Low Impact Design Toolkit

How will San Francisco Plan for Stormwater?
Urban Watershed Planning Charrette
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Cover image:
Map of San Francisco drainage basins and historic hydrology

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Thank you for participating in San Francisco’s Western Basins Urban Watershed Planning Charrette. A charrette is a collaborative exercise in which participants draft a solution to a design and planning problem. Charrettes often take place in sessions in which larger groups divide into sub-groups, work on a design problem, and then present their work to the full group as material for future dialogue and planning. Charrettes serve as a way of quickly drafting design solutions while integrating the aptitudes and interests of a diverse group of people.

While there are many planning challenges facing San Francisco, this charrette will focus on integrating urban stormwater into San Francisco’s built environment using green stormwater management technologies collectively known as “Best Management Practices” (BMPs), “Low Impact Design” (LID) or “Green Infrastructure.” The goal is to identify LID techniques that reduce the peak flows and volumes of stormwater runoff entering the combined sewer and to recharge groundwater. LID has the potential to increase the system’s treatment efficiency by delaying and/or reducing the volumes of runoff flowing to the combined sewer, providing stormwater treatment, enhancing environmental protection of receiving waters, and reducing the volume and frequency of combined sewer discharges (CSDs). These technologies, if properly designed, can also provide ancillary benefits that include: beautification, groundwater recharge, reduction of potable water demand, recreational space, and habitat enhancement. They can be integrated into the existing urban fabric to give streets, parks, plazas, medians, and tree wells multiple functions.

Before San Francisco developed into the thriving city it is today, it consisted of a diverse range of habitats, including: oak woodlands, native grasslands, creeks, riparian areas, wetlands, and sand dunes. These habitats provided food and foraging space for a wide range of plants, animals, and insects. The natural hydrologic cycle, working its way through each of these ecosystems, kept the air and water clean and recharged the groundwater.
Today, much of the city is paved or built upon and plumbed with a combined sewer to convey stormwater and wastewater. Former creeks have been diverted to the sewers. Wastewater from homes and runoff from rain events flow to treatment facilities to be treated and discharged into the bay and the ocean. During large storm events, the combined sewer system occasionally discharges partially treated flows into surrounding water bodies and can back up in low-lying areas. In areas not served by the combined sewer, untreated stormwater discharges directly into water bodies. Large quantities of impervious surfaces means that there are very few places where infiltration can occur and recharge groundwater aquifers.

Low Impact Design (LID) is a stormwater management approach that aims to re-create and mimic pre-development hydrologic processes by increasing retention, detention, infiltration, and treatment of stormwater runoff at its source. LID is a management strategy that emphasizes on-site source control and multi-functional design, rather than conventional pipes and gutters. Whereas BMPs are the individual, discrete water quality controls, LID is a comprehensive, watershed- or catchment-based approach. These decentralized, small-scale stormwater controls allow greater adaptability to changing environmental and economic conditions than centralized systems.

What is Low Impact Design?
LID has the potential to reduce the severity of localized flooding and combined sewer discharges in San Francisco by slowing or intercepting stormwater before it reaches the sewer pipes. Roof runoff from buildings can be intercepted by vegetated roofs. Downspouts from roofs can be redirected to landscaped areas or cisterns where the water can be stored and used during the dry season for irrigation or other non-potable uses.

Runoff from streets, parking lots, and other paved areas can be directed to detention ponds or bioretention planters where it is filtered and infiltrated. An expanded urban forest can also intercept and uptake excess water. Historical creeks can be diverted away from the sewer system and returned to the surface. Together, these approaches increase the efficiency of the sewer system and treatment facilities, reduce the likelihood of flooding and CSDs, and recharge our local groundwater reserves.
Goals of LID

The SFPUC is pursuing LID strategies for the following reasons:

- Increase the level of service for wet weather management by increasing drainage capacity and complementing existing infrastructure
- Increase the City’s resiliency to impacts such as flooding and drought associated with climate change
- Decrease combined sewer discharges
- Reduce the amount of power and chemicals needed to manage stormwater
- Increase the ecological function of the cityscape
- Increase groundwater recharge
- Reduce the urban heat island effect
- Treat stormwater as a resource and diversify the water portfolio
- Enhance wildlife habitat
- Provide multi-purpose design

Playing the Game

For the purposes of the Urban Watershed Planning Charrette, each team will be asked to apply appropriate stormwater BMPs within the boundaries of San Francisco’s four western watersheds.

Each BMP performs specific functions such as reducing flooding by delaying peak flows. These functions can be quantified based on studies and modeling that has been calibrated for San Francisco. This booklet introduces and describes the benefits and limitations of each BMP used in today’s charrette. Each basin has a set of stormwater management goals for runoff reduction. Your job is to identify appropriate locations for the BMPs described in this booklet to address surface water management goals in your watershed. Each turn will consist of placing your BMP in the landscape and tallying the benefits and costs. Be sure to look for opportunities for partnerships, multi-purpose projects, and synergies between adjacent or nearby developments within the neighborhood. Your team then calculates the benefits and costs and determines how closely you meet your stormwater management goals and stay within your budget. These proposals will assist the SFPUC in the selection of LID strategies and projects.

This toolkit describes each BMP and provides specific details on the siting, performance, benefits and limitations, and the costs of implementation and maintenance.
Bioretention
(also known as: bioretention cell, bioretention planter, curb-side planter, above-ground planter, flow-through planter, stormwater planter, and rain garden)

DESCRIPTION
Bioretention refers to the use of stormwater facilities that rely on vegetation and either native or engineered soils to capture, infiltrate and transpire water, and remove pollutants from runoff. It reduces stormwater volume, attenuates peak flow, and improves stormwater quality. Bioretention BMPs feature vegetation that can tolerate periodic inundation and contain soils with high organic content. If designed properly, they can be an aesthetic and habitat amenity as well as a stormwater treatment facility.

SITING
- Bioretention systems can be used in a variety of contexts, including residential yards, office and commercial storefronts, parks, roadway median strips and rights-of-way, parking lots, and other landscaped areas.
- Bioretention systems can be easily integrated into retrofits of existing sites.
- Bioretention planters can be integrated into the building’s foundation walls either at grade using an inground planter or above ground using a contained planter.
- Ideally, bioretention planters should be situated in areas with less than 5 percent slope, but they can be effective at up to 20 percent slopes with proper flow control designs.

Bioretention planter at Glencoe Elementary School in Portland, OR
PERFORMANCE

Pollutant Removal

Target Pollutants
- Sediment
- Nutrients
- Organics
- Trash
- Metal
- Bacteria
- Oil/Grease

Volume Reduction

Peak Flow Reduction

Low  Moderate  High  Requires  Pre-treatment

TARGET POLLUTANTS

PERFORMANCE

Boardwalks provide access across waterfront bioretention facilities in Seattle, WA

BENEFITS:
- Easy and inexpensive to install
- Wide range of scales and site applicability
- Reduces runoff volume where infiltration is feasible and attenuates peak flows
- Improves water quality and air quality
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- Improves water quality and air quality
- Increases effective permeable surfaces in highly urbanized areas
- Creates habitat and increases biodiversity in the city (with appropriate vegetation)
- Provides aesthetic amenities
- Facilitates groundwater recharge (infiltration-based systems only)
- Facilitates evapotranspiration

LIMITATIONS:
- Requires relatively flat site and sufficient hydraulic head for filtration

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PLANTERS:

Bioretention planters in Mint Plaza, San Francisco, CA

BOARDWALKS:

Boardwalks provide access across waterfront bioretention facilities in Seattle, WA
Tree Basin
(also known as: tree box, tree well, tree pit, street tree)

**DESCRIPTION**

A tree basin is a depressed area in a sidewalk, plaza, or parking lot surface that allows stormwater runoff to infiltrate into the soil. There can be an underdrain if infiltration is not feasible. Trees help manage stormwater by intercepting rainfall before it reaches the ground and uptaking the water that does reach the ground, thereby reducing runoff volume and peak flows. Tree roots and organic leaf litter help to increase soil permeability. In addition to stormwater benefits, trees remove particulates, cool the air, and beautify the city.

**SITING**

- Can be used in a variety of contexts, including sidewalks, office and commercial storefronts, roadway median strips and rights-of-way, parking lots, and other paved areas
- Easily integrated into retrofits of existing sites

Tree basins in the public right-of-way in Portland, OR
PERFORMANCE

**Pollutant Removal**

- Sediment
- Nutrients
- Organics
- Trash
- Metal
- Bacteria
- Oil/Grease

**Target Pollutants**

- Low
- Moderate
- High
- Requires Pre-treatment

**Volume Reduction**

**Peak Flow Reduction**

**BENEFITS**

- Easy and inexpensive to install
- Wide range of scales and site applicability
- Needs limited space
- Reduces runoff volume where infiltration is feasible and attenuates peak flows
- Improves water quality and air quality
- Increases effective permeable surfaces in highly urbanized areas
- Creates habitat and increases biodiversity in the city
- Provides aesthetic amenity
- Facilitates groundwater recharge (infiltration-based systems only)
- Facilitates evapotranspiration

**LIMITATIONS**

- Not appropriate for handling large volumes of stormwater
- Requires relatively flat site and sufficient hydraulic head for filtration
- Should be situated in areas with less than 5 percent slope, but can be effective at up to 20 percent slopes with proper flow control designs

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Tree basins in the public right-of-way in Portland, OR

Tree basins in a high-density housing community in Portland, OR
Infiltration Trench
(also known as: infiltration gallery, soakage trench)

DESCRIPTION
An infiltration trench is a long, narrow, rock-filled trench, with no outlet, that receives stormwater runoff. Water is stored in the void spaces in the gravel layers and slowly infiltrates through the bottom of the trench into the soil, thus contributing to groundwater recharge. Before entering the trench, runoff should pass through pretreatment measures, such as vegetated swales, sediment basins, or swirl separators, to remove coarse sediment that can clog the void spaces between the aggregate and render the trench ineffective. Infiltration trenches perform well for removal of fine sediment and associated pollutants. As with any infiltration BMP, the potential for groundwater contamination must be assessed.

SITING
• Drainage area typically less than 5 acres and slope less than 15%
• Seasonally high groundwater elevation and depth to bedrock should be at least 4 feet from trench bottom
• Trench should be set back a minimum of 10 feet downgradient from building foundations and 150 feet from drinking water wells

This infiltration vault doubles as a parking strip along the Sustainable Streetscapes and Fish Habitat Enhancement Project: Crown Street, Vancouver, British Columbia
PERFORMANCE

- Pollutant Removal
  - Sediment
  - Nutrients
  - Organics
  - Trash
  - Metal
  - Bacteria
  - Oil/Grease

Target Pollutants

- Low
- Moderate
- High
- Requires
- Pre-treatment

Volume Reduction

Peak Flow Reduction

BENEFITS

- Improves water quality by removing sediment, nutrients, organic matter, and trace metals
- Reduces runoff volume and attenuates peak flows
- Improves urban hydrology and facilitates groundwater recharge
- Low construction and maintenance costs

LIMITATIONS

- Suitable for drainage areas of approximately 5 acres or less
- Must have minimum soil infiltration rate of 0.5 inch/hour, not appropriate for Hydrologic Soil Types C and D (impermeable soils)
- If infiltration rates exceed 2.5 inches/hour, runoff should be fully treated prior to infiltration to protect groundwater quality
- 4 foot minimum separation from trench bottom to groundwater is required
- Depth to bedrock must be over 4 feet for infiltration-based systems
- Not suitable on contaminated soils, industrial sites, or sites where spills are likely to occur
- Not suitable on fill sites or slopes greater than 15 percent
Permeable Pavement

(also known as: pervious paving, porous pavement, grass pavers, green parking, pervious concrete, porous asphalt, turf blocks, unit pavers, ungrouted brick/stone, crushed aggregate)

DESCRIPTION

Permeable pavement is any porous load-bearing surface that temporarily stores rainwater in an underlying aggregate layer until it either infiltrates into the soil below, recharging groundwater, or is routed to a collection system. Permeable pavement reduces annual runoff volumes, attenuates peak flows, and improves water quality by removing oil and grease, metals, and suspended solids. It does not typically remove nutrients. Infiltration rates of permeable surfaces may decline over time to varying degrees depending on design and installation, sediment loads, and consistency of maintenance. Common materials for the paving surface include porous asphalt, pervious concrete, interlocking block pavers, and plastic grid systems.

SITING

Areas with low-speed travel (30 miles per hour or slower) and light to medium-duty loads, such as:

- parking lots
- low-traffic streets
- parking lanes
- driveways
- bike paths
- patios
- plazas
- sidewalks

Site conditions, including native soil infiltration rate, depth to groundwater, depth to bedrock, slope, and adjacent land uses, should be assessed to determine whether infiltration is possible beneath permeable pavement and to ensure that off-site sediment and pollutants are not directed onto the permeable surface. The minimum recommended setback of permeable pavement from building foundations is 10 feet if receiving run-on from adjacent surfaces and no setback if there is no run-on.
BENEFITS

- Reduces runoff volume and attenuates peak flows
- Improves water quality by reducing fine-grained sediment, organic matter, and trace metals
- Reduces the heat island effect
- Facilitates groundwater recharge
- Provides noise reduction
- Increases driving safety by reducing ponding
- May increase safety for persons with disabilities by providing textured, non-slip surfaces and reducing ponding
- Can be used as a design element to provide aesthetic benefits
- Construction costs can be comparable to or less than traditional paving

LIMITATIONS

- Limited to paved areas with slow traffic and low traffic volumes
- Limited to sites with slopes that do not exceed 5%
- Difficult to use where soil is compacted: infiltration rates must be at least 0.5 inch per hour
- Depth to bedrock and groundwater must be greater than 4 feet for infiltration based systems
Vegetated Roof
(also known as: eco-roof, green roof)

DESCRIPTION

Vegetated roofs are roofs that are entirely or partially covered with vegetation and soils. These roofs improve water quality by filtering out contaminants including suspended solids, metals, and polycyclic aromatic hydrocarbons (PAHs) as the runoff flows through the growing medium or through direct plant uptake. The engineered soils absorb rainfall and release it slowly, thereby reducing the runoff volumes and delaying peak flows. Vegetated roofs include engineered soils as a growing medium, subsurface drainage piping, and a waterproof membrane to protect the roof structure.

SITING

- Can be installed on most types of commercial, multifamily, and industrial structures, as well as on single-family homes, garages, and sheds
- Can be used for new construction or to re-roof an existing building
- Roof must have sufficient structural support to hold the additional weight of the vegetated roof (generally a minimum of 10 to 25 pounds per square foot)
- Roof slopes between 5 and 20 degrees are most suitable

The Academy of Sciences building in San Francisco, CA has a nearly 2.5-acre vegetated roof
**BENEFITS**

- Provides insulation and can lower heating and cooling costs for the building
- Extends the life of the roof – a green roof can last twice as long as a conventional roof, saving replacement costs and materials
- Provides noise reduction
- Reduces urban heat island effect
- Lowers the temperature of stormwater runoff, which maintains cool temperatures for fish and other aquatic life
- Creates habitat and increases biodiversity in the city
- Provides aesthetic and recreational amenities

**LIMITATIONS**

- Limited to roof slopes less than 20 degrees (5-in-12 pitch)
- May Require additional structural and seismic support to bear the added weight
- Irrigation may be needed to establish plants and maintain them during extended dry periods (depending on plant types)
Rainwater Harvesting

DESCRIPTION
Rainwater harvesting is the practice of collecting and using rainwater from impervious surfaces, such as roofs and patios, for non-potable use, such as irrigation and toilet flushing. It is now legal to divert stormwater from San Francisco’s combined sewer system. In 2005, city staff amended the plumbing code via Ordinance 137-05, making it possible to direct rainwater to alternative locations such as rain gardens, rain barrels, and cisterns. Proper design and sizing of the rainwater harvesting system are critical to ensure full runoff reduction benefits.

SITING
- Both rain barrels and above-ground cisterns must be sited in a stable, flat area
- Rain barrels and cisterns may not block the path of travel for fire safety access
- Overflow locations, which can include rain gardens, additional rain barrels or cisterns, or a discharge point to the collection system, must be designed to both direct outflow away from building foundations and prevent nuisance flows to adjacent properties
- Tanks should be placed in a cool or shaded area to avoid algal growth
BENEFITS

- Offsets the volume of potable water used for non-potable applications, such as irrigation and toilet flushing
- Keeps relatively clean water out of the combined sewer system, thereby enhancing the performance and lengthening the life of the City’s combined sewer infrastructure
- Reduces the volume and peak flows of stormwater entering the sewer
- Reduces the energy and chemicals needed to treat stormwater in the City’s sewage treatment plants
- Reduces the energy expended transporting potable water from distant sources
- Low maintenance requirements (for above ground cisterns)
- Good for sites where infiltration is not an option

LIMITATIONS

- Requires infrastructure (pumps or valves) to use stored water
- Roof surfaces serving as catchments for watering shall not include copper or materials treated with fungicides or herbicides

Rainwater Harvesting at Layfayette Elementary School, located in the Sunset Basin in San Francisco, CA
Detention Pond
(also known as: dry pond, dry detention basin, extended detention basin)

DESCRIPTION
Detention ponds are temporary holding areas for stormwater that store peak flows and slowly release them, lessening the demand on treatment facilities during storm events and decreasing the likelihood of flooding. Detention ponds can be used to provide flood control by including additional flood detention storage. Multi-purpose detention ponds are only filled with water during storm events and can act as open spaces, such as large play areas, dog parks, or athletic fields during dry weather.

SITING
- There are relatively few siting constraints for detention ponds, making them one of the most applicable technologies for stormwater management

A dry detention pond in the Algeurao Mem-Martins, located outside of Lisbon, Portugal, provides flood control during the short, wet season and serves as a neighborhood park with picnic tables, frequented by children riding bicycles and skateboards, during the rest of the year.
In urban commercial centers, detention ponds serve as a visual amenity and natural oasis, as in this example located in Berlin, Germany.

Detention basins can take on a formal arrangement in a courtyard space such as this one in Germany.

**BENEFITS**

- Reduces runoff volume and attenuates peak flows
- Improves water quality by removing particulate matter and sediment (extended detention ponds only)
- Removes trash and debris
- Provides protection against flooding
- Low construction and maintenance costs
- Good for sites where infiltration is not an option
- Multi-purpose detention ponds can provide space for recreation, create habitat, and increase biodiversity

**LIMITATIONS**

- Limited pollutant removal potential (except extended detention ponds); ineffective at removing soluble pollutants (all types)
- Potential for groundwater contamination in coarse, well-drained soils (primarily extended detention ponds)
- 5-acre minimum drainage area for extended detention ponds
- Application limited by slope
- Site must have no risk of land slippage if soils are heavily saturated
- Must be sited with sufficient distance from existing foundations, roads, subsurface infrastructure, drinking water wells, septic tanks, and drain fields
DESCRIPTION

Constructed wetlands are man-made wetlands designed to collect and purify stormwater through microbial transformation, plant uptake, settling, and adsorption. Water is stored in shallow vegetated pools that are designed to support wetland plants. Constructed wetlands have many of the same ecological functions as natural wetlands and are beneficial for flood control and water quality improvement.

SITING

- Wetlands must be sited on a relatively flat area with less than 2 percent slope, but can receive drainage from upstream slopes of up to 15 percent
- Wetlands typically occupy 1 to 3 percent of their contributing drainage area
PERFORMANCE

Pollutant Removal

Target Pollutants
- Sediment
- Nutrients
- Organics
- Trash
- Metal
- Bacteria
- Oil/Grease

Volume Reduction

Peak Flow Reduction

Low Impact Design Toolkit

BENEFITS
- Effective at removing stormwater pollutants (sediment, nutrients, organic compounds, pathogens, heavy metals)
- Reduces stormwater peak flows, can reduce overall volume if runoff is stored and used
- Attractive landscape feature and potential community park amenity
- Provides valuable wetland habitat
- Good in areas unsuitable for infiltration or with high groundwater table
- Easily customizable to various sizes and dimensions, based on site, budget, and design intent
- Can be designed to treat and store water for local non-potable use (e.g., for irrigation, toilet flushing, or fire protection), depending on site conditions and stormwater characteristics

LIMITATIONS
- Requires relatively large land area
- Variation in water quality improvement as plants senesce seasonally

Constructed wetland in Tanner Springs Park in Portland, OR

Stormwater conveyance at the constructed wetland in Tanner Springs Park in Portland, OR
Creek Daylighting

DESCRIPTION
Creek daylighting refers to projects that uncover and restore creeks, streams, and rivers that were previously buried in underground pipes and culverts, covered by decks, or otherwise removed from view. The City of San Francisco has several historical creeks. Water from these creeks currently runs via the combined sewer system to treatment plants and then to the Bay and Ocean. Daylighting these historical creeks can decrease demand on the treatment facilities and enhance local neighborhoods.

SITING
- Creek daylighting is well suited for creeks that traverse existing open space or the public right-of-way

Daylit creek in Zurich, Switzerland
**BENEFITS**
- Reduces runoff volume and attenuates peak flows
- Improves water quality
- Improves urban hydrology and facilitates groundwater recharge
- Replaces deteriorating culverts with an open drainage system that can be more easily monitored and repaired
- Creates habitat and increases biodiversity in the city
- Provides recreational amenities
- Provides educational opportunities

**LIMITATIONS**
- High installation costs
- May have high maintenance costs
- May have land requirements
- Some benefits are lost if only fragmented segments are daylit

*Daylit creek in Zurich, Switzerland*
Basin Information
Groundwater + Recycled Water Context

A series of groundwater basins underlie San Francisco. The largest of these basins is the Westside Basin. Prior to the 1930s and the construction of the Hetch Hetchy Reservoir, water from the Westside Basin was used for the City's drinking supply, as well as for non-potable purposes. After the 1930s, groundwater has been used only for non-potable purposes. The SFPUC is currently developing plans to use groundwater from the Westside Basin for municipal supply again, increasing the importance of groundwater recharge to the basin.

The projects described below are part of a larger strategy for using local sources to diversify the SFPUC’s water-supply portfolio. This diversification would help to increase water supply reliability during dry years and in emergencies.

SAN FRANCISCO GROUNDWATER SUPPLY PROJECT

As part of the San Francisco Groundwater Supply Project, the SFPUC has proposed the construction of six wells in the western part of the City. The wells would extract up to 4 million gallons per day from the Westside Basin. The extracted groundwater would be used both for regular and emergency water supply purposes and would be blended with imported water before entering the municipal water system. The San Francisco Groundwater Supply Project is part of the SFPUC’s Water System Improvement Program.

PROPOSED WESTSIDE RECYCLED WATER PROJECT

The proposed Westside Recycled Water Project is part of the SFPUC’s Water System Improvement Program. It would deliver highly treated recycled water to customers through a system of pipelines, pump stations, storage tanks and reservoirs. The system would bring recycled water from a proposed recycled water treatment facility in Golden Gate Park to the San Francisco Zoo, Golden Gate Park, and Lincoln Park and Golf Course. Recycled water would be used for irrigation at all three sites; additionally it would be used for non-potable purposes at the Zoo and in Golden Gate Park, including at the California Academy of Sciences.

more information can be found at: sfwater.org/groundwater and sfwater.org/recycledwater
Natural History

**Crispy Field Marsh, 1870s**

The area now known as Crissy Field was originally part of a rich 127 acre backdune marsh. In 1915, the marsh was completely filled for the Panama Pacific International Exposition. Part of the newly created land was developed into a military airfield. In 1999 the National Park Service reintroduced tidal action into a restored section of the original marsh.

**The Financial District, 1849**

Historically, the underlying soil of the Northshore Basin was primarily sand with serpentine outcroppings. The basin’s shoreline and soil composition changed when large sections of waterfront, now the Financial District, Fisherman’s Wharf and the Marina District, were filled in with sand, bay mud, and urban detritus to make new land for development. Yerba Buena Cove, now the Financial District, was originally a mud flat at low tide. Urban rubble was gradually poured in alongside the cove’s piers and ships to create more land. In addition to creating space for development, the new land reached deeper water allowing for the creation of a deeper harbor.

**El Polin Spring, 1947**

Because of urban fill, substantial sections of the Northshore Basin are subject to liquefaction. During the 1989 Loma Prieta earthquake, the Marina District suffered more damage than any other city neighborhood.

**Northshore Basin’s remaining significant natural areas are located in Golden Gate National Recreation Area, primarily in the Presidio. The Presidio’s Tennessee Hollow Watershed is currently undergoing a major habitat revitalization process. Tennessee Hollow stretches from El Polin Spring to Crissy Field. A small section of the creek known as Thompson’s Reach was recently daylighted, and work is underway to establish a continuous habitat corridor connecting spring to marsh. The recently restored section of the Crissy Field Marsh already provides habitat for wildlife and plants that have not existed in the Presidio in over a century. The marsh supports at least 70 invertebrate taxa, 19 fish taxa, and numerous migrating and wintering shorebirds.**

**Shoreline Morphology**

**Pre-1850 Shoreline**

Historically, Cow Hollow was originally filled with freshwater bodies, though they were rare and their water precious. The most famous was Washerwoman’s Lagoon in Cow Hollow, used first for drinking and later for laundry. By 1882, the lagoon was also filled due to water contamination and a cholera outbreak.

**1869 Shoreline**

North Beach’s proximity to the docks and Yerba Buena Cove made it a gateway for immigrants from South America, Europe and the Australian penal colonies settled there. Later it became known for Italian residents - immigrants who likely settled there in part due to proximity to the wharf and fishing industry.

**1929 Shoreline**

Immigrants from South America, Europe and the Australian penal colonies settled there. Later it became known for Italian residents - immigrants who likely settled there in part due to proximity to the wharf and fishing industry.

**Current Projects**

**Doyle Drive Replacement Project**

**Northeast Embarcadero Study + Fisherman’s Wharf Public Realm Plan**

**Tennessee Hollow Watershed Revitalization Project**

**North Beach, 1875**

North Beach is currently undergoing a major habitat revitalization process. Tennessee Hollow stretches from El Polin Spring to Crissy Field. A small section of the creek known as Thompson’s Reach was recently daylighted, and work is underway to establish a continuous habitat corridor connecting spring to marsh.

**Chinatown, 1899**

Chinese immigrants first arrived in San Francisco in the 1840s. Immigrants came for the gold rush and to work on the railroads and in agriculture and mining. Many settled in Portsmouth Square to serve the city’s growing population. By 1882, when Congress passed the Chinese Exclusion Act, Chinatown had grown to 15,000 people and occupied the area that remains its core today.

**The Financial District, 1970s**

The Financial District began in 1855 as a small development on the shore of Yerba Buena Cove. The neighborhood grew slowly until 1849 when large numbers of immigrants came for the gold rush. The gold rush was followed by the Nevada silver strikes of the 1860s and 70s which generated the first wave of wealth that built the Financial District.
Northshore Basin Aerial Imagery

watershed basins
Northshore Basin
Sewer System
Urban Nature Notes

* Natural Areas: Data courtesy of SF Recreation and Parks Department, Golden Gate Gate National Recreation Area, and the Presidio Trust.

** Urban Forest Data: Please note that there are more street trees than shown here. This map only depicts trees mapped by Dept. of Public Works and Friends of the Urban Forest.

Endangered Flora and Fauna Sitings: The following is a list of endangered flora and fauna that have been sighted in the Northshore Basin. This data comes from the California Natural Diversity Database, but should not be considered a comprehensive inventory of all the sensitive species that can or do live in the basin.

San Francisco gumplant
Presidio clarkia
San Francisco owl’s clover
Marin Western flax
San Francisco Bay spineflower
San Francisco leschkea
marsh sandwort

Presidio manzanita
round-headed Chinese house
beach layia
rose linanthus
marsh microseris
monarch butterfly
Northshore Basin
Zoning

- P: Public Use
- RH-1: Single-Family Residential
- RH-2: 2-Family Residential
- RH-3: 3-Family Residential
- RH-4: High-density Residential-Commercial
- RM-1: Low-density Mixed Residential
- RM-2: Moderate-density Mixed Residential
- RM-3: Medium-density Mixed Residential
- RM-4: High-density Mixed Residential
- C-1: Commercial (general)
- C-2: Community Business District
- C-3-O: Downtown Office
- C-M: Heavy Commercial
- C-1-O: Downtown Office
- C-2-O: Community Business District
- C-3-O: Downtown Office
- NC-1: Small-scale Neighborhood Commercial
- NC-2: Small-scale Neighborhood Commercial
- NC-3: Moderate-scale Neighborhood Commercial

- arterial streets
- watershed basins
Northshore Basin LID Opportunities

- watersheds
- auxiliary water supply cisterns
- low-lying areas
- priority areas for flow reduction
- waterbodies
- federal land
- state land
- public schools
- private schools
- sewer easements
- sewer projects
- repaving projects
- inactive pipes
- city parks
- natural areas

* Natural Areas: The locations mapped here are the SF Recreation and Parks Department’s Significant Natural Areas and areas currently being considered for inclusion in Significant Natural Areas. Data courtesy of SF Recreation and Parks Department, Golden Gate Recreation Area, and the Presidio Trust.
“Water is the most critical resource issue of our lifetime and our children’s lifetime. The health of our waters is the principal measure of how we live on the land.”

- Luna Leopold