El Cerrito Green Streets

Installation of Bioretention Rain Gardens to Achieve Pollutant Reduction

Why Rain Gardens?

Green infrastructure (GI) is a resilient approach to managing stormwater at its source while also delivering environmental, social, and economic benefits. GI uses vegetation, soils, and other elements to restore more natural watershed processes that mimic nature to soak up stormwater, provide habitat, clean the air, and filter out pollutants from urban stormwater runoff. GI can reduce peak flows and stream erosion; recharge groundwater; and improve water quality in urban stormwater that drains to San Francisco Bay.

As we add GI into our cities' landscapes, we need to develop and implement projects that result in the most cost-effective benefits. To do this, we need to understand how GI works in our climate, what designs work best, the optimal places for implementation, and the maintenance needs to keep these systems performing properly. This is particularly important given a future when GI will begin to increase in our cities. The City of El Cerrito, using grant money from the Department of Water Resources, partnered with the San Francisco Estuary Partnership and the San Francisco Estuary Institute-Aquatic Science Center to construct the rain gardens, and monitor their effectiveness, thereby contributing to the regional and national knowledge base on bioretention performance for pollutant removal.

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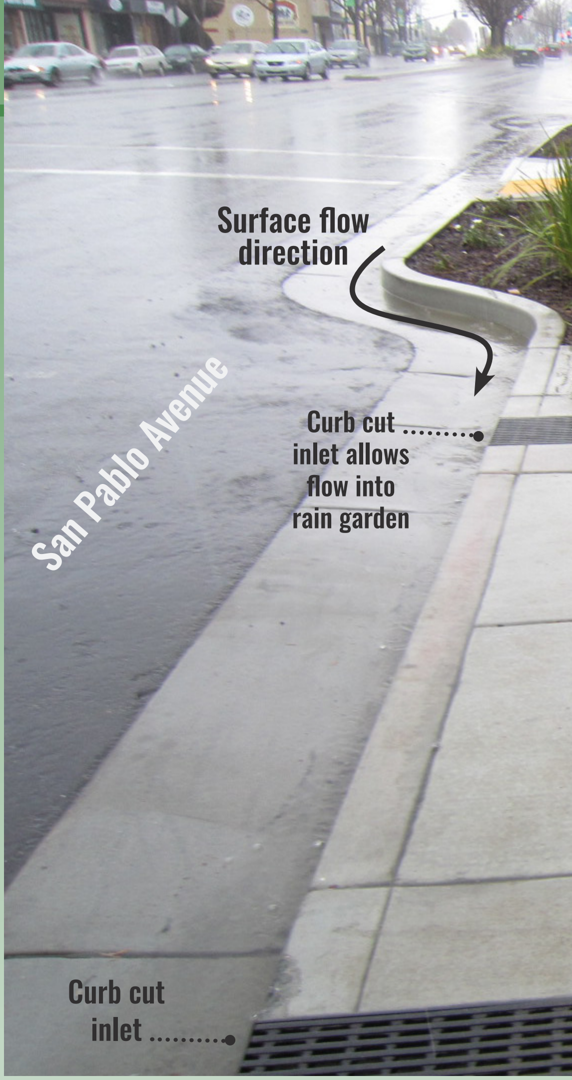
EL CERRITO BIORETENTION RAIN GARDENS

Year constructed	Fall 2010
Type of Green Infra-structure	Bioretention rain garden, 12 individual cells
Watershed Area	43,920 ft^2 (~1 acre)
Watershed Land Use	67% roads, 20% high density residential, 13% commercial offices
Green Infrastructure surface area	68 ft^2 for monitored cell; 814 ft^2 for all cells total
Soil and Drainage	18 inches of bioretention soil mix (70% sandy loam, 10% clay, 20% composited organic matter) on top of native soil; underdrain 28 inches below surface, installed in drain rock
Surface ponding depth	6 inches
Monitoring period	11 storms during the winters of 2011-12, 2013-14, and 2016-17
Pollutants	Suspended Sediment Concentration (SSC), Polychlorinated Biphenyls (PCBs), Copper (Cu), Mercury (Hg), Methylmercury (MeHg), microplastics
Likely pollutant sources	Older buildings (1940-1965), transformers, roadway



Which pollutants were measured, and where do they come from?

Polychlorinated Biphenyls (PCBs)

PCBs were a commercially synthesized oily compound used in hundreds of industrial and commercial applications. PCBs are highly toxic and were therefore banned in 1979, but continue to persist in the environment. The most likely sources in the rain garden watershed include atmospheric deposition, leakage from electrical transformers (there are two in the drainage area to the rain gardens) and caulking materials in the buildings.

Mercury (Hg)

Mercury is an extremely toxic natural element. Hg in stormwater runoff contributes to higher Hg levels in fish; eating fish is the main pathway that humans, birds, and other animals are exposed to Hg. The most likely sources of Hg in the rain garden drainage area include atmospheric deposition, and gasoline residues.

Copper (Cu)

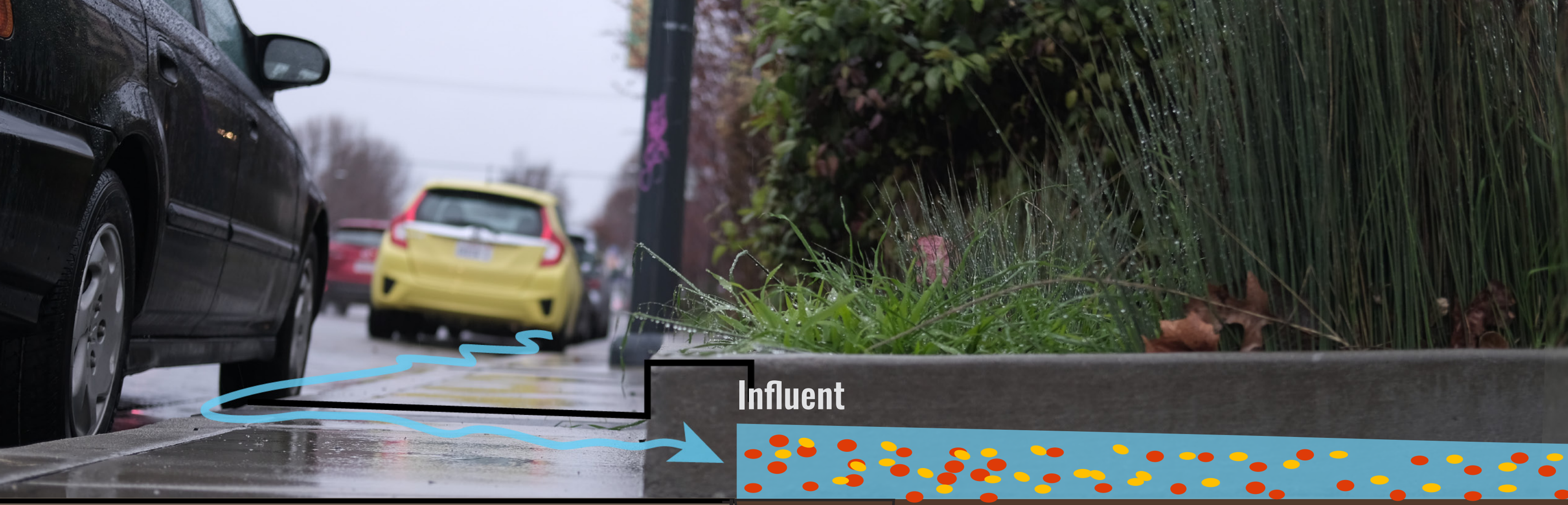
Copper is a toxic, naturally occurring element used in a myriad of urban applications. The most direct sources to stormwater include roofing, external paints, biocides, and brake pads. Any of these common sources could contribute to the El Cerrito rain garden.

Microplastics

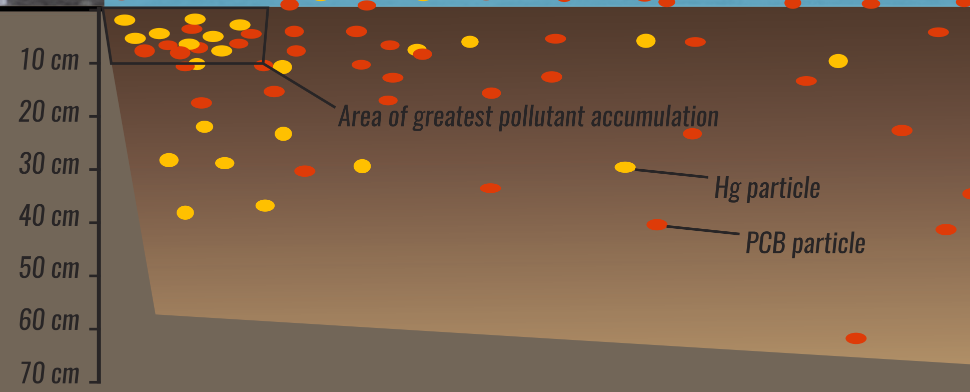
Microplastics are tiny particles of plastic five millimeters or smaller. Beauty products with microbeads, synthetic clothing, plastic bags, polystyrene foam packaging, and disposable plastic items can all contribute to microplastic pollution. Wildlife mistake microplastics for food; wildlife and humans can consume microplastics from contaminated fish. Microplastics in the rain gardens likely come from tire wear, cigarette filters, and larger plastic trash that breaks down into smaller particles.

The El Cerrito Bioretention Rain Gardens were constructed along San Pablo Avenue between Eureka and Lincoln Avenues in 2010. The garden cells were constructed to allow runoff from the street to enter the gardens, while maintaining a sidewalk for pedestrian traffic and public safety. Runoff that previously would have entered the stormdrain system untreated is now routed to each of the garden cells via curb cut inlets. The runoff slowly infiltrates through the soil media, enters a subdrain pipe at the bottom of each cell, and finally is routed back into the stormdrain system. By infiltrating through the soil, the stormwater is filtered and pollutants are trapped in the soil media. To quantify the bioretention rain garden's benefit for improving water quality, influent at the curb cut inlets and effluent at the sampling hatch was analyzed for 11 storm events.

Map of the watershed area draining to the El Cerrito Rain Gardens. The green and blue areas drain to the rain garden cells. The green area (1 acre) drains to the monitored cell. The blue area (0.7 acres) drains to the other cells. As cells become full, water bypasses to more southern cells along San Pablo Avenue. The monitored cell and adjacent cell drain to a common subdrain.



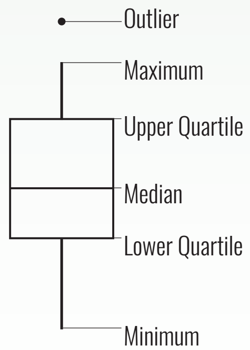
Soil core samples were analyzed for concentrations of PCBs, Hg and MeHg. Concentrations were higher toward the surface and lower at greater depths. On the surface, the highest concentrations were found nearest the inlets. Out of all the pollutant mass captured, 92% of PCBs, 76% of Hg and 58% of MeHg mass was captured in just the top 10 cm of the unit.

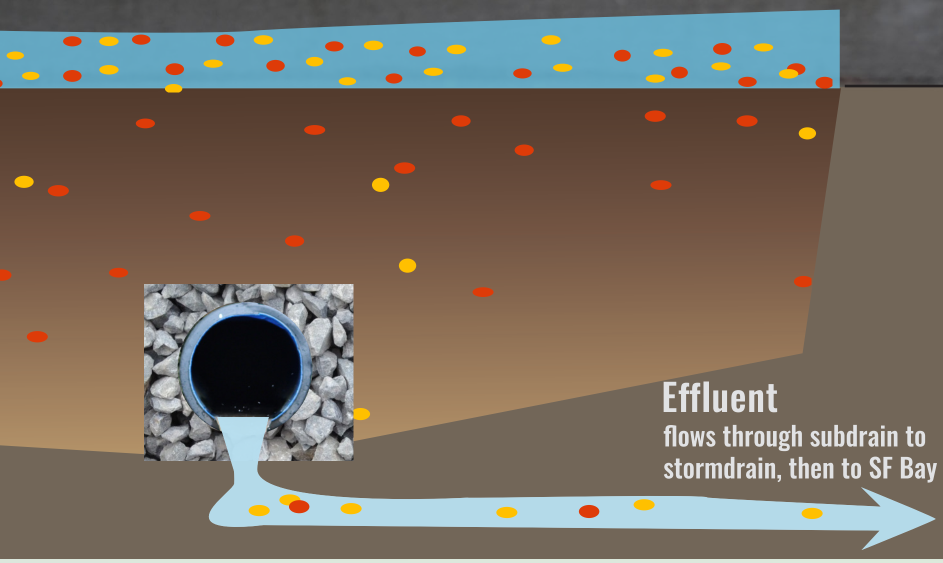


WHAT HAVE WE LEARNED?

- Water quality was improved by 37-96% with PCBs and suspended sediments being more effectively removed from stormwater than some metals. For the most part, dissolved pollutants cannot be physically filtered out with bioretention.
- The reduction in suspended sediment concentration between inlet and outlet increased through time, suggesting improved filtration due to the soil settling and compaction as the system matured.
- Influent PCB concentrations were much greater than expected given the land use. Congener fingerprinting indicates likely two different PCB sources.
- Methylmercury was significantly reduced in effluent, and was likely aided by the presence of the subdrain, preventing anaerobic conditions from developing.
- Average concentration of microplastic particles measured in influent was 160 particles/100 L of water. Fibers, fragments, and microbeads composed 58%, 22%, and 20% of the particles. The difference between influent and effluent concentrations revealed that the rain garden removed over 90% of of the plastic that would have otherwise flowed into the Bay.
- Most of the pollutants measured have much more variable inlet concentrations. Filtration through the rain garden muted that variation, leading to consistently lower outlet concentrations.

How to Read a Box and Whisker Plot

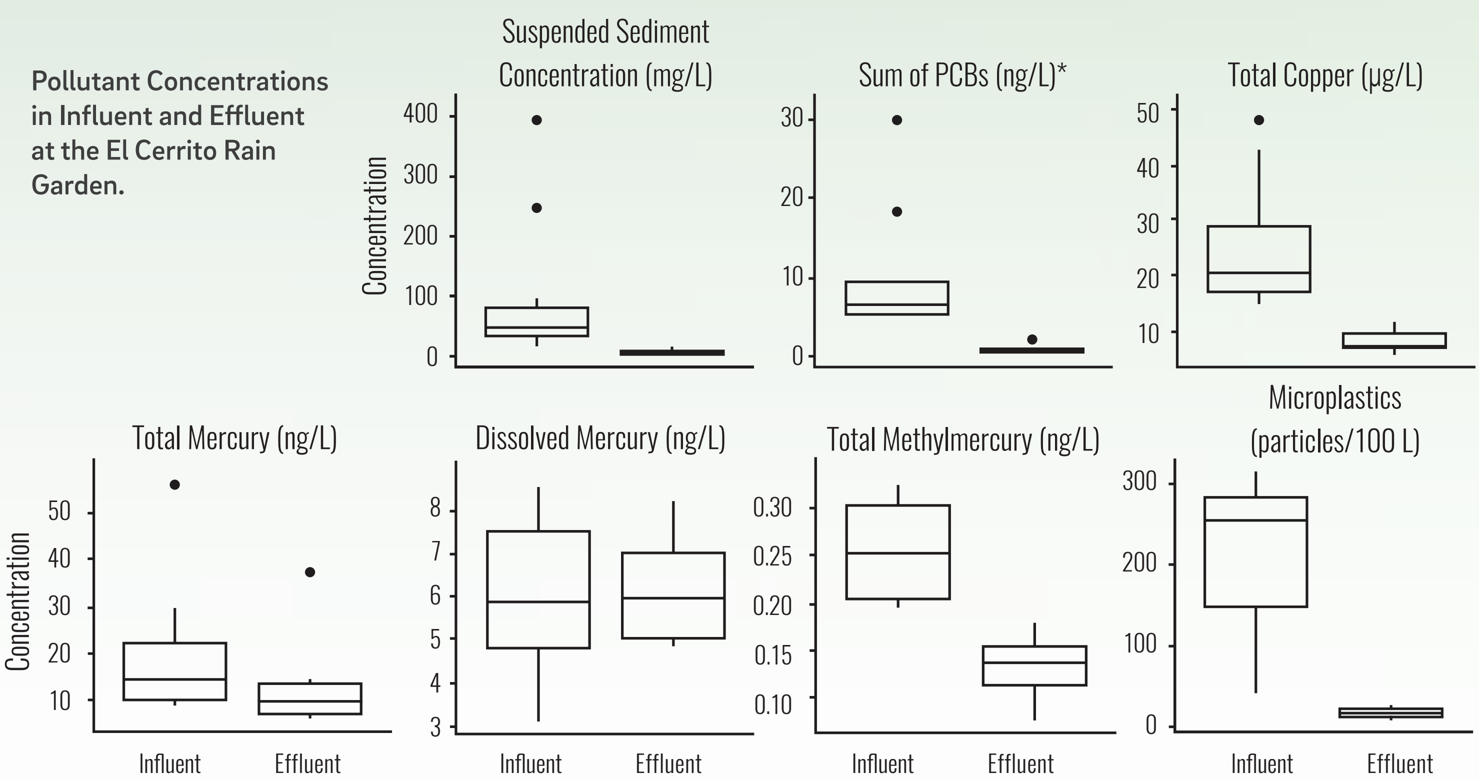




From Influent to Effluent:

- 94% reduction in sediments
- 96% reduction in PCBs
- 68% reduction in total copper
- 37% reduction in total mercury
- no significant reduction in dissolved mercury
- 49% reduction in total methylmercury
- 92% reduction in microplastics

Pollutant Concentrations in Influent and Effluent at the El Cerrito Rain Garden.



* Note: one high outlier for PCBs in influent not shown. PCB concentration was 226 ng/L.

MAINTENANCE NEEDS

The rain gardens require minor maintenance to keep them beautiful, functioning and effective. Maintenance includes removing trash, clearing debris that blocks the inlets, repairing sinkholes, trimming vegetation immediately in front of the inlet, watering vegetation, adding mulch for soil moisture, and periodically replacing the pollutant-laden upper soil layers.

BROADER LESSONS LEARNED

This study shows that bioretention rain gardens can effectively capture PCBs, Cu, Hg, MeHg and microplastics. Only dissolved species of Hg were not significantly reduced, presumably because the primary mechanism of pollutant removal is physical filtration. In this first study of microplastics in stormwater runoff in the Bay Area, we found that even a very small urban drainage area contributes microplastics to stormwater; luckily however, common designs for bioretention are extremely effective at capturing those microplastics. Given that the pollutants dominantly accumulate in the surface soil layer of the unit, it is estimated that in 8 or 31 years (for residential and industrial soil screening levels of concern, respectively) the soil surface will reach levels of concern and some maintenance of that layer will be required. This gives managers an idea of how often they may need to perform surface soil maintenance and can include those activities in the life cycle costs.

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