup>
Confluence Eucalyptus Grove	759 <sup>3</sup>	585 <sup>3</sup>	
Main Fork: Oxford Street Culvert	1,163 <sup>3</sup>	874 <sup>3</sup>	426 <sup>5</sup>

cfs = cubic feet per second, 1 cfs = ~ 450 gallons per minute

- 1) Kuntz, G.T. "Storm Drainage Study: Strawberry Creek Watershed", prepared for LBL Plant Engineering Department, February 1980
- 2) Charbonneau, Strawberry Creek Management Plan, December 1987
- 3) Phillip Williams & Associates 1988 bank stabilization study.
- 4) CS Young, UC Berkeley Campus Utility Infrastructure Study Storm Sewer System Study, July 23, 1993
- 5) CH2M Hill, City of Berkeley Storm Drainage Master Plan, July 1994.
- 6) EH&S estimate, 2004

In general, storm drains on the campus have been designed to accommodate runoff for a 25-year storm (CS Young, 1993) with significant flood control improvements having been made after the October 1962 storm. However, portions of the system are not capable of draining a 25-year storm flow, including the City of Berkeley culvert at Oxford Street where flooding potential has been identified.



Backup at Oxford Street culvert during storm event February 25, 2004



Oxford Street culvert during low flow

## 1.8 Future Development

The 1987 Strawberry Creek Management Plan estimated that 4.4 acres of impervious surface might be added to the North Fork sub-watershed and 4.6 acres to the South Fork sub-watershed in projects planned at that time (including LBNL development). The SCMP concluded that the relatively small amount of additional impervious surface “should not significantly impact the hydrologic regime of the creek drainage system”. The SCMP also concluded that “continued development in the future will likely produce deleterious effects over the long term”.

The extent of increase in impervious surface in the watershed since 1987 has not been assessed comprehensively, and the significance of any impact due to additional impervious surface was not measured. The SCMP predicted that “some accelerated streambank erosion may occur in the unnamed branch of Strawberry Creek west of the Botanical Garden and in the North Fork channel on the central campus, as these channel reaches will bear the brunt of the additional storm runoff from projects previously outlined”. Observations show these predictions were accurate as the outfall of the Winter Creek storm drain culvert in the Mather Grove and downstream stretches have experienced increased erosion and scour. On the Campus Park, two North Fork grade control structures have recently collapsed: the confluence check dam in 2002 and the VLSB bend retaining wall in 2004.

Because the Strawberry Creek watershed is already approximately 40% impervious (and even more so downstream of the Central Campus in the City of Berkeley) any additional increase in impervious area that is not mitigated by detention is expected to have continued detrimental effects on habitat and bank stability. The table below, Runoff coefficients for Different Land Uses, shows examples of runoff coefficients (the ratio of runoff to precipitation) and percentages imperviousness by cover by land use type from a number of sources.

Design of future projects on the Central Park and Hill Campus will follow mitigation measures outlined in the 2020 Long Range Development Plan (University of California, Berkeley 2005), which includes no net increase in impervious area on the campus, and will be regulated under a Municipal Small Separate Stormwater System (MS4) Permit which may require post-construction stormwater treatment and runoff control measures for some sites disturbing as little as 10,000 square feet and possibly less. Both water treatment and runoff controls will be implemented through a Storm Water Management Plan and through Storm Water Pollution Prevention Plans already required by the state General Construction Stormwater Permit for larger sites (greater than one acre). Both of these permits will require implementation of post-construction designs to treat and retain stormwater. Stormwater treatment methods are expected to also significantly improve water quality in Strawberry Creek.

### Runoff coefficients for Different Land Uses

Type of Drainage Area	Runoff Coefficient	
	D.O.T. 1995	City of Berkeley, 1994 CH2M Hill
<b>Business:</b>		
Neighborhood Areas	0.50 - 0.70	
Commercial		0.8
Industrial		0.75
<b>Residential</b>		
Single-family area	0.30 - 0.50	0.4
Multi-units, detached	0.40 - 0.60	0.5
Multi-units, attached	0.60 - 0.75	0.6
Suburban	0.25 - 0.40	
Apartment Dwelling Areas	0.50 - 0.70	
Parks, Cemeteries	0.10 - 0.25	0.1
Playgrounds	0.20 - 0.40	
Unimproved Areas	0.10 - 0.30	0.0
<b>Lawns:</b>		
Sandy soil, flat (2%)	0.05 - 0.10	
Sandy soil, average (2-7%)	0.10 - 0.15	
Sandy soil, steep (7%)	0.15 - 0.20	
Heavy soil, flat (2%)	0.13 - 0.17	
Heavy soil, average (2-7%)	0.18 - 0.25	
Heavy soil, steep (7%)	0.25 - 0.35	
<b>Streets:</b>		
Asphaltic	0.70 - 0.95	
Concrete	0.80 - 0.95	
Brick	0.70 - 0.85	
Drives and walks	0.75 - 0.85	
<b>Roofs</b>	0.75 - 0.95	

## **Hydrology References:**

Chronicle of the University of California, Volume 1, Number 1, Spring 1998, "Alarums and Diversions, Disasters at Cal"

CH2M Hill. 1994. City of Berkeley Storm Drainage Master Plan. Presented to the City of Berkeley. July 1994.

CS Young, UC Berkeley Campus Utility Infrastructure Study Storm Sewer System Study, July 23, 1993.

Converse Consultants, Hill Area Dewatering and Stabilization Studies, October 1984.

D.O.T. 1995. California Department of Transportation. 1995. Highway Design Manual. 5<sup>th</sup> ed. Sacramento, CA

East Bay Municipal Utility District (EBMUD), 1999 edition, "Its Name Was M. U. D." Book 1, by Noble, John Wesley

Finacom, Steve, The Strawberry Creek Flood of 1962, Chronicle of the University of California, Volume 1, Number 1, Spring 1998.

Goodridge, J.D. 1998. California Rainfall Records 1967-1997. CD. September, 1998. Mendocino, CA

Haltiner, Jeffrey, Phillip Williams and Associates, Strawberry Creek Bank Stabilization Study, University of California at Berkeley, June 1988.

Harding Lawson Associates. 2000. Preliminary Geotechnical Investigation. Stanley Hall Replacement. Capital Projects Reference No. 912040. University of California, Berkeley, CA.

Hyde, G.C., Gray, H.F., Rawn, A.M., "East Bay Cities Sewage Disposal Survey, Report Upon the collection, Treatment and Disposal of Sewage and Industrial Wastes of the East Bay Cities, California" The Board of Consulting Engineers, June 30, 1941.

Kuntz, G. T., Storm Drainage Study Strawberry Creek Watershed at University of California Lawrence Berkeley Laboratory, February 1980.

Lawrence Berkeley Laboratory. 1992. Lawrence Berkeley Laboratory Storm Water Pollution Prevention Plan. Prepared for U.S. Department of Energy under Contract No. DE-AC03-76SF00098. September 30, 1992.

Marangio, M. and S. Poitras,. 1983. comparison of storm response of north and south forks of Strawberry Creek. Special project for L.A. 222, L.B. Leopold (Instructor).



Norfleet, Groundwater Study and Water Supply History of the East Bay Plain, Alameda and Contra Costa Counties, CA, June 15, 1998, by S. Figuers, Nortfleet Consultants, for The Friends of the San Francisco Estuary.

Null, Jan, Golden Gate Weather Services, 2004, <http://ggweather.com/basi.htm>

Rantz, S. E., Mean Annual Runoff in the San Francisco Bay Region, California, 1933-70, Pamphlet to Accompany map MF- 61, United States Geological Survey, Department of the Interior.

RWQCB 1999, California Regional Water Quality Control Board San Francisco Bay Region, East Bay Plain Groundwater Basin Beneficial Use Evaluation Report, Alameda and Contra Costa Counties, CA, June 1999.

University of California, Berkeley. 2005, 2020 Long Range Development Plan and Final Environmental Impact Report, [http://www.cp.berkeley.edu/LRDP\\_2020.htm](http://www.cp.berkeley.edu/LRDP_2020.htm), January 2005.

University of California, Berkeley, EH&S, First Progress Report: Strawberry Creek Pollution Study, March 16, 1971.

U.S. Fish and Wildlife Service, Department of the Interior, 50 CFR Part 17 \*RIN-1018-AJ16 \* Endangered and Threatened Wildlife and Plants; Proposed Designation of Critical Habitat for the California Red-legged Frog (*Rana aurora draytonii*) Federal Register: April 13, 2004 (Volume 69, Number 71, Page 19619-19642) [Proposed Rules]

Willey, S.H. 1887. The History of the College of California.