Strawberry Creek Watershed Storm Plan

University of California, Berkeley

Office of Environment, Health & Safety

Authors: Karl Hans, Aysha Massell, Tim Pine

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Appendix E- History of the Upper Watershed Storm Drain System

Berkeley EH&S

I. Introduction

Scope

This Watershed Storm Plan (WSP) focuses on efforts campus operations staff should take prior to and during a predicted storm event in which peak runoff flow could overwhelm the Strawberry Canyon detention dam[1] (hereafter referred to as the dam) and/or the Oxford Street culvert and cause flooding on the central campus or the City of Berkeley adjacent to the campus. This document also supports campus planning efforts to achieve climate resilience in the decades ahead.

This WSP does not include an evaluation or recommendations on efforts the campus could make toward improving storage capacity of the Strawberry Canyon dam, or reducing runoff in the hill area to more historic conditions in a way that would reduce the flood risk, both of which are worthy of study but beyond the scope of this plan.

Historical Context

In early October 1962, a record storm brought 18 inches of rain over three days to UC Berkeley, causing heavy damage to buildings, construction sites, roads and landscape across campus and the City of Berkeley. In the East Bay, two deaths and millions of dollars of damage were attributed to the storm, which may be the worst Berkeley storm in recorded history (reference: October 15, 1962 Berkeley Daily Gazette)[2].


BERKELEY DAMAGE IN MILLIONS

Berkeley Daily Gazette

U.S. Holding Six In Armed Attack On Cuban Boat

Coakley Endorses Battle on Crime

Storm Kills Son of UC Aide; Hill Area a Mess

Tunnel Highway Closed

"Y" Planning Stepped-Up Teen Work

[1] Note that "detention dam" is the more accurate current definition for this structure. Historical documents sometimes refer to the dam as a "retention basin".

[2] *The Bay Area Storm Index http://ggweather.com/basi.htm ranks the October 12, 1962 storm as the third strongest storm on record for the SF Bay Area with a BASI ranking of 9.7 out of 10, with the other stronger storms being the December 12, 1995 (10.0) and December 22, 1955 (9.8).*

Strawberry Creek, whose South Fork headwaters begin high in the "Hill Campus", and bisects the University from east to west , became a raging torrent of water, mud, and debris that overtopped its banks at many points on the central campus, pouring devastation into the ground floors and basements of many campus buildings (Finacom, 1998).

The deluge prompted an "all hands" response in an attempt to prevent the worst of the damage but after the clouds departed, the full extent of the damage became clear. Costs for repairs ran into the hundreds of thousands of dollars and prompted campus to embark on an ambitious project, the Strawberry Canyon dam, to reduce the potential for future similar storm events to cause similar impacts to campus assets.

Current Conditions

Jumping forward to today, scientists monitoring oceanic El Nino conditions (associated with past above normal rainfall years for California) warned that the 2015-2016 season would be one of most, if not *the* most severe El Ninos recorded, with rainfall totals potentially exceeding the 189% of normal experienced during the 1997-98 season. The imperative for robust storm preparations by UC Berkeley operations staff was clear. The WSP was therefore developed early in the 2015-16 rainy season and was intended to be both a planning and operations guide for campus staff to prepare for and take actions during severe rain events in the Strawberry Creek watershed.

While the 2015-16 rain year for the UC Berkeley campus turned out to be close to normal with no storms posing a significant flood risk, the evaluation completed for the El Nino year has provided useful information to assist the campus for future potential storms that could flood Strawberry Canyon. The findings of the evaluation made it clear that a flood risk will always be present due to the hill area development at Lawrence Berkeley National Labs (LBNL) and Hill Campus facilities. In addition, this study found that the earthen dam is effective as mitigation for moderate to strong storms but that it can be overtopped at some time in the future.

The evaluation also concluded that an extreme storm can occur at almost any time of the rainy season regardless of El Nino conditions or time of year (the October 12, 1962 storm occurred during an El Nino year but early in the season before normal saturated conditions had evolved). Therefore this WSP is intended to provide guidance to campus in perpetuity for rapid response to anticipated severe storms that pose a flood risk.

Attachment E. History of the Upper Watershed Storm Drain System

Introduction to Appendix E: History of the Upper Watershed Storm Drain System

Diverting the canyon portion of Strawberry Creek into culverts started in the early 1920s with the construction of Memorial Stadium. The Little Inch culvert was built to carry the creek under Strawberry Field (now Witter Field) and the stadium to where it emptied onto campus at the Women's Faculty Club.

In 1951 cracks were discovered in the Little Inch Culvert due to stress caused by the Hayward Fault zone. The culvert was repaired at a cost of $225,000 and a new "Big Inch" [1] culvert bypass and a basin and settling basin were constructed just above the Haas pools with the Big Inch emptying next to the Faculty Club.

After the 1962 Columbus Day storm that caused extensive flood damage, the campus began storm drain improvements including widening the creek and building a retaining wall at the Dining Commons and extending the Big Inch Culvert and building a large detention dam in the canyon at the entrance to the Lower Fire Trail. In 1966 the Big Inch bypass was extended 1100 feet to the detention dam which was designed with the intention of preventing the type of flooding that occurred on the campus in 1962. The earthen detention dam has a flood storage capacity of 1.5 million cubic feet (= 11,200,000 gallons). The basin outlet serves to control the flow of water into the Big Inch bypass culvert through use of the 48" X 42" hydraulically operated slide gate. This is the only means of regulating flow coming onto campus.

Lennart (1972) estimated that the maximum peak flow rate potentially entering the bypass system was 1,650 cfs based on a 25 year recurrence interval and that limiting the flow into the bypass system to 850 cfs could avoid damage to the central campus. The remaining runoff could be held in the basin until it reached its capacity with additional runoff overflowing onto Centennial. At the time it was constructed, system was designed to have the flood gate along Centennial Drive at the top of the driveway to the Haas pools closed so runoff could bypass the pools and flow over Strawberry Field onto South Rimway Drive and beyond (which is where the overflow went during the 1962 storm).

In 1963 Lennert and Associates (Lennert) completed a cursory evaluation of runoff and storm flow conditions to address the progressive increased flooding that was occurring post- WWII due to development of the Hill Campus. The report included observations from the October 1962 Columbus Day storm that resulted in significant flood damage to a number of campus locations, overflow of the creek at Oxford down Center Street, and flooding in downstream sections of open channels of Strawberry Creek in west Berkeley. Following is a summary of their observations, particularly ones relevant to current conditions that may assist the campus in response to potential storm drain system overflow in a large storm.

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[1] *No records have been found that explain the naming of these culverts as the Big Inch and Little Inch. It is likely, given the construction of the Big Inch in 1951 shortly after World War II, that the engineers of the system were emulating the naming of the War Emergency Pipelines constructed from Texas to New Jersey which were named the "Big Inch" and "Little Big Inch".*

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History of Campus development obligating peak flow controls in Strawberry Canyon

Just after World War II, the Upper Strawberry Canyon Watershed, designated Zone IV by Lennert, (the watershed above the existing Big Inch Culvert inlet where it was located below Chicken Creek in 1962) was largely undeveloped. Lennert estimated the time of accumulation (time of concentration or time to peak flow) to have been two hours with a runoff coefficient of 0.5 leading to a peak storm flow of 350 cfs (for a 10 year storm) (Zone IV p.8). In 1945 the accumulation time for flow from the upper watershed into Lower Strawberry Creek on campus was estimated to be at least two hours and its contribution to peak flood-flow in the creek was minor. By 1960 the accumulation time had shortened to around one-half hour and the maximum peak storm-flow in lower Strawberry Creek was in the order of double the maximum flow in 1945. (Lennert Zone II, November 2, 1960 p.3-4)

The Little Inch, which had been constructed in the early 1920s to intercept all of Strawberry Creek flow through a channel under Memorial Stadium, was adequate to carry the storm flow until 1950 but apparently not after that time and the Big Inch bypass culvert was therefore constructed in 1951 (Charbonneau, p. 30 and Lennert Zone III December 17, 1962 p. 2). The Big Inch was designed to carry peak flow and the Little Inch to carry the normal low-rate flow, in order to provide a permanent flow into the Faculty Glade area for "esthetic reasons". (Lennert Zone III December 17, 1962 p. 1)

By 1962 the runoff had increased to the point that that the Zone IV watershed had flooded the lower canyon area during every heavy runoff event since 1955, reported to be three times in seven years (Zone IV p. 11), even though the storms had not been 10 year events. Lennert reported that "it seems most probably that we have yet to see the effects of a true "ten year storm" on the Strawberry Creek watershed". They also concluded that the development that had occurred to 1962 had already increased the majority of the peak runoff that would occur with the proposed 1962 LRDP development and that if the watershed were to be developed to the degree of central campus, the peak runoff value would increase by a large factor (in the range of 1,700 cfs, p. 8).

Flooding of the lower canyon was attributed to plugging of the Big Inch culvert and the effects of the peak runoff did not reach the campus. Lennert estimated that had the peak runoff of a ten year storm dumped on to lower Strawberry Creek on campus the creek would overflow at certain points due to inadequate channel capacity, as well as to the "shoaling "effect of the new coarse bed load materials and that the resulting flooding and damage seen in October 1962 might well have been more severe and costly ("quite spectacular" Zone IV p. 12). The creek on campus during that storm was described as a raging torrent, and caused estimated $100,000 damage to the University (Finacom, pages 107-109). Flooding occurred in Haas Clubhouse, the International House, Cowell Hospital, at Sather Gate, in the Student Center complex where water poured into the underground garage and basement offices of what is now the Chavez Center, and into Center Street in downtown Berkeley. Three major buildings under construction, Barrows, Wurster, and Etcheverry were also flooded, giving an idea of the wide areal extent of the flood conditions and how different they were than the low flow creek channel.

Due to the condition of the system in 1962 as evaluated by Lennert, they recommended, as the highest priority measure, the construction of a new inlet system to the Big Inch and the simultaneous reconstruction of lower Strawberry Creek on campus (Lennert, April 11, 1963 cover, p. 3). They recommended the new inlet system be moved upstream and raised in elevation (to improve hydraulic efficiency, prevent plugging, and provide greater hydraulic head than the flat portion of the pipe where the existing inlet was placed [March 30, 1963 p. 12]) and that a surface diversion to carry peak flow in excess of a 10 year storm be constructed to drain flow down “North Canyon Road to Gayley Road, thence to University Drive, thence to Oxford Street”. They stated, “A low basin would provide the best solution, offering a good surcharge head for the sewer, a hydraulically efficient inlet structure, positive control of bed and float load, and storage for clipping the peaks off peak storm runoff.” (Zone III December 17, 1962, p.4) The purposeful overflow at the Big Inch culvert was intended to result in a splitting the peak flow to limit flooding and damage on the central campus. In fact, in their evaluation the creek on campus in not adequate to carry a ten year storm… and some areas are probably grossly inadequate to carry the flow and accompanying bed and float loads from a three years storm, “ and so “we believe that the only reason that severe flooding, erosion, and re-channeling has not taken place during the last five years, is that malfunctioning of the inlet to the Big Inch storm sewer has “split” the peak flows and the creek has thus not experienced a true peak flow for over five years. (Lennert, March 30, 1963 p. 10)

The report also recommended numerous other measures that exacerbated the flooding conditions, such as rerouting LBNL diversions to Chicken Creek back to Blackberry Creek (North Fork), and the armoring Chicken Creek where landslides of loose Orinda formation soils resulting in discharges of bed material. Kuntz also reported exposed construction at two locations, including “extensive earthwork in progress it the Building 77 area” cause the rain to carry tons of earth, mud and rock downstream to the Big Inch bypass (Kuntz 2004, p. 2). [2]

[2] *On March 25, 2016 UC and LBNL staff met with 93 year old Ted Kuntz. Mr. Kuntz, who was a LBNL site engineer at the time of the 1962 Columbus Day storm, confirmed the plugging of the Big Inch resulted from bed material released from a construction site. Over 100 linear feet of the culvert was plugged and had to be cleared after the storm by laborers using hand shovels and wheelbarrows.*

By 1966 the earthen detention dam and Big Inch Bypass extension and Bypass were constructed. Work was also completed on campus in the 1960s for improvements recommended by Lennert so that the creek on campus could carry peak flows and accompanying bed and float loads. Extensive modifications recommended included elimination or bypass of sharper bends in the upper area, enlargement of the flow section, stabilization of creek embankments and underpinning of some abutting facilities. (March 30, 1963 p. 13) Many of these corrections were probably made in the 1960s and 1970s such as the bypass at the Old Art Museum to prevent the shoaling at Sather Gate and flooding into the Chavez area that occurred in the October 1962 storm (note this was re-configured as a high-flow bypass in the late 1980s as part of the Strawberry Creek Management Plan implementation).

Runoff for Design

The Lennert report section on the Zone IV- Upper Strawberry Canyon Creek Watershed provides the runoff calculations used as a basis to size a control structure in the canyon. Page 5 provides a good explanation of how runoff from a given storm drainage area varies widely with intensity and duration of precipitation:

"If a storm gradually builds in intensity over, say, 2 hours ending with a severe ½ hour deluge, it will, in a watershed such as Zone IV, produce a peak runoff of extreme magnitude. This is due to the overlapping of peak runoffs from areas of decreasing accumulation times, ending with the final introduction of a severe peak from the areas of short accumulation time which correspond to the last ½ hour peak intensity of the storm and producing a runoff coefficient of nearly unity for all areas. At the other extreme, if a storm of ½ hour duration is not preceded by a "cascading" buildup in intensity, the runoff coefficient will be unity only for the low accumulation-time areas, and all other areas will show only factional runoff coefficients resulting in a greatly reduced peak runoff. The intensity – duration pattern of most real storms lies somewhere between these extremes."

They explain that properly designed and effective storm drainage systems are not designed for daily flow, but are designed for a peak storm runoff lasting only a fraction of an hour, which will occur only once in 10, 20 or 30 years, as it is these infrequent storms which cause severe flooding and damage and must be contained. Where flooding will result in great damage the engineer might designed a system for a 20 year storm and allow the street system to take all other peak flow, or to a 50 year storm without any serious damage but very few are designed this way due to the extreme cost. (p. 6)

Due to the "wringer" effect of the Berkeley Hills Lennert assumed double the intensity in the hills for a 15 minute storm compared to the flat area below. Bursts of rainfall of high intensity and short duration probably occur more often in the hill areas than in the flat areas below. For the purpose of the report they used the following Duration- Intensity relationships and calculated the rough estimate total peak flow into the Big Inch Culvert inlet.

Duration (hours)	Intensity (Inches per hour)
½	2 ½
1	1 ½
2	1

This resulted in peak flow calculated to be = 1150 cfs (and 1460 cfs for a cascading flow). Therefore they concluded that the range of peak runoff was:

Minimum Peak Flow= 700 cfs
Maximum Peak Flow = 1,500 cfs

This estimate included all development anticipated by the 1962 Long Range Development Plan.

Kuntz (2004) estimated at peak flow from the upper watershed at the Big Inch inlet to be 920 cfs from a 100- year storm. This calculation is lower than the Lennert report in part because the Chicken Creek watershed was removed from the flow to the inlet when the Big Inch was extended 1,100 feet up the canyon in 1966, removing a peak flow of 149 cfs from Chicken Creek. Other differences in calculations need to be evaluated, but these estimates provide some insight into the type of storm event that could deliver sufficient peak flow quantities of runoff to overwhelm the detention dam.

Low-flow vs. peak-intensity runoff pattern

Peak-intensity runoff pattern bears little resemblance to the low-flow pattern, due to inadequacy of the culvert inlet system and plugging of the inlets. ("In many campus areas there is no resemblance between low flow patterns and those at peak flow" March 30, 1963 p. 11). Peak-flow drainage is dependent on street and ground configuration. Thus while the low-intensity flow pattern , as set by the storm sewer-culvert-inlet system protects the campus at low flows, at peak intensity flows can flood areas as occurred during 10/62 at Haas Recreation Center, Cowell Hospital, International House, and the Student Center (presumably Chavez), and also at Center Street downtown. Lennert recommended an "entire area layout" design that includes the peak flow drainage in a Master Drainage Plan for present and all future development. (Lennert Summary Letter 11/9/62)

References

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Kuntz, G. T. Storm Drainage Study of Eastern Portion of the Strawberry Creek Watershed at University of California Lawrence Berkeley National Laboratory, October 2004

Lennert, Preliminary Storm Drainage Investigations and Recommendations for Remedial Measures, May 3, 1963 (including numerous referenced reports as attachments)