BANK ON IT

SLOWING THE FLOW ON STRAWBERRY CREEK

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At A Glance:

- 1/2 acre eco-revelatory stormwater and creek enhancement project in the heart of campus
- 2 acre stormwater drainage management area (DMA) addressed by design
- Stormwater “Treatment Train” captures, treats, and gradually releases ~4,200 ft^3 of stormwater into Strawberry Creek during an 80th-percentile rain event
- Enhanced creek bed and banks provide ~2,000 ft^3 of dynamic instream storage during peak flows
- Multibenefit design addresses high priority campus health and safety concerns

ABSTRACT

Bank On It integrates green infrastructure on the banks of Strawberry Creek to support campus flood mitigation and stormwater objectives. The project transforms a polluting parking lot and a neglected reach of Strawberry Creek into a vibrant, multifunctional plaza converging people and water. Permeable pavers, subterranean check dams, and terraced bioretention cells provide a stormwater "treatment train" to capture, clean and slowly release runoff into an enhanced stream corridor. *Bank On It* goes further: declaring our campus and surrounding community deserve a space to discover and celebrate a critical cornerstone of UC Berkeley and its watershed. *Bank On It* utilizes an eco-revelatory design approach to spotlight Strawberry Creek as the ecological heart of the UC Berkeley campus and challenges the campus community to reconsider its role in regional hydrologic dynamics. The overarching objectives of *Bank On It* are framed in contexts beyond the concerns of a single campus: global climate change is driving more frequent wildfires and atmospheric rain events in the region, posing dramatic stormwater impacts. *Bank On It* reimagines Strawberry Creek as more than a stormwater conveyance system and redefines it as an opportunity to explore sustainable development and take steps toward a more resilient, vibrant future.

INTRODUCTION

Meet Strawberry Creek

The University of California at Berkeley (UC Berkeley) was established along the banks of Strawberry Creek. For the Trustees the creek provided an idyllic landscape and a freshwater source for a growing educational community. Strawberry Creek's North and South Forks were the geographic features around which buildings, pathways and vegetation would be organized. Proximity to the creek was alluring but development along the riparian corridor also impaired stream health, an ongoing dynamic which campus managers refer to as "loving the creek to death". The creek became a refuse pathway: used to flush sewage and wastewater off campus.

In the 20th century, an engineering-centered approach to water management, aimed at shunting water through and off campus as quickly as possible, further altered Strawberry Creek. On campus, the creek became increasingly fortified with masonry structures to hem in the creek's waters. Perceptions of reduced flood risk led buildings and infrastructure to encroach ever closer to the creek, thus functionally eliminating most of the natural floodplain.

In the 1960's an increased awareness around clean water and ecosystem health on campus and in the community began to transform Strawberry Creek. Wastewater discharges were identified through dye tests, connections were terminated and pipes removed. Water quality remediation later expanded to stream channel improvements, like regrading for fish passage and replacing riprap used for bank stabilization with redwood cribwalls. Most recently, student-organized efforts have focused on removing highly-invasive plants like Himalayan blackberry and Algerian Ivy and replanting the banks with native vegetation.

Strawberry Creek is the outdoor classroom for students studying stream restoration, benthic macroinvertebrates, water quality and much more. The creek is the introductory landscape for science education for thousands of UC Berkeley's students and the testing ground for new study methods and technologies. Any conversation around water on campus, both instream and anthropogenic, starts with Strawberry Creek.

Unfortunately, and in spite of recent progress made in addressing creek health on campus, Strawberry Creek remains impaired. An immediate challenge to remediation is that the creek seems to slip in and out of focus across campus. In interviews with campus and community members at the demonstration project site, over 60% of people surveyed did not know the name of Strawberry Creek. Over 10% of surveyed students did not know there were waterways on campus.

Strawberry Creek Hydrology

Strawberry Creek connects the UC Berkeley campus and the greater Berkeley community. The creek's North Fork runs from residential neighborhoods in the Berkeley hills and enters the north side of campus, carrying approximately three quarters of the water passing through the campus. The longer South Fork drains a large, mostly undeveloped canyon upstream, before converging with the North Fork and discharging into Berkeley's municipal stormwater culvert at the western edge of campus. Strawberry Creek reemerges from stormwater culverts in parks and residential backyards, and was the first waterway in the nation to be successfully daylit through a grass-roots campaign led by community members and UC Berkeley faculty and students. As the most prominent and historically significant waterway in Berkeley's history, the health and condition of Strawberry Creek symbolizes the environmental ethic and commitment of UC Berkeley and the greater community.

Water Quality

In 2016, Strawberry Creek was listed by the San Francisco Bay Regional Water Quality Control Board as a water body impaired by trash (SFRWQCB, 2016). The listing points to a growing prevalence of trash and refuse within and adjacent to the creek, though a 2007 San Francisco Bay Rapid Trash Assessment (RTA) located trash hotspots in the lower reaches of the creek (SWAMP, 2007). Monitoring in lower campus sites identified substantially lower trash deposition, which can be attributed in part to efforts by students and campus planners and the longitudinal position in the watershed (EHS, 2006).

Strawberry Creek water quality and aesthetics are overseen by the Department of Environment, Health and Safety (EHS). Monitoring by EHS showed trash as having an insignificant effect on bacteria levels in the creek. Generally, samples collected along Strawberry Creek do not exceed the San Francisco Regional Water Quality Control Board and the Basin Plan requirements for common stormwater pollutants like metals, nutrients and bacteria.

Current and Future Flooding

Supplanting water quality concerns on campus are those of flooding. As a highly-developed, urban riparian corridor, Strawberry Creek takes a narrow and incised pathway through campus, flanked by impermeable concrete pathways and buildings. In the City of Berkeley this path continues, at times narrowing at stormwater culverts. With an average flow of <1 cubic feet per second (cfs) during dry weather, the creek channel is generally sufficient for conveyance. During a recent storm event where 1.09 inches of rain fell over 24 hours, the flow increased to about 12 cfs.

In the one hour, 10-year recurrence interval storm, the flows are expected to be above 100 cfs. Dropping from 1,760 feet above sea level at the top of the watershed to 200 feet above sea level at the base of campus, the South Fork of Strawberry Creek has a steep profile and there are few places were the creek slope eases and infiltration of flows into the stream bed can occur. A steep slope compounded by its narrow stream profile results in fast, flash flows through Strawberry Creek during heavy rainfall events.

Flow rates at Strawberry Creek Stream Gages are as follows:

Year Storm	Oxford Street Culvert (cfs)	South Fork (cfs)	North Fork (cfs)
10	426	111	315
15	463	120	343
20	500	130	370
25	534	139	395
50	684	178	506
75	797	207	590
100	874	227	647

Extreme rainfall events have resulted in flooding and damages to property downstream in addition to hazardous on-campus conditions, both are major liabilities for campus administration. In 1995, a winter storm caused Strawberry Creek to overtop its banks on campus, flooding the adjacent neighborhood. Beyond damage to property and risks to the campus community, flooding results in sheeting water along roadways: mobilizing pollutants and compromising the quality of receiving waters. Minimizing stormwater runoff is one of the priority goals of the Alameda Countywide Municipal National Pollutant Discharge Elimination System (NPDES) Stormwater Permit.

According to a UCLA study published in 2018, California is expected to see more severe droughts and winter storms, fueled by a warmer climate and an increase in atmospheric water vapor. The study found over the course of the next 40 years, the state is 300 to 400 percent more likely to have prolonged storm sequences, back-to-back rain events cause flooding as severe as the Great Flood of 1862, which inundated and damaged one-third of California's taxable land (UCLA, 2018). These predictions do not bode well for a highly constrained Strawberry Creek; and emphasize the priority of creating spaces to store and slow its flows.

PROJECT GOALS + OBJECTIVES

Bank On It draws from the team's stormwater and stream restoration expertise to create a high-performance landscape to treat stormwater, mitigate flood risk, improve campus safety and engage the broader community. Interdisciplinary design objectives include:

- Slowing stormwater runoff to infiltrate flows, and contain and treat nonpoint source pollutants through visually appealing green infrastructure.
- Expanding Strawberry Creek channel width to handle existing and predicted flood risk by improving the nature-based performance of the site.
- Installing weir and energy dissipators to create pool formations to demarcate rainfall and flood stage along the creek during storm events.
- Providing viewing platforms as informal gathering and educational spaces to attract visitors while also introducing the dynamic nature of the creek.
- Enhancing energy dissipators above and below ground to improve creek management while offering multi-sensory experiences for site visitors.
- Creating accessible routes to experience Strawberry Creek to increase interaction while managing inadvertent harm to the urban riparian corridor.

- Curate compelling viewsheds to increase site security and activate the site with new interest.

To frame the theoretical approach to the site selection, design process and research rationale, the team was compelled by an underlying interest in integrating *Eco-Revelatory* design principles. Indeed, by "highlighting the particular ecological relationships at a given site...such design can punctuate and enliven our environment and sensitize us to what is known about its interlocking complexities" (Brown, Harkness and Johnston; 1998). Thus, the objectives identified above were conceived and pursued within a framework based on improving hydrologic, ecologic and human flows while illustrating their interrelationships.

SITE SELECTION + DESCRIPTION: Strawberry Creek at Wheeler Glade

The South Fork of Strawberry Creek flows under a 60-foot wide bridge, which is framed by Sather Gate, an iconic landmark on Sproul Plaza. This is the heart of campus, where thousands of students pass each day on their way to class. It is surrounded by UC Berkeley's Student Center and Services buildings, Zellerbach Hall's 2,500-seat performance venue, and the de-facto gateway to Berkeley's "Southside" converge. Despite its centrality, the creek is screened by overgrown vegetation and parked cars: and is thereby essentially disconnected from the bustle of Sproul Plaza.

Strawberry Creek at Wheeler Glade, located just north of Sather Gate, is a site which allows for immediate interaction with the creek, but is generally underused and is impacted by trash. One bank features a small amphitheater overlooking the creek as it meanders to a rocky outcropping (which provides a potentially dangerous "informal crossing" for students) and plunges 50" into a deep pool. Wheeler Glade is accessed on the south side through a 25-stall parking lot or from the opposite bank along a narrow trail through thick ivy. Wheeler Glade embodies the complex relationship between the campus community and the creek insofar as it is both neglected and used as an informal crossing site. Furthermore, the wide and shallow morphology of the glade and its stormwater context make it an excellent demonstration site for a stormwater management area. Wheeler Glade provides distinctive green infrastructure and landscape design opportunities to accomplish the following:

- Treat and Slow Flows: Wheeler Glade is a uniquely wide and flat section of Strawberry Creek. Over the 250-foot reach, the creek only drops six feet. Spreading across 0.344 acres of Wheeler Glade is a relatively wide, albeit altered, riparian buffer area, providing an excellent opportunity for expanding the stream channel itself and augmenting the bankside green infrastructure to treat stormwater. Strawberry Creek at Wheeler Glade is the receiving water for a number of stormwater outfalls draining nearby buildings, Sproul Plaza, concrete pathways, roads and a particularly problematic and polluting parking lot. Green infrastructure can protect the creek from wet-weather impairment from sediment, nutrients, heavy metals, pathogens, pesticides, car oil and grease, trash and leaf litter and toxic organic compounds.
- Connect Community to Creek: Wheeler Glade is just upstream from a primary pathway through campus. Its centrality offers an opportunity to engage the greater campus community in observing and better understanding campus hydrology through green infrastructure. The site is currently underutilized and even avoided by some due to safety concerns. It is prone to accumulation of trash and is at times the site for illegal drug usage and homeless encampments.
- Support Safe Circulation: Eliminating car-based traffic within campus is a campus planning goal. The 25-stall parking lot adjacent to Wheeler Glade is one of the few remaining surface parking lots on campus. The parking lot is located at the dead end of a road and availability of parking is unmarked:

requiring drivers to reverse or complete a three-point turn out of the parking lot. The adjacent nine foot sidewalk connecting the eastern half of campus to Sproul Plaza barely supports the high yield of pedestrians and bikers. As a result the small area is often overwhelmed by cars, bikers and pedestrians hurriedly circumventing each other. Removing cars from the space and widening the path, allows for safer passage by bikers and pedestrians, and improved access for ADA users. It also removes the visual obstacles currently blocking Wheeler Glade and continues to detach campus from the creek.

When the *Bank On It* team consulted with campus planners, Wheeler Glade was identified as an ideal place for stream improvements and green infrastructure. Wheeler Glade has been identified for further development in long-range development planning documents.

RESEARCH + DESIGN METHODS

The *Bank On It* team members applied individual expertise to generate a comprehensive profile of the site. Team members with stormwater management and stream ecology experience conducted a disturbance survey of the site, identified nonpoint sources and opportunities for stream enhancement. Team members with an interest in placemaking and human experience conducted usage surveys of the site and surrounding areas. The team catalogued the plant species present at the site. Through a series of conceptual and schematic design charettes and reviews, the project developed through the integration of technical analysis and formal landscape architectural design and environmental planning processes.

Hydrology

The hydrology team was responsible for surveying of stream ecology and stormwater conditions along the reach, including mapping the site's drainage management area (DMA). The creek's flows were also examined and modeled based on campus gages and historic storm events. Most of the year Strawberry Creek trickles through Wheeler Glade. The stream channel is approximately three feet wide, one foot deep and the bank and stream bed have been lined on all sides with concrete and cobble to prevent erosion and improve laminar flow. The mostly linear stream conditions limit habitat complexity, the propagation of streamside vegetation and reduce shelter for aquatic species in high-flow events.

At Wheeler Glade, Strawberry Creek emerges from a meandering canyon-like channel. The creek path careens around a final elbow turn before entering the glade. At this elbow, campus planners installed a culvert to allow for high flows to punch through the existing embankment and prevent erosion. During flood stage, the creek flows through the culvert and overtops the existing banks and sweeps through the glade. The team identified storm drains and stormwater outfalls connecting campus to the creek and monitored for visible nonpoint source pollutants. Trash, leaf litter and car oil and grease were the most prevalent pollutants identified in dry weather conditions.

Vegetation

Presently Wheeler Glade supports a mix of plants native to coastal California and highly-invasive non-native species. The south bank is dominated by a stand of mature Coast Redwood (Sequoia sempervirens) trees. Office of Environment, Health and Safety identified specific individual trees for removal due to their age and health. Algerian Ivy and Himalayan Blackberry dominate most of the north bank, covering the steeper north bank slope from the creek to a retaining wall.

Pedestrian Use

Current uses of Wheeler Glade and the surrounding areas were monitored by the team at different times on weekends and weekdays in order to identify current circulation patterns, activities and user profiles. The most heavily used area is the southwest corner of the site; a mulched open area that sits between the parking lot, Sproul Plaza and a pedestrian walkway. Pedestrians cut across this corner as a shortcut when the node is heavily trafficked, affirming the need for widened access points between the site and Sproul Plaza.

Campus Experts + Community Interviews

The *Bank On It* design process was informed by interviews conducted with campus administration and staff involved in Strawberry Creek care, stormwater management and campus long-term planning. The University's Assistant Vice Chancellor and Campus Architect, Wendy Hillis, and Environmental Health and Safety Office provided planning and design guidance in addition to the provision of technical files by the Office of Capital Projects. In-field surveys of students, community residents and visitors helped develop a basic understanding of the site's presence and role in terms of awareness.

DESIGN

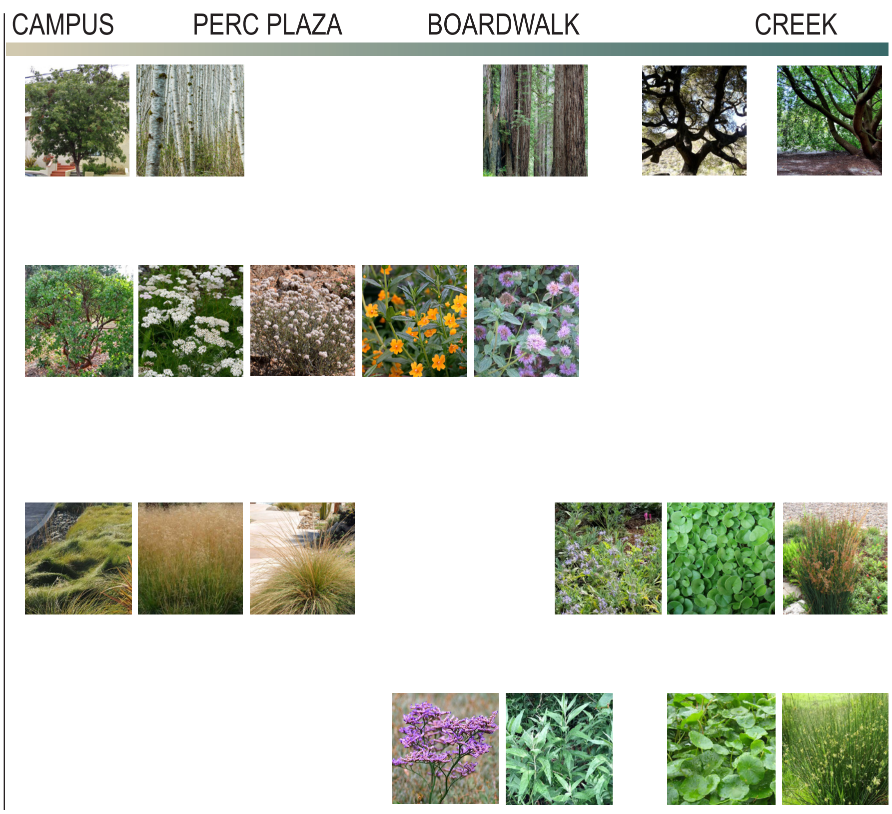
Emanating from the creek's morphology, the south bank's design pays homage to the naturalistic forms Frederick Law Olmsted hoped would be preserved in the eventual campus plan by contrasting curvilinear stormwater terraces with more angular geometries defining human spaces. The design also leverages gradients of human activity and planting choices, encouraging high use amid woody species near the plaza, and transitioning to herbaceous riparian species beyond the boardwalk, thereby protecting the banks from compaction and over-use. The gradient is visually represented below:

TREES:
Red Alder
Catalina Ironwood

SHRUBS:
Manzanita Densiflora
Red Twig Dogwood
Coffee Berry
Yarrow
Mimulus Arantiacus
Narrow Leaf Buckwheat
Coyote Mint

GRASSES + GROUNDCOVER:
Molate Fescue
Purple Three-Awn
Salvia Sonomensis
Dichondra
California Grey Rush

EMERGENT:
Pacific Rush
Marsh Rosemary
Mugwort
Marsh Pennywort



South Bank: Approach

Bank On It proposes a high-performance green infrastructure project spanning from the current entrance of the parking lot to the Strawberry Creek bank edge. In its new form, the south bank slows and retains stormwater runoff for infiltration from surrounding areas to a) treat non-point source pollution and b) reduce surface flows entering the stream which would trigger subsequent downstream flooding during peak rainfall.

The stormwater "treatment train" on the south bank begins with gravity-fed capture of DMA stormwater at the permeable plaza, an inviting yet intimately scaled space which features social seating beneath flowering dogwood trees. After flowing through the pervious pavers, an underground check dam system slows the water, enabling it to pool and infiltrate. Excess runoff flows into a series of five bioretention terraces. These terraces flank the redwood boardwalk, constructed with trees removed during site regrading. Experientially, visitors on the boardwalk become immersed within the green infrastructure, directly observing the bioretention cell functionality. Finally, water exits the terraces by spilling onto reclaimed concrete gabions, infilled with concrete from site demolition, lining the creek edge. The gabions form an armored "apron" at the toe of the bioretention terrace which dissipates energy and prevents downcutting.

Rainfall and resulting the stormwater volume influences how and when each step of the treatment train is activated. During low-rainfall events, runoff may be retained in totality within the permeable paver system, where runoff will seemingly disappear from sight into the subsurface gallery. During higher rainfall events, the entire system can be visibly activated, where runoff beyond the pervious paver's capacity will spill over into the first bioretention cell. As the cell becomes overtopped with water, the runoff will decant over terraced walls and cascade through the bioretention terrace to each subsequent cell. In extreme rain storm events, excess flows filtered of first-flush pollutants will outfall into the creek.

The project's design language aims to increase the legibility of the site's functionality. Bioretention terraces nearest the boardwalk are marked and labeled with percolation time horizons below the notches, indicating to visitors how much time has passed since a major rain event filled the cell. When rain events surpass the permeable plaza's storage capacity, excess water flows from under the "unraveled" western edge of the plaza into the first bioretention planter, thereby illuminating the plaza's subterranean design features. Finally, interpretive signage near the plaza and the two redwood viewing decks invite visitors to explore the site's functionality more deeply, and provide space for outdoor classrooms and lab activities.

South Bank: Methods

The low impact development best management practices (BMP) employed in *Bank On It* are derived from the Provision C.3 handbook, a policy-based technical guide for green infrastructure compliance with the municipal stormwater permit set forth by the San Francisco Regional Water Quality Control Board for post-construction stormwater treatment. The team also consulted stormwater professionals at Sherwood Design Engineers and utilized the BMP handbook from the California Stormwater Quality Association (CASQA). AECOM civil engineers advised the team regarding successes of recently-installed, local green infrastructure. The successful conversion of a street adjacent to campus into a permeable paver system with underground check dams capable of slowing, capturing and detaining stormwater has led the City of Berkeley to advocate for broader implementation of these structures locally and attracted attention of campus planners.

To start, the team surveyed a DMA associated with the existing stormwater outfalls which included rooftop areas of adjacent buildings, hardscapes, sidewalks, a road and parking lot. The team identified pollutants present in the DMA and entering Strawberry Creek at the site, including nutrients, pesticides, bacteria, heavy metals, toxic organic compounds, oil, grease and sediment.

South Bank: Volume-Based Runoff Treatment

A volume-based treatment approach, using retention and infiltration of stormwater, is the primary tool for runoff treatment on the south bank. Per C3 Provisions, treatment BMPs are designed to capture 80% of the average annual rainfall, i.e., 80th percentile rain event, equivalent to a 0.95-inch rain event. The following equation is used to determine the design volume required to be treated and the sizing of the BMP features used in the project:

Design Volume = (Effective Impervious Area) * 0.95”
Design Volume = [(0.1 * pervious area) + (1 * impervious area)] * 0.95”
BMP footprint = Volume / (BMP depth * porosity)

Additionally, the design volume has been upsized by 10% to account for regional predictions in precipitation during the wet season. The treatment train proposed *Bank On It* will have a total treatment capacity of 4,962 ft3.

DMA	Area	Pervious-ness	Storm Depth	Design Volume	Projected Storm Depth	Projected Design Volume	Proposed Treatment Volume
South Bank	2 ac	32%	0.95 in	4.024 cf	1.05 in	4,427 cf	4,962 cf

Pervious Pavers

The project site’s existing parking lot will be replaced with a plaza with pervious pavers to reduce overall DMA imperviousness and generated runoff volumes. Pervious pavers are the first line of stormwater management in the *Bank On It* design. Unlike conventional sidewalk treatment, pervious pavers have porous joints to promote infiltration into a gravel subsurface gallery for storage, and capture and remove pollutants from runoff. Because the pervious pavers are on a sloped decline, a series of 8 check dams in the subsurface gallery will slow flows to maximize infiltration. The substrate contains pollutants from cars and landscaping: total suspended solids, sediment, heavy metals, nutrients, and hydrocarbons. But, pervious pavers do not actually treat pollutants; captured pollutants remain trapped in the subsurface gravel layer and need to be manually removed during maintenance.

Pervious Paver Area	Gallery Depth	Porosity	Effective Depth	Net Treatment Volume	Infiltration Rate	Drawdown Time
2,585 sf	1 ft	30%	0.3 ft	421 cf[1]	.1 in/hr[2]	36 hours

[1] Treatment volume takes into account capacity reduction due to slope decline and check dam system.
[2] Conservative estimate of infiltration rate, to be verified by geotechnical engineer.

South Bank: Bioretention Terrace

Runoff not stored within the pervious pavers system overflows into a series of stepped bioretention cells, whose walls are cast-in-place reinforced concrete. Bioretention BMPs are vegetation-based treatment systems consisting of a ponding area to retain runoff, vegetation to filter and treat runoff pollutants, and planting soil to promote infiltration. Bioretention planters have high treatment rates for identified pollutants for *Bank On It*, including TSS/sediment, heavy metals, nutrients, hydrocarbons, pathogens, trash/debris, and organics. Vegetation in these cells are selected to filter pollutants and provide phytoremediation to break down pollutants, a process unique to this BMP.

Bank On It integrates stepped biofiltration cells which cover a total of 4,541 square feet, and follows the meander of the bank edge while terracing down from the pervious paver plaza. Each cell has a ponding depth of 1 ft, with surface areas varying from 627 square feet to 1,488 square feet, and is designed to overflow into the downstream neighboring cell, treating runoff before it reaches the creek. When fully activated, the cells can store and treat a total of 4,541 cubic feet of runoff.

Cells are filled with layers of native soils and cobble, gravel, and sand: planted with species recommended by the Alameda County Clean Water Program which outlines green infrastructure best practices. The planting palette shown previously includes native species Molate Fescue, Purple Three Awn, and California Grey Rush which integrate vibrant aesthetic and stormwater performance.

The drawdown time (the time it takes for water to infiltrate soils and completely vacate the infiltration system) is a critical performance consideration for the proposed system as a) vector control can prevent mosquito breeding, and b) drawdown rates informs sizing. According to the C3 stormwater manual, the maximum allowable drawdown time is 5 days, or 120 hours but with predictions of heavier, back-to-back rainfall events in California, the system needs to handle consecutive storms with already saturated soils. *Bank On It* uses a conservative drawdown rate of about 0.1 inches per hour, meaning the pervious paver drawdown time is 36 hours and bioretention terrace drawdown time is 120 hours. Since pervious pavers are the pre-treatment application and have a faster drawdown time, they are able to handle initial runoff from subsequent rainstorms, allowing time for bioretention terraces to drawdown before handling subsequent runoff volumes.

Terrace	Area	Ponding Depth	Treatment Volume	Infiltration Rate	Drawdown Time
1	1,488 sf	1 ft	1,488 cf	.1 in/hr[1]	120 hours
2	733 sf	1 ft	733 cf		
3	873 sf	1 ft	873 cf		
4	627 sf	1 ft	627 cf		
5	820 sf	1 ft	820 cf		

[1] Conservative estimate of infiltration rate, to be verified by geotechnical engineer.

Creek Enhancement

Bank On It proposes expanding the Strawberry Creek channel within Wheeler Glade to increase in-stream flow capacity and retention during high flow events. Strawberry Creek will be regraded to

a) change the existing channel width from two feet to twelve feet and

b) replace the existing four-foot plunge pool and waterfall formation with two eighteen-inch tall notched weirs.

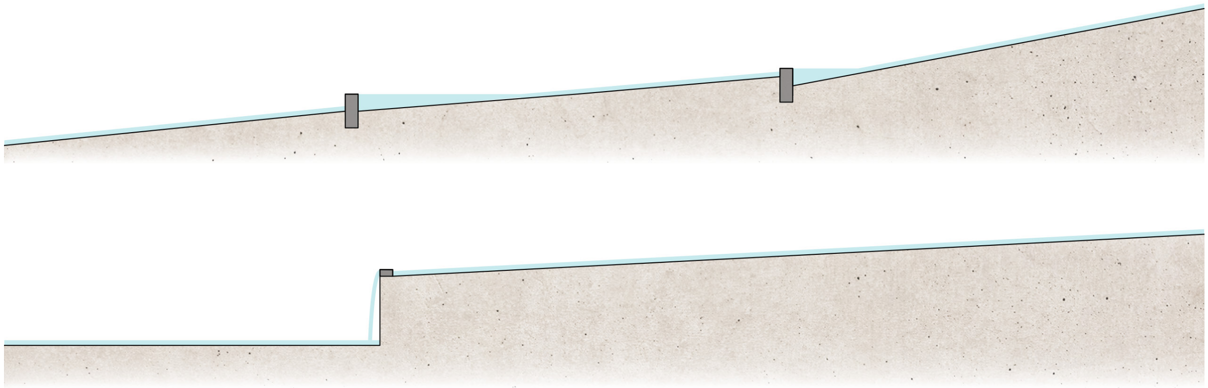


Figure 1: Creek Bed Profile. A primary strategy for enhancing the creek bed involves replacing the existing four-foot plunge pool and waterfall formation with two 18-inch weirs

Each proposed concrete weir spans the width of the channel and features a raked notch which allows for Strawberry Creek to flow through during dry weather. In high flow events, the raked feature captures trash and debris but allow for sediment to flow through. The new weir formation will decrease abrupt elevation changes and allow for improved fish passage.

The new channel formation boasts two basins which can pool with water and slow flow during rain events, but permit the stream to flow during dry-weather conditions. The larger of the two, the upstream basin, will provide temporary storage capacity in a basin resulting from regrading of creek banks.

The proposed stream bank will be planted with native plants like Pacific Rush, native rosemary species and mugwort to stabilize bank composition and provide food and shelter to local fauna. The south bank, where green infrastructure meets the creek, will be stabilized by tiered gabion walls to prevent scour and undermining of the system during high flow events.

Additionally, the treatment train of pervious pavers and bioretention terraces will retain runoff to minimize hydromodification of Strawberry Creek due to excess runoff flowing into a naturalized water channel. Hydromodification refers to the alteration of natural watershed hydrology due to land use changes which increase flows and contribute to physical and biological stream degradation from erosion, sedimentation, and natural habitat disturbances. By converting the existing parking lot to pervious surfaces, the volume of generated runoff is reduced, and the proposed treatment train design for *Bank On It* will retain runoff volumes from the 80th percentile rain event. This reduction will minimize flow disturbances to Strawberry Creek and the proposed channel enhancements, allowing the newly-established wildlife flourish and thrive.

North Bank: Objectives + Approach

Bank On It proposes the north bank as a habitat enhancement zone, focusing on invasive species removal in early stages and revegetation after construction of the project. With no direct pedestrian access, this side of the creek provides attractive habitat for fauna, becoming an ecological theater for human spectators on the opposite bank.

Monocultures of Algerian ivy and Himalayan blackberry currently dominate the north bank and will be replaced by native riparian grasses like Pacific reed grass and striped rush, and high stature shrubs like coffeeberry, manzanita, and willows. Native species provide food and shelter for local fauna, fish, and aquatic benthic macroinvertebrates, while stabilizing the north bank.

IMPLEMENTATION

Community Engagement

UC Berkeley is a living lab providing several scales of study and possible application. The University prides itself as an institution involved with analyzing and solving local, regional, national, and international issues. At the most intimate scale, *Bank On It* provides opportunities for local elementary, middle, and high school environmental education throughout the implementation process and post-construction. The enhanced legible landscape can visualize datums such as inches of rainfall, flood stage height, or creek flow clearly marked on the green infrastructure. While the campus is predominantly a curated landscape with a legacy of design and planning, it sits within the larger East Bay region which contains several impaired waterways. Several low-income East Bay communities would benefit from Bank On It as a model for waterway enhancement and stormwater management in a dense, urban environment, particularly those surrounding Lion Creek and Arroyo Viejo Creek in East Oakland.

Phasing Plan + Cost Estimate

Due to the dynamic nature of this site, implementation of the design would occur over several phases. Logistical stages:

1. Establish a Stormwater Pollution Prevention Plan and implement temporary erosion control BMPs
2. Demolish parking lot surface and site temporary parking lot (see Figure 2)
3. Construct temporary coffer dams and creek flow bypass
4. Remove and grind trees marked for removal
5. Demolish existing retaining wall on the north bank and existing 4-foot weir structure, store demolished concrete on site for reuse
6. Regrade both the north bank and creek bed, store demolished concrete on site for reuse
7. Regrade the south bank and construct bioretention terraces and micro-check dams. Gabions filled with stored concrete.
8. Construct two new weirs within the creek bed
9. Build plaza surface and site furnishings
10. Build boardwalk structure and surface
10. Install new trees, shrubs, and other plants specified in design planting palette

Figure 2: As the campus moves toward a reduced-parking future, removing the 25 stall parking lot would require staging at least 10 stalls in a temporary parking lot to the east of the Old Art Gallery. The Architecture and Engineering (A + E) Building is slated for demolition in future campus planning initiatives, after its removal the site could serve as additional temporary parking space as well. In either iteration of the temporary parking lot, Bank On It accounts for its surface runoff within the treatment plan.

Cost Estimate

Costs for the installation of Bank On It were estimated using several resources (see table below). Quantities were calculated from the project design files and digital models developed by the team and project advisors.

Item Description	Unit	Qty	Unit Price ($)	Subtotal ($)	Unit Price Source
Permeable pavers and aggregate placement	SF	2765	22.51	$62,244.65	SFPUC Wiggle 95% Cost Estimate
Wooden boardwalk	SF	2515	100	$251,500.00	Permatrak estimate escalated
Replace retaining wall on north bank at new location	EA	1	50000	$50,000.00	
Replace energy dissipater with new weirs (24' x 1' x 1.5')	EA	2	$50,000	$100,000.00	Project advisor estimate
Bioretention planting, 15-gallon plants	EA	8	80	$640.00	Project advisor estimate
Bioretention planting, 5-gallon plants	EA	8	52.54651163	$420.37	SFPUC Wiggle 95% Cost Estimate
Bioretention planting, 1-gallon plants	EA	524	11.48837209	$6,019.91	SFPUC Wiggle 95% Cost Estimate
Bioretention planting, 4-inch pots	EA	3379	10.6744186	$36,068.86	SFPUC Wiggle 95% Cost Estimate

Item Description	Unit	Qty	Unit Price ($)	Subtotal ($)	Unit Price Source
(6 bioretention basins, all 1' deep, each with different SF)	CF	6973	31.39534884	$218,919.77	CAPTURE Guidance, California State Water Board
Earthwork	CY	1976	10	$19,760.00	
Remove parking lot AC (assuming 1' depth of material?)	CY	316	425.5813953	$134,483.72	SFPUC Wiggle 95% Cost Estimate
Remove concrete overflow culvert on north bank	EA	1	100000	$100,000.00	Project advisor estimate
Remove existing energy dissipater	EA	1	700	$700.00	Project advisor estimate
			Item Total	$980,757.28	
			Mobilization	$29,422.72	
2016$ to 2020$ conversion (RS Means)	1.16		Demobilization	$19,615.15	
			Design and Construction Contingency	$196,151.46	
			Grand Total	$1,225,946.60	

Financing

Bank On It can leverage several financing resources to supply funds for the implementation and maintenance of the project, the following is a comprehensive list of options the project could approach:

UC Berkeley The Green Initiative Fund (TGIF): *TGIF provides funding, via grants, for projects that improve and support UC Berkeley's campus sustainability efforts. TGIF is able to award between $250,000-$350,000 per year.*[1]

[1] http://tgif.berkeley.edu/

UC Berkeley University Development and Alumni Relations: UC Berkeley is fortunate to have a robust development team focused on fundraising for a variety of campus initiatives, goals, and support. *The Major Gifts team focuses on securing philanthropic support among University alumni, parents, and friends across a range of geographical regions and/or affinities.* [2]

[2] https://udar.berkeley.edu/content/major-gifts

California Resilience Challenge: Announced on December 2, 2019, the Bay Area Council in partnership with several stakeholders will host a statewide competition to solicit innovative strategies for addressing climate change in California. *By emphasizing local solutions to the global problem of climate change, communities can create scalable plans and infrastructure to meet their immediate and long-term climate adaptation needs. Recipients will receive grant awards of up to $200,000 for climate adaptation planning projects.* [3]

[3] http://documents.bayareacouncil.org/11.27.19_crc_rfp.pdf

California State Proposition 68 Funds: *Per Senate Bill 5: California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access For All Act of 2018.* [4] Funds for improving water, parks, and access to California natural resources may be allocated. The California State Parks Department is currently tasked with allocating these funds and previous successful campaigns include park enhancement and tree planting campaigns at the county level.
[4] https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB5

EPA Urban Waters Small Grants: The Urban Waters Small Grants program *recognizes that healthy and accessible urban waters can help grow local businesses and enhance educational, recreational, social, and employment opportunities in nearby communities.* [5] UCLA received a grant in 2014 for the Los Angeles River Watershed, a project led by students and carried out as an interdisciplinary effort.
[5] https://www.epa.gov/urbanwaters/urban-waters-small-grants#california

US Forest Service Urban and Community Forestry Program: The Urban and Community Forestry Program supports *fact-based and data-driven best practices in communities, maintaining, restoring, and improving the more than 140 million acres of community forest land across the United States.* [6]
[6] https://www.fs.fed.us/managing-land/urban-forests/ucf

National Park Service Rivers, Trails, and Conservation Assistance Program (RTCA): RTCA offers support to projects aimed at improving outdoor recreation at the community level. The initiative also supports projects to *conserve natural lands, rivers, and watersheds [and] strengthen the conservation and stewardship of public lands, waterways, and wildlife habitat.* [7]
[7] https://www.nps.gov/orgs/rtca/upload/RTCA_Application_2019_Example.pdf

California State Water Resources Control Board Storm Water Grant Program (SWGP): SWGP aims *to promote the beneficial use of storm water and dry weather runoff in California by providing financial assistance to eligible applicants for projects that provide multiple benefits while improving water quality.* [8]
[8] https://www.waterboards.ca.gov/water_issues/programs/grants_loans/swgp/

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