Adaptation Responses

ADAPTING TO RISING TIDES PROJECT JULY 2013

In considering how to best address the vulnerabilities identified in the ART subregion, the project team and working group determined the need for comprehensive approach that went beyond a simple list of strategy names. The result was the development of the ART subregional adaptation responses that clearly link

actions to the vulnerability(s) that they would reduce, identify when it is important to take a phased or sequential approach, and acknowledge alternative actions that will require considering trade-offs and costs/benefits. For the cross-sector, crossjurisdictional issues identified in the ART project, the adaptation responses are a springboard for participating agencies, organizations and communities to collectively begin to take action together. For the issues identified that affect a single jurisdiction or agency, the subregional adaptation responses are the foundation from which an adaptation plan can be developed or individual actions can be selected, refined and initiated.

The ART adaptation response contains three core elements: (1) a key vulnerability; (2) actions to directly address the vulnerability; and (3) the likely steps, partners, and processes necessary to initiate and administer the actions. Additionally, each action was characterized by its type and priority, and the scale(s) at which it would be implemented. The ART **adaptation responses** consist of three elements:

A **key vulnerability** provides a direct link to the outcomes of the assessment so that the most critical issues identified are addressed. Including the key vulnerability is a clear and transparent means to ensure that each action is connected to an identified planning issue.

One or more **actions**. While some vulnerabilities can be addressed by a single action most require multiple actions. Many actions can be taken at the same time, while others act as a series of sequential steps that incrementally build towards resilience.

Implementation options are a guide for those that want to initiate actions. The options identify the possible actors that will need to be at the table, whether actions could be incorporated into existing planning or collaborative processes, or if new initiatives will be needed.

Components of an Adaptation Response

Assessment findings for the ART subregion were summarized within and across the twelve asset categories evaluated. This organization allowed the project team to identify asset categories that had similar vulnerabilities identified relationships and dependencies among the assets, eliminated redundancies, and highlighted the unique vulnerabilities of specific asset categories.

Five broader asset categories were developed from the original 12 asset categories assessed within the subregion:

- Overarching Vulnerabilities that cut across many or all asset categories.
- Community Land Use Community Land Use, Facilities and Services, Contaminated Lands and Hazardous Material Sites
- Transportation Ground Transportation, Airport and Seaport
- Utilities Energy, Pipelines & Telecommunications, Stormwater and Wastewater
- Shorelines Natural Shorelines, Structural Shorelines and Parks and Recreation Areas

Key vulnerabilities were identified for these broader categories and this formed the basis of subregional scale adaptation responses.

Key Vulnerability

The ART subregional adaptation responses start with a key vulnerability that had been classified using the system developed by the ART project to characterize and communicate vulnerabilities and risks¹. The vulnerability classifications – information, management, physical and functional – classifications make it easier to identify specific and appropriate actions, the potential actors to be involved, and the processes and scales at which to implement the actions.

For example, "information vulnerabilities" describe assets and issues where a lack of information or inadequate access to information makes it difficult to assess the problem and develop an appropriate response. Information vulnerabilities that were identified during the ART assessment include a lack of information on the condition of shoreline protection; difficulty in obtaining access to information regarding the elevations and condition of ground transportation; and a lack of analysis and data on how ground water will be affected by rising sea levels. These kinds of vulnerabilities are more economically and effectively

¹ See Chapter 3 of the ART Vulnerability and Risk Assessment Report for a description of the classification system (*www.adaptingtorisingtides.org/vulnerability-and-risk-report/*).

addressed through evaluations or assessments conducted at a regional or system-wide scales. Informational vulnerabilities are often the necessary first step before more refined assessments can be conducted or actions prioritized and implemented.

Understanding the type of vulnerability can more quickly lead to a targeted and appropriate response to resolve the real issues faced, avoiding potentially costly and unnecessary actions.

Action

Each action in the adaptation responses is described and identified by action types² - evaluation, policy development, coordination, program/operation, and education/outreach. These action types communicate the activities and processes required, and provide a means to identify actions requiring similar kind of efforts.

Implementation Options, Possible

The adaptation responses include implementation options that highlight the potential actors –the agencies, organizations, individuals or groups – who should be involved and the processes into which the actions could be integrated.

Possible Actors in the ART Subregion

Possible actors are identifies in the ART subregional adaptation responses that will likely be involved in action initiation and administration. Actors include those that are likely to lead action implementation (often asset owners or operators), as well as potential decision-making or funding partners, regulatory or permitting agencies, non-profit and community organizations, the private sector, landowners, and the owners and operators of adjacent properties or interconnected infrastructure.

Not all of the actors identified will either choose or need to be engaged in implementation. In other cases, the list of possible actors is not comprehensive and it will be necessary to seek a broad range of participation from all levels of governance³ – from the private sector, to community organizations, to surrounding neighborhoods, organizations and agencies, as well as others with adjacent or interconnected assets.

Acronym	Full Name			
ACEH	Alameda County Environmental Health			
ACFCWCD	Alameda County Flood Control & Water Conservation District			
ACPHD	Alameda County Public Health Department			
AT&T	American Telephone and Telegraph Company			
ABAG	Association of Bay Area Governments			
BAAQMD	Bay Area Air Quality Management District			
BART	Bay Area Rapid Transit			

² Action Type was adapted from the Association of Bay Area Government's (ABAG) Regional Resilience Initiative Action Plan, available at http://quake.abag.ca.gov/resilience_initiative/.

³ For information on issues regarding governance and adaptation, see the *Adapting Governance to Rising Tides Issue Paper* available at http://www.adaptingtorisingtides.org/governance/.

Caltrans	California Department of Transportation
CalEMA	California Emergency Management Agency
CPUC	California Public Utilities Commission
СТС	California Transportation Commission
ССЈРА	Capital Corridor Joint Powers Authority
CUPA	Certified Unified Program Agency
СВО	Community Based Organization
СМА	Congestion Management Agency
CDPH	California Department of Public Health
DBW	Department of Boating and Waterways
DFW	Department of Fish and Wildlife
DPW	Department of public works
DTSC	Department of Toxic Substances Control
DWR	Department of Water Resources
EBDA	East Bay Dischargers Authority
EBMUD	East Bay Municipal Utility District
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HARD	Hayward Area Recreation and Park District
JPC	Joint Policy Committee
МТС	Metropolitan Transportation Commission
NOAA	National Oceanic and Atmospheric Administration
NPO	Non Profit Organization
OPR	Office of Planning and Research
OLSD	Oro Loma Sanitary District
PG&E	Pacific Gas & Electric
PHMSA	Pipeline and Hazardous Materials Safety Administration
RAPC	Regional Airport Planning Committee
RASPA	Regional Airport Systems Planning Analysis
RDA	Regional Development Agency
RWQCB	Regional Water Quality Control Board
BCDC	San Francisco Bay Conservation and Development Commission
SFBRA	San Francisco Bay Restoration Authority
SFEP	San Francisco Estuary Partnership
SWRCB	State Water Resources Control Board
UP	Union Pacific Railroad
USD	Union Sanitary District
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USACE	US Army Corps of Engineers
DOT	US Department of Transportation
WETA	Water Emergency Transportation Authority

Possible Processes

For the ART subregional adaptation responses, the possible planning mechanisms, governance structures or collaborative approaches that could be used to implement adaptation actions were grouped into eight broad categories. These include most of mechanisms, structures and approaches that agencies, organizations and stakeholders in the ART subregion currently use, as well as a new initiative category that indicates the possible need for changes to existing laws and policies, other organizational shifts, or a need for new funding sources.

Capital Planning	Project Planning and Design
Capital improvement plans Caltrans Project in Development (PID)	Private and public development projects Restoration project planning and permits
Codes and Standards	Long-Range Planning
Building codes and standards City ordinances Construction codes Design standards State and federal standards Other standards, e.g., professional organizations or committees	Agency or facility master plan Climate Action Plan Community-based planning Regional Airport Sustainability Plan (RASP) Regional Transportation Plan (RTP) Sustainable Communities Strategy (SCC) Integrated Water Resource Management Plan (IRWMP)
Emergency and Hazard Planning	Land-Use Planning
Emergency and Hazard Planning State or local hazard mitigation plans Emergency response and recovery plans Standardized Emergency Management Systems (SEMS) National Incident Management System	Land-Use Planning General plan Specific plan Land use plan
Emergency and Hazard Planning State or local hazard mitigation plans Emergency response and recovery plans Standardized Emergency Management Systems (SEMS) National Incident Management System Operations	Land-Use Planning General plan Specific plan Land use plan New Initiatives

Action Implementation

Actions are also characterized according to potential priority, phasing, and scale of action implementation. Four of the action characterizations – Unlocking, Do It Yourself, Multi-Benefit, and Long Lead Time – indicate the potential timing or priority of action initiation, while one – Scale – indicates the possible geographic scales at which an action could be implemented.

Action Characterization	Description
Unlocking	Actions that can enable other actions. Some unlocking actions contribute independently to resilience, while others serve primarily as stepping stones to other actions. Unlocking actions are generally high priority for implementation as they are often the foundation on which many other actions depend. However, depending on the vulnerability the action addresses and the potential magnitude of the consequences, not all unlocking actions will be taken first as other actions may be higher priority or provide multiple benefits and therefore would be easier to gain support and funding for.
Do it Yourself (DIY)	Actions that an asset owner or operator could take on independently without the formation of new partnerships or collaborations. DIY does not imply a 'go it alone' approach, as owners and operator will need to comply with existing regulations and it may be beneficial to seek participation from other entities. DIY does indicate the actions that can be taken without changes to existing regulations, possibly using existing funding streams or operational processes such as regular maintenance or upgrades tied to asset lifecycle
Multi-benefit	Actions that will improve asset performance or provide community benefits beyond improving the resilience to climate change. These benefits may including addressing other hazards such as earthquakes, improving the local quality of life, for example through new recreational opportunities, or encouraging the local economy. Investments in actions that provide multiple benefits that in near term can improve sustainability and help to address address existing challenges.
Long Lead Time	Actions that should be implemented early as they generally require the coordination of many partners, will result in formal agreements, joint planning or funding decisions, require difficult decision making or are controversial, include a number of different assets, or require collaborative regional planning or research.
Scale	Indicates the geographic scale at which an action could be carried out. Local actions are those that would be taken at the city or county level; regional actions across the entire nine county Bay Area by the agencies, organizations or entities that operate at this scale; state actions by state agencies or state-wide organizations or entities; or at the federal level by national agencies or partners

The elements of each adaptation response are presented together in the **ART Subregional Adaptation Response Cards**, organized according to the five broader categories. A **Guide** that explains each element presented on the adaptation response cards follows

The ART Subregional Adaptation Responses

Guide to the Adaptation Response Cards

<u>Vulnerability Classification</u>: Indicates whether the vulnerability is related to lack of information, management control challenges, physical qualities or functional qualities.

Vulnerability: A brief description of the subregional vulnerability addressed in the adaptation response. Vulnerabilities are numbered for navigation only and number does not indicate priority.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
Actions are numbered to assist with navigation. They do not to indicate ranking or priority. For actions that can be taken sequentially the numbers indicate that order.	The action or actions to address the identified vulnerability. Some responses include a series of related actions that could or should be taken together.	The type of action, categorized into one of five general themes.	The mechanism(s) through which the action could be implemented. Some processes are existing and possibly ongoing, while others will be new initiatives. There can be more than one process by which to implement any given action.	Agencies and organizations that could be involved in implementing the action. Actors include lead agencies (often asset owners or operators), as well as regulators, funders, and other potential partners.	Guidance for selecting and prioritizing actions.
Action Types	Proc	esses	A	ction Characterization	
 Evaluation – actions to information or conduct Program/Operation – a procedures or manage Policy development – a revise policies and gui Coordination – actions partnerships Education/ outreach – communicate information awareness 	 improve data and t new analyses actions to update plans, ment activities actions to develop or delines to initiate or expand actions to tion and build 	Long–range planning, action plan Land use planning, e.g. Capital planning, e.g., o Operations, e.g., annua Codes and Standards, standards Emergency & hazard p mitigation plans Project planning & des development projects New Initiatives e.g., leg	e.g., master plan, climate ., general plan, specific plan capital improvement plan l budgeting e.g., city ordinance, design olanning e.g., hazard sign, e.g., private and public gislation, ballot measure	Local, Regional, State, Federal: implementation Unlocking: enables other actio Do it Yourself: land owner or r implement within existing law with existing funding sources Multi-Benefit: confers benefits and storm event resilience Long Lead Time: Urgent due to timeframe, near-term impacts process, or large number of ac	e scale(s) of ns nanager could vs and policies and s beyond sea level rise o long implementation , complex planning tors

Information Vulnerability

Vulnerability O1: Information about the effects of sea level rise on groundwater levels and salinity intrusion is insufficient for assessing vulnerability and risk, supporting identification of priority issues, and developing adaptation responses.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
01.1	Coordinate with local, regional, state, and federal agencies, academic researchers, and the private sector to improve the region's understanding of how sea level rise will affect groundwater levels	Evaluation, Coordination	Long-range Planning, New Initiative	USGS, FEMA, NOAA, USACE, RWQCB, ABAG, Regional Agencies, DTSC, Cities, County, Water Districts, Academic Institutions, Private Sector	Unlocking, Multi- benefit, Regional, Long Lead Time
01.2	Develop a collaborative monitoring program to measure groundwater levels and salinity intrusion through cost-sharing or other agreements, and make the data publically available through a centralized database	Evaluation, Coordination	Long-range Planning, Operations, New Initiative	USGS, FEMA, NOAA, USACE, RWQCB, ABAG, DTSC, Cities, County, Water Districts, Private Sector	Unlocking, Multi- benefit, Regional, Long Lead Time

Information Vulnerability

Vulnerability O2: There is limited availability of and access to regionally relevant, current and historic weather data needed to understand flood risk.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
02.1	Develop agreements with state and federal agencies to make historic weather observations easily accessible, improve collection of current weather and water condition data, and provide summarized weather data through a centralized coordinated database	Coordination	New Initiative	NOAA, USGS, USACE, FEMA, DWR, BCDC, SCC, RWQCB	Multi-benefit, Unlocking, Regional, State, Long Lead Time

Information Vulnerability

Vulnerability O3: Flood risk maps rely on historic flooding to determine coastal hazard zones and do not factor in sea level rise. Additionally, many communities do not have access to recent coastal hazard (100-year flood) maps or the underlying data that could support shoreline adaptation planning.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
O3.1	Engage federal agencies including FEMA, NOAA and USGS in a regional coordination effort to ensure the timely update of flood maps and access to data, studies, and models to help the region better understand future risks as sea level rises	Coordination	Long-range Planning, New Initiative	NOAA, USGS, USACE, FEMA, OPR, DWR, ABAG, BCDC, SCC, RWQCB, Cities, County, Flood Control Districts	Unlocking, Multi- benefit, Regional, Long Lead Time

Information Vulnerability

Vulnerability O4: There is a limited understanding of how dynamic baylands habitats such as tidal marshes, intertidal mudflats, and subtidal areas will respond to accelerating sea level rise, or how these habitats will be affected by shoreline adaptation responses (e.g., structural solutions such as levees) that may change tide, wave or sediment conditions.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
04.1	Establish and support a regional research agenda to advance the understanding of how baylands will respond to accelerating sea level rise in light of declining sediment supply and limited space to migrate inland	Evaluation, Coordination	Long-range Planning, New Initiative	EBRPD, HARD, ACFCWCD, SCC, DFW, BCDC, RWQCB, Port, USACE, USFWS, FEMA, City, County, CBOs, Private Sector, SFBRA	Unlocking, Regional, Long Lead Time
04.2	Research and test restoration and management actions that will improve baylands resilience	Evaluation	Project Planning and Design	EBRPD, HARD, ACFCWCD, SCC, DFW, BCDC, RWQCB, Port, USACE, USFWS, FEMA, City, County, CBOs, Private Sector, SFBRA	Unlocking, Regional, Long Lead Time
04.3	Develop and implement a Regional Sediment Management Plan for the Bay	Coordination, Policy Development	Long-range Planning, New Initiative	CSMW, BCDC, USEPA, USACE, RWQCB, LTMS stakeholders, USFWS, NOAA, City DPW, Flood Control Agencies, Private Sector	Unlocking, Multi- benefit, Regional, Long Lead Time

Information Vulnerability

Vulnerability O4 (continued): There is a limited understanding of how dynamic baylands habitats such as tidal marshes, intertidal mudflats, and subtidal areas will respond to accelerating sea level rise, or how these habitats will be affected by shoreline adaptation responses (e.g., structural solutions such as levees) that may change tide, wave or sediment conditions.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
O4.4	Develop a decision-making framework for selecting resilient, multi-objective shoreline adaptation responses given economic, environmental and social equity trade-offs	Policy Development	New Initiative	EBRPD, HARD, ACFCWCD, SCC, DFW, BCDC, RWQCB, Port, USACE, USFWS, FEMA, City, County, CBOs, Private sector, SFBRA	Unlocking, Regional, Long Lead Time

Information Vulnerability

Vulnerability O5: Proactive management of baylands to improve their resilience to sea level rise and storm events involves confronting regulatory requirements related to state and federal threatened, endangered, and special status species. Maintenance, upgrade, repair and restoration of baylands require review and authorization from multiple state and federal agencies, often with limited work windows and restrictions on the type of actions that can be taken.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
O5.1	Research the potential benefits or conflicts of various types of potential baylands adaptation responses to better quantify potential impacts to habitat values and ecosystem services in the short and long term and at the local and regional scale	Evaluation	New Initiative	EBRPD, HARD, ACFCWCD, SCC, DFW, BCDC, RWQCB, Port, USACE, USFWS, FEMA, City, County, CBOs, Private Sector, SFBRA	Unlocking, Regional, Long Lead Time

Management Control Vulnerability

Vulnerability O6: Capital investment planning, design, and funding for new infrastructure or for substantial repairs and improvements to existing infrastructure do not consider sea level rise impacts. Infrastructure designed to remain in place for longer spans of time and that is not built or rebuilt to be resilient to flooding and salt-water exposure will need to be protected or retrofitted long before the end of the expected life of the infrastructure. Resources to maintain or improve existing infrastructure are limited, and investments needed in the future to address sea level rise will affect financial resources, economic opportunities, and communities.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
O6.1	Develop policies or incentives to require or encourage the consideration of sea level rise and storm events in developing, planning, and funding capital investments	Policy Development	Long-range Planning, Land Use Planning, Capital Planning, Codes and Standards	DWR, BCDC, ABAG, MTC, CPUC, Caltrans, CMAs, County, Cities	Do It Yourself, Unlocking, Local, Regional, State
O6.2	Prioritize capital investments and new infrastructure in low-risk areas; in particular, plan and construct new public infrastructure in areas not projected to be at risk of sea level rise or storm events	Policy Development, Program/Operation	Long-range Planning, Land Use Planning, Capital Planning	DWR, BCDC, ABAG, MTC, CPUC, Caltrans, CMAs, County, Cities	Do It Yourself, Local, Regional, State
O6.3	Develop a decision-making framework for determining if substantial repairs or improvements to protect existing infrastructure from sea level and groundwater rise should be made, or if it should be located or relocated in an area not at risk	Policy Development	Long-range Planning, Capital Planning, New Initiative	DWR, BCDC, ABAG, MTC, CPUC, Caltrans, CMAs, County, Cities	Do It Yourself, Unlocking, Local, Regional, State, Long Lead Time

Management Control Vulnerability

Vulnerability O7: Many of the plans, policies, and practices that guide community development, land use planning, emergency planning, and capital investments do not consider sea level rise or the adaptation responses that will be necessary to reduce the vulnerabilities and risks to both natural and built environments associated with sea level rise.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
07.1	Qualify for and maintain the highest feasible rating under the Community Rating System of the National Flood Insurance Program to reduce flood risks and the cost of private property insurance	Policy Development, Program/Operation	Emergency and Hazard Planning	ABAG, FEMA, CalOES, Cities, County	Do It Yourself, Local
07.2	Prepare, adopt, implement, and update comprehensive recovery plans to direct how and where state or federal disaster recovery funds are used to rebuild resilient communities after storm events	Policy Development	Emergency and Hazard Planning	ABAG, FEMA, CalOES, Cities, County	Do It Yourself, Multi- benefit, Local, Regional, State, Long Lead Time
07.3	Require the consideration of sea level rise in land use plans and project designs, e.g., General Plan Safety Elements	Policy Development	Land Use Planning, Codes and Standards	Cities, Counties, OPR	Do It Yourself, Unlocking, Local, Regional, State
07.4	Evaluate the feasibility of applying adaptive management to Land Use Planning and decision making	Evaluation	New Initiative	BCDC, ABAG, MTC, OPR	Regional, State

Management Control Vulnerability

Vulnerability O7 (continued): Many of the plans, policies, and practices that guide community development, land use planning, emergency planning, and capital investments do not consider sea level rise or the adaptation responses that will be necessary to reduce the vulnerabilities and risks to both natural and built environments associated with sea level rise.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
07.5	Improve coordination among agencies to ensure consistent regulatory and planning approaches to sea level rise adaptation, and to reduce programmatic or legislative barriers to assessing and addressing future risks	Coordination, Policy Development	Long-range Planning	BCDC, ABAG, MTC, Cities, County	Unlocking, Regional, Long Lead Time
07.6	Develop incentives for clustered development in low-risk areas using density bonuses, reduced impact fees, tax incentives and streamlined permitting	Policy Development	Long-range Planning, Land Use Planning	BCDC, ABAG, MTC, OPR, Cities, County, California Natural Resources Agency	Do It Yourself, Local, Regional, State
07.7	Create a voluntary transfer of development rights program to allow property owners to sell development rights in high-risk areas in exchange for rights in a low-risk areas	Policy Development	Land Use Planning, Codes and Standards	Cities, County, State	Do It Yourself, Local, Regional, State
07.8	Use rolling easements to establish a boundary that moves inward as sea level rises along the Bay shoreline	Policy Development	Long-range Planning, Land Use Planning, Legislation	Cities, County, Special Districts, State	Do It Yourself, Local, Regional, State

Management Control Vulnerability

Vulnerability O8: Non-profit, faith, and community-based organizations play a critical role in building and maintaining community resilience. Many of these organizations do not have the capacity to fully participate in climate planning efforts. Government agencies and organizations also lack the capacity and processes to engage non-governmental organizations in planning and decision-making to ensure the robust, sustained partnerships that will be necessary to address climate change in an equitable, environmentally conscientious, and economically feasible manner.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
O8.1	Conduct community-led campaigns to build public support for community groups and leaders to participate in collaborative efforts to address current and future climate stressors, including sea level rise and storm events	Education/ Outreach	Long-range Planning, New Initiative	BCDC, ABAG, MTC, BAAQMD, Cities, Counties, NPOs, CBOs, CDPH	Unlocking, Local, Regional
O8.2	Work with decision-makers to provide public funds for community groups to participate in local climate resilience building efforts, for example in developing and implementing local climate adaptation plans or conducting public education on local climate impacts and emergency response in multiple languages	Policy Development	New Initiative	BCDC, ABAG, MTC, BAAQMD, Cities, Counties, NPOs, CBOs, CDPH, State, Federal	Unlocking, Regional, State, Federal, Long Lead Time
O8.3	Create and implement a framework that government agencies, organizations and community partners can use to engage in open, transparent, and well publicized planning and decision making processes	Education/ Outreach, Program/ Operation	New Initiative	BCDC, ABAG, MTC, BAAQMD, Cities, Counties, NPOs, CBOs, CDPH	Multi-benefit, Local, Regional, Long Lead Time

Functional Vulnerability

Vulnerability O9: Proper functioning of utilities, which themselves are vulnerable to sea level rise and storm events, is essential for communities to effectively respond during a disaster, and for communities, businesses, the airport, seaport, parks and recreation areas, and natural shorelines to function on a day-to-day basis.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
O9.1	Reduce downstream flood risk and stress on stormwater and flood control systems by minimizing runoff volumes and peak flow rates from new developments and substantial redevelopments using site- specific low impact design (LID) and source control techniques	Policy Development	Land Use Planning, Codes and Standards	Cities, County, RWQCB, SFEP	Do It Yourself, Multi- benefit, Local, Regional
O9.2	Avoid new development and substantial redevelopments that will require expanding the capacity of utilities and infrastructure in areas at risk	Policy Development	Land Use Planning, Codes and Standards	Cities, County, RWQCB, CPUC, City DPW, ACFCWCD	Local, Regional

Functional Vulnerability

Vulnerability O10: Some assets along the Bay shoreline function as a continuous corridor, or as a series of linked segments, and impacts to one segment of the Bay shoreline can compromise the function of the other segments. This is especially true of the system of natural and structural shorelines along the Bay edge; energy, gas, and pipelines infrastructure; and for long, linear ground transportation assets such as the Bay Trail and the regional rail network.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
O10.1	Conduct a regional evaluation of transportation and utility networks that are vulnerable to sea level rise to determine hot spots or weak links that would cause significant disruption to the regional economy and quality of life	Evaluation	Long-range Planning, Operations, Capital Planning	Caltrans, BART, CCJPA, UP, PG&E, Kinder Morgan, EBMUD, EBDA, Cities, County, MTC, Private Sector, Regional Agencies	Do It Yourself, Unlocking, Regional
O10.2	Conduct a regional evaluation of structural shorelines and determine how they are connected/interconnected to natural shorelines in providing flood risk reduction benefits	Evaluation	New Initiative	Cities, County, USACE, EBRPD, HARD, ABAG (Bay Trail), DFW, USFWS, BCDC, City DPW, ACFCWCD, SCC, Regional Agencies	Unlocking, Regional

Physical Vulnerability

Vulnerability O11: Changes in groundwater levels due to sea level rise may increase the risk of liquefaction during an earthquake. Residences, utilities and other infrastructures that are not designed for these conditions are likely to be damaged during an earthquake. Long, linear infrastructure such as utility pipelines, surface roads, and rail lines are highly susceptible to damage during earthquakes, particularly due to liquefaction. Much of the airport is built on Bay fill, which has a high liquefaction potential. During an earthquake, liquefaction could cause damage to runways and other infrastructure, and could cause the perimeter levee to fail.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
011.1	Conduct a regional study on the impacts of rising sea level on groundwater elevations, and on the potential for increased liquefaction potential	Evaluation	New Initiative	USGS, FEMA, NOAA, USACE, RWQCB, Regional Agencies, ABAG, DTSC, Cities, County, Water Districts, MTC, Caltrans, BCDC, Private Sector	Unlocking, Multi- benefit, Regional
011.2	Conduct vulnerability assessments of critical infrastructure and land uses in areas exposed to sea level rise and liquefaction to identify strategies that can improve resilience to both hazards	Evaluation	Long-range Planning, New Initiative	ABAG, Caltrans, MTC, BCDC, ABAG, Special Districts, Cities, County, Private Sector	Do It Yourself, Unlocking, Multi- benefit, Local, Regional

Physical Vulnerability

Vulnerability O12: Public health, safety, and welfare are at risk from sea level rise and storm events, particularly where the land uses are predominately residential, e.g., single-family, multi-family, and senior housing. These communities were developed in a manner that makes protecting them from future flood risks extremely challenging. It is likely that planning for future growth in the region will follow this past pattern without consideration of future flooding, increasing the number of people at risk.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
012.1	Initiate a regional collaboration to discuss and analyze approaches to improve the resilience of current vulnerable communities and how to plan future growth to avoid placing more of the region's population at risk	Evaluation, Coordination	New Initiative	Local, Regional, State, Federal, Private sector, NPOs, CBOs	Unlocking, Regional, Long Lead Time
012.2	Improve regional coordination on policies targeted at improving Bay Area resilience to climate change	Coordination	Long-range Planning, New Initiative	JPC Agencies	Unlocking, Regional, Long Lead Time

Information Vulnerability

Vulnerability T1: There is a lack of detailed, easily accessible, and well-coordinated transportation infrastructure information, which is necessary for vulnerability and risk assessments.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T1.1	Review existing transportation asset management plans to identify gaps in completeness, quality and accessibility of information most relevant to emergency response, adaptation planning, and federal funding	Evaluation	New Initiative	ABAG, BCDC, MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, FTA, FHWA	Do It Yourself, Unlocking, Multi- benefit, Local, Regional
T1.2	Develop and maintain transportation asset management plans with information on structures, including age, condition, expected useful life, replacement cost, rehabilitation schedule and costs, location, elevation, etc.	Program/operation	New Initiative, Long- range Planning, Capital Planning, Project Planning and Design	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, FTA, FHWA	Do It Yourself, Multi- benefit, Local, Regional
T1.3	Adopt data management and sharing agreements among transportation asset managers to ensure that complete and high quality asset information is available and accessible	Policy Development	New Initiative	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA	Multi-benefit, Regional, State, Federal

Information Vulnerability

Vulnerability T1 (continued): There is a lack of detailed, easily accessible, and well-coordinated transportation infrastructure information, which is necessary for vulnerability and risk assessments.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T1.4	Develop and maintain a centralized database of key transportation asset information that non-transportation agencies and organizations can use in planning for sea level rise and storm events	Program/operation	New Initiative	ABAG, BCDC, MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, CBOs	Multi-benefit, Local, Regional, Long Lead Time

Management Control Vulnerability

Vulnerability T2: The number and relationships of public agencies and private entities that own and operate transportation assets complicates planning and implementing improvements or use changes. Due to the function and physical characteristics of these assets, numerous agencies and organizations will be affected by the temporary disruption and permanent loss, or adaptation responses for, transportation assets.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T2.1	Develop multi-agency agreements that result in shared transportation management objectives and identify decision- making and funding responsibilities related to maintenance, repair, or upgrade	Coordination, Policy Development	New Initiative	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA	Unlocking, Multi- benefit, Local, Regional, Long Lead Time
T2.2	Expand or form broad public- private partnerships (multi- sector/agency) to guide the planning and implementation of multi-objective transportation improvements and new investments that are resilient to sea level rise and storm events	Coordination	Long-range Planning, New Initiative	ABAG, MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, CBOs, Private Sector	Unlocking, Local, Regional
T2.3	Work with adjacent communities, regions, and states to develop and jointly implement transportation adaptation strategies that address changes in transportation system condition and use due to sea level rise and storm events	Coordination	New Initiative, Emergency and Hazard Planning	ABAG, BCDC, MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Adjacent Regions and States	Multi-benefit, Regional, State, Federal, Long Lead Time

Management Control Vulnerability

Vulnerability T3: The capacity to plan for sea level rise and storm event impacts on transportation infrastructure in a timely manner is limited due to the current lack of financing and regulatory mechanisms.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T3.1	Expand or form multi-agency partnerships to facilitate cost- sharing in planning for multi- objective transportation improvements and new investments that avoid or address sea level rise and storm events	Coordination, Policy Development	Long-range Planning, New Initiative	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA	Local, Regional, Long Lead Time
T3.2	Review and update existing policies, procedures, and practices, particularly weather- related planning and management, to support the planning, design, or redesign of transportation assets to reduce vulnerabilities to sea level rise and storm events	Evaluation, Policy Development	Operations, Codes and Standards, Project Planning and Design	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, FTA, FHWA	Do It Yourself, Local, Regional, State, Federal
Т3.3	Require an evaluation of sea level rise and storm events in planning capital improvements and infrastructure investments, including an evaluation of whether an alternative location or design would reduce future risks and lifecycle costs	Policy Development, Program/operation	Long-range Planning, Codes and Standards, Capital Planning, Project Planning and Design	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, FTA, FHWA	Do It Yourself, Local, Regional, State, Federal

Management Control Vulnerability

Vulnerability T4: Public agencies and private entities that own or manage transportation assets do not have control over the surrounding land, road, or transit that provide access to their facilities or services, or in some cases provide protection against flooding. Ensuring that access to these facilities remains viable and that current levels of flood protection are maintained will require cooperation that goes beyond the agencies operating the transportation infrastructure. This is of particular importance to regionally and nationally significant infrastructure such as the Oakland International Airport, the Port of Oakland seaport, the interstate system, and lifeline facilities.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T4.1	Form partnerships among public agencies and private entities to engage in collaborative multi- objective planning to improve the resilience of vulnerable transportation assets, the populations and facilities they serve, and the inland areas they protect as the first line of defense against flooding	Coordination	Long-range Planning, New Initiative	ABAG, BCDC, MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, CBOs, Private Sector, USACE, FEMA	Unlocking, Local, Regional, Long Lead Time
T4.2	Develop a framework for regional transportation planning (particularly transit-oriented development plans) and for the acquisition of easements and access agreements that incorporates sea level rise and storm events	Policy Development	Long-range Planning	ABAG, BCDC, MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, CBOs, Private Sector, USACE, FEMA	Unlocking, Regional

Functional Vulnerability

Vulnerability T5: Alternative routes have limited additional capacity to accommodate re-routed commuter traffic (e.g., buses or carpools) or goods movement. If significant roadways or nodes are disrupted, re-routing would result in heavy congestion that could overwhelm the region's roadways and interstates as well as non-motorized transportation corridors (bike and pedestrian).

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T5.1	Conduct a "hot spot" analysis to identify key routes and nodes critical to traffic flow, assess their vulnerability and risk, and develop actions to improve their resilience to sea level rise and storm events	Evaluation	Long-range Planning, Operations, Emergency and Hazard Planning, New Initiative	ABAG, MTC, Caltrans, AC Transit, County, Cities, CMA	Do It Yourself, Unlocking, Multi- benefit, Local, Regional
T5.2	Identify and invest in non-motorized transportation corridors (bike and pedestrian) that will provide alternatives if significant roadways and interstates are disrupted	Program/operation	Long-range Planning, Operations, Capital Planning, Emergency and Hazard Planning, Project Planning and Design	ABAG, MTC, Caltrans, AC Transit, County, Cities, CMA	Multi-benefit, Local, Regional
Т5.3	Increase the capacity to accommodate re-routed traffic on alternative routes, or build new routes, in areas not at risk from sea level rise and storm events	Program/operation	Long-range Planning, Capital Planning	MTC, Caltrans, AC Transit, County, Cities, CMA	Local, Regional, Long Lead Time
Т5.4	Develop currently underused, unused, or new pedestrian rights- of-way as non-motorized emergency evacuation alternative routes	Program/operation	Capital Planning, Operations, Codes and Standards, Project Planning and Design, Emergency and Hazard Planning	MTC, Caltrans, AC Transit, County, Cities, CMA	Multi-benefit, Local, Regional

Functional Vulnerability

Vulnerability T5 (continued): Alternative routes have limited additional capacity to accommodate re-routed commuter traffic (e.g., buses or carpools) or goods movement. If significant roadways or nodes are disrupted, re-routing would result in heavy congestion that could overwhelm the region's roadways and interstates as well as non-motorized transportation corridors (bike and pedestrian).

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T5.5	Prioritize funding to improve alternative ground transportation routes, enhance or develop public transportation, bike and pedestrian options, and replace or retrofit vulnerable critical lifeline infrastructure	Policy Development	Long-range Planning, Capital Planning	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA	Multi-benefit, Local, Regional, State, Federal

Functional Vulnerability

Vulnerability T6: The temporary disruption or permanent loss of public transportation assets due to sea level rise and storm events, and the lack of sufficient alternatives, could leave residents in some communities unable to travel on a day-to-day basis, compounding evacuation challenges during an emergency.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T6.1	Identify public transportation assets at-risk of flooding that serve transit-dependent populations	Evaluation	Long-range Planning, Operations, New Initiative	MTC, Caltrans, BART, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, County Health, CBOs	Do It Yourself, Unlocking, Local, Regional
T6.2	Proactively protect public transportation assets that serve transit-dependent populations, or prioritize development of alternative transit options to serve these populations	Program/ operation	Capital Planning, Operations, Codes and Standards, Project Planning and Design	MTC, Caltrans, BART, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, County Health, CBOs	Local, Regional
Т6.3	Include strategies that ensure the safe evacuation of transit- dependent populations in emergency response plans, e.g., designate evacuation routes and bus assignments, coordinate with local school bus fleets, transportation service providers, and wheelchair accessible vehicles to expand the pool of available vehicles for evacuation	Program/ operation	Emergency and Hazard Planning	ABAG, MTC, Caltrans, BART, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, County Health, CBOs, CalEMA	Multi-benefit, Local, Regional

Functional Vulnerability

Vulnerability T7: The rail system lacks redundancy, and fixed stations and maintenance yards serve long, linear lengths of track. The interconnected nature of rail and the lack of redundancy mean that damage at any point in the system can disrupt commuter and goods movement system-wide, causing significant economic effects in the region, particularly if there is a loss of service to the seaport or airport. Repair or relocation of rail infrastructure may require significant investment to ensure public safety and security.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T7.1	Conduct an assessment to identify hot spots or weak links in the regional rail system (fixed facilities and track) that are vulnerable to sea level rise and storm events (in particular, assets along the shoreline, in low-lying areas, on levees, or across tidal streams or the Bay) and to identify areas of potential conflict where other infrastructure is either above or below the rail line, or where the line or facilities are in or adjacent to high value natural areas	Evaluation	Long-range Planning, Operations, Emergency and Hazard Planning, New Initiative	MTC, BART, UP, Amtrak, CCJPA, Caltrans, Transportation Authorities, Cities, Counties, CPUC, FRA	Do It Yourself, Unlocking, Regional
T7.2	Prioritize maintenance, repair, and retrofit of bridges and levees vulnerable to damage from sea level rise and storm events	Program/operation	Capital Planning, Operations	BCDC, USACE, RWQCB, MTC, UP, Caltrans, CCJPA, Cities, Counties	Do It Yourself, Regional

Functional Vulnerability

Vulnerability T7 (continued): The rail system lacks redundancy, and fixed stations and maintenance yards serve long, linear lengths of track. The interconnected nature of rail and the lack of redundancy mean that damage at any point in the system can disrupt commuter and goods movement system-wide, causing significant economic effects in the region, particularly if there is a loss of service to the seaport or airport. Repair or relocation of rail infrastructure may require significant investment to ensure public safety and security.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T7.3	Develop or update Continuity of Operations Plans (COOPs) to include sea level rise and storm events, and work with other regional transportation providers to identify alternative facilities and services to provide continuity of operations during an emergency	Program/operation	Emergency and Hazard Planning, Operations	MTC, Caltrans, BART, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Private Sector, CBOs	Multi-benefit, Regional, Long Lead Time
Т7.4	Develop design standards for new infrastructure and capital improvements investments that will protect critical elements from sea level and groundwater rise	Policy Development	Codes and Standards, Capital Planning, Long range Planning	UP, Amtrak, Caltrans, CCJPA, Cities, Counties	Do It Yourself, Unlocking, Regional
T7.5	Install manual, remote control, or automatic temporary barriers or waterproof closures to protect at- or below-grade critical elements such as station entrances, tunnels, maintenance facilities, asset storage areas, and rail alignments	Program/operation	Capital Planning, Operations, Codes and Standards, Project Planning and Design	UP, Amtrak, Caltrans, CCJPA, Cities, Counties	Do It Yourself, Unlocking, Regional

Functional Vulnerability

Vulnerability T7 (continued): The rail system lacks redundancy, and fixed stations and maintenance yards serve long, linear lengths of track. The interconnected nature of rail and the lack of redundancy mean that damage at any point in the system can disrupt commuter and goods movement system-wide, causing significant economic effects in the region, particularly if there is a loss of service to the seaport or airport. Repair or relocation of rail infrastructure may require significant investment to ensure public safety and security.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
Т7.6	Construct permanent structures to protect at- or below-grade critical elements such as station entrances, tunnels, maintenance facilities, and asset storage areas	Program/operation	Capital Planning, Operations, Codes and Standards, Project Planning and Design	UP, Amtrak, Caltrans, CCJPA, Cities, Counties	Do It Yourself, Unlocking, Regional
T7.7	Raise the elevation of at- or below- grade critical elements such as station entrances, maintenance yards, and rail alignments	Program/operation	Capital Planning, Operations, Codes and Standards, Project Planning and Design	UP, Amtrak, Caltrans, CCJPA, Cities, Counties	Do It Yourself, Unlocking, Regional
T7.8	Relocate critical elements that are necessary to ensure regional rail system function to areas that are not at risk from sea level rise and storm events	Program/operation	Capital Planning, Land use planning, Project Planning and Design	UP, Amtrak, Caltrans, CCJPA, Cities, Counties	Regional, Long Lead Time
T7.9	Develop a decision-making framework for determining if new infrastructure and capital improvements should be protected from sea level and groundwater rise, or if the infrastructure should be located/relocated in an area not at risk from sea level rise and storm events	Policy Development	Long-range Planning, New Initiative	UP, Amtrak, CCJPA, CPUC, FRA, Private Sector, CBOs, BCDC, ABAG, MTC	Unlocking, Regional, Long Lead Time

Functional Vulnerability

Vulnerability T8: Certain communities or facilities are linked by only one or two access-ways (e.g., road, rail, or transit) and could become isolated during disasters. For example, the majority of access roads to the Port of Oakland's seaport and Oakland International Airport are vulnerable, and if they flood they could isolate these regionally significant facilities.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T8.1	Identify specific communities and facilities served by limited or sole access-ways that are vulnerable to sea level rise and storm events	Evaluation	New Initiative	MTC, Caltrans, BART, AC Transit, County, Cities, CMA, CCJPA, Port, UP, WETA, County Health, CBOs	Do It Yourself, Unlocking, Local, Regional
T8.2	Prioritize protection of sole or limited access to communities or facilities, and/or develop alternative access to these communities and facilities	Program/operation	Long-range Planning, Capital Planning	MTC, Caltrans, BART, AC Transit, County, Cities, CMA, CCJPA, Port, UP, WETA, County Health, CBOs	Local, Regional, Long Lead Time
Т8.3	Develop and adopt plans for future relocation of people, uses, and services that are at risk of becoming isolated where sole or limited access-ways cannot be improved or protected, and where no other alternative means of access is feasible	Program/operation	Long-range Planning	ABAG, MTC, Caltrans, BART, AC Transit, County, Cities, CMA, CCJPA, Port, UP, WETA, County Health, Private Sector, CBOs	Local, Regional, Long Lead Time

Functional Vulnerability

Vulnerability T9: The Port of Oakland seaport exports a significant amount of perishable goods, such as agricultural products. Sea level rise and storm events could delay and disrupt the movement and delivery of these goods.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
Т9.1	Review and improve understanding of critical partners, timelines, and pathways for perishable goods movement, using past disruptions at the Port of Oakland as a source	Evaluation	Operations	Port, Private Sector	Do It Yourself, Unlocking, Local
T9.2	Conduct an economic analysis of the consequences of perishable goods not being delivered, using past disruptions at the Port of Oakland to inform understanding of the types of products that would perish if delivery is delayed and the length of time within which a delivery would have to be made	Evaluation	Long-range Planning, New Initiative	Port, Private Sector	Do It Yourself, Multi- benefit, Local
Т9.3	Develop contingency plans for perishable goods if seaport operations are disrupted, including developing secondary markets and alternative transportation options	Program/operation	Long-range Planning, New Initiative	Port, Private Sector	Do It Yourself, Local
Т9.4	Identify other seaport facilities in the Bay Area that may serve as a backup to the Port of Oakland for perishable goods export	Evaluation	Long-range Planning, New Initiative	Northern California Ports	Regional, State

Functional Vulnerability

Vulnerability T10: The seaport facilities in the San Francisco Bay region do not have sufficient capacity to handle additional cargo if operations at the Port of Oakland seaport were disrupted by sea level rise and storm events.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T10.1	Update plans that evaluate the capacity for handling different types of cargo at the region's seaports, e.g., the Cargo Monitoring Report, Seaport Plan, and seaport Master Plans to factor in sea level rise and storm events	Policy Development, Program/operation	Long-range Planning	Port, BCDC, MTC	Do It Yourself, Unlocking, Local, Regional
T10.2	Develop contingency plans for using other port facilities within or outside of the region in the event of temporary or permanent disruption at the Port of Oakland	Policy Development	Long-range Planning, New Initiative	Northern California Ports	Multi-benefit, Regional, State

Functional Vulnerability

Vulnerability T11: There is not sufficient commercial airport runway capacity in the San Francisco Bay Area to serve as a short- or long-term alternative to Oakland International Airport if it were damaged or disrupted due to sea level rise or storm events.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T11.1	Update the San Francisco Bay Area's Regional Airport Systems Planning Analysis (RASPA) to consider sea level rise, storm events, earthquakes, and other hazards	Evaluation	Long-range Planning	RAPC, ABAG, BCDC, MTC, Regional Airports, FAA	Unlocking, Regional
T11.2	Analyze sea level rise, storm events, earthquakes, and other hazards in updating the Master Plans of the region's airports	Evaluation	Long-range Planning	Regional Airports, FAA	Unlocking, Local, Regional
T11.3	Consider sea level rise and storm event impacts when developing passenger and cargo demand projections for the region's runway capacity	Program/operation	Long-range Planning	Regional Airports, FAA	Regional
T11.4	Develop a stakeholder group to identify sea level rise and storm event adaption options for the Oakland International Airport that considers airport assets, key infrastructure that the airport relies on (transportation, power, water, etc.), and opportunities to benefit adjacent, non-airport vulnerable assets	Coordination	New Initiative	Port, FAA, RAPC, ABAG, BCDC, MTC, Cities, Counties, CBOs, Private Sector	Local, Regional, High Priority

Physical Vulnerability

Vulnerability T12: Many high-cost and critical elements of transportation infrastructure are highly vulnerable to flooding because they are located at or below grade (tubes, tunnels, ventilation), in low-lying areas (airport runways, storage and maintenance facilities), or on top of levees (rail alignments).

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T12.1	Manage stormwater at or near critical facilities and transportation elements by prioritizing regular maintenance, investing in drainage improvements (under or cross drains, backflow or flex valves, perimeter walls or pile/column foundations), and using low impact development (LID) techniques	Program/operation	Capital Planning, Operations, Codes and Standards	RWQCB, MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Local, Regional
T12.2	Prepare for recovery from flooding by stockpiling materials, establishing turn- key agreements for equipment rental, and pre-positioning emergency power generation capacity, portable pumps, and debris removal equipment	Program/operation	Emergency and Hazard Planning	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Multi- benefit, Local, Regional
T12.3	Identify locations that are not at risk of flooding to temporarily store mobile equipment, rolling stock, or other assets (may require agreements or permission from private property owners), and develop clear procedures for how and when to use these sites when flooding is predicted	Program/operation	Emergency and Hazard Planning	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Local, Regional

Physical Vulnerability

Vulnerability T12 (continued): Many high-cost and critical elements of transportation infrastructure are highly vulnerable to flooding because they are located at or below grade (tubes, tunnels, ventilation), in low-lying areas (airport runways, storage and maintenance facilities), or on top of levees (rail alignments).

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T12.4	Install manual, remote control, or automatic temporary barriers or waterproof closures to protect at- or below-grade critical elements such as roadways, tube and tunnel openings, ventilation grates, switchgears, maintenance facilities, and asset storage areas	Program/operation	Capital Planning, Project Design and Planning	Caltrans, BART, Port, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Local, Regional
T12.5	Construct permanent structures to protect at- or below-grade critical elements such as roadways, tube and tunnel openings, ventilation grates, switchgears, maintenance facilities, and asset storage areas	Program/operation	Capital Planning, Project Design and Planning	Caltrans, BART, Port, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Local, Regional
T12.6	Raise the elevation of at- or below-grade critical elements such as entrances, mechanical or electrical equipment, and ventilation grates	Program/operation	Capital Planning, Project Design and Planning	Caltrans, BART, Port, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Local, Regional
T12.7	Develop or improve design standards to require protection of new infrastructure and capital improvement investments from sea level rise, storm events, and elevated groundwater levels	Policy Development	Codes and Standards	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Local, Regional, Long Lead Time

Physical Vulnerability

Vulnerability T12 (continued): Many high-cost and critical elements of transportation infrastructure are highly vulnerable to flooding because they are located at or below grade (tubes, tunnels, ventilation), in low-lying areas (airport runways, storage and maintenance facilities), or on top of levees (rail alignments).

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T12.8	Relocate critical transportation system components to areas that are not at risk from sea level rise or storm events	Program/operation	Capital Planning, Project Design and Planning	MTC, Caltrans, BART, Port, County, Cities, CMA, CCJPA, UP, WETA, Private Sector, CBOs	Local, Regional, Long Lead Time

Physical Vulnerability

Vulnerability T13: Water and salt-sensitive electronic and mechanical components and power supplies critical to the continued function of transportation infrastructure are often at or below grade and therefore are vulnerable to sea level rise, storm events, and elevated groundwater levels.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T13.1	Monitor groundwater and salinity levels near vulnerable infrastructure by leveraging existing data or collecting site- specific data as necessary	Evaluation	Operations, New Initiative	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Unlocking, Local, Regional
T13.2	Increase inspection and maintenance of infrastructure that is sensitive to water or salt in areas at risk from sea level rise, storm events, or elevated groundwater levels	Program/operation	Operations	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Multi- benefit, Local, Regional
T13.3	Review and update standards, codes, and regulations for the construction and placement of transportation infrastructure to avoid or address sea level rise, storm events, and elevated groundwater levels	Policy Development	Codes and Standards	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Unlocking, Local, Regional, Long Lead Time
T13.4	Follow existing or develop new standards requiring that waterproof materials be used in the construction of new infrastructure and in the repair or protection of existing infrastructure	Policy Development, Program/operation	Operations, Project Planning and Design, Codes and Standards	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, FEMA, CalEMA, Private Sector	Do It Yourself, Local, Regional, State, Federal

Physical Vulnerability

Vulnerability T13 (continued): Water and salt-sensitive electronic and mechanical components and power supplies critical to the continued function of transportation infrastructure are often at or below grade and therefore are vulnerable to sea level rise, storm events, and elevated groundwater levels.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T13.5	Follow existing or develop new standards to ensure corrosion-resistant materials or cathodic coatings are used when installing new or upgrading existing cables and pipelines	Policy Development, Program/operation	Operations, Project Planning and Design, Codes and Standards	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, FEMA, CalEMA, Private Sector	Do It Yourself, Local, Regional, State, Federal
T13.6	Follow existing or develop new standards requiring elevation of sensitive components above anticipated flood levels	Policy Development, Program/operation	Operations, Project Planning and Design, Codes and Standards	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, FEMA, CalEMA, Private Sector	Do It Yourself, Local, Regional, State, Federal
T13.7	Require adequate backup power to minimize interruptions to critical facilities, including lifeline facilities, e.g., on-site power generators with sufficient fuel for several days, portable backup power generators, or pre-position access through rental or leasing agreement	Policy Development, Program/operation	Operations, Codes and Standards	MTC, Caltrans, BART, Port, AC Transit, County, Cities, CMA, CCJPA, UP, WETA, Private Sector	Do It Yourself, Multi- benefit, Local, Regional

Physical Vulnerability

Vulnerability T14: Certain assets such as bridges across tidal streams or in the Bay, and infrastructure located under the wharves at the Port of Oakland seaport, may be increasingly vulnerable to high water levels and wave erosion during storm events, which can disrupt asset function, cause scour, require additional maintenance, and potentially shorten asset life span.

Action Number	Action	Action Type	Process	Possible Actors	Action Characterization
T14.1	Conduct analyses of critical infrastructure to identify the potential for increased erosion, scour and wear due to increased tide and wave energy	Evaluation	New Initiative, Operations	BART, Caltrans, Port, County, Cities, UP, CCJPA, WETA, CMA	Do It Yourself, Unlocking, Local, Regional
T14.2	Require and implement improvements to, and new investments in, existing infrastructure across tidal streams or in the Bay to increase resilience to sea level rise and storm events	Policy Development, Program/operation	Codes and Standards, Capital Planning	BCDC, RWQCB, USACE, FEMA, NOAA, BART, Caltrans, Port, County, Cities, UP, CCJPA, WETA, CMA	Local, Regional

Sources Used to Develop the ART Subregional Adaptation Responses

Input from Subregional ART Working Group Working Group Meeting #9, March 26, 2013 http://www.adaptingtorisingtides.org/news-events/

Adapting to Climate Change: A Planning Guide for State Coastal Managers NOAA Ocean and Coastal Resources Management Center for Climate Strategies http://coastalmanagement.noaa.gov/climate/adaptation.html

Synthesis of Adaptation Options for Coastal Areas EPA Climate Ready Estuaries http://www.epa.gov/climatereadyestuaries/downloads/CRE_Synthesis_1.09.pdf

Flood Damage Reduction Measures US Army Corps of Engineers http://www.nwo.usace.army.mil/nfpc/NFPC_Measures_Matrix.pdf

Center for Climate Strategies Adaptation Guidebook: Comprehensive Climate Action Center for Climate Action http://www.climatechange.ca.gov/ecrcf/docs/CCSAdaptationGuidebook2011.pdf

California Climate Adaptation Planning Guide California Natural Resources Agency and California Emergency Management Agency http://resources.ca.gov/climate_adaptation/local_government/adaptation_policy_guide.html

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Flooded Bus Barns and Buckled Rails: Public Transportation and Climate Change Adaptation Federal Transit Administration Office of Research, Demonstration and Innovation http://www.fta.dot.gov/research

Taming Natural Disasters: ABAG Multi-Jurisdictional Local Hazard Mitigation Plan for the San Francisco Bay Area (2010 Update of 2005 Plan) Association of Bay Area Governments http://quake.abag.ca.gov/mitigation/

Adapting to Climate Change Project Summary Report and Action Plan City of Castlegar and Colombia Basin Trust http://www.cbt.org/Initiatives/Climate_Change