CITY OF CARMEL-BY-THE-SEA
CLIMATE COMMITTEE

Contact: 831.620.2000 www.ci.carmel.ca.us/carmel

All meetings are held in the City Council Chambers
East Side of Monte Verde Street
Between Ocean and 7th Avenues

REGULAR MEETING
Thursday, November 16, 2023

3:30 PM

This meeting will be held in person and via teleconference ("hybrid"). The public is welcome to attend the meeting in person or remotely via Zoom, however, the meeting will proceed as normal even if there are technical difficulties accessing Zoom. The City will do its best to resolve any technical issues as quickly as possible. To view or listen to the meeting from home, you may also watch the live stream on the City's YouTube page at: https://www.youtube.com/@CityofCarmelbytheSea/streams. To participate in the meeting via Zoom, copy and paste the link below into your browser:

https://ci-carmel-ca-us.zoom.us/j/81498010625 Webinar ID: 814 9801 0625 Passcode: 518074 Dial in: (253) 215-8782

The public may give public comment at this meeting in person, or using the Zoom teleconference module, provided that there is access to Zoom during the meeting. Zoom comments will be taken after the in-person comments. The public can also email comments to yculver@ci.carmel.ca.us. Comments must be received at least 2 hours before the meeting in order to be provided to the committee members. Comments received after that time and up to the beginning of the meeting will be made part of the record.

CALL TO ORDER AND ROLL CALL

PUBLIC APPEARANCES

Members of the public are entitled to speak on matters of municipal concern not on the agenda during Public Appearances. Each person's comments shall be limited to 3 minutes, or as otherwise established by the Chair. Matters not appearing on the agenda will not receive action at this meeting and may be referred to staff. Persons are not required to provide their names, and it is helpful for speakers to state their names so they may be identified in the minutes of the meeting.

ANNOUNCEMENTS

ORDERS OF BUSINESS

Orders of Business are agenda items that require Committee discussion, debate, direction to staff, and/or action.

1. Receive a presentation from Integral Corp./Haro Kasunich & Associates/EMC Planning Group regarding the results of the Coastal Engineering Condition Evaluation, Task 1, and Shoreline and Beach Change Analysis, Task 2, which is part of the Coastal Engineering Study
2. Review list of Adaptation Strategies for Climate Action and Adaptation Plans and Provide Feedback for Monitoring the Implementation of the Plans

FUTURE AGENDA ITEMS

ADJOURNMENT

This agenda was posted at City Hall, Monte Verde Street between Ocean Avenue and 7th Avenue, Harrison Memorial Library, located on the NE corner of Ocean Avenue and Lincoln Street, the Carmel-by-the-Sea Post Office, 5th Avenue between Dolores Street and San Carlos Street, and the City's webpage http://www.ci.carmel.ca.us in accordance with applicable legal requirements.

SUPPLEMENTAL MATERIAL RECEIVED AFTER THE POSTING OF THE AGENDA

Any supplemental writings or documents distributed to a majority of the Climate Committee regarding any item on this agenda, received after the posting of the agenda will be available at the Public Works Department located on the east side of Junipero Street between Fourth and Fifth Avenues during normal business hours.

SPECIAL NOTICES TO PUBLIC

In compliance with the Americans with Disabilities Act, if you need special assistance to participate in this meeting, please contact the City Clerk's Office at 831-620-2000 at least 48 hours prior to the meeting to ensure that reasonable arrangements can be made to provide accessibility to the meeting (28CFR 35.102-35.104 ADA Title II).

CITY OF CARMEL-BY-THE-SEA
Climate Committee
Staff Report

November 16, 2023
ORDERS OF BUSINESS

TO:	Climate Committee Members
SUBMITTED BY:	Mary Bilse, Environmental Programs Manager
SUBJECT:	Receive a presentation from Integral Corp./Haro Kasunich & Associates/EMC Planning Group regarding the results of the Coastal Engineering Condition Evaluation, Task 1, and Shoreline and Beach Change Analysis, Task 2, which is part of the Coastal Engineering Study

RECOMMENDATION:

Receive a presentation from Integral Corp./Haro Kasunich & Associates/EMC regarding the results of the Coastal Engineering Condition Evaluation, Task 1, and Shoreline and Beach Change Analysis, Task 2, which is part of the Coastal Engineering Study.

BACKGROUND/SUMMARY:

At their August 2, 2022 meeting, the City Council adopted the City of Carmel-by-the-Sea's Climate Adaptation Plan and Climate Action Plan under Resolution 2022-064. Council commented that implementation of these Plans is imperative and requested the Climate Committee to continue to oversee the implementation of certain projects, including the Coastal Engineering Study.

At the November 2022 meeting, the City Council adopted Resolution 2022-094 awarding a Professional Services Agreement with EMC Planning Group, for a not-to-exceed fee of $175,000, to conduct the Coastal Engineering Study and Adaptation Planning Project. Key subconsultants for this study are Integral Corporation and Haro Kasunich & Associates.

To develop the project's scope of work, the Consultant team reviewed the 2001 Coastal Development Permit for Scenic Road Armoring Repairs, 2003 Shoreline Management Plan (Shonman and D'Ambrosio), 2016 Carmel Shoreline Assessment Update, 2016 Assessments of Shoreline Improvements at Carmel Beach (Easton Geology), and the City's 2022 Climate Adaptation and Climate Action Plans.

The Study will be completed in two phases, Phase 1 is funded in the current Capital Improvement Plan (CIP), while Phase 2 has recently been approved for funding by a non-competitive California Coastal Commission grant of $500,000. Phase 2 will include Hazard Policy review and revisions, public outreach, and adaptation pathway development. The results of Phase 2 will be brought back to the Climate Committee in the future.

At today's Climate Committee meeting, Matt Jamieson, Project Scientist, from Integral Corp will present their key findings of Phase 1, Task 1, Coastal Engineering Condition Evaluation **(Attachment #1)** and the Phase I Task 2, Carmel Climate Change Vulnerability Assessment and the Shoreline and Beach Change Analysis: Seasonal and Long Term **(Attachment #2)** to the Committee and the public. Previously, the consultant team presented their findings to the Forest and Beach Commission at the March 2023 and the August 2023 meetings. Below is a brief summary of the key tasks and associated deliverables for Phase 1:

Phase 1 – Coastal Engineering and Hazard Assessment

Task 1 – Coastal Engineering Condition Evaluation

The following table summarizes the key issues of the Condition Assessment.

Coastal Infrastructure	Total Number	In Need of Repair	High Priority Repairs
Seawalls	11	2-4	1
Beach Access Stairs	11	9	3
Revetments	6	4	3

Task 2 - Shoreline and Beach Change Analysis – Long Term and Seasonal

This study determined the seasonal and historical trends of shoreline position and beach sand widths using historic reports and imagery data dating back to the 1940s.

Long Term

- The sand affecting Carmel Beach extends beyond the City limits north to include Pebble Beach along the 10th golf course hole.
- Overall, the long-term shoreline position and beach widths have been relatively stable. This indicates a relatively stable amount of sand in the sandy beach compartment.
- On average, the beach widths were narrower south of Eighth Avenue, wider at Pebble Beach, and the widest in the dune-backed areas near the Del Mar parking lot.

Seasonal

- The beach widths change seasonally, where the narrowest beach widths occur in the spring (after winter storm waves), and the widest beach widths occur in the fall (after small summer waves).
- The highest range in beach widths occurs south of Eighth Avenue and near Pescadero Creek (around the offshore rock).
- The beach width was most stable in the dune-backed areas near the Del Mar parking lot.

Storm Impacts and Recovery

- During strong west swells (often in El Niño years), when beach erosion is highest, most of the sand is moved offshore, exposing bedrock under the sand in some areas.
- The highest observed cliff erosion was between 20-40 feet and was observed following the 1982-1983 El Niño.
- Recovery after large storm events occur can take a few years, and the area south of 8th Avenue usually takes the longest.

The additional Phase 1 tasks include:

Task 3 – Shoreline and Beach Erosion Exposure Modeling

Deliverables: Technical memo of methods and maps showing results of the projected existing and future coastal hazard extents, and one public presentation.

Task 4 – Coastal Hazard and Sea Level Rise Vulnerability Assessment
Deliverables: Executive summary of results, up to five sector profile summaries (land use, transportation, utilities, etc.), and one public presentation.

Task 5 – Policy Review
Deliverables: Consultants prepared a memo summarizing the City's existing coastal hazard policies that will lead into an Action Plan for Revised Hazards Policies to be prepared in Phase 2.

The results of Task 2 will lead into Task 3, Shoreline and Beach Erosion Modeling where Integral will conduct Coastal Hazard Exposure modeling. In Winter of 2023/2024, the consultants will also provide input on the effect of erosion by existing armoring (revetments, seawalls) and what happens when the structures fail or are removed.
In Task 4, the consultants will conduct a vulnerability assessment and summarize the results by hazard type, sea level rise, coastal bluff and roadway impacts. The report will state whether an impact is anticipated in the near-term or long term.
The results of Tasks 3, 4, and 5 will be brought back to the Climate Committee for discussion in the near future.

FISCAL IMPACT:

No direct fiscal impact for this presentation. In November 2022, the City Council awarded a Professional Services Agreement to EMC/Integral/Haro Kasunich, for a not-to-exceed fee of $175,000, for the first phase of the Coastal Engineering Study, a Capital Improvement Project.

Phase 2 of the Coastal Engineering Study has recently been approved for funding by a non-competitive California Coastal Commission grant of $500,000.

ATTACHMENTS:

Attachment #1 - Coastal Protection Evaluation Memorandum
Attachment #2 - Shoreline and Beach Change Analysis - Long Term and Seasonal

HARO, KASUNICH AND ASSOCIATES, INC.

CONSULTING GEOTECHNICAL & COASTAL ENGINEERS

Date: 27 April 2023
Client: City of Carmel
Subject: Carmel Beach Coastal Protection Assessment
Reference: Carmel Beach Adaptation Plan
Project No.: 12176

CARMEL BEACH COASTAL PROTECTION ASSESSMENT REPORT

EXECUTIVE SUMMARY

Previous evaluations of coastal protection structures have focused on maintenance and repair. For this evaluation HKA inventoried the length, footprint and other factors. Using engineering judgment HKA determined the effectiveness of restacking rip rap revetment structures and lateral/vertical extensions of both revetments and vertical seawalls. HKA estimated the existing life of structure until it ceases to adequately provide protection for the bluff and roadway. HKA provided this written condition and assessment report and tabular inventory.

In December 2022 through February 2023 Haro Kasunich and Associates Inc. evaluated the condition of the coastal protection structures and stairways that were visible at Carmel Beach. Fortunately, severe winter storms and ocean wave runup scoured portions of the beach in early 2023, temporarily removing beach sand that covered the lower portions of some coastal protection structures, allowing them to be inspected. These structures consisted of 8 publicly owned seawalls, 6 publicly owned revetments and 11 publicly owned stairways were inspected. Two privately owned seawalls (S1 and S11), one at each end of the beach were viewed fom the beach but not inspected in detail. One coastal access path retaining wall that is not subject to wave runup or wave impact was viewed but not evaluated. It total we inspected 5537 lineal feet of coastline, which contained 4119 lineal feet of coastal armoring.

The Appendices in this report include a Coastal Protection Datasheet (in Appendix A) listing and detailing numerous characteristics of the coastal protection structures we evaluated; as well as a Coastal Protection Map (in Appendix B) locating and labeling the coastal protection structures we evaluated. Vertical seawalls are labeled with S, sloping revetments are labeled with R and stairways are labeled with ST. Our evaluation began at the Frank Lloyd Wright home at the south (downcoast) end of Carmel Beach and ended at Pescadero Creek at the north (upcoast) end of

Carmel beach.

All but one of the publicly owned seawalls are presently providing adequate protection. One seawall is in need of replacement (S10; at the Dunes Outfall); potential collapse of this structure poses a risk to beach users. We recommend this seawall have a high priority for replacement; a detailed set of plans and specifications will be required for that work. One spot on another seawall at a failed storm drain outlet needs repair (S7; by 10th Avenue), which we rank as a medium priority. There was an area of exposed concrete grout on the beach seaward of S3; by 13th Avenue; this poses a hazard to barefoot beach users. In our opinion most of the seawalls have at least 30 years of remaining useful life, with the exception of seawall S10 at the Dunes Outfall, which could fail anytime in the next 10 years.

Of the 6 rip-rap revetments, only 4 could be assessed because the other two (R5 and R6) were buried by beach and dune sand. All four of those revetments need repair, with 3 of them found to be high priority and 1 to be medium priority. None of the 4 are providing adequate protection along their full lengths. The anticipated repairs at 3 of the revetments (The north 1/3 of R1, the south 1/4 of R3, and the north 1/3 of R4) consist of restacking the quarrystone rip-rap boulders; a detailed set of plans and specifications will be required for that work. The north 1/3 of one of the revetments (R1; by Santa Lucia Avenue) is oversteepened and potentially unstable, posing a safety risk to beach users. Revetment R2 (in Cooks Cove between 12th and 13th Avenue) is composed of undersized quarrystone and is failing. The south 1/4 of Revetment R3 (between 11th Avenue and 12th Avenue) is poorly stacked had has evidence of instability. The north 1/3 Of Revetment R4 consists of very undersized rock that provides little coastal protection. We recommend the two revetments that were buried by beach and dune sand be inspected and evaluated whenever they are next exposed.

Of the 11 stairways we inspected, we found that 9 are in need of repair. We found that 4 have high priority for repair; 4 have medium priority for repair; and 3 have low priority for repair. Three have bent or broken or missing guards and/or handrails. Two were undermined and had vertical drop-offs from the lowest stair tread to the beach as a result of natural beach scour. Three terminate at an elevation before they reach the beach, requiring beach users to traverse slippery irregular rip-rap or bedrock surfaces to traverse the remaining distance to the beach. Two have worn and irregular tread surfaces. Three appear to have substantial corrosion of hardware and reinforcing bar. Further evaluation of the structure by an independent licensed structural engineer

(and if need be a licensed corrosion engineer) should be scheduled to verify the structure is safe for public use. Regular maintenance of all stairways is essential for pedestrian safety. Of the 11 stairways inspected, we found that 3 pose risks to stairway users during periods (seasons) of beach scour, 5 will pose risks to stairway users until they are repaired, and 1 is unknown until a structural and corrosion inspection is completed, which we recommend be a high priority.

Table 1 is a condensed version of Appendix A, containing selected data and findings concerning the coastal protection structures and stairways that Haro Kasunich and Associates Inc. evaluated.

TABLE 1 City of Carmel Coastal Protection Data

4/21/2023 Haro Kasunich and Associates, Inc.

Structure Identifier	Approximate Location	Adequate Protection?	Repair Needed?	Risk to Beach Users	Priority of Repair	Estimated Existing Life of Structure Until it Ceases to Protect Coastal Access Path, Stairs and Roadway (Yrs)	Notes
Seawalls							
S1	At FLW House	YES	UNKNOWN	NO	NA	30+?	Private Property, Upcoast Corner Will Need Maintenance at Some Future Point
S2	FLW Home to Santa Lucia Avenue	YES	NO	NO	VERY LOW	30+	Good Condition, Slight Undermining Noted in Two Spots
S3	13th Avenue	YES	NO	YES	VERY LOW (Upcoast) LOW (Downcoast)	Upcoast Part = 50 Downcoast Part = 20+	In Cove, Sloppy Pumped Concrete on Beach, Downcoast Part is Subject to Slow Undermining
S4	N of 13th Avenue	YES	NO	NO	VERY LOW	Most =30+	Mostly Good Condition; Founded on Bedrock Platform
S5	Outfall at 12th Avenue	YES	NO	NO	VERY LOW	30+	Good Condition, Monitor Annually
S6	Scenic Rd Retaining Wall	YES	NO	NO	NA	Not a Coastal Protection Structure	Short Coastal Path Wall Not Subject to Wave Impact
S7	Between Stairways 6 and 7	YES	YES	NO	MEDIUM	30	Wall Crack Below Failed Metal 16 " Dia Storm Drain Pipe Thru Seawall; Pipe Replacement Needed
S8	Retaining Wall at 8th Ave	YES	NO	NO	VERY LOW	30+	Blufftop Retaining Wall Around Pump Station
S9	Outfall at 8th Ave	YES	NO	NO	VERY LOW	20	CMP Storm Drain Headwall ; 60 LF Scattered Rip-rap Below; Rip-rap Foundation Condition Uncertain
S10	Dunes Outfall	NO	YES	YES	HIGH	0 to 10 Until Collapse	Failing/Failed 3'x3' Box Culvert Storm Drain Outfall Wall; Needs Replacement
S11	At Pescadero Creek Home	YES	UNKNOWN	NO	NA	30?	Private Property; Not Evaluated, No Obvious Need for Repairs is Evident

TABLE 1 City of Carmel Coastal Protection Data

4/21/2023 Haro Kasunich and Associates, Inc.

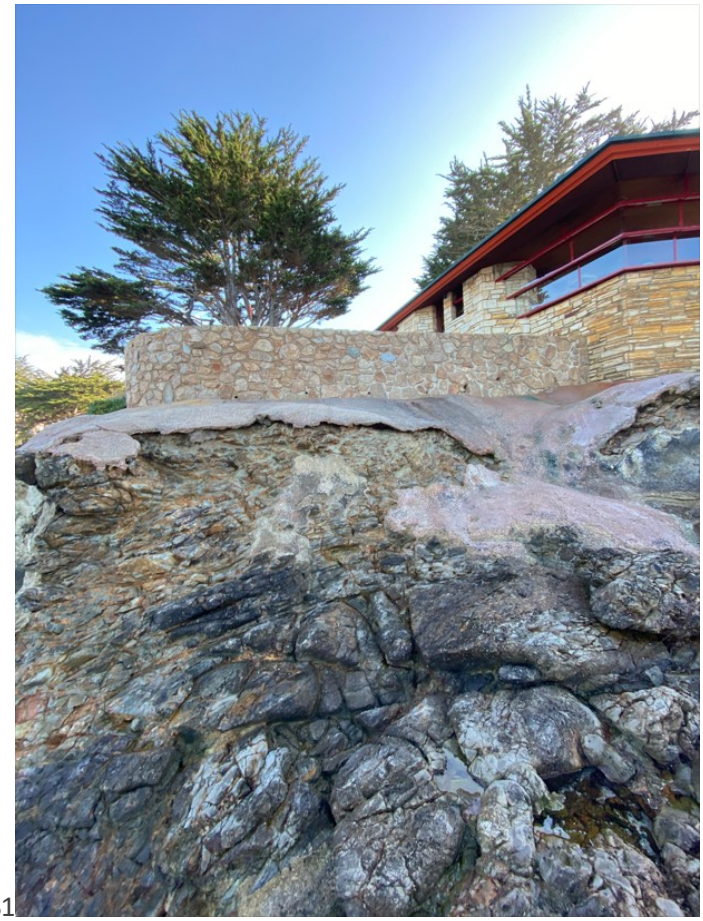
Structure Identifier	Approximate Location	Adequate Protection?	Repair Needed?	Risk to Beach Users	Priority of Repair	Estimated Existing Life of Structure Until it Ceases to Protect Coastal Access Path, Stairs and Roadway (Yrs)	Notes
Revetments							
R1	Between S2 and S3	NO Upcoast 1/3	YES Upcoast 1/3	YES	HIGH	Upcoast 1/3 = 0	Upcoast 1/3 Oversteepened, No Filter Fabric Unstable, Potentially Unsafe
R2	Between S3 and S4	NO	YES	NO	HIGH	0 to 5	Failing Structure, Has Voids, Undersized Quarrystone
R3	Between 11th and 12th Ave	YES Upcoast 3/4	YES Downcoast 1/4	NO	MEDIUM (Downcoast 1/4) VERY LOW (Upcoast 3/4)	Downcoast 1/4 = 10 Upcoast 3/4 = 30	Downcoast 1/4 Poorly Stacked, Has Had Instability; Upcoast 3/4 REJA 1983
R4	Between 10th and 11th Ave	NO Upcoast 1/3	YES Upcoast 1/3	NO	HIGH (Upcoast 1/3) UNKNOWN (Downcoast 2/3)	Upcoast 1/3= 0 to 5 Downcoast 2/3 = Unknown	Undersized rock Upcoasst 1/3 ; Few Quarrystones Visible; Back Beach Vegetated 12/2022; Monitor When Exposed
R5	Between 8th and 10th Ave	MAYBE	Unable to Assess	NO	Unable to Assess	Unknown	Few Quarrystones Visible 1/2023; Monitor When Exposed; May Be Founded on Sand; Downcoast End Has Slumped;
R6	At Ocean Avenue	MAYBE	Unable to Assess	NO	Unable to Assess	10 to 30 years?	Few Quarrystones Visible 1/2023; Monitor When Exposed; May Be Founded on Sand; Downcoast End Has Slumped;

TABLE 1 City of Carmel Coastal Protection Data

4/21/2023 Haro Kasunich and Associates, Inc.

Structure Identifier	Approximate Location	Adequate Protection?	Repair Needed?	Risk to Beach Users	Priority of Repair	Estimated Existing Life of Structure Until it Ceases to Protect Coastal Access Path, Stairs and Roadway (Yrs)	Notes
Stairways							
ST1	Martin Way	NA	YES	UNKNOWN***	MEDIUM***	Regular Maintenance Essential	Corroded Structural Elements, Footing on Bedrock
ST2	Santa Lucia Avenue	NA	YES	NO	LOW	Regular Maintenance Essential	Downcoast Railing Bent from Log Impact
ST3	13th Avenue	NA	NO	YES During Scour Events	NONE NOW	Regular Maintenance Essential	Great Condition, Stairs End on Elevated Bedrock Platform; Consider Extending Stairs to Scoured Beach Level
ST4	12th Avenue	NA	YES	YES	HIGH	Regular Maintenance Essential	Hazardous; Undermined in EG Fig 1 (2016) Corroded Hardware
ST5	11th Avenue	NA	YES	YES During Scour Events	MEDIUM	Regular Maintenance Essential	Concrete Treads Worn; Stairs End on Elevated Bedrock Platform; Consider Extending Stairs to Scoured Beach Level
ST6	S of 10th Avenue	NA	YES	YES	MEDIUM	Regular Maintenance Essential	Needs Minor Tread Work; Corroded Rebar Exposed; Concrete Spalling
ST7	N of 10th Avenue	NA	YES	YES During Scour Events	HIGH***	Regular Maintenance Essential	Toe of Stairs Undermined by Scour 1/2023; Hazardous; Easton (2016) Said Look at 2008 CRP Photo
ST8	9th Avenue	NA	YES	YES During Scour Events	HIGH	Regular Maintenance Essential	Stairway Terminates Before Reaching Beach During Scour; Needs Seaward Extension Across Revetment
ST9	8th Avenue	NA	YES	YES	MEDIUM	Regular Maintenance Essential	Rock and Mortar Steps; Worn Natural Rock Surfaced Treads Create Slippery Condition
ST10	Ocean Avenue	NA	NO	NO	NONE NOW	Regular Maintenance Essential	Coastal Overlook and Boardwalk Not Subject to Wave Impact
ST11	Dunes	NA	YES	YES	HIGH	Regular Maintenance Essential	Hazardous; Broken Guard and Handrail on Upcoast Side of lowest Run

REPORT AND PHOTOGRAPHS


S1

Photograph 1: Privately Owned Seawall S1 on December 22, 2022

Photograph 1 shows a seawall located on private property at the well-known Frank Lloyd Wright designed oceanfront home at the southern end of Carmel Beach on December 22, 2022. It appears to be in good condition. At some point it will need maintenance and/or repair. Close inspection was not possible without entering onto the private property.

Photograph 2: Unnamed shotcrete between S1 and S2 on December 22, 2022

Photograph 2 shows some shotcrete or gunite fascia exists on the bedrock portion of the coastal bluff face between S1 and S2 (where located on the map contained in Appendix B) north from the Frank Lloyd Wright home on December 22, 2022. Its age, origin, and position relative to the boundary between the privately owned and publically owned upland parcel's common boundary line is unknown. It looks to be in good condition.

Photograph 3: Seawall S2 on December 22, 2022

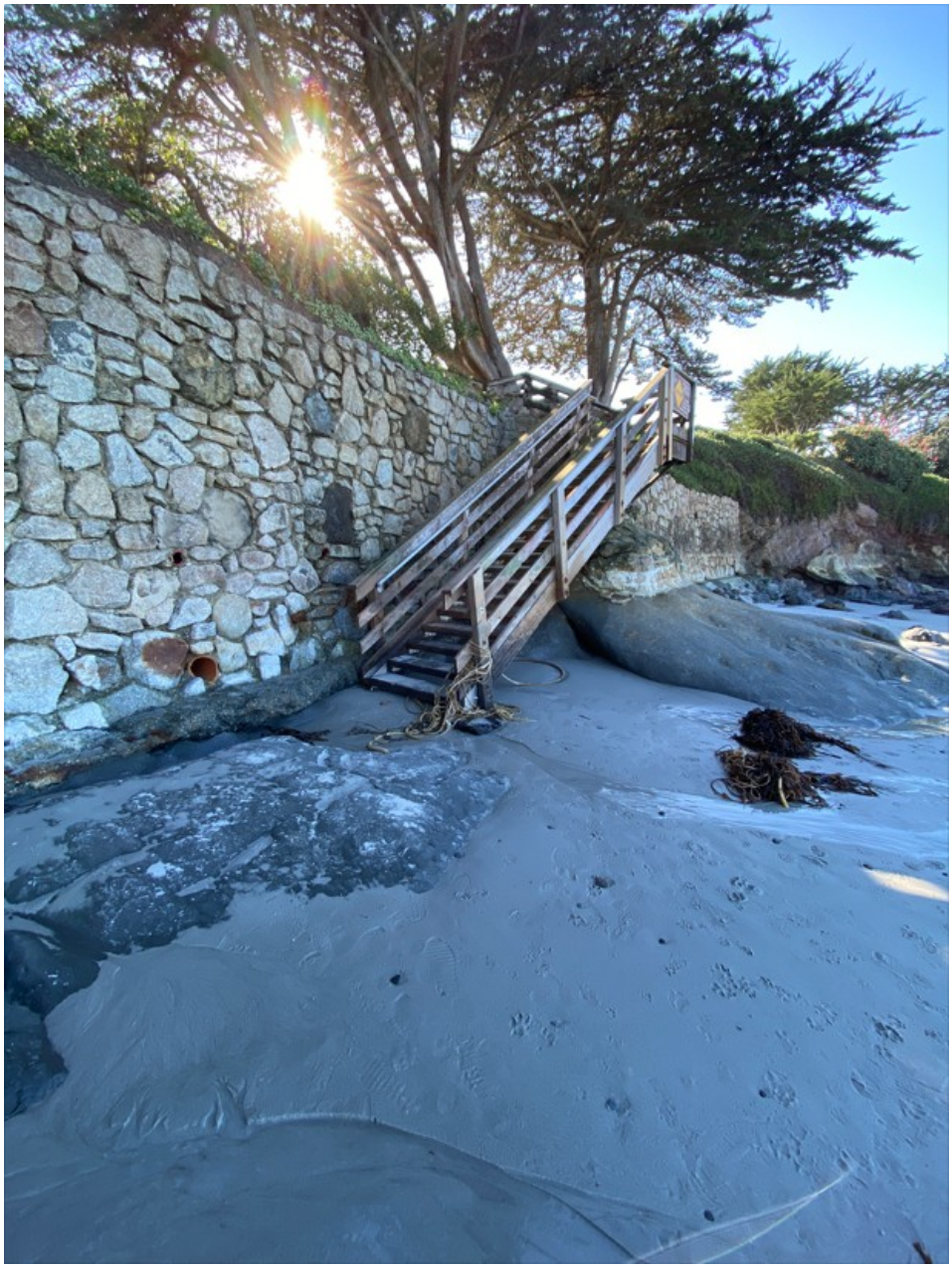
Photograph 3 shows a view looking north at Seawall S2, which extends from the Frank Lloyd Wright home to Santa Lucia Avenue, on December 22, 2022. This seawall is in good condition.

Photograph 4: Stairway ST1 on December 22, 2022

Photograph 4 shows Public Access Stairway ST1 located at Martin Way on December 22, 2022 which is in average condition.

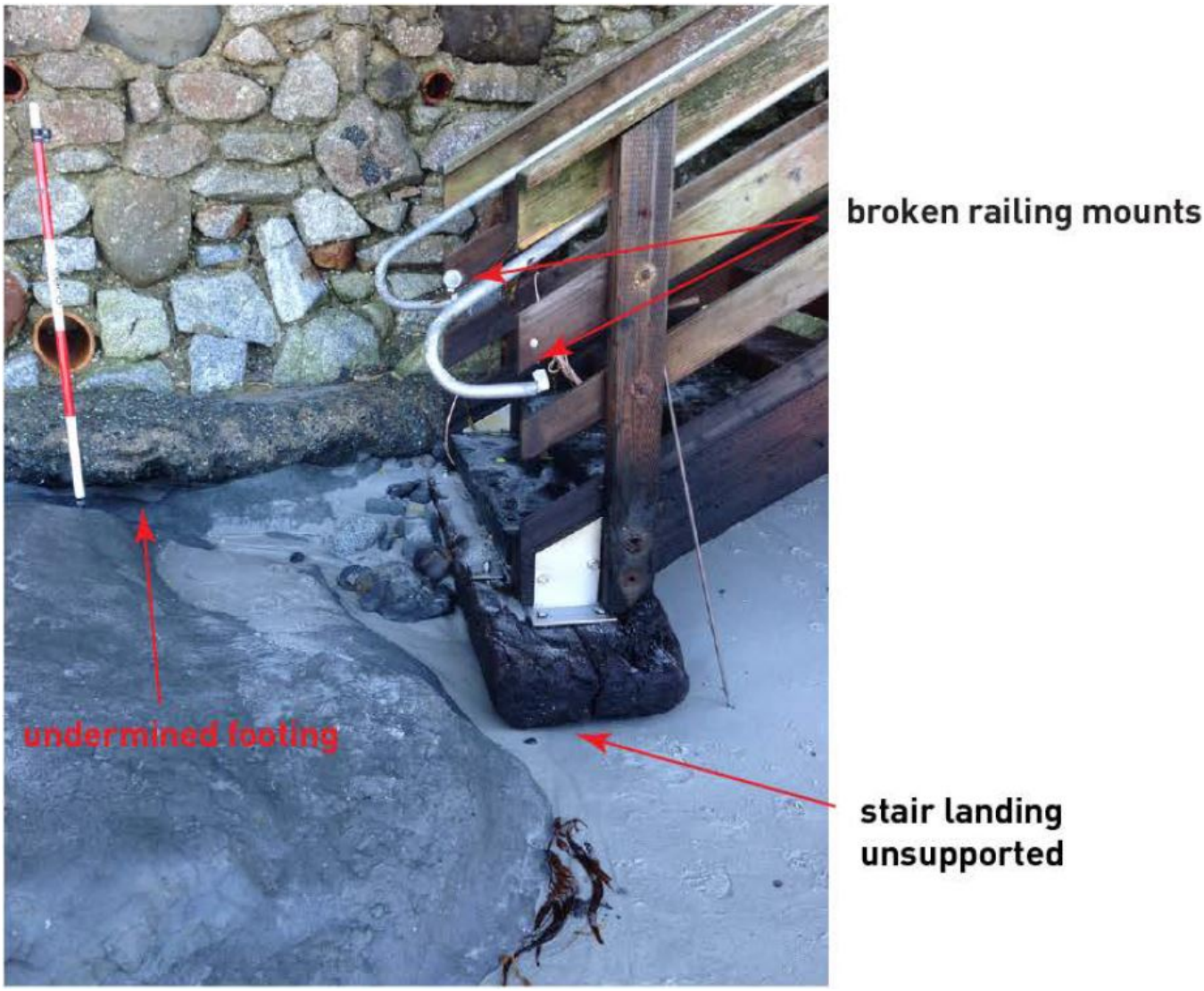
Photograph 5: Public Access Stairway ST1 on December 22, 2022

Photograph 5 shows Public Access Stairway ST1 on December 22, 2022. Corrodible fasters and brackets were used on this stairway and those are deteriorating. At some point it will need maintenance and/or repair. Visually it appears satisfactory to us at this time. Further evaluation of the structure by an independent licensed structural engineer (and if need be a licensed corrosion engineer) should be scheduled to verify the structure is safe for public use, and recommend any needed repairs.



Photograph 6: Showing Stairway ST1 on January 30, 2023

Photograph 6: shows Stairway ST1 along Seawall S2 on January 30, 2023. The beach sand level was scoured lower compared to December 2022. The Seawall S2 foundation is exposed and is bearing upon sandstone bedrock; no maintenance is presently recommended.



Photograph 7: Showing Stairway ST1 in February 2016 (Photo from Easton Geology)

Stairway ST1 was unsupported in 2016 as shown in Photograph 7 by Easton Geology. The landing area is ian irregular surface and the seawall footing is slightly undermined. We recommend it be verified that the stairway structure is presently founded upon bedrock. Repairs appear to be needed due to corrosion of fasteners and hardware. We rank the repair as a medium priority, pending structural and corrosion inspection, which we rank as a high priority. There is an unknown risk to users of the stairs.

Photograph 8: Showing Seawall S2 on January 30, 2023

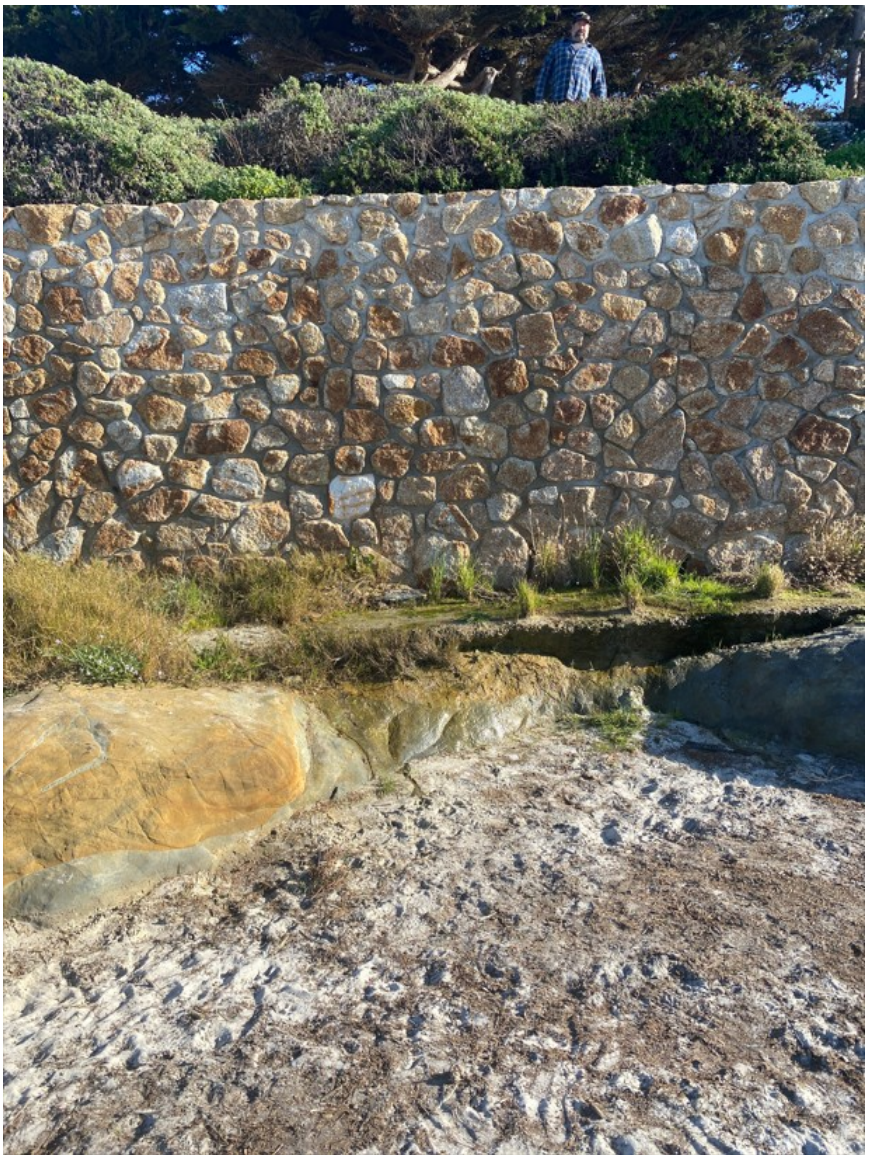
Photograph 8 shows Seawall S2 on January 30, 2023 inspection. No rip riprap revetments seaward of the seawall were evident during our inspection. Some bedrock platform exposures are observed seaward of seawall, indicating scour levels were near the bottom of the sand deposit.

Photograph 9: Seawall S2 on December 22, 2022

Photograph 9 shows Public Access Seawall S2 on December 22, 2022. The exposed portion is in excellent condition. The seawall foundation is buried by beach sand, which is normal. After severe ocean storms in January 2023 we revisited this location and almost all of this seawall's foundation was still buried by beach sand. Whenever it is next exposed by natural beach sand scour processes, it should be inspected. That may not be for a decade, but could be possible this winter. No repairs appear needed at this time and the seawall does not pose any extraordinary risks to beach users. This seawall appears to have more than 30 years of remaining life.

Photograph 10: Storm Drain near NorthNorthern End of Seawall S2 on December 22, 2022

Photograph 10 shows a Storm Drain Outfall near the north end of Seawall S2 on December 22, 2022. Storm runoff had gullied the beach sand at that location. Minor erosion had occurred adjacent to the seawall foundation footing. This location should be periodically monitored as time passes, so that if repairs are needed (such as plugging cavity under the footing) they can be done in a timely manner. No repair work is presently needed.



Photograph 11: North End of Seawall S2 on December 22, 2022

Photograph 11 shows an area at the northern end of Seawall S2 on December 22, 2022, where the edge of the seawall footing is exposed and it has been slightly undermined. Easton Geology inspected this location as well. Photograph 12 (below) is an Easton Geology photograph of the north end of Seawall S2 showing it was undermined in 2016. Comparison of that photo with the 2022 photo (above) shows there has been very little change in the conditions; there has been no continued undermining during that 7 year period. It is likely that this area was buried in beach sand during most of those 7 years; when the bedrock supporting the footing is buried, wave action does not contact the bedrock and no erosion or bedrock retreat occurs under the footing.

Photograph 12: Easton Geology Photograph of the North End of Seawall S2 in June 2016

Photograph 13: North End of Seawall S2 on December 22, 2022

Photograph 13 shows the very northern tip of Seawall S2 on December 22, 2022, where noticeable groundwater seepage is present.The end of the seawall was historically undermined and a repair consisting of a small concrete patch was done in the past. This area appears to be in reasonable condition, and the seawall appears to be stable.

Photograph 14: Public Access Stairway ST2 on December 22, 2022

Photograph 14 shows the seaward portion of Public Access Stairway ST2, located at Santa Lucia Avenue, on December 22, 2022, which is in good condition. The south handrail of ST2 is bent; likely from a wave carried log impacting it. The stairway seems functional despite this minor damage. The bottom of the stairway foundation is buried by beach sand, which is the normal condition.

Photograph 15: Showing Revetment R1 and Stairway ST2 on January 30, 2023

Photograph 15 shows Revetment R1, which is located between Seawalls S2 and S3, and shows Stairway ST2 during our January 30, 2023 inspection after severe ocean storms occurred in January 2023 and it was still buried by beach sand. Whenever it is next exposed by natural beach sand scour processes, it should be inspected. That may not be for a decade but could be possible this winter. The estimated life of Stairway ST1 is 30 years or more. The south railing is bent from floating log impact. This does not pose a substantial risk to users of the stairs. We rank the repair as a low priority.

Photograph 16: Showing Revetment R1 on January 30, 2023

Photograph 16: shows Revetment R1 on January 30, 2023.

Photograph 17: Revetment R1 on December 22, 2022

Photograph 17 shows the southern end of Revetment R1 on December 22, 2022, which consists of ovelysteep riprap, making it relatively unstable. One displaced boulder (a "fugitive" rock) can be seen poking out of the beach sand seaward of the revetment. Historic instability and the use of undersized boulders to construct this revetment have caused cavities to develop in the revetment and have diminished the erosion protection it provides. We recommend the holes in the revetment structure be filled and the 1 to 4 ton rocks be restacked. It is presently unsafe.

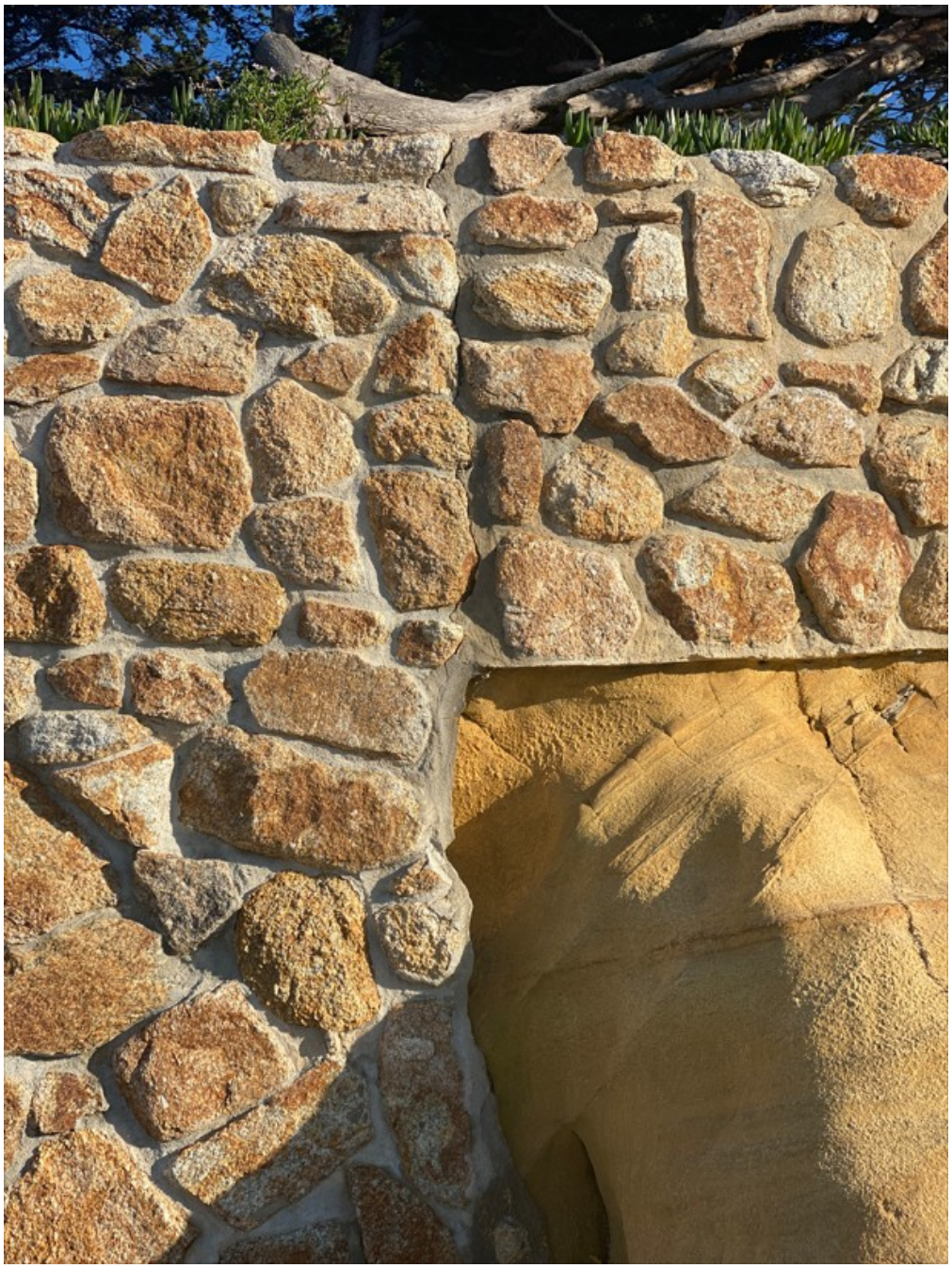
Photograph 18: Revetment R1 Showing Undersized Overly Steep Riprap on December 22, 2022

Photograph 19: Revetment R1 on December 22, 2022

Photograph 19 shows the northern end of Revetment R1 on December 22, 2022, which consists of overly steep riprap at a 0.5:1 (H:V) gradient. The northern 1/3 of the Revetment R1 riprap is unstable, poses risks to beach users, and we recommend it has a high priority for repair. We recommend bringing in additional larger riprap quarrystone boulders to lower the revetment gradient. Alternately the revetment could be removed and replaced with a vertical seawall to match the appearance of the other nearby seawalls along Carmel Beach.

Photograph 20: Showing Revetment R1 and the Southern End of Seawall S3 on January 30, 2023

Photograph 20 shows Revetment R1 and the South End of Seawall S3on January 30, 2023.



Photograph 21: Very Southern End of Seawall S3 on December 22, 2022

Photograph 21 shows Seawall S3 where it's foundation is founded on bedrock and steps upward at the very southern end of Seawall S3, which is located near 13th Avenue, on December 22, 2022. A vertical crack, which appears to be a shrinkage crack or expansion crack,is visible, but is not of concern.

Photograph 22: Southern End of Seawall S3 on December 22, 2022

Photograph 22 shows a view looking to the south along Seawall S3 on December 22, 2022.

Photograph 23: Concrete Debris on Beach at Base of Seawall S3 on December 22, 2022

Photograph 23 shows Seawall S3 on December 22, 2022 which has pumped concrete debris located on the beach at base of the seawall. Easton Geology inspected Seawall S3 in February 2016 and again in June 2016 for the City. Photograph 24 from Easton Geology shows that the beach was more scoured then than during our 2022 and 2023 inspections.

Photograph 24: Southern End of Seawall S3 in February 2016 Photographed by Easton GeologyShowing Pumped Concrete Repair of Undermining of Seawall S3

Photograph 25: Looking North at Seawall S3 on December 22, 2022

Photograph 25 is looking north along Seawall S3 on December 22, 2022. At that time the seawall foundation was buried by beach sand, which is normal. After severe ocean storms in January 2023, we revisited this location and it was still partially buried by beach sand. This seawall, including the portion of the foundation we were able to inspect, appears to be in satisfactory condition. Whenever it is next exposed by natural beach sand scour processes, it should be inspected. That may not be for a decade but could be possiblеduring any winter. Except for the possible removal of some of the pumped concrete on the beach at the southern end, no repairs appear needed at this time, and the seawall does not pose any significant risks to beach users. This seawall appears to have more than 30 years of remaining life.

Photograph 26: Seawall S3 Showing Missing Rock on December 22, 2022

Photograph 27: Public Access Stairway ST3 on December 22, 2022

Photograph 27 shows the seaward portion of Public Access Stairway ST3 located at 13th Avenue, on December 22, 2022, which is in good condition. Seawall S3 is on both sides of ST3.

Photograph 28: Showing Public Access Stairway ST3 with Seawall S3 on Both Sides On January 30, 2023

Photograph 28 shows the seaward portion of Public Access Stairway ST3 on January 30, 2023, when beach sand levels were scoured much lower in elevation than in December 2022. Stairway ST3 is primarily a rock and mortar set of steps that appear to be performing well. This staircase terminates onto a bedrock platform that was an approximately 5 feet vertical height drop from the platform down to beach level at the time of the photograph. This is not a safe transition for public use and it should be investigated for a safer alternative stair termination that accounts for scoured beach conditions. Stairway ST3 repairs do not appear to be needed, but extension of the stairs does appear to be prudent. There is risk to users of the stairs because they do not extend to beach level during periods of low sand levels from scouring. We rank extension of the stairs to beach level as a low priority if they are securely closed off at both the top and bottom during times of low beach levels.

North of Public Beach Access Stairway ST3, Seawall S3 had an exposed foundation in February 2016. Easton's June 2016 letter states "exposed undercuts *(identified and documented in February 2016)* between the wall footing and the underlying bedrock within the 13th Avenue Cove *(referred to as S3 in this document)* were filled with concrete" *(between February and June 2016) (italicized portions added by HKA for clarity)*. Photographs 29 and 30 from Easton Geology illustrate the condition of S3 in 2016.

Photograph 29: Seawall S3 Just North of ST4 in February 2016 (Easton Geology)

Photograph 30: Seawall S3 Just North from ST4 in February 2016 (Easton Geology)

Photograph 30 shows that the footing of Seawall was bearing on bedrock and slightly undermined in 2016.

Photograph 31: Looking South at Seawall S3 Adjacent to ST3 on January 30, 2023

Photograph 31 shows Seawall S3 at the south end of Cooks Cove, adjacent to ST3, showing its foundation is still bearing on a sandstone bedrock platform, and the footing remains slightly undermined. It is still performing well, and we have no recommended maintenance at this time. We note that when beach sand levels are naturally higher, the footing is buried and naturally protected from wave impact, resulting in no undermining occurring during those time periods, which are typically present in most years all year long. We recommend the undermining shown in Photographs 30 and 31 be photographically monitored whenever it is exposed, to verify the that undermining is occurring atover time.

Photograph 32: North End of Seawall S3 on December 22, 2022

Photograph 32 shows the north end of Seawall S3 where it adjoins Revetment R2 on December 22, 2022. The north end of Seawall S3 was historically slightly undermined, and the resultant cavities have been repaired with concrete patchwork, and or grouted riprap. The north end of Seawall S3 appears to be stable.

Photograph 32: Showing Revetment R2 between Seawalls S3 and S4 on January 30, 2023

As shown in Photograph 32, the beach at Revetment R2, which is located between Seawalls S3 and S4, had similar sand levels on January 30, 2023 as it did during our December 2022 inspection.

Photograph 33: Showing South End of Revetment R2 on December 22, 2022

Photograph 33 shows the south end of Revetment R2 on December 22, 2022, which has some displaced fugitive riprap. The revetment surface gradient is not uniform and the coastal erosion protection this revetment provides could be improved from restacking the riprap boulders. Revetment R2 includes a large volume of undersized riprap, which is vulnerable to plucking from wave attack. Revetment R2 poses risks to beach users, and we recommend it as a high priority for repair. The base of the revetment was buried by beach sand during our inspections and so its condition is unknown. Whenever it is next exposed by natural beach sand scour processes, it should be inspected. That may not be for a decade but could be possible any winter.

Photograph 34: Showing North End of Revetment R2 on December 22, 2022

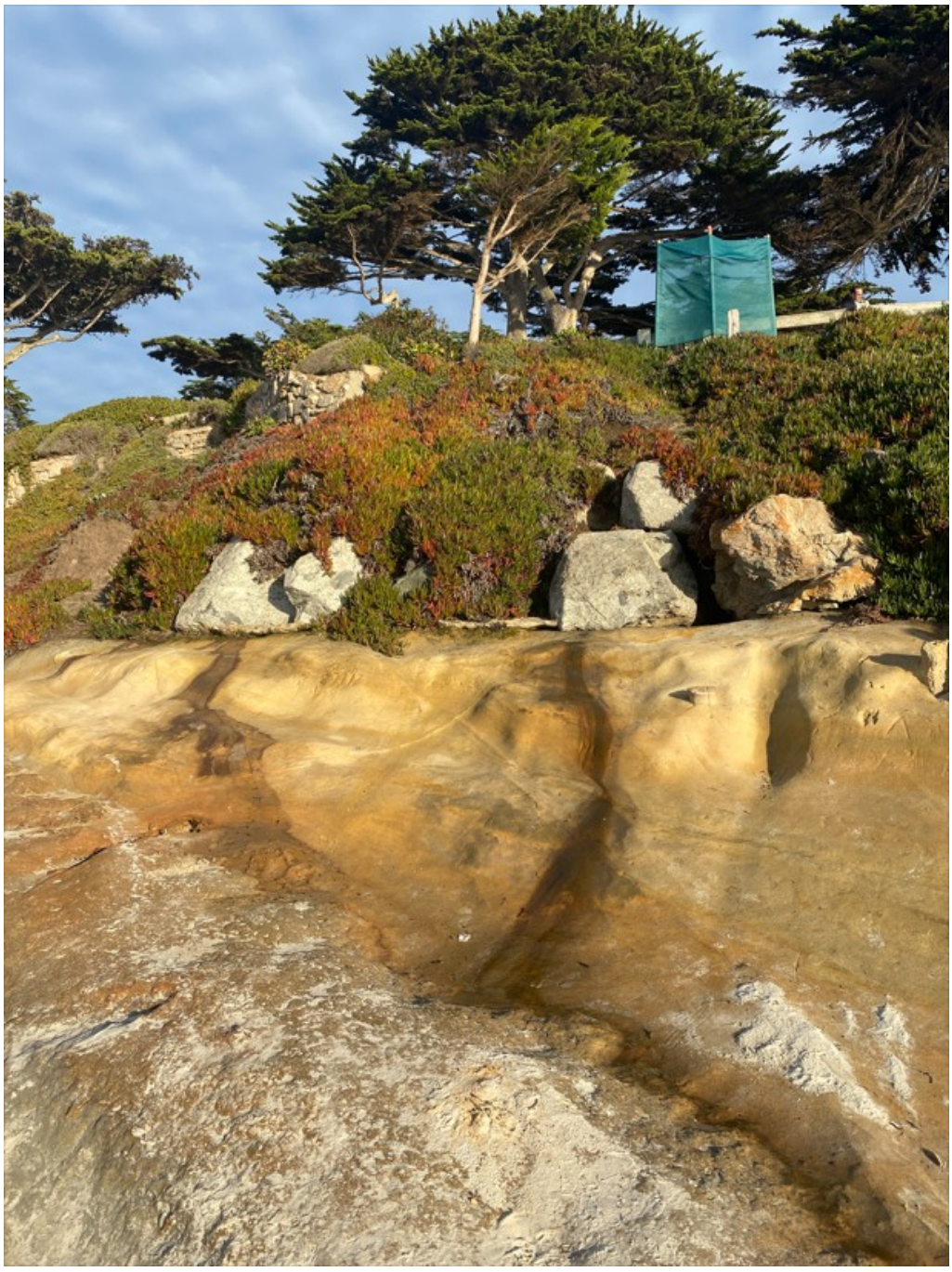
Photograph 34 shows the north end of Revetment R2 on December 22, 2022,

Photograph 35: Showing Seawall S4 on January 30, 2023

Photograph 35 shows the southern portion of Seawall S4 on January 30, 2023 which is in similar conditions to when our December inspection was done. This seawall is in good to excellent condition and is founded on the bedrock platform. No repairs appear to be needed.

Photograph 36: Showing North Portion of Seawall S4 on December 22, 2022

Photograph 36 shows the north portion of Seawall S4 on December 22, 2022, which is founded on a natural bedrock platform that is elevated above the beach level. This wall was designed by Neill Engineers and constructed in 2001.



Photograph 37: Showing Unnamed Rip-rap Boulders North of Seawall S4 on December 22, 2022

Photograph 37 shows a few rip-rap boulders located north of Seawall S4 and south of Public Access Stairway ST4 on December 22, 2022. These boulders are founded on a natural bedrock platform that is elevated above the beach level. They presently appear stable.

Photograph 38: Showing Public Access Stairway ST4 on December 22, 2022

Photograph 38 Shows Public Access Stairway ST4, located at 12th Avenue, on December 22,2022. This stairway was undermined as shown in Photograph 39 (below) contained in a letter from Easton Geology dated February 8, 2016

Photograph 39: Undermined Stairway ST4 in February 2016 (Easton Geology)

The undermined portion of Stairway ST4 that was visible in 2016 was not visible during our December 2022 inspection but was subsequently exposed by beach scour and visible in our January 2023 inspection. The metallic hardware for the railing is severely corroded and is expanding and splitting the timber framework of these stairs, which are located at 12th Avenue.

As shown in Photograph 40 (below) the foundation of Public Access Stairway ST4 was not exposed during either our December 2022 inspection or our January 2023 inspection. Whenever it is next exposed by natural beach sand scour processes, it should be inspected. That may not be for a decade but could be possible during any winter.

Photograph 40: Showing Base of Stairway ST4 naturally buried in beach sand on December 22, 2022

Stairway ST4 has severely corroded hardware and fasteners as well as some split timber elements, as shown in Photographs 41 and 42 below. Further evaluation of the structure by an independent licensed structural engineer (and if need be a licensed corrosion engineer) should be scheduled to verify the structure is safe for public use, and recommend any needed repairs.

Photograph 41: Showing Corroded Hardware and Split Timbers on Stairway ST4 on December 22, 2022

Photograph 42: Showing Corroded Hardware and Split Timbers on Stairway ST4 on December 22, 2022

Stairway ST4 repairs appear to be needed due to corrosion of fasteners and hardware, split timbers, and the vertical drop off and lack of foundation support at the base of the stairs during times of beach scour. Extension of the stairs does appear to be prudent. There is risk to users of the stairs because they do not extend to beach level during periods of low elevation sand levels. Due to the vertical drop off we rank extension of the stairs to beach level as a high priority and recommend prompt structural and corrosion inspection. There is a high risk to users of the stairs.

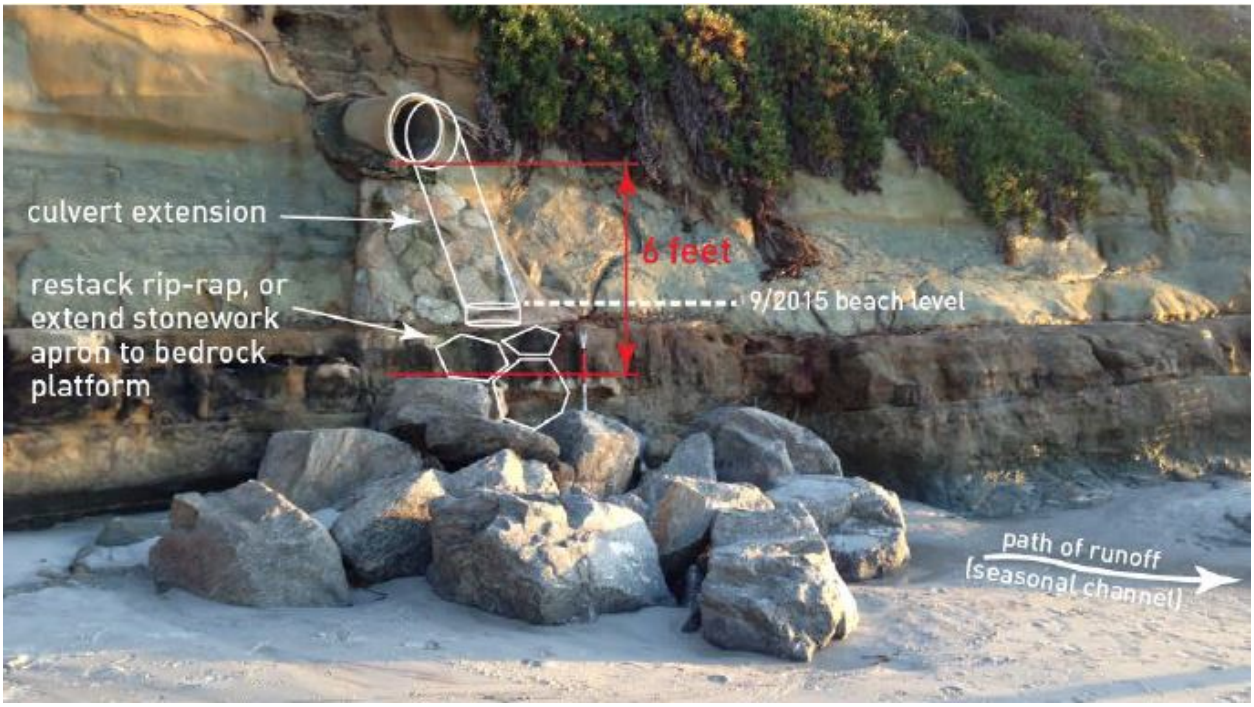
Photograph 43 (below) shows a storm drain outfall just northeast of Stairway ST4 with a rock and mortar seawall that armors the bluff face below the outfall that is Seawall S5. A small amount of riprap below the outfall and Seawall S5 was barely visible during our December 2022 inspection.

Photograph 43: Storm Drain Outfall and Seawall S5 Northeast from Stairway ST4 on December 22, 2022

Seawall S5 is immediately below the storm drain outfall near 12th Avenue.

Photograph 44: Storm Drain Outfall with Minor Armoring Between ST4 and R3 on January 30, 2023

As Photograph 44 shows, a greater amount of riprap below the outfall and Seawall S5 was visible during our January 2022 inspection. The rip-rap dissipates the energy from the runoff flowing onto the beach and serves to reduce bedrock erosion during times of low beach elevation.



Photograph 45: Seawall S5 Just North from ST4 in February 2016 (Easton Geology)
Easton Geology's Recommendations Are Shown on the Photo

Photograph 43 shows a storm drain outfall with minor armoring (Seawall S5) south of Revetment R5 and Stairway ST4 on December 22, 2022. Photograph 44 shows the same outfall and Seawall S5 after during January 2023 when considerable additional sand scour had occurred, exposing the grouted riprap energy dissipater placed on the bedrock platform below the outfall. About 75% of the coastal bluff height consists of erosion resistant bedrock, and appears to be in good shape. A seawall may be needed to slow bluff retreat in the future. Photograph 45 by Easton Geology (above) shows the conditions in February 2016, and includes their recommendations regarding extending the culvert and restacking the rip-rap they made at that time. Seawall S5 has no maintenance recommended by HKA at this time. It appears to have at least 30 years remaining life.

Revetment R5, which is between 8th and 10th Avenue, starts northnorth from Seawall S5.

Photograph 46: Looking South along Revetment R3 towards ST4 on December 22, 2022

Photograph 47: Revetment R3 Showing Scattered Rip-rap Boulders on December 22, 2022

Photograph 47 shows Revetment R3 with scattered rip-rap boulders on December 22, 2022. We recommend that Revetment R3 be restacked to increase coastal protection and reduce the revetment footprint.

Photograph 48: Revetment R3 Showing Area of Rip-rap on December 22, 2022

Where the Public Could Benefit from Quarrystone Re-stacking

The southern 1/4 of the Revetment R3 riprap unstable, poses risks to beach users, and we recommend it as a high priority for repair. The over-steepened portion of R3 should be re-stacked to alower gradient to increase its stability and provide better coastal protection.

Photograph 49: Showing Revetment R3 Looking South on January 30, 2023

Most of the portion of R3 shown in Photograph 49 has begun to slump and requires routine maintenance. needs to be re-stacked. The portion of R3 shown in Photograph 48 appears to have been constructed at a different time using smaller rock that may have been dumped into place rather than placed boulder by boulder, perhaps due to emergency conditions during construction. There is displaced undersized rock at the toe of the revetment at a lower gradient, and the revetment appears to be founded on the sandstone bedrock platform and we expect it will continue to provide service for 10 to 20 years. However, the rip-rap boulders are subject to displacement from wave impact. We recommend a vertical reinforced concrete seawall with rock fascia be designed and planned for and considered as a replacement for this portion of the R3 Revetment. The public coastal access at the top of the bluff is reliant upon bluff toe stability, which is currently provided by the R3 rip-rap armoring.

Photograph 50: Most of Revetment R3 is in Good Condition on December 22, 2022

The northern three-quarters of Revetment R3 is composed of 2-to-4-ton riprap stacked at approximately a 1.5 to 1.7 to 1 (H:V) gradient and looks to be performing well. No maintenance is recommended here.

Photograph 51: Showing the Middle Portion of Revetment R3 on January 30, 2023

Photograph 51 shows the middle portion of Revetment R3 with bearing support on the bedrock platform and on the outboard side of keyway, with the bedrock still providing lateral support of the toe of the structure, except in a couple locations. Twoover-steepened sections could benefit from re-stacking, however, this riprap revetment is in good condition and performing well.

Photograph 52: Showing Revetment R3 Looking North on January 30, 2023

Photographs 51 and 52 show Revetment R3 looking north and south. The portion of R3 shown in Photograph 52 is in great condition.

Photograph 53: Profile View of Revetment R3 on January 30, 2023

Photograph 53 is a profile view of Revetment R3. It was constructed following the severe 1983 storms with the toe of riprap revetment structure properly keyed into the bedrock platform, and still is performing well.

Photograph 54: Over-steepened portion of Revetment R3 on December 22, 2022

Photograph 55 shows that small portions near the north end of Revetment R3 are overly steep and could be re-stacked to be more stable and resistant to wave impact energy. During repair of the south 1/4 of R3, this area should be checked and the positions of a few boulders should be adjusted to improve boulder stability.

Photograph 55: Another Profile View of Revetment R3 on January 30, 2023

Photograph 56: Showing Stairway ST5 on January 30, 2023

Stairway ST5 is located at 11th Avenue and terminates on a bedrock platform, which is exposed when natural beach scour has lowered the beach elevation.

Photograph 57: Showing Stairway ST5 on January 30, 2023

Stairway ST5 repairs are needed due to corrosion of the concrete reinforcing, concrete spalling, and worn irregular concrete tread surfaces. We rank the concrete repair as a medium priority to abate slip and fall hazards. There is risk to users of the stairs because they do not extend to beach level during sand scour events. Extension of the stairs appears to be prudent. We rank extension of the stairs to beach level as a low priority if they are securely closed off at both the top and bottom during times when beach sand

elevations are low as a result of periodic natural beach scour.

Photograph 58: Showing Stairway ST5 and North End of Revetment R6 on December 22, 2023

Photographs 57 and 58 show Stairway ST5 before and after the severe January 2023 coastal storms and ocean wave events that resulted in beach scouring. Photograph 58 is a December 2022 photo of ST5 to show the influence of the scour event on beach conditions. This staircase is bearing upon sandstone bedrock platform and appears to be stable. The handrails are in decent shape. The ST5 stair treads are

worn and cracked and should be resurfaced.

We note that Seawall S6, which was initially mapped by Integral Consulting as a seawall, is not actually a seawall, but rather is a blufftop retaining wall located at the top of the bluff along Scenic Road. It is not influenced by the ocean. It appears to be in good condition; no repairs appear needed.

Photograph 59: Showing Bluff South of Revetment R4 on January 30, 2023

At the time of our inspection along the bluff face between Stairway ST5 and Revetment R4, a sandstone bedrock platform was discontinuously exposed, with very few fugitive riprap boulders exposed along the toe of the bluff at beach level. The bedrock exposed in the vertical lower bluff face appears to be erosion resistant and in good shape. No maintenance or armoring is necessary now. However, a future bluff face seawall with artificial rock fascia may be needed in the future to retard long-term erosion.

Photograph 60: Showing Very Few Boulders Exposed in Revetment R4 Area on December 22, 2022

Revetment R4 is located between 9th Avenue and 10th Avenue and was mapped by Integral Consulting extending from Stairway 5 and Stairway 6.

Photograph 61: Northern 1/3 of Revetment R4 Showing Scattered Undersize Riprap Boulders on January 30, 2023

Photograph 61 shows Revetment R4 in profile view showing over 50% of the visible structure is composed of veryy undersized scattered rock, that is subject to displacement and scattering onto the beach from wave action. The northern 1/3 of the Revetment R4 riprap is unstable, poses risks to beach users and we recommend it as a high priority for repair. Because this structure is composed of undersized, unstable rock, it increases the rate of bedrock erosion when the boulders are tumbled by wave action and abrade the bluff and bedrock platform. We recommend bringing in additional larger riprap quarrystone boulders to lower the revetment gradient. Alternately the revetment could be removed and replaced with a vertical seawall to match the appearance of the other nearby seawalls along Carmel Beach.

Photograph 62: Northern 1/3 of Revetment R4 Showing Very Undersized Scattered Rock on January 30, 2023

We recommend that Revetment R4, which is composed of very undersized scattered rock be completely reconstructed or replaced with a vertical concrete seawall faced with rock fascia.

Photograph 63: Showing Few Boulders Exposed at the North End of Revetment R4 On December 22, 2022

Photographs 61, 62 and 63 show Revetment R4, which is comprised of mostly undersized rock and broken concrete debris. The exposed portion of R4 where we observed substantially undersized scattered rock is approximately 225 feet in length and 8 to 10 feet tall. This structure has been undermined and has collapsed. Undersized riprap has been tumbling around in the wave action and is abrading the bedrock platform seaward of the riprap revetment structure toe. Future wave action could cause the steep slope below the path to slump, undermining the large cypress trees and public pathway along Scenic Road. A vertical concrete seawall at the toe of the bluff would be a preferred alternative here, as opposed to the riprap revetment structure, which requires more maintenance, and takes up a larger footprint.

Recommended maintenance and repair is to clean up the undersized riprap and replace it with a properly engineered, riprap revetment structure, founded into the bedrock platform. Alternately, this revetment could be removed, uncovering beach area, and a vertical seawall could be constructed at the toe of the bluff to prevent Scenic Road from being undermined.

Photograph 64: Showing Stairway ST6 on December 22, 2022

Photograph 64 shows Stairway ST6 is located south of 10th Avenue. The base of the stairs was buried in beach sand.

Photograph 65: Showing Recent Maintenance on Stairway ST6 on December 22, 2022

Photographs 65, 66 and 67 show Stairway ST6, which is a combination reinforced concrete (lower portion) to wooden (upper portion) public beach access staircase. The base of the staircase is founded on the sandstone bedrock platform below the beach sand. Several stair treads have spalled concrete areas, exposing highly corroded rebar, which is expanding, resulting in internal pressures within the concrete, which causes the stair treads to spall. This spalling creates a hazardous condition, and we recommend it be repairedand maintained to a safe standard for public use, using corrosion resistant reinforcing bar such as ChromX 4100 or 9100. Stairway ST5 repairs are needed due to corrosion of the concrete reinforcing, concrete spalling, and worn irregular concrete tread surfaces. We rank the concrete repair as a medium priority to abate slip and fall hazards.

Photograph 66: Stairway ST6 Well Founded in Bedrock on January 30, 2023

Photograph 67: Stairway ST6 with Tread Deterioration on January 30, 2023

Photograph 68: South Foundation of Seawall S7 on January 30, 2023

Photograph 68 shows the south foundation of Seawall S7, located between Stairways ST6 and ST7, is bearing on the sandstone bedrock platform. The foundation is in good condition. Seawall S7 is flanked by the north end of R6.

Photograph 69: Storm Drain Outfall near South End of Seawall S7 on January 30, 2023

Photograph 69 shows the south end of Seawall S7 where a 24-inch diameter concrete storm drain culvert outfall is in good condition. No maintenance is recommended here.

Photograph 70: Seawall S7 Foundation on January 30, 2023

Photograph 70 shows the Seawall S7 foundation, which was partially exposed during our inspection. This foundation appears to be a conventional spread footing foundation, approximately 20 inches wide at its toe and embedded in bearing upon the sandstone bedrock platform. The seawall above grade has slowly deteriorating mortar between individual rocks that form the wall face. The seawall foundation appears to be in good condition, and no maintenance is recommended at this time.

Photograph 71: Seawall S7 Foundation on January 30, 2023

Photograph 71 shows a view looking down coast at Seawall S7, showing additional exposed foundation area that is bearing on the sandstone bedrock platform.

Photograph 72: Storm Drain in Seawall S7 on January 30, 2023

Photograph 72 shows a storm drain culvert projecting out of the top portion of S7. This culvert is composed of highly corroded corrugated metal pipe that is 16 inches in diameter and appears to be collapsed about 3 feet landward of the wall. We observed large cracks in the seawall just below the culvert outfall. We recommend replacing this corrugated metal culvert with watertight HDPE N-12 storm drainpipe. We classified this as a medium priority. Except for this area of recommended repair, Seawall S7 has 30 years of remaining life.

Photograph 72: Stairway ST7 on December 22,2022

Photograph 72 shows Stairway ST7, which is located north of 10th Avenue.

Photograph 73: Stairway ST7 on January 30, 2023

Photographs 72 and 73 show Stairway ST7 at different beach scour conditions. Photo 73 shows the lower end of the stairs ending in mid-air at the time of our January inspection. Stairway ST7 repairs are needed due to corrosion of fasteners and hardware, and the vertical drop off and lack of foundation support at the base of the stairs during times of low beach surface elevations from scour. We rank the repair as a high priority and recommend prompt structural and corrosion inspection. There is a high risk to users of the stairs.

Photograph 74: Stairway ST7 on January 30, 2023 Showing Undermining

Photograph 74 illustrates the 2 1/2-foot vertical drop down to current beach sand elevation after the considerable winter scour event. At the time of our inspection the stairs were unsafe for public use in this condition. Extension of the stairs does appear to be prudent. We recommend that the stairs should be structurally evaluated and extended down to a landing constructed on the bedrock platform that they are secured to at their base. There is risk to users of the stairs because they do not extend to beach level during times of low beach sand surface elevations. Due to the vertical drop off we rank extension of the stairs to beach level as a high priority and recommend prompt structural and corrosion inspection. There is a high risk to users of the stairs.

Photograph 75: South Portion of Revetment R5 on January 30, 2023 Showing Bedrock Platform Below Beach Sand and Old Erosional Scarp in Ice Plant Above Revetment

Photograph 75 shows the southern end of Revetment R5, which is located between 8th Avenue and 10th Avenue, and was possibly initially founded on beach sand in an emergency effort to buttress the bluff failure above it. The wave action then likely scoured away the beach sand, and undermined the emergency revetment, causing it to collapse, and spread boulders out onto the beach.

Photograph 76: Showing Collapsed Southern End of Revetment R5 on January 30, 2023

Photograph 76 shows the southern end of Revetment R5, which has partially collapsed, and a majority of the riprap is now fugitive. We recommend re-stacking the fugitive riprap boulders on and at the toe of the existing revetment at a 1.5 to 1 slope gradient with the total base of the revetment structure founded below the beach sand on the bedrock platform.

Photograph 77: Southern Portion of Revetment R5 on January 30, 2023 Showing Steep Slope

Photograph 77 shows the southern portion of Revetment R5 and large cypress trees on the bluff face where driftwood has washed up onto the bluff face by waverunup. The upper portion of the riprap revetment looks steep. The top of the riprap revetment elevation is unknown. The estimated total height of the riprap revetment is 12 to 15 feet high and is likely sloped at a 1.5:1 or 2:1 (H to V) slope gradient.

Photograph 78: Central Portion of Revetment R5 on January 30, 2023

Photograph 78 shows the central portion of Revetment R5, where the coastal access path at the top of the bluff is dependent on bluff toe armoring and stability. A riprap revetment structure which is armoring the toe of the bluff is barely visible,. About 3 to 5 feet of the revetment height is visible The total height of a revetment is unknown, but estimated at 12 to 15 feet. Future wave action could cause the steep slope below the path to slump, undermining the large cypress trees, and public pathway along Scenic Road. A vertical concrete seawall at the toe of the bluff would be a preferred alternative here, as opposed to the riprap revetment structure, which requires more maintenance, and takes up a larger footprint.

Photograph 79: Showing Beach Access Stairway ST8 on January 30, 2023

Photograph 79 shows Beach Access Stairway ST8, which is near 9th Avenue just south of the central part of Revetment R5. It is a wooden stairway that is in good condition; however, it terminates before reaching the beach when the beach sand levels are seasonally low. We recommend that that the stairway be extended approximately 12 vertical feet down to the bedrock platform (which is presently buried by beach sand) at beach level. The existing beach access path across the R5 rip-rap below these stairs is hazardous and poses risk to stair users attempting to cross the revetment. Extension of the stairs is a high priority. This stairway does not have any other maintenance recommended at this time. Extending the stairway across the rip-rap revetment should be done carefully. A detailed design study will be necessary to properly found the stairway in and seaward of Revetment R5.

Photograph 80: Showing South End of Central Portion of Revetment R5 on January 30, 2023

Photograph 80 shows the south end of the central portion of Revetment R5 adjacent to Stairway ST8.

Photograph 81: Small Amount of Revetment R5 Riprap on January 30, 2023

As shown in Photograph 81, in the center portion of Revetment R5 we observed a small amount of visible riprap which was approximately 12 feet long and 6 feet tall. It was not possible to see enough riprap to draw meaningful conclusions regarding the extent, dimensions, condition and need for repair (if any) of this reported structure.

Photograph 82: Showing A Small Amount of Additional Revetment R5 Riprap on January 30, 2023

Photograph 83: Showing Additional Revetment R5 Rip-rap on January 30, 2023

Photograph 84: Showing a Small Amount of Revetment R5 Riprap on January 30, 2023

Photographs 82, 83 and 84 show the location of the center portion of Revetment R5 where we observed approximately 100 linear feet of 3-to 5-foot-high rip-rap that was exposed. It was not possible to see enough riprap to draw meaningful conclusions regarding the extent, dimensions and condition of this reported structure. We suspect most of this revetment structure is below sand level, not visible during our inspection.

Photograph 85: Location of North Area of Revetment R5 on January 30, 2023

We observed the area where the north portion of Revetment R5 was mapped by Integral Consulting. No riprap was visible.

Photograph 86: Stairway ST9 on January 30, 2023

Photographs 86 and 87 show Stairway ST9, which is near 8th Avenue, is a set of rock and mortar landscape or decorative steps. No recommended maintenance at this time is needed. The natural rock (Carmel Stone) treads are becoming worn, and their irregular surface should be evaluated for safety and code compliance by a qualified professional. A detailed study would be required to assess how to protect the stairs from being undermined.

Photograph 87: Toe Conditions at Seaward End of Stairway ST9 on January 30, 2023

Because the treads of Stairway ST9 are worn and have an irregular (bumpy) surface that poses some slip and fall risks to stair users, we recommend they be repaired and classify that as a medium priority.

Photograph 88: Seawall S8 on January 30, 2023

Photograph 88 shows Seawall S8 on January 3, 2023. It is a retaining wall (not a seawall) near 8th Avenue and Stairway ST9 and appears to be supporting a cut slope created to construct a municipal infrastructure system. It is not influenced by ocean wave impact. Seawall S8 appears to have at least 30 years of remaining life and no repairs are needed now.

Photograph 89: Revetment R5 and Seawall S9, Showing Small Amount of Riprap Boulders on January 30, 2023

Photograph 89 shows that Seawall S9 is a storm drainpipe headwall just north of 8th Avenue. No noticeable maintenance is recommended at this time. As exposed during our inspection, the north end of Revetment R5 has scattered riprap in this location and it does not seem laterally continuous. During our inspection, only the crest of the revetment structure was visible during inspection. Seawall S9 appears to have 20 years of remaining life and no repairs are needed now.

Photograph 90: Stairway ST10 Overlook Platform on January 30, 2023

Photograph 90 shows a Public Overlook Platform at the end of a boardwalk at the end of Ocean Avenue, we have named ST10, as seen on January 30, 2023. Our firm (Haro Kasunich and Associates Inc.) assisted in the design of this overlook in 2012. The ST10 wooden platform has reinforced concrete pierssupporting it that appear to be performing reasonably well and we do not note the need for any maintenance at this time. We estimate the anticipated life of the structure is approximately 20 years. We recommend that the platform structure be monitored for deterioration of the wood and corrosion of the metallic hardware and reinforcing. If any problems are noted in the future, appropriate maintenance and repair should be done.

Photograph 91: Revetment R6 Showing Small Amount of Rip-rap Boulders on January 30, 2023

Photograph 91 shows riprap that forms part of the R6 Revetment structure seaward of the end of Ocean Avenue which incorporates a storm drain outfall, as seen on January 30, 2023. The rip rap has an approximately 2:1 (H to V) surface slope gradient and the exposed portion is 6 to 7 feet tall. The remainder of the revetment, including its foundation condition, is buried in sand and is unlikely to be visible until the next extreme scour event. Whenever it is next exposed by natural beach sand scour processes, it should be inspected. That may not be for a decade but could be possible during any winter. Based on what we observed, no maintenance is presently recommended. We estimate the lifespan of this structure is 10 to 30 years, depending upon its foundation condition.

Photograph 92: Seawall S10 on January 30, 2023

Photographs 92, 93, 94 and 95 show Seawall S10 on January 30, 2022. This seawall is a storm drain headwall for a 3 by 3-foot reinforced concrete box culvert located in the dunes area north of Ocean Avenue. It is in poor condition. Photograph 92 shows that the central part of the Seawall S12 foundation is bearing upon sandstone bedrock. In adjacent areas the foundation is partially undermined horizontally up to 16 inches at the toe.

Photograph 93: Central Part of Foundation of Seawall S10 on January 30, 2023

Photograph 93 is a photograph that shows concrete spalling, exposing steel reinforcement.

Photograph 94: Seawall S10 on January 30, 2023

Photograph 94 is a photograph that shows Seawall S12 being undermined where it steps up the coastal bluff on the north side. Also visible is that the guard at the top of the wall is broken creating an unsafe condition there that needs to be remedied.

Photograph 95: Seawall S10 on January 30, 2023

Photograph 95 is a photograph that shows a large structural crack in Seawall S12 above the box. The crack is wider at the top than the bottom and the wall has been displaced. Reinforcing bars have been exposed by spalling concrete. It appears the south side of the seawall has rotated out in the seaward direction. The north side of the seawall appears to bevertical (plumb) and straight. Most of the rebar of the structure is corroded and not salvageable. We recommend reconstruction of the box culvert and seawall in its entirety. The down coast end of the seawall is outflanked and has been partially undermined, contributing to instability on that side of the structure. This structure has 0 to 10 years of remaining service life before it may collapse. It could collapse catastrophically this year. We do not expect it to survive 10 years. We recommend the City budget for and construct a new structure as soon as possible. This structure poses risks to beach users, and we recommend it have a high priority for replacement

Photograph 96: Stairway ST11 on January 30, 2023

Photograph 96 shows Public Beach Access Stairway ST11, located in the dunes area north of Ocean Avenue, on January 30, 2022. Our firm (Haro Kasunich and Associates Inc.) designed this stairway. The lowest elevation run of the stairway has a damaged handrail, minor corrosion in a few spots along the handrail, a broken wooden guard and handrail on the north side of the lowest flight of stairs. The bottom 3 or so feet of the stairs were buried in beach sand at the time of our inspection. We recommend re-inspection during the next natural beach scour event that exposes the lowest portion of the stairs which were founded on bedrock at the time of initial construction. Further evaluation of the structure by an independent licensed structural engineer (and if need be, a licensed corrosion engineer) should be scheduled to verify the structure condition is safe for public use. We recommend the broken guard and handrail be repaired or replaced for the sake of pedestrian safety, and rank that as a high priority, since the current conditions pose slip and fall risks to stair users.

Photographs 97, 98 and 99 show Seawall S11 on January 30, 2022. This is a privately owned seawall and is the furthest north coastal protection structure protecting the furthest north home in the City of Carmel. The total height of the seawall is unknown. Photograph 71 shows the north portion. At the time of our inspection 6 to 10 feet of retaining wall was exposed above the beach sand level. The seawall appeared to be in good condition, and we did not observe any maintenance or repair that was needed.

Photograph 97: South Portion of Privately Owned Seawall S11 on January 30, 2023

Photograph 97 shows the south part of Seawall S11 on January 30, 2022. The south portion is approximately 6 feet high. This portion includes a private access stairway at the south end. The seawall appeared to be in good condition, and we did not observe any maintenance or repair that was needed.

Photograph 98: Central Portion of Privately Owned Seawall S13 Center on January 30, 2023

Photograph 98 shows the central part of Seawall S11 on January 30, 2022. The center portion is approximately 6 feet high. The seawall appeared to be in good condition, and we did not observe any maintenance or repair that was needed.

Photograph 73: North Portion of Privately Owned Seawall S11 on January 30, 2023

Seawall S11 connects to a retaining wall along the margin of Pescadero Creek that has steel H-beam soldier piles and wood lagging. Evaluation of it is outside of our scope of services.

References

Easton Geology, 8 February 2016, Mid-winter Assessment of Shoreline Improvements at Carmel Beach, Carmel-by-the-Sea, California.
Easton Geology, 13 June 2016, Second Winter Inspection of Shoreline Improvements at Carmel Beach, Carmel-by-the-Sea, California

APPENDIX A

Carmel Adaptation Coastal Protection Datasheet
Dated 4-27-2023

APPENDIX A Haro Kasunich and Associates, Inc.

City of Carmel Coastal Protection Datasheet

4/27/2023

Structure Identifier	Approximate Location	Date of Inspection	Length (Ft)*	Visible Height (Ft)	Total Height (Ft)	Guesstimated Footprint Area (Ft^2)	Estimated Surface Slope Gradient (H:V)	Estimated Quarrystone Size Range (Tons)	Estimated Rip Rap Volume (CY)	Adequate Protection?	Repair Needed?	Risk to Beach Users	Priority of Repair	Estimated Existing Life of Structure Until it Ceases to Protect Coastal Access Path, Stairs and Roadway (Yrs)	Note 1	Note 2
Seawalls																
S1	**At FLW House**	**12/22/2022 & 1/30/2023**	27	5	5	162	0:1 (Vertical)	NA	0	YES	UNKNOWN	NO	NA	30+?	Private Property, Not evaluated; Upcoast Corner Will Need Maintenance at Some Future Point	Private Property
S2	**FLW Home to Santa Lucia**	**12/22/2022 & 1/30/2023**	565	8 to 13	8 to 13	1695	0:1 (Vertical)	NA	0	YES	NO	NO	VERY LOW	30+	Good Condition, Slight Undermining Noted in Two Spots	Upcoast End (Last 5 Ft) Has been Undermined and Patched, Some Seepage Below Wall
S3	**13th Avenue**	**12/22/2022 & 1/30/2023**	556	6 to 14	11 to 14?	1668	0:1 (Vertical)	NA	0	YES	NO	YES	VERY LOW (Upcoast) LOW (Downcoast)	Upcoast Part = 50, Downcoast = 20+	In Cove, Sloppy Pumped Concrete on Beach, Downcoast Part is Subject to Slow Undermining	Upcoast Part is Newer Neill Engineers Wall (2010?)
S4	**N of 13th Avenue**	**12/22/2022 & 1/30/2023**	168	6 to 8	6 to 8	504	0:1 (Vertical)	NA	0	YES	NO	NO	VERY LOW	Most =30+	Mostly Good Condition; Founded on Bedrock Platform	
S5	**Outfall at 12th Avenue**	**12/22/2022 & 1/30/2023**	13	8	8	39	0:1 (Vertical)	NA	0	YES	NO	NO	VERY LOW	30+	Good Condition, Monitor Annually	Small Storm Drain Splash Block Armor
S6	**Scenic Rd Retaining Wall**	**12/22/2022 & 1/30/2023**	317	3	3	951	0:1 (Vertical)	NA	0	YES	NO	NO	NA	Not a Coastal Protection Structure	Short Coastal Path Wall Not Subject to Wave Impact	
S7	**Between Stairways 6 and 7**	**12/22/2022 & 1/30/2023**	241	8 to 13	8 to 13	723	0:1 (Vertical)	NA	0	YES	YES	NO	MEDIUM	30	Wall Crack Below Failed Metal 16 " Dia Storm Drain Pipe Thru Seawall; Pipe Replacement Needed	Mortar is starting to deteriorate; maintenance consisting of mortar tuck pointing by a stone mason is needed
S8	**Retaining Wall at 8th Ave**	**1/30/2023**	37	2 to 4	2 to 4	111	0:1 (Vertical)	NA	0	YES	NO	NO	VERY LOW	30+	Blufftop Retaining Wall Around Pump Station	Good Condition
S9	**Outfall at 8th Ave**	**1/30/2023**	13	8 to 10	8 to 10	39	0:1 (Vertical)	NA	0	YES	NO	NO	VERY LOW	20	CMP Storm Drain Headwall ; 60 LF Scattered Rip-rap Below; Rip-rap Foundation Condition Uncertain	Monitor during Scour
S10	**Dunes Outfall**	**1/30/2023**	31	15	15	93	0:1 (Vertical)	NA	0	NO	YES	YES	HIGH	0 to 10 Until Collapse	Failing/Failed 3'x3' Box Culvert Storm Drain Outfall Wall; Needs Replacement	Concrete Cracked, Undermined, Outflanked, Corroded Rebar, Visually Undesirable; Replacement Recommended
S11	**At Pescadero Creek Home**	**1/30/2023**	290	6 to 10	Unknown	2900	0:1 (Vertical)	NA	0	YES	UNKNOWN	NO	NA	30?	Private Property; Not Evaluated, No Obvious Need for Repairs is Evident	Private Property
Revetments																
R1	**Between S2 and S3**	**12/22/2022 & 1/30/2023**	118			2360	Upcoast 1/3 is 1:1	Upcoast 1/3 is 1 Ton		NO; Upcoast 1/3	YES; Upcoast 1/3	YES	HIGH	Upcoast 1/3 = 0	Upcoast 1/3 Oversteepened, No Filter Fabric, Unstable, Potentially Unsafe	Public Will Benefit from Replacement
R2	**Between S3 and S4**	**12/22/2022 & 1/30/2023**	50			1000	3:1?	< 1 Ton		NO	YES	NO	HIGH	0 to 5	Failing Structure, Has Voids, Undersized Quarrystone	Public Will Benefit from Restacking or Replacement; Consider Vertical Wall Here
R3	**Between 11th and 12th Ave**	**12/22/2022 & 1/30/2023**	406	Unknown	Unknown	8120	1.5 to 2.0:1	Upcoast 3/4; 2 to 4 Ton		YES; Upcoast 3/4	YES; Downcoast 1/4	NO	MEDIUM (Downcoast 1/4); VERY LOW(Upcoast 3/4)	Downcoast 1/4 = 10; Upcoast 3/4 = 30	Downcoast 1/4 Poorly Stacked, Has Had Instability; Upcoast 3/4 REJA 1983	Upper 1/2? Covered by Iceplant; Could Not Inspect It
R4	**Between 10th and 11th Ave**	**12/22/2022 & 1/30/2023**	336	Unknown	Unknown	6720	Unknown	Unknown	Unknown	NO; Upcoast 1/3	YES; Upcoast 1/3	NO	HIGH (Upcoast 1/3); UNKNOWN (Downcoast 2/3)	Upcoast 1/3= 0 to 5; Downcoast 2/3 = Unknown	Undersized rock Upcoast 1/3 ; Few Quarrystones Visible; Back Beach Vegetated 12/2022; Monitor When Exposed	Downcoast 2/3 Not Exposed Enough to Inspect Now; Recommend Re-Inspection When Exposed
R5	**Between 8th and 10th Ave**	**1/30/2023**	815	6**	Unknown	16300	Unknown	Unknown	Unknown	MAYBE	Unable to Assess	NO	Unable to Assess	Unknown	Few Quarrystones Visible 1/2023; Monitor When Exposed; May Be Founded on Sand; Downcoast End Has Slumped;	Not Exposed Enough to Inspect Now; Recommend Re-Inspection When Exposed
R6	**At Ocean Avenue**	**1/30/2023**	136	6 to 7			2:1			MAYBE	Unable to Assess	NO	Unable to Assess	10 to 30 years?	Few Quarrystones Visible 1/2023; Monitor When Exposed; May Be Founded on Sand; Downcoast End Has Slumped;	Not Exposed Enough to Inspect Now; Recommend Re-Inspection When Exposed
Stairways																
ST1	**Martin Way**	**12/22/2022 & 1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	YES	UNKNOWN***	MEDIUM***	Regular Maintenance is Essential	Corroded Structural Elements, Footing on Bedrock	Maintenance Is Essential for Pedestrian Safety
ST2	**Santa Lucia Avenue**	**12/22/2022 & 1/30/2023**	NA	NA	Attachment 1	NA	NA	NA	NA	NA	YES	NO	NONE NOW	Regular Maintenance is Essential	Downcoast Railing Bent from Log Impact	Maintenance Is Essential for Pedestrian Safety
ST3	**13th Avenue**	**12/22/2022 & 1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	NO	YES During Scour Events	LOW	Regular Maintenance is Essential	Great Condition, Stairs End on Elevated Bedrock Platform; Consider Extending Stairs to Scoured Beach Level	Maintenance Is Essential for Pedestrian Safety
ST4	**12th Avenue**	**12/22/2022 & 1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	YES	YES	HIGH	Regular Maintenance is Essential	Hazardous; Undermined in EG Fig 1 (20167), Corroded Hardware	Maintenance Is Essential for Pedestrian Safety
ST5	**11th Avenue**	**12/22/2022 & 1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	YES	YES During Scour Events	MEDIUM	Regular Maintenance is Essential	Concrete Treads Worn; Stairs End on Elevated Bedrock Platform; Consider Extending Stairs to Scoured Beach Level	Maintenance Is Essential for Pedestrian Safety
ST6	**S of 10th Avenue**	**12/22/2022 & 1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	YES	YES	MEDIUM	Regular Maintenance is Essential	Needs Minor Tread Work; Corroded Rebar Exposed; Concrete Spalling	Maintenance Is Essential for Pedestrian Safety
ST7	**N of 10th Avenue**	**1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	YES	YES During Scour Events	HIGH***	Regular Maintenance is Essential	Toe of Stairs Undermined by Scour 1/2023; Hazardous; Easton (2016) Said Look at 2008 CRP Photo	Maintenance Is Essential for Pedestrian Safety
ST8	**9th Avenue**	**1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	YES	YES During Scour Events	HIGH	Regular Maintenance is Essential	Stairway Terminates Before Reaching Beach During Scour; Needs Seaward Extension Across Revetment	Maintenance Is Essential for Pedestrian Safety
ST9	**8th Avenue**	**1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	YES	YES	MEDIUM	Regular Maintenance is Essential	Rock and Mortar Steps; Worn Natural Rock Surfaced Treads Create Slippery Condition	Maintenance Is Essential for Pedestrian Safety
ST10	**Ocean Avenue**	**1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	NO	NO	NONE NOW	Regular Maintenance is Essential	Coastal Overlook and Boardwalk; Not Subject to Wave Impact	Maintenance Is Essential for Pedestrian Safety
ST11	**Dunes**	**1/30/2023**	NA	NA	NA	NA	NA	NA	NA	NA	YES	YES	HIGH	Regular Maintenance is Essential	Hazardous; Broken Guard and Handrail on Upcoast Side of lowest Run	Maintenance Is Essential for Pedestrian Safety

Total Armor Length (feet) 4119

Total Coastline Length (feet) 5537

*** = As mapped by Integral consulting; Some structures may not exist or be of different as-built length**

**** = Scattered Spots Along < 10% of Length Observed**

***** = Structural and Corrosion Inspection is High Priority**

APPENDIX B

Carmel Coastal Protection Map
With Structure Identifiers and Structure Lengths
Dated 4-27-2023

S# = SEAWALL NUMBER WITH APPROXIMATE LENGTH IN FEET NOTED

R# = REVETMENT NUMBER WITH APPROXIMATE LENGTH IN FEET NOTED

ST# = STAIRWAY NUMBER

2023-4-27 Carmel Coastal Protection Structures & Stairways

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MEMORANDUM

To:	Mary Bilse, Environmental Programs Manager and Robert Harary, Director of Public Works, City of Carmel-by-the-Sea
From:	David Revell, Integral Consulting Inc.
Date:	October 4, 2023
Subject:	Carmel Climate Change Vulnerability Assessment, Shoreline and Beach Change Analysis: Seasonal and Long Term
Project No.:	C3016

EXECUTIVE SUMMARY

Carmel Beach is a 1.25-mile-long pocket beach with sand constrained by two rocky headlands—Arrowhead Point in the north and Carmel Point and an offshore reef in the south. As a large pocket beach, the volume of sand is mostly contained between the headlands, where very little sediment is gained or lost within the system. Sediment movement within the system can occur either north or south (alongshore) or off and onshore (cross shore) based on seasonal changes in wave energy and direction and in response to large storm wave events. Note that the movement of sediment in coastal environments is a dynamic and ongoing process. Sediment transport at Carmel Beach will be influenced by sea-level rise and increased storminess, which are long-term factors influenced by climate change. This report focuses only on typical historical conditions and does not project the potential hazard at Carmel Beach due to climate change. This will occur in future tasks.

The following is a highlight of this study's major findings for shoreline and beach change organized by **long-term historical trends** (decadal scale), **seasonal trends** (monthly to annual scale), **storm impacts** (event specific), and **recovery** (both seasonal and long term).

Long-term Historical Trends

- Over the last 80 years, while there have been many observed changes in dry sand beach widths due to a sequence of storm and recovery events, there is no long-term erosion trend as evidenced by a relatively stable average shoreline position

derived via satellite measurements. This lack of an erosion trend indicates that there has been a consistent volume of sand in this pocket beach at Carmel Bay.

- The stable beach volume in this area is rather unique in California. Most of the other littoral cells (or beach compartments) have a set of sand sources and a sink (like a submarine canyon) where sand is lost from the beach system.
- On average, dry beach widths were narrower south of 8th Avenue, wider in the north by the Pebble Beach Golf Links, and the widest in the dune-backed areas near the Del Mar parking lot.

Seasonal Trends

- The dry sand beach widths change seasonally, where the narrowest beach widths occur in the spring (after winter storm waves move sand offshore) and the widest beach widths occur in the fall (after small summer waves bring that same sand back onshore).
- The highest range in beach widths occurs around the area of 4th Avenue and Pescadero Canyon (around the offshore rock).
- The beach width remains most consistent in the dune-backed areas near the Del Mar Parking lot, presumably as a result of sand being eroded from the dunes and nourishing that portion of the beach.

Storm Impacts

- The biggest storm impacts occur during strong west swells (often El Niño years), which approach the beach straight on. When erosion is highest, dry sand beach widths are the narrowest as most of the sand is moved from the dry sand beach and into nearshore bars. This erosion and sand transport during storms can expose the sandstone bedrock underlying the sand in some areas resulting in challenges to beach access and damaging coastal armoring. When the beach is narrowest, the waves can break closer to shore, overtop the coastal armoring, and lead to erosion of the cliffs and bluffs.
- The most significant observed cliff erosion ranged between 20–40 ft and was observed following the 1982–1983 El Niño in areas where coastal armoring was already in place.

Recovery

- Recovery of the dry sand beach after large storm events can take a few years. The area south of 8th Avenue usually begins recovery earliest but takes the longest to recover.
- Recovery time varies but is related to waves with smaller wave heights and longer periods and coming from both the north and south angles to the beach.

INTRODUCTION

Purpose of this Study

This study is part of the City of Carmel Coastal Engineering and Hazard Assessment and serves as a technical memorandum to complete the deliverable for Task 2 of the Carmel Climate Change Vulnerability Assessment, Shoreline and Beach Change Analysis: Seasonal and Long Term. This technical memo intends to explain the physical processes that lead to seasonal changes in the beach, document the extent of historic erosion, and quantify changes to the shoreline, cliffs, and dunes.

During this task in the project, large ocean swells associated with the energetic winter storms of 2022–23 caused substantial beach scouring. Examples of these hazardous conditions can be seen in Figure 1 below, where scouring made beach access difficult (see Figure 1, left) and portions of the beach became difficult to navigate (see Figure 22, right).

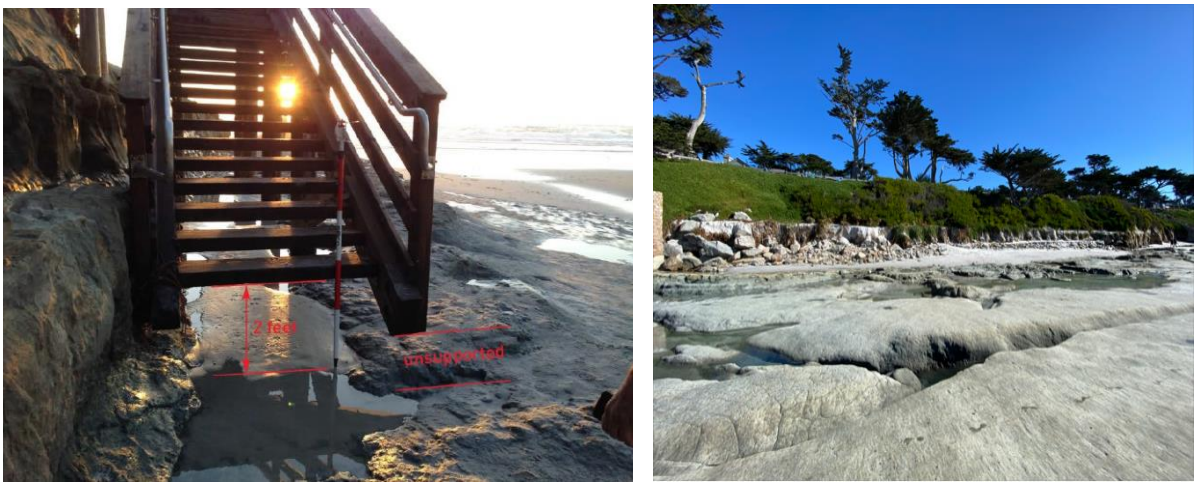


Figure 1. Left, undermined 12th Avenue stairway following the El Niño Winter of 2015–16 (January 24, 2016). Source: Easton Geology (2016)
Right, the beach scoured down to bedrock near 10th and 11th avenues following strong winter storms of 2022–23 (January 30, 2023). Source: HKA (2023).

These storm events highlighted the need to identify priority locations for repairs (see Task 1 report by Haro, Kasunich & Associates, Inc., Carmel Beach Coastal Protection Assessment). As results from Task 1 were presented and the project progressed, some of the key questions being asked by members of the City of Carmel-by-the-Sea for this task included:

- What is the long-term trend in shoreline change, and is there a narrowing of beach widths?
- What changes do large storm events cause?

- How long does the beach take to recover following large storm events?

This study will serve to provide an understanding for how this beach system changes both seasonally and long term, and these findings will inform sea-level rise and coastal hazard modeling efforts for Task 3, Shoreline and Beach Erosion Exposure Modeling, and improve understanding of potential exposure and vulnerabilities to city infrastructure and development for Task 4, Coastal Hazard and Sea Level Rise Vulnerabilities.

Study Area

This study focuses on Carmel Beach within Carmel Bay, illustrated by the brackets in Figure 2. Carmel Beach is a pocket beach extending between Arrowhead to Carmel Points, the city portion of Carmel Beach encompasses the lower three-fourths of this northern pocket beach (from Pescadero Canyon to Carmel Point), with the Pebble Beach section extending north towards Arrowhead Point[1] (see Figure 2). As the city and non-city portions of Carmel Beach form a connected system, the analysis is focused on both portions.

[1] Named for the golf course located just inland of this location and not to be confused with the actual Pebble Beach, a small pocket beach located in the north of Carmel Bay.

Figure 2. Project Study Area.

Beach Sections and Coastal Access

The city beach is a 22.5-acre public park accessed by locals and visitors alike. It is served by an extensive public access system that includes 10 beach access stairways and four sand ramps. Beach access parking is available at the Del Mar Parking Lot (122 spaces), as well as along Scenic Road (127 spaces) and North San Antonio Avenue in the north (10 spaces) (Shonman and D'Ambrosio 2003) (see Figure 3).

The beach sections referenced in this study emerged from the City's Climate Change Vulnerability Assessment report (2021). One of the priorities of this report was to identify how adaptation options and strategies along the coast may vary for four distinct planning areas within the City (see the areas identified in Figure 3). The planning areas identified include:

- Mostly armored cliffs and bluffs along Scenic Road south of 8th Avenue. Henceforth referred to as **Section 1, South Beach** (Figure 4).
- Unarmored dunes along private property between 8th Avenue and Del Mar Parking Lot. Henceforth referred to as **Section 2, Central Beach** (Figure 5)**.**
- Mostly natural, unarmored North Dunes area. Henceforth referred to as **Section 3, North Dunes** (Figure 6).
- Armored private properties on the cliffs at the north end of the City. Henceforth referred to as **Section 4, North Beach** (Figure 7).

For the sake of brevity, each beach section in this memo will be referred to by section number and/or its short name, South Beach, Central Beach, North Dunes, or North Beach. Also included is the beach section north of the City limits, referred to in this study as **Section 5, Pebble Beach** (Figure 8).

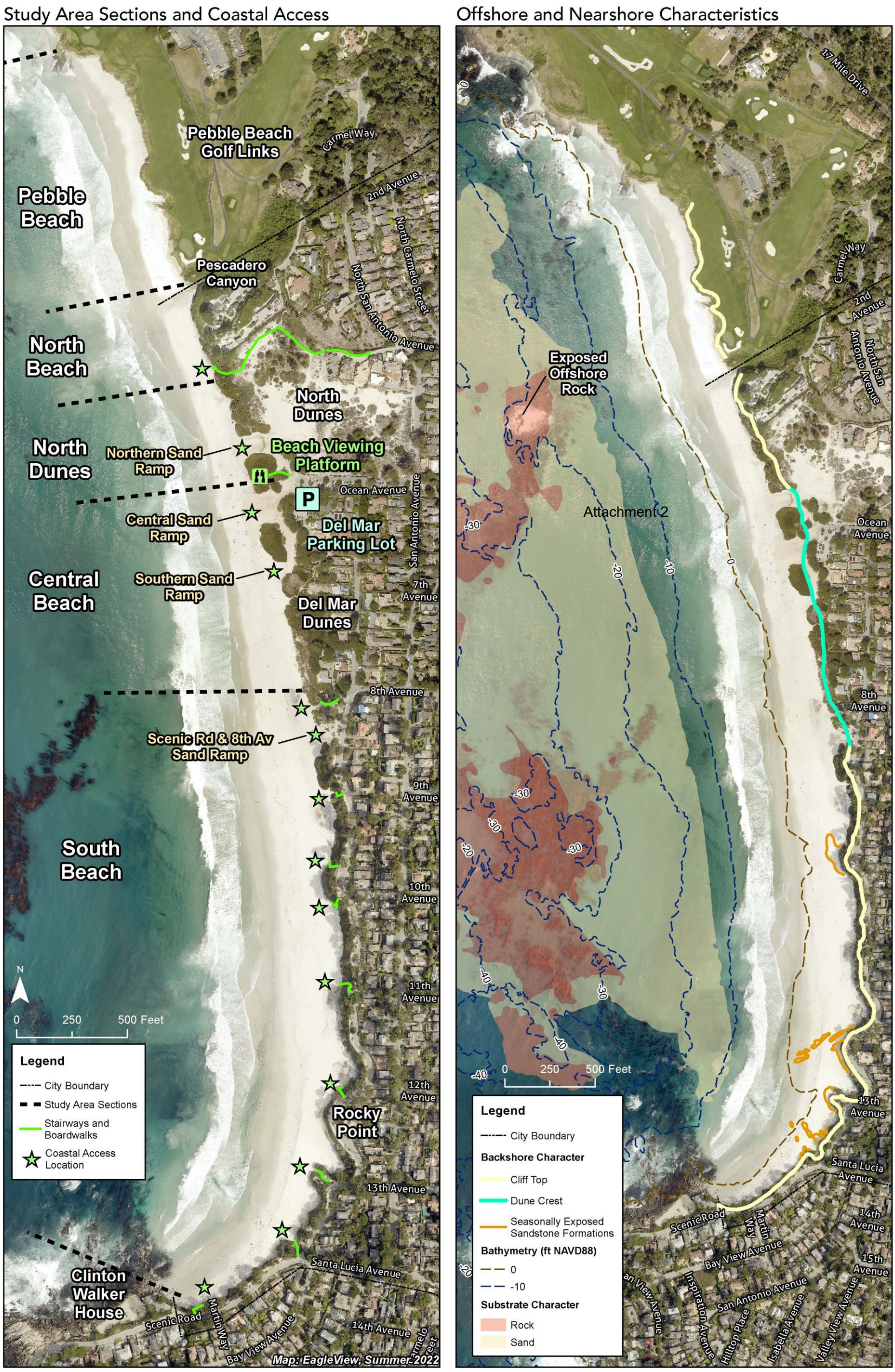


Figure 3. Carmel Beach Sections and Coastal Access (left), and Offshore and Nearshore Characteristics (right)

Figure 4. Section 1, South Beach. Source: California Coastal Records Project (2018)

Figure 5. Section 2, Central Beach. Source: California Coastal Records Project (2018)

Figure 6. Section 3, North Dunes. Source: California Coastal Records Project (2018)

Figure 7. Section 4, North Beach. Source: California Coastal Records Project (2018)

Figure 8. Section 5, Pebble Beach. Source: California Coastal Records Project (2018)

COASTAL PROCESSES AND MORPHOLOGY

The coastal zone is influenced by a multitude of marine forces including tides, waves, and wind, and extends seaward to the point at which waves no longer interact with the seabed. This section will provide an overview of the coastal processes that are pertinent to Carmel Beach. Note that Carmel has cliffs, dunes, and beaches that behave differently and quasi-independently.

Coastal processes that create coastal hazards include tides, waves, and related storm conditions. An important measure of coastal hazards is the total water level (TWL) elevation, which is the combined effect of wave run-up height, storm surge, tides, and sea-level elevations (**Error! Reference source not found.**Figure 9). At Carmel Beach, river discharge is not a contributing factor to TWL in the study area as flows from Pescadero Creek are low, and there is very little interaction with Carmel River and San Jose Creek in the southern Carmel Bay beach compartment due to Carmel Point. A combination of large waves occurring at high tides during storm conditions poses the largest potential threat for coastal erosion. Coastal erosion is comprised of both beach narrowing and cliff retreat. Beach narrowing and cliff retreat are two separate processes, but a narrower beach can lead to increased cliff retreat, which is explained further below. In the future, as sea levels rise, both the wave run-up dynamics and the tidal elevations will change, leading to higher TWLs for longer durations, accelerating both beach narrowing and cliff retreat. Each coastal process is summarized in **Error! Reference source not found.**.

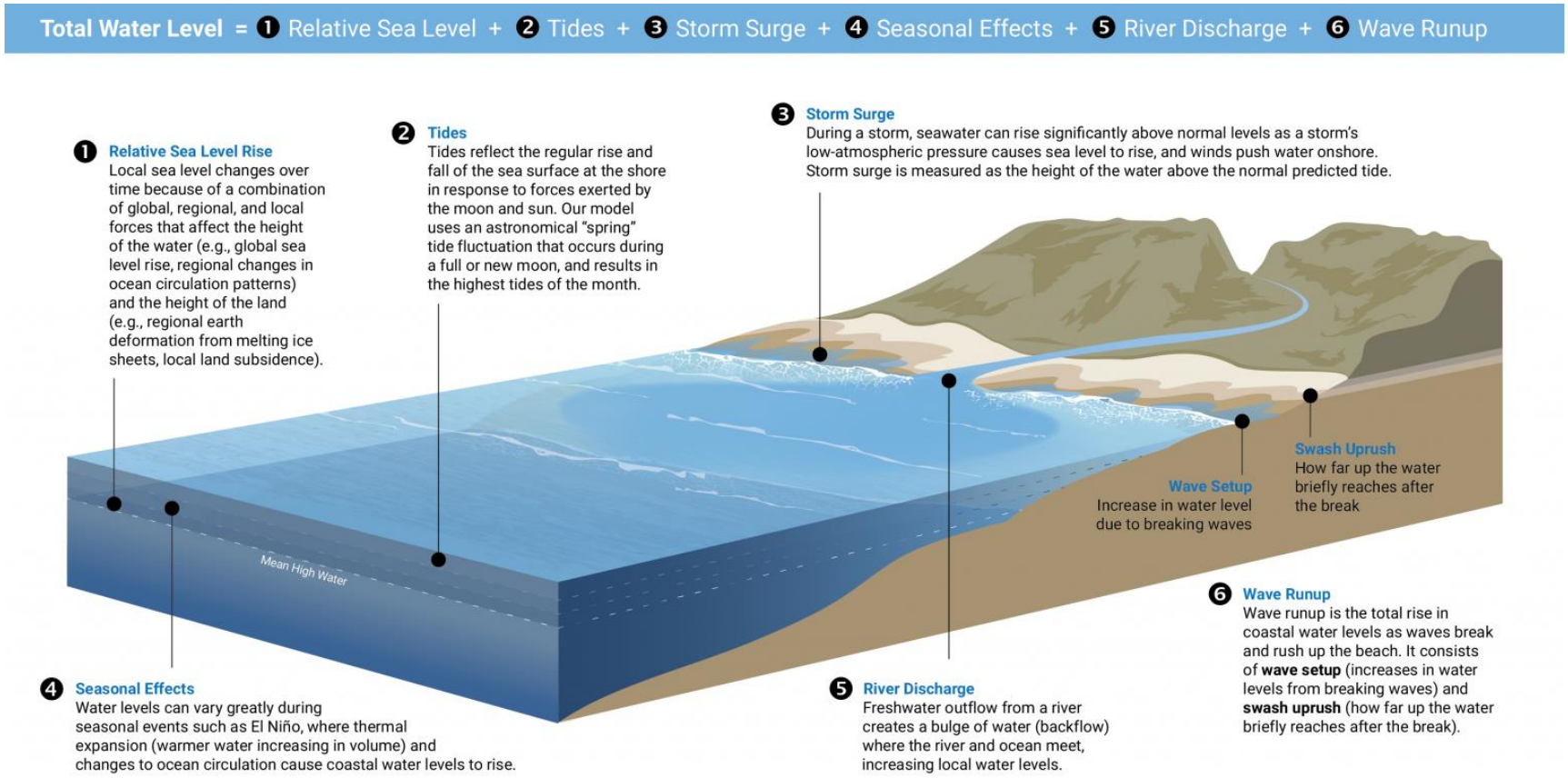


Figure 9. Conceptual diagram of the components of total water level.
Source: Our Coast Our Future Web Platform, Point Blue Conservation Science and USGS (2021).

Tides

Tides in the study area are mixed, predominantly semidiurnal, and are composed of two low and two high-water levels of unequal heights per 24.8-hour tidal cycle. Typically, the largest tide ranges in a year occur in late December to early January when the moon and sun are in alignment and closest in their orbits to the earth. These astronomical high tides are known as “king tides” and often result in coastal flooding unrelated to storm events.

Maximum water levels occur due to astronomical tides, wind surges, wave setup, density anomalies, long waves (including tsunamis), and cyclic El Niño and Pacific Decadal Oscillations. On longer time scales, the tides will reach higher elevations as sea levels rise. The National Oceanic and Atmospheric Administration (NOAA) Monterey tide gauge (Station 9413450) is the closest tide gauge to Carmel with readings extending only to the 1970s, whereas some gauges date back much further. For instance, the San Francisco tide gauges dates back to the mid-1800s. The relative rise in sea level, based on the Monterey gauge, is 1.62 millimeters per year (mm/yr.), based on monthly mean sea level data from 1973–2022, with a 95% confidence interval of 0.70 mm/yr. (Figure 10). This indicates that sea levels have risen 0.3 ft since the early 1970s. These measured local relative sea-level rise trends when compared to the global average provide estimates of land motion. In this case, the land is rising but just not as fast as sea levels.

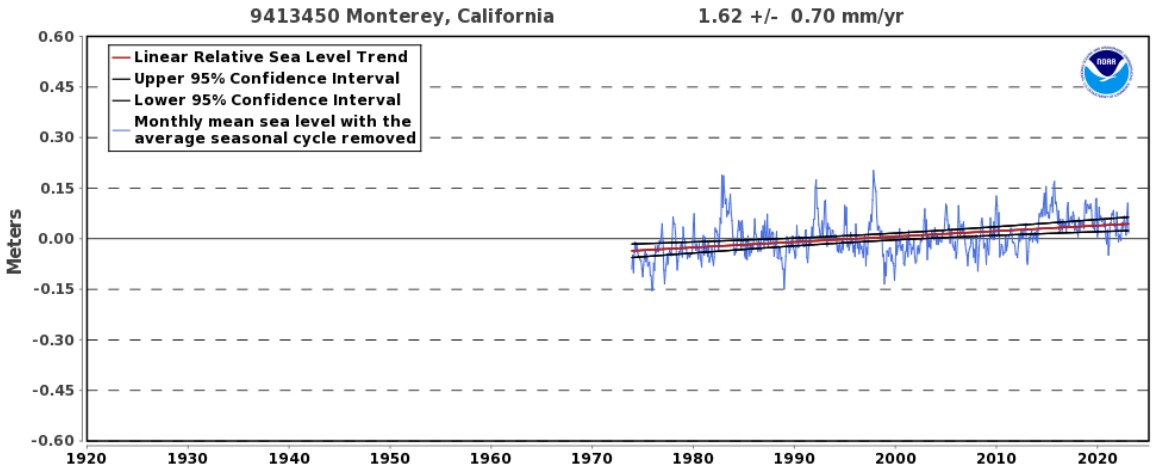


Figure 10. Relative Sea Level Trend for the NOAA Monterey Tide Gauge (NOAA Station 9413450)

Waves

The waves that approach Carmel Beach are characterized by three dominant types depending on their wave source and direction (see **Error! Reference source not found.**)**Error! Reference source not found.**. Most wave energy approaches the study site from the northwest and west (Storlazzi and Wingfield 2005) by waves generated by

cyclones in the North Pacific and tends to peak in wave height during the winter months (up to 25 ft). During the summer, southern hemisphere waves produce smaller waves with longer wave periods (greater than 20 seconds). Between April and October, mid-sized and slightly shorter period wind waves also approach Carmel Beach from the northwest (Storlazzi and Wingfield 2005). In general, smaller waves tend to move sand volumes up the beach profile and feed the dry sand beach while larger waves tend to move sand off of the dry sand beach.

The wave climate fluctuates over interannual and longer time periods with ocean-atmosphere oscillations like the El Niño Southern Oscillation (ENSO). These storms tend to follow a more southerly track when El Niño conditions are strongest, resulting in more erosion potential for the study area. El Niño conditions generally occur every three to seven years, with particularly intense events every 10 to 20 years (Storlazzi and Griggs 1998). There are also longer-term climatic oscillations such as the Pacific Decadal Oscillation (PDO). PDO warm phases have been associated with periods of increased storm frequency and intensity, resulting in accelerated erosion rates (Russell and Griggs 2012).

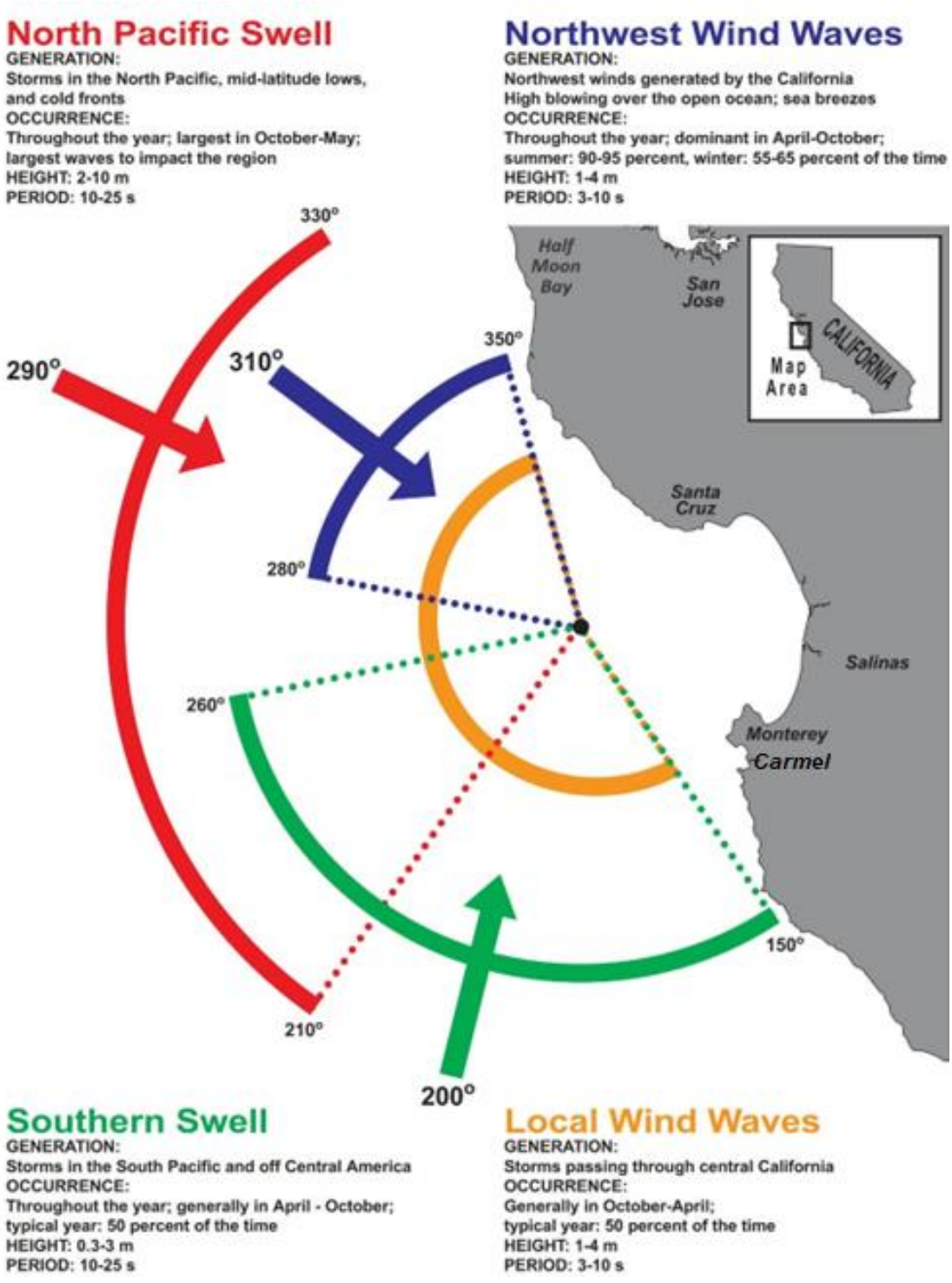


Figure 11. Diagram depicting dominant wave types, directions, and seasons for Carmel Beach and Monterey Bay.
Source: Storlazzi and Wingfield (2005)

FEMA Storm Wave Hazard Zones

The National Flood Insurance Program, administered by the Federal Emergency Management Agency (FEMA), is intended to reduce future flood damage by encouraging local governments to adopt floodplain management regulatory programs. The regulatory Flood Insurance Rate Maps identify base flood elevations according to a 1%-annual-chance TWL elevation at the coast. The base flood elevations are depicted in **Error! Reference source not found.** (right) and vary from 16 to 31 ft. FEMA has determined that the highest wave runup extents between 9th and 11th avenues, and this is the one location where FEMA projects that the current 1%-annual-chance wave runup hazards to overtop the crest of the bluff.

Figure 12. City stormwater and water ponding areas (left), and FEMA 1%-annual-chance storm wave flood extent (right). Water ponding locations represent general areas, and were sourced from differences between winter 2009 and summer 2010 digital elevation models, as well as aerial images from 2003–2022.

Geomorphology

Carmel Beach's sediment originates from the granodiorite formations in the Pacific Grove and Monterey peninsula areas. Additionally, there have been minor contributions from sediment deposition at Pescadero Canyon and erosion of the sandstone cliffs in the central and southern regions of the beach. Eventually, sediment is gradually transported southward through a small channel, making its way out towards the Carmel submarine canyon (Storlazzi and Field 2000). Over the course of geological timescales (i.e., millennia), these sources have contributed to the composition of Carmel Beach.

Over the course of human timescales (i.e., decades to centuries), the sediments in Carmel Bay mostly remain between Arrowhead and Carmel points. Unlike most other California beaches that are located on exposed, open coastlines, Carmel Beach is a pocket beach situated between two headlands. On an open, exposed coastline, a beach can receive sediment from adjacent beaches. At Carmel, however, the headlands impede the delivery of sediment into and out of the beach. Therefore, Carmel receives very little sediment via alongshore littoral transport from the beaches north (Monterey Bay) and south (Carmel River State Beach) (see Figure 2. Project Study Area.Figure 2), and the sediment mostly moves in the cross-shore direction seasonally, as explained below.

Beach Dynamics

A beach is not just the dry sand above the waves; it also includes sediment volumes extending until the offshore. Figure 13 illustrates a cross-shore section of the beach, starting inland and extending offshore. Starting inland, the following describes the different portions of the beach cross section:

- **Backshore**: The dry sand beach starts at the toe of a cliff or dune and extends to the highest of high tides (also known as mean higher high hater [MHHW]). In this zone, the sand might build up to form a berm crest. The dominant force that shapes the beach in this zone is the wind, or aeolian forcing.
- **Nearshore**: This nearshore can also be considered the “surf zone.” This zone extends from the MHHW location on the beach to the offshore point where the sand no longer feels the effects of waves. The dominant force that shapes the beach in this zone are the waves. This section also includes the **beachface**, also known as a foreshore, which is the gently sloping part of a beach that is closest to the water's edge. It is the part of the beach that is typically exposed to the daily rise and fall of tides. The beachface is important in this study because this is the zone that the satellite imagery uses to demarcate the shoreline. The nearshore section also includes sandbars, which are berms of sand that are underwater and in nearshore waters.

- **Offshore:** The offshore portion of the beach is in deeper water. The sediment in this portion does not contribute to the beach since the sediment does not feel wave action at this depth. Dominant forces in this zone are ocean currents.

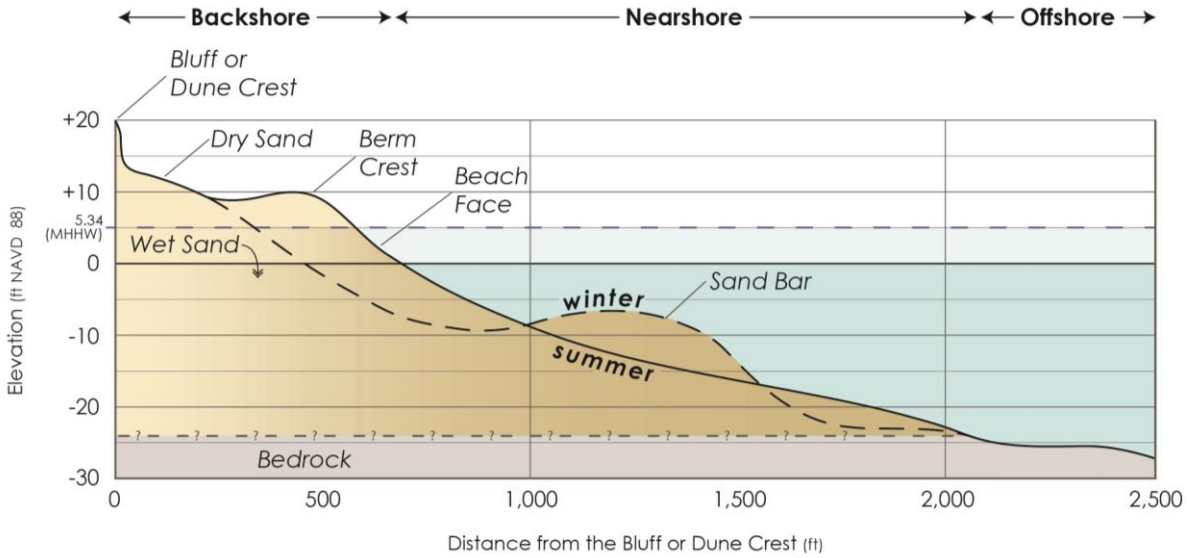


Figure 13. Example of a cross-shore profile showing seasonal change for Carmel Beach. The beach profile changes seasonally with a widening of the beach typically occurring between April and September, and a narrowing of the beach occurring in conjunction with winter storms and large waves, typically occurring in the winter months. The solid black line represents a typical summer profile, with a beach berm forming in spring and summer and a widening of the dry sand beach by as much as 200 ft. The hatched line represents a typical winter profile, with the beach face retreating and a longshore bar developing in the nearshore.
Image adapted from Waves and Beaches by Willard Bascom, 1964 (updated in 2020 by Kim McCoy).

The movement of sediment on and offshore throughout the seasons is influenced by various natural processes, including changes in wave action, tides, and weather patterns. The following is an overview of how sediment can move across the beach profile:

- **Winter season (offshore movement):** During the winter months, storms and strong winds are more common. These weather events generate powerful waves and increased wave energy. Powerful waves can erode the beach face and the backshore, picking up sand and sediment from the beach. Sediment is transported off the beach as the waves carry it away from the shore and onto nearshore sand bars.
- **Spring season (onshore movement):** In the spring, weather patterns often become milder with reduced storm activity. As wave energy decreases, sediment that was transported offshore into nearshore sand bars during the winter begin to

move back toward the shore, which is known as onshore sediment transport. Beaches then experience accretion, where sand is deposited back onto the beachface, widening the shoreline.

- **Summer season (onshore movement and stabilization):** During the summer, waves are typically calmer, and the beach may stabilize as sediment transport slows down. Beaches may reach their widest points during this season, providing ample space for beachgoers and recreational activities.
- **Autumn season (variable conditions):** In the autumn, weather patterns can vary, with occasional storms and changing wave conditions. Sediment movement can be influenced by the specific weather events that occur during this season. Storms can lead to erosion and offshore sediment transport, while calmer periods may promote onshore sediment transport and beach accretion.

Note that the movement of sediment in coastal environments is a dynamic and ongoing process. Sediment transport will also be influenced by long-term factors, such as sea level rise, increased storminess, and changes in the underlying geology. This report focuses only on historical typical conditions, and does not project the hazard of sea level rise and potential erosion in the future.

Cliff Dynamics

The Carmel cliffs are comprised of variable materials, and each material will erode differently depending on its strength and other factors. Three types of material comprise these backshore areas: 1) marine terraces that are generally composed of loose deposits of layered sands, clays, and gravels; 2) dune sands (largely quartz sands) and 3) generally dense sandstone bedrock, often overlayed by deposits of siltstone and claystone (Shonman and D'Ambrosio 2003).

In nearshore waters, sediment pockets overlay and fill areas of sandstone bedrock, which are punctuated by areas of Salinan Block granodiorite (see Figure 3, right). This rock serves as a holdfast for kelp, which is visible in many aerial photos offshore of the South and North Beach areas. Approximately 1,000 ft seaward of the North Beach section near Pescadero Canyon an offshore rock outcrop emerges from the bay, and these rocks can affect wave refraction and breaking wave patterns.

Carmel Beach is backed by sandstone cliffs and sand dunes. The cliff-backed portions make up 64% of the city's backshore and are comprised of sandstone overlayed by loose terrace deposits (see Figure 3, right). The dune-backed portions of the shore comprise 36% of the city's backshore and are comprised of sandstone at an unknown depth and location, overlayed by windblown dune sands and dune vegetation (see **Error! Reference source not found.**, which shows the underlying sandstone exposed).

Figure 14. The exposed sandstone formation, indicated in red, located at the central sand ramp near the Del Mar Parking Lot.

Cliff erosion and bluff failures tend to happen more rarely and are episodic in nature. There are different mechanisms for failure or erosion, and these can be divided into two different types. The first type of failure mechanism is driven by coastal forces (i.e., waves and tides), and will be directly related to whether or not the beach is wide or narrow; a wider beach will protect the cliffs and bluffs from wave exposure. The second type of failure is driven by terrestrial forces (i.e., rain, stormwater, groundwater), and is not affected by beach widths. The two types of failures are detailed below:

Coastal-driven failure mechanisms: Powerful waves, especially during storms, can directly impact terraces and cliffs. The force of the waves and the backshore currents that are created can lead to abrasion of the sandstone rock, undercut the base of the cliffs, and lead to failures and collapse of the terraces above. Tides can also contribute to erosion, especially when powerful waves coincide with high tides. At these times, wave runup can exceed the crest elevation of the coastal armoring, and erosive forces can reach the softer terrace deposits and topsoil. The repeated wetting and drying of the materials in the terrace deposits can also lead to weakening over time. Wind-driven spray from breaking waves can further saturate terrace soils and accelerate failures along the bluff face.

Terrestrial-driven failure mechanisms: Other erosive forces include those from subaerial forces including stormwater runoff and focused sheet flow. This is most pronounced during periods of heavy rainfall, which can saturate the topsoil, lead to runoff that can carry away loose sediments and make terrace areas prone to landslides. In addition, the

movement of groundwater within the bluff or terrace can erode materials from within, weakening their structural integrity.

CARMEL BEACH: A BRIEF OVERVIEW AND HISTORY

Carmel Beach is a dynamic landscape featuring a diverse range of cliff and dune formations. These formations have been impacted by human actions that have ultimately shaped the beach into its present state. This section will detail these geomorphic processes and provide an overview of human influences, synthesizing their interplay in the evolution of Carmel Beach.

Figure 15 provides a shore-parallel cross section of the varying vertical cliff and dune formations, as well as a diagram of coastal armoring locations and seasonal beach widths. Along the beach, the contact between the less consolidated softer marine terrace deposits and the dense sandstone basal unit varies but tends to be lower in the Central Beach section between 11th and 8th avenues, and highest in the North Beach and South Beach. Sandstone underlies the terrace for the entirety of the beach, however in the central portion of the beach, remnant windblown Pleistocene sand dunes and dune vegetation overlay the basal sandstone geologic unit (James C. Reynolds and Associates 1986, Shonman and D'Ambrosio 2003).

Since 1958, the City—and to a lesser extent, private homeowners—have built numerous seawalls and riprap revetments to protect portions of the shoreline cliffs and bluffs. Seawalls and revetments protect about 68% of the city's backshore, including a large private seawall in the north and numerous City-maintained seawalls in the south. Riprap revetments can be found throughout the beach, primarily in the wider beach areas in the north of Section 1 as well throughout Sections 2 and 3. The locations and conditions of these are documented extensively in the Task 1 report by Haro, Kasunich & Associates, Inc. (2023). Since the 1960s, the City has often managed sand to improve access along the city's sand ramps and cover the riprap revetments for both appearance and public safety (see Beach Management section below).

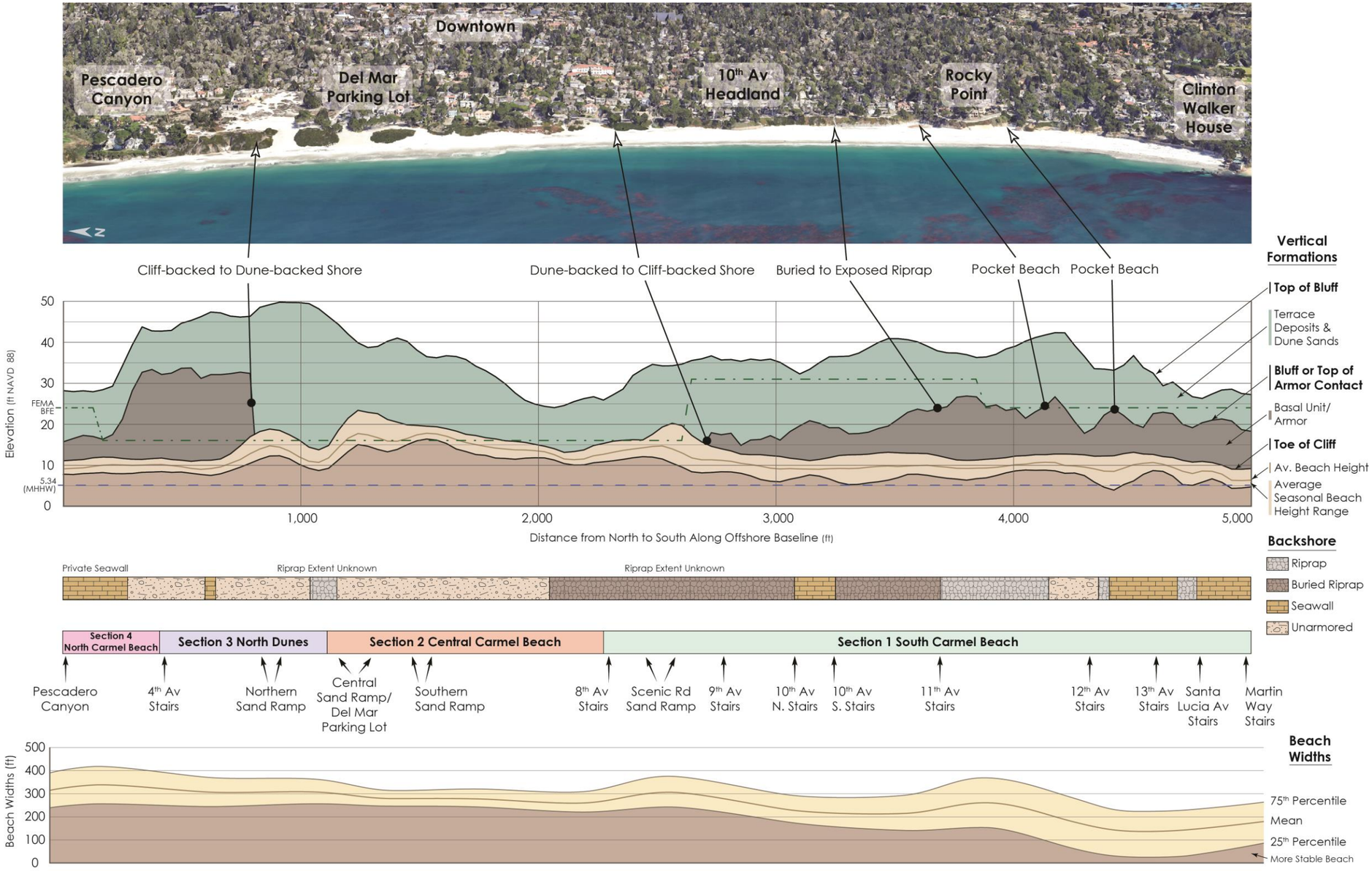


Figure 15. Beach locations (first/top panel), a cross section of the geology (second panel), a depiction of backshore protection (third panel), beach sections (fourth panel), and beach width measurements from CoastSat (fifth/bottom panel). Note that the mean 25th and 75th percentile beach widths are from the entire satellite-derived beach width dataset (years 1984–2021). Approximately half of the linear distance of the city's shoreline protection structures are seawalls; however, as they have been built on many crenulated portions of the backshore, this distribution is not reflected in the figure, which follows a linear path along the foreshore.

Table 1. Beach sections, geomorphology, backshore protection, beach width, and flood height information

Name and Extent	Geomorphology	Backshore Characteristics	Beach Width Range 25th-75th Percentiles	FEMA Flood Elevation
North Beach Pescadero Canyon to 4th Avenue	Sandstone overlayed by terrace deposits up to 45 ft	Private seawall near Pescadero Canyon and unarmored cliffs	Relatively wider beach with some variability 200–400 ft	24 ft (max) 16 ft (min)
North Dunes 4th Avenue to the Central Sand Ramp	Sandstone overlayed by windblown beach sands ranging between 25–50 ft	Mostly unarmored, one sea wall protecting an outfall, and buried riprap	Relatively stable beach 280–310 ft	16 ft
Central Carmel Beach Central Sand Ramp to 8th Avenue	Sandstone overlayed by windblown beach sands ranging between 25–35 ft	Mostly unarmored and some buried riprap (the extent of this riprap is unknown)	Relatively stable beach 280–310 ft	16 ft
South Carmel Beach 8th Avenue to Martin Way	Sandstone overlayed by terrace deposits between 25–45 ft	Mostly armored with riprap and seawalls	The narrowest beach width with the greatest seasonal variability 150–300 ft	31 ft (max) 16 ft (min)

The highest beach widths are found in the central and northern sections of Carmel Beach (between Pescadero Canyon to 8th Avenue), with beach widths of around 300 ft. As higher and wider beaches serve to dissipate storm wave impacts, there is a clear connection between seawall armoring and narrower average beach widths. The average beach width declines south of 8th Avenue, with the lowest average beach width of 100 ft located around the small rocky headland at 13th Avenue. The range of beach widths shows the extent to which seasonal change occurs, indicating that sections that experience the greatest scouring also experience the greatest recovery.

The variability of dry sand beach widths (explained in more detail in the Dry Sand Beach Widths section), is usually due to seasonal changes as opposed to inter-annual changes. The southern section (south of 8th Avenue) has the highest variability in the dataset, with beach widths ranging 175 ft (50–225 ft) between the 25th and 75th percentiles. The northern sections (between Pescadero Canyon and the Central Sand Ramp) also had high variability, generally ranging from 150 ft (between 250–400 ft). The most stable beach

section is found in the largely unarmored dune-backed stretches of the Del Mar and North dunes. The beach widths in these sections usually range approximately 50 ft (between 250–300 ft) between the 25th and 75th percentiles.

Beach Management – Sand Redistribution Program, Beach Berm, and Water Ponding

The city's sand redistribution program has involved bulldozing sand from the lower beach (located above high tide line) to the upper beach and is intended to improve public safety and compensate for sand that is naturally pushed downslope by visitors (see Figure 16). This program has been in place since the 1960s and originally operated below the Del Mar parking lot in late spring/early summer. Starting in 1984, the sand redistribution plan expanded, and sand was also bulldozed to cover the riprap revetments (see Figure 17 as a reference from 2003). The total sand redistribution volume varies between 50–100,000 cubic yards depending on conditions (mild winter requires less sand movement than severe winters) (Shonman and D'Ambrosio 2003).

Figure 16. Active Beach Management near the Del Mar Parking Lot
Source: Coastal Records Project (August 2003)

Figure 17. Beach management with sand bulldozed over the riprap revetments near 13th Avenue
Source: Coastal Records Project (August 2003).

During the spring and early summer, beach-building process lead to the development of a wide sand berm in the foreshore of the beach. Behind this berm, the sand level will typically be lower. Intermittently, and most often during periods of high tide, wave runup can overtop the berm and settle in the lower areas of the back beach. During fall and early winter, stormwater runoff can also create scour pockets near the city's outfalls and rain and stormwater can settle in these lower areas. Figure 12 (left) shows the locations of the city's outfall network as well as the general locations of water ponding.

BEACH WIDTH DATA AND ANALYSIS METHODS

This study builds on a large body of work including the City's Shoreline Management Plan (2003), Coastal Access and Recreation Element (2003), Coastal Resource Element (2003), Climate Change Vulnerability Assessment (2021), as well as numerous other studies, including those led by Willard Bascom in 1945–47. This study relies primarily on publicly accessible shoreline position data from CoastSat extending from 1984–2021, digital elevation models from 1997–2018, aerial photos from 1941–2022, as well as storm damage photos and firsthand accounts of city staff and residents.

Datasets

The primary datasets used in this analysis include:

- Waves
    - NDBC Buoy Station 46042 (NOAA)
- Shoreline Position
    - CoastSat shoreline positions ~monthly from 1984–2021 (University of New South Wales and USGS)
    - Aerial photographs from 1941–2022 (numerous sources)
- Elevations
    - Digital elevation models, 8 flights from 1997–2018 (NOAA, U.S. Geological Survey [USGS], FEMA, U.S. Army Corp of Engineers, Association of Monterey Bay Area Governments)
    - Beach profile surveys by Willard Bascom, monthly from 1946–47 (archived and sourced from the University of California, San Diego [UCSD])
- Others
    - Reports, historical photos, winter of 2022–23 field visits.

Dry Beach Change Analysis

Seasonal and interannual beach width trends were assessed using satellite-derived shoreline positions between 1984 and 2021. These approximately monthly shoreline positions were sourced from the CoastSat project; an open-source and joint development effort between the Water Research Laboratory of the University of New South Wales in Sydney, and USGS (Vos et al. 2019). CoastSat extracts shoreline positions from Landsat 5, Landsat 7, Landsat 8, Landsat 9, and Sentinel-2 satellite images with a horizontal accuracy of +/- 10 m (33 ft) and provides the largest repository of historical shoreline positions for Carmel Beach with over 15,000 observation records. CoastSat delineates the shoreline as the wet/dry line in each satellite image (see orange shoreline, **Error! Reference source not found.**). Beach widths, therefore, represent the visible dry sand beach and are representative of the distribution of sand across the entire nearshore profile. This wet/dry line was determined at every time step where there was a non-obscured image (usually due to cloudy or foggy weather) available; about monthly or bi-monthly.

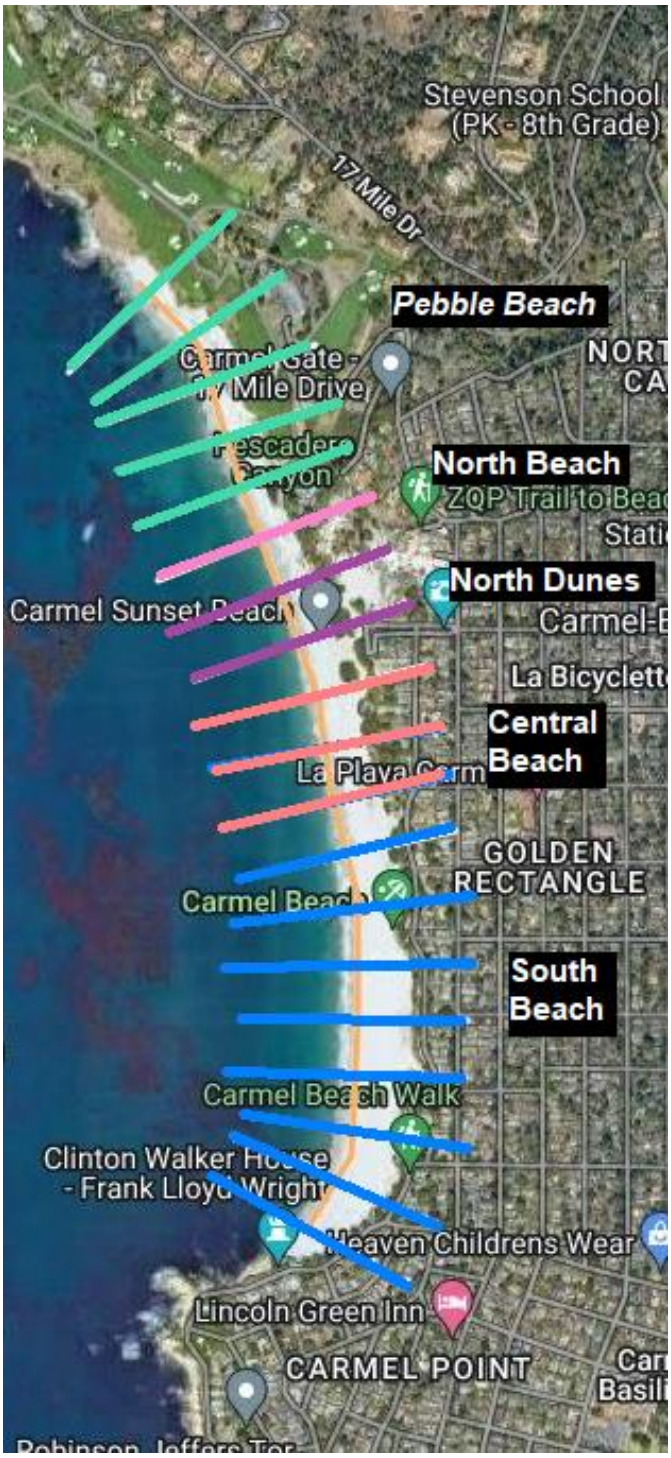


Figure 18. CoastSat transects and groupings based on beach section. Interactive map and data available at: http://coastsat.wrl.unsw.edu.au/

For this study, 18 cross-shore transects were grouped by section: South Beach, Central Beach, North Dunes, North Beach, and Pebble Beach. At each transect, a backshore toe location was determined for the most landward side of the transect, and this toe location was subtracted from the shore position to determine a dry sand beach width for each time step. These dry sand beach widths were then analyzed for overall, seasonal, and interannual trends, and the findings are presented below.

Caveats

The analysis in this report included the years when there was an active sand redistribution program on the City portion of the beach. Therefore, the natural evolution of the beach is not necessarily observed but one that is influenced by the City's redistribution efforts. The sand redistribution program moves sand the lower beach to the upper beach, a process that largely mimics, but speeds up, the natural process of beach width recovery through wind and wave action. The nuances of how this program has influenced the CoastSat shoreline positions cannot be determined. In the data, it may register as the beach building out faster over the long term than it naturally would (i.e., faster recovery rates).

Cliff Erosion Analysis

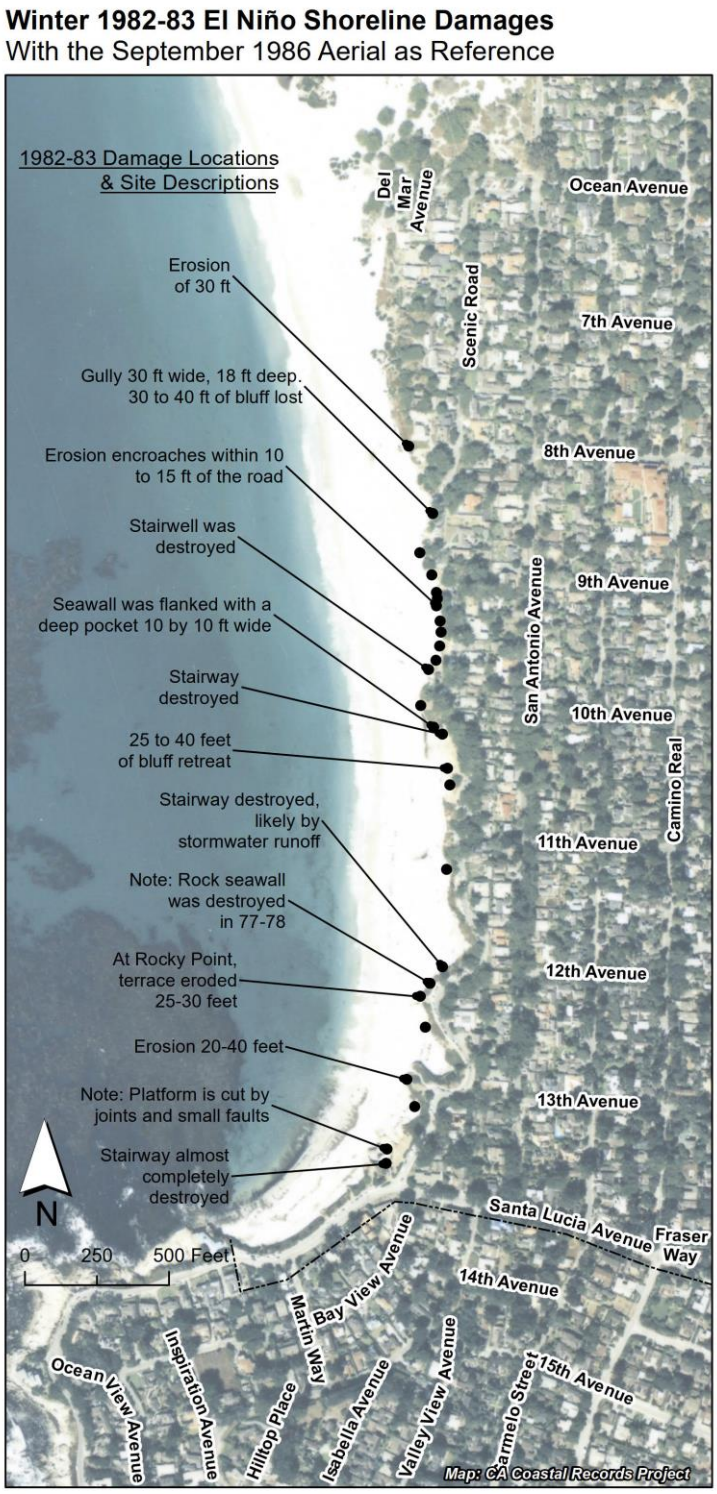
Typically, the evaluation of the long-term trend in cliff erosion is performed by comparing a series of historical aerials and surveys. However, along the City's shoreline, this is made difficult by shoreline protection and recovery efforts including the filling and armoring of eroded areas following storm events. The majority of these occurred following the Carmel Beach Rehabilitation Project (1983–1988), where the City added significant fill material to Carmel's coastal bluffs following erosion events, Scenic Road was repaved, the seaward curb and pedestrian pathway was redesigned (moving the bluff top edge seaward), and the stormwater system was rebuilt and conveyance improved to reduce future erosion (Shonman and D'Ambrosio 2003).

In addition, determining a cliff top position is made difficult due to a lack of georectified and high-resolution historical aerial photographs, as well as obstructions from the dense vegetation along the City's bluffs. However, the unarmored cliffs along the Pebble Beach Golf Links can be used as a proxy for a similar geologic setting, and the results can inform what a long-term erosion rate[2] for the city may have been without human intervention[3].

[2] It is important to note that erosion of an average annual sense can be a bit misleading, since erosion rarely occurs during average conditions, but rather larger failures tend to occur during major storm events.
[3] Cliff face areas along the Pebble Beach Golf Links have been armored as well, however much less so than the city portions of the beach.

The Integral Consulting Inc. (Integral) team analyzed shoreline position change for ~1,000 ft of the largely unarmored cliffs along Pebble Beach, stretching along the 10th fairway to Pescadero Canyon. The team used the Digital Shoreline Analysis System (DSAS) tool from USGS, which enables the calculation of rate-of-change statistics from multiple historical shoreline positions. It provides an automated method for establishing measurement locations, performs erosion rate calculations, and provides the statistical data necessary to assess the robustness of the erosion calculations.

CLIFF EROSION



The cliffs and bluffs along the City's shoreline have endured numerous erosion events, with perhaps the most notable in recent memory being the 1982–83 El Niño winter. As recounted in local media and post-storm surveys, the beach was heavily scoured following a series of storms. This left the bluffs less protected from wave attack and exposed them to considerable amounts of subaerial erosion processes. The City contracted Rogers E. Johnson and Associates to perform a post-storm assessment, and a map of observed damage locations from the assessment can be found in

Figure 19 (Rogers E. Johnson and Associates 1984).

Figure 19. Winter of 1982–83 shoreline damages. Observations compiled from Rogers E. Johnson and Associates

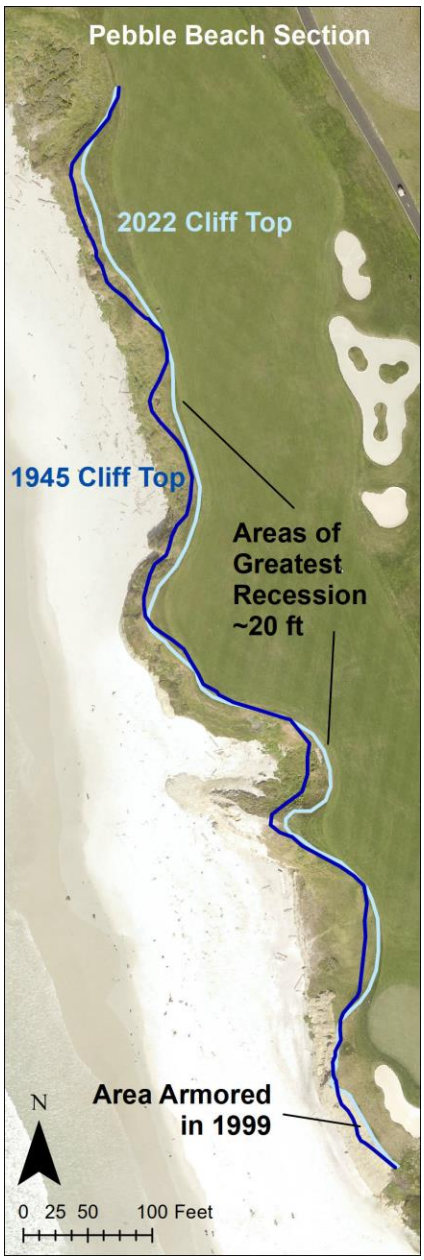


Figure 20. Bluff-top position for the Pebble Beach section along Carmel Beach.

As part of this 1984 assessment, Rogers E. Johnson and Associates calculated the long-term trends in historical erosion between 1908 and 1983. They determined that the northern portion of the beach experienced **4.8 in./yr.** of erosion and the southern portion experienced **3.6–8.4 in./yr.**; with much of this erosion occurring in the winter of 1982–83. This included some major erosion hotspot locations such as 30 ft of bluff loss between 8th and 9th avenues, 25–40 ft of bluff between 10th and 11th Avenue, 20–40 ft of bluff between 9th and 10th avenues, and 30 ft of bluff near Santa Lucia Avenue (Rogers E. Johnson and Associates 1984). It is important to note that the large erosion distances observed during this event occurred on bluffs that already had coastal armoring.

As part of the background investigation, the Integral team reviewed other erosion studies, including the UCSD and Scripps Historical Coastal Erosion Study (Zuzanna and Young 2022) and the USGS Statewide Assessment (Hapke and Reid 2007). The UCSD Scripps Study found negligible (0.0001 in./yr.) erosion between 2010 and 2016, likely due to the very short sample period. The USGS Statewide Assessment is reported for the area from Point Piños to Gorda and shows **11.8 in./yr**. from 1930s to 2002; however, this is for a much wider area of study.

The Integral team used the DSAS tool to determine both an endpoint erosion rate and a linear regression erosion rate for the Pebble Beach section of cliffs. The average bluff top recession from 1945 to 2022 was found to be just over 1 in./yr (as an averaged linear rate), with the greatest erosion occurring at two locations where erosion averaged ~3 in. a year or ~20 ft total (see the areas noted in).

These bluff top erosion rates will be incorporated into the next phase of work projecting future coastal erosion distances exacerbated by sea-level rise.

DRY SAND BEACH WIDTHS: SEASONAL AND STORM EVENT RESPONSE

Seasonal Dry Sand Beach Widths

Analyzing the trends in the CoastSat dataset, the change in dry sand beach widths over time (variability) was mostly due to seasonal, rather than interannual (i.e., between years) changes, with beach widths being the narrowest in the spring months and widest in the fall months (Figure 21). To determine how the beach widths changed throughout the year, the shoreline positions were averaged over each month for all of the years in the dataset, and the results are presented in Figure 21**Error! Reference source not found.**. The sections between 4th Avenue and 8th Avenue (North Dunes and Central Beach) were more stable throughout the year than the other sections, since they had more similar winter and summer beach. The ends of the beach, south of 8th Avenue (South Beach) and north of 4th Avenue (North Beach), were the least stable throughout the year, since they had the narrowest beach width in the winter and widest beach width in the summer. The southern section had the narrowest beach widths overall, particularly in the winter season.

Widening and narrowing along the beach happened at different times for different sections of the beach. Both the extreme north (Pebble Beach) and south were more likely to recover earlier in the year, with beach widths widening beginning in late winter (i.e., March), whereas the central areas of Carmel Beach often recovered later in the year, with beach widths widening in the late spring or summer (i.e., June). The first section of the beach that eroded was Pebble Beach; Pebble Beach began to narrow in the late summer.

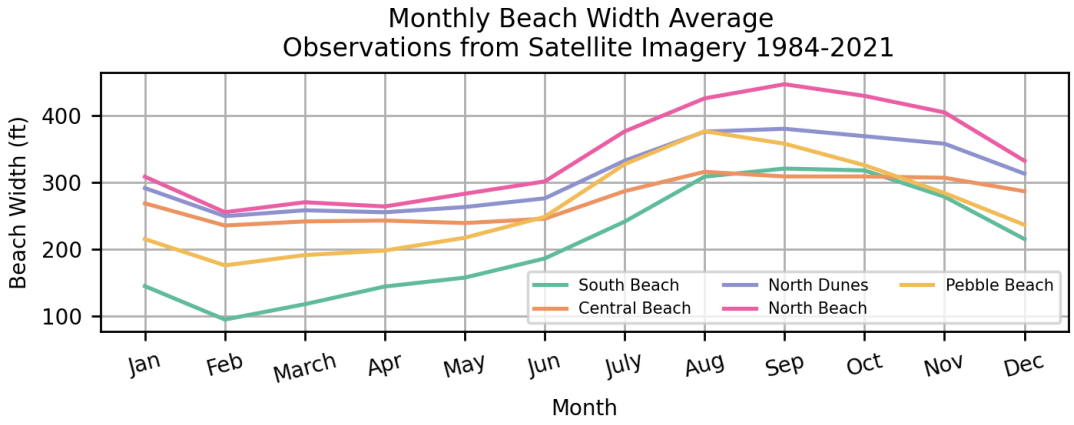


Figure 21. Beach widths were averaged by month for the entire dataset and grouped by beach section. The beach widths show a seasonal oscillation.

Beach Volume Change; Storm Response

During major storms, which are more frequent and intense during El Niño years, large storm wave events can scour and narrow the protective beach. In addition, large storms bring high rainfall, which saturates and weakens coastal bluffs, elevates sea levels causing waves to break closer to shore, and is often accompanied by larger waves leading to more erosion. Storlazzi and Griggs have found that 75% of shoreline erosion and damage has occurred during El Niño winters, and the moderate- to high-intensity El Niños do most of the damage (Storlazzi and Griggs 1998).

Figure 22. In response to winter storms (seen here in 2023), it is common for the steep sand dunes around Del Mar Avenue to scarp on the seaward edge (left), and for scouring to expose the underlying base of sandstone outcroppings (right) and footings of the coastal armoring in the southern areas of the beach.
Source: Integral Consulting (February 1, 2023)

The winter of 1997–98 was a very strong El Niño for California with one of the wettest winters on record. This marks the first major El Niño event where digital elevation surveys are available both pre- and post-storm season. The changes in beach elevation and volumes correspond with the CoastSat dry sand beach width data, with a significant narrowing of areas south of 8th Avenue and much less in the dune-backed Del Mar and North Dunes areas. The North Dunes area even saw some accretion, perhaps explained by sediment eroding from the upland dunes down onto the dry sand beach and foreshore. The maximum scour of sand levels between fall and spring was ~14 ft, with a total of ~300,000 cubic yards of sand moved from the beach into nearshore bars (see Figure 23). By comparison, the City's summer sand redistribution program moves 50,000–100,000 cubic yards of sand depending on conditions (Shonman and D'Ambrosio 2003).

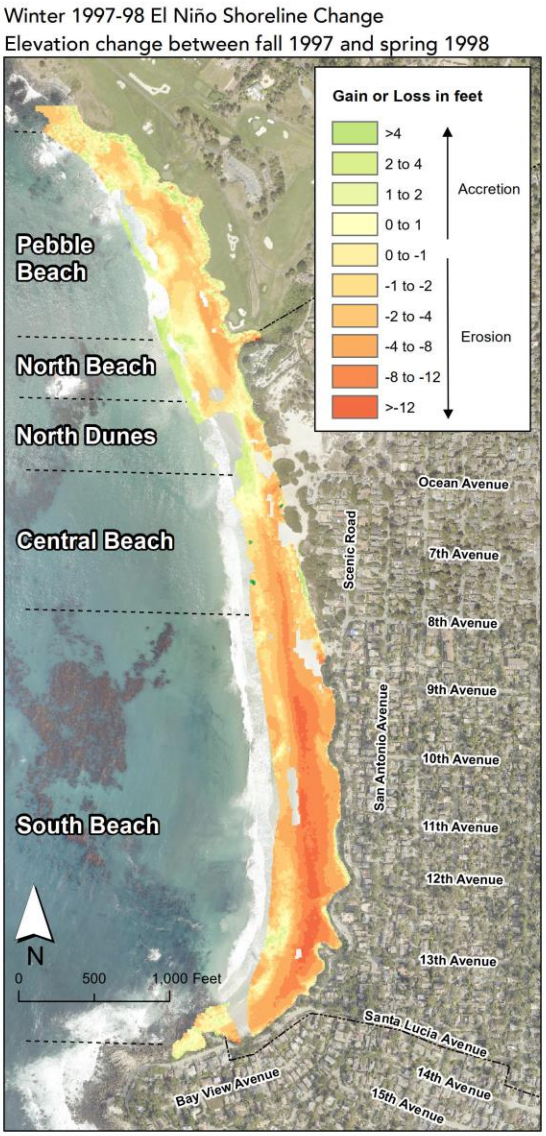


Figure 23. Beach elevation change following the El Niño winter of 1997–98

The beach scouring that occurred in the winter of 1997–98 corresponds with observations and documentation of other El Niño years that have occurred.

Following the 1982–83 El Niño, City staff reported that the level of back beach areas was 4 to 10 ft lower than it normally is in July (Rogers E. Johnson and Associates 1983). In addition, significant erosion took place in the Del Mar Dunes, which led to the placement of engineered revetments, and necessitating the City to restore the dunes to their original size (Shonman and D'Ambrosio 2003).

According to city inspections in January 2016 (another El Niño year), measurements showed that the sand level on the beach along the south side of 12th Avenue had dropped by nearly 6 feet. Sand began to be redeposited at various shoreline sites during February, and this became very noticeable in the coves at 12th and 13th Avenues later in the season (City of Carmel-by-the-Sea 2016).

LONG-TERM DRY SAND BEACH WIDTH CHANGE AND RECOVERY

Overall, while the shoreline was variable both seasonally and in response to large storm events, it showed a mostly stable long-term trend between 1984 to 2021 across all beach sections. To examine any long-term trends in dry sand beach widths, the beach widths were averaged by year, and the results are plotted in Figure 24.

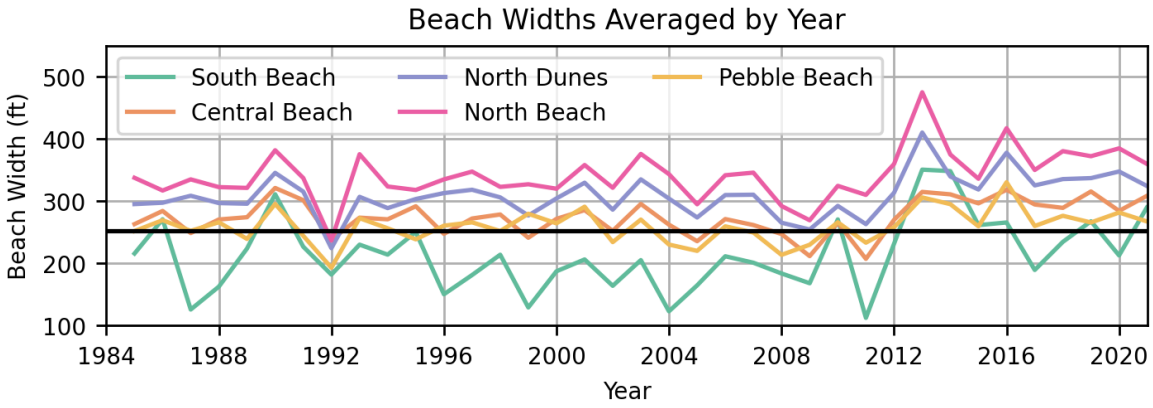


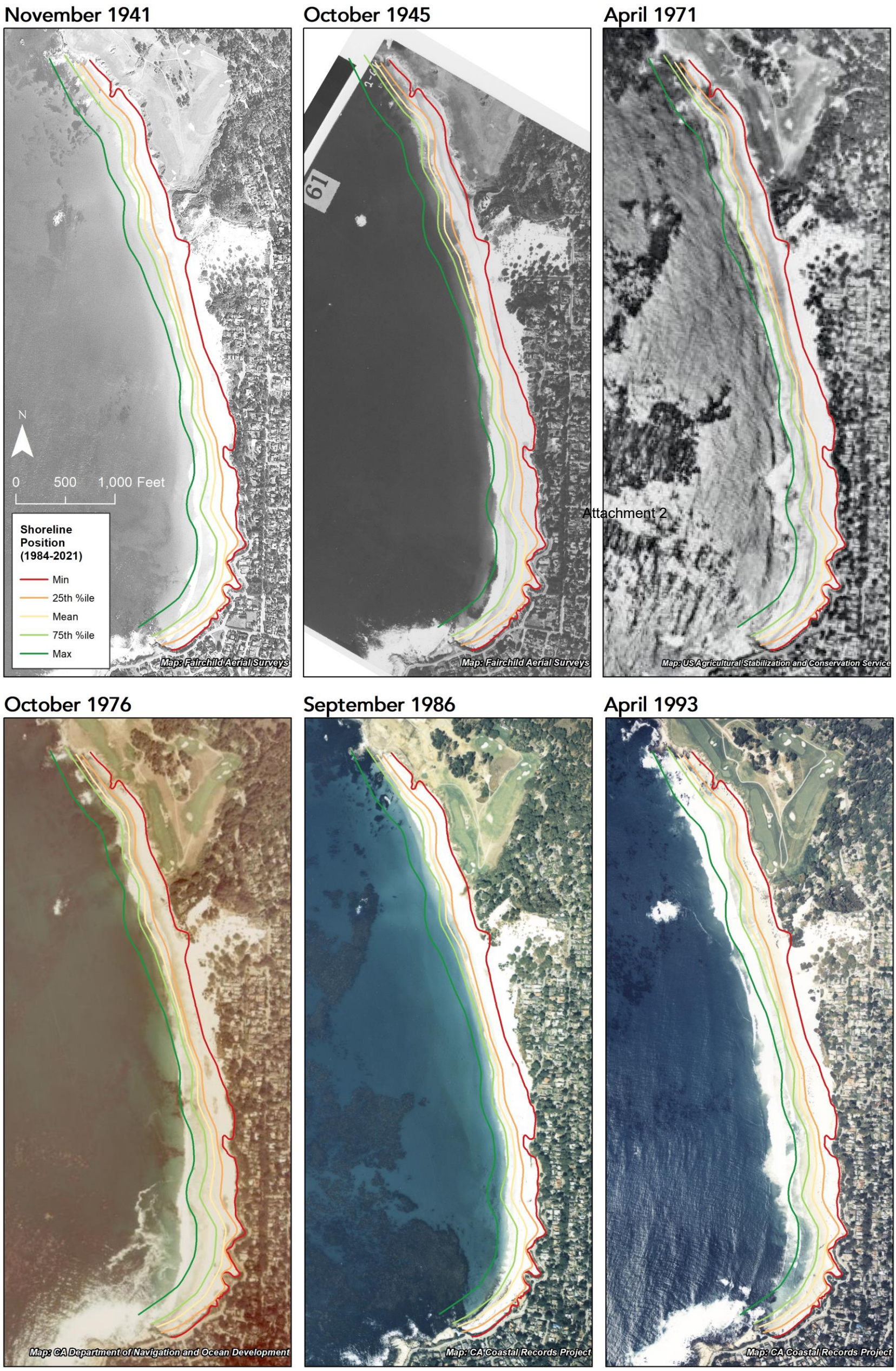
Figure 24. Beach widths were averaged by year for the entire dataset and grouped by beach section. The beach widths are generally stable and deviate about a mean.

The beach widths average about 250 ft without any significant trend (no obvious accretion or erosion) in the 40-year dataset. This provides good evidence that over the last 40 years, the sand volume in the Carmel Bay pocket beach has stayed relatively constant.

Overall, dry sand beach widths are lower for the ends of the beach (Pebble Beach and South Beach), and higher in the central portions, which can also be seen in satellite images of April 1971, October 1976, April 1993, and spring 2006 (Figure 25, Figure 26).

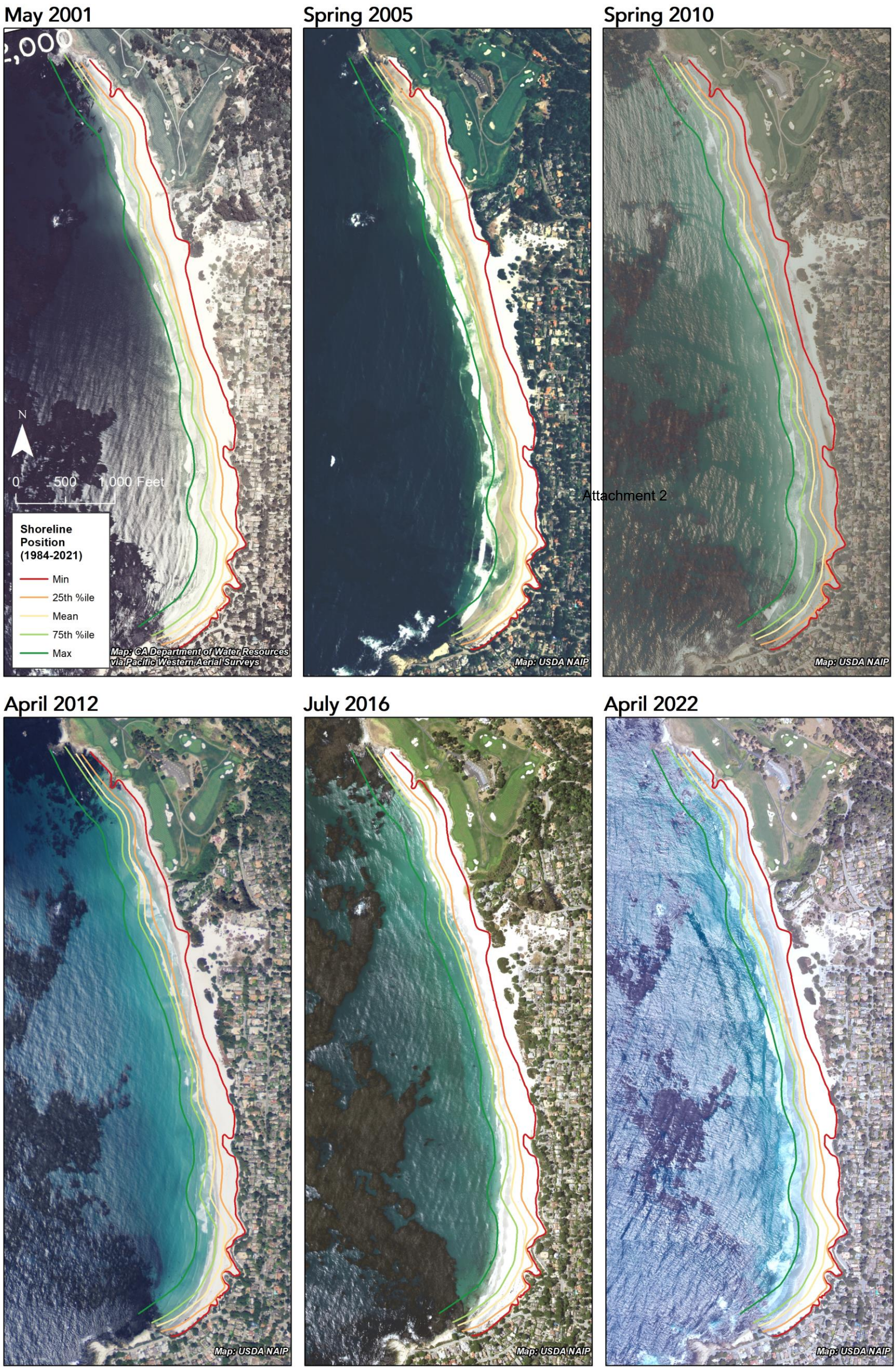
The southern section of the beach has had historically lower beach widths than the other sections, and a particularly good example of a narrow southern beach section can be seen in the spring 2005 image (Figure 26). A particularly narrow beach occurred in 1992 (which is likely related to the 1992 El Niño), and 2009 and 2011, when the beach widths dropped to below average (Figure 26). An example photo of a narrow Carmel Beach can be seen in the spring of 2010 (Figure 25). After 2011, all dry sand beach widths recovered to higher than average, before decreasing after 2013 to below or about average. Example photos of wide beach widths can be seen in September 1986, May 2001, and July 2016 imagery (Figure 25, Figure 26). In recent years, since around 2018, the southern section of the beach has seen wider beach widths than the extreme northern section (Pebble Beach).

Figure 25 and Figure 26 also show that the widest beach widths did not occur in the earliest aerial images of 1941 and 1945, providing additional evidence that sand volumes in Carmel Bay have likely been relatively stable over the last 80 years.



Attachment 2

Figure 25. Aerial time series for select years from 1941–1993 with shoreline beach positions from 1984-2021.



Attachment 2

Figure 26. Aerial time series for select years from 2001–22 with shoreline beach positions from 1984–2021.

Beach Width Recovery

Recovery Time Scales and Rates

One of the questions that the Carmel community has been asking, especially after the energetic winter erosion from January and February of 2023, is about the timing of the dry sand beach recovery. To address this question, the recovery time scale was defined annually as the number of days that it took for a beach to build back up from the most eroded position (narrowest beach width) to the most accreted position (widest beach width) for that year. The recovery rate is defined as the speed (measured by the number of days) for the beach to go from narrowest to widest as calculated as the distance the beach recovered divided by the number of days the beach took to recover. Figure 27 shows that higher recovery rates correspond to a lower number of days, meaning that the beach recovered quickly in that specific year. On average, it took the beach ~160 days (about 4 months) at a rate of 1.2 ft/day for the beach to reach its maximum position. Fast recovery rates tended to follow El Niño events, as seen in the years 1993 and 2016, showing that the beach wants to build back up to a mean position.

Interannual recovery for each beach section can also be seen in Figure 24 when beach widths increase. After the 1992 El Niño, beach widths for all beach sections dropped and then recovered the following year (1993), except for the southern portion of the beach. Beach widths for the southern portion of the beach remained narrow until about 2013 when it recovered again. The years 2011–2013 also saw high recovery rates, when beach widths widened until the 2014 El Niño when they narrowed again.

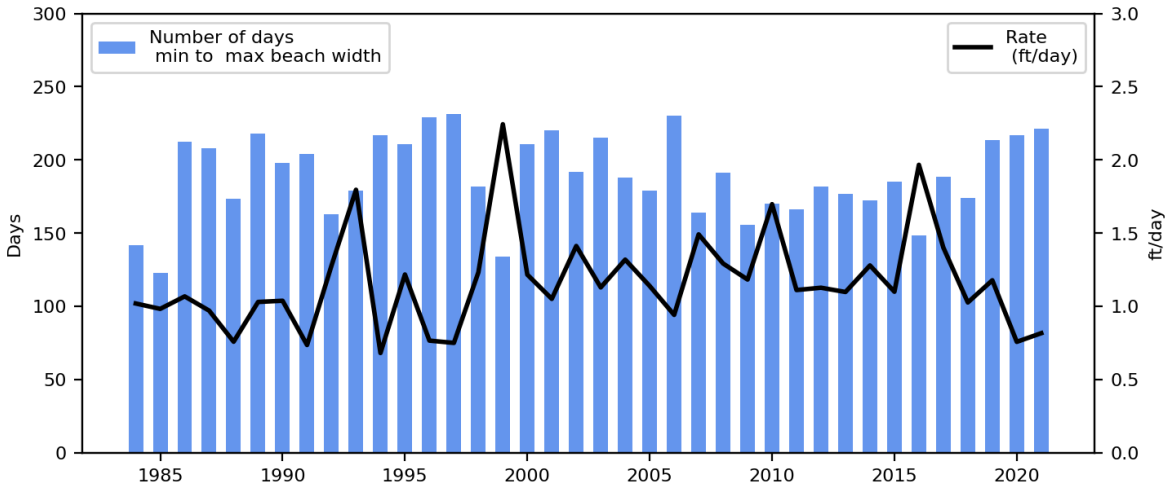


Figure 27. Recovery time scales. Note the sharp peaks in recovery rates around the stronger El Niño years of 1997–98 and 2014–16.

Wave Conditions During Dry Sand Beach Recovery

It is generally understood that beach recovery occurs when waves are smaller and have longer periods. To examine what conditions contributed to high recovery rates, an analysis of the offshore wave conditions that co-occurred with high and low recovery rates was conducted (Table 2). Table 2 divides the wave conditions into three wave directional categories, and then identifies the average wave height and period for each direction. Results show that faster recovery rates corresponded with waves that came from either the north or south and not head-on, and the southern waves have smaller wave heights and longer periods than lower-recovery years. Seasons with lower recovery rates had more waves coming head-on (from a western direction) and larger waves from the north and south.

It appears that a combination of north and south-angled waves, smaller wave heights and longer wave periods are associated with higher recovery rates. However, it is not clear how the relative contributions of the wave direction and smaller wave heights drive physical processes to accelerate recovery rates. A more detailed analysis of recovery events, including spectral information from the wave buoys, and potentially numerical model simulations would be required to determine more specific characteristics and the dynamic details of the recovery process.

Table 2. Wave conditions that co-occur for recovery. Wave data are taken from the Monterey Bay buoy. Each row represents wave information from a different direction. The first row is waves from the northwest/north northwest, the second row is waves from the west. The wave information is the percentage of waves, wave height, and wave period.

	Recovery rate > 1ft/day	Recovery rate 0–1ft/day
Northwest Bin (Waves coming from the north >310 degN)	**13% of waves** Average wave 6.3 ft @ 8.7 seconds	**12% of waves** Average wave 7.2 ft @ 8.7 seconds
West Bin (Waves coming from 240-310 degN, head-on)	**75% of waves** 6.5ft @ 10.8 seconds	**81% of waves** 6.6ft @ 10.7 seconds
Southwest Bin (Waves coming from 180-240 degN, head-on)	**12% of waves** 4.6ft @ 15.5 seconds	**7% of waves** 4.8ft @ 14.4 seconds

CONCLUSIONS

Large storm waves have historically caused dramatic short-term erosion impacts along Carmel Beach that have damaged coastal accessways, narrowed the dry sand beach, and led to the construction of coastal armoring along more than half of the City's backshore. Through analysis of historical reports, aerial and satellite imagery, shoreline position trends, and beach volume changes, Carmel Beach has shown no long-term erosion trend.

This positive finding appears related to a relatively stable volume of sand in this pocket beach constrained in the north by Arrowhead Point, in the south by Carmel Point, and offshore by the granodiorite basal rock.

Based on a 40-year record of approximately monthly shoreline positions, dry sand beach widths vary seasonally and in response to large wave events which narrow the beaches and move sand into nearshore sandbars in the winter and then onshore back onto the dry sand beaches in the summer. An analysis of Willard Bascom's studies on Carmel Beach dating to the mid-to-late 1940s, highlights that this has been occurring for over 80 years.

There has been considerable concern among community members over the future of the dry sand beach and shoreline, especially in response to rising sea levels and potential climate change-induced shifts in weather patterns. Over the short term, the beach will continue to narrow and recover seasonally, and given the stable sand volumes, these seasonal dynamics and storm response and recovery can be expected to continue.

However, as sea levels rise rates accelerate and wave heights increase, various bluff-top and upland resources and infrastructure may be more significantly impacted by erosion, and the narrowing of the beach with additional beach elevation scour caused by more routine interactions with existing coastal armoring may become more frequent and significant.

The extent and potential implications of erosion to Carmel's beaches and bluffs to sea level rise will be explored further in Task 3, Shoreline and Beach Erosion Exposure Modeling. Once this modeling is completed, a vulnerability assessment will be completed to identify potential impacts on the various City assets, infrastructure, and upland development in Task 4, Coastal Hazard and Sea Level Rise Vulnerability.

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ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

backshore	Extreme inland limit of the beach
basal unit	Lower geologic formation of the cliff (sandstone in Carmel)
bluff	Soft unconsolidated materials found in the marine terrace deposits
bluff contact	Location where the bluff meets the cliff
bluff top	Location where there is an identifiable break from the steeper cliff and bluff to the gently sloping inland areas
cliff	Hard consolidated rock under the bluff
CoSMoS	Coastal Storm Modeling System (USGS)
DEM	Topographic Digital Elevation Model
dry sand beach	The portion of the beach that is landward of the mean high water mark
DSAS	Digital Shoreline Analysis System (USGS)
erosion (coastal)	Can refer to either beach narrowing and cliff retreat. For cliffs, this refers to the long-term loss or removal of land due to coastal or terrestrial processes. For beaches, this may refer to either the long-term, short-term, or localized (see scouring) removal of sediments from the beach.
ENSO	El Niño Southern Oscillation
FEMA	Federal Emergency Management Agency
MHW	Mean high water
MHHW	Mean higher high water
MLW	Mean low water
NAVD 88	North American Vertical Datum of 1988 (NAVD 88). The vertical control datum used for surveying.
NOAA	National Oceanic and Atmospheric Administration
PDO	Pacific Decadal Oscillation
scour (beach)	Process by which waves and currents remove sediment from the beach (usually localized)
shoreline	Typically where water meets the land. In this report, it refers to the wet/dry line

toe of the cliff	Location where the dry sand beach meets the base of the cliff
TWL	Total water level. The combined effect of wave run-up height, storm surge, tides, and sea level elevations
USGS	U.S. Geological Survey

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CITY OF CARMEL-BY-THE-SEA
Climate Committee
Staff Report

November 16, 2023
ORDERS OF BUSINESS

TO:	Climate Committee Members
SUBMITTED BY:	Mary Bilse, Environmental Programs Manager
SUBJECT:	Review list of Adaptation Strategies for Climate Action and Adaptation Plans and Provide Feedback for Monitoring the Implementation of the Plans

RECOMMENDATION:

Review list of adaptation strategies for Climate Action and Adaptation Plans and provide feedback for monitoring the implementation of the Plans.

BACKGROUND/SUMMARY:

In September 2019, the City of Carmel-by-the-Sea (City) began the process of developing Climate Adaptation and Action Plans that would establish a roadmap to reduce local greenhouse gas (GHG) emissions and adapt to climate change. In August, 2022, the Carmel City Council adopted Resolution 2022-064 adopting the City of Carmel-by-the-Sea's Climate Adaptation Plan and Climate Action Plan.

The Climate Adaptation Plan and Climate Action Plan include numerous projects, initiatives, and programs that will be implemented over many years. Several projects have been completed including the purchase of an electric sweeper, electric vehicles, electric bicycles, preparation of an energy efficiency study (Willdan), electric heaters in City facilities, and coordination with PG&E to develop more Electric Vehicle charging stations at City facilities and parking lots. The City has initiated the coastal engineering study to determine potential pathways for sea level rise adaptation, and updating the City's design guidelines. Additional projects and initiatives are also included in the 5-year Capital Improvement Plan.

At the November 2023 Climate Committee Meeting, the Committee will discuss the status of the implementation of our Climate Action and Adaptation Plans (**Attachment #1 - Climate Adaptation Tracking Table,** and **Attachment #2 – Climate Action Plan Implementation Table**). Both the Adaptation Plan and Action Plan spreadsheets show the short-term vs. medium-term and long-term actions as well as a column for project status and notes.

FISCAL IMPACT:

Cost ranges to implement the actions are included in the Climate Adaptation Tracking Table and Climate Action Plan Implementation Table. Some actions will require minimal capital investment and will primarily rely on staff time to implement, while other actions will require large capital investments in excess of $100,00 for each action to complete.

ATTACHMENTS:

Attachment #1 - Climate Adaptation Tracking Table
Attachment #2 - Climate Action Implementation Table

City of Carmel-by-the-Sea Potential Adaptation Strategies

Background

Carmel-by-the-Sea (City) is currently experiencing, and will continue to experience, climate change impacts, including stronger storms, increased wildfire risk, sea level rise, extended drought conditions, and increased temperature. The City developed a Climate Adaptation Plan to increase resilience of the community and assets in Carmel-by-the-Sea. In September 2019, a Climate Committee was convened to develop and guide the preparation of the Climate Adaptation Plan. The City published a Climate Change Vulnerability Assessment in July 2021. The Vulnerability Assessment characterizes climate hazards that will impact the community and City-owned assets, describes the community's major climate vulnerabilities, and identifies work that has already been done by the City to improve resilience.

This workbook provides the City's Climate Adatpation Goals, Policies and Actions to take to improve the resilience of its community members, natural environment, infrastructure and built environment. The adaptation goals, policies, and actions were developed to address all priority assets at risk in the City's Vulnerability Assessment. The **All Goals, Policies & Actions** tab shows all adaptation goals, policies and actions developed. The **Near-Term**, **Mid-Term**, and **Long-Term** tabs provides actions to be completed in the near term, mid-term, and long-term, respectively (organized by goal and policy) to support implementation.

Definitions

Goals: Broad statements describing community desires. The Carmel-by-the-Sea adaptation goals are modeled after the Adaptation Vision and Principles developed by the California Governor's Office of Planning and Research (OPR) Integrated Climate Adaptation & Resiliency Program (ICARP). Each goal is focused on increasing the resilience of one of the following broad asset categories: community, natural assets, and infrastructure and the built environment.
Policies: Specific position statements that support the achievement of goals and serve as guides to City Council, Planning Commission, and city staff, when making decisions.
Actions: Specific methods to implement and achieve policies and goals.

City of Carmel-by-the-Sea Adaptation Strategies

Goal/Policy/Action	Climate Hazard	Asset	Metric	Timeframe	Implementation Lead	Cost	Source
Goal 1. A Healthy, Safe, and Resilient Community							
Policy 1.1. Provide effective emergency preparedness and response in anticipation of potential climate-related disasters				Near-term (1-2 years); Mid-term (3-5 years); Long-term (5-10 years)		$-Low (<$50K); $$-Medium ($50K - $100K); $$$-High (>$100K)	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies
Action 1.1.1. Maintain and Update Evacuation Plan. Maintain and update an Evacuation Plan every 8 years at a minimum to account for all types of emergencies. The plan should focus on the most vulnerable groups including the elderly community and persons with disabilities.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Evacuation Plan updated every 8 years, with the first update by 2023	Near-term (by 2024) and Ongoing	Police & Fire	$	Suggested by Climate Committee Members
Action 1.1.2. Update Emergency Preparedness. Incorporate climate change risk and impact considerations into Carmel-by-the-Sea CERT programming and materials to promote emergency preparedness at a neighborhood block-by-block scale. CERT to promote block-by-block scale emergency preparedness by organizing City by blocks and recruiting Block Captains.	All	Residents, Local Businesses, Second Homes	Number of block captains formed, climate change risk incorporated into CERT materials	Near-term (by 2024)	Police & Fire	$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions
Action 1.1.3. Collaborate with Monterey Fire. Collaborate with Monterey Fire on its inspection and outreach efforts to reduce fire risks. Continue to coordinate with the CERT program and reach out to new potential outreach partners such as local businesses, community groups, and utilities to help distribute information to increase resident and homeowner awareness and knowledge of how to prepare for emergencies.	Wildfire	Residents, Local Businesses, Second Homes	Number of meetings held with Monterey Fire and CERT program; educational materials distributed	Near-term (by 2024)	Police & Fire	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 1.1.4. Publicize Local Evacuation Routes. Publicize both City and Monterey County evacuation routes for the community on the City's website, and in the newsletter and brochures. Target additional outreach to the most vulnerable such as the elderly and people with disabilities in the event of a wildfire or other disaster.	All	Elderly Population and People with Disabilities, Residents	Educational materials distributed	Near-term (by 2024)	Police & Fire	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 1.1.5. Evaluate Evacuation Route Capacity. Evaluate evacuation route capacity, safety, and viability under a range of emergency scenarios and identify and implement mitigating actions in 2022, in accordance with Assembly Bill 747.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Analysis evaluating evacuation route capacity completed	Mid-term (by 2027)	Police & Fire	$$	Assembly Bill 747 Requirement
Action 1.1.6. Evacuation Alternatives and Access. Identify neighborhoods that have single ingress/egress, pursuant to Senate Bill 99, and develop and employ evacuation alternatives, such as a gathering facility, and/or alternative emergency access routes in those neighborhoods. Evaluate potential congestion issues in the event of an evacuation and develop and maintain a list of residents who may have difficulty evacuating. Evaluate options to provide evacuation, such as a shuttle service, for residents with mobility challenges.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Analysis identifying neighborhoods that have single ingress/ egress and evacuation alternatives completed; List of limited-mobility residents developed	Mid-term (by 2027)	Police & Fire	$$	Senate Bill 99 Requirement
Action 1.1.7. Develop Local Partnerships to Increase Resistance to Wildfire Structural Damage. Work with local community groups to publicize the Firewise Community Certification program (e.g., on the City website and in the newsletter and brochures) and encourage resident involvement.	Wildfire	Residents, Second Homes	Number of meetings held to publicize Firewise Community Certification	Mid-term (by 2027)	Police & Fire	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Policy 1.2. Focus adaptation efforts and engagement on the most vulnerable populations.							Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies
Action 1.2.1. Establish a Resilience Hub. Formally designate a physical resilience hub, such as the Youth Center or Public Library, and make it available during extreme heat events, poor air quality, severe weather events, and other highly hazardous conditions for use by the community. Provide the following essential resources in the resilience hub(s): health programming and resources, food, refrigeration, charging stations, basic medical supplies, and other emergency supplies. Electrified heating and cooling paired with backup power sources like battery storage provides redundancy and continues services in the event of a power outage. Designate a virtual resilience hub on the City website where residents can access information about the physical resilience hub and resilience efforts.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Resilience Hub established; Existing facilities upgraded to provide all essential resources	Near-term (by 2024)	Public Works / Police & Fire / Library	$$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions
Action 1.2.2. Limit the Impacts of Climate Change on the Most Vulnerable Populations. Develop a framework to define equity in Carmel-by-the-Sea and develop adaptation approaches that are equitably implemented.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Carmel-by-the-Sea Equity Framework developed	Mid-term (by 2027)	Community Planning & Building	$	Inspired by the City of Berkeley Existing Building Electrification Strategy
Action 1.2.3. Engage the Community. Develop educational materials notifying the community about the resilience hub and how to access it by sharing updates across city and community channels. Partner with the CERT program and block captains, and community groups, to prioritize disadvantaged/marginalized communities including the elderly and individuals with disabilities.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Community engagement plan developed	Near-term (by 2024)	Library / City Hall / Police Department	$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions

Action 1.2.4. Social Support Network. Collaborate with the Carmel Foundation and other community-based organizations (e.g., Carmel Residents Association) to develop an inventory of locations with isolated elderly residents and people with disabilities and develop a plan for a social support network to increase resilience to climate change, for example by promoting home electrification.	All	Elderly Population and People with Disabilities	Social support network created; Inventory of locations created	Mid-term (by 2027)	Police Department / CERT / Community Planning & Building	$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions
Action 1.2.5. Back-up Power for Vulnerable Populations. Coordinate with 3CE, PG&E, and emergency management services to establish backup power and emergency grid shutdown protocols that protect the most vulnerable populations.	All	Elderly Population and People with Disabilities	Number of households with backup power established	Long-term (by 2032)	Police & Fire / Public Works	$$$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions
Policy 1.3. Minimize health impacts of climate change.							Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies
Action 1.3.1. Partner with Monterey County Health Department. Coordinate with Monterey County Health Department to develop and enhance disaster and emergency early warning systems to incorporate objective data and information for potential health threats such as heat-illness, and illnesses complicated by low air quality due to climate change hazards. Include information on early warning systems and other resilience efforts on the City's virtual resilience hub (Action 1.2.1.)	All	Elderly Population and People with Disabilities, Residents, Local Businesses, Service Industry Workers	Emergency early warning systems updated	Near-term (by 2024)	Police & Fire	$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions
Action 1.3.2. Initiate a Heat Pump Retrofit Program. Create a program to help fund property owners to convert HVAC units to heat pumps, which provide water heating and space heating in addition to cooling and can improve indoor air quality and community adaptation to extreme heat. Include a microgrid energy storage component to increase power reliability. Prioritize at-risk populations for retrofit incentives.	Wildfire, Increased Temperature	Elderly Population and People with Disabilities, Residents, Local Businesses, Service Industry Workers	Number of heat pumps installed; Number of heat pumps serving at risk residents	Mid-term (by 2027)	Community Planning & Building	$$	Inspired by the City of Berkeley Existing Building Electrification Strategy
Action 1.3.3. Invest in Improving Resilience in Critical Facilities. Invest in sustainable backup power sources to provide redundancy and continued services for critical facilities, including City Hall, Carmel Police Department, Carmel Fire Department, the Libraries, and assisted living facilities, in the event of a power outage triggered by a climate event.	All	Elderly Population and People with Disabilities, Residents	Number of critical facilities with sustainable backup power sources.	Mid-term (by2027)	Public Works	$$$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions
Action 1.3.4. Conduct a Feasibility Study for Existing Building Electrification and Back-up Power. Perform an electrification feasibility study/existing building analysis in order to understand the potential for, and associated costs of, electrification retrofitting, including heat pumps, along with on-site energy generation and battery storage to provide a more resilient back-up power supply. Establish a plan for reducing or eliminating natural gas from existing buildings, potentially through a reach code, and building resilience to potential electrical grid shutoffs.	Wildfire, Increased Temp	Elderly Population and People with Disabilities, Residents	Feasibility Study for Existing Building Electrification and Back-up Power completed	Mid-term (by 2027)	Public Works	$$	Inspired by the City of Berkeley Existing Building Electrification Strategy
Action 1.3.5. Improve Resilience in Existing Building Stock. Develop a program for identifying funding and incentives to weatherize residential and commercial buildings that addresses severe weather protection, energy efficiency, indoor air quality improvements, and other housing improvements. Include an outreach	All	Elderly Population and People with Disabilities, Residents	Nubmer of retrofitted structures	Long-term (by 2032)	Community Planning & Building	$$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies (City of Placentia policy) Passive House Principles
Action 1.3.6. Promote Funding Opportunities. Work with partners like 3CE and PG&E to identify and promote potential resilience opportunities and accessible funding and financing mechanisms to pay for building electrification, weatherization, and battery backups.	All	Elderly Population and People with Disabilities, Residents, Local Businesses	Funding identified and promoted to community; Number of projects initiated with incentives	Near-term (by 2024)	Community Planning and Building/Police and Fire/Public Works	$	Inspired by the City of Pacifica All-Electric Reach Code
Policy 1.4. Increase economic resilience.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions
Action 1.4.1. Develop Partnerhsips to Provide Support to Displaced Workers. Work in partnership with the Monterey County Workforce Development Board and the Carmel Chamber of Commerce to develop a plan to provide support for displaced workers that establishes education and training partnerships for workers displaced or workers negatively impacted by climate change or climate adaptation policies.	All	Service Industry Workers, Local Businesses	Commitment from business community to develop a plan to support displaced workers	Near-term (by 2024)	Community Planning & Building / City Hall	$$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies
Action 1.4.2. Establish Partnerships to Develop a Resilient Economy. Partner with the County of Monterey Economic Development Department, Carmel Chamber of Commerce, and the Monterey County Workforce Development Board, to develop more integrated strategies for protection of jobs, economic sustenance, and for the protection of vulnerable populations more at-risk of temporary or permanent job dislocation due to climate change.	All	Service Industry Workers, Local Businesses	Number of meetings held to develop strategies for job protection	Mid-term (by 2027)	Community Planning & Building / City Hall	$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies
Action 1.4.3. Business Resilience Outreach Program. Collaborate with businesses in the city to better understand shared climate risks and identify opportunities to advance shared climate resilience priorities. Partner with the Carmel Chamber of Commerce and Visit Carmel to pilot and implement a local business resilience initiative to build small business capacity before a time of crisis by increasing the awareness of, and preparedness for, business continuity risks faced by the city's local businesses, providing a toolkit of intervention to help local businesses manage risks and enhance business resilience, and conducting outreach campaigns to engage leaders from the business, government, and community sectors to enhance preparedness for economic resilience.	All	Service Industry Workers, Local Businesses	Toolkit of intervention developed to help support local businesses manage risks and enhance resilience	Near-term (by 2024)	Community Planning & Building / City Hall	$$	Adapted from Gateway Cities Climate Adaptation Model General Plan Language (December 2018)
Action 1.4.4. Hire a Grant Writer/Climate Coordinator. Hire a grant writer/Climate coordinator to pursue available grants to fund climate adaptation implementation and track progress.	All	All	Grant writer/climate coordinator hired	Near-term (by 2024)	City Hall	$$$	Suggested at the 11/18/2021 public meeting
Goal 2. A Natural Environment Resilient to Climate Hazards							
Policy 2.1. Protect and restore climate-vulnerable habitat and ecosystems.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions

Action 2.1.1. Increase Funding for Climate Adaptation. Earmark Capital Improvement Program (CIP) funding for design, permitting, and implementation of adaptation projects and strategies, such as those in the 2021 Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) and Integrated Regional Watershed Management Program (IRWMP).	All	Urban Forest, Mission Trail Nature Preserve, North Dunes, Carmel Beach, Water Supply	Number of adaptation projects funded through CIP	Near-term (by 2024)	Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 2.1.2. Increase Urban Forest Resilience. Update and implement the Forest Management Plan to: 1. Review and consider modifications to the preferred urbanized tree species that would result in improved resilience in the context of the expected climate of the second half of the century, reduce wildfire hazard, and that takes into account aesthetics and the ecological benefits of natives or near-native (e.g., native species from the Southwestern US or Mexico would likely be preferred to European species). 2. Include planting and maintenance guidelines to improve tree health, particularly in the public right-of-way 3. Incorporate tree species that have greater drought and wildfire resistance 4. In addition to drought-tolerant landscaping, include landscaping guidelines that reduce wildfire hazard on private property. 5. Enhance carbon sequestration potential Update of the Plan should include collaboration and engagement with stakeholders, such as the Monterey Pine Forest Watch, California State University, Monterey Bay, and vulnerable communities.	Drought, Increased Temp, Wildfire	Urban Forest	Forest Management Plan Updated	Near-term (by 2024) and Ongoing	Public Works Forestry Division / Forest and Beach Commission	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 2.1.3. Increase Resilience of the Mission Trail Nature Preserve and Pescadero Canyon. Update and implement the Mission Trail Nature Preserve Master Plan to consider the potential impacts of climate change and to reduce wildfire risk for neighboring private properties. Coordinate with CAL FIRE and the Monterey Fire Departments to incorporate Best Practices into an annual maintenance plan, including cost estimates for implementation and revenue sources for implementation. Continue to coordinate with CalFire and the Pebble Beach Community Services District on wildfire mitigation in Pescadero Canyon.	All	Mission Trail Nature Preserve	Mission Trail Nature Preserve Master Plan updated	Mid-term (by 2027) and Ongoing	Community Planning & Building and Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 2.1.4. Increase Resilience of the North Dunes. Continue to fund maintenance and monitoring at the North Dunes to determine how the changing climate will affect dune habitats. Implement enhancement efforts to improve resilience of the North Dunes.	All	North Dunes	Regular maintenance and monitoring occurring at North Dunes	Ongoing	Community Planning & Building and Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 2.1.5. Increase Resilience to Stronger Storms. When designing projects in the city, including those recommended in the Mission Trail Stream Stability Study, size improvements to handle larger storms consistent with best available climate change projections.	Stronger Storms	Mission Trail Nature Preserve	Number of projects sizing improvements to handle larger storms.	Near-term (by 2024)	Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 2.1.6. Beach Sand Monitoring Program. Reinstate beach sand monitoring program described in the Shoreline Management Plan.	Sea Level Rise	Carmel Beach	Active beach sand monitoring program in place	Near-term (by 2024)	Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 2.1.7. Carmel Cove Sand Supply. Partner with local researchers (e.g., California State University Monterey Bay) or other sources to conduct Carmel Cove sand supply dynamics analysis.	Sea Level Rise	Carmel Beach	Carmel Cove sand supply dynamics analysis completed	Long-term (by 2032)	Community Planning & Building and Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Goal 3. Resilient Infrastructure and Built Environment							
Policy 3.1. Support greater resilience, redundancy, and reliability of local and regional infrastructure and the built environment.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions
Action 3.1.1. Underground Utilities in Fire Hazard Zones. Determine the feasibility of, and community support for, undergrounding power lines in the Mission Trail Nature Preserve, designated evacuation routes, and in other high priority areas in the Very High Fire Hazard Severity Zone. Develop a plan for undergrounding utilities based on results from the feasibility study and begin implementation in the most vulnerable communities.	Wildfire	Water Supply, Sanitary Sewer System, Power Grid, Overhead Communication, PG&E/Communication Underground Lines-gas, cable	Feasibility Study completed; Plan developed based on Feasibility Study; Number of utilities moved underground	Near-term (by 2024)	Community Planning & Building and Public Works	$$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 3.1.2. Increase Green Infrastructure. Modify Capital Improvement Program (CIP) project design to consistently evaluate the potential for green infrastructure to be incorporated in CIP projects in the public right-of-way and on public lands. Identify and develop a green infrastructure pilot project that will reduce runoff volume and capture and infiltrate stormwater, based on projected changes in precipitation amounts due to climate change, and incorporates tree and shrub planting to increase carbon sequestration in the city.	Stronger Storms, Increased Temp, Wildfire	Urban Forest, Storm Drain System	Change in impervious surface coverage.	Near-term (by 2024)	Public Works	$$	Adapted from the Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 3.1.3. Public Building Electrification. Identify opportunities to incorporate electrification of City facilities and buildings, including solar photovoltaic power system and battery backup installation, into the Capital Improvement Program (CIP). As an initial step, identify and develop a pilot project to electrify a city building or facility, including the installation of a photovoltaic power system.	Stronger Storms, Wildfire	Power grid, City facilities	Public building electrification pilot project completed	Mid-term (by 2027)	Public Works	$$$	Suggested by City Council
Action 3.1.4. Reduce Stormwater Runoff. Reduce stormwater runoff through implementation of stormwater diversion and infiltration projects that reduce pollution problems caused by more frequent and intense storms and more extreme flooding events.	Stronger Storms	Storm Drain System, Carmel Beach	Stormwater diversion project implemented	Long-term (by 2032)	Public Works	$$$	Suggested by Climate Committee Members

Action 3.1.5. Storm Drain Repair Funding and Improvements. Earmark Capital Improvement Program (CIP) funding for design, permitting and implementation of storm drain repairs. Include strategies in the 2021 Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) for potential regional funding. Upsize Storm Drain Master Plan (SDMP) improvements, especially when making repairs in the lower reaches of watersheds, to handle larger storms.	Stronger Storms	Storm Drain System	Number of adaptation projects funded through CIP	Near-term (by 2024)	Public Works	$$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 3.1.6. Retrofit Existing Critical Buildings and Related Infrastructure. Conduct an evaluation of all first-responder and municipal facilities to determine retrofits that may be needed for long-term resilience to climate change hazards including sea-level rise related flooding and erosion, increased wind/storm events, an increase in high heat days, and/or wildfire depending upon location and risk factors. Develop a budget and schedule for retrofits based on the findings of the municipal facilities. Retrofit existing critical buildings as detailed in the program schedule.	All	Emergency Response Facilities – Fire station, EOC, PD, PW, City Hall, etc., Hospital and Emergency Medical Care Facilities	List of critical buildings and related infrastructure requiring retrofits	Near-term (by 2024)	Public Works	$$$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies
Action 3.1.7. Water Conservation. Partner with the Monterey Peninsula Water Management District to reduce water demand and increase water recycling, such as stormwater capture and grey water reuse, through education and outreach. Provide information and incentives for residential water use reduction, focusing engagement on vulnerable communities first.	Drought	Water Supply	Water demand reduced, incentives for grey water reuse developed and shared	Near-term (by 2024)	Community Planning & Building and Public Works	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 3.1.8. Bluff Structural Monitoring Program. Implement bluff structural monitoring program and do follow-up monitoring post-storm to identify additional footing stability issues.	Sea Level Rise	Carmel Beach	Bluff structural monitoring program implemented	Mid-term (by 2027)	Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 3.1.9. Sea Level Rise Coastal Vulnerability Study. Hire coastal engineer with experience in planning for climate change to: 1. Conduct research and prepare a Sea-Level Rise Vulnerability Study to further assess the risks to the city's coastal assets, including the beach, sea walls, revetments, bluffs, stairs and access, public bathrooms, parking areas, drainage infrastructure, and utilities. 2. Determine adaptation measures and Local Coastal Program policy options, including but not limited to: a) Mostly natural, unarmored North Dunes area; b) mostly armored bluffs along Scenic Roach south of 8th Avenue; c) Unarmored dunes along private property between 8th Avenue and Del Mar Parking Lot; d) Armored private properties on the bluffs at the north end of the City (Pescadero Canyon area). 3. Evaluate the use of thresholds for phasing adaptation projects based on changing coastal conditions. Consider applying an adaptive pathways approach which establishes trigger thresholds for different adaptive measures based on the severity of the impact from flooding and erosion associated with sea-level rise.	Sea Level Rise	Carmel Beach, Shoreline Access Infrastructure, Seawall and Revetments	Sea-level rise vulnerability study completed	Near-term (by 2024)	Public Works	$$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 3.1.10. Wastewater Treatment. Collaborate with the Carmel Area Wastewater District (CAWD) to increase the facility's resilience to sea level rise and stronger storms. Maintain staff/council personnel as liaisons to CAWD.	Sea Level Rise, Stronger Storms	Water Supply, Storm Drain System	Number of collaboration meetings with CAWD regarding facility's resilience	Near-term (by 2024) and Ongoing	Community Planning & Building and Public Works	$	Suggested by Climate Committee Members
Policy 3.2. Incorporate climate change adaptation into relevant plans and standards.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions
Action 3.2.1. Development Standards. Evaluate City's development standards for consistency with best practices for reducing climate change risk (e.g., wildfire risk) for both new and existing development, including but not limited to incorporating defensible space design in landscaping guidelines and permitting the use of fire-resistant building materials that may conflict with current Design Guidelines. Develop a project checklist for building and site adaptation measures. The checklist, included with permit applications, should serve to provide education to permit applicants on modifications to site plans and structures that can improve a project's resilience to existing and potential future climate change hazards.	All	Residents, Local Businesses, Second Homes	Number of projects implementing adaptation measures, City development standards consistent with best practices for reducing wildfire risk	Mid-term (by 2027)	Community Planning and Building	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 3.2.2. Update City Planning Guidelines. Update the City's municipal code to maintain consistency with current California codes (California Building Code Chapter 7 and California Residential Code R337) throughout the City.	Wildfire, Stronger Storms, Wildfire	Residents, Local Businesses, Second Homes	City municipal code consistent with current California codes	Near-term (by 2024)	Community Planning and Building	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)
Action 3.2.3. Incorporate Climate Change Adaptation into Local Plans. Prioritize the update of local plans, including the Climate Change Vulnerability Assessment, Local Coastal Program, General Plan, Mission Trails Nature Reserve Master Plan, Del Mar Master Plan, Shoreline Management Plan, and drought planning to promote climate change resilience as new information is available.	All	All	Number plans updated to incorporate adaptation	Mid-term (by 2027)	Community Planning & Building / Public Works	$$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies
Action 3.2.4. Update Shoreline Management Plan. Update Shoreline Management Plan and Local Coastal Program based on results of Sea-level Rise Vulnerability Study.	Sea Level Rise	Carmel Beach	Shoreline Management Plan and Local Coastal Program updated	Long-term (by 2032)	Community Planning & Building and Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)

Action 3.2.5. Multi-Jurisdictional Hazard Mitigation Plan. Maintain a comprehensive list of projects, based on existing plans and gaps identified in the Vulnerability Assessment, to provide to Monterey County during updates to the Monterey County Multi-Jurisdictional Hazard Mitigation Plan in 2022 and beyond.	All	All	Number of adaptation projects included in the Multi-Jurisdictional Hazard Mitigation Plan	Near-term (by 2024)	Community Planning & Building, Police, and Public Works	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)

City of Carmel-by-the-Sea Near-Term/Ongoing Adaptation Strategies

Goal/Policy/Action	Climate Hazard	Asset	Metric	Timeframe	Implementation Lead	Cost	Source	Status	Notes
Goal 1. A Healthy, Safe, and Resilient Community									
Policy 1.1. Provide effective emergency preparedness and response in anticipation of potential climate-related disasters				Near-term (1-2 years); Mid-term (3-5 years); Long-term (5-10 years)		$-Low (<$50K); $$-Medium ($50K - $100K); $$$-High (>$100K)	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies		
Action 1.1.1. Maintain and Update Evacuation Plan. Maintain and update an Evacuation Plan every 8 years at a minimum to account for all types of emergencies. The plan should focus on the most vulnerable groups including the elderly community and persons with disabilities.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Evacuation Plan updated every 8 years, with the first update by 2023	Near-term (by 2024) and Ongoing	Police & Fire	$	Suggested by Climate Committee Members		
Action 1.1.2. Update Emergency Preparedness. Incorporate climate change risk and impact considerations into Carmel-by-the-Sea CERT programming and materials to promote emergency preparedness at a neighborhood block-by-block scale. CERT to promote block-by-block scale emergency preparedness by organizing City by blocks and recruiting Block Captains.	All	Residents, Local Businesses, Second Homes	Number of block captains formed, climate change risk incorporated into	Near-term (by 2024)	Police & Fire	$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 1.1.3. Collaborate with Monterey Fire. Collaborate with Monterey Fire on its inspection and outreach efforts to reduce fire risks. Continue to coordinate with the CERT program and reach out to new potential outreach partners such as local businesses, community groups, and utilities to help distribute information to increase resident and homeowner awareness and knowledge of how to prepare for emergencies.	Wildfire	Residents, Local Businesses, Second Homes	Number of meetings held with Monterey Fire and CERT program; educational materials distributed	Near-term (by 2024)	Police & Fire	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	5%	Monterey Fire and Fire Safety Council for Monterey County both attended Earth Day 2023, where they brought information for FireSafe Communities for residents
Action 1.1.4. Publicize Local Evacuation Routes. Publicize both City and Monterey County evacuation routes for the community on the City's website, and in the newsletter and brochures. Target additional outreach to the most vulnerable such as the elderly and people with disabilities in the event of a wildfire or other disaster.	All	Elderly Population and People with Disabilities, Residents	Educational materials distributed	Near-term (by 2024)	Police & Fire	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)		
Policy 1.2. Focus adaptation efforts and engagement on the most vulnerable populations.							Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies		
Action 1.2.1. Establish a Resilience Hub. Formally designate a physical resilience hub, such as the Youth Center or Public Library, and make it available during extreme heat events, poor air quality, severe weather events, and other highly hazardous conditions for use by the community. Provide the following essential resources in the resilience hub(s): health programming and resources, food, refrigeration, charging stations, basic medical supplies, and other emergency supplies. Electrified heating and cooling paired with backup power sources like battery storage provides redundancy and continues services in the event of a power outage. Designate a virtual resilience hub on the City website where residents can access information about the physical resilience hub and resilience efforts.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Resilience Hub established; Existing facilities upgraded to provide all essential resources	Near-term (by 2024)	Public Works / Police & Fire / Library	$$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions	0%	
Action 1.2.3. Engage the Community. Develop educational materials notifying the community about the resilience hub and how to access it by sharing updates across city and community channels. Partner with the CERT program and block captains, and community groups, to prioritize disadvantaged/marginalized communities including the elderly and individuals with disabilities.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Community engagement plan developed	Near-term (by 2024)	Library / City Hall / Police Department	$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions	0%	
Policy 1.3. Minimize health impacts of climate change.							Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies		
Action 1.3.1. Partner with Monterey County Health Department. Coordinate with Monterey County Health Department to develop and enhance disaster and emergency early warning systems to incorporate objective data and information for potential health threats such as heat-illness, and illnesses complicated by low air quality due to climate change hazards. Include information on early warning systems and other resilience efforts on the City's virtual resilience hub (Action 1.2.1.)	All	Elderly Population and People with Disabilities, Residents, Local Businesses, Service Industry Workers	Emergency early warning systems updated	Near-term (by 2024)	Police & Fire	$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 1.3.6. Promote Funding Opportunities. Work with partners like 3CE and PG&E to identify and promote potential resilience opportunities and accessible funding and financing mechanisms to pay for building electrification, weatherization, and battery backups.	All	Elderly Population and People with Disabilities, Residents, Local Businesses	Funding identified and promoted to community; Number of projects initiated with incentives	Near-term (by 2024)	Community Planning and Building/Police and Fire/Public Works	$	Inspired by the City of Pacifica All-Electric Reach Code	5%	Energy Efficiency Study (Willdan); Electric Heat Pumps in City Facilities; 3CE - sweeper (Rob); PG&E EV Chargers (Javier)
Policy 1.4. Increase economic resilience.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 1.4.1. Develop Partnerhsips to Provide Support to Displaced Workers. Work in partnership with the Monterey County Workforce Development Board and the Carmel Chamber of Commerce to develop a plan to provide support for displaced workers that establishes education and training partnerships for workers displaced or workers negatively impacted by climate change or climate adaptation policies.	All	Service Industry Workers, Local Businesses	Commitment from business community to develop a plan to support displaced workers	Near-term (by 2024)	Community Planning & Building / City Hall	$$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies	0%	Although not related to this specific topic, CCC helped organize our inaugural Earth Day event in 2023; this can be considered development of this partnership
Action 1.4.3. Business Resilience Outreach Program. Collaborate with businesses in the city to better understand shared climate risks and identify opportunities to advance shared climate resilience priorities. Partner with the Carmel Chamber of Commerce and Visit Carmel to pilot and implement a local business resilience initiative to build small business capacity before a time of crisis by increasing the awareness of, and preparedness for, business continuity risks faced by the city's local businesses, providing a toolkit of intervention to help local businesses manage risks and enhance business resilience, and conducting outreach campaigns to engage leaders from the business, government, and community sectors to enhance preparedness for economic resilience.	All	Service Industry Workers, Local Businesses	Toolkit of intervention developed to help support local businesses manage risks and enhance resilience	Near-term (by 2024)	Community Planning & Building / City Hall	$$	Adapted from Gateway Cities Climate Adaptation Model General Plan Language (December 2018)	0%	
Action 1.4.4. Hire a Grant Writer/Climate Coordinator. Hire a grant writer/Climate coordinator to pursue available grants to fund climate adaptation implementation and track progress.	All	All	Grant writer/climate coordinator hired	Near-term (by 2024)	City Hall	$$$	Suggested at the 11/18/2021 public meeting	0%	
Goal 2. A Natural Environment Resilient to Climate Hazards									
Policy 2.1. Protect and restore climate-vulnerable habitat and ecosystems.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 2.1.1. Increase Funding for Climate Adaptation. Earmark Capital Improvement Program (CIP) funding for design, permitting, and implementation of adaptation projects and strategies, such as those in the 2021 Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) and Integrated Regional Watershed Management Program (IRWMP).	All	Urban Forest, Mission Trail Nature Preserve, North Dunes, Carmel Beach, Water Supply	Number of adaptation projects funded through CIP	Near-term (by 2024)	Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	0%	
Action 2.1.2. Increase Urban Forest Resilience. Update and implement the Forest Management Plan to: 1. Review and consider modifications to the preferred urbanized tree species that would result in improved resilience in the context of the expected climate of the second half of the century, reduce wildfire hazard, and that takes into account aesthetics and the ecological benefits of natives or near-native (e.g., native species from the Southwestern US or Mexico would likely be preferred to European species). 2. Include planting and maintenance guidelines to improve tree health, particularly in the public right-of-way 3. Incorporate tree species that have greater drought and wildfire resistance 4. In addition to drought-tolerant landscaping, include landscaping guidelines that reduce wildfire hazard on private property. 5. Enhance carbon sequestration potential Update of the Plan should include collaboration and engagement with stakeholders, such as the Monterey Pine Forest Watch, California State University, Monterey Bay, and vulnerable communities.	Drought, Increased Temp, Wildfire	Urban Forest	Forest Management Plan Updated	Near-term (by 2024) and Ongoing	Public Works Forestry Division / Forest and Beach Commission	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	30%	Update of Urban Forest Master Plan in progress, community survey almost closed and draft is completed

Action 2.1.4. Increase Resilience of the North Dunes. Continue to fund maintenance and monitoring at the North Dunes to determine how the changing climate will affect dune habitats. Implement enhancement efforts to improve resilience of the North Dunes.	All	North Dunes	Regular maintenance and monitoring occurring at North Dunes	Ongoing	Community Planning & Building and Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	80%	ND project has been onging since 2016 with CDP renewed til Aug. 2016; DD&A recently contracted to continue restoration work
Action 2.1.5. Increase Resilience to Stronger Storms. When designing projects in the city, including those recommended in the Mission Trail Stream Stability Study, size improvements to handle larger storms consistent with best available climate change projections.	Stronger Storms	Mission Trail Nature Preserve	Number of projects sizing improvements to handle larger storms.	Near-term (by 2024)	Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	5%	
Action 2.1.6. Beach Sand Monitoring Program. Reinstate beach sand monitoring program described in the Shoreline Management Plan.	Sea Level Rise	Carmel Beach	Active beach sand monitoring program in place	Near-term (by 2024)	Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	0%	Coastal Engineering Adaptation Project underway
Goal 3. Resilient Infrastructure and Built Environment									
Policy 3.1. Support greater resilience, redundancy, and reliability of local and regional infrastructure and the built environment.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 3.1.1. Underground Utilities in Fire Hazard Zones. Determine the feasibility of, and community support for, undergrounding power lines in the Mission Trail Nature Preserve, designated evacuation routes, and in other high priority areas in the Very High Fire Hazard Severity Zone. Develop a plan for undergrounding utilities based on results from the feasibility study and begin implementation in the most vulnerable communities.	Wildfire	Water Supply, Sanitary Sewer System, Power Grid, Overhead Communication, PG&E/Communication Underground Lines-gas, cable	Feasibility Study completed; Plan developed based on Feasibility Study; Number of utilities moved underground	Near-term (by 2024)	Community Planning & Building and Public Works	$$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	0%	
Action 3.1.2. Increase Green Infrastructure. Modify Capital Improvement Program (CIP) project design to consistently evaluate the potential for green infrastructure to be incorporated in CIP projects in the public right-of-way and on public lands. Identify and develop a green infrastructure pilot project that will reduce runoff volume and capture and infiltrate stormwater, based on projected changes in precipitation amounts due to climate change, and incorporates tree and shrub planting to increase carbon sequestration in the city.	Stronger Storms, Increased Temp, Wildfire	Urban Forest, Storm Drain System	Change in impervious surface coverage.	Near-term (by 2024)	Public Works	$$	Adapted from the Carmel-by-the-Sea Vulnerability Assessment (July 2021)	5%	Prepared stormwater management plan Initiated stormwtaer projects
Action 3.1.4. Storm Drain Repair Funding and Improvements. Earmark Capital Improvement Program (CIP) funding for design, permitting and implementation of storm drain repairs. Include strategies in the 2021 Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) for potential regional funding. Upsize Storm Drain Master Plan (SDMP) improvements, especially when making repairs in the lower reaches of watersheds, to handle larger storms.	Stronger Storms	Storm Drain System	Number of adaptation projects funded through CIP	Near-term (by 2024)	Public Works	$$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	5%	Prepared stormwater management plan Initiated stormwtaer projects
Action 3.1.5. Retrofit Existing Critical Buildings and Related Infrastructure. Conduct an evaluation of all first-responder and municipal facilities to determine retrofits that may be needed for long-term resilience to climate change hazards including sea-level rise related flooding and erosion, increased wind/storm events, an increase in high heat days, and/or wildfire depending upon location and risk factors. Develop a budget and schedule for retrofits based on the findings of the municipal facilities. Retrofit existing critical buildings as detailed in the program schedule.	All	Emergency Response Facilities – Fire station, EOC, PD, PW, City Hall, etc., Hospital and Emergency Medical Care Facilities	List of critical buildings and related infrastructure requiring retrofits	Near-term (by 2024)	Public Works	$$$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies	0%	
Action 3.1.6. Water Conservation. Partner with the Monterey Peninsula Water Management District to reduce water demand and increase water recycling, such as stormwater capture and grey water reuse, through education and outreach. Provide information and incentives for residential water use reduction, focusing engagement on vulnerable communities first.	Drought	Water Supply	Water demand reduced, incentives for grey water reuse developed and shared	Near-term (by 2024)	Community Planning & Building and Public Works	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	5%	MPWMD attended Earth Day 2023 and provided outreach to attendees
Action 3.1.8. Sea Level Rise Coastal Vulnerability Study. Hire coastal engineer with experience in planning for climate change to: 1. Conduct research and prepare a Sea-Level Rise Vulnerability Study to further assess the risks to the city's coastal assets, including the beach, sea walls, revetments, bluffs, stairs and access, public bathrooms, parking areas, drainage infrastructure, and utilities. 2. Determine adaptation measures and Local Coastal Program policy options, including but not limited to: a) Mostly natural, unarmored North Dunes area; b) mostly armored bluffs along Scenic Roach south of 8th Avenue; c) Unarmored dunes along private property between 8th Avenue and Del Mar Parking Lot; d) Armored private properties on the bluffs at the north end of the City (Pescadero Canyon area). 3. Evaluate the use of thresholds for phasing adaptation projects based on changing coastal conditions. Consider applying an adaptive pathways approach which establishes trigger thresholds for different adaptive measures based on the severity of the impact from flooding and erosion associated with sea-level rise.	Sea Level Rise	Carmel Beach, Shoreline Access Infrastructure, Seawall and Revetments	Sea-level rise vulnerability study completed	Near-term (by 2024)	Public Works	$$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	15%	Coastal Engineering Adaptation Project underway
Action 3.1.9. Wastewater Treatment. Collaborate with the Carmel Area Wastewater District (CAWD) to increase the facility's resilience to sea level rise and stronger storms. Maintain staff/council personnel as liaisons to CAWD.	Sea Level Rise, Stronger Storms	Water Supply, Storm Drain System	Number of collaboration meetings with CAWD regarding facility's resilience	Near-term (by 2024) and Ongoing	Community Planning & Building and Public Works	$	Suggested by Climate Committee Members	30%	Pipe-bursting underway, CAWD sent 60% proposal and aim for 90% soon
Policy 3.2. Incorporate climate change adaptation into relevant plans and standards.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 3.2.2. Update City Planning Guidelines. Update the City's municipal code to maintain consistency with current California codes (California Building Code Chapter 7 and California Residential Code R337) throughout the City.	Wildfire, Stronger Storms, Wildfire	Residents, Local Businesses, Second Homes	City municipal code consistent with current California codes	Near-term (by 2024)	Community Planning and Building	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)		
Action 3.2.5. Multi-Jurisdictional Hazard Mitigation Plan. Maintain a comprehensive list of projects, based on existing plans and gaps identified in the Vulnerability Assessment, to provide to Monterey County during updates to the Monterey County Multi-Jurisdictional Hazard Mitigation Plan in 2022 and beyond.	All	All	Number of adaptation projects included in the Multi-Jurisdictional Hazard Mitigation Plan	Near-term (by 2024)	Community Planning & Building, Police, and Public Works	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	0%	

City of Carmel-by-the-Sea Mid-Term Adaptation Strategies

Goal/Policy/Action	Climate Hazard	Asset	Metric	Timeframe	Implementation Lead	Cost	Source	Status	Notes
Goal 1. A Healthy, Safe, and Resilient Community									
Policy 1.1. Provide effective emergency preparedness and response in anticipation of potential climate-related disasters				Near-term (1-2 years); Mid-term (3-5 years); Long-term (5-10 years)		$-Low (<$50K); $$-Medium ($50K - $100K); $$$-High (>$100K)	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies		
Action 1.1.5. Evaluate Evacuation Route Capacity. Evaluate evacuation route capacity, safety, and viability under a range of emergency scenarios and identify and implement mitigating actions in 2022, in accordance with Assembly Bill 747.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Analysis evaluating evacuation route capacity completed	Mid-term (by 2027)	Police & Fire	$$	Assembly Bill 747 Requirement		
Action 1.1.6. Evacuation Alternatives and Access. Identify neighborhoods that have single ingress/egress, pursuant to Senate Bill 99, and develop and employ evacuation alternatives, such as a gathering facility, and/or alternative emergency access routes in those neighborhoods. Evaluate potential congestion issues in the event of an evacuation and develop and maintain a list of residents who may have difficulty evacuating. Evaluate options to provide evacuation, such as a shuttle service, for residents with mobility challenges.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Analysis identifying neighborhoods that have single ingress/egress and evacuation alternatives completed; List of limited-mobility residents developed	Mid-term (by 2027)	Police & Fire	$$	Senate Bill 99 Requirement		
Action 1.1.7. Develop Local Partnerships to Increase Resistance to Wildfire Structural Damage. Work with local community groups to publicize the Firewise Community Certification program (e.g., on the City website and in the newsletter and brochures) and encourage resident involvement.	Wildfire	Residents, Second Homes	Number of meetings held to publicize Firewise Community Certification	Mid-term (by 2027)	Police & Fire	$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)		
Policy 1.2. Focus adaptation efforts and engagement on the most vulnerable populations.							Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies		
Action 1.2.2. Limit the Impacts of Climate Change on the Most Vulnerable Populations. Develop a framework to define equity in Carmel-by-the-Sea and develop adaptation approaches that are equitably implemented.	All	Elderly Population and People with Disabilities, Residents, Service Industry Workers	Carmel-by-the-Sea Equity Framework developed	Mid-term (by 2027)	Community Planning & Building	$	Inspired by the City of Berkeley Existing Building Electrification Strategy		
Action 1.2.4. Social Support Network. Collaborate with the Carmel Foundation and other community-based organizations (e.g., Carmel Residents Association) to develop an inventory of locations with isolated elderly residents and people with disabilities and develop a plan for a social support network to increase resilience to climate change, for example by promoting home electrification.	All	Elderly Population and People with Disabilities	Social support network created; Inventory of locations created	Mid-term (by 2027)	Police Department / CERT / Community Planning & Building	$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Policy 1.3. Minimize health impacts of climate change.							Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies		
Action 1.3.2. Initiate a Heat Pump Retrofit Program. Create a program to help fund property owners to convert HVAC units to heat pumps, which provide water heating and space heating in addition to cooling and can improve indoor air quality and community adaptation to extreme heat. Include a microgrid energy storage component to increase power reliability. Prioritize at-risk populations for retrofit incentives.	Wildfire, Increased Temperature	Elderly Population and People with Disabilities, Residents, Local Businesses, Service Industry Workers	Number of heat pumps installed; Number of heat pumps serving at risk residents	Mid-term (by 2027)	Community Planning & Building	$$	Inspired by the City of Berkeley Existing Building Electrification Strategy	5%	We have promoted 3CE's electric heat pump rebate programs but I don't believe we have created our own
Action 1.3.3. Invest in Improving Resilience in Critical Facilities. Invest in sustainable backup power sources to provide redundancy and continued services for critical facilities, including City Hall, Carmel Police Department, Carmel Fire Department, the Libraries, and assisted living facilities, in the event of a power outage triggered by a climate event.	All	Elderly Population and People with Disabilities, Residents	Number of critical facilities with sustainable backup power sources.	Mid-term (by2027)	Public Works	$$$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions	5%	Police building renovation proj has been initiated; City Hall improvements
Action 1.3.4. Conduct a Feasibility Study for Existing Building Electrification and Back-up Power. Perform an electrification feasibility study/existing building analysis in order to understand the potential for, and associated costs of, electrification retrofitting, including heat pumps, along with on-site energy generation and battery storage to provide a more resilient back-up power supply. Establish a plan for reducing or eliminating natural gas from existing buildings, potentially through a reach code, and building resilience to potential electrical grid shutoffs.	Wildfire, Increased Temp	Elderly Population and People with Disabilities, Residents	Feasibility Study for Existing Building Electrification and Back-up Power completed	Mid-term (by 2027)	Public Works	$$	Inspired by the City of Berkeley Existing Building Electrification Strategy	5%	Wallace Group conducted energy efficiency study Heat pumps placed in PW, libraries, FD, City Hall
Policy 1.4. Increase economic resilience.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 1.4.2. Establish Partnerships to Develop a Resilient Economy. Partner with the County of Monterey Economic Development Department, Carmel Chamber of Commerce, and the Monterey County Workforce Development Board, to develop more integrated strategies for protection of jobs, economic sustenance, and for the protection of vulnerable populations more at-risk of temporary or permanent job dislocation due to climate change.	All	Service Industry Workers, Local Businesses	Number of meetings held to develop strategies for job protection	Mid-term (by 2027)	Community Planning & Building / City Hall	$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies		
Goal 2. A Natural Environment Resilient to Climate Hazards									
Policy 2.1. Protect and restore climate-vulnerable habitat and ecosystems.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 2.1.3. Increase Resilience of the Mission Trail Nature Preserve and Pescadero Canyon. Update and implement the Mission Trail Nature Preserve Master Plan to consider the potential impacts of climate change and to reduce wildfire risk for neighboring private properties. Coordinate with CAL FIRE and the Monterey Fire Departments to incorporate Best Practices into an annual maintenance plan, including cost estimates for implementation and revenue sources for implementation. Continue to coordinate with CalFire and the Pebble Beach Community Services District on wildfire mitigation in Pescadero Canyon.	All	Mission Trail Nature Preserve	Mission Trail Nature Preserve Master Plan updated	Mid-term (by 2027) and Ongoing	Community Planning & Building and Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	0%	
Goal 3. Resilient Infrastructure and Built Environment									
Policy 3.1. Support greater resilience, redundancy, and reliability of local and regional infrastructure and the built environment.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 3.1.3. Public Building Electrification. Identify opportunities to incorporate electrification of City facilities and buildings, including solar photovoltaic power system and battery backup installation, into the Capital Improvement Program (CIP). As an initial step, identify and develop a pilot project to electrify a city building or facility, including the installation of a photovoltaic power system.	Stronger Storms, Wildfire	Power grid, City facilities	Public building electrification pilot project completed	Mid-term (by 2027)	Public Works	$$$	Suggested by City Council	0%	
Action 3.1.8. Bluff Structural Monitoring Program. Implement bluff structural monitoring program and do follow-up monitoring post-storm to identify additional footing stability issues.	Sea Level Rise	Carmel Beach	Bluff structural monitoring program implemented	Mid-term (by 2027)	Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	30%	Coastal Engineering study related Phase I, Task I
Policy 3.2. Incorporate climate change adaptation into relevant plans and standards.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 3.2.1. Development Standards. Evaluate City's development standards for consistency with best practices for reducing climate change risk (e.g., wildfire risk) for both new and existing development, including but not limited to incorporating defensible space design in landscaping guidelines and permitting the use of fire-resistant building materials that may conflict with current Design Guidelines. Develop a project checklist for building and site adaptation measures. The checklist, included with permit applications, should serve to provide education to permit applicants on modifications to site plans and structures that can improve a project's resilience to existing and potential future climate change hazards.	All	Residents, Local Businesses, Second Homes	Number of projects implementing adaptation measures, City development standards consistent with best practices for reducing wildfire risk	Mid-term (by 2027)	Community Planning and Building	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)		
Action 3.2.3. Incorporate Climate Change Adaptation into Local Plans. Prioritize the update of local plans, including the Climate Change Vulnerability Assessment, Local Coastal Program, General Plan, Mission Trails Nature Reserve Master Plan, Del Mar Master Plan, Shoreline Management Plan, and drought planning to promote climate change resilience as new information is available.	All	All	Number plans updated to incorporate adaptation	Mid-term (by 2027)	Community Planning & Building / Public Works	$$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies	10%	Coastal Engineering study related Phase II received CCC grant funding

City of Carmel-by-the-Sea Long-Term Adaptation Strategies

Goal/Policy/Action	Climate Hazard	Asset	Metric	Timeframe	Implementation Lead	Cost	Source	Status	Notes
Goal 1. A Healthy, Safe, and Resilient Community									
Policy 1.2. Focus adaptation efforts and engagement on the most vulnerable populations.							Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies		
Action 1.2.5. Back-up Power for Vulnerable Populations. Coordinate with 3CE, PG&E, and emergency management services to establish backup power and emergency grid shutdown protocols that protect the most vulnerable populations.	All	Elderly Population and People with Disabilities	Number of households with backup power established	Long-term (by 2032)	Police & Fire / Public Works	$$$	Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions	0%	
Policy 1.3. Minimize health impacts of climate change.							Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies		
Action 1.3.5. Improve Resilience in Existing Building Stock. Develop a program for identifying funding and incentives to weatherize residential and commercial buildings that addresses severe weather protection, energy efficiency, indoor air quality improvements, and other housing improvements. Include an outreach campaign as part of this program to advertise the benefits of weatherizing and	All	Elderly Population and People with Disabilities, Residents	Nubmer of retrofitted structures	Long-term (by 2032)	Community Planning & Building	$$	Adapted from the Southern California Adaptation Planning Guide, Appendix F - General Plan and Local Coastal Plan Model Policies (City of Placentia policy) Passive House Principles	0% 0%	
Goal 2. A Natural Environment Resilient to Climate Hazards									
Policy 2.1. Protect and restore climate-vulnerable habitat and ecosystems.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 2.1.7. Carmel Cove Sand Supply. Partner with local researchers (e.g., California State University Monterey Bay) or other sources to conduct Carmel Cove sand supply dynamics analysis.	Sea Level Rise	Carmel Beach	Carmel Cove sand supply dynamics analysis completed	Long-term (by 2032)	Community Planning & Building and Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	0%	
Goal 3. Resilient Infrastructure and Built Environment									
Policy 3.1. Support greater resilience, redundancy, and reliability of local and regional infrastructure and the built environment.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 3.1.3. Reduce Stormwater Runoff. Reduce stormwater runoff through implementation of stormwater diversion and infiltration projects that reduce pollution problems caused by more frequent and intense storms and more extreme flooding events.	Stronger Storms	Storm Drain System, Carmel Beach	Stormwater diversion project implemented	Long-term (by 2032)	Public Works	$$$	Suggested by Climate Committee Members	5%	
Policy 3.2. Incorporate climate change adaptation into relevant plans and standards.							Adapted from the Southern California Adaptation Planning Guide, Appendix B Matrix of Adaptation Strategies and Actions		
Action 3.2.4. Update Shoreline Management Plan. Update Shoreline Management Plan and Local Coastal Program based on results of Sea-level Rise Vulnerability Study.	Sea Level Rise	Carmel Beach	Shoreline Management Plan and Local Coastal Program updated	Long-term (by 2032)	Community Planning & Building and Public Works	$$	Carmel-by-the-Sea Vulnerability Assessment (July 2021)	0%	

Climate Action Plan
Implementation - All Actions

Action	2030 GHG Reduction Achieved (MT CO2)		Metric	Timeframe	Implementation Lead	Corresponding Adaptation Measure	Status	Notes
	No Enhancing	With Enhancing						
Measure 1.1 Energy Efficiency Training, Education, Incentives and Recognition for Residential and Commercial								
Action 1.1.1: Energy Efficiency Outreach Post links on website and social media and provide materials at public events re: energy efficiency and electrification resources for residential and commercial, and green building programs such as Leadership in Energy and Environmental Design (LEED), Passive House, Active House, and Energy Upgrade California Promote an annual energy efficiency fair. Promote PG&E energy center and online resources. Hold trainings on energy efficiency and Title 24 requirements.	Supporting Action	Supporting Action	- Energy efficiency resources on website, Friday Letter, social media - Energy efficiency fair held (Earth Day) - Title 24 training held	2022-2024	Building, Planning, Public Works, Community Activities	1.3.6	5%	Energy Efficiency Study (Willdan); Electric Heat Pumps in City Facilities; 3CE - sweeper (Rob); PG&E EV Chargers (Javier)
Action 1.1.2: Energy Efficiency and Electrification Incentives Partner with AMBAG, PG&E and 3CE to promote incentive programs for residential and commercial efficiency and electrification, including heat pump retrofits and gas appliance and fireplace retrofits.	71.1	71.1	- Incentive programs posted on website, Friday Letter, social media - Incentive programs promoted at energy fair - Incentive program promoted thru Green Business and Green Citizen programs	2023-2025	Building, Planning, Public Works	1.3.2, 1.3.6	5%	3CE rebate programs have been included in FL
Action 1.1.3: Energy Efficiency Audits Promote PG&E energy audits and tools for residential and commercial	Supporting Action	Supporting Action	- Audit Information on website, Friday Letter, social media - Information shared at annual fair	2022-2024	Planning, Public Works		5%	3CE rebate programs have been included in FL
Measure 1.2 Energy Efficiency in Renovation Projects								
Action 1.2.1: Feasibility Study for Existing Building Electrification and Back-up Power. Perform an electrification feasibility study/existing building analysis in order to understand the potential for, and associated costs of, electrification retrofitting, including heat pumps, along with on-site energy generation, battery storage, and electric car readiness to provide a more resilient back-up power supply. Establish a plan for reducing or eliminating natural gas from existing buildings, through a reach code, and building resilience to potential electrical grid shutoffs.	Supporting Action	Supporting Action	- Feasibility Study for Existing Building Electrification and Back-up Power completed	2022-2024	Building, Planning, Public Works	1.3.4	5%	Wallace Group conducted energy efficiency study Heat pumps placed in PW, libraries, FD, City Hall
Action 1.2.2: Residential Home Energy Renovations. Enhance enforcement of Title 24 compliance and promote participation in green building programs. Develop a Reach Code based on the results of the Feasibility Study (Action 1.2.1). If feasible, the Reach Code should require electrification retrofits, including electric car readiness, in major home renovations/additions. Evaluate feasibility of streamlining online permitting to facilitate electrification retrofits	1,217.50	1,294.60	- 100% of regulated projects are Title 24 compliant - Reach Code Adopted by City Council - Online permitting streamlined for electrification-only retrofits - Passive House, LEED, Build It Green, Energy Star information on City website and at energy fair	2023-2025	Building, Planning		0%	need to check with planning

Action 1.2.3: Residential Home Energy Renovation Incentives. Develop a program to promote home energy efficiency and electrification benefits, advertise incentives, and recognize residents that implement retrofits, such as a Green Citizen Program. Promote financing programs for home upgrades, such as Home Energy Renovation Opportunity (HERO) and Property Assessed Clean Energy (PACE) Promote incentives available to homeowners to convert to all-electric homes and install EV chargers. Evaluate the feasibility of providing additional incentives.	Supporting Action	Supporting Action	- Green Citizen Program developed - Financing information on website, at energy fair - Incentive information on website, at energy fair	2022-2024	Building, Planning, Public Works	1.3.6	5%	included info from PGE and 3CE in FL
Action 1.2.4: Commercial Energy Renovations. Enhance enforcement of Title 24 compliance Develop a Reach Code based on the results of the Feasibility Study (Action 1.2.1). If feasible, the Reach Code should require electrification retrofits in major commercial renovations/expansions, unless the business can show a need for natural gas (restaurants, pottery kilns etc.) Promote participation in green building programs such as Leadership in Energy and Environmental Design (LEED), Passive House, and Energy Upgrade California. Evaluate the feasibility of streamlining online permitting to facilitate electrification retrofits	1,206.20	1,666	- 100% of regulated projects are Title 24 compliant - Reach Code Adopted by City Council - Online permitting streamlined for electrification-only retrofits - Passive House, LEED, Build It Green, Energy Star information on City website and at energy fair	2023-2025	Building, Planning		0%	
Action 1.2.5: Commercial Energy Renovation Incentives. Partner with AMBAG and 3CE incentive programs to increase business participation in commercial energy efficiency programs Promote financing programs for home upgrades, such as Property Assessed Clean Energy (PACE) Initiate a Green Business Certification Program for businesses that follow the California Green Business Program standards (www.greenbusinessca.org). Promote existing incentives for businesses to convert to all-electric buildings. Evaluate the feasibility of providing additional incentives.	69.4	69.4	- Green Business Program initiated - Financing information on website, at energy fair - Incentive information on website, at energy fair, and shared via GBP	2022-2024	Building, Planning, Public Works	1.3.6	0%	
Measure 1.3 Energy Efficiency in New Construction								
Action 1.3.1: Energy Efficiency in New Residential Construction Educate City staff and developers on future Title 24 updates. Promote CalGreenTier 1 and Tier 2 green building ratings such as Passive House, LEED, Build it Green or Energy Star certified buildings. Evaluate feasibility of streamlining online permitting. Develop a Reach Code based on the results of the Feasibility Study (Action 1.2.1). If feasible, the Reach Code should require new residential buildings to be all-electric homes.	0.01	0.01	- 100% of projects are Title 24 compliant - Reach Code Adopted by City Council - Online permitting streamlined for electrification-only retrofits - Passive House, LEED, Build It Green, Energy Star information on City website and at energy fair	2023-2025	Building, Planning		0%	
Action 1.3.2: Energy Efficiency in New Commercial Construction Educate City staff and developers on future Title 24 updates. Promote CalGreen Tier 1 and Tier 2 green building ratings such as Passive House, LEED, Build it Green or Energy Star certified buildings. Evaluate feasibility of streamlining online permitting. Develop a Reach Code based on the results of the Feasibility Study (Action 1.2.1). If feasible, the Reach Code should require new commercial buildings to be all-electric with exemptions for business that can show a need for natural gas (restaurants, pottery kilns etc.)	0	0	- 100% of projects are Title 24 compliant - Reach Code Adopted by City Council - Online permitting streamlined for electrification-only retrofits - Passive House, LEED, Build It Green, Energy Star information on City website and at energy fair	2023-2025	Building, Planning		0%	

Measure 2.1. Alternative Transportation Options								
Action 2.1.1: Reduce Reliance on Automobiles. Work with AMBAG, TAMC and Caltrans to remove barriers to alternative transportation such as safe pedestrian and bicycle access to the City across Highway 1. Promote and provide incentives for bus ridership Explore the feasibility of increasing land use density in downtown during the next General Plan Land Use Element update. Identify and promote within the hotels and visitors center existing shuttle services between Carmel and the airports. Work with Monterey Airport and AMBAG to explore the feasibility of an electric shuttle service between Monterey Airport and destinations in the City.	Scope 1 563 Scope 3 89	Scope 1 563 Scope 3 89	- Outreach on shuttle services created and provided in Carmel hotels - Incentives developed and promoted to encourage bus use - Coordination meetings held with AMBAG, Monterey Airport on shuttle options - Coordination meetings held re: alternative transportation to Carmel - General Plan Land Use Element updated	2023-2030	Planning, Public Works		5%	Bike lane project initiated
Action 2.1.2: Develop Bicycle Master Plan to Create Safe Bike Routes around the City Develop customized bike routes to improve bike transit. Provide signage, reduce speed limits as necessary, and develop safety education programs on "sharing the road" with bikes.	10	10	- Bicycle master plan created - Signage installed - Outreach materials created and shared via City website, newsletters, local newspapers, and other outlets.	2024-2026	Planning, Public Works		5%	Bike lane project initiated
Action 2.1.3: Ride-Sharing and Bike to Work Programs within City Operations and Businesses Promote ride-sharing and facilitate air district incentives for ride-sharing Provide reserved preferential parking spaces for ride-sharing, carpooling, and ultra-low or zero emission vehicles in City parking lots. Encourage the same at private businesses that have employee parking. Require businesses of a certain size to provide facilities such as bike racks and showers.	Supporting Action	Supporting Action	- Incentives for ride-sharing created and advertised - Incentives for bike riding created and advertised - Reserved parking spaces created for ride-sharing, and low/zero emission vehicles - Bike racks included in design guidelines for commercial remodels	2022-2024	Planning, Public Works		0%	
Measure 2.2. Electrify the Fleet								
Action 2.2.1: Prioritize Electric Vehicles (EVs) Promote electric vehicle incentive programs at outreach events. Apply for grants to install e-chargers at public facilities. Work with community groups and businesses to install additional e-chargers. Encourage hotels to provide priority parking for electric vehicles and provide e-chargers. Provide priority parking for bus tours that use electric buses. Work with Visit Carmel to develop and initiate a Green Visitor Program that rewards tourists that use electric vehicles, carbon credits for air-miles, and that adhere to the City's sustainability practices while visiting the City. Require or incentivize major commercial building renovations/expansions to install e-chargers.	Scope 1 1,511 Scope 3 1,425	Scope 1 1,538 Scope 3 1,452	- EV incentives shared on City website, newsletters, and at energy fair - EV chargers installed at City parking lots - Electric bus parking created and associated outreach - Green Visitor Program established - Outreach at Visit Carmel re: EV chargers on hotel properties - EV chargers included in design guidelines for commercial remodels	2024-2026	Planning, Public Works, Community Activities		10%	FL, PW fleet, EV sweeper; updating EV chargers at Sunset and VL
Measure 2.3 Initiate Origin/Destination								
Action 2.3.1: Develop Model Develop an Origin Destination Transportation Model focused on Carmel-by-the-Sea using the AMBAG regional model as a base. Update the CAP with new VMT data once the Origin Destination Model is completed.	N/A	N/A	- ODTM Model developed - ODTM results incorporated in updated CAP	2024-2026	Planning, Public Works		0%	
Measure 3.1. Promote Clean Energy								
Action 3.1.1: Incentivize Clean Energy Installations Promote clean energy incentives to the community Incentivize solar panels installation on existing residential units Require or incentivize solar panel installation on major commercial building retrofits/expansions and commercial parking lots. Promote energy storage system installation with solar panels.	364	364	- Incentive information on website, at energy fair, and shared via new City outreach and recognition programs - Incentive for solar panel and/or energy storage installation developed	2024-2026	Building, Planning, Public Works	1.3.6	5%	included info in FL
Action 3.1.2: Increase uptake of 3CE Renewable Generation portfolio Switch the City's electricity to 3CE's 100 Percent Renewable Energy Option Promote 3CE's 100 Percent Renewable Energy Option by encouraging residents and businesses to participate in the program.	-	-	- City electricity accounts switched to 3CE's 100% renewable option - 3CE 100% renewable energy option promoted at energy fair and via City outreach and recognition programs	2022-2024	Public Works, Planning		0%	

Measure 4.1. Water Conservation in Landscaping								
Action 4.1.1: Continued Implementation and Promotion of City and Model Water Efficient Landscaping Ordinance Water Conservation Standards Increase promotion of landscaping water conservation standards on website and social media Ensure all projects comply with the City's low-irrigation landscaping requirements. Work with the Monterey Peninsula Water Management District (MPWMD) to promote incentives for existing landscaping retrofits to reduce water use.	2.9	3	- Landscaping water conservation information on website - 100% of projects including landscape retrofits comply with requirements - Landscape retrofit incentives developed and promoted in documents and outreach for development projects	2023-2025	Planning, Forestry, Public Works	3.1.7	0%	
Action 4.1.2: Exceed Water Efficiency Standards In partnership with the MPWMD, conduct direct outreach to HOAs, businesses, residents re: water conservation, grey water, rainwater harvesting Allow and promote recycled water for commercial and multi-family residential landscape irrigation. Allow and promote greywater systems and rainwater harvestine.	Supporting Action	Supporting Action	- Direct outreach to HOAs, businesses, residents thru outreach and recognition programs - Recycled water Standard Operating Guidance developed and promoted for commercial and multi-family construction projects - Grey water systems and rainwater harvesting information promoted in documentation for development projects	2024-2026	Building, Planning, Forestry	3.1.7	0%	still developing
Measure 5.1. Reduce Waste that goes to the Landfill								
Action 5.1.1: Increase the City's solid waste diversion to reduce landfill methane emissions Promote zero waste events, including the use of reusable rather than recyclable materials, and buy local to reduce waste. Work with the Monterey Regional Waste Management District and the waste hauler to implement the requirements of SB 1383, including organic waste collection for all commercial and residential properties to process into compost. Conduct outreach to residents and businesses to ensure compliance and to minimize contamination. Promote home composting and community gardens. Educate the community on proper use of the City-provided grey/green/blue containers.	1500	1500	- Develop zero waste event checklist and require City events to abide by it. - SB 1383 requirements implemented and waste diversion tracked - Outreach to residents and businesses through mailers, newsletters, City website, hauler website, letters, direct outreach.	2022-2024	Public Works, Community Activities		80%	
Measure 6.1. Urban Forest Maintenance for Shade and								
Action 6.1.1: Urban Forest Maintenance and Improvement Maintain the health of the urban forest tree canopy in the City to keep streets shaded and maintain cool surface and ambient air temperatures. Continue to work with the Friends of Carmel Forest and the community to facilitate urban forest maintenance. Update the City's Urban Forest Management Plan to include tree planting guidelines to promote tree health and maintain a healthy urban forest canopy.	-	-	- Urban Forest Management Plan Updated - Tree planting and maintenance guidelines updated - Number of replacement trees planted	2023-2025	Forestry, Public Works	2.1.2	30%	Update of Urban Forest Master Plan in progress, community survey almost closed and draft is completed
Measure 6.2. Light-reflecting Surfaces for Energy								
Action 6.2.1: Allow Cool Roof Options Evaluate the feasibility of allowing cool roof options in residential and commercial areas of Carmel. If feasible, revise existing ordinances to allow cool roof options on residential, commercial and office buildings. Support the use of "Green Roofs" as an option for cool roofs with the use of drought-tolerant plants.	-	-	- Cool roof options researched and evaluated for consistency with Carmel design guidelines - Design Guidelines and/or ordinances revised	2024-2026	Planning		0%	