SAN DIEGO REGION

Military Installation Resilience

Military Installation Resilience Framework

Prepared for:

Navy Region Southwest

One Team, One Voice, One Mission

SANDAG

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Disclaimer

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Executive Summary

To prepare and adapt to the challenges from climate change, the San Diego region must adjust how it responds to the impacts of climate change today to become more resilient to future impacts. The San Diego Association of Governments (SANDAG) is working with local governments and regional stakeholders so communities, local and regional economies, and natural resources and recreational spaces can endure, recover, and thrive in response to the impacts of ongoing climate change. SANDAG is committed to helping the region continue to meet its climate goals so that every resident can enjoy a safe and sustainable future.

The San Diego region has the second largest naval personnel concentration in the country, and it is the home port for nearly 20% of the U.S. Navy's vessels. The ability to remain mission ready and resilient to anticipated climate impacts is vital to the success of the region's economy and to the safety of the nation. To identify and address climate change impacts to military installations,[1] SANDAG and the Navy have been collaborating on the Military Installation Resilience (MIR) project, which is comprised of two phases and is funded by a grant from the Department of Defense's (DOD) Office of Local Defense Community Cooperation (OLDCC).

During Phase 1, SANDAG and the Navy worked with regional stakeholders to complete an initial assessment of climate change threats to military installations and surrounding transportation infrastructure. Building off Phase 1, the Phase 2 study identified three primary corridors (Pacific Highway [US 101], Harbor Drive, and State Route [SR] 75/SR-282) that have high strategic importance for Navy mission readiness and are at highest risk of climate change impacts. This *Military Installation Resilience Framework* (framework) documents the coordination, methodologies, and project recommendations completed during Phase 2 of the grant. It uses data to identify and support resilient infrastructure needs and sustainable transportation options for military personnel and their respective installations.

Resilient Infrastructure

Phase 2 identified three primary corridors that are at risk of anticipated impacts from sea level rise (SLR). These primary corridors are essential to transporting Navy personnel and equipment. They are part of the National Highway System, which includes the Strategic Highway Corridor Network and highway connectors, and are important to the United States strategic defense policy and provide defense access, continuity, and emergency capabilities for the movement of personnel, materials, and equipment in both peace time and war time.[2]

Resilient Infrastructure

Infrastructure that is planned, designed, built, and operated in a way that anticipates, prepares for, and adapts to changing climate conditions.

[1] The term "military installation" means a base, camp, post, station, yard, center, or other activity under the jurisdiction of the Secretary of a military department or, in the case of an activity in a foreign country, under the operational control of the Secretary of a military department or the Secretary of Defense, without regard to the duration of operational control. 10 USC § 2801(c)(4). Retrieved from Cornell Law on April 10, 2023 https://www.law.cornell.edu/definitions/uscode.php?width=840&height=800&iframe=true&def_id=10-USC-691149203-172027741&term_occur=999&term_src=.

[2] Code of Federal Regulations. "Title 23, Part 470." 62 FR 33355, 19 June 1997. eCFR :: 23 CFR Part 470 -- Highway Systems.

SLR impacts are likely to be seen in adjacent corridors, not just along the primary corridors identified in this report. For example, impacts could appear as storm drain backups or pipe failures as a result of repeated exposure to corrosive sea water. Phase 2 developed adaptation pathways (a future date to implement an adaptation project) to help inform decision makers about the impacts climate change may have on the built environment by advising on the timing of project selection, development, and prioritization.

For each corridor, this framework established a unique Corridor Adaptation Timeframe (CAT) that is based on specific locations of risk, and it identified a set of project solutions, including nature-based solutions (NbS)[3] and civil engineering projects (CEP). The project CATs use a methodology that is based on corridor elevations and environmental thresholds that inform the planning process.

Sustainable Transportation

Sustainable transportation consists of strategies and services that make it easier to carpool, bike, walk, take transit, and rideshare — all of which reduce harmful impacts to the region's air quality, congestion, and vehicle miles traveled (VMT). By offering incentives, subsidies, and educational programs, SANDAG provides services to help the public choose a ride that works best for them.[4]

Sustainable Transportation

Promotes the connection of multimodal transportation options that reduce the harmful impacts to air quality, congestion, and VMT.

This framework established a comprehensive list of strategy types and a discrete list of recommended proposed sustainable transportation strategies that can be used to reduce VMT that is generated by military personnel and visitors traveling to installations in the study area. The strategies seek to reduce VMT and to improve traffic congestion by encouraging the use of alternative modes of transportation.

Military Installation Resilience Hub

This framework developed a data-sharing platform, the MIR Hub, that supports collaboration between the region's sustainability and resilience planning practitioners. The MIR Hub houses data to support the risk assessment and development of adaptation pathways, and it can be used to streamline future coordination efforts along the primary corridors.

[3] The Federal Emergency Management Agency (FEMA) defines nature-based solutions as "…sustainable planning, design, environmental management and engineering practices that weave natural features or processes into the built environment to promote adaptation and resilience." https://www.fema.gov/emergency-managers/risk-management/nature-based-solutions#:~:text=Nature%2Dbased%20solutions%20are%20sustainable,Reduce%20flood%20risk.

[4] SANDAG. "Sustainable Transportation Services." 2023, https://www.sandag.org/projects-and-programs/regional-initiatives/sustainable-transportation-services.

1 Introduction

Military Installation Resilience

The capability for a military installation to minimize, avoid, or adapt to and recover from the impacts of climate change.

MIR is vital to the San Diego region's success. San Diego is the Navy's most strategic port, and it is the location for many operational and administrative headquarters. As the home port for nearly 20% of Navy vessels and 17% of active-duty personnel, San Diego has the second largest naval personnel concentration of any region in the country. More than 115,000 active-duty service members call San Diego home. They work alongside 3,000 military reservists, and 29,000 civilians are directly employed in federal defense jobs. In 2022, defense-related contract spending in San Diego grew by 4% to $19.3 billion, which funded another 209,000 jobs, and these people generate additional economic activity as they live and spend within San Diego.[5]

In June 2020, through the DOD, SANDAG was awarded a grant from the OLDCC that supports efforts to analyze and implement actions to foster, protect, and enhance MIR. This grant has two phases. The findings from the Phase 1 assessment are summarized in the *Military Installation Transportation Corridor Report* (September 2021),[6] which established an understanding of the vulnerability profiles for key transportation facilities and Navy installations in the region. Additionally, Phase 1 performed a climate resilience assessment that established the primary threats to climate change, provided a list of adaptation planning and design considerations, and developed a data-sharing framework (DSF) that established the specific data to collect around military travel behavior.

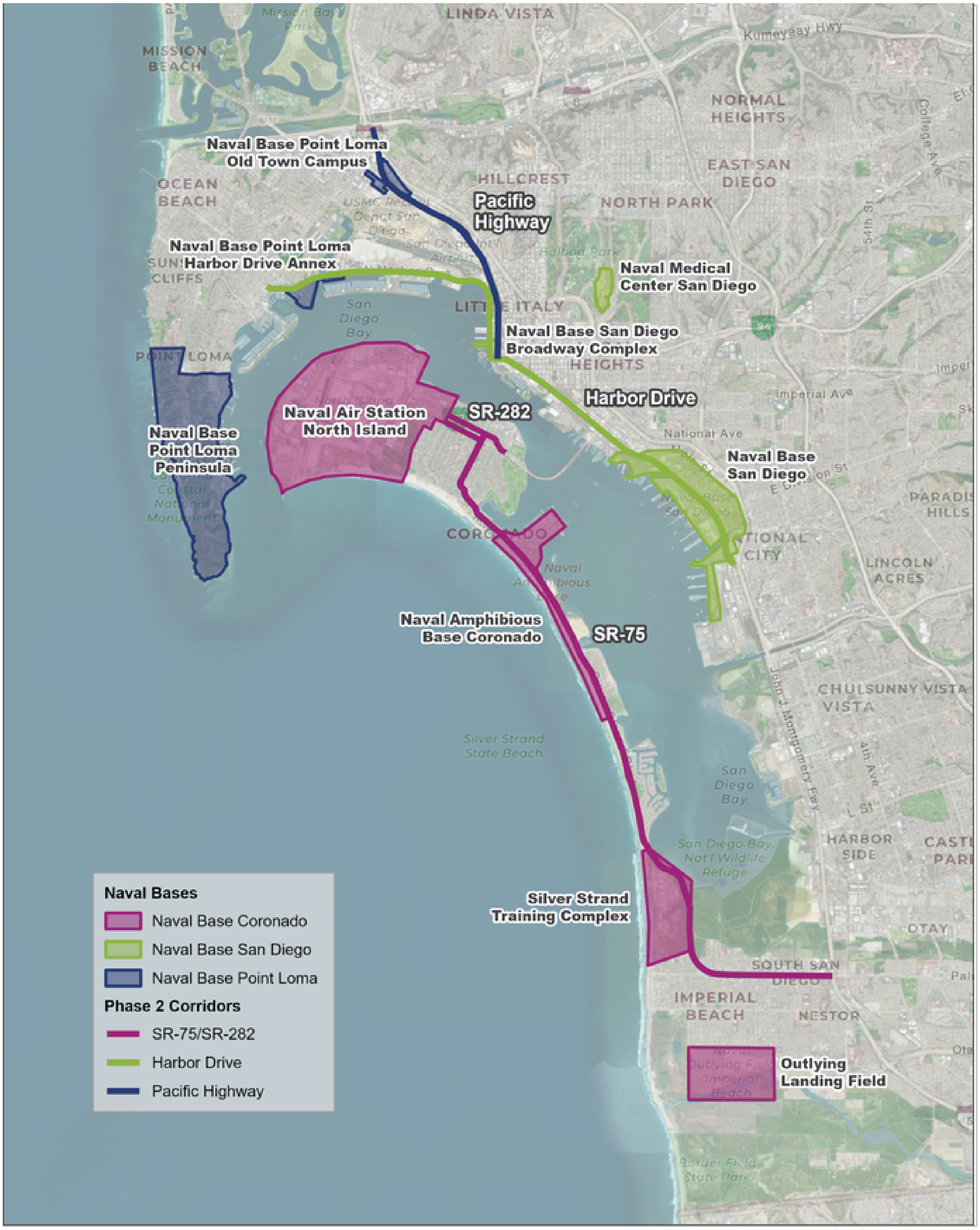
Phase 2 focuses on three key transportation corridors that support mission readiness: the Pacific Highway (US 101), Harbor Drive, and SR-75/SR-282. These corridors are the primary connection for personnel and training equipment needed to support the military installations, and they are at the greatest risk from SLR. The ability of these corridors to be resilient to climate change will facilitate the Navy's ability to be "mission ready." Figure 1-1 shows the Phase 1 study area, and Figure 1-2 shows the Phase 2 study area.

[5] San Diego Military Advisory Council. 2022. Military Economic Impact Report 2022. Defense Spending in San Diego: A Provider of Stability During Challenging Times. Available at https://www.sdmac.org/impact-study/sdmac-2022-military-economic-impact-report-2022-meir/.

[6] SANDAG. 2021. Military Installation Resilience Transportation Corridor Report. Available at https://www.sandag.org/-/media/SANDAG/Documents/PDF/projects-and-programs/environment/climate-resilience-and-adaptation/holistic-adaptation-planning/military-installation-resilience-report-2021.pdf.

Figure 1-1. Phase 1 Study Area

Figure 1-2. Phase 2 Study Area



Phase 2 developed the framework to further Military Installation Resilience, which identifies resilient infrastructure and sustainable transportation options for the Pacific Highway, Harbor Drive, and SR-75/SR-282, by setting up the following:

- Comprehensive data inventory (Appendix A), which is a list of over 160 datasets that support resilient planning.
- MIR Hub, which organizes a variety of data that will support future development of resilient transportation and sustainable transportation projects.
- A set of resilient infrastructure project guides (Appendix B) that summarize the progression of NbS into the CEPs.
- CATs for each corridor that provide a set of years to implement a project category, which are based on two projected SLR heights (Appendix B).
- SLR and Flooding Checklist to assess a proposed project's impact (Appendix C).
- List of proposed sustainable transportation strategies in the study area (Appendix D).
- VMT Reduction Toolkit that includes strategies to advance sustainable transportation in the region (Appendix E).

1.1 Navy Installation Summary

The three Navy bases included in this framework are described in the following sections.

1.1.1 Naval Base San Diego

Naval Base San Diego (NBSD) is the principal homeport for the U.S. Pacific Fleet (Figure 1-3). It employs 41,500 sailors, civilians, contractors, and ship-repair contractors, and it houses almost 5,000 service members, their families, and students. The NBSD installations in the study area include the base itself, the Naval Base San Diego Broadway Complex (NBSDBC), and the Naval Medical Center San Diego (NMCSD).

Figure 1-3. Naval Base San Diego

Source: Image courtesy of Navy (provided March 31, 2023)

NBSD is the largest concentration of Navy surface vessels on the west coast. The installation has 12 piers, and it is the homeport to 62 Navy ships, seven Navy Military Sealift Command ships, two Coast Guard cutters, several research and auxiliary vessels, and over 200 individual commands. The NBSD is the largest concentration of Navy surface vessels on the west coast, and it supplies pier space and waterfront operational services.

The NBSDBC is a bayside military facility located in downtown San Diego. It houses the primary offices of the Navy Region Southwest.

The NMCSD is a technologically advanced Navy medical treatment facility. As a major training facility, and it is affiliated with other medical facilities in the region, such as the Scripps Clinic and the University of California, San Diego.

1.1.2 Naval Base Coronado

Naval Base Coronado (NBC) supports over 30,000 military and civilian personnel who use three airfields, three ports, multiple training ranges, and over 1,400 buildings (Figure 1-4). The NBC installations in the study area are Naval Air Station North Island (NASNI), Naval Amphibious Base Coronado (NABC), Silver Strand Training Complex (SSTC), and Naval Outlying Landing Field Imperial Beach (NOLF IB).

Figure 1-4. Naval Air Station North Island

Source: Image courtesy of Navy (provided March 31, 2023)

NBC supports over 142 tenant commands and over 35,000 military and civilian personnel. It provides a shore-based platform for helicopters, aircraft carriers, SEAL (Sea, Air, and Land) teams, and other ashore and afloat commands to access ground, sea, air, and undersea operational and training spaces.

NASNI facilitates the requirements for 19 helicopter squadrons, two fixed-wing squadrons, and three aircraft carriers, and it hosts Fleet Readiness Center Southwest, which is the largest aerospace employer in the San Diego region.

NAB Coronado employs 6,000 military personnel and civilians, and it is composed of the main base, training beaches, the California Least Tern preserve, and a part of the Silver Strand State Beach. SR-75 separates NAB Coronado into oceanside and bayside areas.

The SSTC employs approximately 3,000 people, and it provides amphibious and special warfare training to U.S. and allied forces.

NOLF IB is located within Imperial Beach, near the U.S.-Mexico border. The airfield provides training for the Pacific Fleet helicopter squadrons based at NASNI. Approximately 900 personnel work on the base, and approximately 850 are civilians.

1.1.3 Naval Base Point Loma

Naval Base Point Loma's (NBPL) primary mission is to sustain the fleet and to enable the fighting forces. It is home to over 70 tenant commands, including four submarines and a floating dry dock (Figure 1-5). The NBPL installations in the study area are the Naval Base Point Loma Peninsula (NBPLP), Naval Base Point Loma Harbor Drive Annex (NBPLHDA), and Naval Base Point Loma Old Town Campus (NBPLOTC).

Approximately 10,000 employees work at the NBPLP, and the number of commuting personnel can vary depending on the number of submarines docked that require maintenance. It is home to the Command Third Fleet, Naval Information Warfare Center Pacific, Submarine Squadron 11, Naval Supply Systems Command Fleet Logistics Center, Naval Health and Research Center, explosive ordnance disposal training units, and many more.

The NBPLHDA houses the Naval Mine and Anti-Submarine Warfare Complex, Fleet Intelligence Training Center Pacific, U.S. Naval recruiting buildings, Navy Gateway Inns & Suites, and a conference center.

The NBPLOTC is located southwest of Interstate 5 (I-5) along the Pacific Highway. It is home to Naval Information Warfare Systems Command Headquarters.

Figure 1-5. Naval Base Point Loma Peninsula

Source: Image courtesy of the Navy (provided March 31, 2023)

2 Military Installation Resilience Framework Development

This framework supports climate change planning efforts through the analysis and development of resilient infrastructure and sustainable transportation solutions. It includes a series of tools that have been created to support MIR along the three primary corridors identified in Section 1.

The following sections introduce the framework's foundation and describe the stakeholder engagement that was conducted through Phase 2.

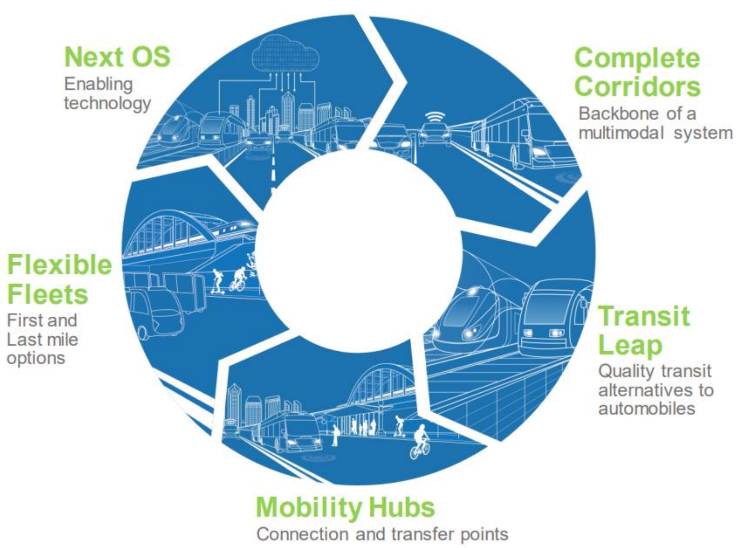
2.1 Framework Foundation

The process of developing this framework included the review of and alignment with SANDAG's *2021 Regional Plan*,[7] the South Bay to Sorrento and Central Mobility Hub comprehensive multimodal corridor plans (CMCPs), and findings from Phase 1.

The *2021 Regional Plan* and the CMCPs are data-driven plans that help the San Diego region compete for local, state, and federal funds. The CMCPs analyze demographics, employment centers, economics, and travel patterns to help SANDAG and the California Department of Transportation (Caltrans) make informed decisions on strategies and funding in major travel corridors throughout the region. The goal is to reduce congestion in highly traveled corridors by providing more transportation choices for residents, commuters, visitors, and commercial cargo, while also preserving the local community and social character and creating opportunities for neighborhood enhancement projects.

Figure 2-1 provides an overview of the "5 Big Moves" in the *2021 Regional Plan* with expanded descriptions directly after it.

Figure 2-1. 2021 Regional Plan's 5 Big Moves



[7] SANDAG. "2021 Regional Plan." 2023, https://www.sandag.org/regional-plan/2021-regional-plan.

1. **Complete Corridor** strategies include developing a balance of dedicated, safe spaces for everyone, including people who walk, bike, drive, ride transit, and use Flexible Fleets.
2. **Transit Leap** envisions a network of fast, high-capacity, high-frequency transit services that connect major residential areas to employment centers and attractions throughout the region.
3. **Mobility Hubs** are places of connectivity where different travel options — walking, biking, transit, and shared mobility — come together.
4. **Flexible Fleets** provide different mobility options and vehicles for all types of trips (reducing the need to own a car) by connecting users to the first and last mile of a destination. Flexible Fleet strategies include micromobility (small, low-speed vehicles like e-scooters, bicycles, etc.), microtransit (multipassenger shuttles that carry up to 15 riders), rideshare (uberPOOL, Lyft Shared), and ridehailing (Uber, Lyft, or taxis).
5. **Next Operating Systems (Next OS)** consist of integrating data sources through web services, developing applications and services, and providing users access to these technologies.

2.2 Stakeholder Engagement

SANDAG and the Navy convened a Project Development Team (PDT) to share best practices and lessons learned and to inform development of the framework. In addition to project team from SANDAG and the Navy, the PDT included climate and resilience practitioners from the SANDAG Military Working Group, City of San Diego, City of Coronado, City of Imperial Beach, Port of San Diego, San Diego County Regional Airport Authority, California Coastal Commission, and Caltrans District 11.

This PDT met 10 times between February 2022 and May 2023. Through group discussions and additional one-on-one meetings, the PDT served as a critical part of the framework's development, including the interactive MIR Hub. Due to the dynamic nature of resilience planning, collaboration and coordination among these stakeholders will continue to be essential along these primary corridors and throughout the region.

3 Data

Data informs decision making around climate change. Stakeholder access to data and technical resources for resilience planning is necessary to improve sustainable transportation options and to develop adaptation solutions that promote resilient infrastructure.

SANDAG and the Navy are collaborating to compile and leverage data to support Navy mission readiness. Building upon the DSF established in Phase 1, SANDAG will need to continue working with the Navy to understand military travel behavior and its regional impacts.

3.1 Data Inventory

The Phase 1 DSF outlined the specific set of military travel behavior data that can inform regional travel patterns. The Phase 2 study established Appendix A. Data Inventory to organize, prioritize, and document the existing, current, and ongoing data in the region. This inventory will support MIR and further data-sharing efforts between SANDAG and the Navy.

The data inventory comprises over 160 individual datasets related to climate change, military travel, and infrastructure datasets that inform project planning along the primary corridors (Pacific Highway, Harbor Drive, and SR-75/SR-282). The inventory includes all data within the MIR Hub, and any data that informed the creation of the military travel behavior assessment (discussed further in Section 3.2). The following categories of data were collected:

- Travel
- Military Travel
- Flood Projections
- Transportation Infrastructure
- Land Use
- Future Land Use and Population
- Environmental
- Other Hazards

3.2 Military Travel Behavior Assessment

To inform the development of strategies that promote Sustainable Transportation, the Phase 2 study included an assessment of military personnel travel behavior to and from study installations. Normally, the SANDAG Activity-Based Model (ABM) is the preferred tool for forecasting regional travel behavior. However, the following limitations for using the ABM for military travel behavior were identified:

- Travel demand was dictated by how many people live and work in a military installation. Although the Navy provided the number of people who work at each installation, due to security, the home locations of military personnel could not be provided to calibrate the ABM.
- The ABM relied on travel behavior surveys (among other things) for targeted populations, and there were not enough survey samples from military installations for the ABM to understand military personnel travel behavior.
- Within military installations, the characteristics of roadway networks and the locations of activity centers were not well known, and these directly affected travel behavior for trips within and transiting through communities adjacent to installations.

Given these limitations, it was concluded that using the SANDAG ABM to understand military travel behavior was not appropriate for the Phase 2 study.

Replica, which is a big data platform that utilizes mobile phone location and GPS data, consumer data, land use and real estate data, credit transaction data, and ground truth data to simulate travel behavior, was identified as the best available data source to assess military travel behavior. Given that mobile phone ownership is estimated at 97% and smartphone ownership is at 85%[8], it is believed that overlooking those without mobile phones would apply to a small fraction of the population and would not significantly influence this analysis. However, the following limitations with using Replica data were identified:

- Replica provides travel behavior based on cellular and consumer data, among other data. Travel behavior might not be accounted for if people make few or no purchases via electronic payment methods, do not use a mobile phone, or if mobile phone activity is limited. Known limitations of mobile phone use by military personnel include:
  - Some areas within military bases do not have cellular service due to military mission requirements. Trips made to and from these areas would not be included.
  - Navy personnel are encouraged to disable their smartphones from consistently transmitting their geographic location to their mobile phone carrier. This would limit the amount of location-based cellular data collected.

While the total number of trips to study installation areas and the time distributions of trip arrivals at the NBSD, NASNI, and NBPL provided by Replica were inconsistent with data from the Defense Manpower Data Center database, mode split data (i.e., the percent of people commuting via automobile, bicycle, or other modes) and transit use data were generally consistent with known travel patterns.

3.3 Data to Inform Resilient Infrastructure and Sustainable Transportation Planning

Some of the questions that arose with the PDT in the development of this framework included:

- **What** has been identified as previous need? Goal? Priority?
- **Who** in the region is doing similar work?
- **Where** is risk highest?
- **When** is protection needed?
- **What** are my options?
- **How** do I advance adaptation projects for my agency?

These questions prompted the development of multiple inventories centered around geospatial data, reports, people, and project types that support the data inventory of climate change data, as described in Section 3.1 Data Inventory. Generating these inventories led to the recognition that there was value in organizing the data within a single platform, the MIR Hub. The development of the MIR Hub is described in Section 4.4 Military Installation Resilience Hub Development.

[8] Pew Research Center. 2021. Mobile Fact Sheet. 7 April 2021. Available at https://www.pewresearch.org/internet/fact-sheet/mobile/#:~:text=The%20vast%20majority%20of%20Americans,smartphone%20ownership%20conducted%20in%202011

4 Resilient Infrastructure

Resilient infrastructure can withstand environmental stressors, climate change impacts, and other hazards that impact the reliability of the system. This framework often refers to the effort to create resilient infrastructure as "adaptation efforts." It identified a methodology that includes the recommended timing needed to construct adaptation projects along the three primary corridors (Pacific Highway, Harbor Drive, and SR-75/SR-282) based on the anticipated impacts from flooding and SLR.

The following section includes an overview of the project categories and timeframes that are provided in the Corridor Adaptation Timeframes (CAT). Additionally, a comprehensive list of specific project types is provided in Appendix B. Resilient Infrastructure Project Guides.

4.1 Project Categories and Project Types

Adaptation projects or projects that promote resilient infrastructure can be grouped into two general project categories: NbS and CEP. Adaptation solutions can include NbS, CEP, and/or a combination of the two. These general categories include a wide range of project types that are successful in specific areas and that come with a wide list of considerations that impact the cost to develop and maintain the project.

An NbS uses sustainable planning, environmental management, and engineering design to incorporate natural features into the built environment to promote adaptation and resilience (FEMA 2023). Specific project examples include beach nourishment, eelgrass, coastal wetlands, and urban trees. An NbS can provide numerous protection measures from hazards, such as providing mitigation coastal buffering and wave attenuation, in addition to erosion control and sediment transport benefits. An NbS typically provides additional social and environmental benefits, including offering carbon storage, habitat, and aesthetic added benefits.

A CEP involves the development of artificial structures that are used to protect against flooding and erosion, such as floodable or elevated parks, drainage infrastructure improvements, seawalls, or levees. These structures are typically complex in their design, permitting requirements, and environmental impacts during and after construction. These structures may also be more costly to build and possibly to maintain compared to an NbS. A CEP can provide protection measures by offering coastal buffering in addition to providing protection from storm surge, SLR, and riverine flooding.

4.2 Timeframe Development Methodology

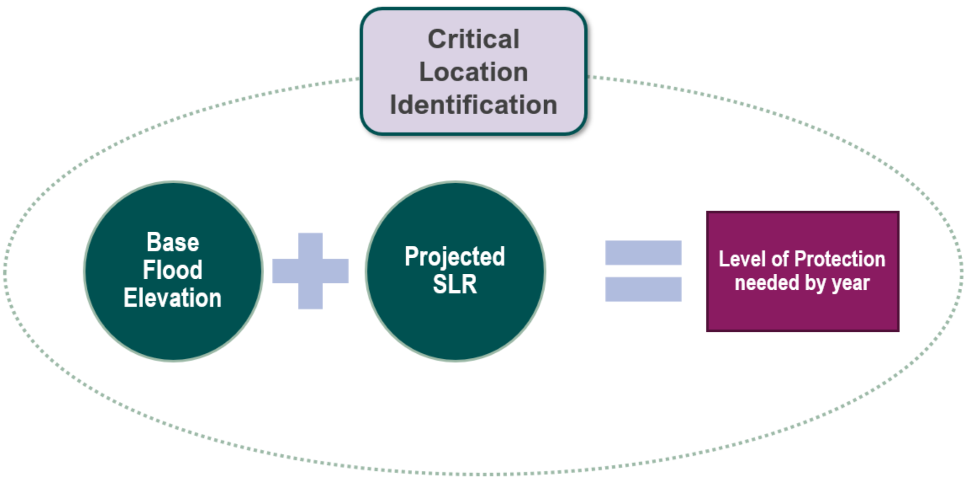
As determined in Phase 1, these three primary corridors, which have high strategic importance for Navy mission readiness, are considered the highest risk based on the expected level of flooding or SLR expected along the road. The goal of this framework was to establish timeframes to implement an NbS, CEP, or a combination of the two based on SLR or flooding risk at specific locations along the three primary corridors. To identify specific locations along the corridor to implement a NbS, CEP, or combination project, critical locations were established to narrow in on the proposed timeframe to implement a project category. These project categories and timeframes are provided within the CATs at the end of this section. The following methodology describes the steps to identify the timeframes and the assignment of project categories.

4.2.1 Assigning Timeframes for Project Categories

Based on a review of riverine floodplain and SLR projections, this framework identified critical locations, which are the most vulnerable or at-risk areas on each corridor. These risks included the extreme and medium-high increased flood risks, or exceedance probabilities, through the year 2100.

After pinpointing the critical location, elevations, and flood projections, SANDAG and the Navy can determine the year a level of protection should be implemented. Figure 4-1 demonstrates the process, which is described in detail below.

Figure 4-1. Methodology for Project Timeframes



4.2.1.1 Identification of Critical Locations

Critical locations were established by reviewing the United States Geological Survey (USGS) coastal storm modeling system (CoSMoS) projections for the year 2050 and by visually identifying areas where flood water is expected to impact the corridor. Twelve critical locations were identified across the three primary corridors, five on SR-75/SR-282, five on Harbor Drive, and two on the Pacific Highway listed in Table 4-1 (ordered north to south). Each critical location name references the geographic area where it is located.

Table 4-1. Critical Location by Corridor

SR-75/SR-282	Harbor Drive	Pacific Highway
Third and Fourth Avenues (SR-282)	Harbor and Laurel	at A Street
Fiddler's Cove	Broadway Complex	at Barnett
The Strand	Convention Center	
The Cays	Chollas Creek	
Imperial Beach	Seventh Street Channel	

4.2.1.2 Low Elevation

After the critical locations were identified, the low road elevations along the road were obtained to determine the potential flood pathway. Elevations were provided by the USGS National Elevation Dataset that are sourced from Esri, USGS, FEMA, and the United States Department of Agriculture (USDA), among others. Road centerlines were obtained from the National Highway System network.

Figure 4-2 displays the approximate lowest ground elevation along the centerline of northbound SR-75 heading into Coronado.

Figure 4-2. Road Profile at Fiddler's Cove

Source: Esri & the National Elevation Dataset

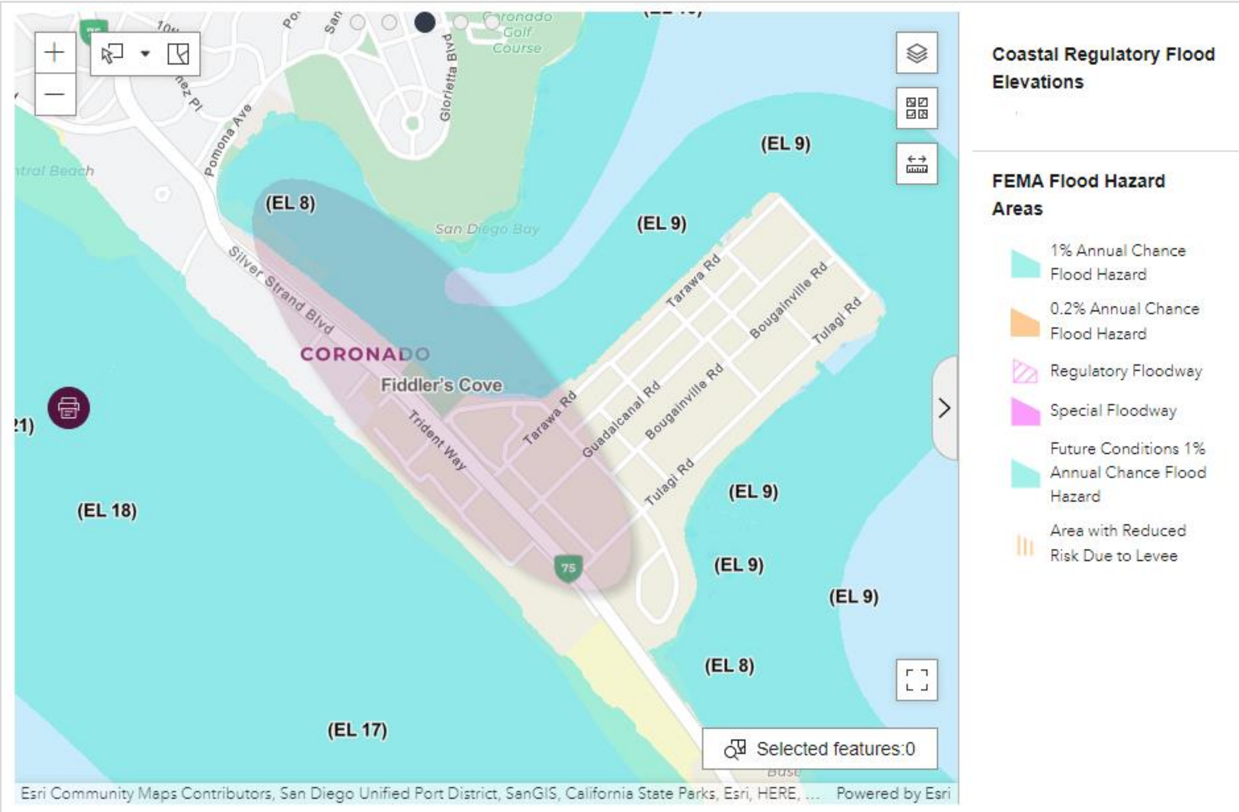
4.2.1.3 Projected Flood Risk

The next step in establishing CATs is to gather current and projected flood risk elevations at each critical location.

First, the 1% annual chance or 100-year base flood elevation is obtained from the current day FEMA special flood hazard area flood insurance rate maps (for San Diego County, these maps were last published on October 15, 2020). This elevation becomes the baseline to which the projected SLR exceedance probabilities will be added to.

Figure 4-3 displays the existing flood elevations in the area of Fiddler's Cove.

Figure 4-3. Current Flood Elevations at Fiddler's Cove



Source: Esri and the National Flood Hazard Layer

EL = elevation

Second, the expected flood heights associated with the exceedance probabilities in Table 4-2. are applied to the base flood elevation from Figure 4-3. These elevations are considered to be the closest to the USGS CoSMoS increments when guided by the California Coastal Commission's 2018 projections.[9] The exceedance probabilities (as compared to current FEMA base flood elevations) are applied for years 2030, 2050, and 2100 for three different risk scenarios (low-risk, medium-high risk and high risk). It should be noted that the low risk aversion scenario did not prompt a project timeframe.

Table 4-2. Exceedance Probabilities[10]

Scenario	2030	2050	2100
Low-Risk Aversion Scenario	+0.8 feet	+0.8 feet	+3.3 feet
Medium-High Risk Aversion Scenario	+0.8 feet	+1.6 feet	+6.6 feet
Extreme Risk Aversion Scenario	+0.8 feet	+2.5 feet	+6.6 feet

Source: USGS CoSMoS and California Coastal Commission

[9] City of San Diego. 2020. Climate Change Vulnerability Assessment. Available at https://www.sandiego.gov/sites/default/files/climate-change-vulnerability-assessment.pdf

[10] Exceedance probabilities are how much higher SLR is expected to be under different scenarios and years as compared with current flood risk levels (or the FEMA base flood elevation).

4.2.1.4 Levels of Protection

Lastly, a three-tiered planning approach is established according to the different flood risk conditions for each low-lying area within the critical location.

Level 1 Protection: When flood risk is no higher than 1 foot below the low road elevation.

Level 2 Protection: When flood risk is no higher than 1 foot above the low road elevation.

Level 3 Protection: When flood risk is more than 2 feet above the low road elevation.

Each timeframe follows the same four-step progression at each critical location, assigning project categories according to the expected level of protection needed, as presented in Figure 4-4.

Figure 4-4. Project Timeframe Progression

Planning and Project Development is the process required to develop specific project concepts and designs and to secure the necessary regulatory approvals. Community engagement is also critical during this phase. The CATs recommend this occur seven to 10 years before an NbS or CEP project is needed.

NbS can provide the first level of protection, and they are the least disruptive to the surrounding environment. This level of protection (Level 1) mitigates early flooding impacts, and it is programmed when flooding risk is expected to be 1 foot below the existing roadway elevation at the critical location.

> **NbS and CEP**
>
> **In practice, a combination of NbS and CEP will be needed at each stage to protect the corridor. The progression in Figure 4-4 will guide stakeholders when considering solutions according to the projected level of risk.**

Localized CEP and/or NbS should be considered when an intermediate level of protection is needed. At this stage, corridors could experience localized impacts at their most vulnerable areas. This level of protection (Level 2) mitigates localized flooding risks at that critical location, and it is programmed to occur when flooding risk is expected to be 1 foot above the existing roadway elevation.

Corridor-wide CEP can provide the most protection when impacts are expected to be more extensive. This level of protection (Level 3) is programmed to occur when flooding risk is expected to be 2 feet above the existing roadway elevation at the critical location, which is indicative of extensive flooding risk along the corridor. These projects will likely be more costly and impactful to the surrounding environment.

4.2.1.5 Corridor Adaptation Timeframes

Each of the corridor's critical locations are organized within the CATs in Figure 4-5 through Figure 4-9. When applicable, all four steps identified above were provided an elevation that determined the year for the level of protection.

Two pathways were identified for each critical location, one for the extreme risk scenario (red boxes) and one for the medium-high risk scenario (blue boxes). Planning activities would start 7-10 years before the first action in either pathway. Potential project partners were also identified to inform the collaboration that may be necessary to move a specific project type forward.

Over the next 80 to 100 years, it is expected that without NbS, flooding risk will reach 2 feet above existing roadway elevations at all critical locations, ultimately requiring Level 3 protection along all three corridors. For a detailed description of each NbS and CEP project type, refer to Appendix B. Resilient Infrastructure Project Guides.

Figure 4-5. SR-75/SR-282 CAT for Critical Locations 1-3

Corridor Adaptation Timeframe

State Route 75/State Route 282

Critical Location[1]	Project Description	Planning Start[2]	Extreme Risk	Med-High Risk
SR 282 shoreline	Study flooding risks and identify applicable site specific solutions.	2025		
	Construct NbS to address limited flooding risk (Level 1)		-[3]	-[3]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2035	2040
	Construct CEP to address corridor-wide flooding risk (Level 3)		2045	2080
Potential Project Partners	*City of Coronado, Port, State Parks, Navy, SANDAG, Scripps Institute of Oceanography*			
Fiddler's Cove	Study flooding risks and identify applicable site specific solutions.	2035		
	Construct NbS to address limited flooding risk (Level 1)		-[3]	-[3]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2045	2080
	Construct CEP to address corridor-wide flooding risk (Level 3)		2060	-[4]
Potential Project Partners	*City of Coronado, Port, Navy, State Parks, Caltrans, SANDAG, Scripps Institute of Oceanography*			
The Strand	Study flooding risks and identify applicable site specific solutions.	2030		
	Construct NbS to address limited flooding risk (Level 1)		-[3]	-[3]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2040	2050
	Construct CEP to address corridor-wide flooding risk (Level 3)		2050	2100
Potential Project Partners	*City of Coronado, City of Imperial Beach, Caltrans, State Parks, Navy, SANDAG*			

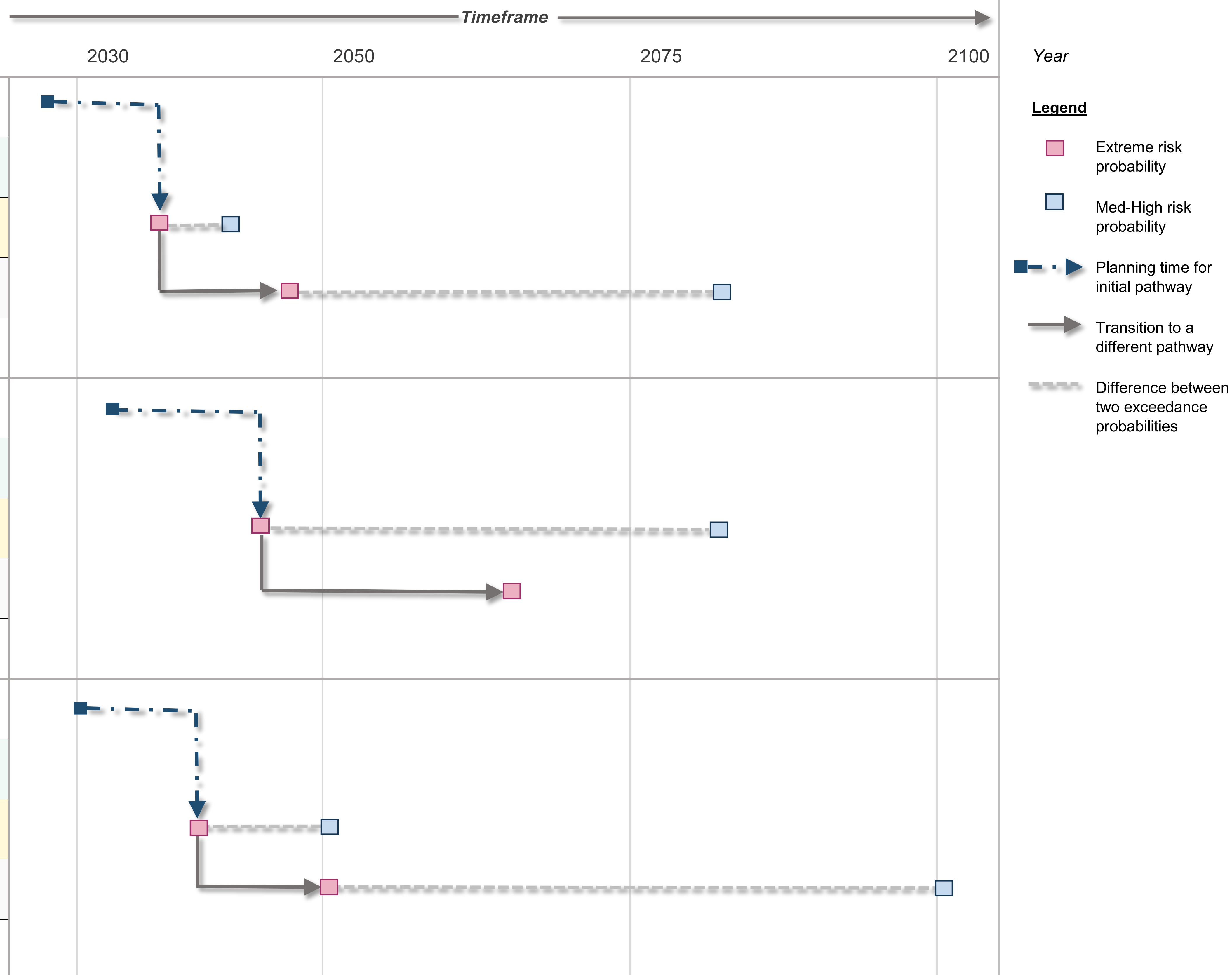
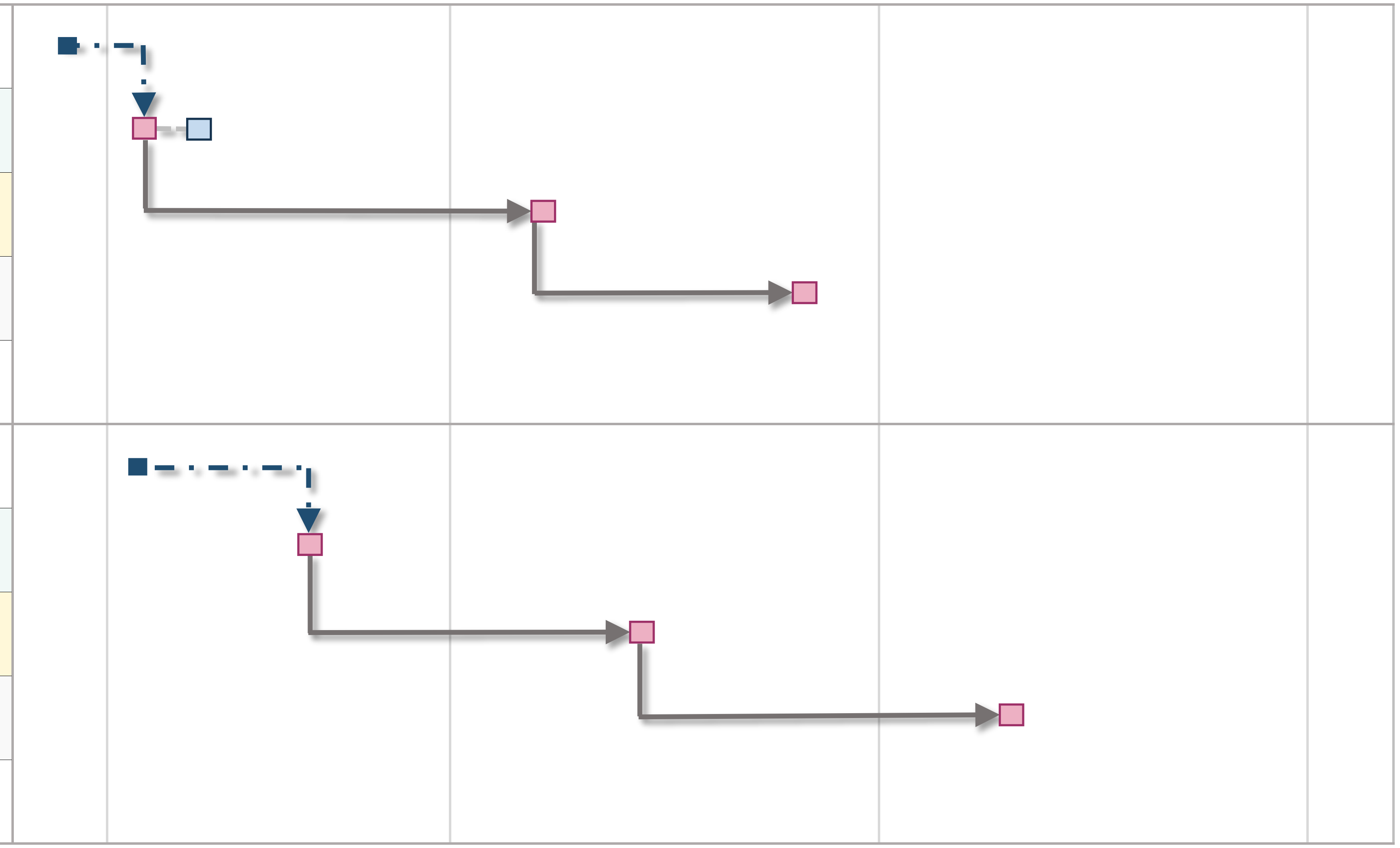


Figure 4-6. SR-75/SR-282 CAT for Critical Locations 4 & 5

The Cays	Study flooding risks and identify applicable site specific solutions.	2025		
	Construct NbS to address limited flooding risk (Level 1)		2032	2035
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2055	-[4]
	Construct CEP to address corridor-wide flooding risk (Level 3)		2070	-[4]
Potential Project Partners	*City of Coronado, City of Imperial Beach, Navy, Caltrans, SANDAG*			
Imperial Beach	Study flooding risks and identify applicable site specific solutions.	2032		
	Construct NbS to address limited flooding risk (Level 1)		2042	-[4]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2065	-[4]
	Construct CEP to address corridor-wide flooding risk (Level 3)		2080	-[4]
Potential Project Partners	*City of Imperial Beach, Navy, Caltrans, SANDAG*			



Notes:

1. Critical Location: Low elevation points along roadway where flood risk is highest.
2. Planning start estimated to be 10 years before extreme scenario need.
3. No date. Current flood risk is beyond this level of protection.
4. No date. Flood risk not anticipated to require this level of protection before 2100.

Figure 4-7. Harbor Drive CAT for Critical Locations 1-3

Corridor Adaptation Timeframe

Harbor Drive

Critical Location[1]	Project Description	Planning Start[2]	Extreme Risk	Med-High Risk
Harbor and Laurel	Study flooding risks and identify applicable site specific solutions.	2025		
	Construct NbS to address limited flooding risk (Level 1)		–[3]	–[3]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2030	–[3]
	Construct CEP to address corridor-wide flooding risk (Level 3)		–[3]	–[3]
Potential Project Partners	*Coast Guard, Port & Port Tenants (Sea Port Village), City of San Diego, Airport, Navy, SANDAG*			
Broadway Complex	Study flooding risks and identify applicable site specific solutions.	2025		
	Construct NbS to address limited flooding risk (Level 1)		–[3]	–[3]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2035	2040
	Construct CEP to address corridor-wide flooding risk (Level 3)		2045	2085
Potential Project Partners	*City of San Diego, Port & Port Tenants, Caltrans, Navy, SANDAG*			
Convention Center	Study flooding risks and identify applicable site specific solutions.	2025		
	Construct NbS to address limited flooding risk (Level 1)		–[3]	–[3]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2032	2035
	Construct CEP to address corridor-wide flooding risk (Level 3)		2045	2070
Potential Project Partners	*City of San Diego, Port & Port Tenants (San Diego Convention Center Corp), Caltrans, MTS, Navy, SANDAG*			

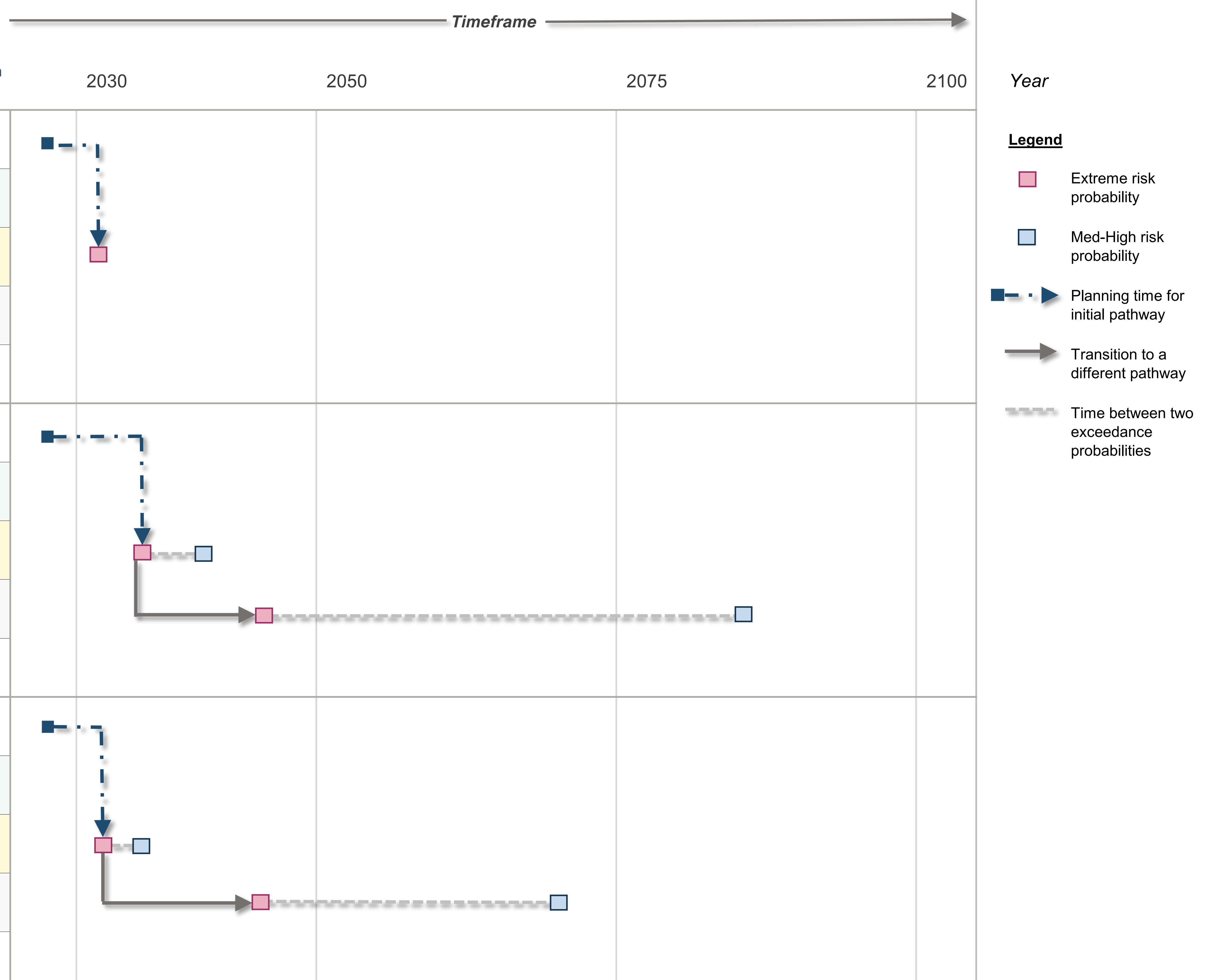
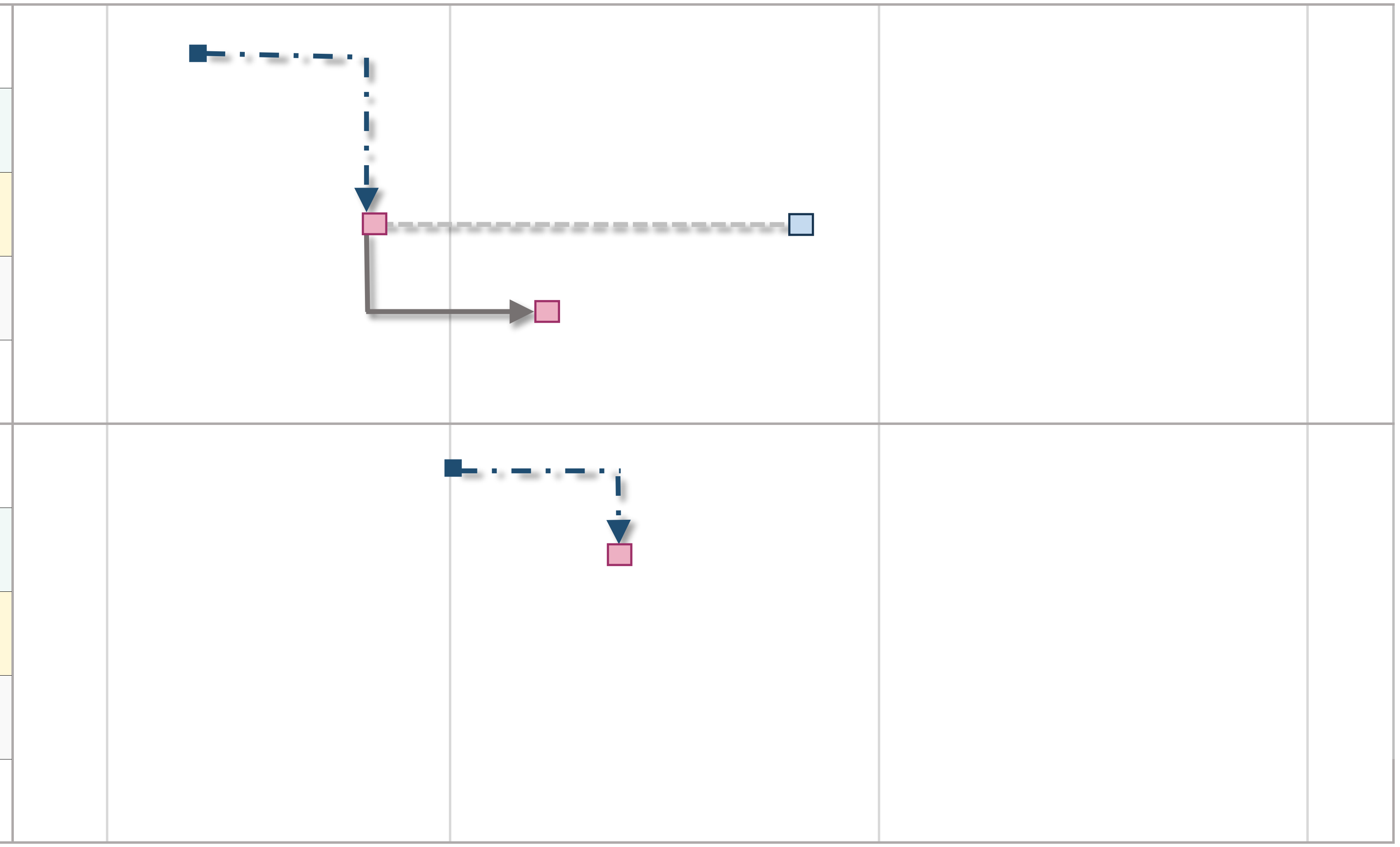


Figure 4-8. Harbor Drive CAT for Critical Locations 3 & 4

Chollas Creek	Study flooding risks and identify applicable site specific solutions.	2035		
	Construct NbS to address limited flooding risk (Level 1)		-[3]	-[3]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2045	2070
	Construct CEP to address corridor-wide flooding risk (Level 3)		2055	-[4]
Potential Project Partners	*City of San Diego, Port, Navy, SANDAG*			
Seventh Street Channel	Study flooding risks and identify applicable site specific solutions.	2050		
	Construct NbS to address limited flooding risk (Level 1)		2060	-[4]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		-[4]	-[4]
	Construct CEP to address corridor-wide flooding risk (Level 3)		-[4]	-[4]
Potential Project Partners	*City of San Diego, Port, Navy, SANDAG*			



Notes:

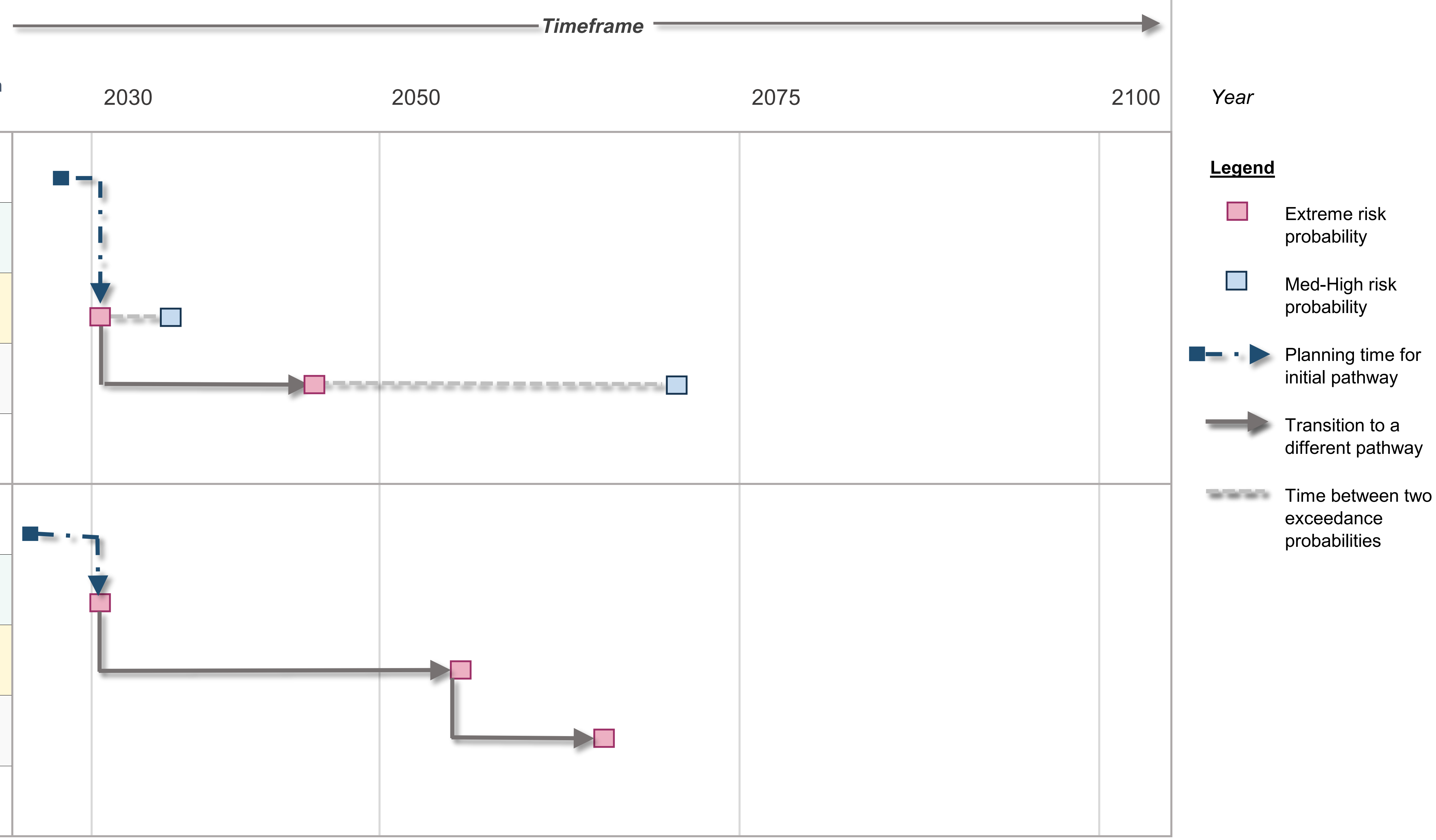
1. Critical Location: Low elevation points along roadway where flood risk is highest.
2. Planning start estimated to be 10 years before extreme scenario need.
3. No date. Current flood risk is beyond this level of protection.
4. No date. Flood risk not anticipated to require this level of protection before 2100.

Figure 4-9. Pacific Highway CAT for Critical Locations 1 & 2

Corridor Adaptation Timeframe

Pacific Highway

Critical Location[1]	Project Description	Planning Start[2]	Extreme Risk	Med-High Risk
PH at A Street	Study flooding risks and identify applicable site specific solutions.	2025		
	Construct NbS to address limited flooding risk (Level 1)		-[3]	-[3]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2030	2035
	Construct CEP to address corridor-wide flooding risk (Level 3)		2045	2070
Potential Project Partners	*City of San Diego, Port & Port tenants (Sea Port Village), Caltrans, Navy, SANDAG*			
PH at Barnett	Study flooding risks and identify applicable site specific solutions.	2023		
	Construct NbS to address limited flooding risk (Level 1)		2030	-[4]
	Construct localized CEP &/or NbS to address localized flooding risk (Level 2)		2055	-[4]
	Construct CEP to address corridor-wide flooding risk (Level 3)		2065	-[4]
Potential Project Partners	*City of San Diego, Caltrans, Navy, SANDAG*			

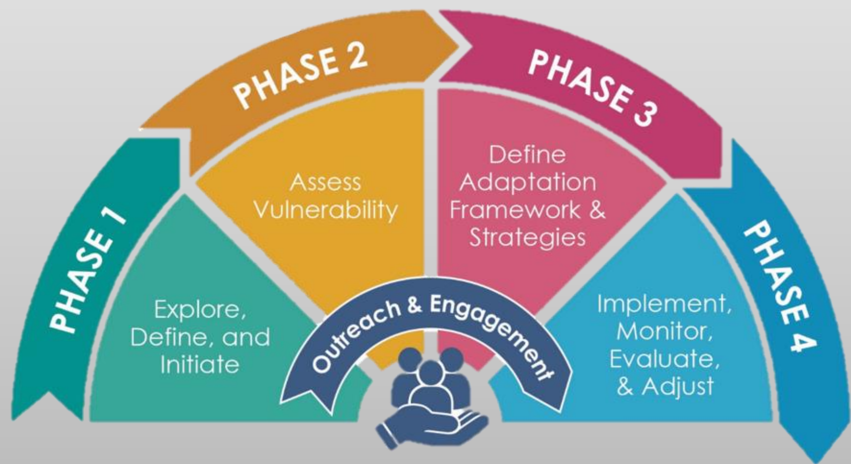


Notes:

1. Critical Location: Low elevation points along roadway where flood risk is highest.
2. Planning start estimated to be 10 years before extreme scenario need.
3. No date. Current flood risk is beyond this level of protection.
4. No date. Flood risk not anticipated to require this level of protection before 2100.

4.3 Project Implementation

The *California Adaptation Planning Guide* (CAPG) provides a four-phase approach to adaptation planning. The following figure demonstrates that outreach and engagement is involved throughout each phase and can be modified to suit the unique needs of any given community. Communities can follow a basic process with readily available data and minimal staff commitment, or they can take a more in-depth approach.



This framework was informed by the CAPG graphic above.[11] The CATs developed in this framework completed portions of CAPG Phase 3 by identifying resilient infrastructure projects and approximate timeframes for the implementation of NbS, CEP, or combination projects along the three corridors. Once projects are identified, stakeholders should utilize the Sea Level Rise and Flooding Checklist (Appendix C) to evaluate each project's potential risk. The checklist provides stakeholders with a step-by-step approach for considering a project's vulnerability and adaptative capacity risk. Once initiated, project sponsors should coordinate early and often with appropriate stakeholders (e.g., local, state, and federal entities) to ensure proper actions are taken during each stage of project development.

The next step for resilient infrastructure projects identified in this framework — which coincides with initial activities in CAPG Phase 4 — is to implement a specific project type based on the unique needs of the project area. Project implementation includes planning and project development, construction, and operations and maintenance, which continues until the built infrastructure is decommissioned or reaches its end-of-life phase and is replaced in turn by a new project. Each stage can vary widely in the amount of time, effort, and funding needed depending on the project type, complexity, location, characteristics, and requirements of key stakeholders. Project requirements could also differ in future years as best practices and standards evolve. Each of the three implementation stages is described in the following sections.

[11] California Governor's Office of Emergency Services. California Adaptation Planning Guide. June 2020. Available at https://resilientca.org/apg/

4.3.1 Planning and Project Development

The Planning and Project Development stage includes all pre-construction activities. The duration and complexity of specific activities varies depending on project type and should include:

- Conceptual Planning
- Advanced Planning
- Environmental Review (California Environmental Quality Act [CEQA] & National Environmental Policy Act [NEPA] Clearance)
- Funding Strategy Development
- Delivery Method Identification
- Preliminary Engineering
- Final Design

4.3.2 Construction

The construction phase typically begins following the completion of final design. It involves the physical development of individual projects or programs. Construction durations depend on the type of project being built (i.e., NbS and/or CEP).

4.3.3 Maintenance and Operations

Once a project is constructed, periodic operations and maintenance must be conducted to ensure the built infrastructure assets retain their efficacy throughout their life cycle. Projects should be monitored, evaluated, and updated, as needed, based on observed effectiveness, local changes, and new science.

4.4 Military Installation Resilience Hub Development

As described in the Data to Inform Resilient Infrastructure and Sustainable Transportation Planning section, the questions discussed in the PDT informed the creation of a collaboration or hub website as a part of the Phase 2 study. This is where the CAT, Resilient Infrastructure Project Guides, and many of the data inventories described in the Data section reside for the PDT's reference.

This framework established the primary goals for the development of a technology application to support resilient infrastructure planning, which included:

- Providing valuable resources for resilience planning efforts.
- Developing an easy to navigate site that provides intuitive content.
- Using flexible technology with the ability to easily share information.
- Minimizing maintenance requirements.
- Identifying timeframes for high-risk years for recommended projects along the three primary corridors.

Finally, the Phase 2 study established a set of user stories to inform the development of the application. A summary of each identified need is provided below:

- Organize regional technical reports, vulnerability assessments, and adaptation plans that support resilience planning.
- Provide the point of contact for regional partners involved in resilience planning.
- Establish a simple way to document flooding observations to inform future resilience planning efforts.
- Create a digital map that includes data related to climate change projections and other environmental, land use, and infrastructure information to inform planning across jurisdictions.
- Develop a checklist that can assess a project's impact from flooding and SLR.
- Establish a set of resilient infrastructure project guides that inform adaptation project selection.
- Provide a process to identify ideal timeframes for future resilience planning efforts based on risk.
- Inform users on how to interact with and manage the data within the website.

The hub modules provide digital interactive libraries for reports, people, and flooding observations. Additionally, the website houses the CATs, Resilient Infrastructure Project Guides, and geospatial data that will inform future climate projects. These modules aim to satisfy the list of functionality requirements that were established from the above user stories. These modules, provided in the hub, aim to satisfy the list of functionality requirements that were established from the above user stories:

- Reports
- Participants
- Flooding Observations
- Data Viewer
- Flooding and Sea level Rise Checklist
- Resilient Infrastructure Project Guides
- Corridor Adaptation Timeframes
- MIR Hub User Guides

5 Sustainable Transportation

Sustainable transportation choices can support a more resilient transportation network by reducing congestion and by helping mitigate climate change impacts. This framework includes a VMT Reduction Toolkit (Appendix E) that identifies strategies that promote sustainable transportation for people traveling to Navy installations within the study area. The toolkit recommends strategies that reduce VMT and vehicular congestion for Navy personnel and visitors by encouraging the use of alternative modes of transportation. These strategies, along with the methodology used to identify them, are provided in Appendix D. Sustainable Transportation Strategy Development, Strategy List, & Maps.

5.1 Strategy Development

Strategies that help reduce VMT were identified on and/or adjacent to study installations based on current and anticipated conditions and traveler needs. VMT reduction strategies are organized into the following categories:

- **Active Transportation/Shared Use Mobility** includes installing and expanding bicycle and pedestrian infrastructure (e.g., new sidewalks or bike lanes), bicycle resources (e.g., new bike racks) and education, and micromobility services.
- **Transit** includes strategies to implement fixed-route shuttle services, modifications to existing or planned transit services, enhancements to existing transit frequencies, transit stop improvements, transit speed and reliability improvements, and microtransit pilot programs.
- **Transportation Demand Management** includes programs and services that encourage transportation alternatives, reduce reliance on the private automobile for travel, and reduce VMT and greenhouse gas emissions. Strategies include carshare and vanpool programs, commute benefit programs, parking management programs (e.g., electric vehicle parking), congestion management (e.g., telework), and mobility management (e.g., expanding existing mobility programs and ride-matching services).

Appendix D summarizes the approach to identify sustainable transportation projects. It includes a list of recommended projects and key information that includes which installation(s) would benefit, implementation timelines, stakeholder interest in the implementation, level of stakeholder coordination required, relative capital cost, and strategic partner(s). The strategies identified in Appendix D are recommended; their inclusion does not commit project partners to implement them.

5.2 Strategy Implementation

This section summarizes the recommended next steps to implement the specific strategies found in Appendix D. The process for implementing sustainable transportation strategies for resilient infrastructure projects is described in Section 4.3.

As conditions and needs change over time, so may the applicability or effectiveness of the strategies identified. As such, it will be important for stakeholders to continue coordination and to re-evaluate strategy effectiveness. The strategy implementation best practices (described below) are recommended.

- **Estimate Costs and Identify Funding**. Planning-level capital (for projects like new bike lanes) and ongoing operations and maintenance cost estimates should be calculated, and funding sources and amounts should be identified for each strategy.
- **Prioritize Strategies**. Depending on projected costs, funding availability, and stakeholder needs, strategies should be identified as near, mid, and long term. Depending on potential costs and funding availability, strategies could be built in phases. A phased implementation plan can be an effective way to realize near-term benefits in situations where funding to build an entire strategy is not currently available, but will be in the future.
- **Develop a Monitoring Plan**. This should identify a process for monitoring progress on project implementation. Ongoing monitoring will help determine the success of strategies and the timing of the implementation of future strategies. The plan should identify which data types should be collected to evaluate strategy effectiveness based on performance metrics/measures as identified by key stakeholders and/or other simple performance measures.
- **Conduct Pre-construction Activities (for projects)**. This includes conceptual and advanced planning, environmental review (CEQA and NEPA) as needed, delivery method identification, preliminary engineering, and final design.
- **Implement Strategies**. This involves the physical development — construction for projects and implementation for programs — of individual projects or programs.
- **Conduct Operations and Maintenance (for projects)**. Once a project is completed, ongoing operations and periodic maintenance must occur to ensure projects retain efficacy throughout their life cycle.

The success of these strategies depends on coordinated implementation between multiple jurisdictions to promote sustainable transportation programs. For example, a new transit shuttle route can reduce VMT for people traveling to or from Navy installations; however, Navy personnel will continue to drive if they are not aware of these programs or how to use them. As a result, it is important for SANDAG and the Navy to work together to promote the strategies identified in this framework. This can be accomplished by the following:

- **Outreach:** SANDAG and Navy staff can host informational sessions, possibly in the form of “lunch-and-learn” events, to inform Navy personnel about existing or new sustainable transportation strategies and how to use them. For example, Navy personnel can learn how to ride transit and which transit services they could use to travel to and from their installation.
- **Strategy Gamification:** Navy staff can host competitions — either within or between installations — that incentivize personnel to reduce their VMT by modifying travel behavior during a specific timeframe. As Navy personnel engage in these competitions, they will learn about the benefits and ease of using alternative modes, which can help change travel behavior.

Additionally, the VMT Reduction Toolkit (Appendix E) provides a comprehensive list of strategy types that decision makers (i.e., base commanders, community planning liaison officers, adjacent jurisdiction representatives, etc.) can use to identify VMT reduction strategies in the future. The strategy implementation best practices should be used once any new strategies are identified.

6 Framework Recommendations

6.1 Conclusion

Collaboration among regional stakeholders is imperative to supporting the Navy's ability to remain mission ready. Phase 2 focused on the specific needs of the three primary transportation corridors, and developed a framework to inform future projects. The Data, Resilient Infrastructure, and Sustainable Transportation sections in this framework identify best practices and outline next steps to advance resiliency planning along these corridors.

6.2 Next Steps

To continue resilience planning efforts along the three primary corridors, it is recommended that stakeholders consider the following next steps.

Data

- Continue collaboration efforts between SANDAG and the Navy to implement the DSF identified in Phase 1 and refined in Phase 2.
  - SANDAG will provide assumed demographic data to the Navy for review and approval before incorporating it into the ABM
  - Establish a priority and refresh cycle for the identified list of Military Travel Behaviors.
- Add to the data inventory in Appendix A as new climate, infrastructure, or military travel behavior data becomes available.
- Continue to maintain the MIR Hub.
  - Update the hub as new climate data becomes available.
  - Identify ways to expand on the hub to further sustainable transportation project identification.
  - Provide annual training to onboard any new stakeholders.

Resilient Infrastructure

- Continue to coordinate with regional stakeholders to build consensus on resilient infrastructure needs and priorities for the three primary corridors.
- Use the Resilient Infrastructure Project Guides provided in Appendix B to inform project selection.
- Revise the CATs as new climate projection guidance is provided.
- Complete the Sea Level Rise and Flooding Checklist (provided in Appendix C) for new projects along the corridor.
- Collect flooding observations and inform the SLR and Flooding Checklist observed impacts.
- Pursue grant funding opportunities that can be used to advance resilient infrastructure projects. The timing of project funding and implementation should be determined using the CATs.

Sustainable Transportation

- Continue to coordinate with local and regional stakeholders to prioritize and implement the sustainable transportation strategies identified in Appendix D.
- Monitor strategy performance and re-evaluate the potential for new and innovative strategies. New strategies can be selected from the VMT Reduction Toolkit provided in Appendix E.
- Pursue grant funding to implement projects that support increased active transportation trips and sustainability goals. One such source, Caltrans' Active Transportation Program, recently awarded the city of Imperial Beach funds to reallocate a portion of 9th Street to introduce protected bike lanes, slow vehicular speeds, and create a more pedestrian-friendly environment.

To implement this framework, stakeholders are encouraged to continue coordinating on the prioritization of sustainable transportation strategies and resilient infrastructure projects. As new climate projections or project development data improve and evolve, projects and strategies should be re-evaluated. The best practices established in this framework and lessons learned through future project implementation can help guide regional resilience planning.

Abbreviations and Acronyms

Abbreviation/ Acronym	Definition
ABM	Activity-Based Model
CAPG	California Adaptation Planning Guide
CAT	Corridor Adaptation Timeframes
CEP	Civil Engineering Projects
CEQA	California Environmental Quality Act
CMCP	Comprehensive Multimodal Corridor Plan
CoSMoS	Coastal Storm Modeling System
DOD	Department of Defense
DSF	Data-sharing Framework
FEMA	Federal Emergency Management Agency
MIR	Military Installation Resilience
NABC	Naval Amphibious Base Coronado
NASNI	Naval Air Station North Island
NBC	Naval Base Coronado
NBPL	Naval Base Point Loma
NBPLP	Naval Base Point Loma Peninsula
NBPLHDA	Naval Base Point Loma Harbor Drive Annex
NBPLOTC	Naval Base Point Loma Old Town Campus
NbS	Nature-based Solutions
NBSD	Naval Base San Diego
NBSDBC	Naval Base San Diego Broadway Complex
NEPA	National Environmental Policy Act
NMCSD	Naval Medical Center San Diego
NOLF	Naval Outlying Landing Field
OLDCC	Office of Local Defense Community Cooperation
PDT	Project Development Team
SANDAG	San Diego Association of Governments
SLR	Sea Level Rise
SR	State Route
SSTC	Silver Strand Training Complex
USGS	United States Geological Survey
VMT	Vehicle Miles Traveled

Key Definitions

Military Installation Resilience (MIR): The capability of a military installation to minimize, avoid, or adapt to and recover from the impacts of climate change.[12]

Resilient Infrastructure: Infrastructure that is planned, designed, built, and operated in a way that anticipates, prepares for, and adapts to changing climate conditions.[13]

Sustainable Transportation: Strategies and services that make it easier to carpool, bike, walk, take transit, and rideshare to reduce the harmful impacts of driving to air quality, congestion, and VMT.[14]

[12] SANDAG. 2021. Military Installation Resilience Transportation Corridor Report. Available at https://www.sandag.org/-/media/SANDAG/Documents/PDF/projects-and-programs/environment/climate-resilience-and-adaptation/holistic-adaptation-planning/military-installation-resilience-report-2021.pdf.
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