Putting A Price On Riparian Corridors As Water Treatment Facilities

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Abstract

The monetary value of natural riparian environments that provide water quality treatment functions by processing nutrients, storing sediment, moderating temperatures, and other services can be estimated by calculating the costs associated with the construction of brick and mortar water treatment plants built to achieve similar functions. A demonstration urban runoff treatment plant built by the City of Santa Monica provides similar services as a 4,000-5,000 lineal foot riparian corridor does, and has annualized costs of approximately $730,000 per year over a 20-year period taking into account the revenues the plant may accrue by selling its recycled water. The annualized costs for similar water quality treatment services provided by a natural riparian system were estimated by recording the costs of protective easements, fee acquisition, and restoration of riparian areas located in an urban context. A large, federally-funded, multi-objective flood control project with water quality benefits annualized over 20 years has about the same costs as the treatment plant. Urban stream restoration projects for 5,000 lineal feet of stream with riparian habitat can range in cost from $15,550 to $155,000 per year annualized over 20 years. Cost estimates of a range of restoration scenarios are given, including land acquisition and maintenance costs. While costs for all the alternative water treatment scenarios were given in 2005 dollar values and annualized over 20 years for purposes of comparison, most riparian restoration projects will be providing benefits over a 100 year period or in perpetuity, while the life span of the structural plant is expected to be 20 years or less.

Cost Comparisons: Man-made Systems- Naturally Occurring Systems

The first of its kind, state-of-the-art stormwater treatment plant located in Santa Monica, California gives us the opportunity to compare the benefits and costs of a physical “brick and mortar” stormwater facility with the benefits and costs of naturally occurring or restored riparian environments while evaluating their respective abilities to affect the quality of stormwater runoff. The Santa Monica Urban Runoff Recycling Facility (SMURRF) collects polluted runoff from the Los Angeles area and reclaims it sufficiently so that it can be re-used for landscape irrigation or dual plumbing systems. The plant came on line in February 2001 and is located near the Santa Monica pier. The building design involved a collaboration of engineers and artists. The plant features interesting architecture, art, and on-going visitor tours with public education about urban stormwater runoff, making this interesting, pioneering engineering facility an engaging

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This plant is intriguing for reasons other than its merits as a currently one-of-a kind centralized stormwater collection and treatment facility. The presence of a physical plant and the costs associated with its construction and operations and maintenance provide the first opportunity to assign long term costs and benefits to a man-made stormwater treatment plant with the treatment capabilities and costs and benefits of a natural, functioning riparian system. Of course there may be no costs associated with the presence of a naturally existing riparian corridor, and in these cases we can better understand their monetary value by examining the costs of protecting the services they provide. If we do allocate financial resources to protecting riparian resources or to restoring degraded waterways this comparison gives us a basis for assigning costs and benefit values in dollars for these natural systems compared to the monetary costs and benefit values of constructed treatment plants.

The Policy Context For The Comparisons

Ecologically functioning riparian environments are valued for the fact that they provide aquatic and terrestrial habitat for fish, amphibians, reptiles, mammals, and birds, and recreational and open space opportunities for the public. Yet little or no research appears to be available on the economic benefits of riparian areas to society for their water quality treatment functions. Riparian areas improve water quality by removing nutrients, improving dissolved oxygen, storing sediment and regulating temperatures among other benefits. These benefits can be achieved by protecting existing healthy riparian environments, or by restoring degraded areas into functioning ecosystems. Protection can be achieved by voluntary ecologically sound landowner practices, and/or through regulation, conservation easements, or fee purchase of riparian corridors. One method of assigning monetary value to these natural systems therefore, is to record what society pays to prevent farming or other land uses in these areas, pass protection regulations, purchase easements or full public rights to the riparian land, and/or to restore the ecosystem. In many circumstances, particularly in urban environments, the monetary costs of protecting a healthy system can be difficult to estimate. The comparison made here emphasizes the relative benefits and costs of two different types of stormwater treatment options which is typically a ubiquitous management problem in urban areas. For that reason, this paper focuses on the more readily available data on the costs and benefits of urban stream and riparian corridor restoration as one method of deriving their monetary value.

This research is not intended to evaluate whether the SMURFF Plant is cost effective for the primary problem it was meant to solve which is to assure safe recreational use of the beach at the Santa Monica pier. Nor does this research intend to answer the question of what array of storm water treatment management systems are the most cost effective for the treatment of runoff pollutants for different urban situations. Research is only now just becoming available on the relatively new application of low impact development (LID) , decentralized stormwater infiltration systems. These landscape swales, “rain gardens” and permeable surfaces are constructed into commercial, industrial or residential landscapes or “streetscapes” to temporarily capture and slow stormwater to reduce the peaks of hydrographs for small to moderate rainfall events. Some of these systems are currently undergoing evaluations for their capacities to treat urban runoff to also reduce pollutant loads to streams and other natural water bodies and their costs are being compared against conventional curb, gutter detention pond collection and treatment systems. Unfortunately, only a few studies have dealt so far with assigning monetary benefits to these systems. (ECONorthwest 2007) A comprehensive costs- benefits analysis of a whole array of stormwater treatment options , that include these newer LID approaches will hopefully be the topic of someone’s future research. The comparisons described in this research however focus on the task of putting the benefits and services of a riparian environment into perspective by describing what we need to pay if we were to substitute these naturally occurring services with a constructed plant.

The SMURRF Plant Functions and Costs

The SMURRF Plant construction costs were approximately $13.6 million dollars (in $2005 dollars) (City of Santa Monica 2003), and the annual maintenance and operations costs are about $200,000 a year (Shapiro 2005). The plant treats about 320,000 gallons of runoff a day (City of Santa Monica 2003). One function of the plant is to remove fine sediments from the water, which is accomplished with a rotating drum screen. A second chamber removes grit and sand. Oil and grease are then removed in a unit that aerates the water using a compressed air unit (the dissolved air flotation unit.) This unit brings the oil and greases to the top so they can be skimmed off.

The next process in the plant is micro-filtration, which helps reduce the turbidity of the water by forcing the water through membranes. The membranes have to be periodically cleaned of pollutant build-up. The final step in the treatment process is to disinfect bacteria and viruses by passing the water under ultraviolet radiation lamps. The basic functions of the plant therefore are to filter sediment, reduce turbidity, trap oil and grease, and treat bacteria and viruses. Removal of sediment can also benefit removal of nutrients and other pollutants that may adhere to it (City of Santa Monica 2003). A separate trash collecting unit, which cost $200,000, catches trash from about 50,000 gallons a day before it enters the plant (Shapiro 2005).

Comparing A Treatment Plant To A Stream

In order to compare the costs and benefits of a plant against the costs and benefits of a riparian corridor we need to identify whether the water treatment functions of the plant and the riparian corridor are similar, and we need to compare the treatment of similar quantities of stormwater. The SMURRF plant treats approximately 320,000 gallons of water a day. The water treated is not wet weather runoff but dry weather run-off collected from about 5,100 urbanized acres. Stormwater flows from winter rainfall continue to run untreated into the ocean (Shapiro 2005). Theoretically, the plant could be expanded to treat wet and dry weather runoff, but for now I am going to assume that the costs per gallon of either dry season or wet season runoff are comparable. It is important to keep in mind that the plant may treat runoff from 5,100 acres but only treats a small portion of the runoff from that acreage. Therefore, we cannot use as a basis of comparison the number of acres served by our man made and natural "facilities," but we need to compare systems that can accommodate similar quantities of water.

A stream flowing at 1 cfs (cubic foot per second) produces a volume of water equal to 646,272 gallons per day. The 320,000 gallons treated by the plant equates to about .5 cfs flow per day. Using watershed and hydrologic information from a Bay Area stream we can estimate the size of the drainage area and creek that would produce a flow of about .5 cfs and then evaluate the ability of a stream of this scale to treat stormwater naturally. We can also compare the costs and benefits associated with restoring a length of stream that would treat a similar average annual flow to the costs and benefits of the stormwater plant.

The San Francisco Bay Area creek we will use for a costs and benefits comparison with the plant is Wildcat Creek located in the cities of Richmond and San Pablo, and the East Bay Regional Park system in Alameda and Contra Costa Counties. The average discharge or average annual flow (the arithmetic mean of the daily flows for the period of the hydrologic record) of Wildcat Creek using twenty years of gage data located on the creek is approximately 7 cfs for the location we are going to evaluate on the lower portion of Wildcat Creek. This twenty-year average for the daily flow takes into account the occurrence of large fluctuations of flows during the year, including very low summer flows where the creek may dry up in places, to high flood flow events—as high as 2,000 cfs or more. Wildcat Creek drains a watershed area of about 11 square miles and the length of the creek is about 11 miles.

The length of the Wildcat Creek stream channel is about 5,280 feet for each square mile of watershed drained, and the average daily flow from this square mile is about .64 cfs. Using this hydrologic information for the Wildcat Creek watershed we can estimate that a section of creek channel about 4,125 feet long comprising an area of .78 square miles of the lower watershed will produce a .5 cfs average daily flow on an annual basis. Another way to describe the scale of this watershed is as a 500-acre area. In 2000, the Wildcat San Pablo Creeks Watershed Council completed a restoration project 5,000 feet long on lower Wildcat Creek where the average daily discharge is about 7cfs. The width of the riparian corridor varies from 50 feet to 65 feet. The channel width is 10 feet and the floodplain located outside the riparian zone is maintained in grasses, shrubs, and cattails. The entire corridor is 250 feet wide. If you evaluated this reach of creek in isolation from the rest of the watershed it would produce about .6 cfs average daily discharge. The scale of this project and the discharges produced by this reach if considered separated from other watershed runoff , make it a reasonable case study with which to make comparisons to the SMURRF plant, which treats an average daily discharge of .5 cfs.

Natural Riparian Systems Functions and Costs

Comparing Water Quality Treatment Functions

Research and collected field data is now available that addresses the issue of not only the water treatment functions riparian systems perform but also the area of the natural systems that produce the treatment results. A significant body of water quality research details the ability of riparian systems to store sediment, and retain and transform excess nutrients, pesticides, and toxic substances. (Meyer et al. 2003; Klapproth and Johnson 2000); Wenger 1999; Osborne and Kovacic 1993; Peterjohn and Cornell 1984; Chagrin River Watershed Partners 2006). The literature represents a wide range of environmental conditions and landscapes and therefore produces a range of quantifiable findings. For example, researchers in Corvalis, Oregon found that 60 to 80 percent of sediment generated from forest roads were captured by less than 250 feet of a healthy riparian system in point bars and pools, and their measurements indicated that stream systems could store sediment for as long as 114 years (Meyer et al. 2003). A study in the Southern Appalachian Mountains indicates that phosphorous- and nitrogen-containing compound ammonium traveled less than 65 feet downstream before being removed from the water by riparian areas (Meyer et al. 2003). First order headwater streams in the northeastern United States have been found to be responsible for 90 percent phosphorus removal (Meyer et al. 2003. A mathematical model based on research in 14 headwater streams throughout the country shows that 64 percent of inorganic nitrogen entering a small stream is transformed within 3,000 feet of stream channel (Naiman et al. 1997).

In general, riparian areas are found to be efficient at processing organic matter and sediments, and sediment bound pollutants carried in surface runoff are deposited effectively in riparian forests and floodplain areas. The finer sediments are removed from runoff as a result of deposition and erosion, infiltration, dilution, and adsorption/desorption reactions with woodland soil and litter (Bhowmilk et al. 1980). Riparian systems are known to have significant impacts on water temperatures and microclimates (Naiman et al.1997).

Scientist have described how the oxidized hyporheic water from the stream bed mixes with the interstitial water flowing from riparian zones, which reduces the transfer of inorganic nitrogen and phosphorous to stream water. Ecological process that occur in the hyporheic zones have strong effects on water quality in which bacteria, fungi, and other microorganisms living in stream bottoms consume nutrients and convert them to less harmful, more biologically beneficial compounds (Naiman 1997). Riparian areas and their floodplains have been measured to remove 80 to 90 percent of the sediments contributed by agricultural areas (Cooper et al. 1987). Plant uptake can be an important mechanism for nutrient removal in riparian forests in both intermittent and perennial streams (Karr and Schlosser 1978). The width and length of riparian corridors needed to act as chemical filters for nitrogen varies by stream environment, but researchers have found that riparian areas as narrow as 48 feet were effective in removing it. (Cooper et al. 1986). Even smaller headwater areas have been found to rapidly take up and transform nutrients within just hundreds of lineal feet (Peterson, et al. 2001).

Researchers have also found that the loss of riparian areas to clearing and channelization not only equates to a loss of these treatment functions but may also result in the disturbance of areas that have served as nutrient sinks for sediment and sediment associated nutrients, which then causes the export of the nutrient sink accumulated over many years (Kuenzler et al. 1977). Removal of wooded areas and the subsequent changes in the peak discharges and shortening of runoff lag time typically results in geometric increases in sediment loads being transported by streams (Leopold 1981).

Research also indicates that healthy aquatic systems can transform animal waste and chemical fertilizers into less harmful substances. Vegetated buffers and protected riparian areas with contiguous riparian corridors have been shown to be effective in reducing pathogens such as coliform and cryptosporidium parvuum (Meyer et al. 2003; Tate, et al. 2004; Tate, III, 1978; Balance Hydrologics 2007).

The Wildcat Creek restoration project of 5,000 lineal feet, which has an average width of 60 feet, should have similar water quality treatment capacities as the SMURRF plant in respect to sediment removal, nutrient absorption, and breakdown of grease and oils, as described above. This riparian area also has the inherent capacity to reduce bacteria and viruses. The ultraviolet light treatment for pathogens is likely a more consistently reliable treatment for the latter; therefore, this may be the one area in which natural riparian system do not have equal treatment capacity.

Comparing Costs

If it is fair to argue that, conservatively, this 4,000 to 5000 foot riparian environment can perform water quality functions equivalent to this plant, can we then compare the relative cost of these systems?

Two of the most effective and commonly used methods to protect and or restore streams is to fence out livestock and or purchase conservation easements to remove riparian corridors from grazing or other agricultural uses. Only very limited cost information is available for purchase of conservation easements to protect riparian resources in the San Francisco Bay Area. The Napa Valley Regional Natural Resources Conservation Service office located in an agrarian region contiguous with the more urban part of the San Francisco Bay Area, reports that it is exceedingly rare for the federal wetland and floodplain reserve programs to be used to acquire easements in the more urbanized coastal, high value urban and agricultural lands. This rarity of conservation easements is a result of the fact that most of the Bay Area landowners generally want in-fee purchase for the total land values, and land trusts are reticent to accept the maintenance and management costs associated with conservation easements for relatively small linear tracts of property characteristic of riparian corridors as opposed to the advantages of purchasing large parcels of property for open space and wildlife refuges. The U.S. Department of Agriculture reports that its wetland reserve program was used once in the past decade in the Bay Area in partnership with Marin Audubon Society in east Marin County, where the easement price was capped at $5,000 an acre. Most wetland reserve programs are capped at $3,000 per acre federal acquisition costs, but coastal counties in

California are allowed a $5,000 cap. In Stanislaus County (inland from the Bay Area) easements purchased in 1999 along the Tuolumne River required a combination of funding sources to cover costs as high as $4,000 an acre (Blake 2008); (Fourkey 2008). If the per acre cost of $5,000 is applied to a 150-foot-wide riparian corridor it puts the cost of a riparian easement at $86,000 for 5,000 lineal feet of stream. Fencing costs to protect riparian corridors can typically range from $19,000 to $26,000 for a 5,000-foot length of creek (including both banks) (Blake 2008). The costs estimates in this paper focus on the costs of both in-fee acquisition of land and restoring a 5,000 foot riparian corridor in urban western Contra Costa County and represent low, moderate and high costs associated with an urban environment.

To perform cost comparisons it is useful to annualize the cost of the SMURRF Plant over a twenty-year period using 2005-dollar values. The City Engineer's best estimate on the life of this plant is twenty years, based on the technology becoming obsolete by that time, although she cautions that breakdowns and replacements of machinery are inherent in the use of the new technology. The plant construction and land costs converted to 2005 dollars are $13.63 million and land values estimated by the county assessor are $33,000 (Higbee 2007). Annual maintenance costs are now approximately $200,000 per year. Therefore, the SMURRF construction and operations and maintenance costs annualized over this length of time come to $883,600 per year for the treatment of .5 cfs per day (Lowell 2005).

There are a number of scenarios for urban riparian protection and management that we can now compare against this dollar value. A wide range of restoration projects can be selected for making comparisons with, and it is a challenge to define a "typical" restoration project. The following restoration case used to make benefit and costs comparisons with the SMURRF project is a stream channel, floodplain, and riparian restoration project planned, designed, and constructed through a multi-agency watershed council. The project used for the comparisons involves a 250-foot-wide, 5,000-foot-long stream channel and its associated riparian habitat along Wildcat Creek. All values shown for costs use published data contained in government reports, which were then converted to 2005 dollar values based on the Consumer Price Index. The Wildcat Creek case allows us to compare very high and low range costs associated with stream restoration projects that occurred along the same reach of channel at different times.

Between 1986 and 1989, the Army Corps of Engineers, in partnership with Contra Costa County, constructed a multi-objective flood damage reduction project which included acquisition of the 250-foot-wide-corridor, and creation of a floodplain, vegetated corridor, and stream channel within the 250-foot-wide-corridor. Objectives of the project were to provide for a naturally functioning bankfull stream channel and adjacent floodplain, and protection of a riparian corridor. Army Corps projects represent the high end of costs for stream and river restoration work. The costs in this case equated to $2,706 per lineal foot. The total construction costs for 5,000 lineal feet (the total length of the project on Wildcat Creek was 10,000 feet) was $13.5 million, and land costs and relocation costs were $1.9 million for a total project cost of about $15.4 million. The annual maintenance costs expended by the county for this project area and staff support for the watershed council, which oversees the long tem management of the project area, is approximately $4,500 per year, for a twenty-year maintenance cost of $90,000. The annualized costs over a twenty year period of time for the high end cost Army Corps project is approximately $777,000 a year (Refer to the Summary Costs Table. For purposes of calculating a cost-benefit ratio for a multi-objective flood control project the Army Corps s amortizes the costs and benefits over a 100 year period.)).

In 2000, the watershed council implemented a 5,000-lineal-foot project along a reach in the same corridor to bring the project into conformance with the latest in geomorphic and engineering design knowledge and to provide a stream system with improved environmental values that could better maintain itself in an equilibrium condition. This project restored the stream channel to new dimensions, increased its sinuosity, and increased the average width of the riparian corridor from 30 to 55 feet. The 2000 project represents a major design and construction effort of the county and a non-profit organization; however, the project represents the lower end of the costs spectrum for restoration work at only $24.00 per lineal foot, for a total cost of $113,400. The Army Corps did provide a design document that helped validate the restoration design prepared by the non-profit organization. If the cost of that document is included, the cost of this restoration project is increased to $221,100, with a per lineal foot cost of $44.00. The annualized cost of this 2000 restoration project for a twenty-year period is $15,550. per year including maintenance costs; if we add in the original land acquisition costs covered by the earlier project the average annual cost increases to $112,000.

These costs provide actual figures for expensive and low cost projects; therefore, it is also useful to estimate costs that better represent average costs for stream restoration projects. Based on the experience of the author, who is involved in implementing stream restoration projects and comparing costs with other practitioners, a reasonable average lineal foot cost for a project of this scope conducted in 2005 in the San Francisco Bay Area would range between $300 and $600. Using the higher average value of $600 per lineal foot, a good estimate for a 5,000-foot riparian restoration project in the median range would be $3 million. Adding in average annual maintenance costs of $5,000 per year brings the annualized costs over a 20-year period to $155,000 per year.

Thus far, we have established that our total project cost comparisons on an annualized basis are $884,000 a year for the SMURRF plant, and the restoration projects range from $777,000 to $155,000 and $15,550 a year. Research indicates that the wide riparian and floodplain corridor and project length should be more than adequate to insure equivalent water treatment functions and benefits as the plant except psooibly virus control. The reason I choose to evaluate a 5,000 foot restoration corridor on Wildcat Creek is that this length of corridor, if it was viewed in isolation from the rest of the watershed, would produce approximately an equivalent average daily flow of about .6 cfs compared to the SMURRF plant average daily discharge of .5 cfs. However, we do have to recognize that we are probably not comparing equivalent water treatment functions because the average daily discharge that flows through this restored section of Wildcat Creek—because it is part of a larger watershed—is closer to 7 cfs, as opposed to the .5 cfs treated by the plant. Again it is reasonable to assume that the riparian corridor is affecting the quality of the total average daily 7 cfs. We could correct for the equivalent costs for “treatment” of .5 cfs by proportionately lowering the costs to approximate the costs per cfs treated. For example the treatment by a riparian system of 7 cfs average annual flow comes at a cost of $15,550, or $777,000. and therefore theoretically the costs for treating only .5-.6 cfs would recalculate the annualized costs at $1,100. or $55,000. for the expensive federal project.

Considering Multiple Benefits of Riparian Areas

This analysis so far restricts itself to only the comparable water treatment functions of the riparian system and the SMURRF plant. There are additional benefits of both the SMURRF Plant and the riparian systems that should be recognized and these can be described in either qualitative or quantitative terms. These benefits should also influence our evaluations of the relative values of these two very different systems.

The SMURRF plant also serves as a public education facility in which visitors can tour the plant and read interpretive displays about the plant and stormwater management. City records indicate that the plant averages about 230 visitors a year (Higbee 2005). Some of the water treated by the SMURRF plant is sold to customers, including the City of Santa Monica, for landscape irrigation and use in dual plumbing systems. Currently the water supplied by the plant is used in the new dual- plumbed Santa Monica Public Safety Building housing the police and fire departments, and the water is used to irrigate the grounds of the civic center parking structure, city parks, and cemetery, and Caltrans applies it to Santa Monica freeway landscaping. The income receipts for this water use currently total $32,000 a year based on 2003-2004 records (Lowell 2005). New water customers just now hooking up include a state-of-the art Rand Corporation Building and a commercial building know as The Water Gardens, which will be dual plumbed. It is estimated that this may increase the use of the water from the plant by 20 percent; therefore, receipts in the next few years could reasonably expect to increase to almost $40,000 annually. Unused flows return to the regional sewage treatment plant. It is very hard to predict future demand for the water cleaned by the plant because high volume estimates would be based on demand for newly constructed dual plumbing systems. The city water resources engineer’s best estimate of a potential full use annual income if there is a demand for the full 230,000 gallons a day (based on a three tier pricing rate structure) is about $390,000 per year by 2016 (Lowell 2005). If we apply some optimistic assumptions about increasing demand over time for the water supply created by the plant, which includes a demand for the full amount treated by 2016, the plant will bring in an average annual income, based on a plant life of twenty years, of about $150,000 per year. (The plant may reasonably bring in total revenue of about $3,068,000 during its life span.) This benefit helps offset the annual management costs of $200,000, and lowers the total annualized costs of the plant to approximately $730,000 per year.

It can be argued that the SMURRF plant benefit of creating a recycled water supply cannot be compared against the benefits of the restoration project, which did not have the objective of developing a supply for purchase by urban water users. Likewise, it may not be appropriate to compare the substantial flood damage reduction benefits of the restoration projects against the benefits of the SMURRF plant because flood control was certainly not an intended objective of the SMURRF plant. In this case it is appropriate to compare water quality treatment functions only, and it is likewise appropriate to compare environmental and public education benefits, which are shared objectives of both projects. (The quantifiable flood damage reduction benefits are cited in the Projects Benefits Table.)

The restoration project has enabled an adjacent regional trail to be developed, and the project serves as a part of the educational opportunities for a very disadvantaged elementary school serving an impoverished community located next to the creek. The creek restoration area is also the focus for a Richmond High School environmental education program that serves about 25 students a year. The elementary school located next to the restored creek banks serves about 307 students a year. The project also serves as an anadromous steelhead (a threatened species) fisheries habitat restoration project and supports habitat and protection for the endangered California clapper rail and salt marsh harvest mouse. It is known that the restored riparian system offers habitat for mammals, raptors and other birds, and a range of aquatic organisms. One of the important objectives of the restoration project is to protect 200 acres of high quality brackish marsh from degradation by sedimentation. Environmental organizations hold regularly scheduled birding and wildlife hikes along the creek. The restored creek serves as the location for an on-going inner city youth environmental stewardship, training, and employment program that has involved an average of another 15 students on an annual basis for the past ten years, and there are varying numbers of community based water quality monitoring volunteers. This particular program has attracted over $200,000 in grants and donations to the community's desperately needed youth programs in a ten-year period.

The SMURRF plant serves as an educational facility for the general public and sponsors education tours for school classes. The plants sign-in records indicate an average of 230 visitors a year. The plant provides protection for recreationists at the beach in the Santa Monica pier area and a clean, safe area for use by surfers.

Economists can assign actual dollar values to the estimated visitor days and enjoyment of either the plant or the creek. They can also assign monetary values people place on seeing wildlife and protecting it. This paper is not intended to take the economic analysis to this level of detail. The point to be made here is that while the plant does have multiple human interest and educational values, there is a range of values intrinsic to a natural environment that a brick and mortar plant cannot emulate.

Analysis of Cost Comparisons

The costs data calculated compare three different categories of projects: a multi-objective flood damage reduction project that represents the high end of the costs spectrum; a local government-non-profit sponsored project that represents the low end of the spectrum; and average restoration costs based on the author's experience. The project benefits we are comparing are water quality and environmental education. The Army Corps flood control project did not explicitly have a water quality objective but was required by the regulatory process to avoid impacting water quality. The main purpose for which the Corps project was authorized was flood control, and this purpose or function alone produced annual net benefits. Because many of the costs are associated with delivering flood control benefits, the project does not provide a direct means of comparing the costs of two different kinds of water quality projects. However, what we do learn from this comparison is that the cost of a constructed stormwater treatment plant is equivalent to a moderate size Army Corps of Engineers flood control project.

Water Quality Program Policy Implications

Water quality programs have followed a logical progression from the first emphasis on the treatment of "point pollution" discharges from sewage treatment plants and industrial facilities. The second generation of water quality programs has focused on the avoidance and treatment of polluted runoff from "non-point" sources. The U.S. Environmental Protection Agency has identified six categories of non-point sources of polluted runoff including: urban properties and streets; farm fields, pastures and operations; forestry activities; marinas and recreational boating; hydromodifications of streams such as channelization, bank stabilization projects and stormwater discharge increases; and alteration of wetland and riparian areas. The three strategies applied to managing non-point sources pollution are prevention of pollution at the source, control and reduction of unavoidable runoff, and cleanup and remediation of pollutants that remain. Best management practices including environmentally sensitive land use and development site plans, and stormwater catchment and detention and filtering systems are common examples of source control and remediation.. Protecting riparian areas, of course, directly addresses avoiding pollution from environmentally damaging hyrdomodifications and alterations of wetland areas. The evaluation most often missing from this non-point source management model is the recognition of the role of natural riparian areas to serve as part of the remediation system for runoff that escapes catchment and or detention near its source. This gives added value to riparian areas of not only addressing a part of the strategy to avoid degradation but also pro-actively remediating the impacts of various causes of non-point source pollution. A possible practical application of this information could be to assign water quality credits for meeting TMDL requirements in a watershed through the implementation of stream protection and restoration projects.

Current water quality budgets and priorities should evaluate the expenditures that have gone into treatment plants in the past and the expenditures that could occur in the future with mechanical stormwater treatment facilities, and use this evaluation as a budgeting framework for addressing the next generation of treatment systems. The comparisons described here indicate that the costs to restore degraded stream environments as fully functioning water treatment systems (which provide a significant range of other environmental benefits), can reasonably range from an average annual cost of $15,550. to a median of $155,000 and a high of $777,000 annualized over an inappropriately short period of twenty years and involving discharge amounts much greater than those addressed by a treatment plant. These costs and benefits compare to the annual cost of the stormwater treatment plant of around $730,000 for a system that treats a fraction of the amount of water and that has inherent limitations on additional environmental benefits. This represents a substantial magnitude in cost differences while the benefits of riparian environmental protection or restoration should be viewed as a more sustainable approach for attaining many more benefits through time.

Comparison of Project Costs

Wildcat Creek Project Costs*		**Costs of the SMURRF Plant**
A. 1986 U.S. Army Corps of Engineers multi-objective flood damage reduction project (This project was 10,000 feet long on Wildcat Creek, The costs shown here use the unit costs contained in the Design Memorandum applied to a 5,000-foot-long project.) Estimated construction costs for 5,000 lineal feet; $13,530,000. Estimated permanent rights of way and relocation costs for 5,000 lineal feet: $1,916,424. Total project costs: $15,448,505. Maintenance costs: $9,000 annually for 10,000 feet. Average annual costs for 5,000 feet are $4,500.	B. 2000 Watershed Council Restoration Project (executed by Contra Costa County and a non-profit) No land acquisition costs Channel excavation and partial revegetation for 5,021 feet of project channel Costs: $107,710 for design and construction by the watershed council Construction Costs per lineal feet: $18.92 $113,379 Army Corps planning Total Cost: $221,089 Average Annual cost of restoration project: $11,054.00 Design and construction per lineal foot including Army Corps planning; $44.00 per foot Average Annual Maintenance including management of the watershed council: $4,500.	Values provided by City of Santa Monica, Construction costs: $13,638,740. Land Costs: The land used for construction of the SMURRF plant was in city ownership and is an odd shaped parcel, which made it infeasible to develop. The Los Angeles Assessors' office values the parcel of land, 2,783 sq. ft at $33,300. The footprint of the plant is 1,200 sq. ft. Average annual cost: $683,000. Average Annual Management costs: $200,000; for twenty years: $4 million (Plans are to offset maintenance costs by an estimated $3,068,000 income from recycled water sales over a 20-year period. This would reduce the total maintenance costs to $932,000 and average annual maintenance costs to $50,000.)
Total Annual Average Cost including lands and relocations cost ($1,916,424) and maintenance: $ 777,900.	**Total Average Annual Costs for 5,000-foot project including maintenance: $15,550.00**	**Total Average Annual Costs assuming projected income from water sales: $730,200.**

*Values shown are based on costs published in existing documents, converted to 2005 dollars based on the Consumer Price Index. Costs for all three projects amortized over 20 years.

Data from:

- Contra Costa County Wildcat and San Pablo Creeks Project Cost Summary
- 1985 U.S. Army Corps of Engineers Design Memorandum for the Wildcat- San Pablo Creeks Flood Control Project, Richmond, Contra Costa County, Calif.
- City of Santa Monica

Comparison of Projects Benefits

Summary of Benefits of the Wildcat Creek Project for 100 years or less	**Summary of Benefits of the SMURRF Project for 20 years or less**
• 6.9 acres of high quality riparian corridor with a diversity of species and forest tiers to support wildlife habitat • 5,000 lineal feet of fish habitat and habitat for other aquatic species • Water quality functions: sediment collection and storage; nutrient uptake and conversion; bacteria reduction • Watershed Council conducts biannual community sponsored program of trash clean up • Water quality functions for average annual flows and greater magnitude flows • Flood storage and conveyance sufficient to protect the surrounding community from the damages associated with the one in one hundred year flood. Estimated average annual savings from avoided flood control damages calculated by the Army Corps of Engineers in 1986 for the period 1988-2088 is $871,000. • Active, hands-on environmental education experiences including water quality monitoring, and cleanup and revegetation projects for 340 plus elementary school students and other local public schools and community members • Youth training and employment projects (ten year program attracted more than $200,000 to community youth programs) • Riparian corridor bird habitat and bird watching for hikers who use the creekside trail. (The Sierra Club, schools and other organizations sponsor hikes.) • Riparian corridor and floodplain protect 250 acres of downstream brackish and saltwater wetlands and San Francisco Bay water quality. • Endangered species habitat	• 1,200 sq.ft. educational facility for the public. Visitors recorded averaged 230 annually • Partial trash collection • Treatment of low-flow dry weather runoff • Water Quality functions: sediment removal; nutrient removal to a water treatment plant for further treatment; bacterial treatment, and virus control • Protection of the Santa Monica beach and the surfers and other public who frequent the ocean in the area • Income from the sale of recycled water averages $153,000 a year. • Water conservation for avoidance of use of equivalent potable supplies.

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