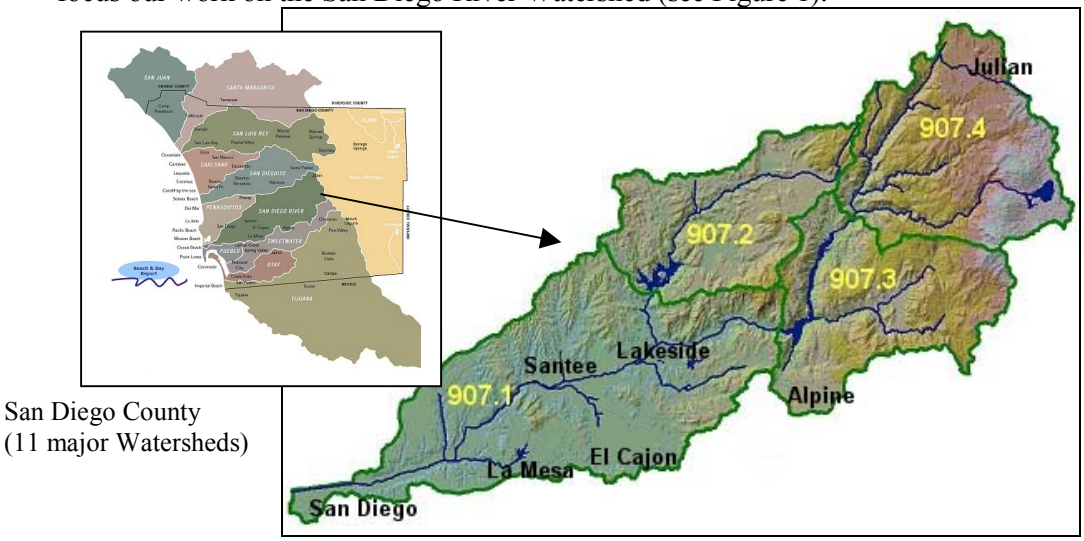
4. Narrative Description

National goals of vibrant economic development with simultaneous progress in environmental restoration and preservation emphasize the need to bring together the public, decisionmakers, and scientists in effective strategies. The attainment of these goals is not mutually exclusive, but can be assured only with the integration of ecological, social, and economic approaches to environmental management problems. …Watershed management is one method for addressing these needs for integration. (*National Research Council 1999 New Strategies for America's Watersheds, Committee on Watershed Management, Water Science and Technology Board*).

4.1 Fostering sustainable economic and societal well-being: A Watershed approach

The slogan "water will become the oil of the 21st Century" is indicative of a major shift in thinking about the economic value of natural resources. Early pronouncements of environmental crisis warned us about "Limits to Growth." During the 1970s, scholars sounded the alarm that the world's rapidly growing economy would soon outstrip the earth's supplies of non-renewable natural resources. Now, three decades later, the status of renewable natural resources (e.g., water, ecosystems) has become the greater source of concern (Costanza et al. 1997). The prospect of depleting non-renewable resources (e.g., oil, minerals) is still with us, but a distinct shift in emphasis has taken place. This is clearly evident in the rise of discourse emphasizing "sustainable development"—typically defined as development geared to balancing economic, equity, and environmental objectives. In the landmark publication on this subject, Our Common Future, the World Commission on Economic Development points out: "We have in the past been concerned about the impacts of economic growth upon the environment. We are now forced to concern ourselves with the impacts of ecological stress--degradation of soils, water regimes, atmosphere, and forests--upon our economic prospects" (WCED 1987: 5).

The concept of sustainable development suggests how the lessons of ecology can be applied to economic processes--both locally and globally. The rise of "Watershed Partnerships" is indicative of the search for this kind of integration. The "Watershed Partnership for Innovation" we are proposing will extend the information and visualization innovations of university-based research to a group of local and regional government agencies and private companies, all seeking to address crucial problems in sustainable economic and regional development. Our strategy to spur innovation will produce three synergistic components: (1) a Watershed Planning Support System, (2) an economic assessment of policy options, and (3) a service learning and workforce development program in sustainability science. We will focus our work on the San Diego River Watershed (see Figure 1).



San Diego County
(11 major Watersheds)

Figure 1: San Diego River Watershed (Hydrologic Units 907.1 - 907.4)
Source: Project Clean Water, County of San Diego

4.1.1. San Diego River Watershed (SDRW) Pilot Project

We chose to focus on the **San Diego River Watershed** (SDRW) for a number of key reasons. It provides an excellent test bed given its combination of urban, industrial, agricultural, and coastal activities. With a land area of approximately 440 square miles, the SDRW is the second largest hydrologic unit in San Diego County. It also has the highest population (~475,000) of the County's watersheds and contains portions of the cities of San Diego, El Cajon, La Mesa, Poway, and Santee and several unincorporated jurisdictions. Important hydrologic resources in the watershed include five water storage reservoirs, a large groundwater aquifer, extensive riparian habitat, coastal wetlands, and tidepools. Approximately 58.4% of the SDRW is currently undeveloped. The majority of this undeveloped land is in the upper, eastern portion of the watershed, while the lower reaches are more highly urbanized with residential (14.9%), freeways and roads (5.5%), and commercial/ industrial (4.2%) land uses predominating. The five reservoirs in the SDRW supply water to as many as 760,000 residents in the region. Other areas including the Cleveland National Forest, Mission Trails Regional Park and the river flood plain near Lakeside represent three important undeveloped areas that host a wide variety of intact habitats and endangered species like the arroyo toad, least bell's vireo, and the southwestern pond turtle. In addition, Famosa Slough, near the mouth of the San Diego River contains extremely productive wetlands habitat (details cited at the County of San Diego's Project Clean Water Web site 2003).

Urban runoff, agricultural runoff, mining operations, sewage spills, and sand mining are all impacting water quality in the San Diego River Watershed. The impacts include surface water quality degradation, habitat degradation and loss, sediment, invasive species, eutrophication, and flooding. Pollutants include coliform bacteria, nutrients, petroleum chemicals, toxics, and trash. The mouth of the San Diego River, where it meets the Pacific Ocean, is on the impaired list. The extensive groundwater resources beneath the San Diego River provide a cost effective and reliable water supply to four local water districts and the City of San Diego. However, excessive extraction, increasing total dissolved solids, and contamination by the gasoline additives now threatens this resource. There is also cause for concern regarding San Diego's reservoirs and wetlands. From the perspective of watershed planning and management, the penalty for failing to address these issues in advance will result in expensive mitigation in the future, placing real financial burdens on the future generation that are dramatically larger than many of the positive economic impacts projected for other university/industry partnerships. The California Resources Agency (CRA) and State Water Resources Control Board (SWRCB) currently estimate that $14.8 billion is needed to combat point source and non-point sources of water pollution in the California (CRA, SWRCB 2002).

In a widely noted case from New York (the upper reaches of New York City's watershed), approximately 1 billion dollars was invested in strategic watershed planning and the implementation of more ecologically-friendly forms of development. This investment, which also included 250-300 million dollars for land acquisition and conservation practices, averted the need to invest 4 billion to 6 billion dollars it would have cost New York taxpayers to build massive water filtration plants (a function now provided free of charge by stocks of "natural capital"—e.g., wetlands, riparian zones and the environmental services they provide by assimilating wastes, thereby diminishing pollution). Economic calculations underscore the value provided to us from nature's environmental services. For instance, the EPA estimates that treating stormwater naturally via wetlands ($0.73 per 1,000 gallons) is significantly cheaper than using conventional wastewater treatment plants ($3.06 per 1,000 gallons). (US EPA: Urban Runoff and Stormwater Management Handbook.1990). In another example, a new 667 acre residential development near Chicago put non-conventional, ecologically-friendly infrastructure in place to minimize environmental harm. Among other things, the developer minimized the area of impervious sidewalks (allowing for greater aquifer recharge), and installed vegetated swales and detention ponds instead of storm sewers. As Hawkin, Lovins, and Lovins (1999: 109) point out, "these measures saved $4,400 per lot, which was reinvested in common areas and other project amenities, increasing property values."

The lesson here is clear; major economic benefits can be realized from effective watershed planning and management. In a major study by the National Research Council (1999), titled New

Strategies for America's Watersheds, the authors examined the utility and limitations of the watershed-based policy-making and management. The report, as is the case with this proposal, grew out of recognition of the emerging trends toward integrative watershed management and the need to improve communication between scientists and decision makers. One of the report's conclusions was that any effort to sustain economic prosperity while preserving environmental quality will require management approaches that integrate human and natural systems. Yet the capacity to do this is limited. In a benchmark work on this subject, Kenney, et al. (2000) underscore the need for the engineering and scientific communities to "develop better, more user-friendly decision support systems to help decision makers understand and evaluate alternative approaches". This proposal pursues this challenge in its aim to develop a Watershed Planning Support System (WaPSS).

4.2. Partnership Rationale

This Partnership brings together academic, local government, industry, and non-profit organizations. Most of these partners already have a track record working together in the context of our multi-campus Regional Workbench Consortium (RWBC), funded in large part by the Outreach Core of UCSD's Superfund Basic Research Program since 2000. The RWBC is a "knowledge-action collaborative" geared to linking science and technology to policy and planning and to enhancing infrastructure for research, education, and service learning <http://regionalworkbench.org>. While our NSF-Partnership for Innovation grows out and benefits from the RWBC's collaborative networks, it is also distinct. The RWBC is an innovation incubator that supports various projects depending on availability of funds and interest. To date, the RWBC has had limited resources and has not been able to mobilize a full fledged multi-sector partnership with a clear project focus. This will be the first major funded (flagship) project of the RWBC.

The selection of partners in this proposal attempts to capture a range of stakeholders with an interest in sustainable economic and societal well-being, especially with respect to water quality. The academic partners include a robust mix of technology, computer, physical and social science experts. Currently, the academic partners are working together on a RWBC "regional canvas" project that will provide an excellent platform for meeting our NSF-PFI objectives. Details about this can be viewed on the RWBC Web site at: http://www.regionalworkbench.org/html/vis.html. The regional canvas is a Solid Terrain Model (STM) of the larger Southern California-Northern Baja California U.S.-Mexico border region. In the course of working on this and other projects (especially Superfund), the academic, industrial, local government, and non-profit partners have begun to develop close working relationships. Over the past 18 months, there have been three showcase workshops at the SIO Visualization Center. Collectively, the group is honing skills in five innovative information technology and visualization domains. This bundling of technology expertise comes together in a powerful synergistic mix. We will apply combinations of these tools in the context of our efforts to empower watershed planning and management. The suite of tools (the sum of which is far greater than the parts) will be further developed, applied, tested, and evaluated. It is worth noting that the technology skill set does not reside among the academic partners alone. Most of our off-campus partners, including government, industry and non-profit colleagues also have IT and Visualization skills. These tools include: (1) Solid Terrain Models (STM), (2) 3D visualization merged with Geographic Information Systems (GIS), (3) online interactive mapping employing methods for data and collection management , and (4) new technologies to store, manage, disseminate, and share valuable data sets across our regional partnership (this involves information extraction, digitization, digital library and archive creation).

Our goal is to see the most useful IT and visualization technologies become part of the ongoing decision-support and management systems of our partner agencies focused on watershed planning and management. We aim to enable an innovative synergy of information technology and visualization systems with science and policy development. This is a necessary step toward creating more efficient, interactive, and equitable methods for integrating university-based science with the fast-changing needs of industry, government, non-profit and community-based organizations. Our approach will add value to, not replicate, existing data warehouses and regional/geographic information systems.

Besides combining a mix of IT and Visualization capabilities, the partnership was chosen with geographic and programmatic foci in mind. In geographic terms all the partners have an interest in the San Diego River Watershed and all have a concern with issues of sustainability, quality of life and water. The management section of this proposal lists each partner's role, resources, and business impact. Our innovative work as a group aims to reveal insights, and extract lessons, in four economic and social development contexts: (1) industrial cluster efficiencies (focusing on tourism, building industry, and agriculture), (2) market forces and regulatory innovation in the context of Environmental Management Systems (EMSs) and Best Management Practices (BMPs), (3) urban design innovation highlighting the value of natural capital and environmental services in the context of community revitalization and recreation assets, and (4) new capacities for watershed planning involving robust civic engagement (this involves culture change and issues of social equity). The common thread across these contexts is our focus on the way in which the **mitigation of adverse environmental impacts** has been handled over the past 13 years, since 1990. Once we "process" this data (put it into multiple forms for access and visualization) it will be possible to examine the pattern of past required mitigation, and the types of BMPs implemented. This will enable us to undertake a more ambitions agenda over the long term to determine: (i) whether the mitigation was carried out, (ii) whether it was successful, and (iii) whether it was efficiently carried out given other options. This will enable us to think about how to change the current policy to achieve "better" results and to better understand what additional sources of data are needed to better make policy decisions.

4.3. Partnership Goals

The fundamental goal of this proposal is to enable economically efficient, environmentally sound, and equitable watershed management and planning. To do this we propose three strategies: (1) create a Watershed Planning Support System (WaPSS), (2) produce an economic assessment of policy options, and (3) launch a service learning and workforce development program in sustainability science.

4.3.1. Watershed Planning Support System (WaPSS)

The formation of watershed partnerships has emerged as a favored strategy to improve regional economic and regulatory efficiencies in environmental management, especially water pollution prevention (P2). The California Resources Agency and the State Water Resources Control Board, as well as California's nine Regional Water Quality Control Boards, the U.S. Environmental Protection Agency, and other water authorities, are thus pinning high hopes on watershed partnerships as a vehicle to catalyze new proactive and cost-effective environmental management strategies. In an memo titled, "Committing EPA's Water Program to Advancing the Watershed Approach," the EPA states "multi-stakeholder efforts within hydrologically defined boundaries to protect and restore our aquatic resources and ecosystems, offers the most cost-effective opportunity to tackle today's challenges" (G. Tracy Mehan, III, Dec. 3, 2002). To be effective, watershed partnerships, including water authorities as well as industry and community-based stakeholders need good Watershed Planning Support Systems (WaPSS).

A fully developed WaPSS would include an entire suite of computer programs with components consisting of databases, simulation models, decision models, and user interfaces that assist a decision-maker in evaluating the economic and environmental impacts of competing watershed management alternatives. This will take some time to create, going beyond the tenure of this two year grant. What we propose here is the first stage beginning with a well defined data set. Specifically, our core focus during the two years for which we seek funding from the NSF-PFI will concentrate on water quality and efforts by public and private sector entities to mitigate adverse impacts caused by development in the San Diego River Watershed. Environmental impact mitigation is required when a developer impacts sensitive habitat and/or the beneficial use of a water body. There is a public record of these mandated mitigations housed in the data archives of the San Diego Regional Water Quality Control Board (Section 401 Water Quality Certifications). Each of the certification applications constitute a lengthy report with information detailing

site location, type of water body impacted, geographic area, costs, mitigation methods, and type of best management practice implemented, among other variables. The SDRWQCB began collecting this information in 1990. Staff estimates that the agency holds approximately 1,200 of the reports (roughly 100 per year processed over the past 12 years). Roughly 50 of these concern the San Diego River Watershed. Our plan is to begin by digitizing all of the reports for the San Diego River Watershed--including all graphical, numeric and narrative data from 1990-2002. As this database develops, our plan is to test, and evaluate it from the perspective of three end users: government (San Diego Regional Water Quality Control Board, City of San Diego Water Department, County of San Diego), industry (Industrial Environmental Association, with representatives from select industrial clusters including tourism, agriculture, and building industry), and environmental groups (San Diego River Park Foundation). The evaluations will be conducted using focus groups and interviews. Feedback will also be gathered at the three workshops we plan to conduct. We view this initiative as catalyzing innovation at the frontier between Information/Visualization Technology and the human elements of regional decision making. Through a combination of data resources, IT developments, virtual and physical terrain models, we propose to create a forum for the effective sharing of data and goals, allowing the joint exploration of obstacles and opportunities. To make this happen we will be merging the talents of the SIO Geological Data Center, SDSC's Sustainable Archives and Digital Library Lab, our off-campus partner agency TELESIS—developer of the San Diego Regions most comprehensive Quality of Life Data Warehouse, and our Sparkers, Inc. partner, specializing in data capture services in paper documents and digitization.

When developers are required to do mitigation, they must identify suitable locations—which can be either on or off-site. This can be a lengthy and, therefore, expensive process. Currently, each project is done on an individual basis. In cases involving water, California resource agencies issue discretionary permits to applicants to modify, fill or dredge streams, wetlands, rivers, lakes, bays, sloughs, or vernal pools. The environmental analysis for these discretionary permits require a thorough and fundamental understanding of the fluvial-habitat systems to be impacted, the historical context of what the particular system used to be, and the proposed mitigation for the anticipated impact. These discretionary permits are typically conditioned with performance criteria for mitigation success. This is where the permitting system, as a whole, is on shaky ground. There is no common, easily accessible or standards-based system for digitally storing impact or mitigation information. The decision to use a particular area for mitigation is based upon ad hoc knowledge of the permitting professional and their peers in other agencies. There is no common database for the agencies to tap into and see if the proposed mitigation area is acceptable to use (e.g., there is no easy way to know if the mitigation is proposed over an area already designated for mitigation—a situation known as "double-dipping," or if the proposed mitigation targets an area already having protected status). Furthermore, there is no computer system for monitoring the success or failure of these mitigation areas. The tracking is done on a case-by-case, agency-by-agency basis which is (cumulatively) very expensive to all agencies and applicants. All of this makes a persuasive case that the San Diego city-region needs a WaPSS. Our partnership for innovation will begin the collaborative task of building a WaPSS to improve environmental impact mitigation and management practices in the San Diego River Watershed Management Area (WMA).

The lack of capacity to track, prioritize, compare, evaluate, or visualize mitigation project data (past and present) in a regional context, against other relevant data, raises many problems. There are economic inequities in so far as uneven enforcement of the Clean Water Act and other laws may result in an uneven playing field for firms/developers seeking to follow the rules, and overall results may constitute either too little or too much mitigation. This latter point is problematic for the region as a whole if mitigation in the larger watershed context is failing (i.e., there is an overarching, long term ecosystem degradation despite a patch work quilt of mitigation efforts to offset negative impacts).

One of the most tangible outcomes of building a watershed-based planning support system is an integrated Geographic Information System. TELESIS has the expertise to move that forward quickly. They will provide the partnership with full access to their holdings of over fifteen gigabytes of quality of life data, high-end computer servers and social and epidemiological research personnel. TELESIS has a particular expertise in on-line interactive mapping and will help us coordinate the mapping of data pulled

out of the Regional Water Quality Control Boards mitigation data archives. TELESIS is currently building community portfolios that highlight many of the social, health and environmental issues facing people in our area of study. The goal of the web-based community portfolios is to give community workers tools to make informed decisions that affect their service area and to promote policy changes that better their living environment. A key aspect of these community portfolios is a sound base of environmental data. One way to improve the capacity to visualize connections of this sort in the context of watershed planning, is the merging of 3D visualization and GIS. We plan to do this in a series of working group sessions at the SIO Visualization Center. We will also rely on our partnership with Solid Terrain Modeling (STM). STM builds 3-dimensional models with extraordinarily rich color imaging applied to the surface. These models combine the worlds of flat maps, satellite imagery and 3-dimensional physical terrain models. They help people see and understand topography in a direct and reliable way. When looking at an actual physical model the information is immediately available, everyone "gets it" right away- scale, distance, terrain, points of view, sight lines, etc. allowing for a deeper understanding of the information presented. Both the City of San Diego's Water Department, and the San Diego River Park Foundation have agreed to purchase solid terrain models (with their own funds) to work with us in testing and evaluating the utility of these tools in the context of watershed planning.

4.3.2. Economic assessment of policy options

The combined data will facilitate an economic assessment of the policy options in the permitting process. Researchers in the Economics Department at UCSD will be focusing on ensuring that the appropriate data needed for making economic assessment of policy options be identified. These efforts will concentrate on three areas.

(1) As mentioned above, each discretionary permit requires a thorough and fundamental understanding of the affected environmental system. However, the impact of a particular firm clearly depends on how many other sources of pollution are already located in the watershed. For example, if there are already several stakeholders whose combined effect is close to the assimilative capacity of the watershed, any additional impact has to be completely offset by a mitigation measure. This raises a difficult question about how best to allocate the mitigation cost among firms and might create a first-mover advantage. Even though the impact of each individual firm might be minor, the combined impact can still be substantial. Using the work by Peyton (1985) we will outline the optimal allocation of the mitigation cost among the different stakeholders.

(2) Besides the theoretical discussion about optimal cost allocation, we would also like to evaluate the discretionary case-by-case permitting process. Specifically, has it yielded an efficient allocation of mitigation cost between different firms? Has it resulted in a level playing field? The one-thousand two hundred (1200) "Water Quality Certification Application" data files list the name of each company as well as their exact location. This data can be merged with information about the firm (Standard Industrial Classification code, number of employees, and measures of output). An even more complete picture will emerge when we factor in the EPAs Toxic Release Inventory (TRI) data. Some firms in our study area are required to report their releases (emissions) of toxicants as mandated by the Emergency Planning and Community Right to Know Act (the requirement to report depends on the firm size and whether or not their emissions exceed certain thresholds set by the EPA). Over 600 toxic chemicals and chemical categories are currently listed as reportable on a biannual basis. The combined database can be used to investigate several questions. Are the mitigation costs as reported in the water quality certification application proportional to the predicted environmental impact, a necessary condition for an efficient permitting system, or are there certain industries that faces significantly less stringent requirements. Besides the comparison of costs between firms, we can use these findings to stimulate a more general discussion about the optimal *overall* level of permitting.

Furthermore, careful cross-validation of the mitigation sites will be required to rule out that stakeholders systematically over-report the assumed mitigation cost to avoid very stringent requirements or to establish a good reputation with the regulator. The evaluation measures described in section 4.3.1

will shed interesting light on how the proposed mitigation sites compare with the observed implementation. This will give us a basis for further examinations as to whether the mitigation sites accomplished their desired goals and test whether firms comply with environmental regulations. There is a major debate going on in recent economics literature concerning what combination of self-reporting, inspections, and fines induces compliance of behalf of firms.

(3) Finally, we would like to lay the foundation for a more comprehensive analysis about the optimal permitting rule that specifically incorporates the stochastic nature of precipitation and runoff events. The stochastic nature of watershed translates into varying runoff conditions and a probability distribution of adverse effects. The regulator hence faces a decision problem that is non-deterministic. An economic question then becomes to determine what the optimal decision criteria should be for the regulator: Is the main goal to minimize the expected number of adverse effects, e.g., beach closures, or should we care about other elements of the distribution. For example, while it might be acceptable to observe one adverse effect per month for three months, it might be less acceptable to observe three in one month and then none for the next two.

The Industrial Environmental Association (IEA), one of the partners on our NSF-PFI team can help us bridge the economic analysis with the tasks we face in creating a Watershed Planning Support System. The IEA was formed in 1983. They have an expanding role as the "voice" for manufacturing and associated companies in San Diego, not only on legislative matters but on a variety of environmental issues that affect the quality of life of businesses in the region. Pezzoli, a co-PI on this grant proposal, has been active in the IEA's Environmental Management System track for sustainability. Through these relationships the work of our partnership will be made available to the Cal/EPA's Sustainability Program. Pezzoli has been working with members of this group since 2000 when he participated their conference, "Learning Together 2000: Environmental Management Systems, Regulatory Innovation, and Sustainability" (Pezzoli 2000).

4.3.3 Service learning and workforce development

The San Diego River Park Foundation, with some input from TELESIS, will perform classroom and In-Field Training of 2 teams (total 20 members each) per year from the Urban Corps. The Urban Corps of San Diego (UCOSD) is a local non-profit conservation corps, job training and education program serving young adults 18-23 years of age. UCOSD aims to help young adults develop their job skills, work habits, social skills, self-esteem, academic and leadership abilities. The diversity of this group is 47% African-American, 45% Latino, 2% Caucasian, 2% Asian/ Pacific Islander, and 4% Other. We will also involve 2 undergraduate students per year from the Urban Studies and Planning Program at UC San Diego. All Urban Corp members and undergraduate students will receive training necessary to record on-site environmental characteristics involving the mitigation data we will enter into the Watershed Planning Support System. The cost of the undergraduate students will be covered from other funds (Superfund Basic Research Program Outreach Core). The San Diego River Park Foundation will also develop a Solid Terrain Model of the San Diego River Watershed (shown as an in-kind contribution on this grant) to help with this training and with public education. Over a two-year period, the Foundation will train four Urban Corps member teams, a total of 40 individuals, to use GPS equipment and to evaluate the mitigation sites. The data collected will be geo-referenced and exchanged with interested parties.

Telesis Corporation has developed similar programs with neighborhood collaboratives; so they will assist with this task. Data collection would include location using a GPS device and the completion of a conditions assessment survey. The survey would be developed by the San Diego River Park Foundation. Information would be entered into a database and transferred electronically so it can be included in the larger data system. Any mitigation sites identified during the field checks not previously identified would be added to the data collection effort.

The participants in this component of our project will gain experience in an initiative to link science and technology to economic policy and planning. This lies at the heart of the "sustainability

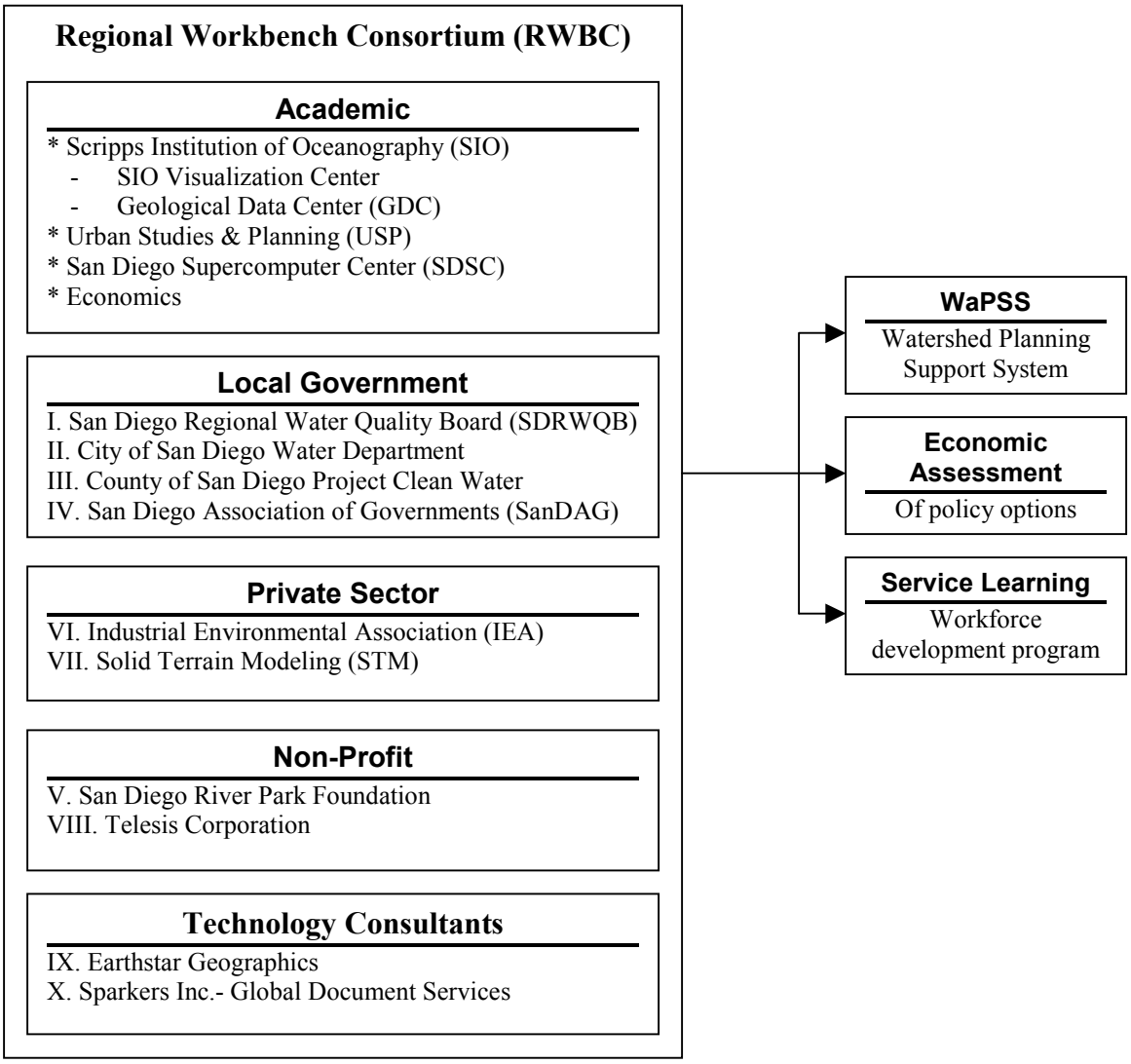
science" challenge (National Research Council 1999). The Regional Workbench Consortium which spawned this Partnership for Innovation is a member of the *Forum on Science and Technology for Sustainability*, one of the world's most significant global networks and forums dedicated to sustainability science: http://sustsci.harvard.edu/ We embrace the initiative's guiding principles in that we are: "*regional and place-based*, focusing at intermediate scales where multiple stresses intersect, where complexity is comprehensible, where integration is possible, where innovation and management happen, and where significant transitions toward sustainability have begun." The type of training we will give these young people and undergraduate students is also a form of workforce development. In an important book by Sonnert (2002) titled, Ivory Bridges: Connecting Science and Society, the author argues we need to do more to encourage "citizen-scientists"—a new form of engaged scholar able to bridge disciplines and link science and technology to policy and planning. We view the need to empower the next generation of young scientists and scholars with this kind of ethic and commitment to civic engagement as a high priority. This is crucial for workforce development at the dawn of the 21st century.

4.4. Implementation Plan to Assure Long Term Sustainability

Our strategy sought out those partners most interested in adopting new technologies for purposes of increasing regional economic and regulatory efficiencies. The Industrial Environmental Association is in a good position to embrace what we develop and help us move it to new heights in the post-NSF-PFI grant period. Likewise, the San Diego Regional Water Quality Control Board, the City of San Diego Water Department, the San Diego Association of Governments, and the County of San Diego's Project Clean Water all have a great deal to gain over the long term by collaborating in our Partnership for Innovation. Our Regional Workbench Consortium (which spawned our proposed NSF-PFI partnership)is an active member of San Diego Association of Governments Stakeholders Working Group. The Stakeholders Working Group is tasked to help write a new "Regional Comprehensive Plan (RCP)." Our partnership will add value to the RCP and efforts to implement it. In particular, our innovative Watershed Planning Support System, and economic analysis of policy options, will help shape the RCP's Healthy Ecosystems Chapter, which includes a major focus on water quality and watersheds. Given that our partnership also has a major objective to broaden the participation of underrepresented groups in watershed planning and management, our work will also further the long term objectives of the Environmental Justice and Social Equity program of the RCP.

There is a great deal of literature documenting the need for effective regional partnerships in the context of economic development (Pastor et al., 2000; Dreirer, et al. 2001). Increasing emphasis is being placed on watershed partnerships as a way forward. Billions of dollars will be allocated in California and nationally to those regions who most effectively organize watershed management plans. In California this is pushed by the State Water Resources Control Board through their "Watershed Management Initiative." At the federal level serious attention is being given to promoting market-based incentives at a watershed level, such as watershed based permitting to deal with environmental problems. The point to stress here is that our work is at the front edge of a tidal wave of transformation. As Jane E. Fountain (1998) finds in her study of social capital as an enabler of innovation, "The trend toward inter-organizational linkages in the form of partnerships and consortia has contributed to a strong resurgence of the U.S. economy. Many firms, industries, and regions that are currently successful have formed productive collaborative relationships with a variety of other firms, laboratories, universities, and governments at both state and federal levels in order to leverage the benefits of cooperation." We plan to use the tremendous social capital (networks of relationships and informational resources) built up over the past three years by the Regional Workbench Consortium (RWBC) to facilitate the implementation of our work and to ensure its sustainability over the long term.

5. Management Plan



I. San Diego Regional Water Quality Control Board (SDRWQCB) -http://www.swrcb.ca.gov/rwqcb9/

- ***a. mission:*** preserve, enhance and restore the quality of the San Diego region water resources. Programs include water resource protection *(land discharge, site mitigation & cleanup, water quality standards, pollutant load reduction)* and watershed supervising *(marine waters, inland surface waters, watershed management, industrial compliance).*
- ***b. partnership role*:** partner to explore how the 401 Water Quality Certification process can lead to a planning support system for mitigation information for agency and business use.
- ***c. resources:*** archive of paper mitigation documents, documented business processes, certification & regulatory expertise.
- ***d. business impact:*** significant financial savings for businesses developing or redeveloping in the region.

II. City of San Diego Water Department -- http://www.sannet.gov/water/quality

a. ***mission:*** develop guidelines for new development w.r.t. to the water supply and avoid negative impacts of drinking water reservoirs.
b. ***partnership role:*** provide expert help on land-use and business development in reservoir water quality and identify reservoir area mitigation opportunities.
c. ***resources:*** drinking water reservoir & watershed data.
d. ***business impact:*** strong financial impact on business development costs in the region.

III. County of San Diego Project Clean Water -- http://www.projectcleanwater.org

a. ***Mission:*** a County of San Diego Board of Supervisors –initiated project, to establish a framework and local commitment for restoring and enhancing the quality of coastal and inland waters in the San Diego region.
b. ***partnership role:*** through its "Comprehensive Planning Committee (of which Keith Pezzoli is a member), provide feedback on watershed protection planning and how it relates to other types of planning efforts.
c. ***resources:*** data is being collected on the San Diego River Watershed.
d. ***business impact:*** interest in linking clean water to the economic viability of the San Diego region.

IV. San Diego Association of Governments (SanDAG) -- http://www.sandag.org

a. ***mission:*** to serve as the forum for decision-making on regional issues such as growth, transportation, land use, the economy and the environment. Its board of directors is composed of mayors, council members, and supervisors from each of the region's 19 local governments.
b. ***partnership role:*** provide data, guidance, feedback for our pilot project through the Regional Planning Stakeholders Working Group (of which Keith Pezzoli is a member), one of three committees of the new Regional Comprehensive Plan.
c. ***resources:*** will provide the project with $10K in matching funds, a research intern, and senior analyst time. More importantly, SanDAG provides key base maps and data for the region: demographics, GIS data, economic reports, and industrial cluster knowledge.
d. ***business impact:*** the Regional Comprehensive Plan will serve as the foundation for integrating land uses, transportation systems, infrastructure needs, and public investment strategies for the San Diego region. Business leaders from the agricultural, building, and housing industries are represented.

V. San Diego River Park Foundation -- http://www.sandiegoriver.org/

a. ***mission:*** to create a park stretching from the river's headwaters near Julian to the Pacific Ocean.
b. ***partnership role:*** will help the project with establishing a mitigation urban core (group of citizens interested in civic engagement and monitoring the river's health).
c. ***resources:*** will provide the project $10K in matching funds.
d. ***business impact:*** this project is likely to have a colossal impact on businesses in the watershed in the years to come: a Conservancy was recently created (state agency) to fund preservation and restoration of the river, also the Governor of California promised initial funding of $12 million.

VI. Industrial Environmental Association (IEA) -- http://www.ieasdc.org

a. ***mission:*** promotes environmental responsibility through interaction with its members, government, regulatory agencies, business and the community.
b. ***partnership role:*** evaluate our pilot project and help engage local businesses in the San Diego River watershed.
c. ***resources:*** represents the environmental "voice" of many local businesses.
d. ***business impact:*** represents local businesses.

VII. Solid Terrain Modeling (STM) -- http://www.solidterrainmodeling.com

a. ***mission:*** creates physical terrain models from 3D data.
b. ***partnership role:*** will help create up to 4 (3' x 2') models of the San Diego river watershed, reservoirs, and hot-spot mitigation areas.
c. ***resources:*** will provide the project with $10K matching funds and help consult on 3D visualization techniques.
d. ***business impact:*** businesses, citizens, and local government groups expected to come together around physical models, to discuss common interests.

VIII. Telesis Corporation -- http://www.qolsandiego.net

a. ***mission:*** provide planning and evaluation support for the County of San Diego Health Services.
b. ***partnership role:*** will assist with interactive mapping, health indicators, and integrated 3D imagery. Will also help with urban core project component, through its experience with neighborhood collaborative and training of citizen groups to use IT and monitor their own neighborhoods.
c. ***resources:*** will provide the project with $40K matching funds. Will also share GIS data, data warehouse access.
d. ***business impact:*** can help link business data with the mitigation data pilot.

IX. EarthStar Geographics – http://www.es-geo.com

a. ***mission:*** provides consulting services in aerial remote sensing, image processing and GIS mapping applications.
b. ***partnership role:*** will assist in the development of the Watershed Planning Support System.
c. ***resources:*** EarthStar has developed unique regional data sets that they are willing to share with us (mosaic-ed county wide orthophoto layers, and others).
d. ***business impact:*** can help link into the mitigation database, detailed imagery of value to businesses.

X. Sparkers Inc. – http://www.sparkersinc.com/gds/

a. ***mission:*** provide business processing outsourcing using innovative document management technologies.
b. ***partnership role:*** will enable access and management of large volumes of data in support of the project objectives.
c. ***resources:*** will provide expertise, in-house programs, and process modeling techniques.
d. ***business impact:*** will help with business process engineering and business process engineering to help lower business mitigation costs.

6. Innovation Outcomes

Project Timeline

	2003			2004												2005								
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Strategy 1: *WaPSS & visualization*	X	X	X	X		X	X	X		X	X	X	X		X	X	X	X		X	X	X	X	X
Strategy 2: *economic assessment*				X	X	X	X				X	X	X	X					X	X	X	X		
Strategy 3: *workforce development*				X	X	X										X	X	X					X	

Workshops				X									X									X	
Confs.								X										X					
Models (STM)				X				X					X					X					

We are planning on conducting **three workshops** during the course of the project to monitor and assess progress. These workshops will be held at the SIO Visualization Center.

Two presentations will also be made at the annual RWBC Expo (May 2004 & May 2005). Publications, a UCSD-TV documentary on the project.

Also, **four Solid Terrain Models** will be generated (these will likely cover the San Diego River Watershed, 2 of the reservoirs, and 1 hot-spot mitigation area).

Follows, a more detailed description of the activities each of the strategies pursued will lead to:

Strategy 1: Watershed Planning Support System (WaPSS)

This is the main strategy thread that runs through the entire 2-year project (conference and workshop events prompt a break in this stream, to reassess progress each time). A mitigation certification database will be built from scratch, starting with the mining and modeling of the paper archives of the RWQCB office. SDSC SALT lab experts, SIO senior staff with expertise in automation of dataflow and writing scripts to harvest digitized documents, analyze them and store data in standards-based data formats (XML, and others), will participate up-front. Consultants from Sparkers, Inc., specializing in business process modeling and document management automation will also help shape and define the major activities in this strategy.

While the complexity of the database will grow over the 2-year period, a simple prototype will be generated within the first three months. This will enable the start of Strategy 2 & 3 activities. Other partners, helping evaluate the components of the WaPSS will also be able to participate, as successive data layers are considered for integration into the initial database. This will include our visualization and GIS partners. Investigations into augmenting this initial database with economic data, statistical and urban data from SanDAG, quality of life data from TELESIS, etc. will be enabled and will continue to ramp up over the course of the 2-year project. SANDAG maintains an extensive Geographic Information System (GIS) inventory, which aids local decision-making and provides information on a broad range of topics pertinent to the region's quality of life. Advancements in Information Technology are critical to SANDAG, as the regional decision-making forum for this area's 18 cities and county government. The proposed system is of importance to such agencies, as they intend to develop: Solid Terrain Models (STMs); 3D visualization merged with GIS; and online interactive mapping.

Strategy 2: Economic assessment of policy options

The three phases in the above timeline (each roughly running for 4 months and staged), reflect the three economic assessment areas of this strategy:

- Study of the optimal cost allocation of mitigation the different stakeholders
- Merging of individual mitigation records with other economic data
- Comprehensive analysis about the optimal permitting rule

These tasks have some level of independence however, task 2 will require that data be available from the first phase of Strategy 1 (database of individual mitigation records needs to be created).

Strategy 3: Service learning and workforce development

- Jan-Mar 2004:
    - Week 1: Classroom and in-field training of 2 teams (total 20 urban Corpsmembers)
    - Week 2-7: Urban Corpsmembers in field conducting site surveys.
    - Week 8-12: Data entry and status report finalization.
- Jan-Mar 2005:
    - Week 1: Classroom and in-field training of 2 teams (total 20 urban Corpsmembers)
    - Week 2-7: Urban Corpsmembers in field conducting site surveys.
    - Week 8-12: Data entry and status report finalization.
- Aug 2006:
    - Final Report.

Monthly meetings used to update regional partners on our progress and monitor advances in the region, will take place throughout the course of the project, at the following partner locations:

San Diego Association of Governments (SanDAG)

- **The Regional Planning Stakeholders Working Group**
    - Fourth Tuesday of each month from 3 to 5 p.m. at SANDAG.
    - *The Regional Planning Stakeholders Working Group is a standing working group which provides advice to the Regional Planning Committee and the SANDAG Board of Directors on the development and implementation of the Regional Comprehensive Plan (RCP). The working group consists of stakeholders from throughout the region representing issues such as the environment, transportation, housing, the international border, agriculture, building interests, equity, advocacy, and others. Its membership was appointed by the Regional Planning Committee in December 2002. In addition to providing input to the Regional Planning Committee on the RCP, members also communicate RCP issues to the groups they represent.*
- **The Regional Planning Committee**
    - First Friday of the month, from noon to 2 p.m. at SANDAG
    - *The Regional Planning Committee provides oversight for the preparation and implementation of the Regional Comprehensive Plan (RCP) that is based on the local general plans and regional plans and addresses interregional issues with surrounding counties and Mexico. The components of the plan could include: transportation, housing, environment (shoreline, open space, air, water quality, habitat), economy, regional infrastructure needs and financing as well as land use and design components of the regional growth management strategy. The Regional Planning Committee receives input from the Regional Planning Technical Working Group (planning directors from throughout the region) and the Regional Planning Stakeholders Working Group (stakeholders from throughout the region). Recommendations of the Committee are forwarded to the SANDAG Board of Directors for action.*

Project Clean Water, County of San Diego:

- **Steering Committee**
    - Second Wednesday of even months from 1:30 - 3:30 pm, alternate locations
- **Comprehensive Planning Technical Advisory Committee**
    - Last Friday of every other month
    - *The Project Clean Water Comprehensive Planning Technical Advisory Committee, is exploring current research and management issues, as they pertain to water quality protection, investigation, and enhancement.*

Industrial Environmental Association (IEA):

- **Annual conference**
    - Every November. We will report there (as we have done the for the last few years).
    - *The IEA will help us bridge the economic analysis with the tasks we face in creating a Watershed Planning Support System.*

Outcomes:
Notable outcomes that foster innovation include:

- IT infrastructure for research and education
- Economic assessment analyses
- Broadened participation of underrepresented groups

Outcomes of the grant will be shared nationally and globally through the Association of Collegiate Schools of Planning (ACSP), the Global Planning Education Association Network (GPEAN), and the Sustainability Science Initiative.

One of the most tangible outcomes of working towards understanding and building the foundation of a watershed-based planning support system is the ability to seamlessly integrate information from multiple spatial sources including a mitigation / Best Management Practices database, economic indicators, GPS citizen-collected data, EPA-maintained databases such as TRI, publicly available internet map servers. This will allow across-discipline analysis of watershed pollution and mitigation efforts. A first step in this process is the ability to present heterogeneous spatial data served by different servers, in a single interface from which analysts can issue complex queries against multiple databases. Such integration will help identify most efficient mitigation practices, and help their dissemination through the efforts of county agencies, non-profits, citizen groups, and businesses alike. At the same time, the technology we develop will make data integration less costly, as individual agencies and businesses will be accessing common data layers from other servers instead of maintaining expensive in-house databases. In particular, this will require online summarization of demographic data by watersheds, and development of mechanisms for handling semantically and structurally different spatial sources (including ArcIMS and WMS spatial servers, pure XML/GML sources, and the ability to construct single interactive presentations on the fly from heterogeneous fragments.

Leveraging these efforts:
Such technology is being explored in the context of several NSF-funded grants to SDSC (I2T, Geon). Its application to watershed mitigation and planning will be innovative in several respects: identifying and translating complex watershed queries into query fragments against heterogeneous sources and presenting results in the form suitable for economic analysis; online on-demand aggregation of spatial data of different spatial types by watersheds, as part of source wrappers; development of mapping interfaces capable of constructing online maps from multiple heterogeneous fragments.

7. List of Partnership Organizations and Personnel

Academic Institutions

Scripps Institution of Oceanography (SIO)

- Charles F. Kennel, Dean of SIO
- John Orcutt, Professor of Geophysics, Interim Dean of Marine Sciences

* **Geological Data Center (GDC)** -- http://gdc.ucsd.edu

- Dru Clark, Staff Researcher Associate
- Stephen Miller, Director

* **SIO Visualization Center** -- http://siovizcenter.ucsd.edu

- Graham Kent, Director
- Debi Kilb, Science Director

University of California, San Diego (UCSD)

* **Economics** -- http://econ.ucsd.edu
    - Richard Carson, Chair
    - Wolfram Schlenker, Assistant Professor

* **San Diego Supercomputer Center (SDSC)** -- http://daks.npaci.edu
    - Richard Marciano, Lab Director

* **Urban Studies & Planning (USP)** -- http://regionalworkbench.org
    - Keith Pezzoli, Supervisor of Field Research,
      Regional Workbench Consortium Director

Local Governments

City of San Diego Water Department -- http://www.sannet.gov/water/quality
- Bob Collins, Chair, Watershed Coordination Technical Workgroup
- Jeff Pasek, Senior Biologist, Source Water Protection Program

County of San Diego Project Clean Water -- http://www.projectcleanwater.org
- Teresa Brownyard, Director

San Diego Association of Governments (SanDAG) -- http://www.sandag.org
- Mike Mclaughlin, Director of Regional Planning
- Carolina Gregor, Senior Regional Planner
- Jeff Tayman, Director of Research

San Diego Regional Water Quality Board (SDRWQB) –
http://www.swrcb.ca.gov/rwqcb9/
- John Robertus, Executive Director

Private Sector Organizations

Industrial Environmental Association (IEA) -- http://www.ieasdc.org
- Patti Krebbs, Executive Director

Solid Terrain Modeling (STM) -- http://www.solidterrainmodeling.com
- Lawrence Faulkner, President

Non-Profit Organizations

San Diego River Park Foundation -- http://www.sandiegoriver.org/
- Rob Hutsel, Director

Telesis Corporation -- http://www.qolsandiego.net
- David Cleveland, President

Technology Consultants

Earthstar Geographics – http://www.es-geo.com
- Eric Augenstein, President

Sparkers Inc. - Global Document Services -- http://www.sparkersinc.com/gds/
- Jyotin Purohit, President

8. Intellectual Property Rights)

Title to any invention, development or discovery arising under this Agreement ("Invention") shall be determined in accordance with United States Patent Law, Title 35 United States Code. Any Invention, which is made exclusively by an employee of either University or any other project participants, shall be solely owned by the respective inventing party.

Any Invention, which is made in part by an employee of both University and participants, shall be jointly owned by the parties.

Any technology developed under the project shall be licensed or otherwise managed in accordance with the policies of the technology owner and in accordance with NSF policy.