ADMINISTRATIVE DRAFT:
SEA-LEVEL RISE & CLIMATE ADAPTATION PLAN
FOR THE CITY OF CARPINTERIA
Vulnerability Assessment & Strategy Program

A Professional Project
presented to
the Faculty of California Polytechnic State University,
San Luis Obispo

In Partial Fulfillment
of the Requirements for the Degree
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in Engineering (Transportation Planning Specialization)

by
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ABSTRACT

Administrative Draft: Sea-Level Rise & Climate Adaptation Plan

for the City of Carpinteria

Vulnerability Assessment & Strategy Program

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Sea-level rise (SLR) is one consequence of global climate change and given Carpinteria's location right along the coast, the City will likely face the threats of sea-level rise and other impacts in greater frequency and intensity. The intent of this administrative draft is to provide a foundation for future development of a **Climate Adaptation Plan**, a starting point for the City's climate initiatives. This administrative draft consists of background information on Carpinteria, a preliminary vulnerability assessment, and a list of potential strategies for City-led implementation. An adaptation plan is sound planning that recognizes the community's vulnerabilities and attempts to minimize climate change impacts through preemptive action.

Keywords: climate change, climate adaptation, sea-level rise, coastal cities, vulnerability assessment

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EXECUTIVE SUMMARY

The City of Carpinteria is concerned about the impacts of climate change, especially for its coastal resources and its Beach Neighborhood, a residential neighborhood within a few feet of sea level. **Sea-level rise (SLR)** has the potential to have far-reaching effects on the physical composition of Carpinteria, particularly the loss of beaches and increased likelihood of flooding and inundation in established neighborhoods. Sea-level rise is a significant problem that has ramifications for Carpinteria's ecological, physical, and economic interests.

The intent of this administrative draft is to provide a foundation for future development of a **Climate Adaptation Plan**, a starting point for the City's climate initiatives. A Climate Adaptation Plan recognizes the urgency of climate change impacts and presents strategies to address them, while incorporating sound planning practices that support the vitality of the City. This administrative draft consists of background information on Carpinteria, a preliminary vulnerability assessment, and a list of potential strategies for City-led implementation. The tentative framework/outline proposed is inspired by cities that have paved the way for the introduction of adaptation to the mainstream. The vulnerability assessment serves as the core of the administrative draft, but is not complete without the public participation. Since public outreach and implementation is not covered by the administrative draft, the City of Carpinteria will initiate and lead this effort.

The core of a climate adaptation plan is the **vulnerability assessment**, an investigation of climate change impacts on the community and the community's ability to become resilient to these impacts, sudden or gradual. Increasing **resiliency** in a community is an important goal because it reflects the degree to which the city can restore essential functions and structures after

a disaster. The framework for conducting the full vulnerability assessment consists of an evaluation of the following components:

- Exposure: climate change impacts that the community will experience
- Sensitivity: degree to which community assets will be affected by impacts
- Potential Impacts: the effects of the impact on a particular asset
- Adaptive Capacity: the ability of the community to cope with impacts
- Risk and Onset: the probability and frequency of impacts

The primary climate change impacts that will affect Carpinteria are sea-level rise and altered precipitation patterns. Secondary impacts related to sea-level rise are inundation, coastal erosion, and extreme high tide. A concern with SLR is the narrowing of the City's two most popular beaches, Carpinteria City and Carpinteria State Beaches, but SLR does not directly cause beach loss. Development on the shore acts as a barrier from natural beach migration and it is these residential properties that are at risk from sea-level rise. According to a recent report from the National Research Council, which provides regional projections of sea level rise for the California coast report, potential sea-level rise of **seven inches** by 2030 and **14 inches** by 2050 is expected for this region. It is recommended that the **year 2050** projection models be used as the framework for policy development in Carpinteria. Greater certainty with the models and ample time for planning are reasons to adopt the 2050 scenario as a planning horizon.

Although there is potentially less rain as temperatures increase, global weather patterns will affect the frequency and intensity of storm events at the local level. Secondary impacts of altered precipitation patterns include storm surges and flooding. For coastal cities like Carpinteria, storm surges, which are created by high winds and low pressures from "coastal storms [that] force water onto the shore," are expected every year (NRC, 2012, pg. 60). As air

warms and brings more moisture inland, these storms can cause destruction in a single event with higher volumes of precipitation in a short timeframe. Drainage is constrained because of the flatness in the Beach Neighborhood. After previous storm events, roadways and homes have been flooded for extended periods because excess water cannot drain as readily as it would have if the area had a positive grade. Therefore, upgrades to drainage and stormwater infrastructure to improve drainage capacity are a crucial step for Carpinteria to build resilience to impacts.

Since climate change is a critical global problem but with local implications, implementation strategies must be appropriate for the community. The establishment of an adaptation planning working group is an essential part of strategy building. Collaboration between community stakeholders and City staff can support and inform the prioritization of action steps that are feasible and cost-effective. During the public outreach process, feedback from community members can assist with the prioritization of actions based on relative benefits and ranking criteria such as cost, staff time, and time frame. The framework for the City's climate adaptation strategy is a hybrid of different approaches proposed by agencies and research entities. The potential action items, organized under major categories, represent strategies that the City can undertake over time to adapt to a changing climate. The categories of *Land Use Planning & Regulation*, *Design & Engineering*, and *Community Engagement* is a proposed organizational framework that describes potential City-initiated action, which places greater emphasis on the City's role.

Since the vitality of Carpinteria is inextricably tied to its coastal assets, it is important for the next phase of the City's climate adaptation planning to focus on the economic consequences of inadequate preparation for impacts like sea-level rise and altered precipitation patterns. To build consensus among community members, it is critical to emphasize the City's reliance on

tourism and recreation, which is an integral part of the City's economy. A recent economic study estimates that a 1.4 meter SLR can potentially result in up to \$10 million dollars in damages to beach structures and assets (King, 2011, pg. 64). Another study suggests that the economic value of Carpinteria's beaches is about \$30.7 million annually based on the number of tourists and average spending on local businesses (King, 2001, pg. 4). In addition, a focus on properties in flood risk areas can also build a case for longer-term solutions that safeguard not only beaches but whole neighborhoods as well. Sea-level rise and other climate change impacts will alter the coastline, but the City of Carpinteria can take preemptive action and minimize negative effects. A Draft Climate Adaptation Plan is the first step for the City towards strategy implementation that will truly make a difference.

INTRODUCTION

The City of Carpinteria is concerned about the impacts of climate change on its coastal resources and its Beach Neighborhood, a residential neighborhood within a few feet of sea level. Sea-level rise (SLR) is one consequence of global climate change and given Carpinteria's location right along the coast, the City will likely face the threats of sea-level rise and other impacts in greater frequency and intensity. Currently, flooding from winter storms diminish the quality of the City's ecological assets and shoreline properties, both of which contribute to the City's important tourism economy. Sea-level rise will likely exacerbate severe weather events and threaten the beaches that attract many visitors and residents to Carpinteria. The intent of this project is to provide a foundation for future development of a **Climate Adaptation Plan**, a starting point for the City's climate initiatives. An adaptation strategy is sound planning that recognizes the community's vulnerabilities and attempts to minimize climate change impacts through preemptive action.

Purpose

The professional project is a requirement of the master's degree in City and Regional Planning from Cal Poly San Luis Obispo. Jean Long is a graduate student in the program and will complete her degree upon completion of this project. Her efforts, with the focus on sea-level rise impacts, will help the City of Carpinteria create an adaptation plan to manage the long-term effects of climate change. Jean's deliverable will consist of background information on Carpinteria, a preliminary vulnerability assessment, and a list of potential strategies for City-led implementation. The research will help inform the potential steps for the City to augment its protection strategies for critical community assets.

Setting

The City of Carpinteria is a coastal community in Santa Barbara County known for its calm beaches and small-town character. It is approximately 11 miles east of the City of Santa Barbara (Figure 1). The population is 13,040 in a land area approximately 2.6 square miles (U.S. Census, 2010). In total, the area within the City limits is 7.3 square miles but 4.7 miles of that are actually tidelands that extend about 2.5 miles offshore (City of Carpinteria General Plan, 2003). Incorporated in 1965, the City lies within the greater Carpinteria Valley. Its economic base is primarily in manufacturing and accommodation/food services in terms of employees (U.S. Economic Census, 2007).

Figure 1: City of Carpinteria, Santa Barbara County. [Google Earth, 2013]

Figure 2: City of Carpinteria.[Google Maps, 2013]

Rationale

Sea-level rise has the potential to have far-reaching effects on the physical composition of Carpinteria, particularly the loss of beaches and increased likelihood of flooding and inundation in established neighborhoods. Due to the attractive beaches that draw people to Carpinteria, tourism is an integral part of the local economy. A recent economic study estimates that a 1.4 meter SLR can potentially result in up to \$10 million dollars in damages to beach structures and assets (King, 2011, pg. 64). **Sea-level rise** can refer generally to the global increase in the mean level of the ocean (IPCC, 2007a), but the relevant estimates for a local climate adaptation plan require data at a regional or local scale. Sea-level rise is the height of water along the coast, which can be variable based on the specific point on land where local tide stations record measurements (Henson, 2011, pg. 118). According to the Intergovernmental Panel on Climate Change (IPCC), “sea level has been rising at a rate of around 3 mm per year,

significantly higher than the average during the previous half century” since 1993. As average global temperature rises, land-based ice melts and surface water runoff reaches the ocean at faster rates. This extra volume of water contributes to gradual sea-level rise, which is also result of thermal expansion (the volume of water increases as heat increases) (IPCC, 2007a, FAQ 5.1). Extreme high tides, storm surges, and inadequate stormwater drainage can exacerbate the impacts of sea-level rise.

Content

This draft SLR Action Plan consists of three chapters. The first chapter regarding climate change at the local level provides a summary of climate change science, the policy context, and the background information of the City of Carpinteria. The second chapter provides a preliminary vulnerability assessment that serves as the information needed to support the conceptualization, adoption, and implementation of climate change policy actions. The third and final chapter focuses on a potential adaptation strategy program for Carpinteria and suggested next steps for the City to move climate planning into the next stage. Draft plans for adoption by the City Council require public engagement and input as an essential component of any comprehensive plan. This project presents the preliminary research needed to provide the context and rationale to the community. The next phase for a complete Climate Adaptation Plan is the development of a public outreach strategy that will inform the prioritization of climate change adaptation goals.

CHAPTER 1: CLIMATE CHANGE AT THE GLOBAL AND LOCAL LEVEL

The Science

Without greenhouse gases (GHGs) like carbon dioxide and methane trapping the sun's heat, the earth would be a cold and barren planet unable to support life. While the concentration of atmospheric gases and corresponding temperature changes have fluctuated over billions of years, the dramatic increase of carbon emissions in the last half-century has become a point of concern. Scientific consensus from various research fields acknowledges that there are observational changes to the physical environment that suggests overall warming.

There is also strong evidence indicating that this increase in carbon dioxide is attributed to human activities as people burn fossil fuels for transportation and energy generation, releasing carbon compounds into the atmosphere (Cayan et al, 2009, pg. 1). It is the amplification of the greenhouse gas effect that has led to global warming, or a rise in the average temperatures. This rise in temperature has altered climate patterns across the globe, bringing less predictable seasonal patterns and more severe weather events.

Carbon dioxide, methane, water vapor, nitrous oxide and other GHGs absorb some of the outgoing radiation in the atmosphere. These gases re-emit this as infrared radiation back to Earth, which converts to heat energy to warm the surface. The critical issue now is the overabundance of GHGs, trapping more heat within the atmosphere than necessary (Henson, 2011, pg. 24). This increase in temperature has been a major factor in more frequent and severe weather events that have devastating consequences on communities. There have been observable changes throughout the state due to global warming, such as reduced snowpack as well as shifting growing seasons (California Climate Change Center, 2006, pg. 2).

While there has been debate over whether anthropogenic greenhouse gas emissions are the root cause of global warming, there is consensus among scientists who have gathered data from the past 100 years that there is indeed an increase of (1.3° F) in average surface air temperature. A climate science authority is the Intergovernmental Panel on Climate Change (IPCC), a consortium of scientists who evaluate and summarize the numerous studies on climate science in periodic reports, which represent the best available science that can be used in developing policy. The data trends reveal upward trajectories in both temperature and greenhouse gas emissions in recent years and for future projections. Taking into account regular El Nino/La Nina events and other periodic climactic phenomena, IPCC has “high confidence” that the global temperature has risen and that even a one-degree change can have dramatic effects on the planet (IPCC, 2007a).

Climate Change Impacts for Coastal Communities

According to the 2009 California Climate Adaptation Strategy (CAS), 85% of California residents live and work in coastal counties. This significant portion of the state population will be at risk from the climate impacts that will affect coastal regions, particularly sea-level rise (pg. 65). The impacts of sea-level rise have already been felt along some critical points along the coast, notably the San Francisco Bay and upper estuaries and Southern California (Moser, et al., 2009, pg. 24). Some of the anticipated future conditions and impacts that coincide with sea-level rise are storm surges, tides, and climactic fluctuations that will likely cause widespread inundation along the coasts (Moser, et al., 2009, pg. 49). Accelerated sea-level rise coupled with severe storm events caused by changes in global weather patterns will exacerbate the frequency and intensity of coast flooding and erosion rates (CNRA, 2009, pg. 65). All of these events combine to threaten property as well as economic and ecological assets along the coasts.

Communities can and should take addressing local climate impacts into their own hands and initiate the conversation about building **resilience**, or the ability of a system to absorb disturbances while retaining essential functions (IPCC (a), 2007). In other words, resilience is how well a city can “bounce back” after a major disaster. In

Resilience: The ability of a social or ecological system to absorb disturbances such as extreme events to retain the same basic structure and ways of functioning (IPCC , 2007c).

addition, resilience also represents a community’s ability to avoid and/or to limit the impact in the first place. Through climate **adaptation**, or an adjustment in systems to minimize harm arising from climate impacts (IPCC, 2007), cities can implement strategies that ensure that their community is more resilient.

Sea-Level Rise Projections

Sea-level rise is a direct impact of climate change due to the increased melting of land-based ice such a glaciers and the thermal expansion of oceans as temperature increases (Moser, et al., 2009, pg. 24). The IPCC (2007), states that these processes of “thermal expansion and the exchange of water between oceans and other land-based reservoirs (including anthropogenic modifications to land hydrology)” influence the global mean sea level but can also affect the non-uniform sea-level rise changes in different regions of the world (IPCC Intro, 2007).

As for the state, an assessment conducted in 2009 reveals that the 100-year flood plain areas after a 55 inch sea-level rise will endanger about half a million people who live on the California coast and about \$100 billion in property damage (CNRA, 2009, pg. 65). The anticipated 55-inch sea level rise by 2100 of areas subject to coastal flooding is based on the estimate generated by the IPCC reports on the global scale. The California Coastal Commission has recommended a study that provides preferred ranges for SLR planning in the state. This

recent report(2012) provides SLR projections for the coasts of California, Oregon, and Washington (pg. 6), which are lower than the global projections from the IPCC report. For relevance in to a particular jurisdiction, local and regional data should be used for adaptation planning if it is available. **Table 1** shows ranges of sea level rise for the California coast south of Cape Mendocino in the northeastern part of the state:

SLR Projections (relative to 2000)	SLR Range (in centimeters)	SLR Range (in inches)	Average
2030	4 – 30 cm	1.57 – 11.81 in.	17 cm (6.7 in)
2050	12 – 61cm	4.72 – 24.01 in.	36.5 cm (14.4 in)
2100	42 – 167 cm	16.53 – 65.74	104.5 cm (41.1 in)

Table 1: Sea-Level Rise Projections for California South of Cape Mendocino. [National Research Council, 2012]

Legislation on Sea-Level Rise

California’s legislators have also looked into the issue of climate change and are proposing new bills that would mandate local governments to take initiative on a sea-level rise action plan. The most relevant piece of legislation is AB 752 by Assemblymember Brownley from Santa Monica. The bill, which is currently in committee sessions, states that “the preparation of a sea level action plan for all of its legislatively granted public trust lands pursuant to this section shall be among the management priorities of a local trustee of granted public lands (Tidelands and submerged lands: sea level action plan, AB 752. § 6315 (2011). In the event that this bill passes, the City of Carpinteria will be ahead in the planning process for a sea-level action plan because of the preliminary research and recommendations produced in this project’s deliverables.

The Development of Adaptation Policy for Local Jurisdictions

The *California Climate Adaptation Planning Guide: Planning for Adaptive Communities* (APG) was released in 2012 as a resource for local and regional governments. Prior to the release of the guide, information on climate adaptation was widely available but there was no guidance as an introduction for agencies that wanted to integrate adaptation principles into their policies. The APG is not intended to be prescriptive, but it lays the foundation for government staff to ask the right questions and to draw upon research and data most relevant to their jurisdiction. The draft SLR adaptation plan draws upon the framework presented in the APG, which is outlined in five steps: 1) Exposure to Climate Change Impacts; 2) Sector/Asset Sensitivity; 3) Potential Impacts; 4) Adaptive Capacity; and 5) Risk and Onset. The schematic for the adaptation policy development for local government is delineated by the following steps. The discussion of each component should occur in this order, but some steps do overlap. For example, the community assessment of climate exposure and sensitivity will be done in tandem as background for the evaluation of potential impacts and adaptive capacity.

Roles of Federal and State Agencies

While climate adaptation is certainly focused on the local community's capacity to deal with the impacts, the planning effort crosses jurisdictional boundaries. The Federal Emergency Management Agency (FEMA) provides the floodplain maps that delineates flood risk areas, which has implications for property insurance rates as well as the standards for building. If the climate adaptation strategy is related to some type of structure on the shoreline, the California Coastal Commission has influence because of their power to approve permits. The City of Carpinteria should consider the role of these external agencies during the climate adaptation planning process.

Federal Emergency Management Agency (FEMA)

Carpinteria identifies flood hazards according to FEMA's National Flood Insurance Rate Maps (FIRM) that indicate the areas of the City that are in the 100-year floodplain. FEMA recently updated Carpinteria's flood map in February 2013 to reflect the appropriate areas vulnerable to this hazard. The City also updates its municipal codes to comply with the National Flood Insurance Program (NFIP), which makes the community eligible for insurance compensation when a disaster occurs. Adherence to the stipulations in FEMA's flood program ensures that property owners in the designated floodplain can purchase federal flood insurance. The NFIP allows for "implementation of improvements standards [that] prevents or reduces property loss and enhances recover," an important aspect in hazard mitigation planning (City of Carpinteria, 2012, pg.2). The summary staff report of the flood insurance program included the following updates to the municipal code (pg. 3):

- Structures (A-O Zone) - All new construction and improvements of residential structures must have the lowest floor elevated above the highest adjacent grade at least as high as the depth number specified in the City's FIRM. Non-residential structures must also comply with the same depth number in addition to flood-proofing of utility and sanitary facilities to meet standards.
- Non-Residential Structures – All new construction and substantial improvements of non-residential structures must be designed so that below base flood level the structure is watertight with walls that are impermeable to the passage of water.
- Drainage Paths near Structures (AH and AO Zones) – Drainage paths around structures are required to guide floodwaters around and away from proposed structures adequately.

California Coastal Commission

The California Coastal Commission works in conjunction with 15 counties and 60 cities in the 1100-mile coastal zone for planning, regulation, and permitting. The Commission's primary authority is derived from the Coastal Act of 1976, establishing a coastal protection program to preserve wetlands and environmentally sensitive habitats, public access to the coastline, recreational uses, scenic integrity, fisheries, and community character (Coastal Commission, Website accessed Jun 2012).

If any development is to occur within the city, communities under the Coastal Commission's purview must have an approved local coastal program/plan (LCP) or get a coastal development permit certified by the Commission. The jurisdiction of the LCP and the Coastal Commission applies to "future development and protection of coastal resources of 76 coastal cities and counties," which ensures that changes to land and water uses conform to the Coastal Act (Coastal Commission, 2012, para. 1). It applies to coastal development only, and does not hold influence over the entire city's territory. Carpinteria is a part of the South Central Coast Area. The City's 2003 General Plan is a combined general plan with the local coastal land use plan and environmental impact report with full consideration of the requirements of a local coastal plan set by the California Coastal Commission.

Since coastal communities generally cannot develop in areas in the Coastal Zone without Commission approval, strategies that involve the building of any structures need to be assessed for its compliance with Coastal Act regulations. For climate adaptation in Carpinteria, the Coastal Commission can be a facilitator in preventing further development on the coast that may be vulnerable to sea-level rise, but the Commission can also be an obstacle in getting approval

for offshore structures that can protect existing property. Communication with the Coastal Commission will be necessary for adaptation efforts.

Adaptation for the City of Carpinteria

In the City of Carpinteria, areas along the shoreline flood regularly because of winter storms, threatening the quality of the City's ecological assets and shoreline properties. Sea-level rise will likely exacerbate these severe weather events and threaten the beaches that are a cornerstone of Carpinteria's economy.

Climate Adaptation Plan Framework (Tentative)

Climate adaptation planning has become increasingly more pertinent as governments and constituents are realizing that global climate change impacts occur at the local level. Resources and references from state agencies, university researchers, and non-profit organizations have emerged to support the development of climate adaptation plans that take into account the community's concerns, needs, and capabilities to adapt to changes in climate and weather events.

Examples that the City of Carpinteria should draw upon include the following:

- City of Santa Cruz. (2011). *Climate Adaptation Plan: An Update to the 2007 Local Hazard Mitigation Plan, 2012 – 2017*
- City of Santa Barbara. (2012). *Climate Action Plan, Chapter 3 Adaptation to Climate Change*
- City of Santa Barbara. (2012). *Sea-Level Rise Vulnerability Study*
- City of San Diego and ICLEI. (2011). *Sea Level Rise Adaptation Strategy for San Diego Bay, Regional Vulnerability Assessment*

The tentative framework/outline proposed is inspired by cities that have paved the way in introducing adaptation into the mainstream. It serves as the basis for the administrative draft of the climate adaptation plan, but is not complete without the public participation component. Since public outreach and implementation is not covered by the administrative draft, the City of Carpinteria will initiate and lead this effort. Guidance documents that have been instrumental in creating the foundation of the draft include the following:

- Cal EMA and CNRA. (2012). *California Adaptation Planning Guide: Planning for Adaptive Communities*.
- University of California, Santa Cruz. (2012). *Adapting to Sea Level Rise: A Guide for California's Coastal Communities*.
- University of Washington, King County, Washington State and ICLEI. (2007). *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*.

Proposed Outline of Draft Climate Adaptation Plan*(based on guidance documents above)*

I. Climate Adaptation Planning Motivation and Scope

II. Overview of Climate Change Science and Data Analysis

A. Global and Regional Sea Level Rise Projections

III. Role of Local Government and State and Federal Agencies

IV. Background & Characteristics of Carpinteria

A. Identification of Major Sectors Potentially Impacted by Climate Change (Economy, Ecological Resources, Infrastructure, etc.)

B. Identification of Vulnerable Planning Areas

V. Ongoing Policies Related to Climate Change Adaptation

A. Current Planning Policy Audit

VI. Vulnerability Assessment

VII. Potential Adaptation Strategies

VIII. Community Involvement

A. Establishment of a Vision and Preparedness Goals

B. Prioritization of Actions

VIV. Implementation and Plan Maintenance

A. Development of Measures to Gauge Resilience Building

Hazard Mitigation and Adaptation Approaches

Adaptation planning and hazard mitigation planning have similar approaches when dealing with disasters that threaten communities. Minimizing the detrimental impacts of natural and human-caused disasters is the crux of hazard mitigation planning, but one of many considerations in climate adaptation planning. Hazard mitigation as defined by the Federal Emergency Management Agency (FEMA) is “any action taken to reduce or eliminate risk to human life and property from natural hazards,” but many municipalities broaden the definition to include human-caused disasters as well. A “hazard” is an event or condition with the potential to cause fatalities or property loss (Cal-EMA, 2010, pg.4). Common examples include wildfire, earthquakes, and flooding. Hazard mitigation is based on historic records of recurring disasters to formalize strategy plans for preparedness, response, recovery, and mitigation.

Climate adaptation, in contrast, is focused on future climate change natural disasters but integrates other socioeconomic impacts as well, such as climate change impacts on ecological conservation, agriculture, economic vitality, and public health. Hazard mitigation is typically posited in historic patterns, which may not be relevant to a future climate scenario where conditions are unpredictable (Boswell et al, 2012, pg. 157). Climate change will affect the

frequency and severity of hazards, so adaptation planning takes this into consideration by assessing potential impacts with adjusted risk profiles of the community. For example, a local hazard mitigation plan for a community in an area of high fire risk will focus on annual wildfire events but an adaptation plan will discuss how climate change can increase the frequency and intensity of seasonal fires and provide ways to deal with this shift. Adaptation strategies range from short-term coping actions, such as rainwater storage for excess water during storms, to longer-term investment in upgrading stormwater infrastructure to handle excess capacity from increased storm events. These efforts, or adjustments in the system, are measures that help reduce vulnerability to climate change impacts (Boswell et al, 2012, pg. 153). Adaptation planning support existing hazard mitigation procedures, and if necessary, creates new measures that go above the scope of the current hazard plans.

Carpinteria: Hazard Mitigation Planning

The City of Carpinteria's recent completion of its Local Hazard Mitigation Plan (LHMP) in 2012, an annex to the County of Santa Barbara's Multi-Jurisdictional HMP, is an informative source (County of Santa Barbara, 2012). A list of critical facilities and description of the current status of flooding in the City are valuable to the development of Carpinteria's adaptation plan. An addition tool used for hazards planning is the MyPlan map application provided by the California Emergency Management Agency (Cal-EMA), which is available at <http://myplan.calema.ca.gov/>. In the LHMP (2012), the hazard planning committee ranked flooding (with coastal surge) as the most significant hazard type (pg. 10-35). Although climate change is not explicitly acknowledged in this LHMP, the City also recognizes the risks of coastal surges caused by intense and frequent storm events, which may increase with climate change. Carpinteria is a coastal community that has suffered from intense storms and subsequent flood

hazards in the past, so the City has made proactive efforts to mitigate the impact of flooding in their community (pg. 10-25). Several of these actions include the following from the LHMP (pg. 10-21):

- Santa Barbara County Flood Control District performs routine maintenance (sediment and debris removal from creeks) to allow water to flow freely while controlling flooding
- Public Works Department conducts a full inspection of drain pipes, ditches, and culverts annually to minimize drain blockages that can impede flow
- Capital Improvement Plan includes a proposal for new underground storm drains in Downtown and Beach Neighborhoods that bear the brunt of flooding

Carpinteria: Adaptation Planning

The City of Carpinteria is extremely conscious of their vulnerability to flooding hazards. The City has been preemptive in making the City more resilient as sea-level rise becomes a major problem. The City is collaborating with agencies, such as FEMA and USGS, to gather more reliable data on how sea-level rise will affect risk areas. The City has rezoned many areas to be recreation or open space areas along the coast, but there are still many buildings that are in danger of inundation because of their proximity to the beach. In the Beach Neighborhood, many older homes are built at grade, most likely constructed before the requirement of minimum two feet above base flood elevation became part of the zoning code (City staff, personal communication, 2013). However, the City has allowed a minimum of only six inches in the Beach Neighborhood to protect coastal views. Newer homes in Carpinteria are typically built two feet above base flood elevation, with newer homes elevated about two to six feet above grade as a precaution against flooding (J. Campbell, personal communication, 2013).

While the City has not officially adopted a formal adaptation plan, it has already started a conversation about actions that will increase the community's resilience to flood events. Based on the content from the safety element, the LHMP (2012) summarizes the following as ongoing policies (pg. 10-19):

- Build a sand berm annually during the winter months to protect structures and property along the City Beach
- Pursue a vegetated dune system at the City Beach
- Ensure that all new construction and reconstruction be built to standards that protect the property from intense wave action
- Enforce adherence to County of Santa Barbara Floodplain Management ordinance for all new development proposed in the 100-year floodplain seeking building permits
- Discourage critical facilities from being built in the floodplain
- Consider water runoff and drainage for any development

Data Sources

Despite its small size and population of about 14,000 people, the City of Carpinteria has been the subject of several technical studies of the coastline. The beachfront, coastal bluffs, salt marsh, and other natural features provide various features to be examined. The diversity of different study cases in such a small area, particularly for coastal studies, is attractive to agencies and research groups. Carpinteria is fortunate to have these technical studies available to supplement data collection for further adaptation planning (J. Campbell, personal communication, 2013). A survey of maps based on Cal-Adapt and Google Earth data sets are also available in the appendix.

Google Earth Data Sets:

1) USGS. (2011). Flood Hazard Scenario – Baseline Jan 2010 with 50- and 100-year Sea Level Rise [**INTERNAL USE ONLY**]

2) FEMA. (2013). National Flood Hazard Layer. Retrieved from <https://msc.fema.gov/webapp/wcs/stores/servlet/info?storeId=10001&catalogId=10001&langId=-1&content=nfhlResources&title=NFHL%20Resources>

3) FEMA. (2013). Stay Dry and Flood Smart! Mapping Information Platform. Retrieved from <https://hazards.fema.gov/femaportal/wps/portal/NFHLWMSkmzdownload>. [kmz files for Google Earth currently undergoing update].

CHAPTER 2: VULNERABILITY ASSESSMENT

The City should integrate adaptation principles into its existing policies and create a climate adaptation plan that is the unifying document intended to minimize the impact of climate change on Carpinteria. The core of a climate adaptation plan is the vulnerability assessment, an investigation of climate change on the community and the community's ability to become resilient to these impacts, sudden or gradual. For example, a coastal city like Carpinteria should plan for punctuated severe storm events but also consider long-term inundation of beach neighborhoods because of sea-level rise. Increasing **resiliency** in a community is an important goal because it reflects the degree to which the city can restore essential functions and structures after a disaster.

As described in the *Adaptation Planning Guide*, the framework for conducting the full vulnerability assessment consists of the following:

- Exposure: climate change impacts that the community will experience
- Sensitivity: degree to which community assets will be affected by impacts
- Potential Impacts: the effects of the impact on a particular asset
- Adaptive Capacity: the ability of the community to cope with impacts
- Risk and Onset: the probability and frequency of impacts

The primary climate impact that Carpinteria will be exposed to is sea-level rise, which can lead to secondary impacts of inundation/long-term waterline change, extreme high tide, and coastal erosion. Coupled with the gradual onset of sea-level rise, altered precipitation regimes exacerbate these secondary impacts. Climate change-related weather will likely bring more intense and frequent rainstorms to the coastal regions of California and shift expected seasonal patterns. The

analysis and interpretation of currently available sea-level rise data will help inform the City of the appropriateness of adaptation strategies.

Climate Condition	Associated Impacts
Sea Level Rise	Inundation, Coastal Erosion, Extreme High Tide
Change in Temperature	Increased Warm Weather Days
Change in Precipitation Patterns	Intense Storm Events, Flooding

Table 2: Summary Table of Primary and Secondary Impacts. [California Adaptation Planning Guide, 2012, pg. 17]

A vulnerability assessment is a critical step in determining the potential climate change impacts on the community. It is the most significant component of climate adaptation planning. The method of doing a vulnerability assessment will reveal the possible impacts as well as the community's capacity to deal with the social, economic, environmental, and political changes resulting from sea level rise, extreme temperatures, and shifting climate patterns. The *California Adaptation Planning Guide: Planning for Adaptive Communities* is a good preliminary reference for conducting a vulnerability assessment because the guide is intended to be a simple but comprehensive framework for governments to start thinking about climate change in their community (Cal EMA, 2012, pg. 31)

Using the Cal-Adapt Tool

The Cal-Adapt Tool (*cal-adapt.org*) is a convenient tool for planners who want an introduction to adaptation planning and the potential impacts of climate change on their respective communities. Cal-Adapt is a product of the Public Interest Energy Research (PIER) program. While the tool provides a satisfactory overview, it presents data on the statewide scale to capture the breadth of climate change through the state but does not have the resolution

necessary to do localized planning. Other studies pertaining to Carpinteria will be used to develop a more accurate determination of sea-level rise and other climate impacts.

The primary source for the temperature, precipitation, and snowpack estimates in Cal-Adapt is research from the Scripps Institution of Oceanography. Four models were used to estimate the changes in these direct climate change indicators under two different scenarios. The A2 High Scenario is the IPCC medium-high emissions scenario, which assumes that there is continued population growth with uneven economic and technological growth. CO₂ concentration triples by 2100. The B1 Low Scenario is the IPCC low emissions scenario, which assumes a shift towards less fossil fuel-intensive industries and more clean technologies. In this B1 Scenario, CO₂ concentration will double from today's levels by 2100 (State of California, Public Interest Energy Research (PIER), 2012).

Cal-Adapt Data: Assumptions, Uncertainties, and Limitations

While the Cal-Adapt maps are a starting point for climate change impact estimates, communities need to evaluate the data and its implications in order to refine and validate the projections for appropriateness. Moreover, the Cal-Adapt disclaimer explains that there is a degree of uncertainty because the visualizations consist of average values from numerous scenarios and models. Without knowing the exact methodology of the models, it is difficult to discern the accuracy of the values that underlie all the assumptions made in the Cal-Adapt models. Although Cal-Adapt is a good preliminary tool to evaluate potential impacts on a community, there are concerns such as coastal erosion and beach loss specific to Carpinteria that Cal-Adapt does not address. Several coastal organizations and government agencies such as USGS have published reports about these issues that may provide a more comprehensive look at Carpinteria's climate change vulnerability.

Exposure to Sea-Level Rise

The method of a vulnerability assessment can apply regardless of the jurisdiction or location, including the coastal communities of California. The first two key considerations for starting a vulnerability assessment are **exposure**, or the climate change impacts the community is subject to, and **sensitivity**, the degree to which local physical and social assets and functions are affected by potential climate change (ICLEI-USA and San Diego Foundation, 2012, pg. 18).

Exposure: *Exposure* is a determination of whether community assets will experience a specific changing climate condition (ICLEI-USA, 2012, pg. 18). Direct climate changes include average temperature, annual precipitation, and sea-level rise.

By understanding a community's exposure and sensitivity profile as an initial first step, it can inform the overall potential climate change impacts that threaten the community, particularly by taking into account the extent of the impact over time and space, and the level of disruption the impact could inflict on normal city function. Based on the data available on Cal-Adapt, Carpinteria is vulnerable to changes in sea-level rise, temperature change, and precipitation. Brief summaries describe the scale, distribution, timing, and change from current conditions for each relevant impact.

Sea-Level Rise

With thermal expansion of water and melting of glaciers and other large masses of ice because of the warming planet, sea-level is expected to rise over the century (Cal EMA, 2012, pg.26). In reference to the IPCC reports that cite general agreement on sea-level rise projections to be 55-inches (1.4 meters) by the year 2100, the Cal-Adapt models have used this parameter to assess the potential risk of inundation from sea-level rise. The maps display areas at risk during a 100-year flood event.

Year		Average of Models	Range of Models
2030		7 in (18 cm)	5-8 in (13-21 cm)
2050		14 in (36 cm)	10-17 in (26-43 cm)
2070	Low	23 in (59 cm)	17-27 in (43-70 cm)
	Medium	24 in (62 cm)	18-29 in (46-74 cm)
	High	27 in (69 cm)	20-32 in (51-81 cm)
2100	Low	40 in (101 cm)	31-50 in (78-128 cm)
	Medium	47 in (121 cm)	37-60 in (95-152 cm)
	High	55 in (140 cm)	43-69 in (110-176 cm)

Table 3: Sea-Level Rise Interim Guidance Document - Recommended Projections. [California Ocean Protection Council, 2010]

SLR in California

Although the various models used for sea-level rise are generally in agreement through year 2050, the models increasingly diverge from each other as the projections approach 2100. Sea-level rise is expected to increase 1.4 meters (55 inches) by the year 2100 on a global scale, which is the average projection under a high greenhouse gas emissions future. This standard is the average of a range of models and is a conservative estimate because it does not account for catastrophic ice melting (CNRA, 2009, pg. 4). The following chart is from the *Interim Sea-Level Rise Guidance* document, a preliminary first-cut framework for SLR in California. It is currently in development as a project of the SLR Task Force of the Coastal and Ocean Working Group of the California Climate Action Team (CO-CAT). These estimates are taken from the IPCC's reports, which reflect possible scenarios of SLR around the world (**Table 3**).

In their report for SLR vulnerability assessment, Russell and Griggs (2012) provide guidance on obtaining sea-level information, which is important to determine how a community will be affected by climate change but it is not always a simple task. NOAA provides a wealth of information through data collected from their regional tide gauges. The authors suggest that, “an important consideration in the use of this data is the time period covered by the closest gauges to

a particular community” (Russell et al, 2012, pg. 15). While Carpinteria should consider available studies that provide regional SLR data for policy making, local information will provide a level of accuracy to the planning process but typically require funding for the study. Details about the tidal gauges are for general knowledge about the area. Two water-level stations are located near Carpinteria, one to the north in Santa Barbara and one to the south at Rincon Island. The data was obtained from: <http://tidesandcurrents.noaa.gov/sltrends/sltrends.shtml>

Figure 3: Tidal Gauges Nearest to Carpinteria. [Google Maps, (2012)]

- *Rincon Island:* The mean sea level trend is 3.22 mm/year with a 95% confidence interval of ± 1.66 mm/year based on monthly mean sea level data from 1962 to 1990, equivalent to a change of 1.06 feet in 100 years (NOAA, 2012).

Figure 4: Mean Sea Level Trend, Rincon Island Tidal Gauge. [NOAA, 2012]

- *Santa Barbara:* The mean sea level trend is 1.25 mm/year with a 95% confidence interval of ± 1.82 mm/year based on monthly mean sea level data from 1973 to 2006, equivalent to a change of 0.41 feet in 100 years (NOAA, 2012).

Figure 5: Mean Sea Level Trend, Santa Barbara Tidal Gauge. [NOAA, 2012].

Although it seems as if the sea level is not rising significantly, the positive trend of a few millimeters suggests that the climate is changing enough to have an effect on SLR. Linear relationships should not be used for sea-level rise because the constant rate may not reflect future conditions (CNRA, 2009, pg. 6). Given the huge range of possibilities of climate change impacts due to increases in GHG emissions, it is not prudent to rely on linear relationships that represent a point in time when the carbon dioxide levels are vastly different. Global projections, even when downscaled, have an inherent degree of uncertainty. However, the projections for sea-level rise increase exponentially to 2100, so 40 inches is plausible if global temperatures continue to rise. Until 2050, the consensus among scientists on potential sea-level rise is generally in agreement, but after that point, the projections diverge quite dramatically.

Figure 6: Sea-Level Rise Projection for Carpinteria - 2000 to 2100. [State of California, 2012].

SLR in Carpinteria

For Carpinteria, the estimated acreage at risk in 2000 was 4,210 (**Figure 6**). On the Cal-Adapt map, dark blue shaded areas represent areas at risk currently. The yellow areas depict areas that are threatened by expected sea-level rise, which is about 6,570 acres at risk of a 55-inch sea-level rise by the year 2100. This is a difference of 2,360 acres, or a 36% change in acreage between 2000 and 2100.

Since the sea-level rise projections by the IPCC are on a global scale, it is more accurate to refer to other sources that pertain to Carpinteria. Without local specific studies, the best practice is to use the most recent and smaller-scale studies that can provide information that is relevant to the City's circumstances. One potential source is the recent report from the National Research Council, which provides regional specific data. **Table 4** shows ranges of sea level rise for the California coast south of Cape Mendocino in the northeastern part of the state. The City should also consider planning for potential sea-level rise of **7 inches by 2030** and **14 inches by 2050** because it is a reasonable average that reflects best available science at the time of this report. Area maps and cross-sections of the elevation along the shoreline with a 7-inch SLR are visualizations that can help convey the potential impacts of climate change. Technical studies from USGS and Army Corps of Engineers, such as the *Carpinteria Coastal Processes Survey* (2008), provide some of the necessary data analysis.

SLR Projections (relative to 2000)	SLR Range (in centimeters)	SLR Range (in inches)	Average
2030	4 – 30 cm	1.57 – 11.81 in.	17 cm (6.7 in)
2050	12 – 61cm	4.72 – 24.01 in.	36.5 cm (14.4 in)
2100	42 – 167 cm	16.53 – 65.74	104.5 cm (41.1 in)

Table 4: Sea-Level Rise Projections for California Coast south of Cape Mendocino. [National Research Council, 2012].

For policy development in Carpinteria, it is recommended that the year 2050 projection models instead be applied. Greater certainty with the models and ample time for planning are reasons to adopt the 2050 scenario as a planning horizon. The average of the study models from the IPCC for 2050 is **14 inches** (36 cm.), between a range of 10 to 17 inches (California Ocean Protection Council, 2010, pg. 4). Until there are local studies that provide a higher level of accuracy of SLR, the state-recommended SLR projections are a rational starting point for SLR planning. As more data and certainty of the potential impacts are defined in the future, the plan should be modified accordingly.

Secondary Impacts of Sea-Level Rise

Associated secondary impacts from sea-level rise include long-term coastal inundation, extreme high tide, and coastal erosion. Inundation refers to a condition in which water covers and infiltrates normally dry land (NOAA, 2012) permanently, and sea-level rise will be a factor in regional inundation over a longer period of time. This is especially problematic because buildings and other structures are built in areas that are presumably safe from these weather events.

As climate patterns change globally, an increase in the frequency and intensity of ocean storms is expected. One primary concern for Carpinteria is flooding resulting from storm surges (tropical storms with strong winds that drive water to the shore) compounded by SLR, high tides, and El Nino events (NRC, 2012, pg. 59). **Flooding**, or the overflow of water over land that is typically dry, is used as a general term in this document, but the type of floods that have impacted Carpinteria and will continue to do so are caused by a storm surge with excessive water that has nowhere to go or intense wave action and high tide, even in the absence of rain. In contrast, **inundation** is long-term or permanent flooding in areas that were previously dry. As sea-level rises, it can leave shoreline areas completely inundated, which threaten coastal properties.

Residential homes in the low-lying areas near Carpinteria City Beach area are vulnerable to flooding, particularly as a result of intense precipitation that falls over a short period. These areas are very flat, so drainage after major storms is slow, leaving homeowners in stagnant water. Carpinteria has experienced major flood events in 1980, 1981, 1983, 1995, and 2005 (County of Santa Barbara, 2012, pg. 10-30). Since the city is built on top of marshland, the water table is very high (J. Campbell, personal communication, 2013). During storm surges or extreme high tide,

the Carpinteria Salt Marsh may reach capacity and the underlying marshland beneath buildings cannot retain excess water. Therefore, without drainage maintenance and upgrades, stormwater may backflow into flat beach neighborhoods.

A concern with SLR is the narrowing of the City's two most popular beaches, Carpinteria City and Carpinteria State Beaches. The shoreline is about 13,450 feet (2.5 miles) long, with the City Beach and State Beach at 1,450 feet and 4,100 feet respectively. With increasing SLR, the beaches could narrow to less than 50 feet, which is considered less than optimum for recreational visitors to Carpinteria (USACE, 2003, pg. 4.9). Due to tidal and seasonal fluctuations, the width of the City Beach is not constant, but is relatively stable (USGS, 2008, pg. 28). The summer/fall beach width at the City beach is within a range of 82 feet (25m) to 196 feet (60m) (pg. 26). Several studies have already been completed to assess the current rate of coastal erosion along Carpinteria's shoreline. The *USGS Carpinteria Coastal Processes Study* (2008) notes that the City has experienced some erosion and storm damage, almost 2 meters per year in some places, as confirmed by a reconnaissance survey conducted by the Army Corps of Engineers (ACE) in 2003 (USACE, 2003, pg. 11). The study reveals that there is a trend of beach erosion in the western shoreline along the beaches and accretion (sediment restoration) in the eastern part of the study area.

Sea-level rise does not directly cause potential beach loss. Without barriers, such as a seawalls or building, beaches tend to migrate landward as it has done for thousands of years. However, with constraints such as development on the shoreline, there is potential beach loss as a rising sea level and wave runup pushes sand landward against the barrier (Russell, pg. 23). In addition, beach volumes have also decreased over time, starting with the construction of the Santa Barbara Harbor in 1930 that affected typical wave patterns and sedimentation for

downcoast communities (pg 25). Typical solutions for coastal erosion involve protection and retreat (City of Santa Barbara, 2012, pg. 67.). Protection measures range from soft infrastructure such as beach berms to the more imposing sea walls.

Annual Precipitation

The Cal-Adapt map for state precipitation using historic records and projections of decadal averages reveal little change in total annual precipitation, but there is no consistent trend among the available models for the next century (State of California, 2012). Since California is a relatively dry state with huge demands for water, small changes in precipitation can have a profound impact on public health, agriculture, and economic interests. In addition, precipitation that falls as rain rather than snow can drastically reduce water supply because snowpack in the Sierra Nevada essentially act as reservoirs that feed into the state's complex water conveyance system (Cal-EMA, 2012, pg. 69).

For Carpinteria, overall precipitation levels are expected to decline to 17 (high emissions scenario) to 21 inches (low emissions scenario) of annual precipitation by the year 2100. In 2000, the annual precipitation total was approximately 25 inches. Although there is potentially less rain as temperatures increase, global weather patterns will affect the frequency and intensity of storm events at the local level. For coastal cities like Carpinteria, storm surges, which are created by high winds and low pressures from "coastal storms [that] force water onto the shore," are expected every year (NRC, 2012, pg. 60). As air warms and brings more moisture inland, these storms can cause destruction in a single event with higher volumes of precipitation in a short timeframe. The City, however, is fortunate to have the Carpinteria Salt Marsh as an ecological feature that serves as a water retention area during high tides and storms. The concern

is that a major storm can overwhelm the estuary, preventing water from draining away from the Beach Neighborhood and resulting in flooding.

Figure 7: Precipitation Changes in Carpinteria (2010 – 2100). [State of California, 2012]

As noted above, this combination of sea-level rise and severe storm events can lead to increased flooding, particularly in the low-lying neighborhood bounded by Ash Avenue, Linden Avenue, and the railroad tracks. An estimated 200 residential structures are in flood plain areas designated by FEMA’s Flood Insurance Rate Maps. Based on City GIS data, the Beach Neighborhood has approximately 535 residential units (single-family, condominiums, and apartments) and an additional 81 mobile home units at Silver Sands Mobile Home Park (City of Carpinteria, 2013, author generated).

In the Beach Neighborhood, many older homes are built at grade, most likely constructed before the requirement of minimum two feet above base flood elevation became part of the zoning code. However, the City has allowed a minimum of only six inches for new development in the Beach Neighborhood to protect access to coastal views. Newer homes have been elevated

about two to six feet above grade as a precaution against flooding (City staff, personal communication, 2013). Drainage is constrained because of the flatness in the area. After previous storm events, homes had been flooded for extended periods because excess water cannot drain as readily as it would have if the area had a positive grade.

Another issue compounding flooding damage is backflow from stormwater infrastructure during these events. During storm surges and high tide, the salt marsh has less capacity to handle the excess water, which causes it to remain in the Beach Neighborhood until the tide falls and rains and runoff decrease. Therefore, upgrades to drainage and stormwater infrastructure are a crucial step for Carpinteria to build resilience to impacts. The City's Local Hazard Mitigation Plan has a thorough list of Carpinteria's critical assets and infrastructure.

Sector/Asset Sensitivity

Sensitivity is the degree that the system, or in this context, the community, would be impaired by the impacts of climate change if they were exposed those impacts. Systems that are greatly impaired by small changes in climate have a high sensitivity, while systems that are minimally affected by the same small change in climate have a low sensitivity (ICLEI-USA and San Diego Foundation, 2012, pg. 18).

The process for evaluating sector/asset sensitivity is similar to the process for hazard mitigation, which is the identification of the facilities, systems, and other community resources that might be affected.

Carpinteria's LHMP, an annex to the 2011 County of

Santa Barbara's Multi-Jurisdiction Hazard Mitigation Plan, is the major source for determining

Sensitivity: Sensitivity is the degree to which changes in climate conditions or impacts affect the built, natural, or human system, either adversely or beneficially (CNRA, 2009, pg. 141). The system is considered sensitive to climate change if it is likely to be affected by the projected climate change condition or impact (University of Washington and ICLEI-USA, 2007, pg. 68).

which community assets are at risk from natural hazards related to climate change. The following checklist (**Tables 5 and 6**) is adapted from the Adaptation Planning Guide, which organizes assets under three general categories of 1) essential functions, 2) structures, and 3) populations. Although the checklist for population-related assets is longer in the guide, only a few checklist items were relevant for Carpinteria due to the demographic makeup.

Lists of critical facilities varying by hazard are available in Carpinteria's LHMP, which is a valuable reference for identifying important facilities necessary for continued community function. For the major climate change impacts such as sea-level rise, flooding and inundation, or coastal erosion, the critical facilities do not lie in the study area in question. Regardless, the critical facilities list can inform City staff on potential asset sensitivity as floodplain and flood hazard maps become updated. More details about the degree of sensitive for select asset categories will be discussed in the Potential Impacts section.

Functions	Applicable?
Agriculture, Forest, and Fishery Productivity	
Business Continuity	
Ecological Function	X
Emergency Services	X
Emotional and Mental Health	
Employment and Job Access	
Energy Delivery	
Food Security	
Government Continuity	
Housing Access	X
Industrial Operations	
Mobility / Transportation Access	
Public Health	
Public Safety	X
Quality of Life	X
Recreation	X
Social Services	X
Tourism	X
Water/Sewer/Solid Waste	X

Table 5: Asset Sensitivity - Functions.
[Cal-EMA, 2012]

Structures	Applicable?
Residential	X
Mobile Homes	X
Commercial	
Industrial	
Government	
Institutional	
Parks and Open Space	X
Recreational Facilities	X
Transportation Facilities and Infrastructure	X
Marin Facilities	X
Communication Facilities	
Dikes and Levees	
Water Treatment Plant and Delivery Infrastructure	
Wastewater Treatment Plant and Delivery Infrastructure	X

Populations	Applicable?
Renters	X
Seasonal Residents	X
Homeowners	X

Table 6: Asset Sensitivity - Structures and Population. [Cal-EMA, 2012]

Potential Impacts

An assessment of potential impacts requires detailed input from City staff to estimate how climate change will affect the sensitivity categories identified in the previous section. The critical point of this step is to illustrate the temporal and spatial effects of sea-level rise on the functions, structures, and populations as well as the permanence and the extent to how the impact will interrupt community operations (Cal-EMA, 2012, pg. 25).

Economy, Tourism, and Recreation

The Carpinteria City Beach extends about a quarter mile long, from the Carpinteria Salt Marsh to Linden Avenue in the City's downtown corridor. The Carpinteria State Beach Park extends from Linden Avenue to Tar Pit Park for 0.82 miles. These beaches enhance the natural beauty as well as to contribute to the local identity and culture of this coastal town. Both of these beaches are popular with tourists, especially families, because of weak wave activity along this particular shoreline that makes it "safer" relative to other beaches. Tidelands and steep bluffs characterize the rest of the coastal territory belonging to Carpinteria (City of Carpinteria General Plan, 2003, pg. 105).

One primary concern with SLR is the elimination of the City's two beaches, Carpinteria City and Carpinteria State Beaches. The Carpinteria shoreline is about 13,450 feet (2.5 miles) long, with the City Beach and State Beach at 1,450 feet and 4,100 feet respectively. The City also manages another 7,900 feet of shoreline to the southeast. Due to the attractive beaches that draw people from the region, tourism is an integral part of the local economy. A recent economic study estimates that a 1.4 meter SLR can potentially result in up to \$10 million dollars in damages to beach structures and assets (King, 2011, pg. 64). Another study suggests that the economic value of Carpinteria's beaches is about \$30.7 million annually based on the number of

tourists and average spending on local businesses (King, 2001, pg. 4). With increasing SLR, the beaches could narrow to less than 50 feet, which is considered less than optimum for recreational visitors to Carpinteria (ACE, 2004, pg. 4.9). Due to tidal and seasonal fluctuations, the width of the City Beach is not constant, but is relatively stable (USGS, 2008, pg. 28). The summer/fall beach width at the City beach is within a range of 82 feet (25m) to 196 feet (60m) (pg. 26).

- Sensitivity: High
- Temporal: increased frequency in flooding events due to storm surge in near future
- Spatial: neighborhood south of the railroad between Ash and Linden Ave, mobile home community near Franklin Creek, structures in open space areas at Carpinteria City Beach and State Beach.

Housing and Property

Housing and property loss is a primary concern because of the close proximity of neighborhoods close to the shore. As shown above in the USGS sea-level rise maps, 50-year sea level rise will affect about 108 structures, and 100-year sea level rise will affect these 108 structures plus an addition of about 95 structures, including the mobile homes near Franklin Creek. However, these numbers represent only a portion of the structures that will be subjected to flooding. The updated FEMA floodplain map (February 2013) depicts larger areas that expand past the boundaries of areas that will be inundated as sea-level rises.

Sea-level rise along with a higher frequency of storm events can lead to an increased chance of flooding, particularly in the low-lying neighborhood bounded by Ash Avenue, Linden Avenue, and the railroad tracks (**Appendix C**). An estimated 200 residential structures, including about 95 structures at the Silver Sands Mobile Home Park near Franklin Creek are in flood plain areas designated by FEMA's Flood Insurance Rate Maps. This neighborhood has an average of

535 residential units (single-family, condominiums, and apartments) and an additional 81 mobile home units at Silver Sands (City of Carpinteria GIS, 2013).

As demonstrated by a recent home value estimate of about \$544,000 (Zillow, Overview 2012), Carpinteria's typical property values are slightly lower than nearby coastal regions of Santa Barbara County, like Montecito and Santa Barbara City. In the neighborhood south of the railroad between Ash and Linden Ave, approximately 108 buildings are at the most risk due to sea-level rise. However, this neighborhood in particular, is the closest residential area to the shoreline and property values can range from \$300,000 for a one bedroom condo to \$1 to 4 million single family homes right on Carpinteria City Beach. Single family homes in this neighborhood are generally valued between the high \$500,000 and mid-\$700,000.

Land costs are widely varied depending on the unique characteristics of the lot's location, views, and surrounding infrastructure. According to the City's *Housing Element* (2009-2014), infill lots within the city have asking prices about \$499,000 for 6,750 square feet while large vacant lots have been sold for \$350,000 to \$700,000 per acre (City of Carpinteria, 2011, Technical Appendix, Page C-2).

- Sensitivity: High
- Temporal: increased frequency in flooding events due to storm surge in near future
- Spatial: neighborhood south of the railroad between Ash and Linden Ave, mobile home community near Franklin Creek, structures in open space areas at Carpinteria City Beach and State Beach.

Ecological Function

The shoreline, which includes estuarine and marine environments, is a valuable part of Carpinteria's identity. The beach ecosystem is a buffer and acts as a water filtration system that protects water quality. At 230 acres, the Carpinteria Salt Marsh is an estuarine habitat that supports a variety of plant and animal species and is an important yet vulnerable part of flood control in the area. A number of entities, including the University of California, land trusts, and the City of Carpinteria, purchased more than 50% of the wetland to protect the salt marsh from further deterioration due to human activities nearby (University of California, 2012). Important species to consider include endangered birds like Light-Footed Clapper Rails and Belding's Savannah Sparrows and endangered plants like Salt Marsh Bird's Beak and other estuarine vegetation (University of California, 2012, para. 12).

The Draft Management Plan for the Carpinteria Salt Marsh Reserve notes that the Salt Marsh's hydrologic functions include "shoreline protection from major winter storms, storm runoff capacity during flooding, and protection of groundwater resources as a transition between saline and freshwater resources" (University of California, 2012, para. 10). In a 2012 workshop for Santa Barbara Ecosystems and Climate Change, local beaches and climate change was a topic of discussion. Potential impacts on ecological systems include habitat loss and fragmentation, loss of biodiversity, and reduced function such as wildlife support, nutrient cycling, and water filtration (Dugan, 2012, slide 12). The University of California Natural Reserve System periodically conducts research projects specifically for the Salt Marsh, which are cataloged here: <http://nrs.ucop.edu/grants/mathias/carpinteria.htm>. Future studies to determine the extent to which climate change will alter current ecological systems should be incorporated in the next iteration of the climate adaptation plan.

- Sensitivity: Medium
- Temporal: TBD
- Spatial: complete inundation of Salt Marsh (230 acres) during high tide and storm surges

Emergency Services

Carpinteria has developed the 2009 Emergency Operations Plan (EOP) that covers the overall organization for response and recovery during extreme disaster and emergency events. The plan describes the emergency responders' roles, the setup of an emergency operations center, and other logistics (County of Santa Barbara, 2012, pg. 10-12). The City has also emphasized emergency preparedness by disseminating information to the community through their "Don't Panic!" campaign, including a comprehensive disaster survival guide.

Carpinteria partners with other agencies for disaster services because it is a small city of only 13,000. For example, the City itself does not have a fire department, but it contracts with the Carpinteria-Summerland Fire Protection District, which has mutual aid agreements with the Ventura and Santa Barbara County Fire Departments (County of Santa Barbara, 2012, pg. 10-19). Flooding is featured in the EOP as the third major threat after earthquakes and hazardous materials incidents. The flooding assessment describes the potential land area vulnerable to flooding but does not include a general response schematic. Flooding due to a combination storm surges and high tide conditions is typical during the winter months in Carpinteria (City of Carpinteria EOP, 2009, pg. I-50). A response document specifically for flooding in low-lying neighborhoods can be helpful to inform responders about the protocol for evacuation, sandbag protection, and warning systems.

- Sensitivity: Medium (TBD)
- Temporal: increase in frequency of events needing emergency services in the near future

- Spatial: residential neighborhoods within flood plain

Critical Facilities and Infrastructure

The Carpinteria Valley Water District (CVWD) supplies water to Carpinteria through pipeline and storage facilities controlled by the district. The Carpinteria Valley Sanitation District handles wastewater treatment at their 6th Street facilities. The Coastal Act also requires Carpinteria to prevent depletion of groundwater supplies, which ensures water supplies. Sea-level rise, flooding from storm surges, and coastal erosion can potentially damage the water infrastructure (County of Santa Barbara, 2012, pg. 10-20). However, the City works with the Santa Barbara Flood Control District to prioritize pipelines, pumps, and other facilities slated for upgrades or fixes. According to the LHMP, which has an extensive list of facilities, few critical facilities are within the 100-year floodplain, but the recent revisions to the FIRM map in 2013 may alter the floodplain boundaries (County of Santa Barbara, 2012, pg. 10-43). The number of facilities that are vulnerable to flooding should be reevaluated in the next LHMP update.

- Sensitivity: Medium/High (TBD)
- Temporal: Increase in impacts to infrastructure in later future, but depends on current condition and maintenance of facilities
- Spatial: Pipelines in vulnerable areas as determined by flood maps

Adaptive Capacity

Adaptive capacity is the ability of a community asset to make adjustments or changes in response to climate impacts, in order to maintain its primary functions. This does not necessarily mean that the system must look the same as before the impact, but it should provide the same services and functions as it did before the impact occurred.

Sector/System	Current and Expected Stresses	Projected Impacts	Ability of City to Accommodate Projected Impacts	Adaptive Capacity
Economy (Tourism and Recreation)	- Narrowing beaches (expected)	- Diminished beach quality and area	- Cannot remove residents from coastal properties - Adjacent areas have been zoned open space or recreation, creating a buffer area	TBD
Housing and Property	- Flooding (current and expected)	- Property damage	- Annual berm to protect properties	TBD
Ecological Assets	- Inundation of marshland (expected)	- Reduced capacity to handle winter storm surges - Potential negative consequences on ecosystems	- Studies underway with other research entities to determine climate change implications	TBD
Stormwater Management and Infrastructure	- Combined sewer overflows during storm surge	- Inadequate drainage can lead to more flooding in low-lying areas	- Periodic checks of infrastructure integrity, but flatness of grade in beach neighborhoods is a challenge	TBD

Table 7: Example Table for Assessing Adaptive Capacity - Sector. [UWash & ICLEI, 2007, pg. 81]

A key consideration that needs thorough analysis is the jurisdiction’s adaptive capacity. This critical step evaluates the community’s current ability to adapt to projected impacts. For example, an audit of local policies and a table organizing the severity of the impact (e.g. loss of snowpack) with the community’s adaptive capacity (e.g. secured water source) can reveal some of the strengths in addition to gaps that the city must address to ensure resilience in their community in restoring critical functions after a disastrous event. The evaluation of **adaptive capacity** can also be described in terms of the City’s regulatory and planning capabilities, administrative and technical capabilities, fiscal capacity, and infrastructure (Russell et al, 2012, pg. 30). Below is an example summary of the City of Carpinteria’s adaptive capacity:

Regulatory & Planning	<ul style="list-style-type: none"> • Ordinance (No. 658) – Modification of Chapters 14.40 and 15.50 of Municipal Code Pertaining to Flood Damage Protection • Zoning Code, Chapter 14.40 - Flood Hazard Overlay District • Buildings and Construction Code, 15.50 – Flood Damage Protection • Stormwater Management Plan (2010) • Emergency Operations Plan (2009) • Hazard Mitigation Plan – SB County Plan Annex (2012) • General Plan Safety Element (2003)
Administrative & Technical	<ul style="list-style-type: none"> • Staff: Community Development Director, Assistant Planner, Public Works Director, Parks and Recreation Director, Emergency Services Director • Digital Flood Insurance Rate Map (Feb 2013) • Google Earth Data Sets
Fiscal Capacity	<ul style="list-style-type: none"> • To Be Determined • Staff Time • Application NOAA National Sea Grant
Infrastructure & Systems	<ul style="list-style-type: none"> • Flood detention basins and Bank protection structures (SWMP, 2010, pg. 24) • Cooperation with Flood Control District for periodic upgrades • Annual beach berm construction

Table 8: Example Table for Assessing Adaptive Capacity- City Tools

Current Program for Property Protection

Beach Berm

Significant erosion and storm damage over the last decade has become an observable concern, so several studies have been conducted to better understand the current condition of the beaches in Carpinteria. A *U.S. Geological Survey Coastal Processes Study* from 2005 – 2007 finds that Carpinteria's beach volumes have declined because of the Santa Barbara Harbor, which was built in 1929. The harbor affected the wave patterns along the shore and caused erosion on downward beaches (USGS, 2008, pg. 25). While beach widths have stayed within a range of 25 and 60 meters without a single event to explain the occurrences of variability, the narrowing of beaches will be a future problem related to sea-level rise (USGS, 2008, pg. 26).

The City of Carpinteria's current program for residential property protection in the Beach Neighborhood is an example of an ongoing adaptation strategy that supports the City's adaptive capacity to minimize impacts. For the last ten years, the City has relied on a sand berm to mitigate the impact of winter storms and subsequent flooding in the low-lying neighborhoods near the beaches. The City of Carpinteria has a permit approved by the Coastal Commission and the Army Corps of Engineers (ACE) to build a 1,500 foot long berm along the back of the City Beach from Ash Avenue to Linden Avenue. Every year, a crew from public works department removes sand from other parts of the beach and accumulates the sand until the berm is about six feet tall. Construction of the berm begins in November and is taken down in April as the winter storms abate and the beach tourism season begins. Under the management of the Parks and Recreation Department, the berm permit is valid until 2015, with renewal of the permit every 5 years. Property fees collected from neighborhoods in the impacted areas fund the berm construction at the cost of \$30,000 annually (BEACON, 2008).

Although the sand berm has been the City's default solution to minimize the impact of winter storms in the adjacent neighborhoods, it is still considered a short-term answer to a problem that will become progressively worse with climate change. Since Carpinteria's economy relies on beach tourism, a particular type of sand is needed to maintain the quality the local beaches. The preferred course of action for constructing the berm is to use local sand that is already there. With the gradual narrowing of beaches as sea-level rise occurs, there will be less sand available to build the berm. If there are fewer storms because of drier climate conditions on the coast, the berms can be an adequate tool to protect the properties. With sea-level rise and global climate change, it is still uncertain if the sand berms are a long-term fix to the problem.

Figure 8: Constructing the beach berm along Carpinteria City Beach. [Google Images, 2012].

In light of these circumstances, the City is also pursuing long-term solutions to protect homes and build resilience to future storm surges that can overtop berms. While the berm construction is affordable for now, costs may increase over time, particularly if there is a decline in available sand to build the berm. Thus, the Parks and Recreation Department is considering a beach nourishment program. Beach nourishment requires the import of sand from other places to maintain the quality and width of the beach. However, to retrieve the specific kind of sand suited for Carpinteria's beaches will most likely be very costly unless the City settles for a lower sand quality to reduce costs. The sand berm is a temporary, low-cost solution to mitigate yearly storms and flooding, but sea-level rise can reduce the amount of sand available locally to build the berm year to year. Therefore, long-term adaptation strategies to protect the beaches but also increase the **adaptive capacity**, or the ability of built, natural, and human systems to accommodate climate change impacts with minimal disruption or cost, of these neighborhoods will be critical as climate change becomes a more serious and profound issue (ICLEI, 2007b, pg. 78).

Adaptive Capacity: The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007b).

Risk and Impact Assessment

Risk and onset is listed as the last step in the *Adaptation Planning Guide*, but the evaluation will most likely happen concurrently with the discussion of impacts

Risk: The likelihood or probability that a certain magnitude/extent/scale of potential impact will occur (Cal-EMA, 2012, pg. 29).

and local capacity (Cal-EMA, 2012, pg. 29). This component addressing the probability of the extent and scale of the potential impact is one the more challenging parts of the vulnerability assessment because of the inherent uncertainty associated with this work and the pressure from the community to provide substantial evidence that climate change is occurring. Therefore, it is crucial to emphasize that despite the degree of uncertainty, the community could still benefit from preemptive planning that safeguards local assets and the livelihood of the people who live there.

Several guidance documents have recommended the use of matrices that compare two categories (e.g. potential impact vs. adaptive capacity) to determine their relative ranking (low, medium, high) to each other. When data is scarce or uncertain, the matrix can assist with the organization and balance of priorities and next steps. The exact parameters of low, medium, and high vary depending on the two categories being compared, so matrices should be read carefully. In essence, these matrices serve as visual aids that aggregate seemingly disparate priorities and produce a picture that can pinpoint a direction for the City to take. For example, if an impact is rated as highly significant and the City has limited adaptive capacity to deal with the impact, the matrix's gradation system that can highlight that this particular impact should be given attention in the prioritization process.

- **Risk** = Probability of Impact Occurring x Magnitude of Consequence (Russell et al., 2012, pg. 31)
- **Adaptation Need** = Potential Impact x Adaptive Capacity (Cal-EMA, 2012, pg. 32)
- **Time-Frame** = Impact Onset x Ease of Implementing Strategy (financial and/or political constraints) (Cal-EMA, 2012, pg. 33)
- **Prioritization** = Impact x Risk/Uncertainty (Cal-EMA, 2012, pg. 37)

RISK		Probability/Likelihood of Occurrence		
		High	Moderate	Low
Magnitude of Consequence	High	Inundation of Beach Neighborhood	Narrowing of Beaches	
	Moderate	Flooding in Beach Neighborhood	Inundation of Carpinteria Marsh	
	Low			

Figure 9: Example Matrix for Assessing Risk

The proposed matrix design(**Figure 9**), adapted from examples found in *Adapting to Sea Level Rise: A Guide for California's Coastal Communities* and *Local Climate Action Planning*, is a model that the City can use to as a starting point when assessing the risk and onset of impacts. This is intended to be a hypothetical evaluation until the climate adaptation team can work together with more data and information and reach consensus on the risk. As a example,

after evaluating the different climate change impacts and their consequences, flooding in the Beach Neighborhood has been determined to have a high probability with significant detrimental impacts on the community. In contrast, the narrowing of beaches is a concern, but current land use and zoning regulations has limited development along the shoreline that would allow for beaches to move landward as sea level rises. Examples can be found in the following documents and print publications:

- City of Santa Barbara. (2012). *Sea-Level Rise Vulnerability Study*
- Cal EMA and California Natural Resources Agency. (2012). *California Adaptation Planning Guide: Planning for Adaptive Communities*.
- University of Santa Cruz. (2012). *Adapting to Sea Level Rise: A Guide for California's Coastal Communities*.
- Boswell, M.R., Greve, A.I., and Seale, T.L. (2012). *Local Climate Action Planning*. Pg. 176.

CHAPTER 3: ADAPTATION STRATEGY PROGRAM

Since climate change is a global problem but with local implications, implementation strategies must be appropriate for the community. The establishment of an adaptation planning working group is an essential part of not only detailed impact assessment, but also strategy building. Collaboration between community stakeholders and City staff can support and inform the prioritization of action steps that are feasible and cost-effective.

During the public outreach process, feedback from community members can assist with climate adaptation efforts. For example, the effectiveness of a particular strategy can be determined by ranking criteria such as cost, staff time, and time frame of implementation. A policy matrix can depict the strategy's relative benefits and weaknesses compared to other strategies. The climate adaptation working group should also consider impacts that will have a quick onset or have devastating consequences regardless of time frame, cost or difficulty. These impacts should be determined with community feedback. However, these time frames below can help organize the multi-pronged effort needed to launch a climate adaptation initiative as an initial step. Each strategy should be adjusted to reflect actual time commitments, but this preliminary categorization can help whittle down a daunting list of strategies.

- Near-Term Strategies (1 – 2 years): Strategies that should be initiated first because of coinciding priorities for the City. Strategies feasible within a short period of time and ongoing efforts are also included in this category.
- Mid-Term Strategies (3 – 4 years): Strategies that will require more than two years because of project scale but are still feasible with staff time

- Long-Term Strategies (5 years): Large scope of tasks that will require community outreach and time investment for implementation

The framework for this climate adaptation strategy program is a hybrid of different approaches proposed by agencies and research entities. The potential action items, organized under major categories, represent strategies that the City can undertake. A robust adaptation strategy program is built upon the findings from the vulnerability assessment. A strategy program will assist the City of Carpinteria in prioritizing and planning for climate change by presenting an array of options with the relative advantages and disadvantages of each. Hard shoreline protection devices, like seawalls and other types of armoring, are not included as strategies because it is prohibited per the Local Coastal Plan. (City of Carpinteria, 2003, pg.158) because of adverse effects related to sand drift in littoral zones.

The following list of strategies are options that the City of Carpinteria can pursue. The categories of *Land Use Planning & Regulation*, *Design & Engineering*, and *Community Engagement* is a proposed organizational framework that describes potential City action, which places greater emphasis on the City's role at this juncture of the climate adaptation effort. Guidance documents also suggest organizing strategies to focus on a particular impact. With more detail and feedback from a climate adaptation team, the strategies can then be grouped by the degree to which the strategy addresses a specific exposure (e.g. sea-level rise, flooding, storm surge, etc.) or by sector (e.g. tourism, housing and property, etc.) if appropriate.

Land Use Planning & Regulation

	Strategy	Time Frame
Comprehensive Planning	Acknowledge SLR concerns in General Plan Update	Long
	Ensure adaptation plan is consistent with hazard mitigation and local coastal program	Mid
Zoning	Amend zoning ordinance for areas that are vulnerable to impacts (e.g. requirements for base flood elevation in beach neighborhoods)	Near
	Impose regulations that could prohibit or limit expansion of rebuilding damaged structures	Long
	Modify shoreline overlay zones for protection, accommodation, retreat, and preservation	Mid
	Adjust setback and buffer distances from shore according to SLR projections	Mid
Floodplain Regulations	Update coastal policies with latest FEMA floodplain map (February 2013)	Near
	Provide guidance for elevating homes above the floodplain (e.g. minimize habitation on ground level)	Near
Conditional Development	Set up program for conditions to rebuild, which involve mitigation measures for SLR	Mid
	Establish requirements for building construction in vulnerable areas	Mid
	Require impact fees for emergency response costs	Mid
	Require structures in 100-year flood plain to be elevated or strengthened	Long

Table 9: Land Use Planning & Regulation Strategies

Design & Engineering

	Strategy	
Infrastructure	Upgrade stormwater infrastructure (e.g. drainage in beach neighborhoods to prevent combined sewer overflows)	
	Relocate or replace critical sewer lines and pumping stations	
	Site future municipal buildings in areas not impacted by SLR	
Resilient Design	Collaborate with green building experts to develop framework for resilient design (low-impact development)	Mid
	Encourage property owners through incentives to retain natural features that serve beneficial functions such as wetlands that prevent runoff and flooding	Near
	Implement appropriate low-impact development (retention basins, swales, etc.)	Mid
Coastal Management	Research shoreline protection methods to develop contingency plans (beach nourishment, retreat, etc.	Mid
	Continue efforts to maintain health of wetlands	Near
	Continue beach berm program every winter	Near
	Initiate restoration of dune habitats to maintain beach	Mid

Table 10: Design & Engineering Strategies

Community Engagement

	Strategy	Time Frame
Initial Organization	Form Climate Adaptation Team with key personnel from City Departments and community groups	Near
	Revise and build upon draft Climate Adaptation Plan	Mid
	Secure grants to support climate efforts	Near
	Allocate revenue from coastal property fees for staff time or consultant on climate adaptation	Mid
Emergency Management	Consult with Emergency Services Coordinator for development of community evacuation plans	Near
Public Outreach	Hold community workshops on climate adaptation and SLR to present case and to receive feedback	Mid
	Provide best management guides for property owners to address SLR	Long
	Increase awareness of SLR through signage and marketing (e.g. advertise that properties are at risk from increased SLR)	Mid

Table 11: Community Engagement Strategies

Next Steps for the City of Carpinteria

Since this administrative draft did not include any community feedback, the next major step for the City of Carpinteria is to build a climate adaptation working group and to conduct a public outreach campaign. With the right people at the table, the adaptation group can build upon the preliminary research and background in this draft. Below are next steps for the City to consider for the next phase of this project.

Preliminary Steps:

- 1) Conduct kick-off public meeting to introduce climate adaptation to community
- 2) Garner support from relevant city departments and commissions.
- 3) Determine budget costs and staff time devoted to the project.
- 4) Research potential grant opportunities and collaboration with universities.
- 5) Pass an administrative order from City Council in support of climate adaptation plan.

Core Development:

- 1) Create climate adaptation team consisting of city staff and community stakeholders.
 - Discuss climate adaptation and implications of SLR for Carpinteria
 - Ask individual team members to review relevant documents pertaining to their field of expertise.
- 2) Review administrative draft adaptation plan and confirm potential impacts for Carpinteria.
- 3) Develop strategic goals and objectives (e.g. building resilience) for climate adaptation.
 - Set preferable outcomes because of SLR adaptation strategy implementation
- 4) Review relevant planning documents (General Plan, LHMP, etc.) for current adaptation policies briefly and confirm/modify assertions made in administrative draft.

5) Confirm planning horizon (2050) and scenarios (7 inch SLR by 2050).

6) Continue evaluation of impact risk and onset as data becomes available.

7) Develop presentation for public outreach. Possible questions:

- What is climate adaptation and why should we do this?

Trend towards local initiatives to deal with a changing climate.

- What are the benefits of climate adaptation?

Save money in the long run, safeguards critical assets

- How will the City pay for this?

Minimize costs as much as possible, adaptation strategies should be done in concert with other policy items.

GLOSSARY

100-year flood: The United States government uses the 1-percent annual exceedance probability (AEP) flood as the basis for the National Flood Insurance Program. Because the 1-percent AEP flood has a 1 in 100 chance of being equaled or exceeded in any 1 year, and it has an average recurrence interval of 100 years, it often is referred to as the “100-year flood” (USGS 2010).

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC (b), 2007).

Adaptive Capacity: The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences (IPCC, 2007b).

Exposure: Exposure is the determination of whether community assets will experience a specific changing climate condition (ICLEI-USA, 2012, pg. 18). Direct climate changes include altered average temperature and annual precipitation regimes, and sea-level rise.

Resilience: The ability of a social or ecological system to absorb disturbances such as extreme events to retain its basic structure and ways of functioning (IPCC (c), 2007). Resilience does not guarantee that a system will return to the previous state before an extreme event. A resilient system can bounce back and recover, and will transform itself, if necessary, to provide essential services that it has evolved or designed to provide (CNRA, 2009, pg. 141).

Risk: The likelihood or probability that a certain magnitude/extent/scale of potential impact will occur (Cal-EMA, 2012, pg. 29).

Sensitivity: Sensitivity is the degree to which changes in climate conditions or impacts affect the built, natural, or human system, either adversely or beneficially (CNRA, 2009, pg. 141). For example, an increase in temperature with more frequent heat advisory days will impact a community with a large elderly population (high sensitivity) to a great extent than an area that is sparsely populated (low sensitivity). The system is considered sensitive to climate change if it is likely to be affected by the projected climate change condition or impact (University of Washington & ICLEI-USA, 2007, pg. 68).

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APPENDICES

A. Cal-Adapt Maps: Data Source (Pacific Institute)

The Pacific Institute and the U.S. Geological Survey (USGS) provided the data sets used for sea-level rise projections on Cal-Adapt. The data for Carpinteria is from Pacific Institute Coastal Data studies. The data set includes current 100-year flood areas for the baseline year of 2000 compared to estimates of 100-year flood areas under a 55-inch sea-level rise scenario.

Figure 10: Sea-Level Rise Risk for Carpinteria. [Pacific Institute, 2009]

B. USGS Flood Area Map with Sea-Level Rise

(Baseline 2010 and 50- and 100-year SLR)

The Flood Hazard Scenario created by USGS shows the areas vulnerable to flooding with January 2010 as the base year and estimates of sea level rise for 50 and 100 years. This data has not been publicly released and is included here for a general estimate of threatened areas. The author of this administrative draft selected the building footprints of structures in the shaded areas of the USGS map using overlays with Carpinteria's GIS files to generate **Figures 11 and 12**. These properties lie in the yellow and red-shaded areas of the draft Flood Hazard Scenario map. This map below (**Figure 11**) focuses on the residential properties identified by the City to be most at risk from sea-level rise as well as coastal storm surges that can potentially flood neighborhoods.

Two related documents can elucidate the type of data analysis required to create these maps because the same authors created the map in Figure 11.

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[<http://pubs.usgs.gov/of/2009/1073/>].
- Barnard, P.L., and Hoover, D., 2010, A seamless, high-resolution coastal digital elevation model (DEM) for southern California. U.S. Geological Survey Data Series 487, 8 p. and database

Figure 11: Flood Hazard with SLR Map, City of Carpinteria. [USGS, 2010] - INTERNAL USE ONLY

Figure 12: Areas at risk with 50 years of SLR (from baseline 2010). 108 buildings in yellow. [USGS, 2011] - INTERNAL USE ONLY

Figure 13: Areas at risk with 100 years of SLR (from baseline 2010). 57 buildings in red. [USGS, 2011] - INTERNAL USE ONLY