EPA United States Environmental Protection Agency
Office of Water

Constructed Wetlands for Wastewater Treatment and Wildlife Habitat

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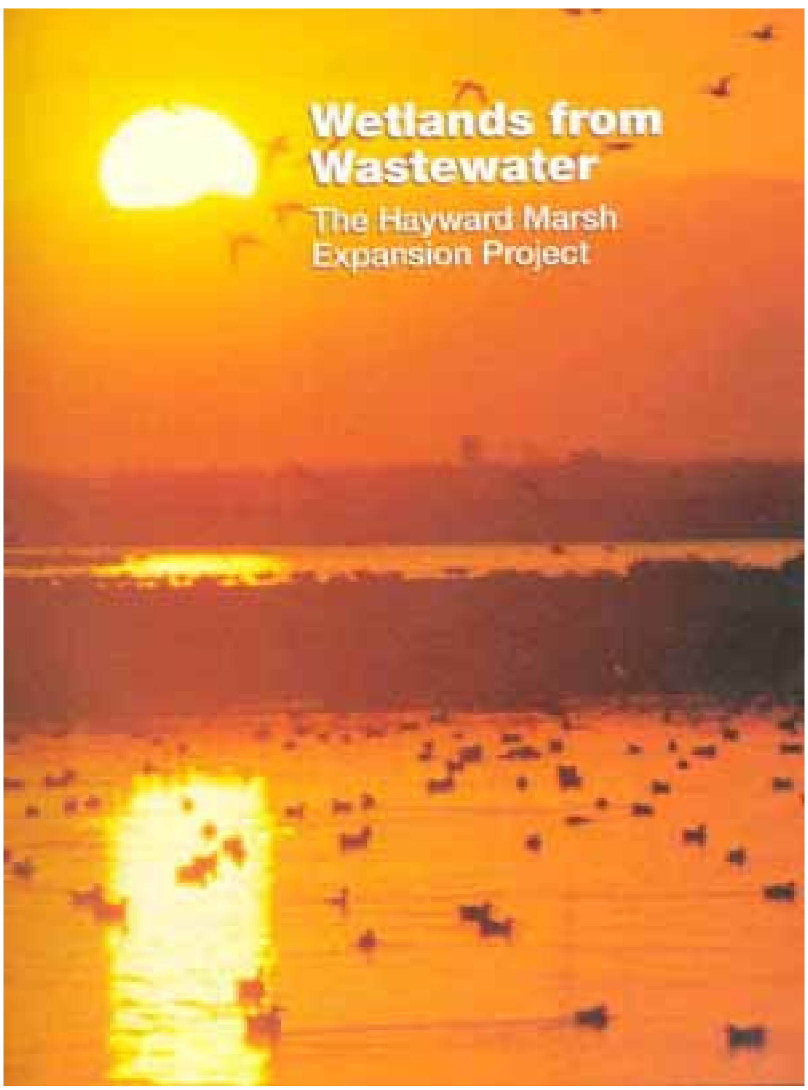
Hayward Marsh, CA - Wetlands from Wastewater: The Hayward Marsh Expansion Project



The Hayward Marsh Expansion Project: Wetlands From Wastewater

Can treated sewage effluent be used to enhance and create wetlands? This brochure documents the innovative and effective use of secondary wastewater on wetlands in a northern California coastal community. The community, Hayward, is on the eastern shore of San Francisco Bay. The project, Hayward Shoreline Marsh Expansion Project, is a part of a larger marsh restoration and enhancement plan.

The Hayward Shoreline Marsh Expansion Project addresses two growing urban issues: the restoration and enhancement of declining wetlands areas in the United States, and the additional treatment and beneficial uses that can be achieved from the utilization of wastewater. The shoreline and marsh in this case are roughly 172 acres of a 400-acre restoration and enhancement area. The source of the wastewater is primarily residential and light industry.

Biodegradable mesh was laid on banks near inlet and outlet structures during construction.

The History of the Project, Marsh and Shoreline

In 1971 the Hayward Area Shoreline Planning Agency was formed by five groups to restore about 1,800 acres of Hayward shoreline. The five included: the City of Hayward, Hayward Area Recreation District, East Bay Regional Park District (EBRPD), and the Hayward and San Lorenzo Unified School Districts. The 1,800-acre area had been a part of the Bay area salt-and-brackish-marsh system until the later part of the 19th century. At that time the marsh was eliminated by creation of a dike to hold out tidal action to allow for commercial salt production. Salt production ceased in the 1940s, but the area was not returned to marshland until more than 40 years later.

The Two Phases


A 27-acre corner of Hayward Marsh has been set aside as a preserve for the salt marsh harvest mouse.

The restoration and enhancement of the diverse 400-acre marsh—part of the 1,800 acres of Hayward shoreline-was planned in two phases. The first phase was completed in 1980 when extensive grading and breaching of the dikes allowed tidal action to be restored to approximately 200 acres. This created the conditions necessary for natural restoration of a tidal cord grass and pickleweed salt marsh. The second phase, the Hayward Shoreline Marsh Expansion Project, involved restoring 172 acres to fresh and brackish marshes. Using existing and newly created channels and dikes, a five-basin marsh system was formed. This second phase of newly created fresh and brackish marshes began operation in April 1988 and relies on secondary treated wastewater as its freshwater source.

Funding for the 172-acre marsh expansion totaled $713,570 and has come from four sources: the U.S. Fish and Wildlife Service for designs and specifications; City of Hayward for design, contract documents and permits; the EBRPD's appropriation from the 1980 California Parklands Act for marsh enhancement and recreational facilities; and a grant from the State Coastal Conservancy for the major portion of construction.

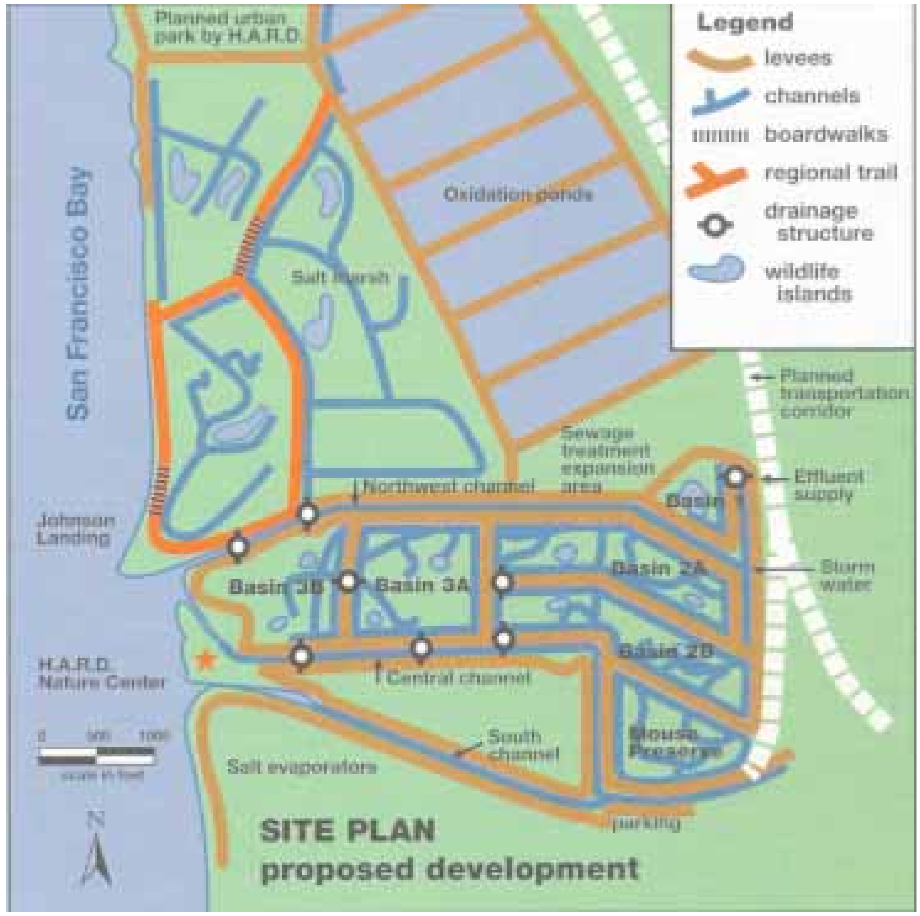
EBRPD and the East Bay Dischargers Authority (EBDA) are the joint holders of the National Pollution Discharge Elimination System (NPDES) permit for the marsh. Flow to the marsh, primarily from Union Sanitary District, is diverted from EBDA’s forcemain, which runs along the eastern edge of the Bay and discharges effluent from six municipal wastewater treatment plants to the deep waters of San Francisco Bay. The anticipated success of the Hayward Marsh may provide EBDA and its member agencies with the opportunity to develop other constructed wetlands along the Bay.

EBRPD has acquired control of the site, including the 400 acres designated for marsh restoration, by purchase of 495 acres and by long-term lease with other agencies. EBRPD is responsible for the operation and maintenance of the marsh. When completed, the Hayward Marsh will be the largest restoration and enhancement project on the West Coast to date.

The 172-acre area is actually divided into six sections: the five basins mentioned earlier and a preserve set aside for the salt marsh harvest mouse, an endangered species. The five basins include three freshwater basins and two brackish water basins.

Basin 1 receives the treated, chlorinated

Vegetation begins to colonize Basin 2A, a newly created freshwater marsh.



Schematic of the Hayward Shorline Marsh Expansion Project.

secondary effluent. The water that enters the marsh meets standards for both biochemical oxygen demand and suspended solids, as well as for coliform bacteria. Residual chlorine is allowed to dissipate in this basin. Basin 1 is about 15 acres and is operated at a depth of between 5 and 8 feet. From Basin 1 the water is discharged to a channel leading to Basins 2A and 2B.

Basins 2A and 2B are identical 35-acre freshwater marshes with internal channels and islands. The marshes were designed to have a range of depths: there are shallow areas of two feet or less and the perimeter and internal channels are six feet deep. Basins 3A and 3B are brackish and receive a combination of approximately 25 percent bay water and 75 percent effluent from Basins 2A and 2B. These two basins are each 30 acres and also have internal channels and islands.

The 27-acre mouse preserve, on the southeastern corner of Hayward Marsh, is an area of pickleweed marsh set aside specifically as habitat for the salt marsh harvest mouse. This area receives storm water runoff, but not treated effluent.

Wastewater: Resource Versus Liability

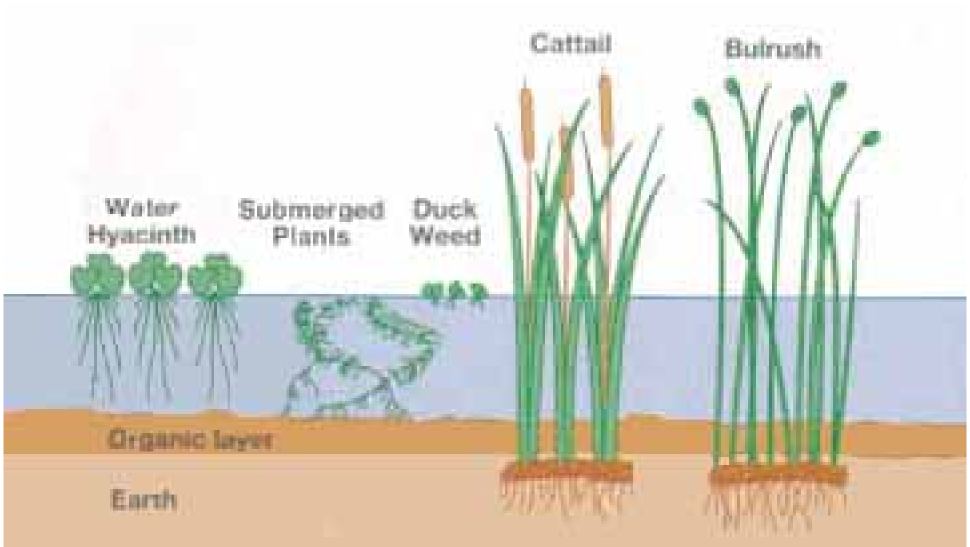
Wastewater has been treated and reused successfully as a water and nutrient resource in agriculture, silviculture, aquaculture and golf course and green belt irrigation. By regarding wastewater as a resource rather than a liability, it is now being viewed as water pollution control with positive benefits.

The Hayward Shoreline Marsh Expansion Project has three main objectives: creation of a diversified marsh system using secondary effluent; maximization of public benefits including wildlife habitat, preservation of open space, and creation of educational, research and aesthetic opportunities; and meeting NPDES requirements.

The marsh system removes pollutants from the treated wastewater it receives, so its final discharge to the bay is water of higher quality.

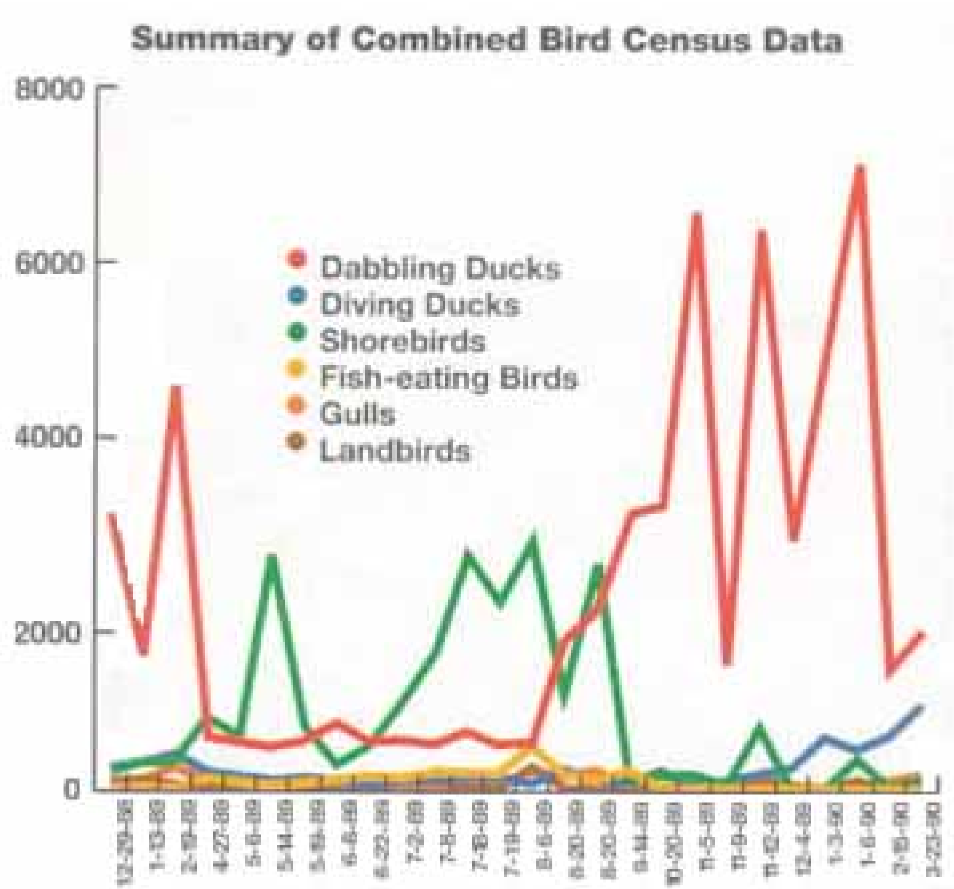
The increased interest in wastewater wetlands treatment systems can be attributed to three factors: recognition of the natural treatment functions of aquatic plant systems and wetlands, particularly as nutrient processors and buffering zones; emerging or renewed application of aesthetic, wildlife and other incidental environmental benefits associated with the preservation and enhancement of wetlands; and rapidly escalating costs of construction and operation associated with conventional treatment facilities. Constructed wetlands have become attractive as a treatment and disposal alternative for secondary wastewater for several reasons: they physically entrap pollutants through adsorption in the surface soils, in organic litter and on suspended particulates; through their utilization and transformation of pollutants by microorganisms; and because of their low-energy and low-maintenance requirements to attain consistent treatment levels.

Flora and Fauna



The first plants to emerge at Hayward Marsh were grasses, fat hen and pickleweed which had colonized the levees prior to project construction. Recolonization by plants has been slowed somewhat because of residual soil salinities from earlier commercial salt production and because topsoil was disturbed during construction.

Planting efforts have met with varying degrees of success. Seeds of alkali bulrush (Scirpus robustus) and watergrass (Echinochloa crusgalli) were eaten by ducks. Shoots of other bulrush species were eaten by waterfowl and geese or were dislodged by high winds. Subsequent planting efforts have been more successful due to protective cages that exclude predators and help block the wind. Once the plants become well established the cages will be removed.



There are 3 main species of terns that forage at the marsh including the Forster's tern (pictured above). The endangered Least tern stopped

The fauna that use the marsh include waterfowl, shorebirds, small mammals, amphibians, reptiles and fish. As many as 94 species of birds have been recorded using the site for feeding, nesting, hunting, foraging or as a refuge during high tide. Hayward Marsh is strategically located on the bird migration route known as the Pacific flyway. On any given day during the winter migratory season, thousands of ducks can be seen resting on the freshwater marshes.

at Hayward Marsh on its migratory journey and nested successfully in 1990. Efforts to provide suitable nesting habitat for the tern include covering one of the islands with crushed oyster shells.

Birds using Hayward Marsh have been categorized as follows: dabbling ducks, shorebirds, diving ducks, fish-eating birds, gulls and landbirds. Dabbling ducks include mallard, northern pintail, gadwall, cinnamon teal and the northern shoveler. Dabblers feed on or near the surface of the marsh and eat seeds and shoots of aquatic plants, aquatic invertebrates, minnows, snails, grain, grass and insects.

Shorebirds also migrate through San Francisco Bay and use the brackish water sections of Hayward Marsh during the spring and fall. Common visitors to the marsh include the American avocet, black-necked stilt, Caspian tern, Forster's tern, sandpiper, willet and killdeer.

Diving ducks have included the scaup, canvasback, bufflehead and ruddy duck. Diving ducks feed either within the water column or by diving to the bottom for mollusks, crustaceans, aquatic insects and invertebrates, crayfish and, to a lesser degree, aquatic plants.

Geese, ducks, and shorebirds produce hundreds of offspring at the marsh each year.

Fish-eating birds have included heron, egret, grebe, tern and pelican. Fisheaters either wade or dive for food. Their diet, in addition to fish, may include crustaceans, aquatic insects, frogs, small vertebrates and crayfish. It was not at all a coincidence that a large flock of opportunistic pelicans visited immediately after hundreds of pounds of Sacramento blackfish were introduced to the marshes.

Land birds at the marsh have included raptors, such as an endangered peregrine falcon that preys upon ruddy ducks and sandpipers. The marsh is within the peregrine‘s established territory. Seed-eating songbirds and insect eaters such as swallows are regular inhabitants of the marsh area.

Gathering the Data

Marsh Influent Water Quality 1990

	Range mg/l
Biochemical Oxygen Demand	5.2-22.0
Suspended Solids	10.3-22.0
Oil and Greese	3-10
Cyanide	<.01-.04
Residual Chlorine	6.0-9.3
pH (Units)	7.0-7.4
Arsenic	<.01-.002
Cadmium	<.01-.039
Chromium	<.00003-.0074
Lead	<.0002-.036
Mercury (1)	<.000025
Nickel	<.005-.13
Zinc	<.001-.14
Selenium	<.00005-.0022

(1) None of the 11 samples contained concentrations above the detection limit.

The second step is to determine the concentration of metals in the water, the sediment, and the plants and animals living in the marsh. There are 10 metals for which the marsh is being tested: arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver and zinc.

There are three methods being used to study the marsh. First, the wetland itself is being sampled. Second, a

The EBRPD, EBDA and the Union Sanitary District (USD) are the team responsible for providing the treated effluent to the marsh, monitoring the water quality within the system and managing the wetland. The team's tasks include everything from analyzing for residual chlorine to sampling fish and aquatic invertebrate populations.

One of the most beneficial aspects of the Hayward Marsh Project is that the team is encouraging and supporting research studies of the effect of effluent heavy metals on the marsh and its inhabitants. EBDA and USD have contracted with the University of California-Berkeley, Hayward State University and Woodward-Clyde Consultants to conduct a three-year research project to study heavy metals in the marsh.

Research questions and answers are complicated by the complexities inherent in a marsh. There are many chemical reactions, biological interactions and physical processes that take place every day in this 172-acre marsh. The research project first has to identify all of the major biological organisms that live in the marsh. This means counting birds and their nests, digging up worms and other invertebrates that live in bottom muds, and identifying the plants that grow in, on, and right up through the water.

Wetland Design Criteria

Average Daily Flow (1)	9.68 mgd
Maximum Daily Flow (2)	25.92 mgd
Minimum Daily Flow (3)	0
Bay Inflow (4)	2.5 mgd
Total Wetland Area	172 acres

mesocosm or small-scale marsh located adjacent to Hayward Marsh is being used to create and test future conditions that will occur in the marsh. And third, laboratory experiments mimicking sediments, water and phytoplankton are being used to isolate and analyze specific metal-uptake processes that occur in the field. This extensive research program is partially funded by an $80,000 grant from the U.S. Environmental Protection Agency with the remainder of the total research costs of $539,000 supported by EBDA and USD. The park district supports the research efforts with in-kind services.

Trace amounts of heavy metals are a normal occurrence in our environment. The key questions research will answer include: 1) Are the metals being concentrated in the wetland? and 2) Are the metals having an adverse effect on the marsh's biota? To predict potential effects to the wildlife, the concentrations of metals in the organisms will be measured and then compared with published values for metals that have been found harmful to wildlife.

Detention Time............................14 days

Basin 1......................................15 acres

Marsh 2A...................................35 acres

Marsh 2B...................................35 acres

Marsh 3A...................................30 acres

Marsh 3B....................................30 acres

Mouse Preserve...........................27 acres

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(1) This is Union Sanitary District treated effluent.

(2) Maximum flows may be used as a management tool, such as to flush waterfowl disease bacteria out of hte system.

(3) The ability to shut off the flow facilitates maintenance.

(4) Bay water mixes with the treated effluent in Marshes 3A and 3B.

Water Quality Analyses

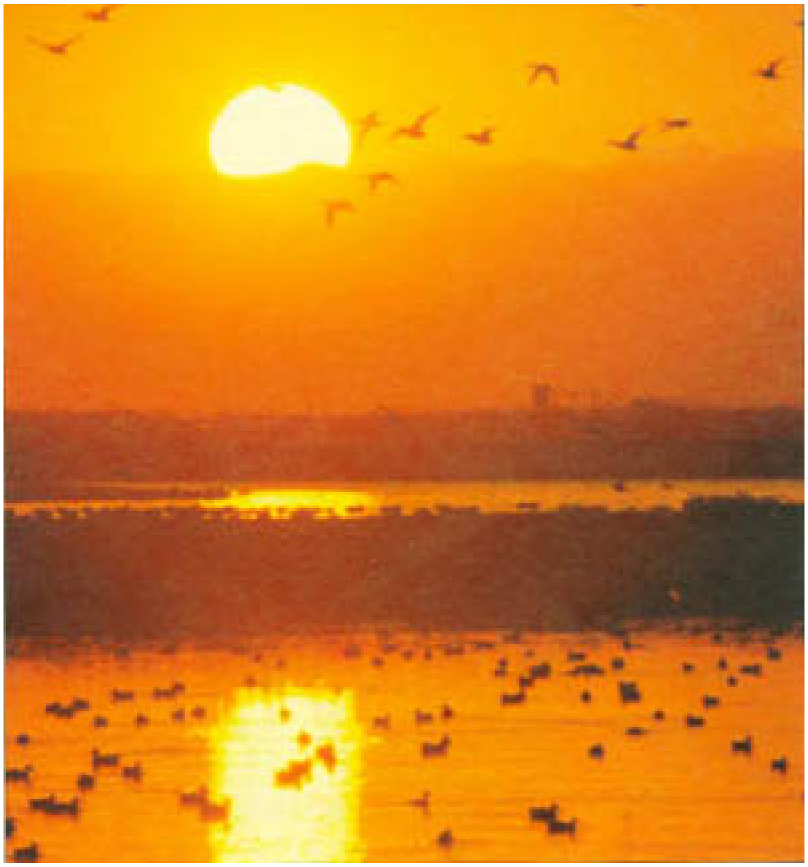
Parameter	**Daily** Basin 1	**Weekly** Basins 2A, 2B, 3A, 3B &	**2x/week** Basins 1, 2A 2B Receiving Water	**Monthly** Basin Effluents 1, 2A, 2B, 3A, 3B & Receiving Water	**Biweekly** 12 Stations in Marsh
Dissolved Oxygen	*	*			*
Temperature	*	*			*
pH	*	*			*

MPN Coliform Bacteria	*			
Ten Metals			*	
Total Ammonia		*	*	*
Un-ionized Ammonia		*	*	*
Nitrites		*	*	*
Nitrate		*		
Salinity			*	
Chlorophyll a			*	
PAHs			*	
Suspended Solids			*	
Avian Census			*	
Fish Bioassay			* (1)	

Ten Metals Analysis: Analysis for 10 metals is being performed twice on multiple samples of sediments, fish, emergent and floating vegetation, phytoplankton, addled eggs, acquatic invertebrates and benthic invertebrates in both Hayward Marsh and the mesocosm.

(1) Effluent only

The Promise of Wastewater Wetlands



Growing numbers of communities around the country have created wetland projects to create wildlife habitat and to further treat secondary effluent as a low-cost, energy-efficient disposal alternative. This method is especially suitable for smaller communities with available land.

A wastewater wetland created as a treatment facility will be designed differently than one built primarily to enhance wildlife habitat. The differences may be in design depths, basin configurations, flow rates and vegetation types. But a wetland built as a treatment facility may also yield other benefits. It may be useful for some wildlife and may provide recreational trails. Likewise, a wastewater wetland created for wildlife habitat may also improve the quality of water that flows through it to the sea.

The Hayward Marsh Expansion Project is a case-in-point of innovative engineering and science applied to the conversion of secondary wastewater effluent into a resource; a project that holds great promise for a growing environmental problem.

This brochure was created with funding from the U.S. Environmental Protection Agency. Requisition No. A22190.

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