Chapter 6

STORMWATER MANAGEMENT: BERKELEY'S ALTERNATIVES

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Pollution from stormwater runoff is a major problem in both the City of Berkeley and the Bay Area. Previous papers in this report have documented the detrimental effect stormwater has on Aquatic Park and the Berkeley shoreline. Surface runoff also degrades the bay; seasonally, runoff contributes nine percent of the total suspended solids loading and up to 63 percent of the heavy metal load to the waters of the bay system (Chan et al., 1982).

Stormwater runoff is known to include many pollutants including volatile and suspended solids, phosphates, fecal coliforms, chlorides, heavy metals and BOD loading (Table 1). All of these pollutants can have a detrimental effect on the plants and animals present in the receiving water. Volatile and suspended solids increase turbidity, phosphates increase algae growth and eutrophication, fecal coliforms are associated with many disease-causing organisms (as discussed in earlier papers), chlorides increase salinity, heavy metals can be poisonous, and BOD loading decreases oxygen levels.

Oil and grease are two of the major pollutants of stormwater in the Bay Area. On an area basis, runoff from parking lots and commercial streets constitutes the largest contributor of oil and grease

	Unit	Mean	Range
BOD	mg/l	13.1	1-234
Volatile Solids	mg/l	298	20-1110
Suspended Solids	mg/l	185	5-2000
Total Phosphate	mg/l	1.3	.02-4.3
Fecal Coliforms	per 100ml	12,500	2-86,000
Chloride as NACl	mg/l	12.6	3-705
Heavy Metals	ppm	0.56	.0005-3.0

TABLE 1: Average Concentrations of Pollutants in Urban Runoff
Source: Bryan , 1972.

to stormwater (Stenstrom et al., 1982). Results of an Association of Bay Area Governments' (ABAG) study indicate that a 90% reduction in oil and grease from commercial streets and parking lots, which make up only 11.8% of the total land area, would result in a 50% reduction in total oil and grease loading in the bay (Stenstrom et al., 1982).

The Clean Water Act requires state and local governments to develop management plans to control stormwater runoff and to implement Best Management Practices for controlling nonpoint source pollution. ABAG also recognizes that urban runoff is a priority water quality problem. Policy 8 of ABAG's Water Quality Management Plan for the San Francisco Bay area states: "Establish a program of surface runoff controls that emphasize low cost measures to reduce pollutant load from this source" (ABAG 1980, p. 21).

There have been numerous studies on stormwater pollution and stormwater management that have produced a variety of books and models, including some very sophisticated computer models. Most of the studies have been funded by the federal government, and although these studies are good sources for general data, each one must be adapted to the specific problems found in Berkeley if it is to be useful.

There are three categories of stormwater management available to a city like Berkeley, that is already developed and has an existing stormdrain system separate from the sewer system: education, ordinances, and treatment. Education and ordinances are aimed at decreasing the amount of pollutants that enter stormwater. Treatment is directed at removing pollutants from stormwater. This paper will discuss these three approaches in general and then focus on specific solutions for Berkeley.

Education

The public is often not aware of the ultimate fate of stormwater runoff and its contaminants. A direct approach to reducing runoff pollution is to educate the public as to where runoff ends up and the effect it has on the receiving water. A well publicized clean-up campaign is one approach that can be used to educate the public and provide motivation for cleaning up of their premises and disposing of their accumulated trash.

Actively pushing oil recycling should be another goal of public education. Used oil often ends up in runoff after being dumped directly into catchbasins or onto the ground, from which it is washed into the storm drain system. Setting up oil recycling centers and publicizing their whereabouts may eliminate some of this oil pollution.

Ordinances

Another direct approach to reducing runoff pollution is effective and enforceable regulations relating to street cleanliness. Anti-litter ordinances can be passed in conjunction with a public education campaign. Specific regulations may be directed at the following typical sources of litter in the urban environment: garbage and refuse collection, open trucks, solid waste disposal sites, construction sites, restaurants, theaters and exhibition halls, distribution and handling of notices and political posters, street vending and direct discharges into storm sewers (EPA, 1977). Local governments can do their part by providing an adequate number of easily accessible litter containers that are emptied frequently.

A specific ordinance can also be directed at another major source of stormwater pollution--automobiles. A significant decrease in oil and grease pollution results from improved vehicle performance and maintenance, since 35% of crankcase oil may be released into the environment during normal vehicle operations (Stenstrom, 1982). A vehicle inspection could include regulations concerning oil emissions and leakage. An inspection and maintenance program would result in a decrease in oil associated with particulate emissions, but limiting oil leakage would probably be more difficult. There are many potential sites for oil leakage in an automobile, many of which are quite expensive to repair. Requiring repair of leaks may not be feasible, but an inspection program may provide incentive for some people to repair their automobiles.

Ordinances can also be passed to prevent pollution of runoff due to the indiscriminate use of fertilizers and pesticides. The chemicals should be used only for their intended purpose, with careful attention paid to their storage and distribution. A professional licensing system for handlers and users of practicularly harmful pesticides would help ensure proper use. Alternatives to the use of fertilizers and pesticides should also be promoted.

The effectiveness of local ordinances will depend on adequate monitoring of both the potential sources of runoff pollution and the runoff itself. Monitoring can help detect offenders of ordinances, help determine if new ordinances are needed, and help in the evaluation of the effectiveness of the stormwater management program.

Treatment

The treatment of stormwater can be divided into two categories. The first category includes techniques for removing pollutants after deposition but before they enter the stormdrain system. These techniques include the use of porous pavement, greenbelts, catch basins, and street sweeping. The second category includes mechanisms for treating polluted runoff prior to discharge into the receiving waters. These mechanisms include sewage treatment plants and wetlands.

Porous pavement - Porous pavements, which allow oil and grease to penetrate into soil layers, are designed to promote a high rate of infiltration through the omission of fine material during pavement construction (Lynard, 1980). This infiltration allows the pollutants to become available for biodegradation (Figure 1). Estimates of the cost of using porous pavement for roads and parking lots vary from no more expensive than conventional pavement (Becker et al., 1973) to up to 50% more expensive (Dinitz, 1980). The economic benefits of porous pavement are enhanced by the added value

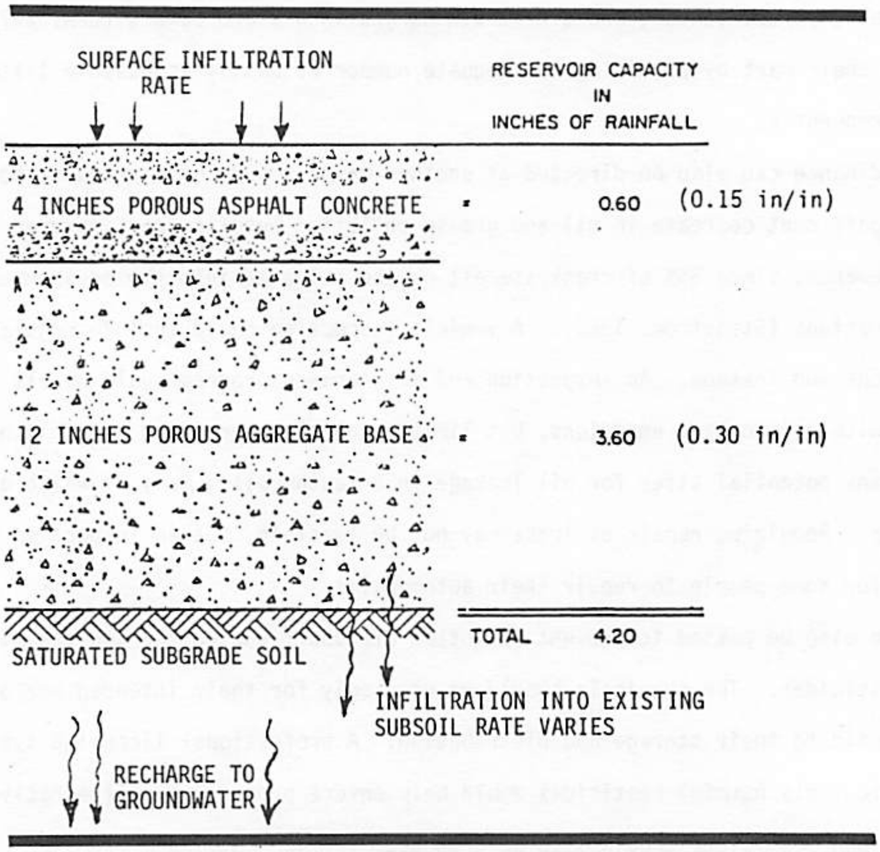

FIGURE 1: Typical Porous Pavement.
Source: Hannon, 1980.

The depth of the asphalt concrete surface can vary from 4 to 7 inches. The depth of the base can vary from 6 to 22 inches.

of increased groundwater recharge, improved traffic safety, relief from flash flooding and the reduction for the need for catchment basins and gutters.

However, durability of porous pavement is not known (Stenstrom et al., 1982). Since there is no long-term record, it is difficult to assess how long the material can be used without restoration, a vital economic consideration. Oil and grease may eventually "plug" the pavement, reducing its porosity and economic viability. Porous pavement may also contribute to groundwater contamination.

Other types of porous surfaces may be practical for parking areas, including precast lattice blocks or bricks which would allow grass or other vegetation to grow in the parking areas. These systems offer many of the same advantages and disadvantages of porous pavement, and suffer the same lack of proven history (Stenstrom et al., 1982).

Greenbelts - The construction of greenbelts is another innovative technique that is especially suited for decreasing pollution from parking lots. The purpose of these grassy areas is to catch runoff from a large paved area and allow it to percolate through the soil, where pollutants can undergo biodegradation. Figure 2 shows a typical greenbelt application, in which the lot is graded to channel all runoff into the greenbelt.

The major cost involved in using greenbelts is the land requirement. Maintenance, including trash collection, gardening service, and perhaps dry season watering may also be a significant cost. However, aesthetic benefits may help defray many of these costs.

Catch Basins - Catch basins also act to decrease stormwater pollution. They are rectangular pits with concrete sides covered with steel grates that act as the interface between runoff and the stormdrain system. A goose-neck storm lead is normally connected 10 inches to 3 feet above the bottom of the

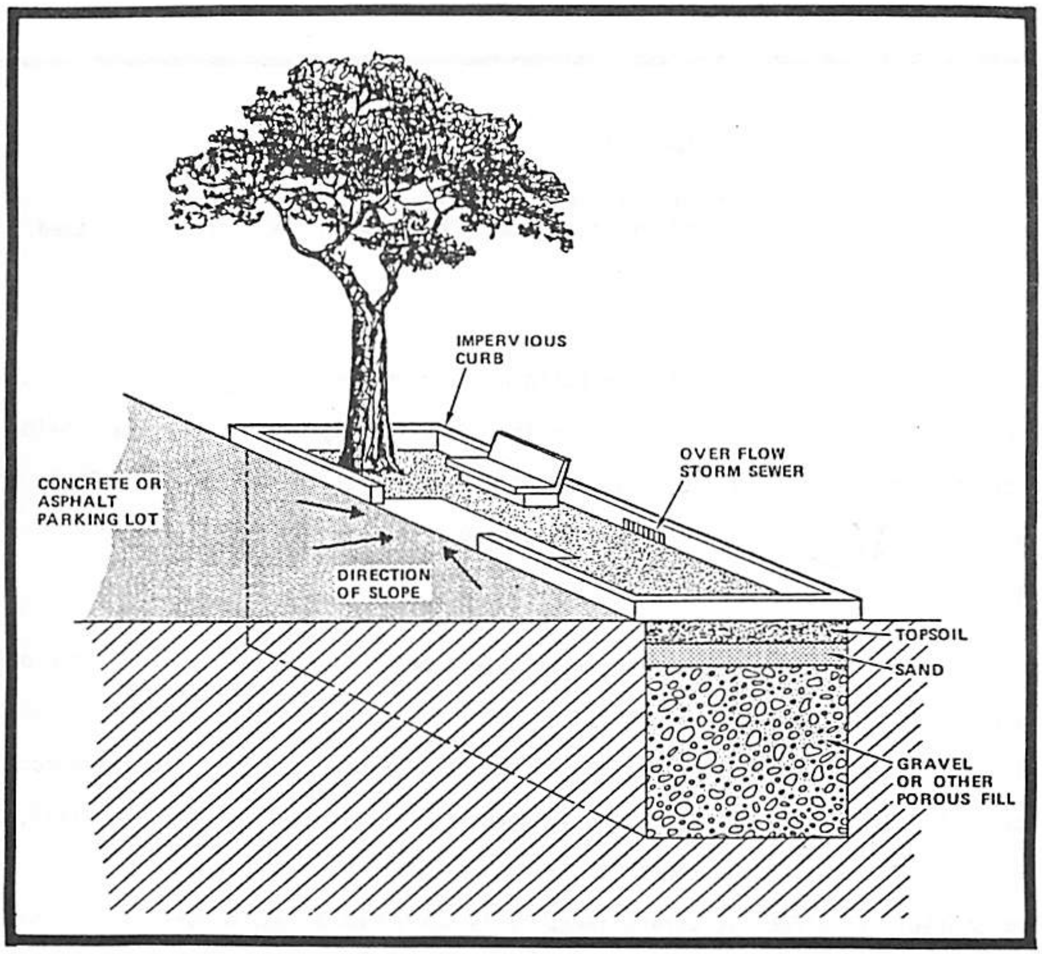

FIGURE 2: Hypothetical Green Belt
Source: Stenstrom, et al., 1982.

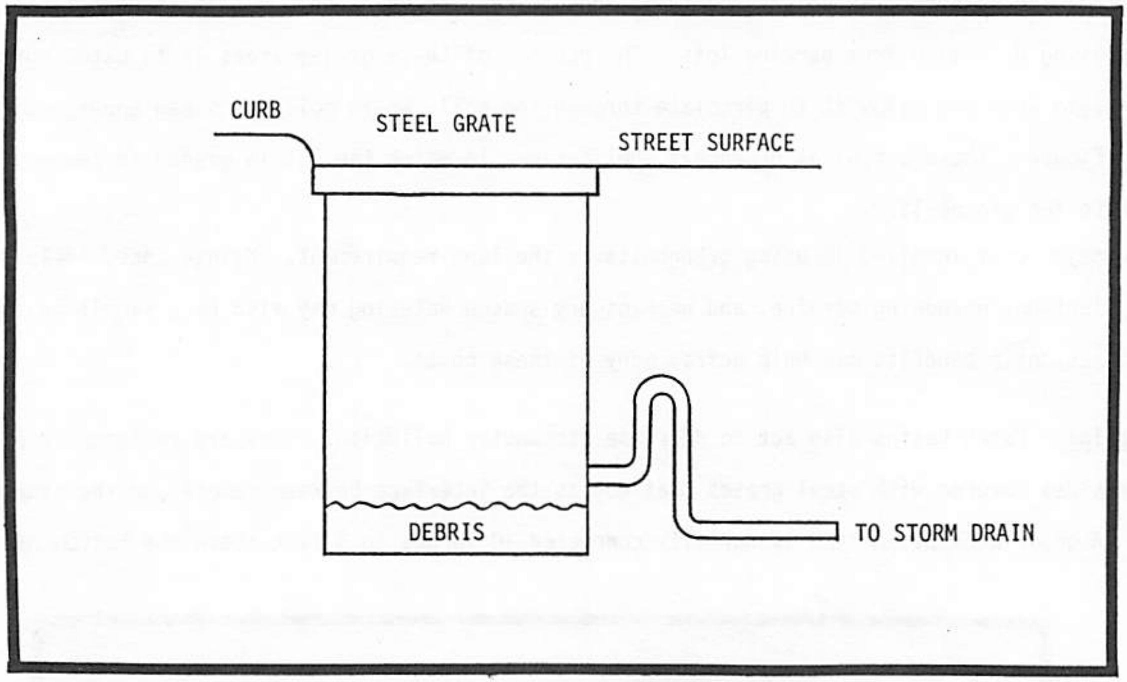

FIGURE 3: Typical Catch Basin
Source: Raxtor, 1983

In Berkeley, the drain is often connected directly to the bottom of the catch basin with the gooseneck omitted.

basin so that any material washed into the basin will be trapped (Figure 3). When regularly cleaned, catch basins are found to be effective in removing approximately 56% of the total solids and 40% of the BOD from stormwater (EPA, 1977). However, if the basins are not cleaned regularly they can become full and no longer able to decrease pollution loading. The city is normally responsible for catch basin cleaning.

Street sweeping - Street sweeping is also an efficient means of decreasing stormwater pollution. Street sweeping has been shown to remove 25% of the total solids, 45% of the total pesticides, 45% of the nitrates, 45% of the BOD loading, 20% of the phosphates and 50% of the heavy metals found on the streets (EPA, 1977). Sweeping efficiency, however, varies with the area, rainfall, frequency of passes, frequency of cleaning and the skill of the operator.

A major obstacle to effective street sweeping is parked cars, which make it impossible to clean all of the street. Part of this problem may be solved by parking regulations which prohibit parking during specific hours. In residential areas, these parking restrictions may apply once or twice a week, whereas in commercial areas they may apply daily.

Since parking lots are a major source of runoff pollutants, it appears economical to reduce oil and grease from parking lots and commercial streets. This approach would affect a relatively small area but provide a large amount of pollutant control.

Wetlands - Wetlands offer a mechanism for treating stormwater runoff after contamination but prior to discharge into the receiving waters. It is difficult to generalize about the water purification functions of the wide diversity of wetland types and their individual characteristics. However, basic analysis of the processes involved in natural water purification by wetlands requires consideration of various physical, biological and chemical characteristics, including those which:

1. aid in mechanical dispersion and/or removal of particulate matter;
2. enhance or contribute to physical absorption of pollutants;
3. promote chemical precipitation and/or ion exchange; and
4. result in biochemical uptake, assimilation and synthesis (Repport et al., 1979).

The potential removal efficiencies of wetlands for some water pollutants are very high, as shown in Table 2.

	Suspended Solids	BOD 5	Nitrogen	Phosphorus	Heavy Metals
Removal Efficiences (%)	87-99	54-97	0-95	37-99	25-99

TABLE 2: Removal Efficiences for Water Pollutants
Source: Chan et al., 1981.

The cost of wetlands as a stormwater treatment method appears to be relatively high because it requires a large amount of land. However, these high costs will be partially offset by improved aesthetics, wildlife habitats, and recreation areas.

Treatment plant - A second alternative for treating stormwater runoff is to pump the runoff through a treatment plant. Building a plant solely for the treatment of stormwater is both inefficient and uneconomical, due to Berkeley's seasonal rain pattern, which would leave the treatment plant idle for half the year. A 5 million gallon per day plant could treat most of Berkeley's runoff but would cost more than $2.5 million (Stenstrom et al., 1982). This investment would be prohibitively large for almost all communities.

A slightly more economical system would be to provide large storage facilities for the runoff so that it could be treated at existing sewage treatment plants during non-peak hours. The disadvantages of such a system are the physical size of the required storage facilities (probably on the order of tens of millions of gallons), the need for periodic cleaning of the facility of sediments, and the high costs of building and operating the system (Stenstrom et al., 1982).

Berkeley's Alternatives

In all three areas previously discussed, education, ordinances and treatment, there are options available to Berkeley. The City of Berkeley covers about 10 square miles, has 213 miles of streets, 426 miles of street surface gutters and 1900 catch basins (Raxter, 1983, pers. comm.). Nobody has ever measured the amount of runoff from Berkeley during a typical storm, but it can be easily estimated if it is assumed that roughly 35 percent of residential land surfaces are impervious (Poertner, 1980). During a one inch rain approximately 60 million gallons of water will run off from Berkeley into the bay. This is a great deal of water and has potential for carrying a large amount of pollution. Berkeley will require a comprehensive plan of stormwater management effectively to diminish the amount of pollution in the storm water.

Education

An informal survey of sixty people in Berkeley on March 25 and 26, 1983 was conducted as part of this report. Less than 25% of the people questioned knew that storm runoff entered the bay virtually untreated. Many were surprised when informed of the fate of stormwater. A public education program about stormwater and its fate must be a part of any stormwater management plan. One economical method for educating the public would be to include a flyer about stormwater in existing mailings, such as the water bill or the city tax bill. Another possibility would be to declare a water awareness week in which the many issues concerning water could be discussed.

The California Solid Waste Management Board's Used Oil Recycling Program is responsible for conducting a public education program. The program's goal is to inform the public of the needs for, and benefits of, collecting and recycling used oil in order to conserve resources and preserve the environment. The Board is willing to help Berkeley put on local events, conferences and lectures to educate the public. It is also willing to provide assistance to community-based organizations and local governments to establish more local recycling stations (Moskat, 1983, pers. comm.). Berkeley presently has five local gas stations acting as collection centers for oil recycling. Their phone numbers are available from the Ecology Center (548-2220).

Ordinances

Berkeley Municipal Code 12.40 covers litter and garbage. The code prohibits, among other things, weeds and debris on sidewalks and the depositing of garbage on public or private property. The law is generally only used when there is a citizen complaint. This law appears to be working well, but it could be strengthened to cover a wider variety of problems. For example, a "pooper scooper" law could require pet owners to clean up after their pets. A similar law was passed in San Francisco, and has moderately corrected the problem. A similar law could be effective in Berkeley, especially if used in conjunction with a public education program. The papers by Irvin Betts and Teresa Simonitch on Aquatic Park and the Shoreline in this report point out the need for such a law.

Another law which would help clean up stormwater is one aimed at decreasing oil leakage from automobiles. Section 172 of the Federal Clean Air Act mandates that individual states, in areas of non-attainment of air quality objectives, establish a specific schedule for implementation of a vehicle emission control inspection program. Berkeley is in such an area, and the State Legislature passed a law requiring automobiles in non-attainment areas to undergo inspection starting sometime within the next two years. It may be possible to expand the objectives of the inspection to include some regulations concerning oil leakage.

Regulations to prevent pollution due to pesticide and fertilizer use probably will not be required in Berkeley. With Berkeley's Mediterranean climate, most of the rain falls during winter. Since pesticides and fertilizer are generally applied during spring and summer and are generally not too environmentally persistent, the amount of pesticides and fertilizers that enter stormwater may be insignificant. A sampling of stormwater should be carried out to determine if this hypothesis is true.

Treatment

Porous pavement and greenbelts - Even though there is little new development in Berkeley, there are opportunities to use porous pavement and greenbelts as a method of removing pollutants after deposition but prior to degrading stormwater. Parking lots and roads wear out and need to be replaced. On city-owned or maintained lands, porous pavement or greenbelts could be tested on a small scale to determine the economic feasibility and benefits of techniques. If they prove to be successful, they could then be used on a larger scale.

In regard to private construction, the City of Berkeley could require porous pavement or greenbelts to be used through zoning laws or by way of the City's permit-granting authority. A cost/benefit analysis should first be carried out to determine if the requirements would be fair to developers. A less rigid approach would be to have the city recommend, by way of zoning or permits, that greenbelts, porous pavement or some other stormwater management technique be incorporated into construction projects done in the city.

Catch basins - Berkeley's 1900 catch basins are cleaned with a vacuum truck once a year starting in August. The work starts in the flatlands and proceeds up hill until the rain begins. In the budget this year is an allocation for a new vacuum machine which will speed up the process of catch basin cleaning. Since catch basins decrease pollution only if cleaned regularly enough, the cleaning schedule for catch basins should be evaluated to see if more frequent cleaning is needed.

Unfortunately, many of Berkeley's catch basins do not have gooseneck leads connected above the bottom of the basin (as in Figure 3). They have outlets connected directly to the bottom of the catch basin, which prevents them from removing pollutants. Replacing or modifying these catch basins would be very expensive.

Street sweeping - The Berkeley Department of Public Works currently has two street sweeping machines and three hand crews involved in street sweeping. The sweeping is concentrated in the commercial areas of downtown Berkeley. During the leaf drop season, from August to April, concentration is on streets with an abundance of trees. The city is also divided into districts which are swept on a rotating basis. Parked cars and a lack of manpower are major obstacles preventing effective street sweeping.

As mentioned earlier in this paper, it appears to be economical to sweep parking lots and commercial streets selectively in an effort to decrease pollution loading. Since commercial parking lots are not presently swept due to the lack of manpower, machines or sweeping requirements, it may be feasible to require commercial establishments to pay a fee enabling the city to periodically sweep their parking lots.

Wetlands - Berkeley currently has a unique opportunity to use wetlands for its stormwater treatment. Berkeley's waterfront is relatively undeveloped, and the planning process for development is now being started. The only marshes in the area presently are the Emeryville Crescent to the south of Berkeley and the Albany Marsh to the north (Figure 4). The cost of using either of these marshes for Berkeley's stormwater treatment would be prohibitive because new pipelines would have to be built in conjunction with large pumps to move the water to either of these marshes. A more economical use of these marshes would be to treat runoff from Emeryville or Albany.

A feasible alternative would be to build some new marshlands on Berkeley's waterfront. There are presently some areas that could easily be converted into marshlands since they are already partially sheltered from the bay wave action (see Figure 4). Since a waterfront park is being considered for the area south of University Avenue, the stormdrain outlets in this area and the outlets from Aquatic Park could be diverted to the North Waterfront Area. This large, sheltered area would be ideal for marshland.

A large marshland along the waterfront would be valuable to aquatic birds, marshland plants, and the bay ecosystem as a whole. The salt-marsh harvest mouse, an endangered species, could also be introduced into this new marshland. Raised boardwalks, interpretive signs, trailmarkers, and observation platforms for bird watching could also be constructed for public enjoyment. The interpretive signs could include information about the treatment of stormwater by marshlands and the benefits of marshlands in the bay ecosystem.

REFERENCES CITED

1. Association of Bay Area Governments (ABAG), May 1980. Bay Area Water Quality Management Plan, 79pp.

2. Becker, B., M. Clar, R. Kautzman, 1973. Approaches to Stormwater Treatment, Office of Water Resources Research, Dept. of the Interior, 258pp.

3. Bryan, E.H., 1972. Quality of Stormwater Drainage from Urban Land. Water Resources Research Institute Bulletin, Vol. 8, No. 3.

4. Chan, E., T. Bursztynsky, N. Hantzche, Y. Litwin, 1981. The Use of Wetlands for Water Pollution Control, ABAG, 245pp.

5. Chan, E., G. Silverman, T. Bursztynsky, 1982. San Francisco Bay ARea Regional Wetlands Plan for Urban Runoff Treatment, Volume I, ABAG, 49pp.

6. Dinitz, E.V., 1980. Porous Pavement, Phase 1, EPA - 600/2-80-135, 135pp.

7. EPA, January 1977. Preventive Approaches to Stormwater Management, 440/9-77-001, 207pp.

8. Hannon, J.B., 1980. Underground Disposal of Stormwater Runoff, FHWA - TS-80-218, U.S. Department of Transportation, 189pp.

9. Lynard, W.G., 1980. Urban Stormwater Management and Technology: Case Histories, EPA - 600/8-80-035, 320pp.

10. Moskat, G., Manager, Used Oil Recycling Program, State of California. Personal communication, 1983.

11. Poertner, H., 1980. Stormwater Management in the United States, Dept. of Interior, 240pp.

12. Raxter, D.H., Senior Supervisor, Public Works Maintenance, City of Berkeley. Personal communication, 1983.

13. Repport, R., W. Sigleo, E. Stakhiv, L. Messman, C. Meyers, 1979. Wetland Values, Concepts, and Methods for Wetland Evaluation, U.S. Army Corps of Engineers, 109pp.

14. Sloan, D., ed., 1982. The East Bay Shoreline: Selected Environmental Issues, Environmental Sciences Group Major, University of California, Berkeley, 249pp.

15. Stenstrom, K., G. Silverman, T. Bursztynsky, 1982. Oil and Grease in Stormwater Runoff, ABAG, 241pp.

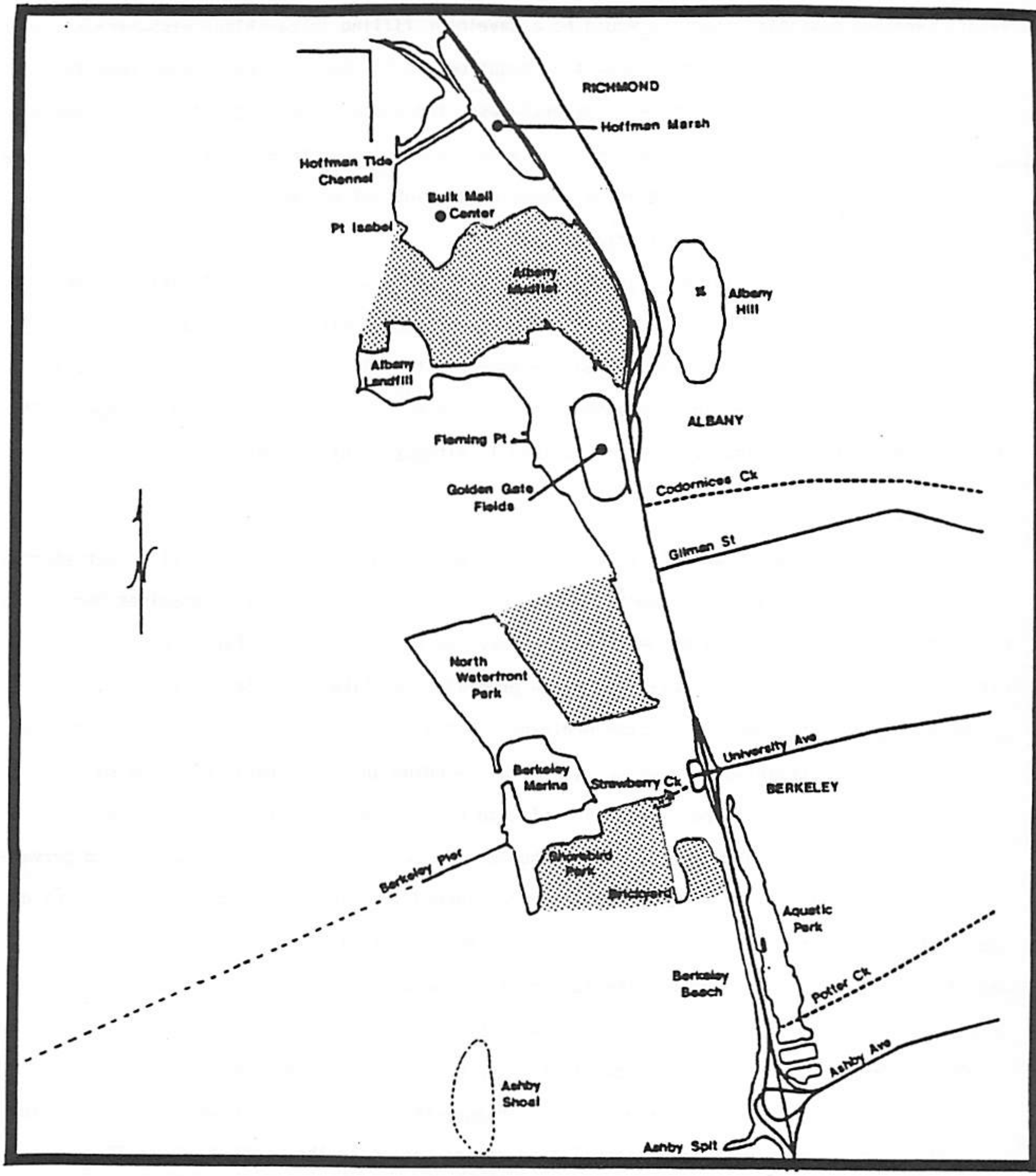

FIGURE 4: Possible Sites for Marshlands
Base Map Source: Sloan, 1982.

The possible sites for new marshlands are shown with a stiple pattern.

The cost of constructing the marshes could be mitigation, paid for by the developer of the waterfront. Another possible financier would be a developer filling in marshland elsewhere around the bay.

The designing, financing, and permitting requirements of constructing a marsh that is suitable for stormwater treatment are complex. Nevertheless, the Association of Bay Area Governments (ABAG) is currently undergoing the process for a wetlands project in Coyote Hills in Fremont. ABAG has published a number of books and technical memos on the subject and would offer assistance if Berkeley decides to develop new marshland areas.

The possibility of building large storage facilities to store the runoff until it can be treated is not feasible in Berkeley. In order to store the projected sixty million gallons of runoff, even with a water depth of ten feet, would require approximately 800,000 square feet. The cost of building and maintenance would be prohibitive. The only logical location for a storage facility would be near the shoreline, an area where land is already in high demand.

Conclusions

The first step towards an effective stormwater management program is admitting that stormwater pollution is a problem and that something can be done about it. This paper examines Berkeley's alternatives to stormwater management and can serve as a starting point for an effective stormwater management program. A public education program seems like a logical first step, followed by the passage of stronger anti-litter ordinances and a "pooper scooper" law. Due to Berkeley's current budget constraints, more effective street sweeping and catch basin cleaning may not be a viable alternative, but it would be informative to review the city's current practices. The use of porous pavement and greenbelts in Berkeley should also be considered on both public and private lands.

The best solution, and one that should be considered immediately, is the possibility of developing marshlands for stormwater pollution control. Berkeley is in a unique position since it has a waterfront that is not developed. The future of the waterfront is now being decided. The cost of developing marshlands need not rest solely with the city, as it may be possible to use marshland development as mitigation for development of other ports of the waterfront.

A real possibility is that Berkeley will continue to do nothing about stormwater pollution until the Federal Government starts penalizing cities violating the section of the Clean Water Act directed at non-point source pollution. By then, Berkeley's waterfront may be developed and the possibility of using marshlands for treatment may no longer be an alternative.

As the margins of the bay continue to be developed, the stress on the bay will continue to increase. Managing stormwater pollution is an effective tool that can be used in helping to maintain the integrity of a valuable resource--the bay.