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San Francisquito Creek—The Problem of Science in Environmental Disputes

Joint Fact Finding as a Transdisciplinary Approach toward Environmental Policy Making

Professional Paper 1710

U.S. Department of the Interior
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Contents

Figures

Tables

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Joint Fact Finding as a Transdisciplinary Approach toward Environmental Policy Making

By Nicolas L. Rofougaran[1] and Herman A. Karl[2]

Abstract

We studied the role of scientists and scientific information in the decision-making processes used by local jurisdictions and communities in San Mateo and Santa Clara Counties, California, to address a contentious environmental dispute involving flooding and habitat restoration of the San Francisquito Creek. Although a great number of scientific studies have been undertaken and continue to be commissioned, the parties have not used the results to help resolve the dispute. We conclude that the absence of an effective collaborative process, which is based on consensus seeking strategies, is a major reason why science is not effectively used and why the communities cannot reach agreement on a solution to the dispute. In this regard, we studied the growing demand for greater public participation, as contrasted to traditional public involvement, in science-related policy making and in decision-making in general. We suggest that Joint Fact Finding as a component of a comprehensive consensus building and participatory decision-making process is a better approach for incorporating science into environmental policy making. Joint Fact Finding enables the active participation of citizens as partners with governmental representatives in framing the questions that address the issues and in designing and implementing the studies. This process maintains the independence of the scientists and their commitment to the best science. A well-designed Joint Fact Finding process will improve the capacity of all participants to learn from all forms of knowledge and to reach resolution of contentious environmental disputes.

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Introduction

The San Francisquito Creek Project is an experiment to engage citizens as active partners in the design and implementation of a project to address environmental issues of concern within the San Francisquito Creek watershed in Menlo Park, California. The communities in the San Francisquito Creek watershed hold different values and cannot agree on land-use planning and environmental policy within the watershed. Messages on a community list server established after the creek flooded in 1998 reveal an angry public that is in disagreement as to solutions to flooding and habitat restoration. We investigated the potential of the community and regulatory jurisdictions in the watershed to take a collaborative problem solving approach to seek consensus on solutions to land-use planning and environmental policy concerns. The purpose of this paper is to discuss the results of our investigation and to draw lessons about the use of science in this situation. First, we provide background on the overall purpose and structure of the project.

Definition of the Issue and Overall Project Design

Thousands of communities in small watersheds across the nation are or will be facing issues of flooding, water supply, habitat restoration, aging dams, and stream impairment by sediment and pollutants from non-point sources. Communities in the San Francisquito Creek watershed face all of these issues.

Background

This watershed encompasses 45 square miles and includes a wide diversity of natural habitats and land-use types (fig 1). San Francisquito Creek is the last riparian unchannelized urban creek on the southern San Francisco Peninsula. It begins as overflow from the Searsville Lake dam built in 1892 in Stanford University's Jasper Ridge Biological Preserve. The creek flows for 14 miles from its source to its terminus in San Francisco Bay. Rural areas and open space characterize

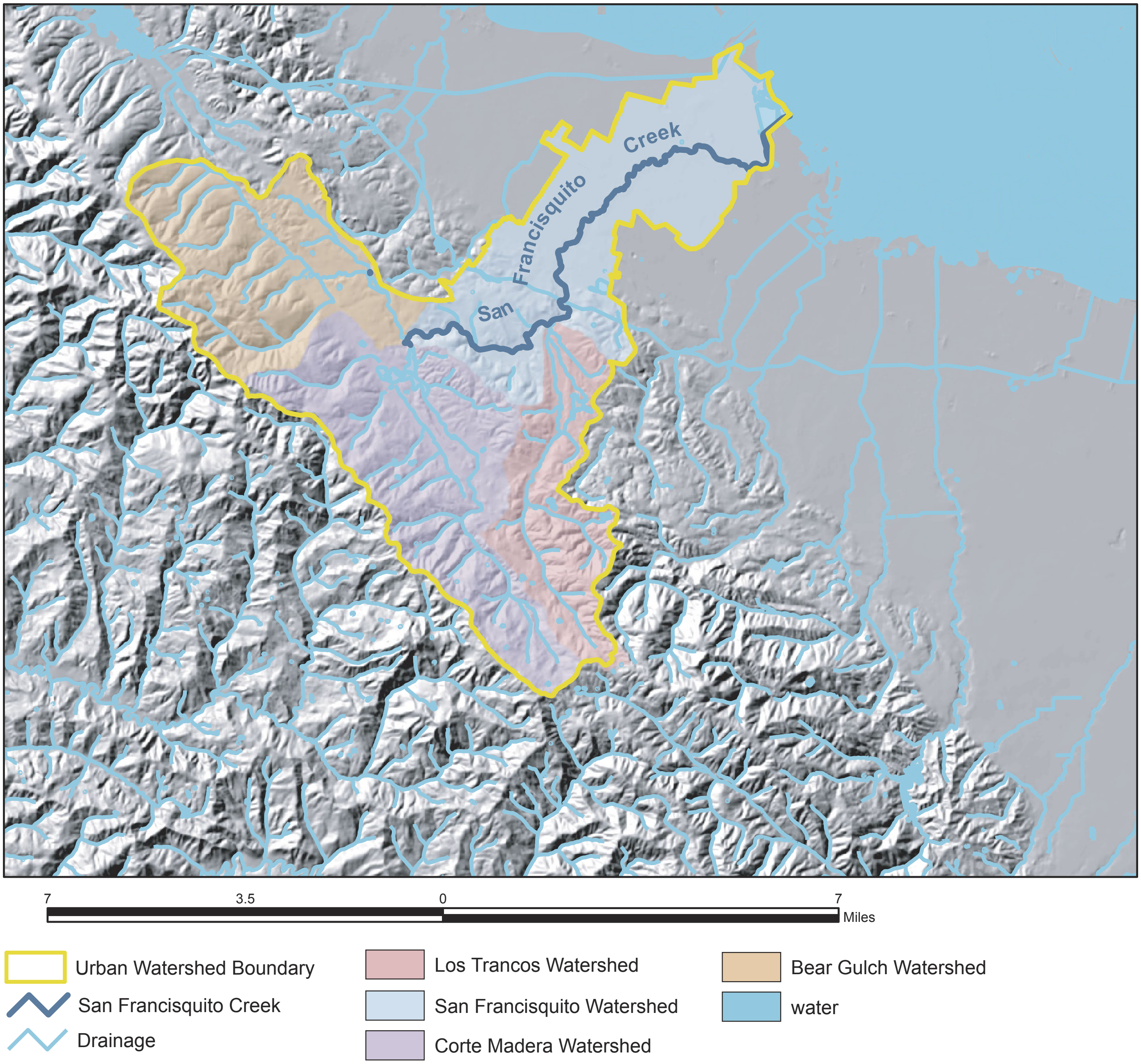

Figure 1 Boundaries of San Francisquito Creek Watershed and subwatersheds.

the upper watershed. In its lower reaches the creek courses through densely populated cities. San Francisquito Creek is the boundary between two counties—Santa Clara and San Mateo and flows through parts of five municipalities—Menlo Park, Palo Alto, East Palo Alto, Portola Valley, and Woodside (fig. 2). It empties into San Francisco Bay at the city of East Palo Alto. The towns and cities in the watershed vary greatly in wealth from tremendous affluence to significant poverty.

The reservoir behind the dam, Searsville Lake, is projected to fill completely with sediment in 15 to 40 years depending upon future weather patterns. The consequence of the reservoir filling on riparian habitat and flooding is unknown. In 1998, San Francisquito Creek flooded along its downstream reaches, causing $28 million in damage. The creek has the last remaining run of steelhead trout (a federally listed threatened species) in the southern part of the San Francisco Bay. It has been listed under section 303(d) of the Clean Water Act as impaired with regard to Total Maximum Daily Load (TMDL). These four issues, flooding, aquatic habitat restoration, dam removal, and TMDL impairment, are of concern to the communities in the San Francisquito Creek watershed. A committee, composed of a subgroup of citizens

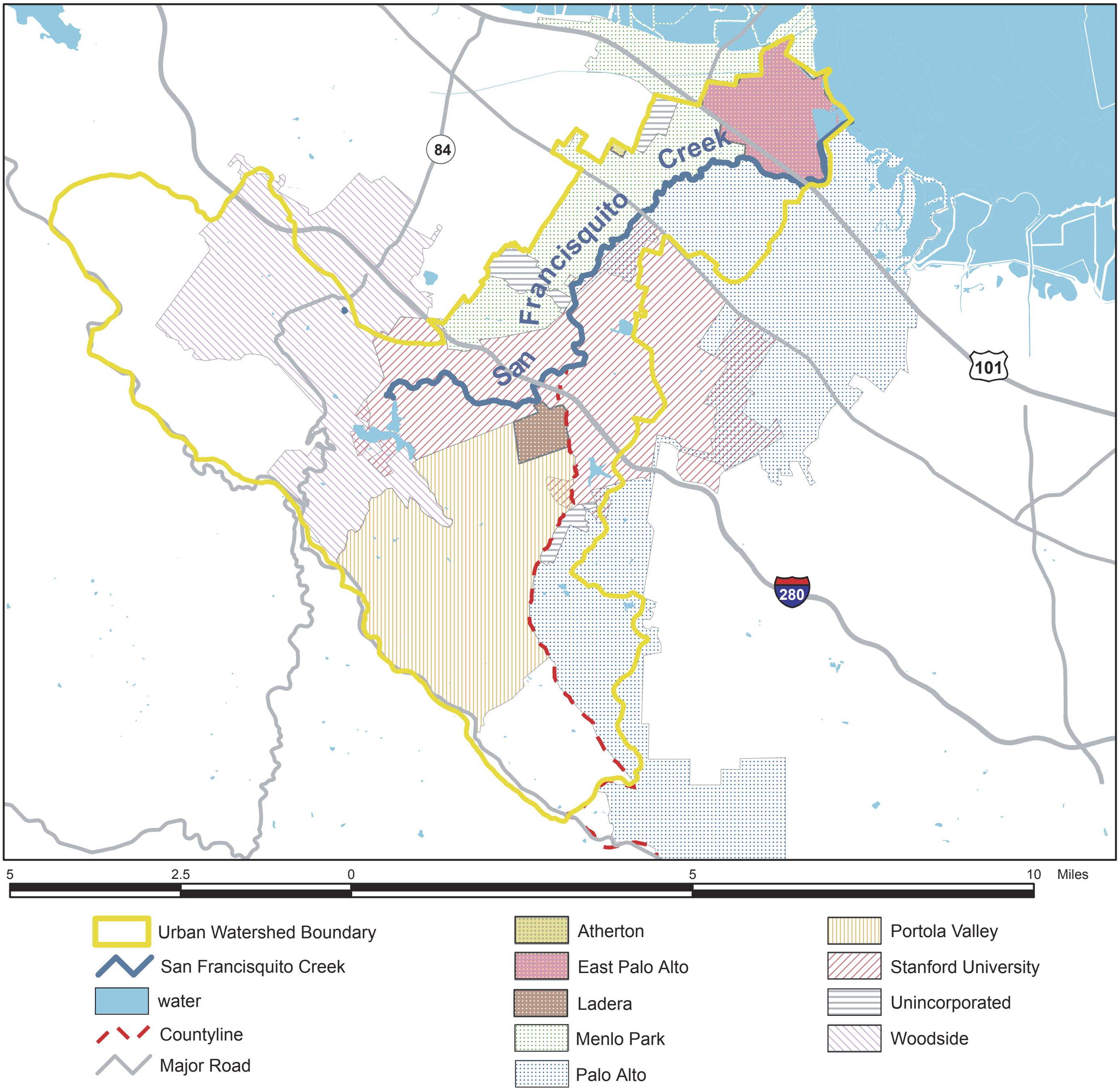

Figure 2. Jurisdictional boundaries of municipalities and principal institutional property owners within the San Francisquito Creek watershed.

from the Watershed Council and U.S. Geological Survey (USGS) scientists, decided that a sediment budget needed to be established for the watershed to aid in decisions concerning the four issues.

The following questions must be answered to evaluate the impact of sediment and to make informed choices about the management of the creek: (1) What has been the effect of land-use change in contributing sediment to the reservoir and on landscape change? (2) Is the watershed impaired with regard to sediment? (3) What impact will this sediment have on the carrying capacity of the creek and aquatic habitat? (4) How can the multiple uses of an urbanized watershed be managed to minimize impact to the ecological habitat? Overarching questions to these are: (1) How do we connect people and science so that science becomes an integral part of decisions? (2) How can the scientific findings be effectively communicated to decision-makers? (3) How can the competing interests be examined and reconciled to achieve balanced solutions to land-use and environmental policy?

The project was designed by a group of citizens in dialogue with scientists. Four citizens and one scientist comprised the project steering committee. It began in fall of

2000 and it ended in 2004. The project consists of three major components divided into specific tasks derived from deliberations of the steering committee.

(1) Biophysical and Geographic Scientific Studies

- Overland sediment transport in the upper watershed
- Sedimentological interpretation of flooding history
- Land-cover/land-use model
- Native/invasive species (steelhead trout/Chinese mitten crab)

(2) Social Dynamics Studies

- Information Technology and decision-making
- Role of science in environmental resource management/consensus building
- Role of community values versus science
- Role of informal and formal community structures

(3) Communication and Learning

- GIS/web-site development
- Teacher training and school curriculum
- Community education
- Game and simulation development to assist in stakeholder decision-making

A multidisciplinary team of scientists, educators, practitioners and theorists of consensus building and environmental negotiation, urban and land-use planners, and local community leaders and decision-makers was assembled to accomplish the project objectives. Each of the components above is linked through a series of feedback loops. The purpose of the project is more than just to provide scientific information to help solve specific issues in the San Francisquito Creek watershed. An overarching goal of the entire team as an objective of the Social Dynamics Studies component is to explore the role of science, scientists, and scientific analysis in negotiations regarding the management of environmental resources. Herein we present our findings in that regard.

I. Transdisiplinarity— science in a political and social context

The concepts discussed and ideas put forth in this paper, especially in this section, are an amalgam of our understanding of a diverse literature on the role of science within a political and societal context and participatory decision making processes (Raiffa, 1982, Susskind and Cruikshank, 1987, Jasanoff, 1990, Ozawa, 1990, Lee, 1993, Irwin, 1995, McLain and Lee, 1996, Susskind and Field, 1996, Susskind and others, 1999, Wondolleck and Yaffee, 2000, Kates and others, 2001, Nowotny and others, 2001, and Andrews, 2002). The scientific community across the Western world has long recognized the social dimension of ecology and the need for participatory procedures to solve environmental problems. There is little doubt left as to the unintended consequences of scientific progress. We have gone beyond the stages of our modernity where it was unconditionally assumed that science always benefits humanity and that socially optimal outcomes are the automatic results of scientific research, regardless of its social objectives or its connections with societal needs. As for the laws regulating science and technology, the decision-making processes that are implemented today in science-intensive public disputes are often ineffective. Scientists, on the other hand, fail to fulfill what is traditionally expected from them, namely to solve society's problems. The main reason for these failures is the apparent disconnect between research and its social outcomes and our inadequate knowledge of the relationships between our science programs and their social implications. We must therefore seek a better understanding of these relationships and implement strategies that are likely to bridge the existing gaps between the scientific, political, and public spheres.

Whatever technical or scientific solutions are adopted for environmental problems, they must be socially viable. Ecosystems and socioeconomic systems, as it is often acknowledged, are closely interconnected. However, this reality is not yet reflected in the ways science is structured, practiced, and used today. Typically, citizens are represented by elected and appointment officials. At best, this gives them only the most indirect involvement in the production of knowledge regarding environmental policy decisions. Indeed, public participation in environmental decision-making is often ineffective for several reasons: (1) not all relevant stakeholders are involved, and for those stakeholders who are, their involvement remains partial or indirect; (2) the knowledge and the skills that the public often lacks is not dealt with in a way as to empower the public to articulate its concerns in scientifically meaningful terms; (3) the final decisions do not faithfully reflect public concerns which makes those decisions less likely to be accepted by the public; and (4) most importantly, in the absence of an adequate consensus building process, scientific debate, argument and multi-hypothesis testing is used in an adversarial way by antagonists, which causes additional confusion and distrust in the public. These factors hamper the public's ability and right to participate in the process of decision-making. Indeed, the negative consequences of using science within an adversarial process suggest that the credibility of scientific expertise, i.e. the perceived quality of science, depends largely on the manner in which scientific information is gathered (Ehrman and Stinson, 1999).

The interdisciplinary aspect of environmental issues is traditionally understood as the necessity for scientists from diverse disciplines to collaborate in order to cover complex ecological phenomena. By contrast, transdisciplinarity is being defined today as the necessity to situate scientific research in its social and political context (Klein and others, 2001). In this sense, transdisciplinarity requires that scientists collaborate not only with their colleagues from other disciplines but also with concerned decision-makers and relevant stakeholders. As a defining element of transdisciplinarity and an alternative to science conducted within an adversarial process, Joint Fact Finding is a process of participatory inquiry that fosters cooperation between and allows the direct involvement of all relevant stakeholders in the decision-making process as well as in the actual production of scientific knowledge. The necessity of placing Joint Fact Finding within a larger consensus building process cannot be overemphasized. The Consensus Building Institute (Cambridge, Mass.) developed the two diagrams reproduced below (figs. 3, 4). Figure 3 shows where Joint Fact Finding fits within the framework of a consensus decision process and figure 4 illustrates the six key Joint Fact Finding steps. When thus used and structured, a Joint Fact Finding process should allow citizens' active participation in framing the questions to be studied in the formulation of research designs and in the actual activities of data collection; the concerned citizens would thus participate in reviewing early drafts of analyses prepared by experts and they would help select the experts and research methods to be applied. More importantly, they would be involved in the efforts to make the normative leap from analysis to prescription, and finally, they would participate in the implementation and monitoring processes. This may happen by selecting a cross section of citizens (or a blue-ribbon committee of citizens) to offer their views as observers or advisors and by asking groups involved in a controversy to nominate participants to represent them throughout the research process as partners with the agencies involved. This may also happen through open public comment and review either at key moments or in an ongoing fashion or through real-time interactive computer-based systems.

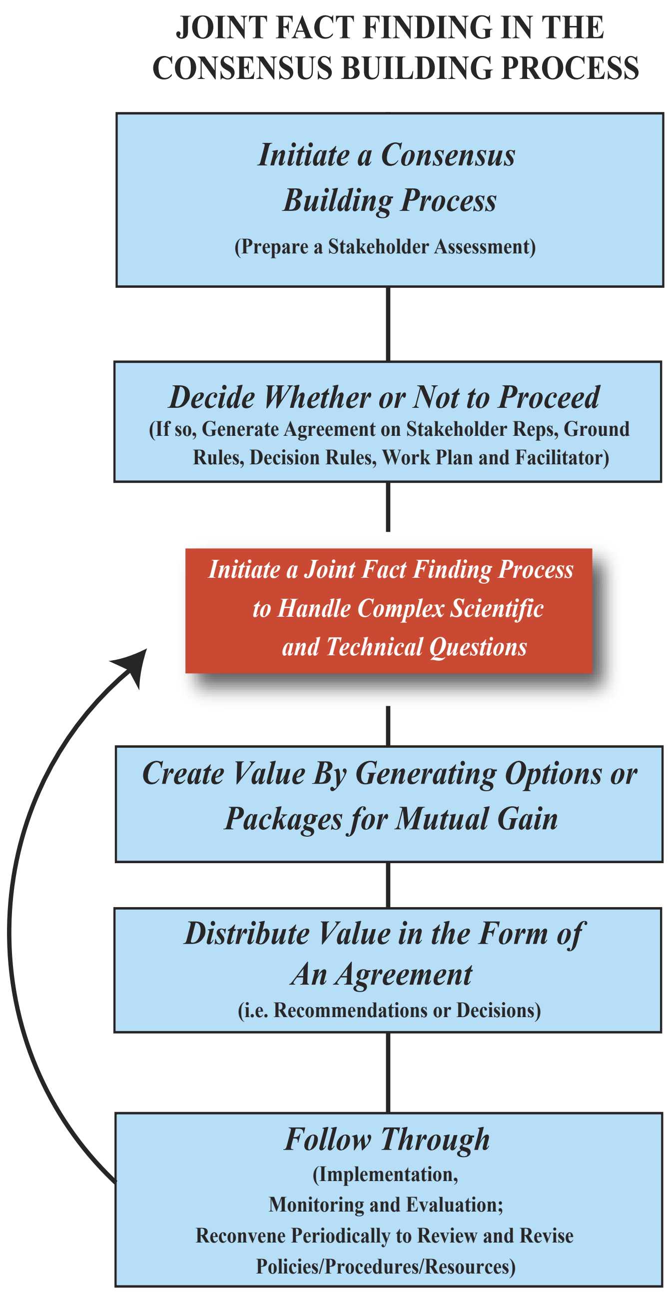

Figure 3. Joint Fact Finding needs to be done within a consensus-building process. However, not all consensus-building processes need to include Joint Fact Finding. (Copyrighted image courtesy of the Consensus Building Institute, Cambridge, Mass.)

In science-intensive public issues such as environmental disputes, knowledge often reflects the power in the hands of respective parties. In the context of science used within an adversarial process in particular, knowledge becomes a powerful instrument of legitimization and authority. Those parties who have the means to "buy" scientific information that supports their own position will be perceived as possessing an unfair advantage over those parties who do not have the same access to scientific expertise. The information gap—that is the perceived imbalance between stakeholders who have scientific competence (or have access to scientific expertise) and those who do not constitute a serious obstacle in the way to negotiated agreement. In contrast with adversarial science, Joint Fact Finding leaves room for the parties to negotiate on a more equal footing by avoiding the information gap. Collaboration among parties should also help them deal more effectively with the difficulties of multiple interpretations of the data and the problem of distrust that follows almost mechanically from contradictory interpretations between decision-makers, scientists, and the public. Indeed, in adversarial contexts, parties with conflicting interests interpret data differently. In the absence of cooperative relationships between parties, partisanship and neutrality become survival strategies and, as suggested above, science itself becomes a strategic tool (Andrews, 2002).

A direct and cooperative involvement of the non-expert stakeholders in the process of knowledge production should lead not only to a better understanding of the science at stake but also to a common understanding of often complex issues. This better and common understanding, in turn, should lead to

JOINT FACT FINDING: KEY STEPS IN THE PROCESS

STEP 1 PREPARE for Joint Fact Finding	STEP 2 SCOPE the Joint Fact Finding Process	STEP 3 DEFINE the Most Appropriate Methods of Analysis	STEP 4 CONDUCT THE STUDY	STEP 5 EVALUATE the Results of Joint Fact Finding	STEP 6 COMMUNICATE the Results of Joint Fact Finding Process
Take account of how JFF ought to fit into a larger consensus building process.	Work with stakeholders to draft ground rules specifying the roles scientists will and won't be expected to play.	Assist parties in translating general questions into researchable questions.	Undertake the work as appropriate. Ensure the credibility and transparency of the process by consistently checking in with the parties and staying in touch with the constituencies.	Use sensitivity analysis to examine the overall significance of assumptions, data variability, and outcomes.	Jointly present findings and answer stakeholder and policy-maker questions about how the work was done.
Document the interests of all relevant policy-makers and stakeholders using a formal stakeholder analysis.	Generate technical questions that need to be answered given the goals of the process and the interests of the parties.	Identify relevant methods of information gathering and analysis; highlight the benefits and disadvantages of each.	Draw on expertise and knowledge of stakeholders (including non-experts) as needed.	Compare findings to the published literature.	Scientists communicate JFF results to various constituencies and policy-makers via face to face discussions, fact sheets, presentations, panels, etc., to be sure findings are understood.
Work with a professional "neutral" (i.e. facilitator or mediator) to determine the most useful role for scientists.	Identify existing information and knowledge gaps likely to affect the group's ability to answer its questions.	Determine costs and benefits of alternative information collection strategies and "the expected value" of further study.	Review drafts of the final joint fact finding report.	Analyze the findings to determine what they "mean." Assist parties in translating findings into a menu of possible policy responses.	Assist stakeholders in determining if further JFF is necessary.
Convene a joint fact finding process.	Advise on methods for dealing with conflicting data and interpretations of facts and forecasts.	Determine whether proposed data collection and technical studies will enable stakeholders to meet their interests.		Clarify remaining uncertainties and appropriate contingent responses.	
				Assist in determining whether and how the results of the JFF process have (or have not) key to the consensus building effort.	

Figure 4. Understand, determine, scope, define, evaluate, and communicate are the six key steps that constitute the Joint Fact Finding process as defined by the Consensus Building Institute. (Copyrighted image courtesy of the Consensus Building Institute, Cambridge, Mass.)

better and more durable agreements. For example, when the data that is jointly gathered, analyzed, and synthesized appears to be inconclusive, the stakeholders who happen to be the "coauthors" of the study, are likely to see why that is the case, and for this reason, they are also likely to accept the negative results of the study as well as the subsequent decisions that are based on them. By contrast, when adversarial science prevails, each party will typically seek to discredit the science used by the opponents, and any decisions reached under such conditions will be subject to rampant criticisms and will be in danger of ultimate rejection.

Joint Fact Finding will be treated here as a working hypothesis, the validity of which may be verified on the ground, that is in the context of real world science-intensive public disputes. Joint Fact Finding is a procedure for involving those affected by policy decisions in the continual process of generating and analyzing the scientific information used to inform those decisions, while preserving the best practices of scientific inquiry. It allows for the consideration of local/cultural knowledge as well as expert knowledge. Three minimal conditions must be met for a consensus-based approach that includes Joint Fact Finding:

- Representation: All key stakeholders need to be involved in framing the inquiry. They need to choose who will do the research.

- Engagement: A trained professional neutral must manage the conversations and all the stakeholders— including the scientists and technical experts— must be engaged in the conversations. The scientists and technical experts cannot leave the table when they finish the scientific report. They need to be part of the conversation about the implications of the research and its application to policy. An important condition for USGS scientists is that they must not advocate a particular policy or decision.

- Agreement: The convener must agree to a written statement binding the convener to implement the decision reached by the group.

Testing the Joint Fact Finding hypothesis is a central task of INCLUDE (Integrated-science and Community-based Values in Land-use Decision-making), an experimental project launched by U.S. Geological Survey in late 1998. INCLUDE fosters a broad range of research that analyzes the role of scientists in ecosystems, natural resource management, and environmental policy decisions. This research includes experimenting with collaborative approaches that use Joint Fact Finding, whereby citizens cooperate with discipline experts to work together on complex, science-intensive environmental disputes. Central to the INCLUDE project are three hypotheses that ought to be tested in the context of San Francisquito Creek Project and in other watershed and land-use based disputes. The three hypotheses are as follows:

(1) "The direct involvement of non-expert citizens (including decisionmakers) in the knowledge-production and decision-making relevant to any environmental policy controversy increases the acceptance, on the part of those citizens, of the environmental policy decisions that are made."[3]

(2) "The more you involve the people affected by a policy decision in the design of the supporting scientific inquiry, the greater the chance that they will use and value the results in the decisions that get made."

(3) "The selection and mix of scientists and disciplinary experts involved in science-intensive policy studies need to be open to scrutiny by the affected parties. The public needs to be consulted in the selection of disciplinary experts."

This paper attempts to contribute to the body of applied social-science scholarship that can be used to inform the design of public involvement programs, particularly those related to the science-intensive choices typical of environmental policymaking. The paper is based on written artifacts generated by the participants during the San Francisquito Creek controversy and semistructured interviews with most of the scientists, policymakers and citizen activists involved in the controversy, The methodology adopted for this study draws on the growing body of academic work that uses case studies (see for example, Gillham, 2000) to test various hypotheses about public policymaking. Our field research consisted of two series of interviews focused on the history of the controversy and the problems that scientists and decisionmakers have encountered in their interactions with each other and with the community. It also involved the collection and analysis of primary and secondary documents concerning the case.

One of the goals of INCLUDE is to find favorable testing grounds to verify the validity of an adaptive and collaborative approach that is based on Joint Fact Finding. Despite the obstacles that this study attempts to identify, the three working hypotheses on the impact of Joint Fact Finding on the effectiveness of environmental decisionmaking and the causal mechanisms of that impact find a particularly propitious testing ground in the San Francisquito Creek watershed. When compared with other watersheds in the United States, where the collaborative processes are either dysfunctional or non-existent, the San Francisquito Creek watershed displays a capacity to generate a model of integrated science and citizen-based decisionmaking as defined in the guidelines of the INCLUDE project. In this sense, the existing decisionmaking process in this watershed may be described as a precollaborative process. The formation, in 1998, of a Joint Powers Authority (JPA) indicates that the decisionmakers of the watershed have recognized the necessity for cooperation between the different jurisdictions sharing San Francisquito Creek as their principal natural resource. The formation (and the continued functioning) of the JPA is, in itself, a major accomplishment and an important step towards the establishment of a collaborative decisionmaking process. However, in order for the above hypotheses to be tested, the scientists must be willing to collaborate with the public and the decisionmakers with scientists and vice versa. This implies that new incentives must be created for the parties to open sufficient space for a zone of overlap in which a transdisciplinary model could be adopted and a Joint Fact Finding process implemented.

The five local governments with jurisdiction in the Creek have differing regulations and permit requirements, as well as unequal financial structures and seemingly diverging economic and political interests. However, the case has a strong potential for a collaborative and mediated solution. The San Francisquito

[3]The independent variable here is the direct involvement of citizens in the processes of knowledge-production and decision-making. The dependent variable is the level of acceptance on the part of those citizens (and (or) possibly others) of the policy decisions that are made.

Creek cuts across many political jurisdictions. This fact has hampered its management for decades, but at the same time, this fact is the very cause of the Creek's ecological uniqueness. Indeed, it is the last remaining creek on the peninsula that has not been diverted into a concrete channel in its downstream reaches. Paradoxically, the impossibility of appropriately managing the Creek has saved it. However, over the last decade, an effort has been made to develop a cooperative, large-scale, long-term watershed management plan. "What used to be an obstacle," as a local environmental activist declared, "is now an opportunity." Realizing that no sustainable and comprehensive decision could be made unless it is made in a collaborative fashion, local political leaders have responded to the situation by forming the JPA, a group that gathers the main decisionmakers of the watershed.

To take only the example of the most urgent problem, JPA has considered several options for the flood control issue. The first possible option is no project at all. In that case, the local jurisdictional authorities would intervene in critical situations and property owners would be required to purchase flood insurance if they are within Federal Emergency Management Agency (FEMA) designated flood zones. The second option is natural channel widening. Even though environmentally friendly, this option would entail the acquisition of several dozens of rather expensive properties along the Creek, which would be a politically sensitive process and would take a very long time. The third option is creating a detention basin upstream. With this option, a loss of riparian habitat below the dam and the elimination of upstream fish passage would be two among other environmental impacts. The construction of an underground concrete diversion conduit is the fourth option. Again, riparian habitat would be lost and the social impact would be significant. Even though this option would provide full protection against major flood events, it would entail the relocation of several hundreds of families, utilities would be often interrupted, and traffic would be disrupted for several years. Moreover, this last option would be extremely costly and State and Federal funds would become necessary. Since the beginning of its history in 1998, JPA has repeatedly commissioned scientific and technical studies corresponding to each of the above options, and accumulated information without being able to make much use of it to form its decisions. In order to remedy this problem with prescriptive insights, we must inquire about the causes of the ineffectiveness in the interface between involved scientists, local decisionmakers, and the concerned public.

Local history plays a major part in determining the present terms and structure of the controversy. The decisionmaking procedures established by the JPA and the general focus of the agency, for instance, are largely determined by its historical background, in particular by two major events that we will describe in our historical section, namely the incorporation of East Palo Alto as a city in 1983 and the flood of February 1998. These events have prompted the agency's formation and shaped its political configuration, while impairing trust among its members and, as we will show, among decisionmakers, scientists, and the public. However, we will argue that, although distrust among the parties has historical causes, the more immediate and actionable conditions that have contributed to the growth of distrust among the parties and have hampered the collaborative process are essentially social factors. Indeed, the lack of an appropriate collaborative decisionmaking process may be shown to be the main reason why trust cannot be built among the parties. The seeming circularity of this argument is due to a conception of trust as the precondition for collaboration (Sabel, 1992). Experience in the fields of negotiation and conflict resolution, however, suggests that, if designed and managed adequately, a collaborative process may well generate trust, even in the most desperate situations (p. 720, 814, 999, 1033-1034 in Susskind and others, 1999).

II. A brief history of the controversy

On the 22nd of December 1955, San Francisquito Creek overflowed its banks in the reach between Bayshore Freeway and Middlefield Road into the northern portions the City of Palo Alto, resulting in $2 million of damage from the inundation of 700 homes.[4] This brought the creek problem to a head in a disastrous hurry for the first time. Indeed, the creek had flooded its surroundings many times before this date but the confluence of three events made the 1955 flood significantly more destructive than previous floods—(1) an exceptionally high tide had interfered with the creek's flow of water; (2) a large amount of rain fell during the days prior to the storm that hit the region on the day of the flood saturating the ground, in an area that was already highly developed and as such had lost much of its natural water absorption capacity; and (3) the lack of attention in keeping the creek clean of debris, including a drainage system that was in place at the Bayshore Highway, had made dams out of old and ill designed bridges on the creek. These three components or causes of the flood capture the notion that this natural disaster was also a human one. Once a source of gravel and a place for fishing and recreation activities, San Francisquito Creek had become a dumping place for residents, public agencies, and Stanford University.

Following the flood event of 1955, different collaborative community initiatives helped keep the creek cleaner and a political collaboration between the concerned jurisdictions led to the construction of levees downstream that aimed at minimizing the risk of flood. The problem, however, remained unsolved and a multijurisdictional controversy emerged, the general structure of which is still unchanged. By the end of 1958, an agreement was signed between San Mateo County and Santa Clara County to maintain levees, but for some mysterious reason, the concrete meaning of "maintenance"

[4] The Chronology of the San Francisquito Creek Project that we have established (see the appendix) contains a more complete list of events than the above historical section. The latter includes only the more significant events.

was never clearly defined by the two parties. As a result of this lack of clarity in the initial agreement between the two counties, Santa Clara County was soon accused of not fulfilling its own share of the maintenance of the Creek.

The levees being only a partial solution for the flood problem, a long series of discussions on how to keep the creek within its banks followed that culminated, in 1960, with a decision to ask the U.S. Army Corps of Engineers to make a study for flood control measures on the creek. In 1961, the Army Engineers performed an extensive control survey and released a "Report of Survey for Flood Control and Allied Purposes, San Francisquito Creek." The latter identified several flood control alternatives including bank protection and floodwalls, levees, concrete channelization, and a multipurpose reservoir. The Corps recommended the construction of a dam near Ladera. The Ladera Dam alternative, as it was called, was found to be economically feasible as a flood control solution when combined with the recreation and water supply benefits of a permanent storage reservoir. As mentioned above, the proposal generated considerable local opposition and various studies were performed to refute the Corps' findings and recommendations. Graduate civil engineering students at Stanford University performed the most significant and thorough study, with a report authored by James Robert Vincent (1968). This report provided new hydraulic analyses and stated that estimated flood flows were significantly lower than the Corps of Engineers Study had claimed. It recommended that improvements to increase the capacity of the channel down stream of the Pope-Chaucer Bridge would alleviate the potential flood problem and that the channel should be maintained on a continuing basis to keep the channel clear of debris and other obstructions to the flow of water. After long and heated discussions, the Stanford report was finally accepted both by local agencies and the Corps of Engineers. The San Mateo County Flood Control District and the Santa Clara Valley Water District initiated negotiations that led to an agreement to construct the improvements as recommended by the Stanford Report. Again, a collaborative process was initiated that did not survive for long. A citizens advisory committee composed of representatives of the cities that were part of the San Francisquito Creek watershed was formed for the San Mateo County side to provide citizen input for the project. The committee met occasionally to discuss issues concerning the creek for about 5 years and eventually disappeared in the early 1980's. The Stanford proposal was nonetheless implemented. The creek's banks were lined with concrete riprap at many locations downstream of the Pope-Chaucer Bridge and construction of walls along sections of the creek downstream of University Avenue. By the end of the 1970's, local environmental awareness had grown higher, and citizens of the watershed were increasingly concerned about what they considered as their main local natural resource. Attempts were therefore made to provide for trees and other natural vegetation within the project area in order to preserve the natural habitat wherever possible.

During the 1960's, small segments of the population living near the creek, in particular those living outside the flood zone, had strongly opposed both constructions inside the channel and engineered solutions for the flood problem. Their priorities were focused on the preservation of the creek as a natural resource. However, what saved the creek from being paved with concrete or channelized was not the influence of, or the political pressure exerted by environmental groups. Rather, it was the political complexity, that is the multijurisdictional geography of the watershed that made it impossible for the decisionmakers to agree on the solution to adopt. The State legislature created the San Mateo County Flood Control District in 1967, and it became a major player in the controversy over the creek owing both to its financial capacities and technical expertise. The legislature requires that a flood control district be established over an entire watershed. San Francisquito Creek is the boundary between San Mateo and Santa Clara Counties. During the same year, San Mateo County formed the San Francisquito Creek Flood Control Zone to finance improvements in cooperation with the Santa Clara County Water District. The San Mateo County Board of Supervisors, adopted, in 1969, a regulation for construction in San Francisquito Creek, still in effect. It was and remains ineffective, because it is applicable only in San Mateo County and affects only one side of the creek.

The high costs of engineered solutions, and thereby, the difficult problem of cost allocation among different jurisdictions led the controversy to an impasse that has lived on to this day. This left enough room for environmental groups to take important steps toward the protection of the Creek. On September 25, 1969, the Menlo Park Beautification Commission held a meeting to develop a policy for the preservation of San Francisquito Creek as a natural asset. The agenda and the minutes of that meeting indicate that the attendance included representatives from Palo Alto, Stanford University, the San Mateo Flood Control District, Santa Clara County, San Mateo County, East Palo Alto Municipal Council, Portola Valley, and Woodside. The diversity of the attendance is a good reflection of the collaborative efforts made by these agencies, institutions, and cities for the preservation of the creek. By then, it was clear to all the major decision-makers that the "concrete" solution as a way of flood prevention was not acceptable. These collaborative efforts culminated with a series of protective resolutions adopted by decisionmakers representing the above entities. The first among those resolutions designated, on March 14, 1972, San Francisquito Creek as a "scenic stream (City Council of the City of Menlo Park, 1972)." The last in date among those resolutions was adopted on January 30, 1990, and it designated the entire length of the San Francisquito Creek lying within the boundaries of Menlo Park as "The San Francisquito Park." Although environmentally friendly, these efforts remained partial with respect to the full length of the Creek and lacked both a systemic coordination and an holistic understanding of the watershed. In 1976, the City of Menlo Park took the leadership in forming a creek protection board that consisted of one council member from Menlo Park, one Council member from Palo Alto and a representative from Stanford University. This protection board managed to mobilize a group of local individuals for volunteer work, and for several years, it managed relatively well to develop some erosion measures, to control water pollution, and to keep the creek bed and banks clear of man-made debris. By the end of the 1970's, however, the committee fell apart before the pollution or erosion plans it had developed could be fully implemented. Indeed, the committee had interest in only one section of the creek[5] and had neglected to approach the creek as one element of a watershed as a whole. In June 1973, the Planning Commission of Menlo Park adopted an Open Space and Conservation Element of the Menlo Park General Plan. Again, this plan was never implemented.

As mentioned above, the jurisdictional map of the watershed—especially in the vicinity of San Francisquito Creek—is complex, that is both multiple and interlocked. In addition to two counties and five cities, several agencies have jurisdiction over portions or all of the Creek. The Federal U.S. Army Corps of Engineers has jurisdiction over the Creek because it falls within their definition of "navigable waterway." For obvious reasons, State agencies such as the Water Quality Control Board and the Department of Fish and Game also have jurisdiction over the Creek. The San Mateo County Flood Control District and the Santa Clara County Water District are the principal local agencies that have responsibilities for the maintenance of San Francisquito Creek. Stanford University, as the main landowner and research institution in the watershed has also a strong interest in the Creek. In addition to being complex, however, the jurisdictional map of the watershed has changed during the last two decades. In 1983, East Palo Alto was incorporated as a city. This change in the political geography of the watershed still has a strong impact on the structure of the controversy today. A number of physical structures and a relatively important amount of lands were handed off to East Palo Alto when it was incorporated, and it did not have the resources necessary for their maintenance. Also, decisions that were made between the two counties such as the 1958 agreement for the maintenance of the levees could not legally bind East Palo Alto because it did not formally exist when those decisions were made.

During the 1980's, various groups were formed to protect the creek and foster a healthy environment for the watershed, while seeking viable solutions for the flood problem. None of these initiatives, however, were comprehensive enough to be capable of building any durable consensus on the issues at hand. In the early 1990's, a small portion of the inhabitants of the watershed started a movement that aimed at promoting a watershed approach of environmental and technical problems posed by the creek. On November 30, 1993, representatives from 40 organizations, ranging from government agencies to community groups and landowners, met at Stanford University and established a Coordinated Resource Management Planning (CRMP) group for the San Francisquito Creek watershed. CRMP operated under the auspices of the Peninsula Conservation Center, a local nonprofit organization, but it had no formal authority. In principle, all interested stakeholders were welcome to participate in a process that the founders of CRMP envisioned as deliberative and informal. In fact, CRMP did succeed in raising the public ecological awareness in the watershed and became an excellent catalyst for research and public participation in the debates. Few people, however, were reached by and included in the CRMP process.

The flood of February 1998 prompted the formation of the JPA in May 1999. Contrary to CRMP, the JPA was provided with a formal structure—it was set to follow government processes and be subject to the Brown Act.[6] Despite its mission of a collaborative and holistic approach, however, the JPA was subject to internal tensions and diverging agendas from the very beginning of its history. Each agency within the JPA tended to pursue its own political and economic interests without paying much attention to the concerns common to the watershed as a whole. The flood event of February 1998 had determined the focus of the JPA. Much attention, as a result, was given to the flood issue, and indeed, short-term solutions were devised while other problems persisted in the watershed that were both related to the flood issue and important for their own sake. The question posed on the removal or reconstruction of the Searsville dam upstream is one example of such issues. Stanford University, an associate nonvoting member of the JPA, is a major stakeholder in this particular aspect of the controversy. It is the owner of the Searsville dam as well as a major research entity, and thereby, a major social—if not political—player in the region. Yet, despite the wealth of both useful scientific and relevant historical knowledge that it could provide and its socioeconomic weight in the watershed, Stanford University was not made a full decisionmaking partner by JPA, nor was it used to help design and implement collaborative science programs. A similar observation could be made on the rather ambiguous role of CRMP (now called The Watershed Council), another major stakeholder in the controversy. From the first years of its formation, CRMP formed extremely educated opinions on what issues were at stake and what was needed for the watershed. It produced highly instructive studies such as the "Reconnaissance Investigation Report of San Francisquito Creek," published in 1997 and updated in 1999. CRMP's position as formulated in its mission statement, however, was poorly understood. CRMP's studies were recognized as valuable but no one knew how to use them. Its

[5] More precisely from the Southern Pacific railroad bridge to Alpine Road, that is one third of the full length of the Creek.

[6] The Ralph Brown Act is California's open meeting statue. It requires all regular meetings to be open and the public permitted to attend. It also requires the dissemination of information to the public and the media. As a government agency, the JPA is governed by the Brown Act. The original JPA agreement states, "each regular, adjourned, regular, or special meeting of the Board shall be called, notified, held and concluded in accordance with the Ralph Brown Act." (Sections 54950 of Government Code.)

steering committee tried to influence decisions, but in vain, as it was not a nonprofit entity in its own right, or a government agency, or an important local institution. As a purely volunteer group, and despite its vision and competence, CRMP was practically excluded from the decisionmaking process in the watershed and again, as a result of this, the valuable information it provided was unevenly distributed and poorly utilized.

The close connections between purely ecological issues (such as the invasion of non-native species or the problem of endangered species) and the more technical issue of floods emerged in specific terms during the late 1990's. In February 1998, the first Chinese mitten crab was found in the creek at Jasper Ridge Biological Preserve. Stanford researchers then suggested that the burrowing of this non-native crab had been contributing to the accelerated erosion of the creek's banks and more dangerously to the gradual destruction of the levees downstream, increasing in this way the risk of flood. In addition, the crab's preying on native fish species and eggs was thought to be altering the natural ecosystem in undetermined ways. Concerns about the general health of the creek's ecosystem led to water quality studies during the winter of 1999. As a result, in May 1999, San Francisquito Creek and its watershed were officially listed under the Clean Water Act of 1972 (sect. 303, d.) as impaired owing to excessive levels of both diazinon and sediment.

This and other ecological, hydrological, and geological problems related to the creek and its watershed attracted the attention of Robert Barrett, a local mediator for environmental disputes, who suggested the idea of San Francisquito Creek as a project for USGS in a meeting with Herman Karl, USGS marine geologist at the Stanford Center on Conflict and Negotiation. Karl had started thinking about a collaborative problem solving approach to environmental disputes during the mid 1990's and the idea of a San Francisquito Creek Project was an opportunity for him to implement INCLUDE, Integrated-science and Community-based Values in Land-use Decision-making. INCLUDE was, therefore, launched in 1998 at USGS and was headquartered at the Western Geographic Science Center (Menlo Park, Calif.) as a core element of an interdivisional research agenda. On April 21, 1999, Herman Karl addressed the San Fancisquito Creek Watershed Council Steering Committee. Following that address, collaboration between USGS (INCLUDE) and CRMP began and a subcommittee was formed by volunteers from CRMP to design and implement an INCLUDE citizen-centered project. The subcommittee was named "Sediment Work Group." In July 1999, gathering of background information on the creek and previous studies began at USGS as part of the collaboration between USGS and CRMP. A Geographic Information System (GIS) was initiated with the guidance of the creek project steering committee and GIS maps of the San Francisquito Creek watershed were produced. This collaborative effort was unvield to the local public in May 2000 at a USGS Western Region open house, through an interactive public exhibit on the creek project. Two months later, on the 1st of October, an "Integrated Study of an Urbanized Watershed" was awarded funds by the USGS Geography Discipline research prospectus to conduct a one-year study ending September 30, 2001. This, in turn, led USGS to establish an Assistance Award with the Consensus Building Institute to conduct research on the role of science and scientists in science-intensive public issues and on the potential effectiveness of Joint Fact Finding in collaborative decision-making processes.[7]

While the local agencies and institutions made uncoordinated and unilateral decisions that affected both the natural and the social systems of the watershed[8], the decisionmakers of the different jurisdictions who were concerned with the flood issue gathered to form an interjurisdictional agency with the intent of approaching the issue from the perspective of the watershed as a whole. In May 1999, the San Francisquito Creek Joint Powers Authority (JPA) was created through a creek coordinating committee. It was formed as a cooperative effort to improve community storm preparation and flood management. The Cities of Palo Alto, Menlo Park, and East Palo Alto and the Santa Clara Valley Water District and San Mateo County Flood Control District were included as voting members of the JPA, and Stanford University joined the agency a few months later as a nonvoting member. The representatives of these institutions and agencies gathered on September 21, 1999 to hold the first official and public meeting of the JPA. The creation of the agency showed to the public that the local decisionmakers were willing to cooperate in order to solve the problem of flood. However, it became clear that the mere creation of the agency was insufficient to change the respective attitudes and the political configuration of the controversy. Indeed, the local agencies continued to make uncoordinated and unilateral decisions.

Nevertheless, the JPA soon gained relative independence and started working on its mission. In March 2001, the agency assumed inkind services of the Clerk of the Board role from the Santa Clara Valley Water District and Legal Counsel services from the City of East Palo Alto, and later in the month of July of the same year, it

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[7] This paper is among the studies initiated through the collaboration between the Consensus Building Institute and the INCLUDE Project at U.S. Geological Survey.

[8] In 1999, San Mateo County started the process of writing a 12-page ordinance to establish riparian corridors and buffer zones along the San Francisquito Creek in order to prevent further erosion of the banks. This meant that physical structures located within the buffer zone would be subject to restrictions—additions or renovations to homes, garages, or swimming pools, for example, would not be allowed. As a result, the property values of homes and buildable lots, if labeled non-conforming by the County ordinance, would collapse. Thus, the ordinance prompted the formation of Families for Fair Government, a protest movement of concerned property owners who fought the planned buffer zone as well as other related projects proposed by local agencies. This is an example of a unilateral public policy decision that affected the local social system. Indeed, it provoked the formation of new obstacles on the way to building consensus on fair and durable solutions.

was empowered by the JPA Board to operate as its own fiscal agent and independent employer. The same board approved, in September 2001, a resolution for the Levee Restoration Project. This represented the first capital improvement undertaken by the JPA. The levees in Palo Alto and East Palo Alto had settled and eroded and plans to restore them to 1958 levees began in earnest. In May 2002, the House of Representatives Committee on Transportation and Infrastructure passed a resolution authorizing an U.S. Army Corps of Engineers Reconnaissance Study. This was the first step in the bringing a long-term flood management project to San Francisquito Creek watershed. And finally, in August 2002, construction broke ground on the Levee Restoration Project. In a public meeting, Duane Bay, then East Palo Alto mayor, called this "the first major visible success for the JPA." The problems, however, remained unsolved and even though there were sporadic communications between INCLUDE at USGS and the JPA on the possibilities of a collaborative problem solving approach and of Joint Fact Finding, the JPA did not engage in implementing these processes. To this date, the great wealth of scientific information that both USGS and Stanford University could provide on San Francisquito Creek remains underutilized and scientists, therefore, cannot play the constructive role they could in the decisionmaking process.

III. Science as a Source of Confusion and Distrust

A science-centered mode of thinking

As we emphasized earlier in the paper, the issues that the inhabitants and decisionmakers of the San Francisquito Creek watershed must face are typical of most small watersheds. The presence of Stanford University and of USGS in this watershed, however, makes this case particularly interesting for the study of the role of science in environmental disputes. With this regard, it is the very role of science, or rather the perception thereof, and the shared assumptions on the nature of science and its relations with society that seem to constitute major obstacles on the way to collaborative and sustainable solutions for environmental disputes. In this sense, our findings as to the role of science in the San Francisquito Creek controversy may also be generalized. Indeed, the assumptions on the nature of science and the perceptions of the role scientists that we were able to identify through our interviews with the main players in the controversy can be traced back to the foundation of our scientific culture during the seventeenth century.

Since the advent of the Scientific Revolution during the seventeenth century and more markedly since the Industrial Revolution of the nineteenth century, Western societies center around the values and ideals represented by scientific communities and institutions. We tend to view science mainly as a source of solutions to the problems posed to humanity and to the environment. This fact and its multiple ramifications allow a qualification of Western societies as science-centered. In the Postmodern era, by contrast, science is often viewed as a source of uncertainty, despite its now traditional role of provider of objective truth. This recent critical characterization of science remains, however, science-centered, as the notion of uncertainty is itself appropriated by science and fully integrated among the established parameters of scientific culture. Scientists are all well familiar with uncertainty. They define, quantify, and manipulate it in ways that serve the purpose of science as a source of truth. Paradoxically, "uncertainty," as implied and applied by scientists helps to confirm conventional perception of science as a source of certainties.

It is not the object of this analysis to discuss the intrinsic nature of science, even though the very notion that science has a nature that may be known independently from its social and political contexts is subject to serious questioning.[9] However, public science as it is perceived outside the scientific community is both more and less than just a source of truth or uncertainty. The decisionmakers involved in the San Francisquito Creek Project speak of their experience with science in terms and tones that imply confusion and distrust as the main effects of the ways science has been used in their decisionmaking. When interviewed on the subject, most representatives serving as board members of the JPA, did not express their concerns about science in terms of quantified margins of error as scientists do. Rather, they complained about their inability to rely on scientists' competence to make consistent and useful recommendations. These views are remarkable when contrasted with other views that express and confirm the reputation of excellence shared by USGS and Stanford scientists. "I don't know what to believe any more," said a local decisionmaker, "our local scientists change their mind too often and they disagree with each other too radically."[10] Another decisionmaker confessed off record that he did not even trust some scientists as far as their real intentions are concerned, let alone their capacity to produce useful studies. He described, as a way of illustrating his opinion, a recent episode in which a scientific study was commissioned not for the benefit of local communities or for a better understanding of the San Francisquito Creek's ecosystem, but seemingly for the purpose of postpon-

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[9] Since the publication of Thomas Kuhn's seminal work, "The Structure of Scientific Revolutions" in 1969, the literature in the fields of history, sociology, and anthropology of science abounds in studies showing the deep impact of local contexts on all aspects of science. Some authors such as S. Shapin, go as far as arguing for a characterization of scientific discourse as a mere social construction. Lawrence E. Susskind and Louise Dunlap raise the same issue but from a contemporary and practical perspective in their analysis of the role of non-objective knowledge in ecological issues in "The Importance of Non-objective Judgments in Environmental Impact Assessments," Environmental Impact Assessment Review, December 1981, v. 2, no. 4, December 1981, p. 335-366.

[10] Dena Mossar, City of Menlo Park, interview on March 12, 2001.

ing a decision that would have compromised the implementation of a housing project with important prospective tax incomes for the City of East Palo Alto and political benefits for its elected representatives. He saw a connection of complicity between the board members of the JPA who proposed and pushed for the study and the scientists who conducted it. The JPA, the mentioned decisionmaker concluded, was used both by its own members and by "their scientist allies" to protect special interests. This usage of science is more than just adversarial. Some decisionmakers and informed citizens of the San Francisquito Creek watershed perceive this usage of science as both strategic and illegitimate. Indeed, it is this perception of science that makes science a source of distrust rather than just a source of uncertainty.

A lack of collaborative relationships between the parties in the San Francisquito Creek watershed constitutes a major obstacle on the way to building trust. The consequences resulting from lack of trust in our case is consistent with the idea that distrust in general is a serious obstacle in any decision-making context. The difficult question, however, is posed as to how to explain, and thereby, how to remedy a situation in which the very individuals and institutions that are expected to produce objective truth and propose impartial solutions are disqualified on both accounts. Lack of trust is a real barrier, just as ineffective communication of scientific information, inadequate distribution of power, or conflicting interests among stakeholders are often identified as obstacles on the way to effective environmental policymaking. However, it may be argued that these obstacles, although real, are in fact surface effects. More specifically, there is a lack of an adequate collaborative *process*, the establishment of which would help overcome distrust between the parties as the main barrier to achieving solutions. An effective collaborative process would also help overcome the other obstacles just mentioned, in particular ineffective communication of scientific information.

As far as the communication and usage of science are concerned, the actual obstacles are the causes of the failure of stakeholders to collaborate effectively in the processes of decisionmaking and of knowledge production. These causes may be identified at three levels—social, epistemological, and cultural. From a practical perspective, the social level is concerned mainly with the process and structure of decisionmaking. The causes found at this level are actionable on a relatively shortterm and they can be subject to negotiations. They stress the notion that the real obstacles on the way to sustainable solutions for environmental issues are not mainly technical but rather social. The epistemological level is that of the underlying assumptions shared both by scientists and nonscientists on the nature and role of science in contemporary society. These assumptions are often deeply rooted in individuals' psyche and well established in their intellectual and professional ethos. As such, they may be more difficult to transform. However, although abstract in nature, these assumptions, as we will see, determine the structure of scientific practice, that is the way science is institutionalized and the scientists' behavior with respect to the usage of science in both the scientific and the public spheres. As for the cultural level, it is to be approached from the perspectives in which sociologists and anthropologists of science study scientific communities and the ways they participate in their disciplinary and local cultures. Fundamental institutional change is needed at this level in order to promote a transdisciplinary culture. Indeed, in order for transdisciplinarity to be established in Western societies, governments, agencies, and institutions of higher learning must understand but also actively support and effectively integrate collaborative processes, such as Joint Fact Finding, and more generally deliberative approaches to science-intensive public issues.

The three dimensions or levels of explanation of the role of science in environmental disputes, namely the social, epistemological, and cultural levels, were the subject matter of two series of interviews conducted with the main players in the San Francisquito Creek controversy. Through a number of overarching questions addressed to all the interviewees, we attempted to explore the ways in which scientists perceive their own role in the creek project as well as the ways in which they are perceived by nonscientists such as the local decisionmakers, science managers, and the citizens of the watershed who were involved in the creek project. A close analysis of the answers then led us to the underlying assumptions that ought to account for the mentioned perceptions. The interviews, therefore, were essentially designed as qualitative inquiries and were not structured as a survey. They did, however, provide us with indications as to the perceptions and assumptions concerning the role of science and scientists in the creek project.

Table 1 is a summary of the answers to five of the main questions. Represented in the table is the common denominator found in the answers of each category of interviewees. The latter belonged to five categories—(1) the interviewed scientists were selected from the USGS and Stanford scientists who were involved in the San Francisquito creek project; (2) the engineers were chosen from the technical staff of the local agencies; (3) the science managers were those employed by USGS and Stanford University; (4) the decisionmakers were chosen from the members of the JPA and from representatives of other communities in the watershed who have not (yet) joined the JPA; and (5) local citizens interviewed were selected from the most active and informed volunteers for the San Francisquito creek project. The questions are abbreviated in the table and were formulated as follows— (A) How satisfied are you with the interactions between the scientists and decision-makers in the San Francisquito Creek Project? (B) What is the role of scientists in the project? (C) How do scientists handle the fact-value dilemma[11]? (D) How do scientists and the technical people, that is engineers, interact? and (E) What kind of change would you like to see in the role of scientists in the project?

[11] The "fact-value dilemma" refers to situations where an individual, say an expert-scientist, must report on facts that may contradict his or her values; or situations where reported facts may lead to decisions that are not desired by the author of the report.

Questions → ↓Interviewees	A. Science and Decisions?	B. Scientists' role?	C. Fact-Value Dilemma?	D. Science and Engineering?	E. What should change?
1. Scientists	Highly dissatisfied	Neutral providers of objective truth	Not perceived as a problem	Engineers think in short terms	More freedom for scientists
2. Engineers	Relatively satisfied	Providers of useful opinions, sometimes	Scientists can separate facts and values	Scientists think in abstract (irrelevant) terms	Scientists must improve their communication skills
3. Science-Managers	Dissatisfied	Neutral providers of objective truth	Scientists can separate facts and values	Do not always understand each other	Science programs must be provided with more funds
4. Decision-makers	Highly dissatisfied	Advisers, often tools in the hand of the "opponent"	Suspicious as to scientists' capacity to distinguish facts from values	Engineers are the indispensable "translators" of scientific studies	Scientists must demontrate their neutrality and competence
5. Citizens	Dissatisfied	Experts are often manipulated by decision-makers	A real problem with Stanford scientists but not with USGS scientists	Scientists and Engineers don't always understand each other	Scientists must be neutral and more present and active in public meetings

Table 1. A summary of two series of interviews with the main players in the San Francisquito Creek Project.

Scientists' unwillingness to participate in public decision-making is one of the most unequivocally shared attitudes that emerged from our interviews with both USGS and Stanford scientists. Most scientists involved in the San Francisquito Creek Project acknowledged the fact. However, they found it nonproblematic as far they are concerned. When questioned on the reasons why they prefer not to cross what they call the "neutrality line" between the scientific and the public spheres, the first motive they often mentioned was unsurprisingly lack of time. Management decisionmaking, they complained, is a long process. They found themselves unable to justify spending time in what they often consider as "chaotic public meetings." However, when asked to explain and further develop on the issue of time, other motives emerged that are enlightening as to their underlying assumptions on the nature of science and their perception of what role a scientist ought to play in science related public issues. "Well, it takes a tremendous amount of time to educate the public and the decisionmakers" (David Freyberg, Stanford University, interview on June 3rd, 2001).

> "Management decisions," he continued, "take time and the decisions are made interdependently. We're not used to this. We are used to making our own decisions in our own time frame. And the notion that scientific knowledge exists independently of the decision-making process, that there is a correct fact associated with the decision is built into the way we are educated and the way we do our research."

The assumption that science is independent from society and that, contrary to the public and politicians, scientists are "free thinkers" is deeply rooted in the ways scientists understand science and its role in society and thereby in the ways they perceive themselves. However, the most pervasive assumption from the scientists' part, but also from the nonscientists' point of view is that the former must educate the latter. Science is the only legitimate source of truth and therefore nonscientists can only be passive receptacles of knowledge provided by scientists. The idea of the public's passivity with respect to science is also closely linked to a notion of the public as a homogeneous entity, which is a blatant denial of a social reality that stands out with clarity in the San Francisquito Creek watershed where the public is very diverse as far as its environmental awareness and its general access to expert knowledge are concerned. The presence of Stanford University and USGS in the watershed, of course, play a major role in the local cognitive diversity. The cognitive diversity of the public may seem to create a pedagogic obstacle for scientists in their interactions with the public as they must adapt their language to an audience the background of which is heterogeneous. However, scientists do not acknowledge this heterogeneity. Instead, they perceive the public as homogeneous with regard to its assumed scientific illiteracy. Lack of time on the scientists' side and lack of scientific understanding on the public's side do not provide a convincing explanation for the lack collaboration between scientists and nonscientists. Scientists' unwillingness to participate in public decisionmaking must therefore be accounted for from a perspective other than that adopted by the scientists themselves.

A science-centered view of society, and more generally, a science-centered mode of thinking emerge from answers to the question on scientists' lack of participation in the decisionmaking process, despite critical statements suggesting scientists' awareness of the problematic aspect of such a view. For instance, a USGS scientist admitted to the following:

> "Scientists have a problem with people doubting whether what a scientist says is true. They have a lot of trouble making a case beyond what they perceive as facts. We have difficulties admitting that there is a lot more fuzziness to scientific discourse than there appears to be. And it is very difficult for a scientist to be in a situation where he is not believed," (Ken Bencala, USGS. Interview on June 5, 2001).

It is remarkable, however, that science-centered assumptions are not threatened in any way by scientists' awareness of the inadequacy and ineffectiveness of these assumptions. This could be explained with the consideration of scientists' material and institutional interests to remain within the boundaries of academia. Along these lines, a scientist spoke of "negative reward" for those who cross the neutrality line:

> "There is, in the academia, a certain distrust for the colleagues who are adept at working in the public sphere or in the political environment. How could they be good scientists if they are able to work in a context in which they must compromise? There is negative reward for academics to spend time in the public sphere." (Mary Lou Zoback, USGS. Interview on June 6, 2001.)

Negative reward combined with the assumption of an essentially passive and homogeneously ignorant public make it seem a plausible description of the reasons why the very possibility of a dialogue or a mutual learning process may not even be considered. However, when asked in which situations scientists found less difficulty communicating with nonscientists or for that matter with colleagues from other disciplines, some scientists answered "in the field," meaning in situations where they had to work closely with one another. Contrary to conditions in which scientists and decisionmakers communicate through formal reports or summaries of scientific studies, in the field or in the laboratory where there is a face-to-face communication or actual collaboration, language barriers, often invoked as a serious obstacle, tend to fall.

The informational decisionmaking model

The consequences of assuming that the public is essentially ignorant and passive and that science is objective, value-free, and independent from society appear to be highly disruptive.[12] Indeed, once these notions are admitted, any problematic relationship between scientists, decisionmakers, and citizens is bound to be attributed to either public ignorance or public irrationality. The only legitimate goal then follows uncritically—to inform the public of what scientific thinking is about. Although a critical evaluation of scientific institutions may be in order, considerable and often useless efforts are made to confirm and reinforce the obsolete and indeed deceptive centrality of science. The decisionmaking process so far adopted by the decision-making bodies in the San Francisquito Creek watershed is a good illustration of the disruptive consequences of science-centered assumptions. The process follows an informational model (fig. 5), namely a transfer of information from scientists to the decisionmakers via the technical staff of agencies such as the Santa Clara Flood Control District (fig. 6). Relying on the information gathered in public meetings, the board of the JPA commissions studies to be conducted on often-isolated issues. Then, after a few months of little or no contact between the scientists and the decisionmakers, the results of those studies reach the board members of the JPA in a prepackaged form. The latter form is a summarized and reinterpreted version of the scientific studies prepared by the technical staff of the government agencies for the decisionmakers.

The lack of personal contact between scientists and decisionmakers allows an instrumentalization of science and opens room for misinterpretations and mishandlings of scientific information, which in turn leads to the implicit view among scientists that the "uneducated" decisionmakers and the "ignorant public" form a barrier to intelligent and constructive deci-

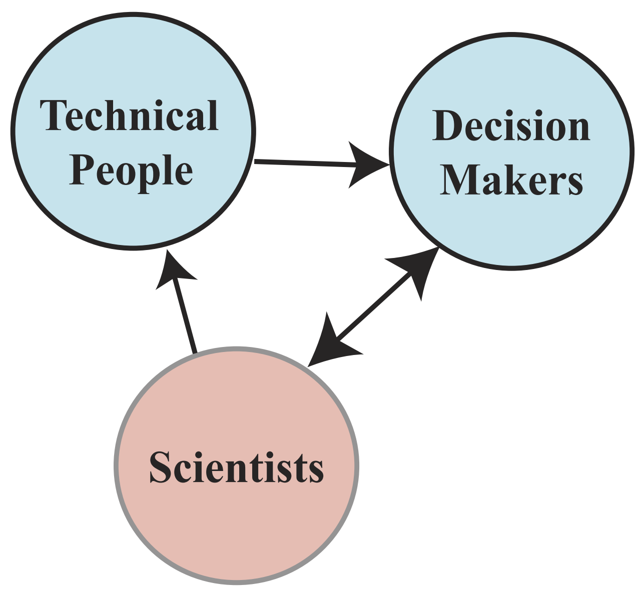

Figure 5. The informational model. For an alternative view of visualizing the informational model, see Ozawa, 1991.

[12] In his work "Citizen Science," Alan Irwin examines the disruptive consequences of science-centered assumptions in great detail and in various cases. See Irwin, 1995.

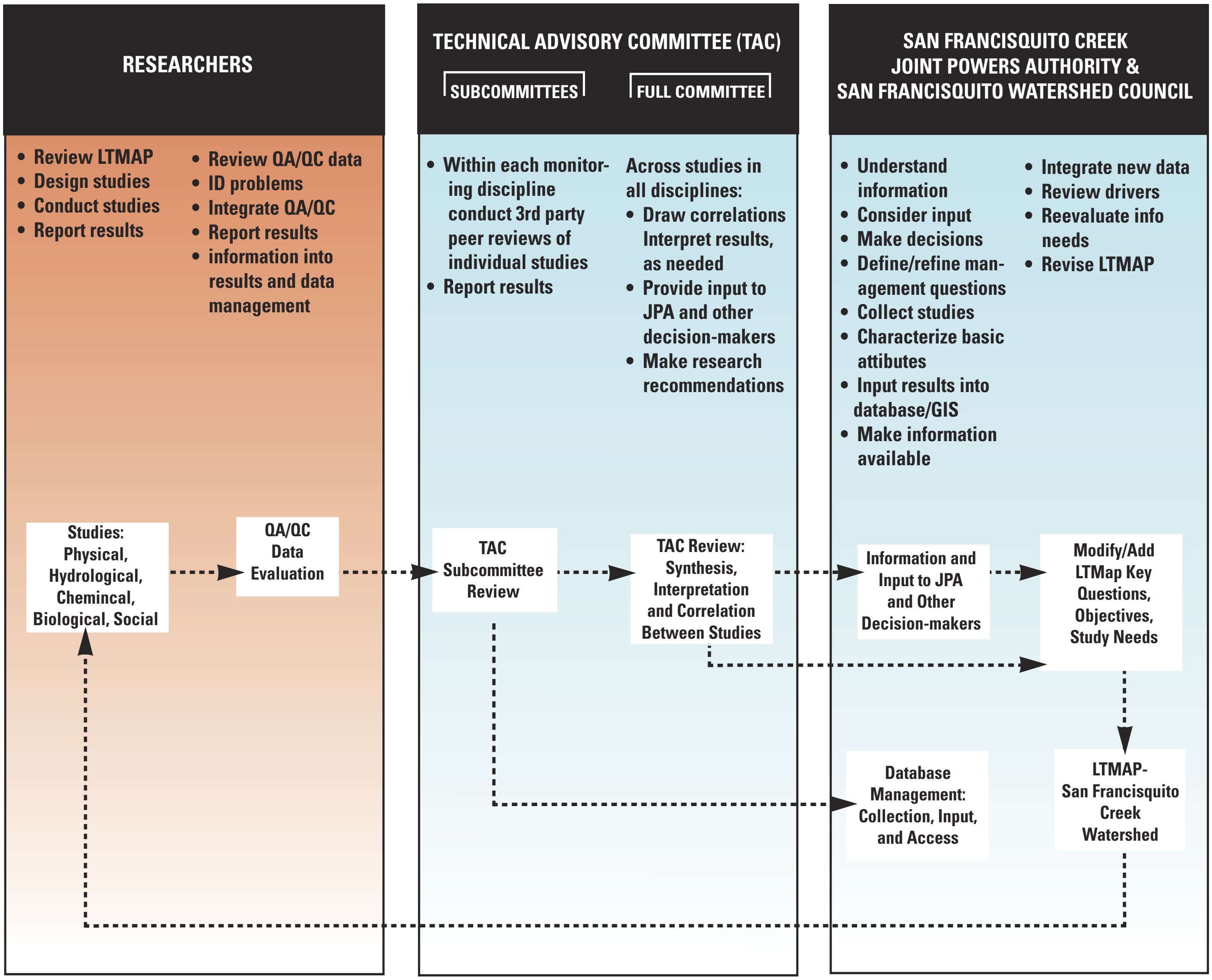

Figure 6. An example of an informational model. This diagram is an excerpt from the "Long-Term Monitoring and Assessment Plan for the San Francisquito Creek Watershed" published by the San Francisquito Watershed Council (formerly Coordinated Resource Management Planning) in February 2002. It is meant to visualize the information management process followed by the San Francisquito Creek Joint Powers Authority. The diagram separates the scientists from the decisionmakers, with the agencies' technical staff as an intermediate. Moreover, the model excludes the public, and symptomatically, it neglects to represent the stakeholders and their differing interpretations of the relevant information as well as their differing notions of the information management process itself.

sionmaking. As a result of this, language barriers and distrust are perceived as the ultimate obstacles to overcome. In fact, the lack of personal contact and cooperation between decision-makers and scientists, as well as the exclusion of the public from the decisionmaking process favor—not to say cause—distrust between the parties. It is in this sense that, despite its reality, distrust among decisionmaking partners may be said to be a surface effect. As redundant or circular as it may seem, it appears that the real obstacle to a collaborative decisionmaking process is the very lack of a collaborative decisionmaking process. The members of the JPA failed to see the distinction between a true collaborative Joint Fact Finding process and the standard mode of passive public involvement. Collaboration is unlikely to occur as long as the public sphere is separate from the political and the scientific spheres, as it is the case in the informational model. We need to create a zone of overlap between the three spheres, within which zone collaboration between all stakeholders is legitimized, if not institutionalized, by the political and academic authority. A transdisciplinary decision-making process would then be possible within that zone of overlap. A Joint Fact Finding process as described above may be designed and implemented only if the creation

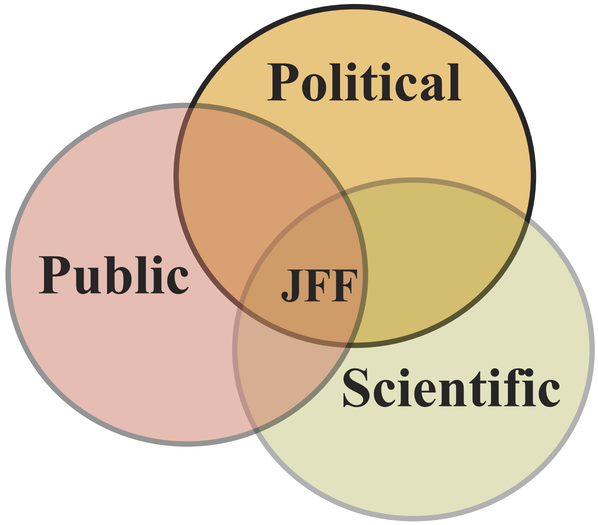

Figure 7. Joint Fact Finding (JFF) within a zone of overlap between the public, scientific, and political spheres.

of a zone of overlap between the three spheres is possible (fig. 7).

The transdisciplinary decisionmaking model

In the San Francisquito Creek Project as in any other science-intensive public dispute, there is a critical need for open processes, that is processes that are open to public scrutiny, open to change over time (see Susskind and Cruikshank, 1987), and open to a wider range of information sources. In other words, we must abandon the "public ignorance" model. Management decisions and environmental policies cannot be sustainable unless the needs of lay groups are addressed and their understandings captured. This means that forms of knowledge other than scientific must be recognized as legitimate and used as useful sources of information. Local narratives, for instance, constitute a wealth of knowledge that may not only complement scientific knowledge but also inform the process of knowledge production with regards tp public interests and concerns. Indeed, knowledge whether scientific or popular is not neutral; it reflects the perspectives and interests of its producers.

Several Stanford scientists who were involved in research projects in the Jasper Ridge Preserve upstream of San Francisquito Creek recalled episodes where the results of their research were, often to their utter amazement, rejected by lay groups. In each case, there was a clear incompatibility between scientists' technical conclusions and the public's empirical knowledge of the issue. When confronted with public's total rejection of what he thought to be a "scientific truth," a scientist spoke of an "Alice-in-Wonderland-experience," expressing in this way his incomprehension of the reason why people would not accept conclusions logically drawn from a study conducted by professional scientists on the sediment issue in Searsville Lake:

> "The study by Balance Hydrologics," he said, "clearly demonstrated that we were getting extraordinarily high levels of sediments coming in, and that these high levels of sediments appeared to be the result of natural background erosion, though one could argue that the erosion was the result of the clear cutting that occurred in the middle of the 19th century. But I think that that would be a very difficult case to make. I think it would be really hard to show that that's the case because most of that upper watershed is open space preserve; it's unbroken canopy, and it's in very good shape… So we got this study done, we got this analysis, we met with the residents, and they rejected all the findings. It was sort of an Alice-in-Wonderland-experience for me." (Philippe Cohen, Director of the Jasper Ridge Preserve, Stanford University; interview on March 29, 2001).

Had he consulted both the scientists and the residents for the design and the implementation of his study, he would have collected better results as far as the social acceptance of his research is concerned. And had the residents participated in all the stages of the study, the conclusions would most probably be different, and in any case, less likely to be rejected by the residents. Indeed, having different needs and goals, lay people and scientists also have different perspectives on how to investigate and interpret environmental data (Brown, 1992; Chambers, 1997, Collin and Collin, 1998; Dryzek, 1997; Epstein, 1996; Ezrahi, 1990; Gibbons, 1999; Gieryn, 1995; Jasanoff, 1991; Wynee, 1996; Yearley, 2000). Their methods of data collection, the theoretical scope of their studies, and their timing differ, to mention only a few differences. The latter are often disruptive and lead to paralyzing miscommunications that could be avoided if the processes of knowledge production and of decisionmaking were integrated. Accounting for these differences in terms of public irrationality, as scientists often do, stems, as we saw, from science-centered presuppositions.

The transdisciplinary decision-making model (fig. 8) is based on three main principles:

(1) Narratives, whether popular, historical, political, or scientific, are the starting point of environmental disputes. Therefore, they should all be heard. The sine qua non condition for any sustainable decision making process is constant reference or regular return to the relevant narratives. For this reason, the diagram represents a cycle that starts and ends with narratives. Practically speaking, this principle could be realized in the form of mediated public meetings where everyone is free to tell his or her story.

(2) A zone of overlap between the three spheres is needed. The boundaries that separate the public, the political, and the scientific spheres are obstacles on the way to sustainable solutions. Following a Joint Fact Finding process,

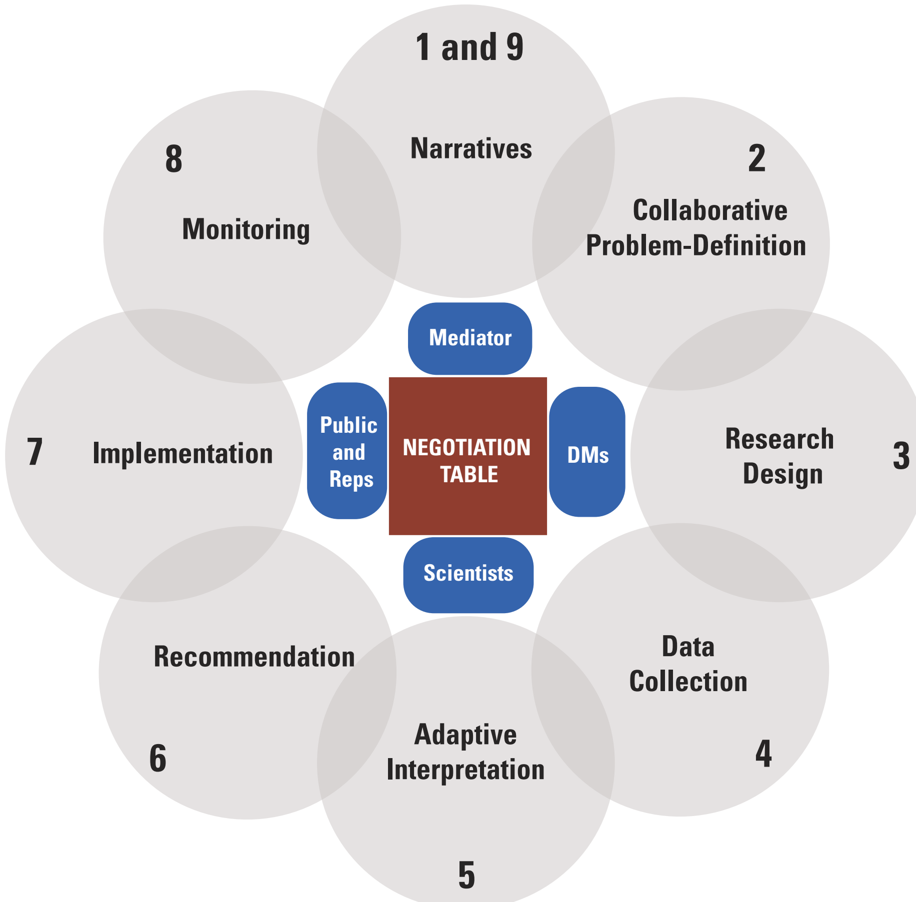

Figure 8. The transdisciplinary decisionmaking model. DMs, decisionmakers; Reps, stakeholder's representatives.

scientists and decisionmakers together with the public's representatives may collaborate in all the phases of the processes of decisionmaking and of the production and usage of scientific knowledge. For this to happen, it is crucial that scientists be provided with sufficient intellectual, institutional, and financial incentives. New reward structures should therefore be created for them within the scientific community and without. Moreover, a class of scientific synthesizers (Karl and Turner, 2002) could be developed whose functions would be threefold—(1) to facilitate communication and collaboration between scientists from different disciplines, (2) to facilitate communication and collaboration between scientists and decisionmakers, (3) to report both to competent academics and to the concerned communities in the appropriate form and language and engage both sides in an ongoing feedback system. On the academic side, this would ensure peer reviewing, that is scientific quality control as well as an intellectual recognition of the value of scientists' public involvement, and on the community side, the synthesizers would support and fortify the democratic structure of the decisionmaking process. Indeed, scientific synthesizers must make sure that scientists are selected according to impartial criteria, that sound science is practiced, and that the stakeholders are informed of and "understand" the science.

(3) Mediation and Consensus Building are necessary for two reasons—(1) the stakeholders are usually numerous and have very different interests and positions, and (2) due to diverging expert opinions, science can be a source of additional controversy and confusion. Assisted by scientific synthesizers, a mediator or a team of mediators can handle both the collaborative problem-solving and the conflictual aspects of the decisionmaking process. As part of a consensus building process, Joint Fact Finding must be led by a mediator.

One of the dangers of having scientists and decisionmakers collaborate on a regular basis is to create a destructive interference between the political and scientific spheres and see the purely theoretical and often open ended controversies between experts complicate or paralyze the decisionmaking process. Mediators may therefore lead parallel and provisionally separate negotiations between experts on one hand, and between decisionmakers on the other and use the results of these negotiations as a basis for the selection of experts and additional relevant decisions. The crucial issue of the selection of experts is one among other critical issues that could be represented on the diagram above according to the specific context of each science-intensive public dispute. The first question with this regard of course is who should select the experts? A general answer to this question is: the stakeholders' representatives in close association with the decisionmakers. However, the more specific questions as to how they should proceed to the selection, according to which criteria, and at what point in the decisionmaking process may not be answered independently from the circumstances that define the context of each particular case. Indeed, in a collaborative process, the mentioned questions must be subject to negotiation between the parties. Once the experts are selected and their role determined, comes the time when the stakeholders and the scientists must select the methods of analysis. The guidelines of Joint Fact Finding as drawn above could be followed here. However, the methods of analysis must also be the outcome of negotiated agreements. Another important issue that could be represented on the diagram is the way experts are supposed to interact with decisionmakers and with the stakeholders' representatives—how they must communicate their findings; how they should scope their analysis; how they should adapt the timing of their interventions to the decisionmaking time frame; and how they should act when sought after information is not available in order to prevent what often occurs when information is not ready for usage, namely the blockage of the decisionmaking process. Along with the lack of information, there are often irreducible differences between scientists that the mediator must handle and use to build consensus around. He or she must then present those differences to the decisionmakers in a way as to avoid confusion and distrust. The discussion among scientists must remain open at all stages in the process and political concerns should not affect the quality of science that is produced. However, it is of vital importance in a transdisciplinary process that the normative leap from analysis to prescription be made by the scientists themselves. This must be done without compromising scientific impartiality. Indeed, the main danger for scientists to make prescriptive statements about policy is to fall into the trap of "advocacy science," which is often perceived as incompatible with scientific excellence. For this reason, rather than actually prescribing a policy, scientists may advise on the consequences of policy options leaving prescription of specific policy options to policymakers. In this way scientists can make the normative leap from analysis to prescription without actually prescribing policy. Indeed, scientists must participate in the decisionmaking process for the practical reasons that we mentioned above. However, scientists also have a social responsibility that they often refuse to acknowledge. Participating in the decisionmaking process is one way for scientists and scientific institutions to be socially responsible, but it is also a way to reestablish the eroded trust between the scientific community and the public.

Conclusion

Although science has become central to modern societies, its public status and, in particular, its role in environmental disputes, are increasingly contentious. The traditional image of the neutral and disinterested science expert who was expected to be the rational and authoritative arbiter of public disputes is no longer a credible image. Indeed, environmental disputes often start with or lead to disputes between experts themselves. As it is the case in the San Francisquito Creek controversy, when experts do not actively participate in political processes as declared or implicit advocates, they may be perceived as tools in the hands of decisionmakers. And often, when these experts are expected to cross the boundaries of their disciplines in order to take part in the decisionmaking process, they invoke scientific neutrality as the *sine qua non* condition of good science in order to justify their reluctance to collaborate with nonscientists. As a result of this, science conducted within the traditional adversarial process fosters major difficulties for decisionmaking. It burdens communities and societies with enormous and often useless costs. It creates disruptive confusion among decisionmakers and the public. And, as we saw in the San Francisquito Creek case, science conducted within an adversarial process erodes both political and public trust in the objectivity and neutrality of scientific expertise. Indeed, the absence of an effective collaborative process in the San Francisquito Creek Project led to numerous problems that impaired the trust between the players—(1) the scope of scientific studies were often narrowly defined; (2) enough time was not given to scientists for the design of their studies and the coordination of their research programs with the actual management needs; (3) the cost allocations for the common projects were never structured in a satisfactory way for all parties; (4) even when sufficient, the available information was not properly used; (5) there was a mismatch between the capabilities of involved agencies and decisionmakers and their responsibilities as to how to fund the studies or how to implement the recommendations drawn from those studies; and (6) the public was never adequately involved in the processes of knowledge production and of decisionmaking. Finally, these problems led to a perception of science as a source of confusion and distrust.

In the face of these disruptive problems in the case we studied but also in general, the growing demand for greater public participation in science-related policy making becomes an understandable phenomenon as well as a clear indication as to the road to take towards an integrated approach to these problems. Considering that, on one hand, citizens are impacted by environmental policy making, and that the sustainability of policy decisions, on the other hand, may depend on the degree and quality of citizens' participation in the decisionmaking process, there are both ethical and practical imperatives to respond to the demand for more and better public participation in policymaking. A transdisciplinary approach of environmental issues is integrated in the sense that it does not privilege scientists and their knowledge. Instead, it includes scientists as participants into the wider political debate. This means that the prominent role of nonexperts in the decision-making process is acknowledged and an enhanced public space is created for the concerned citizens to participate in the decisionmaking process. Science then may become more visible to the public, and the role of scientists in environmental disputes may become easier to redefine and reevaluate. Thus, a transdisciplinary approach to environmental disputes and the implementation of Joint Fact Finding within the larger framework of consensus building strategies may not only democratize decisionmaking and produce more sustainable results. It may also provide societies with an informal but effective means of science and technology assessment. The traditionally institutionalized methods of science and technology assessment are based on the artificial and misleading separation of the public and scientific spheres. These methods tend to protect the authority of scientific experts, disadvantage the public, and perpetuate a social distribution of power that has proved to be counterproductive and undemocratic, that is ineffective and unfair. Indeed, if the socially conditioned and contingent nature of scientific knowledge and practice is acknowledged and understood, then the methods of assessing the role of science in environmental disputes as well as the methods of resolving those disputes may not remain science centered.

Both the scientific community and the public must revise their understanding of science as a neutral human activity. If scientific research is to bear an unambiguous prescriptive value and if public trust in science is to be reestablished, decisionmakers must create opportunities for adopting consensus building strategies and allow integrated collaborative methods of research such as Joint Fact Finding to be tried on the ground. We presented, in this paper, Joint Fact Finding as a set of testable hypotheses, the essence of which consists of the contention that the direct involvement of nonexpert citizens in the processes of knowledge production and of decisionmaking increases the acceptance, on the part of those citizens, of the environmental policy decisions that are made. Increased acceptance would render policy making more effective and the science that is used in support of the policy decisions more relevant to societal needs. Furthermore, with increased relevance, the direct involvement of citizens in the mentioned processes will provide science with enhanced credibility and legitimacy. Ultimately, if the Joint Fact Finding hypotheses are tested and the transdisciplinary approach to environmental problem solving is proved to be more effective than the traditional disciplinary or multidisciplinary approaches, it is the very role of science in environmental disputes that will be transformed and, indeed, improved.

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Appendix 1. Chronology of the post-World War II community actions with regard to San Francisquito Creek and the USGS San Francisquito Creek Project

1946-55: Post war urbanization boom. Residential homebuilding takes off along the San Francisquito Creek. More area previously relied upon as flood plain and for water absorption becomes developed.
1955: Different collaborative community initiatives help keep the Creek cleaner and a political cooperation between the concerned jurisdictions leads to the construction of levees downstream in order to minimize flood risks.
December 22nd, 1955: San Francisquito Creek overflows its banks into the northern portions the City of Palo Alto, flooding 750 homes and resulting in $2 million of damage.
June 1957: Congress approves funds to begin United States Army Corps of Engineers (USACE) study on San Francisquito Creek.
April 1958: The San Francisquito Creek over flows its banks again. The creek reaches the top of sand bag emplacements at Edgewood and Greer Roads. Levee near Palo Alto airport collapses.
December1958: An agreement is signed between San Mateo County and Santa Clara County to maintain levees along San Francisquito Creek.
January 1961: USACE performs an extensive flood control survey and releases a "Report of Survey for Flood Control and Allied Purposes, San Francisquito Creek." The report recommends a Ladera Dam flood control project. Proposed plan calls for 97-foot-high, 500-acre multipurpose dam and reservoir on Stanford University lands near Sand Hill Road between Searsville and Felt Lakes.
1962: Stanford University opposes Ladera Dam Project, saying it goes against plans they had to build Stanford Linear Accelerator Center (SLAC) on the site. Stanford University also objects that the proposed dam would directly threaten the university's Jasper Ridge Biological Preserve. Ladera Dam flood control project is defeated. USACE declares that it would not consider other flood control plans unless the community is of the mind and public opinion is unified before they would move ahead with any project.
1967: The State legislature creates the San Mateo County Flood Control that is to become a major player in the controversy over the San Francisquito Creek both for its financial capacities and its technical expertise. During the same year, San Mateo County also creates a San Francisquito Creek Flood Control Zone to finance improvements in cooperation with the Santa Clara County Water District.
1968: Urbanization intensifies, Willow Road Expressway is proposed. The plan calls for covering the San Francisquito Creek with expressway interchanges at Alma Street near El Palo Alto.
June 1968: The most significant and thorough report on flood control along the creek, entitled "Alternative Methods of Flood Control, San Francisquito Creek, California," is written as a Ph.D. dissertation by James Robert Vincent, a graduate civil engineering student at Stanford University.
1969: Small but rapidly growing environmental movement in the local community helps defeat Willow Road interchange plan. Cities consider the construction of a diversion channel underneath Willow Road and out to the San Francisco Bay. One element of the plan calls for creating a concrete channel between El Camino Real and Middlefield Road and diverting water north under Middlefield road to Willow Road.
July 1969: A regulation of construction in San Francisquito Creek is adopted.
September 25, 1969: The Menlo Park Beautification Commission held a meeting to develop a policy for the preservation of San Francisquito Creek as a natural asset.
March 14, 1972: San Francisquito Creek is declared a "scenic stream" and an open space plan is proposed for the creek and its environment.
August 1972: A Stanford University proposal is implemented, the San Francisquito Creek's banks are lined with concrete rip-rap at many locations downstream of the Pope-Chaucer Bridge and construction of walls along sections of the Creek downstream of University Avenue.
October 1972: Diversion channel proposal is scrapped after USACE releases a study that suggests that the diversion channel would not be a viable solution for flood control.
June 1973: The Planning Commission of Menlo Park adopts the Open Space and Conservation Element of the Menlo Park General Plan.
1976: The City of Menlo Park takes leadership in forming a San Francisquito Creek Protection Board that consists of one council member from Menlo Park, one from Palo Alto, and a representative from Stanford University. The Protection Board manages to mobilize a group of local individuals for volunteer work on the creek.
1979: Flood mitigation measures are proposed as an alternative flood control approach. A good example of this kind of initiatives is a "Flood Insurance Study of Palo Alto" prepared by the Federal Emergency Management Agency (FEMA).
January 1982: Rising water as the result of winter storms comes to within one foot of overflowing San Francisquito Creek's banks and causing flooding in Menlo Park and Palo Alto at Pope-Chaucer Street Bridge.
1983: East Palo Alto is incorporated as a City. This event significantly changes the political geography of the watershed.
March 1988: Jim Johnson, the stream keeper of the San Francisquito Creek finds two 30-inch long steelhead trout floating dead in the creek near El Palo Alto near downtown Palo Alto. Nobody knew steelhead trout were still swimming up the creek. The event becomes a turning point in public

environmental awareness. Jim Johnson brings to light the garbage and homeless encampment problems along the creek near El Palo Alto.

1989: Friends of San Francisquito Creek, an important environmental activist group, is formed.

1990: Dena Mossar, a local decisionmaker, and Trish Mulvey, a environmental activist, convene a series of round-table meetings to discuss issues related to San Francisquito Creek with representatives from Santa Clara Valley Water District (SCVWD), California Fish and Game, City of Palo Alto staff and environmental leaders.

Summer 1993: Jim Johnson convenes several meetings of agency representatives, neighborhood people, Stanford University staff, and environmental groups to discuss creating a Coordinated Resource Management Planning (CRMP) organization.

November 30, 1993: Representatives from 40 organizations, ranging from government agencies to community groups and landowners, meet at Stanford University and establish a Coordinated Resource Management Planning Program (CRMP) for the San Francisquito Creek watershed.

September 1995: Stanford Fish Ladder opens at confluence of Los Trancos Creek and San Francisquito Creek.

Late 1995: FEMA begins a restudy of the flood insurance requirements for Palo Alto, Menlo Park, and East Palo Alto. (The flood zone map and damage analysis in this report are based on preliminary maps provided in 1996 from the restudy. These maps will be finalized in 1999.)

1997: CRMP starts a Reconnaissance Study on the Creek.

August 1997: Alma Street pedestrian/bike bridge between Menlo Park and Palo Alto is completed. This brings the public in closer contact with the San Francisquito Creek.

February 1998: The San Francisquito Creek over flows its banks, flooding 1,700 homes and resulting in $27 million in damage across 11,000 acres of East Palo Alto, Menlo Park, and Palo Alto.

March 1998: CRMP's "Reconnaissance Investigation Report of San Francisquito Creek" is completed. The report offers different alternatives for the Creek.

Early 1998: First Chinese mitten crab (Eriocheir sinensis) found in the Creek at Jasper Ridge Biological Preserve. The burrowing of this nonnative crab has been determined to accelerate erosion of banks and levees. The crab preys on native fish species and their eggs and is thought to be altering the natural ecosystem in other undetermined ways.

Late 1998: INCLUDE (Integrated-science and Community-based Values in Land-use Decision-making) is launched at USGS with a Geologic Division Venture Capital award.

Early December 1998: Dr. Herman Karl, formerly USGS Western Geographic Science Center chief scientist responsible for development of INCLUDE, and Dr. Richard Bernknopf, currently USGS Western Geographic Science Center chief scientist responsible for development of risk communication strategies, meet with Richard Reuben, Associate Director of the Stanford Center on Conflict and Negotiation, and Robert Barrett, Mediator and founder of Collaborative Decisions. Robert Barrett suggests that San Francisquito Creek would make a good case study.

January 1999: INCLUDE is headquartered at the USGS Western Geographic Science Center (USGS, Menlo Park, Calif.) as a core element of an interdivisional research agenda.

January 1999: San Francisquito Creek Bank Stabilization and Revegetation Master Plan is completed. The scope of the three-part study is 6.5-mile-long portion of the creek between Junipero Serra Boulevard and Highway 101. The report details bank stabilization and revegetation measures and provides extensive site data and maps to support the findings.

April 21, 1999: Herman Karl addresses the San Fancisquito Creek Watershed Council Steering Committee. Collaboration between USGS (INCLUDE) and CRMP begins and a subcommittee is formed by volunteers from CRMP to design and implement an INCLUDE citizen-centered project. The subcommittee is named "Sediment Work Group."

May 1999: San Francisquito Creek Joint Powers Authority (JPA) is created through a creek coordinating committee. It is formed as a cooperative effort to improve community storm preparation and flood management. Cities of Palo Alto, Menlo Park, and East Palo Alto, and the Santa Clara valley Water District and San Mateo County Flood Control District are included as voting members.

May 1999: San Francisquito Creek and its watershed are listed under the Clean Water Act of 1972 (sect. 303, d.) as impaired due to excessive levels of both diazinon and sediment.

July 1999 Gathering of background information on the San Francisquito Creek and previous studies begins at USGS as part of the collaboration between USGS and CRMP. A geographic information system (GIS) is started with the guidance of the Creek Project Steering Committee, and GIS maps of the San Francisquito Creek watershed are produced.

September 1999: JPA holds its first meeting**.**

May 2000: An interactive public exhibit on the Creek Project is displayed to the public at a USGS Open House, Menlo Park, Calif.

August 2000: JPA Executive Director Cynthia D'Agosta is hired to develop a JPA work plan and direct the agency.

October 1, 2000: An Integrated Study of an Urbanized Watershed awarded funds by the USGS Geography Discipline research prospectus to conduct a one-year study ending September 30, 2001.

December 2000: Prof. Lawrence Susskind presents a seminar at USGS, as part of the INCLUDE Seminar Series, on the role of science and scientists in collaborative processes.

March 2001: JPA assumes inkind services of the Clerk of the Board role from the Santa Clara Valley Water District and Legal Counsel services from the City of East Palo Alto.

June 2001: Stanford University releases the draft Searsville Lake Sediment Study that begins to look at the fate of altering or removing of Searsville Dam.

July 2001: The Alma Street pedestrian/bike bridge is dedicated and named after Ira Bonde, former mayor of Menlo Park, who made efforts in the 1960's and 70's to improve San Francisquito Creek.

August 2001: USGS establishes an Assistance Award with the Consensus Building Institute (CBI) to conduct research on the role of science and scientists in collaborative processes. The San Francisquito Creek watershed is a case study in that respect. Dr. Lawrence Susskind is the principal contact at CBI.

August 2001: USGS establishes an Assistance Award with Duke University's Nicolas School of the Environment to conduct research and to advise on aspects of the San Francisquito Creek Project. Dr. Kathi Beratan is the principal contact at Duke.

January 2001: A proposal entitled, "A collaborative problem solving approach toward watershed-based land-use planning: empowering citizens to use integrated multidiscipline information in community-based decision-making" is submitted to the USGS Director's Venture Capital fund requesting support to develop the community values/social issues component of the INCLUDE project. Funding is awarded for a 3-year study beginning March 2001.

July 2001: The JPA is empowered by the JPA Board to operate as its own fiscal agent and independent employer.

September 2001: JPA Board approves a resolution for the Levee Restoration Project. This represents the first capital improvement undertaken by the JPA. The levees in Palo Alto and East Palo Alto have settled and eroded and plans to restore them to 1958 levels begin in earnest.

May 2002: JPA Board authorizes the JPA to be the Local Lead Sponsor to work with the USACE on a new Reconnaissance Study and a Feasibility Study on alternative flood control along San Francisquito Creek.

May 2002: The U.S. House of Representatives Committee on Transportation and Infrastructure passes a resolution authorizing a USACE Reconnaissance Study. This is the first step in the bringing a long-term flood management project to San Francisquito Creek watershed.

August 2002: Construction breaks ground on the Levee Restoration Project. East Palo Alto mayor Duane Bay calls it the first major visible success for the JPA.

USGS

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