ADAPTING TO RISING TIDES ISSUE PAPER
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# ADAPTING GOVERNANCE FOR RISING TIDES

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www.adaptingtorisingtides.org

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# 1. Governance and planning for climate change

The Adapting to Rising Tides (ART) project evaluates how the San Francisco Bay Area can become more resilient to climate change, and in particular the impact of sea level rise and more frequent and severe storm events. The project — a collaborative effort involving community officials and stakeholders — is framed by two guiding questions:

- How will sea level rise and other climate change impacts affect the future of the Bay Area's communities, ecosystems, infrastructure, and economy?

- What strategies should we pursue, both locally and regionally, to address these challenges and to reduce and manage these risks?

To begin to answer these questions, we must consider the capacity of existing institutions to carry out necessary adaptation efforts. Climate change presents serious challenges for the municipalities, agencies, community organizations, business interests, and many other institutions that will play a part in planning for resilience. However, the Bay Area's vulnerability may be greatly reduced if robust and thoughtful adaptation strategies are put to work. Such an effort will require coordination, cooperation, and engagement across different sectors and jurisdictional lines, and among a variety of organizations. In some instances, new programs, policies, and institutional arrangements will also be required.

This issue paper highlights the role of governance in the task of planning for climate change. It examines the factors that may help or hinder Bay Area institutions as they work to foster resilience to climate change. Current institutional arrangements, decision-making processes, and laws and regulations need to be reviewed in light of the challenges presented by sea level rise and storm events. The models and case studies presented in this paper are

intended to assist the region in the early identification of the vulnerabilities facing institutions, organizations, and communities, as well as to provide guidance as we begin to formulate a response. As adaptation planning moves forward, the Bay Area must consider how to adapt, adjust, and even transform in order to implement strategies that make our communities more resilient to climate change.

## WHY FOCUS ON GOVERNANCE?

The ART project considers issues related to governance at each stage in its planning process.* Precisely why governance must be an area of focus in planning for climate change merits discussion at the outset of this issue paper.

Govern*ance* is broader than govern*ment*. It widens the scope of investigation beyond the state and the mechanisms for decision-making codified in the law, acknowledging the role that civil society and non-state actors play in making decisions and setting priorities.[1] Planning for sea level rise and storm events is not only the domain of regulators and politicians. It also involves private landowners, businesses near the coastline, non-profit and community organizations, and others.

Governance also describes the process involved in implementing policies and planning for the future. Institutional arrangements, decision-making processes, financing mechanisms, and various laws and regulations shape how this process unfolds. To plan for sea level rise and storm events, it becomes necessary to examine the ways in which differences are negotiated, obstacles are overcome, decisions are made, and funding is provided for implementation. To be resilient, the Bay Area and its communities must anticipate and respond to obstacles in these processes that have the potential to delay, eliminate, or reduce available adaptation options.

Finally, governance can be examined as a critical determinant of the region's capacity to adapt to climate change. Such "adaptive capacity" is defined as the ability of a system to accommodate or adjust to the stressors associated with climate change.[2] Just as economic wealth or technical solutions can bolster a community's capacity to adapt to climate change, so can effective institutions when combined with empowered and informed communities and organizations.[3] Does the Bay Area have greater adaptive capacity as a result of the framework already in place to manage critical infrastructure, emergency response, natural systems, community values and resources, and other systems? Perhaps so, particularly if the experience and expertise embedded in the Bay Area's organizations, communities, and agencies can be leveraged to respond to the effects of climate change.[4] However, this same network might actually diminish adaptive capacity if its institutions are unable to alter (and when necessary, transform) their practices to respond to new challenges or are unable to collaborate beyond divides created by jurisdictions, sectors, and traditional roles.[5] Confronting climate change will require a degree of agility and a capacity for robust participation that our current governance arrangements lack. For the Bay Area to enhance its resilience to the effects of climate change, increased collaboration, participation, and

* Governance is one the four overarching frames, along with Economy, Environment, and Society and

problem-solving will be necessary among all those who make up the governance landscape in the Bay Area, including non-profit groups, regulatory agencies, educational institutions, private landowners, businesses, city and county governments, and organizations that provide critical services, infrastructure, and utilities.

## CURRENT ADAPTATION REGULATIONS, FUNDING OPPORTUNITIES, AND GUIDANCE

### Federal

Federal agencies have started to develop policies and programs to address planning for climate change. All federal agencies received guidance on adaptation planning from the Interagency Climate Change Adaptation Task Force, convened by President Obama in 2009. In March 2011, the Task Force issued instructions to federal agencies on climate change adaptation, requiring that each agency undertake the process of (1) establishing a climate change policy, (2) increasing understanding within the agency of climate change, (3) applying this understanding to the agency's mission and operations, (4) developing, prioritizing, and implementing adaptation actions, and (5) evaluating and learning from the process by participating in interagency workshops.[6] The Task Force has also promoted the development of "cross-cutting strategies" to link adaptation strategies among agencies on efforts including freshwater resources management, coasts and oceans stewardship, and species and natural resource protection.[7]

Currently, the central roles played by the federal government in adaptation planning are in providing guidance or in funding pilot adaptation efforts around the country. While this approach has supported important efforts, some would like to see a clearer role for the federal government. The nonpartisan Center for Climate and Energy Solutions (C2ES), which has cataloged federal adaptation policy to date, reports that "federal agencies are stepping forward to meet this challenge and are beginning to 'mainstream' consideration of climate change adaptation across their operations, programs and policies."[8] The National Academies has called for a more ambitious national adaptation strategy and program, an effort that would require participation from the state and local jurisdictions, NGOs, and the private sector, but for which the federal government would play a key role as facilitator and coordinator.[9]

### State

The state of California has likewise requested that state agencies assess the vulnerability of the state to climate change and to undertake planning efforts to adapt. Executive Order S-13-08 requires that agencies consider the vulnerability of new projects to inundation under a range of sea level rise scenarios for the years 2050 and 2100. E.O. S-13-08 also assigns duties to state agencies and executive offices in order to lay the groundwork for a statewide adaptation response on issues including land use planning

in response to climate impacts, the vulnerability of transportation systems to sea level rise, and coastal management.

Under the governor's directive in E.O. S-13-08, the California Natural Resources Agency coordinated with other agencies to write the state's Climate Adaptation Strategy, the first version of which was released in 2009. The Climate Adaptation Strategy includes a vulnerability assessment across seven sectors (public health, biodiversity and habitat, ocean and coastal resources, water management, agriculture, forestry, and transportation and energy infrastructure), as well as adaptation strategies by sector and comprehensive strategies for the state.[†,10]

The state has also made technical assistance and data and research available to assist in adaptation planning efforts:

- The California Natural Resources Agency and the California Emergency Management Agency created the California Climate Adaptation Guide, a series of reports designed to assist localities and regions in California to undertake climate change vulnerability assessments and adaptation strategy development.[11]

- The California Energy Commission's Public Interest Energy Research (PIER) Program maintains the Cal-Adapt website, a clearinghouse of data and scientific research on climate change. The website is designed to provide decision-makers and the research community with access to information about local effects of climate change in California.

- At the state's request, the National Academy of Science has produced a report summarizing published research on sea level rise and its localized effects on the California Coast.[12]

### Regional and Local

Through coordinated efforts such as the ART project, as well as through individual efforts, many of the local institutions involved in the governance of the Bay Area, including municipal governments, special districts, non-profit groups, and regional agencies, are incorporating adaptation into procedures and long-term planning efforts. The role of the ART project is documented throughout this report and others available on the ART project website.[‡] Several other notable Bay Area examples include:

[†] These strategies are (1) promote comprehensive state agency adaptation planning (i.e. institutionalize adaptation planning into "state planning processes, budgets, and policy development"); (2) integrate land use planning and climate change planning in various manners, including revisions to CEQA guidelines and the criteria guiding development patterns and transportation funding under Senate Bill 375; (3) improve emergency preparedness and response capacity for climate change impacts; and (4) expand California's climate change research and science programs, and expand public outreach of research to policy-makers and the general public.

[‡] http://www.adaptingtorisingtides.org

- Berkeley: The City of Berkeley's Climate Action Plan, adopted in 2009, incorporates measures to both mitigate the city's contribution to climate change and to adapt practices and policies in response to climate change impacts.[13] Adaptation policies contained in the plan include the conservation and diversification of water resources, efforts to reduce property damage from flooding and erosion, and increasing urban tree cover to prepare for more extreme heat. Berkeley's adaptation efforts will often require partnerships with state and regional agencies, a reality acknowledged in the plan. To avoid the tendency to delay adaptation efforts in order to focus on mitigation efforts, the plan identifies and prioritizes strategies that have the effect of both mitigating and adapting to climate change. One example is greywater reuse, which reduces the energy required to treat and transport water and simultaneously helps to guard against water shortages in times of low supply.[14]

- Oakland: Oakland's Energy and Climate Action Plan was shaped in dialogue with community members organized together under the Oakland Climate Action Commission (OCAC). More than 50 NGOs, advocacy groups, and community organizations contributed to the effort as coalition members and allies.[15] Community meetings provided a forum to discuss the implications of the plan as it was being developed, allowing for focused dialogue on the impact of adaptation strategies on Oakland's communities.[16]

- San Jose: While updating its General Plan, the City of San Jose incorporated requirements to reduce the likelihood of new development that will be prone to flooding under anticipated sea level rise scenarios. A more detailed case study of San Jose's General Plan update is provided in the next chapter.

## KEY CHALLENGES: UNCERTAINTY, COMPLEXITY, AND RESOURCE CONSTRAINTS

The observations and recommendations made in this issue paper are offered in response to specific challenges identified within the ART project area,[§] though many observations may be relevant to other regions and at different geographical scales. Three overarching governance challenges are identified and discussed in the chapters that follow — the *uncertainty*, *complexity*, and *resource constraints* that confront the region in planning for climate change. [**††]

[§] The project's study area is the portion of the Alameda County shoreline from Emeryville to Union City. The study area extends inland approximately a half-mile beyond the area projected to be exposed to storm event flooding with 55 inches of sea level rise. This subregion was selected based on local community and stakeholder interest and the capacity for participation, its diverse shoreline features, and the presence of regionally significant transportation infrastructure.

[**] The author developed these categorizations after conducting a review of research related to governance

## Uncertainty

Uncertainty presents itself as a challenge for governance in that:

- The timing, severity, and degree to which climate stressors will threaten communities, ecosystems, and the processes and institutions that govern them is not fully understood, and assumptions about the future are based on imperfect data, models, and information, meaning that events may unfold in unanticipated ways.

- Events both related and unrelated to climate change (e.g., the possibility of other events occurring simultaneously, such as earthquakes, wildfires, and floods) will affect capacity to adapt to climate change in potentially unknown ways.

- Planning for adaptation will happen over longer time horizons than are typically considered. A long-term perspective necessarily entails confronting uncertainty — a task made difficult by the many gaps in long-range climate models, economic forecasts, and other planning tools.

## Complexity

Complexity is observed as a complicating factor for adaptation planning in that:

- A network of institutions and organizations will often be necessary in order to adequately assess vulnerability and develop and implement adaptation responses, requiring coordination to manage logistics and divide responsibilities. In some cases this division could lead to needlessly duplicative work. In other instances, thoughtfully planned efforts could result in collaborative and productive partnerships.

- Most environmental laws, regulations, and management plans are crafted in response to observed, rather than anticipated, problems. Absent an existing regulatory or review framework for climate change adaptation, projects and policies that incorporate vulnerability assessments and adaptation responses have primarily been developed on a voluntary basis.

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challenges already identified in the course of the ART project's planning process. Two ART project reports in particular form the basis of this analysis: The "Existing Conditions and Stressors Report" (January 2012) and the "Vulnerability and Risk Assessment Report" (September 2012). Both are available on the project's website, http://www.adaptingtorisingtides.org.

[††] A detailed synthesis of the governance challenges identified as part of the ART project planning process is provided in the appendix to this issue paper. This analysis documents governance challenges encountered within the ART project area across 12 categories of assets: (1) airport, (2) community land use, (3) contaminated lands, (4) energy, pipelines, and telecommunications infrastructure (5) ground transportation, (6) hazardous waste, (7) non-structural shorelines (wetlands), (8) parks and recreation areas, (9) seaport, (10) stormwater management, (11) structural shorelines, and (12) wastewater facilities.

- Complex institutional arrangements, existing regulatory requirements, and the large number of organizations involved has the potential to create barriers and delays to certain adaptation responses, especially if timely action is required.

### Resource constraints

Resource constraints will occur as institutions confront climate change in that:

- Future and current resource and fiscal constraints facing institutions and organizations may delay, limit, or impede vulnerability assessments and the development and implementation of adaptation responses.

- Obtaining resources may be difficult, particularly if it requires approval from taxpayers or elected officials, or if there is no appropriate mechanism in place to receive funding.

- Where there is a "mismatch of scale" between the necessary adaptation response and the institution or organization responsible for developing and implementing the response, there may insufficient financial resources, technical expertise, legal authority, or staff resources to plan, finance, or implement an adaptation response.

We cannot dismiss the real challenges that climate change poses to institutions, organizations, and communities in the Bay Area. These challenges are wide-ranging and the necessary responses are likely to be both challenging and costly to implement. However, the overarching governance challenges identified here — uncertainty, complexity, and resource constraints — are frequently encountered by officials, regulators, organizations, community members, businesses, and others involved in planning for a range of other concerns, from disaster response to resource management. Further, it is possible to draw upon case studies and scholarly work written in response to other management challenges in order to plan for adaptation.

The next three chapters of this paper offer models and case studies intended to provide insight for communities in the region as they seek to manage the uncertainties, cope with the complexities, and confront the resource constraints that manifest themselves in adaptation planning. A common theme emerges across these three chapters: the important role of collaboration among the many institutions and organizations involved in crafting and implementing adaptation strategies. In response to this crosscutting theme, an additional chapter is devoted to models that might be of use to institutions and organizations in the ART project area seeking to foster a greater degree of coordination with one another, be it through informal means or formalized arrangements.

## LESSONS FOR ADAPTATION PLANNING IN THE BAY AREA

### 1. Plan for climate change by planning for effective governance.

A significant aspect of developing responses to complex issues will be to create and support the processes through which vulnerability can be assessed and adaptation plans developed and implemented. In other words, the processes need to be able to result in action. Governance is therefore a critical determinant of a community's capacity to adapt to climate change. The challenges resulting from climate stressors are far reaching, and many cannot be tackled within the confines of existing institutional and jurisdictional boundaries. In most cases, resilience will only be possible through the type of collaboration and coordination capable of producing action.

### 2. Involve the full range of institutions and interests that will play a part in adaptation responses.

Climate change will affect an incredibly diverse set of interests, and many different communities, constituencies, private interests, and government institutions will need to play a role in identifying vulnerabilities and prioritizing, shaping, and implementing effective adaptation responses. These interests should be involved in adaptation planning early in the process, and decision-making should be clear and transparent.

### 3. Make use of existing arrangements as a starting point.

Existing institutional arrangements, decision-making processes, and laws and regulations provide the framework upon which many future adaptation responses will be built. Many vital and complex societal functions are managed through the collective experience and expertise embodied in these arrangements — experience and expertise that will be critical to our region's capacity to adapt to climate change. Faced with new challenges, the region must reevaluate the strengths and weaknesses of these arrangements, and ask if it is possible to adjust them so that they may carry out necessary adaptation responses.

### 4. Provide opportunities for "soft" starts (i.e., informal or low-stakes joint efforts) that might evolve into robust adaptation responses.

An inescapable challenge in planning for climate change is that there are no time-tested approaches upon which to model an effective response. While fields such as resource management and disaster response offer parallels that might provide insight to planners and decision-makers, there are far fewer examples to draw upon for adaptation as a planning and policy domain. In some instances, then, it may make sense to begin some efforts, even if the authority or resources attached to an effort are less than desired. Chapter 5 of this issue paper presents a spectrum of institutional arrangements capable of spanning institutional divides, from the informal to highly formalized and binding

structures. Important first steps might be more easily achieved through soft starts that bring different interests to the table without creating burdensome demands or high barriers to entry for participants. The ART project, which brings a broad range of participants into a process to identify vulnerabilities and adaptation approaches for a portion of the Alameda County shoreline, is one example of such a soft start. From these beginnings, more formal arrangements might evolve, benefitting from the groundwork laid by the initial efforts.

### 5. Evaluate a coordinated regional approach for adaptation planning.

There are some vulnerabilities and issues resulting from climate change that may make a case for a regional approach to adaptation planning in the Bay Area. Coordinated action at a regional scale permits for strategies that cut across many jurisdictional and institutional lines while remaining responsive to the local impacts of climate change. The ART project's vulnerability and risk assessment highlights many instances in which a climate stressor experienced in one jurisdiction or one sector would have consequences felt across the entire region. (One example is the potential for inundation of portions of the rail corridor, which would disrupt the entire passenger and cargo rail system in the Bay Area.) In a region of nine counties and more than 100 cities, concerned parties on a range of issues have called for better mechanisms for regional coordination. The case is perhaps uniquely strong for climate change adaptation, which to be effective will require joint decision-making, coordinated responses, and in many cases, cost sharing.

### 6. Establish and work toward a shared vision of resiliency.

Collaboration among different institutions, organizations, and interests is essential to overcome the uncertainty, complexity, and resource constraints faced in planning for climate change. As partnerships and new efforts are formed to develop joint adaptation efforts, an important first step will be to identify a shared vision of their purpose and the potential outcomes of their work. By developing shared goals intended to increase resilience, partners may define duties and responsibilities; identify potential challenges, consequences, or alternatives; and establish methods by which plans can be reevaluated and changed to suit evolving conditions.

# 2. MANAGING UNCERTAINTY

Confronting uncertainty is not a new challenge to public officials, institutions, organizations, community members, and business interests who are regularly asked to make decisions in the absence of perfect information. In planning for climate change, however, the degree of uncertainty facing decision-makers is high.

While scientific models exist to show the likely scope and severity of impacts such as sea level rise, decision-makers must plan for surprises, including the possibility that communities and ecosystems will face exposure of greater-than-anticipated magnitude, and earlier than predicted. It may become increasingly difficult to make assumptions about how ecosystems will respond to stressors, as climate change may compromise their resilience.[17]

Some common assumptions about basic governance processes will also be thrown into doubt by climate change. Adapting to climate change is something that many institutions and organizations are only now beginning to consider, and at present the field is "characterized by weakly defined ambitions, responsibilities, procedures, routines, and solutions."[18] Those involved must not only consider the best course of action, but also how they will muster the resources, including the political support, to execute their adaptation strategy and balance it against competing priorities.

Hansen and Hoffman outline three methods for incorporating uncertainty into governance and management.[19] The first approach is to employ *the precautionary principle*, a method for decision-making designed to minimize actions (or inaction) that may cause harm in the future. The second approach is to adopt an *adaptive management strategy*, in which the effectiveness of an adaptation strategy is regularly scrutinized and reevaluated. The third is

a practice called *scenario planning*, in which planning is undertaken for a range of possible future outcomes. This chapter explores these three approaches as tools that can be employed to confront the many uncertainties associated with planning for climate change. While a measure of uncertainty is inevitable in planning for climate change adaptation, these approaches can help to guide the ways in which institutions, organizations, and communities in the Bay Area plan amidst uncertainty.

## How uncertainty complicates decision-making

More and more, institutions will need to reevaluate established practices made under assumptions of a stable climate. Some practices will no longer be valid, and some may even be counter productive. The National Research Council (NRC) of the National Academies highlights four new conditions that will particularly complicate decision-making in an era of climate change:[20]

### 1. Longer time horizons

Because adaptation strategies may take years, even decades, to implement, decision-makers will be required to consider the effect of their choices many decades into the future. This long-term perspective necessarily entails confronting uncertainty — a task made difficult by the many limitations in long-range climate models, economic forecasts, and other planning tools. Decision-making for the long-term exacerbates the potential for mistakes, missteps, and unexpected consequences.[21] While long-term planning is already practiced in many fields (e.g., infrastructure plans often have 30- to 50-year planning horizons, and city and county General Plans often look 20 or more years into the future), a good amount of planning happens in response to the annual budgeting process.[22] Further, most environmental laws, regulations, and management plans are crafted in response to observed, rather than anticipated, problems.[23]

### 2. Place-specific effects

"Universal" approaches, such as federal laws, will often prove to be less useful in adaptation planning than in other policy arenas because the stressors caused by climate change can vary a great deal from place to place. Sea level change, for instance, varies in magnitude at the regional level as a result of weather patterns, plate tectonics and other natural factors.[24] This reality poses specific governance challenges when there is a "mismatch of scale" between the climate change stressor and the authority responsible for addressing it.[25] A local municipality may have the land use authority, but lack the financial resources or technical expertise needed to tackle the climate change challenges within its jurisdiction. An agency at a different scale of government (e.g., the state or federal level) may have the technological or financial resources to address such a challenge, yet lack the authority or local knowledge necessary to do so.

### 3. Surprise as normal

As Box and Draper have observed, "all models are wrong, but some are useful."[26] The limitations of models for sea level rise mean that, in some instances, events will unfold in ways not anticipated by scientists. And as models increase in sophistication, they may demonstrate that environmental processes are being affected by climate change more rapidly or in different ways than previously expected, or even in ways that had not been imagined.[27] Factors not captured by the models may also have significant implications for the resilience of a community or natural system.[28]

### 4. Climate change in a changing world

Other unforeseeable events — both related and unrelated to climate change — will invariably shape the nature of our adaptation efforts and even our capacity to successfully adapt to climate change impacts. For instance, if the resource and fiscal constraints facing local and state government today persist, the result may be delays in adaptation and further strain on emergency preparedness and response organizations.[29,30]

## ACTION VS. INACTION: USING THE PRECAUTIONARY PRINCIPLE TO MAKE CHOICES

The precautionary principle is one method by which decisions can be weighed in spite of uncertainty about future conditions. With rising sea levels and storm events, there are risks of both action and inaction. Absent perfect information about the rate at which sea levels will rise, the degree to which they will rise, and the externalities that a particular adaptation strategy might cause, the temptation will often be to avoid action until more is known. In some instances, delaying action may be advisable; it could save a community from spending money or diverting resources for a poorly suited adaptation measure. In other instances, however, the risk of inaction and delay may prove to be even more severe (e.g., loss of property or endangering public safety). By invoking the precautionary principle, decision-makers weigh the risk of inaction against the risk of taking unnecessary action.

The precautionary principle is often employed to aid decisions about sensitive policy matters. In the regulation of drugs, the Food and Drug Administration requires clinical trials and research that delay the release of potentially life-saving drugs onto the market because the yet-unknown side effects they may present are in some cases more dangerous to human health than the ailments the drugs are designed to treat. Another application of the precautionary principle comes from fisheries management. Complete bans on harvesting certain stocks of fish are in place because the threat of species collapse has been deemed greater than the known economic losses for the fishing industry.[31]

One application of the precautionary principle in planning for sea level rise comes from New York City's long-term planning document, PlaNYC, which considers a range of forecasts for sea level rise. Planners elected to include a scenario in which sea levels rose rapidly because of severe melting of polar ice sheets. This scenario came from modeling that was not supported by the same level of confidence as the other sea level rise scenarios presented in PlaNYC, but because of the high consequence a rapid ice-melt scenario posed to New York City, planners decided it would be too risky to not include it.[32]

## How to plan with the precautionary principle in mind

Hansen and Hoffman illustrate how a decision can be approached with the precautionary principle using the model presented in Figure 1. As they explain,

> The horizontal axis represents our predictions about how severe some sort of event of change (e.g., drought frequency or duration) is likely to be. If the predicted severity is low, there is no need to act, but as the predicted severity increases, it eventually crosses some threshold (represented here by the vertical line) beyond which we would take action to prevent undesirable consequences. The vertical axis reflects the actual severity of the event or change, and the horizontal line the threshold beyond which undesirable consequences would occur should we fail to act.[33]

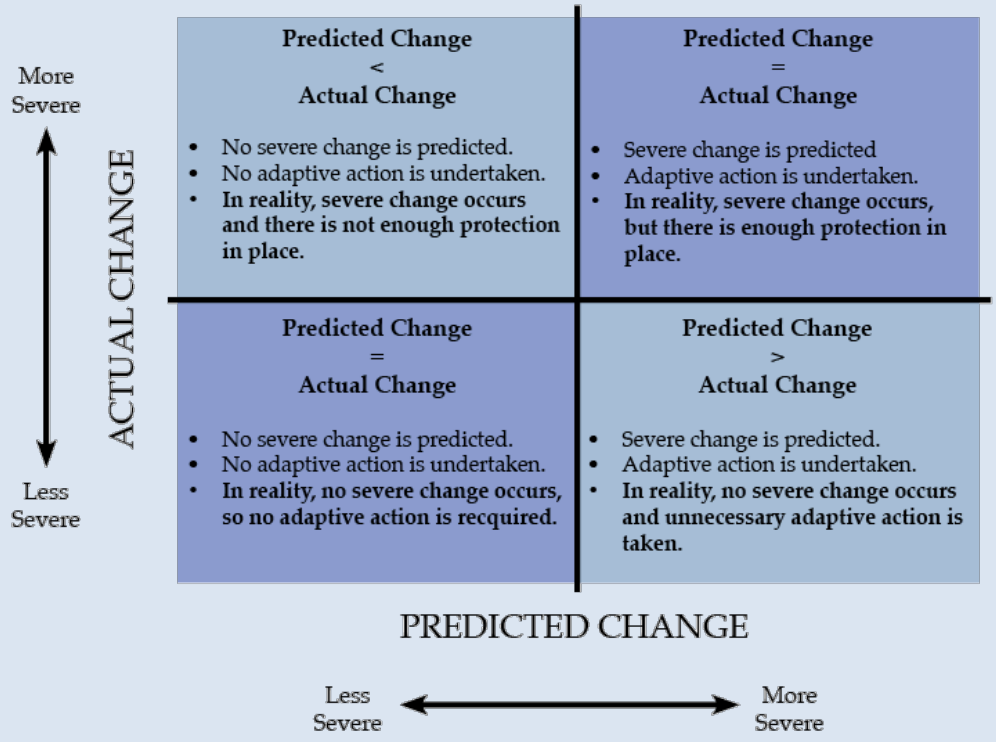



**Figure 1: Model for planning with the precautionary principle (adapted from Hansen and Hoffman). Faced with uncertainty, decision-makers weigh the consequences of not taking action when they should have (Predicted Change < Actual Change) versus taking unnecessary, possibly wasteful action (Predicted Change > Actual Change).**

## Coping with imperfect information through adaptive management

The adaptive management model is helpful in confronting gaps in data and available information. Originally developed by scientists in response to the uncertainty that exists in managing natural systems, it seeks to overcome doubt by creating mechanisms to regularly monitor the effectiveness of a strategy over time. If the outcome is different than was anticipated by the plan, planners and managers learn from the outcome and incorporate this knowledge into an adjusted management plan.[34] While originally developed to monitor and adapt the management of natural systems, the principle of adaptive management may also be a valuable approach for assessing the utility of policies and programs that address the impacts of climate change on the built environment.

An adaptive management approach involves:

1. Defining the goal of the management system.

2. Outlining current conditions and understandings about how the system works.

3. Identifying unknowns that might affect planning and the kinds of information that will be needed to conduct an evaluation of the eventual outcomes.

4. Developing possible management plans that incorporate what is known and unknown.

5. Crafting and implementing a monitoring plan that tests assumptions and evaluates the effectiveness of the management system.

6. Utilizing data from ongoing monitoring to adjust management as necessary.[35]

The ART project itself fits within the adaptive management approach. It has laid a strong foundation for adaptation planning with its rigorous analysis of existing conditions and stressors across 12 categories of assets in the project area, and its vulnerability and risk assessment highlights unknowns and missing information that will be necessary in the development of an effective monitoring and evaluation process. Going forward, it will be critical to establish mechanisms that evaluate and reassess the effectiveness of adaptation strategies that come out of the ART planning process. The knowledge gained from ART project's planning process — both its successes and shortcomings — can thus be utilized to improve the outcomes of the project, and also to inform the design of other adaptation planning efforts in the Bay Area and elsewhere.

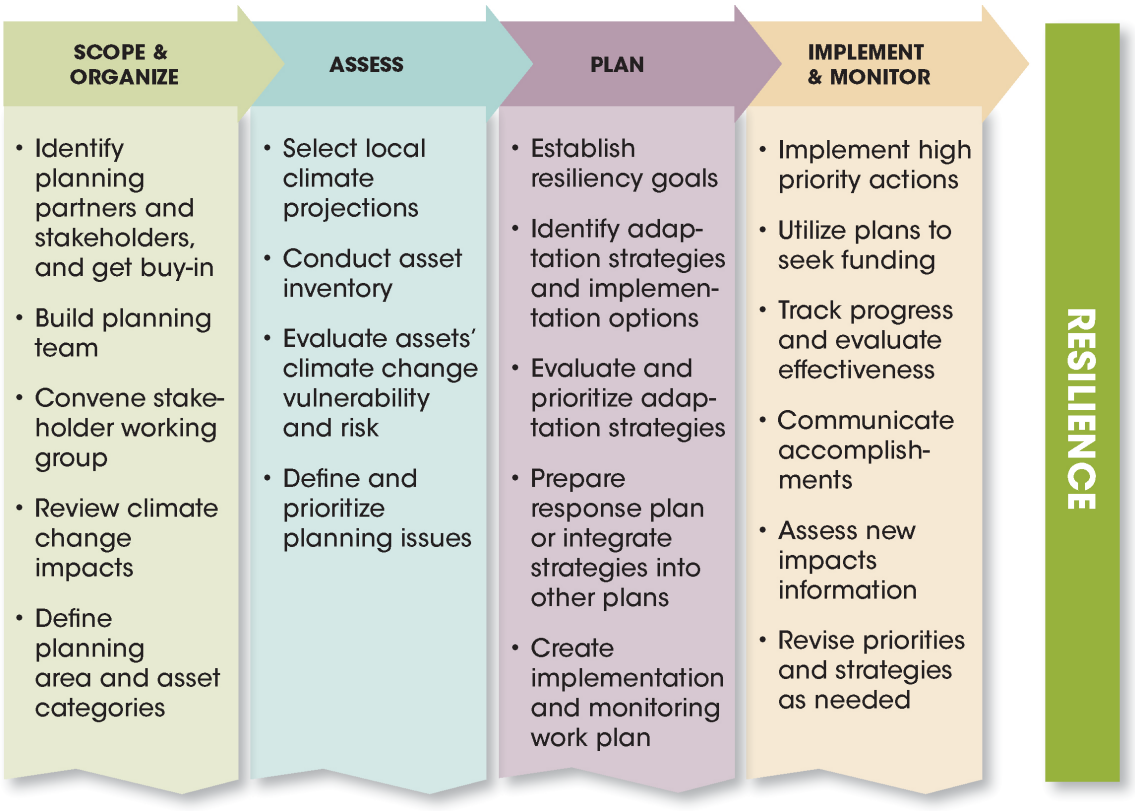



**Figure 2: The planning process employed by the ART project. The ART project makes use of adaptive management techniques through its plans to assess new information on impacts and revise strategies and priorities accordingly.**

## INCORPORATING CLIMATE UNCERTAINTY INTO SAN JOSE'S GENERAL PLAN

San Jose's newly revised General Plan includes specific strategies and policies to assist in climate change adaptation efforts. California law requires each city and county to prepare a general plan. Each plan must address seven mandatory elements.[36] The San Jose General plan partially satisfies two of these seven elements (land use and safety) through provisions that consider the impact of flooding related to sea level rise and storm events. Among its policies related to flooding hazards is EC-5.13:

> As a part of the City's policies for addressing the effects of climate change and projected water level rise in San Francisco Bay, require evaluation of projected inundation for development projects near San Francisco Bay or at flooding risk from local waterways which discharge to San Francisco Bay. For projects affected by increased water levels in San Francisco Bay, the City requires incorporation of mitigation measures

> prior to approval of development projects. *Mitigation measures incorporated into project design or project location shall prevent exposure to substantial flooding hazards from increased water levels in San Francisco Bay during the anticipated useful lifetime of structures* [emphasis added].[37]

The San Jose General Plan also allows for flexibility in adaptation responses in light of uncertainty as to the severity of climate stressors and the response that will be necessary from an adaptation standpoint. Among its actions on flooding hazards is EC-5.20:

> Monitor information from regional, state, and federal agencies on water level rises in San Francisco Bay on an on-going basis. Use this information to determine if additional adaptive management actions are needed and implement those actions to address flooding hazards from increasing sea levels for existing or new development and infrastructure.[38]

## THE SOUTH BAY SALT POND RESTORATION PROJECT'S ADAPTIVE MANAGEMENT PLAN

The South Bay Salt Pond Restoration Project Adaptive Management Plan developed adaptive management practices to allow for a variety of different responses depending on the effects of management actions and climate change on San Francisco Bay. The project has established certain core objectives, including maintaining existing pond habitat and restoring wetland habitat, though its management plan also recognizes that many uncertainties exist (in sediment dynamics, bird response to changing habitats, social dynamics, and other areas) that will require further study and monitoring. Because of these uncertainties, the project managers at the outset did not determine the exact mix of habitats that will result from the restoration at the outset. Instead, managers will implement the restoration in phases based on monitoring, applied studies that address identified uncertainties and regular reevaluation to determine the ideal mix of habitat. Planning scenarios range from a 50/50 mix of wetlands and ponds to 90 percent wetlands and 10 percent ponds.[39]

The project's Environmental Impact Report (EIR) was designed with the adaptive management process in mind. It evaluates alternative scenarios over a period of 50 years and highlights likely climate change effects on various environmental variables. The EIR also includes mechanisms to allow for the incorporation of updated sea-level rise estimates and data on marsh accretion and land subsidence at the design stage of each phase of the project.[40]

## HEDGING BETS WITH SCENARIO PLANNING

As a result of the uncertainty that climate change introduces into the planning process, decision-makers will often need to confront a wide range of possible future outcomes as they craft adaptation strategies. Scenario planning is a method of planning that works to "maximize the likelihood of some net positive outcome across a range of plausible futures."[41] Planners first identify a range of plausible futures, and then develop adaptation responses that are appropriate given the anticipated conditions. Possible scenarios may emerge after statistical analysis of likely future conditions, or they may be decided as result of a more intuitive and qualitative approach that makes use of stakeholders' expertise.

Scenario planning emerged out of military strategizing following the Second World War. The practice became popular in business circles after a sudden spike in oil prices in 1973, a development that went against conventional wisdom that prices would rise slowly and gradually over time. Most oil companies were not well positioned to take advantage of the spike. Shell Oil, however, had planned for this unlikely event as one of several possible scenarios and its business benefitted as a result.[42] More recently, the Intergovernmental Panel on Climate Change (IPCC) crafted a variety of scenarios to account for different developments in global economic growth, technological advancement, and other factors in order to predict a range of likely levels for greenhouse gas emissions and the resulting rate and severity of climate change.[43]

In the context of adaptation planning, scenario planning offers several distinct benefits. It may help planners identify which strategies are likely to work across a range of possible future conditions. Scenario planning also helps to mitigate the element of surprise associated with stressors such as sea level rise, as plans can be fashioned in response to multiple possible outcomes.[44] The ART project, like most adaptation planning efforts, makes use of scenario planning techniques. The project's assessments and recommendations are crafted in response to a set of likely scenarios for sea level rise in the project area.‡‡ Vulnerability and risk were assessed in relation to each of these likely scenarios. Forthcoming evaluations of potential adaptation strategies will also be crafted in response to these scenarios.

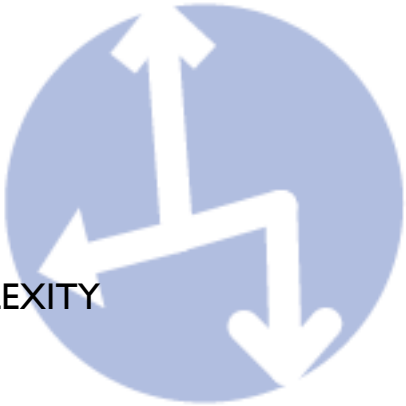
Scenario planning presents certain challenges for decision-makers, given the wide range of possible futures and potential outcomes that might result from any given adaptation strategy. Scenario planning does not overcome the subjectivity involved in predicting these possible outcomes. One variation on scenario planning, developed by the Rand Corporation, uses advanced computer modeling technologies and large sets of quantitative data to assess the implications of a range of different policy options. The goal is to identify robust strategies — those that can be expected to work reasonably well across many different future scenarios.[45] This "Robust Decisionmaking" method has been applied by water resource managers in Southern California and contributed to the California Department of Water Resources' projections for future water demand as part of its 2005 update to the California Water Plan.[46]

‡‡ The ART project assessment included two sea level rise projections (16" and 55", approximately rise at 2050 and 2100) and three Bay water levels (the mean higher high water, the 100-year extreme water level, and the 100-year extreme water level combined with wind-driven waves).

## Summary

Planning for future events invariably requires decision-makers to confront uncertainty. In planning for climate change, these uncertainties are greater than in most other circumstances. Imperfect assumptions about the magnitude and severity of climate impacts, as well as their effects on ecosystems and communities, must be anticipated. Doubt also extends to basic assumptions about governance: the role that existing institutions will play in adaptation efforts, the ways in which such efforts might be realized in the face of resource constraints, lack of clear authority and roles, and other limiting factors.

This chapter presented three methods that allow for such uncertainty to be acknowledged and incorporated into long-term planning efforts. These methods — the precautionary principle, adaptive management, and scenario planning — are already widely used in many disciplines. Each offers a strategy to confront the challenges of long term planning, and indeed all three may be incorporated into the adaptation planning process together. Further, all three are iterative — they are designed in such a way that the assumptions built into the process will be questioned, evaluated, reevaluated, and reformed if (and likely when) new information indicates this is needed. Planning for climate change will require on-going learning and refinement, a task that can help to overcome the many uncertainties it presents.



# 3. Coping with complexity

The ART project area is governed by a large number of institutions and organizations. A wide range of government departments, agencies, and special districts operating at the municipal, county, regional, state, and federal levels will have a role to play in adaptation planning. Businesses, landowners, and other private entities, as well as non-governmental and community organizations will be critical partners and participants in vulnerability assessments and adaptation planning. These institutions are linked together through informal ties (e.g. professional networks) as well as laws, regulations, statutes, court judgments, or contracts that stipulate shared oversight, ownership or management of an asset or a hazard.

Climate change impacts such as sea level rise provide cause to reevaluate existing, often complex, institutional arrangements. The trend toward specialization among organizations (and among departments and staff within organizations) may, in some instances, prove to be a liability in the context of climate change. Tackling a multi-faceted problem often requires a diverse set of viewpoints, knowledge bases, and skill sets. However, the fact that climate change has impacts across so many natural and social systems — from transportation to telecom to wastewater management, to name a few — means that the governance landscape for adaptation is highly fragmented.[47]

The inherent risk in a governance landscape characterized by fragmentation and highly specialized organizations and regulatory bodies is that attempts at adaptation will be frustrated by complexity. Relocating a piece of inundated infrastructure, for instance, could prove to be a daunting task in the face of obtaining necessary permits and political approvals, meeting design guidelines, and so forth. Many scholars on governance for climate change adaptation have focused on the need to enhance institutional and regulatory

flexibility as a means of responding to the uncertain conditions that result from climate change.[48, 49, 50]

In many contexts, effective planning for climate change adaptation will require governance structures and regulatory mechanisms that foster cooperation among institutions and organizations. Through such coordination, planning for the impacts of climate change can be undertaken holistically, rather than in isolation by sector, as well as benefit from the expertise and skills of a wide range of participants, such as community groups and businesses.[51, 52] Absent coordination, adaptation responses are more likely to contain flaws and gaps, especially as related to consequences for equity, the environment, and the economy. For instance, an adaptation response crafted for one problem may actually be maladaptive in the context of another concern (e.g., armoring a coastline to protect a piece of infrastructure might result in increased erosion or inundation risks to neighboring wetlands, parks, or communities). An adaptation response crafted in isolation might also be duplicative of a similar effort by another institution, leading to needless expenditure of time and resources.

How can cooperative, holistic and flexible planning take root? Termeer et al., examining the challenge of adaptation planning for regional governance in the Netherlands, identify a set of strategies for bringing together "actors, issues, sectors, and scale levels … to realize creative climate change options that do justice to different values, interests, and motives."[53] These strategies include (1) the synchronization of policy processes among different jurisdictions and policy domains, (2) linking adaptation efforts across different scales of government, from the local to the national levels, (3) launching experiments and pilot projects to forge new connections, and (4) making use of individuals capable of organizing networks across different institutions.

## SYNCHRONIZING ADAPTATION POLICIES

Institutions crafting an adaptation response in isolation may at times find their efforts frustrated because it does not conform to procedures or laws set out by another institution that has a say in the management or oversight of the community. In the ART project area, for instance, the Oakland International Airport will become increasingly sensitive to storm events that cause water to overtop levees protecting the sole runway for commercial flights (Runway 11/29). A short-term response might be to reroute these flights to runways on the North Field, which is less sensitive to inundation in the near future. Yet the Port of Oakland, which operates the airport, does not have unilateral authority to make this decision. It is currently prohibited from relocating commercial flight takeoffs and landings because of various federal airspace regulations and a local ordinance. These controls were crafted in response to various concerns, such as limiting the noise experienced by residents in the vicinity of the airport.

What can be done when a necessary adaptation response for one purpose does not conform to existing laws and regulations issued and enforced to serve another concern? Perhaps more importantly, how can such conflicts be avoided in the first place? Termeer et al. observe that fragmented governance systems are often made up of institutions characterized by "different

assumptions, aims, procedures, and networks."[54] In order to organize to avoid fragmentation that might impede necessary adaptation, they advocate "connecting policy domains." This connection involves the synchronization of policy processes, or possibly the elimination of the barriers that occur when an adaptation strategy must clear legal and procedural hurdles across different domains. Such system synchronization can be achieved by "new boundary arrangements," which might include the appointment of liaisons or ambassadors whose function is to integrate decision-making processes and streamline procedures so that obtaining licenses, permits and agreements does not serve as an impediment to necessary action.[55]

The Bay Area has examples to draw upon for system synchronization. Joint Powers Authorities (JPAs) such as the Hayward Area Shoreline Planning Agency (HASPA) and the San Francisquito Creek JPA have created coordinated oversight and action on the behalf of assets across jurisdictional lines. At a regional level, the Bay Area Joint Policy Committee (JPC) was created to coordinate the planning efforts of the Association of Bay Area Governments (ABAG), the Bay Area Air Quality Management District (BAAQMD), the San Francisco Bay Conservation and Development Commission (BCDC), and the Metropolitan Transportation Commission (MTC). Arrangements such as these offer examples, and closer evaluation may offer insights into the capacity of similar structures to undertake vulnerability assessments and to develop adaptation responses that are effective, transparent, and clear.

## Coordinating local, regional, state, and federal efforts

Synchronizing policy across different domains and institutions can help to avoid needless frustrations and delays. A step beyond synchronization is coordination. Coordination is particularly important in our federal system of government, where an ambitious adaptation project might require substantial and sustained involvement from partners at the municipal level (e.g., a city's transportation department), the regional level (e.g., the Metropolitan Transportation Commission), the state level (e.g., Caltrans), and the federal level (e.g., the U.S. Department of Transportation), as well as private interests and community groups.

Termeer et al. therefore advocate "connecting scale levels" by "establish[ing] effective and legitimate governance arrangements that align national, regional, and local planning, and investment processes, in order to safeguard long-term climate robustness."[56] Achieving a successful multi-level governance arrangement requires the involvement of relevant institutions from all levels from the local to the federal, establishing responsibilities among the various actors (possibly through formal arrangements such as contracts), and setting up mechanisms for sharing information. Such an arrangement can achieve (1) "organized interfaces" between different levels of government, (2) "centralized and decentralized steering" so that all parties have defined roles and responsibilities, and (3) learning among experienced partners at different levels of government.

## Launching experiments and pilot projects

The synchronization and coordination of policy efforts are not new ideas. That said, they are not necessarily easy tasks, perhaps especially on a cross-cutting issue such as climate change, where partners who may have little experience working together might need to cooperate. The ART project's assessment of vulnerability and risk identifies major issues that cross existing jurisdictional and sectoral lines and that are likely to require integrated adaptation due to their complex nature. One example is the regional rail link running through the ART project area. Rail lines run primarily at-grade and close to the shoreline. Even limited inundation of rail would impair the function of the network, as rail traffic cannot be diverted to another route in most cases. This vulnerability affects not only passenger rail carriers, such as Amtrak, and freight carriers, such as Union Pacific, but also shipments from the Port of Oakland and the regional economy more broadly. Adaptation strategies capable of addressing such a scenario involve private actors, community members, and institutions at every level of government and across multiple jurisdictional lines.

The challenge is to create the space and context within which such integrated responses can be formed and sustained. Teermer et al. urge "connecting the old and the new" by launching experiments and pilot projects to overcome barriers and forge new linkages. The ART project itself fits within this strategy by bringing together a wide range of institutions operating in the Bay Area in order to analyze vulnerability and develop adaptation responses for the local, subregional and regional levels. Termeer et al. stress the value of experimentation with different arrangements of organizational space, as the new setting "can be an effective way of loosening up policy systems" and creates a climate in which "established policy objectives may be questioned, modified, or even abandoned, and alternative strategies can be tested and implemented."[57]

## Fostering relationships that bridge institutional divides

Most people would agree that in order to forge the sort of cooperation highlighted in the sections above, the existence of personal connections among individuals representing different institutions is a critical starting point. Complex problems often require unconventional solutions and partnerships. Without precedent to guide the creation of a new process, the very first step might come in the form of a phone call, email, or informal meeting from a person who identifies and acts upon the need to launch a cooperative effort.

Of course, many strategies already exist that provide a framework to allow for informal interpersonal coordination that might develop into a more formal approach. Termeer et al. offer one method to specifically forge connections on climate adaptation strategies. By "connecting leadership," they argue, the power of individuals can be leveraged to organize networks and facilitate discussions that are required to link different institutions and individuals who need to be involved in assessing vulnerability and developing adaptation responses. These leaders create a setting in which shared vulnerabilities are evaluated and adaptation options are considered, in the process creating trust and legitimacy for shared governance arrangements. In the Netherlands, this function has been formalized, with the

creation of an office of the national climate director and seven regional directors.[58] The state of California's Climate Action Team (CAT) was designed for a similar purpose — to begin to coordinate the efforts of many state agencies through a body that brings together persons in leadership positions within these agencies.[59]

## Innovative collaboration for groundwater management planning

No statewide regulation of groundwater allocation or management exists in California. This lack of top-down control may exacerbate the problem much of the state faces from groundwater overdrafts. In the void left by the state, a large number of local agencies take on management responsibilities. While this arrangement has drawn much criticism, a recent report from Stanford University finds that "a treasure trove of innovative strategies for groundwater management" has grown out of the complex, multi-agency network.[60] Local water agencies have developed means of forging connections with partners and planning in cooperation with one another that merit attention in the context of adaptation planning.

Just as with adaptation to climate change-induced stressors, state law currently does little to compel local jurisdictions to engage in groundwater management. The Stanford report finds that many local districts have implemented impressive conservation strategies, nonetheless. A key innovation has been the formation of partnerships to facilitate the groundwater management planning process. The report cites examples of agencies that have involved a broad range of stakeholders, including other water agencies, agricultural and business interests, and environmental and community groups such as the Sierra Club and the League of Women Voters. The range of voices involved in planning has helped to avoid conflicts that could otherwise derail a plan, and helped to promote consistency in plans across jurisdictional lines.[61]

In order to ensure the realization of Groundwater Management Plans, local districts have experimented with a variety of governance structures to facilitate coordination of the management actions necessary for their plans' implementation. These structures have ranged from groupings based around Memoranda of Understanding (MOUs), to the creation of voluntary non-profit corporations, to the formation of Joint Powers Authorities (JPAs). MOUs are rather loose groupings that serve primarily to facilitate coordination among members. Non-profit corporations, created and funded by member agencies, dedicate resources to the help in the selection and coordination of management actions. JPAs, the most formalized arrangements studied in the report, have the authority to "issue bonds, employ staff, and construct, operate and maintain facilities" and can independently prepare, adopt, and implement a Groundwater Management Plan.[62] The same structures could be used in the Bay Area to undertake coordination of adaptation-related activities.

## Summary

Planning for climate change entails planning across a wide range of institutions and organizations, both governmental and non-governmental. The process may involve strategies not accounted for in existing laws, regulations, statutes or contracts. Many institutions will need to confront new challenges and adjust existing practices, and will often need to coordinate and cooperate with others.

This chapter presents strategies to allow institutions to undertake cooperative, holistic planning for climate change across traditional sectoral and jurisdictional lines. These strategies include synchronizing adaptation policies, better coordinating efforts, launching experiments and pilot projects, and fostering relationships that might bridge institutional divides. The number and variety of institutions that will play a part in assessing vulnerability and developing adaptation responses may be seen as a barrier to implementation if one believes they are too many and too varied to coordinate in complicated planning processes. However, we may also think about the number and variety of those involved in Bay Area governance as a virtue and key component of the region's adaptive capacity — a source of great knowledge, expertise and experience that can be focused on this difficult set of problems.

# 4. CONFRONTING RESOURCE CONSTRAINTS

The costs associated with adapting to climate change-induced stressors such as sea level rise and storm events will in many cases be quite high. Such costs are likely to impose serious constraints on the resources and finances of institutions and organizations that need to conduct vulnerability assessments and develop adaptation responses for the region's assets and communities. If the constraints are not addressed, adaptation efforts may not be initiated, or if initiated, may be delayed or compromised. Institutions facing new demands on their resources as a result of climate change may also find that these demands diminish their capacity to meet their other organizational priorities.

The strain associated with climate change-related resource constraints may pose a particular burden for local governments, non-profit and community groups, and businesses. Within a multi-level governance arrangement, the burdens that face smaller units of government (in some cases disproportionately) as a result of climate change may in instances constitute a "political and distributional equity issue."[63] There is a mismatch of scale between the climate change stressor and the institution responsible for resolving it if that institution lacks the financial resources, technical expertise, or human resources necessary to plan, finance, or implement the response.

Any discussion of adaptation governance must therefore confront the matter of identifying or developing the resources necessary for such a response — and not just the financial resources necessary for conducting vulnerability assessments and developing adaptation responses. Staff resources, expertise, technological resources, and community support for adaptation must be considered. This chapter explores several strategies for making the case that adaptation planning is a critical need, for finding the necessary resources, and for redistributing costs more equally across different institutions.

## PROACTIVE ADAPTATION IS OFTEN THE COST-EFFECTIVE

While the cost associated with some adaptation strategies is high, proactive responses may help to reduce the overall cost associated with adaptation to climate change. A robust vulnerability and risk assessment enables development of adaptation responses that to address the highest risk issues, and demonstrates where delaying action can lead to greatest consequences, including economic costs. For one, adapting to an impact only after it affects a community or an asset will likely result in the loss or disruption of critical services or impacts to public health. It will also require that a response be hastily developed and implemented, possibly resulting in a loss of political and community support and often costing more money to realize. The need to respond to an event that has already occurred or that is imminent might mean taking money from other important priorities and programs, whereas a response planned in advanced could be budgeted for.

The best responses will often be those crafted proactively. Proactive adaptation "seek(s) to formulate long-term strategies for infrastructure, education, outreach, and improving collective capacities to adapt, as well create(s) incentives to change behaviors suited to the shifting climate."[64] A proactive response tends to have flexibility. As a result, it may prove to be more cost-effective and less likely to result in trade-offs (e.g., damaging the environment or impacting surrounding communities to maintain the function of a key asset or piece of infrastructure).[65]

## ADAPTATION CAN BE INCORPORATED INTO EXISTING PRACTICES

Strain on financial and staff resources may be reduced if adaptation can be incorporated into existing practices of institutions and organizations. This "mainstreaming" of adaptation into "ongoing policy interventions, planning and management" can reduce the costs and disruptions associated with adaptation planning and implementation, particularly if the assessment of vulnerability and the development of adaptation responses are done in coordination with periodic plan reviews.[66] San Jose, for instance, has updated its general plan to reflect the risks associated with rising water levels in the San Francisco Bay (see Chapter 2). Through this update, the city has required development projects at risk of inundation to incorporate mitigation measures that prevent significant exposure to flooding before they are granted approval.[67]

In the near term especially, institutions may also choose to emphasize adaptations that overlap with existing non-climate-related priorities. So-called "co-benefit" and "no-regret" adaptations are designed to serve dual purposes. They reduce the vulnerabilities associated with climate change, but also produce other public benefits, providing net benefits irrespective of climate change's impacts on a community.[68] For instance, the restoration of tidal wetlands or development of a park may be an effective adaptation strategy in certain areas because it provides a buffer between the Bay and the built environment. Such an effort might simultaneously serve to restore habitat, improve water quality, or provide for recreation.

In order to spur on assessments and the development of adaptation responses in the short term despite uncertainties about the magnitude of the vulnerabilities facing a community or asset, it is possible to make use of a variety of techniques to reduce the costs of planning and implementation. In addition to adaptation strategies with multiple benefits, Walker et al. identify a suite of strategies designed to use resources efficiently. These include adaptation strategies that:

- Provide net benefits, regardless of climate change
- Are modifications that create low-cost "extra" margins of safety (e.g., additional stormwater capacity)
- 
- Can be easily modified in the future and do not lock an institution into a particular approach to adaptation.
- Have short planning horizons, so that easier adaptation strategies can be implemented in the near-term.
- Are characterized by reduced complexity and scope (e.g., at the local or asset-specific scale), enabling adaptation in the near term, even while planning for more far-reaching, complex adaptation responses is underway.
- Incorporate variability or scenarios in planning, to reorient planning away from averages (e.g., mean sea level) to relevant extremes (e.g., extreme high water mark), and better prepare for the variability that will result from climate change.[69]

## COSTS CAN BE REDISTRIBUTED MORE EQUITABLY AMONG INSTITUTIONS

While proper planning for adaptation may allow institutions to more easily absorb the costs of adaptation planning and implementation, the truth remains that some necessary adaptation measures are likely to result in significant strain on resources, particularly for local governments and smaller organizations and institutions. It may become necessary to shift some of the costs of adaptation planning and implementation away from these smaller institutions and organizations and toward the state and federal levels of government. Climate change-induced stressors will be felt unevenly from municipality to municipality — e.g., a community on the shoreline may incur great costs for adaptation, even as its inland neighbor needs to do little — so distributing the costs across taxpayers on a state or federal level may prove to be necessary. This redistribution could take many forms, including grant and loan programs to benefit affected municipalities and communities (e.g., grants for hazard mitigation planning) or technical assistance from staff at state and federal agencies.[§§]

[§§] Even if this redistribution were to occur at a grand scale, it is unlikely to alleviate concerns about the costs associated with adaptation. It is reasonable to assume that a wholesale readjustment of federal and state funding priorities may become necessary to shoulder the costs of adaptation.

## Costs can be shared through a variety of new governance structures

What can communities do to confront the costs of adaptation beyond finding new sources of revenue or receiving assistance from the state and federal governments? Creating and strengthening connectivity across different sectors and jurisdictions may again prove to be a helpful tactic. As highlighted in the next chapter, institutional arrangements such as Joint Powers Authorities and special districts may be structured to allow for powers to tax and issue bonds, as well as to provide dedicated staff resources to grant seeking and technical, policy, and community engagement work. Because these arrangements can be structured to cross jurisdictional lines, they provide one method of better distributing the costs of adaptation across the region.

## All involved in governance have a role to play

In some cases, it will be necessary for institutions to look outward to find the resources required to respond to climate change. As discussed above, this may be because an institution or organization lacks the ability to generate the financial resources to develop an adaptation response or even properly assess its vulnerability. Another likely scenario will be that an institution or organization lacks staff expertise or capacity to formulate or carry out the response. In certain instances, institutions will face a third important type of resource constraint: a deficit of political will or support.

Deciding upon appropriate adaptation responses will often entail confronting difficult decisions, weighing the consequences of different course of action, and selecting one path over another. For instance, to retrofit or replace a piece of inundated infrastructure, an agency might need to ask voters to approve new taxes or incur new debt obligations. Or, if coastal armoring is put in place to protect a community or piece of infrastructure, planners and decision-makers will have to justify the decisions they make on its siting and design — and face questions such as why certain areas are prioritized over others, and whether resulting erosion or sediment accumulation that may affect adjacent neighbors is appropriate or can be addressed separately.

The diversity of interests and communities affected by climate change speaks to the importance of the role played by those outside the institutions responsible for conducting assessments and developing and implementing adaptation responses. Other agencies, non-governmental organizations, community groups, interest groups, businesses, landowners, and other interests, play and will continue to play a vital role in governance as it relates to climate change adaptation. In many cases, public consent and support for adaptation needs to be earned. It is important to include all of the affected parties early in the adaptation planning process, ideally presenting and receiving input on the goals of the adaptation planning effort and the criteria that will be used to evaluate different actions. Earning support may also entail undertaking public education and outreach efforts. To win the

adoption of its Climate Action Plan, Berkeley's Office of Energy and Sustainable Development leveraged stakeholder groups that had been influential in passing the city's Bicycle Plan and Green Building Initiative, but also established new ties by hosting multiple community workshops, meetings, and events.[70]

When citizens, community groups, and other organizations believe that the institutions that govern them are failing to adequately prepare for climate change impacts, their capacity to protest such a failing may be an important factor in ultimately achieving resilience for their community. Much of the grassroots citizen activity around climate change has focused on achieving greater reductions in greenhouse gas emissions, but as planning efforts shift to adaptation (or when planners, managers, and decision-makers fail to focus on such matters), the community voice may be important in determining what adaptation planning will accomplish in the Bay Area. The community coalition that worked with the City of Oakland to craft its Energy and Climate Plan calls the plan "the boldest and most equitable…of any city in the country," and credits its passage to "unprecedented community participation."[71] That effort involved more than 50 coalition members and allies, and was able to bring focus to the intersection between issues related to climate change mitigation and adaptation, on the one hand, and low-income communities and communities of color, on the other.

### FACING DOWN FINANCIAL RISKS IN THE SHARED GOVERNANCE OF INTEROPERABLE COMMUNICATION SYSTEMS

Aspland[72] undertook a review of the shared governance arrangements that arose in Marin and Monterey counties in order to facilitate a redesign of the radio communication systems used by emergency responders and public works departments. In these counties and elsewhere, neighboring public service jurisdictions often operated radio systems that ran on different infrastructure and that could not communicate with one another. After new requirements from the Federal Communications Commission and the Department of Homeland Security required interoperability of communications systems, public service jurisdictions were put in a position where they needed to join together to oversee a complete redesign of their radio systems.

Predictably, the task of designing and implementing new systems was complex, requiring "public safety groups to join together to leverage funding sources, management experience and develop requests for proposals for new systems including standard operating procedures, use agreements and shared governance".[73] For the groups involved, shared governance entailed risks. The expenses involved were high, and joint operations meant that a member of the group might lose a degree of autonomy, or possibly find itself backed into a system that was ill-suited to its needs.

Yet the risks entailed in shared governance can be seen as trade-offs necessary to achieve something that participants could not accomplish working in isolation. Aspland writes:

> Achieving interoperability is considerably less expensive for public service jurisdictions working collaboratively rather than individual jurisdictions building their own independent systems. Independent systems may result in the acquisition of a variety of hardware and software solutions that may not be interoperable with neighboring jurisdictions. The failure to establish shared governance will undermine any efforts toward interoperability since there will be no anchor point to sustain changes over the long term.[74]

Financial risks, in particular, were high in the development of a system requiring significant up-front costs. However, the push toward shared governance was encouraged by both regulatory sticks and carrots. Federal grant programs administered by the Department of Homeland Security to public safety agencies were tied to satisfying of interoperability requirements. And fears about municipal finances were cited as an additional impetus for cooperation, especially because smaller jurisdictions benefited by not having to shoulder the cost of building a radio system alone.[75] Additionally, the consequences of failure to public health and safety were quite high.

## Summary

Planning for climate change will involve confronting resource constraints. The lack of financial resources currently available for adaptation are one significant constraint. As this chapter highlights, resource constraints may also come in other forms, from limits to the capacity and expertise of an institution or organization's staff, to the lack of community or political support for an adaptation response. Approaches to overcoming such constraints presented in this chapter include assessing vulnerability and developing adaptation responses proactively (and thus cost-effectively), incorporating adaptation planning into existing practices, redistributing costs equitably among partnering institutions, sharing costs through new institutional arrangements, and turning to all participants (inside and outside government) to overcome resource constraints. The discussion about creating or expanding the resources available for adaptation planning cannot be limited to using existing sources of revenue and financial assistance. This chapter highlights the role of citizens, community groups, businesses, landowners, and other affected parties in building support for necessary adaptation responses, suggesting that political backing and popular support for adaptation might be a critical factor in overcoming resource constraints.

# 5. Considering different institutional arrangements

The previous three chapters examined the overarching governance challenges facing the Bay Area in its efforts to adapt to rising sea levels and storm events. One common idea emerges as a thread that connects many of the models and case studies presented in these chapters: the need for close collaboration or partnerships among the many institutions and organizations involved in planning for climate change adaptation. While collaboration among existing institutions and organizations will be essential in assessing vulnerability and developing and implementing adaptation responses, some actions necessary to increase the region's resilience may require the creation of new institutions.

This chapter presents a number of models and arrangements to create frameworks (Table 3) for cooperation and collaboration across institutions and organizations, and in some cases, to respond to the challenges presented in the previous three chapters.

For an adaptation strategy that requires collaboration or partnership among two or more institutions or organizations, the following arrangements may be considered to foster a closer degree of cooperation:

- Informal arrangements and networks
- Municipal resolutions
- Memoranda of Understanding (MOUs)
- Legal contracts

Where an adaptation response is beyond the scope and authority of existing institutions or organizations it may be necessary to create a new institution. In such cases, the following arrangements might be considered:

- Joint Powers Authorities (JPAs)
- Special districts and regional authorities

The institutional arrangements highlighted in this chapter are presented in rough order of least to most formalized. Less formal arrangements may be easier to put into practice, as there are generally fewer barriers to their establishment. More formal arrangements, however, may prove to be more stable, as institutions may be bound through legal structures or be responsible for fulfilling contractual or legislative obligations.

The institutional arrangements presented here also differ somewhat in terms of their capacities to address the governance challenges highlighted in the previous three chapters of this issue paper. These differences are explored below in relation to each model of collaboration. Ultimately, form should follow function, as the particular issues related to the vulnerability and the necessary adaptation response should inform the type of arrangement most appropriate and most likely to be effective. In short, institutional arrangements should be developed in response to an identified problem or gap, once there has been a clear articulation of the need.

## Informal arrangements and networks

Informal arrangements and networks can strengthen adaptation by creating opportunities for representatives from different institutions to share information and assist one another in assessing vulnerability and developing adaptation responses. Informal networks tend to be easier to develop than more formalized arrangements because they can be created through personal and professional relationships. They may also provide a setting in which participants are more willing to think creatively about new solutions and develop alternative strategies.[76]

The networks may take the form of informal coalitions and working groups, or they might grow out of planned events such as conferences and seminars. The ART project, which benefits from an engaged group of stakeholders from many different sectors and governmental agencies, itself demonstrates the potential that informal arrangements have to spur action on climate change adaptation.

Informal arrangements and networks can help to reduce uncertainty by allowing for the dissemination of new information and techniques in adaptation planning. For example, a May 2012 conference in Berkeley brought together local planners, resource managers, flood protection managers, and other professionals for workshops that demonstrated new coastal adaptation and decision-support tools for sea level rise developed by NOAA, PBRO

Conservation Science, and others.[77] Informal arrangements also have the potential to reduce complexity. For instance, potential roadblocks and barriers (e.g., a legal or procedural hurdle) might come to light earlier if individuals from different institutions are in communication with one another while assessing vulnerabilities and developing adaptation responses. On the other hand, informal arrangements will less often be useful in resolving resource constraints, as participants will lack any formal mechanisms for sharing or redistributing among one another the financial costs, technical resources, and staff time involved in an adaptation planning process.

## Municipal resolutions

Municipal resolutions can be enacted by city councils to signal their intention to enter into a partnership designed to undertake adaptation planning. While resolutions do relatively little to formally bind partners together, they can be useful as markers that partners will coordinate and work together on an effort and offer the public and others an opportunity to weigh in on such arrangements

Municipal resolutions may reduce the complexity of adaptation planning by clarifying the intentions of participants, thus helping to establish the role and responsibility of the institutions involved. In doing so, they also reduce some degree of the uncertainty involved in adaptation planning. Municipal resolutions are unlikely to do much to lessen resource constraints, unless the resolution also assigns funding or staff time to the effort. While a municipality might pledge certain financial or staff resources to a planning effort through a resolution, that resolution lacks the enforceability that comes through an actual contractual agreement. A resolution can provide a way for a municipality to indicate a commitment to adaptation planning and thus make it more competitive for grant or special funding associated with such planning.

## Memoranda of understanding (MOUs)

Memoranda of Understanding (MOUs) are agreements that municipalities, agencies, and other entities may enter into in order to establish and define the nature of a partnership among participating institutions. MOUs offer a flexible and relatively easy method for institutions to coordinate, as their formation requires just the adoption by participants.[78] However, as member institutions retain full legal autonomy, an MOU generally has no formal authority of its own and does not change the authority or financial resources available to the signatory agencies.[79]

The management and coordination between Bay Area airports offer a case study in the benefits and limitations of MOUs. The Regional Airport Planning Committee (RAPC), is organized pursuant to an MOU between three regional agencies. RAPC recently conducted an evaluation of the benefits and drawbacks of its current arrangement. Its evaluation concluded that an MOU provided great flexibility as a tool for forming a committee — the

arrangement makes adding new members easy, a plus in that the membership can be expanded to include interests that were not originally part of the MOU or that become relevant at a later time as new issues emerge. The MOU's lack of formal authority was cited both as a strength (e.g., in providing a neutral forum for the discussion of issues) and a weakness (e.g., at times it can be difficult to get participation from outside stakeholders who are not formally obliged to cooperate). The lack of dedicated funding and staff to address the agenda and work of RAPC was cited as the most significant downside of the MOU arrangement.[80]

## Legal contracts

Legal contracts allow institutions to formalize joint responsibilities and establish accountability among participants. Because they are enforceable, contracts offer a level of accountability that less formalized arrangements such as MOUs cannot necessarily ensure.

Like MOUs, legal contracts are likely to reduce the complexity involved in adaptation planning because they provide a mechanism through which a coordinated response can be fashioned. Indeed, they may be more effective in this regard because the division of responsibilities among involved parties is clearly delineated by the contract and participants are bound to fulfill their obligations. Used to formalize financial agreements between institutions, legal contracts might be a tool to redistribute the cost of an adaptation among institutions. In so doing, they may be used as a tool to help overcome "mismatch of scale" problems, as an institution without the resources could enter into a contract with an institution that does.

## Joint powers authorities (JPAs)

Joint Powers Authorities (JPAs) are formed, pursuant to state law, by contractual agreements among governmental entities. JPAs allow for the joint operation of a specific facility or program, or for a joint planning process. The scope of a JPA's authority is determined by its members upon its formation, and member entities may cede to it certain powers and responsibilities. However, JPAs may not exercise powers that the member entities do not have individually. Member entities are generally obliged to provide funding or technical support to their JPA, and the JPA may hire its own staff and create its own policies. As entities with defined authority, responsibilities, and resources, JPAs tend not to suffer from the shortcomings identified for MOUs above. However, the more formalized arrangement make JPAs more difficult to enact in the first place, as the stakes are higher for entities weighing membership (e.g., the cost of funding the JPA and the loss of certain independent powers and authority). For the same reason, it may also be difficult to restructure an existing JPA to allow for the addition of new members or to respond to new tasks should conditions dictate a change.[81]

An example of the role a JPA might play in responding to governance challenges associated

with climate change exists within the ART project area. In 2010, a study prepared on the behalf of the Hayward Area Shoreline Planning Agency (HASPA) weighed the creation of a new JPA to facilitate the shoreline management demands brought on by sea level rise.*** The study suggested that the adaptation measures required to respond to sea level rise might require a change in governance structure, in particular an enhanced degree of cooperation with partners that have regulatory oversight over the shoreline (e.g., the San Francisco Bay Conservation and Development Commission, the Regional Water Quality Control Board, and the State Lands Commission) or shared interests at the shoreline (e.g., Alameda County Flood Control and Water Conservation District and East Bay Dischargers Authority). The study also identified several key advantages to the JPA structure: (1) its potential to raise money by issuing bonds, (2) its ability to enter into contracts for shore processes studies, planning, environmental review, permitting, engineering, and construction, and (3) the simplification it provides for permitting of projects over multiple property parcels.[82]

## SPECIAL DISTRICTS & REGIONAL AUTHORITIES

Special districts are entities permitted under state law to perform governmental functions within set boundaries that quite often cross jurisdictional lines. Most special districts focus on the provision of a single service or the management of a particular facility (or set of facilities within a set boundary).[83] The formation of a special district that is regional in nature would first require enactment of a special law by the state.[84] Thus, existing institutions cannot themselves create a regional authority to tackle adaptation, because district formation requires action by the Legislature. However, recognizing the need for a regional authority to tackle an aspect of climate change adaptation, existing institutions (inside and outside of government) might pressure legislators to take such action. For instance, Save the Bay, a nonprofit organization, built pressure for the formation of a special district dedicated to overseeing Bay wetland restoration funding with its 2007 "Greening the Bay" report.[85] In 2008, the San Francisco Bay Restoration Authority was created to perform this duty, given authority to "levy benefit assessments and special taxes, apply for and receive grants from federal and state agencies, solicit and accept gifts, fees, grants, and allocations from public and private entities, issue revenue bonds, incur bond indebtedness, and [itself] enter into joint powers agreements."[86]

*** HASPA is itself a JPA, formed in 1970 by the Hayward Area Recreation and Park District, the East Bay Regional Park District, and the City of Hayward.

| ARRANGEMENT | DESCRIPTION | MANAGING UNCERTAINTY | COPING WITH COMPLEXITY | CONFRONTING RESOURCE CONSTRAINTS |
|---|---|---|---|---|
| **Informal arrangements and networks** | Collaboration through personal and professional networks. | ⍰ Allow for easy dissemination of new information and techniques.<br>× No formal mechanisms for accountability among participants. | ⍰ Forum for participants to learn about, negotiate and potentially bypass potential roadblocks (e.g. legal and procedural hurdles). | ⍰ Forum for informal resource sharing (e.g., expertise, political knowledge).<br>× No formal mechanisms for sharing or redistributing financial costs among participants. |
| **Municipal resolutions** | Signals a municipality's intention to enter into a partnership to conduct adaptation planning or implement adaptation responses. Enacted by vote of a city council. | ⍰ Formally establish the intention of a partner upon entry into a joint adaptation strategy.<br>— By issuing a resolution, the municipality is accountable to its constituents to act in accordance with the agreement. Partners outside the municipality do not have a formal mechanism to ensure accountability. | ⍰ Formal declaration of the duties and responsibilities of the partners. | — Mechanism through which a municipality might pledge certain financial or staff resources to an adaptation strategy. However, a resolution lacks the enforceability that comes through a contractual agreement. |
| **Memoranda of Understanding (MOUs)** | Describes the terms and responsibilities of parties entering into a joint adaptation strategy. Partners retain full legal autonomy from one another. | ⍰ Provides an organizational structure within which an adaptation effort, or an ongoing adaptation strategy, can be executed.<br>— Operates on consensus, and action may depend upon successful internal organizing among partners. | ⍰ A flexible, relatively easy method for partners to coordinate. Formation requires just adoption by participants.<br>⍰ Arrangement makes adding new partners easy (requiring approval by existing and new members).<br>⍰ May provide a "stepping stone" to a contractual relationship in which responsibilities are enforceable. | ⍰ Partners may contribute specialized resources to a joint effort (e.g., staff expertise and technical skills).<br>× Generally lacks a dedicated stream of funding and independent staff, a potential roadblock to projects requiring a significant outlaying of resources by partners. |
| **Legal contracts** | Formalize and make enforceable the responsibilities of each partner working on a shared adaptation effort. | ⍰ Planning efforts can be undertaken with greater assurances of the role played by each partner.<br>× In light of uncertain future conditions, the rigidity of the structure may hinder formation if potential partners are unwilling to make a firm commitment. | ⍰ Division of responsibilities among partners is clearly delineated and obligations can be enforced. | ⍰ Provide a tool through which the cost of an adaptation effort might be redistributed, taking resource strains off of partners unable to shoulder them alone.<br>× Offers no mechanism for marshaling new resources (e.g., levying a tax). |
| **Joint Powers Authorities (JPAs)** | Contractual agreements among governmental entities, allowing for the joint operation of a facility or program, or for a joint planning process. Partners typically cede certain powers, responsibilities, and/or resources to the JPA, giving the JPA a degree of independent authority. | ⍰ Planning efforts can be undertaken with greater assurances of the role played by each partner.<br>× In light of uncertain future conditions, the rigidity of the structure may hinder formation if potential partners are unwilling to make a firm commitment. | ⍰ Permits for a high degree of coordination among partners, who make commitments to certain action and may even cede certain responsibilities to the JPA in an effort to realize an adaptation effort.<br>× Rigidity of structure may make adding members or redefining mission after formation difficult. | ⍰ Generally structured to receive funding or technical support from founding partners.<br>⍰ May have the ability to raise revenue (e.g., levy a tax, issue a bond) and hire its own staff.<br>× Cost of formation may be high. |
| **Special districts and regional authorities** | Established by state law to perform governmental functions within set boundaries (which often cross jurisdictional lines). | ⍰ Could provide dedicated and long-term support to the accomplishment of an adaptation effort, even if conditions change. | ⍰ May consolidate responsibilities that were spread across multiple jurisdictions into one body, making decision-making and long-range planning easier. | ⍰ May be structured to raise revenue through taxes, benefit assessments and/or service charges. |

**Figure 3: Institutional arrangements that aid adaptation.** ⍰ = Potential asset, × = Potential liability, — = Positive & negative aspects.

# 6. Conclusion

The degree to which the Bay Area is resilient to climate change depends in large measure on our capacity to develop and implement plans that adapt to new conditions. To the extent that this capacity is strong or can be strengthened, in most cases it will be possible to remain resilient despite stressors such as sea level rise and storm events. To the extent that such capacity is weak or absent, the region and its communities are more vulnerable.

This issue paper highlights the role of governance in fostering resilience to climate change, and identifies three core challenges – exemplified through the ART project – for the many institutions and organizations that need to participate in assessing vulnerability and developing and implementing adaptation responses: uncertainty, complexity, and resource constraints. http://www.seacrestschool.org/docs/summer_registration13.pdfIn light of these challenges, existing institutional arrangements, decision-making processes, and laws and regulations should be re-evaluated. Where they are deficient, the frameworks and models presented here might provide a starting point for those involved in adaptation planning efforts.

## SUMMARY OF FINDINGS

### Uncertainty

Within the ART project area, uncertainty presents itself as a challenge for governance in that:

- The timing, severity, and degree to which climate stressors will threaten communities, ecosystems, and the processes and institutions that govern them is not fully understood, and assumptions about the future are based on imperfect data, models, and information, meaning that events may unfold in unanticipated ways.

- Events both related and unrelated to climate change (e.g., the possibility of other events occurring simultaneously, such as earthquakes, wildfires, and floods) will affect capacity to adapt to climate change in potentially unknown ways.

- Planning for adaptation will happen over longer time horizons than are typically considered. A long-term perspective necessarily entails confronting uncertainty — a task made difficult by the many gaps in long-range climate models, economic forecasts, and other planning tools.

To confront these challenges, this paper makes use of Hansen and Hoffman's analysis of three methods designed to incorporate uncertainty into governance and management.[87]

- *The precautionary principle* provides a method for decision-makers to make choices in light of a high degree of uncertainty about future conditions. With the precautionary principle, the risk of inaction or delay is weighed against the risk of taking what may ultimately prove to be unnecessary action.

- *Adaptive management strategies* allow decision-makers to the confront gaps in data and information that accompany planning for long-term time horizons by incorporating methods and mechanisms to study and reevaluate the effectiveness of an adaptation response over time.

- *Scenario planning* is a method to identify a range of possible future conditions and craft strategies that will be appropriate. Scenario planning may reduce the likelihood of surprise, and also helps decision-makers identify responses that are likely to work across a spectrum of possible outcomes.

## Complexity

Complexity is observed as a complicating factor for adaptation planning in the ART project area in the following ways:

- A network of institutions and organizations will often be necessary in order to adequately assess vulnerability and develop and implement adaptation responses, requiring coordination to manage logistics and divide responsibilities. In some cases this division could lead to needlessly duplicative work. In other instances, thoughtfully planned efforts could result in collaborative and productive partnerships.

- Most environmental laws, regulations, and management plans are crafted in response to observed, rather than anticipated, problems. Absent an existing regulatory or review framework for climate change adaptation, projects and policies that incorporate vulnerability assessments and adaptation responses have primarily been developed on a voluntary basis.

- Complex institutional arrangements, existing regulatory requirements, and the large number of organizations involved has the potential to create barriers and delays to certain adaptation responses, especially if timely action is required.

To reduce the complexities associated with planning for sea level rise and storm events, a set of approaches put forth by Termeer et al. are presented as means to organize cooperation across institutional divides:

- *Synchronizing adaptation policies* across institutions and organizations helps to avoid barriers imposed by procedures and laws that are incompatible with necessary adaptation responses.

- *Coordinating local, regional, state, and federal efforts* for adaptation is a method of overcoming the divisions within a multi-level governance setting. Through this coordination, planning priorities and funding options can be aligned, allowing for better outcomes than would be possible in a setting of fragmented governance.

- *Launching experiments and pilot projects* can create linkages between institutions and organizations that foster closer cooperation and even joint partnerships. Through closer coordination, barriers facing adaption are more easily identified and overcome.

- *Fostering relationships that bridge institutional divides* likewise reduces complexities by lessening barriers to coordination among institutions and organizations. Individuals can often play a particularly important role in creating networks across institutions.

## Resource constraints

Resource constraints will come to bear as institutions in the ART project area confront climate change:

- Future and current resource and fiscal constraints facing institutions and organizations may delay, limit, or impede vulnerability assessments and the development and implementation of adaptation responses.

- Obtaining resources may be difficult, particularly if it requires approval from taxpayers or elected officials, or if there is no appropriate mechanism in place to receive funding.

- Where there is a "mismatch of scale" between the necessary adaptation response and the institution or organization responsible for developing and implementing the response, there may insufficient financial resources, technical expertise, legal authority, or staff resources to plan, finance, or implement the response.

This issue paper presents methods for institutions and organizations to reduce the costs associated with adaptation planning, or alternatively, to redistribute the costs across a variety of different institutions:

- *Proactive planning* is generally a more cost-effective and flexible approach than as delayed action, which can result in inefficiencies and wasted resources.

- *Incorporating adaptation measures into existing practices* reduces resource strains. Adaptation strategies can often serve a dual purpose, offering advantages to a community beyond additional adaptive capacity.

- *Redistributing costs among multiple institutions* may make it possible to implement a strategy that a single institution cannot shoulder on its own.

- *New governance structures* can be created to allow for joint spending among institutions and organizations, to raise new forms of revenue for adaptation measures, or to provide dedicated staff resources to an adaptation response.

- *All involved in governance have a role to play*, including citizens and community groups, who provide the popular and political support that might be necessary for an adaptation effort to win approval, or that might be necessary to achieve adaptation in the face of institutional foot-dragging or resistance.

## Considering Different Institutional Arrangements

Inter-institutional collaboration emerges again and again as an important remedy to the governance challenges highlighted in this issue paper. A variety of models for collaboration, therefore, are presented for consideration here. These models, already widely in use in various contexts in the Bay Area, have the potential to reduce some degree of the uncertainty, complexity, and resource constraints encountered by institutions involved in adaptation planning. The extent to which a particular model will prove to be an effective tool will depend on the specifics of the challenge encountered and the adaptation response in question. This list constitutes a starting point for institutions interested in identifying arrangements that are capable of fostering a higher degree of cooperation and coordination. Institutional arrangements presented here include:

- Informal arrangements and networks
- Municipal resolutions
- Memoranda of Understanding (MOUs)
- Legal contracts
- Joint Powers Authorities (JPAs)
- Special districts and regional authorities

# APPENDIX

## GOVERNANCE IN THE ART PROJECT AREA: EXISTING CONDITIONS AND VULNERABILITIES

The following is a summary of governance issues highlighted within each of the twelve categories of assets examined as part of the ART project. Each section begins with a very brief summary of the perceived vulnerability of these assets to rising sea levels and storm events, as well as a discussion of the institutions that make up the governance landscape in the subregion and the legal and regulatory structures that might influence the nature of the appropriate adaptation responses. Each section also contains a discussion on the consequences of the climate impacts for governance. This discussion represents the author's attempt to create categorizations for the governance challenges that climate change presents for the ART project area. The resulting overarching categorizations — uncertainty, complexity, and resource constraints — informed the research conducted for the body of this report.

# 1. Airport

Oakland International Airport, bordered on its northern, western, and southern sides by the San Francisco Bay, is likely to face daily inundation of its General Aviation facilities and North Field runways with 16 inches of sea level rise. During storm events at 16 inches of sea level rise, other facilities including the commercial runway would be exposed. At 55 inches of sea level rise, every facility at the airport is likely to experience some form of inundation. The airport is sensitive to impacts in surrounding areas, particularly along major access roads. It is particularly sensitive to storm events that could cause water to overtop protective levees.

The airport is owned and operated by the **Port of Oakland**, an autonomous department of the **City of Oakland**. It is governed by a **Board of Port Commissioners**, each of whom are nominated by the **Mayor of Oakland** and appointed by vote of the **Oakland City Council**. The airport funds its own operations. It receives no tax money from the city, but does benefit from various government grants, the largest of which is distributed by the **Federal Aviation Administration (FAA)**.

The airport contains facilities operated by a variety of private companies. A number of commercial airlines operate out of the airport (Oakland is a focus city for **Southwest Airlines** and **Allegiant Air)**. A large amount of air cargo is handled at the airport, by **FedEx** and other operators. Two fixed-base operators, **KaiserAir** and **Business Jet Center**, provide general aviation services.

Many local and federal laws regulate operations at the airport. For example, the Port agreed to prohibit the use of its North Field runways to regularly scheduled large commercial aircraft due to concerns about noise. The agreement was the result of a settlement among the Port, the **City of San Leandro**, the **City of Alameda**, and others.

## Consequences of climate impacts for governance

- COMPLEXITY: In the event of a significant disruption, such as the flooding of a runway, the regulatory structure of the airport may affect its capacity to adapt operations. As it stands, the airport's sole runway for commercial flights (Runway 11/29) is the runway must vulnerable to flooding. However, a large number of overlapping local and federal airspace regulations might prevent attempts to swiftly relocate commercial flights to other runways in the event of flooding. The North Field runways are off-limits to regularly scheduled large commercial aircraft as a result of an agreement between the Port and surrounding communities to reduce noise pollution. In addition, the FAA imposes, nationwide, a 24-hour noise abatement policy that prohibits certain large loud and large aircraft from departing and landing on several secondary runways.

- RESOURCE CONSTRAINTS: The airport may face significant challenges in arranging funds for immediate repairs because of the complexity of facility operations and management budgets. Capital projects are funded through a mix of

sources. One source is Passenger Facility Charges (PFC), ticket fees collected by the airlines from departing passengers and distributed through a competitive process to airports across the country by the FAA. Congress determines the amount of the maximum PFC charge. The FAA distributes other grants in the form of Airport Improvement funds (AIP), which may pay for up to 80 percent of eligible projects. Capital projects are also funded by aviation-generated operating revenue and debt.

- RESOURCE CONSTRAINTS: The airport's capacity to plan for future climate impacts and to respond to potential disruptions is limited by the inadequacy and uncertainty of funding for upkeep and the repair of critical infrastructure. A backlog of unfunded infrastructure projects will only be completed when unexpected funding sources, such as government grants or better-than-expected revenues from airport operations, become available.
-
- RESOURCE CONSTRAINTS, COMPLEXITY: The airport will face regulatory and financial burdens without proper flood protection in place. The existing perimeter dike structure does not meet FEMA 100-year flood protection standards, which means it is no longer accredited under FEMA's flood programs. As a result, the airport must obtain federal flood insurance on top of the private flood insurance the Port already carries. If the airport does not upgrade the dike to FEMA standards, it would become largely ineligible for federal disaster assistance in the event of a levee failure. It would also be required to develop a Flood Plain Management Plan, greatly restricting the airport's ability to construct or renovate buildings at the low elevation of the airport's grounds.

## 2. Community Land Use

The ART project has conducted a community land use assessment that considers the climate-related vulnerability and risk facing people (where they live and work), the property they own, and the services and facilities that tie their neighborhoods together. With 16 inches of sea level rise at the new daily high tide, flooding is expected to:

- Affect 2,000 residents;
- Affect 1,000 employees; and
- Expose property with an assessed value of $694 million[†††] or a replacement value of $323 million.[‡‡‡]

In the most extreme scenario considered by the ART project, with wind waves and 55 inches of sea level rise, flooding is expected to:

- Affect 123,000 residents;
- Affect 71,000 employees; and
- Expose property with an assessed value of $19.6 billion[§§§] or a replacement value of $10.7 billion.[****]

The community land use assessment also examined the potential impact to community facilities and services. The ART project area contains:

- Thirty-five emergency response facilities (including hospitals, police stations, and fire stations), few of which face serious flooding risk;
- Two hundred facilities servicing at-risk populations (including health care facilities, homeless shelters, group homes, food banks, and jails). Few of these facilities face exposure to flooding, but those that do are highly vulnerable because of the sensitivity of the populations they serve;
- Six hundred-fifty facilities serving vulnerable, less mobile populations (including senior housing, long-term care, childcare centers, and schools), which have relatively low exposure system-wide, but are nonetheless highly vulnerable because of the

[†††] Based on Assessor's data.

[‡‡‡] Based on HAZUS model data.

[§§§] Based on Assessor's data.

[****] Based on HAZUS model data.

challenges involved in evacuating the populations they serve; and

- One animal care facility (an animal shelter in Alameda) that is very vulnerable because of its exposure to flooding, the challenges involved in evacuating its animals, and the lack of redundancy in the animal care system.

### Consequences of climate impacts for governance

- COMPLEXITY, RESOURCE CONSTRAINTS: The agencies that issue permits for construction along the shoreline may face a significant number of new requests from property owners seeking to build protective features, putting strain on agency staff.

- COMPLEXITY, RESOURCE CONSTRAINTS: City and county governments may need to revise regulations and building codes in order to protect residents and workers near the shorelines, a time-consuming and sensitive task.

- COMPLEXITY: A large number of facilities and services are likely to be affected by sea level rise and storm events. As a result, many different stakeholders and agencies may need to be involved in the preparation of evacuation plans, in ensuring that adequate shelters are available, and in emergency response preparations.

## 3. Contaminated lands

The ART project's vulnerability and risk assessment considered eight types of contaminated lands: Federal Superfund sites; Site Cleanup Program sites; sites with Leaking Underground Storage Tanks (USTs); Military Cleanup sites; Department of Toxic Substances (DTSC) sites (which include some Site Cleanup Program and UST sites); and closed and active landfills. There are nearly 1,000 contaminated land sites within the project area. Most will not be exposed to the daily high tide with 16 or 55 inches of sea level rise. During a storm event with 55 inches of sea level rise, 261 sites (approximately 25 percent) may be exposed, with an additional 163 sites exposed to wind waves only.

While some contaminated land sites, including most landfills, are owned by municipalities, the majority are on privately owned land. Multiple agencies are tasked with regulating and overseeing cleanups of contaminated lands. In some instances, authority is shared among multiple agencies. The table below, created for the vulnerability and risk assessment, describes the categories of contaminated land sites examined in the project area along with the regulatory agencies involved in monitoring and cleanup efforts.

**Table 1. Types of contaminated lands addressed in this report and number of each type documented in the ART project area**[88]

| Type of Site | # | Description | Regulatory Agencies |
|---|---|---|---|
| Superfund | 2 | A federal Superfund site is an abandoned area where hazardous waste is located, possibly affecting local ecosystems or people. These areas have been designated on a National Priorities List through the federal Superfund cleanup program. | The **US Environmental Protection Agency (US EPA)** has primary jurisdiction over Superfund sites, with the involvement of the **Regional Water Quality Control Board (RWQCB)** and **the State Department of Toxic Substances Control (DTSC)** |
| Site Cleanup Program | 303 | Cleanup program sites are locations that have had unauthorized releases of pollutants that have contaminated soil or groundwater, and in some cases surface water and sediment. | **California State Water Resources Control Board's (SWRCB)** and RWQCB |
| Leaking UST | 405 | Leaking USTs are sites that have or had leaking USTs. The vast majority of leaking UST sites are contaminated with petroleum products associated with gasoline service station operation. Tetrachloroethylene (TCE) is another common contaminant from leaking USTs | Generally under jurisdiction of **State Water Board** with Regional Water Board or DTSC as lead agency for cleanup |

| | | | |
|---|---|---|---|
| | | and is commonly associated with the dry cleaning process. | |
| Military UST | 43 | Military facilities with leaking USTs. | SWRCB, RWQCB, and **Department of Defense (DOD)** |
| Military Cleanup | 96 | Sites at military facilities with water quality issues. The facilities that require environmental cleanups range from UST sites to Superfund sites, and can be part of other sites such as DTSC sites. | SWRCB, RWQCB, DOD, DTSC |
| DTSC | 112 | DTSC sites can be State Cleanup, leaking UST, or other contaminated lands sites for which the Department of Toxic Substances Control is the lead agency for cleanup. | DTSC |
| Landfill (closed) | 15 | A landfill is a solid waste management facility where waste is or once was disposed of on land or in tidal areas. Landfills do not include surface impoundments, waste piles, land treatment units, injection wells, or soil amendments. Some of the sites identified as landfills in this report are waste treatment areas that are not permanently used for storing waste – for example, 5 sites are "processing" facilities such as green waste chipping and composting sites or sites where construction and demolition materials are processed before being transported elsewhere. | SWRCB and RWQCB with other state & local agencies such as **CalRecycle**, Counties, and Cities |
| Landfill (active) | 6 | | |
| **Total** | **982** | | |

## Consequences of climate impacts for governance

- COMPLEXITY: The large number of agencies that regulate contaminated lands and their cleanup has the potential to cause delays and inefficiencies. This might present challenges both for long-term planning and the immediate response required by short-term stressors, such as storm events. However, it may also be the case that the large number of regulators involved will result in greater resiliency, as redundancies may reduce the likelihood of oversights.

- RESOURCE CONSTRAINTS: Cleanup efforts are already constrained by inadequate funding. Sea level rise poses a challenge in that rising water levels may "mobilize" contaminants and result in new instances of exposure to humans and natural systems. To decrease the likelihood of such events, funding for cleanups would need to grow in proportion to the threat.

## 4. Energy, pipelines, and telecommunications infrastructure

The ART project has assessed the vulnerability and risk facing power plants, substations, transmission lines, natural gas and liquid petroleum pipelines, telephone poles, and underground cables within the project area.

The electricity infrastructure assessed as part of the ART project includes an oil-powered plan in Oakland owned by **Dynegy**; a natural gas and diesel plant in Alameda owned by the **Northern California Power Agency (NCPA)**; 15 electricity substations operated by various operators including **Pacific Gas and Electric Company (PG&E)**, the **Port of Oakland**, **Owens Illinois**, **AMP**, **Domtar Gypsum**, NCPA and Dynegy; and transmission lines owned operated by PG&E. The **Federal Energy Regulatory Commission (FERC)** operates aspects of the transmission of electricity, while at the state level the **California Public Utilities Commission (CPUC)** regulates the natural gas and electricity grid.

Fuel pipeline infrastructure is owned by private companies including **Shell** and **Kinder Morgan**. Pipelines are generally located on the privately owned land of a separate entity (e.g., the **Southern Pacific Railroad**). The **United States Department of Transportation's Office of Pipeline Safety (OPS)** develops regulations and risk management approaches to achieve greater safety at pipeline facilities. At the state level, the CPUC and the **California Office of the State Fire Marshall** regulate pipelines.

Telecommunications and fiber optic lines are owned by service providers including **AT&T**, **Qwest**, and **Comcast**. Lines often run on property owned by another entity. The **Federal Communications Commission (FCC)** and the CPUC regulate aspects of the telecommunications infrastructure.

### Consequences of climate impacts for governance

- COMPLEXITY: Regulatory oversight for energy, pipelines, and telecommunications infrastructure is mostly at the state and federal levels, although local jurisdictions can influence the placement of infrastructure through general plans, specific plans, and zoning ordinances.

- COMPLEXITY: In the event of an emergency, coordination among the private owners of this infrastructure, regulating agencies, and emergency responders would be necessary. Coordination of this response might be challenging, especially in an event that affected multiple facilities at once.

## 5. Ground transportation

Ground transportation in the ART project area — consisting of roadways, interstates, the **Bay Area Rapid Transit (BART)** system, rail lines, bus routes, ferry routes, and bicycle and pedestrian pathways — is generally quite sensitive to sea level rise and storm events. However, redundancy in the overall system means that ground transportation has medium to high adaptive capacity (with a few exceptions, such as rail serving cargo, and shoreline bicycle and pedestrian pathways).

The ART project area contains three major interstates and several highways (Interstate 80/580, Interstate 880, Interstate 980, California State Highway 92, and California State Highway 81). The San Francisco-East Bay Bridge connects the East Bay to San Francisco and the San Mateo-Hayward Bridge provides a connection to Silicon Valley. Components of the road network fall within the jurisdiction of municipalities, the **Federal Highway Administration (FWA)**, and the **California Department of Transportation (Caltrans)** and others (e.g., the **Bay Area Toll Authority**).

**AC Transit**, a public transit agency, operates the majority of bus routes in the project area. Other bus routes are operated by cities, including the **Emery Go Round**, Oakland's **Broadway Shuttle**, and **Union City Transit**. The project area contains three BART stations.

**Amtrak** runs its California Zehpyr and Northern California regional service within the project area. **Capitol Corridor Joint** Powers Authority also runs its passenger service within the project area. National freight carriers, including **Union Pacific** and **Burlington Northern Santa Fe**, service the Port of Oakland and share at-grade railroad tracks with Amtrak that run roughly parallel to Interstate 880.

Ferry terminals operate at Jack London Square in Oakland, the Alameda Ferry Terminal in the City of Alameda, and the Harbor Bay Ferry Terminal on Bay Farm Island, providing connections to San Francisco's Ferry Building and the South San Francisco Ferry Terminal. The ferries are operated by the Blue and Gold Fleet for the **Water Emergency Transportation Authority**.

### Consequences of climate impacts for governance

- RESOURCE CONSTRAINTS: Sea level rise and storm events are likely to increase (perhaps significantly) long-term operations and management costs for the project area's transportation network.

- COMPLEXITY: The planning process for transportation networks is generally quite complex, as it requires cooperation among multiple agencies at all levels of government, including funding agencies, operating agencies, and regulatory agencies, as well as land owners and land managers.

- COMPLEXITY, RESOURCE CONSTRAINTS: Funding for transportation projects often involves a mix of federal, state, and local government subsidies. Some projects may also require winning approval from voters through the initiative process.

## 6. Hazardous waste

Very few of the 152 sites that generate hazardous waste in the ART project area will be exposed to the daily high tide or storm event flooding with 16 inches of sea level rise. However, a third are exposed to wind waves at 16 inches of sea level rise. With 55 inches of sea level rise, more than 30 sites will be exposed to the daily high tide, and nearly 100 sites will be exposed to storm event flooding with wind waves.

In the event that they are flooded, the degree to which communities in the subregion are made vulnerable will depend on the ability of emergency responders to contain or manage hazardous waste. Both federal and state laws regulate hazardous wastes, and a large number of regulators and agencies are involved in cleanup efforts and tasked as responders in the event of an emergency.

The primary federal law regulating hazardous waste, called the Resource Conservation and Recovery Act (RCRA), is implemented through the **United States Environmental Protection Agency (US EPA)**.

State agencies participate directly in waste management, including the **California Environmental Protection Agency (Cal EPA)**, the **Department of Toxic Substance Control (DTSC)**, the **State Water Resources Control Board (Water Board)**, the **California Emergency Management Agency (Cal EMA)**, and the **State Fire Marshall**. These agencies provide support and oversight to city and county agencies.

The city and county agencies authorized to carry out programs that deal with permitting and managing hazardous wastes are known as Certified Unified Program Agencies (CUPAs). The city agencies that serve as CUPAs in the ART project area are the **Hayward City Fire Department**, the **Oakland City Fire Department**, the **City of San Leandro Environmental Services Section**, and the **Union City Environmental Program Division**. The **Alameda County Environmental Health Department**, also a CUPA, covers the cities of Alameda, Emeryville, and San Lorenzo, as well as unincorporated areas and other cities outside the ART project area.

### Consequences of climate impacts for governance

- COMPLEXITY: A large number of agencies at the federal, state, and local levels play a role in the regulation and management of hazardous materials. Each of these agencies has somewhat different operating procedures.

- COMPLEXITY: There is the potential for confusion and overlap in the event a hazardous materials release. The response will involve CUPAs and local responders and up to 25 state agencies. If there are insufficient resources for the response in the immediate area, other local and county agencies may need to be involved.

- RESOURCE CONSTRAINTS, COMPLEXITY: Faced with a storm event or another stressor that results in hazardous materials release over a large region, agencies might be overburdened or forced to prioritize sites or types of materials in their response.

- COMPLEXITY: Determining what might be exposed in the event of a climate event could be complicated by the many different reporting systems, regulations, and databases that exist to address different materials.

## 7. Non-structural shorelines (wetlands)

The ART project has assessed the vulnerability of twelve tidal marshes and five managed marshes in the project area. Modeling for the marshes (conducted in collaboration with PRBO Conservation Science) suggests that marshes are sensitive to a high rate of sea level rise.

Wetlands in the ART project area are managed by the **East Bay Regional Park District**, the **California Department of Fish and Game**, and the **California Department of Parks and Recreation (California State Parks)**.

An effort to restore or protect a wetland may involve a wide variety of agencies and organizations, including the agency managing the wetland, as well as organizations focused on planning and funding (e.g., **San Francisco Bay Joint Venture**), regulating (e.g., **U.S. Fish and Wildlife Service**, **U.S. Army Corps of Engineers**, **San Francisco Bay Conservation and Development Commission**, and the **San Francisco Bay Regional Water Quality Control Board**), restoration design (e.g., **Phillip Williams & Associates – Environmental Science Associates**), and research (e.g., **United States Geological Survey** and **PRBO Conservation Science**).

### Consequences of climate impacts for governance

- COMPLEXITY: There is no single institutional decision-maker that deals with wetland restoration and protection. Instead, such an effort requires multiple organizations and agencies (see above). As a result, effective and timely decision-making can be a challenge.

- RESOURCE CONSTRAINTS, COMPLEXITY, UNCERTAINTY: Efforts to improve the resilience of wetlands may prove to be costly, and decisions about wetlands restoration and protection will have to be made alongside the potential impacts facing other parts of the natural and built environment.

## 8. Parks and Recreation Areas

The ART project has assessed the vulnerability of 18 parks, 5 golf courses, and the portions of the San Francisco Bay Trail within the project area. Sea level rise will affect nearly every park and recreation facility examined in the ART project area. With 16 inches of sea level rise, the majority of parks and recreation facilities will be exposed during a storm event. With 55 inches of sea level rise, all but a few parks will be highly exposed to the new daily high tide.

The Bay Trail crosses several jurisdictional lines in the project area, and responsibility for upkeep and maintenance falls to a variety of agencies, including the **East Bay Regional Park District,** the **City of Emeryville**, the **City of San Leandro**, the **Department of Fish and Game**, and **Hayward Area Recreation and Park District**. Private land owners are responsible for trail maintenance as required by development permits issued by the **San Francisco Bay Conservation and Development Commission (BCDC)**.

Other parks and facilities considered in the ART project area are owned and managed by the **City of Emeryville's Department of Community Services**, the **Port of Oakland**, the **City of Oakland's Office of Parks and Recreation**, the **City of Alameda's Recreation and Park Department**, the **City of San Leandro's Department of Recreation and Human Services**, **East Bay Regional Park District**, and **Hayward Area Recreation and Park District**.

### Consequences of climate impacts for governance

- RESOURCE CONSTRAINTS: Addressing the effects of climate change on parks and recreation areas is likely to require costly maintenance and repairs. This may exacerbate budget shortfalls that have hit the cities, agencies, and non-profit organizations that operate parks, facilities, and recreational services. With less funding, maintenance and long-term planning is more likely to be deferred, and programs, services, and operating hours are more likely to be cut.

- COMPLEXITY, RESOURCE CONSTRAINTS, UNCERTAINTY: Should park managers need to make modifications to parks in response to climate stressors, regulatory requirements will add to planning costs and potentially reduce timeliness. Projects will often require multiple permits and approvals from agencies such as BCDC and the Regional Water Quality Control Board. They will also generally require an Environmental Impact Report that describes impacts and mitigations to comply with the California Environmental Quality Act. Further, agencies may have difficulties obtaining permits for adaptive management strategies that are not currently addressed in existing environmental and building regulations and policies.

- RESOURCE CONSTRAINTS, COMPLEXITY: In the wake of storm events, managing agencies may face damage to multiple parks within their jurisdiction. This could result in difficult trade-offs as agencies seek to prioritize recovery efforts, and might strain relationships between agencies that co-own or co-manage a park should their priorities differ.

- UNCERTAINTY, RESOURCE CONSTRAINTS: The management needs at some parks and managing agencies are likely to change as a result of sea level rise impacts. For instance, there may be increased need for staff that can focus on disaster preparedness and response. As a result, an agency may need to retrain staff or hire differently trained staff, as well as reallocate operating funds.

## 9. Seaport

The **Port of Oakland's** seaport facilities are not likely to face major exposure to sea level rise in the near- or mid-term. Most seaport facilities are likely to be exposed during major storm events in a scenario of 55 inches of sea level rise. However, provided that financing is available to replace and rehabilitate these facilities with sea level rise and storms in mind, these facilities are likely to be resilient to climate stressors. The rail system and road infrastructure that move cargo to and from the Port is more highly vulnerable. With 16 inches of sea level rise, portions of the road and rail systems will be exposed during the daily high tide and storm events.

The Port of Oakland is an autonomous department of the **City of Oakland**. It owns and builds most of the port infrastructure. However, the private shipping companies leasing terminals from the Port are responsible for operations at those terminals. Private operators include **Ports America Outer Harbor LLC**, **TransPacific Container Service Corporation (TraPac)**, and others.

Two intermodal rail yards service the Port. One, Oakland International Gateway, is operated by **Burlington Northern Santa Fe** on Port-owned land. The other, Railport, is owned and operated by **Union Pacific Railroad** on private property adjacent to the Port.

A number of government agencies play a role in regulating operations at the Port. Expansion or renovation of piers and berths and the maintenance or deepening of harbor channels may require permits and approval from agencies including the **San Francisco Bay Conservation and Development Commission (BCDC)**, the **United States Army Crops of Engineers**, the **United States Environmental Protection Agency (US EPA)**, the **San Francisco Bay Regional Water Quality Control Board**, the **State Lands Commission**, the **California Department of Fish and Game**, and the **United States Fish and Wildlife Service**.

### Consequences of climate impacts for governance

- COMPLEXITY, RESOURCES CONSTRAINTS: Sea level rise may result in greater damage to Port facilities and lower the operational life spans of critical infrastructure. The Port's ability to redevelop its facilities in response to sea level rise stressors is dependent on its gaining approval from a variety of regulatory agencies. Current regulatory requirements that dictate how and when shoreline development can occur may limit the Port's ability to undertake these renovations in a timely manner.

- UNCERTAINTY, COMPLEXITY: The most immediate vulnerability facing the seaport comes from the potential interruptions to rail and truck service because of partial inundation of tracks and roadways outside the Port's property and jurisdiction.

## 10. Stormwater management

Stormwater infrastructure in the ART project area is sensitive to sea level rise and storm events. Exposure to rising waters could reduce the capacity, and therefore the effectiveness, of the pipes, channels, and creeks that carry stormwater to a discharge location, as well as many of the pump stations within the subregion.

Stormwater infrastructure within the ART project is owned by the cities and the county. Their stormwater management activities are regulated by the **San Francisco Bay Regional Water Quality Control Board (Regional Board)**, which issues National Pollution Discharge Elimination System (NPDES) permits within the region. One NPDES permit has been issued to the **Alameda Countywide Clean Water Program (ACCWP)**, which represents seventeen cities, unincorporated areas, and flood control districts in Alameda County. Cities and the county perform regular maintenance and inspections of the storm water and flood control system to comply with the NPDES permit.

In most of the ART project area, stormwater is routed into a regional flood control system owned and maintained by the **Alameda County Flood Control and Water Conservation District (ACFCWCD)**. The **City of Alameda** is the exception; its stormwater is routed through city-owned pipes and channels.

### Consequences of climate impacts for governance

- COMPLEXITY: Effective stormwater management requires coordination among the jurisdictions that span a watershed. One likely adaptation strategy — reducing the peak flows of stormwater entering the system — will require cities and the county to coordinate to improve management practices and prioritize approaches such as Low Impact Development.

## 11. Structural shorelines

Structural shorelines run between San Francisco Bay and developed land in much of the ART project area. Non-natural shoreline structures in the project area include: engineered flood protection (e.g., levees and flood walls) that protect inland areas from inundation; engineered shoreline protection structures (e.g., revetments and bulkheads) that harden the shoreline to reduce erosion and prevent land loss, and; non-engineered berms that protect marshes and ponds from wave erosion and provide flood protection to inland development. The sensitivity and adaptive capacity of each stretch of shoreline differs somewhat, but exposure to sea level rise and storm events is high. During a storm event with 16 inches of sea level rise and wind waves, much of the shoreline will overtop. With 55 inches of sea level rise and a storm event, the majority of the shoreline will overtop.

Ownership, maintenance, and regulation of shoreline assets is spread among a large number of private and public entities operating within the ART project area. Portions of shoreline fall under the jurisdiction of the **Port of Oakland**, the **Alameda County Flood Control and Water Conservation District (ACFCWCD)**, the **California Department of Transportation**, the **U.S. Army Corps of Engineers**, **East Bay Regional Parks District**, **Hayward Area Recreation and Park District**, and the **California Department of Fish and Game**. The owners and managers of shoreline assets are often required to coordinate with regulatory agencies including the **San Francisco Bay Conservation and Development Commission (BCDC)**, the **San Francisco Bay Regional Water Quality Control Board (Regional Board)**, the **California States Lands Commission**, the **U.S. Fish and Wildlife Service**, and the **National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries)**.

### Consequences of climate impacts for governance

- COMPLEXITY: Shoreline assets are owned by a mix of private and public entities and regulated by agencies at the local, regional, state, and federal levels. An effective, properly financed, and timely response to climate change stressors presents significant challenges in terms of coordination and logistics.

- RESOURCE CONSTRAINTS, UNCERTAINTY: The cost of maintaining or improving shoreline assets is often quite high, requiring funding for design, permitting, materials, and construction. Gaining access to such funding will present challenges for both private and public entities.

## 12. Wastewater facilities

Sea level rise and storm events may pose significant operating challenges to wastewater facilities. A number of service providers make possible the collection, treatment, and disposal of wastewater within the ART project area. The public wastewater collection system is made up of sewer mains, interceptors, and pump stations owned and operated by five cities — **Alameda**, **Emeryville**, **Oakland**, **Hayward**, and **San Leandro** — and three districts — the **Oro Loma Sanitary District (OLSD)**, the **Union Sanitary District (USD)**, and the **East Bay Municipal Utility District (EBMUD)**. There are five wastewater treatment plants in the ART project area. One plant is owned jointly by OLSD and the **Castro Valley Sanitary District**. EBMUD, USD, the City of Hayward, and the City of San Leandro are the respective owners of the other four plants. EBMUD, and the **East Bay Dischargers Authority (EBDA)** are the entities responsible for handling the discharge of wastewater.

### Consequences of climate impacts for governance

- COMPLEXITY: Significant inter-agency and cross-jurisdictional coordination may be required in the event that one or more facilities is effected by sea level rise or a storm event.

- RESOURCE CONSTRAINTS: The impacts of climate change may require service providers to adopt new operations or procedures, technologies, or financing strategies in order to meet regulatory requirements for wastewater treatment and discharge.

- COMPLEXITY, RESOURCE CONSTRAINTS: Many pieces of wastewater infrastructure are protected from storm event flooding by shore protection features that are owned and operated by others (e.g., levees and earth berms). If these systems fail due to the stressor of climate change, or if they need to be repaired or enhanced in order to remain effective, addressing the consequences may prove to be a complex, costly, and time-consuming process.

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