EAST BAY CRESCENT - RICHMOND FOCUS AREA

EXAMPLE APPLICATION OF THE ADAPTATION PLANNING PROCESS

DRAFT – December 2019

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DISCLAIMER

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ACRONYMS / ABBREVIATIONS

Acronym	Signification
ACS	American Communities Survey
ART	Adapting to Rise Tides
BCDC	San Francisco Bay Conservation and Development Commission
OLU	Operational Landscape Unit
CBO	Community-based Organization
SFEI	San Francisco Estuary Institute
TWL	Total Water Level
PMT	Project Management Team
MTC	Metropolitan Transportation Commission
EBMUD	East Bay Municipal Utility District

1 Introduction

Since its inception in 2010, the Adapting to Rising Tides (ART) program has developed tools and resources to support sea level rise (SLR) and climate change adaptation planning for the nine San Francisco Bay Area counties. Most recently, the program developed an 8-step "Adaptation Guidance" (Guidance) document to advance and support adaptation planning by local communities and municipalities (Figure 1). This example application of the Guidance (this report) uses a portion of the City of Richmond's shoreline in the East Bay Crescent Operational Landscape Unit (OLU), (East Bay Crescent) as a preliminary focus area (Figure 2). Note that while the Guidance includes a detailed explanation of what each step in the process should consist of, in the interest of brevity that detail is not reproduced in this report. The goal of this planning exercise is to test the Guidance and provide feedback on how the ART tools and resources can be used to support or reinforce each step. These findings are intended to help BCDC refine their adaptation process document and demonstrate to local communities how the adaptation process can be applied using a hypothetical adaptation planning process at an actual San Francisco Bay shoreline location.

A study area in the East Bay Crescent OLU was chosen for this exercise in consultation with the Adapting to Rising Tides Project Management Team (PMT) based on the ART Regional Sea Level Rise Vulnerability Assessment Framework. This Framework assessed the relative vulnerability of the 30 OLUs in the Bay Area based on impacts to transportation, priority development areas, priority conservation areas, and vulnerable communities. The 15 most vulnerable OLUs were considered, based on the Framework scores for the 36" total water level (TWL) scenario. The 36" TWL scenario was used because this is the highest sea level rise scenario considered by MTC's Horizon initiative. In addition to vulnerability scores, the PMT wished to consider: 1) areas where no in-depth sea level rise planning process was in place or currently underway, 2) areas that included a variety of shoreline and land use types, and 3) areas that included a significant Caltrans asset (in order to recognize the transportation focus of the grant funding for this project). Based on these factors, the East Bay Crescent and Suisun Slough OLUs were selected to test the guidance. Adaptation strategies for Suisun Slough are explored in a separate report.

This size of the entire East Bay Crescent OLU was too large for this exercise. A smaller study area was chosen that includes many factors that are representative of sea level rise adaptation challenges in many regions of the Bay Area: marsh habitat in danger of inundation, critical transportation infrastructure, sites contaminated by pollutants, and residential areas with high social vulnerability. For a detailed description of how this study area was delineated, please see 4.1.1 Study Area Delineation. This document is not intended to be a formal sea level rise adaptation plan for the chosen study area. This application of the Guidance did not include engagement with the City, affected communities, businesses, or landowners. This test application was completed to inform the Guidance, and the identified adaptation actions and strategies should only be considered as potential examples for application in East Bay Crescent. In practice, the City or its designee would lead the application of the Guidance, and substantive community outreach and engagement would be required to confirm local vulnerabilities, identify a potential suite of actions and strategies to mitigate or reduce those vulnerabilities, solicit input and feedback from the community, and evaluate those actions and strategies to develop preferred solutions.

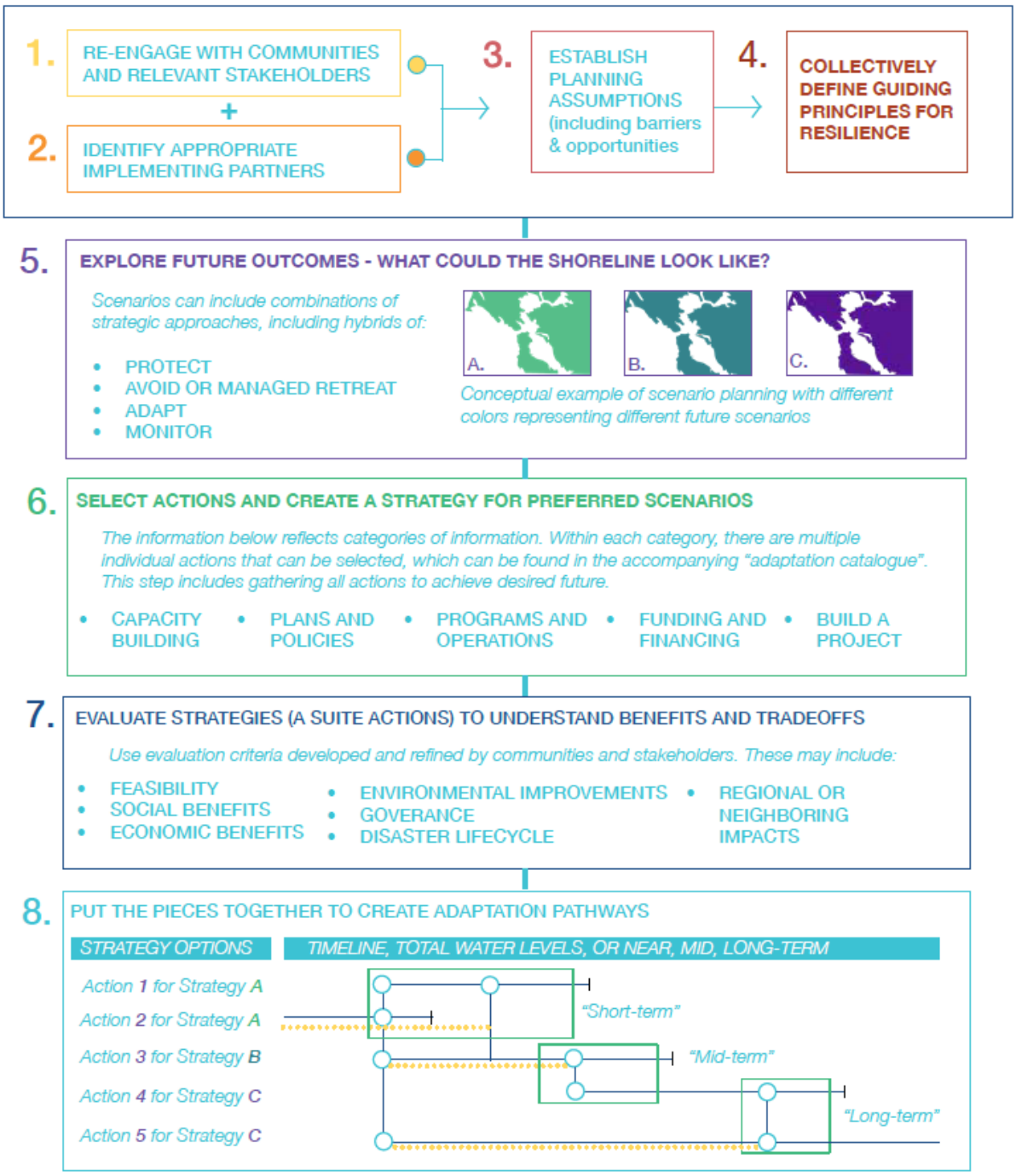

Figure 1: Conceptual Diagram of the Plan Step Guidance: Advancing Adaptation

1.1 Richmond Focus Area

The Richmond Focus Area is located in the East Bay Crescent OLU (Figure 2). This OLU includes portions of Contra Costa and Alameda counties from Point Potrero to the eastern touchdown of the Bay Bridge. This includes parts of the cities of Richmond, El Cerrito, Albany, Berkeley, and Oakland.

The Richmond Focus Area is in the center of the East Bay Crescent OLU, extending from Marina Bay in the north to Cerrito Creek in the south. The majority of the Focus Area is within the City of Richmond, but a small portion along Cerrito Creek is located within El Cerrito. This focus area includes the neighborhoods of Marina Bay and Richmond Annex. It includes several major transportation corridors such as I-580 (which crosses the Bay and joins Highway 101 in Marin), I-80 (which heads northeast to Sacramento), and the Union Pacific railroad (which carries freight and Amtrak trains along the eastern edge of the Bay).

The shoreline within the focus area is dominated by a series of wetlands, including Meeker Slough, Stege Marsh, and Hoffman Marsh, as well as the Point Isabel Regional Shoreline. Central to the Focus Area is the Richmond Field Station, a series of research and development laboratories and offices owned by UC Berkeley. Point Isabel is also home to the SF Bay Area US Postal Service Distribution Center and the EBMUD Point Isabel Wet Weather Treatment Plant. For a map of the Richmond Focus Area, please see 4.1.1 Study Area Delineation.

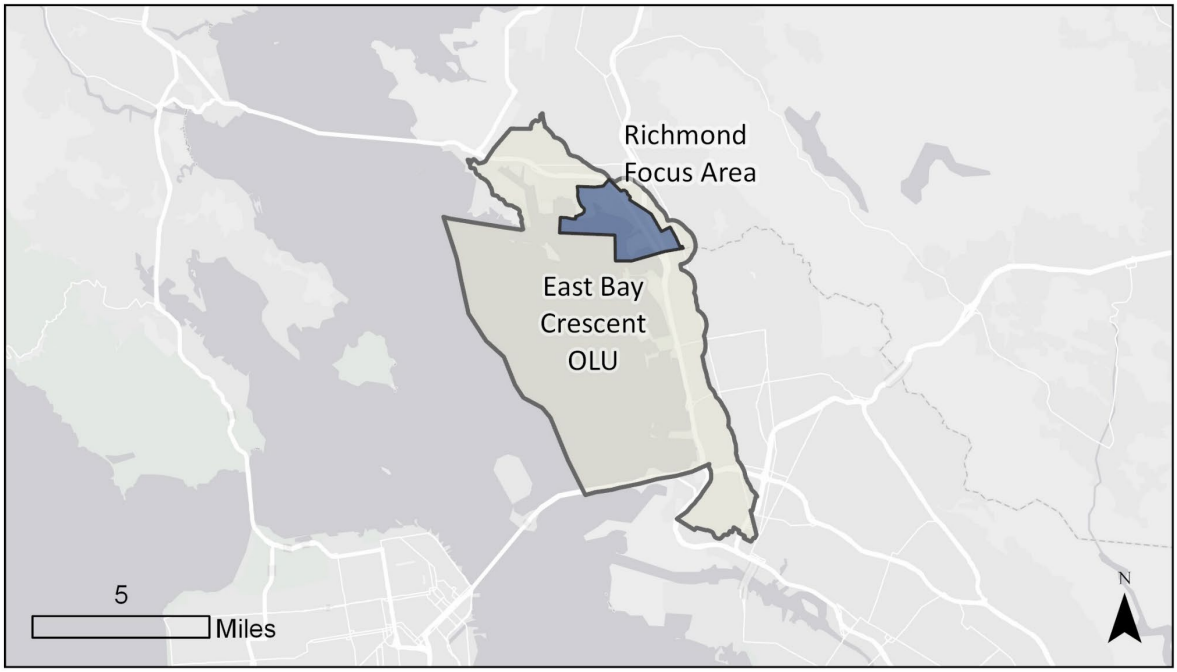

Figure 2: Location of the East Bay Crescent OLU and Richmond Focus Area

Figure 3. Richmond Focus Area Study Boundary

1.2 Report Organization

This report is organized following the 8-steps in the Guidance, as shown in Figure 1; however, equal treatment was not given to each of the steps (and the step numbers don't equate the section numbering in this report). Guidance Steps 1 and 2, which include community outreach and identifying appropriate implementing partners, are discussed in Sections 3 and 4. In these sections, suggestions are provided for the types of outreach and engagement that could occur when the Guidance is followed by the City or its designee. In this example application, no outreach with the community or potential partners occurred. Steps 3 and 4, discussed in Sections 4 and 5 respectively, focus on establishing planning assumptions and defining guiding principles for resilience. This application relies on the overarching ART guiding principles along with limited desktop research to identify potential opportunities and constraints within the focus area. Ideally, Steps 3 and 4 would be led by the City, and planning assumptions and resilience goals would consider and reflect the unique needs of the City and the community. This report focuses on Steps 5 and 6 (Sections 6 and 7, respectively), which include exploring shoreline vulnerabilities, identifying a range of potential actions to address the identified vulnerabilities, and combining actions to create strategies that align with the guiding principles for resilience. These sections include descriptions of the resources used, how and why the actions and strategies where selected, and the challenges that were encountered while applying the Guidance. The

strategies are evaluated under Step 7 (Section 8); however, because local municipalities were not engaged in the development of this report, Step 7 is limited to select example evaluation criteria. In a more thorough application, the evaluation criteria would be developed and refined by the City in collaboration with stakeholders. Step 8 (Section 9) includes assembling actions into an "Adaptation Pathway" that helps define when actions could be implemented over time (e.g., near-term, mid-term, long-term). This includes defining the thresholds (e.g., specific future Bay water levels or sea level rise amounts that would result in flooding or other consequences) or triggers (e.g., specific future Bay water levels, changes in the climate science, increased development or population density above planned changes, etc.), that would prompt the City to either begin the planning process for the next action in the pathway or review and revise the adaptation pathway to better meet changing conditions.

2 Resources Used

This focus area assessment relied on materials developed for the ART program and on numerous readily available materials, studies, reports, or data layers. This section provides a list of the primary resources used in this assessment. For a more extensive list, please see Section 10: References.

- ART Bay Area Shoreline Flood Explorer: https://explorer.adaptingtorisingtides.org/
- ART Bay Area Sea Level Rise Analysis and Mapping (Vandever et al., 2017)
- ART Regional Sea Level Rise Vulnerability Assessment Framework (BCDC et al., 2019)
- Easy Bay Crescent OLU Vulnerability Profile Sheet
- FEMA National Flood Hazard Layer, https://hazards-fema.maps.arcgis.com/apps/webappviewer/
- Google Earth Aerial Imagery and Historical Aerial Imagery
- Richmond General Plan 2030 (City of Richmond, 2012)
- Richmond Bay Specific Plan (City of Richmond, 2016)
- Richmond Climate Change Adaptation Study (City of Richmond, 2016)
- San Francisco Bay Shoreline Adaptation Atlas (SFEI and SPUR, 2019)

3 Engage with Communities and Relevant Stakeholders

3.1 Potential Stakeholders

Although this test-run of the Adaptation Guidance did not include a full stakeholder engagement process, our team used available resources to identify points in the process where stakeholders and

community organizations would ideally be involved. Although this application does not include community engagement, it does provide suggestions for how this step could be performed, including identifying the points in the process where community engagement would be beneficial and proposing a range of potential stakeholders that could participate in the process. Ideally, community and stakeholder engagement should begin at the start of the planning process, which is why the Guidance recommends this as Step 1 (Figure 1).

A list of relevant stakeholders including community-based organizations (CBOs), major landowners in the study area, and managers of public infrastructure (roads, rail, etc.) was developed using available resources including the community/stakeholder engagement sections of plans listed in the ART East Bay Crescent Vulnerability Profile that were relevant to the study area. The Contra Costa County online county assessor parcel map was used to identify major landowners in the study area that could be potential project stakeholders.

The Table 1 below summarizes the results of the review of potential stakeholders. The list includes key stakeholders, such as the city governments, federal and state agencies, community-based organizations, major landowners, etc. The list represents a suggested stakeholder list only and would need to be vetted and revised using local knowledge and information at the outset of the planning process. The level of engagement of the entities listed and their respective stake/interest in the process could also be confirmed and the engagement plan adjusted accordingly.

Table 1: Potential Stakeholders for the Richmond Focus Area

Stakeholder Group	Organization Name	Relevance and/or Description
Community-based Organizations	Communities for a Better Environment (CBE)	Active on Chevron and GHG issues
	Asian Pacific Environmental Network (APEN)	Focused on protecting health of residents near Chevron refinery
	Alliance of Californians for Community Empowerment (ACCE)	Grassroots statewide organization with a chapter in Richmond; issues such as racial and economic justice.
	YES – Nature to Neighborhoods	Cultivates youth and adult leaders in Richmond who lead healthy, connected lives and motivate change in their neighborhoods.
	The Watershed Project	Mission is to inspire Bay Area communities to understand, appreciate, and protect local watersheds. Based in Richmond.
	Richmond Trees	Advocate to promote and grow Richmond's urban forest and green infrastructure
	Groundwork Richmond	Environmental organization working with area youth
	Western County Toxics Coalition	Non-profit to empower low- and moderate-income residents to exercise greater control over environmental problems that impact quality of life in West Contra Costa County.
	Richmond Progressive Alliance	Goal is to take political decision-making back from corporations and put power in the hands of the

Stakeholder Group	Organization Name	Relevance and/or Description
		people. Active on Chevron and other environmental issues.
	Y-Plan	Student projects in Richmond - some have been partnered with Resilient by Design and UC Berkeley
	Friends of Five Creeks	Friends of Five Creeks mobilizes volunteers of all ages to restore, maintain, and enjoy the creeks and watersheds of the East Bay from North Berkeley to Richmond.
	Richmond Neighborhood Councils	Relevant councils may include: Marina Bay, Southwest Richmond Annex, Richmond Annex, Parkview, Panhandle Annex, Eastshore Community, Cortez/Stege
Major Landowners	UC Berkeley	Owns and operates research labs and other facilities, including some contaminated lands in a large portion of the study area north of Meeker Slough and Stege Marsh
	US EPA Region 9	Operates a major laboratory north of Meeker Slough
	East Bay Regional Park District (EBRPD)	Owns and maintains the Point Isabel Regional Shoreline and several EBRPD-managed stretches of the Bay Trail. Also owns a portion of Hoffman Marsh.
	United States Postal Service	Operates a large distribution center on Point Isabel
	Union Pacific	Owns the majority of Hoffman Marsh
	PG&E	Natural gas pipeline within the Richmond Focus Area
Federal Agencies	US Fish and Wildlife Service (USFWS)	Permit Agency, compliance with Endangered Species Act (ESA)
	Federal Emergency Management Agency (FEMA)	Compliance with National Flood Insurance Program (NFIP)
	NOAA Fisheries/ US National Marine Fisheries Service (NMFS)	Permit Agency, compliance with Endangered Species Act (ESA)
	U.S. Environmental Protection Agency (EPA)	Permit Agency, potential funding partner
	US Army Corps of Engineers (USACE)	Permit Agency for waterways, levees
State and Regional Agencies	Bay Conservation and Development Commission (BCDC)	Permit Agency for Baylands development and Bay fill
	State Lands Commission (SLC)	Manages tidal and submerged lands, monitors waterfront land granted in trust to local jurisdictions, protects state waters from invasive species introductions.

Stakeholder Group	Organization Name	Relevance and/or Description
	California Department of Toxic Substances Control (DTSC)	Permits and oversees toxic remediation and cleanups, currently actively involved in several toxic sites in the Focus Area Assists with applying tor federal EPA remediation grant programs and administers state-level programs
	California Department of Transportation (Caltrans)	I-580 and I-80 traverse the Focus Area, administers SB1 grants
	Coastal Conservancy	Administers the Climate Ready grant program and implements restoration and public access projects
	Capitol Corridor Joint Powers Authority (CCJPA)	Capitol Corridor trains run on track adjacent to I-580 which is projected to be impacted by sea level rise
	Association of Bay Area Governments (ABAG)	Manages the San Francisco Bay Trail program jointly with MTC
	Metropolitan Transportation Commission (MTC)	Manages the San Francisco Bay Trail program jointly with ABAG. Allocates regional funding for transportation improvement projects.
	San Francisco Regional Water Quality Control Board	Permitting agency for projects that would impact water quality
	San Francisco Bay Restoration Authority	Allocates funds raised by the Measure AA parcel tax
County and City Government	City of Richmond – City Government, Planning, Public Works	Key stakeholder and governmental entity for the City of Richmond, which makes up a majority of the Focus Area.
	City of Richmond - Department of Water Resource Recovery	Operates and maintains stormwater and wastewater infrastructure within the Focus Area
	City of El Cerrito	A small portion of the Focus Area near Cerrito Creek is within the City of El Cerrito
	Contra Costa County Board of Supervisors	Stakeholder for issues of countywide importance
Public	All residents of Richmond and El Cerrito	A plan with broad community support would be more implementable and less likely to hit political roadblocks

Each type of stakeholder has valuable input to provide at various stages of the process. The table below summarizes which stakeholder groups could be incorporated at each step in the process, what the purpose of their feedback/input would be, and potential methods for engaging them.

Table 2: Potential Stakeholder Involvement in the Adaptation Process by Step

Step	Stakeholder Groups	Purpose of Feedback/Input	Example Methods
Step 1: Re-engage with Communities and Relevant Stakeholders	CBOs, Major Landowners, Federal Agencies, State and Regional Agencies,	Determine level of interest and how best to involve each potential stakeholder in the subsequent steps	Meetings, Surveys
Step 2: Identify Appropriate Implementing Partners	Major Landowners, Federal Agencies, State and Regional Agencies, County and City Government	Determine how each regulatory partner could be involved in the subsequent steps – do they want to be active collaborators or only approvers?	Meetings, Consensus-building, potential formation of an Advisory Committee
Step 3: Establish Planning Assumptions	City Government, CBOs, Major Landowners	This is mostly a technical step – however local stakeholders could provide valuable information on opportunities and constraints in the focus area.	Meetings, Focus Groups, Surveys
Step 4: Collectively Define Guiding Principles for Resilience	CBOs, Major Landowners, County and City Government, Public	Ensure that the Guiding Principles govern the project reflect the needs and priorities of local stakeholders.	Workshop
Step 5: Explore Future Outcomes	CBOs, Major Landowners, County and City Government, Public	Collaborative development of visions for the future shoreline that meet the Guiding Principles.	Workshop, Focus Groups
Step 6: Select Actions and Create Strategy for Preferred Scenarios	City Government, Major Landowners, CBOs	This is a technical step that would likely involve minimal stakeholder reengagement beyond lead implementors and CBOs with knowledge of the focus area	Meetings
Step 7: Evaluate Strategies to Understand Benefits and Tradeoffs	CBOs, City and County Government, Public City Government, State and Regional Agencies, CBOs	Selection of evaluation criteria that reflect the priorities of all stakeholders, with an emphasis on regulators, local public, and potential funders Collaborative evaluation of strategies by technical stakeholders using selected criteria	Workshop Meetings, Focus Groups
Step 8: Put the Pieces	City Government, Major Landowners	This is a technical step that would likely involve minimal stakeholder	Meetings

Step	Stakeholder Groups	Purpose of Feedback/Input	Example Methods
Together to Create Adaptation Pathways		reengagement beyond lead implementors	

3.2 Identify Appropriate Implementing Partners

Although this test-run of the approach did not involve coordination with partners or potential funders, points in the process where city and county departments, state agencies, regulatory agencies, and funding partners could be engaged were identified. The tables in Section 3.1 identify several federal, state, and regional agencies that have permitting authority in the focus area. During a full application of this planning process, the project team could reach out to each regulatory partner to understand their level of interest in the project and in what capacity they would be involved, ranging from active collaboration to review/approval of proposed strategies.

To understand potential funding partners/opportunities and how they might influence the types of adaptation strategies identified in the focus area, the funding sections in several Resilient by Design reports were reviewed, as well as Paying for Climate Adaptation in California: A Primer for Practitioners, a report developed by AECOM and the Resources Legacy Fund. The table below summarizes the results of this review. The list is not intended to be an exhaustive list of funders but is instead focused on major funding sources that would warrant targeting outreach to corresponding entities and an invitation to collaborate on key decisions in the planning process.

Table 3: Potential Funding and Financing Sources for Sea Level Rise Adaptation in the Richmond Focus Area

Funding Type	Examples	Relevance/Types of actions that can be funded
Federal Grants	EPA Brownfields Program	Remediation of toxic sites
	DOT TIGER Grants	Transportation resilience projects
	FEMA Hazard Mitigation Grant Program	Flood hazard mitigation
State/Regional Grants	Measure AA	Habitat restoration, and flood protection projects or shoreline access/recreational amenities projects that are part of a habitat restoration project
	Coastal Conservancy Climate Ready Grant	Living shorelines/ecotone levees, green stormwater infrastructure, wetland restoration, sea level rise adaptation planning
	Prop 1 State Water Bond	Groundwater sustainability, flood management, protection of streams and coastal waters
	SB5 Resources and Climate Bond	Parks, open space, natural resources and water infrastructure

Funding Type	Examples	Relevance/Types of actions that can be funded
	SB1 Adaptation Planning Grants (Caltrans)	Planning projects that address climate impacts on transportation assets
	DTSC Targeted Site Investigation Program	Environmental services for brownfield sites where redevelopment or re-use is being considered
	Prop 68 Parks & Water Bond (DPR)	Eligible projects must create a new park or expand/renovate an existing park.
Institutional/Private Funders	UC Berkeley	Large landowner with real estate development plans for the focus area
	Union Pacific Railroad	Owns the railroad tracks in the Focus Area
	Trust for Public Lands Conservation Funds	Can provide technical assistance in creating legislative and ballot measures than could unlock more funding
Generic Local Funding Tools	Municipal, County Budgets	Flexible, but limited
	Parcel Tax	Flexible, but subject to voter approval
	Assessments	Flexible use, costs are allocated to those who benefit. For example, an assessment district could be created to fund flood protection infrastructure that includes all properties protected by that structure.
	Property-related Fees	Water, stormwater, and wastewater fees could be used to fund physical improvements such as pump stations, relocation of outfalls, and other stormwater improvements
	Other taxes (e.g. sales, gas, hotel utility users)	Flexible, but subject to voter approval
Generic Local Financing Tools	Municipal bonds	Flexible, but subject to voter approval
	Green bonds	Publicizes commitment of spending towards environmental purposes, appeals to impact investors

4 Establish Planning Assumptions

Advancing the SLR adaptation planning process requires setting reasonable planning parameters such as defining the area to be assessed, identifying physical planning units that can help set the scale of potential adaptation actions, and establishing the planning horizon. This section provides the assumptions used within the focus area for:

- Identifying physical planning units – defining the scale of shoreline and communities impacted by SLR to be addressed;
- Establishing a planning horizon – defining SLR scenarios to guide adaptation strategies; and
- Identifying local opportunities and constraints

4.1 Identified Physical Planning Units

4.1.1 Study Area Delineation

A study area was delineated based on shoreline edge type, assets threatened, and an examination of flood pathways (using SLR inundation and overtopping hazard layers from BCDC's Online Flood Explorer and GIS data layers). The goal was to select a focus area of the shoreline within which adaptation planning could be approached as a "unit".

In consultation with the Project Management Team (PMT) and using BCDC's regional vulnerability framework findings, the East Bay Crescent OLU was selected to prioritize for testing of the Adaptation Guidance. A subsection of the OLU along the Richmond shoreline was then selected as a focus area that included vulnerable transportation assets, habitat, and disadvantaged communities.

The shoreline segments where flooding of key assets would originate and where the strategies necessary to adapt would be further developed were then identified.

The southern boundary, Cerrito Creek, was chosen because it is both a physical feature and a jurisdictional boundary (border of both Richmond and Contra Costa County). The northern boundary (Barbara and Jay Vincent Park at the mouth of Inner Harbor Basin) was chosen because it was anticipated that adaptation strategies in Inner Harbor Basin would be distinct from the marshes that make up most of the shoreline in the focus area.

To determine the inland extent of the focus area, the ART total water level inundation layers were compared with satellite imagery in ArcGIS. The total water level datasets can be downloaded directly from the ART website. This step could also be accomplished by using the ART Bay Shoreline Flood Explorer interactive online map. For the most part, the study area was delineated by following major streets around the entire area inundated at 108" (the highest scenario in the ART mapping products). In the western portion of the study area, flooded areas at 108" connect with flooding from other stretches of shoreline outside the focus area boundary. To keep the study area to a manageable size lower Total Water Levels (TWLs) were used to delineate the landward boundary in this area, although future collaboration with stakeholders to the north and west of the focus area would be required to address long-term sea level rise vulnerabilities.

4.1.2 Shoreline Reaches

The shoreline within the focus area was then divided into reaches based on shoreline edge type, shoreline geometry (elevation and slope), and natural features, such as marshes and creeks. Figure 4 shows the delineation of the nine shoreline reaches identified for the Focus Area.

Shoreline reaches tend to be divided by creeks and have similar characteristics. Dividing the shoreline in this way meant strategies that would be applicable across an entire reach due to similar shoreline characteristics within each reach could be considered.

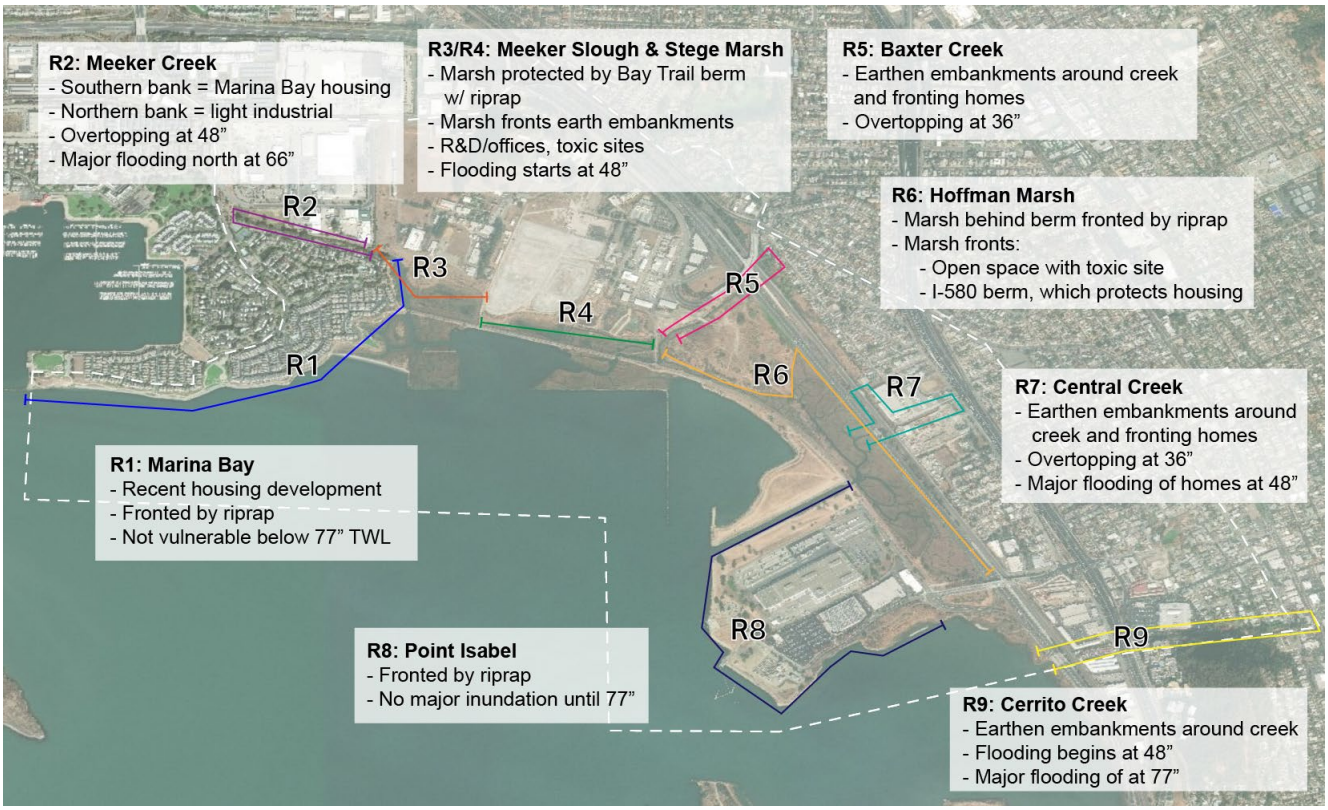

Figure 4: Richmond Focus Area Reaches

4.2 Establish Planning Horizon

Due to the uncertainties inherent in sea level rise adaptation planning, the planning horizon for this example was defined based on water level rather than time.

All vulnerabilities up to 108” TWL were considered. As this project uses an Adaptation Pathways approach, understanding impacts at higher water levels that would likely occur far in the future was necessary to understand how choices made in the near term could maintain flexibility for future actions.

Once the overall planning horizon was established, an analysis of triggers and thresholds throughout the focus area was used to delineate near, mid, and far-term horizons based on TWLs. For a detailed discussion of triggers and thresholds across the planning horizon, please see Section 4.4: Triggers and Thresholds.

4.3 Assess Local and Regional Opportunities and Constraints

The review of study area conditions began with a review of the East Bay Crescent ART Vulnerability Profile to understand vulnerabilities in the study area. As previously mentioned, the ART Regional Vulnerability Framework also informed the understanding of vulnerabilities within this OLU.

A review of key plans relevant to developing sea level rise adaptation strategies in the study area was also carried out, including the Richmond Bay Specific Plan and the City of Richmond Climate Adaptation Study. A summary of the vulnerabilities and potential strategies are noted below:

Richmond Bay Specific Plan

The Richmond Bay Specific Plan (RBSP), completed in 2016, envisions that the light industrial/R&D areas on either side of the UC Berkeley-owned proprieties in the study area would be developed into mixed-use developments.

However, the RBSP was based on the understanding that UC Berkeley would develop the Richmond Global Campus on their property. As of 2016, this project has been indefinitely suspended by UC Berkeley. It is unclear to what extent the ambitious development plans for the study area are feasible without this anchor development.

The RBSP complies with the City of Richmond Municipal Code and General Plan in requiring that the grade of all parts of the Plan Area be increased to 1 foot above the Base Flood Elevation (BFE) at 3 feet of sea level rise in order to address up to 36 inches of sea level rise. It also acknowledges possible impacts to stormwater infrastructure from sea level rise. The RBSP makes two concept-level infrastructure recommendations – a flood embankment along Meeker Slough and an elevated shoreline road fronting the Zeneca site north of Stege Marsh

City of Richmond Climate Adaptation Study

This study is an appendix to the City's Climate Action Plan, adopted in 2016. It provides a high-level overview of vulnerabilities to various climate hazards, including coastal flooding from sea level rise, and describes response actions by asset type.

The following sea level rise vulnerabilities identified in the Richmond Climate Adaptation Study are relevant to the study area:

- **Inundation of tidal marshes -** Increased inundation of tidal marshes leading to drowning and loss of marsh vegetation, fragmentation of wetland, loss of high tide refugia for dependent species, and inundation and erosion of parklands.

- **Flooding of commercial and industrial areas** – Increased frequency and depth of coastal flooding could cause more frequent damage to commercial and industrial properties in flood prone-areas and more frequent disruptions of power and goods movement and hinder the ability of employees to access their job site or place of employment.

- **Groundwater flooding of residential areas** – The Southwest Annex and Atchison Village neighborhoods have multifamily units not directly at risk of sea level rise that could be impacted by street or basement flooding if the stormwater system backs up due to insufficient capacity to store and convey flows during storm events. There is already a problem in many low-lying areas along the Richmond shoreline where historic marshes were filled for development. Richmond Annex neighborhood already experiences "sunny day flooding" when stormwater does not drain during high tide and backs up into people's homes.

- **Groundwater flooding of contaminated sites** – As the Bay rises it is predicted that groundwater levels could also rise, which could contribute to mobilizing pollutants that are currently in vadose zone at brownfields and other contaminated lands. Many common brownfields contaminants that remain on site post-cleanup are at levels that are not harmful to people, however the levels that remain on sites cleaned up to upland standards can be harmful to aquatic receptors. If released to the Bay and shoreline, these contaminants would have significant adverse impacts on aquatic species.

While the response actions described in the Climate Adaptation Study are mostly broad actions at the city level, the actions below are directly relevant to the study area. Note that several of these actions are also in the City of Richmond General Plan.

- Prioritize the remediation of contaminated sites based on the timing of exposure to sea level rise, storm events, and elevated groundwater, degree of vulnerability, and extent of the consequences.

- Construct vital transportation infrastructure at elevations that would not be exceeded by flood waters.

- Seek collaboration between private rail owners (UP and BNSF), local agencies that own or manage adjacent lands, and those that rely on rail either for providing service or for flood protection, to find and implement appropriate, multi-benefit solutions to address flood risks.

- Develop an Adaptive Management Plan that outlines an institutional framework, monitoring triggers, and a decision-making process, and creates an entity with taxing authority that would pay for infrastructure improvements necessary to adapt to higher than anticipated sea levels.

- Construct a shoreline protection system and storm drainage system that are initially built to accommodate a mid-term rise in sea level of 16 inches, with a design that is adaptable to meet higher than anticipated values in the mid-term, as well as for the far-term.

Next, a more comprehensive spatial assessment of vulnerabilities was conducted using GIS (ESRI's ArcGIS). This step involved overlaying spatial datasets of assets with the inundation mapping products produced by ART to understand what is vulnerable to inundation at each water level. Asset datasets included GIS layers that were gathered as part of the ART Regional Vulnerability Framework project. Google Maps was used to understand what types of businesses are present in the vulnerable commercial areas and to identify other specific assets.

Table 4. Asset Types and Data Sources

Asset Type	Dataset(s)	Source
Shoreline Edge Type	SF Bay Shore Inventory	SFEI
Vulnerable Communities	Social Vulnerability by Block Group	BCDC
Priority Development Areas	PDA Boundaries	MTC
Priority Conservation Areas	PCA Boundaries	MTC
Natural Areas	Satellite Imagery	ESRI
Highways	State and National Highways	Caltrans
Local Roads	Satellite Imagery Road Names	ESRI Google Maps
Rail Lines	Passenger Railways California Rail Network	MTC Caltrans
Bay Trail	Bay Trail Alignment	MTC
Toxic and Remediated Sites	Richmond Bay Specific Plan BCDC Contaminated Sites	City of Richmond BCDC
Residential Areas	Satellite Imagery	ESRI
Commercial Areas	Satellite Imagery Business Names and Types	ESRI Google Maps
Creeks	Guide to San Francisco Bay Area Creeks	Oakland Museum of California
Jobs and Housing	Parcel-level Job Spaces and Residential Units for 2010 and 2040	MTC

Static maps from the SFEI SF Bay Shoreline Adaptation Atlas (Chapter 3: Characterizing the OLUs) were used to further characterize the study area. The high-resolution version of this document can be enlarged to examine individual OLUs. In addition, the source notes in each map can be used to search for the raw input data used to develop the maps if more specific data is required. The characteristics reviewed using this method included:

- Surficial geology – all the land along the shoreline in the focus area is artificial fill, while some land landward of the highways consists of alluvial fan deposits.
- Watershed sediment loads – of the four creeks that drain in the focus area, none have sediment loads greater than 5,000 MT/year. Compared to creeks draining larger watersheds elsewhere in the Bay Area, these sediment loads are relatively minor.
- Historic and Modern baylands – historically, the shoreline consisted of tidal flats backed in some areas by tidal marsh. Now much of the baylands have been filled and developed into residential neighborhoods. A thin strip of tidal flats and a few patches of tidal marsh remain.
- Bathymetry – offshore depth in the focus area is less than 1.5 meters
- Tidal range – tidal range in the focus area is 1.9-2.1 meters
- Wind wave action – wave heights vary throughout the focus area but appear to be highest against the riprap fronting the marshes in front of the Zeneca site

For an initial overview of adaptation opportunities, the East Bay Crescent section in “Chapter 5: Adaptation Opportunities by OLU” of the SFEI SF Bay Shoreline Adaptation Atlas was reviewed. This short narrative described the applicability of various nature-based, physical, and policy strategies at the OLU level, some of which was applicable to the study area. Although this source includes a map depicting suitable areas for various nature-based strategies, as the East Bay Crescent study area is only a small portion of the OLU, the map’s scale was too large to provide specific information.

Instead, the GIS layers used to develop the nature-based strategy suitability maps were obtained from SFEI (Figure 5). As discussed further below, this GIS data was a key input in the development of physical adaptation strategies in a later phase. “Chapter 4: Adaptation Measures” includes an explanation of how suitable areas for each type of nature-based strategy were determined, which enables readers to understand the limitations of the strategy suitability maps and the site level.

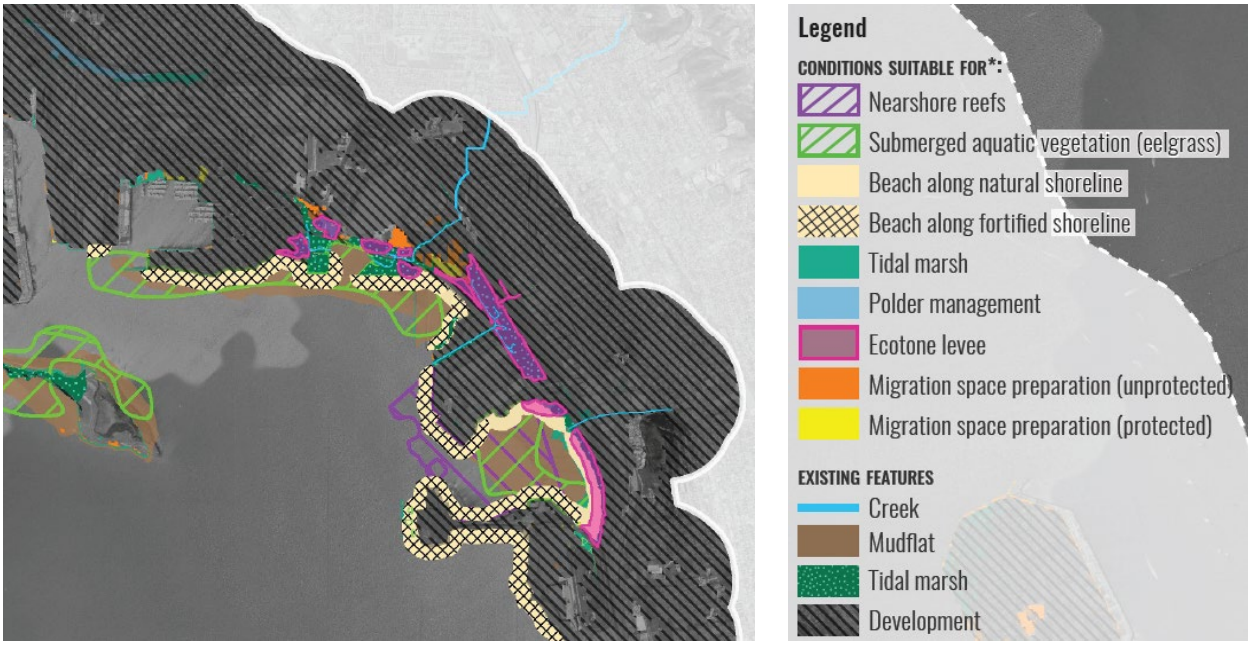

Figure 5: SFEI Nature-based Adaptation Opportunities Map

Based on the various sources described previously, the following opportunities and constraints were identified in the focus area, summarized below. The opportunities and constraints listed here inform Section 6.1 – Consider Which Problems to Respond To and Section 7.2 – Summary of Physical Actions.

Constraints

- **Several toxic sites** in the focus area (even those that have been remediated or capped) may be in danger of pollutant mobilization from groundwater flooding well before surface inundation is apparent. Strategies to prevent spread of contamination—either excavating and transporting contaminated sediment or sealing off with slurry walls—could be very costly. Modern incarnations of the entities responsible for the contamination are generally opposed to funding cleanup efforts beyond the minimum legal requirements.

Table 5: Status of Contaminated Sites within the Focus Area

Site	Contamination	Remediation Status	Vulnerability
Liquid Gold	Contaminated soils and groundwater with metals and petroleum hydrocarbons	Former Superfund site. Remaining contaminated soils have been covered with a vegetated cap.	Surface flooding occurs to cap at 24", but contaminants are below the surface and may be mobilized by groundwater flooding at 12" TWL or earlier.
Former Pistol Range	Unclear from available information (likely lead contamination from bullets)	Cleanup active	Surface flooding occurs at 24", but since groundwater is less than 1 ft below the surface, contaminants may be mobilized at 12" TWL or earlier.
Blair Landfill	Technologically enhanced naturally occurring radioactive materials (TENORM)	As of 2018, soil tests have revealed TENORM concentration above allowable standards	Perimeter of mound flooded at 66" TWL, groundwater flooding may occur before.
Zeneca Site	Byproducts of pesticide and pharmaceutical processes including benzene, arsenic and polychlorinated biphenyls	Remediated with a thin concrete cap, but most toxins remain in the soil and deed restrictions prohibit first floor residential uses.	Perimeter of concrete cap not flooded until 108" TWL. However, contaminants are below the surface and may be mobilized by groundwater flooding well before 108" TWL
Bio Rad	Chloroform and other volatile organic compounds (VOCs) in soil, groundwater, and soil vapor	As of 2016, California DTSC recommended placing an asphalt cap over toxic soils rather than removing them.	Surface flooding begins at 84" TWL, contaminants may be mobilized at lower TWLs.

Figure 6: Contaminated Sites within the Focus Area

- As most of the land in the focus area is developed, there is **little migration space for marshes** to move inland as sea levels rise. While in some areas there is open land seaward of I-580, in other areas the highway effectively forms a barrier that the marshes cannot cross.

- Residential areas in the Richmond Annex neighborhood are already **prone to groundwater flooding** because they are built on historic marshes. Risk of groundwater flooding means that without pumping, or raising floodproofing of individual homes, structural strategies such as floodwalls, berms, or levees alone may not prevent flooding of residential areas by themselves.

Opportunities

- The City of **Richmond's Adaptation Strategy** acknowledges potential sea level and groundwater rise impacts on toxic sites and the City's stormwater system. To address these issues, it recommends prioritizing remediation of toxic sites that are in danger of pollutant mobilization. This presents an opportunity to develop strategies that address contamination within areas exposed to sea level rise hazards.

- While the Richmond Bay Specific Plan does propose mixed-used development in some areas that are vulnerable to sea level rise, it did consider sea level rise impacts and proposed high level strategies to reduce vulnerability in those areas. The feasibility and timeline for development has likely been impacted by the suspension of the UC Berkeley Global Campus project. This presents an opportunity for **future development plans for this area to consider higher levels of sea level rise**.

- While some of the residential areas in the focus area are vulnerable to groundwater flooding, **no residential areas are expected to experience surface flooding in the near term**. This means that if strategy implementation begins now, there is ample time to design and construct physical and non-physical strategies to protect these areas.

- While some commercial and light industrial uses are vulnerable to flooding in the mid term, most of these uses are low density and are located in the area because of relatively inexpensive land. As flood risks increase, owners of businesses on these properties may wish to relocate. Therefore, **buy outs of these properties could likely be initiated without strong opposition** to create space for physical strategies to protect socially vulnerable residential areas.

4.4 Triggers and Thresholds

4.4.1 Triggers

In this report "triggers" are interpreted as decision points that would be important to understand shifts in vulnerability, risk, or adaptation direction. Identification of triggers seemed to be a process that would benefit from discussion with the community and stakeholders to understand key local drivers and considerations around risk tolerance and other factors. For example, a trigger point could be a facility reaching the end of its useful life at which point the land could be acquired or the need to protect it from flooding and SLR diminishes (for example, the future decommissioning of the Point Isabel Wet Weather treatment facility). Or, a trigger could be a community experiencing a certain frequency of flooding or repetitive flood damages, which could trigger a specific adaptation action. Determination of such triggers would likely need to be coupled with a monitoring and adaptive management plan. Without the extensive engagement and coordination with the local community required for this adaptation planning process, it was difficult to identify trigger points for this pilot. Instead, thresholds (described below) were used to initiate subsequent adaptation actions. Triggers were identified based on an estimate of the lead time required to implement an action by the time it is necessary based on a threshold (see Section 9: Create an Adaptation Pathway).

4.4.2 Thresholds

In this report "thresholds" are interpreted to be TWLs where critical assets (or distinct clusters of assets) become exposed to inundation.

- Thresholds were identified by assessing flood pathways and documented using two techniques:
    - TWL vs Reaches (Table 6): This matrix describes where flooding originating from each shoreline reach goes and what it impacts at each TWL (i.e., flooding pathway assessment)
    - TWL vs asset types (Table 7): This matrix describes how each asset type is impacted at each TWL (i.e., exposure assessment)
      See the matrices on the following pages. Grey cells indicate TWLs where overtopping and minimal inundation occurs and blue cells indicate TWLs where substantial inundation occurs.
- Major TWL thresholds identified in the study area are:

- Near-term (12”, 24”, 36”) – all wetlands are inundated and some contaminated sites impacted; some open space areas inundated
- Mid-term (48”, 52”) – major flooding of residential areas begins, including socially vulnerable communities
- Mid-term (66”) – commercial uses in three separate portions of the study area are impacted
- Far-term (77”, 84”, 96”, 108”) – flooding of rail line and highways begins, and an additional socially vulnerable residential area is flooded

Table 6: TWLs and Flood Impacts by Reach

Reach	R1: Marina Bay Shore	R2: Meeker Creek	R3: Meeker Slough	R4: Stege Marsh	R5: Baxter Creek
Edge Description	Shoreline Protection Structure (riprap)	Earthen Embankment	Earthen embankment (behind marsh) Wetland, beach, berm (in front of marsh)	Earthen embankment (behind marsh) Wetland, berm (in front of marsh)	Earthen embankment, channels under I-580 and railroad.
12" TWL			Tidal marsh inundated	Tidal marsh inundated	
24" TWL				Embankments inundated	
36" TWL		Creek channel full			Overtopping under Bayview overpass Overtopping behind homes east of I-580
48" TWL		Overtopping begins (minimal)	Overtopping of open space south of EPA lab starts to flood	Eastern lagoon inundated (likely contaminated) - flooding extends into LI area just north	Flooded area expands slightly
52" TWL	Flooding of shoreline path begins		More open space flooded	Flooding of LI area increases	
66" TWL		Large portion of LI area north of Creek channel floods	Flooding extends into research lab area	Flooding extends past Commodore Dr	I-580 northbound Bayview Ave exit and I-580 southbound onramp flooded
77" TWL	Major flooding of shoreline path	Majority of LI area flooded, flooding follows Regatta Blvd to flood areas of Marina Bay		Flooding expands west, almost touching the eastern side of the Zeneca concrete cap	Flood paths from Baxter and Central Creek join behind homes

Reach	R1: Marina Bay Shore	R2: Meeker Creek	R3: Meeker Slough	R4: Stege Marsh	R5: Baxter Creek
		outside study area			
84" TWL		Entire LI area flooded	Flooding extends to western side of Zeneca concrete cap		I-580 southbound offramp flooded
96" TWL		Southern bank overtops, flooding streets and a few homes in the northeastern corner of the Marina Bay Community			
108" TWL	Major overtopping of shoreline flooding streets and homes in Marina Bay Community			Western lagoon overtopped (likely contaminated)	

Reach	R6: Central Creek	R7: Hoffman Marsh	R8: Point Isabel Shoreline	R9: Cerrito Creek
Edge Description	Earthen embankment landward of I-580	Earthen embankments around open space. I-580 and railroad act as de facto shoreline protection	Shoreline protection structure (riprap)	Earthen embankments along creek channel
12" TWL		Tidal marsh inundated		
24" TWL				
36" TWL	Overtopping begins (minimal)			Overtopping begins (minimal)
48" TWL	Extensive flooding of residential area between I-580 and I-80			Small portions of LI parcels between highways starts to flood
52" TWL				
66" TWL	Flooded area expands to more homes	At southern part of marsh, flood overtops Rydin drive and starts to flood	Riprap edge inundated	

Reach	R6: Central Creek	R7: Hoffman Marsh	R8: Point Isabel Shoreline	R9: Cerrito Creek
		commercial area on Point Isabel, including Central Ave		
77" TWL		Flooding extends to include most of southeast portion of Central Ave Sward outside land of I-580 flooded	Flooding starts at Dog park Central Ave overtopped across from Costco parking lot	Flooding expands dramatically: I-80 and I-580, overtopped, Southern Annex and east of I-80 flooded
84" TWL	Flood path overtops I-80 and floods homes on landward side I-580 impassable			
96" TWL			Flooding expands dramatically to inundate majority of USPS distribution center and EBMUD Point Isabel WWTP	
108" TWL				

Table 7: TWLs and Flood Impacts by Asset Types

TWL	General	Socially Vulnerable Communities	Contaminated Sites	PDAs/Developed Area	PCAs/Natural Areas
12" TWL	All marshes inundated		Liquid Gold Site likely exposed to groundwater flooding	Marshes within the South Richmond PDA are inundated	All marshes inundated
24" TWL	Protection structures behind marshes begin to be inundated		Flooding adjacent to Liquid Gold cap (likely contamination of water below surface)	Flooding of dry land (near Liquid Gold Site)	
36" TWL	Baxter Creek and Central Creek banks/channel overtopped landward of I-580	Flooding in backyards/open space behind ~15 homes adjacent to I-580 (from Baxter Creek)		Flooding from Baxter Creek behind homes east of I-580	
48" TWL	Major flooding from Central Creek channel landward of I-580	Major flooding of homes between I-580 and I-80 begins (from Central Creek)	Vegetated cap over Liquid Gold site starts to be inundated	Major flooding of homes between I-580 and I-80 begins (from Central Creek)	
52" TWL	Meeker Creek Channel overtopped	Central Creek flooding expands			
66" TWL	Meeker Slough overtops north of Marina Bay			Extensive flooding of commercial/LI area north of Marina Bay from Meeker Creek. LI area east of Zeneca Site floods. Developed area on Point Isabel first flooded (SFEI building)	
77" TWL	Cerrito Creek banks flood landward of I-580	Cerrito Creek banks flood homes/businesses north of the creek	Edges of Zeneca site concrete cap become inundated (likely infiltration of groundwater before)	San Pablo Ave Corridor PDA homes flooded. Embankment overtopped in Marina Bay (South Richmond PDA). Majority of commercial/LI	Significant inundation of Point Isabel regional shoreline begins

TWL	General	Socially Vulnerable Communities	Contaminated Sites	PDAs/Developed Area	PCAs/Natural Areas
				area north of Marina Bay flooded.	
84" TWL	Flooding from Central Creek extends landward of I-80		Majority of Liquid gold site inundated	Point Isabell Wet Weather Facility exposed	
96" TWL		Flooding from Central Creek overtops I-80 and floods homes on eastern side	Flooding of Marina bay begins - possible groundwater contamination earlier	Flooding of some homes in Marina Bay from Meeker Slough	
108" TWL			Liquid Gold site completely inundated Flooding of area ~300 ft from contaminated portion of UC Berkeley Field Station	Major flooding of streets and homes in Marina Bay (South Richmond PDA)	

TWL	Highways	Rail	Bay Trail	Local Roads
12" TWL				
24" TWL				
36" TWL	Some flooding of culverts/channels beneath I-580, and areas beneath I-580 ramp/overpasses but no overtopping			Area under Bayview Ave overpass seaward of I-580 is inundated
48" TWL			Portions around Costco vulnerable but there is route redundancy	Flooding of roads landward side of I-580 begins
52" TWL				Flooding of roads in industrial area east of Zeneca site begins

TWL	Highways	Rail	Bay Trail	Local Roads
66" TWL	Flooding of shoulders for both highways	Overtopping begins at southern boundary of study area	Section just south of Costco vulnerable	Access road to Marina Bay flooded. Access road to Costco/USPS flooded.
77" TWL	Lanes of I-80 are vulnerable	Major inundation (30 freight trains per day, 2,500 commuters per day + long distance riders)	Major inundation starts here. However, erosion forced may damage berm before bathtub model predicts inundation.	Flooding of roads landward side of I-580 expands dramatically. El Cerrito creek overtops and neighborhood roads are flooded. Flooding of PG&E lot north of Marina Bay
84" TWL	Lanes of I-580 inundated			Flooding from Central Creek of roads east of I-80
96" TWL	Long stretches of I-580 inundated		Almost all Bay Trail within the study area is inundated	Roads in Marina Bay residential area flooded Extensive flooding of USPS parking lots
108" TWL	Majority of I-580 within the study area is inundated			Extensive flooding of roads in Marina Bay

4.5 Identify and Assess Impacted Populations

Available parcel-level data from 2010 on residential units and job spaces from MTC were used to understand the numbers of residential units and job spaces vulnerable at each TWL.

BCDC's block group level social vulnerability index was used to identify residential areas with High or Highest social vulnerability to flooding. Almost all impacted residences within the study area are within High or Highest social vulnerability block groups. This dataset is particularly useful because in addition to the vulnerability rating, it includes a series of block-level socioeconomic indicators pulled from American Communities Survey (ACS) data that are specifically relevant to social vulnerability to flooding (Table 8). This greatly streamlined the process of accessing socioeconomic data.

Table 8: Indicators Used in BCDC's Social Vulnerability to Flooding Index

Indicators from ACS	Social Vulnerability Rating
Renters	Moderate
Under 5	4-5 indicators in 70th percentile; and/or
Very low income	3 indicators in the 90th percentile
Not U.S. citizens	
Without a vehicle	High
People with disability	6-7 indicators in the 70th percentile; and/or
Single parent families	4-5 indicators in the 90th percentile
Communities of color	
Over 65 who live alone	Highest
Limited English proficiency	8+ indicators in the 70th percentile; and/or
Without a high school degree	6+ indicators in the 90th percentile
Severely housing cost burdened	

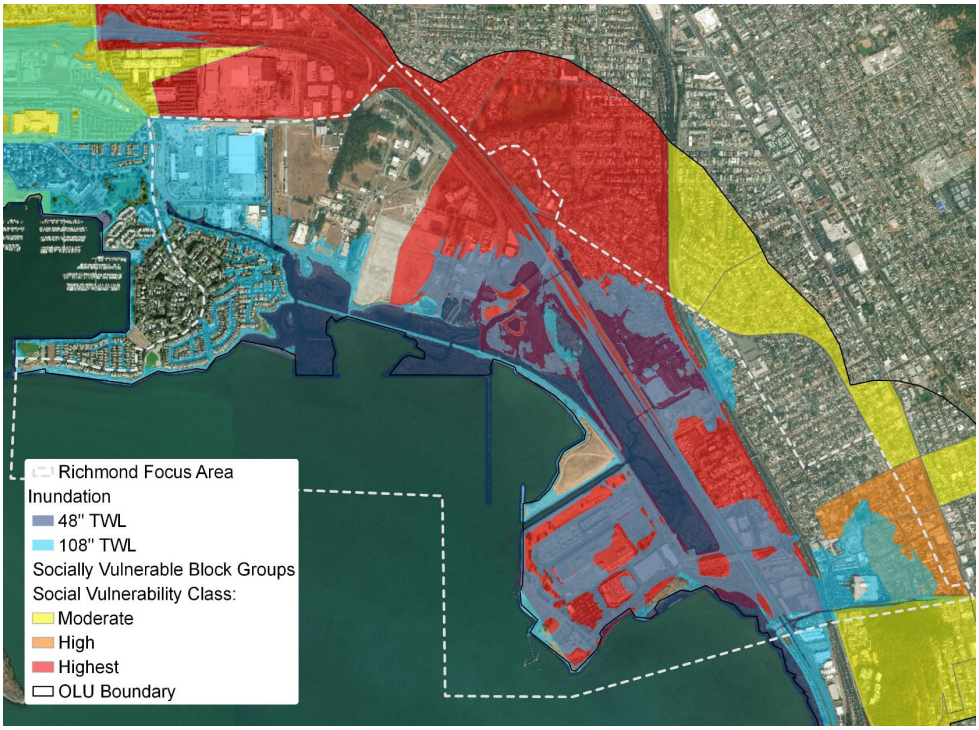

Figure 7: Social Vulnerability to Flooding

The first residential areas flooded between I-580 and I-80 are in the Highest social vulnerability category. Areas further inland flooded from Cerrito Creek at higher TWLs are in the High social

vulnerability category. Marina Bay is not a socially vulnerable area based on the BCDC designations reviewed for this study.

4.6 Challenges and Observations

- It was not useful to use Priority Conservation Areas (PCAs) as the primary dataset to identify important natural areas within the focus area, because none of the marshes, and only one of the creeks (Cerrito Creek) were designated as PCAs within the study area. Instead, satellite imagery, the SFEI Bay Area Aquatic Resource Inventory (BAARI), and maps found via desktop research (see below) were used to identify and understand natural assets.

- It was not necessary to gather exhaustive GIS data on every asset type and physical feature to inform a preliminary vulnerability assessment and adaptation planning. For example, a formal dataset of marshes was unnecessary because it was more efficient to refer to satellite imagery and use web searches to identify the names of the different marshes. For creeks, GIS data found did not appear to accurately reflect the locations of the culverted areas of smaller creeks. However, a web search revealed more accurate non-GIS maps of individual creeks available from the Oakland Museum of California's website, which could be cross-referenced with satellite imagery.

- A challenge faced in assessing opportunities and constraints was finding a reliable source of information on the toxic and remediated sites located throughout the study area. Both major toxic sites (Zeneca and Liquid Gold) are embroiled in controversies where official government information on what toxic substances are present and to what degree the sites have been remediated are being called into question. A map contained in the Richmond Bay Specific Plan was used to identify the locations and extents of each toxic site and web research helped gain a general sense of the status of each site.

- Use of MTC's residential and job projections – This parcel level data was an output of MTC's UrbanSim model intended for regional analysis, so results for individual parcels are often questionable. For example, the UrbanSim model allocates residential growth to parcels based on zoning but does not consider individual parcel deed restrictions or recent changes in development plans. The available data projected 1,347 residential units on the Zeneca site, even though the site's current level of remediation is only enough for commercial and industrial uses. 1,404 residential units are projected for the parcel containing the Liquid Gold toxic site, but a deed restriction currently prohibits residential use (EPA). The large parcel owned by UC Berkeley that was supposed to be the site of the Richmond Global Campus is projected to have almost 12,000 additional job spaces by 2040, but this is unrealistic given the fact that development plans for this site have been indefinitely suspended by UC Berkeley since 2016 (Taylor 2016). In light of these inaccuracies, 2010 numbers were used, noting that the data is now almost a decade old.

- Identification of triggers and thresholds – It was difficult to identify appropriate triggers for adaptation actions in the absence of more extensive community and stakeholder engagement that would be required for an adaptation planning process. It may be helpful to users of the guidance document to provide more examples and guidance on the difference between triggers and thresholds – in particular, the process by which triggers (decision points) can be identified and how discussions of risk tolerance can be had with the community to understand how climate impacts may influence decisions on initiation of subsequent adaptation actions.

5 Define Guiding Principles

According to the ART Approach, Guiding Principles should flow directly from project resilience goals, which are developed with stakeholder and public input at an earlier stage. To simulate this process (since stakeholder engagement was not conducted as part of this hypothetical planning exercise), the ART Program Regional Resilience Goals were used as a stand-in for project-specific Resilience Goals.

The ART Program Regional Resilience Goals are high level goals that reflect a balanced quadruple bottom line approach (Economy, Society/Equity, Environment, and Governance) and can be found on BCDC's ART website[1].

For each of these priorities a Guiding Principle was developed based on specific vulnerabilities in the study area to guide the development of adaptation strategies as part of this hypothetical adaptation planning pilot. Definition of project-specific goals would in reality be an iterative and collaborative process with the community and stakeholders, so these are just hypothetical placeholder goals to facilitate testing of the process.

- Economic – Protect regionally critical transportation network assets and minimize impacts to employment and commercial areas.
- Environmental – Promote the long-term vitality and biodiversity of natural areas through habitat creation, restoration, preservation, and by minimizing spread of toxic substances from contaminated sites.
- Social – minimize displacement of socially vulnerable communities due to sea level rise and create structures for equitable relocation when necessary.
- Governance – develop capacity for sea level rise by implementing the policy and governance structures necessary to support physical infrastructure development and community resilience.

[1] https://www.adaptingtorisingtides.org/

6 Explore Future Outcomes

Future outcomes aim to establish potential visions of the future shoreline that meet the resilience goals by bringing together the planning baseline (e.g., existing conditions, vulnerabilities, physical planning units, and opportunities and constraints) with the planning horizon and the guiding principles. This step in the process is designed to be collaborative, through visioning workshops with various stakeholder groups, to gather a wide variety of insights and concerns about the potential future of East Bay Crescent when considering SLR and climate change. In the absence of city, community, and stakeholder engagement, the concepts and ideas outlined in this section are illustrative.

6.1 Consider which "problems" to respond to

Based on the review of existing conditions and future vulnerabilities carried out during the Establish Planning Assumptions Phase, five primary vulnerabilities in the Focus Area were identified, which strategy alternatives developed in in later phases sought to address. Note that when a local community follows the Adaptation Guidance with a full public engagement process, the identification of primary vulnerabilities would be informed by community and stakeholder engagement

- Habitat – all the marshes in the study area (Meeker Slough, Stege Marsh, and Hoffman Marsh) may be impacted by SLR unless actions are taken to support marsh accretion and to provide ecotone slopes for habitat to migrate upwards in elevation as sea levels rise. This portion of the central Bay has relatively low suspended sediment availability and the local creeks and drainages are relatively small and developed and also provide low supplies of terrestrial sediment to marshes. Marsh evolution modeling conducted by Point Blue suggests that marshes in this area could experience habitat conversation from mid-marsh to low-marsh under a high SLR scenario by 2050 and potentially convert to mudflat by end-of-century.

- Socially vulnerable residential areas – at 48" TWL, overtopping of the banks of Central Creek may expose over 50 residential buildings to inundation. More structures in this area could be impacted at higher water levels. This area scores as Very High on BCDC's social vulnerability to flooding index. At 77" TWL, overbank flooding from Cerrito Creek could expose more than 80 residential buildings in a second area to inundation. This area scores as High on the social vulnerability index.

- Toxic sites – several sites in the study area contain soils contaminated with metals, hydrocarbons, and radioactive material. Even for the sites that have been remediated or capped, a rising groundwater table could still mobilize toxic substances from beneath; however, a detailed assessment of this potential impact has not been conducted. Multiple sites located in open spaces bayward of I-580 are vulnerable at 12" TWL.

- Regional transportation network – both I-580 and I-80 are critical transportation corridors that enable large amounts of people and goods to move throughout the region. On average,

84,500 vehicles per day pass though the study area on I-580. 225,500 vehicles per day pass through the study area on I-80. In addition, a heavy rail line landward of I-580 is a major corridor for Amtrak and freight, with 2,500 passengers and 30 freight trains daily on average. Flooding of the rail line from Cerrito Creek first occurs at 66" TWL. Flooding of I-80 from both Cerrito Creek and Central Creek occurs at 77" TWL. Flooding of I-580 begins in the shoulder lanes at 66" TWL and by 84" TWL extends across the highway.

- Commercial, light industrial, and R&D areas – several vulnerable areas within the study area are a mixture of low density commercial, light industrial, and R&D land uses. Some of these uses, such as garden supply yards and industrial supply stores, could potentially relocate when frequent flooding becomes an issue. One critical land use in the study area is the US Post Office Distribution Center on Point Isabel. Road access to this facility is cut off at 66" TWL and extensive flooding of the facility itself is projected at 96" TWL.

While the Point Isabel Wet Weather Facility is located within the inundated area at 84" TWL, the facility is planned for retirement by 2035. Even though increased water levels could have some impact on outfall capacity before 84" TWL, State of California Guidance climate change projections predict 18" of SLR or less by 2035 (OPR 2018). Therefore, potential impacts to this facility were not considered a major vulnerability in the study area. Decommissioning of this facility could be identified as a trigger (decision point) to re-evaluate land use at this location and consider additional adaptation strategies that may provide protection to other inland assets in the Point Isabel area.

6.2 Identify possible strategic approaches that fit existing and future conditions

In order to generate a series of alternatives that could be evaluated against each other, three concept-level alternative approaches for the study area were developed. Each alternative uses a mixture of the strategic approaches outlined in the Adaptation Guidance. Abbreviated versions of the definitions from the Adaptation Guidance are provided for reference below:

- **Protect**: This approach leads to outcomes that would protect an area with critical assets from flooding. This could include physical barriers to prevent water from getting to an area where it is not wanted, redirecting water to a less desirable area, or slowing or absorbing water through nature-based solutions.
- **Retreat or Avoid**: This approach leads to outcomes that would let an area flood but ensure that it does not contain critical assets. For areas that already contain critical assets, retreat would involve removing or relocating those assets. This could be done through buyouts, rerouting critical services to different areas, or allowing assets at the end of their useful life to not be replaced.
- **Adapt**: This approach leads to outcomes that would let an area flood but ensures that the assets it contains are capable of flooding without any major consequences. This could include retrofitting existing structures through elevation or changing materials or ensuring that new structures or assets are elevated or floodproof.

- **Prepare**: This approach includes any actions that monitor conditions or establishes processes and structures that will support future decision-making that will lead to adaptive outcomes down the line.

Each of the three alternatives meet all the Guiding Principles, but each alternative emphasizes one Guiding Principle more than the others. The guiding principles were used more as initial prompts to generate ideas for different alternatives than rigid singular tracks that the alternatives had to conform to.

- "Maintain and Expand Habitat" (emphasizes the environmental guiding principle)
- "Protect in Place" (emphasizes the social guiding principle)
- "Maximize Resilience of Regional Transportation Network" (emphasizes the economic guiding principle)

The governance guiding principle was not used to guide an individual alternative. Instead, this guiding principle informed all strategy alternatives.

6.3 Summarize vision statement for desired future outcomes

A series of hypothetical vision statements were then developed based on the Guiding Principles, opportunities and constraints, and primary vulnerabilities defined in earlier stages. In practice, the vision statements would be crafted with input from the community and stakeholder groups. One vision statement was created to guide development of each of the alternative approaches:

- "Maintain and Expand Habitat" – Without intervention, existing marshes could experience habitat conversion due to SLR and groundwater inundation of sites containing contaminated soils may occur earlier. To maintain and expand habitat, wetlands would be restored, preserved, and created through a series of strategies including thin sediment dispersal to support marsh accretion, cleanup activities triggered by groundwater and soil monitoring, construction of ecotone levees, and the preparation of migration space. For residential areas threatened by groundwater flooding, programs and policies would be implemented to support a just and equitable relocation and preparation of these spaces to become natural wetlands or floodable open space.

- "Protect in Place" – Without intervention major flooding of residential neighborhoods containing populations with socially vulnerability communities rated as Very High may occur at 48" TWL. To protect these communities in place, physical strategies to support protecting the highway would also be designed to provide flood protection to the communities behind it, low value/low density commercial parcels near creek banks would be acquired to provide space for bank raising and floodplain expansion, and programs to support individual floodproofing of

homes would be implemented in phases as the vulnerable area expands.

- "Maximize Resilience of Regional Transportation Network" – Without intervention, rail lines and highways critical to the regional movement of people, goods, and services could be threatened beginning at 66" TWL. While in other alternatives, portions of highway and rail lines could be protected by bayward earthen levees (or targeted raising of low-lying segments of road or rail), this alternative would seek to maximize the resilience of the transportation network by elevating road/rail with either earthen berms directly underneath, or by raising the assets on piles. Sections on earthen berms could be elevated in phases to minimize disruption of the network. Sections on piles could provide the secondary benefit of increasing habitat connectivity and providing redundant flood protection for these critical transportation assets.

6.4 Challenges and Observations

- The example vision statements provided in the Adaptation Guidance seemed more like summaries of potential strategies as opposed to desired outcomes, or a combination of both. Although vision statements were developed to match the examples, in general, a vision statement describes more what the outcome would be, rather than how to get there. This could be a potential source of confusion for local communities following the Adaptation Guidance.
- Developing substantially different strategies that still met all the Guiding Principles was challenging. While BCDC's reluctance to encourage the development of "extreme" strategy alternatives was understood, if the end goal is a combination of the best parts of each strategy, allowing the development of strategy alternatives that do not meet all guiding principles may generate a wider variety of ideas. The final combined strategy could still be required to meet all guiding principles.

7 Select Actions and Create Strategies

7.1 Overview

Given Bay Area-wide interest and emerging best practices in emphasizing nature-based strategies, SFEI's GIS data on nature-based strategy suitability was used as a baseline for all 3 alternatives. The strategy descriptions in the SFEI Adaptation Atlas were used to understand strengths and weaknesses of each strategy type (including grey and policy strategies). The document also explains the methodology and data sources used to assess spatial suitability of nature-based strategies, which enabled the GIS data to be used with a critical eye and to understand what assumptions were made.

Starting with a satellite imagery, conceptual schematic diagrams were developed in Adobe Illustrator. The purpose of the schematics is to map physical strategies as well as the spatial dimensions of policy strategies. The schematics were purposely kept at the concept level due to the lack of public and

stakeholder engagement in this test-run of the Adaptation Guidance and should not be viewed as plans or BCDC's or AECOM's formal recommendations for adaptation strategies in this study area.

Three schematics were developed for each alternative approach, based on the near-/mid-/far-term horizons defined in an earlier phase and repeated for reference here:

- Near-term (12", 24", 36")
- Mid-term (48", 52", 66")
- Far-term (77", 64", 96", 108")

For physical strategies identified in the schematics, policy strategies necessary to enable each action were identified using BCDC's Adaptation Catalog. A table of policy strategies that support individual actions identified in the strategies is included in the report along with a representative list of general policy strategies to give readers an understanding of potential strategies from the Adaptation Catalog that, while not necessary to implement a specific individual physical strategy, could apply more broadly in the study area.

These schematics were then used to inform the development of adaptation pathways, where differences/divergences between the alternatives are decision points in the pathway (see Section 9: Create an Adaptation Pathway).

7.2 Summary of Physical Actions

This section includes a discussion of each of the three strategy alternatives, including illustrative schematics for near, mid, and far term strategies. Note that since all strategy alternatives are designed to respond to the same Guiding Principles, the strategy alternatives do share many of the same actions. Differences between the strategies stem from the emphasis of each strategy (see 6.2 Summarize Vision Statement for Desired Future Outcomes) and are called out specifically in the strategy alternative narratives below.

7.2.1 Strategy Alternative 1: Maintain and Expand Habitat

This strategy emphasizes preserving, restoring, and creating bayland habitat. Thin sediment dispersal and construction of ecotone levees would support marshes in migrating upland as sea levels rise. Clean-ups of contaminated sites would be triggered based on soil and groundwater monitoring. In this alternative the residential and commercial areas that become frequently flooded from groundwater would be acquired in phases and returned to open space/marsh. Note that these are all areas that were originally wetlands and were filled. For residential areas threatened by groundwater flooding, programs and policies could be implemented to support a just and equitable relocation and preparation of these spaces to become natural wetlands or floodable open space.

The progression of the selected actions across the planning horizons is presented in three figures and described below.

- Near-term (12", 24", 36") – Figure 8

Thin sediment dispersal: Nourish existing marshes with gradual thin sediment dispersals that mimic natural sediment deposits to promote marsh accretion at pace with SLR.

Migration space preparation: Preserve open space adjacent to existing marsh to provide room for the construction of ecotone slopes in a later phase.

New marsh and ecotone slope creation: Place dredged material in subtidal zone/mudflats to build up elevation for vegetated marsh. Fill slope along back of marsh to create transitional habitat/ high tide refugia.

Beach creation and nourishment: Carry out periodic coarse sand, gravel, or shell placements along existing riprap edges. Coarse sand works its way into riprap and traditional or natural groins would help retain beach material as shoreline forming waves from the SW push sand to the NE.

Subtidal habitat creation: Install physical structures or implement plantings to support eelgrass and oyster reefs.

Toxic site groundwater monitoring: Monitor groundwater levels and soil at the Liquid Gold site to anticipate contaminant mobilization before it happens. Soil removal may be required to prevent spread of contamination as groundwater table rises and to prepare upland area for marsh migration (indicated in purple).

Buy-out of select commercial properties: Acquire commercial properties along creeks as they become flood-prone to make space for infrastructure to protect homes in the future (indicated in orange).

- Mid-term (48”, 52”, 66”) – Figure 9

  Raise banks: Raise northern bank of Meeker Creek to prevent flooding of the adjacent commercial area.

  Toxic site remediation: Before the Liquid Gold site (indicated in orange) is inundated, excavate contaminated soil to prevent contaminant mobilization and allow the site to transition to marsh.

  Migration space transitions to ecotone slopes: Construct ecotone slopes on open space adjacent to baylands that was preserved during the near-term phase, providing space for marsh vegetation and species to migrate inland and upwards in elevation.

  Naturalize Central Creek inland of I-580: transition previously acquired commercial properties now in the floodplain to open space, re-align the creek channel and floodplain through the middle of the open space, and raise the creek’s banks to protect adjacent homes from flooding.

  Toxic site groundwater monitoring: Groundwater at the Zeneca site is currently 11-15 ft below surface. Monitor groundwater levels and soil to anticipate contaminant mobilization

before it happens. Removal of concrete cap and soil excavation may be necessary to prevent contamination.

Dispersed green infrastructure: Construct diffuse green infrastructure improvements throughout Baxter Watershed (especially in upper watershed) to lessen riverine flooding from Baxter Creek NE of I-580 and improve water quality.

Buy-out of select commercial properties: Commercial parcels north of Cerrito Creek are currently within the 100-year flood zone. As flood risk increases, implement buyout program to acquire space for the construction of infrastructure to the protect residential area north of the commercial properties in a later stage.

Consider buy-out of residential properties: Consider buy-back program to support relocation if groundwater or stormwater flooding makes staying in place infeasible for low-lying residential neighborhoods adjacent to I-580.

Continuation of near-term actions: Continue to support and nourish marshes, beaches, eelgrass beds, and oyster reefs for as long as is feasible.

- Far-term (77", 64", 96", 108") – Figure 10

  Raise roads and stretches of highways: raise key roads on earthen levees, including Marina Bay Parkway north of Marina Bay, Central Ave and the I-580 eastbound onramp on Point Isabel, which could also double as flood protection. Also raise key stretches of highways, including I-580 south of Central Ave, I-80 south of Central Ave, and I-80 adjacent to the commercial properties acquired during the near-term horizon.

  Construct levees/berm along I-580: Construct a traditional earth levee at the crest of the existing ecotone slope to prevent overtopping of the highway.

  Construct levee on Point Isabel: construct an earthen berm along Point Isabel to prevent overtopping. Depending on the direction and strength of wave action, this could either be an earthen berm or a hardened levee.

  Open space and flood protection along Cerrito Creek: Convert flooded commercial parcels north of Cerrito Creek to open space and use this open space to construct earthen levees to protect vulnerable residential areas further north.

  Consider expanding open space into residential areas: Groundwater inundation may make protection of residential areas infeasible, even with construction of levees and berms. If so, implement buyout programs.

  Protect Marina Bay: raise the southern bank of Meeker Creek and construct floodwalls along low segments of the Marina Bay shoreline to prevent overtopping and flooding of this residential area.

Support reconnection of marsh habitats: Continue to support marsh habitats with thin sediment dispersal. As marshes accrete above pockets and strips of land, allow the marshes to reconnect. Raise breakwaters that protect marshes from wave action. If beach nourishment becomes infeasible, allow sand to be reworked by waves and dispersed throughout marshes.

Habitat conversion: Convert stormwater area adjacent to Bayview Ave overpass to wetland as sea levels rise.

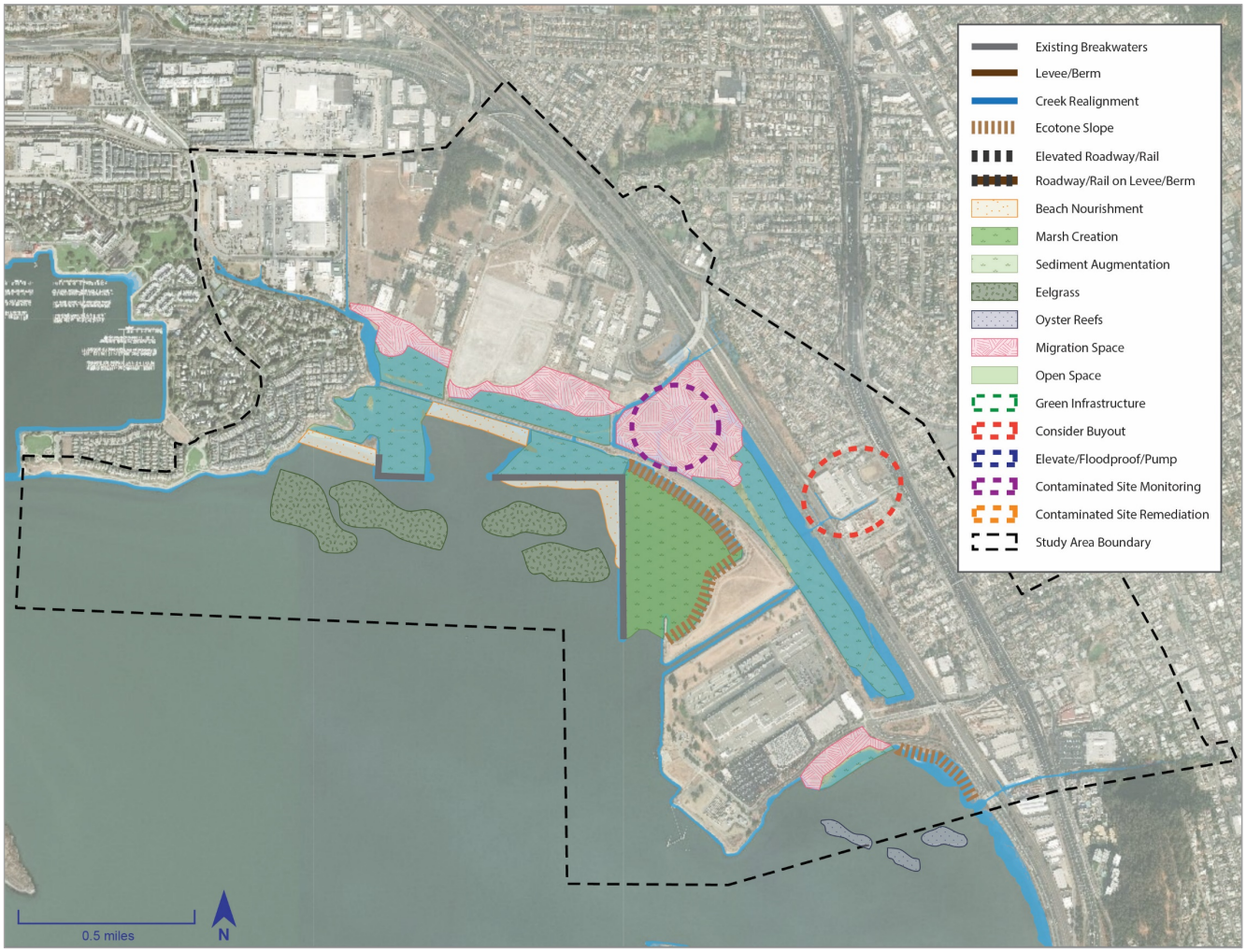

Figure 8: Strategy Alternative 1: Maintain and Expand Habitat, Near-Term Schematic

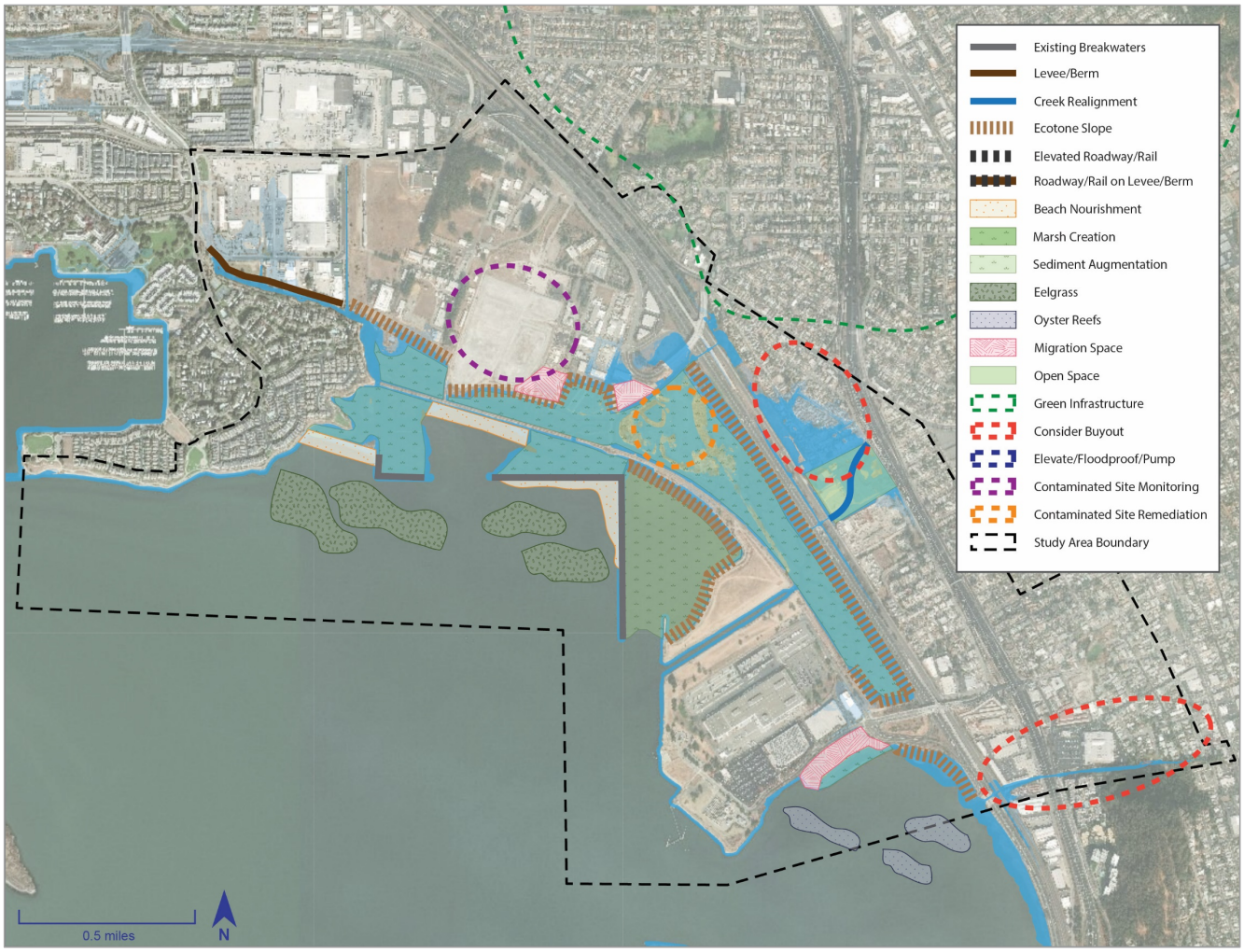

Figure 9: Strategy Alternative 1: Maintain and Expand Habitat, Mid-term Schematic

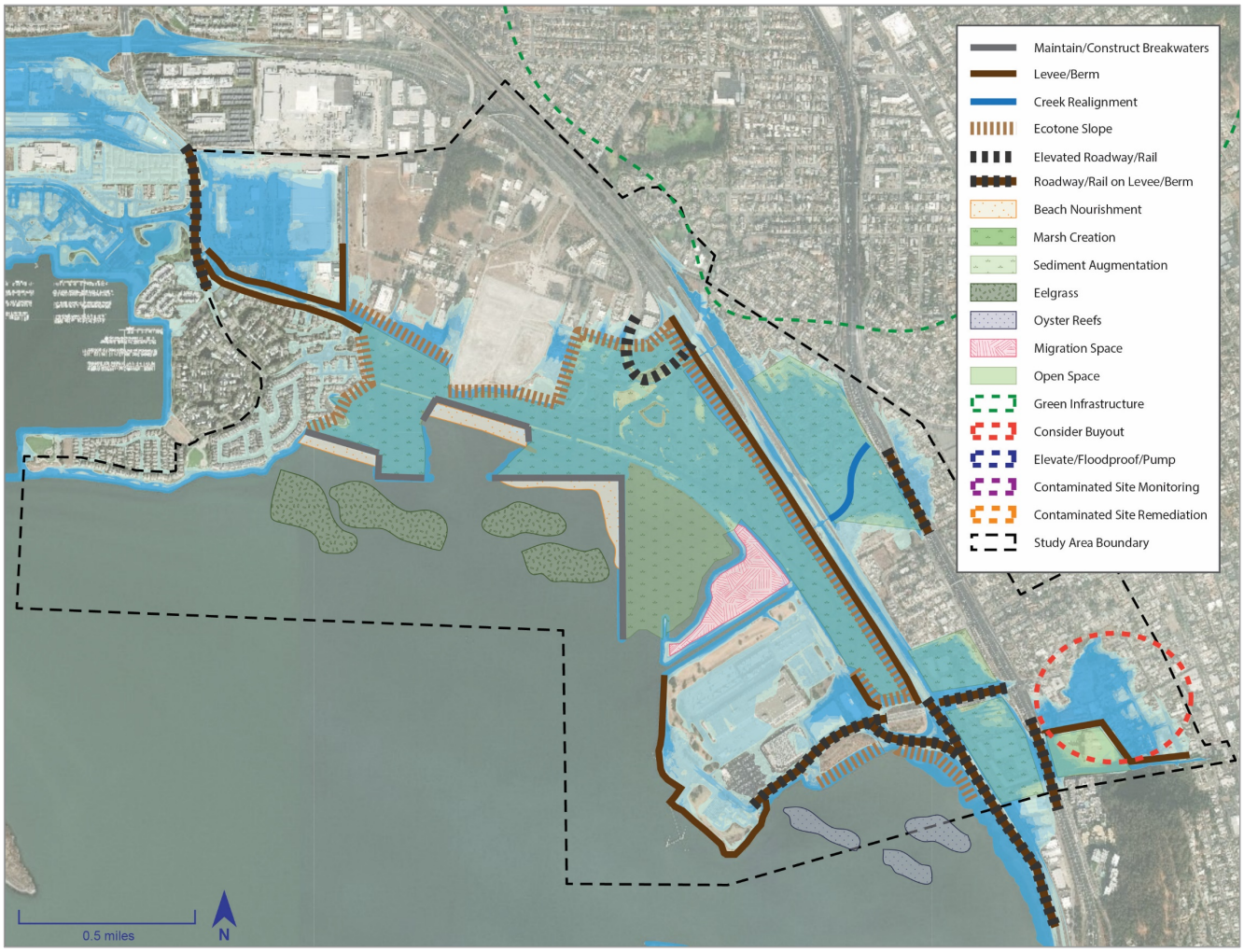

Figure 10: Strategy Alternative 1: Maintain and Expand Habitat, Far-term Schematic

7.2.2 Strategy Alternative 2: Protect in Place

This strategy emphasizes preventing displacement of socially vulnerable communities in the study area. To protect these communities in place, physical strategies to support protecting the highway could also be designed to provide flood protection to the communities behind it. Low value and low-density commercial parcels near creek banks could be acquired to provide space for bank raising and floodplain expansion. Where and when these strategies are insufficient due to groundwater flooding, programs to support individual floodproofing of homes could be implemented in phases as the vulnerable area expands. While existing habitat is protected and supported, there is less emphasis on new habitat creation than in Strategy Alternative 1.

The progression of the selected actions across the planning horizons is presented in three figures and described below.

- Near-term (12", 24", 36") – Figure 11

  The near-term actions for Strategy Alternative 2 are similar to those described for Strategy Alternative 1 except for the following exceptions:

  Strategy Alternative 2 does not include the construction of physical structures to support subtidal habitat such as eelgrass beds and oyster reefs.

  Strategy Alternative 2 does not include the creation of new marsh habitat in the mudflats between North Point Isabel/McLaughlin Eastshore State Park and the north-south breakwater. Instead, periodic coarse sand, gravel, or shell placements attenuate waves and provide an additional recreation amenity.

- Mid-term (48", 52", 66") – Figure 12

  The mid-term actions for Strategy Alternative 2 are similar to those described in Strategy Alternative 1 except for the following actions:

  New park inland of I-580: Construct a new park on previously acquired commercial properties now in the floodplain, convert to open space, re-align the creek channel and floodplain through the middle of the park, and raise the creek's banks to protect adjacent homes from flooding. The park could be designed to accommodate flooding (i.e., floodable park) so that the creek banks can be raised less, preserving access to the creek.

  Policy and physical actions to protect residential neighborhood: Implement site and policy-level actions to cope with flooding, rather than implementing a buyout program. Actions could include constructing additional pump capacity to minimize ponding and/or programs to provide financial assistance to homeowners to elevate/raise/floodproof homes.

- Far-term (77", 64", 96", 108") – Figure 13

  The far-term actions for Strategy Alternative 2 are similar to those described in Strategy Alternative 1 except for the following actions:

Protect neighborhoods in place: Unlike Strategy Alternative 1, no residential parcels are acquired through buyout programs. Instead, creek banks could be raised to reduce risk of riverine flooding and continue to implement site level actions to support residential areas. Some commercial parcels may need to be acquired to create space for physical strategies to protect homes.

Protect commercial area adjacent to Cerrito Creek: Construct an earthen levee along the northern bank of Cerrito Creek east of I-80 to protect the commercial area, which provides the surrounding community with a grocery store and local jobs. Portions of the parking lots in this area may need to be acquired to create space for physical infrastructure.

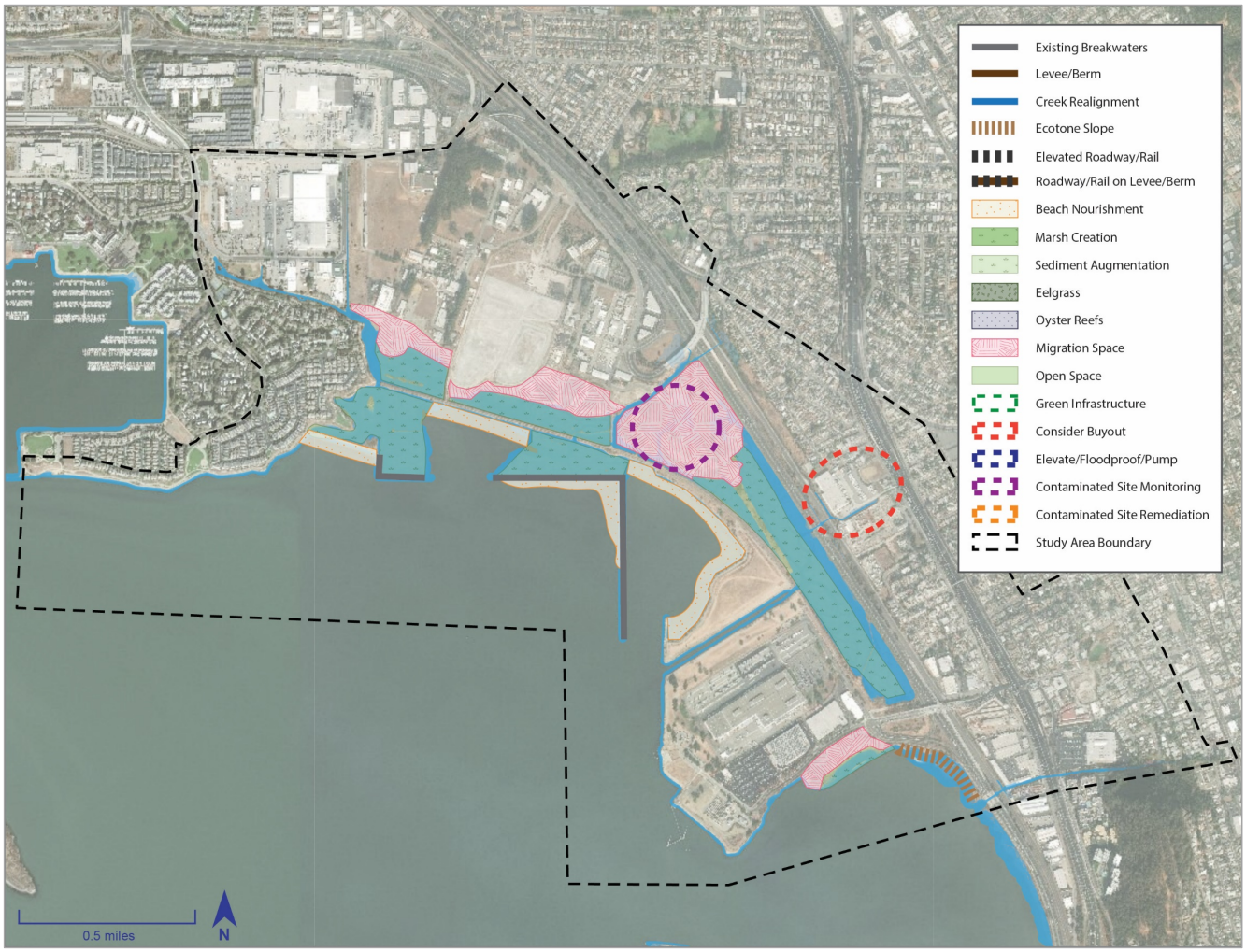

Figure 11: Strategy Alternative 2: Protect in Place, Near-term Schematic

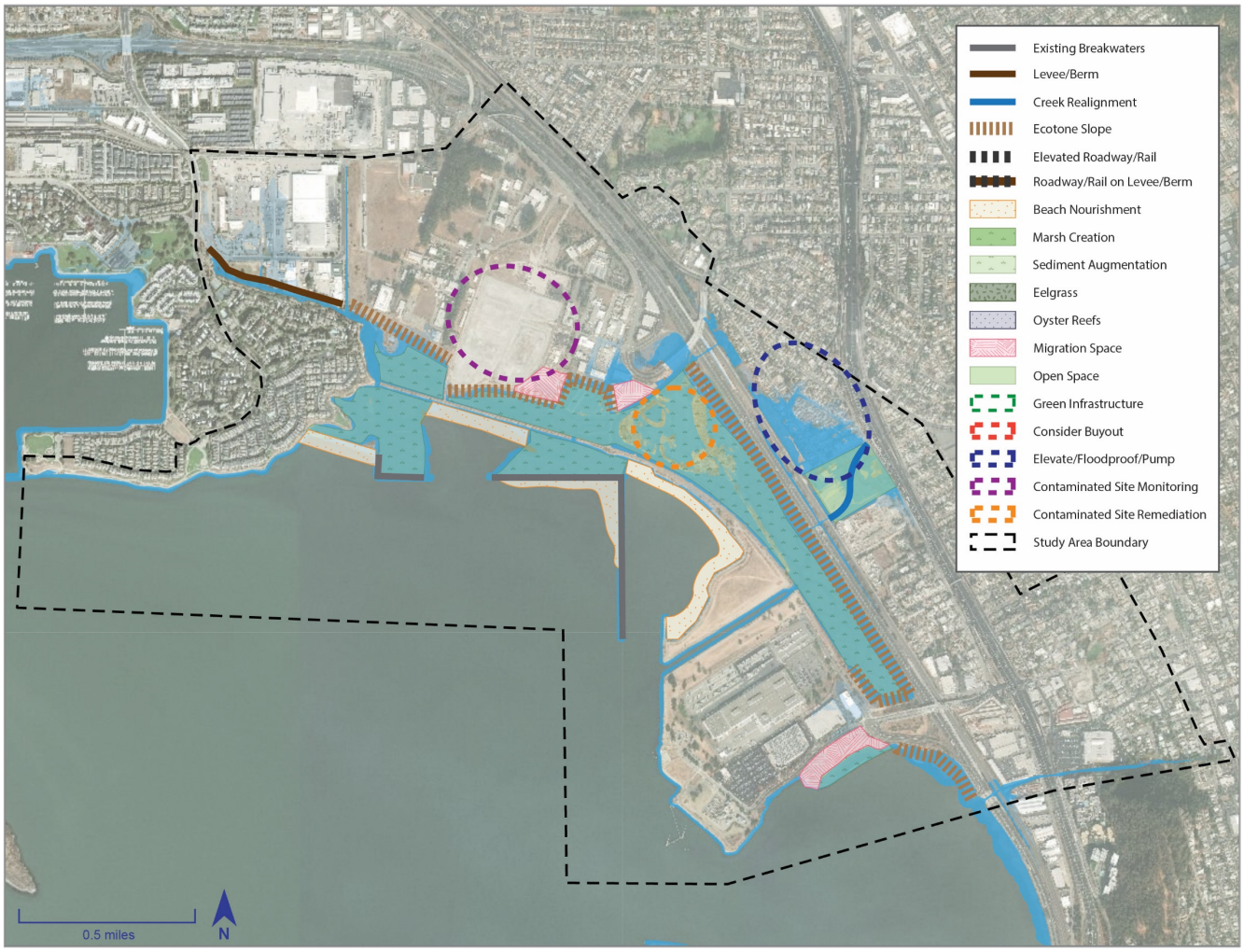

Figure 12: Strategy Alternative 2: Protect in Place, Mid-term Schematic

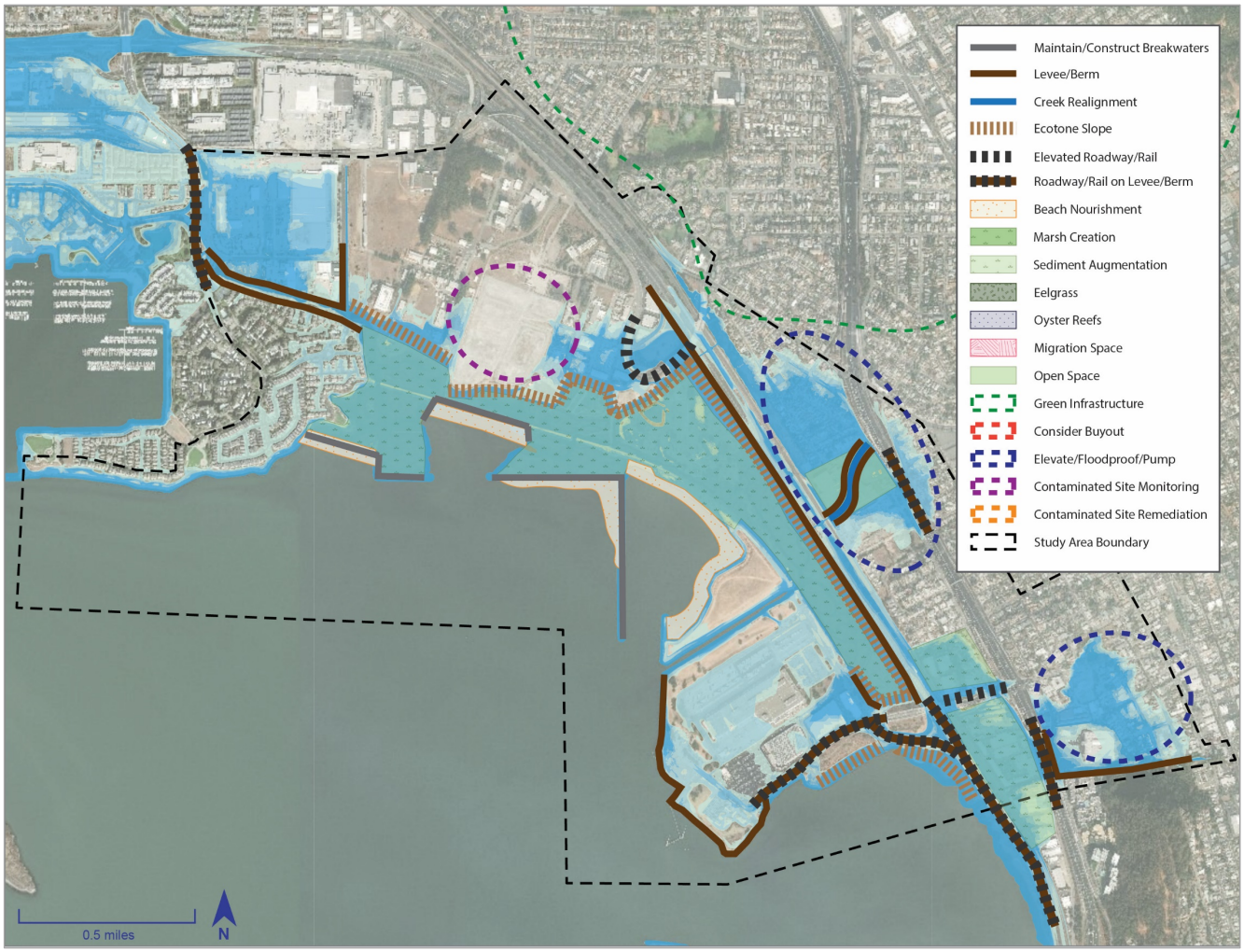

Figure 13: Strategy Alternative 3: Protect in Place, Far-term Schematic

7.2.3 Strategy Alternative 3: Maximize Resilience of Regional Transportation Network

Without intervention, rail lines and highways critical to the regional movement of people, goods, and services could be threatened beginning at 66" TWL. While in other alternatives, portions of highway and rail lines could be protected by bayward earthen levees (within raising of targeted low-lying segments of road), this alternative would seek to maximize the resilience of the transportation network by elevating road/rail with either earthen berms directly underneath, or by raising the assets on piles. Sections on earthen berms could be elevated in phases, to minimize disruption of the network. Sections on piles could provide the secondary benefit of increasing habitat connectivity from one side of the road/rail and the other, while providing redundant flood protection for these critical infrastructure assets.

- Near-term (12", 24", 36") – Figure 14

The near-term actions for Strategy Alternative 3 are identical to those described for Strategy Alternative 2.

- Mid-term (48”, 52”, 66”) – Figure 15

  The mid-term actions for Strategy Alternative 3 are similar to those described in Strategy Alternative 2 except for the following:

  Strategy Alternative 3 includes the residential buyouts proposed in Strategy Alternative 1 to prepare the area for potential groundwater flooding.

  Strategy Alternative 3 does not include the full ecotone slope along I-580 that is proposed in Strategy Alternative 2. This is in anticipation of the Hoffman Marsh being reconnected with areas that are returned to wetland inland of I-580 in the far-term by raising I-580 and the railroad on piles (see below).

- Far-term (77”, 64”, 96”, 108”) – Figure 16

  The far-term actions for Strategy Alternative 3 are similar to those described in Strategy Alternative 1 except for the following:

  Rather than a traditional levee at the crest of the ecotone slope bayward of I-580 along Hoffman Marsh, this section of highway, and the railway that runs parallel to it, would be raised on piles. By raising stretches of the highway/railway on piles, the new wetlands formed inland could be connected to Hoffman Marsh, increasing habitat connectivity as a secondary benefit.

  Ecotone slopes would be constructed backing the flooded open space inland of I-580 to provide transitional and upland habitat and storm surge protection to the remaining residential areas.

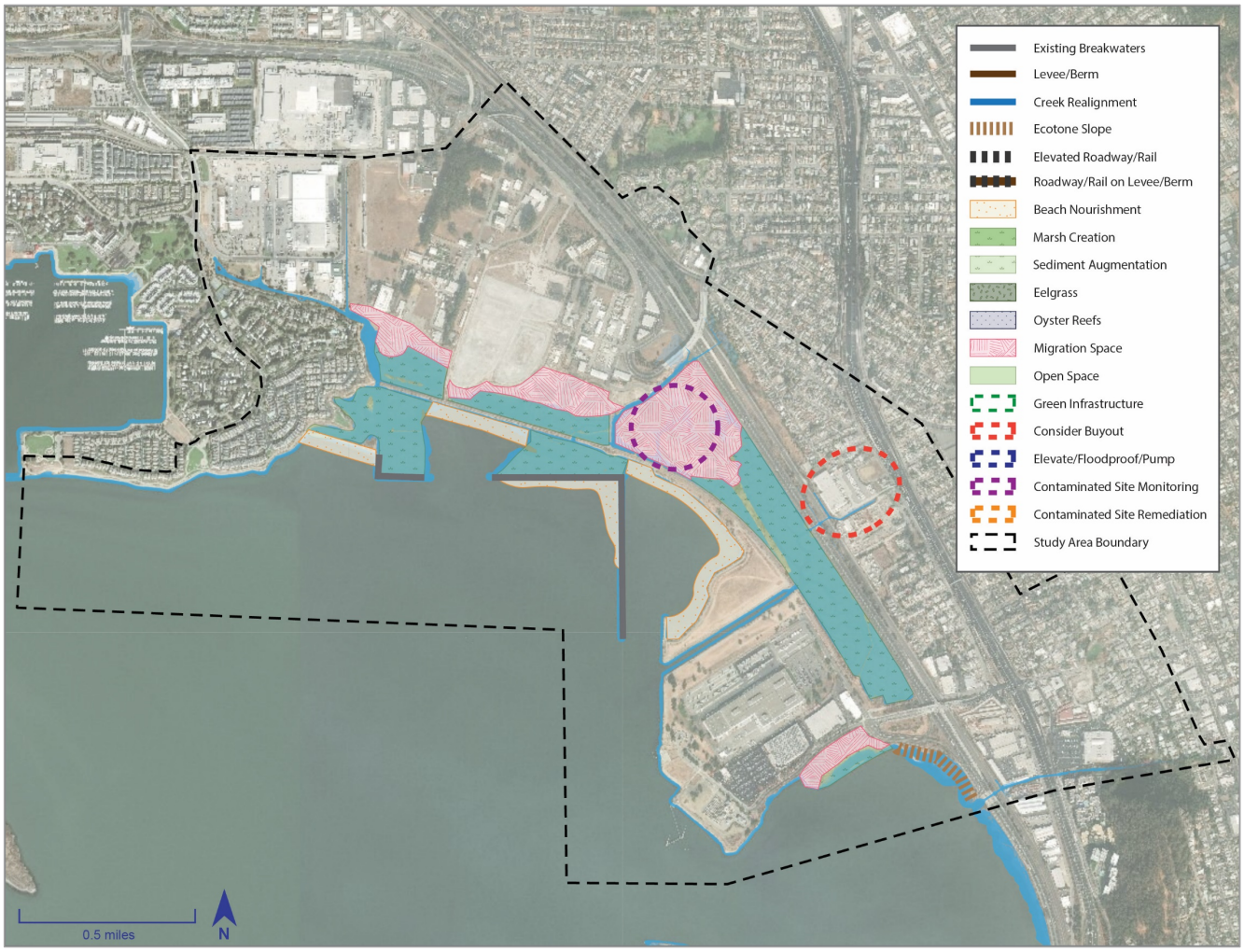

Figure 14: Strategy Alternative 3: Maximize Resilience of Regional Transportation Network, Near-term Schematic

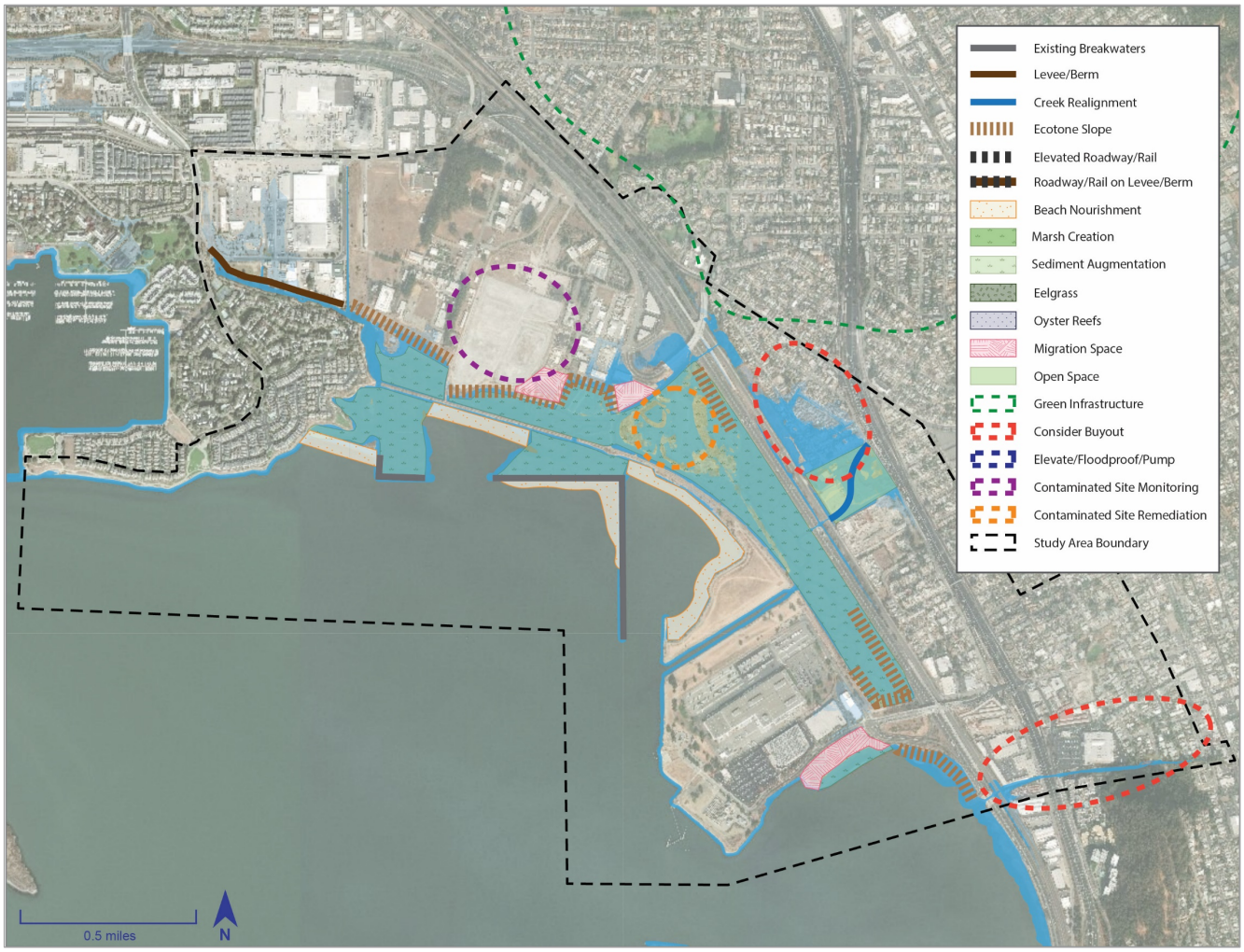

Figure 15: Strategy Alternative 3: Maximize Resilience of Regional Transportation Network, Mid-term Schematic

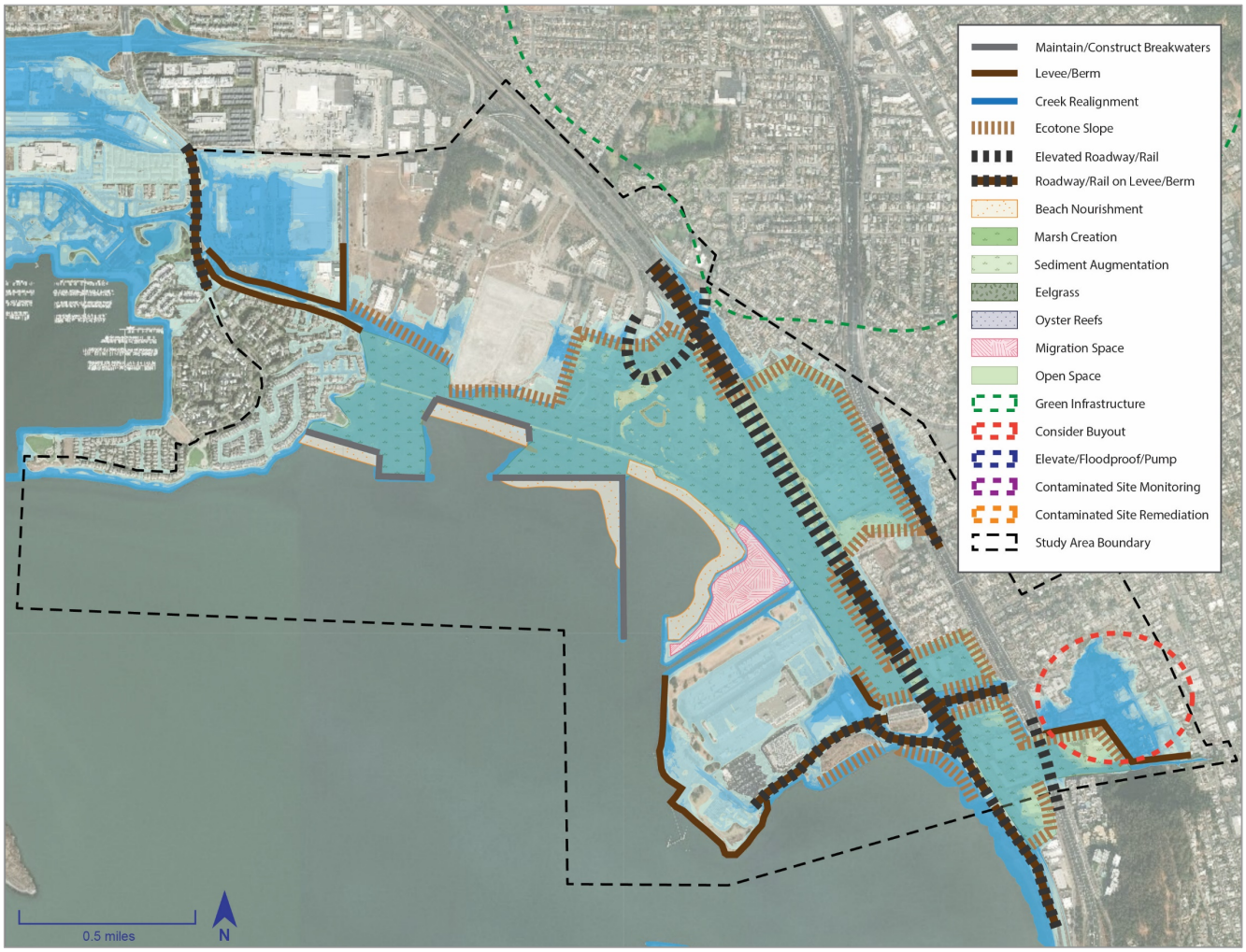

Figure 16: Strategy Alternative 3: Maximize Resilience of Regional Transportation Network, Far-term Schematic

7.3 Plans, Policies, and Programs

The Adapting to Rising Tides Adaptation Catalog was used as a starting point for developing a list of plans, policies, and programs that would support the implementation of physical actions identified in the Strategy Alternatives.

Table 9: Potential Governance Actions for the Richmond Focus Area

Action Type	Action Name	Relevance to Focus Area	Supports a Physical Action?
Plan	General Plan	General Plans set forth the goals, policies and directions each city plans to take in managing its future. Both the Richmond and El Cerrito General Plans could be updated to include their visions for responding to sea level rise.	Yes
Plan	Local Hazard Mitigation Plan Update	To be eligible for federal disaster and flood insurance, localities must have a regularly updated hazard mitigation plan. As flood risk changes in the Focus Area (from overtopping and groundwater), the LHMP may need to be updated accordingly.	Yes
Plan	Develop Adaptation Plan	Develop an adaptation plan for the Focus Area following the Adaptation Guidance and building upon the initial work documented in this pilot and the Richmond Climate Action Plan. Consider using the Adaptation Pathways approach to ensure that decisions regarding the implementation of actions in the Focus Area consider the impact that choices made now could have on the flexibility of future decisions.	Yes
Plan	Green Infrastructure Plan	The City of Richmond Green Infrastructure Plan, approved in September 2019, seeks to guide a shift from conventional “collect and convey” storm drain infrastructure to more resilient, sustainable stormwater management that improves water quality, reduces runoff volumes and reduces flood risk. The City’s Green Infrastructure Plan could play a key role in reducing flood risk at the tidal/riverine interface through the reduction of peak flows that could cause flooding when extreme precipitation events overlap with high tides.	Yes
Zoning	Zoning Update	Many of the physical actions identified in the previous section could require zoning changes (i.e., commercial land to open space) that must be reflected in municipal zoning ordinances to be implemented.	Yes
Zoning	Land Use Restrictions	All of the Strategy Alternatives presented in the previous section rely to some degree on the preservation of migration space for marsh habitat and	Yes

Action Type	Action Name	Relevance to Focus Area	Supports a Physical Action?
		for the construction of ecotone slopes. In order to ensure that these areas are not developed, and to prevent additional development along the shoreline that would then need to be protected, land use restrictions may need to be put in place.	
Zoning	Overlay Zones/Districts	Overlay zones superimpose additional regulations on an existing zone based upon special characteristics of that zone. Overlay zones could be used to require stronger building codes for residential and commercial properties in areas with heightened flood risk.	Yes
Zoning	Transfer of Development Rights	A Transfer of Development Rights (TDR) program is designed to limit potential development in vulnerable areas, while compensating property owners for the reduction in property values. A locality can identify vulnerable “sending” areas, where development intensity could remain low, and upland “receiving” areas where higher density development is more suitable. A market can be established where landowners in the sending area can be compensated for the transfer of some of their development rights to a property owner in the receiving area. Localities may also choose to compensate these landowners through tax credits.	Yes
Zoning	Retreat	Significant portions of the Focus Area are either open space or low density/low value commercial land. It is unlikely that private landowners or public agencies would be willing to provide the funds necessary to protect these areas. Therefore, a managed retreat and decommissioning of structures in these areas may be necessary. In addition, at higher TWLs the threat of groundwater flooding may make protecting key residential areas infeasible and necessitate some retreat from residential neighborhoods as well.	Yes
Policy	Building codes and retrofits	This approach involves requiring new building projects to build above the projected flooding level. For existing buildings, many approaches to flood-proof structures can be utilized.	Yes
Program	Buyout Programs	The Strategy Alternatives identify two types of buyout programs: 1) buyouts to acquire parcels necessary to build physical infrastructure to protect the greater neighborhood and 2) buyouts to support the relocation of communities as a last resort if staying in place becomes infeasible due to heightened flood risk.	Yes

Action Type	Action Name	Relevance to Focus Area	Supports a Physical Action?
Program	Monitoring	The Strategy Alternatives identify two types of monitoring: 1) monitoring of toxic sites to anticipate and prevent contaminant mobilization and 2) monitoring of groundwater in residential and commercial areas to trigger either physical strategies (pump stations, building retrofits, etc.), or policies such as buyouts.	Yes
Program	Economic Risk Analysis	The high cost of infrastructure necessary to adapt to sea level rise is a major barrier to implementation. However, demonstration that the cost of inaction is much higher can build support for adaptive infrastructure. An economic risk analysis of the study area could consider impacts on jobs, residential property values, contaminant dispersal, and regional mobility.	No
Funding	Mello-Roos Bonds	Locally issued bonds that are repaid by a special tax imposed on property owners within a community facilities district established by a public agency. The bond proceeds can be used for public improvements and for a limited number of services. (Institute for Local Governments 2010)	Yes
Funding	Stormwater Management Fees	Stormwater fees could be used to fund physical improvements such as pump stations, relocation of outfalls, and other stormwater improvements	Yes
Funding	Special Assessments	An assessment district could be created to fund flood protection infrastructure that includes all properties protected by that structure. This approach would likely be more politically palatable than a city-wide tax or fee that would require residents and business outside of the vulnerable areas to pay for flood protection.	Yes
Funding	Grant Application Program	As described in Section 3.2 of this report, implementation of physical and governance actions in the Focus Area would require targeted pursuit of a range of grant funding opportunities, including but not limited to California state agency grants, federal agency grants, regional agency grants, and private/philanthropic grants.	Yes
Funding	Evaluate Political Feasibility of Various Tax Options	The cities of Richmond and El Cerrito, as well as the East Bay Regional Parks District could evaluate the feasibility of funding shoreline improvements through various taxes, such as property taxes, parcel taxes, or other taxes (utility, sales, gas, etc.). The political ramifications of these strategies should be carefully	Yes

Action Type	Action Name	Relevance to Focus Area	Supports a Physical Action?
		considered, and benefits must be conveyed to residents that live outside the vulnerable areas.	
Funding	Utility Fees	Utility fees could be used to fund any projects that increase the resilience and reliability of utility provision in the face of changing groundwater conditions.	Yes
Coordination	Establish a Cooperative Shoreline Management Program	The disjointed ownership of land across the Richmond Focus Area means that land managers could benefit from a cooperative shoreline management program. This would likely begin with a Memorandum of Understanding and creation of a steering committee comprised of major landowners, jurisdictions, and agencies.	Yes
Coordination	Coordination for Soil Management	The physical actions identified in the Strategy Alternatives (i.e., marsh nourishment, ecotone slopes, earthen levees), would require a great deal of sediment that meets specifications required by the Regional Water Quality Control Board. The Adapting to Rising Tides Program proposes a coordinated, collaborative and regional approach to finding, sorting, moving, storing and utilizing soil for sea-level rise improvements.	Yes
Coordination	Proactive Partnerships with Regulatory Agencies	As described in Sections 3.1 and 3.2, federal, state, and regional permitting agencies could be proactively invited to collaborate on all planning/design processes to for the Focus Area, to ensure that the outcomes of these processes meet all legal requirements.	Yes
Public Engagement	Community Emergency Response Team (CERT)	This program educates volunteers about disaster preparedness for the hazards that may impact their area and trains them in basic disaster response skills, such as fire safety, light search and rescue, team organization, and disaster medical operations. Through CERT, the capabilities to prepare for, respond to and recover from disasters is built and enhanced. As residential areas become particularly vulnerable to groundwater flooding, community response could increase resilience against flood events.	No
Public Engagement	Workshops to Educate private Landowners on Climate Risks	Communicate increased flood risks in the Focus Area to both small and large landowners.	No
Public Engagement	Sensing Stations and Monitoring	Build permanent sensing stations and use citizen science to better understand sediment flows, salinity,	No

Action Type	Action Name	Relevance to Focus Area	Supports a Physical Action?
		tidal currents, flood levels and scouring in creeks and tidal zones.	

8 EVALUATE STRATEGIES

The ART Bay Area project report includes a comprehensive list of potential evaluation criteria that can be used by communities as a tool for exploring the benefits and tradeoffs for different strategies. Since the pilot process did not include public or stakeholder engagement, for this report tthe evaluation step was not be carried out. If this project had included public or stakeholder engagement, evaluation criteria would have been selected through a workshop process to ensure that the criteria reflected the needs and priorities of local stakeholders. Then technical stakeholders would have helped rate each strategy for each criterion (see 3.1 Potential Stakeholders).

A list of potential criteria presented by BCDC in an exercise during the ART Bay Area Regional Working Group meeting on June 19, 2019 was reviewed. Based on the strategies identified in the Focus Area, a subset of these criteria were selected to be illustrative of some of the key criteria that the community could consider in the strategy evaluation process. In lieu of stakeholder engagement, criteria were selected that were either representative of one or more Guiding Principles (see Section 5: Define Guiding Principles) or are a key determinant of feasibility. The Table 10 below lists the chosen criteria, a description based on ART materials, and the reason they were included.

Table 10: Illustrative Criteria for Evaluation of Strategy Alternatives

Criteria Category	Illustrative Criteria	Description	Relevant Guiding Principle
Feasibility	Cost	Does this strategy have a reasonable cost compared to other actions?	Feasibility
	Community Support	Will the strategy be supported by a strong advocate or local champion?	Feasibility
Regional Impacts	Regional Transportation	Will the strategy help maintain regional services from airports, ports, highways, rail systems, and/or major transportation hub services?	Economic
	Regional Habitat	Does the strategy help achieve regional habitat goals?	Environmental
Social Benefits	Access	Will the strategy protect access to transportation (car, public transit, bike, or pedestrian), housing, jobs, or services?	Economic
	Vulnerable Residents	Will the strategy help protect vulnerable communities and/or help address chronic issues faced by vulnerable communities?	Social

Criteria Category	Illustrative Criteria	Description	Relevant Guiding Principle
	Contaminants	Will the strategy prevent the mobilization of contaminants from hazardous sites?	Environmental
	Displacement	Will the strategy help avoid displacement of vulnerable communities?	Social
Disaster Lifecycle	Risk	Does the action help mitigate risk?	Economic, Environmental, Social
Economic Benefits	Commuter and Goods Movement	Will the strategy help maintain or enhance commuter movement or movement of goods?	Economic
	Infrastructure	Will the strategy help protect infrastructure investments (e.g., roads, highways, rail, water treatment facilities, substations, etc.) and/or address current needs for upgrades to infrastructure?	Economic, Environmental
	Vulnerable Communities	Does the strategy help protect community services, homes, and businesses of vulnerable communities?	Social
Environmental Improvement	Habitats and Biodiversity	Will the strategy help create or maintain biodiversity and resilient habitat (e.g., does habitat drown with projected sea level rise)?	Environmental
	Nature-Based	Will the strategy promote nature-based solutions as opposed to traditional gray/hard infrastructure?	Environmental
Governance	Partnerships	Will the strategy help streamline regulatory processes when possible?	Governance, Feasibility
	Communities	Will the strategy help facilitate and fund participation with diverse stakeholders, including vulnerable communities?	Social

Based on these criteria, an example rating matrix was developed, displayed below:

Table 11: Example Rating Matrix for Strategy Evaluation

Criteria Category	Illustrative Criteria	Strategy Alternative 1: Maintain and Expand Habitat	Strategy Alternative 2: Protect in Place	Strategy Alternative 3: Maximize Resilience of Regional Transportation Network
Feasibility	Cost	-	-	-
	Community Support	-	-	-
Regional Impacts	Regional Transportation	-	-	-
	Regional Habitat	-	-	-
Social Benefits	Access	-	-	-
	Vulnerable Residents	-	-	-
	Contaminants	-	-	-
	Displacement	-	-	-
Disaster Lifecycle	Risk	-	-	-
Economic Benefits	Commuter and Goods Movement	-	-	-
	Infrastructure	-	-	-
	Vulnerable Communities	-	-	-
Environmental Improvement	Habitats and Biodiversity	-	-	-
	Nature Based	-	-	-
Governance	Partnerships	-	-	-
	Communities	-	-	-

For each criterion, developing specific definitions for rating options is suggested in order to ensure consistency in how different strategies are rated for the same criteria. Each criterion could be rated either by using an ordinal ranking system with several options, or a binary ranking system with two options. Illustrative rating options for example criteria are shown in Table 12 and Table 13 for ordinal and binary rating systems.

Table 12: Illustrative Ordinal Ranking Rationale for Example Criteria

Ordinal Rank	Notation	Habitats and Biodiversity	Access
Significantly Positive	++	Habitat and species enhanced or expanded by alternative	Shoreline access enhanced/created by alternative
Positive	+	Habitat and species protected by alternative	Shoreline access protected by alternative
Neutral	0	No impacts on habitat and species	No impact to shoreline access
Negative	-	Habitat and species harmed by alternative	Shoreline access somewhat impeded by alternative
Significantly Negative	--	Habitat and species substantially harmed by alternative	Shoreline access substantially impeded by alternative

Table 13: Illustrative Binary Rating Rationale for Example Criteria

Binary Rating	Notation	Habitats and Biodiversity	Access
Positive	+	Habitat and species enhanced or protected by alternative	Shoreline access protected, enhanced, or created by alternative
Negative	-	Habitat and species harmed by alternative	Shoreline access impeded by alternative

9 CREATE AN ADAPTATION PATHWAY

9.1 Overview

The Adaptation Guidance instructs local communities to develop adaptation pathways based off the strategy alternatives identified and evaluated in the previous steps. The Guidance defines an adaptation pathway as a “strategic approach to adaptation over time”. Adaptation pathways are an emerging and increasingly popular approach for accommodating the uncertainty of SLR projections into the phasing of strategies (Deltares, Zandvoort et al 2017, Bloemen et al 2017).

The approach encourages planners to think through the phasing of individual actions and when decisions need to be made about which action(s) to implement based on triggers and thresholds. An adaptation pathway answers questions such as: for how much sea level rise will a given strategy be effective, and based on the lead time required, when should the implementation of a subsequent strategy begin? How will the decision to implement a certain strategy influence which strategies can be implemented further in the future? The purpose is to maintain flexibility, avoid strategy lock-in, and choose which actions to implement based on the merits of the pathways they enable.

Adaptation pathways are generally conveyed as a graphic that merges the functionality of a phasing diagram and a decision tree. However, there is no universally accepted graphic standard or method for producing an adaptation pathways diagram as they are customized to the context of each project. For this pilot, an example adaptation pathways graphic was developed and tested on a portion of the Focus Area (Figure 17) that was well-suited because the strategy alternatives identified a variety of potential actions for that subarea.

9.2 Process of Developing an Adaptation Pathway

In order to develop an adaptation pathway that both reflected best practices and was applicable to the specific site, a review of several examples of adaptation pathways diagram was carried out. The pros and cons of each example were identified, with the focus on graphical clarity and information density (i.e., ability of a reader to easily understand the graphic).

The review of examples revealed the following observations:

- At a minimum, an adaptation pathways diagram should include: an axis based on time or amount of sea level rise and various potential actions, with each action identifying implementation timing, useful life, lead time requirements, and decision points.
- Adaptation pathways diagrams should be information dense, but not be so complicated that they are not intuitive. Since the purpose of the diagram is to help conceptualize decision-making, it is important that the graphic facilitates understanding, rather than becoming an additional source of confusion. The most intuitive diagrams used simple shapes and colors to convey the elements described in the bullet above.
- While the spatial scale of strategies shown on an adaptation pathways diagram may vary, a diagram should only include actions that are related to or influence each other's implementation. If a site includes multiple reaches or regions where a choice of action in one area will not substantially impact choices in another area, these areas should be depicted on different diagrams.
- The adaptation pathways approach is most useful in situations where there are several viable options and choices made will influence future options. In situations where there is only one viable pathway, a diagram can still be developed, but without decision points the graphic will not be substantially different than a standard phasing diagram.

Based on this information, a subarea within the Richmond Focus Area was selected to test out the approach (Figure 17). The residential and commercial area landward of I-580 was selected because 1) all flooding originates from Central Creek, which means that all actions implemented to protect that area would be related, and 2) the area is well-suited for the adaptation pathways approach because the strategy alternatives developed in previous steps identified many possible actions for this area. The adaptation pathway diagram is shown in Figure 18 and discussed in Section 9.3.

For an additional example of a similar adaptation pathways diagram applied in a different context, please refer to the Suisun City Focus Area Report (May et al. 2019).

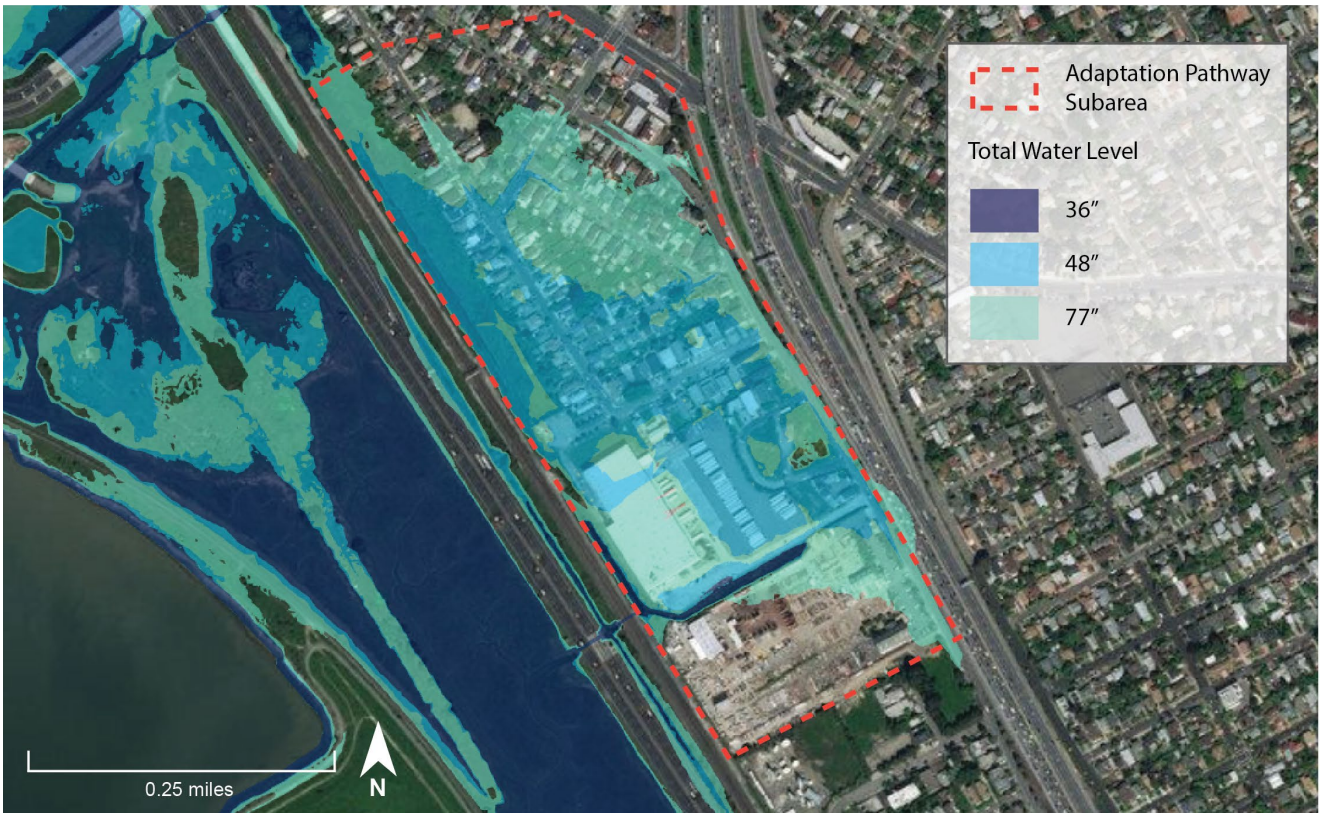

Figure 17: Illustrative Adaptation Pathway Subarea Context Map

9.3 Illustrative Adaptation Pathway

The illustrative adaptation pathway diagram (Figure 18) includes the following elements:

- **Total Water Levels**: to accommodate the uncertainty around sea level rise projections, the x-axis of the diagram is based on the 10 TWLs, rather than time. Keeping the diagram "time agnostic" allows for flexibility in the pathway—an action that is intended to be implemented starting at 24" TWL would be implemented before that level of sea level rise is predicted to occur. Current sea level rise projections for two emissions scenarios, RCP 4.5 and RCP 8.5, are depicted as ranges above the the diagram. For example, the teal bar under 2100 indicates the range of sea level rise projected for 2100 under RCP 4.5. As sea level rise projections change, this portion of the graphic can easily be updated by modifying the ranges without needing to update the adaptation pathway portion.
- **Actions**: each potential action is depicted by a solid horizontal line. The color of the line indicates the type of action: nature-based (green), plan/policy/program (purple), or grey infrastructure (blue). Each action has the following attributes:
    - **Time of Implementation**: depicted by a large grey circle at the beginning of each action line, this marks the point where the action would be implemented and fully functional. For physical actions this means that the infrastructure would be constructed and operational. For governance actions, this means that the policy or program would be

authorized by applicable decision-makers and rolled out. Implementation times for each action are located just before the end of action lifespan for the preceding action.

- **Useful life**: the length of the solid line indicates the range of TWLs for which the action would provide protection, bounded by implementation and end of lifespan
- **End of action lifespan**: depicted by a vertical bar at the end of each action line, this marks the point where the action will no longer be able to provide the protection that it is intended to. The end of action lifespan is based on thresholds. For example, the end of action lifespan for the no action option is located at 48" TWL, because that is the threshold at which overtopping from Central Creek begins.
- **Lead time**: a light grey circle, followed by a dashed line precedes the implementation of each action. This represents the time when activities must begin to ensure implementation by the time the action is necessary. Longer dashed lines indicate that the action has a longer lead time. The light grey circle represents the trigger for when activity to implement this action must begin. For physical actions, the lead time includes funding, planning, design, permitting, and construction. For governance actions, the lead time includes funding, passing any necessary legislation, and any other activities preceding roll-out for a policy or program (such as stakeholder engagement and elected officials briefings). Note that there is uncertainty inherent in estimating the lead time for actions that will occur far in the future, as the regulatory, financial, and/or political environment may change substantially by then.

- **Decision Point**: depicted by a black triangle, decision points mark when a decision needs to be made between two or more actions. The decision point is always located just before the longest lead time of the actions being considered, because after this point the chance to implement that action by the time it is needed will have passed. Groups of actions with shorter lead times will have a decision point closer to implementation.

The adaptation pathways diagram should be read as a decision tree, beginning with the no action/existing condition and then diverging based on which action(s) are chosen. Each iteration of decisions represents a potential adaptation pathway. An individual adaptation pathway begins at 0" TWL on the no action line and then can transfer to other actions via the vertical grey lines as sea level rises, or ends at any of the end of action lifespan bars if no transfer is made. The actions listed above the no action line in Figure 18 are intended to address surface flooding/overtopping, while the actions listed below the no action line are intended to address groundwater flooding.

The simplest, and least flexible pathway, consists of taking no action until just before 48" TWL, when a floodwall would be constructed to prevent flooding from the overtopping of Central Creek. On the diagram, this pathway starts at 0" TWL, skips the decision point just before 24" TWL and then transfers from no action to wall just before the no action's end of action lifespan at 48". This pathway provides the benefit of not requiring any landowners to retreat. However, a major downside to this pathway is that while it provides protection until 77" TWL, there is no option to transfer to another action beyond that because all decision points have already been passed. If sea level rises above 77" TWL, this pathway would not be sufficient and would have resulted in maladaptation/strategy lock-in.

Other pathways preserve the flexibility to adapt to sea levels up to 108" TWL and beyond but require a decision just before 24" TWL in order to be implemented. For pathways in the upper portion of the diagram, the decision would be made to begin acquiring the commercial parcels adjacent to Central

Creek in order to prepare the area for the overtopping and flooding that would begin at 48”. Acquiring privately held land would likely require substantial lead time, as shown in the diagram. After the commercial land is acquired, the next decision would be whether to convert this land into a park with a realigned river channel and raised banks or convert into open space and allow it to return to marsh/floodplain. While the park option would provide a new recreational amenity, after 77” TWL so much of the area would be flooded that maintaining the park would no longer be feasible. The decision point located on the park option just before 77” TWL represents the option to transfer to the restore option and transition the park to marsh.

The lower portion of the diagram represents series of options that involve addressing groundwater flooding of residential areas at the individual property level. The home retrofit option would only be viable until 66” TWL, and the pumping option only viable until 77” TWL, at which point the adaptation pathway would transfer to the buyout option. Alternatively, the home retrofit option could be skipped and the pumping or buyout options could be implemented starting at 36”. While this lower branch of the diagram is flexible and accommodates TWLs of up to 108” and beyond, it also requires retreat from a large residential area, which would be politically challenging.

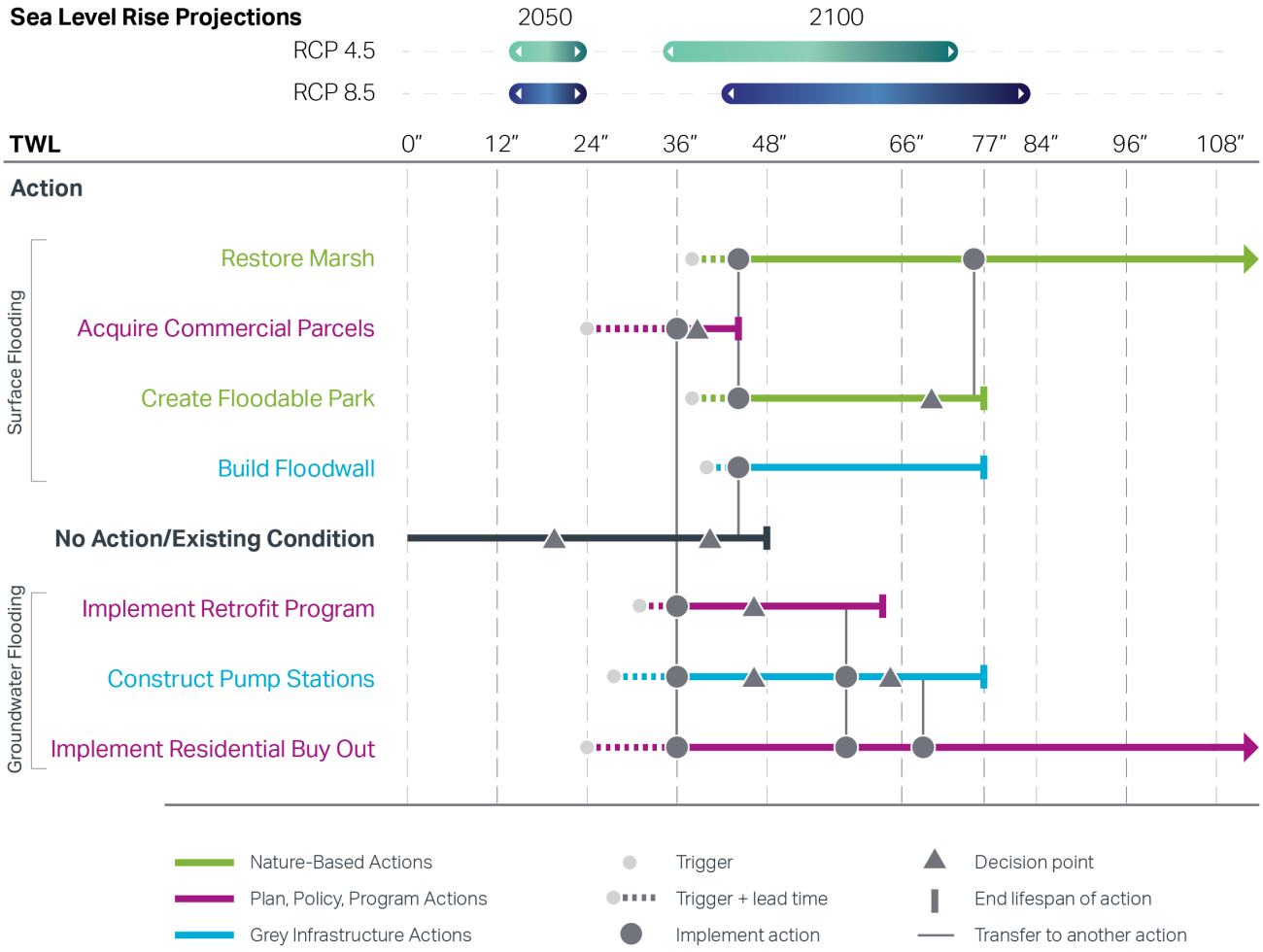

Figure 18: Illustrative Adaptation Pathway Graphic

10 CONCLUSION

This report describes the process and outcomes of a hypothetical pilot test of the ART Program Adaptation Guidance to a portion of shoreline in the City of Richmond selected in consultation with the PMT. The pilot exercise followed all steps in the Adaptation Guidance, with the notable exception that a public engagement process with stakeholders and the local community was not carried out. Instead, a list of potential stakeholders was developed, steps in the process where engagement was absent were noted, and the ART Program Regional Resilience Goals were used as a stand-in for project-specific resilience goals.

The pilot exercise generated three Strategy Alternatives, which each emphasized a different resilience goal, but addressed all of them to some degree. Potential evaluation criteria were then proposed from

a menu of criteria developed by BCDC. If the pilot had included a full stakeholder/community engagement component, the selected criteria would have been used to evaluate each of the Strategy Alternatives. Through this process, the Strategy Alternatives would be narrowed down and/or merged to form a single alternative based on stakeholder/community input.

An illustrative adaptation pathways diagram was developed to help show hypothetical decision-makers multiple potential adaptation futures and help them understand that adaptation decisions made in the near-term may either facilitate or exclude potential adaptation actions in the future (i.e., near-term decisions may create or reduce number of pathways available in the future).

This report concludes with key observations made during the pilot exercise, which are explained in greater detail in the previous sections and summarized below:

- As public engagement is a major emphasis of the Adaptation Guidance, completing a pilot exercise without this step was challenging and not fully representative of the adaptation process as it is currently envisioned. In particular, the following steps would have benefited greatly from actual stakeholder engagement:
    - Step 3: Establish Planning Assumptions (including barriers & opportunities)
    - Step 4: Define Guiding Principles
    - Step 5: Explore Future Outcomes
    - Step 7: Evaluate Strategies
- The use of Priority Conservation Areas and Priority Development Areas as datasets representing regions of environmental importance and dense settlements was challenging. These classifications were developed by MTC and ABAG for the specific purpose of allocating certain types of regional funding. Therefore, the PCA dataset does not include some key habitat areas that are already protected or not identified for funding and the PDA dataset does not include substantial built areas if they are not identified for continued growth (and this dataset is out-of-date). Instead SFEI's BAARI dataset was used for representing habitat, and it was decided to not confine assessments of developed area vulnerability to PDAs.
- BCDC's Social Vulnerability to Flooding dataset is a useful dataset to identify areas where residents are vulnerable to flooding based on socioeconomic characteristics. The dataset is well-researched, vetted through stakeholder engagement, and combines a variety of indicators into an intuitive rating scale at the census block level.
- Developing substantially different strategies that still met all the Guiding Principles was challenging (as opposed to a scenario-based approach that uses "extreme" or "bookend" scenarios to highlight different areas of emphasis when developing strategies). While this preference was understood, if the end goal is a combination of the best parts of each strategy, allowing the development of bookend strategy alternatives that do not meet all guiding principles may generate a wider variety of ideas and help stakeholders better understand trade-offs among strategies. The final combined strategy could still be required to meet all guiding principles.
- Adaptation pathways diagrams should be information dense, but not be so complicated that they are not intuitive. If a site includes multiple reaches or regions where a choice of action in one area will not substantially impact choices in another area, these areas should be depicted on different diagrams.

- The triggers, thresholds, and lead times identified in an adaptation pathways diagram should only be considered accurate if they are based on actions that have been taken beyond the conceptual design phase (i.e., technical drawings and implementation plan have been developed). As the Strategy Alternatives were purposefully kept at a concept level due to lack of community engagement, the diagram should be considered illustrative only.

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