

Appendix E

Bluff Retreat Evaluation Report

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<u>Section</u>	<u>Page #</u>
Bluff Retreat Evaluation Report	E-1

BLUFF RETREAT EVALUATION REPORT

**DECOMMISSIONING AND REMEDIATION OF
THE CARPINTERIA OIL AND GAS PROCESSING FACILITIES
CARPINTERIA, SANTA BARBARA COUNTY, CALIFORNIA**

Project No. 2002-5211

Prepared for:

Chevron West Coast Decommissioning Program
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TABLE OF CONTENTS

	Page
1.0 INTRODUCTION.....	1-1
2.0 PROJECT UNDERSTANDING.....	2-1
3.0 WORK PERFORMED.....	3-1
4.0 FINDINGS.....	4-1
4.1 SITE LOCATION.....	4-1
4.2 SITE CONDITIONS.....	4-1
4.2.1 Existing Land Uses.....	4-1
4.2.2 Topography and Drainage Conditions.....	4-1
4.3 GEOLOGIC CONDITIONS.....	4-1
4.3.1 Regional Setting.....	4-1
4.3.2 Local Geology.....	4-2
4.4 GROUNDWATER CONDITIONS.....	4-2
4.4.1 Site Specific Hydrogeology.....	4-2
5.0 METHODS.....	5-1
5.1 LIDAR DATA ANALYSIS.....	5-1
5.2 HISTORICAL AERIAL PHOTOGRAPH ANALYSIS.....	5-1
5.3 ESTIMATED AVERAGE ANNUAL RETREAT RATE.....	5-1
6.0 DISCUSSION.....	6-1
7.0 CLOSURE AND LIMITATIONS.....	7-1
8.0 REFERENCES.....	8-1

LIST OF TABLES

1	Summary of LiDAR Data.....	5-1
2	Summary of Historical Aerial photographs.....	5-1

LIST OF PLATES

1	Site Location Map
2	Site Vicinity Map
3	Regional Geology Map
4	Edge of Bluff 2020, 2018, and 1998
5	Bluff Retreat

1.0 INTRODUCTION

The following Bluff Retreat Evaluation Study has been prepared in support of the proposed pipeline removal located within the coastal bluff area of the Chevron Oil and Gas Processing Facility (OGPF), 5675 Carpinteria Avenue, Carpinteria, Santa Barbara County, California (Project Site). The Project location is shown on Plate 1 - Site Location Map.

2.0 PROJECT UNDERSTANDING

The Project Site is located along the coastal bluffs that comprise the southern property boundary of the Chevron OGPF located adjacent to Dump Road in the City of Carpinteria. Currently, Chevron is planning for the removal, future abandonment, and restoration of the OGPF Project Site. Removal of three outfall pipeline bundles from the coastal bluffs is included in the planning of the overall abandonment, remediation, and restoration of the Project Site.

The purpose of this study is to estimate an average annual retreat rate of the coastal bluffs to aide in planning for the removal of the pipeline outfalls located at the Project Site. . Whereas, for the purposes of this study, coastal bluffs will be defined as the edge of sea-cliff located at the crest of the coastal bluff. The bluff retreat rates contained in this study were estimated based on the retreat of the edge of sea-cliff.

3.0 WORK PERFORMED

The scope of work for this investigation was developed through correspondence with Chevron and was conducted in general accordance with our proposal dated April 21, 2020. The services provided by Padre included the following tasks for this study:

- Review of available historical: geologic reports and maps relevant to the Project Site; documented local retreat rates; aerial photography; elevation data (i.e., light detection and range [LiDAR]); and groundwater data;
- Mapping of historical edge of sea-cliff;
- Estimating an average annual retreat rate for use by designers in evaluating an appropriate setback from the top of bluff; and
- Preparation of this report presenting our data and findings.

4.0 FINDINGS

4.1 SITE LOCATION

The Chevron OGP is comprised of approximately 55-acres of land located within the City of Carpinteria, Santa Barbara County, California. Project related facilities located in proximity to the coastal bluffs include the former marine terminal pipelines and the Platform Grace and Gail pipeline bundle (refer to Plate 2). Approximate latitude and longitude at the center of the coastal bluffs Project Site are:

- Latitude 34° 23' 9.174" North
- Longitude -119° 30' 28.468" West

4.2 SITE CONDITIONS

4.2.1 Existing Land Uses

The Project Site is located within the Carpinteria Valley within an area that has been historically utilized for agricultural production and oil and gas development support activities. The Project Site was historically operated by Chevron to receive, process, and transport oil and gas produced from offshore oil platforms located within the Santa Barbara Channel beginning in approximately 1959 (Plates 1 and 2). Venoco, Inc. owned and operated the facility from approximately 1999 to 2017. The Project Site was re-acquired by Chevron U.S.A. in 2017 (Padre, 2021).

4.2.2 Topography and Drainage Conditions

Ground surface elevations at the Project Site range from approximately 5 to 57 feet AMSL south of the Union Pacific Railroad (UPRR) property. The Project Site is bordered by the UPRR, the pier parking lot, and FSBA to the north; the Tee-Time golf driving range and agricultural property to the northeast; Tar pits Park to the west; a residential neighborhood to the northwest; and the Pacific Ocean to the south.

4.3 GEOLOGIC CONDITIONS

4.3.1 Regional Setting

The Project Site is located along the south margin of the Transverse Ranges Geomorphic Province. These mountains represent a large east-west-trending anticline that has been complexly faulted. The Santa Ynez Mountains and adjacent coastal lowlands, on which the Project Site is situated, are composed of sedimentary rocks ranging in age from Eocene to Holocene (Geotechnical Consultants, 1976; Plate 3).

Quaternary marine terrace deposits that consist primarily of silty and sandy clays to coarse-grained sands underlie the Project Site. These marine terrace deposits overlie the

Miocene Monterey Formation, which consists of marine shales and siltstones. The regional structure of the Monterey Formation in this area is complex with a series of northwest-trending flexures mapped in the sea cliff south of the Project Site. Beneath the Project Site the Monterey Formation is thought to have a near vertical dip (Patry, 1983). The Monterey Formation has been upthrown along the east-west-trending Carpinteria Fault, which is a south-dipping reverse fault. This fault forms the southeastern boundary of the Carpinteria Basin, a faulted syncline containing Eocene through Miocene sediments and up to 4,000 feet of Plio-Pleistocene and younger sediments (Patry, 1983). The Carpinteria Basin has been divided into two distinct areas by the southerly-dipping Rincon Creek thrust fault, which is located approximately 0.4 mile north of the site (Maltby, 1984).

4.3.2 Local Geology

The maximum depth of recent soil assessment activities completed at the Project Site was approximately 30 feet below ground surface (bgs). Earth materials encountered during assessment activities generally consisted of unconsolidated sediments including poorly-graded sand, well-graded sand, silty sand, clayey sand, silt, and subordinate layers of clay. Native soil at certain areas of the Project Site is covered by thin layers (approximately 6- to 24-inches) of imported fill material and/or concrete. The underlying weathered bedrock surface of the Monterey Formation (logged as siltstone, shale, or hard silt / weathered bedrock) was observed at several drill hole locations at depths ranging from approximately 12 feet to 25 feet bgs. Tar and/or oil seep deposits consistent with documented naturally-occurring petroleum hydrocarbon deposits were found locally in the Monterey Formation. Bedrock materials of the Monterey Formation are typically known and documented to contain naturally-occurring petroleum hydrocarbons that are present at and below the Project Site, as evidenced in the wave-cut platform and sea-cliff. Naturally occurring petroleum hydrocarbons are present as seeps and tar sands, as well as, solidified along bedding planes and in bedrock joints and fractures that are exposed on the sea-cliff (Padre, 2021).

4.4 GROUNDWATER CONDITIONS

4.4.1 Site Specific Hydrogeology

Quaternary marine terrace deposits (silty and sandy clays to coarse-grained sands) underlie the Chevron OGP to depths of approximately 10 to 25 feet bgs. These materials overlie the Miocene Monterey Formation, which is approximately 1,450 feet thick and is classified as a non-water bearing formation due to its low storage capacity (Geotechnical Consultants, 1976). Groundwater was generally not encountered within drill holes that Padre has historically advanced at the northern and eastern areas of the OGP during soil and groundwater assessment activities. Where present, first subsurface water was encountered in the marine terrace deposits within the western portions of the OGP at depths ranging from approximately 5 feet to 22 feet bgs and is perched above the Monterey Formation. Depth to water measurements recorded at the OGP groundwater monitoring well locations on February 20, 2019, ranged from 4.73 feet (MW-O/G-8) to 19.02 feet (MW-O/G-10) below the tops of the well casings, corresponding to groundwater elevations of 37.92 feet and 44.12 feet AMSL, respectively. Potentiometric surface elevation data collected on February 20, 2019, at the

existing groundwater monitoring well network indicate that the groundwater flow direction beneath the OGPF is toward the north to northwest.

5.0 METHODS

5.1 LIDAR DATA ANALYSIS

LiDAR elevation data was obtained for the years of 2020, 2018, and 1998 (Table 1). The LiDAR data was collected via aircraft using laser scanning technology to capture coordinate location data as northing, easting, and elevation data as a point cloud. The point cloud data was interpolated by the data collection agencies and provided to Padre as polyline feature contour data delineating the sea-cliff at the Project Site. The edge of sea-cliff was delineated in geographic information systems (GIS) from the contour LiDAR data for each data set: 2020; 2018; and 1998 (Plate 4).

Table 1. Summary of LiDAR Data

Year	Source
2020	KCSI Aerial Patrol
2018	NOAA USGS Lidar: Southern CA Wildfires (Job629750_ca2018_wildfires)
1998	NASA/NOAA/USGS ATM Lidar: West Coast, Post-El Nino (CA, OR, WA) (Job629769_1998_SpringWC)

5.2 HISTORICAL AERIAL PHOTOGRAPH ANALYSIS

Historical aerial photographs corresponding to the years of LiDAR data were used to fine tune the delineation of the top edge of the coastal bluff (Table 2). Aerial photographs were viewed in two-dimension (2D or planar view) and in three-dimension (3D) in ArcMap and Google Earth Pro, respectively. It should be noted that a 1998 aerial photograph of sufficient quality for analysis was unavailable for use at the time of this study; however, a 1994 aerial photograph was available from Google Earth Pro that generally agreed with the 1998 edge of coastal bluff and was used as background imagery for display purposes (Plate 4).

Table 2. Summary of Historical Aerial Photographs

Year	Source
2020	KCSI Aerial Patrol
2018	Google Earth Pro Image
1994	Google Earth Pro Image

5.3 ESTIMATED AVERAGE ANNUAL RETREAT RATE

Annual retreat rates for the edge of the coastal bluff at the Project Site were estimated at eleven points that were selected based on proximity to the proposed pipeline landfall removal locations (Plate 5). Additionally, retreat rates were estimated at locations between the pipeline

landfall locations where significant retreat was evidenced by the historical LiDAR data and aerial photographs. Estimated annual retreat rates shown on Plate 5 were calculated using the change in distance of the 2020 and 1998 LiDAR defined edge of bluff divided by the 22 years separating the collection of the data sets. An estimated average annual retreat rate of 14 centimeters per year (cm/yr) for the Project Site was calculated based upon the average of the eleven point specific retreat rates displayed on Plate 5.

6.0 DISCUSSION

The Project Site is composed of a non-water bearing Miocene aged Monterey Shale coastal bluff that is continually exposed to the effects of coastal processes contributing to weathering and erosion of the bluff. Whereas, the Monterey is non-water bearing, ground water does not influence the internal weathering of the shale unit. Therefore, wave action is the primary hydraulic weathering process affecting the coastal bluff at the Project Site, with the changing tides and wave action expanding existing fractures and joints to loosen material that is eroded away. Large winter storm events are the primary source of bluff erosion and generally remove enough material in one or two events to equal the estimated average annual erosion rate: bluff erosion and retreat generally do not take place as incremental events happening over the course of the year, but rather the result of one or two major events (von Thury, 2013). It should be noted that major erosional events may not occur annually. The retreat rates estimated in this study are based on LiDAR data collected in the most recent 20 years; therefore, if LiDAR were available over a larger time period, the rates may vary. Although, vegetation removal or tree falls; rainfall and associated runoff; and anthropogenic installations such as drainage outfalls and irrigation can contribute to weathering and erosional processes, they are not considered to be major factors contributing to bluff erosion and retreat at the Project Site.

Additional factors such as aspect, tidal influence, and rock strength also contribute to the range of estimated retreat rates at the Project Site: 6 to 28 cm/yr (Plate 5). The retreat rates at the lower end of the range are found at locations where the bluff has been armored at the toe with riprap (large boulders) or the bluff top edge of cliff was reinforced with a concrete pad. In general, higher rates of retreat were associated with sections of the bluff with a western aspect.

An estimated average annual retreat rate of 14 cm/yr was calculated for the Project Site from a comparison of 2020 versus (vs.) 1998 LiDAR data. In 2013, a University of California, Santa Barbara Master of Science Thesis, *Using Laser Scanning Technology to Monitor Coastal Erosion and Sea-Cliff Retreat in Southern Santa Barbara County, California*, estimated regional erosion rates for the stretch of bluff in the vicinity of Tar Pits Park, the Carpinteria Pier, and the Carpinteria Bluffs Nature Preserve to be approximately 11 cm/yr. The 2013 study calculated estimated annual erosion rates using 2010 vs. 1998 and 1997 NOAA LiDAR data. The 1998 NOAA LiDAR data set used in the 2013 study is the same elevation data set that was used in the current study conducted by Padre (von Thury, 2013). The retreat rates estimated for both this study and the von Thury 2013 study generally agree with a 2005 study by Gary Griggs et al that calculated retreat rates based on monument measurements at various locations in southern Santa Barbara County between Point Conception and Rincon Point to range from 8 to 30 cm/yr.

7.0 CLOSURE AND LIMITATIONS

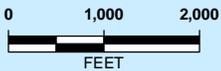
Padre prepared the findings and data presented herein in accordance with generally accepted geologic and geotechnical engineering practices at the time and location that this report was prepared. No other warranty, express or implied, is made.

Soil and rock materials are typically not homogenous in type, strength, and other geotechnical properties and can vary between points of observation and exploration. In addition, groundwater and soil moisture conditions can vary seasonally and for other reasons. Padre does not and cannot have a complete knowledge of the subsurface conditions underlying a site. The data presented in this report are based upon the findings at the points of interpolation and extrapolation of information between and beyond those points of analysis.

8.0 REFERENCES

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PLATES



LEGEND:

Approximate Limits of Chevron-Owned Land

MAP EXTENT:



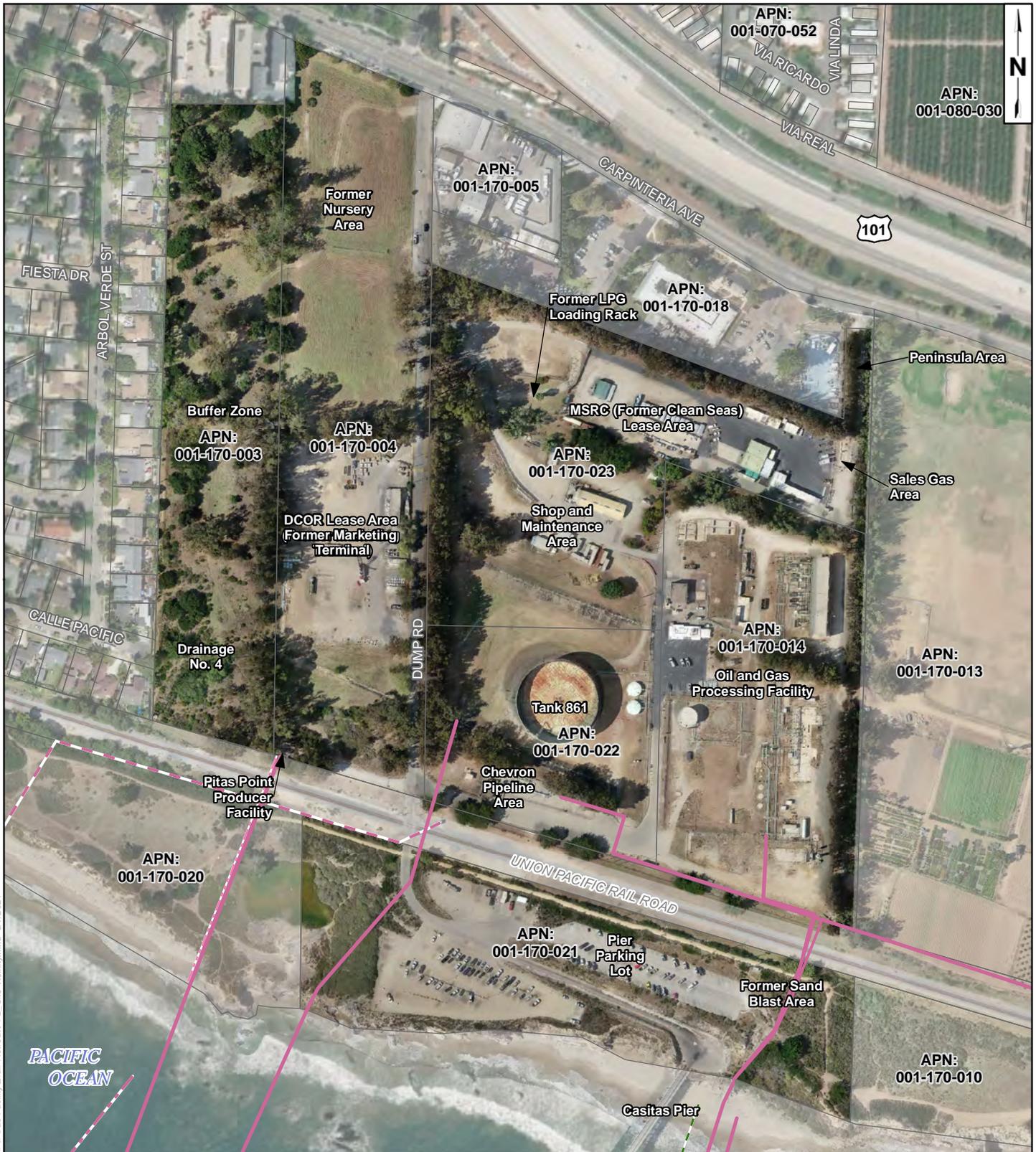
Source: Esri Online Topo Basemap, County of Santa Barbara
 Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
 Notes: This map was created for informational and display purposes only.



PROJECT NAME: BLUFF RETREAT STUDY CARPINTERIA PLANT DECOMMISSIONING SANTA BARBARA COUNTY, CA	
PROJECT NUMBER: 2002-5211	DATE: June 2021

SITE LOCATION MAP

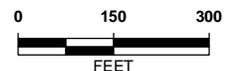
PLATE
1



LEGEND:

□ Assessor Parcel Boundary

- Abandoned Power Cable
- - - Abandoned Pipeline Created from 2013 NOAA Chart
- Oil Pipeline
- - - Abandoned Pipeline
- · - · - Inferred Pipeline



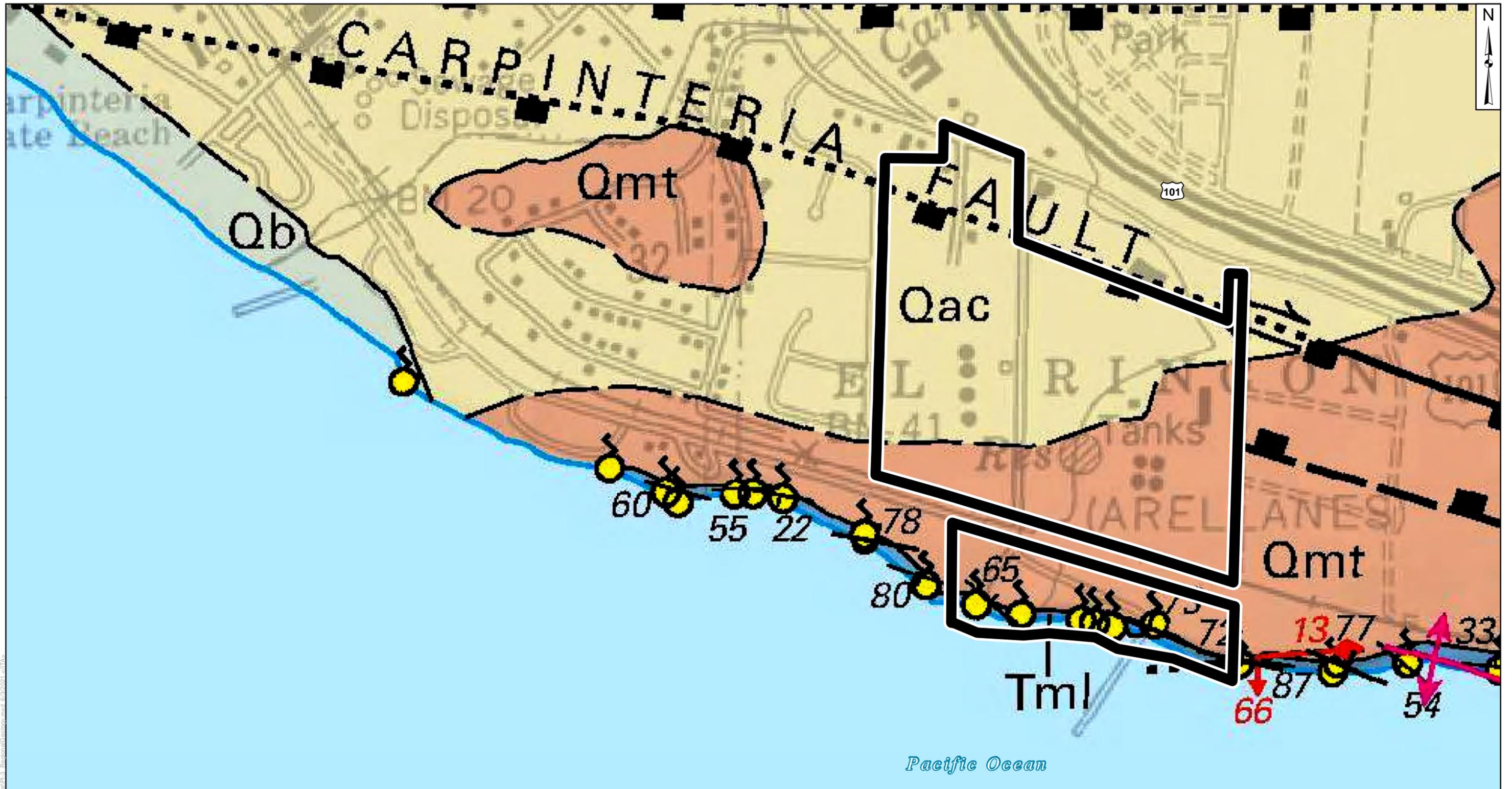
Source: KCSI Aerial Patrol 2020, Assessor parcels downloaded from County of Santa Barbara
 Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
 Notes: This map was created for informational and display purposes only.



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SITE VICINITY MAP

PLATE
2

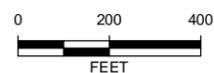


LEGEND:
 Approximate Limits of Chevron-Owned Land

Geologic Unit:

Beach Deposits (Qb)	Marine-Terrace Deposits (Qmt)
Alluvium and Colluvium (Qac)	Monterey Formation, Lower Calcareous Unit (Tml)

MAP EXTENT:



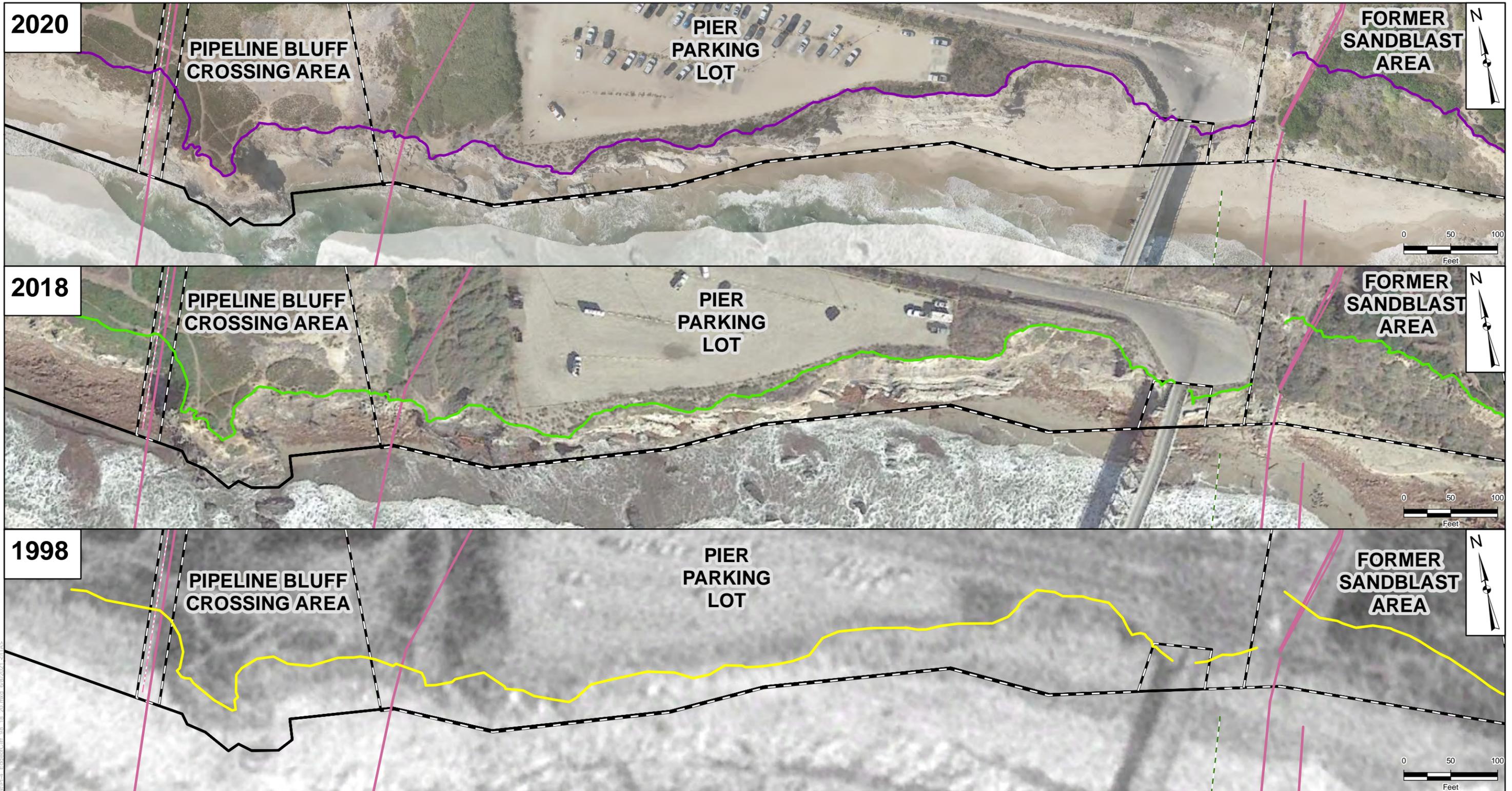
Source: Minor, S.A., et al. (2009), Geologic map of the Santa Barbara Coastal Plain Area, Santa Barbara County, California.
 Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
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 CARPINTERIA PLANT DECOMMISSIONING
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**REGIONAL GEOLOGY
 MAP**

PLATE
 3



LEGEND:

- Edge of Bluff Defined by LiDAR Contour Data
- Edge of Bluff 2020
- Edge of Bluff 2018
- Edge of Bluff 1998
- Abandoned Power Cable
- Oil Pipeline
- Inferred Pipeline
- Operational Area
- Project Site

MAP EXTENT:



Source: KCSI Aerial Patrol 2020; 2018 Ca Wildfires: 1998 Spring West Coast; and 2018 and 1994 Google Pro Images.
 Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
 Abbreviations:
 cm/yr = centimeters per year
 LIDAR = Light Detection and Range
 Notes: 1) 1998 edge of cliff overlay 1994 aerial photo due to poor image quality of 1998 aerial photograph.
 2) This map was created for informational and display purposes only.



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**EDGE OF BLUFF 2020,
 2018, AND 1998**

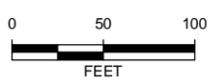
PLATE
4



LEGEND:

- Edge of Bluff Defined by LiDAR Contour Data
- Edge of Bluff 2020
- Edge of Bluff 2018
- Edge of Bluff 1998
- 28 Retreat Rate (cm/yr, 1998 - 2020)
- Abandoned Power Cable
- Abandoned Pipeline Created from 2013 NOAA Chart
- Oil Pipeline
- Inferred Pipeline
- Operational Area
- Project Site

MAP EXTENT:



Source: KCSI Aerial Patrol 2020, 1998 Spring West Coast, 2018 Ca Wildfires
 Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
 Abbreviations:
 cm/yr = centimeters per year
 LiDAR = Light Detection and Range
 Notes: This map was created for informational and display purposes only.



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BLUFF RETREAT

PLATE
5