

Lemos, June

From: Jacob Patterson <jacob.patterson.esq@gmail.com>
Sent: Monday, September 9, 2019 2:28 PM
To: Lemos, June
Subject: Public Comment -- 9/9/19 CC Mtg., Item No. 7A
Attachments: 20190909_120941.jpg; 20190909_120312.jpg; 20190909_120343.jpg; 20190909_120842.jpg; 20190909_120322.jpg; 20190909_120422.jpg; 20190909_120345.jpg

June,

Please include these photos of APN 018-340-03, 601 Cypress Street as a public comment for Item No. 7A.

Thanks,

--Jacob





Lemos, June

From: Jacob Patterson <jacob.patterson.esq@gmail.com>
Sent: Monday, September 9, 2019 3:01 PM
To: Lemos, June
Subject: Public Comment -- 9/9/19 CC Mtg., Item No. 7A (2 of 2)
Attachments: 20190909_093642.jpg; Cupressus goveniana var. goveniana _ Threatened Conifers of the World.pdf; Cupressus goveniana var. pigmaea (Mendocino cypress) description.pdf; Hesperocyparis goveniana.pdf; Cupressus goveniana _ Threatened Conifers of the World.pdf; Gowen Cypress, Hesperocyparis goveniana.pdf

Here is the rest of the attachments for APN 020-520-22 and 020-540-10.

Threatened conifers of the world

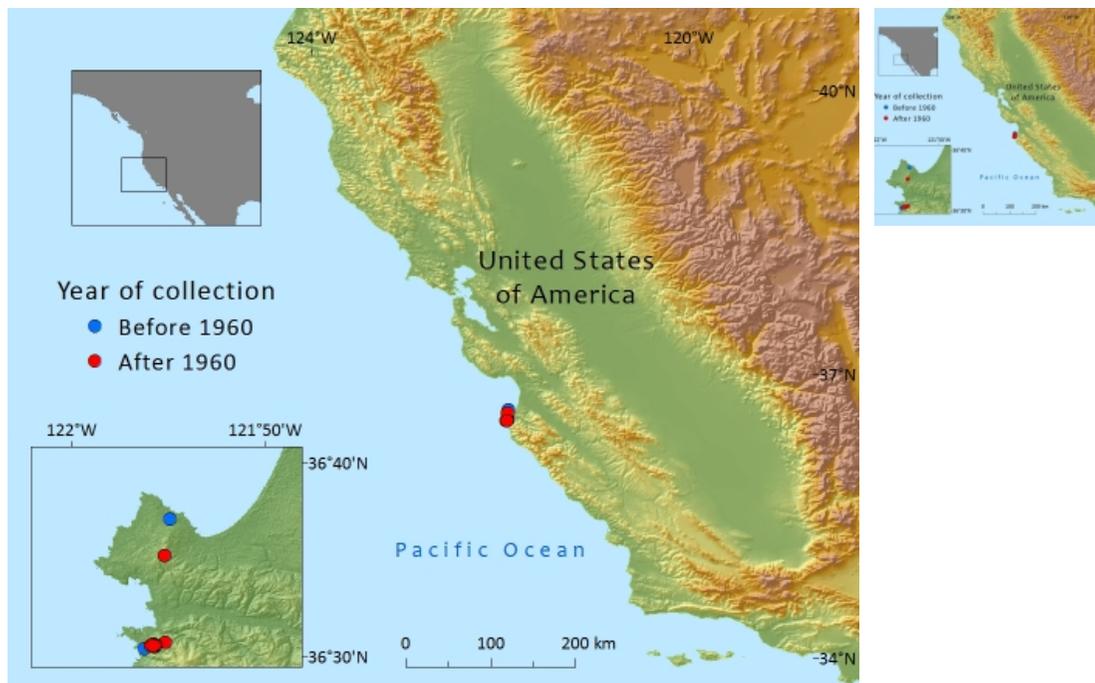
A resource compiled by the International Conifer Conservation Programme, Royal Botanic Garden Edinburgh
(<http://threatenedconifers.rbge.org.uk/>)

Cupressus goveniana *Gordon*

CUPRESSACEAE

Endemic to California, USA where it is facing a range of threats including changes to fire regimes, urbanisation, invasive non-native plants and agriculture.

Associated Names:



Distribution

Distributed in the USA in the Counties of California, Mendocino, Sonoma, Santa Cruz, San Mateo and Monterey. The total population of this species probably consists of fewer than 2300 mature individuals, unless the dwarfed individuals with seed cones on the Mendocino "white plains" are also counted as such.

Habitat and Ecology

Occurs in chaparral, 'pine barrens', and open pine woodland with *Pinus attenuata*, *P. contorta*, *P. muricata*, *P. ponderosa*, *P. radiata*, *Pseudotsuga menziesii*, *Arctostaphylos*, *Quercus*, and *Rhododendron*, often in groves of up to 1000 trees or

Region



- Northern Mexico / SW USA

(<http://threatenedconifers.rbge.org.uk/taxa/category/northern-mexico-sw-usa>).

more; on sandstone outcrops, white or yellow sandy slopes, and leached, virtually sterile sandy 'hardpan', where it becomes dwarfed. The altitudinal range is from near sea level to 1200m The climate is of the Mediterranean type with dry, hot summers, but in a narrow coastal strip cooled by frequent fog, and winter rain.

Human Uses

Although introduced by C. T. Hartweg to England in 1848, this species soon turned out to be tender in NW Europe and its cultivation outside collections ceased. In southern Europe it is grown more widely in gardens and parks and a few cultivars are known, some with doubtful affinity to this species.

Conservation Status

Global status

Endangered

Global rationale

The assessment of the species as a whole is driven by that of the nominate variety (var. *goveniana*) as it has the greatest extent of occurrence (EOO) and area of occupancy (AOO) as well as numbers of mature individuals. This variety was assessed as Endangered under the B criterion.

Global threats

Urbanization, agriculture (conversion of wild land to pasture), changes in fire regimes.

Conservation Actions

Some subpopulations are either completely or partly within protected areas.

References and further reading

1. Adams, R.P., Bartel, J.A. & Price, R.A.. (2009). A new genus, *Hesperocyparis*, for the cypresses of the western hemisphere. *Phytologia* 91(1):160-185.
2. de Laubenfels, D.J. (2009). Nomenclatural actions for the New World cypresses (Cupressaceae). *Novon* 19(3):300-306.
3. Farjon, A. (2005.) *A Monograph of Cupressaceae and Sciadopitys*. Royal Botanic Gardens, Kew.
4. Farjon, A. (2013). *Cupressus goveniana*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 06 July 2013.
5. Little, D.P. (2006). Evolution and circumscription of the true cypresses (Cupressaceae: Cupressus). *Systematic Botany* 31(3): 461-480.
6. Wolf, C.B. (1948). Taxonomic and distributional studies of the New World cypresses. *Aliso* 1:1-250.

External links

Entry information

Entry authors

- A.Farjon
Entry first added:
26 Oct 2012

Entry last edited:
27 Aug 2015

Recommended Citation

A.Farjon, 2015. *Cupressus goveniana*, from the website, Threatened Conifers of The World (<http://threatenedconifers.rbge.org.uk/taxa/details/897>).
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Threatened conifers of the world

A resource compiled by the International Conifer Conservation Programme, Royal Botanic Garden Edinburgh (<http://threatenedconifers.rbge.org.uk/>)

Cupressus goveniana var. goveniana

CUPRESSACEAE

Endemic to California, USA where altered fire regimes and urbanisation are the main threats

Distribution

USA distributed in the Coast Ranges of central and northwestern California: Mendocino, Sonoma and Monterey Counties. Found in the following localities: 1) SW slope of Huckleberry Hill, Monterey Peninsula; 2) Cypress Point Pine Barrens, near a large water reservoir close to Seventeen Mile Drive; 3) A seaward hill slope near Gibson Creek, well above Point Lobos State Park road; 4) Canyon of Gibson Creek ca. 2 miles east of Point Lobos; and 5) Pacific Grove, Monterey peninsula; 6) the "white plains" or "pine barrens" of Mendocino County (sometimes referred to as subsp. *pigmaea*).

This nominate variety is known from less than 2000 mature individuals scattered between about 10 subpopulations in 5 localities. It is unlikely that any of these subpopulations contains more than 250 mature individuals. The dwarf form can produce seed cones when only a few decimeters tall, but in very low quantities. Strictly speaking these are also mature individuals and if counted as such could increase these numbers.

Habitat and Ecology

This variety grows in chaparral, in "pine barrens" [large stands of pines (*Pinus* spp.)], on sandstone outcrops, on white or yellow sandy slopes and on leached, sometimes sterile sandy "hardpan" which causes the dwarfed individuals ("*pigmaea*"). In some areas it is a component of closed-cone pine-cypress woodlands.

Human Uses

Used in southern Europe as an ornamental tree in gardens and parks.

Conservation Status

Region



- [Northern Mexico / SW USA](http://threatenedconifers.rbge.org.uk/taxa/category/northern-mexico-sw-usa) (<http://threatenedconifers.rbge.org.uk/taxa/category/northern-mexico-sw-usa>).

References and further reading

1. Adams, R.P., Bartel, J.A. & Price, R.A.. (2009). A new genus, *Hesperocyparis*, for the cypresses of the western hemisphere. *Phytologia* 91(1):160-185.
2. Farjon, A. (2005). *A Monograph of Cupressaceae and Sciadopitys*. The Royal Botanic Gardens, Kew.
3. Farjon, A. (2013). *Cupressus goveniana* ssp. *goveniana*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 06 July 2013.
4. de Laubenfels, D.J. (2009). Nomenclatural actions for the New World cypresses (Cupressaceae). *Novon* 19(3):300-306.
5. Little, D.P. (2006). Evolution and circumscription of the true cypresses (Cupressaceae: *Cupressus*). *Systematic Botany* 31(3): 461-480.

Global status

Endangered B2ab(ii,iii,v)

Global rationale

This variety meets the B criterion for Endangered due to its limited area of occupancy (AOO) even when calculated with an enlarged grid width of 4km due to missing map points in the northernmost subpopulation (formerly recognized as subsp. *pigmaea*). A continuing decline is suspected due to fire exclusion and indirect threats associated with urban developments.

Global threats

There are threats from development (urbanization, making and maintenance of golf courses, road building), erosion, invasive non-native species and agriculture. Altered fire regimes through fire suppression can favour *Pinus* spp. and could reduce the fecundity of mature cypress trees, which rely on fire for opening the cones and subsequent release of seeds.

Conservation Actions

This variety occurs in S.F.B. Morse Botanical Reserve and Point Lobos Reserve (Monterey Co.) and outside reserves along the coast in Mendocino and NW Sonoma Counties. The S.F.B. Morse Botanical Reserve is located within the Gowen Cypress Planning Area in two parcels to the south and east of Congress Road. The S.F.B. Morse Botanical Reserve was established in 1972 to protect the endangered Gowen Cypress (*sensu stricto*), as well as other species or associations of species found only on the acidic clay-pan soils found in this area. This reserve is adjoined by the 372 acres of the Huckleberry Hill Natural Habitat Area.

This variety is listed under the U.S. Endangered Species Act: and has also been listed as Critically Imperilled on NatureServe database (NatureServe 2012).

6. NatureServe. (2012). NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. Arlington, Virginia Available at: <http://www.natureserve.org/explorer>.

Entry information

Entry authors

- A.Farjon

Entry first added:
26 Oct 2012

Entry last edited:
6 Jul 2013

Recommended Citation

A.Farjon, 2013. *Cupressus goveniana* var. *goveniana*, from the website, Threatened Conifers of The World (<http://threatenedconifers.rbge.org.uk/taxa/details/896>).

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Cupressus goveniana var. pigmaea

Lemmon 1895

Common names

Mendocino or pigmy cypress (Peattie 1950).

Taxonomic notes

Synonymy:

- *Cupressus pigmaea* (Lemmon) Sargent 1901;
- *Cupressus goveniana* subsp. *pigmaea* (Lemmon) A. Camus 1914;
- *Callitropsis pigmaea* (Lemmon) D.P. Little 2006;
- *Hesperocyparis pygmaea* (Lemmon) Bartel 2009;
- *Neocupressus goveniana* var. *pygmaea* (Lemmon) de Laubenfels 2009.

The spelling variants "pigmaea" and "pygmaea" appear in all names.

One molecular analysis has indicated that this taxon may be more closely related to *Cupressus macrocarpa* than to *C. goveniana* (Terry *et al.* 2012), but the results thus far are inconclusive.

Description

Distinguished from the type variety only by its large size and slender, whip-like leader (Wolf 1948), and by its unique growth form on the White Plains, described below.

Distribution and Ecology

USA: California: Mendocino County: two coastal area near Fort Bragg and Mendocino City. Habitat is the Mendocino White Plains, a highly acidic, nutrient-deprived white sandy soil over a hard clay. Some plants are dwarf, flowering when less than 1 m tall, and they occur with two pines (*P. contorta* and *P. muricata*) that flower at similarly diminutive sizes (Lanner 1999).

Big tree

Height 43 m, dbh 213 cm, crown spread 12 m, in Mendocino County, CA (American Forests 2000). A specimen 48 meters (157 feet) tall was reported in 1929 (Lanner 1999).

Oldest

Dendrochronology

Ethnobotany

Observations

Based on historical collections and land preservation patterns, a good place to see the small trees would appear to be the Jackson State Forest, about two miles east of the city of Mendocino. [HERE](#) is a Google Maps image of a likely area.

Remarks

"The pygmy forests of this species and *Pinus contorta* on the shallow hardpan soils of coastal terraces of the Mendocino white plains are a remarkable example of phenotypic plasticity" (Eckenwalder 1993).

Citations

American Forests 2000. The National Register of Big Trees 2000. Washington, DC: American Forests.

Bartel 2009: described in Adams, R. P., J. A. Bartel and R. A. Price. 2009. A new genus, *Hesperocyparis*, for the cypresses of the western hemisphere. *Phytologia* 91(1):160-185.

Lemmon, J. G. 1895. *West-American Cone-Bearers*, 3rd ed. Pp. 76-77.

<http://www.cupressus.net/CUpygmaeaLemmon.html>, courtesy of the Cupressus Conservation Project website.

Terry, R. G., J. A. Bartel, and R. P. Adams. 2012. Phylogenetic relationships among the New World cypresses (*Hesperocyparis*; Cupressaceae): evidence from noncoding chloroplast DNA sequences. *Plant Systematics and Evolution* DOI: 10.1007/s00606-012-0696-3.



Distribution of *Cupressus goveniana* var. *pigmaea* (Griffin and Critchfield 1972).



See also

The species account at [Threatened Conifers of the World](#).

Adams, R. P. and J. A. Bartel. Intraspecific variation in *Hesperocyparis goveniana* and *H. pygmaea*: ISSRs and terpenoid data. *Phytologia* 91(2):277-286.

Bisbee, Jeff. 2006. [Photos](#) at the [Cupressus Conservation Project](#) website.

[Little \(1970\)](#).

Sargent. 1901. North American trees. *Botanical Gazette* 31: 239-240. <http://www.cupressus.net/CUpygmaeaSargent.html>, courtesy of the [Cupressus Conservation Project](#) website.

Home

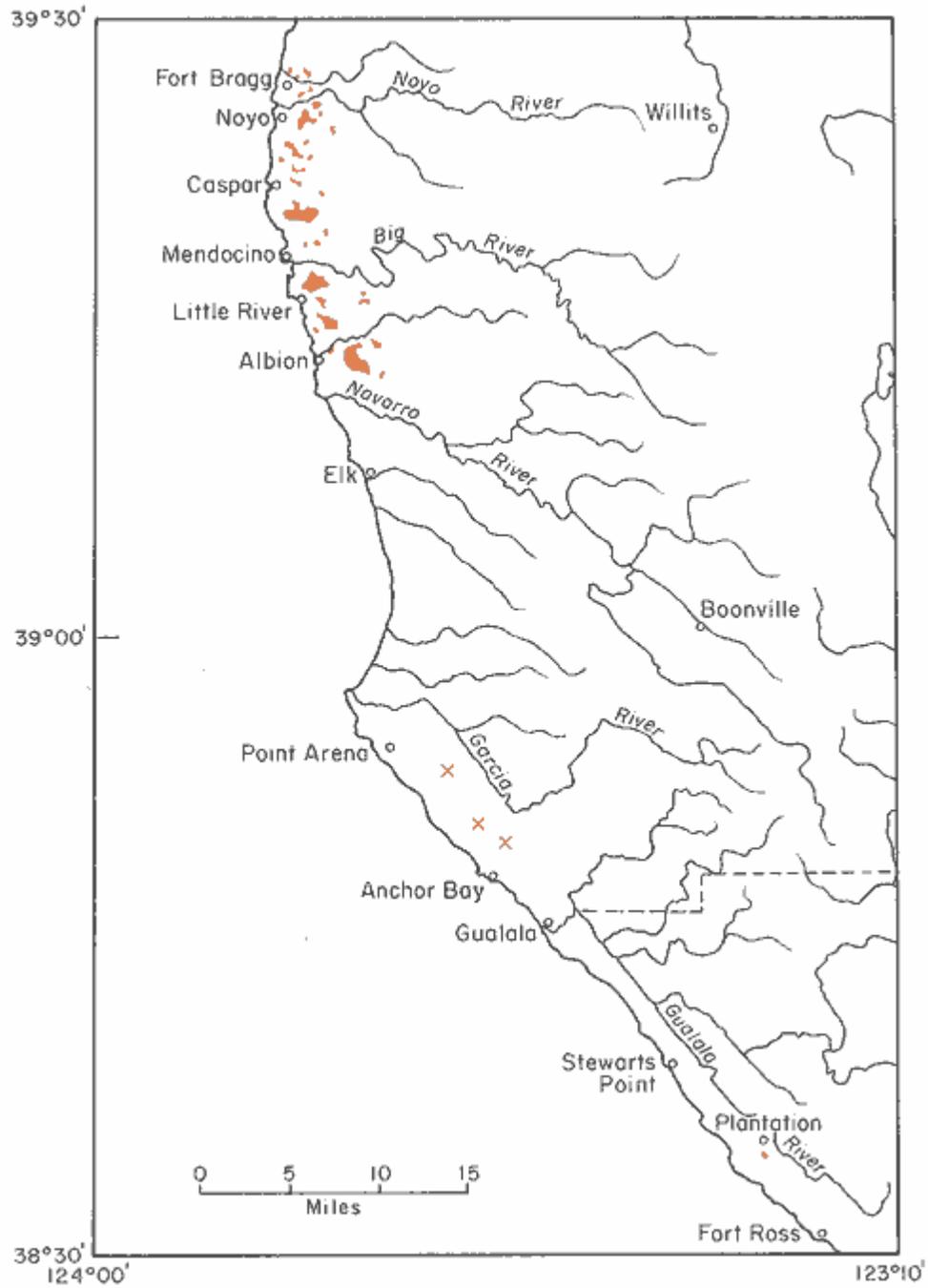
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Edited by Christopher J. Earle
pingora@protonmail.com

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Last Modified 2019-03-01





CALIFORNIA WAY

NO PARKING

NO STOPPING

Lemos, June

From: Jacob Patterson <jacob.patterson.esq@gmail.com>
Sent: Monday, September 9, 2019 3:01 PM
To: Lemos, June
Subject: Public Comment -- 9/9/19 CC Mtg., Item No. 7A (1 of 2)
Attachments: 20190909_093712.jpg; 20190909_093653.jpg; 20190909_093715.jpg; 20190909_093833.jpg

June,

Please include these photos of APN 020-520-22 and 020-540-10 (from Page 11 of Attachment B to the Housing Element) as a public comment for Item No. 7A. I will forward an additional email with another picture and some reference materials about Mendocino Cypress trees, which are endangered and are present on these sites as shown in the pictures.

Thanks,

--Jacob



Lemos, June

From: Jacob Patterson <jacob.patterson.esq@gmail.com>
Sent: Monday, September 9, 2019 3:10 PM
To: Lemos, June
Subject: Public Comment -- 9/9/19 CC Mtg., Item No. 7A
Attachments: 20190909_121535.jpg; 20190909_121609.jpg; 20190909_121647.jpg; 20190909_121534.jpg; 20190909_121602.jpg

June,

Please include these photos of APN 018-090-02 and 018-090-16, 700 River Drive, as a public comment for Item No. 7A.

Thanks,

--Jacob





Lemos, June

From: Jacob Patterson <jacob.patterson.esq@gmail.com>
Sent: Monday, September 9, 2019 3:15 PM
To: Lemos, June
Subject: Public Comment -- 9/9/19 CC Mtg., Item No. 7A
Attachments: 20190909_122531.jpg; 20190909_122739.jpg; 20190909_122215.jpg; 20190909_122533.jpg; 20190514 180 Boatyard CDP - fence.pdf

June,

Please include these photos of APN 018-150-55, 018-150-56, and 018-158-58 (from page 14 of Attachment B to the Housing Element) as a public comment for Item No. 7A. I also included a PC staff report describing the trees and slope of the property in this area that constitute constraints on the development of the vacant and underutilized sites.

Thanks,

--Jacob

MEETING DATE: May 14, 2019

PREPARED BY: M Jones

PRESENTED BY: Marie Jones

AGENDA ITEM SUMMARY REPORT

APPLICATION NO.: Coastal Development Permit 1-19 (CDP 1-19)

PROPERTY OWNERS: Judy L Haun

APPLICANT/AGENT: City of Fort Bragg

PROJECT DESCRIPTION: Construction of three sections of 6 foot high habitat protection fence totaling 250 feet, 450 and 350 linear feet, at the following addresses: 180 Boatyard Drive, 1190 S Main St, 1102 S Main St. The purpose of the fence is to prevent trespassing and homeless encampments and related contamination of these properties with waste and trash.

LOCATION: 180 Boatyard Drive, 1190 S Main St, 1102 S Main St. The project is in the Coastal Zone.

ZONING: Highway Visitor Commercial (CH), Coastal Zone (CZ)

ENVIRONMENTAL DETERMINATION: The City of Fort Bragg is Lead Agency for California Environmental Quality Act purposes, and this project is exempt from CEQA per Section 15303c: accessory structures, including fences.

SURROUNDING LAND USES:

NORTH:	Noyo River & Harbor
EAST:	Noyo River & Harbor
SOUTH:	Hotel and Shopping Center
WEST:	RV Park, Restaurant, and Retail

Recommended Action: Approve Coastal Development Permit 1-19 (CDP 1-19) subject to the Findings and Special and Standard Conditions.

PROJECT HISTORY

IN 2014 the Planning Commission approved a Major Subdivision 4-02/14 (DIV 4-02/14) and Coastal Development Permit 9-02/14 (CDP 9-02/14) to subdivide this 7.13 acre property into four parcels. The CDP included a number of Special Conditions relevant to the proposed project, including special conditions to protect trees and provide a irrevocable offer to dedicate and easement for public access to Noyo Harbor.

The subject property has been the subject of code enforcement activities for more than 12 years to clean up extensive homeless encampments. Just this year, the City, MedoRecycle and the property owner participated in a significant multi-day clean-up effort, involving volunteers, employees of MendoRecycle, the City of Fort Bragg and of the property owner. A total of 80 cubic yards of waste and debris were removed from the property. As part of the Code Enforcement activity the City requested that the property owner apply for a CDP to install a fence to deter future trespassing, homeless encampments and pollution of ESHAs and the Noyo River.

PROJECT DESCRIPTION

Construction of three sections of 6 foot high habitat protective fencing totaling 250 feet, 450 and 350 linear feet, at the following addresses: 180 Boatyard Drive, 1190 S Main St, 1102 S Main St (see Attachment 2 for the fence location). The purpose of the fence is to protect native habitat and Environmentally Sensitive Habitat Area (ESHA) from habitat degradation resulting from illegal camping, illegal dumping and illegal clearing or land for illegal camping. The fence will be constructed of 6 foot high black mesh livestock wire and a combination of T-stakes and wood posts (a similar design to the Coastal Trail property line fencing). The fence is easy to see through but should deter activities that result in habitat degradation within and around a Bishop Pine Forest ESHA (See Attachment 1).

CLUDC Analysis

Land Use. The parcel is located in the Highway Visitor Commercial (CH) zone and a habitat protection fence is consistent with this zoning. The proposed fence would be located outside of all setbacks and thus would comply with setback requirements.

Coastal Development Permit Analysis

Visual Resources. The proposed development is not located in a mapped scenic view area, as shown on Map CD-1, "Potential Scenic Views Toward the Ocean or the Noyo River" of the Coastal General Plan. The proposed fence would allow for visual access to the views from the public right of way as the fence is a coasted black open weave wire fence. This proposed fence is the same as the property line fencing at the Coastal Trail and is illustrated in the photo below:



The photos below illustrate the views from the public right of way and the proposed fence locations (in grey line). As illustrated below the fencing will be virtually invisible (given the distance from the public right of way and the background of obscuring trees and vegetation).



Visual Simulation 1: Proposed Fence location (grey lines) on north side of parcel. View from Highway 1 looking east



Visual Simulation 2: Proposed Fence location (grey lines) at the middle of site. View from Highway 1 looking east



Visual Simulation 3: Proposed Fence location (grey lines) at southern edge of site - Boatyard Dr. looking north

Environmentally Sensitive Habitat Area (ESHA).

The area proposed for the fence is composed of weedy (aka ruderal) vegetation. The property was surveyed in 2013 for potentially sensitive native habitat areas, wetlands, rare plants or other protected wildlife or plant habitats. The survey report, Coastal Act Compliance Report, Riverview, LLC, North Main Street, Fort Bragg, Mendocino County, California, dated May 2013 and prepared by Matt Richmond of WRA Environmental Consultants (located in the project file) indicates that the property contains Northern Bishop Pine Forest, a Department of Fish and Wildlife Communities List plant community with a rarity status warranting protections. The Northern Bishop Pine Forest additionally has the potential to be habitat for Sonoma tree voles, a Department of Fish and Wildlife species of special concern. The easterly portion of the property is Northern Bishop Pine Forest plant community, edging into non-native and ruderal landscaped areas as the property flattens out. See below for a map of the ESHA, the proposed fence locations and the existing unaccepted offer to dedicate (public access trail).

The City's CLUDC sets general development standards for development adjacent to or within an ESHA as follows, along with staff's analysis for compliance with the requirements:

17.50.050 D General development standards.

1. Performance standards. All development adjacent to or within an ESHA shall comply with the following requirements:

- a. New development shall be designed, sited, constructed, and maintained so as to not significantly disrupt the resource.

Siting and construction techniques. The majority of the proposed project has been sited outside off all ESHA habitat, instead it is located within the ESHA buffer. Habitat protective fencing is a permitted use both within and outside of the ESHA buffer per policy OS-1.6 of the Coastal General Plan which allows habitat fencing within an ESHA buffer as a resource dependent use. The proposed fencing, commonly known as livestock fencing, has been used throughout the Coastal Trail project and there is no evidence that it interferes with the movement of native animals or birds. There have been no injuries to any animals or birds associated with the use of this fence on the Coastal Trail which includes more than 5 linear miles of this type of fencing (some of which has been installed specifically to protect native habitat from impacts). The construction process for this type of fencing is minimally impactful as it does not require any digging or concrete for footings. The T stakes are pounded into the ground with a manually operated (non-mechanical) post pounder. Fencing can be installed with a six inch gap on the bottom of the fence to allow small animals such as skunks, raccoons, rats, mice etc. to easily traverse the fence and a special condition is included below to insure that these construction techniques are followed:

Special Condition 1: The fence shall be constructed out of black coated livestock wire. The fence will be held up 6 inches from the ground to allow the easy movement of small mammals through the barrier.

- b. Where feasible, damaged habitats shall be restored as a condition of development approval.

The property owners have removed a significant quantity of waste from this property on multiple occasions over the years. Most recently, this year, the property owners removed 80 yards of trash and debris from the property. The fence will assist in the

restoration of the ESHA by limiting illegal camping, illegal dumping, and habitat destruction that results from people engaging in these activities on the property.

- c. Development shall be consistent with the biological continuance of the ESHA.

The proposed fencing would protect the Bishop Pine Forest from fire risk as a homeless encampment fire was extinguished on this property a few years ago. Additionally it will protect the forest from significant impacts caused by illegal camping, trash dumping and illegal clearing of areas for illegal camping.

- 2. **Vegetation removal.** Existing native vegetation shall not be removed within an ESHA or an ESHA buffer except for: (1) vegetation removal authorized through coastal permit approval to accommodate permissible development, (2) removal of trees for disease control, (3) public safety purposes to abate a nuisance consistent with Coastal Act Section 30005, or (4) removal of firewood for the personal use of the property owner at his or her residence to the extent that such removal does not constitute development pursuant to Coastal Act Section 30106.

No vegetation removal is associated with this project.

- 3. **Landscaping.** A landscaping plan shall be submitted to the City for approval prior to construction for any site where development will disturb existing or potential native plant habitat. The plan shall provide...

No landscaping is associated with this project.

- 4. **Fencing.** Fencing within or adjacent to ESHAs shall be restricted to that which will not impact public views or the free passage of native wildlife, and shall employ design and materials determined by the review authority to be compatible with the visual and biological character of the habitat.

As conditioned the proposed project shall not impact public views or the free passage of native wildlife. Staff recommends that the Planning Commission find that the fencing is compatible with the visual and biological character of the habitat.

- 5. **Resource protection during construction.** Habitat areas containing vegetation that is essential to the maintenance of the habitat and/or rare or endangered plant or animal species shall be protected from disturbance by construction activities. Temporary wire mesh fencing shall be placed around habitat prior to construction, and protected areas shall not be used by workers or for the storage of machinery or materials. Inspections for compliance shall occur during construction.

- 6. **Herbicide use.** The use and disposal of any herbicides for invasive species removal shall follow the written directions of the manufacturer, shall comply with all conditions imposed by the City, and shall be accomplished in a manner that will fully protect adjacent native vegetation.

- 7. **Erosion and sediment control.** During construction, temporary fencing shall be placed around the ESHA buffer area. Prior to issuance of a Coastal Development Permit or any required Grading Permit, an erosion control plan prepared by a registered professional engineer shall be submitted to the City Engineer for approval, including best management practices to minimize siltation, sedimentation, and erosion. To ensure that sediment remains on the site and is not transported into adjacent ESHA, erosion and sediment controls shall be left in place until the site is stabilized with permanent vegetation.

As the project consists of the construction of a resource protection fence, it is clearly duplicative for the applicant to construct a resource protection fence in order to construct a resource protection fence. No herbicide use is proposed as part of the project. Ground disturbance will consist of less than one cubic yard of material (for

corner posts) and the project will take place in the summer. No erosion and sediment control measures are warranted.

As illustrated in the image below the proposed fence would be located outside of all Bishop Pine Forest ESHAs. Additionally all fencing will be located in areas of ruderal vegetation (primarily non-native grass lawns) which is regularly mowed and impacted by human activities.



Figure 5. Potential ESHA within the Study Area

Mendocino County, California

Path: L:\Acad 2000 Files\2100021177\gis\arcmap\ESHA.mxd



Date: September 2012
Map By: Michael Rochelle
Base Source: Bing Maps

In order to ensure that fence posts do not impact the roots of the Bishop Pine trees, Staff recommends the following Special Condition:

Special Condition 2: Fence posts that require post holes shall not be placed within ten feet of any Bishop Pine trees.

The Northern Bishop Pine Forest additionally has the potential to be habitat for Sonoma tree voles, a Department of Fish and Wildlife species of special concern. However the project will not result in the removal of an bishop pine trees, and so will not have any impact on Sonoma Tree voles.

Archaeological and Cultural Resources

An archaeological investigation report by Thad Van Bueren dated June 26, 2005 is located in the project file. The report indicates that a heavily disturbed prehistoric site is present on the property. According to the report, the site appears to consist of re-deposited fill likely derived from a location that was a prehistoric activity area. The site fails to qualify as a historical resource and has also been determined not to be a unique archaeological resource under California law. Additionally, the proposed fencing would be located more than 100 feet from the known arch site even at its closest point. The Sherwood Valley Band or Pomo may determine that they would like to have a Native American monitor present during ground disturbing activities and Special Condition 3 has been added in case of this eventuality.

Special Condition 3: The Applicant shall allow a Tribal Monitor to monitor all ground disturbing activities on projects where cultural resources may be reasonably expected to be located. However the applicant is not obligated to pay for this monitoring. Instead the applicant shall notify SVBP's Tribal Preservation Officer, at (707) 459-9690, 14 days in advance of ground disturbing activities so that the TPO can schedule monitoring if desired by SVBP.

Shoreline Access

An irrevocable offer to dedicate (OTD) a coastal access easement to the Noyo River from the south side of the Noyo River Bridge was recorded on the title for parcel 018-140-02 as part of the minor subdivision for this site in 2014. No governmental agency or non-profit has accepted the OTD.

There has been trespassing on this property for many years for the purposes of inhabiting a number of illegal encampments which have resulted in ESHA habitat destruction and degradation. The proposed habitat protective fence would limit access to the OTD in order to protect the Bishop Pine forest ESHA. Policy OS-16.1 of the Coastal General plan requires "maximum public access consistent with the protection of natural resources areas." Public access will be preserved in this location upon acceptance and development of the Offer to Dedicate of the Coastal Access easement. At that time the access will be developed and natural resources can be protected as part of that project. However public access is not currently consistent with the protection of the Bishop Pine Forest ESHA. Consequently Special Condition 4 is proposed to ensure that a portion of the fencing will be removed at such time as the OTD is accepted and developed for coastal access.

Special Condition 4: Upon acceptance of the OTD and development of a trail to the Noyo River, the fencing shall be removed from the area defined in the OTD.

Environmental Determination. This project is exempt from CEQA per section 15303c which includes an exemption for fences.

RECOMMENDATION

Recommended Action: Approve Coastal Development Permit 6-18 (CDP 6-18) subject to the Findings and Standard Conditions.

GENERAL FINDINGS

1. The proposed project is consistent with the purpose and intent of the zoning district, as well as all other provisions of the General Plan, Coastal Land Use and Development Code (CLUDC) and the Fort Bragg Municipal Code;
2. The design, location, size, and operating characteristics of the proposed activity are compatible with the existing and future land uses in the vicinity;
3. The site is physically suitable in terms of design, location, shape, size, operating characteristics, and the provision of public and emergency vehicle (e.g., fire and medical) access and public services and utilities (e.g., fire protection, police protection, potable water, schools, solid waste collection and disposal, storm drainage, wastewater collection, treatment, and disposal, etc.), to ensure that the type, density, and intensity of use being proposed would not endanger, jeopardize, or otherwise constitute a hazard to the public interest, health, safety, convenience, or welfare, or be materially injurious to the improvements, persons, property, or uses in the vicinity and zoning district in which the property is located; and
4. For the purposes of the environmental determination, the project is exempt under Section 15303c of the California Environmental Quality Act (CEQA).

COASTAL DEVELOPMENT PERMIT FINDINGS

1. The proposed development as described in the application and accompanying materials, as modified by any conditions of approval, is in conformity with the City of Fort Bragg's certified Local Coastal Program and will not adversely affect coastal resources;
2. The project is in conformity with the public access and recreation policies of Chapter 3 of the Coastal Act of 1976 (commencing with Sections 30200 of the Public Resources Code);
3. The proposed use is consistent with the purposes of the zone in which the site is located;
4. The proposed development is in conformance with the City of Fort Bragg's Coastal General Plan;
5. The proposed location of the use and conditions under which it may be operated or maintained will not be detrimental to the public health, safety, or welfare, or materially injurious to properties or improvements in the vicinity; and
6. Services, including but not limited to, water supply, sewage disposal, solid waste, and public roadway capacity have been considered and are adequate to serve the proposed development.
7. The resource as identified will not be significantly degraded by the proposed development;
8. There is no feasible less environmentally damaging alternative;
9. All feasible mitigation measures capable of reducing or eliminating project related impacts have been adopted; and
10. The resource as identified will not be significantly degraded by the proposed development.

SPECIAL CONDITIONS

1. The fence shall be constructed out of black coated livestock wire. The fence will be held up 6 inches from the ground to allow the easy movement of small mammals through the barrier.
2. Fence posts that require post holes shall not be placed within ten feet of any Bishop Pine trees.
3. The Applicant shall allow a Tribal Monitor to monitor all ground disturbing activities on projects where cultural resources may be reasonably expected to be located. However the applicant is not obligated to pay for this monitoring. Instead the applicant shall notify SVBP's Tribal Preservation Officer, at (707) 459-9690, 14 days in advance of ground disturbing activities so that the TPO can schedule monitoring if desired by SVBP.

4. Upon acceptance of the OTD and development of a trail to the Noyo River, the fencing shall be removed from the area defined in the OTD.

STANDARD CONDITIONS

1. This action shall become final on the 11th working day following the decision unless an appeal to the City Council is filed pursuant to Chapter 17.92.030. This action is appealable to the California Coastal Commission pursuant to Chapter 17.92.040.
2. The application, along with supplemental exhibits and related material, shall be considered elements of this permit, and compliance therewith is mandatory, unless an amendment has been approved by the City.
3. This permit shall be subject to the securing of all necessary permits for the proposed development from City, County, State and Federal agencies having jurisdiction. All plans submitted with required permit applications shall be consistent with this approval.
4. This permit shall be subject to revocation or modification upon a finding of any one or more of the following:
 - (a) That such permit was obtained or extended by fraud.
 - (b) That one or more of the conditions upon which such permit was granted have been violated.
 - (c) That the use for which the permit was granted is so conducted as to be detrimental to the public health, welfare or safety or as to be a nuisance.
 - (d) A final judgment of a court of competent jurisdiction has declared one or more conditions to be void or ineffective, or has enjoined or otherwise prohibited the enforcement or operation of one or more conditions.
5. This permit is issued without a legal determination having been made upon the number, size or shape of parcels encompassed within the permit described boundaries. Should, at any time, a legal determination be made that the number, size or shape of parcels within the permit described boundaries are different than that which is legally required by this permit, this permit shall become null and void.
6. This Coastal Development Permit approval shall lapse and become null and void 24 months from the date of approval unless before the passing of 24 months, a Final Map examined and approved by the City Engineer is approved by the City Council and recorded or an extension is requested and obtained.

ATTACHMENTS

1. Photos of Code Violation & Homeless Encampments
2. Site Map - Proposed Fencing Plan



Lemos, June

From: Jacob Patterson <jacob.patterson.esq@gmail.com>
Sent: Monday, September 9, 2019 3:27 PM
To: Lemos, June
Subject: Public Comment -- 9/9/19 CC Mtg., Item No. 7A
Attachments: 20190909_094305.jpg; 20190909_094309.jpg; 20190909_094439.jpg; 20190909_094338.jpg; 20190909_094511.jpg; 20190909_094516.jpg; 20190909_094327.jpg

June,

Please include these photos of the Cedar Street parcels listed on page 8 of Attachment B to the Housing Element as a public comment for Item No. 7A. They show the existing trees on the site, the lack of pedestrian facilities and adequate width of Cedar Street, as well as the use of the vacant parcels as a wildlife corridor. These pictures were taken around noon today.

Thanks,

--Jacob





Lemos, June

From: Jacob Patterson <jacob.patterson.esq@gmail.com>
Sent: Monday, September 9, 2019 3:33 PM
To: Lemos, June
Subject: Public Comment -- 9/9/19 CC Mtg., Item No. 7A
Attachments: Appendix J - Traffic Study.pdf

June,

Please include the traffic study for the proposed Hare Creek Center as a public comment for Item No. 7A.

Thanks,

--Jacob

APPENDIX J
TRAFFIC IMPACT STUDY REPORT FOR THE
HARE CREEK CENTER



HARE CREEK COMMERCIAL CENTER PROJECT TRAFFIC IMPACT STUDY REPORT



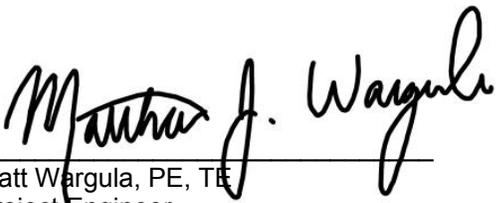
February 14, 2017

**TRAFFIC IMPACT STUDY REPORT
FOR HARE CREEK COMMERCIAL CENTER**

Project No. 11596-8410749

Prepared for: Group II Commercial Real Estate
818 Grayson Road, Suite 100
Pleasant Hill, CA 94523

Prepared by:



Matt Wargula, PE, TE
Project Engineer



February 14, 2017
Date



Matt Kennedy, PE, TE
Project Manager



February 14, 2017
Date

Reviewed by:

GHD Inc.
2235 Mercury Way, Suite 150
Santa Rosa, CA 95407
(707) 523-1010

February 2017

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1. Study Introduction & Analysis Summary

1.1 Study Introduction

This report presents an analysis of the traffic impacts that would be expected from the development of the Hare Creek Commercial Center, a project comprised of retail uses in the City of Ft. Bragg (City). The traffic study was completed in accordance with standard criteria, in coordination with City Staff, and is consistent with California Department of Transportation District 1 (Caltrans) *Guide for the Preparation of Traffic Impact Studies* and *District 1 Supplement* (Caltrans, 2008) and standard traffic engineering techniques. The traffic impact analysis provides an evaluation of operating conditions during the weekday morning and evening peak periods and weekend midday peak periods under Existing, Existing plus Project, Future, and Future plus Project Conditions. Where the Future Condition scenario represent the 20-year growth in traffic to year 2033 based on the *2014 Growth Factors* (Caltrans District 1, 2014) developed from California Air Resources Board (ARB) traffic growth projections and historic traffic growth data.

1.2 Project Summary

The Hare Creek Commercial Center (Project or project) contains a mixture of retail development on approximately 5 acres, bounded by State Route 1 (SR 1 or Hwy 1) to the east and Ocean View Drive to north. The project location is near the intersection of SR 1 and State Route 20 (SR 20 or Hwy 20); however, direct access will not be provided from SR 1 to the project site. The Project proposes to extend a “New Road” from Ocean View Drive to the project access driveways. Upon completion, the Project would comprise approximately 29,500 square feet of commercial related retail uses.

The current project site plan is included in Appendix A.

1.3 Analysis Summary

Five (5) intersections were selected for analysis as the locations most likely to experience impacts due to the project-generated trips. Study intersections were evaluated for four conditions: existing, existing + project, future, and future + project. Anticipated operations and intersection levels of service were assessed for potential impacts using on measures of effectiveness and thresholds of significance established by the California Department of Transportation (Caltrans) and the City of Fort Bragg (City). When evaluated using these criteria, all of the study intersections are expected to operate at acceptable levels during all study conditions and with proposed project improvements to the roadway network.

2. Study Parameters

2.1 Prelude

The purpose of a traffic impact study is to provide State and City staff and policy makers such as Planning Commissioners and Council members with data that they can use to make an informed decision regarding the potential traffic impacts of a proposed project, and any associated improvements that would be required in order to mitigate these impacts to a level of insignificance as defined by the *City of Fort Bragg Coastal General Plan* (City of Fort Bragg, 2008), or other policies, including *Caltrans Guide for the Preparation of Traffic Impact Studies* (Caltrans, 2002), as the intersections evaluated in this study are within the State right-of-way along State Route (SR) 1 and SR 20. The traffic impacts are typically evaluated by determining the number of trips the new use would be expected to generate, distributing the new trips to the surrounding street system based on existing travel patterns or anticipated travel patterns specific to a proposed project, then analyzing the impact the new traffic would be expected to have on critical intersections included in the study.

2.2 Study Intersections and Periods

The intersections analyzed in this study are listed below in Table 1. Intersections have been numbered for ease of reference in the remainder of this report.

Table 1 Study Intersections

	Intersection	Jurisdiction
1.	SR 1/Driveways at Harbor Dr. (near Noyo River Bridge)	Caltrans
2.	SR 1/Ocean View Drive	Caltrans
3.	SR 1/SR 20	Caltrans
4.	SR 20/Boatyard Drive	Caltrans
5.	SR 1/ Simpson Lane	Caltrans

The driveways indicated as Intersection No. 1 are located just south of the Noyo River Bridge, and were analyzed at the request of Caltrans and the City. These driveways are not an actual intersection, and are not considered an intersection henceforth. Further, SR 1 is not striped or marked as an intersection at the location of these driveways. The eastbound driveway approach is stop-controlled and the westbound driveway approach is uncontrolled. Alternate ingress/egress travel routes to these driveways exist, connecting to Boatyard Drive on the east side of SR 1 and Ocean View Drive on the west side.

Traffic conditions at the remaining intersections were analyzed for the weekday a.m. and p.m. peak hours and weekend mid-day peak hour of traffic. The a.m. peak hour of traffic is generally between 7:00 and 9:00 a.m. and the p.m. peak hour is generally between 4:00 and 6:00 p.m., while the weekend mid-day peak hour is generally between 11:00 a.m. and 2:00 p.m. It is during the peak hour of traffic that the most congested traffic conditions generally occur on an average day.

2.3 Study Scenarios

Four scenarios were evaluated in this study, which are Existing Conditions, Existing plus Project Conditions, Future Conditions, and Future plus Project Conditions.

- Scenario 1: Existing Conditions. This scenario represents current traffic operations based on data collected in the field in August 2013.
- Scenario 2: Existing plus Project Conditions. This scenario presents an evaluation of the potential traffic impacts that would be expected to occur with the addition of project-generated traffic to Scenario 1 – Existing Conditions.
- Scenario 3: Future Conditions. This scenario represents traffic operations based on existing traffic volumes factored to the year 2033 utilizing Caltrans *District 1 20-year Growth Factors* (Caltrans, 2014), and including potential growth in surrounding areas.
- Scenario 4: Future plus Project Conditions. This scenario presents an evaluation of the potential impacts that would be expected to occur with the addition of project-generated traffic to Scenario 3 – Future Conditions.

2.4 Data Requirements

The data requirements for the traffic impact analysis include:

- Existing traffic volumes; including new turning movement counts and 24-hour average daily traffic (ADT) vehicle classification counts.
- Intersection geometry and configuration.
- Caltrans District 1 Traffic Signals on State Highways Supplement to the Guide for the Preparation of Traffic Signals and Additions to the Supplement (included in Appendix B)

GHD's traffic data collection subconsultant, Counts Unlimited, Inc., collected existing traffic volumes at all study locations on Thursday, August 22 and Saturday, August 24, 2013. These counts consisted of both turning movement counts taken at all study intersections and 24-hour ADT vehicle classification counts at the following locations:

- SR 1, south of SR 1 and SR 20 intersection
- SR 1, south of Noyo River Bridge
- SR 20, east of SR 1 and SR 20 intersection

The 24 hour ADT vehicle classification counts were utilized in examining existing traffic patterns for project trip generation, distribution and assignment and to calculate heavy vehicle percentages. All intersection turning movement counts and 24-hour ADT vehicle classification counts are included in Appendix C.

2.5 Measures of Effectiveness

Caltrans maintains jurisdiction over the operation of highways and intersections in the study area. Caltrans uses measures of effectiveness (MOEs) to describe the measures best suited for analyzing State highway facilities. MOEs are calculated performance measures that reflect the operating conditions of a facility, given a set of roadway, traffic, and control conditions. These measures are also

recommended for City and County facilities. The City has jurisdiction over streets and intersections within city limits and outside the Caltrans right-of-way (ROW). The County has jurisdiction over streets and intersections outside City limits and Caltrans ROW. Table 2 summarizes the MOEs by facility type recommended by Caltrans, and the MOEs used in this study.

Table 2 Measures of Effectiveness (MOE) by Facility Type

Type of Facility	Caltrans MOE ¹	Study MOE
Signalized Intersections	Control Delay per Vehicle (sec/veh)	Control Delay per Vehicle (sec/veh)
Un-signalized Intersections	Control Delay per Vehicle (sec/veh)	Control Delay per Vehicle (sec/veh)
Roundabouts	None	Control Delay per Vehicle (sec/veh)

¹Source: (Caltrans, 2002).

2.6 Thresholds of Significance

Title 14, Chapter 3 Article 20 §§15382 of the California Code of Regulations defines a *significant effect on the environment* as a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project. Thresholds of significance are principally used to determine whether a project may have a significant environmental effect. A threshold of significance is a quantitative or qualitative standard, or set of criteria from which the significance of a given environmental effect may be determined. In the context of traffic, levels of service based standards are typically used to establish thresholds of significance and qualify potential impacts.

2.6.1 City of Fort Bragg

The *City of Fort Bragg Coastal General Plan* (General Plan) (City of Fort Bragg, 2008) establishes minimum level of service standards (per Policy C-1.1) for the following:

- Signalized and All-Way-Stop Intersections along SR 1: LOS D
- Side Street Stop Sign Controlled Intersections along SR 1: LOS D, or LOS F if there is less than 15 veh./hr. left turns plus through movements from side street and the volumes do not exceed Caltrans rural peak hour signal warrant criteria levels.
- Signalized and All-Way-Stop Intersections not along SR 1: LOS C
- Side Street Stop Sign Controlled Intersections not along SR 1: LOS C, or LOS E if there is less than 15 veh./hr. left turns plus through movements from the side street and the volumes do not exceed Caltrans rural peak hour signal warrant criteria levels.

Additionally, the City's General Plan includes the following provision that is applicable to the study area:

- If volumes at an unsignalized intersection are increased to meet or exceed Caltrans rural peak hour signal Warrant [3] criteria levels and the intersection is operating at an unacceptable level of service, then signalization of the intersection is warranted.

The following goals and policies are established within the Circulation Element of the General Plan:

Goal C-1 Coordinate land use and transportation planning:

- *Policy C-1.2 – Coordinate Land Use and Transportation: Ensure that the amount and phasing of development can be adequately served by transportation facilities.*
 - a) *Program C-1.2.1: Review development proposals for their direct and cumulative effects of roadway Level of Service standards. During the development review process, City staff will determine whether traffic studies need to be carried out and the scope of such studies.*
- *Policy C-1.3 – Do not permit new development that would result in the exceedance of roadway and intersection Levels of Service standards unless one of the following conditions is met:*
 - a) *Revisions are incorporated in the proposed development project which prevent the Level of Service from deteriorating below the adopted Level of Service standards; or*
 - b) *Funding of prorata share of the cost of circulation improvements and/or the construction of roadway improvements needed to maintain the established Level of Service is included as a condition or development standard of project approval.*
- *Policy C-1.4 – Include specific time frames for the funding and completion of roadway improvements for projects which cause adopted roadway and intersection Level of Service standards to be exceeded. Require security, bonding or other means acceptable to the City to ensure the timely implementation of roadway mitigations.*
- *Policy C-1.5 – Traffic Impact Fees. When traffic impact fees are collected, established a schedule from the date of collection of said fee for the expenditure of funds to construct roadway improvements that meets project needs. Where a project would cause a roadway or intersection to operate below the adopted Level of Service standards, the roadway or intersection improvements should be completed in a timely manner but no later than five years after project completion.*

Goal C-2 Develop and manage a roadway system that accommodates future growth and maintains acceptable Levels of Service while considering the other policies and programs of the Coastal General Plan.

- *Policy C-2.1 – Roadway Improvements. In coordination with Caltrans and Mendocino County, plan for and seek funding for on-going improvements to the local and regional road system to ensure that the roadway system operates safely and efficiently and to ensure that SR1 in rural areas outside the Mendocino County urban/rural boundary will remain a scenic two-lane road consistent with Section 30254 of the Coastal Act. Project applicants are fiscally responsible for their fair share of roadway improvements necessary to serve their projects.*
- *Policy C-2.2 – Improvements to major road intersections for public safety or increased vehicle capacity shall be permitted, as necessary, in existing developed areas and where such improvements are sited and designated to be consistent with all policies of the LCP.*
- *Policy C-2.3 – Design Roadways to Protect Scenic Views. In scenic areas, roadway improvements, including culverts, bridges or overpasses, shall be designed and constructed to protect public views and avoid or minimize visual impacts and to blend in with the natural setting to the maximum extent feasible.*
 - *Program C-2.3.1: When traffic analysis of levels of service and/or safety hazards indicates the need, construct the following roadway improvements where such roadway improvements are found to be consistent with all applicable policies of the LCP including, but not limited to, the wetland, environmentally sensitive habitat area, public access and visual protection policies:*
 - *Reconstruct the Main Street/Ocean View Drive intersection at time of development of the property between the College of the Redwoods and Main Street [SR 1]. Require a traffic engineering analysis of the intersection to determine appropriate geometrics and signal timing. Construct turning lane mitigations as needed.*

- *Policy C-2.6 – Traffic Studies for High Trip Generating Uses: Traffic studies shall be required for all major development proposals, including but not limited to, drive-through facilities, fast food outlets, convenience markets, major tourist accommodations, shopping centers, commercial development, residential subdivisions, and other generators of high traffic volumes that would affect a Level of Service. Traffic studies shall identify, at a minimum:*
 - *The amount of traffic to be added to the street system by the proposed development;*
 - *Other known and foreseeable projects and their effects on the street system;*
 - *The direct, indirect and cumulative adverse impacts of project traffic on street system operations, safety and public access to the coast;*
 - *Mitigation measures necessary to provide for project traffic while maintaining City Level of Service standards;*
 - *The responsibility of the developer to provide improvements; and*
 - *The timing of all improvements.*
- *Policy C-2.8 – Continuation of Streets: Require the continuation of streets and bicycle and pedestrian paths through new developments wherever possible.*

2.6.2 Caltrans

The *Guide for the Preparation of Traffic Impact Studies* (Caltrans, 2002) is intended to provide a consistent basis for evaluating traffic impacts to State facilities. Caltrans strives to maintain service levels at the transition between LOS C and LOS D. In cases where this LOS is not feasible the lead agency should consult with Caltrans to establish an appropriate LOS threshold. If an existing State highway facility is operating worse than the appropriate target LOS, the existing Measure of Effectiveness (MOE) should be maintained.

2.7 Level of Service Methodologies

Level of Service (LOS) is used to rank traffic operation on various types of facilities based on traffic volumes and roadway capacity using a series of letter designations ranging from A to F. Generally, LOS A represents free flow conditions and LOS F represents forced flow or breakdown conditions. The LOS designation for intersections is generally accompanied by a unit of measure which indicates a level of delay and/or volume to capacity ratios.

2.7.1 Intersection Level of Service Methodologies

The study intersections were analyzed using methodologies from the *HCM2010 Highway Capacity Manual – Volume 3 Interrupted Flow* (HCM2010) (Transportation Research Board, 2010). This source contains methodologies for various types of intersection control, including signalized intersections, two-way stop-controlled (TWSC) intersections and roundabouts.

The analysis level in this study is recognized as planning and preliminary engineering. The “analysis level” describes the level of detail used when the methodology is applied. The “planning and preliminary engineering level” of analysis requires only the most fundamental types of information. Default values are then used as substitutes for other input data.

The methodologies utilized in this study are for the automobile mode, although other modes are discussed.

Synchro 8 (Synchro) with SimTraffic software was used for the traffic analysis in this study.

2.7.2 Signalized Intersections

The signalized methodology for the automobile mode is based on input data requirements for traffic characteristics, geometric design, signal control and other factors including analysis period duration and approach speed limit.

Traffic characteristic inputs include (among others) demand flow rate, percent heavy vehicles, peak hour factors and base saturation flow rate.

Geometric design inputs include the number of lanes, average lane width, number of receiving lanes, turn bay (or pocket) lengths, presence of on-street parking and approach grade.

Signal control inputs include the type of signal control, phase sequence, protected for permissive left-turn operations, maximum green time, minimum green time, yellow change interval, red clearance, walk time, pedestrian clear time and phase recall.

Computed control delay per vehicle in seconds is used as the basis for evaluation in this LOS methodology to describe the signalized intersection operation as a whole. The ranges of delay associated with the various signalized levels of service are summarized in Table 3.

2.7.3 Two-way Stop-Controlled Intersections

The two-way stop-controlled (TWSC) (unsignalized) intersection methodology for motor vehicles is determined by the computed or measured control delay and the volume-to-capacity ratio. For motor vehicles, LOS is determined for each minor-street movement (or shared movement) as well as major-street left turns by using the criteria shown in Table 4. LOS for TWSC intersections is not defined for the intersection as a whole or for major-street approaches.

The input data required for evaluation of TWSC intersections includes the number and configuration of lanes on each approach; percent heavy vehicles for each movement; demand flow rate for each entering vehicular movement and each pedestrian crossing movement during the peak hour; peak hour factor; existence of a two-way left-turn lane (TWLTL) or raised or striped median storage (or both); approach grades; existence of flared approaches on the minor street; and existence of upstream traffic signals.

Computed control delay per vehicle in seconds and volume-to-capacity (v/c) ratio are used as the basis for evaluation in this LOS methodology to describe each minor-street movement and major-street left-turn movement. LOS F is assigned if the v/c ratio of a movement exceeds 1.0. The ranges of delay associated with the TWSC levels of service are indicated in Table 4.

2.7.4 Roundabouts

The roundabout intersection methodology for motor vehicles is determined by computed control delay per vehicle in seconds for approaches and intersection wide assessment.

The input data required to analyze a roundabout includes the number and configuration of lanes on each approach; demand volume and each pedestrian crossing movement during the peak hour; peak hour factors; percentage heavy vehicles; and volume distribution across lanes for multi-lane entries.

The ranges of delay associated with the roundabout levels of service are indicated in Table 4.

2.8 Vehicle Queuing

Vehicle queuing analysis is completed for all signalized intersections to assess the capacity of intersections to accommodate the number of vehicles expected to wait at the intersections before being able to pass through or turn. This analysis is important because if there is not enough queuing space between intersections, in left-turn or right-turn pockets, the overflow of vehicles can obstruct the operations of the roadway.

The Synchro software program was used to determine the 50th percentile vehicle queue, which is the maximum back of queue on a typical cycle, and the 95th percentile queue which is the maximum back of queue with 95th percentile traffic volumes. The queue analysis will determine the 50th and 95th percentile movement queue lengths based on HCM2010 methodology.

Table 3 Signalized Level of Service

Level of Service	Description	Control Delay (Seconds Per Vehicle)
A	Operations with very low delay occurring with favorable progression and/or short cycle lengths.	< 10
B	Operations with low delay occurring with good progression and/or short cycle lengths.	>10 to 20
C	Operations with average delays resulting from fair progression and/or longer cycle lengths. Individual cycle failures begin to appear.	>20 to 35
D	Operations with longer delays due to a combination of unfavorable progression, long cycle lengths, and/or high volume-to-capacity (V/C) ratios. Many vehicles stop and individual cycle failures are noticeable.	>35 to 55
E	Operations with high delay values indicating poor progression, long cycle lengths, and high V/C ratios. Individual cycle failures are frequent occurrences. This is considered to be the limit of acceptable delay.	>55 to 80
F	Operation with delays unacceptable to most drivers occurring due to oversaturation, poor progression, or very long cycle lengths.	> 80

Source: 2010 Highway Capacity Manual (Transportation Research Board, 2010).

Table 4 TWSC Intersection or Roundabout Level of Service

Level of Service	Description	Control Delay (Seconds Per Vehicle)	LOS by v/c Ratio ≤ 1.0
A	Little or no delay	< 10	A
B	Short traffic delays	>10 to 15	B
C	Average traffic delays	>15 to 25	C
D	Long traffic delays	>25 to 35	D
E	Very long traffic delays	>35 to 50	E
F	Extreme traffic delays with intersection capacity exceeded (for an all-way stop), or with approach/turn movement capacity exceeded (for a side street stop controlled intersection)	> 50.0	≥ 1.0 F

Source: 2010 Highway Capacity Manual (Transportation Research Board, 2010).

3. Existing Conditions

This section describes the existing conditions at the study intersections and roadways during both the weekday a.m. and p.m. peak hours and weekend mid-day peak hour based on peak hour traffic conditions. Also included is a discussion of transportation facilities in the project area, including the roadway network, transit services, and bicycle and pedestrian facilities.

3.1 Study Area

The Hare Creek Commercial Center is to be located on a new road that extends south from Ocean View Drive. Primary access will be from the intersection of SR 1 and Ocean View Drive. At this time, there is no plan to provide direct access to the Hare Creek Commercial Center from SR 1. The study area and intersection locations are shown in Figure 1.

The roadways analyzed in this study are functionally classified by the *City of Fort Bragg Coastal General Plan, 2008* (General Plan). These classifications are *Highways, Arterials, Major collectors, Minor collectors, and Local Streets*. Highways are high speed limited access roadways serving primarily regional and county-wide travel. Arterials are medium-speed, medium capacity roadways that provide travel and access within the City and access to highways. Major Collectors are relatively low-speed, streets that provides access within and between neighborhoods. Minor Collectors are relatively low-speed streets that provide connections between Arterials and Major Collectors and direct access to parcels. The function of local streets is to provide access to adjacent properties.

State Route (SR) 1 is a four-lane or two-lane highway in the vicinity of the proposed Project site. It runs in a north/south direction and passes through the City of Fort Bragg. From the north side of the Hare Creek Bridge SR 1 is a two-lane divided highway. North of the Hare Creek Bridge it widens to a four-lane divided highway. A two-way left-turn lane (TWLTL) is present north of the intersection of SR 1 and Ocean View Drive (Intersection No. 2). The Project site is located adjacent to and west of SR 1. The posted speed limit is 40 miles per hour (mph). Current access to the Project site from SR 1 is by Ocean View Drive.

SR 20 is two-lane east/west highway which terminates at SR 1. A two-way left-turn lane (TWLTL) is present east of the intersection of SR 20 and Boatyard Drive (Intersection No. 4). The posted speed limit is 45 mph.

Ocean View Drive is a two-lane local street providing access to the Todd's Point area from SR 1 (Intersection No. 2). It has a posted speed limit of 25 mph.

Boatyard Drive is a two-lane local street that loops between SR 1 at Ocean View Drive (Intersection No. 2) and SR 20 (Intersection No. 4). It has a posted speed limit of 25 mph, and provides access to the Boatyard Shopping Center.

Harbor Drive is a two-lane frontage road that is located on the west side of SR 1 between Intersection No. 1 and Ocean View Drive. Harbor Drive is a local street that provides access to businesses and residences. It has a speed limit of 25 mph.

The *Hare Creek Bridge*, also known as the Sergeant Emil H. Evensen Memorial Bridge, is a two-lane bridge on SR 1 crossing Hare Creek approximately 300 feet south of Intersection No. 3.

The *Noyo River Bridge*, which was recently widened to four lanes by Caltrans, is located north of Intersection No. 1 on SR 1. The Noyo River Bridge includes striped median separating northbound and southbound lanes. Class II bike lanes are present on both sides. Pedestrian walkways separated from vehicular and bicycle traffic are also present on both sides of the bridge.

3.1.1 Transit Service

The Mendocino Transit Authority provides regional transit service to the City of Fort Bragg Monday through Saturday. Transit Route 5 (BraggAbout) provides local service in and around the City of Fort Bragg. There are two bus stops for Transit Line 5 in the study area, one at College of the Redwoods off of Ocean View Drive and one at the Boatyard Shopping Center off of Boatyard Drive. Transit Route 60 (The Coaster) provides regional service between Fort Bragg and Mendocino/Navarro River. Transit Line 60 connects with Transit Lines 5 and 65 at the College of the Redwoods and Boatyard Shopping Center stops. Transit Line 65 (CC Rider) provides regional service between Fort Bragg, Willits, Ukiah and Santa Rosa.

3.1.2 Rail Service

The Skunk Train is a scenic tourist train that runs between Willits and Fort Bragg seven days a week. Trains depart daily in the morning, with the trip taking approximately 3.5 hours. This rail line is not a commuter rail.

3.1.3 Bicycle and Pedestrian Facilities

Class III bike routes are present along both sides of SR 1 and SR 20 as a paved shoulder separated from vehicular traffic by a striped edge of travel way line. Class III bikeways are unmarked bicycle routes which share the road with other vehicles. The bikeway is generally between 4-ft and 6-ft wide.

Pedestrian facilities in the study area are limited and consist primarily of sidewalks and crosswalks at or near intersections, with exceptions to the Noyo River Bridge and sections of Boatyard Drive (near the Boatyard shopping center). Sidewalks, curb ramps and marked cross walks are present at Intersection No. 2 – Ocean View Dr. and SR 1, No. 3 – SR 1 and SR 20, No. 4 – SR 20 and Boatyard Drive and No. 5 – SR 1 and Simpson Lane.

3.2 Study Intersections

The following intersections (including traffic control type) were identified for analysis as the locations most likely to experience impacts due to the project-generated traffic. The intersections and study area context map are provided in Figure 1.

- | | |
|---------------------------------------|------------|
| 1. SR 1 and Driveways at Harbor Drive | TWSC |
| 2. SR 1 and Ocean View Drive | Signalized |
| 3. SR 1 and SR 20 | Signalized |
| 4. SR 20 and Boatyard Drive | TWSC |

Existing intersection lane configurations are shown on Figure 2.

3.2.1 Existing Sight Distance

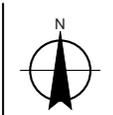
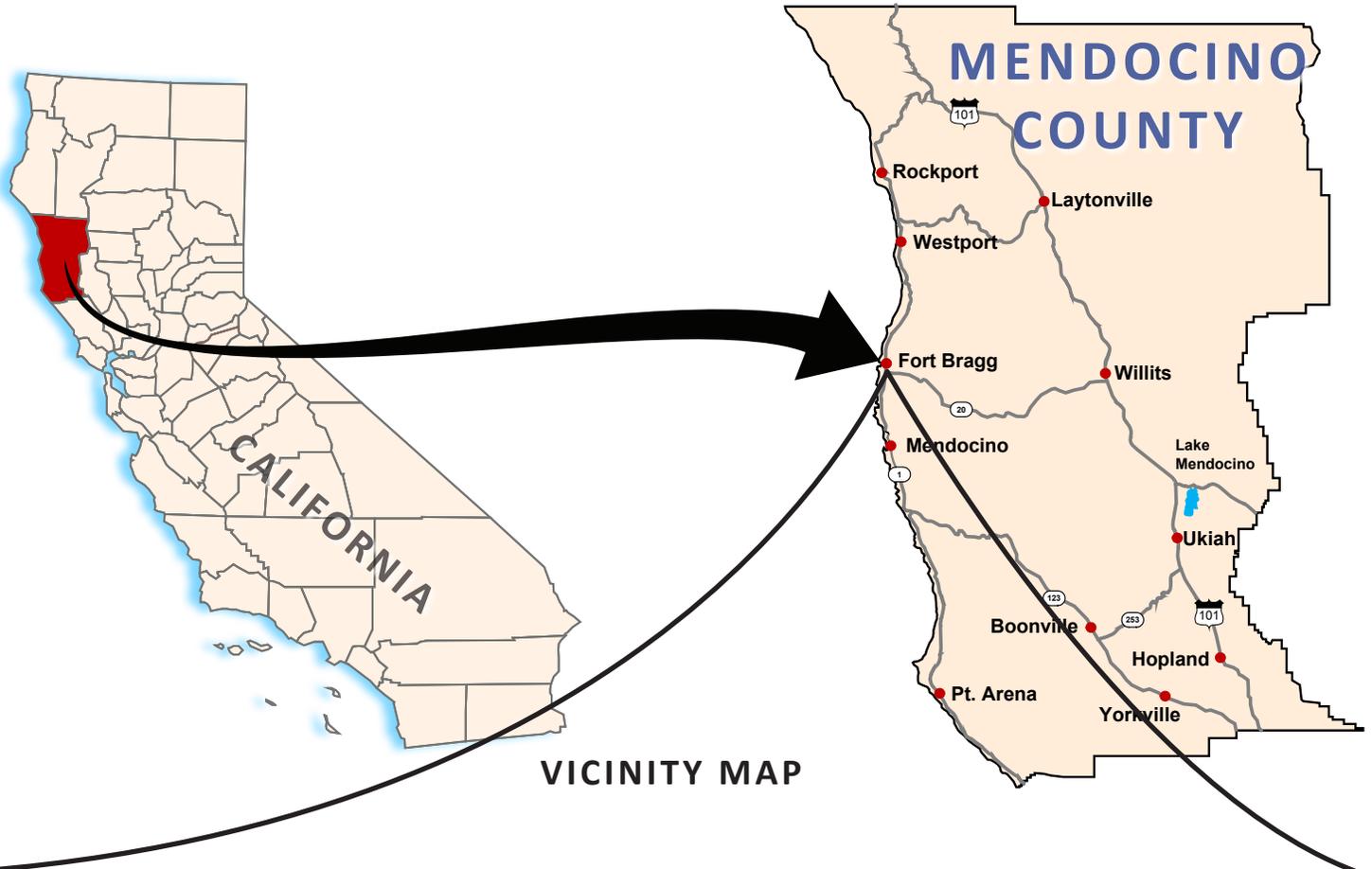
Intersection sight distance is the measurement of the clear line of sight between the driver of a vehicle waiting at the crossroad and the driver of an approaching vehicle. The design standards for intersection sight distance applicable to this study are provided in the Caltrans *Highway Design Manual* (Caltrans, 2012b) and are summarized in Table 5.

Table 5 Intersection Corner Sight Distance¹

Design Speed	Sight Distance
25 mph	275-ft
30 mph	330-ft
35 mph	385-ft
40 mph	440-ft
45 mph	495-ft

¹Source: Caltrans (2012b).

The values for sight distance given above should be applied at all study intersections. These sight distance values were evaluated at all signalized and unsignalized intersections whenever possible. Unanticipated vehicle conflicts can occur due to signal malfunctions, violations of signals, right turns on red, and right of way failures. A review of the existing study intersections indicates that the minimum sight distances are provided based on intersection geometry and posted speed limits.



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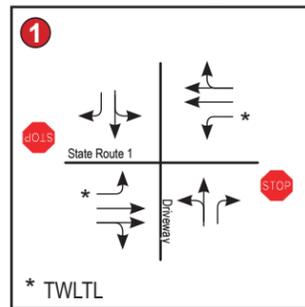
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Project Vicinity and
Location Map

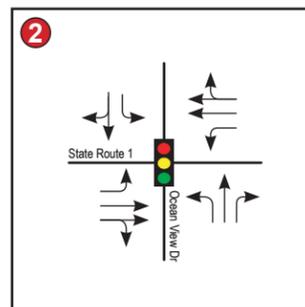
Figure 1



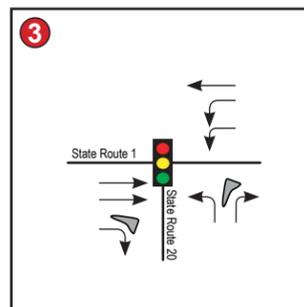
SR1/Driveways



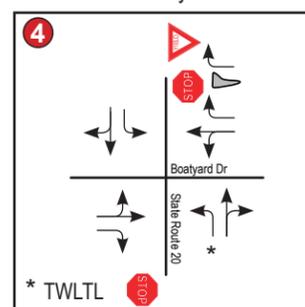
SR1/Ocean View Dr.



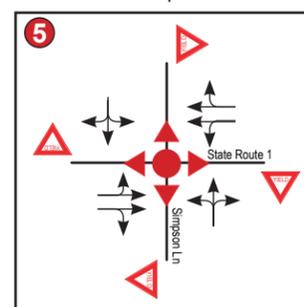
SR1/SR20



SR20/Boatyard Dr.

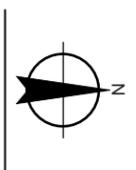


SR1/Simpson Ln.



Legend

- 1 Study Intersection
- Stop Sign
- Signal
- Roundabout
- Yield Sign
- Approximate City Limits
- Channelized Right Turn



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Existing Intersection Lane
Geometry and Traffic Controls

Figure 2

3.3 Traffic Volumes

Peak weekday a.m. and p.m. and peak weekend midday traffic counts were collected as part of this study on Thursday, August 22, 2013 and Saturday, August 24, 2013, respectively. Traffic data is included in Appendix C.

3.3.1.1 24-hour ADT Classification Volume

24 hour ADT counts were included in the analysis to assist with project trip generation, distribution and assignment purposes and to compile general statistics about existing traffic volumes, including heavy vehicle percentage.

Table 6 summarizes the ADT and the heavy vehicles percentage along SR 1 (at two locations) and SR 20 (at one location). The ADT count locations are shown on Figure 3.

Table 6 ADT and Heavy Vehicle Summary

Location	NB/EB		SB/WB		Total	
	ADT (veh./day)	Hvy Veh (%)	ADT (veh./day)	Hvy Veh. (%)	ADT (veh./day)	Hvy Veh. (%)
SR 1 - s/o SR 1/SR 20 Int.	8,839	11.2%	8,975	8.1%	17,814	9.6%
SR 1 - s/o Noyo River Bridge	12,906	10.6%	13,220	14.6%	26,126	12.6%
SR 20 - e/o of SR 1/SR 20 Int.	4,177	17.6%	4,434	11.9%	8,611	14.7%

The heavy vehicle percentages from the ADT summary were applied and used in the traffic analysis.

3.3.1.2 Intersection Turning Movement Volumes

Peak weekday a.m. and p.m. and peak weekend midday intersection turning movement volumes are indicated in Figure 3.

3.4 Existing Conditions Intersection Level of Service Analysis

The results of the intersection level of service analysis based on existing turning movement traffic volumes are summarized in Table 7. The analysis finds that all study intersections are operating acceptably based on Caltrans and City significance thresholds.

Intersection No. 4 – SR 20 / Boatyard Drive exceeds the City thresholds of significance for “Side Street Stop Sign Controlled Intersections not along SR 1” (LOS C, min. per Policy C-1.1). While the combined total left turn plus through movement volume exceed 15 vehicles per hour, the rural peak hour Signal Warrant 3 criteria is not met, therefore this intersection approach operates at an acceptable LOS D or better.

The unsignalized intersections were evaluated using the rural Signal Warrant 3, per the City of Fort Bragg thresholds of significance, which is discussed under the Section 8 of this report. Signal Warrant 3 analysis results are included in Appendix J.

The Existing Conditions Scenario Level of Service calculations are provided in Appendix D.

Table 7 Existing Conditions Scenario Intersection Level of Service

No.	Intersection	Weekday				Weekend	
		a.m.		p.m.		midday	
		Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS
1	SR 1 / Commercial Driveways ¹						
	<i>Northbound left</i>	9.5	A	11.9	B	10.7	B
	<i>Eastbound left-thru-right</i>	25.9	D	>50.0	F	36.3	E
	<i>Westbound left-thru-right</i>	23.2	C	30.3	D	32.2	D
	<i>Southbound left</i>	10.1	B	11.6	B	11.4	B
2	SR 1 / Ocean View Drive ²	12.0	B	19.3	B	15.9	B
3	SR 1 / SR 20 ²	10.1	B	15.0	B	12.9	B
4	SR 20 / Boatyard Drive ¹						
	<i>Northbound left-thru</i>	15.1	C	19.5	C	21.3	C
	<i>Northbound right</i>	0.0	A	9.8	A	10.1	B
	<i>Eastbound left</i>	8.2	A	8.7	A	8.7	A
	<i>Westbound left</i>	0.0	A	0.0	A	8.0	A
	<i>Southbound left-thru</i>	15.5	C	22.4	C	25.5	D
	<i>Southbound right</i>	10.1	B	11.4	B	11.2	B
5	SR 1 / Simpson Lane ³	6.6	A	9.6	A	8.9	A

Notes: Delay is calculated in average seconds per vehicle in queue

LOS = Level of Service

Bold = results exceed acceptable LOS

¹LOS based on HCM2010 method of analysis for TWSC intersections.

²LOS based on HCM2010 method of analysis for Signalized intersections.

³LOS based on HCM2010 method of analysis for Roundabouts.

3.5 Existing Conditions Signalized Intersections Queue Analysis

Existing traffic volumes were applied to signalized study intersections and the peak hour demand 50th and 95th percentile queue lengths were reviewed against the existing lane storage capacity at the intersections.

The Existing Peak Hour Intersection Queue Analysis is summarized in Table 8. Detailed results are provided in Appendix D.

Peak hour 50th and 95th percentile queue lengths are within existing storage lane capacity at all signalized intersections.

Table 8 Summary of Existing Peak Hour Intersection Queue Analysis

Movement	Lanes / Avail. Storage	Queue Length - 50th / 95th (feet/feet)					
		a.m.		p.m.		midday	
Intersection No. 2 - SR 1 / Ocean View Drive							
EBL	1 / 110 ft	10	33	23	57	15	44
EBTR	1 / 110 ft	3	24	5	27	5	29
WBL	1 / 120 ft	9	31	7	27	13	40
WBT	1 / 120 ft	4	19	5	22	6	23
WBR	1 / 120 ft	7	33	31	85	26	73
NBL	1 / 350 ft	7	26	11	40	7	27
NBTR	2 / 350 ft	103	160	126	192	111	172
SBL	1 / 400 ft	37	90	79	226	63	173
SBTR	2 / 400 ft	37	124	70	207	46	154
Intersection No. 3 - SR 1 / SR 20							
WBL	1 / 220 ft	19	52	68	150	50	109
WBR	1 / 120 ft	0	46	0	49	0	40
NBT	2 / 170 ft	30	106	94	160	82	145
NBR	1 / 120 ft	0	22	0	33	0	35
SBL	2 / 320 ft	26	60	48	132	35	97
SBT	1 / 320 ft	62	136	177	344	108	240

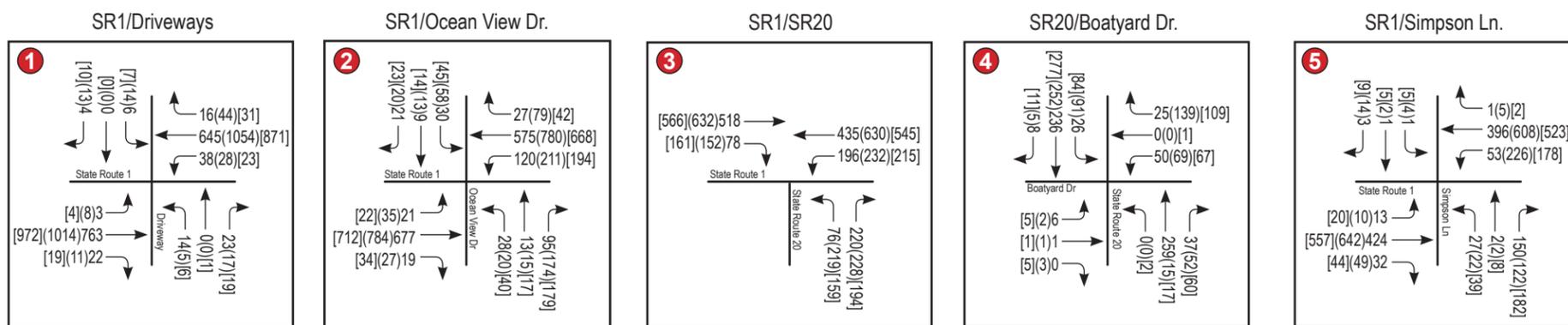
Notes: Queue shown is maximum after two cycles

~ - Volume exceeds capacity, queue is theoretically infinite

- 95th percentile volume exceeds capacity, queue may be longer

M - Volume for 95th percentile queue is metered by upstream signal

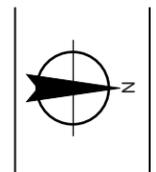
Bold = results where available storage is exceeded by more than one standard vehicle, 25 ft.



Legend

- ① Study Intersection
- XX AM Peak Hour Volume
- (XX) PM Peak Hour Volume
- [XX] Weekend Mid-Day Peak Hour Volume
- NB Northbound
- SB Southbound
- EB Eastbound
- WB Westbound
- - - Approximate City Limits

Average Daily Traffic (ADT)		
①	NB	8,839
	SB	8,975
	Total:	17,814
②	NB	12,906
	SB	13,220
	Total:	26,126
③	EB	4,177
	WB	4,434
	Total:	8,611



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Existing Conditions Intersection
 & ADT Traffic Volumes **Figure 3**

4. Project Trip Generation, Distribution and Assignment

This section discusses the methods and analysis conducted in selecting trip generation rates and assigning Project trips to the existing roadway network. The magnitude of traffic produced by the proposed project and the locations where that traffic would appear is estimated using the three step process of trip generation, trip distribution and trip assignment. The number of project trips generated during the weekday a.m. and p.m. peak hour and weekend (Saturday) midday peak hour were estimated using standard Institute of Transportation Engineers (ITE) *Trip Generation Manual 9th Edition* (ITE, 2012) rates for the Project land use type. This standard reference is used by jurisdictions throughout the country, and is based on actual trip generation studies performed at numerous locations in areas of various populations.

The proposed Hare Creek Commercial Center project site plan is included in Appendix A. An additional element of the project is the widening of the eastbound approach at Intersection No. 2 – SR 1 / Ocean View Drive to add a right turn lane. This geometric change is considered part of the roadway geometry for the Existing Plus Project and Future Plus Project conditions.

All project trips will access the Hare Creek Commercial Center via Intersection No. 2 – SR 1 / Ocean View Drive to a “new road” extension.

4.1 Trip Generation

For the analysis of potential Project-related traffic impacts a trip generation rate was selected for the project based on ITE trip generation rates. Several potential trip generation rates were reviewed for the proposed 39,500 gross square foot retail center. The *Guidelines for Estimating Trip Generation* from ITE *Trip Generation Manual 9th Edition* (ITE, 2012) were utilized in selecting the appropriate trip generation rates. It is important to note that the land use types described in the ITE Trip Generation Manual are not directly related to land use types described in the City’s General Plan, municipal code, or zoning ordinance. The classifications are based on specific sites and data collected over years of study for the purpose of estimating trip generation for specific land usages.

The ITE trip generation rates under the “Retail” land use category (and ITE land use code) selected for evaluation included:

- Shopping Center (820) – “A shopping center is an integrated group of commercial establishments that is planned, developed, owned and managed as a unit. A shopping center’s composition is related to its market area in terms of size, location, and type of store. A shopping center also provides on-site parking facilities sufficient to serve its own parking demands. Shopping centers, including neighborhood centers, community centers, regional centers and super regional centers were surveyed for this land use.”

The “best fit” regression equation was used to establish the total trip generation for the Shopping Center (820) land use. The Hare Creek Commercial Center includes the following uses, which all meet the definition of uses typically included in Shopping Center (820):

- Hare Creek Center – Retail 13,235 gross leasable area (GLA)
- Grocery Outet 15,000 gross floor area (GFA)
- Restaurant 1,265 gross floor area (GFA)

The entire retail center includes 29,500 GLA.

Table 9 shows the trip generation rates and corresponding trips generated for the project for the weekday a.m. and p.m. peak hour and the weekend midday peak hour. Appendix E includes the full trip generation calculation.

Table 9 Project Trip Generation

Land Use (#)	Units (ksf)	Daily		a.m. Peak Hour		p.m. Peak Hour		Weekend Peak Hour	
		Rate	Trips	Rate	Trips	Rate	Trips	Rate	Trips
Shopping Center (820)	29.50	104.73	3,090	2.53	76	9.01	267	13.48	398
Total Project New Trips			3,090		76		267		398

4.2 Discussion about Pass-By Trips

It is acknowledged that the total number of generated trips may be different from the amount of new traffic added to the street system; however, pass-by and diverted linked trips were not evaluated for the Project trip generation as they are not expected to significantly change results of the study.

Retail-oriented developments such as shopping centers often locate adjacent to busy streets in order to attract motorists already on the roadway. These sites attract a portion of their trips from traffic passing the site on the way from an origin to an ultimate destination. These trips are called “pass-by,” which are one component of the trip generation for the site. Trip generation can be broken down into pass-by trips and non-pass-by trips.

Pass-by trips are intermediate stops “on the way” from an origin to a primary destination at the site from a direct driveway access or an adjacent roadway that offers access. The Hare Creek Commercial Center does not intend to provide a driveway to SR 1, which may be prohibited by Caltrans District 1 along this segment of SR 1.

While there will be a percentage of pass-by trips already on the roadway network, the component of the trips is not expected to significantly change the study results; therefore, the study provides a conservative confidence level of the potential impacts from the Project, if any.

4.3 Trip Distribution and Assignment

Trip distribution was based on existing traffic patterns established from the existing 24-hour ADT classification counts and intersection turning movement counts.

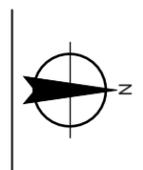
The project-generated trips were distributed to the surrounding roadway system based on probable origins and destinations together with existing traffic patterns in the study area. The trip assignment was

based on an assumed distribution of approximately 50 percent of the traffic to and from the south (SR 1) and east (SR 20) and 50 percent of the traffic to and from the north (SR 1). Trip distribution percentages are shown in Figure 4 and project trips assigned to each intersection are shown graphically in Figure 5.



Legend

- ① Study Intersection
- XX% → Exiting Trip Distribution Percentage
- (XX%) → Entering Trip Distribution Percentage
- Approximate City Limits

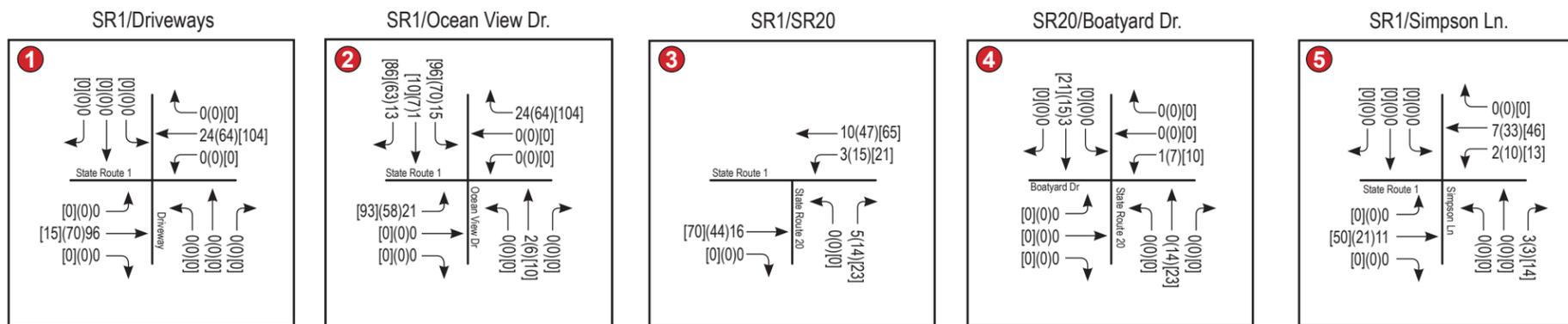


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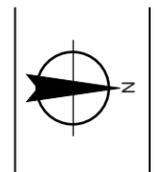
Project Trip Distribution

Figure 4



Legend

- 1 Study Intersection
- XX AM Peak Hour Volume
- (XX) PM Peak Hour Volume
- [XX] Weekend Mid-Day Peak Hour Volume
- - - Approximate City Limits



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Project Trip Assignment
 Traffic Volumes
 Figure 5

5. Existing plus Project Conditions

This section describes the Existing plus Project Conditions Scenario, potential impacts and recommended mitigation measures, if any, at the study intersections during the weekday a.m. and p.m. and weekend midday peak hour.

5.1 Existing Plus Project Conditions Traffic Volumes

Existing plus Project Conditions traffic volumes are shown in Figure 6. Existing plus project traffic volumes are represented by existing traffic volumes with the addition of project related trips assigned to the roadway network, as discussed in Section 4. The roadway network includes the widening of the eastbound approach at Intersection No. 2 – SR 1 / Ocean View Drive to add a right turn lane, which is part of the project.

5.2 Existing Plus Project Conditions Intersection Level of Service Analysis

The results of the intersection level of service analysis based on existing plus project turning movement traffic volumes are summarized in Table 10. Based on this analysis, all of the study intersections are operating acceptably based on City and Caltrans thresholds of significance.

Intersection No. 4 – SR 20 / Boatyard Drive exceeds the City thresholds of significance for “Side Street Stop Sign Controlled Intersections not along SR 1” (LOS C, min. per Policy C-1.1). While the combined total left turn plus through movement volume exceed 15 vehicles per hour, the rural peak hour Signal Warrant 3 criteria is not met, therefore this intersection approach operates at an acceptable LOS D or better.

The unsignalized intersections were evaluated using the rural Signal Warrant 3, per the City of Fort Bragg thresholds of significance, which is discussed under the Section 8 of this report. Signal Warrant 3 analysis results are included in Appendix J.

Results of the Existing plus Project Conditions Scenario Level of Service calculations are provided in Appendix F.

Table 10 Existing Plus Project Scenario Intersection Level of Service

No.	Intersection	Weekday				Weekend	
		a.m.		p.m.		midday	
		Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS
1	SR 1 / Commercial Driveways ¹						
	<i>Northbound left</i>	9.6	A	12.3	B	11.4	B
	<i>Eastbound left-thru-right</i>	27.4	D	>50.0	F	48.2	E
	<i>Westbound left-thru-right</i>	24.1	C	35.4	E	42.1	E
	<i>Southbound left</i>	10.2	B	12.1	B	12.1	B
2	SR 1 / Ocean View Drive ²	12.7	B	24.9	C	21.0	C
3	SR 1 / SR 20 ²	10.2	B	16.1	B	13.6	B
4	SR 20 / Boatyard Drive ¹						
	<i>Northbound left-thru</i>	15.2	C	20.2	C	22.9	C
	<i>Northbound right</i>	0.0	A	9.9	A	10.3	B
	<i>Eastbound left</i>	8.3	A	8.7	A	8.8	A
	<i>Westbound left</i>	0.0	A	0.0	A	8.1	A
	<i>Southbound left-thru</i>	15.7	C	25.2	D	31.6	D
	<i>Southbound right</i>	10.1	B	11.5	B	11.4	B
5	SR 1 / Simpson Lane ³	6.7	A	10.1	B	9.6	A

Notes: Delay is calculated in average seconds per vehicle in queue

LOS = Level of Service

Bold = results exceed acceptable LOS

¹LOS based on HCM2010 method of analysis for TWSC intersections.

²LOS based on HCM2010 method of analysis for Signalized intersections.

³LOS based on HCM2010 method of analysis for Roundabouts.

5.3 Existing Plus Project Conditions Signalized Intersections Queue Analysis

Existing plus Project traffic volumes were applied to signalized study intersections and the peak hour demand 50th and 95th percentile queue lengths were reviewed against the existing lane storage capacity the intersections.

The queue analysis is summarized in Table 11, and also included in Appendix F.

The expected peak hour demand 50th and 95th percentile queue lengths are within existing storage lane capacity at all signalized intersections.

Table 11 Summary of Existing Plus Project Peak Hour Intersection Queue Analysis

Movement	Lanes / Avail. Storage	Queue Length - 50th / 95th (feet/feet)					
		a.m.		p.m.		midday	
Intersection No. 2 - SR 1 / Ocean View Drive							
EBL	1 / 110 ft	15	44	62	113	53	119
EBT	1 / 110 ft	3	16	9	27	8	30
EBR	1 / 110 ft	0	4	0	30	0	39
WBL	1 / 120 ft	9	31	8	28	14	44
WBT	1 / 120 ft	5	21	9	29	9	32
WBR	1 / 120 ft	7	34	40	91	29	82
NBL	1 / 350 ft	14	43	40	114	43	133
NBTR	2 / 350 ft	105	165	142	224	127	206
SBL	1 / 400 ft	38	93	103	270	75	227
SBTR	2 / 400 ft	84	135	180	271	138	227
Intersection No. 3 - SR 1 / SR 20							
WBL	1 / 220 ft	19	54	80	150	52	115
WBR	1 / 120 ft	0	48	1	51	2	47
NBT	2 / 170 ft	63	111	103	172	96	163
NBR	1 / 120 ft	0	22	0	33	0	34
SBL	2 / 320 ft	26	63	58	142	40	118
SBT	1 / 320 ft	64	141	201	393	132	283

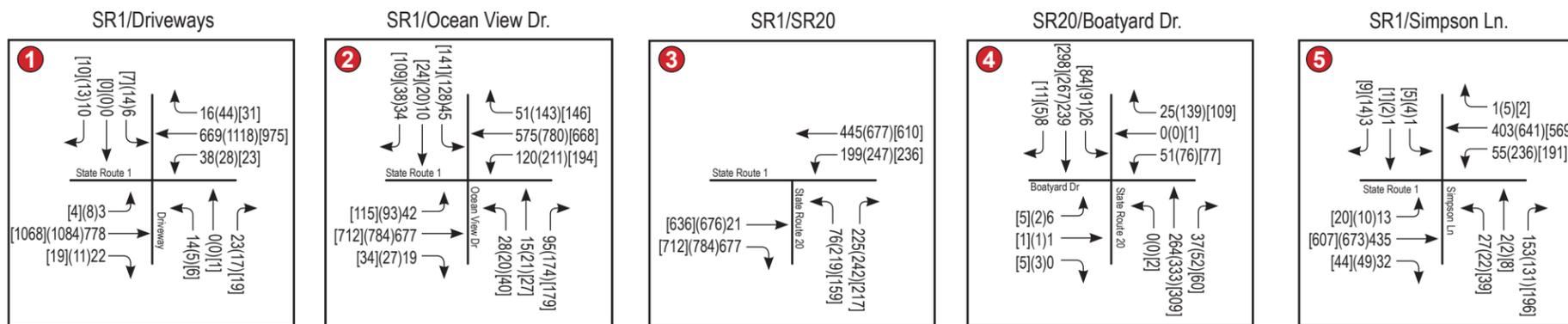
Notes: Queue shown is maximum after two cycles

~ - Volume exceeds capacity, queue is theoretically infinite

- 95th percentile volume exceeds capacity, queue may be longer

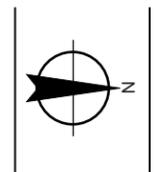
M - Volume for 95th percentile queue is metered by upstream signal

Bold = results where available storage is exceeded by more than one standard vehicle, 25 ft.



Legend

- 1 Study Intersection
- XX AM Peak Hour Volume
- (XX) PM Peak Hour Volume
- [XX] Weekend Mid-Day Peak Hour Volume
- - - Approximate City Limits



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Existing Plus Project Conditions
 Intersection Traffic Volumes **Figure 6**

6. Future Conditions

The potential cumulative impacts of 20-year regional growth to the transportation network were evaluated under the Future Conditions Scenario. The forecasted traffic volumes at each of the study intersections for year 2033 were estimated based applying established growth factors to existing traffic turning movement counts from 2013. The 20-year growth factors were obtained from the Caltrans *2014 Growth Factors* (Caltrans, 2014) developed from California Air Resources Board (ARB) traffic growth projections and historic traffic growth data.

Existing traffic volumes on State Route 1 and State Route 20 were factored upward by 1.15 and 1.05, respectively. The *2014 Growth Factors* (Caltrans, 2014) are included in Appendix G.

The Future Conditions Scenario does not include any planned changes to the roadway network.

6.1 Future Conditions Traffic Volumes

Future traffic volumes are shown in Figure 7. These traffic volumes are represented by the projected future traffic volumes in the year 2033 applied to the existing roadway network and geometry.

6.2 Future Conditions Intersection Level of Service Analysis

The results of the intersection level of service analysis based on future turning movement traffic volumes are summarized in Table 12. Based on this analysis, all of the study intersections are operating acceptably at the threshold between LOS C and LOS D or better during all peak periods for Caltrans facilities.

It is noted that while Intersection No. 2 – SR 1 / Ocean View Drive operates acceptably, the northbound and southbound left turn lanes operate at less than acceptable levels of service during the weekday p.m. and weekend mid-day peak hours based on Caltrans thresholds of significance. Mainline movements and the overall intersection operate acceptably.

It is also noted that while Intersection No. 3 – SR 1 / SR 20 operates acceptably, the southbound left turn lanes operate at less than acceptable level of service during the PM peak hour based on Caltrans thresholds of significance. Mainline movements and the overall intersection operate acceptably.

Intersection No. 4 – SR 20 / Boatyard Drive exceeds the City thresholds of significance for “Side Street Stop Sign Controlled Intersections not along SR 1” (LOS C, min. per Policy C-1.1). While the combined total left turn plus through movement volume exceed 15 vehicles per hour, the rural peak hour Signal Warrant 3 criteria is not met, therefore this intersection approach operates at an acceptable LOS D or better.

The unsignalized intersections were evaluated using the rural Signal Warrant 3, which is discussed under the Section 8 of this report per the City of Fort Bragg thresholds of significance.

Results of the Future Conditions Scenario Level of Service calculations are provided in Appendix H.

Table 12 Future Conditions Scenario Intersection Level of Service

No.	Intersection	Weekday				Weekend	
		a.m.		p.m.		midday	
		Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS
1	SR 1 / Commerical Driveways ¹						
	<i>Northbound left</i>	10.0	B	13.2	B	11.6	B
	<i>Eastbound left-thru-right</i>	34.4	D	>50.0	F	>50.0	F
	<i>Westbound left-thru-right</i>	32.0	D	48.9	E	>50.0	F
	<i>Southbound left</i>	10.8	B	12.8	B	12.6	B
2	SR 1 / Ocean View Drive ²	13.0	B	27.7	C	19.0	B
3	SR 1 / SR 20 ²	10.5	B	18.8	B	14.2	B
4	SR 20 / Boatyard Drive ¹						
	<i>Northbound left-thru</i>	15.7	C	20.8	C	22.9	C
	<i>Northbound right</i>	0.0	A	9.9	A	10.2	B
	<i>Eastbound left</i>	8.3	A	8.8	A	8.8	A
	<i>Westbound left</i>	0.0	A	0.0	A	8.1	A
	<i>Southbound left-thru</i>	16.2	C	25.2	D	28.8	D
	<i>Southbound right</i>	10.2	B	11.6	B	11.4	B
5	SR 1 / Simpson Lane ³	7.2	A	11.4	B	10.2	B

Notes: Delay is calculated in average seconds per vehicle in queue

LOS = Level of Service

Bold = results exceed acceptable LOS

¹LOS based on HCM2010 method of analysis for TWSC intersections.

²LOS based on HCM2010 method of analysis for Signalized intersections.

³LOS based on HCM2010 method of analysis for Roundabouts.

6.3 Future Conditions Intersection Queue Analysis

Future Conditions traffic volumes were applied to signalized study intersections and the peak hour demand 50th and 95th percentile queue lengths were reviewed against the existing lane storage capacity the intersections.

The Future Conditions Peak Hour Intersection Queue Analysis is summarized in Table 13, and copies are provided in Appendix H.

The expected peak hour demand 50th and 95th percentile queue lengths are within existing storage lane capacity at all signalized intersections, with the exception of the following locations:

3. SR 1 / SR 20
 - Southbound Thru Lane (p.m. peak hour / 95th percentile)

The reported available storage for the southbound thru lane at Intersection No. 3 – SR 1 / SR 20 is approximately the length of the southbound left turn lanes. Should the queue exceed this length it will continue to extend on the mainline.

Table 13 Summary of Future Conditions Peak Hour Intersection Queue Analysis

Movement	Lanes / Avail. Storage	Queue Length - 50th / 95th (feet/feet)					
		a.m.		p.m.		midday	
Intersection No. 2 - SR 1 / Ocean View Drive							
EBL	1 / 110 ft	12	39	32	68	19	53
EBTR	1 / 110 ft	3	27	7	31	6	34
WBL	1 / 120 ft	11	37	10	31	17	49
WBT	1 / 120 ft	5	22	8	26	7	27
WBR	1 / 120 ft	15	51	58	118	43	106
NBL	1 / 350 ft	8	30	16	48	9	31
NBTR	2 / 350 ft	125	190	156	232	135	205
SBL	1 / 400 ft	47	111	123	289	82	228
SBTR	2 / 400 ft	45	147	175	256	57	184
Intersection No. 3 - SR 1 / SR 20							
WBL	1 / 220 ft	20	57	90	158	57	124
WBR	1 / 120 ft	0	49	3	53	0	43
NBT	2 / 170 ft	71	125	115	191	101	170
NBR	1 / 120 ft	0	23	0	35	0	36
SBL	2 / 320 ft	31	86	75	158	44	130
SBT	1 / 320 ft	76	169	233	521	142	300

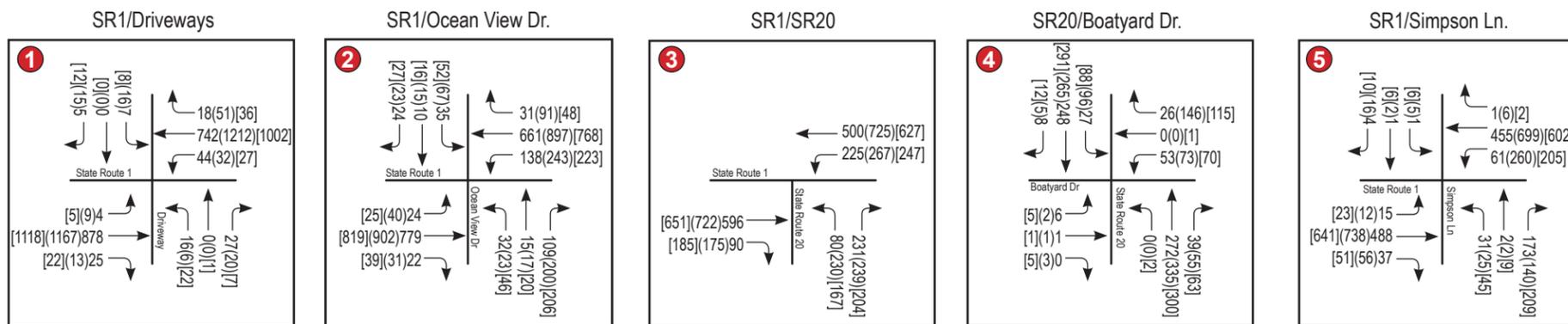
Notes: Queue shown is maximum after two cycles

~ - Volume exceeds capacity, queue is theoretically infinite

- 95th percentile volume exceeds capacity, queue may be longer

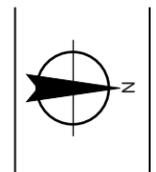
M – Volume for 95th percentile queue is metered by upstream signal

Bold = results where available storage is exceeded by more than one standard vehicle, 25 ft.



Legend

- 1 Study Intersection
- XX AM Peak Hour Volume
- (XX) PM Peak Hour Volume
- [XX] Weekend Mid-Day Peak Hour Volume
- - - Approximate City Limits



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Future Conditions Intersection
 Traffic Volumes

Figure 7

7. Future Plus Project Conditions

This section describes the Future plus Project Conditions Scenario, potential significant impacts and recommended mitigation measures, if any, at the study intersections during the weekday a.m. and p.m. and weekend midday peak hour.

7.1 Future Plus Project Conditions Traffic Volumes

Future plus Project traffic volumes are shown in Figure 8. These traffic volumes are represented by the projected future traffic volumes in the year 2033 with the addition of project generated trips assigned to the roadway network as discussed in Section 4. The roadway network includes the widening of the eastbound approach at Intersection No. 2 – SR 1 / Ocean View Drive to add a right turn lane, which is part of the project.

7.2 Future Conditions Intersection Level of Service Analysis

The results of the intersection level of service analysis based on future turning movement traffic volumes are summarized in Table 14. Based on this analysis, all of the study intersections are operating acceptably at the threshold requirements or better during all peak periods.

It is noted that while Intersection No. 2 – SR 1 / Ocean View Drive operates acceptably, the northbound and southbound left turn lanes operate at less than acceptable levels of service during the weekday p.m. and weekend mid-day peak hours. These movements also operate unacceptably without the project. Mainline movements and the overall intersection operate acceptably.

It is also noted that while Intersection No. 3 – SR 1 / SR 20 operates acceptably, the southbound left turn lanes operate at a less than acceptable level of service during the PM peak hour. This movement also operates unacceptably without the project. Mainline movements and the overall intersection operate acceptably.

Intersection No. 4 – SR 20 / Boatyard Drive exceeds the City thresholds of significance for “Side Street Stop Sign Controlled Intersections not along SR 1” (LOS C, min. per Policy C-1.1). While the combined total left turn plus through movement volume exceed 15 vehicles per hour, the rural peak hour Signal Warrant 3 criteria is not met, therefore this intersection approach operates at an acceptable LOS E or better.

The unsignalized intersections were evaluated using the rural Signal Warrant 3, per the City of Fort Bragg thresholds of significance, which is discussed under the Section 8 of this report. Signal Warrant 3 analysis results are included in Appendix J.

Results of the Future plus Project Conditions Scenario Level of Service calculations are provided in Appendix I.

Table 14 Future Plus Project Conditions Scenario Intersection Level of Service

No.	Intersection	Weekday				Weekend	
		a.m.		p.m.		midday	
		Delay (sec)	LOS	Delay (sec)	LOS	Delay (sec)	LOS
1	SR 1 / Commerical Driveways ¹						
	<i>Northbound left</i>	10.1	B	13.7	B	12.4	B
	<i>Eastbound left-thru-right</i>	36.4	E	>50.0	F	>50.0	F
	<i>Westbound left-thru-right</i>	33.5	D	>50.0	F	>50.0	F
	<i>Southbound left</i>	10.9	B	13.4	B	13.4	B
2	SR 1 / Ocean View Drive ²	13.6	B	35.0	C	25.8	C
3	SR 1 / SR 20 ²	10.6	B	21.7	C	15.4	B
4	SR 20 / Boatyard Drive ¹						
	<i>Northbound left-thru</i>	15.8	C	21.6	C	24.7	C
	<i>Northbound right</i>	0.0	A	10.0	B	10.4	B
	<i>Eastbound left</i>	8.3	A	8.8	A	8.9	A
	<i>Westbound left</i>	0.0	A	0.0	A	8.2	A
	<i>Southbound left-thru</i>	16.5	C	28.5	D	36.7	E
	<i>Southbound right</i>	10.3	B	11.8	B	11.7	B
5	SR 1 / Simpson Lane ³	7.4	A	12.1	B	11.4	B

Notes: Delay is calculated in average seconds per vehicle in queue

LOS = Level of Service

Bold = results exceed acceptable LOS

¹LOS based on HCM2010 method of analysis for TWSC intersections.

²LOS based on HCM2010 method of analysis for Signalized intersections.

³LOS based on HCM2010 method of analysis for Roundabouts.

7.3 Future Plus Project Conditions Intersection Queue Analysis

Future plus Project Conditions traffic volumes were applied to signalized study intersections and the peak hour demand 50th and 95th percentile queue lengths were reviewed against the existing lane storage capacity the intersections.

The Future Conditions Peak Hour Intersection Queue Analysis is summarized in Table 15, and copies are provided in Appendix I.

The expected peak hour demand 50th and 95th percentile queue lengths are within existing storage lane capacity at all signalized intersections, with the exception of the following locations;

3. SR 1 / SR 20
 - Southbound Thru Lane (p.m. peak hour / 95th percentile)
 - Southbound Thru Lane (weekend midday peak hour / 95th percentile)

The reported available storage for the southbound through lane at Intersection No. 3 – SR 1 / SR 20 is approximately the length of the southbound left turn lanes. Should the queue exceed this length it will continue to extend on the mainline.

Table 15 Summary of Future plus Project Conditions Peak Hour Intersection Queue Analysis

Movement	Lanes / Avail. Storage	Queue Length - 50th / 95th (feet/feet)					
		a.m.		p.m.		midday	
Intersection No. 2 - SR 1 / Ocean View Drive							
EBL	1 / 110 ft	18	50	76	119	62	131
EBT	1 / 110 ft	4	19	11	29	10	33
EBR	1 / 110 ft	0	5	0	30	0	41
WBL	1 / 120 ft	11	37	11	30	18	51
WBT	1 / 120 ft	6	24	12	32	12	37
WBR	1 / 120 ft	15	51	67	115	49	115
NBL	1 / 350 ft	15	49	48	123	49	146
NBTR	2 / 350 ft	128	195	175	274	157	246
SBL	1 / 400 ft	48	114	163	318	99	284
SBTR	2 / 400 ft	103	158	227	338	171	273
Intersection No. 3 - SR 1 / SR 20							
WBL	1 / 220 ft	21	58	89	158	60	126
WBR	1 / 120 ft	0	50	11	66	11	62
NBT	2 / 170 ft	74	129	118	205	116	192
NBR	1 / 120 ft	0	23	0	35	0	36
SBL	2 / 320 ft	34	#89	~76	168	51	145
SBT	1 / 320 ft	79	174	254	578	172	355

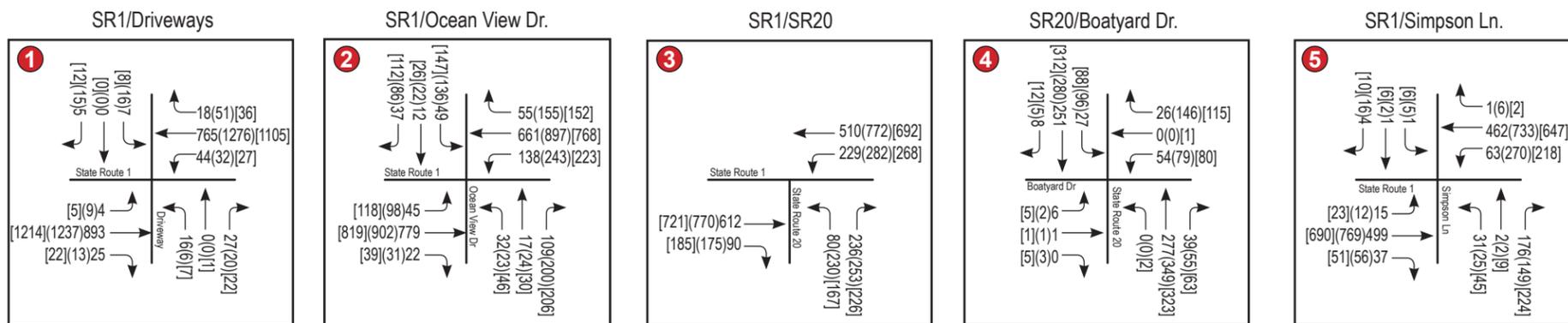
Notes: Queue shown is maximum after two cycles

~ - Volume exceeds capacity, queue is theoretically infinite

- 95th percentile volume exceeds capacity, queue may be longer

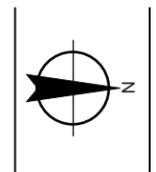
M – Volume for 95th percentile queue is metered by upstream signal

Bold = results where available storage is exceeded by more than one standard vehicle, 25 ft.



Legend

- 1 Study Intersection
- XX AM Peak Hour Volume
- (XX) PM Peak Hour Volume
- [XX] Weekend Mid-Day Peak Hour Volume
- - - Approximate City Limits



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Future Plus Project Conditions
 Intersection Traffic Volumes

Figure 8

8. Peak Hour Traffic Signal Warrant 3

The section presents an evaluation of “rural” Signal Warrant 3 for the peak hour for unsignalized intersections in all scenarios to determine if the warrant is met.

8.1 Peak Hour Signal Warrant 3 Methodology

Traffic Signal Warrant 3 is based on the latest edition of the *California Manual on Uniform Traffic Control Devices* (CAMUTCD) (Caltrans, 2012a). It is noted that Warrant 3 should only be applied in unusual cases, such as at facilities that attract or discharge large amounts of vehicles over short periods of time.

Warrant 3 has two Parts, A and B, either of which must be met to justify the potential need for a signal based on the peak hour. Part A contains three conditions, which are:

1. The total delay experience by traffic on one minor street approach (one direction only) controlled by a STOP sign equals or exceeds four vehicle-hours for one lane approach, or five vehicle-hours for a two-lane approach; AND
2. The volume on the same minor street approach (one direction only) equals or exceeds 75 vph for one moving lane of traffic or 100 vph for two moving lanes (base on City of Ft. Bragg population and speed limit on major street approaches); AND
3. The total entering volume serviced during the hour equals or exceeds 800 vph for the intersection with four or more approaches or 650 vph for intersections with three approaches.

Part B of the Traffic Signal Warrant 3 contains figures that plot minor street versus major street approaches for urban and rural areas. The entire Signal Warrant 3 is included in Appendix J.

Intersections No. 1 and No. 4 meet the definition of “rural.”

The satisfaction of a traffic signal warrant or warrants does not in itself require the installation of a traffic signal, however, the City General Plan Policy C-1.1 states:

If volumes at an unsignalized intersection are increased to meet or exceed Caltrans rural peak hour signal Warrant [3] criteria levels and the intersection is operating at an unacceptable level of service, then signalization of the intersection is warranted.

8.2 Peak Hour Signal Warrant 3 Analysis

Table 16 summarizes the results of the Warrant 3 analysis. Part B is evaluated under “rural” conditions.

Intersection No. 4 – SR 20 / Boatyard Drive is not met presently and will not be met in the future, with or without the addition of project trips.

Because the Warrant 3 is not met under any of the project conditions, there are no project impacts.

Table 16 Summary of Rural Traffic Signal Warrant 3 for Various Conditions Scenarios

Conditions	Part A				Part B
	1	2	3	Met (Y/N)	Met (Y/N)
Intersection	Total Delay (veh-hrs)	Highest Minor Appr. Volume (veh)	Total Entering Volume (veh)		
Existing Conditions Scenario					
No. 1 - SR 1 / Commercial Driveways	0.55	27	2,208	N	N
No. 4 - SR 20 / Boatyard Drive	0.96	177	908	N	N
Existing Plus Project Conditions Scenario					
No. 1 - SR 1 / Commercial Driveways	0.69	27	2,342	N	N
No. 4 - SR 20 / Boatyard Drive	1.24	187	961	N	N
Future Conditions Scenario					
No. 1 - SR 1 / Commercial Driveways	1.48	31	2,540	N	N
No. 4 - SR 20 / Boatyard Drive	1.17	219	980	N	N
Future Plus Project Conidtions Scenario					
No. 1 - SR 1 / Commercial Driveways	2.15	31	2,674	N	N
No. 4 - SR 20 / Boatyard Drive	1.46	196	1,007	N	N

Notes: **Bold** = results where Part A or Part B are met; Warrant 3 met.

9. Conclusions

This section summarizes the conclusions regarding the proposed project and its potential traffic impacts.

9.1 Existing plus Project

9.1.1 Intersection Operations

Intersection No. 4 – SR 20 / Boatyard Drive exceeds the City thresholds of significance for “Side Street Stop Sign Controlled Intersections not along SR 1” (LOS C, min. per Policy C-1.1). The southbound left-thru approach operates at an LOS D during the weekday p.m. and weekend mid-day peak hours. Since the combined total left turn plus through movement volume exceed 15 vehicles per hour but the rural peak hour Signal Warrant 3 criteria is not met, this intersection approach operates at an acceptable LOS D or better. This facility is located within the State right-of-way, and the major mainline movements operate acceptably.

9.1.2 Vehicle Queuing

The expected peak hour demand 50th and 95th percentile queue lengths are within existing storage lane capacity at all signalized intersections.

9.2 Future plus Project

9.2.1 Intersection Operations

Intersection No. 4 – SR 20 / Boatyard Drive exceeds the City thresholds of significance for “Side Street Stop Sign Controlled Intersections not along SR 1” (LOS C, min. per Policy C-1.1). The southbound left-thru approach operates at an LOS D during the weekday p.m. peak hour and LOS E during weekend mid-day peak hour. Since the combined total left turn plus through movement volume exceed 15 vehicles per hour but the rural peak hour Signal Warrant 3 criteria is not met, the intersection approach operates at an acceptable LOS E or better. An alternative route via Intersection No. 4 does exist. The operation of this minor street approach was discussed with Caltrans District 1 staff prior to finalizing this traffic study, and no concerns were expressed. This facility is located within the State right-of-way, and the major mainline movements operate acceptably.

9.2.2 Vehicle Queuing

The expected peak hour demand 50th and 95th percentile queue lengths are within existing storage lane capacity at all signalized intersections, with the exception of Intersection No. 3:

3. SR 1 / SR 20
 - Southbound Thru Lane (p.m. peak hour / 95th percentile)
 - Southbound Thru Lane (weekend midday peak hour / 95th percentile)

The reported available storage for the southbound through lane at Intersection No. 3 – SR 1 / SR 20 is approximately the length of the southbound left turn lanes. Should the queue exceed this length it will continue to extend on the mainline without causing any traffic safety or operational issues.

9.3 Summary

Table 17 summarizes the level of service calculation results for the study roadway network with and without project-generated trips. In conclusion, this study finds that the proposed Project would not be expected to contribute significantly to the potential deterioration of traffic operations or queuing levels in the study area for the conditions analyzed in this study. Each of the study intersections is expected to operate acceptably with or without the project under each of the study scenarios and with the addition of proposed project improvements to the roadway network. Additionally, queue lengths are expected to remain at acceptable levels with or without the Project.

Table 17 Summary of Peak Hour Intersection Level of Service Calculations

No.	Intersections	Existing			Existing plus Project			Future (2033)			Future plus Project		
		a.m.	p.m.	W. E. midday	a.m.	p.m.	W.E. midday	a.m.	p.m.	W.E. midday	a.m.	p.m.	W.E. midday
1	SR 1 / Comm. Driveways ¹												
	Northbound left	9.5/A	11.9/B	10.7/B	9.6/A	12.3/B	11.4/B	10.0/B	13.2/B	11.6/B	10.1/B	13.7/B	12.4/B
	Eastbound left-thru-right	25.9/D	>50.0/F	36.3/E	27.4/D	>50.0/F	48.2/E	34.4/D	>50.0/F	>50.0/F	36.4/E	>50.0/F	>50.0/F
	Westbound left-thru-right	23.2/C	30.3/D	32.2/D	24.1/C	35.4/E	42.1/E	32.0/D	48.9/E	>50.0/F	33.5/D	>50.0/F	>50.0/F
	Southbound left	10.1/B	11.6/B	11.4/B	10.2/B	12.1/B	12.1/B	10.8/B	12.8/B	12.6/B	10.9/B	13.4/B	13.4/B
2	SR 1 / Ocean View Drive ²	12.0/B	19.3/B	15.9/B	12.8/B	25.3/C	21.4/C	13.0/B	27.7/C	19.0/B	13.7/B	35.5/D	26.4/C
3	SR 1 / SR 20 ²	10.1/B	15.0/B	12.9/B	10.2/B	16.1/B	13.6/B	10.5/B	18.8/B	14.2/B	10.6/B	21.7/C	15.4/B
4	SR 20 / Boatyard Drive ¹												
	Northbound left-thru	15.1/C	19.5/C	21.3/C	15.2/C	20.2/C	22.9/C	15.7/C	20.8/C	22.9/C	15.8/C	21.6/C	24.7/C
	Northbound right	0.0/A	9.8/A	10.1/B	0.0/A	9.9/A	10.3/B	0.0/A	9.9/A	10.2/B	0.0/A	10.0/B	10.4/B
	Eastbound left	8.2/A	8.7/A	8.7/A	8.3/A	8.7/A	8.8/A	8.3/A	8.8/A	8.8/A	8.3/A	8.8/A	8.9/A
	Westbound left	0.0/A	0.0/A	8.0/A	0.0/A	0.0/A	8.1/A	0.0/A	0.0/A	8.1/A	0.0/A	0.0/A	8.2/A
	Southbound left-thru	15.5/C	22.4/C	25.5/D	15.7/C	25.2/D	31.6/D	16.2/C	25.5/D	28.8/D	16.5/C	28.5/D	36.7/E
	Southbound right	10.1/B	11.4/B	11.2/B	10.1/B	11.5/B	11.4/B	10.2/B	11.6/B	11.4/B	10.3/B	11.8/B	11.7/B
5	SR 1 / Simpson Lane ³	6.6/A	9.6/A	8.9/A	6.7/A	10.1/B	9.6/A	7.2/A	11.4/B	10.2/B	7.4/A	12.1/B	11.4/B

Notes: Delay is calculated in average seconds per vehicle in queue

LOS = Level of Service

Bold = results exceed acceptable LOS

¹LOS based on HCM2010 method of analysis for TWSC intersections.

²LOS based on HCM2010 method of analysis for Signalized intersections.

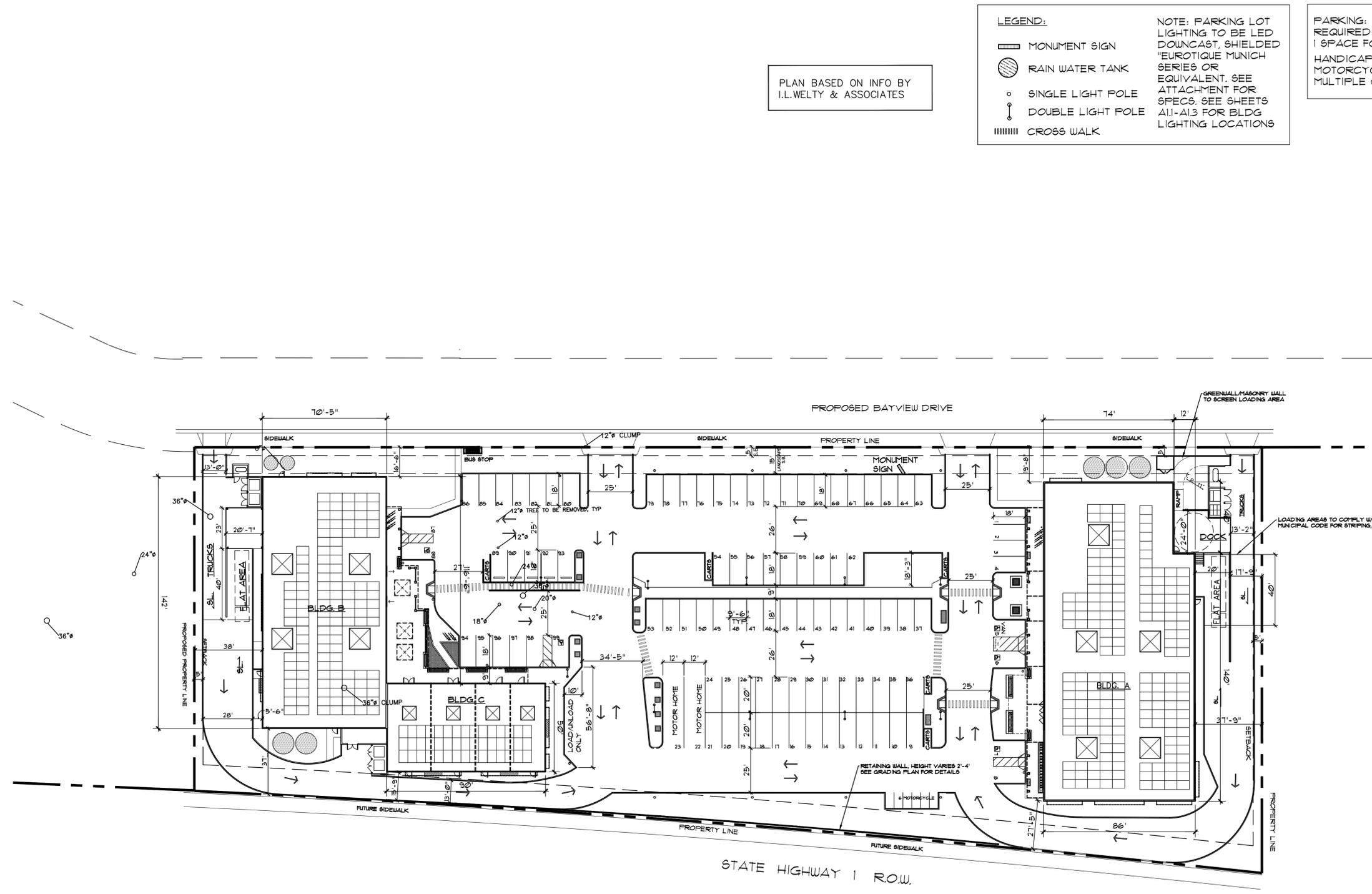
³LOS based on HCM2010 method of analysis for Roundabouts.

References

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Appendices

Appendix A - Project Site Plan



PLAN BASED ON INFO BY
I.L.WELTY & ASSOCIATES

LEGEND:

- MONUMENT SIGN
- RAIN WATER TANK
- SINGLE LIGHT POLE
- DOUBLE LIGHT POLE
- CROSS WALK

NOTE: PARKING LOT LIGHTING TO BE LED DOWNCAST, SHIELDED "EUROTIQUE MUNICH SERIES OR EQUIVALENT. SEE ATTACHMENT FOR SPECS. SEE SHEETS A1.1-A1.3 FOR BLDG LIGHTING LOCATIONS

PARKING: 99 SPACES
REQUIRED: 99
1 SPACE FOR 300 SF.
HANDICAP: 5 SPACES (1 VAN)
MOTORCYCLE: 6
MULTIPLE CYCLE RACKS

TITLE: **SITE PLAN**

PROJECT: **HARE CREEK CENTER**
GROUP II COMMERCIAL REAL ESTATE, INC.
1250 DEL MAR DRIVE
FORT BRAGG, CALIFORNIA
APN# 018-450-41

DATE: 6/18/2014
SCALE: 1" = 30'
DRAWN: MGH
DWG.: A1 SITE PLAN

SHEET
A1.0
OF x SHEETS

SITE PLAN
SCALE: 1" = 30'

Appendix B - Caltrans District 1 Traffic Signal Supplement

Caltrans - District 1
TRAFFIC SIGNALS ON STATE HIGHWAYS
SUPPLEMENT TO GUIDE FOR THE PREPARATION OF TRAFFIC IMPACT STUDIES

FOR NEW AND EXISTING TRAFFIC SIGNALS SERVING PROPOSED AND EXISTING DEVELOPMENTS.

The traffic study for signalized intersections should typically include:

- **PROJECT.** Project impacts and proposed mitigation and improvements. The expected dates of project (normally full build) construction. If a staged or phased project, the date and mitigation/improvements of each phase should be provided. The responsible party for financing, installing, operating and maintaining the traffic signal mitigations and funding energy costs should be indicated.
- **WARRANTS.** Signal warrant worksheets and analysis for new signals.
- **INTERSECTION AND CAPACITY OPERATIONAL ANALYSIS.**
 - Proposed vehicle and pedestrian signal phasing operation, indicating protected and permitted movements.
 - Project trip generation and distribution, traffic and geometric characteristics, including vehicle traffic and pedestrian volumes, lane usage, capacity and level of service (LOS) analysis (HCM operational method) for the various traffic scenarios. The traffic scenarios should typically include existing conditions, proposed project only, existing plus project, cumulative conditions, etc. Annual daily traffic (ADT), morning (AM) and evening (PM) peak hour information should be provided. The analysis should address vehicle queues and storage lengths, accident and safety data, safety, sight distance, turning movement conflicts, truck turn movements, critical speeds (85th percentile) of approaching vehicles, congestion, right of way protection/dedication needs, impacts to adjacent driveways and intersections, parking, bicycle paths, etc.
 - Site plan and conceptual geometric layout plans of the signalized intersection, showing intersection and facility geometrics, right of way, channelization and all existing and proposed lanes for new signals or existing signals requiring modification, including both sides of the highway. Lane, shoulder, crosswalk, sidewalk, and right of way widths should be addressed.
- **SYSTEM AND PROGRESSION OPERATIONAL ANALYSIS.** Coordinated signal timing plans of all signals that may be connected into a coordinated traffic signal system. This should include coordination and intersection analysis and optimized timing, vehicle and pedestrian signal phasing and timing, travel speeds, intersection spacing distances, time-space diagrams, cycle lengths and offsets for both AM and PM peak hours. Protected left-turns should be analyzed as leading left turns. Offsets for Caltrans Model 170/2070 controllers shall be referenced to beginning of yellow. Evaluation of traffic flow and progression of existing and proposed scenarios should be addressed.
- **SOFTWARE.** Synchro plus SimTraffic software should be used for traffic signal analysis. Synchro/SimTraffic computer models should be used to develop and optimize coordinated signal timing plans and system analysis. Signal operation and traffic flows should typically be calibrated. Caltrans should be consulted regarding proposed version of Synchro/SimTraffic software to be used, and whether software data files should be provided with the traffic study.

Additions to the Supplement

- Pedestrian WALK time: 7 seconds
- Pedestrian DONT WALK time: 3.5 feet /sec (or slower) pedestrian walk speed. (Do not subtract yellow and all-red times from the pedestrian calculated times)
- Crosswalk widths are measured from curb to far traveled way. (Section 4E.10 of the CA MUTCD)
- All-Red time: 2.0 seconds.
- Yellow times: Use values per CA MUTCD. Use 3.2 seconds for 30 mph approach speeds and lower.
- Initial green times: 5.0 seconds.
- Lead/Lag option: Protected left-turns shall be Leading phasing.
- Minimum green recall phases: Phases 2 and 6 (NB/SB thru) on S.R. 53
- Minimum green time: 8 seconds
- Saturation flow rate of 1750 should be used for all lanes.
- Ensure that the Simtraffic run times are long enough for the network to fully load (the default time of 10 minutes is often too short)
- Regarding our recommended setting of other Synchro/Simtraffic values, these should be set as local conditions and your proposed modifications dictate.

Appendix C - Intersection Turning Movement Counts and 24-hour ADT Counts

City of Fort Bragg
 State Route 20
 B/ Harbor Drive - Boatyard Drive
 24 Hour Directional Classification Count
 Eastbound

FBG003
 Site Code: 999-13282
 Date Start: 22-Aug-13
 Date End: 22-Aug-13

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
08/22/13	0	16	3	0	0	0	0	0	0	0	0	0	0	19
01:00	0	4	2	0	0	0	0	0	0	0	0	0	0	6
02:00	0	6	4	0	2	0	0	0	3	0	0	0	0	15
03:00	0	7	3	0	0	2	0	1	2	0	0	0	0	15
04:00	0	6	8	0	3	3	0	2	3	1	0	0	0	26
05:00	0	21	24	1	19	5	0	0	5	1	0	0	0	76
06:00	1	45	33	1	22	2	0	4	1	0	0	0	0	109
07:00	3	71	42	2	41	0	0	4	3	0	0	0	0	166
08:00	5	124	86	7	41	2	0	6	5	0	0	0	0	276
09:00	4	130	89	1	37	2	0	3	5	1	0	0	0	272
10:00	0	143	64	5	28	0	0	12	7	1	0	0	0	260
11:00	1	143	79	1	36	0	0	13	2	0	0	0	0	275
12 PM	2	171	83	1	31	0	0	5	4	0	0	0	0	297
13:00	2	173	75	0	29	1	0	7	4	1	0	0	0	292
14:00	1	150	86	0	35	1	0	8	2	0	0	0	0	283
15:00	2	182	89	3	50	0	0	3	3	0	0	0	0	332
16:00	1	188	89	3	26	1	0	10	0	0	1	0	0	319
17:00	2	189	79	0	39	3	0	2	7	0	1	0	0	322
18:00	0	138	81	1	28	0	0	2	3	1	0	0	0	254
19:00	1	123	45	0	27	1	0	1	0	0	0	0	0	198
20:00	0	100	43	0	14	0	0	2	0	0	0	0	0	159
21:00	0	74	22	0	16	0	0	1	0	0	0	0	0	113
22:00	0	42	13	0	7	0	0	2	0	0	0	0	0	64
23:00	0	13	14	0	1	0	0	0	1	0	0	0	0	29
Total	25	2259	1156	26	532	23	0	88	60	6	2	0	0	4177
Percent	0.6%	54.1%	27.7%	0.6%	12.7%	0.6%	0.0%	2.1%	1.4%	0.1%	0.0%	0.0%	0.0%	
AM Peak	08:00	10:00	09:00	08:00	07:00	05:00		11:00	10:00	04:00				08:00
Vol.	5	143	89	7	41	5		13	7	1				276
PM Peak	12:00	17:00	15:00	15:00	15:00	17:00		16:00	17:00	13:00	16:00			15:00
Vol.	2	189	89	3	50	3		10	7	1	1			332
Grand Total	25	2259	1156	26	532	23	0	88	60	6	2	0	0	4177
Percent	0.6%	54.1%	27.7%	0.6%	12.7%	0.6%	0.0%	2.1%	1.4%	0.1%	0.0%	0.0%	0.0%	

City of Fort Bragg
 State Route 20
 B/ Harbor Drive - Boatyard Drive
 24 Hour Directional Classification Count
 Westbound

FBG003
 Site Code: 999-13282
 Date Start: 22-Aug-13
 Date End: 22-Aug-13

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
08/22/13	0	14	5	0	0	0	0	0	0	0	0	0	0	19
01:00	0	5	3	0	1	1	0	0	1	0	0	0	0	11
02:00	0	3	3	1	0	1	0	0	1	0	0	0	0	9
03:00	0	5	5	0	0	0	0	0	1	0	0	0	0	11
04:00	0	9	4	0	0	2	0	0	1	0	0	0	0	16
05:00	0	25	11	1	7	2	0	1	3	0	0	0	0	50
06:00	1	58	29	0	12	0	0	3	6	0	0	0	0	109
07:00	0	144	57	0	15	3	0	1	4	0	0	0	0	224
08:00	1	189	69	0	19	5	0	6	8	1	0	0	0	298
09:00	0	162	67	1	12	3	0	1	4	1	0	0	1	252
10:00	2	173	65	0	24	5	0	4	4	0	0	0	0	277
11:00	1	195	81	2	25	5	0	2	3	0	0	0	0	314
12 PM	6	224	82	1	24	0	0	5	3	1	0	0	0	346
13:00	1	206	57	1	21	2	0	6	3	1	0	0	0	298
14:00	2	229	70	1	18	5	0	9	3	0	0	0	0	337
15:00	3	209	73	1	23	7	0	11	3	0	1	0	0	331
16:00	2	225	92	1	26	6	0	6	4	0	0	1	0	363
17:00	1	211	77	0	28	8	0	13	4	0	0	0	0	342
18:00	0	181	60	1	18	3	0	3	1	0	0	0	0	267
19:00	0	135	38	1	11	0	0	3	3	0	0	0	0	191
20:00	1	106	27	0	6	1	0	5	1	0	0	0	0	147
21:00	0	72	30	1	6	2	0	3	1	0	0	0	0	115
22:00	0	51	7	0	3	0	0	0	1	0	0	0	0	62
23:00	0	31	11	0	0	0	0	1	2	0	0	0	0	45
Total	21	2862	1023	13	299	61	0	83	65	4	1	1	1	4434
Percent	0.5%	64.5%	23.1%	0.3%	6.7%	1.4%	0.0%	1.9%	1.5%	0.1%	0.0%	0.0%	0.0%	
AM Peak	10:00	11:00	11:00	11:00	11:00	08:00		08:00	08:00	08:00			09:00	11:00
Vol.	2	195	81	2	25	5		6	8	1			1	314
PM Peak	12:00	14:00	16:00	12:00	17:00	17:00		17:00	16:00	12:00	15:00	16:00		16:00
Vol.	6	229	92	1	28	8		13	4	1	1	1		363
Grand Total	21	2862	1023	13	299	61	0	83	65	4	1	1	1	4434
Percent	0.5%	64.5%	23.1%	0.3%	6.7%	1.4%	0.0%	1.9%	1.5%	0.1%	0.0%	0.0%	0.0%	

City of Fort Bragg
 State Route 20
 B/ Harbor Drive - Boatyard Drive
 24 Hour Directional Classification Count
 Eastbound, Westbound

FBG003
 Site Code: 999-13282
 Date Start: 22-Aug-13
 Date End: 22-Aug-13

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
08/22/13	0	30	8	0	0	0	0	0	0	0	0	0	0	38
01:00	0	9	5	0	1	1	0	0	1	0	0	0	0	17
02:00	0	9	7	1	2	1	0	0	4	0	0	0	0	24
03:00	0	12	8	0	0	2	0	1	3	0	0	0	0	26
04:00	0	15	12	0	3	5	0	2	4	1	0	0	0	42
05:00	0	46	35	2	26	7	0	1	8	1	0	0	0	126
06:00	2	103	62	1	34	2	0	7	7	0	0	0	0	218
07:00	3	215	99	2	56	3	0	5	7	0	0	0	0	390
08:00	6	313	155	7	60	7	0	12	13	1	0	0	0	574
09:00	4	292	156	2	49	5	0	4	9	2	0	0	1	524
10:00	2	316	129	5	52	5	0	16	11	1	0	0	0	537
11:00	2	338	160	3	61	5	0	15	5	0	0	0	0	589
12 PM	8	395	165	2	55	0	0	10	7	1	0	0	0	643
13:00	3	379	132	1	50	3	0	13	7	2	0	0	0	590
14:00	3	379	156	1	53	6	0	17	5	0	0	0	0	620
15:00	5	391	162	4	73	7	0	14	6	0	1	0	0	663
16:00	3	413	181	4	52	7	0	16	4	0	1	1	0	682
17:00	3	400	156	0	67	11	0	15	11	0	1	0	0	664
18:00	0	319	141	2	46	3	0	5	4	1	0	0	0	521
19:00	1	258	83	1	38	1	0	4	3	0	0	0	0	389
20:00	1	206	70	0	20	1	0	7	1	0	0	0	0	306
21:00	0	146	52	1	22	2	0	4	1	0	0	0	0	228
22:00	0	93	20	0	10	0	0	2	1	0	0	0	0	126
23:00	0	44	25	0	1	0	0	1	3	0	0	0	0	74
Total	46	5121	2179	39	831	84	0	171	125	10	3	1	1	8611
Percent	0.5%	59.5%	25.3%	0.5%	9.7%	1.0%	0.0%	2.0%	1.5%	0.1%	0.0%	0.0%	0.0%	
AM Peak	08:00	11:00	11:00	08:00	11:00	05:00		10:00	08:00	09:00			09:00	11:00
Vol.	6	338	160	7	61	7		16	13	2			1	589
PM Peak	12:00	16:00	16:00	15:00	15:00	17:00		14:00	17:00	13:00	15:00	16:00		16:00
Vol.	8	413	181	4	73	11		17	11	2	1	1		682
Grand Total	46	5121	2179	39	831	84	0	171	125	10	3	1	1	8611
Percent	0.5%	59.5%	25.3%	0.5%	9.7%	1.0%	0.0%	2.0%	1.5%	0.1%	0.0%	0.0%	0.0%	

City of Fort Bragg
 State Route 1
 B/ Hare Creek Bridge - State Route 20
 24 Hour Directional Classification Count
 Northbound

FBG001
 Site Code: 999-13282
 Date Start: 22-Aug-13
 Date End: 22-Aug-13

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
08/22/13	1	16	9	0	3	0	0	0	0	0	0	0	0	29
01:00	0	7	4	0	1	0	0	0	0	0	0	0	0	12
02:00	0	4	1	0	1	0	0	0	0	0	0	0	0	6
03:00	0	8	4	0	0	1	0	0	1	0	0	0	0	14
04:00	0	19	8	0	5	0	0	0	0	0	0	0	0	32
05:00	1	41	34	1	12	0	0	0	1	0	0	0	0	90
06:00	2	88	45	1	20	1	0	5	0	0	0	0	0	162
07:00	3	245	124	3	49	2	0	4	2	0	0	0	0	432
08:00	0	359	150	4	49	3	0	6	1	0	0	0	0	572
09:00	2	344	154	1	56	2	0	3	2	1	0	0	0	565
10:00	3	419	166	2	46	4	0	11	1	0	0	0	0	652
11:00	6	419	152	1	65	2	0	7	0	0	0	0	0	652
12 PM	2	426	186	4	62	2	0	8	0	0	0	0	0	690
13:00	4	444	162	1	58	1	0	6	1	0	0	0	0	677
14:00	3	461	188	0	69	3	0	10	0	0	1	0	0	735
15:00	3	433	198	0	88	1	0	6	0	0	0	0	0	729
16:00	3	455	212	3	78	1	0	3	0	0	0	0	0	755
17:00	7	390	188	0	74	1	0	6	1	0	0	0	0	667
18:00	3	278	114	2	41	0	0	2	1	0	0	0	0	441
19:00	4	209	101	0	30	1	0	1	0	0	0	0	0	346
20:00	1	156	62	0	16	0	0	0	0	0	1	0	0	236
21:00	2	115	40	0	17	0	0	0	0	0	0	0	0	174
22:00	0	70	32	0	6	0	0	0	0	0	0	0	0	108
23:00	0	45	15	0	2	0	0	0	1	0	0	0	0	63
Total	50	5451	2349	23	848	25	0	78	12	1	2	0	0	8839
Percent	0.6%	61.7%	26.6%	0.3%	9.6%	0.3%	0.0%	0.9%	0.1%	0.0%	0.0%	0.0%	0.0%	
AM Peak	11:00	10:00	10:00	08:00	11:00	10:00		10:00	07:00	09:00				10:00
Vol.	6	419	166	4	65	4		11	2	1				652
PM Peak	17:00	14:00	16:00	12:00	15:00	14:00		14:00	13:00		14:00			16:00
Vol.	7	461	212	4	88	3		10	1		1			755
Grand Total	50	5451	2349	23	848	25	0	78	12	1	2	0	0	8839
Percent	0.6%	61.7%	26.6%	0.3%	9.6%	0.3%	0.0%	0.9%	0.1%	0.0%	0.0%	0.0%	0.0%	

City of Fort Bragg
 State Route 1
 B/ Hare Creek Bridge - State Route 20
 24 Hour Directional Classification Count
 Southbound

FBG001
 Site Code: 999-13282
 Date Start: 22-Aug-13
 Date End: 22-Aug-13

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
08/22/13	0	17	5	0	1	0	0	0	0	0	0	0	0	23
01:00	0	6	4	0	0	2	0	0	1	0	0	0	0	13
02:00	0	4	0	0	0	0	0	0	0	0	0	0	0	4
03:00	0	8	3	1	1	0	0	0	2	0	0	0	0	15
04:00	0	12	6	0	2	1	0	0	2	0	0	0	0	23
05:00	0	34	21	0	7	1	0	2	1	0	0	0	0	66
06:00	1	79	38	2	14	0	0	0	3	0	0	0	0	137
07:00	1	170	97	0	22	2	0	3	1	0	0	0	0	296
08:00	2	276	174	0	46	3	0	3	2	1	0	0	0	507
09:00	6	320	156	3	37	4	0	5	2	0	0	0	0	533
10:00	1	359	142	1	33	1	0	3	4	0	0	0	0	544
11:00	5	413	148	2	42	3	0	8	1	0	1	0	0	623
12 PM	5	492	163	1	53	1	0	7	1	1	0	0	0	724
13:00	3	472	149	2	42	1	0	5	0	0	0	0	0	674
14:00	6	484	164	2	41	0	0	9	0	1	1	0	0	708
15:00	7	495	176	3	55	0	0	9	0	0	0	0	0	745
16:00	7	524	224	1	58	0	0	7	0	0	0	0	0	821
17:00	3	519	177	2	39	2	0	10	2	0	0	0	0	754
18:00	5	407	136	0	29	2	0	6	0	0	0	0	0	585
19:00	5	307	111	0	24	0	0	0	0	0	0	0	0	447
20:00	2	239	78	0	13	1	0	3	0	0	0	0	0	336
21:00	0	176	56	0	5	0	0	1	0	0	0	0	0	238
22:00	0	72	12	0	3	0	0	0	1	0	0	0	0	88
23:00	1	47	19	0	4	0	0	0	0	0	0	0	0	71
Total	60	5932	2259	20	571	24	0	81	23	3	2	0	0	8975
Percent	0.7%	66.1%	25.2%	0.2%	6.4%	0.3%	0.0%	0.9%	0.3%	0.0%	0.0%	0.0%	0.0%	
AM Peak	09:00	11:00	08:00	09:00	08:00	09:00		11:00	10:00	08:00	11:00			11:00
Vol.	6	413	174	3	46	4		8	4	1	1			623
PM Peak	15:00	16:00	16:00	15:00	16:00	17:00		17:00	17:00	12:00	14:00			16:00
Vol.	7	524	224	3	58	2		10	2	1	1			821
Grand Total	60	5932	2259	20	571	24	0	81	23	3	2	0	0	8975
Percent	0.7%	66.1%	25.2%	0.2%	6.4%	0.3%	0.0%	0.9%	0.3%	0.0%	0.0%	0.0%	0.0%	

City of Fort Bragg
 State Route 1
 B/ Hare Creek Bridge - State Route 20
 24 Hour Directional Classification Count
 Northbound, Southbound

FBG001
 Site Code: 999-13282
 Date Start: 22-Aug-13
 Date End: 22-Aug-13

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
08/22/13	1	33	14	0	4	0	0	0	0	0	0	0	0	52
01:00	0	13	8	0	1	2	0	0	1	0	0	0	0	25
02:00	0	8	1	0	1	0	0	0	0	0	0	0	0	10
03:00	0	16	7	1	1	1	0	0	3	0	0	0	0	29
04:00	0	31	14	0	7	1	0	0	2	0	0	0	0	55
05:00	1	75	55	1	19	1	0	2	2	0	0	0	0	156
06:00	3	167	83	3	34	1	0	5	3	0	0	0	0	299
07:00	4	415	221	3	71	4	0	7	3	0	0	0	0	728
08:00	2	635	324	4	95	6	0	9	3	1	0	0	0	1079
09:00	8	664	310	4	93	6	0	8	4	1	0	0	0	1098
10:00	4	778	308	3	79	5	0	14	5	0	0	0	0	1196
11:00	11	832	300	3	107	5	0	15	1	0	1	0	0	1275
12 PM	7	918	349	5	115	3	0	15	1	1	0	0	0	1414
13:00	7	916	311	3	100	2	0	11	1	0	0	0	0	1351
14:00	9	945	352	2	110	3	0	19	0	1	2	0	0	1443
15:00	10	928	374	3	143	1	0	15	0	0	0	0	0	1474
16:00	10	979	436	4	136	1	0	10	0	0	0	0	0	1576
17:00	10	909	365	2	113	3	0	16	3	0	0	0	0	1421
18:00	8	685	250	2	70	2	0	8	1	0	0	0	0	1026
19:00	9	516	212	0	54	1	0	1	0	0	0	0	0	793
20:00	3	395	140	0	29	1	0	3	0	0	1	0	0	572
21:00	2	291	96	0	22	0	0	1	0	0	0	0	0	412
22:00	0	142	44	0	9	0	0	0	1	0	0	0	0	196
23:00	1	92	34	0	6	0	0	0	1	0	0	0	0	134
Total	110	11383	4608	43	1419	49	0	159	35	4	4	0	0	17814
Percent	0.6%	63.9%	25.9%	0.2%	8.0%	0.3%	0.0%	0.9%	0.2%	0.0%	0.0%	0.0%	0.0%	
AM Peak	11:00	11:00	08:00	08:00	11:00	08:00		11:00	10:00	08:00	11:00			11:00
Vol.	11	832	324	4	107	6		15	5	1	1			1275
PM Peak	15:00	16:00	16:00	12:00	15:00	12:00		14:00	17:00	12:00	14:00			16:00
Vol.	10	979	436	5	143	3		19	3	1	2			1576
Grand Total	110	11383	4608	43	1419	49	0	159	35	4	4	0	0	17814
Percent	0.6%	63.9%	25.9%	0.2%	8.0%	0.3%	0.0%	0.9%	0.2%	0.0%	0.0%	0.0%	0.0%	

City of Fort Bragg
 State Route 1
 B/ Noyo Bridge - Driveways
 24 Hour Directional Classification Count
 Northbound

FBG002
 Site Code: 999-13282
 Date Start: 22-Aug-13
 Date End: 22-Aug-13

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
08/22/13	0	23	10	0	4	0	0	0	0	0	0	0	0	37
01:00	0	12	7	0	3	1	0	0	0	0	0	0	0	23
02:00	0	8	2	1	2	1	0	0	1	0	0	0	0	15
03:00	2	14	11	0	0	3	0	0	0	0	0	0	0	30
04:00	0	22	11	0	5	2	0	0	2	0	0	0	0	42
05:00	1	56	41	3	13	2	0	0	1	0	0	0	0	117
06:00	2	137	73	1	31	1	0	3	3	0	0	0	0	251
07:00	3	355	160	5	53	5	0	7	4	0	0	0	0	592
08:00	0	521	219	1	69	6	0	4	9	0	0	0	0	829
09:00	3	480	204	3	73	2	0	5	6	1	0	0	0	777
10:00	4	515	234	1	74	8	0	7	6	0	0	0	0	849
11:00	6	585	202	3	90	6	0	7	3	0	0	0	0	902
12 PM	6	671	267	4	94	1	0	10	3	1	0	0	0	1057
13:00	3	686	255	3	84	2	0	6	2	1	0	0	0	1042
14:00	4	665	283	1	82	7	0	8	3	0	1	0	0	1054
15:00	7	629	241	2	95	6	0	16	2	1	0	0	0	999
16:00	3	638	309	4	78	7	0	8	5	0	0	0	0	1052
17:00	5	577	272	0	79	6	0	12	5	0	0	0	0	956
18:00	7	508	189	4	59	2	0	7	1	0	0	0	0	777
19:00	1	325	137	0	31	0	0	4	3	0	0	0	0	501
20:00	3	277	104	0	29	0	0	4	1	0	0	0	1	419
21:00	5	201	75	1	19	3	0	4	1	0	0	0	0	309
22:00	0	131	46	0	6	0	0	0	0	0	0	0	0	183
23:00	0	68	21	1	1	0	0	1	1	0	0	0	0	93
Total	65	8104	3373	38	1074	71	0	113	62	4	1	0	1	12906
Percent	0.5%	62.8%	26.1%	0.3%	8.3%	0.6%	0.0%	0.9%	0.5%	0.0%	0.0%	0.0%	0.0%	
AM Peak	11:00	11:00	10:00	07:00	11:00	10:00		07:00	08:00	09:00				11:00
Vol.	6	585	234	5	90	8		7	9	1				902
PM Peak	15:00	13:00	16:00	12:00	15:00	14:00		15:00	16:00	12:00	14:00		20:00	12:00
Vol.	7	686	309	4	95	7		16	5	1	1		1	1057
Grand Total	65	8104	3373	38	1074	71	0	113	62	4	1	0	1	12906
Percent	0.5%	62.8%	26.1%	0.3%	8.3%	0.6%	0.0%	0.9%	0.5%	0.0%	0.0%	0.0%	0.0%	

City of Fort Bragg
 State Route 1
 B/ Noyo Bridge - Driveways
 24 Hour Directional Classification Count
 Southbound

FBG002
 Site Code: 999-13282
 Date Start: 22-Aug-13
 Date End: 22-Aug-13

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
08/22/13	1	15	8	1	1	0	0	0	1	0	0	0	0	27
01:00	0	10	7	0	0	2	0	0	0	0	0	0	0	19
02:00	0	8	5	0	2	0	0	1	3	0	0	0	0	19
03:00	0	17	7	1	2	3	0	0	5	0	0	0	0	35
04:00	2	19	17	0	6	3	0	1	5	1	0	0	0	54
05:00	1	55	47	0	24	5	0	1	8	1	0	0	0	142
06:00	1	119	69	3	26	2	0	3	2	0	0	0	0	225
07:00	1	259	139	2	61	1	0	5	4	0	0	0	0	472
08:00	10	414	249	6	84	7	0	6	5	0	0	0	0	781
09:00	8	416	235	2	117	4	0	7	8	1	0	0	0	798
10:00	5	478	236	9	101	3	0	8	7	1	0	0	0	848
11:00	7	542	246	4	119	3	0	11	4	0	0	0	0	936
12 PM	6	642	248	3	124	1	0	7	5	1	0	0	0	1037
13:00	6	580	263	2	124	2	0	6	3	0	0	0	0	986
14:00	11	552	294	6	133	1	0	9	3	0	1	0	0	1010
15:00	10	630	303	6	149	0	0	5	2	0	0	0	0	1105
16:00	6	596	367	2	155	2	0	5	0	0	1	0	0	1134
17:00	2	623	335	3	127	4	0	8	9	0	0	0	0	1111
18:00	7	461	257	2	88	0	0	9	1	0	0	0	0	825
19:00	6	362	182	0	84	0	0	5	0	0	0	0	0	639
20:00	0	291	126	0	59	0	0	4	0	0	0	0	0	480
21:00	1	198	84	0	34	0	0	1	0	0	0	0	0	318
22:00	0	93	34	0	13	0	0	2	0	0	0	0	0	142
23:00	1	42	22	0	12	0	0	0	0	0	0	0	0	77
Total	92	7422	3780	52	1645	43	0	104	75	5	2	0	0	13220
Percent	0.7%	56.1%	28.6%	0.4%	12.4%	0.3%	0.0%	0.8%	0.6%	0.0%	0.0%	0.0%	0.0%	
AM Peak	08:00	11:00	08:00	10:00	11:00	08:00		11:00	05:00	04:00				11:00
Vol.	10	542	249	9	119	7		11	8	1				936
PM Peak	14:00	12:00	16:00	14:00	16:00	17:00		14:00	17:00	12:00	14:00			16:00
Vol.	11	642	367	6	155	4		9	9	1	1			1134
Grand Total	92	7422	3780	52	1645	43	0	104	75	5	2	0	0	13220
Percent	0.7%	56.1%	28.6%	0.4%	12.4%	0.3%	0.0%	0.8%	0.6%	0.0%	0.0%	0.0%	0.0%	

City of Fort Bragg
 State Route 1
 B/ Noyo Bridge - Driveways
 24 Hour Directional Classification Count
 Northbound, Southbound

FBG002
 Site Code: 999-13282
 Date Start: 22-Aug-13
 Date End: 22-Aug-13

Start Time	Bikes	Cars & Trailers	2 Axle Long	Buses	2 Axle 6 Tire	3 Axle Single	4 Axle Single	<5 Axl Double	5 Axle Double	>6 Axl Double	<6 Axl Multi	6 Axle Multi	>6 Axl Multi	Total
08/22/13	1	38	18	1	5	0	0	0	1	0	0	0	0	64
01:00	0	22	14	0	3	3	0	0	0	0	0	0	0	42
02:00	0	16	7	1	4	1	0	1	4	0	0	0	0	34
03:00	2	31	18	1	2	6	0	0	5	0	0	0	0	65
04:00	2	41	28	0	11	5	0	1	7	1	0	0	0	96
05:00	2	111	88	3	37	7	0	1	9	1	0	0	0	259
06:00	3	256	142	4	57	3	0	6	5	0	0	0	0	476
07:00	4	614	299	7	114	6	0	12	8	0	0	0	0	1064
08:00	10	935	468	7	153	13	0	10	14	0	0	0	0	1610
09:00	11	896	439	5	190	6	0	12	14	2	0	0	0	1575
10:00	9	993	470	10	175	11	0	15	13	1	0	0	0	1697
11:00	13	1127	448	7	209	9	0	18	7	0	0	0	0	1838
12 PM	12	1313	515	7	218	2	0	17	8	2	0	0	0	2094
13:00	9	1266	518	5	208	4	0	12	5	1	0	0	0	2028
14:00	15	1217	577	7	215	8	0	17	6	0	2	0	0	2064
15:00	17	1259	544	8	244	6	0	21	4	1	0	0	0	2104
16:00	9	1234	676	6	233	9	0	13	5	0	1	0	0	2186
17:00	7	1200	607	3	206	10	0	20	14	0	0	0	0	2067
18:00	14	969	446	6	147	2	0	16	2	0	0	0	0	1602
19:00	7	687	319	0	115	0	0	9	3	0	0	0	0	1140
20:00	3	568	230	0	88	0	0	8	1	0	0	0	1	899
21:00	6	399	159	1	53	3	0	5	1	0	0	0	0	627
22:00	0	224	80	0	19	0	0	2	0	0	0	0	0	325
23:00	1	110	43	1	13	0	0	1	1	0	0	0	0	170
Total	157	15526	7153	90	2719	114	0	217	137	9	3	0	1	26126
Percent	0.6%	59.4%	27.4%	0.3%	10.4%	0.4%	0.0%	0.8%	0.5%	0.0%	0.0%	0.0%	0.0%	
AM Peak	11:00	11:00	10:00	10:00	11:00	08:00		11:00	08:00	09:00				11:00
Vol.	13	1127	470	10	209	13		18	14	2				1838
PM Peak	15:00	12:00	16:00	15:00	15:00	17:00		15:00	17:00	12:00	14:00		20:00	16:00
Vol.	17	1313	676	8	244	10		21	14	2	2		1	2186
Grand Total	157	15526	7153	90	2719	114	0	217	137	9	3	0	1	26126
Percent	0.6%	59.4%	27.4%	0.3%	10.4%	0.4%	0.0%	0.8%	0.5%	0.0%	0.0%	0.0%	0.0%	

City of Fort Bragg
 N/S: State Route 1
 E/W: State Route 20
 Weather: Sunny

File Name : FBG_SR-1_SR-20 AM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

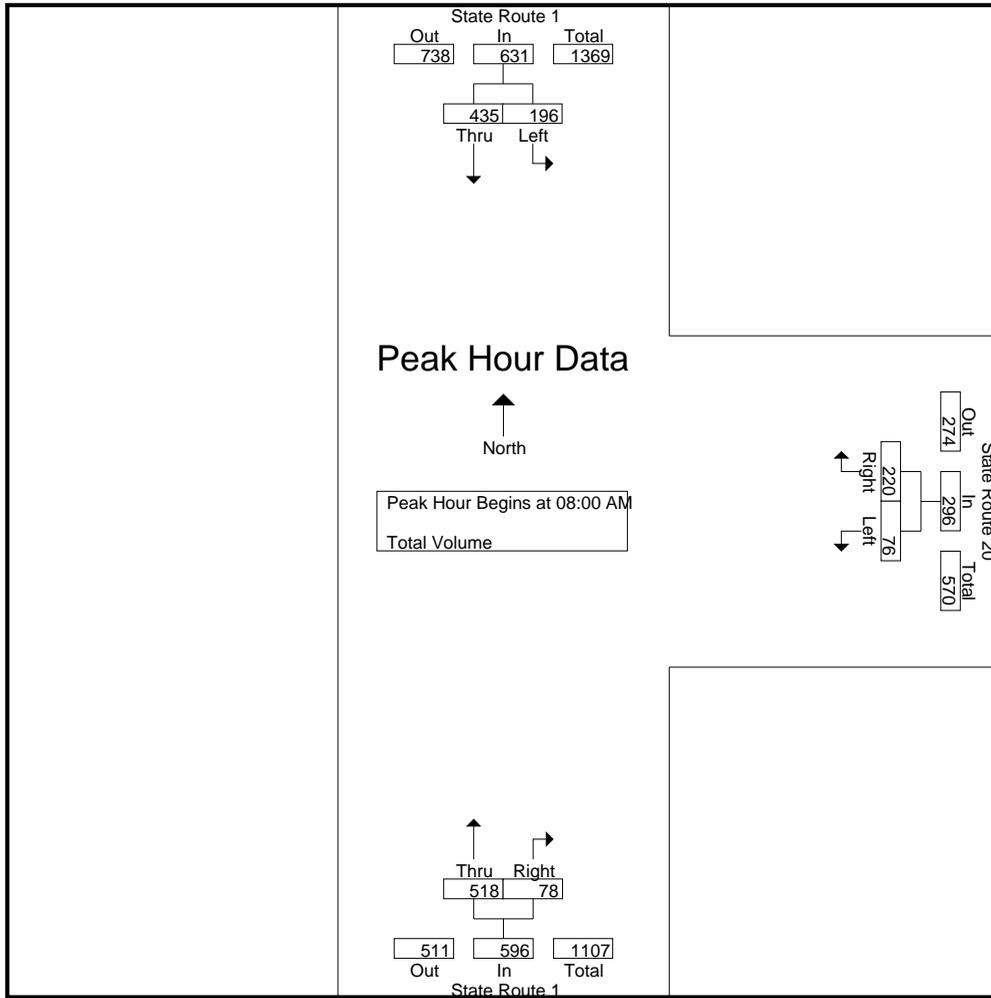
Groups Printed- Total Volume

Start Time	State Route 1 Southbound			State Route 20 Westbound			State Route 1 Northbound			Int. Total
	Left	Thru	App. Total	Left	Right	App. Total	Thru	Right	App. Total	
07:00 AM	29	47	76	8	21	29	56	11	67	172
07:15 AM	30	55	85	8	37	45	83	13	96	226
07:30 AM	21	80	101	14	62	76	111	16	127	304
07:45 AM	34	89	123	14	54	68	139	19	158	349
Total	114	271	385	44	174	218	389	59	448	1051
08:00 AM	52	96	148	15	65	80	134	17	151	379
08:15 AM	42	110	152	17	63	80	130	23	153	385
08:30 AM	58	110	168	18	49	67	123	15	138	373
08:45 AM	44	119	163	26	43	69	131	23	154	386
Total	196	435	631	76	220	296	518	78	596	1523
Grand Total	310	706	1016	120	394	514	907	137	1044	2574
Apprch %	30.5	69.5		23.3	76.7		86.9	13.1		
Total %	12	27.4	39.5	4.7	15.3	20	35.2	5.3	40.6	

Start Time	State Route 1 Southbound			State Route 20 Westbound			State Route 1 Northbound			Int. Total
	Left	Thru	App. Total	Left	Right	App. Total	Thru	Right	App. Total	
08:00 AM	52	96	148	15	65	80	134	17	151	379
08:15 AM	42	110	152	17	63	80	130	23	153	385
08:30 AM	58	110	168	18	49	67	123	15	138	373
08:45 AM	44	119	163	26	43	69	131	23	154	386
Total Volume	196	435	631	76	220	296	518	78	596	1523
% App. Total	31.1	68.9		25.7	74.3		86.9	13.1		
PHF	.845	.914	.939	.731	.846	.925	.966	.848	.968	.986

Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 08:00 AM



Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	08:00 AM			07:30 AM			07:45 AM		
+0 mins.	52	96	148	14	62	76	139	19	158
+15 mins.	42	110	152	14	54	68	134	17	151
+30 mins.	58	110	168	15	65	80	130	23	153
+45 mins.	44	119	163	17	63	80	123	15	138
Total Volume	196	435	631	60	244	304	526	74	600
% App. Total	31.1	68.9		19.7	80.3		87.7	12.3	
PHF	.845	.914	.939	.882	.938	.950	.946	.804	.949

City of Fort Bragg
 N/S: State Route 1
 E/W: State Route 20
 Weather: Sunny

File Name : FBG_SR-1_SR-20 PM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

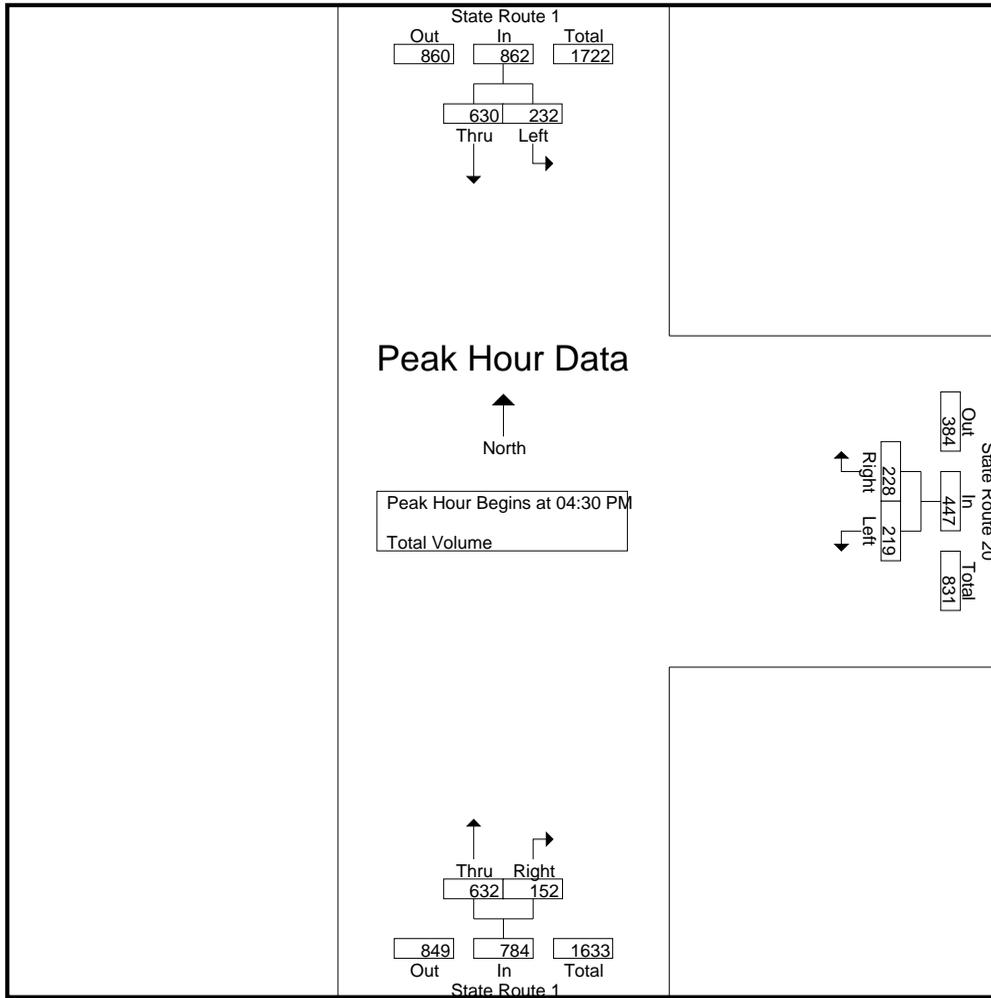
Groups Printed- Total Volume

Start Time	State Route 1 Southbound			State Route 20 Westbound			State Route 1 Northbound			Int. Total
	Left	Thru	App. Total	Left	Right	App. Total	Thru	Right	App. Total	
04:00 PM	75	156	231	54	65	119	138	38	176	526
04:15 PM	37	177	214	43	72	115	144	42	186	515
04:30 PM	64	153	217	71	39	110	160	35	195	522
04:45 PM	48	144	192	51	62	113	162	37	199	504
Total	224	630	854	219	238	457	604	152	756	2067
05:00 PM	56	148	204	44	69	113	154	35	189	506
05:15 PM	64	185	249	53	58	111	156	45	201	561
05:30 PM	45	128	173	45	61	106	113	32	145	424
05:45 PM	52	131	183	41	44	85	109	31	140	408
Total	217	592	809	183	232	415	532	143	675	1899
Grand Total	441	1222	1663	402	470	872	1136	295	1431	3966
Apprch %	26.5	73.5		46.1	53.9		79.4	20.6		
Total %	11.1	30.8	41.9	10.1	11.9	22	28.6	7.4	36.1	

Start Time	State Route 1 Southbound			State Route 20 Westbound			State Route 1 Northbound			Int. Total
	Left	Thru	App. Total	Left	Right	App. Total	Thru	Right	App. Total	
04:30 PM	64	153	217	71	39	110	160	35	195	522
04:45 PM	48	144	192	51	62	113	162	37	199	504
05:00 PM	56	148	204	44	69	113	154	35	189	506
05:15 PM	64	185	249	53	58	111	156	45	201	561
Total Volume	232	630	862	219	228	447	632	152	784	2093
% App. Total	26.9	73.1		49	51		80.6	19.4		
PHF	.906	.851	.865	.771	.826	.989	.975	.844	.975	.933

Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 04:30 PM



Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	04:30 PM			04:00 PM			04:30 PM		
+0 mins.	64	153	217	54	65	119	160	35	195
+15 mins.	48	144	192	43	72	115	162	37	199
+30 mins.	56	148	204	71	39	110	154	35	189
+45 mins.	64	185	249	51	62	113	156	45	201
Total Volume	232	630	862	219	238	457	632	152	784
% App. Total	26.9	73.1		47.9	52.1		80.6	19.4	
PHF	.906	.851	.865	.771	.826	.960	.975	.844	.975

City of Fort Bragg
 N/S: State Route 1
 E/W: State Route 20
 Weather: Sunny

File Name : FBG_SR-1_SR-20 MD
 Site Code : 99913282
 Start Date : 8/24/2013
 Page No : 1

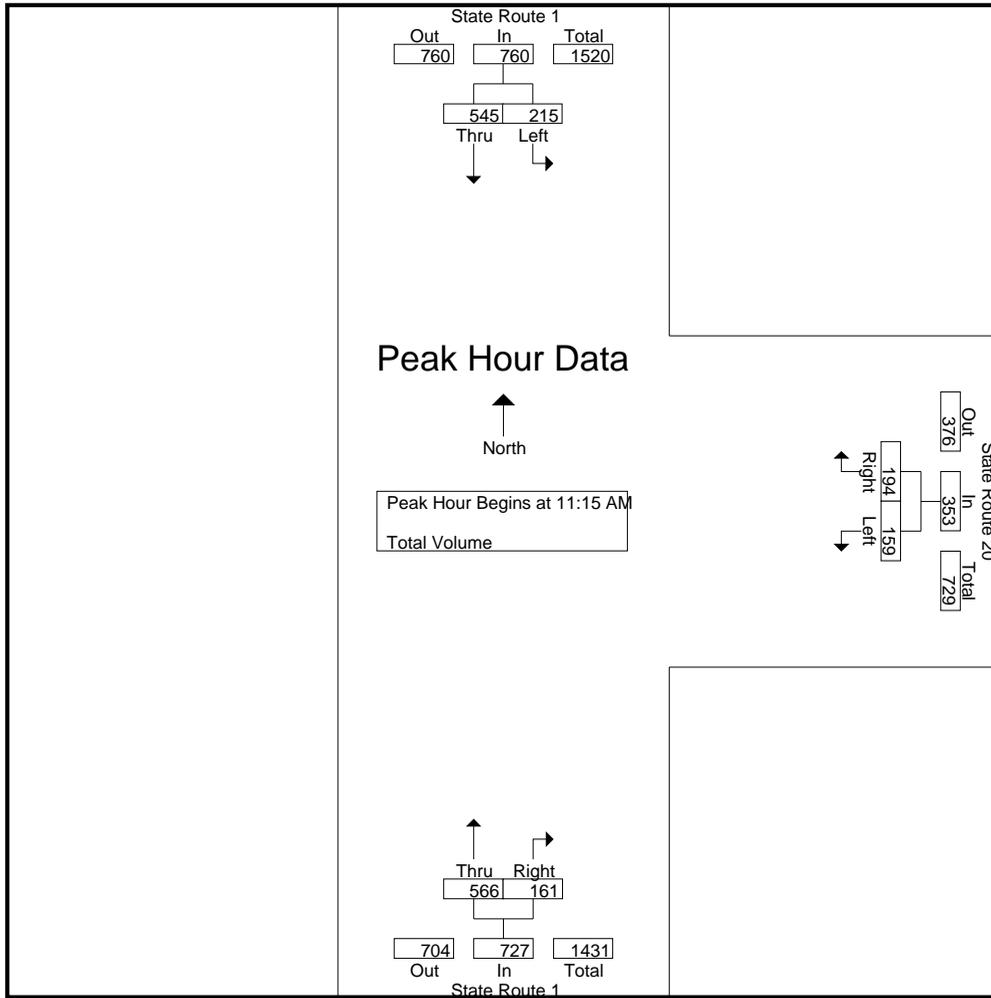
Groups Printed- Total Volume

Start Time	State Route 1 Southbound			State Route 20 Westbound			State Route 1 Northbound			Int. Total
	Left	Thru	App. Total	Left	Right	App. Total	Thru	Right	App. Total	
11:00 AM	52	142	194	49	49	98	99	23	122	414
11:15 AM	54	120	174	31	41	72	157	37	194	440
11:30 AM	52	139	191	43	55	98	120	34	154	443
11:45 AM	50	143	193	50	53	103	138	44	182	478
Total	208	544	752	173	198	371	514	138	652	1775
12:00 PM	59	143	202	35	45	80	151	46	197	479
12:15 PM	56	123	179	45	55	100	133	24	157	436
12:30 PM	49	110	159	44	49	93	135	35	170	422
12:45 PM	54	141	195	44	71	115	133	43	176	486
Total	218	517	735	168	220	388	552	148	700	1823
Grand Total	426	1061	1487	341	418	759	1066	286	1352	3598
Apprch %	28.6	71.4		44.9	55.1		78.8	21.2		
Total %	11.8	29.5	41.3	9.5	11.6	21.1	29.6	7.9	37.6	

Start Time	State Route 1 Southbound			State Route 20 Westbound			State Route 1 Northbound			Int. Total
	Left	Thru	App. Total	Left	Right	App. Total	Thru	Right	App. Total	
11:15 AM	54	120	174	31	41	72	157	37	194	440
11:30 AM	52	139	191	43	55	98	120	34	154	443
11:45 AM	50	143	193	50	53	103	138	44	182	478
12:00 PM	59	143	202	35	45	80	151	46	197	479
Total Volume	215	545	760	159	194	353	566	161	727	1840
% App. Total	28.3	71.7		45	55		77.9	22.1		
PHF	.911	.953	.941	.795	.882	.857	.901	.875	.923	.960

Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 11:15 AM



Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	11:30 AM			12:00 PM			11:15 AM		
+0 mins.	52	139	191	35	45	80	157	37	194
+15 mins.	50	143	193	45	55	100	120	34	154
+30 mins.	59	143	202	44	49	93	138	44	182
+45 mins.	56	123	179	44	71	115	151	46	197
Total Volume	217	548	765	168	220	388	566	161	727
% App. Total	28.4	71.6		43.3	56.7		77.9	22.1	
PHF	.919	.958	.947	.933	.775	.843	.901	.875	.923

Location: Fort Bragg
 N/S: State Route 1
 E/W: State Route 20



Date: 8/22/2013
 File : FBGSR1SR20

WEEKDAY

	North Leg State Route 20	East Leg State Route 1	South Leg State Route 20	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
7:00 AM	0	0	0	0	0
7:15 AM	0	1	0	0	1
7:30 AM	0	0	0	0	0
7:45 AM	0	1	0	0	1
8:00 AM	0	0	0	0	0
8:15 AM	2	0	0	0	2
8:30 AM	0	0	0	0	0
8:45 AM	1	1	0	0	2
TOTAL VOLUMES:	3	3	0	0	6

	North Leg State Route 20	East Leg State Route 1	South Leg State Route 20	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
4:00 PM	0	0	0	0	0
4:15 PM	0	0	0	0	0
4:30 PM	1	1	0	1	3
4:45 PM	0	2	0	0	2
5:00 PM	0	0	0	0	0
5:15 PM	1	1	0	1	3
5:30 PM	0	0	0	0	0
5:45 PM	0	0	0	0	0
TOTAL VOLUMES:	2	4	0	2	8

SATURDAY

Date: 8/24/2013

	North Leg State Route 20	East Leg State Route 1	South Leg State Route 20	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
11:00 AM	2	1	0	3	6
11:15 AM	0	0	1	0	1
11:30 AM	0	0	0	0	0
11:45 AM	1	0	0	1	2
12:00 PM	0	1	0	0	1
12:15 PM	0	3	0	0	3
12:30 PM	2	0	0	2	4
12:45 PM	0	0	0	0	0
TOTAL VOLUMES:	5	5	1	6	17

Location: Fort Bragg
 N/S: State Route 1
 E/W: State Route 20



Date: 8/22/2013
 File : FBGSR1SR20

	North Leg State Route 20	East Leg State Route 1	South Leg State Route 20	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
7:00 AM	0	1	0	0	1
7:15 AM	0	0	0	0	0
7:30 AM	0	0	0	0	0
7:45 AM	0	3	0	0	3
8:00 AM	0	2	0	0	2
8:15 AM	0	2	0	6	8
8:30 AM	0	0	0	3	3
8:45 AM	1	0	0	0	1
TOTAL VOLUMES:	1	8	0	9	18

	North Leg State Route 20	East Leg State Route 1	South Leg State Route 20	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
4:00 PM	0	1	0	1	2
4:15 PM	2	3	0	3	8
4:30 PM	0	4	0	0	4
4:45 PM	2	0	0	2	4
5:00 PM	0	1	0	1	2
5:15 PM	0	1	0	0	1
5:30 PM	0	0	0	0	0
5:45 PM	0	2	0	3	5
TOTAL VOLUMES:	4	12	0	10	26

SATURDAY

Date: 8/24/2013

	North Leg State Route 20	East Leg State Route 1	South Leg State Route 20	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
11:00 AM	0	0	0	1	1
11:15 AM	0	1	0	0	1
11:30 AM	0	1	0	0	1
11:45 AM	0	0	0	0	0
12:00 PM	0	0	0	0	0
12:15 PM	0	0	0	3	3
12:30 PM	0	0	0	2	2
12:45 PM	0	0	0	0	0
TOTAL VOLUMES:	0	2	0	6	8

City of Fort Bragg
 N/S: State Route 1
 E/W: Simpson Lane
 Weather: Sunny

File Name : FBG_SR-1_Simpson AM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

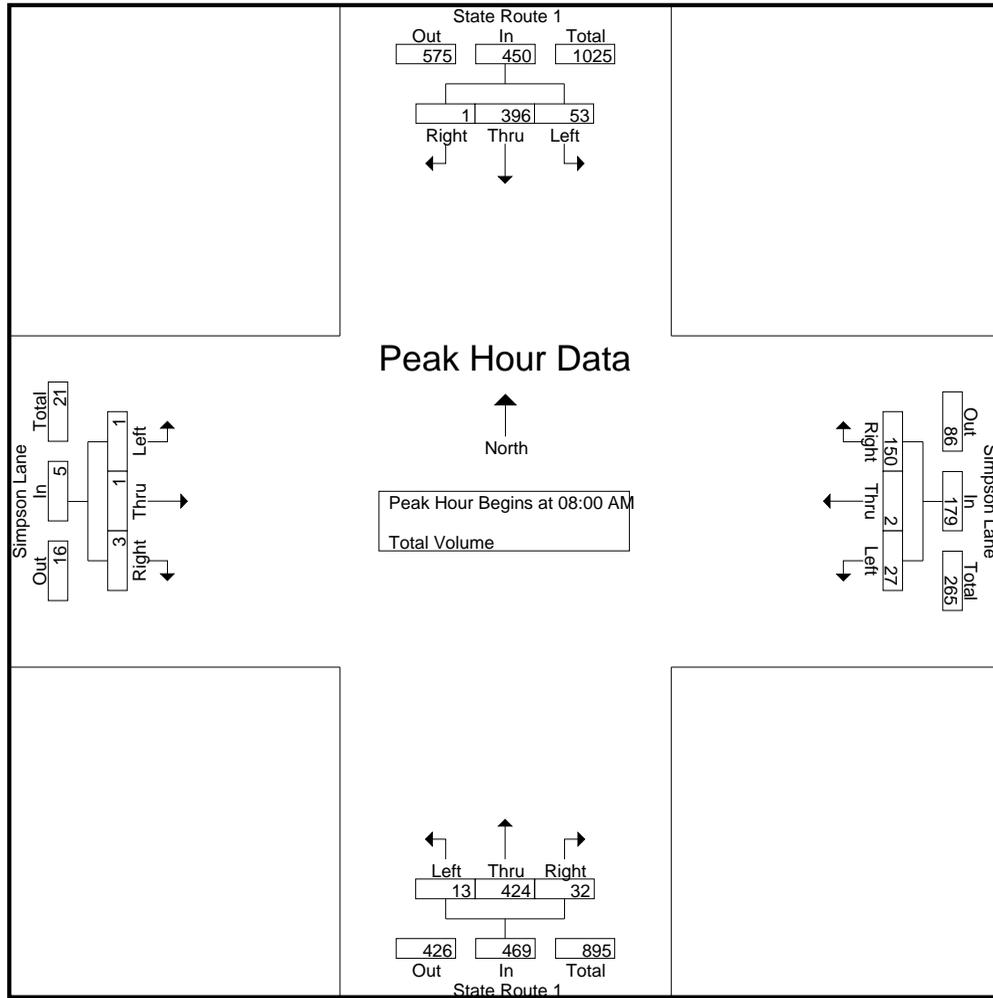
Groups Printed- Total Volume

Start Time	State Route 1 Southbound				Simpson Lane Westbound				State Route 1 Northbound				Simpson Lane Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
07:00 AM	7	40	0	47	5	0	18	23	1	47	3	51	0	0	0	0	121
07:15 AM	8	57	0	65	3	1	26	30	3	48	0	51	0	0	1	1	147
07:30 AM	7	68	0	75	6	2	49	57	1	72	6	79	0	0	1	1	212
07:45 AM	18	71	2	91	11	1	57	69	4	103	1	108	0	0	0	0	268
Total	40	236	2	278	25	4	150	179	9	270	10	289	0	0	2	2	748
08:00 AM	12	88	0	100	7	0	46	53	1	93	6	100	0	0	0	0	253
08:15 AM	8	101	1	110	9	0	31	40	4	119	9	132	0	0	2	2	284
08:30 AM	14	98	0	112	4	2	27	33	3	106	6	115	1	1	0	2	262
08:45 AM	19	109	0	128	7	0	46	53	5	106	11	122	0	0	1	1	304
Total	53	396	1	450	27	2	150	179	13	424	32	469	1	1	3	5	1103
Grand Total	93	632	3	728	52	6	300	358	22	694	42	758	1	1	5	7	1851
Apprch %	12.8	86.8	0.4		14.5	1.7	83.8		2.9	91.6	5.5		14.3	14.3	71.4		
Total %	5	34.1	0.2	39.3	2.8	0.3	16.2	19.3	1.2	37.5	2.3	41	0.1	0.1	0.3	0.4	

Start Time	State Route 1 Southbound				Simpson Lane Westbound				State Route 1 Northbound				Simpson Lane Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
08:00 AM	12	88	0	100	7	0	46	53	1	93	6	100	0	0	0	0	253
08:15 AM	8	101	1	110	9	0	31	40	4	119	9	132	0	0	2	2	284
08:30 AM	14	98	0	112	4	2	27	33	3	106	6	115	1	1	0	2	262
08:45 AM	19	109	0	128	7	0	46	53	5	106	11	122	0	0	1	1	304
Total Volume	53	396	1	450	27	2	150	179	13	424	32	469	1	1	3	5	1103
% App. Total	11.8	88	0.2		15.1	1.1	83.8		2.8	90.4	6.8		20	20	60		
PHF	.697	.908	.250	.879	.750	.250	.815	.844	.650	.891	.727	.888	.250	.250	.375	.625	.907

Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 08:00 AM



Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	08:00 AM				07:30 AM				08:00 AM				08:00 AM			
+0 mins.	12	88	0	100	6	2	49	57	1	93	6	100	0	0	0	0
+15 mins.	8	101	1	110	11	1	57	69	4	119	9	132	0	0	2	2
+30 mins.	14	98	0	112	7	0	46	53	3	106	6	115	1	1	0	2
+45 mins.	19	109	0	128	9	0	31	40	5	106	11	122	0	0	1	1
Total Volume	53	396	1	450	33	3	183	219	13	424	32	469	1	1	3	5
% App. Total	11.8	88	0.2		15.1	1.4	83.6		2.8	90.4	6.8		20	20	60	
PHF	.697	.908	.250	.879	.750	.375	.803	.793	.650	.891	.727	.888	.250	.250	.375	.625

City of Fort Bragg
 N/S: State Route 1
 E/W: Simpson Lane
 Weather: Sunny

File Name : FBG_SR-1_Simpson PM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

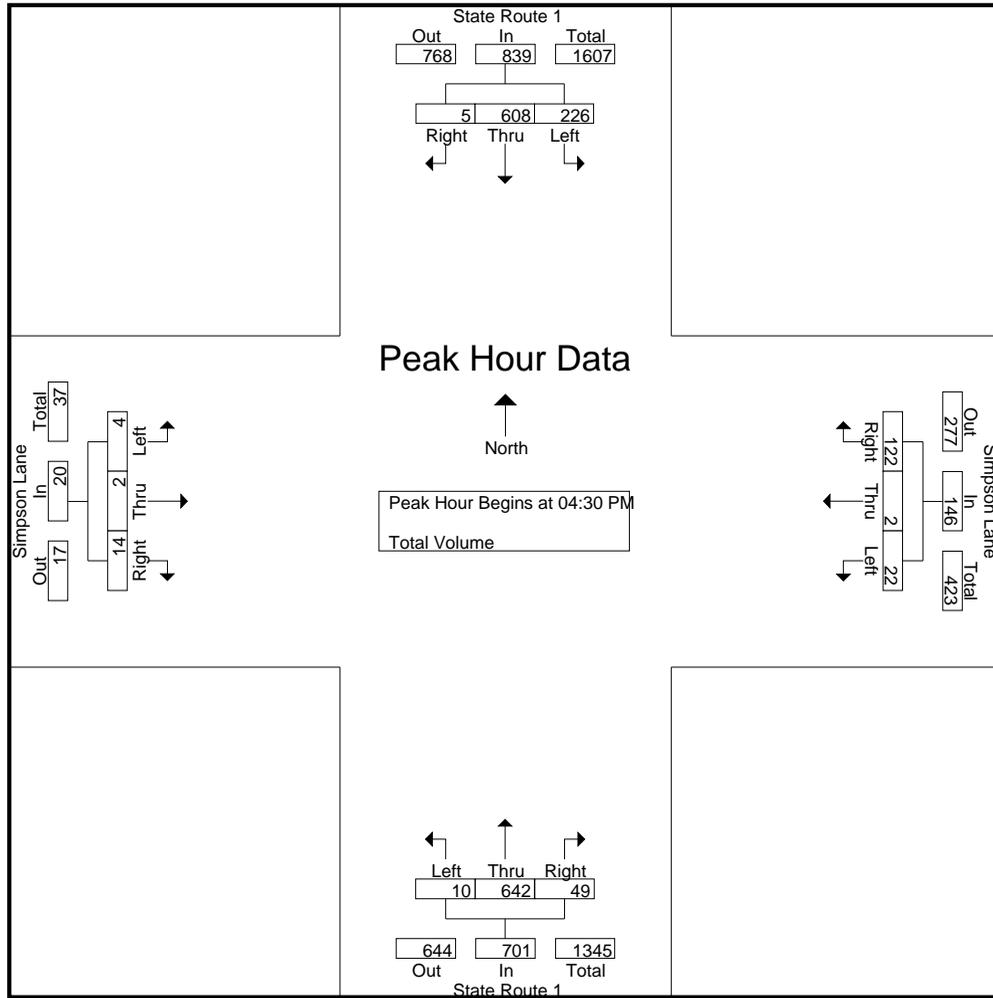
Groups Printed- Total Volume

Start Time	State Route 1 Southbound				Simpson Lane Westbound				State Route 1 Northbound				Simpson Lane Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
04:00 PM	36	125	2	163	6	1	30	37	4	138	20	162	1	0	2	3	365
04:15 PM	44	180	0	224	2	0	24	26	3	155	14	172	1	2	10	13	435
04:30 PM	57	146	4	207	8	0	29	37	0	168	24	192	1	0	5	6	442
04:45 PM	50	146	0	196	6	2	31	39	5	160	5	170	0	0	2	2	407
Total	187	597	6	790	22	3	114	139	12	621	63	696	3	2	19	24	1649
05:00 PM	54	139	1	194	5	0	27	32	3	151	8	162	3	2	4	9	397
05:15 PM	65	177	0	242	3	0	35	38	2	163	12	177	0	0	3	3	460
05:30 PM	53	143	0	196	11	2	22	35	1	128	15	144	1	0	2	3	378
05:45 PM	45	131	0	176	5	0	31	36	2	110	9	121	0	1	3	4	337
Total	217	590	1	808	24	2	115	141	8	552	44	604	4	3	12	19	1572
Grand Total	404	1187	7	1598	46	5	229	280	20	1173	107	1300	7	5	31	43	3221
Apprch %	25.3	74.3	0.4		16.4	1.8	81.8		1.5	90.2	8.2		16.3	11.6	72.1		
Total %	12.5	36.9	0.2	49.6	1.4	0.2	7.1	8.7	0.6	36.4	3.3	40.4	0.2	0.2	1	1.3	

Start Time	State Route 1 Southbound				Simpson Lane Westbound				State Route 1 Northbound				Simpson Lane Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
04:30 PM	57	146	4	207	8	0	29	37	0	168	24	192	1	0	5	6	442
04:45 PM	50	146	0	196	6	2	31	39	5	160	5	170	0	0	2	2	407
05:00 PM	54	139	1	194	5	0	27	32	3	151	8	162	3	2	4	9	397
05:15 PM	65	177	0	242	3	0	35	38	2	163	12	177	0	0	3	3	460
Total Volume	226	608	5	839	22	2	122	146	10	642	49	701	4	2	14	20	1706
% App. Total	26.9	72.5	0.6		15.1	1.4	83.6		1.4	91.6	7		20	10	70		
PHF	.869	.859	.313	.867	.688	.250	.871	.936	.500	.955	.510	.913	.333	.250	.700	.556	.927

Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 04:30 PM



Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1
 Peak Hour for Each Approach Begins at:

	04:30 PM				04:30 PM				04:30 PM				04:15 PM			
+0 mins.	57	146	4	207	8	0	29	37	0	168	24	192	1	2	10	13
+15 mins.	50	146	0	196	6	2	31	39	5	160	5	170	1	0	5	6
+30 mins.	54	139	1	194	5	0	27	32	3	151	8	162	0	0	2	2
+45 mins.	65	177	0	242	3	0	35	38	2	163	12	177	3	2	4	9
Total Volume	226	608	5	839	22	2	122	146	10	642	49	701	5	4	21	30
% App. Total	26.9	72.5	0.6		15.1	1.4	83.6		1.4	91.6	7		16.7	13.3	70	
PHF	.869	.859	.313	.867	.688	.250	.871	.936	.500	.955	.510	.913	.417	.500	.525	.577

City of Fort Bragg
 N/S: State Route 1
 E/W: Simpson Lane
 Weather: Sunny

File Name : FBG_SR-1_Simpson MD
 Site Code : 99913282
 Start Date : 8/24/2013
 Page No : 1

Groups Printed- Total Volume

Start Time	State Route 1 Southbound				Simpson Lane Westbound				State Route 1 Northbound				Simpson Lane Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
11:00 AM	46	128	3	177	7	6	44	57	2	88	17	107	3	1	6	10	351
11:15 AM	34	127	1	162	11	3	50	64	8	146	14	168	2	3	4	9	403
11:30 AM	39	134	1	174	9	1	38	48	5	128	13	146	1	1	1	3	371
11:45 AM	46	120	0	166	12	2	53	67	4	127	7	138	2	0	3	5	376
Total	165	509	5	679	39	12	185	236	19	489	51	559	8	5	14	27	1501
12:00 PM	59	142	0	201	7	2	41	50	3	156	10	169	0	1	1	2	422
12:15 PM	50	120	0	170	12	1	43	56	4	123	14	141	3	1	1	5	372
12:30 PM	34	105	0	139	15	0	36	51	4	146	9	159	1	1	1	3	352
12:45 PM	57	112	1	170	10	0	35	45	5	137	5	147	1	2	4	7	369
Total	200	479	1	680	44	3	155	202	16	562	38	616	5	5	7	17	1515
Grand Total	365	988	6	1359	83	15	340	438	35	1051	89	1175	13	10	21	44	3016
Apprch %	26.9	72.7	0.4		18.9	3.4	77.6		3	89.4	7.6		29.5	22.7	47.7		
Total %	12.1	32.8	0.2	45.1	2.8	0.5	11.3	14.5	1.2	34.8	3	39	0.4	0.3	0.7	1.5	

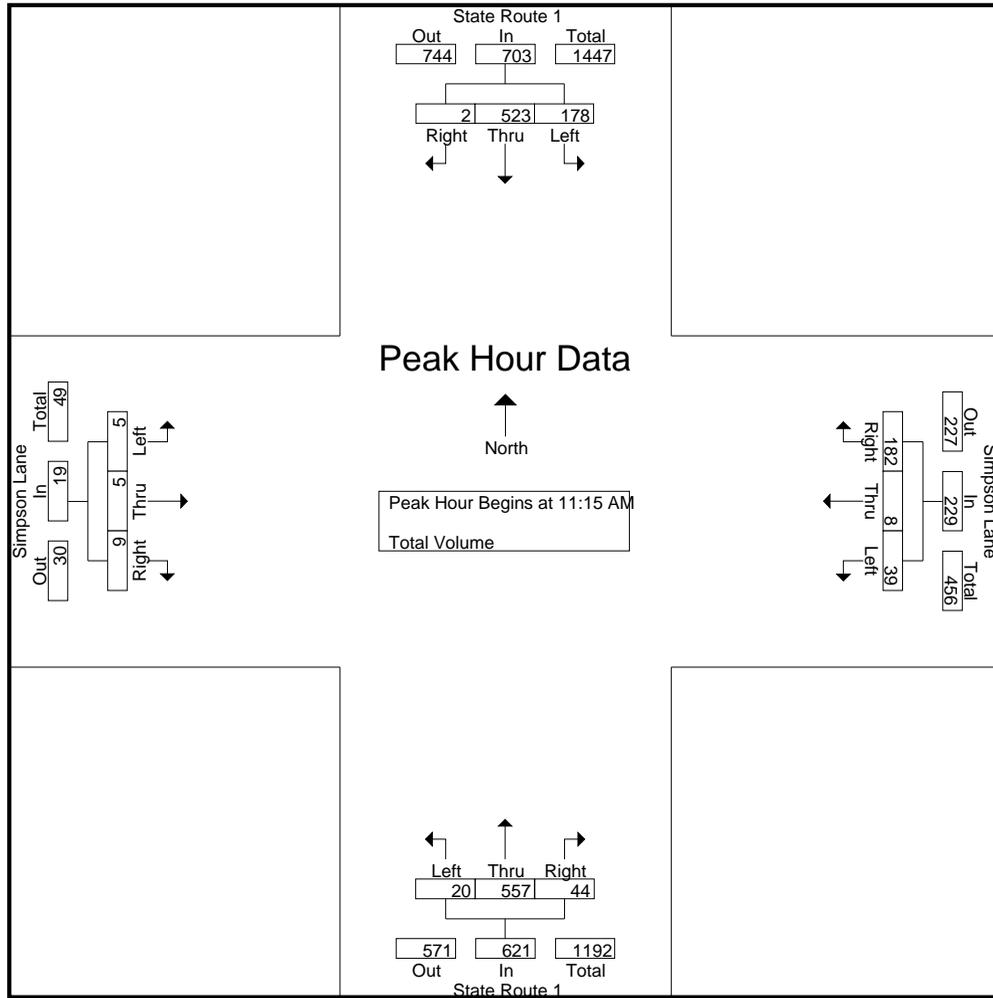
Start Time	State Route 1 Southbound				Simpson Lane Westbound				State Route 1 Northbound				Simpson Lane Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
11:15 AM	34	127	1	162	11	3	50	64	8	146	14	168	2	3	4	9	403
11:30 AM	39	134	1	174	9	1	38	48	5	128	13	146	1	1	1	3	371
11:45 AM	46	120	0	166	12	2	53	67	4	127	7	138	2	0	3	5	376
12:00 PM	59	142	0	201	7	2	41	50	3	156	10	169	0	1	1	2	422
Total Volume	178	523	2	703	39	8	182	229	20	557	44	621	5	5	9	19	1572
% App. Total	25.3	74.4	0.3		17	3.5	79.5		3.2	89.7	7.1		26.3	26.3	47.4		
PHF	.754	.921	.500	.874	.813	.667	.858	.854	.625	.893	.786	.919	.625	.417	.563	.528	.931

Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 11:15 AM

City of Fort Bragg
 N/S: State Route 1
 E/W: Simpson Lane
 Weather: Sunny

File Name : FBG_SR-1_Simpson MD
 Site Code : 99913282
 Start Date : 8/24/2013
 Page No : 2



Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1
 Peak Hour for Each Approach Begins at:

	11:30 AM				11:00 AM				11:15 AM				11:00 AM			
+0 mins.	39	134	1	174	7	6	44	57	8	146	14	168	3	1	6	10
+15 mins.	46	120	0	166	11	3	50	64	5	128	13	146	2	3	4	9
+30 mins.	59	142	0	201	9	1	38	48	4	127	7	138	1	1	1	3
+45 mins.	50	120	0	170	12	2	53	67	3	156	10	169	2	0	3	5
Total Volume	194	516	1	711	39	12	185	236	20	557	44	621	8	5	14	27
% App. Total	27.3	72.6	0.1		16.5	5.1	78.4		3.2	89.7	7.1		29.6	18.5	51.9	
PHF	.822	.908	.250	.884	.813	.500	.873	.881	.625	.893	.786	.919	.667	.417	.583	.675

Location: Fort Bragg
 N/S: State Route 1
 E/W: Simpson Lane



Date: 8/22/2013
 File : FBGSR1SI

WEEKDAY

	North Leg Simpson Lane	East Leg State Route 1	South Leg Simpson Lane	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
7:00 AM	0	0	0	0	0
7:15 AM	0	0	0	0	0
7:30 AM	0	0	0	0	0
7:45 AM	0	1	0	0	1
8:00 AM	0	0	0	0	0
8:15 AM	0	0	0	0	0
8:30 AM	0	0	0	0	0
8:45 AM	0	0	2	0	2
TOTAL VOLUMES:	0	1	2	0	3

	North Leg Simpson Lane	East Leg State Route 1	South Leg Simpson Lane	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
4:00 PM	0	0	0	0	0
4:15 PM	0	0	0	0	0
4:30 PM	0	0	0	0	0
4:45 PM	0	0	0	0	0
5:00 PM	0	0	0	0	0
5:15 PM	0	0	0	0	0
5:30 PM	0	0	0	0	0
5:45 PM	0	0	0	0	0
TOTAL VOLUMES:	0	0	0	0	0

SATURDAY

Date: 8/24/2013

	North Leg Simpson Lane	East Leg State Route 1	South Leg Simpson Lane	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
11:00 AM	0	0	0	0	0
11:15 AM	4	0	1	0	5
11:30 AM	0	0	0	0	0
11:45 AM	1	0	0	0	1
12:00 PM	1	2	0	0	3
12:15 PM	0	0	0	0	0
12:30 PM	0	0	0	0	0
12:45 PM	0	0	0	0	0
TOTAL VOLUMES:	6	2	1	0	9

Location: Fort Bragg
 N/S: State Route 1
 E/W: Simpson Lane



Date: 8/22/2013
 File : FBGSR1SI

	North Leg Simpson Lane	East Leg State Route 1	South Leg Simpson Lane	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
7:00 AM	0	0	0	0	0
7:15 AM	0	0	0	0	0
7:30 AM	0	0	0	0	0
7:45 AM	0	1	0	0	1
8:00 AM	0	0	0	0	0
8:15 AM	0	2	0	4	6
8:30 AM	0	0	0	1	1
8:45 AM	0	0	0	0	0
TOTAL VOLUMES:	0	3	0	5	8

	North Leg Simpson Lane	East Leg State Route 1	South Leg Simpson Lane	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
4:00 PM	1	0	0	0	1
4:15 PM	0	0	0	0	0
4:30 PM	0	0	0	0	0
4:45 PM	0	0	0	1	1
5:00 PM	0	0	0	0	0
5:15 PM	0	0	0	0	0
5:30 PM	0	0	0	0	0
5:45 PM	0	0	0	0	0
TOTAL VOLUMES:	1	0	0	1	2

SATURDAY

Date: 8/24/2013

	North Leg Simpson Lane	East Leg State Route 1	South Leg Simpson Lane	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
11:00 AM	0	0	0	1	1
11:15 AM	0	0	0	1	1
11:30 AM	0	0	0	0	0
11:45 AM	0	0	0	0	0
12:00 PM	0	0	0	0	0
12:15 PM	0	1	0	2	3
12:30 PM	0	0	0	2	2
12:45 PM	0	0	0	0	0
TOTAL VOLUMES:	0	1	0	6	7

City of Fort Bragg
 N/S: State Route 1
 E/W: Ocean View Drive
 Weather: Sunny

File Name : FBG_SR-1_Ocean View AM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

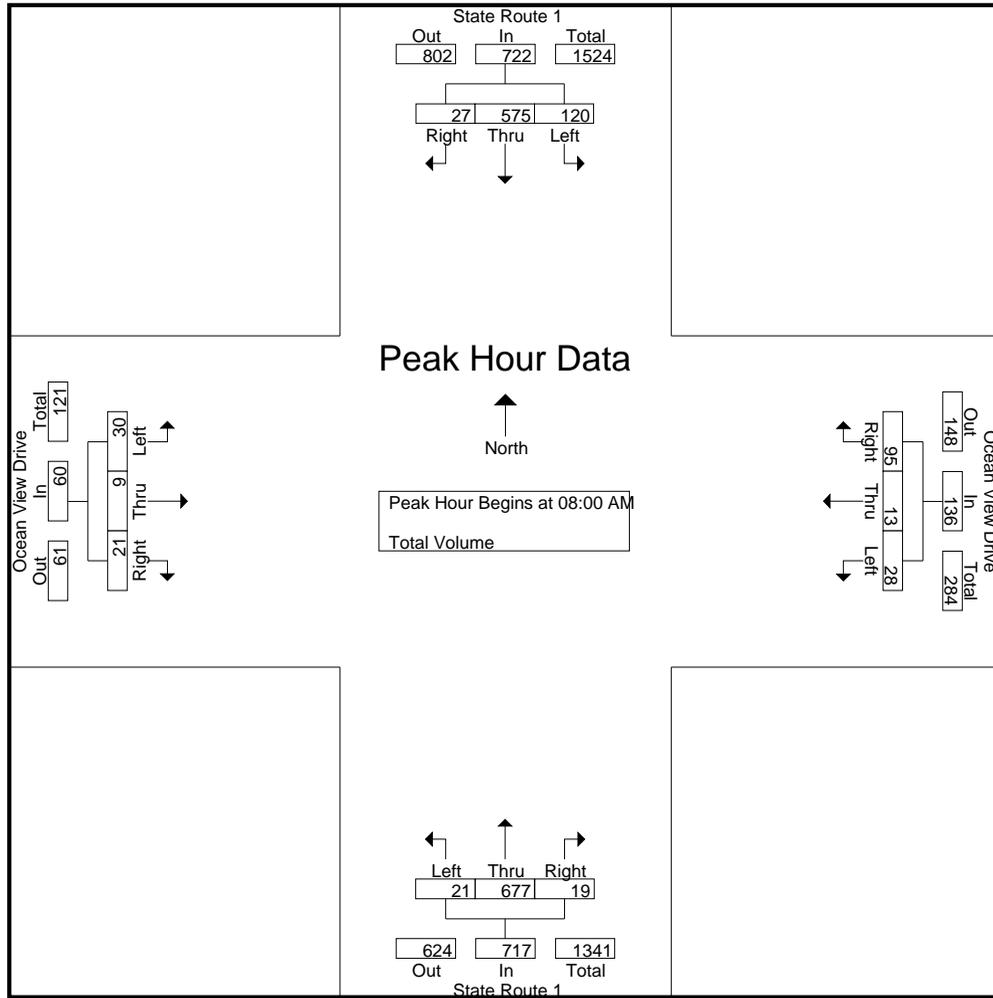
Groups Printed- Total Volume

Start Time	State Route 1 Southbound				Ocean View Drive Westbound				State Route 1 Northbound				Ocean View Drive Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
07:00 AM	12	76	4	92	4	3	6	13	4	73	2	79	3	2	2	7	191
07:15 AM	20	78	2	100	5	1	8	14	0	108	4	112	5	1	1	7	233
07:30 AM	16	100	4	120	2	1	11	14	1	174	6	181	2	4	2	8	323
07:45 AM	22	121	9	152	2	3	22	27	1	176	8	185	4	0	6	10	374
Total	70	375	19	464	13	8	47	68	6	531	20	557	14	7	11	32	1121
08:00 AM	30	137	6	173	5	3	22	30	4	187	4	195	8	2	3	13	411
08:15 AM	34	130	6	170	9	4	24	37	4	183	5	192	8	2	6	16	415
08:30 AM	32	166	8	206	5	4	22	31	7	142	6	155	8	1	8	17	409
08:45 AM	24	142	7	173	9	2	27	38	6	165	4	175	6	4	4	14	400
Total	120	575	27	722	28	13	95	136	21	677	19	717	30	9	21	60	1635
Grand Total	190	950	46	1186	41	21	142	204	27	1208	39	1274	44	16	32	92	2756
Apprch %	16	80.1	3.9		20.1	10.3	69.6		2.1	94.8	3.1		47.8	17.4	34.8		
Total %	6.9	34.5	1.7	43	1.5	0.8	5.2	7.4	1	43.8	1.4	46.2	1.6	0.6	1.2	3.3	

Start Time	State Route 1 Southbound				Ocean View Drive Westbound				State Route 1 Northbound				Ocean View Drive Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
08:00 AM	30	137	6	173	5	3	22	30	4	187	4	195	8	2	3	13	411
08:15 AM	34	130	6	170	9	4	24	37	4	183	5	192	8	2	6	16	415
08:30 AM	32	166	8	206	5	4	22	31	7	142	6	155	8	1	8	17	409
08:45 AM	24	142	7	173	9	2	27	38	6	165	4	175	6	4	4	14	400
Total Volume	120	575	27	722	28	13	95	136	21	677	19	717	30	9	21	60	1635
% App. Total	16.6	79.6	3.7		20.6	9.6	69.9		2.9	94.4	2.6		50	15	35		
PHF	.882	.866	.844	.876	.778	.813	.880	.895	.750	.905	.792	.919	.938	.563	.656	.882	.985

Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 08:00 AM



Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	08:00 AM				08:00 AM				07:30 AM				08:00 AM			
+0 mins.	30	137	6	173	5	3	22	30	1	174	6	181	8	2	3	13
+15 mins.	34	130	6	170	9	4	24	37	1	176	8	185	8	2	6	16
+30 mins.	32	166	8	206	5	4	22	31	4	187	4	195	8	1	8	17
+45 mins.	24	142	7	173	9	2	27	38	4	183	5	192	6	4	4	14
Total Volume	120	575	27	722	28	13	95	136	10	720	23	753	30	9	21	60
% App. Total	16.6	79.6	3.7		20.6	9.6	69.9		1.3	95.6	3.1		50	15	35	
PHF	.882	.866	.844	.876	.778	.813	.880	.895	.625	.963	.719	.965	.938	.563	.656	.882

City of Fort Bragg
 N/S: State Route 1
 E/W: Ocean View Drive
 Weather: Sunny

File Name : FBG_SR-1_Ocean View PM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

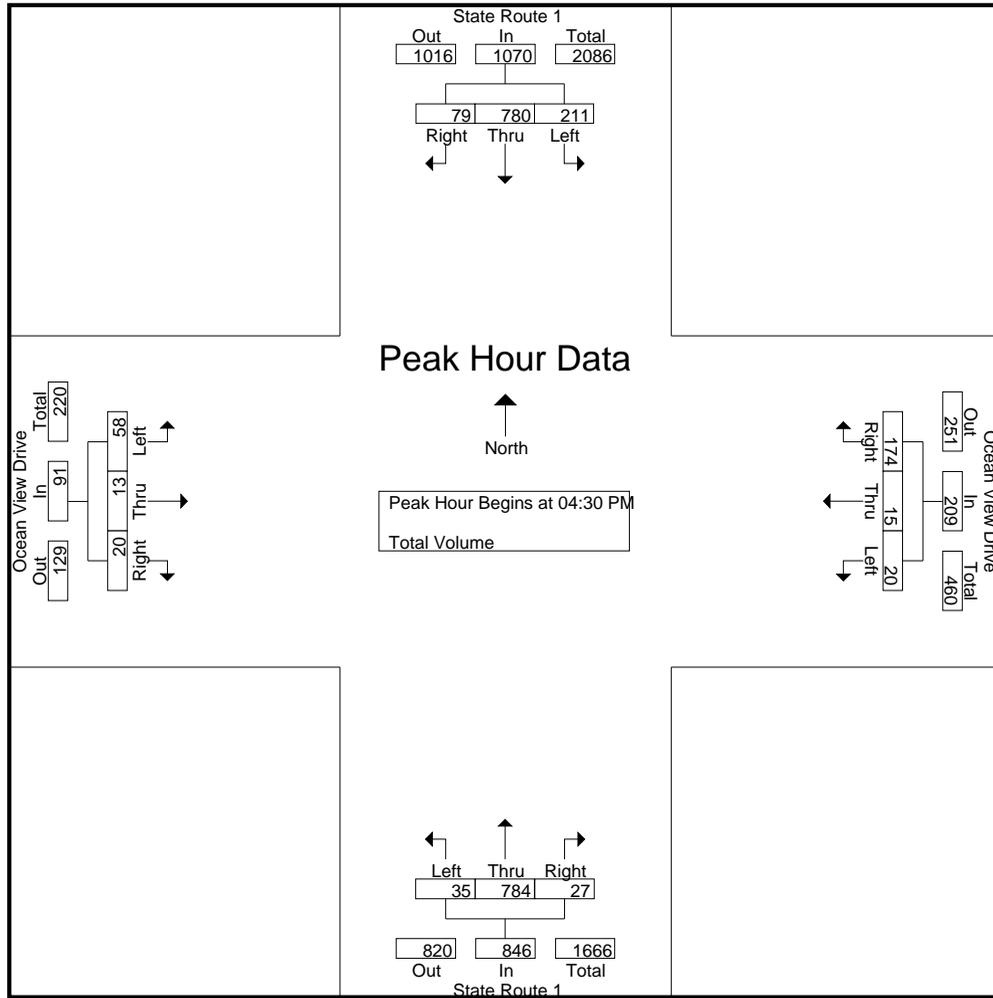
Groups Printed- Total Volume

Start Time	State Route 1 Southbound				Ocean View Drive Westbound				State Route 1 Northbound				Ocean View Drive Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
04:00 PM	49	192	7	248	4	6	46	56	3	188	6	197	26	3	13	42	543
04:15 PM	46	181	10	237	6	0	48	54	5	197	8	210	7	3	7	17	518
04:30 PM	49	199	14	262	3	4	44	51	5	182	7	194	15	5	2	22	529
04:45 PM	54	169	11	234	3	6	37	46	11	200	10	221	12	0	5	17	518
Total	198	741	42	981	16	16	175	207	24	767	31	822	60	11	27	98	2108
05:00 PM	63	212	32	307	9	4	47	60	12	203	5	220	16	6	6	28	615
05:15 PM	45	200	22	267	5	1	46	52	7	199	5	211	15	2	7	24	554
05:30 PM	38	148	22	208	2	4	35	41	9	139	13	161	12	2	10	24	434
05:45 PM	46	166	9	221	5	4	41	50	7	145	2	154	26	2	14	42	467
Total	192	726	85	1003	21	13	169	203	35	686	25	746	69	12	37	118	2070
Grand Total	390	1467	127	1984	37	29	344	410	59	1453	56	1568	129	23	64	216	4178
Apprch %	19.7	73.9	6.4		9	7.1	83.9		3.8	92.7	3.6		59.7	10.6	29.6		
Total %	9.3	35.1	3	47.5	0.9	0.7	8.2	9.8	1.4	34.8	1.3	37.5	3.1	0.6	1.5	5.2	

Start Time	State Route 1 Southbound				Ocean View Drive Westbound				State Route 1 Northbound				Ocean View Drive Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
04:30 PM	49	199	14	262	3	4	44	51	5	182	7	194	15	5	2	22	529
04:45 PM	54	169	11	234	3	6	37	46	11	200	10	221	12	0	5	17	518
05:00 PM	63	212	32	307	9	4	47	60	12	203	5	220	16	6	6	28	615
05:15 PM	45	200	22	267	5	1	46	52	7	199	5	211	15	2	7	24	554
Total Volume	211	780	79	1070	20	15	174	209	35	784	27	846	58	13	20	91	2216
% App. Total	19.7	72.9	7.4		9.6	7.2	83.3		4.1	92.7	3.2		63.7	14.3	22		
PHF	.837	.920	.617	.871	.556	.625	.926	.871	.729	.966	.675	.957	.906	.542	.714	.813	.901

Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 04:30 PM



Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	04:30 PM				04:15 PM				04:30 PM				05:00 PM			
+0 mins.	49	199	14	262	6	0	48	54	5	182	7	194	16	6	6	28
+15 mins.	54	169	11	234	3	4	44	51	11	200	10	221	15	2	7	24
+30 mins.	63	212	32	307	3	6	37	46	12	203	5	220	12	2	10	24
+45 mins.	45	200	22	267	9	4	47	60	7	199	5	211	26	2	14	42
Total Volume	211	780	79	1070	21	14	176	211	35	784	27	846	69	12	37	118
% App. Total	19.7	72.9	7.4		10	6.6	83.4		4.1	92.7	3.2		58.5	10.2	31.4	
PHF	.837	.920	.617	.871	.583	.583	.917	.879	.729	.966	.675	.957	.663	.500	.661	.702

City of Fort Bragg
 N/S: State Route 1
 E/W: Ocean View Drive
 Weather: Sunny

File Name : FBG_SR-1_Ocean View MD
 Site Code : 99913282
 Start Date : 8/24/2013
 Page No : 1

Groups Printed- Total Volume

Start Time	State Route 1 Southbound				Ocean View Drive Westbound				State Route 1 Northbound				Ocean View Drive Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
11:00 AM	47	166	8	221	6	5	42	53	2	140	8	150	12	2	3	17	441
11:15 AM	38	170	11	219	11	1	38	50	5	179	19	203	12	3	3	18	490
11:30 AM	44	164	7	215	10	4	39	53	5	147	18	170	11	1	8	20	458
11:45 AM	55	167	7	229	5	4	48	57	5	182	7	194	11	4	6	21	501
Total	184	667	33	884	32	14	167	213	17	648	52	717	46	10	20	76	1890
12:00 PM	53	180	14	247	13	5	43	61	6	166	9	181	11	6	6	23	512
12:15 PM	48	155	6	209	12	3	51	66	6	188	9	203	13	1	5	19	497
12:30 PM	38	166	15	219	10	5	37	52	5	176	9	190	10	3	6	19	480
12:45 PM	51	170	9	230	4	4	42	50	7	182	8	197	12	2	10	24	501
Total	190	671	44	905	39	17	173	229	24	712	35	771	46	12	27	85	1990
Grand Total	374	1338	77	1789	71	31	340	442	41	1360	87	1488	92	22	47	161	3880
Apprch %	20.9	74.8	4.3		16.1	7	76.9		2.8	91.4	5.8		57.1	13.7	29.2		
Total %	9.6	34.5	2	46.1	1.8	0.8	8.8	11.4	1.1	35.1	2.2	38.4	2.4	0.6	1.2	4.1	

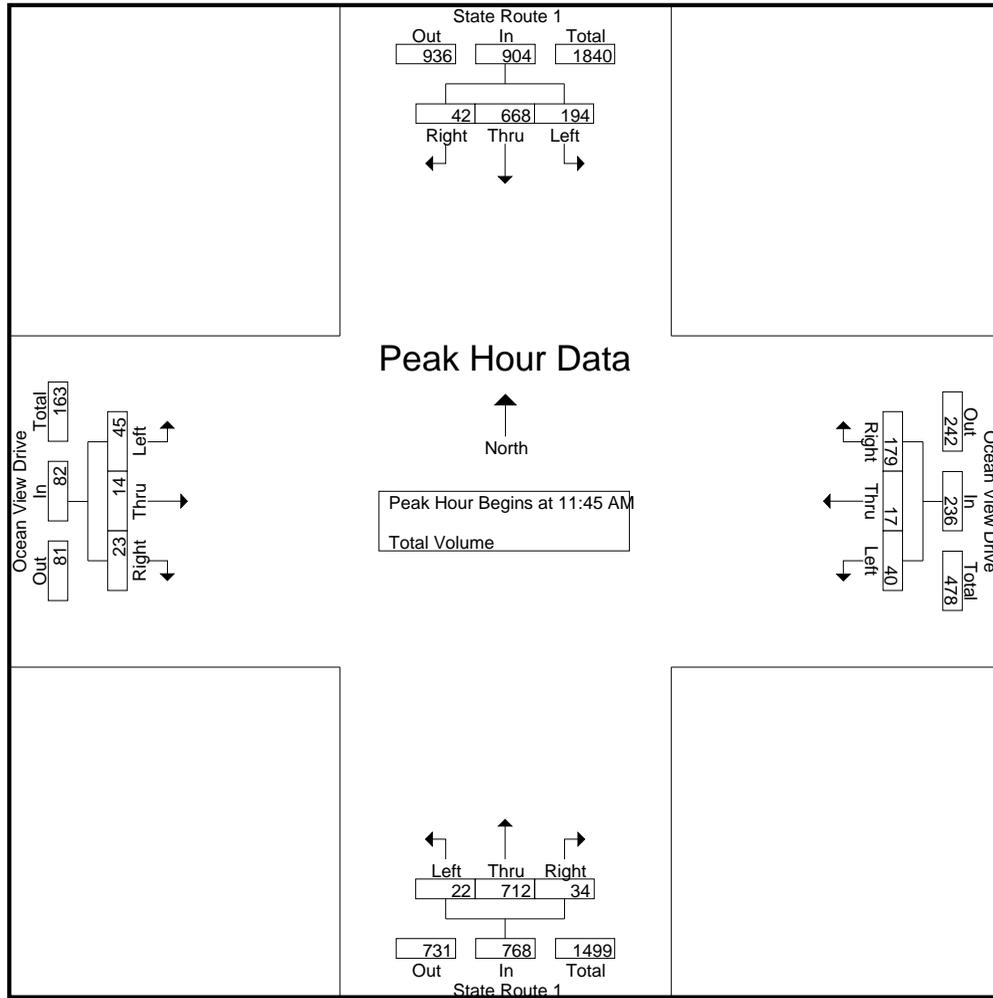
Start Time	State Route 1 Southbound				Ocean View Drive Westbound				State Route 1 Northbound				Ocean View Drive Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
11:45 AM	55	167	7	229	5	4	48	57	5	182	7	194	11	4	6	21	501
12:00 PM	53	180	14	247	13	5	43	61	6	166	9	181	11	6	6	23	512
12:15 PM	48	155	6	209	12	3	51	66	6	188	9	203	13	1	5	19	497
12:30 PM	38	166	15	219	10	5	37	52	5	176	9	190	10	3	6	19	480
Total Volume	194	668	42	904	40	17	179	236	22	712	34	768	45	14	23	82	1990
% App. Total	21.5	73.9	4.6		16.9	7.2	75.8		2.9	92.7	4.4		54.9	17.1	28		
PHF	.882	.928	.700	.915	.769	.850	.877	.894	.917	.947	.944	.946	.865	.583	.958	.891	.972

Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 11:45 AM

City of Fort Bragg
 N/S: State Route 1
 E/W: Ocean View Drive
 Weather: Sunny

File Name : FBG_SR-1_Ocean View MD
 Site Code : 99913282
 Start Date : 8/24/2013
 Page No : 2



Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	11:15 AM				11:30 AM				12:00 PM				12:00 PM			
+0 mins.	38	170	11	219	10	4	39	53	6	166	9	181	11	6	6	23
+15 mins.	44	164	7	215	5	4	48	57	6	188	9	203	13	1	5	19
+30 mins.	55	167	7	229	13	5	43	61	5	176	9	190	10	3	6	19
+45 mins.	53	180	14	247	12	3	51	66	7	182	8	197	12	2	10	24
Total Volume	190	681	39	910	40	16	181	237	24	712	35	771	46	12	27	85
% App. Total	20.9	74.8	4.3		16.9	6.8	76.4		3.1	92.3	4.5		54.1	14.1	31.8	
PHF	.864	.946	.696	.921	.769	.800	.887	.898	.857	.947	.972	.950	.885	.500	.675	.885

Location: Fort Bragg
 N/S: State Route 1
 E/W: Ocean View Drive



Date: 8/22/2013
 File : FBGSR1OV

WEEKDAY

	North Leg Ocean View Drive	East Leg State Route 1	South Leg Ocean View Drive	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
7:00 AM	0	0	4	0	4
7:15 AM	0	1	0	0	1
7:30 AM	0	0	0	0	0
7:45 AM	0	0	2	0	2
8:00 AM	0	0	0	0	0
8:15 AM	0	0	0	0	0
8:30 AM	0	0	1	1	2
8:45 AM	1	0	0	0	1
TOTAL VOLUMES:	1	1	7	1	10

	North Leg Ocean View Drive	East Leg State Route 1	South Leg Ocean View Drive	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
4:00 PM	0	0	0	0	0
4:15 PM	0	1	1	0	2
4:30 PM	0	0	2	0	2
4:45 PM	2	0	2	1	5
5:00 PM	0	0	0	0	0
5:15 PM	0	0	1	0	1
5:30 PM	0	0	0	0	0
5:45 PM	0	2	0	1	3
TOTAL VOLUMES:	2	3	6	2	13

SATURDAY

Date: 8/24/2013

	North Leg Ocean View Drive	East Leg State Route 1	South Leg Ocean View Drive	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
11:00 AM	0	0	0	0	0
11:15 AM	0	1	2	0	3
11:30 AM	0	0	1	0	1
11:45 AM	0	0	0	0	0
12:00 PM	0	0	0	0	0
12:15 PM	0	3	0	0	3
12:30 PM	1	0	0	0	1
12:45 PM	0	0	0	0	0
TOTAL VOLUMES:	1	4	3	0	8

Location: Fort Bragg
 N/S: State Route 1
 E/W: Ocean View Drive



Date: 8/22/2013
 File : FBGSR10V

	North Leg Ocean View Drive	East Leg State Route 1	South Leg Ocean View Drive	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
7:00 AM	0	0	1	0	1
7:15 AM	0	0	0	0	0
7:30 AM	0	0	0	0	0
7:45 AM	0	0	2	0	2
8:00 AM	0	1	0	0	1
8:15 AM	0	0	1	8	9
8:30 AM	0	1	0	1	2
8:45 AM	0	0	0	1	1
TOTAL VOLUMES:	0	2	4	10	16

	North Leg Ocean View Drive	East Leg State Route 1	South Leg Ocean View Drive	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
4:00 PM	0	1	0	1	2
4:15 PM	0	0	0	3	3
4:30 PM	0	0	0	1	1
4:45 PM	0	4	0	0	4
5:00 PM	0	0	1	1	2
5:15 PM	0	1	0	0	1
5:30 PM	0	0	0	0	0
5:45 PM	0	1	0	3	4
TOTAL VOLUMES:	0	7	1	9	17

SATURDAY

Date: 8/24/2013

	North Leg Ocean View Drive	East Leg State Route 1	South Leg Ocean View Drive	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
11:00 AM	1	2	1	3	7
11:15 AM	0	0	0	0	0
11:30 AM	0	1	0	0	1
11:45 AM	0	1	0	0	1
12:00 PM	0	0	0	1	1
12:15 PM	0	2	0	4	6
12:30 PM	0	0	2	4	6
12:45 PM	0	0	0	0	0
TOTAL VOLUMES:	1	6	3	12	22

City of Fort Bragg
 N/S: State Route 1
 E/W: Driveways
 Weather: Sunny

File Name : FBG_SR-1_Driveways AM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

Groups Printed- Total Volume

Start Time	State Route 1 Southbound				Driveway Westbound				State Route 1 Northbound				Driveway Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
07:00 AM	7	81	2	90	0	1	2	3	0	76	4	80	0	0	2	2	175
07:15 AM	8	82	0	90	4	0	8	12	2	108	4	114	1	0	1	2	218
07:30 AM	11	108	2	121	2	1	5	8	0	148	6	154	1	0	1	2	285
07:45 AM	8	140	3	151	2	0	8	10	1	200	5	206	1	0	2	3	370
Total	34	411	7	452	8	2	23	33	3	532	19	554	3	0	6	9	1048
08:00 AM	11	147	4	162	4	0	4	8	1	195	4	200	2	0	0	2	372
08:15 AM	6	161	4	171	5	0	3	8	1	192	7	200	2	0	1	3	382
08:30 AM	11	180	6	197	3	0	9	12	0	189	5	194	1	0	2	3	406
08:45 AM	10	157	2	169	2	0	7	9	1	187	6	194	1	0	1	2	374
Total	38	645	16	699	14	0	23	37	3	763	22	788	6	0	4	10	1534
Grand Total	72	1056	23	1151	22	2	46	70	6	1295	41	1342	9	0	10	19	2582
Apprch %	6.3	91.7	2		31.4	2.9	65.7		0.4	96.5	3.1		47.4	0	52.6		
Total %	2.8	40.9	0.9	44.6	0.9	0.1	1.8	2.7	0.2	50.2	1.6	52	0.3	0	0.4	0.7	

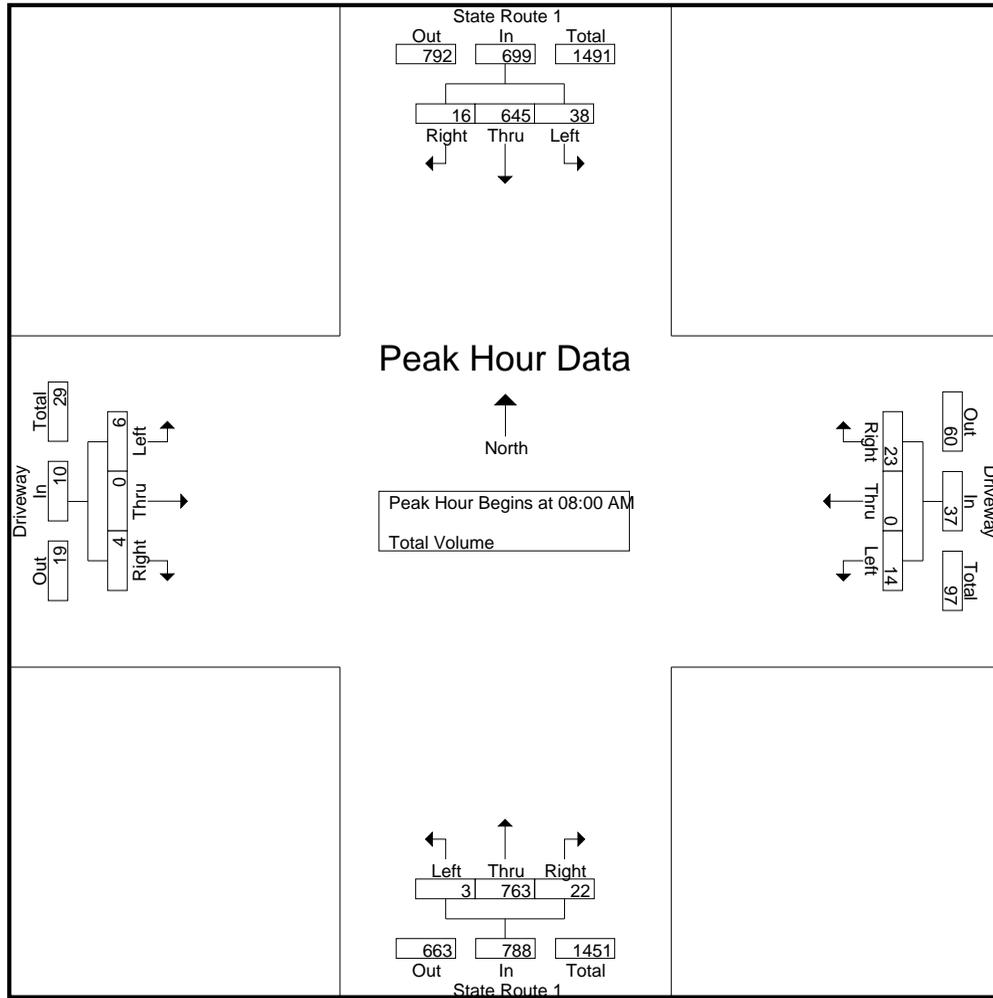
Start Time	State Route 1 Southbound				Driveway Westbound				State Route 1 Northbound				Driveway Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
08:00 AM	11	147	4	162	4	0	4	8	1	195	4	200	2	0	0	2	372
08:15 AM	6	161	4	171	5	0	3	8	1	192	7	200	2	0	1	3	382
08:30 AM	11	180	6	197	3	0	9	12	0	189	5	194	1	0	2	3	406
08:45 AM	10	157	2	169	2	0	7	9	1	187	6	194	1	0	1	2	374
Total Volume	38	645	16	699	14	0	23	37	3	763	22	788	6	0	4	10	1534
% App. Total	5.4	92.3	2.3		37.8	0	62.2		0.4	96.8	2.8		60	0	40		
PHF	.864	.896	.667	.887	.700	.000	.639	.771	.750	.978	.786	.985	.750	.000	.500	.833	.945

Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 08:00 AM

City of Fort Bragg
 N/S: State Route 1
 E/W: Driveways
 Weather: Sunny

File Name : FBG_SR-1_Driveways AM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 2



Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1
 Peak Hour for Each Approach Begins at:

	08:00 AM				07:15 AM				07:45 AM				07:45 AM			
+0 mins.	11	147	4	162	4	0	8	12	1	200	5	206	1	0	2	3
+15 mins.	6	161	4	171	2	1	5	8	1	195	4	200	2	0	0	2
+30 mins.	11	180	6	197	2	0	8	10	1	192	7	200	2	0	1	3
+45 mins.	10	157	2	169	4	0	4	8	0	189	5	194	1	0	2	3
Total Volume	38	645	16	699	12	1	25	38	3	776	21	800	6	0	5	11
% App. Total	5.4	92.3	2.3		31.6	2.6	65.8		0.4	97	2.6		54.5	0	45.5	
PHF	.864	.896	.667	.887	.750	.250	.781	.792	.750	.970	.750	.971	.750	.000	.625	.917

City of Fort Bragg
 N/S: State Route 1
 E/W: Driveways
 Weather: Sunny

File Name : FBG_SR-1_Driveways PM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

Groups Printed- Total Volume

Start Time	State Route 1 Southbound				Driveway Westbound				State Route 1 Northbound				Driveway Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
04:00 PM	3	247	11	261	0	0	4	4	1	256	0	257	5	0	1	6	528
04:15 PM	7	233	11	251	3	0	6	9	4	245	1	250	3	0	0	3	513
04:30 PM	6	266	14	286	2	0	2	4	2	255	5	262	3	0	3	6	558
04:45 PM	9	234	9	252	1	0	4	5	2	255	1	258	3	0	5	8	523
Total	25	980	45	1050	6	0	16	22	9	1011	7	1027	14	0	9	23	2122
05:00 PM	6	268	9	283	2	0	5	7	1	264	4	269	4	0	3	7	566
05:15 PM	7	286	12	305	0	0	6	6	3	240	1	244	4	0	2	6	561
05:30 PM	2	211	11	224	1	0	7	8	2	229	3	234	1	0	4	5	471
05:45 PM	2	213	9	224	1	0	2	3	1	193	2	196	1	0	6	7	430
Total	17	978	41	1036	4	0	20	24	7	926	10	943	10	0	15	25	2028
Grand Total	42	1958	86	2086	10	0	36	46	16	1937	17	1970	24	0	24	48	4150
Apprch %	2	93.9	4.1		21.7	0	78.3		0.8	98.3	0.9		50	0	50		
Total %	1	47.2	2.1	50.3	0.2	0	0.9	1.1	0.4	46.7	0.4	47.5	0.6	0	0.6	1.2	

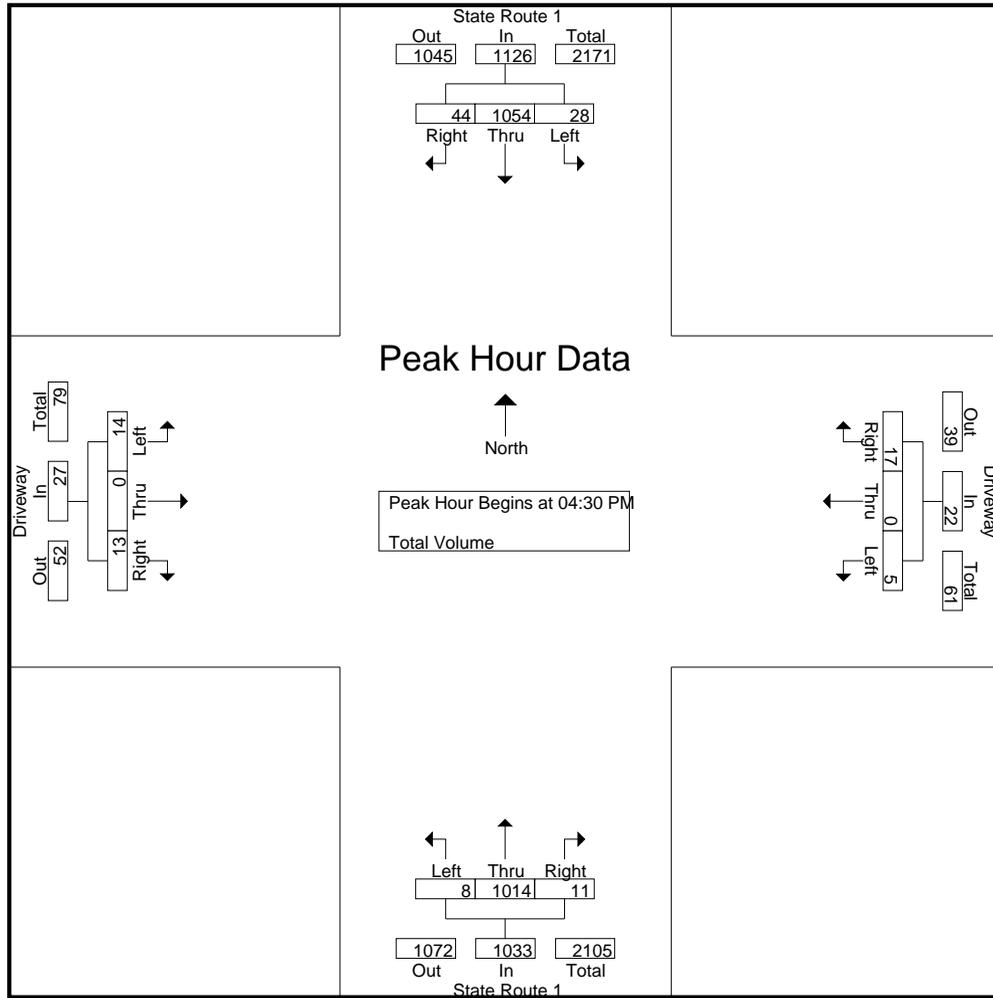
Start Time	State Route 1 Southbound				Driveway Westbound				State Route 1 Northbound				Driveway Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
04:30 PM	6	266	14	286	2	0	2	4	2	255	5	262	3	0	3	6	558
04:45 PM	9	234	9	252	1	0	4	5	2	255	1	258	3	0	5	8	523
05:00 PM	6	268	9	283	2	0	5	7	1	264	4	269	4	0	3	7	566
05:15 PM	7	286	12	305	0	0	6	6	3	240	1	244	4	0	2	6	561
Total Volume	28	1054	44	1126	5	0	17	22	8	1014	11	1033	14	0	13	27	2208
% App. Total	2.5	93.6	3.9		22.7	0	77.3		0.8	98.2	1.1		51.9	0	48.1		
PHF	.778	.921	.786	.923	.625	.000	.708	.786	.667	.960	.550	.960	.875	.000	.650	.844	.975

Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 04:30 PM

City of Fort Bragg
 N/S: State Route 1
 E/W: Driveways
 Weather: Sunny

File Name : FBG_SR-1_Driveways PM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 2



Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	04:30 PM				04:45 PM				04:15 PM				04:30 PM			
+0 mins.	6	266	14	286	1	0	4	5	4	245	1	250	3	0	3	6
+15 mins.	9	234	9	252	2	0	5	7	2	255	5	262	3	0	5	8
+30 mins.	6	268	9	283	0	0	6	6	2	255	1	258	4	0	3	7
+45 mins.	7	286	12	305	1	0	7	8	1	264	4	269	4	0	2	6
Total Volume	28	1054	44	1126	4	0	22	26	9	1019	11	1039	14	0	13	27
% App. Total	2.5	93.6	3.9		15.4	0	84.6		0.9	98.1	1.1		51.9	0	48.1	
PHF	.778	.921	.786	.923	.500	.000	.786	.813	.563	.965	.550	.966	.875	.000	.650	.844

City of Fort Bragg
 N/S: State Route 1
 E/W: Driveways
 Weather: Sunny

File Name : FBG_SR-1_DRIVEWAYS MD
 Site Code : 99913282
 Start Date : 8/24/2013
 Page No : 1

Groups Printed- Total Volume

Start Time	State Route 1 Southbound				Driveway Westbound				State Route 1 Northbound				Driveway Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
11:00 AM	6	212	4	222	2	1	6	9	0	208	1	209	0	0	3	3	443
11:15 AM	10	201	7	218	2	0	4	6	2	218	3	223	2	0	2	4	451
11:30 AM	4	206	4	214	1	0	2	3	5	214	2	221	2	0	1	3	441
11:45 AM	8	234	4	246	3	0	5	8	3	227	2	232	2	0	3	5	491
Total	28	853	19	900	8	1	17	26	10	867	8	885	6	0	9	15	1826
12:00 PM	9	239	9	257	2	0	6	8	1	233	4	238	1	0	2	3	506
12:15 PM	4	200	9	213	0	0	3	3	2	258	3	263	2	0	2	4	483
12:30 PM	6	212	3	221	2	0	2	4	1	247	4	252	2	0	3	5	482
12:45 PM	4	220	10	234	2	1	8	11	0	234	8	242	2	0	3	5	492
Total	23	871	31	925	6	1	19	26	4	972	19	995	7	0	10	17	1963
Grand Total	51	1724	50	1825	14	2	36	52	14	1839	27	1880	13	0	19	32	3789
Apprch %	2.8	94.5	2.7		26.9	3.8	69.2		0.7	97.8	1.4		40.6	0	59.4		
Total %	1.3	45.5	1.3	48.2	0.4	0.1	1	1.4	0.4	48.5	0.7	49.6	0.3	0	0.5	0.8	

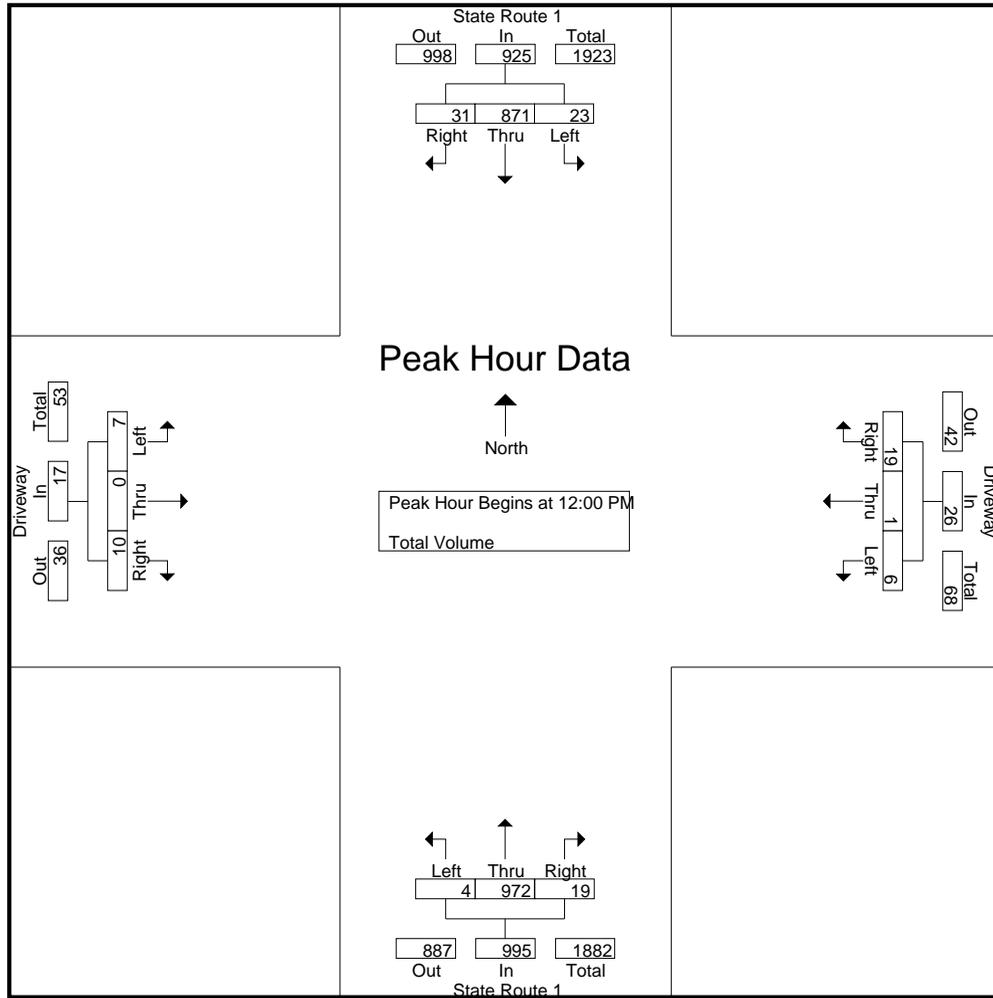
Start Time	State Route 1 Southbound				Driveway Westbound				State Route 1 Northbound				Driveway Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
12:00 PM	9	239	9	257	2	0	6	8	1	233	4	238	1	0	2	3	506
12:15 PM	4	200	9	213	0	0	3	3	2	258	3	263	2	0	2	4	483
12:30 PM	6	212	3	221	2	0	2	4	1	247	4	252	2	0	3	5	482
12:45 PM	4	220	10	234	2	1	8	11	0	234	8	242	2	0	3	5	492
Total Volume	23	871	31	925	6	1	19	26	4	972	19	995	7	0	10	17	1963
% App. Total	2.5	94.2	3.4		23.1	3.8	73.1		0.4	97.7	1.9		41.2	0	58.8		
PHF	.639	.911	.775	.900	.750	.250	.594	.591	.500	.942	.594	.946	.875	.000	.833	.850	.970

Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 12:00 PM

City of Fort Bragg
 N/S: State Route 1
 E/W: Driveways
 Weather: Sunny

File Name : FBG_SR-1_DRIVEWAYS MD
 Site Code : 99913282
 Start Date : 8/24/2013
 Page No : 2



Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1
 Peak Hour for Each Approach Begins at:

	11:45 AM				11:00 AM				12:00 PM				11:45 AM			
+0 mins.	8	234	4	246	2	1	6	9	1	233	4	238	2	0	3	5
+15 mins.	9	239	9	257	2	0	4	6	2	258	3	263	1	0	2	3
+30 mins.	4	200	9	213	1	0	2	3	1	247	4	252	2	0	2	4
+45 mins.	6	212	3	221	3	0	5	8	0	234	8	242	2	0	3	5
Total Volume	27	885	25	937	8	1	17	26	4	972	19	995	7	0	10	17
% App. Total	2.9	94.5	2.7		30.8	3.8	65.4		0.4	97.7	1.9		41.2	0	58.8	
PHF	.750	.926	.694	.911	.667	.250	.708	.722	.500	.942	.594	.946	.875	.000	.833	.850

Location: Fort Bragg
 N/S: State Route 1
 E/W: Driveways



Date: 8/22/2013
 File : FBGSR1DW

WEEKDAY

	North Leg Driveways	East Leg State Route 1	South Leg Driveways	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
7:00 AM	0	1	0	0	1
7:15 AM	0	0	0	0	0
7:30 AM	0	2	0	0	2
7:45 AM	0	0	0	0	0
8:00 AM	0	1	0	0	1
8:15 AM	0	0	0	0	0
8:30 AM	0	2	0	1	3
8:45 AM	0	0	0	0	0
TOTAL VOLUMES:	0	6	0	1	7

	North Leg Driveways	East Leg State Route 1	South Leg Driveways	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
4:00 PM	0	0	0	0	0
4:15 PM	0	2	0	0	2
4:30 PM	0	2	0	0	2
4:45 PM	0	0	0	0	0
5:00 PM	0	1	0	0	1
5:15 PM	0	0	0	0	0
5:30 PM	0	1	0	1	2
5:45 PM	0	2	0	0	2
TOTAL VOLUMES:	0	8	0	1	9

SATURDAY

Date: 8/24/2013

	North Leg Driveways	East Leg State Route 1	South Leg Driveways	West Leg State Route 1	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
11:00 AM	0	1	0	0	1
11:15 AM	0	4	0	1	5
11:30 AM	0	0	0	0	0
11:45 AM	0	2	0	0	2
12:00 PM	0	2	0	0	2
12:15 PM	2	3	1	1	7
12:30 PM	0	0	0	0	0
12:45 PM	0	1	0	0	1
TOTAL VOLUMES:	2	13	1	2	18

Location: Fort Bragg
 N/S: State Route 1
 E/W: Driveways



Date: 8/22/2013
 File : FBGSR1DW

	North Leg Driveways	East Leg State Route 1	South Leg Driveways	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
7:00 AM	0	1	0	0	1
7:15 AM	0	1	0	0	1
7:30 AM	0	0	0	0	0
7:45 AM	0	2	0	0	2
8:00 AM	0	1	0	0	1
8:15 AM	0	0	0	6	6
8:30 AM	0	1	0	5	6
8:45 AM	0	0	0	0	0
TOTAL VOLUMES:	0	6	0	11	17

	North Leg Driveways	East Leg State Route 1	South Leg Driveways	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
4:00 PM	0	5	0	1	6
4:15 PM	0	1	0	1	2
4:30 PM	0	3	0	0	3
4:45 PM	0	3	0	1	4
5:00 PM	0	2	0	1	3
5:15 PM	0	0	0	1	1
5:30 PM	0	2	0	0	2
5:45 PM	0	2	0	3	5
TOTAL VOLUMES:	0	18	0	8	26

SATURDAY

Date: 8/24/2013

	North Leg Driveways	East Leg State Route 1	South Leg Driveways	West Leg State Route 1	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
11:00 AM	0	2	0	2	4
11:15 AM	0	3	0	0	3
11:30 AM	0	1	0	0	1
11:45 AM	0	2	0	0	2
12:00 PM	0	3	0	0	3
12:15 PM	0	3	0	3	6
12:30 PM	0	0	0	5	5
12:45 PM	0	2	0	0	2
TOTAL VOLUMES:	0	16	0	10	26

City of Fort Bragg
 N/S: Boatyard Drive
 E/W: State Route 20
 Weather: Sunny

File Name : FBG_Boatyard_SR-20 AM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

Groups Printed- Total Volume

Start Time	Boatyard Drive Southbound				State Route 20 Westbound				Boatyard Drive Northbound				State Route 20 Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
07:00 AM	4	0	6	10	0	28	5	33	0	0	0	0	2	35	0	37	80
07:15 AM	4	0	3	7	0	37	6	43	0	0	0	0	6	38	0	44	94
07:30 AM	6	0	5	11	0	71	12	83	0	0	0	0	12	28	0	40	134
07:45 AM	12	0	6	18	1	68	8	77	0	0	0	0	9	44	0	53	148
Total	26	0	20	46	1	204	31	236	0	0	0	0	29	145	0	174	456
08:00 AM	14	0	7	21	0	71	9	80	0	0	0	0	5	63	0	68	169
08:15 AM	13	0	5	18	0	73	11	84	1	1	0	2	6	58	3	67	171
08:30 AM	11	0	6	17	0	54	6	60	3	0	0	3	6	65	3	74	154
08:45 AM	12	0	7	19	0	61	11	72	2	0	0	2	9	50	2	61	154
Total	50	0	25	75	0	259	37	296	6	1	0	7	26	236	8	270	648
Grand Total	76	0	45	121	1	463	68	532	6	1	0	7	55	381	8	444	1104
Apprch %	62.8	0	37.2		0.2	87	12.8		85.7	14.3	0		12.4	85.8	1.8		
Total %	6.9	0	4.1	11	0.1	41.9	6.2	48.2	0.5	0.1	0	0.6	5	34.5	0.7	40.2	

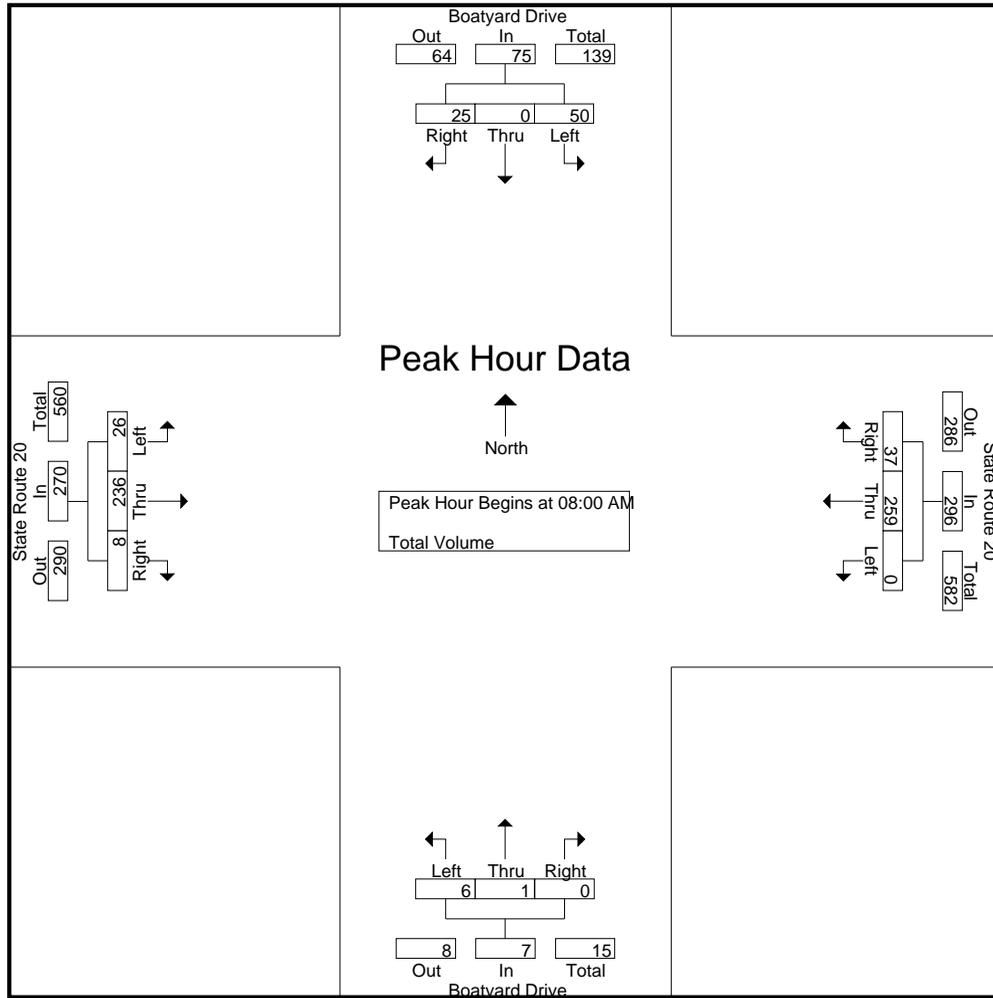
Start Time	Boatyard Drive Southbound				State Route 20 Westbound				Boatyard Drive Northbound				State Route 20 Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
08:00 AM	14	0	7	21	0	71	9	80	0	0	0	0	5	63	0	68	169
08:15 AM	13	0	5	18	0	73	11	84	1	1	0	2	6	58	3	67	171
08:30 AM	11	0	6	17	0	54	6	60	3	0	0	3	6	65	3	74	154
08:45 AM	12	0	7	19	0	61	11	72	2	0	0	2	9	50	2	61	154
Total Volume	50	0	25	75	0	259	37	296	6	1	0	7	26	236	8	270	648
% App. Total	66.7	0	33.3		0	87.5	12.5		85.7	14.3	0		9.6	87.4	3		
PHF	.893	.000	.893	.893	.000	.887	.841	.881	.500	.250	.000	.583	.722	.908	.667	.912	.947

Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 08:00 AM

City of Fort Bragg
 N/S: Boatyard Drive
 E/W: State Route 20
 Weather: Sunny

File Name : FBG_Boatyard_SR-20 AM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 2



Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1
 Peak Hour for Each Approach Begins at:

	08:00 AM				07:30 AM				08:00 AM				08:00 AM			
+0 mins.	14	0	7	21	0	71	12	83	0	0	0	0	5	63	0	68
+15 mins.	13	0	5	18	1	68	8	77	1	1	0	2	6	58	3	67
+30 mins.	11	0	6	17	0	71	9	80	3	0	0	3	6	65	3	74
+45 mins.	12	0	7	19	0	73	11	84	2	0	0	2	9	50	2	61
Total Volume	50	0	25	75	1	283	40	324	6	1	0	7	26	236	8	270
% App. Total	66.7	0	33.3		0.3	87.3	12.3		85.7	14.3	0		9.6	87.4	3	
PHF	.893	.000	.893	.893	.250	.969	.833	.964	.500	.250	.000	.583	.722	.908	.667	.912

City of Fort Bragg
 N/S: Boatyard Drive
 E/W: State Route 20
 Weather: Sunny

File Name : FBG_Boatyard_SR-20 PM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 1

Groups Printed- Total Volume

Start Time	Boatyard Drive Southbound				State Route 20 Westbound				Boatyard Drive Northbound				State Route 20 Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
04:00 PM	22	0	27	49	0	82	8	90	0	0	1	1	23	73	1	97	237
04:15 PM	13	0	31	44	0	86	14	100	1	1	2	4	22	50	2	74	222
04:30 PM	15	0	44	59	0	73	9	82	0	0	0	0	22	72	1	95	236
04:45 PM	19	0	37	56	0	78	21	99	1	0	0	1	24	57	1	82	238
Total	69	0	139	208	0	319	52	371	2	1	3	6	91	252	5	348	933
05:00 PM	16	0	20	36	0	88	8	96	1	0	1	2	14	72	0	86	220
05:15 PM	15	0	29	44	0	80	5	85	0	0	2	2	25	75	0	100	231
05:30 PM	15	0	30	45	0	66	9	75	0	0	1	1	16	63	1	80	201
05:45 PM	12	0	29	41	0	65	9	74	0	0	0	0	19	56	0	75	190
Total	58	0	108	166	0	299	31	330	1	0	4	5	74	266	1	341	842
Grand Total	127	0	247	374	0	618	83	701	3	1	7	11	165	518	6	689	1775
Apprch %	34	0	66		0	88.2	11.8		27.3	9.1	63.6		23.9	75.2	0.9		
Total %	7.2	0	13.9	21.1	0	34.8	4.7	39.5	0.2	0.1	0.4	0.6	9.3	29.2	0.3	38.8	

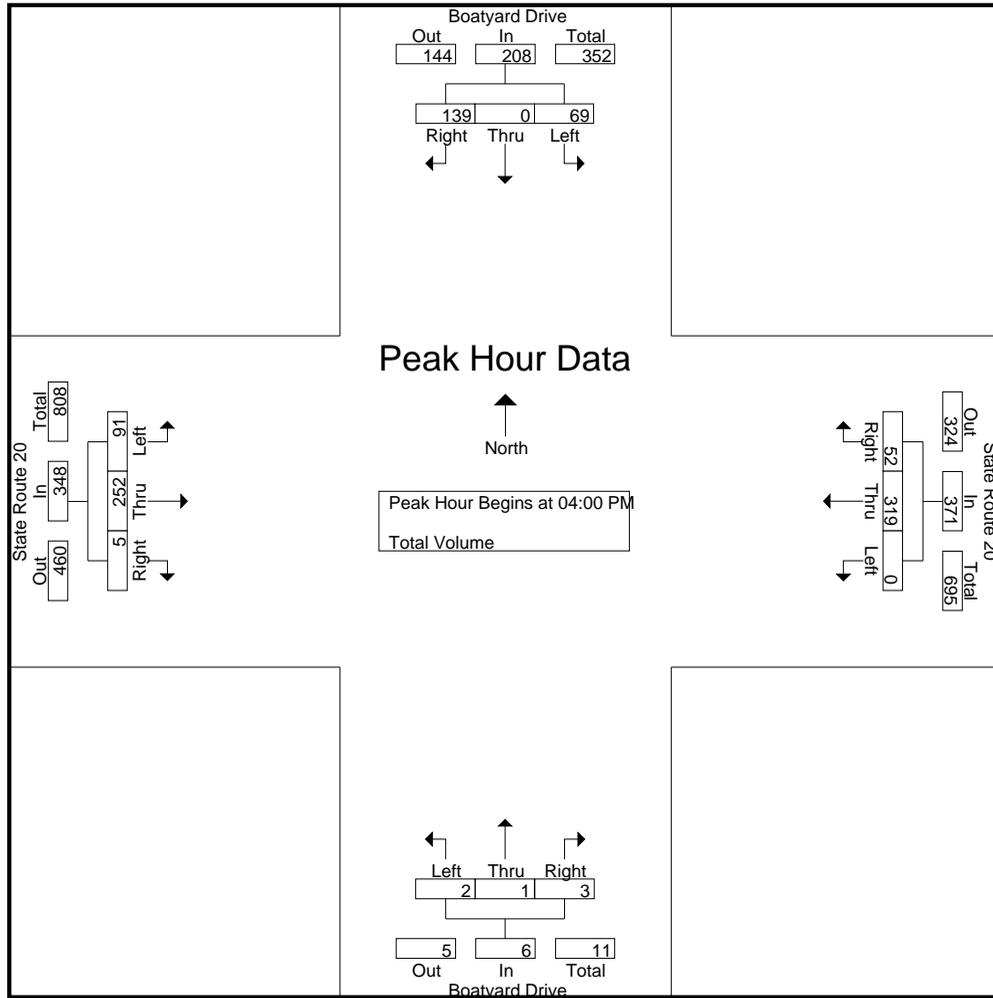
Start Time	Boatyard Drive Southbound				State Route 20 Westbound				Boatyard Drive Northbound				State Route 20 Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
04:00 PM	22	0	27	49	0	82	8	90	0	0	1	1	23	73	1	97	237
04:15 PM	13	0	31	44	0	86	14	100	1	1	2	4	22	50	2	74	222
04:30 PM	15	0	44	59	0	73	9	82	0	0	0	0	22	72	1	95	236
04:45 PM	19	0	37	56	0	78	21	99	1	0	0	1	24	57	1	82	238
Total Volume	69	0	139	208	0	319	52	371	2	1	3	6	91	252	5	348	933
% App. Total	33.2	0	66.8		0	86	14		33.3	16.7	50		26.1	72.4	1.4		
PHF	.784	.000	.790	.881	.000	.927	.619	.928	.500	.250	.375	.375	.948	.863	.625	.897	.980

Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 04:00 PM

City of Fort Bragg
 N/S: Boatyard Drive
 E/W: State Route 20
 Weather: Sunny

File Name : FBG_Boatyard_SR-20 PM
 Site Code : 99913282
 Start Date : 8/22/2013
 Page No : 2



Peak Hour Analysis From 04:00 PM to 05:45 PM - Peak 1 of 1

Peak Hour for Each Approach Begins at:

	04:00 PM				04:15 PM				04:30 PM							
+0 mins.	22	0	27	49	0	86	14	100	1	2	4	22	72	1	95	
+15 mins.	13	0	31	44	0	73	9	82	0	0	0	24	57	1	82	
+30 mins.	15	0	44	59	0	78	21	99	1	0	1	14	72	0	86	
+45 mins.	19	0	37	56	0	88	8	96	1	0	2	25	75	0	100	
Total Volume	69	0	139	208	0	325	52	377	3	1	3	85	276	2	363	
% App. Total	33.2	0	66.8		0	86.2	13.8		42.9	14.3	42.9	23.4	76	0.6		
PHF	.784	.000	.790	.881	.000	.923	.619	.943	.750	.250	.375	.438	.850	.920	.500	.908

City of Fort Bragg
 N/S: Boatyard Drive
 E/W: State Route 20
 Weather: Sunny

File Name : FBG_Boatyard_SR-20 MD
 Site Code : 99913282
 Start Date : 8/24/2013
 Page No : 1

Groups Printed- Total Volume

Start Time	Boatyard Drive Southbound				State Route 20 Westbound				Boatyard Drive Northbound				State Route 20 Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
11:00 AM	11	0	25	36	1	67	18	86	1	0	0	1	10	64	1	75	198
11:15 AM	10	1	23	34	0	58	19	77	2	1	0	3	22	66	2	90	204
11:30 AM	9	0	26	35	0	68	21	89	3	0	0	3	21	63	0	84	211
11:45 AM	17	0	27	44	2	78	15	95	0	1	0	1	27	70	1	98	238
Total	47	1	101	149	3	271	73	347	6	2	0	8	80	263	4	347	851
12:00 PM	16	1	25	42	0	57	18	75	0	0	0	0	21	85	2	108	225
12:15 PM	12	0	25	37	1	81	21	103	3	0	0	3	14	63	2	79	222
12:30 PM	17	0	25	42	0	61	10	71	0	1	2	3	25	63	3	91	207
12:45 PM	22	0	34	56	1	87	11	99	2	0	3	5	24	66	4	94	254
Total	67	1	109	177	2	286	60	348	5	1	5	11	84	277	11	372	908
Grand Total	114	2	210	326	5	557	133	695	11	3	5	19	164	540	15	719	1759
Apprch %	35	0.6	64.4		0.7	80.1	19.1		57.9	15.8	26.3		22.8	75.1	2.1		
Total %	6.5	0.1	11.9	18.5	0.3	31.7	7.6	39.5	0.6	0.2	0.3	1.1	9.3	30.7	0.9	40.9	

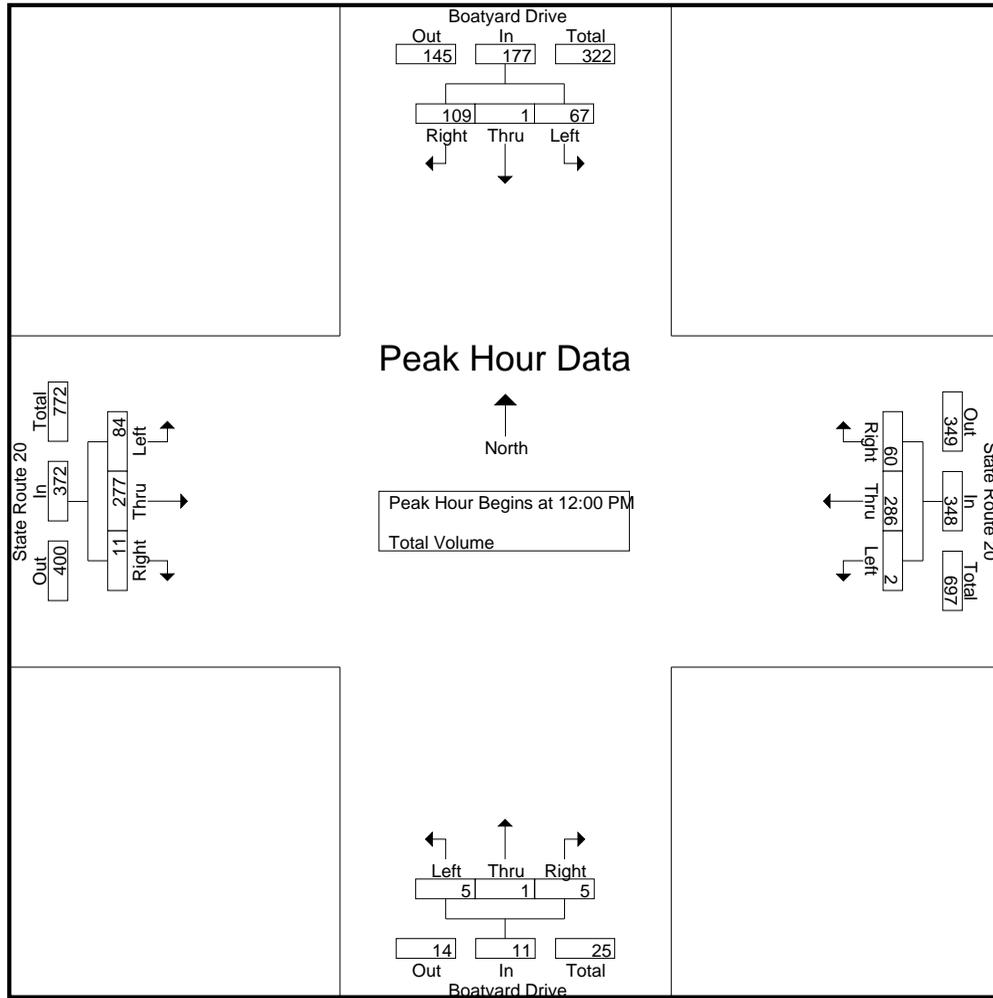
Start Time	Boatyard Drive Southbound				State Route 20 Westbound				Boatyard Drive Northbound				State Route 20 Eastbound				Int. Total
	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	Left	Thru	Right	App. Total	
12:00 PM	16	1	25	42	0	57	18	75	0	0	0	0	21	85	2	108	225
12:15 PM	12	0	25	37	1	81	21	103	3	0	0	3	14	63	2	79	222
12:30 PM	17	0	25	42	0	61	10	71	0	1	2	3	25	63	3	91	207
12:45 PM	22	0	34	56	1	87	11	99	2	0	3	5	24	66	4	94	254
Total Volume	67	1	109	177	2	286	60	348	5	1	5	11	84	277	11	372	908
% App. Total	37.9	0.6	61.6		0.6	82.2	17.2		45.5	9.1	45.5		22.6	74.5	3		
PHF	.761	.250	.801	.790	.500	.822	.714	.845	.417	.250	.417	.550	.840	.815	.688	.861	.894

Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1

Peak Hour for Entire Intersection Begins at 12:00 PM

City of Fort Bragg
 N/S: Boatyard Drive
 E/W: State Route 20
 Weather: Sunny

File Name : FBG_Boatyard_SR-20 MD
 Site Code : 99913282
 Start Date : 8/24/2013
 Page No : 2



Peak Hour Analysis From 11:00 AM to 12:45 PM - Peak 1 of 1
 Peak Hour for Each Approach Begins at:

	12:00 PM				11:30 AM				12:00 PM				11:15 AM			
+0 mins.	16	1	25	42	0	68	21	89	0	0	0	0	22	66	2	90
+15 mins.	12	0	25	37	2	78	15	95	3	0	0	3	21	63	0	84
+30 mins.	17	0	25	42	0	57	18	75	0	1	2	3	27	70	1	98
+45 mins.	22	0	34	56	1	81	21	103	2	0	3	5	21	85	2	108
Total Volume	67	1	109	177	3	284	75	362	5	1	5	11	91	284	5	380
% App. Total	37.9	0.6	61.6		0.8	78.5	20.7		45.5	9.1	45.5		23.9	74.7	1.3	
PHF	.761	.250	.801	.790	.375	.877	.893	.879	.417	.250	.417	.550	.843	.835	.625	.880

Location: Fort Bragg
 N/S: Boatyard Drive
 E/W: State Route 20



Date: 8/22/2013
 File : FBGBYSR20

WEEKDAY

	North Leg State Route 20	East Leg Boatyard Drive	South Leg State Route 20	West Leg Boatyard Drive	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
7:00 AM	0	0	0	0	0
7:15 AM	0	0	0	1	1
7:30 AM	0	0	0	0	0
7:45 AM	0	0	0	0	0
8:00 AM	0	0	0	0	0
8:15 AM	0	0	0	0	0
8:30 AM	0	0	0	0	0
8:45 AM	0	0	0	0	0
TOTAL VOLUMES:	0	0	0	1	1

	North Leg State Route 20	East Leg Boatyard Drive	South Leg State Route 20	West Leg Boatyard Drive	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
4:00 PM	1	1	0	0	2
4:15 PM	0	0	0	1	1
4:30 PM	0	0	0	0	0
4:45 PM	0	0	0	0	0
5:00 PM	0	0	0	0	0
5:15 PM	0	0	0	0	0
5:30 PM	0	0	0	0	0
5:45 PM	1	0	0	0	1
TOTAL VOLUMES:	2	1	0	1	4

SATURDAY

Date: 8/24/2013

	North Leg State Route 20	East Leg Boatyard Drive	South Leg State Route 20	West Leg Boatyard Drive	TOTAL
	Pedestrians	Pedestrians	Pedestrians	Pedestrians	
11:00 AM	0	0	2	2	4
11:15 AM	0	0	1	1	2
11:30 AM	0	0	0	2	2
11:45 AM	0	0	0	0	0
12:00 PM	0	0	0	0	0
12:15 PM	0	0	0	0	0
12:30 PM	0	0	0	0	0
12:45 PM	0	0	0	0	0
TOTAL VOLUMES:	0	0	3	5	8

Location: Fort Bragg
 N/S: Boatyard Drive
 E/W: State Route 20



Date: 8/22/2013
 File : FBGBYSR20

	North Leg State Route 20	East Leg Boatyard Drive	South Leg State Route 20	West Leg Boatyard Drive	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
7:00 AM	0	0	0	0	0
7:15 AM	0	0	0	0	0
7:30 AM	0	0	0	0	0
7:45 AM	0	0	0	0	0
8:00 AM	0	0	0	0	0
8:15 AM	0	0	0	0	0
8:30 AM	0	0	0	0	0
8:45 AM	0	0	0	0	0
TOTAL VOLUMES:	0	0	0	0	0

	North Leg State Route 20	East Leg Boatyard Drive	South Leg State Route 20	West Leg Boatyard Drive	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
4:00 PM	0	0	0	0	0
4:15 PM	0	1	1	0	2
4:30 PM	0	0	0	0	0
4:45 PM	2	0	1	0	3
5:00 PM	0	0	0	0	0
5:15 PM	1	0	0	0	1
5:30 PM	0	1	0	0	1
5:45 PM	0	0	0	3	3
TOTAL VOLUMES:	3	2	2	3	10

SATURDAY

Date: 8/24/2013

	North Leg State Route 20	East Leg Boatyard Drive	South Leg State Route 20	West Leg Boatyard Drive	TOTAL
	Bicycles	Bicycles	Bicycles	Bicycles	
11:00 AM	0	0	0	1	1
11:15 AM	0	0	0	0	0
11:30 AM	0	1	2	0	3
11:45 AM	1	0	0	0	1
12:00 PM	0	0	0	0	0
12:15 PM	0	0	1	0	1
12:30 PM	0	0	0	0	0
12:45 PM	0	0	1	0	1
TOTAL VOLUMES:	1	1	4	1	7

Appendix D - Existing Conditions Scenario Level of Service and Queue Calculations

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing PM Peak Hour



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	72	41	23	17	200	36	845	243	988
v/c Ratio	0.28	0.15	0.09	0.07	0.36	0.18	0.67	0.70	0.49
Control Delay	27.8	16.2	25.4	25.2	12.0	28.8	17.6	39.4	9.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	27.8	16.2	25.4	25.2	12.0	28.8	17.6	39.4	9.8
Queue Length 50th (ft)	23	5	7	5	31	11	126	79	70
Queue Length 95th (ft)	57	27	27	22	85	40	192	#226	207
Internal Link Dist (ft)		199		278			517		601
Turn Bay Length (ft)	100		150			350		400	
Base Capacity (vph)	1265	1219	1265	1265	562	243	2208	347	2237
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.03	0.02	0.01	0.36	0.15	0.38	0.70	0.44

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Queues
3: Hwy 1 & Hwy 20



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	221	230	645	155	267	724
v/c Ratio	0.57	0.44	0.59	0.27	0.76	0.76
Control Delay	27.3	6.5	18.4	4.1	46.7	17.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	27.3	6.5	18.4	4.1	46.7	17.3
Queue Length 50th (ft)	68	0	94	0	48	177
Queue Length 95th (ft)	150	49	160	33	#132	344
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	1027	989	1739	835	350	1295
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.22	0.23	0.37	0.19	0.76	0.56

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Intersection												
Intersection Delay, s/veh	1.6											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	14	0	13	5	0	17	8	1014	11	28	1054	44
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	3	3	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	84	84	84	79	79	79	96	96	96	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	17	0	15	6	0	22	8	1056	11	30	1146	48
Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1775	2314	600	1713	2333	537	1193	0	0	1068	0	0
Stage 1	1230	1230	-	1079	1079	-	-	-	-	-	-	-
Stage 2	545	1084	-	634	1254	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	52	37	444	58	36	488	533	-	-	577	-	-
Stage 1	188	248	-	233	293	-	-	-	-	-	-	-
Stage 2	490	291	-	434	242	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	47	35	443	53	34	487	532	-	-	576	-	-
Mov Capacity-2 Maneuver	47	35	-	53	34	-	-	-	-	-	-	-
Stage 1	185	235	-	229	289	-	-	-	-	-	-	-
Stage 2	460	287	-	396	229	-	-	-	-	-	-	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	73.5			30.3			0.1			0.3		
HCM LOS	F			D								
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	532	-	-	83	170	576	-	-				
HCM Lane V/C Ratio	0.016	-	-	0.387	0.164	0.053	-	-				
HCM Control Delay (s)	11.875	-	-	73.5	30.3	11.598	-	-				
HCM Lane LOS	B			F		D		B				
HCM 95th %tile Q(veh)	0.048	-	-	1.529	0.569	0.167	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing PM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	58	13	20	20	15	174	35	784	27	211	780	79
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	0.99		0.98	0.99		0.99	1.00		0.98	1.00		0.98
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	190.0	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	0	1	1	1	1	2	0	1	2	0
Cap, veh/h	308	118	185	324	340	562	59	1327	45	273	1563	159
Arrive On Green	0.18	0.18	0.18	0.18	0.18	0.18	0.04	0.40	0.40	0.17	0.53	0.53
Sat Flow, veh/h	1153	647	1011	1350	1863	1570	1630	3288	113	1573	2945	299
Grp Volume(v), veh/h	72	0	41	23	17	200	36	425	420	243	503	485
Grp Sat Flow(s),veh/h/ln	1153	0	1658	1350	1863	1570	1630	1712	1688	1573	1652	1591
Q Serve(g_s), s	3.7	0.0	1.4	1.0	0.5	6.4	1.5	13.4	13.4	10.2	14.0	14.0
Cycle Q Clear(g_c), s	4.2	0.0	1.4	2.4	0.5	6.4	1.5	13.4	13.4	10.2	14.0	14.0
Prop In Lane	1.00		0.61	1.00		1.00	1.00		0.07	1.00		0.19
Lane Grp Cap(c), veh/h	308	0	303	324	340	562	59	691	681	273	877	845
V/C Ratio(X)	0.23	0.00	0.14	0.07	0.05	0.36	0.61	0.62	0.62	0.89	0.57	0.57
Avail Cap(c_a), veh/h	776	0	977	874	1098	1200	192	930	918	273	973	938
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	24.6	0.0	23.3	24.3	22.9	16.1	32.2	16.1	16.1	27.4	10.7	10.7
Incr Delay (d2), s/veh	0.4	0.0	0.2	0.1	0.1	0.4	9.7	0.9	0.9	27.8	0.7	0.7
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	1.1	0.0	0.6	0.3	0.2	2.4	0.7	5.1	5.1	5.9	4.8	4.6
Lane Grp Delay (d), s/veh	25.0	0.0	23.5	24.4	23.0	16.5	41.9	17.0	17.0	55.2	11.4	11.4
Lane Grp LOS	C		C	C	C	B	D	B	B	E	B	B
Approach Vol, veh/h		113			240			881			1231	
Approach Delay, s/veh		24.5			17.7			18.0			20.1	
Approach LOS		C			B			B			C	
Timer												
Assigned Phs		4			8		5	2		1	6	
Phs Duration (G+Y+Rc), s		17.6			17.6		8.4	33.3		17.0	41.9	
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2	5.9	
Max Green Setting (Gmax), s		40.0			40.0		8.0	36.9		11.8	40.0	
Max Q Clear Time (g_c+I1), s		6.2			8.4		3.5	15.4		12.2	16.0	
Green Ext Time (p_c), s		1.3			1.3		0.0	12.0		0.0	12.8	
Intersection Summary												
HCM 2010 Ctrl Delay				19.3								
HCM 2010 LOS				B								
Notes												

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	219	228	632	152	232	630
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	280	250	1259	535	373	1046
Arrive On Green	0.17	0.00	0.37	0.00	0.11	0.59
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	221	0	645	0	267	724
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	6.9	0.0	7.7	0.0	4.2	14.9
Cycle Q Clear(g_c), s	6.9	0.0	7.7	0.0	4.2	14.9
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	280	250	1259	535	373	1046
V/C Ratio(X)	0.79	0.00	0.51	0.00	0.72	0.69
Avail Cap(c_a), veh/h	1106	987	1965	835	377	1398
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	20.8	0.0	13.0	0.0	22.5	7.3
Incr Delay (d2), s/veh	4.9	0.0	0.3	0.0	6.3	0.9
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	2.8	0.0	2.7	0.0	1.8	4.7
Lane Grp Delay (d), s/veh	25.8	0.0	13.3	0.0	28.7	8.3
Lane Grp LOS	C		B		C	A
Approach Vol, veh/h	221		645			991
Approach Delay, s/veh	25.8		13.3			13.8
Approach LOS	C		B			B
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			25.2		11.9	37.2
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.2		6.1	41.8
Max Q Clear Time (g_c+I1), s			9.7		6.2	16.9
Green Ext Time (p_c), s			9.3		0.0	10.2
Intersection Summary						
HCM 2010 Ctrl Delay			15.0			
HCM 2010 LOS			B			
Notes						

Intersection												
Intersection Delay, s/veh	5.1											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	91	252	5	0	319	52	2	1	3	69	0	139
Conflicting Peds, #/hr	1	0	0	0	0	1	1	0	1	1	0	1
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	93	93	93	38	38	38	88	88	88
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	101	280	6	0	343	56	5	3	8	78	0	158
Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	400	0	0	287	0	0	858	886	285	859	861	373
Stage 1	-	-	-	-	-	-	486	486	-	372	372	-
Stage 2	-	-	-	-	-	-	372	400	-	487	489	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1077	-	-	1220	-	-	277	284	754	277	293	673
Stage 1	-	-	-	-	-	-	563	551	-	648	619	-
Stage 2	-	-	-	-	-	-	648	602	-	562	549	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1076	-	-	1219	-	-	196	257	753	252	265	672
Mov Capacity-2 Maneuver	-	-	-	-	-	-	196	257	-	252	265	-
Stage 1	-	-	-	-	-	-	510	499	-	587	618	-
Stage 2	-	-	-	-	-	-	495	601	-	501	497	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	2.3			0			16.3			17.5		
HCM LOS	C			C			C			C		
Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2		
Capacity (veh/h)	259	753	1076	-	-	1219	-	-	336	672		
HCM Lane V/C Ratio	0.041	0.007	0.094	-	-	-	-	-	0.39	0.157		
HCM Control Delay (s)	19.5	9.8	8.692	-	-	0	-	-	22.4	11.4		
HCM Lane LOS	C	A	A	-	-	A	-	-	C	B		
HCM 95th %tile Q(veh)	0.127	0.021	0.31	-	-	0	-	-	1.793	0.553		
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

Intersection						
Intersection Delay, s/veh	9.6					
Intersection LOS	A					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2		2	
Conflicting Circle Lanes	2	2	2		2	
Adj Approach Flow, veh/h	36	155	770		965	
Demand Flow Rate, veh/h	37	158	855		1042	
Vehicles Circulating, veh/h	1059	802	292		37	
Vehicles Exiting, veh/h	20	345	803		923	
Follow-Up Headway, s	3.186	3.186	3.186		3.186	
Ped Vol Crossing Leg, #/h	0	0	0		0	
Ped Cap Adj	1.000	1.000	1.000		1.000	
Approach Delay, s/veh	7.7	8.8	10.5		9.1	
Approach LOS	A	A	B		A	
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	37	158	402	453	490	552
Cap Entry Lane, veh/h	538	645	908	921	1099	1101
Entry HV Adj Factor	0.971	0.981	0.901	0.901	0.926	0.927
Flow Entry, veh/h	36	155	362	408	454	511
Cap Entry, veh/h	523	632	818	830	1017	1020
V/C Ratio	0.069	0.245	0.443	0.492	0.446	0.501
Control Delay, s/veh	7.7	8.8	10.1	10.9	8.6	9.5
LOS	A	A	B	B	A	A
95th %tile Queue, veh	0	1	2	3	2	3

Intersection

Intersection Delay, s/veh -

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0

Major/Minor	Minor1	Major1	Major2
Conflicting Flow All	0	0	0
Stage 1	0	-	-
Stage 2	0	-	-
Follow-up Headway	3.518	3.318	2.218
Pot Capacity-1 Maneuver	-	-	-
Stage 1	-	-	-
Stage 2	-	-	-
Time blocked-Platoon, %	-	-	-
Mov Capacity-1 Maneuver	-	-	-
Mov Capacity-2 Maneuver	-	-	-
Stage 1	-	-	-
Stage 2	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s	0	0	0
HCM LOS	A		

Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)	-	-	+	-	-
HCM Lane V/C Ratio	-	-	+	-	-
HCM Control Delay (s)	-	-	0	0	-
HCM Lane LOS			A	A	
HCM 95th %tile Q(veh)	-	-	+	-	-

Notes

~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing Weekend Midday Peak Hour



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	51	42	45	19	201	23	785	211	772
v/c Ratio	0.21	0.16	0.18	0.08	0.35	0.11	0.66	0.58	0.36
Control Delay	25.0	15.3	24.6	23.4	9.8	25.3	17.5	30.6	6.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.0	15.3	24.6	23.4	9.8	25.3	17.5	30.6	6.8
Queue Length 50th (ft)	15	5	13	6	26	7	111	63	46
Queue Length 95th (ft)	45	29	41	23	73	27	172	#173	154
Internal Link Dist (ft)		199		278			517		601
Turn Bay Length (ft)	100		150			350		400	
Base Capacity (vph)	1336	1286	1336	1336	577	254	2323	361	2374
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.03	0.03	0.01	0.35	0.09	0.34	0.58	0.33

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Queues
3: Hwy 1 & Hwy 20

Hare Creek Center Project Traffic Study
Existing Weekend Midday Peak Hour



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	185	226	615	175	229	580
v/c Ratio	0.51	0.46	0.60	0.31	0.58	0.61
Control Delay	24.5	6.6	18.4	4.5	32.7	12.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	24.5	6.6	18.4	4.5	32.7	12.4
Queue Length 50th (ft)	50	0	82	0	35	108
Queue Length 95th (ft)	109	40	145	35	#97	240
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	1117	1056	1879	902	393	1409
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.17	0.21	0.33	0.19	0.58	0.41

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Intersection												
Intersection Delay, s/veh	1.1											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	7	0	10	6	1	19	4	972	19	23	871	31
Conflicting Peds, #/hr	2	0	1	1	0	2	1	0	6	6	0	1
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	85	85	85	59	59	59	95	95	95	90	90	90
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	8	0	12	10	2	32	4	1023	20	26	968	34
Major/Minor	Minor2		Minor1			Major1			Major2			
Conflicting Flow All	1561	2092	509	1581	2099	530	1004	0	0	1045	0	0
Stage 1	1038	1038	-	1044	1044	-	-	-	-	-	-	-
Stage 2	523	1054	-	537	1055	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	76	52	509	73	51	493	634	-	-	589	-	-
Stage 1	247	306	-	245	304	-	-	-	-	-	-	-
Stage 2	505	301	-	496	301	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	66	49	506	68	48	490	631	-	-	586	-	-
Mov Capacity-2 Maneuver	66	49	-	68	48	-	-	-	-	-	-	-
Stage 1	245	292	-	243	302	-	-	-	-	-	-	-
Stage 2	464	299	-	461	287	-	-	-	-	-	-	-
Approach	EB		WB			NB			SB			
HCM Control Delay, s	36.3		32.2			0			0.3			
HCM LOS	E		D									
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	631	-	-	135	176	586	-	-				
HCM Lane V/C Ratio	0.007	-	-	0.148	0.25	0.044	-	-				
HCM Control Delay (s)	10.744	-	-	36.3	32.2	11.423	-	-				
HCM Lane LOS	B		E			D		B				
HCM 95th %tile Q(veh)	0.02	-	-	0.504	0.948	0.137	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing Weekend Midday Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	45	14	23	40	17	179	22	712	34	194	668	42
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		1.00	1.00		0.97	1.00		0.97
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	190.0	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	0	1	1	1	1	2	0	1	2	0
Cap, veh/h	301	103	168	315	305	513	43	1290	62	253	1599	101
Arrive On Green	0.16	0.16	0.16	0.16	0.16	0.16	0.03	0.40	0.40	0.16	0.52	0.52
Sat Flow, veh/h	1155	633	1028	1357	1863	1580	1630	3236	155	1573	3069	194
Grp Volume(v), veh/h	51	0	42	45	19	201	23	396	389	211	391	381
Grp Sat Flow(s),veh/h/ln	1155	0	1661	1357	1863	1580	1630	1712	1679	1573	1652	1612
Q Serve(g_s), s	2.3	0.0	1.3	1.7	0.5	5.8	0.8	10.7	10.7	7.6	8.7	8.7
Cycle Q Clear(g_c), s	2.8	0.0	1.3	3.0	0.5	5.8	0.8	10.7	10.7	7.6	8.7	8.7
Prop In Lane	1.00		0.62	1.00		1.00	1.00		0.09	1.00		0.12
Lane Grp Cap(c), veh/h	301	0	272	315	305	513	43	682	670	253	861	840
V/C Ratio(X)	0.17	0.00	0.15	0.14	0.06	0.39	0.53	0.58	0.58	0.83	0.45	0.45
Avail Cap(c_a), veh/h	897	0	1129	1015	1266	1329	222	1073	1053	316	1123	1096
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	22.0	0.0	21.1	22.4	20.8	15.4	28.3	13.8	13.8	23.9	8.8	8.8
Incr Delay (d2), s/veh	0.3	0.0	0.3	0.2	0.1	0.5	9.7	0.8	0.8	14.4	0.4	0.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.6	0.0	0.5	0.6	0.2	2.1	0.4	4.0	3.9	3.8	2.9	2.8
Lane Grp Delay (d), s/veh	22.2	0.0	21.4	22.6	20.9	15.9	37.9	14.6	14.6	38.3	9.2	9.2
Lane Grp LOS	C		C	C	C	B	D	B	B	D	A	A
Approach Vol, veh/h		93			265			808			983	
Approach Delay, s/veh		21.9			17.4			15.3			15.5	
Approach LOS		C			B			B			B	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		14.8			14.8		7.5	29.4		14.7		36.6
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		8.0	36.9		11.8		40.0
Max Q Clear Time (g_c+I1), s		4.8			7.8		2.8	12.7		9.6		10.7
Green Ext Time (p_c), s		1.4			1.4		0.0	10.5		0.1		11.3
Intersection Summary												
HCM 2010 Ctrl Delay				15.9								
HCM 2010 LOS				B								
Notes												

HCM 2010 Signalized Intersection Summary
3: Hwy 1 & Hwy 20

Hare Creek Center Project Traffic Study
Existing Weekend Midday Peak Hour

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	159	194	566	161	215	545
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	240	214	1220	519	347	1037
Arrive On Green	0.15	0.00	0.36	0.00	0.11	0.59
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	185	0	615	0	229	580
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	5.1	0.0	6.6	0.0	3.2	9.4
Cycle Q Clear(g_c), s	5.1	0.0	6.6	0.0	3.2	9.4
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	240	214	1220	519	347	1037
V/C Ratio(X)	0.77	0.00	0.50	0.00	0.66	0.56
Avail Cap(c_a), veh/h	1247	1113	2202	936	439	1577
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	19.1	0.0	11.8	0.0	20.0	5.9
Incr Delay (d2), s/veh	5.2	0.0	0.3	0.0	2.5	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	2.1	0.0	2.3	0.0	1.2	2.7
Lane Grp Delay (d), s/veh	24.2	0.0	12.1	0.0	22.5	6.3
Lane Grp LOS	C		B		C	A
Approach Vol, veh/h	185		615			809
Approach Delay, s/veh	24.2		12.1			10.9
Approach LOS	C		B			B
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			22.5		10.9	33.4
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.0		6.3	41.8
Max Q Clear Time (g_c+I1), s			8.6		5.2	11.4
Green Ext Time (p_c), s			8.0		0.1	9.0
Intersection Summary						
HCM 2010 Ctrl Delay			12.9			
HCM 2010 LOS			B			
Notes						

Intersection

Intersection Delay, s/veh 5.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	84	277	11	2	286	60	5	1	5	67	1	109
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	86	86	86	85	85	85	55	55	55	79	79	79
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	98	322	13	2	336	71	9	2	9	85	1	138

Major/Minor	Major1	Major2	Minor1	Minor2
Conflicting Flow All	407	0	0	335
Stage 1	-	-	-	-
Stage 2	-	-	-	-
Follow-up Headway	2.362	-	-	2.308
Pot Capacity-1 Maneuver	1070	-	-	1170
Stage 1	-	-	-	-
Stage 2	-	-	-	-
Time blocked-Platoon, %	-	-	-	-
Mov Capacity-1 Maneuver	1070	-	-	1170
Mov Capacity-2 Maneuver	-	-	-	-
Stage 1	-	-	-	-
Stage 2	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	2	0	17.9	19.6
HCM LOS			C	C

Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2
Capacity (veh/h)	235	713	1070	-	-	1170	-	-	305	674
HCM Lane V/C Ratio	0.059	0.009	0.091	-	-	0.002	-	-	0.433	0.136
HCM Control Delay (s)	21.3	10.1	8.702	-	-	8.083	-	-	25.5	11.2
HCM Lane LOS	C	B	A			A			D	B
HCM 95th %tile Q(veh)	0.188	0.026	0.301	-	-	0.006	-	-	2.089	0.471

Notes

~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection						
Intersection Delay, s/veh	8.9					
Intersection LOS	A					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2		2	
Conflicting Circle Lanes	2	2	2		2	
Adj Approach Flow, veh/h	35	269	675		808	
Demand Flow Rate, veh/h	35	274	749		872	
Vehicles Circulating, veh/h	917	705	239		80	
Vehicles Exiting, veh/h	35	283	713		899	
Follow-Up Headway, s	3.186	3.186	3.186		3.186	
Ped Vol Crossing Leg, #/h	0	2	1		6	
Ped Cap Adj	1.000	1.000	0.999		0.994	
Approach Delay, s/veh	6.8	10.8	8.9		8.3	
Approach LOS	A	B	A		A	
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	35	274	352	397	410	462
Cap Entry Lane, veh/h	595	690	945	956	1064	1068
Entry HV Adj Factor	0.995	0.981	0.902	0.902	0.926	0.927
Flow Entry, veh/h	35	269	317	358	380	428
Cap Entry, veh/h	592	677	851	861	979	984
V/C Ratio	0.059	0.397	0.373	0.416	0.388	0.435
Control Delay, s/veh	6.8	10.8	8.6	9.2	7.9	8.6
LOS	A	B	A	A	A	A
95th %tile Queue, veh	0	2	2	2	2	2

Intersection						
Intersection Delay, s/veh	-					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0
Major/Minor	Minor1	Major1		Major2		
Conflicting Flow All	0	0	0	0	0	0
Stage 1	0	-	-	-	-	-
Stage 2	0	-	-	-	-	-
Follow-up Headway	3.518	3.318	-	-	2.218	-
Pot Capacity-1 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Time blocked-Platoon, %			-	-		-
Mov Capacity-1 Maneuver	-	-	-	-	-	-
Mov Capacity-2 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Approach	WB	NB		SB		
HCM Control Delay, s	0	0		0		
HCM LOS	A					
Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT	
Capacity (veh/h)	-	-	+	-	-	
HCM Lane V/C Ratio	-	-	+	-	-	
HCM Control Delay (s)	-	-	0	0	-	
HCM Lane LOS			A	A		
HCM 95th %tile Q(veh)	-	-	+	-	-	
Notes						
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined						

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing AM Peak Hour



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	34	34	31	14	106	23	757	136	684
v/c Ratio	0.14	0.14	0.13	0.06	0.21	0.11	0.56	0.40	0.29
Control Delay	23.7	14.6	23.7	22.9	6.4	24.1	14.4	23.3	5.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	23.7	14.6	23.7	22.9	6.4	24.1	14.4	23.3	5.7
Queue Length 50th (ft)	10	3	9	4	7	7	103	37	37
Queue Length 95th (ft)	33	24	31	19	33	26	160	90	124
Internal Link Dist (ft)		199		278			517		601
Turn Bay Length (ft)	100		150			350		400	
Base Capacity (vph)	1396	1321	1396	1396	559	272	2434	388	2485
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.02	0.03	0.02	0.01	0.19	0.08	0.31	0.35	0.28

Intersection Summary

Queues
3: Hwy 1 & Hwy 20



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	82	237	534	80	209	463
v/c Ratio	0.29	0.53	0.56	0.17	0.47	0.48
Control Delay	20.0	8.2	16.3	4.8	23.7	8.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	20.0	8.2	16.3	4.8	23.7	8.5
Queue Length 50th (ft)	19	0	60	0	26	62
Queue Length 95th (ft)	52	46	106	22	60	136
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	1286	1182	2170	982	445	1596
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.20	0.25	0.08	0.47	0.29

Intersection Summary

Intersection												
Intersection Delay, s/veh	1.2											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	6	0	4	14	0	23	3	763	22	38	645	16
Conflicting Peds, #/hr	0	0	0	0	0	0	1	0	3	3	0	1
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	77	77	77	99	99	99	89	89	89
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	7	0	5	18	0	30	3	771	22	43	725	18
Major/Minor	Minor2		Minor1			Major1			Major2			
Conflicting Flow All	1210	1618	374	1236	1616	399	743	0	0	793	0	0
Stage 1	819	819	-	788	788	-	-	-	-	-	-	-
Stage 2	391	799	-	448	828	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	138	102	623	132	103	601	803	-	-	745	-	-
Stage 1	336	388	-	350	400	-	-	-	-	-	-	-
Stage 2	605	396	-	560	384	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	125	96	621	125	97	599	801	-	-	743	-	-
Mov Capacity-2 Maneuver	125	96	-	125	97	-	-	-	-	-	-	-
Stage 1	335	366	-	349	399	-	-	-	-	-	-	-
Stage 2	571	395	-	522	362	-	-	-	-	-	-	-
Approach	EB		WB			NB			SB			
HCM Control Delay, s	25.9		23.2			0			0.6			
HCM LOS	D		C									
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	801	-	-	184	246	743	-	-				
HCM Lane V/C Ratio	0.004	-	-	0.065	0.195	0.057	-	-				
HCM Control Delay (s)	9.511	-	-	25.9	23.2	10.14	-	-				
HCM Lane LOS	A		D			C		B				
HCM 95th %tile Q(veh)	0.011	-	-	0.208	0.708	0.183	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing AM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	30	9	21	28	13	95	21	677	19	120	575	27
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		1.00	1.00		0.98	1.00		0.97
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	190.0	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	0	1	1	1	1	2	0	1	2	0
Cap, veh/h	297	57	138	292	222	359	45	1397	40	170	1523	72
Arrive On Green	0.12	0.12	0.12	0.12	0.12	0.12	0.03	0.42	0.42	0.11	0.49	0.49
Sat Flow, veh/h	1264	481	1155	1366	1863	1579	1630	3310	94	1573	3125	148
Grp Volume(v), veh/h	34	0	34	31	14	106	23	381	376	136	345	339
Grp Sat Flow(s),veh/h/ln	1264	0	1636	1366	1863	1579	1630	1712	1693	1573	1652	1621
Q Serve(g_s), s	1.1	0.0	0.9	1.0	0.3	2.6	0.6	7.7	7.7	3.9	6.3	6.3
Cycle Q Clear(g_c), s	1.4	0.0	0.9	1.8	0.3	2.6	0.6	7.7	7.7	3.9	6.3	6.3
Prop In Lane	1.00		0.71	1.00		1.00	1.00		0.06	1.00		0.09
Lane Grp Cap(c), veh/h	297	0	195	292	222	359	45	722	714	170	805	790
V/C Ratio(X)	0.11	0.00	0.17	0.11	0.06	0.29	0.51	0.53	0.53	0.80	0.43	0.43
Avail Cap(c_a), veh/h	1235	0	1409	1305	1604	1531	281	1359	1344	400	1422	1395
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	18.8	0.0	18.4	19.2	18.2	14.9	22.3	10.0	10.0	20.2	7.7	7.7
Incr Delay (d2), s/veh	0.2	0.0	0.4	0.2	0.1	0.5	8.7	0.6	0.6	8.4	0.4	0.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.3	0.0	0.3	0.3	0.1	0.9	0.3	2.6	2.5	1.8	1.8	1.8
Lane Grp Delay (d), s/veh	19.0	0.0	18.8	19.4	18.3	15.3	30.9	10.6	10.6	28.6	8.1	8.1
Lane Grp LOS	B		B	B	B	B	C	B	B	C	A	A
Approach Vol, veh/h		68			151			780			820	
Approach Delay, s/veh		18.9			16.4			11.2			11.5	
Approach LOS		B			B			B			B	
Timer												
Assigned Phs		4			8		5	2		1	6	
Phs Duration (G+Y+Rc), s		10.7			10.7		7.2	25.5		10.2	28.5	
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2	5.9	
Max Green Setting (Gmax), s		40.0			40.0		8.0	36.9		11.8	40.0	
Max Q Clear Time (g_c+I1), s		3.4			4.6		2.6	9.7		5.9	8.3	
Green Ext Time (p_c), s		0.8			0.8		0.0	9.9		0.2	10.4	
Intersection Summary												
HCM 2010 Ctrl Delay				12.0								
HCM 2010 LOS				B								
Notes												

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	76	220	518	78	196	435
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	122	109	1178	501	374	1075
Arrive On Green	0.08	0.00	0.34	0.00	0.12	0.61
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	82	0	534	0	209	463
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	1.9	0.0	4.7	0.0	2.4	5.4
Cycle Q Clear(g_c), s	1.9	0.0	4.7	0.0	2.4	5.4
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	122	109	1178	501	374	1075
V/C Ratio(X)	0.67	0.00	0.45	0.00	0.56	0.43
Avail Cap(c_a), veh/h	1495	1335	2649	1126	518	1891
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	17.5	0.0	9.9	0.0	16.3	4.0
Incr Delay (d2), s/veh	6.3	0.0	0.3	0.0	1.3	0.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.8	0.0	1.5	0.0	0.9	1.2
Lane Grp Delay (d), s/veh	23.8	0.0	10.2	0.0	17.6	4.3
Lane Grp LOS	C		B		B	A
Approach Vol, veh/h	82		534			672
Approach Delay, s/veh	23.8		10.2			8.4
Approach LOS	C		B			A
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			19.3		10.4	29.7
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.1		6.2	41.8
Max Q Clear Time (g_c+I1), s			6.7		4.4	7.4
Green Ext Time (p_c), s			6.6		0.1	7.2
Intersection Summary						
HCM 2010 Ctrl Delay			10.1			
HCM 2010 LOS			B			
Notes						

Intersection												
Intersection Delay, s/veh	2.2											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	26	236	8	0	259	37	6	1	0	50	0	25
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	91	91	91	88	88	88	58	58	58	89	89	89
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	29	259	9	0	294	42	10	2	0	56	0	28
Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	336	0	0	268	0	0	636	657	264	637	640	315
Stage 1	-	-	-	-	-	-	321	321	-	315	315	-
Stage 2	-	-	-	-	-	-	315	336	-	322	325	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1139	-	-	1240	-	-	391	385	775	390	393	725
Stage 1	-	-	-	-	-	-	691	652	-	696	656	-
Stage 2	-	-	-	-	-	-	696	642	-	690	649	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1139	-	-	1240	-	-	369	375	775	381	383	725
Mov Capacity-2 Maneuver	-	-	-	-	-	-	369	375	-	381	383	-
Stage 1	-	-	-	-	-	-	673	635	-	678	656	-
Stage 2	-	-	-	-	-	-	669	642	-	671	632	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	0.8			0			15.1			14.3		
HCM LOS	C			A			C			B		
Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2		
Capacity (veh/h)	370	0	1139	-	-	1240	-	-	409	725		
HCM Lane V/C Ratio	0.033	+	0.025	-	-	-	-	-	0.16	0.026		
HCM Control Delay (s)	15.1	0	8.242	-	-	0	-	-	15.5	10.1		
HCM Lane LOS	C	A	A	-	-	A	-	-	C	B		
HCM 95th %tile Q(veh)	0.101	+	0.077	-	-	0	-	-	0.565	0.079		
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

Intersection						
Intersection Delay, s/veh	6.6					
Intersection LOS	A					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2	2		
Conflicting Circle Lanes	2	2	2	2		
Adj Approach Flow, veh/h	9	213	527	511		
Demand Flow Rate, veh/h	9	218	585	552		
Vehicles Circulating, veh/h	584	547	69	52		
Vehicles Exiting, veh/h	20	107	524	713		
Follow-Up Headway, s	3.186	3.186	3.186	3.186		
Ped Vol Crossing Leg, #/h	0	0	2	0		
Ped Cap Adj	1.000	1.000	0.998	1.000		
Approach Delay, s/veh	4.9	8.1	6.5	6.1		
Approach LOS	A	A	A	A		
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.469	0.531
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	9	218	275	310	259	293
Cap Entry Lane, veh/h	751	770	1073	1077	1087	1090
Entry HV Adj Factor	0.996	0.977	0.900	0.900	0.927	0.924
Flow Entry, veh/h	9	213	248	279	240	271
Cap Entry, veh/h	748	753	964	967	1008	1007
V/C Ratio	0.012	0.283	0.257	0.289	0.238	0.269
Control Delay, s/veh	4.9	8.1	6.3	6.7	5.9	6.2
LOS	A	A	A	A	A	A
95th %tile Queue, veh	0	1	1	1	1	1

Intersection						
Intersection Delay, s/veh	-					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0
Major/Minor	Minor1	Major1		Major2		
Conflicting Flow All	0	0	0	0	0	
Stage 1	0	-	-	-	-	
Stage 2	0	-	-	-	-	
Follow-up Headway	3.518	3.318	-	-	2.218	
Pot Capacity-1 Maneuver	-	-	-	-	-	
Stage 1	-	-	-	-	-	
Stage 2	-	-	-	-	-	
Time blocked-Platoon, %	-	-	-	-	-	
Mov Capacity-1 Maneuver	-	-	-	-	-	
Mov Capacity-2 Maneuver	-	-	-	-	-	
Stage 1	-	-	-	-	-	
Stage 2	-	-	-	-	-	
Approach	WB	NB		SB		
HCM Control Delay, s	0	0		0		
HCM LOS	A					
Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT	
Capacity (veh/h)	-	-	+	-	-	
HCM Lane V/C Ratio	-	-	+	-	-	
HCM Control Delay (s)	-	-	0	0	-	
HCM Lane LOS	-	-	A	A	-	
HCM 95th %tile Q(veh)	-	-	+	-	-	
Notes						
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined						

Appendix E - Trip Generation Calculations

Project Trip Generation Estimates for Weekday

Description	Proposed Land Use (ITE Code)	Net Size	Units	Daily Rate	Daily Trips	AM Peak Hour					PM Peak Hour						
						Peak Hour Rate	Splits		Trips		Peak Hour Rate	Splits		Trips		Total	
							Entering	Exiting	Entering	Exiting		Total	Entering	Exiting	Entering		Exiting
Hare Creek Center	Shopping Center (820) (1)	29.50	1,000 Gross Leaseable Area	104.73	3,090	2.53	62%	38%	47	29	76	9.01	48%	52%	128	139	267
					3,090				47	29	76				128	139	267

Project Trip Generation Estimates for Weekend Midday

Description	Proposed Land Use (ITE Code)	Size	Units	Daily Rate	Daily Trips	Midday Peak Hour					
						Peak Hour Rate	Splits		Trips		Total
							Entering	Exiting	Entering	Exiting	
Hare Creek Center	Shopping Center (820) (1)	29.50	1,000 Gross Leaseable Area	146.07	4,309	13.48	52%	48%	207	191	398
					4,309				207	191	398

(1) Shopping Center (820) rate is Fitted Curve Equation

Base Volume

Segment	Arterial	Location	Weekday																	
			ADT						AM Peak						PM Peak					
			Total	NB (EB)		SB (WB)		Total	NB (EB)		SB (WB)		Total	NB (EB)		SB (WB)				
1	SR 1 (south)	B/T Hare Creek Bridge & Int. 3	17,814	33.9%	8,839	34.1%	8,975	33.7%	1,098	34.3%	565	35.0%	533	33.7%	1,421	34.2%	667	34.3%	754	34.2%
2	SR 1 (north)	B/T Noyo Bridge & Int. 1	26,126	49.7%	12,906	49.8%	13,220	49.6%	1,575	49.3%	777	48.1%	798	50.4%	2,067	49.8%	956	49.2%	1,111	50.3%
3	SR 20 (east)	B/T S. Harbor Dr. & Int. 4	8,611	16.4%	4,177	16.1%	4,434	16.7%	524	16.4%	272	16.9%	252	15.9%	664	16.0%	322	16.6%	342	15.5%

Figure 3

Base Intersection Turning Movement Volumes - AM Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
1	SR 1 and Driveways	6	0	4	14	0	23	3	763	22	38	645	16	1534
2	SR 1 and Ocean View Drive	30	9	21	28	13	95	21	677	19	120	575	27	1635
3	SR 1 and SR 20	0	0	0	76	0	220	0	518	78	196	435	0	1523
4	SR 20 and Boatyard Drive	26	236	8	0	259	37	6	1	0	50	0	25	648
5	SR 1 and Simpson Lane	1	1	3	27	2	150	13	424	32	53	396	1	1103

Figure 3

Base Intersection Turning Movement Volumes - PM Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
1	SR 1 and Driveways	14	0	13	5	0	17	8	1014	11	28	1054	44	2208
2	SR 1 and Ocean View Drive	58	13	20	20	15	174	35	784	27	211	780	79	2216
3	SR 1 and SR 20	0	0	0	219	0	228	0	632	152	232	630	0	2093
4	SR 20 and Boatyard Drive	91	252	5	0	319	52	2	1	3	69	0	139	933
5	SR 1 and Simpson Lane	4	2	14	22	2	122	10	642	49	226	608	5	1706

Figure 3

Base Intersection Turning Movement Volumes - Weekend Midday Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
1	SR 1 and Driveways	7	0	10	6	1	19	4	972	19	23	871	31	1963
2	SR 1 and Ocean View Drive	45	14	23	40	17	179	22	712	34	194	668	42	1990
3	SR 1 and SR 20	0	0	0	159	0	194	0	566	161	215	545	0	1840
4	SR 20 and Boatyard Drive	84	277	11	2	286	60	5	1	5	67	1	109	908
5	SR 1 and Simpson Lane	5	5	9	39	8	182	20	557	44	178	523	2	1572

Project Trip Distribution %

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
1	SR 1 and Driveways	0%	0%	0%	0%	0%	0%	0%	50%	0%	0%	50%	0%
2	SR 1 and Ocean View Drive	50%	5%	45%	0%	5%	0%	45%	0%	0%	0%	0%	50%
3	SR 1 and SR 20	0%	0%	0%	0%	0%	11%	0%	34%	0%	11%	34%	0%
4	SR 20 and Boatyard Drive	0%	11%	0%	0%	11%	5%	0%	0%	0%	5%	0%	0%
5	SR 1 and Simpson Lane	0%	0%	0%	0%	0%	7%	0%	24%	0%	7%	24%	0%

Figure 5

Project Trip Assigment AM Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total	Entering	Exiting
1	SR 1 and Driveways	0	0	0	0	0	0	0	14.5	0	0	23.5	0	38	23.5	14.5
2	SR 1 and Ocean View Drive	15	1	13	0	2	0	21	0	0	0	0	24	76	47	29
3	SR 1 and SR 20	0	0	0	0	0	5	0	16	0	3	10	0	34	21	13
4	SR 20 and Boatyard Drive	0	3	0	0	5	0	0	0	0	1	0	0	10	5	5
5	SR 1 and Simpson Lane	0	0	0	0	0	3	0	11	0	2	7	0	24	15	9

Figure 5

Project Trip Assignment PM Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total	Entering	Exiting
1	SR 1 and Driveways	0	0	0	0	0	0	0	69.5	0	0	64	0	134	64	69.5
2	SR 1 and Ocean View Drive	70	7	63	0	6	0	58	0	0	0	0	64	267	128	139
3	SR 1 and SR 20	0	0	0	0	0	14	0	44	0	15	47	0	120	58	63
4	SR 20 and Boatyard Drive	0	15	0	0	14	0	0	0	0	7	0	0	36	14	22
5	SR 1 and Simpson Lane	0	0	0	0	0	9	0	31	0	10	33	0	83	40	43

Figure 5

Project Trip Assignment Midday Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total	Entering	Exiting
1	SR 1 and Driveways	0	0	0	0	0	0	0	95.5	0	0	103.5	0	199	103.5	95.5
2	SR 1 and Ocean View Drive	96	10	86	0	10	0	93	0	0	0	0	104	398	207	191
3	SR 1 and SR 20	0	0	0	0	0	23	0	70	0	21	65	0	179	93	86
4	SR 20 and Boatyard Drive	0	21	0	0	23	0	0	0	0	10	0	0	53	23	31
5	SR 1 and Simpson Lane	0	0	0	0	0	14	0	50	0	13	46	0	123	64	59

Figure 6

Existing Plus Project AM Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total	check
1	SR 1 and Driveways	6	0	4	14	0	23	3	778	22	38	669	16	1572	0
2	SR 1 and Ocean View Drive	45	10	34	28	15	95	42	677	19	120	575	51	1711	0
3	SR 1 and SR 20	0	0	0	76	0	225	0	534	78	199	445	0	1557	0
4	SR 20 and Boatyard Drive	26	239	8	0	264	37	6	1	0	51	0	25	658	0
5	SR 1 and Simpson Lane	1	1	3	27	2	153	13	435	32	55	403	1	1127	0

Figure 6

Existing Plus Project PM Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total	check
1	SR 1 and Driveways	14	0	13	5	0	17	8	1,084	11	28	1,118	44	2342	0
2	SR 1 and Ocean View Drive	128	20	83	20	21	174	93	784	27	211	780	143	2483	0
3	SR 1 and SR 20	0	0	0	219	0	242	0	676	152	247	677	0	2213	0
4	SR 20 and Boatyard Drive	91	267	5	0	333	52	2	1	3	76	0	139	969	0
5	SR 1 and Simpson Lane	4	2	14	22	2	131	10	673	49	236	641	5	1789	0

Figure 6

Existing Plus Project Midday Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total	check
1	SR 1 and Driveways	7	0	10	6	1	19	4	1,068	19	23	975	31	2162	0
2	SR 1 and Ocean View Drive	141	24	109	40	27	179	115	712	34	194	668	146	2388	0
3	SR 1 and SR 20	0	0	0	159	0	217	0	636	161	236	610	0	2019	0
4	SR 20 and Boatyard Drive	84	298	11	2	309	60	5	1	5	77	1	109	961	0
5	SR 1 and Simpson Lane	5	5	9	39	8	196	20	607	44	191	569	2	1695	0

Figure 7

Future AM

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
1	SR 1 and Driveways	7	0	5	16	0	27	4	878	25	44	742	18	1765
2	SR 1 and Ocean View Drive	35	10	24	32	15	109	24	779	22	138	661	31	1881
3	SR 1 and SR 20	0	0	0	80	0	231	0	596	90	225	500	0	1722
4	SR 20 and Boatyard Drive	27	248	8	0	272	39	6	1	0	53	0	26	681
5	SR 1 and Simpson Lane	1	1	4	31	2	173	15	488	37	61	455	1	1269

Figure 7

Future PM

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
1	SR 1 and Driveways	16	0	15	6	0	20	9	1,167	13	32	1,212	51	2540
2	SR 1 and Ocean View Drive	67	15	23	23	17	200	40	902	31	243	897	91	2549
3	SR 1 and SR 20	0	0	0	230	0	239	0	727	175	267	725	0	2362
4	SR 20 and Boatyard Drive	96	265	5	0	335	55	2	1	3	73	0	146	980
5	SR 1 and Simpson Lane	5	2	16	25	2	140	12	738	56	260	699	6	1962

Figure 7

Future Midday

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
1	SR 1 and Driveways	8	0	12	7	1	22	5	1,118	22	27	1,002	36	2258
2	SR 1 and Ocean View Drive	52	16	27	46	20	206	25	819	39	223	768	48	2289
3	SR 1 and SR 20	0	0	0	167	0	204	0	651	185	247	627	0	2081
4	SR 20 and Boatyard Drive	88	291	12	2	300	63	5	1	5	70	1	115	954
5	SR 1 and Simpson Lane	6	6	10	45	9	209	23	641	51	205	602	2	1808

Figure 8

Future Plus Project AM Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
1	SR 1 and Driveways	7	0	5	16	0	27	4	893	25	44	765	18	1803
2	SR 1 and Ocean View Drive	49	12	37	32	17	109	45	779	22	138	661	55	1957
3	SR 1 and SR 20	0	0	0	80	0	236	0	612	90	229	510	0	1756
4	SR 20 and Boatyard Drive	27	251	8	0	277	39	6	1	0	54	0	26	690
5	SR 1 and Simpson Lane	1	1	4	31	2	176	15	499	37	63	462	1	1292

check

0

0

0

0

0

Figure 8

Future Plus Project PM Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
1	SR 1 and Driveways	16	0	15	6	0	20	9	1,237	13	32	1,276	51	2674
2	SR 1 and Ocean View Drive	136	22	86	23	24	200	98	902	31	243	897	155	2816
3	SR 1 and SR 20	0	0	0	230	0	253	0	770	175	282	772	0	2482
4	SR 20 and Boatyard Drive	96	280	5	0	349	55	2	1	3	79	0	146	1016
5	SR 1 and Simpson Lane	5	2	16	25	2	149	12	769	56	270	733	6	2045

check

0

0

0

0

0

Figure 8

Future Plus Project Midday Peak Hour

Intersection	Location	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	Total
1	SR 1 and Driveways	8	0	12	7	1	22	5	1,214	22	27	1,105	36	2457
2	SR 1 and Ocean View Drive	147	26	112	46	30	206	118	819	39	223	768	152	2687
3	SR 1 and SR 20	0	0	0	167	0	226	0	721	185	268	692	0	2260
4	SR 20 and Boatyard Drive	88	312	12	2	323	63	5	1	5	80	1	115	1007
5	SR 1 and Simpson Lane	6	6	10	45	9	224	23	690	51	218	647	2	1931

check

0

0

0

0

0

Appendix F - Existing Plus Project Conditions Scenario Level of Service and Queue Calculations

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing+Project PM Peak Hour



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	158	25	102	23	24	200	97	845	243	1061
v/c Ratio	0.51	0.08	0.28	0.07	0.08	0.34	0.51	0.64	0.89	0.76
Control Delay	33.5	26.1	8.6	26.2	26.2	12.9	43.3	18.8	66.5	19.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	33.5	26.1	8.6	26.2	26.2	12.9	43.3	18.8	66.5	19.5
Queue Length 50th (ft)	62	9	0	8	9	40	40	142	103	180
Queue Length 95th (ft)	113	27	30	28	29	91	#114	224	#270	271
Internal Link Dist (ft)		199			278			517		601
Turn Bay Length (ft)	100		100	150			350		400	
Base Capacity (vph)	1036	1103	963	1036	1036	583	194	1767	274	1814
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.15	0.02	0.11	0.02	0.02	0.34	0.50	0.48	0.89	0.58

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Queues
3: Hwy 1 & Hwy 20

Hare Creek Center Project Traffic Study
Existing+Project PM Peak Hour



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	221	244	690	155	284	778
v/c Ratio	0.60	0.48	0.55	0.24	0.88	0.78
Control Delay	30.4	7.0	17.2	3.8	61.8	17.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	30.4	7.0	17.2	3.8	61.8	17.9
Queue Length 50th (ft)	80	1	103	0	58	201
Queue Length 95th (ft)	150	51	172	33	#142	393
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	948	935	1605	783	323	1195
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.23	0.26	0.43	0.20	0.88	0.65

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Intersection												
Intersection Delay, s/veh	1.8											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	14	0	13	5	0	17	8	1084	11	28	1118	44
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	3	3	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	84	84	84	79	79	79	96	96	96	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	17	0	15	6	0	22	8	1129	11	30	1215	48
Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1881	2457	635	1820	2476	573	1263	0	0	1141	0	0
Stage 1	1300	1300	-	1152	1152	-	-	-	-	-	-	-
Stage 2	581	1157	-	668	1324	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	44	30	421	48	29	463	500	-	-	539	-	-
Stage 1	170	230	-	210	270	-	-	-	-	-	-	-
Stage 2	467	269	-	414	224	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	40	28	420	44	27	462	499	-	-	538	-	-
Mov Capacity-2 Maneuver	40	28	-	44	27	-	-	-	-	-	-	-
Stage 1	167	217	-	207	266	-	-	-	-	-	-	-
Stage 2	437	265	-	376	212	-	-	-	-	-	-	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	92.2			35.4			0.1			0.3		
HCM LOS	F			E								
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	499	-	-	71	146	538	-	-				
HCM Lane V/C Ratio	0.017	-	-	0.453	0.191	0.057	-	-				
HCM Control Delay (s)	12.337	-	-	92.2	35.4	12.092	-	-				
HCM Lane LOS	B			F			E			B		
HCM 95th %tile Q(veh)	0.051	-	-	1.808	0.676	0.179	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing+Project PM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	128	20	83	20	21	174	93	784	27	211	780	143
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	0.99		0.99	1.00		0.98	1.00		0.98
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	186.3	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	1	1	1	1	1	2	0	1	2	0
Cap, veh/h	342	415	346	364	415	606	121	1294	44	253	1275	233
Arrive On Green	0.22	0.22	0.22	0.22	0.22	0.22	0.07	0.39	0.39	0.16	0.47	0.47
Sat Flow, veh/h	1147	1863	1552	1251	1863	1573	1630	3288	113	1573	2708	495
Grp Volume(v), veh/h	158	25	102	23	24	200	97	425	420	243	547	514
Grp Sat Flow(s),veh/h/ln	1147	1863	1552	1251	1863	1573	1630	1712	1688	1573	1652	1551
Q Serve(g_s), s	9.2	0.8	4.0	1.1	0.7	6.6	4.3	14.7	14.7	11.2	19.2	19.2
Cycle Q Clear(g_c), s	10.0	0.8	4.0	1.9	0.7	6.6	4.3	14.7	14.7	11.2	19.2	19.2
Prop In Lane	1.00		1.00	1.00		1.00	1.00		0.07	1.00		0.32
Lane Grp Cap(c), veh/h	342	415	346	364	415	606	121	674	664	253	778	730
V/C Ratio(X)	0.46	0.06	0.29	0.06	0.06	0.33	0.80	0.63	0.63	0.96	0.70	0.70
Avail Cap(c_a), veh/h	713	1017	848	768	1017	1114	180	862	850	253	900	845
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	26.3	22.4	23.7	23.2	22.4	15.9	33.4	17.9	17.9	30.5	15.3	15.3
Incr Delay (d2), s/veh	1.0	0.1	0.5	0.1	0.1	0.3	14.2	1.0	1.0	45.1	2.1	2.2
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	2.7	0.4	1.5	0.3	0.3	2.4	2.1	5.7	5.7	7.4	7.1	6.7
Lane Grp Delay (d), s/veh	27.3	22.5	24.1	23.2	22.5	16.2	47.6	18.9	18.9	75.6	17.4	17.6
Lane Grp LOS	C	C	C	C	C	B	D	B	B	E	B	B
Approach Vol, veh/h		285			247			942			1304	
Approach Delay, s/veh		25.7			17.5			21.9			28.3	
Approach LOS		C			B			C			C	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		21.5			21.5		11.3	34.7		17.0		40.4
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		8.1	36.9		11.8		39.9
Max Q Clear Time (g_c+I1), s		12.0			8.6		6.3	16.7		13.2		21.2
Green Ext Time (p_c), s		1.9			1.9		0.0	12.1		0.0		11.5
Intersection Summary												
HCM 2010 Ctrl Delay				24.9								
HCM 2010 LOS				C								
Notes												

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	219	242	676	152	247	677
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	279	249	1306	555	365	1060
Arrive On Green	0.17	0.00	0.38	0.00	0.11	0.60
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	221	0	690	0	284	778
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	7.1	0.0	8.5	0.0	4.6	17.1
Cycle Q Clear(g_c), s	7.1	0.0	8.5	0.0	4.6	17.1
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	279	249	1306	555	365	1060
V/C Ratio(X)	0.79	0.00	0.53	0.00	0.78	0.73
Avail Cap(c_a), veh/h	1072	957	1905	810	365	1355
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	21.5	0.0	13.0	0.0	23.4	7.7
Incr Delay (d2), s/veh	5.0	0.0	0.3	0.0	10.2	1.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	2.9	0.0	3.0	0.0	2.2	5.4
Lane Grp Delay (d), s/veh	26.6	0.0	13.3	0.0	33.6	9.2
Lane Grp LOS	C		B		C	A
Approach Vol, veh/h	221		690			1062
Approach Delay, s/veh	26.6		13.3			15.7
Approach LOS	C		B			B
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			26.6		12.0	38.6
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.2		6.1	41.8
Max Q Clear Time (g_c+I1), s			10.5		6.6	19.1
Green Ext Time (p_c), s			9.9		0.0	10.7
Intersection Summary						
HCM 2010 Ctrl Delay			16.1			
HCM 2010 LOS			B			
Notes						

Intersection												
Intersection Delay, s/veh	5.4											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	91	267	5	0	333	52	2	1	3	76	0	139
Conflicting Peds, #/hr	1	0	0	0	0	1	1	0	1	1	0	1
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	93	93	93	38	38	38	88	88	88
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	101	297	6	0	358	56	5	3	8	86	0	158
Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	415	0	0	303	0	0	890	918	301	891	892	388
Stage 1	-	-	-	-	-	-	503	503	-	387	387	-
Stage 2	-	-	-	-	-	-	387	415	-	504	505	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1063	-	-	1203	-	-	264	272	739	263	281	660
Stage 1	-	-	-	-	-	-	551	541	-	637	610	-
Stage 2	-	-	-	-	-	-	637	592	-	550	540	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1062	-	-	1202	-	-	186	246	738	239	254	659
Mov Capacity-2 Maneuver	-	-	-	-	-	-	186	246	-	239	254	-
Stage 1	-	-	-	-	-	-	498	489	-	576	609	-
Stage 2	-	-	-	-	-	-	484	592	-	489	488	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	2.2			0			16.8			19.3		
HCM LOS	C			C			C			C		
Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2		
Capacity (veh/h)	247	738	1062	-	-	1202	-	-	315	659		
HCM Lane V/C Ratio	0.043	0.007	0.095	-	-	-	-	-	0.441	0.16		
HCM Control Delay (s)	20.2	9.9	8.746	-	-	0	-	-	25.2	11.5		
HCM Lane LOS	C	A	A			A			D	B		
HCM 95th %tile Q(veh)	0.133	0.022	0.315	-	-	0	-	-	2.158	0.566		
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

Intersection						
Intersection Delay, s/veh	10.1					
Intersection LOS	B					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2		2	
Conflicting Circle Lanes	2	2	2		2	
Adj Approach Flow, veh/h	36	164	805		1014	
Demand Flow Rate, veh/h	37	167	893		1095	
Vehicles Circulating, veh/h	1112	840	304		37	
Vehicles Exiting, veh/h	20	357	844		970	
Follow-Up Headway, s	3.186	3.186	3.186		3.186	
Ped Vol Crossing Leg, #/h	0	0	0		0	
Ped Cap Adj	1.000	1.000	1.000		1.000	
Approach Delay, s/veh	8.1	9.3	11.1		9.5	
Approach LOS	A	A	B		A	
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	37	167	420	473	515	580
Cap Entry Lane, veh/h	519	628	900	913	1099	1101
Entry HV Adj Factor	0.971	0.982	0.900	0.902	0.925	0.927
Flow Entry, veh/h	36	164	378	426	477	537
Cap Entry, veh/h	504	616	810	823	1017	1020
V/C Ratio	0.071	0.266	0.467	0.518	0.469	0.527
Control Delay, s/veh	8.1	9.3	10.6	11.6	9.0	10.0
LOS	A	A	B	B	A	B
95th %tile Queue, veh	0	1	3	3	3	3

Intersection						
Intersection Delay, s/veh	-					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0
Major/Minor	Minor1	Major1		Major2		
Conflicting Flow All	0	0	0	0	0	
Stage 1	0	-	-	-	-	
Stage 2	0	-	-	-	-	
Follow-up Headway	3.518	3.318	-	-	2.218	
Pot Capacity-1 Maneuver	-	-	-	-	-	
Stage 1	-	-	-	-	-	
Stage 2	-	-	-	-	-	
Time blocked-Platoon, %	-	-	-	-	-	
Mov Capacity-1 Maneuver	-	-	-	-	-	
Mov Capacity-2 Maneuver	-	-	-	-	-	
Stage 1	-	-	-	-	-	
Stage 2	-	-	-	-	-	
Approach	WB	NB		SB		
HCM Control Delay, s	0	0		0		
HCM LOS	A					
Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT	
Capacity (veh/h)	-	-	+	-	-	
HCM Lane V/C Ratio	-	-	+	-	-	
HCM Control Delay (s)	-	-	0	0	-	
HCM Lane LOS	-	-	A	A	-	
HCM 95th %tile Q(veh)	-	-	+	-	-	
Notes						
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined						

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing+Project Weekend Midday Peak Hour



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	158	27	122	45	30	201	121	785	211	885
v/c Ratio	0.48	0.08	0.31	0.14	0.09	0.32	0.52	0.68	0.70	0.73
Control Delay	29.3	23.2	7.8	23.9	23.4	9.8	38.8	20.7	42.4	20.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	29.3	23.2	7.8	23.9	23.4	9.8	38.8	20.7	42.4	20.0
Queue Length 50th (ft)	53	8	0	14	9	29	43	127	75	138
Queue Length 95th (ft)	119	30	39	44	32	82	#133	206	#227	227
Internal Link Dist (ft)		199			278			517		601
Turn Bay Length (ft)	100		100	150			350		400	
Base Capacity (vph)	1136	1209	1056	1136	1136	637	232	1933	300	1943
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.14	0.02	0.12	0.04	0.03	0.32	0.52	0.41	0.70	0.46

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Queues
3: Hwy 1 & Hwy 20

Hare Creek Center Project Traffic Study
Existing+Project Weekend Midday Peak Hour



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	185	252	691	175	251	649
v/c Ratio	0.52	0.50	0.63	0.29	0.69	0.67
Control Delay	25.6	7.5	18.5	4.1	38.8	13.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	25.6	7.5	18.5	4.1	38.8	13.6
Queue Length 50th (ft)	52	2	96	0	40	132
Queue Length 95th (ft)	115	47	163	34	#118	283
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	1073	1029	1817	878	365	1353
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.17	0.24	0.38	0.20	0.69	0.48

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Intersection												
Intersection Delay, s/veh	1.3											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	7	0	10	6	1	19	4	1068	19	23	975	31
Conflicting Peds, #/hr	2	0	1	1	0	2	1	0	6	6	0	1
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	85	85	85	59	59	59	95	95	95	90	90	90
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	8	0	12	10	2	32	4	1124	20	26	1083	34
Major/Minor	Minor2		Minor1			Major1			Major2			
Conflicting Flow All	1727	2309	567	1740	2316	580	1120	0	0	1146	0	0
Stage 1	1154	1154	-	1145	1145	-	-	-	-	-	-	-
Stage 2	573	1155	-	595	1171	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	57	38	467	56	37	458	570	-	-	536	-	-
Stage 1	210	270	-	212	272	-	-	-	-	-	-	-
Stage 2	472	269	-	458	265	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	49	36	464	52	35	455	567	-	-	533	-	-
Mov Capacity-2 Maneuver	49	36	-	52	35	-	-	-	-	-	-	-
Stage 1	208	256	-	210	270	-	-	-	-	-	-	-
Stage 2	431	267	-	422	252	-	-	-	-	-	-	-
Approach	EB		WB			NB			SB			
HCM Control Delay, s	48.2		42.1			0			0.3			
HCM LOS	E		E									
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	567	-	-	103	140	533	-	-				
HCM Lane V/C Ratio	0.007	-	-	0.194	0.315	0.048	-	-				
HCM Control Delay (s)	11.397	-	-	48.2	42.1	12.094	-	-				
HCM Lane LOS	B	-	-	E	E	B	-	-				
HCM 95th %tile Q(veh)	0.022	-	-	0.679	1.248	0.151	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing+Project Weekend Midday Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	141	24	109	40	27	179	115	712	34	194	668	146
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		1.00	1.00		0.97	1.00		0.97
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	186.3	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	1	1	1	1	1	2	0	1	2	0
Cap, veh/h	334	392	328	353	392	583	151	1251	60	249	1155	253
Arrive On Green	0.21	0.21	0.21	0.21	0.21	0.21	0.09	0.39	0.39	0.16	0.44	0.44
Sat Flow, veh/h	1144	1863	1559	1232	1863	1581	1630	3236	155	1573	2612	572
Grp Volume(v), veh/h	158	27	122	45	30	201	121	396	389	211	459	426
Grp Sat Flow(s),veh/h/ln	1144	1863	1559	1232	1863	1581	1630	1712	1679	1573	1652	1532
Q Serve(g_s), s	8.6	0.8	4.5	2.0	0.9	6.1	4.8	12.3	12.3	8.7	14.3	14.3
Cycle Q Clear(g_c), s	9.4	0.8	4.5	2.8	0.9	6.1	4.8	12.3	12.3	8.7	14.3	14.3
Prop In Lane	1.00		1.00	1.00		1.00	1.00		0.09	1.00		0.37
Lane Grp Cap(c), veh/h	334	392	328	353	392	583	151	662	649	249	730	677
V/C Ratio(X)	0.47	0.07	0.37	0.13	0.08	0.34	0.80	0.60	0.60	0.85	0.63	0.63
Avail Cap(c_a), veh/h	781	1119	937	834	1119	1200	216	949	931	279	973	902
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	24.9	21.1	22.5	22.2	21.1	15.2	29.6	16.3	16.3	27.2	14.4	14.4
Incr Delay (d2), s/veh	1.0	0.1	0.7	0.2	0.1	0.4	13.2	0.9	0.9	19.4	0.9	1.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	2.5	0.4	1.7	0.6	0.4	2.3	2.4	4.7	4.6	4.6	5.3	4.9
Lane Grp Delay (d), s/veh	25.9	21.1	23.2	22.3	21.2	15.6	42.8	17.2	17.2	46.6	15.3	15.3
Lane Grp LOS	C	C	C	C	C	B	D	B	B	D	B	B
Approach Vol, veh/h		307			276			906			1096	
Approach Delay, s/veh		24.4			17.3			20.6			21.3	
Approach LOS		C			B			C			C	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		19.2			19.2		12.1	31.6		15.7		35.3
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		8.8	36.9		11.8		39.2
Max Q Clear Time (g_c+I1), s		11.4			8.1		6.8	14.3		10.7		16.3
Green Ext Time (p_c), s		2.1			2.1		0.0	11.1		0.1		11.2
Intersection Summary												
HCM 2010 Ctrl Delay				21.0								
HCM 2010 LOS				C								
Notes												

HCM 2010 Signalized Intersection Summary
3: Hwy 1 & Hwy 20

Hare Creek Center Project Traffic Study
Existing+Project Weekend Midday Peak Hour

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	159	217	636	161	236	610
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	239	213	1294	550	363	1069
Arrive On Green	0.15	0.00	0.38	0.00	0.11	0.61
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	185	0	691	0	251	649
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	5.5	0.0	7.9	0.0	3.7	11.4
Cycle Q Clear(g_c), s	5.5	0.0	7.9	0.0	3.7	11.4
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	239	213	1294	550	363	1069
V/C Ratio(X)	0.77	0.00	0.53	0.00	0.69	0.61
Avail Cap(c_a), veh/h	1165	1040	2070	880	397	1473
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	20.5	0.0	12.1	0.0	21.4	6.1
Incr Delay (d2), s/veh	5.3	0.0	0.3	0.0	4.6	0.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	2.3	0.0	2.7	0.0	1.6	3.2
Lane Grp Delay (d), s/veh	25.8	0.0	12.4	0.0	25.9	6.6
Lane Grp LOS	C		B		C	A
Approach Vol, veh/h	185		691			900
Approach Delay, s/veh	25.8		12.4			12.0
Approach LOS	C		B			B
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			24.8		11.5	36.3
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.2		6.1	41.8
Max Q Clear Time (g_c+I1), s			9.9		5.7	13.4
Green Ext Time (p_c), s			8.9		0.0	10.3
Intersection Summary						
HCM 2010 Ctrl Delay			13.6			
HCM 2010 LOS			B			
Notes						

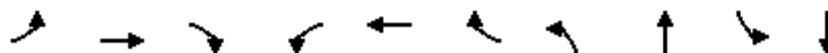
Intersection												
Intersection Delay, s/veh	6											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	84	298	11	2	309	60	5	1	5	77	1	109
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	86	86	86	85	85	85	55	55	55	79	79	79
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	98	347	13	2	364	71	9	2	9	97	1	138
Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	434	0	0	359	0	0	952	987	353	953	959	399
Stage 1	-	-	-	-	-	-	548	548	-	404	404	-
Stage 2	-	-	-	-	-	-	404	439	-	549	555	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1045	-	-	1146	-	-	239	247	691	239	257	651
Stage 1	-	-	-	-	-	-	521	517	-	623	599	-
Stage 2	-	-	-	-	-	-	623	578	-	520	513	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1045	-	-	1146	-	-	174	223	691	217	232	651
Mov Capacity-2 Maneuver	-	-	-	-	-	-	174	223	-	217	232	-
Stage 1	-	-	-	-	-	-	472	469	-	565	598	-
Stage 2	-	-	-	-	-	-	489	577	-	463	465	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	1.9			0			19.1			23.8		
HCM LOS	C			B			C			C		
Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2		
Capacity (veh/h)	215	691	1045	-	-	1146	-	-	276	651		
HCM Lane V/C Ratio	0.065	0.009	0.093	-	-	0.002	-	-	0.524	0.141		
HCM Control Delay (s)	22.9	10.3	8.8	-	-	8.148	-	-	31.6	11.4		
HCM Lane LOS	C	B	A	A			D			B		
HCM 95th %tile Q(veh)	0.206	0.027	0.309	-	-	0.006	-	-	2.822	0.49		
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

Intersection						
Intersection Delay, s/veh	9.6					
Intersection LOS	A					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2	2	2	2
Conflicting Circle Lanes	2	2	2	2	2	2
Adj Approach Flow, veh/h	35	286	730	876	876	876
Demand Flow Rate, veh/h	35	292	810	946	946	946
Vehicles Circulating, veh/h	991	766	256	80	80	80
Vehicles Exiting, veh/h	35	300	770	978	978	978
Follow-Up Headway, s	3.186	3.186	3.186	3.186	3.186	3.186
Ped Vol Crossing Leg, #/h	0	2	1	6	6	6
Ped Cap Adj	1.000	1.000	0.999	0.994	0.994	0.994
Approach Delay, s/veh	7.1	12.1	9.6	8.9	8.9	8.9
Approach LOS	A	B	A	A	A	A
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	35	292	381	429	445	501
Cap Entry Lane, veh/h	565	661	933	945	1064	1068
Entry HV Adj Factor	0.995	0.979	0.901	0.902	0.925	0.926
Flow Entry, veh/h	35	286	343	387	412	464
Cap Entry, veh/h	562	647	839	852	978	983
V/C Ratio	0.062	0.442	0.409	0.455	0.421	0.472
Control Delay, s/veh	7.1	12.1	9.3	10.0	8.4	9.2
LOS	A	B	A	A	A	A
95th %tile Queue, veh	0	2	2	2	2	3

Intersection						
Intersection Delay, s/veh	-					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0
Major/Minor	Minor1	Major1		Major2		
Conflicting Flow All	0	0	0	0	0	
Stage 1	0	-	-	-	-	
Stage 2	0	-	-	-	-	
Follow-up Headway	3.518	3.318	-	-	2.218	
Pot Capacity-1 Maneuver	-	-	-	-	-	
Stage 1	-	-	-	-	-	
Stage 2	-	-	-	-	-	
Time blocked-Platoon, %	-	-	-	-	-	
Mov Capacity-1 Maneuver	-	-	-	-	-	
Mov Capacity-2 Maneuver	-	-	-	-	-	
Stage 1	-	-	-	-	-	
Stage 2	-	-	-	-	-	
Approach	WB	NB		SB		
HCM Control Delay, s	0	0		0		
HCM LOS	A					
Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT	
Capacity (veh/h)	-	-	+	-	-	
HCM Lane V/C Ratio	-	-	+	-	-	
HCM Control Delay (s)	-	-	0	0	-	
HCM Lane LOS	-	-	A	A	-	
HCM 95th %tile Q(veh)	-	-	+	-	-	
Notes						
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined						

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing+Project AM Peak Hour



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	51	11	39	31	17	106	46	757	136	711
v/c Ratio	0.21	0.04	0.13	0.13	0.07	0.20	0.22	0.58	0.44	0.39
Control Delay	24.7	22.5	1.8	23.6	22.9	6.2	25.9	15.9	25.6	10.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	24.7	22.5	1.8	23.6	22.9	6.2	25.9	15.9	25.6	10.4
Queue Length 50th (ft)	15	3	0	9	5	7	14	105	38	84
Queue Length 95th (ft)	44	16	4	31	21	34	43	165	93	135
Internal Link Dist (ft)		199			278			517		601
Turn Bay Length (ft)	100		100	150			350		400	
Base Capacity (vph)	1318	1403	1199	1318	1318	571	245	2250	348	2333
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.04	0.01	0.03	0.02	0.01	0.19	0.19	0.34	0.39	0.30

Intersection Summary

Queues
3: Hwy 1 & Hwy 20

Hare Creek Center Project Traffic Study
Existing+Project AM Peak Hour



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	82	242	551	80	212	473
v/c Ratio	0.29	0.54	0.57	0.17	0.47	0.49
Control Delay	20.5	8.3	16.3	4.6	24.2	8.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	20.5	8.3	16.3	4.6	24.2	8.5
Queue Length 50th (ft)	19	0	63	0	26	64
Queue Length 95th (ft)	54	48	111	22	63	141
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	1271	1171	2136	968	447	1579
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.06	0.21	0.26	0.08	0.47	0.30

Intersection Summary

Intersection												
Intersection Delay, s/veh	1.1											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	6	0	4	14	0	23	3	778	22	38	669	16
Conflicting Peds, #/hr	0	0	0	0	0	0	1	0	3	3	0	1
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	77	77	77	99	99	99	89	89	89
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	7	0	5	18	0	30	3	786	22	43	752	18
Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1245	1660	388	1264	1658	407	770	0	0	808	0	0
Stage 1	846	846	-	803	803	-	-	-	-	-	-	-
Stage 2	399	814	-	461	855	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	130	96	611	126	97	593	784	-	-	734	-	-
Stage 1	323	377	-	343	394	-	-	-	-	-	-	-
Stage 2	598	390	-	550	373	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	117	90	609	119	91	592	782	-	-	732	-	-
Mov Capacity-2 Maneuver	117	90	-	119	91	-	-	-	-	-	-	-
Stage 1	322	355	-	342	392	-	-	-	-	-	-	-
Stage 2	564	389	-	512	351	-	-	-	-	-	-	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	27.4			24.1			0			0.5		
HCM LOS	D			C								
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	782	-	-	173	236	732	-	-				
HCM Lane V/C Ratio	0.004	-	-	0.07	0.204	0.058	-	-				
HCM Control Delay (s)	9.621	-	-	27.4	24.1	10.222	-	-				
HCM Lane LOS	A			D			C			B		
HCM 95th %tile Q(veh)	0.012	-	-	0.222	0.743	0.185	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Existing+Project AM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	45	10	34	28	15	95	42	677	19	120	575	51
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		1.00	1.00		0.98	1.00		0.97
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	186.3	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	1	1	1	1	1	2	0	1	2	0
Cap, veh/h	297	227	190	310	227	364	78	1402	40	170	1399	124
Arrive On Green	0.12	0.12	0.12	0.12	0.12	0.12	0.05	0.42	0.42	0.11	0.47	0.47
Sat Flow, veh/h	1260	1863	1558	1346	1863	1579	1630	3310	94	1573	2984	265
Grp Volume(v), veh/h	51	11	39	31	17	106	46	381	376	136	361	350
Grp Sat Flow(s),veh/h/ln	1260	1863	1558	1346	1863	1579	1630	1712	1693	1573	1652	1596
Q Serve(g_s), s	1.8	0.2	1.1	1.0	0.4	2.6	1.3	7.8	7.8	4.0	7.0	7.0
Cycle Q Clear(g_c), s	2.1	0.2	1.1	1.2	0.4	2.6	1.3	7.8	7.8	4.0	7.0	7.0
Prop In Lane	1.00		1.00	1.00		1.00	1.00		0.06	1.00		0.17
Lane Grp Cap(c), veh/h	297	227	190	310	227	364	78	725	717	170	775	748
V/C Ratio(X)	0.17	0.05	0.21	0.10	0.07	0.29	0.59	0.52	0.53	0.80	0.47	0.47
Avail Cap(c_a), veh/h	1214	1583	1323	1290	1583	1513	277	1342	1327	394	1404	1356
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	19.3	18.3	18.6	18.8	18.3	15.0	22.0	10.1	10.1	20.5	8.5	8.5
Incr Delay (d2), s/veh	0.3	0.1	0.5	0.1	0.1	0.4	6.8	0.6	0.6	8.4	0.4	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.5	0.1	0.4	0.3	0.2	1.0	0.6	2.7	2.6	1.8	2.2	2.1
Lane Grp Delay (d), s/veh	19.5	18.3	19.1	18.9	18.5	15.4	28.8	10.6	10.7	28.9	8.9	9.0
Lane Grp LOS	B	B	B	B	B	B	C	B	B	C	A	A
Approach Vol, veh/h		101			154			803			847	
Approach Delay, s/veh		19.2			16.4			11.7			12.1	
Approach LOS		B			B			B			B	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		10.9			10.9		8.2	25.8		10.3		28.0
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		8.0	36.9		11.8		40.0
Max Q Clear Time (g_c+I1), s		4.1			4.6		3.3	9.8		6.0		9.0
Green Ext Time (p_c), s		0.9			0.9		0.0	10.2		0.1		10.7
Intersection Summary												
HCM 2010 Ctrl Delay				12.7								
HCM 2010 LOS				B								
Notes												

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	76	225	534	78	199	445
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	122	108	1198	509	373	1081
Arrive On Green	0.08	0.00	0.35	0.00	0.11	0.61
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	82	0	551	0	212	473
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	1.9	0.0	4.9	0.0	2.4	5.6
Cycle Q Clear(g_c), s	1.9	0.0	4.9	0.0	2.4	5.6
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	122	108	1198	509	373	1081
V/C Ratio(X)	0.67	0.00	0.46	0.00	0.57	0.44
Avail Cap(c_a), veh/h	1479	1320	2612	1110	521	1870
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	17.7	0.0	9.9	0.0	16.5	4.0
Incr Delay (d2), s/veh	6.4	0.0	0.3	0.0	1.4	0.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.9	0.0	1.6	0.0	0.9	1.3
Lane Grp Delay (d), s/veh	24.1	0.0	10.2	0.0	17.9	4.3
Lane Grp LOS	C		B		B	A
Approach Vol, veh/h	82		551			685
Approach Delay, s/veh	24.1		10.2			8.5
Approach LOS	C		B			A
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			19.7		10.4	30.1
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.0		6.3	41.8
Max Q Clear Time (g_c+I1), s			6.9		4.4	7.6
Green Ext Time (p_c), s			6.8		0.1	7.5
Intersection Summary						
HCM 2010 Ctrl Delay			10.2			
HCM 2010 LOS			B			
Notes						

Intersection												
Intersection Delay, s/veh	2.2											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	26	239	8	0	264	37	6	1	0	51	0	25
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	91	91	91	88	88	88	58	58	58	89	89	89
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	29	263	9	0	300	42	10	2	0	57	0	28
Major/Minor	Major1	Major2			Minor1			Minor2				
Conflicting Flow All	342	0	0	271	0	0	645	666	267	646	650	321
Stage 1	-	-	-	-	-	-	324	324	-	321	321	-
Stage 2	-	-	-	-	-	-	321	342	-	325	329	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1133	-	-	1237	-	-	385	380	772	385	388	720
Stage 1	-	-	-	-	-	-	688	650	-	691	652	-
Stage 2	-	-	-	-	-	-	691	638	-	687	646	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1133	-	-	1237	-	-	363	370	772	376	378	720
Mov Capacity-2 Maneuver	-	-	-	-	-	-	363	370	-	376	378	-
Stage 1	-	-	-	-	-	-	670	633	-	673	652	-
Stage 2	-	-	-	-	-	-	664	638	-	668	629	-
Approach	EB	WB			NB			SB				
HCM Control Delay, s	0.8	0			15.2			14.5				
HCM LOS					C			B				
Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2		
Capacity (veh/h)	364	0	1133	-	-	1237	-	-	403	720		
HCM Lane V/C Ratio	0.033	+	0.025	-	-	-	-	-	0.165	0.026		
HCM Control Delay (s)	15.2	0	8.26	-	-	0	-	-	15.7	10.1		
HCM Lane LOS	C	A	A			A			C	B		
HCM 95th %tile Q(veh)	0.103	+	0.078	-	-	0	-	-	0.586	0.08		
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

Intersection						
Intersection Delay, s/veh	6.7					
Intersection LOS	A					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2	2		
Conflicting Circle Lanes	2	2	2	2		
Adj Approach Flow, veh/h	9	216	540	522		
Demand Flow Rate, veh/h	9	221	600	564		
Vehicles Circulating, veh/h	596	562	72	52		
Vehicles Exiting, veh/h	20	110	533	731		
Follow-Up Headway, s	3.186	3.186	3.186	3.186		
Ped Vol Crossing Leg, #/h	0	0	2	0		
Ped Cap Adj	1.000	1.000	0.998	1.000		
Approach Delay, s/veh	5.0	8.2	6.6	6.1		
Approach LOS	A	A	A	A		
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	9	221	282	318	265	299
Cap Entry Lane, veh/h	745	762	1071	1074	1087	1090
Entry HV Adj Factor	0.996	0.977	0.900	0.900	0.926	0.926
Flow Entry, veh/h	9	216	254	286	245	277
Cap Entry, veh/h	741	745	962	965	1007	1009
V/C Ratio	0.012	0.290	0.264	0.297	0.244	0.274
Control Delay, s/veh	5.0	8.2	6.4	6.8	5.9	6.3
LOS	A	A	A	A	A	A
95th %tile Queue, veh	0	1	1	1	1	1

Intersection						
Intersection Delay, s/veh	-					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0
Major/Minor	Minor1		Major1		Major2	
Conflicting Flow All	0	0	0	0	0	0
Stage 1	0	-	-	-	-	-
Stage 2	0	-	-	-	-	-
Follow-up Headway	3.518	3.318	-	-	2.218	-
Pot Capacity-1 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Time blocked-Platoon, %			-	-		-
Mov Capacity-1 Maneuver	-	-	-	-	-	-
Mov Capacity-2 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Approach	WB		NB		SB	
HCM Control Delay, s	0		0		0	
HCM LOS	A					
Minor Lane / Major Mvmt		NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)		-	-	+	-	-
HCM Lane V/C Ratio		-	-	+	-	-
HCM Control Delay (s)		-	-	0	0	-
HCM Lane LOS				A	A	
HCM 95th %tile Q(veh)		-	-	+	-	-
Notes						
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined						

Appendix G - Caltrans District 1 2014 Growth Factors

Memorandum

*Flex your power!
Be energy efficient!*

To: CHARLIE FIELDER
JANA HOLLIFIELD
MATT BRADY
MARK SUCHANEK

Date: February 3, 2014

File: Growth Factors

From: BRAD METTAM 
Deputy District Director,
Planning and Local Assistance

Subject: 2014 Growth Factors

Attached are the 2014 District 1 growth factor summary, the 2014 District Growth Factor Map, and a “Using D1 Growth Factors” tutorial.

Prior to 1984, Caltrans District 1 projected future traffic volumes based solely on historical growth. Future volumes were calculated using an annual percent increase that was derived from historical traffic volumes. We found that this method produced acceptable results in the short to mid-term, but due to compounding, long-range predictions (20 years or more) tended to be overestimated.

In 1984, in order to eliminate that long-range distortion noted above, we began calculating growth factors as a 20-year straight-line determinant. For example, a segment of highway with a growth factor of 1.4 is predicted to have a 40% increase in traffic over the next 20-years. Likewise, it is predicted to have a 20% increase over 10 years.

Historically, District staff has developed growth factors based on both projected travel trends and historical growth from two data sources—the “California Motor Vehicle Stock Travel and Fuel Forecast” (CMVSTAFF) and historical Average Vehicle Mile Traveled (AVMT) comparisons from “Traffic Volumes on the California State Highway System.” Since CMVSTAFF was not available for the 2014 growth factor update, county growth factor targets were developed based on California Air Resources Board traffic growth projections and historic traffic growth data.

Our growth factors are applied over highway segments that were determined using observed conditions; these segments vary in length, but they are not longer than fifty miles. Traffic volumes over segments are based on a calculated weighted average of

BRAD METTAM
February 3, 2014
Page 2

volumes (Annual Average Daily Traffic) for the entire segment. While actual growth at the local level can vary considerably, we are looking at overall growth over the long-term. If more specific data or information are available for a particular location (actual counts, planned growth, etc.) it may be advisable to calculate a location-specific rate. However, for the purposes of facility design (20-year design-life) our generalized segment growth factors are appropriate. It should be noted that our growth factors forecast traffic growth only for the mainline (State Routes); local streets should be examined separately.

District planning staff reviews growth factors every two years, and typically revise them every two to four years. Growth factors were not updated for several years following 2006, since MVSTAFF data supported higher growth rates at a time when traffic counts were generally level or declining. The most recent MVSTAFF has been removed from the Division of Transportation Planning, Office of Transportation Forecasting and Analysis website, and they recommended using the use of the Air Resources Board EMFAC database as a substitute. Therefore, we based our 20-year District vehicle miles of travel target on ARB data. District staff would prefer to use county travel demand models to project traffic growth, or the MVSTAFF to develop growth factor targets, and we hope to do so in the future. However, neither of these data sources is currently supportable.

If you have any questions regarding the growth factors, please call Rex Jackman at (707) 445-6412 or Chris Dosch at (707) 441-4542.

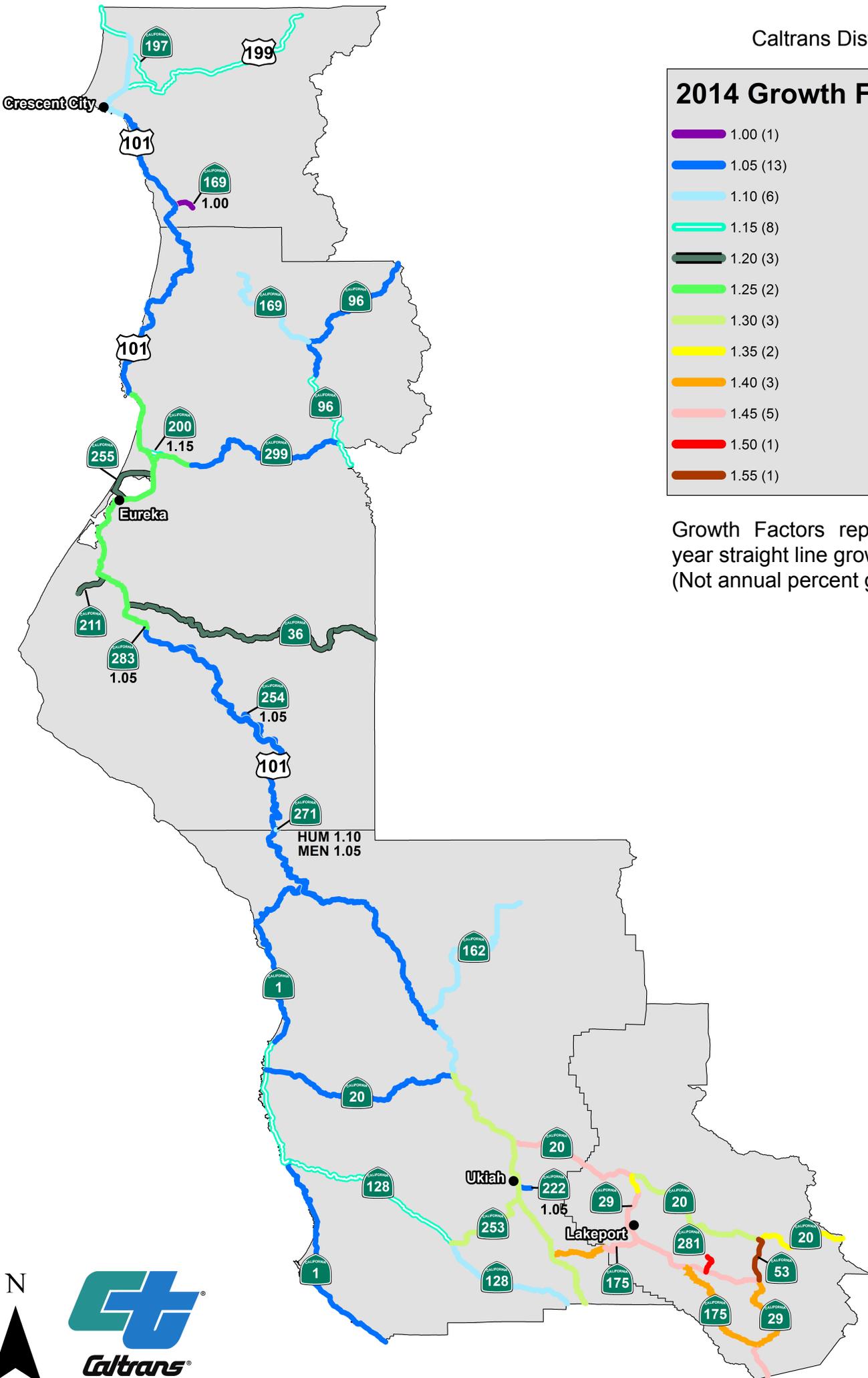
Attachments:
2014 Growth Factor Summary
2014 Growth Factor Map
Using District 1 Growth Factors Tutorial

c: TROY ARSENEAU
DAVID MORGAN
JOHN CARSON
RALPH MARTINELLI
GARRY BANDUCCI
SANDRA ROSAS
STEVE HUGHES
SUSAN ZANCHI
ROYAL McCARTHY
REX JACKMAN

2014 Growth Factor Map



Growth Factors represent a 20 year straight line growth pattern.
(Not annual percent growth)



DISTRICT 1- GROWTH FACTOR SUMMARY

20 YEAR GROWTH FACTORS

SEGMENT	2/2014 G.F.
MEN-1-0.00/40.27	1.05
MEN-1-40.27/64.86	1.15
MEN-1-64.86/105.57	1.05
MEN-20-0.00/33.16	1.05
MEN-20-33.22/44.11	1.45
LAK-20-0.00/8.34	1.45
LAK-20-8.34/31.62	1.30
LAK-20-31.62/46.48	1.35
LAK-29-0.00/5.81	1.45
LAK-29-5.81/20.31	1.40
LAK-29-20.31/48.40	1.45
LAK-29-48.40/52.54	1.35
HUM-36-0.00/45.68	1.20
LAK-53-0.00/7.45	1.55
HUM-96-0.00/16.00	1.15
HUM-96-16.00/44.98	1.05
MEN-101-0.10/47.27	1.30
MEN-101-47.27/55.90	1.10
MEN-101-55.90/104.15	1.05
HUM-101-0.00/51.84	1.05
HUM-101-51.84/100.71	1.25
HUM-101-100.71/137.14	1.05
DN-101-0.00/23.85	1.05
DN-101-23.85/39.98	1.10
DN-101-39.98/46.49	1.15
MEN-128-0.00/29.58	1.15
MEN-128-29.58/50.90	1.10
MEN-162-0.00/34.05	1.10
DN-169-0.0/3.52	1.00
HUM-169-13.20/33.84	1.10
MEN-175-0.00/9.85	1.40
LAK-175-0.00/8.19	1.45
LAK-175-8.25/28.04	1.40
DN-197-0.00/7.08	1.15
DN-199-0.51/36.41	1.15
HUM-200-0.00/2.68	1.15
HUM-211-73.20/79.16	1.20
MEN-222-0.00/2.15	1.05
MEN-253-0.00/17.18	1.30
HUM-254-0.00/46.53	1.05
HUM-255-0.0/8.80	1.20
MEN-271-0.0/22.72	1.05
HUM-271-0.00/0.31	1.10
LAK-281-14.00/17.00	1.50
HUM-283-0.00/0.36	1.05
HUM-299-0.00/5.93	1.25
HUM-299-5.93/38.83	1.05
HUM-299-38.83/43.04	1.15
DISTRICT GROWTH FACTOR (Weighted Average)	1.24

Using District 1 Growth Factors

- To project volumes **20 years** into the future, multiply the base year traffic volume by the growth factor (GF).

Formula: $(GF) * (\text{Base Year Volume}) = \text{Projected Volume}$

Example: The base year volume (2012) is 1500 AADT. The 20-year growth factor for that segment of highway is 1.3. What is the 2032 volume?

$(1.3) * (1500) = 1950$ The projected 2032 traffic volume (AADT) for this segment is 1950.

- To project volumes **Less than or greater than 20 years** into the future, use the following formula:

Formula: $\left[1 + \frac{(GF-1) * (\# \text{ of years into future})}{20}\right] * (\text{starting volume}) = \text{Projected Volume}$

Example: The Base year volume in 2012 is 700 AADT. The 20- year growth factor is 1.4.

A) What is the volume in 27 years?

$$\left[1 + \frac{(1.4-1) * (27)}{20}\right] * (700) = 1078 \quad \text{The projected volume in 2039 is 1078.}$$

B) What is the volume in 7 years?

$$\left[1 + \frac{(1.4-1) * (7)}{20}\right] * (700) = 798 \quad \text{The projected volume in 2019 is 798.}$$

Appendix H - Future Conditions Scenario Level of Service and Queue Calculations

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	83	47	26	20	230	42	972	279	1136
v/c Ratio	0.34	0.18	0.11	0.08	0.45	0.23	0.68	0.89	0.57
Control Delay	32.2	17.9	28.7	28.4	17.4	33.2	17.0	63.5	11.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.2	17.9	28.7	28.4	17.4	33.2	17.0	63.5	11.9
Queue Length 50th (ft)	32	7	10	8	58	16	156	~123	175
Queue Length 95th (ft)	68	31	31	26	118	48	232	#289	256
Internal Link Dist (ft)		199		278			517		601
Turn Bay Length (ft)	100		150			350		400	
Base Capacity (vph)	1169	1132	1169	1169	508	219	2018	313	2068
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.07	0.04	0.02	0.02	0.45	0.19	0.48	0.89	0.55

Intersection Summary

- ~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
- # 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Queues
3: Hwy 1 & Hwy 20



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	232	241	742	179	307	833
v/c Ratio	0.66	0.49	0.52	0.25	1.07	0.79
Control Delay	34.4	7.7	16.5	3.5	108.5	18.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	34.4	7.7	16.5	3.5	108.5	18.7
Queue Length 50th (ft)	90	3	115	0	-75	233
Queue Length 95th (ft)	158	53	191	35	#158	#521
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	841	852	1424	725	286	1061
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.28	0.28	0.52	0.25	1.07	0.79

Intersection Summary

- ~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
- # 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Intersection												
Intersection Delay, s/veh	3.1											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	16	0	15	6	0	20	9	1167	13	32	1212	51
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	3	3	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	84	84	84	79	79	79	96	96	96	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	19	0	18	8	0	25	9	1216	14	35	1317	55
Major/Minor	Minor2		Minor1			Major1			Major2			
Conflicting Flow All	2042	2663	689	1969	2683	618	1373	0	0	1229	0	0
Stage 1	1415	1415	-	1241	1241	-	-	-	-	-	-	-
Stage 2	627	1248	-	728	1442	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	33	22	388	37	22	432	451	-	-	496	-	-
Stage 1	144	202	-	185	245	-	-	-	-	-	-	-
Stage 2	438	243	-	381	196	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	29	20	387	33	20	431	450	-	-	495	-	-
Mov Capacity-2 Maneuver	29	20	-	33	20	-	-	-	-	-	-	-
Stage 1	141	188	-	181	240	-	-	-	-	-	-	-
Stage 2	403	238	-	337	182	-	-	-	-	-	-	-
Approach	EB		WB			NB			SB			
HCM Control Delay, s	171.3		48.9			0.1			0.3			
HCM LOS	F		E									
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	450	-	-	52	114	495	-	-				
HCM Lane V/C Ratio	0.021	-	-	0.71	0.289	0.07	-	-				
HCM Control Delay (s)	13.17	-	-	171.3	48.9	12.822	-	-				
HCM Lane LOS	B		F			E						
HCM 95th %tile Q(veh)	0.064	-	-	2.894	1.099	0.226	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	67	15	23	23	17	200	40	902	31	243	897	91
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	0.99		0.98	0.99		0.99	1.00		0.98	1.00		0.98
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	190.0	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	0	1	1	1	1	2	0	1	2	0
Cap, veh/h	306	131	194	329	364	560	64	1394	47	252	1576	160
Arrive On Green	0.20	0.20	0.20	0.20	0.20	0.20	0.04	0.42	0.42	0.16	0.54	0.54
Sat Flow, veh/h	1119	672	991	1344	1863	1571	1630	3288	112	1573	2944	300
Grp Volume(v), veh/h	83	0	47	26	20	230	42	489	483	279	578	558
Grp Sat Flow(s),veh/h/ln	1119	0	1663	1344	1863	1571	1630	1712	1689	1573	1652	1591
Q Serve(g_s), s	4.8	0.0	1.7	1.2	0.6	8.2	1.9	17.0	17.0	11.8	18.5	18.5
Cycle Q Clear(g_c), s	5.5	0.0	1.7	2.9	0.6	8.2	1.9	17.0	17.0	11.8	18.5	18.5
Prop In Lane	1.00		0.60	1.00		1.00	1.00		0.07	1.00		0.19
Lane Grp Cap(c), veh/h	306	0	325	329	364	560	64	726	716	252	884	852
V/C Ratio(X)	0.27	0.00	0.14	0.08	0.05	0.41	0.66	0.67	0.67	1.11	0.65	0.65
Avail Cap(c_a), veh/h	694	0	901	794	1009	1104	177	856	844	252	895	862
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	26.4	0.0	24.6	25.8	24.2	18.0	35.0	17.1	17.1	31.0	12.3	12.3
Incr Delay (d2), s/veh	0.5	0.0	0.2	0.1	0.1	0.5	11.0	1.7	1.7	89.2	1.7	1.8
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	1.4	0.0	0.7	0.4	0.3	3.1	0.9	6.7	6.6	10.7	6.8	6.6
Lane Grp Delay (d), s/veh	26.8	0.0	24.8	25.9	24.2	18.5	46.0	18.8	18.8	120.2	14.0	14.0
Lane Grp LOS	C		C	C	C	B	D	B	B	F	B	B
Approach Vol, veh/h		130			276			1014			1415	
Approach Delay, s/veh		26.1			19.6			19.9			34.9	
Approach LOS		C			B			B			C	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		19.6			19.6		8.8	37.2		17.0		45.4
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		8.0	36.9		11.8		40.0
Max Q Clear Time (g_c+I1), s		7.5			10.2		3.9	19.0		13.8		20.5
Green Ext Time (p_c), s		1.6			1.5		0.0	12.3		0.0		13.1
Intersection Summary												
HCM 2010 Ctrl Delay				27.7								
HCM 2010 LOS				C								
Notes												

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 		 	
Volume (veh/h)	230	239	727	175	267	725
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	290	259	1345	571	351	1064
Arrive On Green	0.18	0.00	0.39	0.00	0.11	0.60
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	232	0	742	0	307	833
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	7.8	0.0	9.5	0.0	5.3	20.1
Cycle Q Clear(g_c), s	7.8	0.0	9.5	0.0	5.3	20.1
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	290	259	1345	571	351	1064
V/C Ratio(X)	0.80	0.00	0.55	0.00	0.88	0.78
Avail Cap(c_a), veh/h	1028	918	1828	777	351	1300
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	22.2	0.0	13.3	0.0	24.9	8.4
Incr Delay (d2), s/veh	5.1	0.0	0.4	0.0	21.1	2.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	3.2	0.0	3.5	0.0	3.0	6.8
Lane Grp Delay (d), s/veh	27.3	0.0	13.7	0.0	46.0	11.0
Lane Grp LOS	C		B		D	B
Approach Vol, veh/h	232		742			1140
Approach Delay, s/veh	27.3		13.7			20.4
Approach LOS	C		B			C
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			28.1		12.0	40.1
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.2		6.1	41.8
Max Q Clear Time (g_c+I1), s			11.5		7.3	22.1
Green Ext Time (p_c), s			10.5		0.0	10.8
Intersection Summary						
HCM 2010 Ctrl Delay			18.8			
HCM 2010 LOS			B			
Notes						

Intersection

Intersection Delay, s/veh 5.5

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	96	265	5	0	335	55	2	1	3	73	0	146
Conflicting Peds, #/hr	1	0	0	0	0	1	1	0	1	1	0	1
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	93	93	93	38	38	38	88	88	88
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	107	294	6	0	360	59	5	3	8	83	0	166

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	420	0	0	301	0	0	903	932	299	904	905	392
Stage 1	-	-	-	-	-	-	512	512	-	391	391	-
Stage 2	-	-	-	-	-	-	391	420	-	513	514	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1058	-	-	1205	-	-	258	266	741	258	276	657
Stage 1	-	-	-	-	-	-	545	536	-	633	607	-
Stage 2	-	-	-	-	-	-	633	589	-	544	535	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1057	-	-	1204	-	-	178	239	740	233	248	656
Mov Capacity-2 Maneuver	-	-	-	-	-	-	178	239	-	233	248	-
Stage 1	-	-	-	-	-	-	489	481	-	568	606	-
Stage 2	-	-	-	-	-	-	473	589	-	481	480	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	2.3	0	17.2	19.2
HCM LOS			C	C

Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2
Capacity (veh/h)	239	740	1057	-	-	1204	-	-	314	656
HCM Lane V/C Ratio	0.044	0.007	0.101	-	-	-	-	-	0.44	0.169
HCM Control Delay (s)	20.8	9.9	8.788	-	-	0	-	-	25.2	11.6
HCM Lane LOS	C	A	A			A			D	B
HCM 95th %tile Q(veh)	0.138	0.021	0.336	-	-	0	-	-	2.15	0.603

Notes

~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection						
Intersection Delay, s/veh	11.4					
Intersection LOS	B					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2		2	
Conflicting Circle Lanes	2	2	2		2	
Adj Approach Flow, veh/h	42	178	886		1109	
Demand Flow Rate, veh/h	43	182	983		1198	
Vehicles Circulating, veh/h	1218	923	336		44	
Vehicles Exiting, veh/h	24	396	925		1061	
Follow-Up Headway, s	3.186	3.186	3.186		3.186	
Ped Vol Crossing Leg, #/h	0	0	0		0	
Ped Cap Adj	1.000	1.000	1.000		1.000	
Approach Delay, s/veh	8.9	10.5	12.8		10.6	
Approach LOS	A	B	B		B	
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	43	182	462	521	563	635
Cap Entry Lane, veh/h	482	592	878	893	1093	1096
Entry HV Adj Factor	0.975	0.978	0.901	0.901	0.926	0.925
Flow Entry, veh/h	42	178	416	469	521	588
Cap Entry, veh/h	470	579	791	805	1012	1014
V/C Ratio	0.089	0.307	0.526	0.583	0.515	0.580
Control Delay, s/veh	8.9	10.5	12.1	13.5	9.8	11.2
LOS	A	B	B	B	A	B
95th %tile Queue, veh	0	1	3	4	3	4

Intersection

Intersection Delay, s/veh -

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0

Major/Minor	Minor1	Major1	Major2
Conflicting Flow All	0	0	0
Stage 1	0	-	-
Stage 2	0	-	-
Follow-up Headway	3.518	3.318	2.218
Pot Capacity-1 Maneuver	-	-	-
Stage 1	-	-	-
Stage 2	-	-	-
Time blocked-Platoon, %	-	-	-
Mov Capacity-1 Maneuver	-	-	-
Mov Capacity-2 Maneuver	-	-	-
Stage 1	-	-	-
Stage 2	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s	0	0	0
HCM LOS	A		

Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)	-	-	+	-	-
HCM Lane V/C Ratio	-	-	+	-	-
HCM Control Delay (s)	-	-	0	0	-
HCM Lane LOS			A	A	
HCM 95th %tile Q(veh)	-	-	+	-	-

Notes

~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future Weekend Midday Peak Hour



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	58	48	52	22	231	26	903	242	887
v/c Ratio	0.24	0.19	0.22	0.09	0.43	0.13	0.70	0.70	0.43
Control Delay	27.5	16.1	27.1	25.6	13.9	27.9	17.9	38.9	8.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	27.5	16.1	27.1	25.6	13.9	27.9	17.9	38.9	8.9
Queue Length 50th (ft)	19	6	17	7	43	9	135	82	57
Queue Length 95th (ft)	53	34	49	27	106	31	205	#228	184
Internal Link Dist (ft)		199		278			517		601
Turn Bay Length (ft)	100		150			350		400	
Base Capacity (vph)	1267	1220	1267	1267	543	242	2206	345	2254
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.04	0.04	0.02	0.43	0.11	0.41	0.70	0.39

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Queues
3: Hwy 1 & Hwy 20



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	194	237	708	201	263	667
v/c Ratio	0.54	0.47	0.63	0.32	0.74	0.69
Control Delay	26.7	6.9	18.4	4.0	42.9	14.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	26.7	6.9	18.4	4.0	42.9	14.0
Queue Length 50th (ft)	57	0	101	0	44	142
Queue Length 95th (ft)	124	43	170	36	#130	300
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	1049	1009	1775	873	357	1322
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.18	0.23	0.40	0.23	0.74	0.50

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Intersection												
Intersection Delay, s/veh	1.8											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	8	0	12	7	1	22	5	1118	22	27	1002	36
Conflicting Peds, #/hr	2	0	1	1	0	2	1	0	6	6	0	1
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	85	85	85	59	59	59	95	95	95	90	90	90
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	9	0	14	12	2	37	5	1177	23	30	1113	40
Major/Minor	Minor2		Minor1			Major1			Major2			
Conflicting Flow All	1797	2408	585	1820	2416	608	1155	0	0	1202	0	0
Stage 1	1195	1195	-	1201	1201	-	-	-	-	-	-	-
Stage 2	602	1213	-	619	1215	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	50	33	454	48	32	439	552	-	-	509	-	-
Stage 1	198	258	-	196	256	-	-	-	-	-	-	-
Stage 2	453	253	-	443	252	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	41	31	451	44	30	436	549	-	-	506	-	-
Mov Capacity-2 Maneuver	41	31	-	44	30	-	-	-	-	-	-	-
Stage 1	196	242	-	194	253	-	-	-	-	-	-	-
Stage 2	406	250	-	402	237	-	-	-	-	-	-	-
Approach	EB		WB			NB			SB			
HCM Control Delay, s	58.6		52.9			0.1			0.3			
HCM LOS	F		F									
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	549	-	-	90	124	506	-	-				
HCM Lane V/C Ratio	0.01	-	-	0.261	0.41	0.059	-	-				
HCM Control Delay (s)	11.621	-	-	58.6	52.9	12.563	-	-				
HCM Lane LOS	B			F	F	B						
HCM 95th %tile Q(veh)	0.029	-	-	0.953	1.75	0.188	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future Weekend Midday Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	52	16	27	46	20	206	25	819	39	223	768	48
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		1.00	1.00		0.97	1.00		0.97
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	190.0	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	0	1	1	1	1	2	0	1	2	0
Cap, veh/h	288	107	179	306	321	548	47	1337	64	274	1685	105
Arrive On Green	0.17	0.17	0.17	0.17	0.17	0.17	0.03	0.41	0.41	0.17	0.55	0.55
Sat Flow, veh/h	1121	622	1037	1350	1863	1581	1630	3237	154	1573	3073	191
Grp Volume(v), veh/h	58	0	48	52	22	231	26	456	447	242	449	438
Grp Sat Flow(s),veh/h/ln	1121	0	1660	1350	1863	1581	1630	1712	1680	1573	1652	1612
Q Serve(g_s), s	3.1	0.0	1.7	2.3	0.7	7.6	1.1	14.4	14.4	10.2	11.4	11.4
Cycle Q Clear(g_c), s	3.8	0.0	1.7	4.0	0.7	7.6	1.1	14.4	14.4	10.2	11.4	11.4
Prop In Lane	1.00		0.63	1.00		1.00	1.00		0.09	1.00		0.12
Lane Grp Cap(c), veh/h	288	0	286	306	321	548	47	707	694	274	906	884
V/C Ratio(X)	0.20	0.00	0.17	0.17	0.07	0.42	0.56	0.64	0.64	0.88	0.50	0.50
Avail Cap(c_a), veh/h	757	0	979	870	1099	1209	192	932	915	274	975	952
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	25.1	0.0	23.9	25.6	23.5	17.0	32.5	15.9	15.9	27.3	9.5	9.5
Incr Delay (d2), s/veh	0.3	0.0	0.3	0.3	0.1	0.5	10.1	1.0	1.0	26.9	0.4	0.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.9	0.0	0.7	0.8	0.3	2.9	0.5	5.5	5.4	5.7	3.8	3.8
Lane Grp Delay (d), s/veh	25.4	0.0	24.2	25.9	23.6	17.5	42.6	16.9	16.9	54.2	9.9	9.9
Lane Grp LOS	C		C	C	C	B	D	B	B	D	A	A
Approach Vol, veh/h		106			305			929			1129	
Approach Delay, s/veh		24.9			19.3			17.6			19.4	
Approach LOS		C			B			B			B	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		16.9			16.9		7.8	33.9		17.0		43.1
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		8.0	36.9		11.8		40.0
Max Q Clear Time (g_c+I1), s		5.8			9.6		3.1	16.4		12.2		13.4
Green Ext Time (p_c), s		1.6			1.6		0.0	11.3		0.0		13.1
Intersection Summary												
HCM 2010 Ctrl Delay				19.0								
HCM 2010 LOS				B								
Notes												

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	167	204	651	185	247	627
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	249	222	1299	552	372	1071
Arrive On Green	0.15	0.00	0.38	0.00	0.11	0.61
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	194	0	708	0	263	667
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	5.9	0.0	8.3	0.0	4.0	12.3
Cycle Q Clear(g_c), s	5.9	0.0	8.3	0.0	4.0	12.3
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	249	222	1299	552	372	1071
V/C Ratio(X)	0.78	0.00	0.54	0.00	0.71	0.62
Avail Cap(c_a), veh/h	1131	1009	2010	854	386	1430
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	20.9	0.0	12.5	0.0	21.9	6.3
Incr Delay (d2), s/veh	5.2	0.0	0.4	0.0	5.6	0.6
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	2.5	0.0	2.8	0.0	1.8	3.7
Lane Grp Delay (d), s/veh	26.1	0.0	12.8	0.0	27.6	6.9
Lane Grp LOS	C		B		C	A
Approach Vol, veh/h	194		708			930
Approach Delay, s/veh	26.1		12.8			12.8
Approach LOS	C		B			B
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			25.4		11.8	37.2
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.2		6.1	41.8
Max Q Clear Time (g_c+I1), s			10.3		6.0	14.3
Green Ext Time (p_c), s			9.1		0.0	10.6
Intersection Summary						
HCM 2010 Ctrl Delay			14.2			
HCM 2010 LOS			B			
Notes						

Intersection

Intersection Delay, s/veh 5.6

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	88	291	12	2	300	63	5	1	5	70	1	115
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	86	86	86	85	85	85	55	55	55	79	79	79
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	102	338	14	2	353	74	9	2	9	89	1	146

Major/Minor	Major1	Major2	Minor1	Minor2
Conflicting Flow All	427	0	0	352
Stage 1	-	-	-	-
Stage 2	-	-	-	-
Follow-up Headway	2.362	-	-	2.308
Pot Capacity-1 Maneuver	1052	-	-	1153
Stage 1	-	-	-	-
Stage 2	-	-	-	-
Time blocked-Platoon, %	-	-	-	-
Mov Capacity-1 Maneuver	1052	-	-	1153
Mov Capacity-2 Maneuver	-	-	-	-
Stage 1	-	-	-	-
Stage 2	-	-	-	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	2	0	19.1	21.6
HCM LOS			C	C

Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2
Capacity (veh/h)	215	698	1052	-	-	1153	-	-	286	658
HCM Lane V/C Ratio	0.065	0.009	0.097	-	-	0.002	-	-	0.484	0.147
HCM Control Delay (s)	22.9	10.2	8.79	-	-	8.129	-	-	28.8	11.4
HCM Lane LOS	C	B	A			A			D	B
HCM 95th %tile Q(veh)	0.206	0.026	0.322	-	-	0.006	-	-	2.48	0.515

Notes

~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection						
Intersection Delay, s/veh	10.2					
Intersection LOS	B					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2		2	
Conflicting Circle Lanes	2	2	2		2	
Adj Approach Flow, veh/h	41	310	747		930	
Demand Flow Rate, veh/h	41	316	829		1004	
Vehicles Circulating, veh/h	1056	779	277		93	
Vehicles Exiting, veh/h	41	327	820		1002	
Follow-Up Headway, s	3.186	3.186	3.186		3.186	
Ped Vol Crossing Leg, #/h	0	2	1		6	
Ped Cap Adj	1.000	1.000	0.999		0.994	
Approach Delay, s/veh	7.6	13.1	10.1		9.5	
Approach LOS	A	B	B		A	
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	41	316	390	439	472	532
Cap Entry Lane, veh/h	540	655	918	931	1054	1059
Entry HV Adj Factor	0.995	0.980	0.900	0.901	0.926	0.926
Flow Entry, veh/h	41	310	351	396	437	493
Cap Entry, veh/h	537	642	825	838	969	974
V/C Ratio	0.076	0.483	0.425	0.472	0.451	0.506
Control Delay, s/veh	7.6	13.1	9.7	10.4	9.0	9.9
LOS	A	B	A	B	A	A
95th %tile Queue, veh	0	3	2	3	2	3

Intersection						
Intersection Delay, s/veh	-					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0
Major/Minor	Minor1	Major1		Major2		
Conflicting Flow All	0	0	0	0	0	0
Stage 1	0	-	-	-	-	-
Stage 2	0	-	-	-	-	-
Follow-up Headway	3.518	3.318	-	-	2.218	-
Pot Capacity-1 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-
Mov Capacity-1 Maneuver	-	-	-	-	-	-
Mov Capacity-2 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Approach	WB	NB		SB		
HCM Control Delay, s	0	0		0		
HCM LOS	A					
Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT	
Capacity (veh/h)	-	-	+	-	-	
HCM Lane V/C Ratio	-	-	+	-	-	
HCM Control Delay (s)	-	-	0	0	-	
HCM Lane LOS	-	-	A	A	-	
HCM 95th %tile Q(veh)	-	-	+	-	-	
Notes						
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined						

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future AM Peak Hour



Lane Group	EBL	EBT	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	40	38	36	17	121	26	871	157	786
v/c Ratio	0.18	0.16	0.16	0.08	0.25	0.13	0.60	0.46	0.35
Control Delay	26.1	15.5	25.9	25.1	10.0	26.6	14.7	26.6	7.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	26.1	15.5	25.9	25.1	10.0	26.6	14.7	26.6	7.5
Queue Length 50th (ft)	12	3	11	5	15	8	125	47	45
Queue Length 95th (ft)	39	27	37	22	51	30	190	111	147
Internal Link Dist (ft)		199		278			517		601
Turn Bay Length (ft)	100		150			350		400	
Base Capacity (vph)	1314	1244	1314	1314	501	244	2243	347	2444
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.03	0.03	0.01	0.24	0.11	0.39	0.45	0.32

Intersection Summary

Queues
3: Hwy 1 & Hwy 20



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	86	248	614	93	239	532
v/c Ratio	0.30	0.55	0.60	0.18	0.57	0.54
Control Delay	21.1	8.4	16.5	4.4	28.5	9.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.1	8.4	16.5	4.4	28.5	9.3
Queue Length 50th (ft)	20	0	71	0	31	76
Queue Length 95th (ft)	57	49	125	23	#86	169
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	1239	1149	2097	956	422	1542
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.07	0.22	0.29	0.10	0.57	0.35

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Intersection												
Intersection Delay, s/veh	1.5											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	7	0	5	16	0	27	4	878	25	44	742	18
Conflicting Peds, #/hr	0	0	0	0	0	0	1	0	3	3	0	1
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	77	77	77	99	99	99	89	89	89
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	8	0	6	21	0	35	4	887	25	49	834	20
Major/Minor	Minor2			Minor1			Major1			Major2		
Conflicting Flow All	1395	1863	430	1424	1861	459	854	0	0	912	0	0
Stage 1	943	943	-	908	908	-	-	-	-	-	-	-
Stage 2	452	920	-	516	953	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	101	72	573	96	72	549	726	-	-	667	-	-
Stage 1	282	339	-	296	352	-	-	-	-	-	-	-
Stage 2	557	348	-	510	336	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	89	66	572	89	66	548	724	-	-	665	-	-
Mov Capacity-2 Maneuver	89	66	-	89	66	-	-	-	-	-	-	-
Stage 1	280	314	-	294	350	-	-	-	-	-	-	-
Stage 2	517	346	-	466	311	-	-	-	-	-	-	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	34.4			32			0			0.6		
HCM LOS	D			D								
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	724	-	-	137	188	665	-	-				
HCM Lane V/C Ratio	0.006	-	-	0.106	0.297	0.074	-	-				
HCM Control Delay (s)	10	-	-	34.4	32	10.848	-	-				
HCM Lane LOS	B	-	-	D	D	B	-	-				
HCM 95th %tile Q(veh)	0.017	-	-	0.346	1.183	0.24	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future AM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	35	10	24	32	15	109	24	779	22	138	661	31
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		1.00	1.00		0.98	1.00		0.97
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	190.0	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	0	1	1	1	1	2	0	1	2	0
Cap, veh/h	281	59	145	277	232	393	49	1470	42	195	1642	77
Arrive On Green	0.12	0.12	0.12	0.12	0.12	0.12	0.03	0.44	0.44	0.12	0.52	0.52
Sat Flow, veh/h	1244	473	1162	1361	1863	1580	1630	3311	94	1573	3128	146
Grp Volume(v), veh/h	40	0	38	36	17	121	26	438	433	157	397	389
Grp Sat Flow(s),veh/h/ln	1244	0	1635	1361	1863	1580	1630	1712	1693	1573	1652	1622
Q Serve(g_s), s	1.6	0.0	1.1	1.3	0.4	3.3	0.8	10.1	10.1	5.1	8.0	8.0
Cycle Q Clear(g_c), s	2.0	0.0	1.1	2.4	0.4	3.3	0.8	10.1	10.1	5.1	8.0	8.0
Prop In Lane	1.00		0.71	1.00		1.00	1.00		0.06	1.00		0.09
Lane Grp Cap(c), veh/h	281	0	204	277	232	393	49	760	752	195	867	851
V/C Ratio(X)	0.14	0.00	0.19	0.13	0.07	0.31	0.53	0.58	0.58	0.80	0.46	0.46
Avail Cap(c_a), veh/h	1063	0	1233	1134	1405	1388	246	1191	1178	350	1246	1223
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	21.4	0.0	20.8	21.9	20.5	16.2	25.4	11.0	11.0	22.6	7.9	7.9
Incr Delay (d2), s/veh	0.2	0.0	0.4	0.2	0.1	0.4	8.7	0.7	0.7	7.5	0.4	0.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.5	0.0	0.4	0.4	0.2	1.2	0.4	3.6	3.5	2.2	2.5	2.5
Lane Grp Delay (d), s/veh	21.6	0.0	21.2	22.1	20.6	16.7	34.0	11.7	11.7	30.1	8.3	8.3
Lane Grp LOS	C		C	C	C	B	C	B	B	C	A	A
Approach Vol, veh/h		78			174			897			943	
Approach Delay, s/veh		21.4			18.2			12.4			11.9	
Approach LOS		C			B			B			B	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		11.8			11.8		7.5	29.5		11.8		33.7
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		8.0	36.9		11.8		40.0
Max Q Clear Time (g_c+I1), s		4.0			5.3		2.8	12.1		7.1		10.0
Green Ext Time (p_c), s		1.0			1.0		0.0	11.4		0.2		12.4
Intersection Summary												
HCM 2010 Ctrl Delay				13.0								
HCM 2010 LOS				B								
Notes												

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 		 	
Volume (veh/h)	80	231	596	90	225	500
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	123	109	1279	543	368	1107
Arrive On Green	0.08	0.00	0.37	0.00	0.11	0.63
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	86	0	614	0	239	532
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	2.2	0.0	5.7	0.0	2.9	6.6
Cycle Q Clear(g_c), s	2.2	0.0	5.7	0.0	2.9	6.6
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	123	109	1279	543	368	1107
V/C Ratio(X)	0.70	0.00	0.48	0.00	0.65	0.48
Avail Cap(c_a), veh/h	1405	1254	2498	1062	479	1777
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	18.7	0.0	9.9	0.0	17.6	4.1
Incr Delay (d2), s/veh	7.1	0.0	0.3	0.0	1.9	0.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	1.0	0.0	1.8	0.0	1.1	1.6
Lane Grp Delay (d), s/veh	25.8	0.0	10.2	0.0	19.5	4.4
Lane Grp LOS	C		B		B	A
Approach Vol, veh/h	86		614			771
Approach Delay, s/veh	25.8		10.2			9.1
Approach LOS	C		B			A
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			21.4		10.6	31.9
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.2		6.1	41.8
Max Q Clear Time (g_c+I1), s			7.7		4.9	8.6
Green Ext Time (p_c), s			7.7		0.1	8.7
Intersection Summary						
HCM 2010 Ctrl Delay			10.5			
HCM 2010 LOS			B			
Notes						

Intersection

Intersection Delay, s/veh 2.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	27	248	8	0	272	39	6	1	0	53	0	26
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	91	91	91	88	88	88	58	58	58	89	89	89
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	30	273	9	0	309	44	10	2	0	60	0	29

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	353	0	0	281	0	0	667	689	277	668	672	331
Stage 1	-	-	-	-	-	-	336	336	-	331	331	-
Stage 2	-	-	-	-	-	-	331	353	-	337	341	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1122	-	-	1226	-	-	372	369	762	372	377	711
Stage 1	-	-	-	-	-	-	678	642	-	682	645	-
Stage 2	-	-	-	-	-	-	682	631	-	677	639	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1122	-	-	1226	-	-	349	359	762	363	367	711
Mov Capacity-2 Maneuver	-	-	-	-	-	-	349	359	-	363	367	-
Stage 1	-	-	-	-	-	-	660	625	-	664	645	-
Stage 2	-	-	-	-	-	-	654	631	-	657	622	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.8	0	15.7	14.9
HCM LOS			C	B

Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2
Capacity (veh/h)	350	0	1122	-	-	1226	-	-	390	711
HCM Lane V/C Ratio	0.034	+	0.026	-	-	-	-	-	0.178	0.027
HCM Control Delay (s)	15.7	0	8.296	-	-	0	-	-	16.2	10.2
HCM Lane LOS	C	A	A			A			C	B
HCM 95th %tile Q(veh)	0.107	+	0.081	-	-	0	-	-	0.638	0.084

Notes

~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Intersection						
Intersection Delay, s/veh	7.2					
Intersection LOS	A					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2		2	
Conflicting Circle Lanes	2	2	2		2	
Adj Approach Flow, veh/h	10	245	607		587	
Demand Flow Rate, veh/h	10	250	674		634	
Vehicles Circulating, veh/h	671	629	79		59	
Vehicles Exiting, veh/h	22	124	602		820	
Follow-Up Headway, s	3.186	3.186	3.186		3.186	
Ped Vol Crossing Leg, #/h	0	0	2		0	
Ped Cap Adj	1.000	1.000	0.998		1.000	
Approach Delay, s/veh	5.3	9.4	7.1		6.6	
Approach LOS	A	A	A		A	
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	10	250	317	357	298	336
Cap Entry Lane, veh/h	706	728	1065	1069	1081	1084
Entry HV Adj Factor	0.996	0.980	0.900	0.901	0.925	0.925
Flow Entry, veh/h	10	245	285	322	276	311
Cap Entry, veh/h	704	713	956	961	1000	1003
V/C Ratio	0.014	0.344	0.298	0.335	0.276	0.310
Control Delay, s/veh	5.3	9.4	6.9	7.3	6.3	6.7
LOS	A	A	A	A	A	A
95th %tile Queue, veh	0	2	1	1	1	1

Intersection

Intersection Delay, s/veh -

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0

Major/Minor	Minor1	Major1	Major2
Conflicting Flow All	0	0	0
Stage 1	0	-	-
Stage 2	0	-	-
Follow-up Headway	3.518	3.318	2.218
Pot Capacity-1 Maneuver	-	-	-
Stage 1	-	-	-
Stage 2	-	-	-
Time blocked-Platoon, %	-	-	-
Mov Capacity-1 Maneuver	-	-	-
Mov Capacity-2 Maneuver	-	-	-
Stage 1	-	-	-
Stage 2	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s	0	0	0
HCM LOS	A		

Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)	-	-	+	-	-
HCM Lane V/C Ratio	-	-	+	-	-
HCM Control Delay (s)	-	-	0	0	-
HCM Lane LOS			A	A	
HCM 95th %tile Q(veh)	-	-	+	-	-

Notes

~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Appendix I - Future Plus Project Conditions Scenario Level of Service and Queue Calculations

Intersection												
Intersection Delay, s/veh	2.4											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	8	0	12	7	1	22	5	1214	22	27	1105	36
Conflicting Peds, #/hr	2	0	1	1	0	2	1	0	6	6	0	1
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	85	85	85	59	59	59	95	95	95	90	90	90
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	9	0	14	12	2	37	5	1278	23	30	1228	40
Major/Minor	Minor2		Minor1			Major1			Major2			
Conflicting Flow All	1962	2624	642	1978	2632	659	1270	0	0	1303	0	0
Stage 1	1310	1310	-	1302	1302	-	-	-	-	-	-	-
Stage 2	652	1314	-	676	1330	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	38	24	417	37	23	406	496	-	-	463	-	-
Stage 1	168	227	-	170	229	-	-	-	-	-	-	-
Stage 2	423	226	-	409	222	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	30	22	414	33	21	403	494	-	-	461	-	-
Mov Capacity-2 Maneuver	30	22	-	33	21	-	-	-	-	-	-	-
Stage 1	166	212	-	168	226	-	-	-	-	-	-	-
Stage 2	375	223	-	367	207	-	-	-	-	-	-	-
Approach	EB		WB			NB			SB			
HCM Control Delay, s	83.7		80			0			0.3			
HCM LOS	F		F									
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	494	-	-	68	95	461	-	-				
HCM Lane V/C Ratio	0.011	-	-	0.346	0.535	0.065	-	-				
HCM Control Delay (s)	12.366	-	-	83.7	80	13.352	-	-				
HCM Lane LOS	B		F			F			B			
HCM 95th %tile Q(veh)	0.032	-	-	1.289	2.406	0.208	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future+Project Weekend Midday Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	147	26	112	46	30	206	118	819	39	223	768	152
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		1.00	1.00		0.97	1.00		0.97
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	186.3	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	1	1	1	1	1	2	0	1	2	0
Cap, veh/h	323	407	340	349	407	597	153	1303	62	251	1222	241
Arrive On Green	0.22	0.22	0.22	0.22	0.22	0.22	0.09	0.40	0.40	0.16	0.46	0.46
Sat Flow, veh/h	1109	1863	1559	1226	1863	1581	1630	3237	154	1573	2667	527
Grp Volume(v), veh/h	165	29	126	52	34	231	124	456	447	242	517	483
Grp Sat Flow(s),veh/h/ln	1109	1863	1559	1226	1863	1581	1630	1712	1680	1573	1652	1542
Q Serve(g_s), s	10.3	0.9	5.1	2.6	1.1	7.9	5.5	16.1	16.1	11.3	18.3	18.3
Cycle Q Clear(g_c), s	11.4	0.9	5.1	3.5	1.1	7.9	5.5	16.1	16.1	11.3	18.3	18.3
Prop In Lane	1.00		1.00	1.00		1.00	1.00		0.09	1.00		0.34
Lane Grp Cap(c), veh/h	323	407	340	349	407	597	153	689	676	251	757	706
V/C Ratio(X)	0.51	0.07	0.37	0.15	0.08	0.39	0.81	0.66	0.66	0.97	0.68	0.68
Avail Cap(c_a), veh/h	680	1005	842	744	1005	1106	198	852	836	251	870	811
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	27.6	23.0	24.6	24.4	23.1	16.8	32.9	18.0	18.0	31.0	15.8	15.8
Incr Delay (d2), s/veh	1.2	0.1	0.7	0.2	0.1	0.4	17.1	1.4	1.4	47.2	1.8	2.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	3.0	0.4	2.0	0.8	0.5	3.0	2.9	6.5	6.3	7.5	7.0	6.6
Lane Grp Delay (d), s/veh	28.8	23.1	25.3	24.6	23.2	17.2	50.0	19.4	19.4	78.2	17.7	17.8
Lane Grp LOS	C	C	C	C	C	B	D	B	B	E	B	B
Approach Vol, veh/h		320			317			1027			1242	
Approach Delay, s/veh		26.9			19.1			23.1			29.5	
Approach LOS		C			B			C			C	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		21.4			21.4		12.9	35.7		17.0		39.9
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		9.0	36.9		11.8		39.0
Max Q Clear Time (g_c+I1), s		13.4			9.9		7.5	18.1		13.3		20.3
Green Ext Time (p_c), s		2.3			2.3		0.0	11.6		0.0		11.5
Intersection Summary												
HCM 2010 Ctrl Delay				25.8								
HCM 2010 LOS				C								
Notes												

HCM 2010 Signalized Intersection Summary
3: Hwy 1 & Hwy 20

Hare Creek Center Project Traffic Study
Future+Project Weekend Midday Peak Hour

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			 		 	
Volume (veh/h)	167	226	721	185	268	692
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	248	221	1366	581	367	1093
Arrive On Green	0.15	0.00	0.40	0.00	0.11	0.62
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	194	0	784	0	285	736
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	6.2	0.0	9.7	0.0	4.6	14.7
Cycle Q Clear(g_c), s	6.2	0.0	9.7	0.0	4.6	14.7
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	248	221	1366	581	367	1093
V/C Ratio(X)	0.78	0.00	0.57	0.00	0.78	0.67
Avail Cap(c_a), veh/h	1076	960	1912	813	367	1360
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	22.0	0.0	12.7	0.0	23.3	6.7
Incr Delay (d2), s/veh	5.4	0.0	0.4	0.0	10.1	0.9
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	2.6	0.0	3.4	0.0	2.2	4.4
Lane Grp Delay (d), s/veh	27.4	0.0	13.0	0.0	33.5	7.6
Lane Grp LOS	C		B		C	A
Approach Vol, veh/h	194		784			1021
Approach Delay, s/veh	27.4		13.0			14.8
Approach LOS	C		B			B
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			27.5		12.0	39.5
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.2		6.1	41.8
Max Q Clear Time (g_c+I1), s			11.7		6.6	16.7
Green Ext Time (p_c), s			9.9		0.0	11.6
Intersection Summary						
HCM 2010 Ctrl Delay			15.4			
HCM 2010 LOS			B			
Notes						

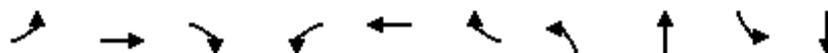
Intersection												
Intersection Delay, s/veh	6.6											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	88	312	12	2	323	63	5	1	5	80	1	115
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	86	86	86	85	85	85	55	55	55	79	79	79
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	102	363	14	2	380	74	9	2	9	101	1	146
Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	454	0	0	377	0	0	996	1033	370	997	1003	417
Stage 1	-	-	-	-	-	-	574	574	-	422	422	-
Stage 2	-	-	-	-	-	-	422	459	-	575	581	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1027	-	-	1129	-	-	223	232	676	223	242	636
Stage 1	-	-	-	-	-	-	504	503	-	609	588	-
Stage 2	-	-	-	-	-	-	609	566	-	503	500	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1027	-	-	1129	-	-	158	209	676	202	218	636
Mov Capacity-2 Maneuver	-	-	-	-	-	-	158	209	-	202	218	-
Stage 1	-	-	-	-	-	-	454	453	-	549	587	-
Stage 2	-	-	-	-	-	-	468	565	-	445	450	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	1.9			0			20.4			26.9		
HCM LOS	C			B			C			D		
Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2		
Capacity (veh/h)	197	676	1027	-	-	1129	-	-	259	636		
HCM Lane V/C Ratio	0.071	0.009	0.1	-	-	0.002	-	-	0.583	0.153		
HCM Control Delay (s)	24.7	10.4	8.893	-	-	8.195	-	-	36.7	11.7		
HCM Lane LOS	C	B	A	A			E			B		
HCM 95th %tile Q(veh)	0.226	0.027	0.331	-	-	0.006	-	-	3.361	0.536		
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

Intersection						
Intersection Delay, s/veh	11.4					
Intersection LOS	B					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2	2		
Conflicting Circle Lanes	2	2	2	2		
Adj Approach Flow, veh/h	41	328	830	997		
Demand Flow Rate, veh/h	41	334	921	1077		
Vehicles Circulating, veh/h	1129	872	293	93		
Vehicles Exiting, veh/h	41	343	877	1113		
Follow-Up Headway, s	3.186	3.186	3.186	3.186		
Ped Vol Crossing Leg, #/h	0	2	1	6		
Ped Cap Adj	1.000	1.000	0.999	0.994		
Approach Delay, s/veh	8.1	15.6	11.3	10.2		
Approach LOS	A	C	B	B		
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	41	334	433	488	506	571
Cap Entry Lane, veh/h	513	614	907	920	1054	1059
Entry HV Adj Factor	0.995	0.981	0.900	0.901	0.926	0.926
Flow Entry, veh/h	41	328	390	440	469	529
Cap Entry, veh/h	510	602	816	829	970	974
V/C Ratio	0.080	0.544	0.478	0.531	0.483	0.543
Control Delay, s/veh	8.1	15.6	10.8	11.8	9.5	10.7
LOS	A	C	B	B	A	B
95th %tile Queue, veh	0	3	3	3	3	3

Intersection						
Intersection Delay, s/veh	-					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0
Major/Minor	Minor1	Major1		Major2		
Conflicting Flow All	0	0	0	0	0	0
Stage 1	0	-	-	-	-	-
Stage 2	0	-	-	-	-	-
Follow-up Headway	3.518	3.318	-	-	2.218	-
Pot Capacity-1 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-
Mov Capacity-1 Maneuver	-	-	-	-	-	-
Mov Capacity-2 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Approach	WB	NB		SB		
HCM Control Delay, s	0	0		0		
HCM LOS	A					
Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT	
Capacity (veh/h)	-	-	+	-	-	
HCM Lane V/C Ratio	-	-	+	-	-	
HCM Control Delay (s)	-	-	0	0	-	
HCM Lane LOS	-	-	A	A	-	
HCM 95th %tile Q(veh)	-	-	+	-	-	
Notes						
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined						

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future + Project AM Peak Hour



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	56	14	42	36	19	121	49	871	157	813
v/c Ratio	0.24	0.06	0.15	0.16	0.08	0.23	0.25	0.63	0.50	0.43
Control Delay	27.1	24.6	2.3	25.8	25.0	9.7	28.6	16.5	29.1	10.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	27.1	24.6	2.3	25.8	25.0	9.7	28.6	16.5	29.1	10.4
Queue Length 50th (ft)	18	4	0	11	6	15	15	128	48	103
Queue Length 95th (ft)	50	19	5	37	24	51	49	195	114	158
Internal Link Dist (ft)		199			278			517		601
Turn Bay Length (ft)	100		100	150			350		400	
Base Capacity (vph)	1226	1306	1122	1226	1226	526	227	2094	324	2278
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.05	0.01	0.04	0.03	0.02	0.23	0.22	0.42	0.48	0.36

Intersection Summary

Queues
3: Hwy 1 & Hwy 20



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	86	254	631	93	244	543
v/c Ratio	0.30	0.55	0.60	0.18	0.59	0.55
Control Delay	21.4	8.5	16.5	4.3	29.5	9.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.4	8.5	16.5	4.3	29.5	9.4
Queue Length 50th (ft)	21	0	74	0	34	79
Queue Length 95th (ft)	58	50	129	23	#89	174
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	1224	1140	2071	945	416	1525
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.07	0.22	0.30	0.10	0.59	0.36

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Intersection												
Intersection Delay, s/veh	1.5											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	7	0	5	16	0	27	4	893	25	44	765	18
Conflicting Peds, #/hr	0	0	0	0	0	0	1	0	3	3	0	1
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	83	83	83	77	77	77	99	99	99	89	89	89
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	8	0	6	21	0	35	4	902	25	49	860	20
Major/Minor	Minor2		Minor1			Major1			Major2			
Conflicting Flow All	1428	1904	443	1452	1902	467	880	0	0	927	0	0
Stage 1	969	969	-	923	923	-	-	-	-	-	-	-
Stage 2	459	935	-	529	979	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	95	68	562	92	68	542	709	-	-	658	-	-
Stage 1	272	330	-	290	347	-	-	-	-	-	-	-
Stage 2	551	342	-	501	326	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	83	63	561	85	63	541	707	-	-	656	-	-
Mov Capacity-2 Maneuver	83	63	-	85	63	-	-	-	-	-	-	-
Stage 1	270	305	-	288	345	-	-	-	-	-	-	-
Stage 2	511	340	-	457	302	-	-	-	-	-	-	-
Approach	EB		WB			NB			SB			
HCM Control Delay, s	36.4		33.5			0			0.6			
HCM LOS	E		D									
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	707	-	-	129	181	656	-	-				
HCM Lane V/C Ratio	0.006	-	-	0.112	0.309	0.075	-	-				
HCM Control Delay (s)	10.121	-	-	36.4	33.5	10.935	-	-				
HCM Lane LOS	B		E			D		B				
HCM 95th %tile Q(veh)	0.017	-	-	0.369	1.24	0.244	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future + Project AM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	49	12	37	32	17	109	45	779	22	138	661	55
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		1.00	1.00		0.98	1.00		0.97
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	186.3	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	1	1	1	1	1	2	0	1	2	0
Cap, veh/h	280	235	196	294	235	395	79	1475	42	195	1527	126
Arrive On Green	0.13	0.13	0.13	0.13	0.13	0.13	0.05	0.45	0.45	0.12	0.51	0.51
Sat Flow, veh/h	1241	1863	1558	1339	1863	1580	1630	3311	94	1573	3004	248
Grp Volume(v), veh/h	56	14	42	36	19	121	49	438	433	157	413	400
Grp Sat Flow(s),veh/h/ln	1241	1863	1558	1339	1863	1580	1630	1712	1693	1573	1652	1600
Q Serve(g_s), s	2.2	0.4	1.3	1.3	0.5	3.3	1.6	10.2	10.2	5.2	8.8	8.8
Cycle Q Clear(g_c), s	2.7	0.4	1.3	1.7	0.5	3.3	1.6	10.2	10.2	5.2	8.8	8.8
Prop In Lane	1.00		1.00	1.00		1.00	1.00		0.06	1.00		0.15
Lane Grp Cap(c), veh/h	280	235	196	294	235	395	79	763	754	195	840	813
V/C Ratio(X)	0.20	0.06	0.21	0.12	0.08	0.31	0.62	0.57	0.57	0.80	0.49	0.49
Avail Cap(c_a), veh/h	1050	1391	1163	1126	1391	1376	243	1179	1166	347	1234	1195
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	21.9	20.6	21.0	21.3	20.7	16.3	25.0	11.1	11.1	22.8	8.6	8.6
Incr Delay (d2), s/veh	0.3	0.1	0.5	0.2	0.1	0.4	7.8	0.7	0.7	7.6	0.4	0.5
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	0.7	0.2	0.5	0.4	0.2	0.0	0.8	3.6	3.5	2.2	2.7	2.8
Lane Grp Delay (d), s/veh	22.2	20.7	21.6	21.5	20.8	16.7	32.8	11.7	11.8	30.4	9.1	9.1
Lane Grp LOS	C	C	C	C	C	B	C	B	B	C	A	A
Approach Vol, veh/h		112			176			920			970	
Approach Delay, s/veh		21.8			18.2			12.9			12.5	
Approach LOS		C			B			B			B	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		12.0			12.0		8.5	29.8		11.8		33.1
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		8.0	36.9		11.8		40.0
Max Q Clear Time (g_c+I1), s		4.7			5.3		3.6	12.2		7.2		10.8
Green Ext Time (p_c), s		1.0			1.0		0.0	11.7		0.2		12.6
Intersection Summary												
HCM 2010 Ctrl Delay				13.6								
HCM 2010 LOS				B								
Notes												

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	80	236	612	90	229	510
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	122	109	1296	551	373	1115
Arrive On Green	0.08	0.00	0.38	0.00	0.11	0.63
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	86	0	631	0	244	543
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	2.2	0.0	5.9	0.0	3.0	6.9
Cycle Q Clear(g_c), s	2.2	0.0	5.9	0.0	3.0	6.9
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	122	109	1296	551	373	1115
V/C Ratio(X)	0.71	0.00	0.49	0.00	0.65	0.49
Avail Cap(c_a), veh/h	1386	1237	2464	1047	473	1753
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	18.9	0.0	9.9	0.0	17.8	4.1
Incr Delay (d2), s/veh	7.3	0.0	0.3	0.0	2.2	0.3
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	1.0	0.0	2.0	0.0	1.2	1.6
Lane Grp Delay (d), s/veh	26.2	0.0	10.2	0.0	20.0	4.4
Lane Grp LOS	C		B		B	A
Approach Vol, veh/h	86		631			787
Approach Delay, s/veh	26.2		10.2			9.2
Approach LOS	C		B			A
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			21.8		10.7	32.5
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.2		6.1	41.8
Max Q Clear Time (g_c+I1), s			7.9		5.0	8.9
Green Ext Time (p_c), s			7.9		0.1	9.0
Intersection Summary						
HCM 2010 Ctrl Delay			10.6			
HCM 2010 LOS			B			
Notes						

Intersection												
Intersection Delay, s/veh	2.3											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	27	251	8	0	277	39	6	1	0	54	0	26
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	91	91	91	88	88	88	58	58	58	89	89	89
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	30	276	9	0	315	44	10	2	0	61	0	29
Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	359	0	0	285	0	0	677	699	280	677	681	337
Stage 1	-	-	-	-	-	-	340	340	-	337	337	-
Stage 2	-	-	-	-	-	-	337	359	-	340	344	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1116	-	-	1222	-	-	367	364	759	367	373	705
Stage 1	-	-	-	-	-	-	675	639	-	677	641	-
Stage 2	-	-	-	-	-	-	677	627	-	675	637	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1116	-	-	1222	-	-	345	354	759	358	363	705
Mov Capacity-2 Maneuver	-	-	-	-	-	-	345	354	-	358	363	-
Stage 1	-	-	-	-	-	-	657	622	-	659	641	-
Stage 2	-	-	-	-	-	-	649	627	-	655	620	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	0.8			0			15.8			15.2		
HCM LOS	C			C			C			C		
Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2		
Capacity (veh/h)	346	0	1116	-	-	1222	-	-	384	705		
HCM Lane V/C Ratio	0.035	+	0.027	-	-	-	-	-	0.183	0.028		
HCM Control Delay (s)	15.8	0	8.314	-	-	0	-	-	16.5	10.3		
HCM Lane LOS	C	A	A	-	-	A	-	-	C	B		
HCM 95th %tile Q(veh)	0.108	+	0.082	-	-	0	-	-	0.662	0.085		
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

Intersection						
Intersection Delay, s/veh	7.4					
Intersection LOS	A					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2	2		
Conflicting Circle Lanes	2	2	2	2		
Adj Approach Flow, veh/h	10	249	620	598		
Demand Flow Rate, veh/h	10	254	689	646		
Vehicles Circulating, veh/h	683	644	82	59		
Vehicles Exiting, veh/h	22	127	611	839		
Follow-Up Headway, s	3.186	3.186	3.186	3.186		
Ped Vol Crossing Leg, #/h	0	0	2	0		
Ped Cap Adj	1.000	1.000	0.998	1.000		
Approach Delay, s/veh	5.3	9.6	7.2	6.6		
Approach LOS	A	A	A	A		
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.471	0.529
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	10	254	324	365	304	342
Cap Entry Lane, veh/h	701	720	1063	1067	1081	1084
Entry HV Adj Factor	0.996	0.980	0.900	0.901	0.925	0.927
Flow Entry, veh/h	10	249	292	329	281	317
Cap Entry, veh/h	698	706	954	959	999	1005
V/C Ratio	0.014	0.353	0.306	0.343	0.281	0.315
Control Delay, s/veh	5.3	9.6	7.0	7.4	6.4	6.8
LOS	A	A	A	A	A	A
95th %tile Queue, veh	0	2	1	2	1	1

Intersection						
Intersection Delay, s/veh	-					
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0
Major/Minor	Minor1		Major1		Major2	
Conflicting Flow All	0	0	0	0	0	0
Stage 1	0	-	-	-	-	-
Stage 2	0	-	-	-	-	-
Follow-up Headway	3.518	3.318	-	-	2.218	-
Pot Capacity-1 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Time blocked-Platoon, %			-	-		-
Mov Capacity-1 Maneuver	-	-	-	-	-	-
Mov Capacity-2 Maneuver	-	-	-	-	-	-
Stage 1	-	-	-	-	-	-
Stage 2	-	-	-	-	-	-
Approach	WB		NB		SB	
HCM Control Delay, s	0		0		0	
HCM LOS	A					
Minor Lane / Major Mvmt		NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)		-	-	+	-	-
HCM Lane V/C Ratio		-	-	+	-	-
HCM Control Delay (s)		-	-	0	0	-
HCM Lane LOS				A	A	
HCM 95th %tile Q(veh)		-	-	+	-	-
Notes						
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined						

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future+Project PM Peak Hour



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	168	27	106	26	28	230	102	972	279	1209
v/c Ratio	0.58	0.09	0.31	0.09	0.10	0.44	0.61	0.63	1.17	0.77
Control Delay	38.5	27.5	8.7	27.5	27.6	17.9	51.7	18.2	147.3	19.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	38.5	27.5	8.7	27.5	27.6	17.9	51.7	18.2	147.3	19.7
Queue Length 50th (ft)	76	11	0	11	12	67	48	175	~163	227
Queue Length 95th (ft)	119	29	30	30	32	115	#123	274	#318	338
Internal Link Dist (ft)		199			278			517		601
Turn Bay Length (ft)	100		100	150			350		400	
Base Capacity (vph)	900	958	852	900	900	517	169	1535	238	1580
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.19	0.03	0.12	0.03	0.03	0.44	0.60	0.63	1.17	0.77

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Queues
3: Hwy 1 & Hwy 20



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	232	256	786	179	324	887
v/c Ratio	0.66	0.53	0.55	0.25	1.13	0.84
Control Delay	34.4	9.5	17.0	3.5	127.1	21.6
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	34.4	9.5	17.0	3.5	127.1	21.6
Queue Length 50th (ft)	90	11	124	0	-84	264
Queue Length 95th (ft)	158	66	205	35	#168	#578
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	841	848	1424	725	286	1061
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.28	0.30	0.55	0.25	1.13	0.84

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Intersection												
Intersection Delay, s/veh	4.1											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	16	0	15	6	0	20	9	1237	13	32	1276	51
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	3	3	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	-	25	-	-	25	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	84	84	84	79	79	79	96	96	96	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2	11	11	11	15	15	15
Mvmt Flow	19	0	18	8	0	25	9	1289	14	35	1387	55
Major/Minor	Minor2		Minor1			Major1			Major2			
Conflicting Flow All	2147	2805	724	2077	2826	654	1442	0	0	1302	0	0
Stage 1	1484	1484	-	1314	1314	-	-	-	-	-	-	-
Stage 2	663	1321	-	763	1512	-	-	-	-	-	-	-
Follow-up Headway	3.52	4.02	3.32	3.52	4.02	3.32	2.31	-	-	2.35	-	-
Pot Capacity-1 Maneuver	27	18	368	31	17	409	423	-	-	463	-	-
Stage 1	131	187	-	167	226	-	-	-	-	-	-	-
Stage 2	417	224	-	363	181	-	-	-	-	-	-	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	23	16	367	27	15	408	422	-	-	462	-	-
Mov Capacity-2 Maneuver	23	16	-	27	15	-	-	-	-	-	-	-
Stage 1	128	173	-	163	221	-	-	-	-	-	-	-
Stage 2	382	219	-	318	167	-	-	-	-	-	-	-
Approach	EB		WB			NB			SB			
HCM Control Delay, s	249.5		60.9			0.1			0.3			
HCM LOS	F		F									
Minor Lane / Major Mvmt	NBL	NBT	NBR	EBLn1	WBLn1	SBL	SBT	SBR				
Capacity (veh/h)	422	-	-	42	96	462	-	-				
HCM Lane V/C Ratio	0.022	-	-	0.879	0.343	0.075	-	-				
HCM Control Delay (s)	13.725	-	-	249.5	60.9	13.426	-	-				
HCM Lane LOS	B			F	F	B						
HCM 95th %tile Q(veh)	0.068	-	-	3.415	1.338	0.243	-	-				
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

HCM 2010 Signalized Intersection Summary
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future+Project PM Peak Hour

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	136	22	86	23	24	200	98	902	31	243	897	155
Number	7	4	14	3	8	18	5	2	12	1	6	16
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	0.99		0.99	1.00		0.98	1.00		0.98
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	186.3	186.3	186.3	186.3	186.3	186.3	171.2	171.2	190.0	165.2	165.2	190.0
Lanes	1	1	1	1	1	1	1	2	0	1	2	0
Cap, veh/h	337	434	362	367	434	603	127	1352	46	235	1297	223
Arrive On Green	0.23	0.23	0.23	0.23	0.23	0.23	0.08	0.41	0.41	0.15	0.47	0.47
Sat Flow, veh/h	1112	1863	1553	1245	1863	1573	1630	3288	112	1573	2737	472
Grp Volume(v), veh/h	168	27	106	26	28	230	102	489	483	279	622	587
Grp Sat Flow(s),veh/h/ln	1112	1863	1553	1245	1863	1573	1630	1712	1689	1573	1652	1556
Q Serve(g_s), s	10.9	0.9	4.4	1.3	0.9	8.3	4.9	18.6	18.6	11.8	25.1	25.2
Cycle Q Clear(g_c), s	11.9	0.9	4.4	2.2	0.9	8.3	4.9	18.6	18.6	11.8	25.1	25.2
Prop In Lane	1.00		1.00	1.00		1.00	1.00		0.07	1.00		0.30
Lane Grp Cap(c), veh/h	337	434	362	367	434	603	127	704	694	235	783	737
V/C Ratio(X)	0.50	0.06	0.29	0.07	0.06	0.38	0.80	0.70	0.70	1.19	0.79	0.80
Avail Cap(c_a), veh/h	641	944	787	708	944	1034	167	800	789	235	835	786
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uniform Delay (d), s/veh	28.2	23.6	24.9	24.4	23.6	17.6	35.8	19.2	19.2	33.6	17.5	17.6
Incr Delay (d2), s/veh	1.1	0.1	0.4	0.1	0.1	0.4	18.6	2.2	2.3	118.4	5.0	5.4
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	3.1	0.4	1.7	0.4	0.4	3.2	2.6	7.6	7.5	12.2	10.1	9.8
Lane Grp Delay (d), s/veh	29.3	23.6	25.4	24.5	23.6	18.0	54.4	21.4	21.4	152.0	22.6	23.0
Lane Grp LOS	C	C	C	C	C	B	D	C	C	F	C	C
Approach Vol, veh/h		301			284			1074			1488	
Approach Delay, s/veh		27.4			19.2			24.6			47.0	
Approach LOS		C			B			C			D	
Timer												
Assigned Phs		4			8		5	2		1		6
Phs Duration (G+Y+Rc), s		23.6			23.6		12.0	38.4		17.0		43.3
Change Period (Y+Rc), s		5.2			5.2		5.9	5.9		5.2		5.9
Max Green Setting (Gmax), s		40.0			40.0		8.1	36.9		11.8		39.9
Max Q Clear Time (g_c+I1), s		13.9			10.3		6.9	20.6		13.8		27.2
Green Ext Time (p_c), s		2.1			2.1		0.0	11.8		0.0		9.7
Intersection Summary												
HCM 2010 Ctrl Delay				35.0								
HCM 2010 LOS				C								
Notes												

						
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations						
Volume (veh/h)	230	253	770	175	282	772
Number	3	18	2	12	1	6
Initial Q (Qb), veh	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00	1.00		1.00	1.00	
Parking Bus Adj	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow veh/h/ln	169.6	169.6	171.2	171.2	175.9	175.9
Lanes	1	1	2	1	2	1
Cap, veh/h	289	258	1382	588	342	1075
Arrive On Green	0.18	0.00	0.40	0.00	0.11	0.61
Sat Flow, veh/h	1616	1442	3423	1455	3250	1759
Grp Volume(v), veh/h	232	0	786	0	324	887
Grp Sat Flow(s),veh/h/ln	1616	1442	1712	1455	1625	1759
Q Serve(g_s), s	8.0	0.0	10.3	0.0	5.7	22.9
Cycle Q Clear(g_c), s	8.0	0.0	10.3	0.0	5.7	22.9
Prop In Lane	1.00	1.00		1.00	1.00	
Lane Grp Cap(c), veh/h	289	258	1382	588	342	1075
V/C Ratio(X)	0.80	0.00	0.57	0.00	0.95	0.83
Avail Cap(c_a), veh/h	1003	895	1783	758	342	1268
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	0.00	1.00	1.00
Uniform Delay (d), s/veh	22.8	0.0	13.4	0.0	25.8	8.9
Incr Delay (d2), s/veh	5.2	0.0	0.4	0.0	35.1	4.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0
%ile Back of Q (50%), veh/ln	3.3	0.0	3.7	0.0	3.8	8.1
Lane Grp Delay (d), s/veh	28.0	0.0	13.7	0.0	60.8	12.8
Lane Grp LOS	C		B		E	B
Approach Vol, veh/h	232		786			1211
Approach Delay, s/veh	28.0		13.7			25.7
Approach LOS	C		B			C
Timer						
Assigned Phs			2		1	6
Phs Duration (G+Y+Rc), s			29.3		12.0	41.3
Change Period (Y+Rc), s			5.9		5.9	5.9
Max Green Setting (Gmax), s			30.2		6.1	41.8
Max Q Clear Time (g_c+I1), s			12.3		7.7	24.9
Green Ext Time (p_c), s			10.9		0.0	10.5
Intersection Summary						
HCM 2010 Ctrl Delay			21.7			
HCM 2010 LOS			C			
Notes						

Intersection												
Intersection Delay, s/veh	5.9											
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Vol, veh/h	96	280	5	0	349	55	2	1	3	79	0	146
Conflicting Peds, #/hr	1	0	0	0	0	1	1	0	1	1	0	1
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	Yield
Storage Length	134	-	-	50	-	-	-	-	25	-	-	100
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	90	90	90	93	93	93	38	38	38	88	88	88
Heavy Vehicles, %	18	18	18	12	12	12	2	2	2	2	2	2
Mvmt Flow	107	311	6	0	375	59	5	3	8	90	0	166
Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	435	0	0	318	0	0	934	963	316	936	937	407
Stage 1	-	-	-	-	-	-	528	528	-	406	406	-
Stage 2	-	-	-	-	-	-	406	435	-	530	531	-
Follow-up Headway	2.362	-	-	2.308	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Capacity-1 Maneuver	1045	-	-	1188	-	-	246	256	724	245	265	644
Stage 1	-	-	-	-	-	-	534	528	-	622	598	-
Stage 2	-	-	-	-	-	-	622	580	-	533	526	-
Time blocked-Platoon, %	-	-	-	-	-	-	-	-	-	-	-	-
Mov Capacity-1 Maneuver	1044	-	-	1187	-	-	168	229	723	221	237	643
Mov Capacity-2 Maneuver	-	-	-	-	-	-	168	229	-	221	237	-
Stage 1	-	-	-	-	-	-	479	473	-	558	598	-
Stage 2	-	-	-	-	-	-	461	580	-	470	472	-
Approach	EB			WB			NB			SB		
HCM Control Delay, s	2.2			0			17.7			21.3		
HCM LOS	C			C			C			C		
Minor Lane / Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1	SBLn2		
Capacity (veh/h)	227	723	1044	-	-	1187	-	-	295	643		
HCM Lane V/C Ratio	0.046	0.007	0.102	-	-	-	-	-	0.492	0.172		
HCM Control Delay (s)	21.6	10	8.84	-	-	0	-	-	28.5	11.8		
HCM Lane LOS	C	B	A	-	-	A	-	-	D	B		
HCM 95th %tile Q(veh)	0.145	0.022	0.34	-	-	0	-	-	2.555	0.618		
Notes												
~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined												

Intersection						
Intersection Delay, s/veh	12.1					
Intersection LOS	B					
Approach	EB	WB	NB		SB	
Entry Lanes	1	1	2		2	
Conflicting Circle Lanes	2	2	2		2	
Adj Approach Flow, veh/h	42	188	920		1160	
Demand Flow Rate, veh/h	43	192	1021		1253	
Vehicles Circulating, veh/h	1273	961	348		44	
Vehicles Exiting, veh/h	24	408	968		1109	
Follow-Up Headway, s	3.186	3.186	3.186		3.186	
Ped Vol Crossing Leg, #/h	0	0	0		0	
Ped Cap Adj	1.000	1.000	1.000		1.000	
Approach Delay, s/veh	9.2	11.2	13.7		11.2	
Approach LOS	A	B	B		B	
Lane	Left	Left	Left	Right	Left	Right
Designated Moves	LTR	LTR	LT	TR	LT	TR
Assumed Moves	LTR	LTR	LT	TR	LT	TR
RT Channelized						
Lane Util	1.000	1.000	0.470	0.530	0.470	0.530
Critical Headway, s	4.113	4.113	4.293	4.113	4.293	4.113
Entry Flow, veh/h	43	192	480	541	589	664
Cap Entry Lane, veh/h	464	577	870	886	1093	1096
Entry HV Adj Factor	0.975	0.979	0.901	0.901	0.925	0.926
Flow Entry, veh/h	42	188	432	488	545	615
Cap Entry, veh/h	452	565	784	798	1012	1014
V/C Ratio	0.093	0.333	0.551	0.611	0.539	0.606
Control Delay, s/veh	9.2	11.2	12.8	14.4	10.3	11.9
LOS	A	B	B	B	B	B
95th %tile Queue, veh	0	1	3	4	3	4

Intersection

Intersection Delay, s/veh -

Movement	WBL	WBR	NBT	NBR	SBL	SBT
Vol, veh/h	0	0	0	0	0	0
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	0	0	0	0	0	0

Major/Minor	Minor1	Major1	Major2
Conflicting Flow All	0	0	0
Stage 1	0	-	-
Stage 2	0	-	-
Follow-up Headway	3.518	3.318	2.218
Pot Capacity-1 Maneuver	-	-	-
Stage 1	-	-	-
Stage 2	-	-	-
Time blocked-Platoon, %	-	-	-
Mov Capacity-1 Maneuver	-	-	-
Mov Capacity-2 Maneuver	-	-	-
Stage 1	-	-	-
Stage 2	-	-	-

Approach	WB	NB	SB
HCM Control Delay, s	0	0	0
HCM LOS	A		

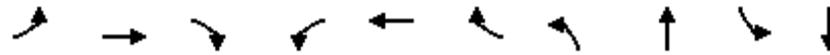
Minor Lane / Major Mvmt	NBT	NBR	WBLn1	SBL	SBT
Capacity (veh/h)	-	-	+	-	-
HCM Lane V/C Ratio	-	-	+	-	-
HCM Control Delay (s)	-	-	0	0	-
HCM Lane LOS	-	-	A	A	-
HCM 95th %tile Q(veh)	-	-	+	-	-

Notes

~ : Volume Exceeds Capacity; \$: Delay Exceeds 300 Seconds; Error : Computation Not Defined

Queues
2: Hwy 1 & Ocean View Dr/Boatyard Dr

Hare Creek Center Project Traffic Study
Future+Project Weekend Midday Peak Hour



Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	SBL	SBT
Lane Group Flow (vph)	165	29	126	52	34	231	124	903	242	1000
v/c Ratio	0.52	0.09	0.32	0.16	0.11	0.39	0.57	0.70	0.88	0.76
Control Delay	32.8	25.6	8.2	26.5	25.8	14.0	43.7	20.5	63.9	20.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	32.8	25.6	8.2	26.5	25.8	14.0	43.7	20.5	63.9	20.5
Queue Length 50th (ft)	62	10	0	18	12	49	49	157	99	171
Queue Length 95th (ft)	131	33	41	51	37	115	#146	246	#284	273
Internal Link Dist (ft)		199			278			517		601
Turn Bay Length (ft)	100		100	150			350		400	
Base Capacity (vph)	1046	1113	984	1046	1046	589	218	1780	276	1785
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.16	0.03	0.13	0.05	0.03	0.39	0.57	0.51	0.88	0.56

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Queues
3: Hwy 1 & Hwy 20

Hare Creek Center Project Traffic Study
Future+Project Weekend Midday Peak Hour



Lane Group	WBL	WBR	NBT	NBR	SBL	SBT
Lane Group Flow (vph)	194	263	784	201	285	736
v/c Ratio	0.55	0.54	0.66	0.31	0.83	0.74
Control Delay	27.8	9.9	18.9	3.8	51.8	15.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	27.8	9.9	18.9	3.8	51.8	15.7
Queue Length 50th (ft)	60	11	116	0	51	172
Queue Length 95th (ft)	126	62	192	36	#145	355
Internal Link Dist (ft)	305		167			496
Turn Bay Length (ft)					320	
Base Capacity (vph)	1015	979	1718	852	345	1279
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.19	0.27	0.46	0.24	0.83	0.58

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Appendix J – Traffic Signal Warrant No. 3

Option:

⁰⁸ If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.

Section 4C.03 Warrant 2, Four-Hour Vehicular Volume

Support:

⁰¹ The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

Standard:

⁰² **The need for a traffic control signal shall be considered if an engineering study finds that, for each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes. On the minor street, the higher volume shall not be required to be on the same approach during each of these 4 hours.**

Option:

⁰³ If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-2 may be used in place of Figure 4C-1.

Section 4C.04 Warrant 3, Peak Hour

Support:

⁰¹ The Peak Hour signal warrant is intended for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street.

Standard:

⁰² **This signal warrant shall be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.**

⁰³ **The need for a traffic control signal shall be considered if an engineering study finds that the criteria in either of the following two categories are met:**

A. If all three of the following conditions exist for the same 1 hour (any four consecutive 15-minute periods) of an average day:

- 1. The total stopped time delay experienced by the traffic on one minor-street approach (one direction only) controlled by a STOP sign equals or exceeds: 4 vehicle-hours for a one-lane approach or 5 vehicle-hours for a two-lane approach; and**
- 2. The volume on the same minor-street approach (one direction only) equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes; and**
- 3. The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.**

B. The plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4C-3 for the existing combination of approach lanes.

Option:

⁰⁴ If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-4 may be used in place of Figure 4C-3 to evaluate the criteria in the second category of the Standard.

⁰⁵ If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal may be operated in the flashing mode during the hours that the volume criteria of this warrant are not met.

Guidance:

⁰⁶ *If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal should be traffic-actuated.*

Section 4C.05 Warrant 4, Pedestrian Volume

Support:

⁰¹ The Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street.

Standard:

⁰² **The need for a traffic control signal at an intersection or midblock crossing shall be considered if an engineering study finds that one of the following criteria is met:**

- A. For each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) all fall above the curve in Figure 4C-5; or**
- B. For 1 hour (any four consecutive 15-minute periods) of an average day, the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) falls above the curve in Figure 4C-7.**

Option:

⁰³ If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 35 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-6 may be used in place of Figure 4C-5 to evaluate Criterion A in Paragraph 2, and Figure 4C-8 may be used in place of Figure 4C-7 to evaluate Criterion B in Paragraph 2.

Standard:

⁰⁴ **The Pedestrian Volume signal warrant shall not be applied at locations where the distance to the nearest traffic control signal or STOP sign controlling the street that pedestrians desire to cross is less than 300 feet, unless the proposed traffic control signal will not restrict the progressive movement of traffic.**

⁰⁵ **If this warrant is met and a traffic control signal is justified by an engineering study, the traffic control signal shall be equipped with pedestrian signal heads complying with the provisions set forth in Chapter 4E.**

Guidance:

⁰⁶ *If this warrant is met and a traffic control signal is justified by an engineering study, then:*

- A. If it is installed at an intersection or major driveway location, the traffic control signal should also control the minor-street or driveway traffic, should be traffic-actuated, and should include pedestrian detection.*
- B. If it is installed at a non-intersection crossing, the traffic control signal should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs, and should be pedestrian-actuated. If the traffic control signal is installed at a non-intersection crossing, at least one of the signal faces should be over the traveled way for each approach, parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the crosswalk or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance, and the installation should include suitable standard signs and pavement markings.*
- C. Furthermore, if it is installed within a signal system, the traffic control signal should be coordinated.*

Option:

⁰⁷ The criterion for the pedestrian volume crossing the major street may be reduced as much as 50 percent if the 15th-percentile crossing speed of pedestrians is less than 3.5 feet per second.

⁰⁸ A traffic control signal may not be needed at the study location if adjacent coordinated traffic control signals consistently provide gaps of adequate length for pedestrians to cross the street.

Figure 4C-101 (CA). Traffic Signal Warrants Worksheet (Sheet 2 of 5)

WARRANT 2 - Four Hour Vehicular Volume **SATISFIED*** YES NO

Record hourly vehicular volumes for any four hours of an average day.

APPROACH LANES	One		2 or More		Hour
Both Approaches - Major Street					
Higher Approach - Minor Street					

*All plotted points fall above the applicable curve in Figure 4C-1. (URBAN AREAS)	Yes <input type="checkbox"/>	No <input type="checkbox"/>
<u>OR</u> , All plotted points fall above the applicable curve in Figure 4C-2. (RURAL AREAS)	Yes <input type="checkbox"/>	No <input type="checkbox"/>

WARRANT 3 - Peak Hour **SATISFIED** YES NO
 (Part A or Part B must be satisfied)

PART A **SATISFIED** YES NO

(All parts 1, 2, and 3 below must be satisfied for the same one hour, for any four consecutive 15-minute periods)

1. The total delay experienced by traffic on one minor street approach (one direction only) controlled by a STOP sign equals or exceeds four vehicle-hours for a one-lane approach, or five vehicle-hours for a two-lane approach; <u>AND</u>	Yes <input type="checkbox"/>	No <input type="checkbox"/>
2. The volume on the same minor street approach (one direction only) equals or exceeds 100 vph for one moving lane of traffic or 150 vph for two moving lanes; <u>AND</u>	Yes <input type="checkbox"/>	No <input type="checkbox"/>
3. The total entering volume serviced during the hour equals or exceeds 800 vph for intersections with four or more approaches or 650 vph for intersections with three approaches.	Yes <input type="checkbox"/>	No <input type="checkbox"/>

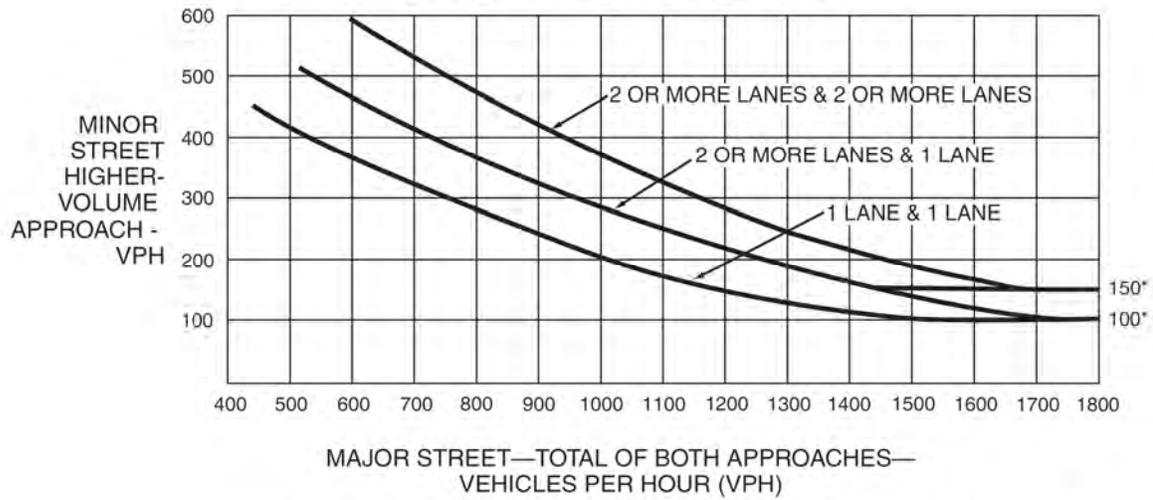
PART B **SATISFIED** YES NO

APPROACH LANES	One		2 or More		Hour
Both Approaches - Major Street					
Higher Approach - Minor Street					

The plotted point falls above the applicable curve in Figure 4C-3. (URBAN AREAS)	Yes <input type="checkbox"/>	No <input type="checkbox"/>
<u>OR</u> , The plotted point falls above the applicable curve in Figure 4C-4. (RURAL AREAS)	Yes <input type="checkbox"/>	No <input type="checkbox"/>

The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal.

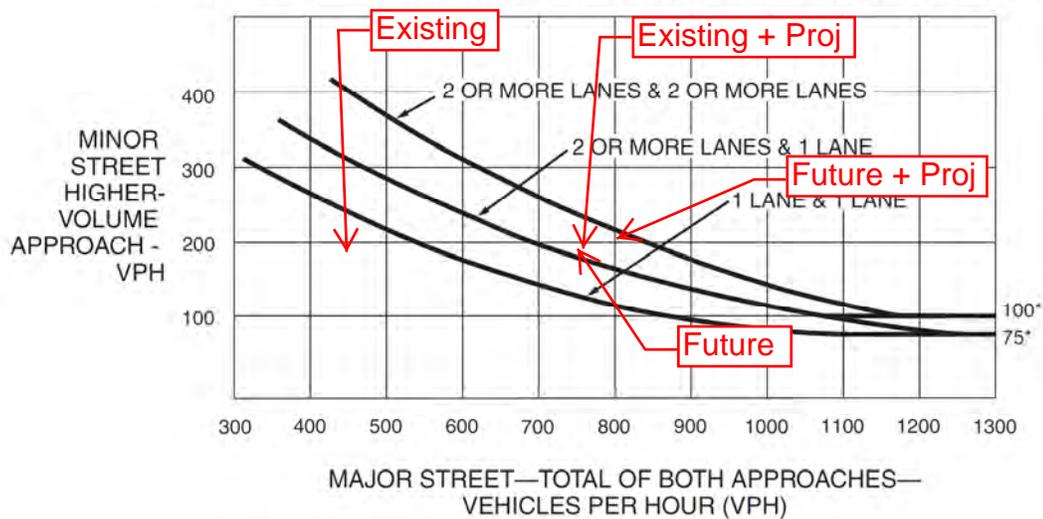
Figure 4C-3. Warrant 3, Peak Hour



*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4C-4. Warrant 3, Peak Hour (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



*Note: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane.

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
1	Matthew Kennedy	Frank Penry		Matthew Kennedy		3/3/2014

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Memorandum

February 15, 2017

To: Group II Commercial Real Estate Ref. No.: 11596-8410749

From: Matt Kennedy, PE, TE Tel: 707-540-9687

Subject: Hare Creek Commercial Center Project Traffic Impact Study: Review of Regional Growth and Traffic Impact Study Results

This memorandum summarizes a review of the results of the Traffic Impact Study (TIS) prepared for the Hare Creek Commercial Center Project (Project) and the potential affect regional growth between August 2013 and February 2017 may have on the analysis results and study conclusions.

July 2014 Draft Traffic Impact Study

A draft TIS report for the Project was issued in July 2014 using traffic count data collected in August 2013. August is considered by the City of Fort Bragg and Caltrans District 1 Transportation Planning as the peak month of traffic in the Fort Bragg area during a typical year. The draft TIS found that for the project conditions analyzed, all study intersections operated acceptably with respect to the established thresholds of significance, queuing and general traffic operation.

An increase in vehicular queuing and delays is anticipated at the southbound minor through-left approach at Study Intersection No. 4 (State Route 20 / Boatyard Drive) with and without the project. This anticipated queuing and delay was discussed with Caltrans District 1 Transportation Planning and was not a subject of concern because mainline traffic operations on State Route 20 remain acceptable and an alternative route to Boatyard Drive at Intersection No. 2 (State Route 1 / Ocean View Drive) exists.

A new right turn lane at the eastbound approach to Study Intersection No. 2 (State Route 1 / Ocean View Drive) is proposed to be added as a part of the project to address queuing and operations at this intersection. This improvement was identified by the City as a future project that would need to be implemented once warranted by traffic conditions.

The final TIS was issued with this Memorandum in February 2017.

Review of Estimated 2017 Traffic Conditions

In general, the results of a traffic study should be reviewed after approximately three years to assess whether changes in traffic volumes since the study was prepared are substantial enough to change the study results. Nearly three years have passed since the draft TIS was completed, and the traffic volumes used in the analysis are over three years old.



A review of Caltrans published peak hour traffic volumes for the study area was performed to assess whether traffic volumes could have increased substantially enough to affect the study results. It is important to note that the Caltrans published traffic volumes are not necessarily based on actual traffic data. Caltrans published traffic volumes often incorporate volume projections based on anticipated regional growth as well as other factors. A review of Caltrans published peak hour traffic volumes for 2013 and 2015 shows approximately a 5 percent increase in peak hour traffic volumes on State Route 1 and approximately a 1 percent increase in peak hour traffic volumes on State Route 20. These estimates are higher than the volume increases estimated for a 3 year period using the Caltrans District 1 20 Year Growth Factors that were used in the study. These growth factors result in a 2.25 percent and 0.75 percent increase in traffic on State Routes 1 and 20, respectively, during a three year period.

A review of the results of the TIS prepared for this project relative to the estimated range of traffic growth described above indicates that the impacts would remain below the thresholds of significance. The vehicular delays, queuing and level of service would be very similar to what was reported in the study with a slight increase in delay and no change in level of service. All study intersections are expected to operate as reported in the TIS.

Matt Kennedy, PE, TE
Project Manager



MEMORANDUM

To: Florentina Craciun, Michael Baker International **JN: 154802**

From: Tom Huang, Michael Baker International 

Date: December 23, 2016

Subject: Follow-up Comments for the *Hare Creek Commercial Center Project Traffic Impact Study Report*, dated March 2014.

Michael Baker International has reviewed the response provided by the traffic engineering consultant (GHD) on December 22, 2016 in regards to our December 16, 2016 peer review comments for the *Hare Creek Commercial Center Project Traffic Impact Study Report*, dated March 2014. Our follow-up comments are summarized below.

Response #1 from Consultant

Traffic studies do have a limited "life", and updates to the data and analysis may be necessary to satisfy AHJ requirements.

Follow-Up Comment for Response #1

New traffic counts should be conducted in January 2017 to validate the August 2013 counts. If the historic 2013 counts are higher or similar to the new 2017 counts, it would not be necessary to update the traffic analysis with the new counts. However, if the historic 2013 counts are lower than the new 2017 counts, the traffic analysis should be updated using the new 2017 counts.

Response #2 from Consultant

The unacceptable operation is in one minor street approach. The overall intersection average delay is acceptable. Alternative routes for traffic exist. Unacceptable operation of this approach occurs with and without the project trips. The intersection does not meet Signal Warrant 3. Caltrans' goal is to maintain safe and efficient operation of mainlines. This is not an intersection by definition, but was evaluated at the request of Caltrans and the City.

Follow-Up Comment for Response #2

We concur. No additional comments.

Response #3 from Consultant

Part B of Warrant 3 is not met. There is a typo in the table for these scenarios.

Follow-Up Comment for Response #3

The typo on Table 16 needs to be corrected.

Conclusion

Comments #1 and #3 need to be addressed by the traffic engineering consultant.

If you have any questions regarding this memorandum, please contact Tom Huang at 949.855.5754 or at tom.huang@mbakerintl.com

MEMORANDUM

To: Florentina Craciun, Michael Baker International **JN: 154802**

From: Tom Huang, Michael Baker International 

Date: December 16, 2016

Subject: Peer Review of the *Hare Creek Commercial Center Project Traffic Impact Study Report*, dated March 2014

Michael Baker International reviewed the *Hare Creek Commercial Center Project Traffic Impact Study Report*, dated March 2014, prepared by GHD. We also reviewed the supplemental submittal letter, dated March 18, 2105. This peer review focused on the adequacy of the traffic study report and its compliance with jurisdictional requirements and standard industry practices. The peer review includes the following subjects:

- **Project traffic generation rates** – The project trips were estimated based on the trip rates published in the Institute of Transportation Engineers (ITE) *Trip Generation Manual, 9th Edition*. The traffic study utilized the regression equation rates instead of the average rates for the Shopping Center use. In this case, the regression equation rates are more conservative (higher) than the average rates. The standard industry practice is to use higher trip rates so that the traffic projections are more conservative. The trip generation calculations are appropriately prepared.
- **Project trip distribution patterns** – The distribution patterns and percentages were estimated based on a review of the existing traffic volumes. The trip distribution assumptions seem reasonable.
- **Study analysis area** – The selection of the 5 analysis intersections seem reasonable based on the project trip generation and trip distribution.
- **Intersection geometry** – The existing lane configurations for the study area intersections appears to be correctly identified.
- **Traffic count data** – The intersection traffic counts and 24-hour average daily traffic (ADT) segment counts were collected on Thursday, August 22 and Saturday August 24, 2013 while school is in not session, and the traffic data is more than two years old. The 3/18/2015 supplemental submittal adequately addressed the issue of the count date that Caltrans and the City preferred the counts to be conducted in August. However, it is recommended that the existing 2013 traffic be revised to reflect 2016 conditions by using the cumulative growth factor with a 3-year growth.

- **Cumulative forecast methodology** – The future traffic scenario is estimated based on a 1.15 traffic growth factor on SR-1 and a 1.05 traffic growth factor on SR-20 to account for cumulative traffic growth in the study area. The 20-year growth factors were obtained from the Caltrans 2014 Growth Factors (Caltrans, 2014) developed from California Air Resources Board (ARB) traffic growth projections and historic traffic growth data. The traffic forecasting methodology is consistent with the standard industry practice.
- **Intersection operations and impact analysis methods** – The intersection analysis was conducted based on the Highway Capacity Manual (HCM) method. The traffic analysis methodology is consistent with the standard industry practice. The analysis result tables show that Intersection #1 (SR1 / Commercial Driveways) and Intersection #4 (SR20 / Boatyard Drive) have Level of Service (LOS) results that “exceed acceptable LOS” which are shown in BOLD, but the report text concludes that “all of the study intersections are operating acceptably based on City and Caltrans thresholds of significance”. Additional discussion may be needed to clarify the discrepancy between the analysis results table and the conclusion in the report text.
- **Signal Warrant Analysis** – The signal warrant analysis was conducted using the California Manual on Uniform Traffic Control Devices. This is consistent with the standard industry practice. The report text states that the signal warrants for “Intersection No. 4 – SR 20 / Boatyard Drive is not met presently and will not be met in the future, with or without the addition of project trips”, but the signal warrant result table (Table 16) shows that Part B of the signal warrant is met. The signal warrant is met when Part A or Part B of Warrant 3 is satisfied. Please clarify the discrepancy between the analysis results table and the conclusion in the report text.

Our comments are summarized below. All the comments need to be addressed by the traffic engineering consultant (GHD).

Comment #1

On page 15, the traffic count data was collected in August 2013, which is more than two years old. It is suggested that the existing 2013 traffic be revised to reflect 2016 conditions by using the cumulative growth factor with a 3-year growth.

Comment #2

On pages 15 and 16, Table 7 shows that Intersection #1 (SR1 / Commercial Driveways) and Intersection #4 (SR20 / Boatyard Drive) have Level of Service (LOS) results that “exceed acceptable LOS” which are shown in BOLD, but the report text concludes that “all of the study intersections are operating acceptably based on City and Caltrans thresholds of significance”. Additional discussion may be needed to clarify the discrepancy between the analysis results table and the conclusion in the report text.

Similar comment for the report text and Table 10 on pages 24 and 25.

Similar comment for the report text and Table 12 on pages 28 and 29.

Similar comment for the report text and Table 14 on pages 32 and 33.

Similar comment for the report text and Table 17 on pages 39 and 40.

Comment #3

On page 36, it states that the signal warrants for “Intersection No. 4 – SR 20 / Boatyard Drive is not met presently and will not be met in the future, with or without the addition of project trips”, but Table 16 (page 37) shows that Part B of the signal warrant is met. The signal warrant is met when Part A or Part B of Warrant 3 is satisfied. Please clarify the discrepancy between Table 16 and the conclusion in the report text.

Conclusion

Michael Baker International has reviewed the traffic study and offered comments, which should be addressed by the traffic engineering consultant.

If you have any questions regarding this memorandum, please contact Tom Huang at 949.855.5754 or at tom.huang@mbakerintl.com



March 18, 2015

Fort Bragg City Council
City of Fort Bragg
416 North Franklin Street
Fort Bragg, CA, 95437

RE: Hare Creek Center Project, Fort Bragg, CA

Dear City Council:

I was recently informed by the proponents of the above referenced project that there are three questions that have been raised with regard to the results of the Traffic Impact Study Report prepared for the project, which is dated March 2014. The general scope of the questions is summarized below, and each of the questions is discussed in detail in the subsequent paragraphs of this letter.

1. Timing of Traffic Counts: There is a question regarding the timing of the traffic counts that were collected for the study, and why the counts were not collected during a time period when area schools were in session;
2. Boatyard Shopping Center Businesses: There is a question regarding a Dollar Tree variety store that recently replaced a Rite Aid pharmacy/drug store in the Boatyard Shopping Center and the potential effect this store may have on area traffic and the results of the Traffic Impact Study; and
3. Level of Service: There is a question regarding the reduction in Level of Service (LOS) from "Future Conditions" to Future plus Project Conditions" at the southbound left-turn/through lane approach at State Route (SR) 20 and Boatyard Drive, and why the study concluded that this reduction is not considered an impact.

Timing of Traffic Counts: The scope of the traffic study and the general timing of the traffic data collection were closely coordinated with the City of Fort Bragg Community Development Department and Public Works Department, and with Caltrans District 1 prior to beginning the study. Caltrans District 1 maintains primary jurisdiction over the intersections analyzed in the study, including SR 1 and SR 20. The traffic counts were collected during the month of August, which is considered by Caltrans and the City as the peak month of traffic for the year in this area of the northern California coast. During other months traffic volumes are generally lower due to a reduction in tourism-related traffic. Traffic counts collected during months other than August are adjusted up to August levels by applying a growth factor provided by the City or Caltrans. During a conference call on May 23, 2013 with Caltrans System Planning and Traffic Operations, a strong preference to collect traffic data during the month of August was expressed by Caltrans representatives. This preference was also expressed by the City Community Development Director in an email correspondence on May 20, 2013 (Attachment 1).

Boatyard Shopping Center Businesses: At the time the Traffic Impact Study was conducted a Rite Aid pharmacy/drug store was doing business in the Boatyard Shopping Center located across the street from the proposed project site. Since the study was completed, Rite Aid left the shopping center and a Dollar Tree variety store began doing business at the former Rite Aid location. There is a question regarding the potential effect this new variety store may have on area traffic and the results of the Traffic Impact Study. The traffic counts collected for the study include traffic generated by the Boatyard Shopping Center. The change in business type from a "pharmacy/drug store" to a "variety store" is not expected to have a statistically significant effect on the peak hour volumes or timing of peak hour traffic for this shopping center. A summary of the peak hour trip generation rates for these land use types from the Trip Generation Manual, 9th edition (ITE, 2012) is summarized in the table below.



Land Use Type	Units	AM Peak Hour		PM Peak Hour	
		Average Rate	Standard Deviation	Average Rate	Standard Deviation
Variety Store (814)	1000 SF GFA	3.81	2.74	6.82	3.80
Pharmacy/Drug Store w/o Drive-Through Window	1000 SF GFA	2.94	2.02	8.40	3.51

Source: ITE, 2012
 SF GFA = square feet gross floor area
 Rate = # trips per unit

As shown in the table, the AM and PM peak hour trip generation rates for these two land use types are very similar, and the standard deviations from the average rates overlap each other. Because the rates are so statistically similar one cannot conclude that there would be a statistically significant change in traffic volumes or in the results of the study associated with the change in land use or business type.

Level of Service: The Traffic Impact Study found that the PM peak hour level of service of the southbound left-turn/through lane approach at SR 20 / Boatyard Drive (Study Intersection 4) degrades from a LOS “D” in the “Future Conditions” analysis to a LOS “E” in the “Future plus Project Conditions” analysis. This intersection is a side street stop controlled intersection not along SR 1, where Boatyard Drive is the minor street with stop control and SR 20 is the major street. The study determined that this reduction in LOS is not a significant impact. Policy C-1.1 of the City of Fort Bragg Coastal General Plan (City of Fort Bragg, 2012) establishes minimum level of service standards for side street stop controlled intersections not along SR 1. Policy C-1.1 states:

Side Street Stop Sign Controlled Intersections not along SR 1: LOS C, or LOS E if there is less than 15 veh./hr. left turns plus through movements from the side street and the volumes do not exceed Caltrans rural peak hour signal warrant criteria levels.

While the combined total left turn plus through movement PM peak hour volume exceed the 15 vehicles per hour criteria threshold, the Caltrans rural peak hour Signal Warrant 3 criteria is not met, therefore this intersection approach operates at an acceptable LOS E and there is no impact from the project.

We welcome the opportunity to assist in clarifying the traffic-related questions you have raised on this important project. Should you have any other questions, please do not hesitate to contact me.

Sincerely,
 GHD Inc.

Matt Kennedy, PE, TE
 Project Manager



3/18/2015

References:

City of Fort Bragg (2012). Fort Bragg Inland General Plan. City of Fort Bragg, CA. November 2012.

ITE (2012). Trip Generation Manual, 9th Edition. Institute of Transportation Engineers, Washington DC. 2012.

Attachments:

1. Project Email Correspondence between Matt Kennedy, City of Fort Bragg, and Caltrans District 1, May 2013.

Attachment 1

Matt Kennedy

From: Jones, Marie <mjones@fortbragg.com>
Sent: Monday, May 20, 2013 4:32 PM
To: Matt Kennedy
Cc: Goble, Dave
Subject: FW: TIS Scoping Meeting (Men 1/Fort Bragg) Hare Creek

CompleteRepository: 8410749
Description: HARE CREEK CENTER TRAFFIC STUDY
JobNo: 10749
OperatingCentre: 84
RepoEmail: 8410749@ghd.com
RepoType: Job

Matt,

Please see Dave Goble's comment below. I would add the City Council in the past has wanted to change this intersection to include bulb-outs and pedestrian features. Additionally in 2011 we have a transportation plan prepared for South Fort Bragg, adopted by City Council, that indicated sidewalks and bicycle lanes be installed by any new development along Main Street, this would include the proposed project. Therefore any proposed new geometry for this location should take into consideration bicycle and pedestrian use and path of travel in addition to auto use.

Also please pay attention to vehicular cueing and the impact of cueing on Ocean Drive and the impacts on driveway access by other vehicles. (I would especially worry about the Dolphin Inn.)

I was not able to review the attachments as they had expired. I am going to assume that they are not considering a traffic circle as we have already discussed and rejected that solution. So access would be from Ocean Drive (correct?).

If the counts are collected during a month other than August I would need to know the month and I can give you an estimated growth factor to account for August traffic levels. Obviously if the counts are conducted in April versus June that would have a significantly different comparable rate than August. It is probably best to conduct the counts in August.

Hope this helps. Call me with any questions.

Thanks,

Marie

Marie Jones
Community Development Director
City of Fort Bragg
707-961-1807

From: Goble, Dave
Sent: Wednesday, May 15, 2013 8:00 AM
To: Jones, Marie
Subject: RE: TIS Scoping Meeting (Men 1/Fort Bragg) Hare Creek

Marie:

The only thing that I'd like to make sure gets evaluated are the turning movements out of Ocean View Drive to identify whether turning movements from the new development would warrant improvements to that intersection. When the motel was developed, they held improvements back to provide adequate space for a right turn pocket when warranted from Ocean View Drive. The City does not own the required right of way, but it could be purchased for development if necessary.

The remainder of the study will focus on State highways and I'll leave that to Caltrans.

Dave

David W. Goble
 Director of Public Works
 City of Fort Bragg
 707-961-2823; Ext. 117
dgoble@fortbragg.com

From: Jones, Marie
Sent: Friday, May 10, 2013 1:41 PM
To: Goble, Dave
Subject: FW: TIS Scoping Meeting (Men 1/Fort Bragg) Hare Creek

Dave do you have any comments on the proposed approach, see below, for traffic models for new development at the hare Creek parcel?

Marie

Marie Jones
 Community Development Director
 City of Fort Bragg
 707-961-1807

From: Matt Kennedy
Sent: Friday, April 26, 2013 11:33 AM
To: 'mjones@fortbragg.com'
Subject: FW: TIS Scoping Meeting (Men 1/Fort Bragg) Hare Creek

Hi Chris,

Thank you for taking the time to speak with me this morning, and to provide your feedback on the scope for a revised traffic study for this project. In summary, the project proposed is a 30,000 GSF commercial development adjacent to SR1 in Fort Bragg between the Noyo Bridge and Hare Creek Bridge (See attached vicinity map). The new land uses are general retail space, a discount grocery store, and possibly a small restaurant or sandwich shop like Subway. A site plan is attached (A1 – SITE PLAN.PDF). The previous project site plan is also attached for context. An initial trip generation estimate is summarized in the table below:

ITE Land Use	ITE Land Use Code	1000 GSF	Average ITE Rate			Peak Hour	
			AM	PM	Sat	AM	PM
Discount Supermarket	854	15.0	2.53	8.34	9.65	38	12
Shopping Center	820	13.5	0.96	3.71	4.82	13	50
Fast Food Restaurant w/o Drive-Thru Window	933	1.5	43.87	26.15	63.50	66	39
	TOTALS	30.0				117	214

The trip generation estimate indicates that a traffic study would be required per the Caltrans TIS Guidelines.

We are proposing to update the previous traffic study we did for the original version of the project following the Caltrans TIS Guidelines and D1 supplements (attached). Pending your feedback on the scope of the study as summarized in this email, we will be updating turning movement traffic counts at the five study intersections (AM, PM and Saturday Mid-day, see attached figure for intersection locations). We will also be collecting 24-hour tube counts and classifications at the following three locations:

- SR 1 Between Hare Creek Bridge and Intersection 3
- SR 1 Between Noyo Bridge and Intersection 1
- SR 20 between S. Harbor Dr. and Intersection 4

Future traffic volumes would be projected using the attached District 1 growth factor map. In addition to your feedback, I would also like to know what factor(s) (if any) we would use to adjust traffic volumes to the month of August (considered the peak month) if the counts are conducted during a month other than August.

Marie, I left you a voice message earlier this week seeking your input on the study. Please let me know if you have any comments on the scope for the traffic study, or other City requirements for the study.

Many thanks!

Matt

Matt Kennedy, PE, TE
Project Manager

GHD

T: 707 523 1010 | D: 707 540 9687 | V: 849687 | F: 707 527 8679 | C: 707 540 3376 | E: matt.kennedy@ghd.com
2235 Mercury Way, Suite 150, Santa Rosa, CA 95407, USA | www.ghd.com
[WATER](#) | [ENERGY & RESOURCES](#) | [ENVIRONMENT](#) | [PROPERTY & BUILDINGS](#) | [TRANSPORTATION](#)

Please consider our environment before printing this email

From: Arseneau, Troy A@DOT [<mailto:troy.arseneau@dot.ca.gov>]
Sent: Wednesday, April 24, 2013 11:13 AM
To: Matt Kennedy
Cc: Jackman, Rex A@DOT; Brunton, Eric S@DOT; Dosch, Christopher L@DOT
Subject: TIS Scoping Meeting (Men 1/Fort Bragg)

Matt,

Got your telephone message. We typically arrange our pre-TIS scoping meetings through our System Planning Branch (Rex Jackman, 707-445-6412). He is out of the office, but Christopher Dosch is Acting for him and can be contacted at 707-441-4542. I am cc'ing him this email, and I have spoken to him on the telephone. Thanks.

Troy

Troy A. Arseneau, P.E., T.E., PTOE
District Traffic/TMP Manager/ICE Coordinator

Chief, Traffic Operations Branch
Caltrans District 1 - Eureka
Tel: 707-445-6377 / Cell: 707-496-1562
Email: troy_arseneau@dot.ca.gov
PO Box 3700, Eureka, CA 95502-3700
<http://www.dot.ca.gov>

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DBL Debra B. Lennox, AIA

Art & Architecture

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3/19/15

Fort Bragg City Council
City of Fort Bragg
416 N. Franklin St.
Fort Bragg, CA 95437

Re: Hare Creek Center Appeals

Dear Council members & City Staff:

I am writing on behalf of our project as the representative for Bill & Greg Patton for the proposed Hare Creek Center. The vote at the Planning Commission meeting regarding the Design Review was taken at the last minute at the end of a very emotional meeting. We did not have adequate time to respond to the Commissioners' questions about the project and feel that with better communication, we can answer those questions and possibly make some modifications. I am confident that with further refinement, you will find that this project is a worthy new addition to the architecture of Fort Bragg.

Bill & Greg have spent years trying to propose a project that will be acceptable to the City and coastal residents for their property on 1250 Del Mar Drive. There has been so much public misinformation and confusion about this project, I would like to clarify the basis for the design decisions we have made while complying with a very comprehensive City General Plan & Coastal Land Use Code incorporating the Citywide Design Guidelines, South Main Street Access & Beautification Plan, as well as CALTRANS' street requirements. The 21 Mitigation Measures and 17 Special Conditions proposed by staff were not lightly considered.

We have been working on this project for 1-1/2 years. There are currently two street frontages, Highway One & our proposed access road, labeled Bay View Drive (we prefer Hare Creek Drive). As mentioned in the Staff Report, we initially rotated the buildings 90 degrees to Highway One in order to meet Design Guidelines. After our first submittal, we added loading dock driveways for circulation around the buildings. Our parking lot has been re-designed many times, and now it is pedestrian friendly, universally accessible, with extra handicap parking access along our covered canopy walkways. We have added a sidewalk on each side of the property in the Caltrans right of way as well as along Hare Creek Drive. No other

pg.2

properties in this area are as accessible and safe. We are at the vanguard of the South Main Beautification Plan, improving the experience of pedestrians and bicyclists as well as shoppers that are driving to our site. We provide bike racks under our canopy as well.

Bill & Greg have been very supportive of the sustainable measures I have proposed for this project. As a LEED accredited architect, I am thrilled to be able to use my expertise to incorporate rainwater collection, photovoltaic technology, daylighting measures, & energy efficient lighting & mechanicals. Our site plan as designed by Lee Welty uses bioswale rain gardens & permeable pavers to filter parking lot runoff as well as a sophisticated stormwater management program that will meet all the necessary CALGREEN requirements for a commercial project of this size. These measures are not inexpensive, and it is almost unheard of for this type of building to embrace these types of technologies that are designed to save energy and provide a healthy environment for the users of these buildings.

This project also exemplifies my preference for a simple, clean “form follows function” architecture. We are invoking the imagery of the ranch or farm with our trellises & water storage tanks as well as the clean lines of the gable profile that break up the mass of the buildings. The trash enclosures and accessory buildings are designed to resemble small outbuildings typically found on a ranch. The history of the property is that of a dairy farm, so we determined this was an appropriate visual reference to use for the building design. In addition, we propose an extensive landscaping plan prepared by our expert Landscape Architect, George Salvaggio of WRA, that includes flowering vines and small trees whose changing leaves and flowers would showcase the changing of the seasons.

However, since the Planning Commission meeting and listening to the public comments, we have reconsidered the landscaping plan and will conform to the requirements that all of the plantings be native. We also added a double row of screen trees south of Building B that will mix with the existing shore pines to create a visual buffer of that south elevation. (See Attachment 7 revised A3.2.) We have already pushed back Bldg C 5 feet per Special Condition 8 and added a landscaping strip of native bushes to screen that building as well. These measures should "soften" the appearance of the buildings, together with our green facade plantings that were already proposed.

I have conducted an investigation into the history of the buildings of Fort Bragg as well as looking at the larger buildings in the City that may be compared to this project. I am planning a PowerPoint presentation for the City Council meeting on Monday, March 23rd that will incorporate my review of Fort Bragg architecture and also provide additional visual information about the local buildings that have influenced my design. I will also discuss the project as viewed from the front entrances (as well as from the Highway) to elaborate on the experience of going to the project as well as driving past it.

Thank you for your consideration.

Sincerely,

Debra Lennox
architect



BLDG B



THE DIFFERENCE IS VISION



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Fort Bragg City Council
City of Fort Bragg
416 N. Franklin Street
Fort Bragg, CA 95437

March 18, 2015

Re: CDP 8-13
Design Review (DR 7-13)
Use Permit USP 5-13
Lot line Adjustment
Hare Creek Center
LLA3-2014

Clarification of Submittal

City Council Members:

It has come to our attention through inquiry and the appeal of the Planning Commission decision, that several grading and drainage concepts of our plan are not fully understood. The two general concepts are the Project Road and the Ground Water Recharge.

Project Road:

The project road is proposed to be located on the west side of the development and runs the length of the project. This road is the extension of Harbor Drive and has always been thought to be a good division between the Highway Visitor Commercial Zone and Residential type of zoning to the west.

For this project we were asked by City Staff to include a future roadway circulation. This shows up on our Topographic Map and our Offsite Improvement Plan as a dashed line. This is not a part of this project. In the past we had designed a road with a cul-de-sac and the City Staff at that time wanted the roadway hooked up to the existing roadway going west. We are now only proposing a turnaround at the south end of the project.

Other comments concerning the roadway stated that the top of the hill with the Coast and Geodetic Monument would be removed. This is not the case and if one would look at our grading plan they would see that the roadway is east of the hill top.

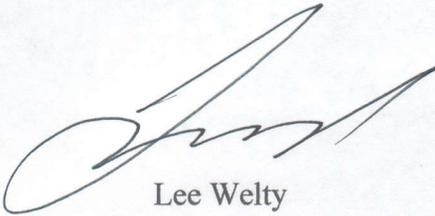
Ground Water Recharge:

The Hydrologic Study provided by Nolan Associates was used in the staff report to give additional information developed on the property relative to ground water recharge. This report was written for a much larger proposed project and it was found that the project did not have a negative impact on the ground water for the area.

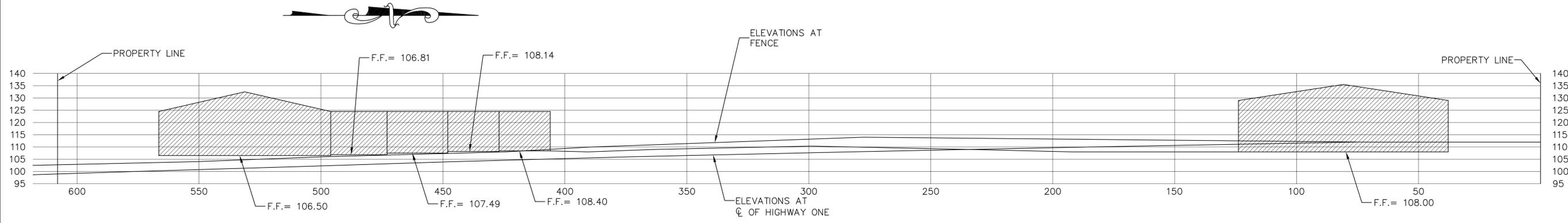
Fort Bragg City Council
March 18, 2015
Page 2 of 2

In the case of our proposed project, it is much smaller and as pointed out in the staff report we are treating and infiltrating 100% of the project water. The project water is defined as the difference in storm water runoff between the development and undeveloped property.

Sincerely Yours

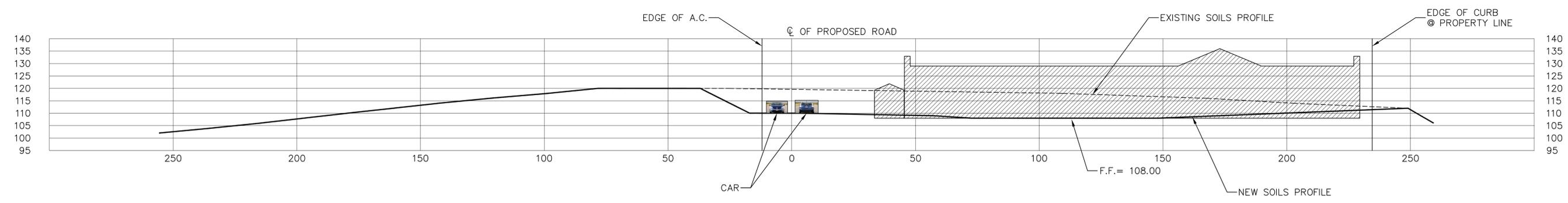
A handwritten signature in black ink, appearing to read 'Lee Welty', written in a cursive style.

Lee Welty



PROFILE LOOKING WEST FROM HIGHWAY ONE

1:20 2



SECTION @ STATION 25+77.23

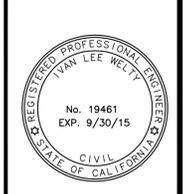
1:20 1

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HARE CREEK DEVELOPMENT
 GROUP II COMMERCIAL REAL ESTATE
 FORT BRAGG
 HARE CREEK CENTER

JOB #1042
 DRAWN TH
 DATE 3/13/2015
 SCALE AS SHOWN
 APPROVED
 R.C.E. 19461



SHEET
G6
 OF 6 SHEETS

Lemos, June

From: Jacob Patterson <jacob.patterson.esq@gmail.com>
Sent: Monday, September 9, 2019 3:44 PM
To: Lemos, June
Subject: Public Comment -- 9/9/19 CC Mtg., Item No. 7A
Attachments: How High Will Seas Rise_ Get Ready for Seven Feet - Yale E360.pdf; CCC 2018 Adopted SLR Guidance Update.pdf

June,

Please include these resources concerning climate change and sea-level rise as public comments for Item No. 7A.

Thanks,

--Jacob



CALIFORNIA COASTAL COMMISSION

SEA LEVEL RISE POLICY GUIDANCE

Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits



Sunset Beach, Photo by Mario Fernandez



Chula Vista, Photo by Lisa Cox



San Francisco, Photo by Mike Baird



Arcata, Photo by Humboldt Baykeeper

Original Guidance unanimously adopted – August 12, 2015

Science Update unanimously adopted – November 7, 2018

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The **original** *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits* was unanimously adopted by the California Coastal Commission on August 12, 2015.

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 Dayna Bochco, *Vice Chair*
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A **Science Update** to the *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits* was unanimously adopted by the California Coastal Commission on November 7, 2018.

Commissioners

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This report was prepared with financial assistance from the National Oceanic and Atmospheric Administration under the Coastal Zone Management Act Section 309 Enhancement Grant Program

SUMMARY OF DOCUMENT REVISIONS

A first draft of this Guidance was released for public review on October 14, 2013. The public comment period was open for 120 days, until February 14, 2014. During that time, the Commission received over 100 comment letters that broke down into over 800 distinct comments. A revised draft was released on May 27, 2015 and presented at the June 2015 Coastal Commission hearing in Newport Beach. Written comments were requested by July 10, 2015, and 28 comment letters were submitted.

On August 12, 2015 the Commission adopted the Recommended Final Draft (dated July 31, 2015 and updated with addenda August 10, 2015) as interpretive guidelines pursuant to Public Resources Code section 30620. The final draft has been posted on the Commission's website and used by the Commission, local governments, project applicants, and other stakeholders since its adoption.

Science-focused updates have now been developed to address evolving science. Acting on direction from Governor Brown, the Ocean Protection Council has released two reports that update our understanding of sea level rise science and best practices for planning for and addressing anticipated impacts. The first of these reports, *Rising Seas in California: An Update on Sea-Level Rise Science*, synthesizes recent evolving research on sea level rise science, and forms the foundation for the second report, the *State of California Sea-Level Rise Guidance: 2018 Update*. The 2018 OPC SLR Guidance provides higher level recommendations for how to plan for and address sea level rise impacts, notably including a set of projections recommended for use in planning, permitting, investment, and other decisions.

In order to reflect the updated best available science, a set of focused updates for the Coastal Commission SLR Policy Guidance have been developed. These include:

- *References to best available science throughout the document, including SLR projection tables, which formerly referenced the 2012 NRC Report, have been updated to reference the 2018 OPC SLR Guidance.*
- *Sections of the Guidance that provided extensive details about the NRC report and/or how to use the information provided within the NRC report (mainly in Chapters 3, 5, and 6 and Appendices A and B) have been removed. In their place, summaries of the Rising Seas science report (2017) and the 2018 OPC SLR Guidance have been added (Chapters 3, 5, and 6, and Appendices A, B, and G).*
- *Some updates have been made to tables of resources meant to assist interested parties in addressing sea level rise (e.g., SLR mapping and modeling tools, grant funding sources, and agency and other stakeholder guidance). However, these tables have not been exhaustively updated, and additional resources may be available.*

On November 7, 2018, the Commission unanimously adopted the Draft Science Update to the Coastal Commission Sea Level Rise Policy Guidance.

How to Use this Document

This document is:	This document is <u>NOT</u> :
Guidance	Regulations
<p><i>This Guidance is advisory and not a regulatory document or legal standard of review for the actions that the Commission or local governments may take under the Coastal Act. Such actions are subject to the applicable requirements of the Coastal Act, the federal Coastal Zone Management Act, certified Local Coastal Programs, and other applicable laws and regulations as applied in the context of the evidence in the record for that action.</i></p>	
Dynamic	Static
<p><i>This Guidance will be updated periodically to address new sea level rise science, information, and approaches regarding sea level rise adaptation, and new legal precedent. The Commission will also continue working on sea level rise through other projects and in a collaborative manner, as outlined in Chapter 9: Next Steps.</i></p>	
Multi-purpose for multiple audiences	Meant to be read cover-to-cover
<p><i>This Guidance is a comprehensive, multi-purpose resource and it is intended to be useful for many audiences. As such, it includes a high level of detail on many subjects. However, chapters were written as stand-alone documents to provide usable tools for readers.</i></p>	
A menu of options	A checklist
<p><i>Since this document is intended for use statewide, it is not specific to a particular geographic location or development intensity (e.g., urban or rural locations). Therefore, not all of the content will be applicable to all users, and readers should view the content as a menu of options to use only if relevant, rather than a checklist of required actions.</i></p>	

Reading Tips

- Look carefully at the Table of Contents and identify sections of interest.
- Do not expect all of the content to apply to your particular situation. As a statewide document, a wide variety of information is included to address the concerns of various users.
- Navigate to your desired level of detail: The *Executive Summary* provides a basic summary of the content; the body of the document provides a detailed discussion; and the *Appendices* provide more scientific and technical detail and a variety of useful resources.

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Commonly Used Acronyms and Agency Names

Terms:

CCT – California Coastal Trail

CDP – Coastal Development Permit

CoSMoS – Coastal Storm Modeling System

ENSO – El Niño Southern Oscillation

ESHA – Environmentally Sensitive Habitat Area

GHG – Greenhouse gas

IPCC – Intergovernmental Panel on Climate Change

LCP – Local Coastal Program

LUP – Land Use Plan

NRC Report – National Research Council Report “*Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*”

PDO – Pacific Decadal Oscillation

SLR – Sea level rise

TNC – The Nature Conservancy

Agency Names:

BCDC – San Francisco Bay Conservation and Development Commission

BOEM – Bureau of Ocean Energy Management

BSEE – Bureau of Safety and Environmental Enforcement

Cal OES – California Governor’s Office of Emergency Services

Caltrans – California Department of Transportation

CCC/Commission – California Coastal Commission

CDFW – California Department of Fish and Wildlife

CNRA – California Natural Resources Agency

CO-CAT – Coast and Oceans Climate Action Team

Conservancy – California State Coastal Conservancy

EPA – Environmental Protection Agency

FEMA – Federal Emergency Management Agency

NERR – National Estuarine Research Reserve

NMS – National Marine Sanctuary

NOAA – National Oceanic and Atmospheric Administration

NPS – National Park Service

OPC – California Ocean Protection Council

OPR – California Governor’s Office of Planning and Research

State Lands – California State Lands Commission

State Parks – California Department of Parks and Recreation

SWRCB – State Water Resources Control Board

USACE – United States Army Corps of Engineers

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey



Executive Summary

Climate change is upon us, affecting almost every facet of California’s natural and built environment. Increasing global temperatures are causing significant effects at global, regional, and local scales. In the past century, average global temperature has increased by about 0.8°C (1.4°F), and average global sea level has increased by 7 to 8 in (17 to 21 cm) (IPCC 2013). Sea level at the San Francisco tide gauge has risen 8 in (20 cm) over the past century, and recent reports developed by the California Ocean Protection Council (OPC) (in conjunction with the OPC Science Advisory Team) project that by the year 2100, sea levels may rise by approximately 2.4 to 6.9 feet, with the potential for rapid ice loss to result in an extreme scenario of 10.2 feet of sea level rise (Griggs *et al.*, 2017; OPC 2018). While the California coast regularly experiences erosion, flooding, and significant storm events, sea level rise will exacerbate these natural forces, leading to significant social, environmental, and economic impacts. The [third National Climate Assessment](#) notes that there is strong evidence showing that the cost of doing nothing to prepare for the impacts of sea level rise exceeds the costs associated with adapting to them by about 4 to 10 times (Moser *et al.* 2014). Therefore, it is critically important that California plan and prepare for the impacts of sea level rise to ensure a resilient California coast for present and future generations.

The California Coastal Act is one of the state’s primary coastal management laws for addressing land use, public access and recreation, and the protection of coast and ocean resources in the coastal zone. It is also the primary coastal hazards law governing development along the coast. Using the Coastal Act, the Coastal Commission and local governments have more than four decades of experience managing coastal development, including addressing the challenges presented by coastal hazards like storms, flooding, and erosion as well as responses to these hazards such as armoring. However, sea level rise and the changing climate present management challenges of a new magnitude, with the potential to significantly threaten many coastal resources, including shoreline development, coastal beach access and recreation, habitats, agricultural lands, cultural resources, and scenic resources, all of which are subject to specific protections and regulations in the Coastal Act. Therefore, effective implementation of the Coastal Act and the protection of California’s coast must address global sea level rise and the greater management challenges it will bring.

This document focuses specifically on how to apply the Coastal Act to the challenges presented by sea level rise through Local Coastal Program (LCP) certifications and updates and Coastal Development Permit (CDP) decisions. It organizes current science, technical, and other information and practices into a single resource to facilitate implementation of the Coastal Act by coastal managers at the state and local level. While the document is intended to guide LCP planning and development decisions to ensure effective coastal management actions, it is advisory and does not alter or supersede existing legal requirements, such as the policies of the Coastal Act and certified LCPs. However, one of the Commission’s priority goals is to coordinate with local governments to complete and update LCPs in a manner that adequately addresses sea level rise and reflects the recommendations in this Guidance.

This Guidance document is also part of a larger statewide strategy to respond to climate change that includes both emissions reductions and adaption planning to address the impacts of a changing climate. In 2008, Governor Schwarzenegger issued an Executive Order (S-13-08) directing state agencies to consider sea level rise as part of planning projects and to support the

preparation of the National Research Council report on sea level rise. Additionally, on April 29, 2015, Governor Brown issued an Executive Order (B-30-15) to establish a new greenhouse gas emission reduction target and called for further action on adaptation. This Guidance is also being coordinated with many statewide initiatives to address climate change and sea level rise, including the 2014 [Safeguarding California](#) plan (an update to the 2009 [California Adaptation Strategy](#); CNRA 2009, 2014), the ongoing update to the [General Plan Guidelines](#) (Cal OPR 2015), the 2013 update to the California Governor’s Office of Emergency Services’ (Cal OES) [State Hazard Mitigation Plan](#), and others.¹ Commission staff has also been and will continue to participate in multi-agency partnerships, including the Coast and Ocean Workgroup of the multi-state agency Climate Action Team and the *State Coastal Leadership Group on Sea-Level Rise*. For more detail on these efforts, see the [Introduction](#).

PRINCIPLES FOR ADDRESSING SEA LEVEL RISE IN THE COASTAL ZONE

This Guidance is rooted in certain fundamental guiding principles, many of which derive directly from the requirements of the Coastal Act. These Principles broadly lay out the common ideas and a framework by which sea level rise planning and permitting actions can be assessed, and as such represent the goals to which actions should aspire. Individual actions and outcomes may vary based on a variety of factors, including applicable policies and location- or project-specific factors that may affect feasibility. The Guiding Principles are summarized below and discussed in greater detail in Chapter 2.

Use Science to Guide Decisions [Coastal Act Sections 30006.5; 30335.5]

1. Acknowledge and address sea level rise as necessary in planning and permitting decisions.
2. Use the best available science to determine locally relevant and context-specific sea level rise projections for all stages of planning, project design, and permitting reviews.
3. Recognize scientific uncertainty by using scenario planning and adaptive management techniques.
4. Use a precautionary approach by planning and providing adaptive capacity for the higher end of the range of possible sea level rise.
5. Design adaptation strategies according to local conditions and existing development patterns, in accordance with the Coastal Act.

Minimize Coastal Hazards through Planning and Development Standards [Coastal Act Sections 30253, 30235; 30001, 30001.5]

6. Avoid significant coastal hazard risks to new development where feasible.
7. Minimize hazard risks to new development over the life of authorized structures.

¹ See the Governor’s Office of Planning and Research’s webpage for the [California Climate Change Document](#), which includes a matrix of additional efforts.

8. Minimize coastal hazard risks and resource impacts when making redevelopment decisions.
9. Account for the social and economic needs of the people of the state; assure priority for coastal-dependent and coastal-related development over other development.
10. Ensure that property owners understand and assume the risks, and mitigate the coastal resource impacts, of new development in hazardous areas.

Maximize Protection of Public Access, Recreation, and Sensitive Coastal Resources [Coastal Act Chapter 3 policies]

11. Provide for maximum protection of coastal resources in all coastal planning and regulatory decisions.
12. Maximize natural shoreline values and processes; avoid expansion and minimize the perpetuation of shoreline armoring.
13. Recognize that sea level rise will cause the public trust boundary to move inland. Protect public trust lands and resources, including as sea level rises. New shoreline protective devices should not result in the loss of public trust lands.
14. Address other potential coastal resource impacts (wetlands, habitat, agriculture, scenic, *etc.*) from hazard management decisions, consistent with the Coastal Act.
15. Address the cumulative impacts and regional contexts of planning and permitting decisions.
16. Require mitigation of unavoidable coastal resource impacts related to permitting and shoreline management decisions.
17. Consider best available information on resource valuation when mitigating coastal resource impacts.

Maximize Agency Coordination and Public Participation [Coastal Act Chapter 5 policies; Sections 30006; 30320; 30339; 30500; 30503; 30711]

18. Coordinate planning and regulatory decision making with other appropriate local, state, and federal agencies; support research and monitoring efforts.
19. Consider conducting vulnerability assessments and adaptation planning at the regional level.
20. Provide for maximum public participation in planning and regulatory processes.

BEST AVAILABLE SCIENCE AND CONSEQUENCES OF SEA LEVEL RISE

The Coastal Act directs the Coastal Commission and local governments to use the best available science in coastal land use planning and development. This Guidance recommends using the best available science on sea level rise projections to inform planning decisions and project design. The State of California has long supported the preparation and provision of scientific information on climate change and sea level rise to help guide appropriate and resilient planning, permitting, investment, and other decisions. For example, the State recently released [California's Fourth Climate Change Assessment](#) to advance actionable science that serves the needs of state and local-level decision-makers. Specific to sea level rise, the State also supported the preparation of the 2012 National Research Council's Report, [Sea-Level Rise for the Coasts of California, Oregon and Washington: Past, Present, and Future](#), as well as the 2017 [Rising Seas in California: An Update on Sea-Level Rise Science](#) (OPC Science Report) and the [State of California Sea-Level Rise Guidance: 2018 Update](#) (2018 OPC SLR Guidance). The 2018 OPC SLR Guidance contains a set of projections for 12 tide gauges throughout California, and the Coastal Commission recommends using these projections and related information as best available science on sea level rise in California (see [Table 1](#) for the projections at the San Francisco tide gauge, and [Appendix G](#) for projections for other tide gauges). The Coastal Commission will re-examine best available science periodically and as needed with the release of new information.

In addition to sea level rise projections, the 2012 NRC report, the 2017 OPC Science Report, and the 2018 OPC SLR Guidance provide information on the impacts of sea level rise in California². According to these reports, sea level rise will cause flooding and inundation, increased coastal erosion, changes in sediment supply and movement, and saltwater intrusion to varying degrees along the California coast. These effects in turn could have a significant impact on the coastal economy and could put important coastal resources and coastal development at risk, including ports, marine terminals, commercial fishing infrastructure, public access, recreation, wetlands and other coastal habitats, water quality, biological productivity in coastal waters, coastal agriculture, and archaeological and paleontological resources.

² Note that while the Coastal Commission now recognizes the 2018 OPC SLR Guidance as best available science on sea level rise projections, the 2012 NRC Report and other related studies still contain valuable information, and references to these documents and studies throughout this guidance remain relevant and applicable.

Table 1. Sea Level Rise Projections for the San Francisco Tide Gauge³ (OPC 2018)

Projected Sea Level Rise (in feet): <i>San Francisco</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.8	1.0
2040	0.8	1.3	1.8
2050	1.1	1.9	2.7
2060	1.5	2.6	3.9
2070	1.9	3.5	5.2
2080	2.4	4.5	6.6
2090	2.9	5.6	8.3
2100	3.4	6.9	10.2
2110*	3.5	7.3	11.9
2120	4.1	8.6	14.2
2130	4.6	10.0	16.6
2140	5.2	11.4	19.1
2150	5.8	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

³ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

ADDRESSING SEA LEVEL RISE IN LOCAL COASTAL PROGRAMS

This document provides a step-by-step process for addressing sea level rise and adaptation planning in new and updated Local Coastal Programs. These Steps, summarized below in text and in [Figure 1](#), can be tailored to fit the needs of individual communities and to address the specific coastal resource and development issues of a community, such as dealing with bluff erosion or providing for effective redevelopment, urban infill, and concentration of development in already developed areas. Ideally, Commission and local government staff will establish regular coordination and work together in the early steps of any LCP planning process. For a detailed explanation of these LCP planning Steps, see [Chapter 5](#). Communities in areas where sea level rise vulnerability assessment work is already underway can start later in the process, at Step 4, or other relevant Step(s).

- Step 1. Determine a range of sea level rise projections relevant to LCP planning area/segment** using best-available science, which is currently the 2018 OPC SLR Guidance.
- Step 2. Identify potential physical sea level rise impacts in the LCP planning area/segment**, including inundation, storm flooding, wave impacts, erosion, and/or saltwater intrusion into freshwater resources.
- Step 3. Assess potential risks from sea level rise to coastal resources and development in the LCP planning area/segment**, including those resources addressed in Chapter 3 of the Coastal Act.
- Step 4. Identify adaptation measures and LCP policy options** to include in the new or updated LCP, including both general policies and ordinances that apply to all development exposed to sea level rise, and more targeted policies and land use changes to address specific risks in particular portions of the planning area.
- Step 5. Draft updated or new LCP for certification with California Coastal Commission**, including the Land Use Plan and Implementing Ordinances.
- Step 6. Implement the LCP and monitor and re-evaluate strategies as needed** to address new circumstances relevant to the area.

Planning Process for Local Coastal Programs and Other Plans

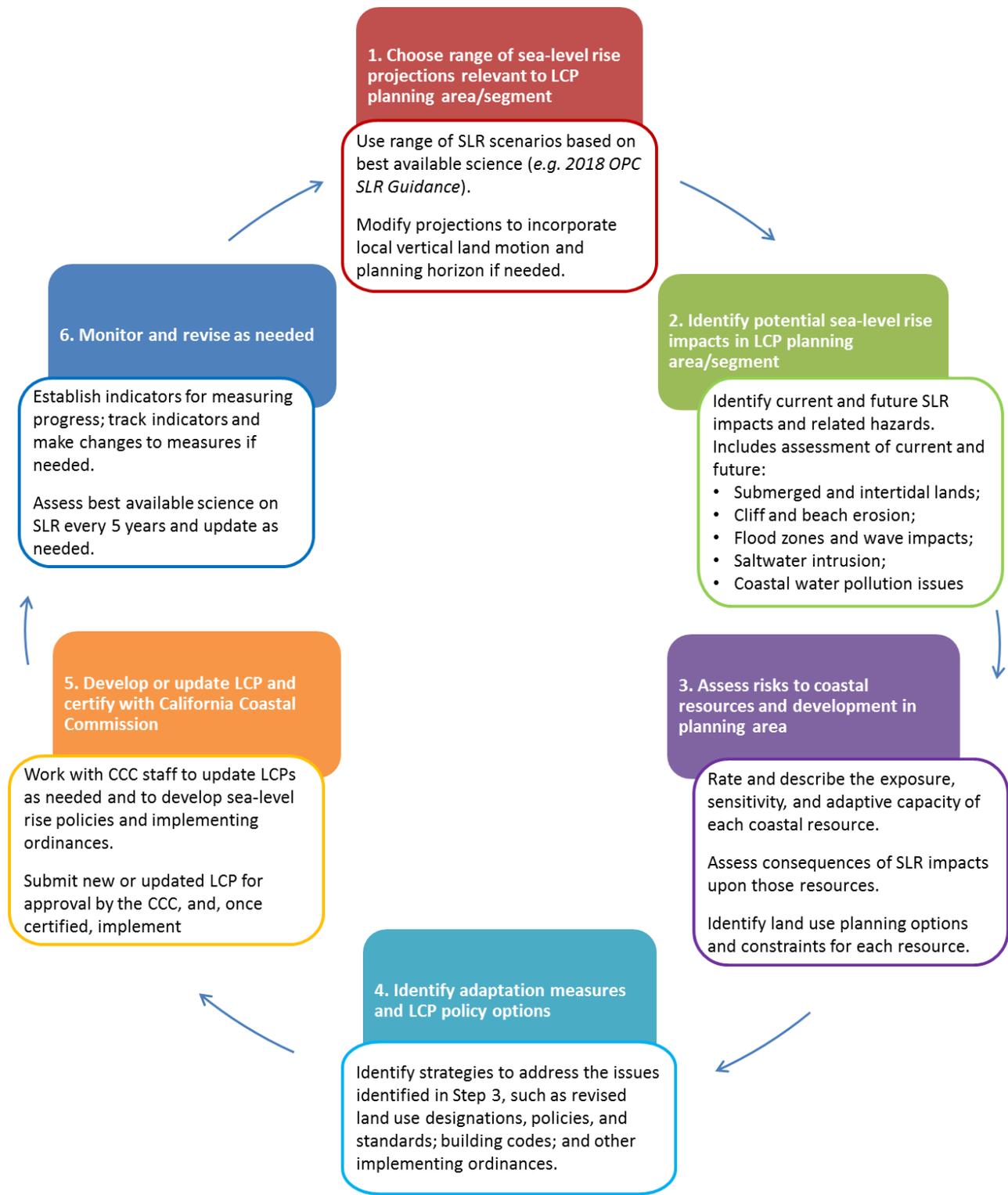


Figure 1. Flowchart for addressing sea level rise in Local Coastal Programs and other plans

ADDRESSING SEA LEVEL RISE IN COASTAL DEVELOPMENT PERMITS

New development within the coastal zone generally requires a Coastal Development Permit (CDP). Many projects reviewed through the CDP application process already examine sea level rise impacts as part of the hazards analysis, though not every CDP application will need to consider sea level rise. In general, sea level rise is only likely to affect those projects that are on low-lying land, on eroding coastal bluffs, are in close proximity to water, or rely upon a shallow aquifer for water supply. This document offers a step-by-step outline, summarized below in text and in [Figure 2](#), for how to conduct such an analysis as a standard part of the CDP application process. The goal of these Steps is to ensure careful attention to minimizing risk to development and avoiding impacts to coastal resources over the life of the project. Early coordination with the Coastal Commission staff is highly recommended, and staff will be available to consult with applicants during this process. Adopting or updating LCPs as recommended in this Guidance should facilitate subsequent review of CDPs. LCPs can identify areas where a closer review of sea level rise concerns is necessary. If kept up to date, they can also provide information for evaluation at the permit stage and specify appropriate mitigation measures for CDPs to incorporate. For a detailed explanation of these steps, see [Chapter 6](#) of this Guidance.

- Step 1. Establish the projected sea level rise range for the proposed project’s planning horizon** using the best available science, which is currently the 2018 OPC SLR Guidance.
- Step 2. Determine how physical impacts from sea level rise may constrain the project site**, including erosion, structural and geologic stability, flooding, and inundation.
- Step 3. Determine how the project may impact coastal resources, considering the influence of future sea level rise upon the landscape** as well as potential impacts of sea level rise adaptation strategies that may be used over the lifetime of the project.
- Step 4. Identify alternatives to avoid resource impacts and minimize risks** throughout the expected life of the development.
- Step 5. Finalize project design and submit CDP application.**

Planning Process for Coastal Development Permits

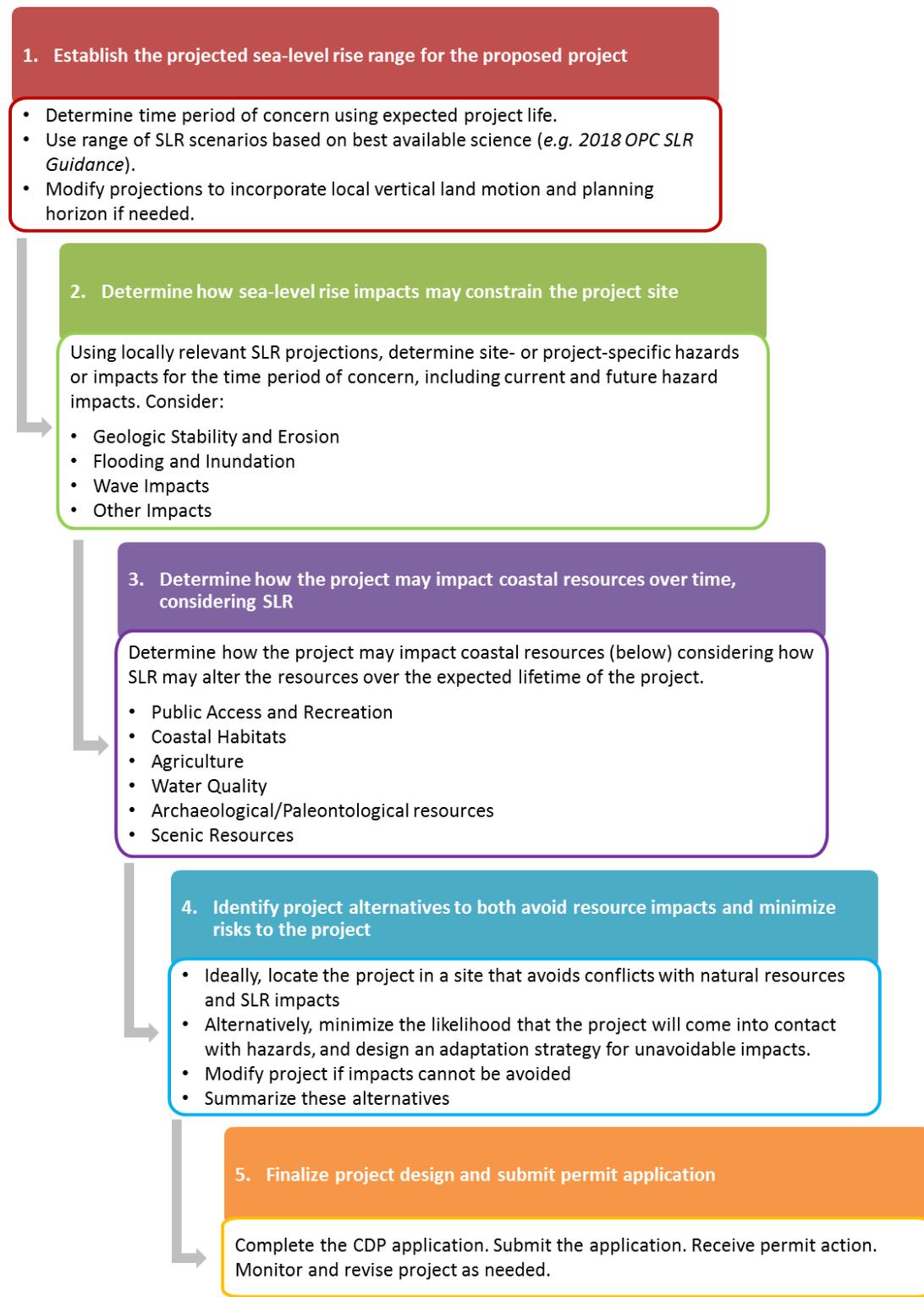


Figure 2. Flowchart for addressing sea level rise in Coastal Development Permits

ADAPTATION STRATEGIES

Steps 1 through 3 of the processes for addressing sea level rise in LCPs and CDPs will help planners and project applicants identify particular vulnerabilities to the planning region and specific project sites. Such vulnerabilities may include impacts to a number of resources identified in the Coastal Act, including development and infrastructure; public access and recreational opportunities; beaches, wetlands, environmentally sensitive habitat areas (ESHA), and other coastal habitats; agricultural resources; water quality; archaeological and paleontological resources; and scenic and visual resources. Planners and project applicants will need to identify, develop, and implement various adaptation strategies designed to protect coastal resources. These strategies should fulfill the hazard minimization and resource impact avoidance policies of the Coastal Act and should account for local conditions. In many cases, strategies will need to be implemented incrementally as conditions change, and planners, project applicants, and partners will need to think creatively and adaptively to ensure that coastal resources and development are protected over time. [Chapter 7](#) of this Guidance summarizes a number of strategies to protect different coastal resources and meet the goals and requirements of the Coastal Act.

ADDITIONAL INFORMATION

In addition to providing a summary of best available science on sea level rise, step-by-step approaches for addressing sea level rise in LCPs and CDPs, and a discussion of numerous adaptation strategies, the Guidance includes the following supplemental information:

- A brief discussion of the legal context of adaptation
- Next steps for Commission staff in coordination with other relevant partners and research institutions, based on objectives and actions from the Commission adopted [California Coastal Commission Strategic Plan 2013-2018](#) (2013a)
- Additional research needs directed toward research institutions at academic, state, federal, and local levels to help communities understand and prepare for sea level rise
- Detailed information on the drivers of sea level rise and sea level rise projections
- A step-by-step methodology for assessing local hazard conditions based on regional sea level rise projections, which is applicable to both LCPs and CDPs
- Lists of useful resources and references, including examples of sea level rise adaptation documents from other state agencies
- Key Coastal Act policies relevant to sea level rise and coastal hazards

CONTEXT OF THIS DOCUMENT

This Guidance is part of a larger body of work on climate change by State agencies, regional collaborations, local leadership, academic research, and other organizations. Many of these efforts are included as resources in [Appendix C](#). Users of the document should take advantage of these existing resources, collaborate with others, and share best practices as much as possible.

Finally, this document is intended to function as interpretive guidance for effective implementation of the Coastal Act and LCPs in light of sea level rise. It is not a regulatory document and does not contain any new regulations. Further, it does not amend or supersede existing legal authorities or the standard of review for Local Coastal Programs and coastal development permit decisions pursuant to the Coastal Act. Those actions are subject to the applicable requirements of the Coastal Act, the Coastal Zone Management Act, certified LCPs, and other applicable laws and regulations as applied in the context of the evidence in the records for those actions. The Commission is adopting this Guidance as interpretive guidelines pursuant to its authority under Public Resources Code Sections 30620.



Chapter 1

Introduction

Climate change is happening now. Rapidly melting ice caps, rising sea levels, floods, extreme heat waves, droughts, and fires are just a few of the effects of climate change. These effects are having profound impacts on our coast and are changing coastal management planning and decision making at global, national, state, regional, local, and individual scales.

Given current trends in greenhouse gas emissions, sea levels are expected to rise at an accelerating rate in the future, and scientists project an increase in California's sea level in coming decades. Until mid-century, the most damaging events for the California coast will likely be dominated by large El Niño-driven storm events in combination with high tides and large waves. Eventually, sea level will rise enough that even small storms will cause significant damage, and large events will have unprecedented consequences (Caldwell *et al.* 2013).

This Guidance provides a framework for addressing sea level rise in Local Coastal Programs (LCPs) and Coastal Development Permits (CDPs). The intended audience for this document includes the Commission and Commission staff, local governments, other public agencies, permit applicants, members of the public, and others who are interested in how to implement and comply with the California Coastal Act (Coastal Act) while taking steps to address sea level rise.

ENVIRONMENTAL, ECONOMIC, AND SOCIAL IMPACTS OF SEA LEVEL RISE

The potential environmental, economic, and social impacts of sea level rise in California underscore the importance of addressing the issue in land use planning and regulatory work. Just over 21 million people lived in California's coastal counties as of July 2014 (CDF 2014), and the state supports a \$40 billion coastal and ocean economy (NOEP 2010).

Many aspects of the coastal economy, as well as California's broader economy, are at risk from sea level rise, including coastal-related tourism, beach and ocean recreational activities, transfer of goods and services through ports and transportation networks, coastal agriculture, and commercial fishing and aquaculture facilities.

In addition to potential losses in revenue, Heberger *et al.* (2009) estimate that \$100 billion worth of property is at risk of flooding during a 100-year coastal flood with 4.6 ft (1.4 m) of sea level rise (the amount projected to occur by the year 2100 in their Pacific Institute study). This property includes seven wastewater treatment plants, commercial fishery facilities, marine terminals, Coastal Highway One, 14 power plants, residential homes, and other important development and infrastructure. More recently, the [Fourth California Climate Assessment](#) found that statewide damages could reach nearly \$17.9 billion from inundation of development under ~20 inches of sea level rise, and those damages would double with the addition of a 100-year flood (Bedsworth *et al.* 2018).

Sea level rise also poses environmental and social justice challenges. This is particularly true for communities that may be dependent upon at-risk industries, are already suffering from economic hardship, or which have limited capacity to adapt, including lower-income, linguistically isolated, elderly, and other vulnerable populations.

Proactive steps are needed to prepare for sea level rise and to protect the coastal economy, California livelihoods, and coastal resources and the ecosystem services they provide. The magnitude of the challenge is clear – not only might the impacts of sea level rise be severe, the costs and time associated with planning for them can be daunting. The [third National Climate Assessment](#), released in May 2014, notes that there is strong evidence to suggest that the costs of inaction are 4 to 10 times greater than the costs associated with proactive adaptation and hazard mitigation (Moser *et al.* 2014). It is critical for California to take proactive steps to address the impacts sea level rise may have on the state’s economy, natural systems, built environment, human health, and ultimately, its way of life.

SEA LEVEL RISE AND THE CALIFORNIA COASTAL ACT

The potential impacts of sea level rise fall directly within the Coastal Commission’s (and coastal zone local governments’) planning and regulatory responsibilities under the Coastal Act. Sea level rise increases the risk of flooding, coastal erosion, and saltwater intrusion into freshwater supplies, which have the potential to threaten many of the resources⁴ that are integral to the California coast, including coastal development, coastal access and recreation, habitats (*e.g.*, wetlands, coastal bluffs, dunes, and beaches), coastal agricultural lands, water quality and supply, cultural resources, community character, and scenic quality. In addition, many possible responses to sea level rise, such as construction of barriers or armoring, can have adverse impacts on coastal resources. For example, beaches, wetlands, and other habitat backed by fixed or permanent development will not be able to migrate inland as sea level rises, and will become permanently inundated over time, which in turn presents serious concerns for future public access and habitat protection.

The Coastal Act mandates the protection of public access and recreation along the coast, coastal habitats, and other sensitive resources, as well as providing priority visitor-serving and coastal-dependent or coastal-related development while simultaneously minimizing risks from coastal hazards. This Guidance document has been created to help planners, project applicants, and other interested parties continue to achieve these goals in the face of sea level rise by addressing its effects in Local Coastal Programs and Coastal Development Permits. Although the focus of the Guidance is on LCPs and CDPS, much of the information contained herein can be useful for other planning documents such as Port Master Plans⁵, Long Range Development Plans, and Public Works Plans. For example, the science applies regardless of the planning documents, and the discussions of how to analyze sea level rise impacts as well as a number of adaptation options may be applicable. In all cases, specific analyses performed and actions implemented will vary based on relevant policies, local conditions, feasibility, and other factors as described throughout the rest of this document.

⁴ The term “coastal resources” is used throughout this Guidance and is meant to be a general term for those resources addressed in Chapter 3 of the California Coastal Act including but not limited to beaches, wetlands, agricultural lands, and other coastal habitats; coastal development; public access and recreation opportunities; cultural, archaeological, and paleontological resources; and scenic and visual qualities.

⁵ Ports are generally subject to Chapter 8 of the Coastal Act. The policies of Chapter 8 acknowledge the special role and needs of ports and differ in significant ways from the Chapter 3 policies of the Act. Significant categories of development in ports, however, remain subject to Chapter 3, including categories of development listed as appealable pursuant to Section 30715 and development located within specified wetlands, estuaries, and recreation areas.

Coastal Commission reports and briefings on sea level rise: Sea level rise is not a new concern for the Commission. The Coastal Act policies on hazard avoidance and coastal resource protection provide the basis for the Commission to consider the impacts of sea level rise (see [Appendix F: Coastal Act Policies Relevant to Sea Level Rise and Coastal Hazards](#)), and the Commission has long considered sea level rise, erosion rates, and other effects of a dynamic climate in its analysis of permits and LCPs, staff recommendations, and Commission decisions. In 1992, Section 30006.5 was added to the Coastal Act which, among other things, directs the Commission to both develop its own expertise and interact with the scientific community on various technical issues, including coastal erosion and sea level rise. The Commission's staff also coordinates its work on sea level rise with other state and federal agencies, local governments, academic institutions, non-profit organizations, citizen groups, permit applicants, property owners, and others.

The Commission has documented its sea level rise adaptation and climate change efforts in numerous papers and briefings, including:

- 1989 Report: [Planning for Accelerated Sea Level Rise along the California Coast](#)
- 2001 Report: [Overview of Sea Level Rise and Some Implications for Coastal California](#)
- 2006 Briefing: [Discussion Draft: Global Warming and the California Coastal Commission](#)
- 2008 Briefing: [A Summary of the Coastal Commission's Involvement in Climate Change and Global Warming Issues for a Briefing to the Coastal Commission](#)
- 2008 White paper: [Climate Change and Research Considerations](#)
- 2010 Briefing: [A Summary of the Coastal Commission's Involvement in Sea Level Rise Issues for a Briefing to the Coastal Commission](#)⁶
- 2015 Report: [CCC Sea Level Rise Policy Guidance](#) (Adopted)
- 2016 Report: [CCC Statewide Sea Level Rise Vulnerability Synthesis](#)
- 2016 Briefing: [Implementation of the Adopted Sea Level Rise Policy Guidance](#)

THE IMPORTANCE OF ADDRESSING SEA LEVEL RISE IN LOCAL COASTAL PROGRAMS

The impacts of sea level rise will be felt at the local level, and therefore local responses will necessarily be part of effective management of these impacts. Fortunately, the California Coastal Act lays out a legal and planning framework for community climate preparedness and resiliency planning. LCPs, in combination with Coastal Development Permits (CDPs), provide the implementing mechanisms for addressing many aspects of climate change within coastal communities at the local level.

The goal of updating or developing a new LCP to prepare for sea level rise is to ensure that adaptation occurs in a way that protects both coastal resources and public safety and allows for

⁶ Verbal presentation to the Coastal Commission on December 17, 2010 by Susan Hansch (Item 4.5). This presentation can be viewed at the Cal-Span website (<[http://www.cal-span.org/media.php?folder\[\]=CCC](http://www.cal-span.org/media.php?folder[]=CCC)>) from approximately minute 22:00 to 24:30.

sustainable economic growth. This process includes identifying how and where to apply different adaptation mechanisms based on Coastal Act requirements, other relevant laws and policies, acceptable levels of risk, and community priorities. LCP and Coastal Act policies are also reflected in CDPs, which implement sea level rise management measures and adaptation strategies through individual development decisions. By planning ahead, communities can reduce the risk of costly damage from coastal hazards, can ensure the coastal economy continues to thrive, and can protect coastal habitats, public access and recreation, and other coastal resources for current and future generations.

The Coastal Commission has made it a priority to support the update of LCPs to address climate change, as demonstrated by Goal 3 of the Commission’s *Strategic Plan* (CCC 2013a), which is to “address climate change through LCP planning, coastal permitting, inter-agency collaboration, and public education.” Specifically, Objective 3.1.1 directs the Commission to “adopt general sea level rise (SLR) policy guidance for use in coastal permitting and LCP planning and amendment based on best available science...” This Guidance document fulfills Objective 3.1.1 and is one of multiple ongoing Commission efforts to support local governments in updating LCPs to address sea level rise.

Funding for LCP updates: Both the [California Climate Adaptation Strategy](#) (CNRA 2009) and the [Safeguarding California](#) plan (CNRA 2014) identified amendments to LCPs as a key strategy for addressing sea level rise in California. However, there are significant funding constraints at both the Commission and local government levels that limit the capacity to update LCPs. Fortunately, three grant programs have recently been funded to support California local governments in updating LCPs to address sea level rise. These grant programs have partially overlapping objectives, as described below. Grant-related information as of the publication of this Guidance is summarized below. For up-to-date information regarding grants, please visit the [Local Assistance Grant Program](#) page on the Coastal Commission website.

- **Coastal Commission LCP Local Assistance Grant Program:** This grant program provides funding to local governments to complete the certification of new and updated LCPs, with an emphasis on addressing impacts from sea level rise and climate change. For fiscal years (FY) 2013/14 and 2014/15, the Coastal Commission received \$1 million per year (\$2 million total) in local assistance funds for the LCP Grant Program. In January 2014, the Coastal Commission awarded \$1 million in LCP Grant funds to 11 jurisdictions throughout the state. In November 2014, the Coastal Commission awarded \$1 million to 12 jurisdictions. This second round of funding was coordinated through a joint application and review process with the OPC LCP Sea Level Rise Grant program (below) in order to maximize funding opportunities. Funding of \$3 million was provided in Commission’s FY 2015/16 Budget. This funding was awarded in two additional grant rounds to a total of 21 jurisdictions. Additional funding from the State’s Greenhouse Gas Reduction Fund is provided in the Commission’s FY 2017/18 and 2018/19 budgets for this grant program; however funding has not yet been awarded.
- **Ocean Protection Council LCP Sea Level Rise Grant Program:** The OPC grant program includes \$2.5 million to support local governments in updating LCPs to address sea level rise, including support of sea level rise modeling, vulnerability assessments, and

adaptation planning and policy development. The OPC is administering the program in partnership with the Coastal Commission and the Coastal Conservancy. In November 2013, the OPC awarded \$1,305,000 to seven jurisdictions based on recommendations from the three coordinating agencies. The remaining funds were awarded to seven jurisdictions in the second round of the grant program in December 2014. This second round of funding was coordinated through a joint application and review process with the Coastal Commission Grant Program, as described above.

- **State Coastal Conservancy Climate Ready Grant Program:** The Climate Ready Grant Program provides funding for climate change-related projects including projects to update LCPs to address sea level rise. Through three rounds of grants, the Conservancy has awarded \$7.3 million for 42 projects. Additional funding is available for this program through the Greenhouse Gas Reduction Fund for projects that use nature-based solutions to adapt to the impacts of climate change.

Coastal Commission Staffing Increase to Support LCP planning: Governor Brown and the California Legislature also approved temporary augmentations to the Coastal Commission’s FY 2013/2014, FY 2014/15 and FY 2015/16 budgets of \$3 million for state operations and 25 additional authorized positions for Coastal Commission staff to work with local governments to prepare, update, amend, and review LCPs with an emphasis on including climate change issues. In FY 2016/17, the \$3 million in funding was included in the Commission’s baseline budget, effectively making the additional \$3 million for state operations and 25 authorized positions a permanent part of the Commission’s budget.

COASTAL RESILIENCY AND PREPARING FOR SEA LEVEL RISE: THE FEDERAL AND STATE CONTEXT

Sea level rise planning efforts are currently taking place at the local, regional, state, and national levels. Framing the efforts in California is a federal strategy to address climate change by both reducing greenhouse gas emissions and adapting to climate change impacts. Recent efforts promoted by the White House include President Obama’s January 2015 Executive Order 13960, which modifies Executive Order 11988, Floodplain Management, by expanding the federal approach for establishing flood risk to include the consideration of climate change. Specifically, it recommends using a new flood standard that accounts for climate change in establishing flood elevation and hazard areas when federal funds are used to build, significantly retrofit, or repair structures.

Additionally, Governor Brown, Supervisor Carbajal (Santa Barbara County), Mayor Garcetti (Los Angeles), and Mayor Johnson (Sacramento) were on President Obama’s State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience, which recently released [recommendations](#) for how to modernize programs and policies to incorporate climate change.⁷ The Coastal Commission’s Guidance document implements many of the Task Force’s recommendations by providing tools and assistance to support sea level rise decision making, by establishing a framework for state, local, and federal partnership and coordination on sea level

⁷ <https://obamawhitehouse.archives.gov/administration/eop/ceq/initiatives/resilience/taskforce>

rise, and by providing guidance on how to improve the resilience of California’s coastal infrastructure, natural resources, human communities, and coastal industries.

The State of California has long been a leader in preparing for sea level rise, and in 2008, Governor Schwarzenegger issued an Executive Order (S-13-08) directing state agencies to prepare guidance on sea level rise and to address sea level rise in any state projects located in vulnerable areas. Since then, state agencies have worked collaboratively to accomplish a variety of different actions related to sea level rise adaptation, many of which are listed below. Ten state and federal agencies⁸ also commissioned the National Research Council’s report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future* (2012), to improve understanding of sea level rise projections for California.

More recently, Governor Brown’s April 2015 Executive Order B-30-15 addresses climate change and sea level rise adaptation, stating that state agencies shall take climate change into account in their planning and investment decisions. The order requires agencies to ensure that priority is given to actions that build climate preparedness and reduce greenhouse gas emissions, provide flexible and adaptive approaches, protect the state’s most vulnerable populations, and promote natural infrastructure solutions. Additionally, AB2516, authored by Assemblymember Gordon and approved in September 2014, established a Planning for Sea Level Rise Database that is available [online](#). The database provides the public with an educational tool from which to learn about the actions taken by cities, counties, regions, and various public and private entities to address sea level rise.

Much of the state’s climate change adaptation work has been coordinated with the *Coast and Ocean Workgroup* of the *Climate Action Team* (CO-CAT), of which the Commission is a member. In addition, Commission staff has been involved in the *State Coastal Leadership Group on Sea-Level Rise*, which was established in early 2014 to develop and implement coordinated approaches to address sea level rise across state agencies. The partnership includes senior management from the Coastal Zone Management Agencies (Coastal Commission, San Francisco Bay Conservation and Development Commission, and State Coastal Conservancy) and land management agencies (State Lands Commission and State Parks) along with the Ocean Protection Council and Natural Resources Agency. This Guidance is being coordinated closely with this work⁹ to ensure that various initiatives do not conflict and to assure an effective response to challenges such as sea level rise.

To that end, the content of this Guidance is aligned with several key concepts in the *Safeguarding California* plan, including hazard avoidance for new development, encouraging innovative designs and adaptation strategies for structures in areas vulnerable to sea level rise hazards, and addressing climate impacts in Local Coastal Programs and General Plan updates,

⁸ The assessment of sea level rise was commissioned by California Department of Water Resources, California Energy Commission, California Department of Transportation, California State Water Resources Control Board, California Ocean Protection Council, Oregon Watershed Enhancement Board, Washington Department of Ecology, National Oceanic and Atmospheric Administration (NOAA), US Army Corps of Engineers (USACE), and US Geological Survey (USGS).

⁹ See the Governor’s Office of Planning and Research’s webpage for the [California Climate Change Document](#) which includes a matrix of additional efforts. Available at: http://opr.ca.gov/s_publications.php

among many others. *Safeguarding California* also calls out the need for state agencies to produce guidance documents addressing climate adaptation, and this sea level rise Guidance is part of the statewide effort to fulfill that mandate. As *Safeguarding California* promotes, this Guidance will be a living document that will be updated and revised as sea level rise science advances and new insights are gained regarding adaptation.

State agency policies and guidance on climate change and sea level rise: As a result of the Executive Order S-13-08 and agency needs for guidance, many state agencies have developed climate change and sea level rise policies and guidance documents. For example:

- The California Natural Resources Agency (CNRA) developed the 2009 [California Climate Adaptation Strategy](#) and the [2014](#) and [2018](#) updates (*Safeguarding California*)
- CNRA and the Governor’s Office of Emergency Services (Cal OES) collaboratively developed the [California Climate Adaptation Planning Guide](#) (2012)
- The Governor’s Office of Planning and Research is updating its [General Plan Guidelines](#) to address climate change (a draft update is anticipated in 2015)
- The Ocean Protection Council established *State Sea-Level Rise Guidance* ([interim](#), 2010, [2013](#), and update, [2018](#)) and passed a *State Sea-Level Rise Resolution* (March 11, 2011)
- The San Francisco Bay Conservation and Development Commission (BCDC) amended the [San Francisco Bay Plan](#) (1968) to update its policies regarding sea level rise (2011) and has been working on actions to reduce vulnerability to sea level rise throughout the San Francisco Bay through the [Adapting to Rising Tides](#) (ART) project
- The California State Coastal Conservancy (Conservancy) established [climate change policies](#), [application guidelines for sea level rise](#), and [climate ready principles](#) (2011)
- Cal OES updated the [State Multi-Hazard Mitigation Plan](#) in 2013
- The California Department of Transportation (Caltrans) developed guidance on incorporating sea level rise into the planning and development of Project Initiation Documents (2011), and how to address adaptation in Regional Transportation Plans (2013), and has completed numerous other [climate change related activities](#)

Other agencies including the California Department of Parks and Recreation and the California State Lands Commission are in the process of developing guidance. The California Department of Fish and Wildlife, the Division of Boating and Waterways, and the Department of Water Resources are all actively addressing sea level rise and have taken steps to conduct research on sea level rise impacts, integrate sea level rise into planning documents, and educate staff on climate change impacts (see [Appendix C](#) for a description of these efforts).

Other efforts: Sea level rise planning efforts taking place at all levels of government and across numerous sectors helped inform this Guidance. Commission staff reviewed scientific publications on sea level rise and climate change, adaptation guidebooks, and existing adaptation principles and best practices described in documents such as [Indicators of Climate Change in California](#) (Cal EPA 2013), [Adapting to Sea Level Rise: A Guide for California’s Coastal Communities](#) (Russell and Griggs 2012), [Climate Smart Conservation: Putting Adaptation Principles into Practice](#) (Stein *et al.* 2014), [Ecosystem Adaptation to Climate Change in](#)

[California: Nine Guiding Principles](#) (RLF 2012), and [Climate Smart Principles](#) (PRBO 2013), and applied relevant information to the Guidance where applicable and consistent with the Coastal Act.

LOOKING AHEAD: PLANNING AND PROJECT DESIGN WITH SEA LEVEL RISE

The coast has always been a place of change due to land modifications such as erosion and vertical land motion, and to water variability such as tides, waves, and storms. Despite this dynamic nature, many areas of the California coast have been developed with an expectation that there will be some permanence to the land area and site safety. Development efforts have used such techniques as setbacks, avoidance of existing floodplain areas, elevation above some base flood level, and compliance with design standards to reduce or minimize coastal risks and to ensure an acceptable level of safety.

However, hazards are rarely eliminated or avoided completely. Sea level rise will exacerbate existing hazards and reduce the period of time over which some existing development can remain relatively safe. As noted in [Governing California through Climate Change](#), “The notion of stable, predictable geography in which to live, work and build permanent buildings will be off the table in decades ahead” (Little Hoover Commission 2014, p. 2). Locations that might have seemed relatively safe from erosion or flooding 20 or 30 years ago may now be shown to have greater vulnerability due to sea level rise. Sites that might have seemed safe for 80 or 100 years might now only be safe for 40 or 50 years.

As coastal change accelerates, it will become more apparent that development close to the coast cannot be treated in the same way as more inland development, where hazardous conditions may be less dynamic. Coastal dynamics have long been part of land use planning considerations and project design; however, the focus on this change will grow in importance with rising sea level. This may mean that as properties are evaluated for proposed development, the type and intensity of the proposed development may need to change to address the dynamic nature of the property and changing nature of the hazards. As coastal areas erode, the carrying capacity of the area may need to be revised. The trend of redeveloping with additions and larger structures may need to change to one of maintaining what is there or redeveloping with smaller structures that better suit site constraints. The changing expectations are an important aspect of sea level rise adaptation and are an important part of the following discussions on how to include sea level rise in Local Coastal Programs, applications for Coastal Development Permits, and adaptation planning.

Sea level rise is one of many climate change effects that will have impacts on coastal resources and development along the California coast. Accelerated coastal erosion, changing precipitation patterns, increasing temperatures, and more extreme storms will pose planning challenges in concert with sea level rise. There are other climate change impacts in the coastal zone, such as changes in water supply, terrestrial habitats, and fire hazards, that are also important to consider in decision making, and the Commission intends to provide guidance on a range of anticipated climate change impacts in the future.

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Chapter 2

Principles for Addressing Sea Level Rise in the Coastal Zone

This chapter summarizes the Coastal Commission’s framing principles for addressing sea level rise, many of which derive directly from the requirements of the Coastal Act. These principles broadly lay out the common ideas and a framework by which sea level rise planning and permitting actions can be assessed, and as such, represent the goals to which actions should aspire. Individual actions and outcomes may vary based on a variety of factors, including applicable policies and location- or project-specific factors that may affect feasibility. There are four categories of principles: using science to guide decisions; minimizing coastal hazards through planning and development standards; maximizing protection of public access, recreation, and sensitive coastal resources; and maximizing agency coordination and public participation. Each category groups important and related concepts that are central to addressing the challenge of rising sea levels. Building on the cumulative knowledge and experience of the Commission, subsequent chapters of this Guidance use these principles to frame practical guidance for addressing sea level rise through planning and permitting decisions in the coastal zone, consistent with the statewide policies of the California Coastal Act as well as the statewide vision of climate resilience outlined in the 2014 [Safeguarding California](#) plan.

USE SCIENCE TO GUIDE DECISIONS [Coastal Act Sections 30006.5; 30335.5]

- 1. Recognize and address sea level rise as necessary in planning and permitting decisions.** Address sea level rise science in all applicable coastal management and decision-making processes, including Local Coastal Programs (LCPs), Port Master Plans (PMPs), Public Works Plans (PWP), Long Range Development Plans (LRDPs), Coastal Development Permits (CDPs), federal consistency reviews, and other Coastal Act decision processes. Sea level rise should be addressed in both hazard analyses and identification of adaptation strategies/alternative analyses, consistent with the policies of the Coastal Act and LCPs as applicable¹⁰.
- 2. Use the best available science to determine locally relevant (context-specific) sea level rise projections and potential impacts for all Coastal Act planning processes, project design, and permitting reviews.** Sea level rise science continues to evolve, and some processes that are not fully understood (*e.g.*, ice sheet dynamics) could potentially have large effects on future sea level rise. At the time of this 2018 update, the best available science on sea level rise in California is the 2018 OPC Guidance, [State of California Sea-Level Rise Guidance: 2018 Update](#) (See [Table 2](#) and [Appendix G](#)). As discussed in greater detail in [Chapter 3](#) of this Guidance, these projections should be used in a scenario-based analysis to

¹⁰ This Guidance document is intended to help implement the Coastal Act and LCPs in the context of sea level rise concerns. However, the standard of review for Commission actions remains the California Coastal Act or applicable certified LCPs. In particular, the recommendations of this Guidance do not constitute “enforceable policies” for purposes of CZMA federal consistency reviews. The enforceable policies for conducting federal consistency reviews will remain the policies of Chapter 3 of the Coastal Act. Also, for federal agency activities, the standard is consistency “to the maximum extent practicable,” with Chapter 3, *i.e.*, federal agency activities must be fully consistent unless existing law applicable to the federal agency prohibits full consistency. See 15 CFR. §§ 930.32 and 930.43(d). However, the Commission looks at sea level rise as one part of determining the coastal effects from an activity through CZMA federal consistency reviews and the use of this Guidance by all parties should help determine what those coastal effects may be or how effects from sea level rise may be mitigated. Pursuant to 15 CFR § 930.11(h), implementation of this guidance would not be grounds for an objection (because it is not an “enforceable policy”) but it might be one means that “would allow the activity to be conducted consistent with the enforceable policies of the program” in order to avoid an objection.

identify potential local impacts from sea level rise, incorporating storms, extreme water levels, and shoreline change. Other authoritative sea level science and projections may also be used, in part or in full, provided they are peer-reviewed, widely accepted within the scientific community, and locally relevant.

The Commission will re-examine the best available science periodically and as needed with the release of new information on sea level rise.¹¹ In addition, Commission staff intends to submit a periodic status report to the Commission describing updates on the best available science and adaptation practices, and any potential recommended changes to the Guidance document.

3. **Recognize and address scientific uncertainty using scenario planning and adaptive management techniques.** Given the uncertainty in the magnitude and timing of future sea level rise, particularly over longer time periods, planners and project designers should use scenario-based analysis to examine a range of possible shoreline changes and sea level rise risks to shape LCPs and other plans and project development designs. As appropriate, development projects, resource management plans, and LCP and other planning updates should incorporate an adaptive management framework with regular monitoring, reassessments, and dynamic adjustment in order to account for uncertainty.
4. **Use a precautionary approach by planning and providing adaptive capacity for the higher end of the range of possible sea level rise.** LCPs and CDPs should analyze the medium-high and/or extreme risk aversion projections (from the 2018 OPC SLR Guidance) of sea level rise, as appropriate, in order to understand the implications of a worst case scenario. In some cases, it may be appropriate to *design* for the local hazard conditions that will result from more moderate sea level rise scenarios, as long as decision makers and project applicants *plan* for adaptation pathways that would allow for the implementation of alternative strategies if conditions change more than anticipated in the initial design. Similar to the recommendation in the Ocean Protection Council's [2011 State Sea-Level Rise Resolution](#) as well as the [2018 OPC SLR Guidance](#), the Commission does not recommend using values solely from the lower end of the ranges as this does not give a full picture of the risks. Looking instead at both high and low projections allows users to build an understanding of the overall risk sea level rise poses to the region or site. Chapters [5](#) and [6](#) have additional detail regarding how to choose appropriate sea level rise projections.
5. **Design adaptation strategies according to local conditions and existing development patterns, in accordance with the Coastal Act.** Design adaptation strategies using best management practices for adaptation, and tailor the design to the specific conditions and development patterns of the area, in accordance with the Coastal Act and certified LCPs. LCPs should continue to serve as a key implementing mechanism for these adaptation strategies. Adaptation strategies should be evaluated for their ability to both minimize hazards and protect coastal resources.

¹¹ Major scientific reports include the release of National and State Climate Assessments, IPCC Assessment Reports, and/or State guidance.

Table 2. Sea Level Rise Projections for the San Francisco Tide Gauge¹² (OPC 2018)

Projected Sea Level Rise (in feet): <i>San Francisco</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.8	1.0
2040	0.8	1.3	1.8
2050	1.1	1.9	2.7
2060	1.5	2.6	3.9
2070	1.9	3.5	5.2
2080	2.4	4.5	6.6
2090	2.9	5.6	8.3
2100	3.4	6.9	10.2
2110*	3.5	7.3	11.9
2120	4.1	8.6	14.2
2130	4.6	10.0	16.6
2140	5.2	11.4	19.1
2150	5.8	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹² Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

MINIMIZE COASTAL HAZARDS THROUGH PLANNING AND DEVELOPMENT STANDARDS [Coastal Act Sections 30253; 30235; 30001, 30001.5]

6. **Avoid significant coastal hazard risks to new development where feasible.** Section 30253 of the Coastal Act requires new development to minimize risks to life and property in areas of high geologic and flood hazard. The strongest approach for minimizing hazards is to avoid siting new development within areas vulnerable to flooding, inundation, and erosion, thus ensuring stable site conditions without the need for long-term financial and resource commitments for protective devices. Methods to direct new development away from hazardous locations are included in [Chapter 7](#) of this Guidance.
7. **Minimize hazard risks to new development over the life of the authorized development.** Coastal Act Section 30253 requires that new development minimize coastal hazard risks without the use of bluff retaining or shoreline protection devices that would substantially alter natural landforms. When hazards from sea level rise cannot be avoided, new development should include provisions to ensure that hazard risks are minimized for the life of the development without shoreline protection, including through future modification, relocation, or removal when they become threatened by natural hazards, including sea level rise.
8. **Minimize coastal hazard risks and resource impacts when making redevelopment decisions.** LCPs should encourage and require, as applicable, existing at-risk structures to be brought into conformance with current standards when redeveloped. Improvements to existing at-risk structures should be limited to basic repair and maintenance activities and not extend the life of such structures or expand at-risk elements of the development, consistent with the Coastal Act.
9. **Account for the social and economic needs of the people of the state, including environmental justice; assure priority for coastal-dependent and coastal-related development over other development.** In planning and project development concerning sea level rise, assure that the social and economic needs of the people of the state are accounted for in accordance with Coastal Act Section 30001.5(b), with special consideration for working persons employed within the coastal zone (Coastal Act Section 30001(d)). Recognize that low-income communities are less equipped to prepare for and respond to the impacts of sea level rise and ensure that LCP and CDP decisions account for environmental justice concerns and include low-income persons and communities in planning efforts.
10. **Ensure that property owners understand and assume the risks, and mitigate the coastal resource impacts, of new development in hazardous areas.** Property owners should assume the risks of developing in a hazardous location (often referred to as internalizing risk). They should be responsible for modifying, relocating or removing new development if it is threatened in the future. Any actions to minimize risks to new development should not result in current and/or future encroachment onto public lands or in impacts to coastal resources inconsistent with the Coastal Act. LCPs and Coastal Development Permits should require recorded assumptions of risk, “no future seawall” conditions, and/or other appropriate mitigation measures to internalize risk decisions with the private land owner.

MAXIMIZE PROTECTION OF PUBLIC ACCESS, RECREATION, AND SENSITIVE COASTAL RESOURCES [Coastal Act Chapter 3 policies]

- 11. Provide for maximum protection of coastal resources in all coastal planning and regulatory decisions.** New and existing development, redevelopment, and repair and maintenance activities as well as associated sea level rise adaptation strategies should avoid or minimize impacts to coastal resources, including public access, recreation, marine resources, agricultural areas, sensitive habitats, archaeological resources, and scenic and visual resources in conformity with Coastal Act requirements. Impacts from development and related activities should be avoided or minimized; unavoidable impacts should be mitigated as necessary.
- 12. Maximize natural shoreline values and processes; avoid expansion and minimize the perpetuation of shoreline armoring.** If existing development (both private and public) is threatened by sea level rise hazards, it should employ the least environmentally damaging feasible alternatives and minimize hard shoreline protection. Priority should be given to options that enhance and maximize coastal resources and access, including innovative nature-based approaches such as living shoreline techniques or managed/planned retreat. If traditional hard shoreline protection is necessary and allowable under the Coastal Act, use the least-environmentally damaging feasible alternative, incorporate projections of sea level rise into the design of protection, and limit the time-period of approval, for example, to the life of the structure the device is protecting. Major renovations, redevelopment, or other new development should not rely upon existing shore protective devices for site stability or hazard protection. Where feasible, existing shoreline protection that is no longer being relied upon in this way, or no longer needed otherwise, should be phased out.
- 13. Recognize that sea level rise will cause the public trust boundary to move inland. Protect public trust lands and resources, including as sea level rises. New shoreline protective devices should not result in the loss of public trust lands.** Where allowed under the Coastal Act or the relevant LCP, shoreline protective devices should be sited, designed, and conditioned to ensure that they do not result in the loss of public trust lands¹³ or encroach onto public trust lands without the permission of the appropriate trustee agency. When sea level rise causes the public trust boundary to move inland such that a protective device that was located on uplands becomes subject to the public trust, the permittee should either obtain permission from the appropriate trustee agency for the encroachment or apply for a permit to remove any encroachments.
- 14. Address potential secondary coastal resource impacts (to wetlands, habitat, agriculture, scenic and visual resources, etc.) from hazard management decisions, consistent with the Coastal Act.** Actions to address sea level rise in LCPs or permits should not exacerbate other climate-related vulnerabilities or undermine conservation/protection goals and broader ecosystem sustainability. For example, siting and design of new development should not only

¹³ The State holds and manages all tidelands, submerged lands, and beds of navigable waterways for the benefit of all people of the State for statewide purposes consistent with the common law Public Trust Doctrine (“public trust”). In coastal areas, the landward location and extent of the State’s trust lands are generally defined by reference to the ordinary high water mark, as measured by the mean high tide line. Public trust uses include such uses as maritime commerce, navigation, fishing, boating, water-oriented recreation, and environmental preservation and restoration.

avoid sea level rise hazards, but also ensure that the development does not have unintended adverse consequences that impact sensitive habitats or species in the area.

15. **Address the cumulative impacts and regional contexts of planning and permitting decisions.** Sea level rise will have impacts at both the site-specific and regional scales. In addition to the evaluation of site-specific sea level rise impacts, LCPs and projects should include an evaluation of the broader region-wide impacts, in two different contexts. First, the LCP or project should consider how sea level rise impacts throughout an entire littoral cell or watershed could affect the LCP jurisdiction or project. Second, the LCP or project should consider how options to adapt to sea level rise could result in cumulative impacts to other areas in the littoral cell or watershed. Actions should be taken to minimize any identified impacts.
16. **Require mitigation of unavoidable coastal resource impacts related to permitting and shoreline management decisions.** Require mitigation for unavoidable public resource impacts over the life of the structure as a condition of approval for the Coastal Development Permit. For example, for impacts to sand supply or public recreation due to armoring and the loss of sandy beach from erosion in front of shoreline protection devices, require commensurate in-kind mitigations, a sand mitigation fee, and other necessary mitigation fees (for example, public access and recreation mitigation). Because the longer term effects can be difficult to quantify, especially given uncertainty about the exact rate of future sea level rise, consider requiring periodic re-evaluation of the project authorization and mitigation for longer term impacts.
17. **Consider best available information on resource valuation when planning for, managing, and mitigating coastal resource impacts.** Planning, project development, and mitigation planning should evaluate the societal and ecosystem service benefits of coastal resources at risk from sea level rise or actions to prepare for sea level rise. These benefits can include flood protection, carbon sequestration, water purification, tourism and recreation opportunities, and community character. Resource values can be quantified through restoration costs or various economic valuation models.

MAXIMIZE AGENCY COORDINATION AND PUBLIC PARTICIPATION [Coastal Act Chapter 5; Sections 30006; 30320; 30339; 30500; 30503; 30711]

18. **Coordinate planning and regulatory decision making with other appropriate local, state, and federal agencies; support research and monitoring efforts.** Given the multitude of sea level rise planning, research, and guidance efforts occurring in California, it is critical for agencies and organizations to share information, coordinate efforts, and collaborate where feasible to leverage existing work efforts and improve consistency. Additionally, since many sea level rise hazards affect multiple jurisdictions, their management may also need to be coordinated through multi-agency reviews and coordinated decision making. The Commission will continue to meet this goal through coordination, engagement with stakeholders, and trainings. However, ongoing financial support for these Commission efforts is critical.

19. **Consider conducting vulnerability assessments and adaptation planning at the regional level.** Where feasible, local governments should coordinate vulnerability assessments and adaptation planning with other jurisdictions in the region that face common threats from sea level rise. A regional vulnerability assessment provides an opportunity to evaluate impacts that span multiple jurisdictions, assess and implement regional adaptation strategies, coordinate responses, and leverage research and planning funds.
20. **Provide for maximum public participation in planning and regulatory processes.** The Coastal Commission will continue to provide avenues for maximum public participation in planning and regulatory processes, and will continue to establish and/or expand non-traditional alliances (*e.g.*, between/among public and private resource managers, tribal groups, scientists, decision makers), share knowledge openly and actively, and regularly and clearly communicate to the public on the science as well as on a range of solutions to prepare for sea level rise.

This document and its guiding principles both reflect and complement the priorities outlined in the State of California’s climate adaptation strategy, the 2014 *Safeguarding California* plan. While this Guidance specifically focuses on the California Coastal Act and the regulatory work of the Coastal Commission, it also echoes key concepts in *Safeguarding California* that apply statewide. For example, a central theme in *Safeguarding California* is to provide risk reduction measures for California’s most vulnerable populations, something that is addressed here in Guiding Principle #9. Similarly, this Guidance and *Safeguarding California* both emphasize the use of best available science (Guiding Principle #2) and the need for communication, outreach, and public participation to increase understanding of climate risks and adaptation options (Guiding Principle #20).

Safeguarding California’s Coast and Oceans chapter also states that “new development and communities must be planned and designed for long-term sustainability in the face of climate change,” which captures a central purpose and focus of this Guidance. It goes on to specify that “California must ensure public access to coastal areas and protect beaches, natural shoreline, and park and recreational resources” and “the state should not build or plan to build, lease, fund, or permit any significant new structures or infrastructure that will require new protection from sea level rise, storm surges or coastal erosion during the expected life of the structure, beyond routine maintenance of existing levees or other protective measures, unless there is a compelling need.” Again, these values are reflected here, as Guiding Principles #6 and #12. In these ways, and through the shared goal of ensuring planning for and resilience against climate change impacts, the two documents are readily consistent and complementary.



Chapter 3

Sea Level Rise Science

This chapter provides information on sea level rise science and covers the following subjects:

- The best available science on sea level rise
- Using scenario-based analysis in response to sea level rise projection ranges
- The physical impacts of sea level rise
- Storms, extreme events, and abrupt change

Sea level rise science continues to evolve, and the discussion below reflects the best available science at the time this document was published.

BEST AVAILABLE SCIENCE ON SEA LEVEL RISE

Scientists widely agree that the climate is changing and that it has led to global increases in temperature and sea level. In the past century, global mean sea level (MSL) has increased by 7 to 8 in (17 to 21 cm; IPCC 2013). It is extremely likely (>95% probability of occurrence) that human influence has been the dominant cause of the observed warming of the atmosphere and the ocean since the mid-20th century (IPCC 2013).

There are a number of methods for projecting future changes in global sea level, including using extrapolations from historical trends and observations, estimations from physical models, and combinations of observations and modeling, known as semi-empirical methods. For a detailed description of these techniques, see [Appendix A](#).

Scientists also measure sea level change at a variety of scales, from the global down to the local level. For example, the sea level rise projections in Intergovernmental Panel on Climate Change (IPCC) reports are based on large scale models that give global projections. But sea level does not change uniformly around the globe, so modifications for local conditions are necessary for adaptation planning.

In particular, global average sea level rise is driven by the expansion of ocean waters as they warm, the addition of freshwater to the ocean from melting land-based ice sheets and glaciers, and from extractions in groundwater ([Figure 3](#)). However, regional and local factors such as tectonics and ocean and atmospheric circulation patterns result in relative sea level rise rates that may be higher or lower than the global average. As such, global-scale models are often “downscaled” through a variety of methods to provide locally relevant data.

For California, the 2018 OPC SLR Guidance, described below, provides sea level rise projections that have been refined for 12 tide gauges throughout California. More detailed refinement of sea level rise projections is not considered necessary at this time, as variations from the nearby tide gauges will often be quite small, and may be insignificant compared to other sources of uncertainty¹⁴. It is important to note, though, that while the sea level rise projections are fairly similar throughout the state, the physical impacts may be quite different,

¹⁴ Although the Commission believes that the OPC Guidance projections can be used without modification, it recognizes that other studies exist with localized data, for example those completed in the Humboldt Bay region, which may also be appropriate for use.

and locally-specific analysis of impacts will be very important. Detail on physical impacts and how to assess them is provided in Section C of this chapter and in [Appendix B](#).

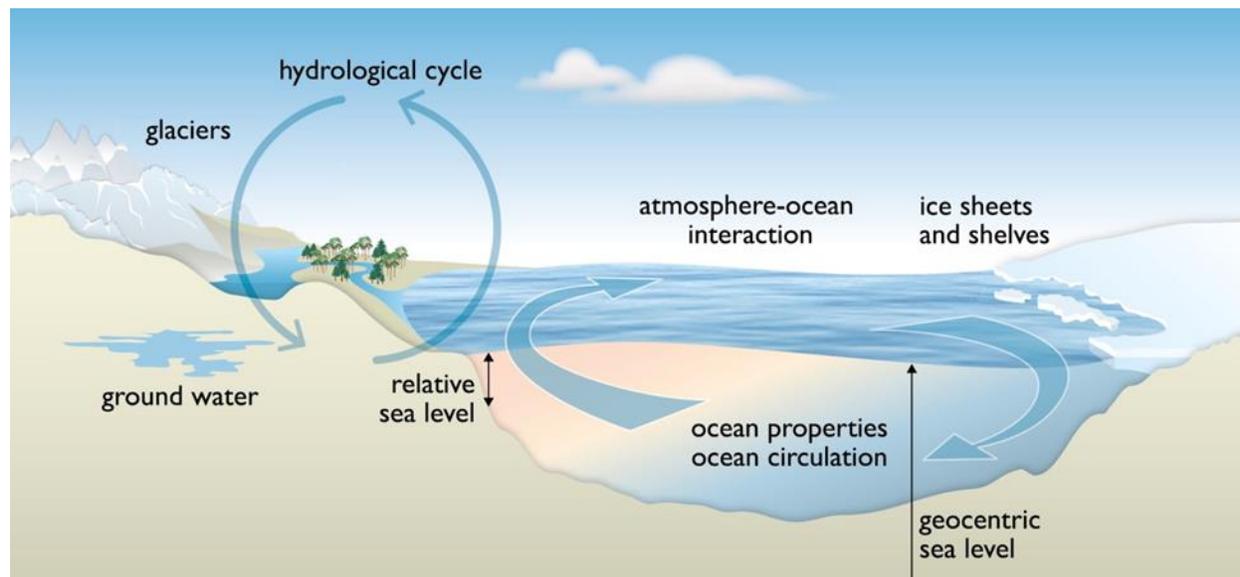


Figure 3. Climate-sensitive processes and components that can influence global and regional sea level. Changes in any one of the components or processes shown will result in a sea level change. The term “ocean properties” refers to aspects such as temperature, salinity, and density, which influence and are dependent on ocean circulation. (Source: IPCC 2013, Figure 13.1)

Global Sea Level Rise Projections

The IPCC [5th Assessment Report](#) (AR5), which was released in September 2013, is the most recent global scale assessment of sea level rise. The report projects a rise in *global* average sea level by 10-39 in (26 to 98 cm) by the year 2100 (relative to mean sea level from 1985 to 2005) depending on the emissions scenario¹⁵ ([Figure 4](#)). These projections are about 50% higher than the projections from the IPCC [4th Assessment Report](#) (AR4, released in 2007). This is because the IPCC changed the climate model inputs between AR4 and AR5. In particular, much of the increase in the amount of sea level rise projected in the AR5 is due to the inclusion of sea level rise resulting from the loss of ice sheets. Ice sheet dynamics were not included in the AR4, but enhancements in physical models that account for such ice sheet dynamics have allowed for a better understanding and greater confidence in this input, and as such were included in the AR5¹⁶. The IPCC also released a special report in October 2018 that discusses the impacts associated with limiting global warming to 1.5°C as compared to 2°C. This report found that sea level rise would be about 10cm less with only 1.5°C, enabling greater opportunities for adaptation in both human and ecological systems (IPCC 2018).

¹⁵ See Appendix A for more detail on emissions scenarios and the IPCC reports.

¹⁶ Many of the other reports and studies cited in this Guidance used the AR4 as a reference (and for this reason detail on the AR4 is included in Appendix A). It is important to note, though, that while these other reports relied on the AR4 scenarios and model outputs for some climatic changes, many (*e.g.*, the *National Climate Assessment* (Melillo *et al.* 2014) and the NRC (2012) reports highlighted below) accounted for the loss of ice sheets through the use of semi-empirical models or other methods, further honing their results.

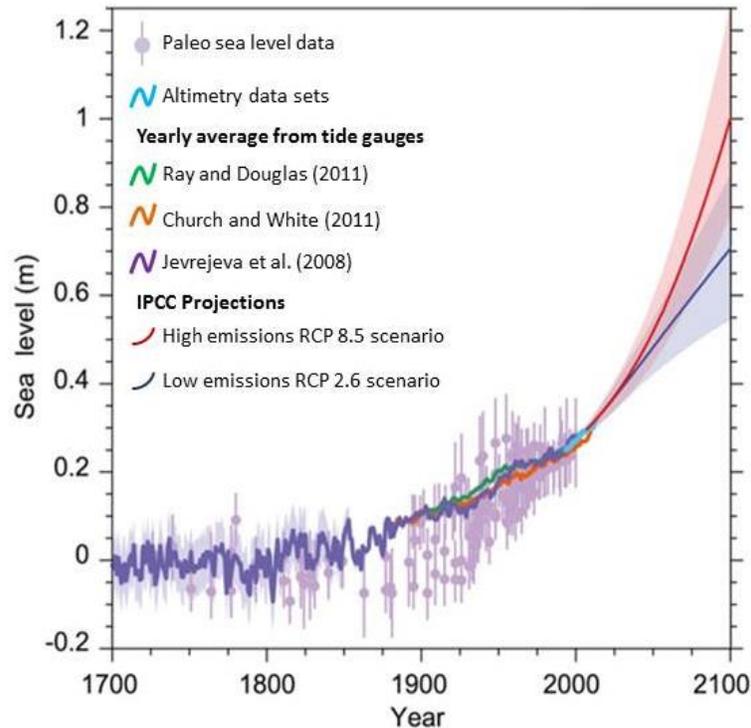


Figure 4. Past and projected future sea level trends (IPCC). Compilation of paleo sea level data, tide gauge data, altimeter data, and central estimates and likely ranges for projections of global mean sea level rise for low emissions RCP2.6 (blue) and high emissions RCP8.5 (red) scenarios, all relative to pre-industrial values. (Source: IPCC 2013, Figure 13.27)

National Sea Level Rise Projections

The [third National Climate Assessment](#) (NCA; Melillo *et al.*) was released in May 2014, and includes the current best-available science on climate change and sea level rise at the *national* scale¹⁷. The sea level rise projections in the NCA were informed by the 2012 NOAA report titled [Global Sea Level Rise Scenarios for the United States National Climate Assessment](#) (Parris *et al.* 2012). This report provides a set of four global sea level rise scenarios ranging from 8 in to 7 ft (0.2 to 2.0 m) by the year 2100 (using mean sea level in 1992 as a baseline) reflecting different amounts of future greenhouse gas emissions, ocean warming and ice sheet loss (Figure 5). The low and intermediate-low scenarios assume very significant reductions in greenhouse gas emissions, and limited changes in ocean warming and ice sheet loss. The intermediate-high scenario is based on the average of the high projections from semi-empirical models, which are based on the highest IPCC 4th Assessment Report (AR4; 2007) emissions scenario (A1FI).¹⁸ The highest scenario (2.0 m) combines the IPCC AR4 projections with the maximum possible ice

¹⁷ Note that the 4th National Climate Assessment is due to be released in late 2018. <https://www.globalchange.gov/nca4>

¹⁸ The IPCC emissions scenarios make assumptions about future changes in population growth, future economic growth and the introduction of clean and efficient technology. The A1FI scenario assumes continued intensive use of fossil fuels, high economic growth, and low population growth that peaks mid-century. The B1 scenario assumes significant reduction in fossil fuel use, an increase in clean technologies, and the same low population growth that peaks mid-century. The A1FI yields the highest CO₂ emissions by 2100 and the B1 scenario yields the lowest.

sheet melt that could occur by 2100. Given the recent studies that suggest that glacier and ice sheet loss could contribute significantly to rising sea levels (*e.g.*, Rahmstorf 2007; Vermeer and Rahmstorf 2009; IPCC 2013; McMillan *et al.* 2014; Morlighem *et al.* 2014) and evidence that current greenhouse gas emissions are tracking with intermediate IPCC AR4 scenarios (Rahmstorf *et al.* 2012), the low and intermediate-low scenarios likely underrepresent future sea level rise unless demonstrable reductions in global greenhouse gas emissions occur soon.

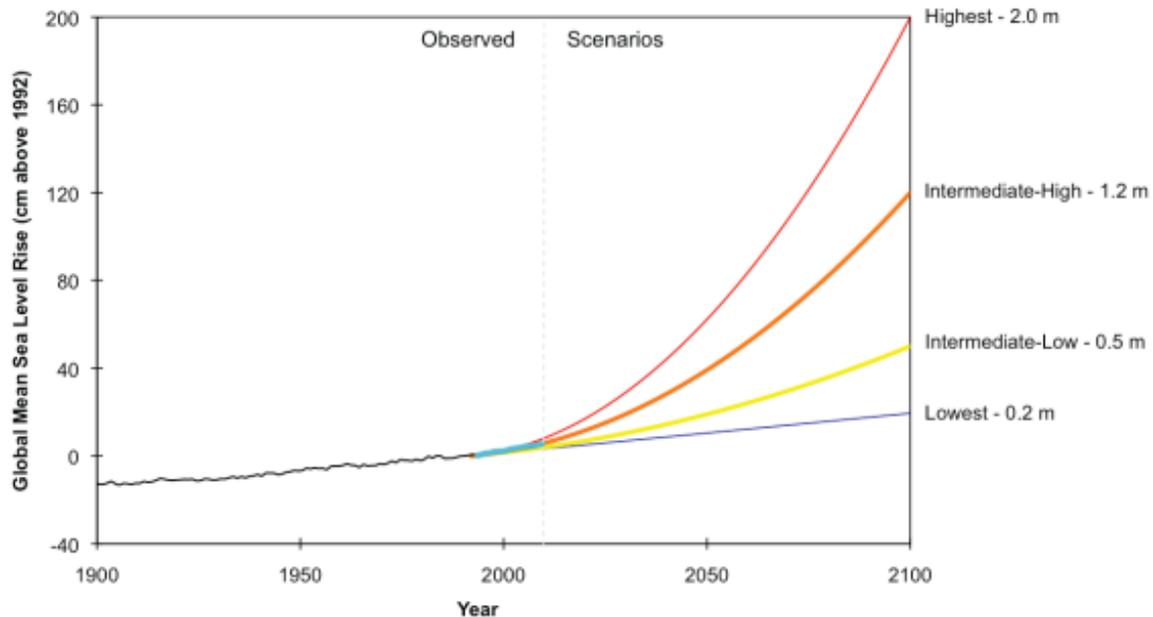


Figure 5. Observed and projected future sea level rise scenarios (Melillo *et al.* 2014). Global mean sea level rise scenarios used in the *US National Climate Assessment*. The Intermediate High Scenario is an average of the high end of ranges of global mean SLR reported by several studies using semi-empirical approaches. The Intermediate Low Scenario is the global mean SLR projection from the IPCC AR4 at 95% confidence interval. (Source: *Global Sea Level Rise Scenarios for the United States National Climate Assessment* (Parris *et al.* 2012))

Sea Level Rise Projections for California

Tide gauges and satellite observations show that in the past century, mean sea level in California has risen 8 in (20 cm), keeping pace with global rise. For the early portion of the 21st century (through approximately 2011), mean sea level in California remained relatively constant, and may have been suppressed due to factors such as offshore winds and other oceanographic complexities. Bromirski *et al.* (2011, 2012) postulated that persistent alongshore winds have caused an extended period of offshore upwelling that has both drawn coastal waters offshore and replaced warm surface waters with cooler deep ocean water. Both of these factors could offset the global sea level rise trend in this region. However, localized sea level suppression will not continue indefinitely. As the Pacific Decadal Oscillation, wind, and other conditions shift, California sea level will continue rising (NRC 2012; Bromirski *et al.* 2011, 2012). Indeed, satellite altimetry data shows that sea level along the west coast of the United States has increased over the past five years, and studies suggest that the shift in sea level in the Pacific Ocean will likely persist in the coming years, leading to substantially higher sea level off the west coast of the United States and lower sea level in the western tropical Pacific (Hamlington *et al.*, 2016).

The State of California has undertaken significant research to understand how much sea level rise to expect over the coming decades and the likely impacts of such sea level rise. In 2013, the Ocean Protection Council (OPC) recognized the National Research Council (NRC) report, *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past Present and Future*, as best available science for the State of California, and recommended in its 2013 State Sea-Level Rise Guidance that state agencies and others use these projections in their planning processes. Likewise, when the Coastal Commission initially adopted this Sea Level Rise Policy Guidance in 2015, it recommended using the NRC report as best available science.

The NRC Report presents sea level rise projections in ranges due to several sources of uncertainty. One significant source of uncertainty is over future greenhouse gas emissions: researchers cannot know the amount or rate of greenhouse gas emissions that will be generated over the coming decades. Large-scale curtailment of greenhouse gas emissions would keep sea level rise towards the lower end of the projections, while business as usual emissions scenarios would result in the higher end of the projections. Because the rate of future greenhouse gas emissions is dependent on global policy decisions, researchers use various climate models that account for different emissions scenarios (business as usual, with little reduction in the current rate of greenhouse gas emissions; large-scale emissions reductions that begin in the near future; and various intermediate scenarios).

A second significant source of uncertainty is related to the dynamics of ice sheet loss. This topic has continued to be extensively researched since the NRC report was published, and recent studies have since informed updated statewide guidance. In April 2017, a Working Group of the Ocean Protection Council’s Science Advisory Team released a report synthesizing current sea level rise science. The report, titled *Rising Seas in California: An Update on Sea-Level Rise Science*, presents advances in sea level rise modeling, notably including improved understanding of the processes that could drive extreme global sea level rise from ice loss from the Greenland and Antarctic ice sheets. A significant finding from this report is that Antarctic ice sheet loss could have an outsized impact on sea level rise in California compared to the global average due to ocean circulation dynamics. Further, the report states that rapid ice sheet loss could result in upwards of 10 feet of sea level rise along the California coast by 2100 (this scenario is referred to as an “extreme scenario” or “H++ scenario” throughout the OPC Science Report and this Guidance).

The Science Report also includes new “probabilistic projections” which associate a likelihood of occurrence with the sea level rise amounts and rates. These probabilistic projections are based on the probabilities that the ensemble of climate models used to estimate contributions of sea level rise (from thermal expansion, ice sheet loss, oceanographic conditions, and other relevant factors) will predict a certain amount of sea level rise. A critical caveat is that these probabilistic projections did not account for the most recent science regarding the potential for rapid ice sheet loss, and therefore may underestimate the probability of higher sea level rise scenarios. It is understood that as inputs to climate models change (based on evolving science for example), so too will the probabilities associated with different projections.¹⁹

¹⁹ The 4th California Climate Assessment developed projections that present a broader range of SLR estimates than the Rising Seas science report and the 2018 OPC SLR Guidance. Both programs’ projections are based on estimates of contributions to SLR from primary sources using different methods, including model projections and expert input. However, the 4th Assessment

OPC incorporated these findings into updates to their 2013 State Sea-Level Rise Guidance. The new *State of California Sea-Level Rise Guidance: 2018 Update* (2018 OPC SLR Guidance) contains projections for 12 tide gauges throughout California (to account for localized variations in vertical land motion and other factors) for each decade from 2030 to 2150. The projection table for the San Francisco tide gauge is provided below in [Table 3](#), and the projection tables for the other tide gauges can be found in [Appendix G](#). The tables are adapted from the 2018 OPC SLR Guidance, and present the three scenarios that OPC recommends for use in planning, permitting, investment, and other decisions. These scenarios include:

1. *Low risk aversion scenario*: the upper value for the “likely range” (which has approximately a 17% chance of being exceeded); may be used for projects that would have limited consequences or a higher ability to adapt.
2. *Medium-high risk aversion scenario*: the 1-in-200 chance (or 0.5% probability of exceedance); should be used for projects with greater consequences and/or a lower ability to adapt.
3. *Extreme risk aversion (H++)*: accounts for the extreme ice loss scenario (which does not have an associated probability at this time); should be used for projects with little to no adaptive capacity that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts should that level of sea level rise occur.

In accordance with this statewide guidance, the Coastal Commission considers the 2018 OPC Sea-Level Rise Guidance (and the related 2017 Rising Seas science report) as the best available science on sea level rise in California, and recommends using the above scenarios in relevant Coastal Commission planning and permitting decisions.²⁰ More information on which scenarios to use in certain circumstances can be found in Chapters 5 and 6. The Commission will continue to periodically re-examine and update sea level rise projections as they evolve with the release of new scientific reports and information on local and regional sea level trends. Additionally, as sea level rise science continues to evolve, equivalent resources may be used by local governments and applicants provided the sources are peer-reviewed, widely accepted within the scientific community, and locally relevant.

The Coastal Commission will be using and recommends that local governments and applicants use best available science, currently identified as the projections provided in the 2018 OPC Sea-Level Rise Guidance ([Table 3](#); [Appendix G](#)), in all relevant local coastal planning and coastal development permitting decisions.

incorporates the findings from the recent studies regarding the potential for rapid loss of Antarctic ice sheets (which results in the H++ scenario of about 10ft. of SLR by 2100) into its probabilistic projections whereas the OPC reports do NOT include this possibility in the probabilistic projections, as explained above.

²⁰ Note that while the Coastal Commission now recognizes the 2018 OPC SLR Guidance as best available science on sea level rise projections, the 2012 NRC Report and other related studies still contain valuable information, and references to these documents and studies throughout this guidance remain relevant and applicable.

Table 3. Sea Level Rise Projections for the San Francisco Tide Gauge²¹ (OPC 2018)

Projected Sea Level Rise (in feet): <i>San Francisco</i>			
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**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

²¹ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

USING SCENARIO-BASED ANALYSIS IN RESPONSE TO SEA LEVEL RISE PROJECTION RANGES

Despite the recent advances in sea level rise science, sea level rise projections, including those in the 2018 OPC SLR Guidance ([Table 3](#); [Appendix G](#)) and other state, national, and global reports, are typically presented in ranges due to several sources of significant uncertainty.

The two primary sources of uncertainty in global sea level projections include:

- 1) Uncertainty about future greenhouse gas emissions and concentrations of sulfate aerosols, which will depend on future human behavior and decision making, and
- 2) Uncertainty about future rates of land ice loss (NRC 2012; McMillan *et al.* 2014; Morlighem *et al.* 2014; Griggs *et al.* 2017; OPC 2018).

Additionally, the further into the future sea level rise is projected, the greater the uncertainty (and therefore the range in projections) becomes. This occurs because the longer the projection period, the greater the likelihood that models will deviate from the actual impacts of climate change (NRC 2012) and the more dependent projections become on the trajectory of greenhouse gas emissions (OPC 2018). This is reflected in the projections included in the 2018 OPC SLR Guidance, which includes single values for the years 2030, 2040, and 2050, but projections for both low and high emissions scenarios in 2060 and beyond. According to the 2018 OPC SLR Guidance, near-term sea level rise has been locked in by past greenhouse gas emissions whereas sea-level rise over the longer-term will become increasingly dependent on efforts to curtail greenhouse gas emissions.

This Guidance recommends using scenario-based analysis to address the uncertainty in sea level projections. Scenario-based analysis (or planning) refers to the idea of developing multiple scenarios from which to analyze vulnerabilities, generate new ideas and adaptation options, and/or test strategies. In the context of this Guidance, scenario-based analysis includes choosing several possible sea level rise amounts as a starting point to evaluate impacts to coastal resources and potential risks to development over time. This type of scenario-based approach is useful because it reveals the full range of possible consequences of sea level rise that can be reasonably expected for particular regions or sites according to the best available science. Additionally, a scenario-based analysis helps to reveal the tipping points indicating if or when sea level rise will become a serious issue in a particular location. In many cases, using multiple sea level rise scenarios will help to hone in on the types of hazards for which to prepare.

In general, the Coastal Commission recommends using best available science (currently the 2018 OPC SLR Guidance) to identify a range of sea level rise scenarios, including the low, medium-high, and, as appropriate, extreme risk aversion scenario²². In practice, the process for choosing scenarios and performing scenario-based analysis will be slightly different for LCP planning and

²² Similar to the recommendation in the OPC's 2011 *State Sea-Level Rise Resolution*, as well as the 2018 OPC SLR Guidance, the Commission does not recommend using projections solely from the lower end of the ranges, as this does not give a full picture of the risks. Looking instead at a range of projections allows users to build an understanding of the overall risk sea level rise poses to the region or site.

CDP applications due to the different planning goals and levels of technical detail required for each.

For a Local Coastal Program (LCP), the general goal is to assess the potential impacts from sea level rise over the entire planning area and over a range of time horizons so that both short and long term adaptation strategies can be identified and implemented. Another important facet of LCP planning is identifying locations that are particularly vulnerable so that additional, more detailed studies can be performed if necessary, and adaptation options and actions can be prioritized. Scenario-based analysis in the context of LCP planning includes choosing a range of sea level rise projections to analyze so as to understand the best and worst case scenarios and to identify amounts of sea level rise and related conditions that would trigger severe impacts and the associated time period for when such impacts might occur. Choosing sea level rise scenarios in the context of LCP planning is described in greater detail in [Chapter 5](#).

In the context of a Coastal Development Permit (CDP) application, the goal is to understand how sea level rise will impact a specific site and a specific project over its expected lifetime so as to ensure that the proposed development is safe from hazards and avoids impacts to coastal resources. Thus, in the context of a CDP, it is important to identify the amounts of sea level rise that could result in effects to a particular site as well as the time period(s) over which those effects could occur so that the proposed development can be safely sited and designed to avoid resource and development impacts. However, some sites will be completely safe from sea level rise under even the highest projection scenarios, while others will depend on the timing and magnitude of sea level rise to determine safety. Therefore, scenario-based planning analysis can be used as a screening process to identify if and when sea level rise might become a problem. Identifying sea level rise scenarios in the context of CDPs is described in greater detail in [Chapter 6](#).

Overall, scenario-based planning should help planners make reasonable and informed decisions about whether their projects or plans are compatible with the local hazards influenced by sea level rise, and identify the types of adaptation measures that might be appropriate given the local circumstances and requirements of the Coastal Act. By exploring the range of future scenarios based on the best available science, users of this document can make decisions based on full understanding of possible future hazards, ultimately achieve outcomes that are safer for both development and coastal resources, and avoid costly damages to projects.

For more information on scenario-based planning in the context of LCPs and CDPs see Chapters 5 and 6, respectively. A number of additional resources related to scenario-based planning are available, including a [handbook](#) from the National Park Service (2013) and [guidance](#) from Point Blue Conservation Science and the California Coastal Conservancy (Moore *et al.* 2013). See [Appendix C](#) for these and other resources related to scenario-based analysis and adaptation planning.

PHYSICAL EFFECTS OF SEA LEVEL RISE

Continued and accelerated sea level rise will have widespread adverse consequences for California's coastal resources (See summary in [Figure 8](#)). The main physical effects of sea level

rise include increased flooding, inundation, wave impacts, coastal erosion, changes in sediment dynamics, and saltwater intrusion. These impacts are interrelated and often occur together. Absent any preparatory action, an increase in sea level may have serious implications for coastal resources and development, as described in [Chapter 4](#). In addition, these physical effects could have disproportionate impacts on vulnerable communities that have lower capacity to adapt.

Physical effects from sea level rise to the coastal zone include the following:

- **Flooding and inundation:** Low lying coastal areas may experience more frequent flooding (temporary wetting) or inundation (permanent wetting), and the inland extents of 100-year floods may increase. Only a 10 cm rise in sea level could double the flooding potential along the west coast in locations such as San Francisco and Los Angeles (Vitousek *et al.* 2017). Riverine and coastal waters come together at river mouths, coastal lagoons, and estuaries, and higher water levels at the coast may cause water to back up and increase upstream flooding (Heberger *et al.* 2009). Drainage systems that discharge close to sea level could have similar problems, and inland areas may become flooded if outfall pipes back up with salt water. In addition, other climate change impacts such as increases in the amount of precipitation falling as rain rather than snow will add to river flooding in some areas.
- **Wave impacts:** Wave impacts can cause some of the more long-lasting consequences of coastal storms, resulting in high amounts of erosion and damage or destruction of structures. The increase in the extent and elevation of flood waters from sea level rise will also increase wave impacts and move the wave impacts farther inland. Erosion rates of coastal cliffs, beaches, and dunes will increase with rising sea level and are likely to further increase if waves become larger or more frequent (NRC 2012).
- **Erosion:** Large sections of the California coast consist of oceanfront bluffs that are often highly susceptible to erosion. With higher sea levels, the amount of time that bluffs are pounded by waves would increase, causing greater erosion (NRC 2012). This erosion could lead to landslides and loss of structural and geologic stability of bluff top development such as homes, infrastructure, the California Coastal Trail, Highway 1, and other roads and public utilities. The Pacific Institute (Heberger *et al.* 2009) estimated that 41 square miles (106 square km) of coastal land from the California-Oregon border through Santa Barbara County could be lost due to increased erosion with 4.6 ft (1.4 m) of sea level rise by the year 2100, and approximately 14,000 people now live in those vulnerable areas. Increased erosion will not occur uniformly throughout the state. Dunes in Humboldt County could erode a distance of approximately 2000 ft (nearly 600 m) by the year 2100 (Heberger *et al.* 2009; Revell *et al.* 2011). In southern California, higher sea level rise could result in a two-fold increase in bluff retreat rates over historic rates, causing a total land loss of 62 – 135 feet by 2100 (Limber *et al.* 2018 (in press)). Man-made structures like dikes and levees may also be impacted by erosion, increasing flooding risk of the areas protected by those structures, such as low-lying agricultural land. Over the long term, rising sea levels will also cause landward migration of beaches due to the combined effects inundation and loss of sediment due to erosion (NRC 2012).



Figure 6. Photo of Esplanade Apartments threatened by cliff erosion in 2013 in Pacifica, CA. (Source: [California Coastal Records Project](#))

- **Changes in beaches, sediment supply and movement:** Sediment is important to coastal systems in, for example, forming beaches and mudflats and as the substrate for wetlands. Sea level rise will result in changes to sediment availability. Higher water levels and changing precipitation patterns could change erosion and deposition patterns. Loss of sediment could worsen beach erosion and possibly increase the need for beach nourishment projects (adding sand to a beach or other coastal area), as well as decrease the effectiveness and long-term viability of beach nourishment if sand is quickly washed away after being placed on a beach (Griggs 2010). Shoreline change models predict that by 2100, without changes in coastal management, 30 to 67% of Southern California beaches may be completely lost due to rising sea level (Vitousek *et al.* 2017; Bedsworth *et al.* 2018). Sediment supplies in wetland areas will also be important for long-term marsh survival. Higher water levels due to sea level rise, however, may outpace the ability of wetlands to trap sediment and grow vertically (Titus 1988; Ranasinghe *et al.* 2012; Van Dyke 2012).
- **Saltwater intrusion and rising groundwater:** An increase in sea level could cause saltwater to enter into groundwater resources, or aquifers. Existing research suggests that rising sea level is likely to degrade fresh groundwater resources in certain areas, but the degree of impact will vary greatly due to local hydrogeological conditions. Generally, the most vulnerable hydrogeological systems are unconfined aquifers along low-lying coasts, or aquifers that have already experienced overdraft and saline intrusion. In California, saline intrusion into groundwater resources is a problem in multiple areas, including but not limited to the Pajaro Valley (Hanson 2003), Salinas Valley (Hanson *et al.* 2002a; MCWRA 2012), Oxnard Plain (Izbicki 1996; Hanson *et al.* 2002b), and the heavily urbanized coastal plains of Los Angeles and Orange Counties (Edwards and Evans 2002; Ponti *et al.* 2007; Nishikawa *et al.* 2009; Barlow and Reichard 2010). Groundwater sources for coastal agricultural lands may also be susceptible to saltwater intrusion. Sea level rise can also result in higher groundwater, presenting another source of flood rise (Hoover *et al.* 2016).

STORMS, EXTREME EVENTS, AND ABRUPT CHANGE

Much of the California coast is currently vulnerable to flooding and wave damage during large storm events, and even more of the coast is vulnerable to storm impacts when they occur during times of heightened water levels, such as high tides, El Niño events, a warm phase of the Pacific Decadal Oscillation, or a combination of these factors. Sea level rise will increase vulnerability to storms even more because rising water levels will result in more areas being impacted.

Climate change will likely modify or change much more than just sea level. One potential climate change-related impact that will interact most directly with sea level rise hazards is a change in frequency or intensity of coastal storms (storminess) and extreme events. The extremes associated with high-intensity events may be particularly devastating since they have the potential to cause broad-scale damage, as seen from recent events such as Hurricanes Katrina and Rita, Superstorm Sandy, and the Tohoku tsunami. Abrupt change in sea levels is another potential impact of climate change. Both potential impacts are described below.

Extreme Events and Storms

There are several ways to describe extreme events, and most definitions tend to frame these events in terms of consequences or past observations. Kruk *et al.* 2013 define extreme events as “the floods that displace us from our homes, the high waves that wash out coastal roads, or the toppling of trees and power poles from a passing storm.” The IPCC defines climate extremes as “the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variables” (IPCC 2012, p. 5). In general, extreme events, by their very nature, are those beyond the normal events that are considered in most shoreline studies. For example, for storm waves and flood conditions, an extreme event will normally be anything worse than the 100-year event.

Extreme events are of particular concern to the examination of coastal vulnerability and damage because they tend to cause the greatest community upheaval and can result in irreversible changes to the coastal landscape. In the El Niño winter of 1982-1983, for example, a series of storms, several of which coincided with high tide, caused more than \$200 million in damage (in 2010 dollars) to coastal California (OPC 2013). Similarly, the 2015/16 El Niño was one of the strongest on record, resulting in significant changes to the shoreline. The 2012 NRC report notes that “waves riding on these higher water levels will cause increased coastal damage and erosion—more than that expected by sea level rise alone” (NRC 2012, p.107), and the 4th California Climate Assessment found that a 100-year coastal flood would almost double the damages associated with just 20 inches of sea level rise alone (Bedsworth *et al.* 2018). These impacts result because a rise in sea level will mean that flooding and damage will likely reach further inland. The IPCC *Fifth Assessment Report* (2013) states that it is very likely²³ that there will be a significant increase in the occurrence of future sea level extremes primarily as a result of an increase in mean sea level, with the frequency of a particular sea level extreme increasing by an order of magnitude or more in some regions by the end of the 21st century.

²³ The IPCC has assigned quantitative levels to various terms of confidence and likelihood. High confidence means there is about an 8 out of 10 chance of being correct. Very likely has a greater than 90% probability of occurrence. Other terms that will be used later in this discussion are likely (> 66% probability of occurrence), medium confidence (about a 5 out of 10 chance), low confidence (about a 2 out of 10 chance). *Source of terms:* http://www.ipcc.ch/pdf/supporting-material/uncertainty-guidance-note_ar4.pdf

According to the 2012 NRC report, if the frequency or intensity of storms changes, then so will the frequency and intensity of extreme sea level events. However, the evidence that storminess will change in the North Pacific Ocean is conflicting and inconclusive (Cayan *et al.* 2009; Lowe *et al.* 2010; Dettinger 2011). Still, even if storminess does not change, sea level rise will exacerbate storm surge and high waves, magnifying their impact on the coastline. For this reason, it is important to include these factors in the analysis of sea level rise hazards. Methodologies for these analyses are included in [Appendix B](#).

Abrupt change

Currently, the best available science is inconclusive as to whether sea level could change abruptly. Thermal expansion and direct melting of land ice is expected to be gradual, leading to slow and steady sea level rise. However, rapid collapse of land-based ice sheets could lead to sudden acceleration of sea level rise, as discussed in the 2017 Rising Seas science report and the 2018 OPC SLR Guidance. Specifically, the science report explains that if greenhouse gas emissions are not curtailed, “glaciological processes could cross thresholds that lead to rapidly accelerating and effectively irreversible ice loss.” Recent ice sheet observations and model simulations that consider positive feedback loops associated with ice sheet melting and related non-linear acceleration of sea level rise have attempted to estimate the maximum physically plausible amount of sea level rise. These studies informed the extreme/H++ scenario included in the OPC science report and 2018 SLR OPC Guidance (of approximately 10 feet by 2100). Importantly, it will be difficult to determine if the world is on track for extreme and irreversible ice loss for some time because the processes that drive extreme ice loss in the later part of the century or beyond are different than those that are driving ice loss now. Thus, the likelihood of extreme sea level rise is uncertain and remains an area in need of future research (NRC 2012; Griggs *et al.* 2017; OPC 2018).

Rapid change in land elevation during an earthquake is another potential cause of an abrupt sea level change in a localized area. A large earthquake in the Cascadia Subduction Zone could cause land in northern California, Oregon, and Washington to suddenly subside relative to sea level, causing a sudden rise in relative sea level by 3-6.5 ft (NRC 2012). Large earthquakes in this zone are expected to occur about every several hundred to one thousand years, and the most recent such earthquake occurred in 1700. The sudden rise or drop in land elevation would occur in a matter of minutes. If the land were to subside, the relative rise in sea level would be rapid and it would add to sea level rise already occurring from climate-related forcing.

There is also potential for oceanographic conditions to lead to a relatively rapid rate of sea level rise in California. Examination of the tidal gauge records indicate that there was no significant interannual rise in California’s sea level from 1983 to 2011, despite a rise in global sea level over the same time period. One explanation, presented by Bromirski *et al.* (2011, 2012), links this suppression of sea level rise with persistent alongshore winds and an extended period of offshore upwelling that has both drawn coastal waters offshore and replaced warm surface waters with cooler deep ocean water. However, this suppression will not continue indefinitely and as the Pacific Decadal Oscillation, wind, and other conditions shift, California sea level will continue rising, likely at an accelerated rate (NRC 2012; Bromirski *et al.* 2011, 2012).



Chapter 4

Consequences of Sea Level Rise for Communities, Coastal Resources, and Development

The physical effects of sea level rise described in the previous chapter could have significant consequences for California’s citizens, coastal communities and the resources protected by the Coastal Act. This chapter describes some of these consequences and notes the relevant Coastal Act policies for convenience. It is important to consider both the direct impacts of sea level rise on coastal resources and what these impacts mean for the people and communities who use and enjoy these coastal resources. It is also important to consider environmental justice when analyzing sea level rise impacts, as described in greater detail in the section below.

SEA LEVEL RISE ADAPTATION PLANNING AND ENVIRONMENTAL JUSTICE

Sea level rise and how we respond to it may result in significant changes in the distribution of environmental benefits, or environmental justice, in California. General planning law in California specifically recognizes and defines environmental justice as “the fair treatment of people of all races, culture and income with respect to the development, adoption, implementation and enforcement of environmental laws, regulations, and policies” (Government Code Section 65040.12; and see Public Resources Code Section 71110-71116). Environmental justice demands that all people, regardless of their race, ethnicity, or level of income, are able to enjoy the benefits of our environmental protection programs and our environment generally. [Safeguarding California](#) (CNRA 2018) identifies climate justice as an important cross-sector theme in the state’s climate adaptation and resilience planning efforts. Additionally, the 2018 OPC SLR Guidance recommends prioritizing social equity, environmental justice, and the needs of vulnerable communities in adaptation planning.

The California Coastal Act also recognizes the fundamental importance of the fair distribution of environmental benefits in Section 30001:

The Legislature hereby finds and declares: (a) That the California coastal zone is a distinct and valuable natural resource of vital and enduring interest to all the people and exists as a delicately balanced ecosystem. (b) That the permanent protection of the state's natural and scenic resources is a paramount concern to present and future residents of the state and nation. (c) That to promote the public safety, health, and welfare, and to protect public and private property, wildlife, marine fisheries, and other ocean resources, and the natural environment, it is necessary to protect the ecological balance of the coastal zone and prevent its deterioration and destruction. (d) That existing developed uses, and future developments that are carefully planned and developed consistent with the policies of this division, are essential to the economic and social well-being of the people of this state and especially to working persons employed within the coastal zone.

The Act thus declares that the protection of the coast is of vital interest to *all* the people, of paramount concern to *present and future residents* of the state and nation, and that careful planning and development is essential to *the economic and social well-being* of the people. This broad direction to protect the coast for everyone is underscored in Section 30006, which declares:

. . . the public has a right to fully participate in decisions affecting coastal planning, conservation and development; that achievement of sound coastal conservation and development is dependent upon public understanding and support; and that the

continuing planning and implementation of programs for coastal conservation and development should include the widest opportunity for public participation.

Hence, everyone is entitled to participate in the management decisions that determine how the benefits and burdens of managing California's coast will be distributed. Ensuring low-income and underserved communities are included in environmental decisions is a key tenet of environmental justice and will minimize disproportionate environmental and public health impacts. Furthermore, in 2016, the Governor signed AB 2616 (Burke), which amended the Coastal Act and gives the Commission new authority to specifically consider environmental justice when making permit decisions. This legislation also cross-references existing non-discrimination and civil rights law in the government code and requires the governor to appoint an environmental justice Commissioner to our board.

The Coastal Act's broad concern for all the people is best borne out in its public access policies, which require the maximum provision and protection of the public's rights of access to and along the shoreline (Sections 30210-214). These policies reflect the judgement of the people of California in passing Proposition 20 in 1972 that public access and recreation along our coast is a fundamental environmental benefit to be protected for and enjoyed by all, not just by those with the good fortune or means to live along the shoreline. Public access to the coast is important to the health and well-being of the public, and promoting public access for all citizens provides low-cost, outdoor recreation that can improve the overall quality of life of the public, including low-income and underserved communities.

Unfortunately, public access is also one of the coastal resources most at risk from accelerating sea level rise. As discussed elsewhere in this Guidance, beaches, accessways, recreational amenities, and even surfing resources may be dramatically impacted by rising seas. Where development already exists, and particularly where there is substantial shoreline armoring to protect this development, California stands to lose significant recreational beach areas. These places that are at increased risk provide environmental benefits for everyone, generally at very low cost, or even free. Thus, the potential loss of beach and shoreline recreation areas represents a significant potential impact to a resource that both is especially important to those with fewer economic resources and one that we endeavor to provide for everyone without discrimination, no matter their income levels, ethnicities or cultures; no matter if they are from coastal or inland areas or from outside the state.

The exacerbation of environmental injustices by anticipated sea level rise may be particularly concerning when the Commission and local governments need to make decisions about shoreline protection and hazard mitigation. As discussed elsewhere in this Guidance, the Coastal Act provides for the protection and mitigation of coastal hazards for existing and new development. But some hazard mitigation, such as seawall development or elevated development on beaches, may have significant impacts to public trust shoreline resources. Thus, we face a situation where widely available public beach resources may be diminished in order to protect private or public development along the shoreline – potentially a significant environmental justice concern. Because of this, it will be important for decision makers to proactively consider all aspects of this Guidance in an effort to avoid and mitigate the potential impacts to coastal resources from hazard response. This is particularly true for recommendations to consider alternatives to

shoreline structure development and, where shoreline structures must be approved, for recommendations to fully mitigate the impacts of such structures on public shoreline resources.

A May 2015 decision made by the Coastal Commission emphasizes the importance of analyzing low-cost recreational opportunities in addition to other coastal resource impacts when evaluating shoreline protection and other responses to sea level rise and coastal hazards. The Coastal Commission approved a revetment at the west end of the Goleta Beach County Park to provide protection against erosion. This park is an important public resource in Santa Barbara County and receives up to 1.5 million visitors each year, a large fraction of which are low-income visitors. Park facilities include picnic areas, open parkland, and access to the ocean and a recreational beach for no or low cost. The revetment was approved contingent upon specific conditions, including continued free public access and vehicle parking for the term of the permit. This decision highlights the importance of protecting wide accessibility to shoreline resources even as sea level rises.

The potential impacts of adaptation responses on public shoreline resources, and thus the potential environmental justice impacts of such actions, will need to be considered for all resources protected under the Coastal Act. It is also true that due to current development patterns along the coast, sea level rise hazards may affect various sections of the population differently, as could the implementation and effectiveness of various adaptation measures. The number of people living along the open coast in areas exposed to flooding from a 100-year flood would increase to 210,000 with a 4.6 ft (1.4 m) increase in sea level; approximately 27% or 56,000 of these are lower income people (those earning less than \$30,000 annually); 45,000 are renters; and 4,700 are linguistically isolated and less likely to understand flood warnings (Heberger *et al.* 2009). According to Heberger *et al.* (2009), the greatest increases in the number of people vulnerable to flooding will occur in Los Angeles, San Diego, Ventura, Humboldt, and San Luis Obispo counties. Sea level rise will likely result in the loss of key infrastructure, intrusion of saltwater into water sources, and the creation of additional coastal hazards. Hazards in vulnerable areas will have disproportionate impacts on communities with the least capacity to adapt, which could deepen and expand existing environmental injustice if adaptation responses are not managed appropriately.

For example, lower-income communities and those who live in rental units are more likely to be displaced by flooding or related impacts as compared to property owners because they lack the funds and/or abilities to rebuild, have less control over their safety, and often have limited access to insurance. Relatedly, these same populations are less likely to be able to take proactive steps to adapt to sea level rise. Additionally, loss of local public beaches or a reduction in public access and recreation opportunities would disproportionately affect low-income communities that have few alternative lower cost recreational opportunities. Tribal communities are also vulnerable to sea level rise because they are often tied to specific locations, and therefore can't easily relocate.

Overall, it will be important for planners and decision makers to not only consider the direct impacts and consequences of sea level rise on coastal resources, but to also consider what those consequences mean for the distribution of environmental benefits and burdens along the coast, and the communities that use and rely on those resources, including those who do not live in the

coastal zone but are still impacted by coastal resource management, including workers and visitors. Low-income and underserved communities are less equipped to prepare for and respond to sea level rise, but community engagement and social cohesion can improve coastal resilience and lead to more equitable adaptation planning. Planners and decision makers should consider environmental justice concerns in the analysis of alternative project designs and adaptation measures and ensure low-income and underserved communities are involved in decision-making and planning efforts. This will better ensure that adaptation efforts benefit all Californians, fairly, and that they do not increase vulnerability to sea level rise among any particular group or demographic, and do not have any unintended consequences that lead to social or environmental injustices. In particular, it will be important to consider the potential impacts of hazard mitigation actions to protect development that may only benefit a few, on the public access and shoreline resources that are available for all Californians to enjoy.

CONSEQUENCES OF SEA LEVEL RISE FOR COASTAL ACT RESOURCES

- **Coastal development (Coastal Act Sections 30235, 30236, 30250, 30253):** Sea level rise will increase the likelihood of property damage from flooding, inundation, or extreme waves, and will increase the number of people living in areas exposed to significant flooding. Increased erosion and loss or movement of beach sand will lead to an increase in the spatial extent of eroding bluffs and shorelines, and could increase instability of coastal structures and recreation areas. Levee systems could also experience damage and overtopping from an increase in water levels, extreme wave conditions, or a loss of wetlands, which buffer impacts from high water. The replacement value of property at risk from sea level rise for the California coast is approximately \$36.5 billion (in 2000 dollars, not including San Francisco Bay) (Heberger *et al.* 2009).

Impacts to public infrastructure, ports, and industrial development include:

- **Public infrastructure:** Low-lying roads, wastewater treatment facilities, energy facilities, stormwater infrastructure, and utility infrastructure such as potable water systems and electricity transfer systems are at risk of impaired function due to erosion, flooding, and inundation. Heberger *et al.* (2009) estimated that 7 wastewater treatment plants, 14 power plants, including one in Humboldt County and 13 in Southern California, and 250 miles (402 km) of highways, 1500 miles (2414 km) of roads, and 110 miles (177 km) of railways could be at risk from a 100-year flood with 1.4-m rise in sea level (Heberger *et al.* 2009). Facilities and highways located on coastal bluffs subject to erosion will become more susceptible in the future. Sections of Highway 1 have already had to be realigned due to erosion or are in the planning stages for realignment projects, including areas in San Luis Obispo County, Monterey Bay, Half Moon Bay, and Marin County and the sections at risk in the future will likely increase.



Figure 7. Photo of infrastructure at risk near Rincon Beach, Ventura, CA, during the King Tide in December 2012. (Photo courtesy of David Powdrell, California King Tides Initiative)

- **Ports (Coastal Act Sections 30703 – 30708):** Sea level rise could cause a variety of impacts to ports, including flooding and inundation of port infrastructure and damage to piers and marina facilities from wave action and higher water levels. A possible benefit could be a decreased need for dredging. But, unless facilities have already included accommodations for larger ships than they currently service, higher water levels could increase the difficulty for cargo handling facilities due to the higher vessel position (CCC 2001; CNRA 2014). Increased water heights could reduce bridge clearance, reducing the size of ships that can access ports or restricting movement of ships to low tides, and potentially increasing throughput times for cargo delivered to ports. Heberger *et al.* (2009) found that significant flooding from sea level rise is possible at the Ports of Los Angeles and Long Beach. Given that these two ports handle 45-50% of the containers shipped into the United States, and 77% of goods that leave the state, sea level rise could affect the efficiency of goods movement, and have serious economic implications for California and the nation (Heberger *et al.* 2009).
- **Industrial development, refineries, and petrochemical facilities (Coastal Act Sections 30260-30266.5):** Sea level rise could reduce areas available for siting or expansion of industrial development. Inundation of contaminated lands near industrial development could lead to problems with water quality and polluted runoff. Sea level rise could lead to an increase in flooding damage of refineries or petrochemical facilities, and impacts from sea level rise could be an issue when locating or expanding refineries or petrochemical facilities, or when mitigating any adverse environmental effects.
- **Construction altering natural shorelines (Coastal Act Section 30235):** Sea level rise may lead to an increase in demand for construction of shoreline protection for existing development, public access, and coastal-dependent uses in danger of erosion. Shoreline protection devices alter natural shorelines and also generally have negative impacts on beaches, near-shore marine habitat, and scenic and visual qualities of coastal areas.

- **Public access and recreation (Coastal Act Sections 30210, 30211, 30213, 30220, 30221):** One of the highest priorities in the Coastal Act is the mandate to protect and maximize public access to the coast. Sea level rise could lead to a loss of public access and recreational opportunities due to permanent inundation, episodic flooding, or erosion of beaches, recreational areas, or trails. In areas where beaches cannot migrate inland due to development or more resistant landforms, beaches will become narrower or will disappear completely. Access and functionality of water-oriented activities may also be affected. For instance, sea level rise, by increasing water levels and altering sediment patterns, could lead to a change in surfing conditions or affect the safety of harbors and marinas (Kornell 2012).
- **Coastal habitats (Coastal Act Sections 30230, 30231, 30233, 30240):** Coastal habitat areas likely to be affected by sea level rise include bluffs and cliffs, rocky intertidal areas, beaches, dunes, wetlands, estuaries, lagoons and tidal marshes, tidal flats, eelgrass beds, and tidally-influenced streams and rivers.

Importantly, there are many endemic and endangered species in California that are dependent on these coastal environments. For example, grunion need a sandy beach environment in order to reproduce and survive, the California clapper rail is dependent on marshes and wetlands, and the black abalone requires rocky intertidal habitat. Nesting habitat, nursery areas, and haul-out sites important for birds, fish, marine mammals and other animals could also disappear as sea levels rise (Funayama *et al.* 2012).

Impacts to wetlands, intertidal areas, beaches, and dunes include:

- **Beaches, dunes, and intertidal areas:** Inundation and increased erosion from sea level rise could convert habitats from one type to another and generally reduce the amount of nearshore habitat, such as sandy beaches and rocky intertidal areas. Sea level rise will cause landward migration of beaches over the long term, and could lead to a rapid increase in the retreat rate of dunes. Beaches with seawalls or other barriers will not be able to migrate landward and the sandy beach areas will gradually become inundated (NRC 2012). A loss of beach and dune areas will have significant consequences for beach and adjacent inland ecosystems. Beaches and dunes provide critical habitat for species and act as buffers to interior agricultural lands and habitat during storms (CNRA 2009).
- **Wetlands:** Sea level rise will lead to wetland habitat conversion and loss as the intertidal zone shifts inland. Of particular concern is the loss of saltwater marshes from sea level rise, which have already decreased by about 90% from their historical levels in California (CNRA 2010). California's 550 square miles (885 km) of critical coastal wetland habitat (Heberger *et al.* 2009, including wetlands in San Francisco Bay) could be converted to open water by 4.6 ft (1.4 m) rise of sea level if they are not able accrete upward or to migrate inland due to natural or anthropogenic barriers. Although barriers are plentiful, inland migration of these wetlands is possible for over 50% of the potentially inundated wetland area based on land use compatibility alone (Heberger *et al.* 2009). Consideration of adequate sediment supply and additional barriers to inland migration would further constrain wetland migration potential. A 4.6 ft (1.4 m) increase in sea level would flood 150 square miles (241 km) of land immediately adjacent to wetlands, which

could become future wetlands if that land remains undeveloped. Loss or reduction of wetland habitat would impact many plant and animal species, including migratory birds that depend on these habitats as part of the Pacific Flyway. Species that are salt-tolerant may have an advantage as sea level rise occurs and exposes new areas to salt water, while species that have narrow salinity and temperature tolerances may have difficulty adapting to changing conditions.

- **Biological productivity of coastal waters (Coastal Act Sections 30230, 30231):** Sea level rise could affect biological productivity of coastal waters by changing the types of habitats that are available. This change could alter species composition, and could potentially result in cascading effects through the coastal food chain. Changes in water quality can have differing impacts on biological productivity. For instance, decreased water quality due to increased nutrient pollution has been found to increase biological productivity at the base of the food chain to undesirable levels, and has been linked to harmful algal blooms which result in hypoxic conditions for other marine species (Kudela *et al.* 2010; Ryan *et al.* 2010; Caldwell *et al.* 2013).
- **Water quality (Coastal Act Section 30231):** Sea level rise could lead to declines in coastal water quality in several ways. First, coastal water quality could be degraded due to inundation of toxic soils and an increase in nonpoint source pollution from flooding. In particular, the presence of facilities or land containing hazardous materials in coastal areas susceptible to flooding or permanent inundation presents toxic exposure risks for human communities and ecosystems. Second, rising seas could impact wastewater facility infrastructure and other methods and structures designed to protect water quality near the coast. In addition to damaging equipment and blocking discharge from coastal outfall structures, floods could force facilities to release untreated wastewater, threatening nearby water quality (Heberger *et al.* 2009). Salt water draining into sewer lines as part of extreme weather flooding might also damage biological systems at wastewater facilities if the organisms present in these systems are not salt-tolerant. Third, sea level rise could lead to saltwater intrusion into valuable groundwater aquifers, potentially rendering some existing wells unusable and decreasing the total groundwater supply in coastal areas. The extent of saltwater intrusion will likely vary based upon local hydrological conditions, with the worst impacts occurring in unconfined aquifers along low-lying coasts that have already experienced overdraft and saline intrusion. This change could force affected communities to turn to more costly water sources such as surface water transfers or desalination. Finally, loss of wetlands could decrease water quality given that wetlands act to improve water quality by slowing and filtering water that flows through them.
- **Coastal agriculture (Coastal Act Sections 30241- 30243):** Sea level rise could lead to an increase in flooding and inundation of low-lying agricultural land, saltwater intrusion into agricultural water supplies, and a decrease in the amount of freshwater available for agricultural uses. Flooding of agricultural lands can cause major impacts on local businesses, national food supplies, and the state's economy.
- **Archaeological and paleontological resources (Coastal Act Section 30244):** Archaeological or paleontological resources could be put at risk by inundation, flooding, or by an increase in erosion due to sea level rise. Areas of traditional cultural significance to California Native American tribes, including villages, religious and ceremonial locations, middens, burial sites, and other areas, could be at risk from sea level rise. For

example, the Santa Barbara Channel area has thousands of archaeological sites dating over 13,000 years that are at risk of being destroyed or altered from small amounts of sea level rise (Reeder *et al.* 2010).

For a summary of some of the sea level rise impacts and potential consequences for the coast, see [Figure 8](#). Many of these consequences are conditions that coastal managers already deal with on a regular basis, and strategies already exist for minimizing impacts from flooding, erosion, saltwater intrusion, and changing sediment patterns. Preparing for sea level rise involves integrating future projections of sea levels into existing hazard analyses, siting, design, and construction processes, ecosystem management, and community planning practices. Processes for integrating sea level rise in Local Coastal Programs and Coastal Development Permit applications are described in the following chapters.

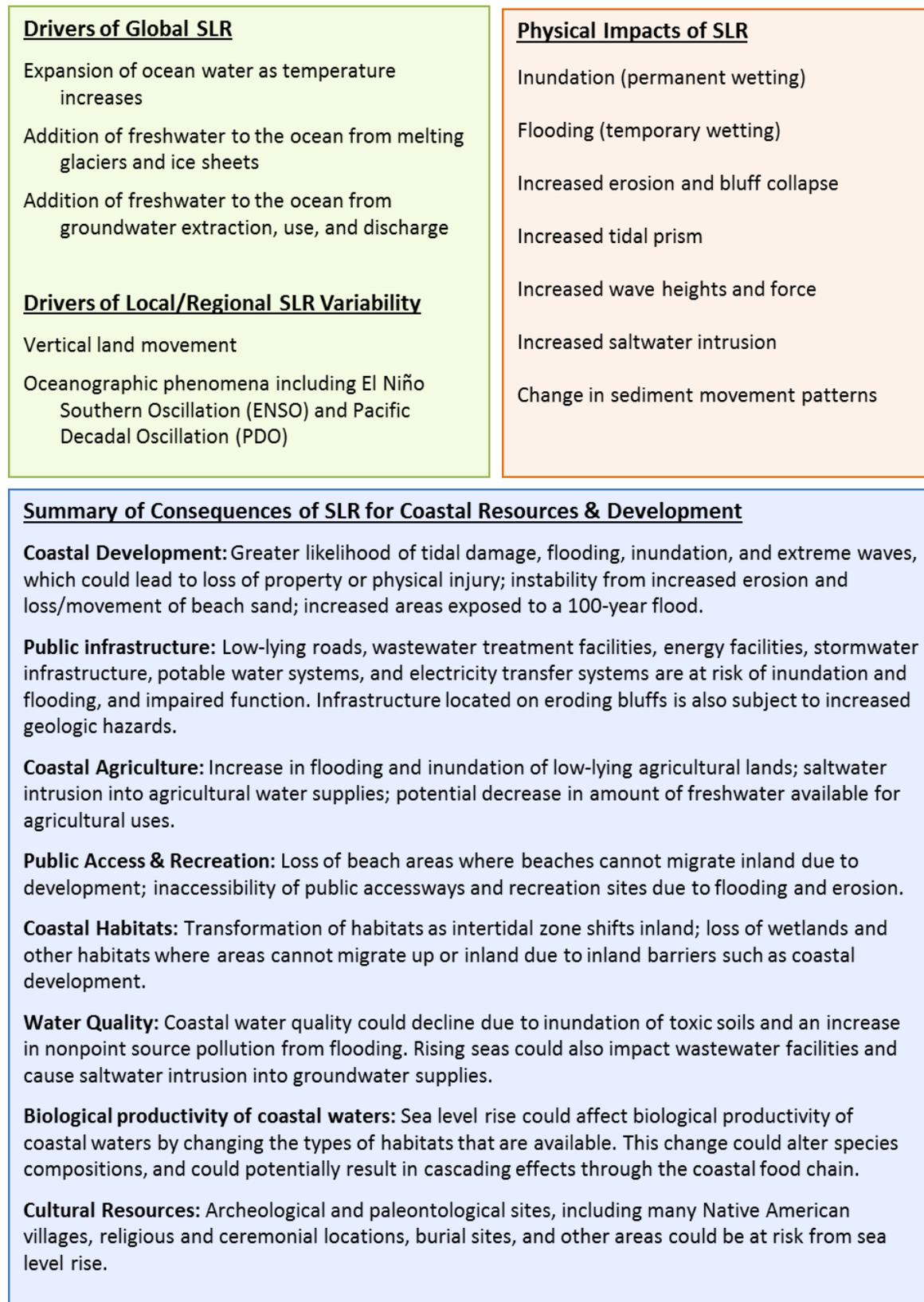


Figure 8. Summary of sea level rise impacts and consequences



Chapter 5

Addressing Sea Level Rise in Local Coastal Programs

The Coastal Act requires that the 61 cities and 15 counties in coastal California prepare Local Coastal Programs (LCPs) to govern land use and development in the coastal zone inland of the mean high tide. LCPs become effective only after the Commission certifies their conformity with the policies of Chapter 3 of the Coastal Act.

LCPs contain the ground rules for future development and protection of resources in the coastal zone. Each LCP includes a Land Use Plan (LUP) and an Implementation Plan (IP). The LUP specifies the kinds, locations, and intensity of uses, and contains a required Public Access Component to ensure that maximum recreational opportunities and public access to the coast is provided. The IP includes measures to implement the LUP, such as zoning ordinances. LCPs are prepared by local governments and submitted to the Coastal Commission for review for consistency with Coastal Act requirements.²⁴

Once an LCP's certification becomes effective, the local government becomes responsible for reviewing most Coastal Development Permit (CDP) applications. However, the Commission retains continuing permit authority over some lands (for example, over tidelands, submerged lands, and public trust lands) and authority to act on appeals for certain categories of local CDP decisions.

To be consistent with the Coastal Act hazard avoidance and resource protection policies, it is critical that local governments with coastal resources at risk from sea level rise certify or update Local Coastal Programs that provide a means to prepare for and mitigate these impacts. The overall LCP update and certification process has not changed. Now, however, the impacts of accelerated sea level rise should be addressed in the hazard and coastal resource analyses, alternatives analyses, community outreach, public involvement, and regional coordination. This Guidance is designed to complement and enhance the existing LCP certification and update steps. Although the existing LCP certification and update processes are still the same, sea level rise calls for new regional planning approaches, new strategies, and enhanced community participation.

LCPs are essential tools to fully implementing sea level rise adaptation efforts. Since many existing LCPs were certified in the 1980s and 1990s, it is important that future amendments of the LCPs consider sea level rise and adaptation planning at the project and community level, as appropriate. The [California Climate Adaptation Strategy](#) (CNRA 2009) and [Safeguarding California](#) (CNRA 2014) specifically identify LCPs as a mechanism for adaptation planning along the California coast. For general guidance on updating LCPs, see the LCP Update Guide, available here: <https://www.coastal.ca.gov/rflg/>.

²⁴ In addition there are other areas of the coast where other plans may be certified by the Commission, including Port Master Plans for ports governed by Chapter 8 of the Coastal Act, Long Range Development Plans for state universities or colleges, and Public Works Plans for public infrastructure and facilities. Following certification of these types of plans by the Commission, some permitting may be delegated pursuant to the Coastal Act provisions governing the specific type of plan.

Steps for Addressing Sea Level Rise in Local Coastal Programs and Other Plans

The Commission recommends the following six steps to address sea level rise as part of the development of an LCP, LCP Amendment, or other plan.²⁵ These steps can be modified and adapted to fit the needs of individual planning efforts and communities and to address the specific coastal resource and development issues of a community, such as addressing bluff erosion or providing for effective redevelopment, infill, and concentration of development in already developed areas. At the start of an LCP update to address sea level rise or a new LCP project, local government planners should contact their local Coastal Commission district office to discuss the LCP goals and to establish a plan for Coastal Commission staff coordination and public involvement throughout the entire process. A key element of any LCP project is public involvement. This can include establishing technical and community stakeholder advisory committees, establishing an interdepartmental sea level rise team of City and County staff representatives, and planning a series of public workshops to gather feedback, in addition to the required public hearings on the LCP.

The steps of this process are illustrated in [Figure 9](#) and described below. They are similar to the standard steps of a long-range planning process and should be familiar to local planners. Steps 1-3 are often referred to as a “sea level rise vulnerability assessment” in other sea level rise planning contexts and therefore are similar to other sea level rise-related resources.

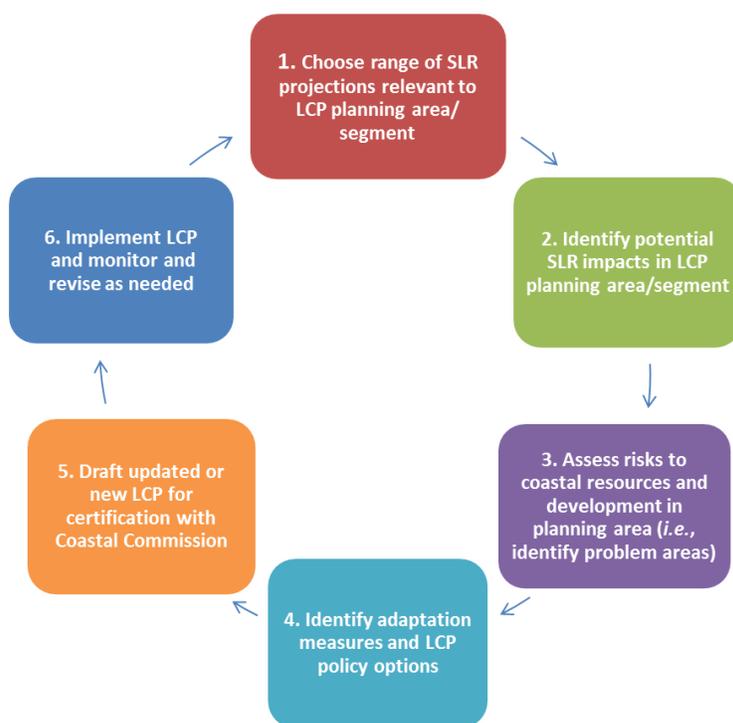


Figure 9. Sea level rise adaptation planning process for new and updated Local Coastal Programs

²⁵ This Guidance uses the term ‘LCP process’ to refer to the LCP process, but many of the concepts included here are applicable to other planning processes, including Long Range Development Plans, Public Works Plans, and Port Master Plans. For example, recommendations for how to analyze sea level rise impacts and perform a vulnerability assessment are broadly applicable. Many adaptation strategies may also be applicable, though in all cases, individual actions taken will vary based on relevant policies, local conditions, feasibility, and other factors.

The Coastal Commission also offers a [Local Coastal Program \(LCP\) Update Guide](#) (2013b) that outlines the broad process for amending or certifying an LCP, and there is naturally some overlap between the content of that document and this Sea Level Rise Policy Guidance document. The general LCP amendment steps are outlined below, in a flow chart (see [Appendix D](#)), and in the [LCP Tips/Best Practices document](#) (2013c), which is available in the [Resources for Local Governments](#) section of the Commission’s website. Local governments should contact the Coastal Commission planner for their area when pursuing a new LCP or LCP amendment.

1. **Initial Amendment scoping and development:** Conduct issues assessment, identify need for amendment, prepare preliminary draft, coordinate with Commission staff, and share early drafts
2. **Local Amendment process:** Notify public, conduct local outreach and hearings, meet with Commission staff to discuss any issues, and adopt LCP at the local level
3. **Prepare Submittal:** assemble LCP materials, discuss with Commission staff prior to submittal, transmit to Coastal Commission, and make available to public
4. **Process Amendment at Coastal Commission:** Commission staff will review submittal within 10 working days for completeness; will address outstanding information needs; will prepare and write staff report; hold public hearing and vote; and transmit action to local government
5. **Effectuate Amendment:** Local acceptance of any modifications or resubmittal within 6 months, finalize local approval, and complete Coastal Commission Executive Director check-off
6. **Implement LCP Amendment, monitor and revise as necessary.**

The step-by-step process for incorporating sea level rise into LCPs outlined in the rest of this chapter fits into these broader LCP amendment steps. Local government planners should use the LCP Update Guide in conjunction with the Sea Level Rise Policy Guidance to inform the LCP.

Use scenario-based analysis

The Guidance recommends using a method called “scenario-based analysis” (described in [Chapter 3](#) of this Guidance). Since sea level rise projections are not exact, but rather presented in ranges, scenario-based planning includes examining the consequences of multiple sea level rise amounts, plus extreme water levels from storms and El Niño events. The goal of scenario-based analysis for sea level rise is to understand where and at what point sea level rise, and the combination of sea level rise and storms, pose risks to coastal resources or threaten the health and safety of a developed area. This approach allows planners to understand the full range of possible impacts that can be reasonably expected based on the best available science, and build an understanding of the overall risk posed by potential future sea level rise. For example, if there are large changes in the hazard zones between two sea level rise amounts, additional analyses may help determine the tipping points when viable land uses will change. In general, scenario-based analyses can help determine the long-term compatibility of certain areas with certain land uses. For further description of this method, see [Chapter 3](#).

Include other topics as applicable or desired

This Guidance recommends a number of analyses that will generate useful information related to sea level rise and other environmental vulnerabilities. Performing these analyses (and the overall planning process) may provide a useful opportunity to include other studies that will complement the goals of Local Coastal Programs and provide valuable insights for community concerns. For example, planners should expand the Coastal Act consideration of lower cost visitor serving facilities to include considerations of social equity and environmental justice in the analyses by determining how climate hazards or the adaptation measures might differentially impact various demographics. Additionally, planners may want to incorporate analysis of the economic implications of various options for adaptation. Important topics such as these should be incorporated into the analyses already underway for the sake of efficiency.

Leverage analyses and share information with other planning-related processes and documents

Sea level rise is addressed in many other planning-related documents and by many other agencies and organizations. Planners should be aware of these documents and the on-going work of state and federal agencies and make an effort to share information in cases where analyses required for some of these documents may overlap with the studies appropriate for sea level rise planning in LCPs. Additionally, these agencies, organizations, and planning efforts may be good resources from which to gather information when performing these analyses for LCP updates.

For example, there is overlap between the required elements of a Local Hazard Mitigation Plan (LHMP) and Local Coastal Programs, and the Commission recommends coordinating an LHMP update with an LCP update if possible. As part of an LHMP, local governments identify the natural hazards that impact their community, identify actions to reduce the losses from those hazards, and establish a coordinated process to implement the plan.²⁶ In order to be eligible for certain types of non-emergency disaster assistance, including funding for hazard mitigation projects, local governments are required by FEMA to complete an LHMP²⁷ and to update the plan every 5 years. Any sea level rise hazard avoidance strategies included in an LCP certification or update, such as relocation of critical facilities must be included in the LHMP narrative to be eligible for funding from FEMA to implement future projects. If a local government has recently updated their LHMP, the city or county can add narrative information on sea level rise strategies through an addendum to the plan, referred to by FEMA as an annex.²⁸

In many cases, the analyses and adaptation options identified in this Guidance could be used for hazard mitigation plans or vice versa, as the goal of each of these planning processes is to

²⁶ <http://www.fema.gov/media-library-data/20130726-1524-20490-5927/67fr8844.pdf>

²⁷ Note that recent revisions to the [State Mitigation Plan Review Guide](#), set to go into effect in March 2016, will require states to analyze the probability and possible impacts due to future hazard events in a way that includes the projected changes in natural hazards resulting from climate change. Failure to include such considerations may result in a state's ineligibility for certain non-emergency mitigation grants.

²⁸ For more information on how to complete or update an LHMP, visit <http://hazardmitigation.calema.ca.gov/> or contact the Cal OES office and a hazard mitigation technical expert can assist local governments with the planning process. For contact information, visit <http://www.caloes.ca.gov/cal-oes-divisions/hazard-mitigation/contacts>.

minimize or avoid impacts from coastal hazards. As a result, there may be opportunities to leverage funding and share work efforts.

A number of other similar planning processes, projects, and documents are listed in [Figure 10](#), and planners may be able to use these studies in the LCP planning process, or, alternatively, share analyses and information performed for LCP planning with the groups working on related projects. Additionally, the forthcoming State of California Planning for Sea Level Rise Database (established by Assembly Bill 2516 and pursuant to Public Resources Code Sections 30961-30968) may become an important tool for identifying past and/or ongoing actions that stakeholders have implemented to address sea level rise. In any case, information sharing is highly recommended to promote efficiency.

Coordinate regionally as appropriate

Many impacts of sea level rise will transcend jurisdictional boundaries. Similarly, the adaptation decisions made by coastal communities could themselves have consequences that affect areas outside the local jurisdiction. For these reasons, regional coordination will often enhance the effectiveness of local adaptation decisions. Indeed, many of the projects identified in [Figure 10](#) have taken this regional approach. Planners should keep this concept in mind as they work through these steps and coordinate regionally where appropriate and possible.

Representative Adaptation Planning Stakeholders

Agencies	<p><u>Local/Regional:</u></p> <ul style="list-style-type: none"> • City/county governments • League of Cities • Association of Counties • Regional entities (e.g., air districts, water boards, metropolitan planning organizations, regional transportation planning agencies) 	<p><u>State:</u></p> <ul style="list-style-type: none"> • Natural Resources Agency • Ocean Protection Council • CA Coastal Commission • State Coastal Conservancy • State Lands Commission • SF Bay Conservation & Development Commission • Office of Planning & Research • Caltrans • Office of Emergency Services • CA Geologic Survey • Dept. of Parks and Rec. • Dept. of Fish and Wildlife • Dept. of Water Resources • State Water Resources Control Board • Air Resources Board • Dept. of Conservation 	<p><u>Federal:</u></p> <ul style="list-style-type: none"> • FEMA • EPA • US Fish and Wildlife Service • NOAA • Gulf of the Farallones NMS • Monterey Bay NMS • SF Bay NERR • Elkhorn Slough NERR • Tijuana River NERR • US Geologic Survey • US Army Corps of Engineers • BOEM, BSEE • National Park Service • Sea Grant
Partner Organizations	<ul style="list-style-type: none"> • Non-Government Organizations (e.g., environmental, social) • Professional organizations (e.g., agricultural, fisheries, communications) • Science organizations • Universities • Private consultants/industry <p><i>Examples include:</i></p> <ul style="list-style-type: none"> • The Nature Conservancy • Surfrider Foundation • Coastkeeper Alliance • Center for Ocean Solutions • Point Blue Conservation Science • Pacific Institute • Natural Capital Project • American Society of Adaptation Professionals 	Coordinated Planning Efforts	<p><u>Regional Environmental Efforts</u></p> <ul style="list-style-type: none"> • Our Coast Our Future (CoSMoS) • So. CA Coastal Impacts Project (CoSMoS) • Humboldt Bay SLR Adaptation Working Group • Monterey Bay Adaptation Group • LA Regional Adaptation Group • Coastal Resilience Ventura • San Diego Regional Climate Collaborative • Santa Barbara and Ventura Co. resilience planning <p><u>Local/Regional Plans</u></p> <ul style="list-style-type: none"> • Local Hazard Mitigation Plans • General Plans • Climate Action Plans • Capital Improvement Plans/Programs • Climate Change Adaptation Plans • Integrated Regional Water Management Plans • Regional Sediment Management Plans • Sustainable Community Plans • Regional Transportation Plans

Figure 10. Agencies, organizations, and planning efforts related to sea level rise adaptation

Step 1 – Determine range of sea level rise projections relevant to LCP planning area/segment

The first step in incorporating sea level rise into the LCP planning process is to identify locally relevant sea level rise scenarios that may occur at given time steps into the future. These scenarios will be carried through the rest of the steps in the sea level rise LCP planning process. Follow these steps to determine the locally relevant sea level rise projections to use in the subsequent steps:

- **Determine planning horizons of concern:** The Coastal Commission recommends taking a long-term view when analyzing sea level rise impacts because the land use decisions made today will affect what happens over the long-term. For example, development constructed today is likely to remain in place over the next 75-100 years, or longer. In practice, many jurisdictions have completed assessments that look at sea level rise vulnerabilities through approximately 2100. Understanding short-term vulnerabilities is also important, and the Coastal Commission recommends assessing vulnerabilities in intermediate planning horizons. For example, many jurisdictions have assessed sea level rise scenarios that correspond to years 2030 and 2050, in line with information provided in the 2012 National Research Council (NRC) [report](#). These time periods may be used, or local governments may identify other relevant planning horizons for their plans and development scenarios, as long as the projections for those time frames are based on the best available and relevant scientific projections.
- **Determine the full range of sea level rise projections from the best available science:** Using best available science, currently the 2018 OPC SLR Guidance (or other comparable study, provided that it is peer reviewed, widely accepted within the scientific community, and locally relevant), determine the range of sea level rise for the planning horizons of concern. The sea level rise projections for the San Francisco tide gauge from the 2018 OPC SLR Guidance are presented in [Table 4](#) below (projection tables for all 12 California tide gauges are presented in [Appendix G](#))²⁹. See below for a discussion of scenario-based planning in the LCP context. The LCP should include a policy to use the best available science about sea level rise.

²⁹ More detailed refinement of sea level rise projections is not considered necessary at this time, as variations from the nearby tide gauges will often be quite small, and may be insignificant compared to other sources of uncertainty. However, the Coastal Commission recognizes that other studies exist with localized data, for example those completed in the Humboldt Bay region, which may also be appropriate for use.

Table 4. Sea Level Rise Projections for the San Francisco Tide Gauge³⁰ (OPC 2018)

Projected Sea Level Rise (in feet): <i>San Francisco</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.8	1.0
2040	0.8	1.3	1.8
2050	1.1	1.9	2.7
2060	1.5	2.6	3.9
2070	1.9	3.5	5.2
2080	2.4	4.5	6.6
2090	2.9	5.6	8.3
2100	3.4	6.9	10.2
2110*	3.5	7.3	11.9
2120	4.1	8.6	14.2
2130	4.6	10.0	16.6
2140	5.2	11.4	19.1
2150	5.8	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

³⁰ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

- **Choose multiple sea level rise scenarios based on range of sea level rise projections.**
The Coastal Commission recommends that all communities evaluate the impacts from the “medium-high risk aversion” scenario. Local governments should also include the “extreme risk aversion” scenario to evaluate the vulnerability of planned or existing assets that have little to no adaptive capacity, that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts should that level of sea level rise occur. Planners may also consider evaluating the lower projections (those with a higher probability) to gain an understanding on what is likely to be vulnerable regardless of modeling uncertainty and future greenhouse gas emissions.

In addition to evaluating the worst-case scenario, planners need to understand the minimum amount of sea level rise that will cause impacts for their community, and how these impacts will change over time, with different amounts of sea level rise. Planners should evaluate enough scenarios to be able to answer the following:

- What are the impacts from the worst-case scenario of the highest possible sea level rise plus elevated water levels from high tide, El Niño and a 100-year storm?
- What is the minimum amount of sea level rise that causes inundation, flooding, or erosion concerns?
- How do inundation, flooding, and erosion concerns change with different amounts of sea level rise?
- Are there any tipping points where sea level rise impacts become more severe? (For example, is there a point at which seawalls or levees are overtopped?)

There are two main ways to choose scenarios from which to evaluate sea level rise: by sea level rise amount or by time-period. Tools that provide maps by sea level rise amount can then be linked to the relevant time period, as shown below in the *Our Coast Our Future* example. There is no single accepted sea level rise mapping methodology for the state of California. Local governments can choose whether to use existing sea level rise tools or to develop their own scenarios and maps. See below for information on scenarios and modeling outputs generated by existing sea level rise modeling tools.

Examples of Choosing Scenarios with Existing Sea Level Rise Modeling Tools

For California, there are two primary methods for identifying sea level rise scenarios, based on two of the currently available SLR mapping tools: CoSMoS (Our Coast Our Future) and Coastal Resilience Ventura (The Nature Conservancy). The type of tool available for sea level rise mapping in a planning area can be a deciding factor for which scenarios to use in the analysis. The Coastal Commission recommends using as many scenarios as necessary to fully analyze the potential impacts to coastal resources, human health, and safety rather than a specific tool or number of scenarios. Examples for choosing scenarios based on the tools available are described below.

Example 1: Identify SLR amounts, then relate to likely time period(s) of occurrence

This method involves first examining different amounts of sea level rise and storm events, and second, looking at the 2018 OPC SLR Guidance projections to determine the range of years during which those impacts could potentially occur. For example, the Our Coast Our Future CoSMoS-based tool provides sea level rise maps for 9 different amounts in 25 cm (0.8 ft) intervals, three different storm scenarios (annual, 20-year, and 100-year), and a king tide scenario. With this tool, users can first evaluate different amounts of sea level rise and storms, determine how different amounts of sea level rise and storm situations affect the planning area, and then determine when the increased water level is likely to occur based on the OPC Guidance projections. The CosMoS tool is currently available from Point Arena (in Mendocino County) through the Mexico border, and an expansion throughout the rest of the state is planned for 2018/2019. The NOAA Sea Level Rise and Coastal Flooding Impacts viewer similarly provides maps for different amounts of sea level rise (in this case, in 1-ft increments), but does not include impacts from storms, erosion or waves. A methodology for adding in these additional impacts is described in [Appendix B](#).

Example 2: Choose applicable years, then identify high, intermediate, and low scenarios

For this method, planners pick specific years, determine the range of sea level rise amounts that could occur by that year, and examine the consequences of three or more sea level rise amounts within that range. For example, the Coastal Resilience Ventura Tool (The Nature Conservancy) provides maps showing inundation, flooding, wave impact zone, and erosion risk zones with low, medium, and high sea level rise scenarios for the years 2030, 2060, and 2100. For local governments within Ventura County, planners may choose to evaluate scenarios according to the 2030, 2060, and 2100 time periods. The model provides maps for both flooding and erosion.

Expected outcomes from Step 1: Upon completing this step, a range of regionally- or locally-relevant sea level rise projections for the time periods of concern should be established. Based on the range of projections, planners will have identified a low, high, and one or more intermediate projections. These projections are the sea level rise scenarios that will be carried through the rest of the planning process.

Step 2 – Identify potential physical sea level rise impacts in LCP planning area/segment

The next step is to identify the physical hazards and impacts (referred to comprehensively as sea level rise impacts) associated with current and future sea level. As described in Section C of [Chapter 3](#) of this Guidance, broad categories of sea level rise impacts may include inundation, flooding, wave impacts, erosion, and saltwater intrusion. In this step, planners should analyze these physical impacts and their various sub-components in order to understand current and future local hazard conditions. The analysis should answer the following basic questions:

- What are the existing hazard conditions that threaten the planning area?
- What is the projected change in hazard conditions due to locally appropriate sea level rise projections and planning horizons of concern?

This analysis should include the following topics, as applicable:

- Local Water Conditions (See [Appendix B](#) for a detailed methodology)
 - Current tidal datum³¹ and future inundation
 - Water level changes from storm surge, atmospheric pressure, the Pacific Decadal Oscillation (PDO), the El Niño Southern Oscillation (ENSO), and/or other basin-wide phenomena
 - Wave impacts and wave runup, including wave runup from a 100-year storm, and based on tides, other water level changes, and future beach and bluff erosion
 - Flooding from extreme events such as storms with intervals greater than 100 years, tsunamis, *etc.*
- Shoreline change (See [Appendix B](#) for more information)
 - Current shoreline erosion rates. For future cliff and dune erosion rates, modify historic erosion rates, to account for the influence of sea level rise (*e.g.*, work by the Pacific Institute – Heberger *et al.* 2009; Revell *et al.* 2011). If possible, modify long-term beach erosion rates to account for changes in El Niño frequency, storm intensity, sediment supply or changing transport conditions. Analyzing wetland responses to sea level rise may require site-specific analyses of various physical and biological factors as described in Heberger *et al.* 2009.
 - Sedimentation rates
- Water quality
 - Current and future saltwater intrusion areas

³¹ Tidal datums are based on the latest National Tidal Datum Epoch (NTDE) published by NOAA and are the mean of the observed sea levels over a 19-year period. The latest published epoch is 1983-2001. This tidal epoch can be considered equivalent to the year 2000 baseline for the OPC projections.

- Current and potential future coastal water pollution issues due to inundation of toxic soils, rising water tables, and increases in nonpoint source pollution

Use existing models, tools, reports, historic records, and other materials ([Table 5](#)) to develop or double check the identified hazard areas. Document the current and future hazard areas in the Land Use Plan using maps, GIS products, graphics, tables, charts, figures, descriptions, or other means. This process should be repeated for each planning horizon and/or sea level rise scenario defined in Step 1.

Expected outcomes from Step 2: Upon completing this step, the potential current and future impacts to the planning area from sea level rise hazards should be identified based on sea level rise projections. These should include impacts from the high, low, and intermediate sea level rise scenarios for the planning horizon(s) of concern. Maps, GIS layers, graphics, figures, charts, tables, descriptions, or another system should be developed to communicate the impacts of current and future hazards.



Flooding Extent



Figure 11. Example of analysis of SLR impacts. Flooding hazards predicted from the CoSMoS hindcast of the January 2010 storm, with and without sea level rise (SLR) scenarios, in the region of Venice and Marina del Rey, CA. (Source: [Barnard et al. 2014](#)).

Resources for Sea Level Rise Mapping

[Table 5](#) includes a list of sea level rise mapping tools. The tools vary in their complexity: some are considered “bathtub models,” because they show future inundation with simple rise in sea level (and no changes to the shoreline caused by other forces). Others include factors like erosion, storms, and fluvial inputs. These tools provide a useful first look at possible sea level rise impacts, but may need to be supplemented with additional, site- or topic-specific analyses, depending on the region. See [Appendix B](#) for additional information on determining hazard impacts and tools for mapping sea level rise.

Table 5. Sea Level Rise Mapping Tools

Tool	Description	Link
Statewide		
NOAA Sea Level Rise and Coastal Flooding Impacts Viewer	Displays potential future sea levels with a slider bar. Communicates spatial uncertainty of mapped sea level rise, overlays social and economic data onto sea level rise maps, and models potential marsh migration due to sea level rise. Maps do not include any influence of beach or dune erosion.	NOAA Office for Coastal Management, http://coast.noaa.gov/digitalcoast/tools/slr
Cal-Adapt – Exploring California’s Climate	Represents inundation location and depth for the San Francisco Bay, the Sacramento-San Joaquin River Delta and California coast resulting from different increments of sea level rise coupled with extreme storm events. Incorporates real, time series water level data from past (near 100 year) storm events to capture the dynamic effect of storm surges in modeling inundation using a three dimensional hydrodynamic model (per Radke, 2017).	http://cal-adapt.org/tools/slr-calflood-3d/
Pacific Institute Sea Level Rise Maps	Downloadable PDF maps showing the coastal flood and erosion hazard zones from the 2009 study. Data are overlaid on aerial photographs and show major roads. Also available are an interactive online map and downloadable maps showing sea level rise, population and property at risk, miles of vulnerable roads and railroads, vulnerable power plants and wastewater treatment plants, and wetland migration potential.	http://www.pacinst.org/reports/sea_level_rise/maps/ For the 2009 report <i>The Impacts of Sea-Level Rise on the California Coast</i> visit: http://pacinst.org/publication/the-impacts-of-sea-level-rise-on-the-california-coast/

<p>Climate Central Surging Seas</p>	<p>Overlays sea level rise data with socio-economic information and ability to analyze property values, population, socio-economic status, ethnicity, and income or areas at risk. Can compare exposure across the state or a county.</p>	<p>http://sealevel.climatecentral.org/ssrf/california</p>
<p>Coastal Storm Modeling System (CoSMoS); tool hosted by Our Coast Our Future</p>	<p>Currently available for Point Arena to the Mexico border, with a statewide expansion anticipated in 2018/2019. The Coastal Storm Modeling System (CoSMoS) is a dynamic modeling approach that allows detailed predictions of coastal flooding due to both future sea level rise and storms, and integrated with long-term coastal evolution (i.e., beach changes and cliff/bluff retreat)</p>	<p>https://walrus.wr.usgs.gov/coastal_processes/cosmos/ http://data.pointblue.org/apps/ocof/cms/</p>
<p>TNC Coastal Resilience</p>	<p>An online mapping tool showing potential impacts from sea level rise and coastal hazards designed to help communities develop and implement solutions that incorporate ecosystem-based adaptation approaches. Available statewide with more detailed modelling for Monterey Bay, Santa Barbara, Ventura, and Santa Monica.</p>	<p>http://maps.coastalresilience.org/california/</p>
<p>Humboldt Bay Sea Level Rise Adaptation Project</p>	<p>This project is a multi-phased, regional collaboration. Phase I produced the <i>Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment</i> which describes current shoreline conditions and vulnerabilities under the current tidal regime. Phase II included hydrodynamic modeling to develop vulnerability maps of areas surrounding Humboldt Bay vulnerable to inundation from existing and future sea levels. Phase II produced the <i>Humboldt Bay Sea Level Rise Modeling Inundation Mapping Report</i> and the <i>Humboldt Bay Sea Level Rise Conceptual Groundwater Model</i>.</p>	<p>All reports are available at: http://humboldtbay.org/humboldt-bay-sea-level-rise-adaptation-planning-project</p>

Step 3 – Assess potential risks from sea level rise to coastal resources and development in LCP planning area/segment

After sea level rise impacts are identified and mapped in Step 2, the next Step is to determine whether sea level rise poses any risks, or potential problems, for coastal resources and development in the LCP planning area (refer to [Chapter 4](#) for a description of the potential consequences of sea level rise for coastal resources). Next, assess whether the LCP planning area's current and planned land uses are appropriate or consistent with Coastal Act or LCP policies given those impacts, or if those land uses should be revised. This step requires an understanding of several characteristics of the coastal resources and development typically found within various land use types. (Much of this information can be produced in a vulnerability assessment, an analysis that is commonly conducted in the planning and climate change adaptation field. See [Appendix C](#) for a list of recent sea level rise vulnerability assessments.) Account for potential impacts to vulnerable, low-income communities and consider coastal development and resources, including but not limited to:

- Existing and planned development
- Coastal-dependent development and uses such as harbors, wharfs, ports, marinas, and commercial and recreational fishing areas and facilities
- Critical infrastructure³² such as wastewater treatment plants, transportation infrastructure, and some power plants and energy transmission infrastructure
- Public accessways, beaches and other recreation areas, and the California Coastal Trail
- State Highway 1, 101, and other state and local roads that provide access to the coast
- Wetlands, environmentally sensitive habitat area (ESHA), and other coastal habitats and sensitive species
- Agricultural areas
- Cultural sites and archaeological or paleontological resources
- Visitor-serving development and uses

Conduct the following tasks for each planning horizon (*e.g.*, the years 2030, 2050, and 2100, or other planning horizons):

1. For the planning horizon of interest, determine what development and coastal resources may be subjected to the sea level rise impacts expected for that time period. Map the coastal resources and development that lie within the sea level rise impact areas for the given time period. (Remember to address the wide range of resources listed above, including both natural resources and development.)

³² Critical infrastructure can vary widely from community to community, and may also include fire stations, police stations, and hospitals. For planning purposes, a jurisdiction should determine criticality based on the relative importance of its various assets for the delivery of vital services, the protection of special populations, and other important functions, as well as the social, environmental, and economic risks associated with loss of or damage to such assets.

2. Determine if sea level rise impacts are a problem or benefit for each resource, and if so, when and to what degree the resource will be impacted. In some instances, sea level rise may result in the creation of new habitat areas that could help to alleviate impacts from the loss of similar habitat in other locations. However, it is more likely, especially in heavily urbanized areas, that sea level rise will result in a net loss of habitat unless steps are taken to preserve these systems.

To accomplish this, consider a wide range of characteristics of each resource, including the following. The questions listed under each characteristic might help guide the consideration of each of these characteristics. These questions are meant to be suggestions rather than a standardized approach, and planners may use scientific literature, best professional judgment, or a variety of other resources to gain a conceptual understanding of the important resources and vulnerabilities in their jurisdictions.

- a. **Exposure.** Will sea level rise impacts affect the resource/development at all?
 - i. Are coastal resources and community assets exposed to sea level rise impacts?
 - ii. Is the resource already exposed to hazards such as waves, flooding, erosion, or saltwater intrusion? If it is, will sea level rise increase hazard exposure?
- b. **Sensitivity.** If resources are exposed, to what degree will coastal resources/development be affected by sea level rise impacts? A simple way to think about this concept is to consider *how easily affected* the resource or development is in regard to sea level rise impacts.
 - i. How quickly will the resource respond to the impact from sea level rise?
 - ii. Will the resource/development be harmed if environmental conditions change just a small amount? What are the physical characteristics of resource/asset (*e.g.*, geology, soil characteristics, hydrology, coastal geomorphology, topography, bathymetry, land cover, land use)? Do any of those characteristics make the resource especially sensitive?
 - iii. Are there thresholds or tipping points beyond which sensitivity to sea level rise increases?
- c. **Adaptive Capacity.** How easily can the resource successfully adapt to sea level rise impacts?
 - i. How well can the resource/development accommodate changes in sea level?
 - ii. Is rate of change faster than the ability of the resource/development to adapt?
 - iii. How easily can development be modified to cope with flooding, inundation, and/or erosion? Can structures be elevated or relocated?

- iv. Are there adaptation efforts already underway? Are there any factors that limit the success of adaptation efforts?
 - v. Do beaches, wetlands and other coastal habitats have room to migrate inland? What is the overall health of existing wetlands and coastal habitats?
 - vi. Are there any other climate change-related impacts to consider? Are there any non-climate stressors that could impair ability to adapt to sea level rise?
 - vii. Is there potential for habitat creation as a result of sea level rise?
 - viii. What are the options to protect, redesign (*e.g.*, elevate), or relocate inland any existing public accessways, recreational beaches, and segments of the Coastal Trail to cope with rising sea levels? Is lateral access compromised with sea level rise?
- d. **Consequences.** When sea level rise and/or sea level rise adaptation measures have impact(s) upon a resource, what are the economic, ecological, social, cultural, and legal consequences?
- i. How severely could each resource be affected? At what scale?
 - ii. Are there cumulative consequences?
 - iii. Are there ripple effects, or secondary consequences to consider?
 - iv. Will human responses cause further adverse impacts?
- e. **Land Use Constraints.** Given the location of sea level rise impacts and the resources currently located in those areas, should the types and intensities of land use be altered to minimize hazards and protect coastal resources?
- i. What is the current pattern of development? Is the area largely developed or does it have significant areas of undeveloped land?
 - ii. Is the area served by infrastructure that is vulnerable to sea level rise impacts?
 - iii. Are large areas of land under common ownership or is land mostly subdivided into smaller lots in separate ownership?
 - iv. What conditions does the land use type, development, or resource require to either exist or fulfill its intended purpose?
 - v. Is it a coastal-dependent use? What is its ideal proximity to the coast?
 - vi. For new development, what is the expected lifespan? Is it economically feasible to locate it in a sea level rise impact area for a certain period of time before it is removed or relocated?
 - vii. For existing development, what are the options available to minimize hazards to the development and protect coastal resources? Note that in

certain situations, the Coastal Act allows existing structures to be protected (Coastal Act Section 30235). What are the coastal resource impacts of such protection, and are there feasible alternatives that avoid shoreline armoring, such as options to provide incentives to property owners to relocate or remove at-risk structures?

- viii. For a natural resource or habitat, what conditions does it require to persist?
- ix. Where would resources/development ideally be located after sea level rise causes environmental conditions to shift?
- x. What changes to existing LCP requirements or other land use restrictions are necessary to maximize opportunities for avoiding hazards or relocating threatened existing development?

After going through the questions listed above, and others that may be relevant to the planning exercise, synthesize the information and determine where sea level rise impacts currently pose problems for coastal resources, what problems may develop over time as sea level rises, and how urgent the problems are. Create maps illustrating the location and extent of vulnerable land uses, such as critical facilities, wastewater infrastructure, and State Highway 1 and other coastal access roadways. This information can also be summarized in narrative form. The analysis should identify resources and development likely to be impacted by sea level rise at various periods in the future, and thus the issues that need to be resolved in the LCP planning process.

Remember that these assessments are not static; existing risks will change and new risks will arise with changes in a community, the emergence of new threats, new information, and the implementation of adaptation actions. For this reason, the analysis should be updated as needed to reflect changes in sea level rise projections, changes in land use patterns, or new threats.

***Expected outcomes from Step 3:** Descriptions of the characteristics that influence risk, including exposure, sensitivity, and adaptive capacity of each coastal resource to sea level rise impacts under each sea level rise scenario identified in Step 1 at the selected planning horizons, along with the expected consequences of those impacts for the resource and broader community. Maps of resources and/or land uses at risk could be produced.*

Example for Step 3

To illustrate the process described in Step 3, consider a hypothetical planning area that includes multiple coastal resources and land use types, including a coastal wetland, bluff-top residential development with a fronting beach, and a wastewater treatment facility, that need to be addressed in the planning process. After Steps 1 and 2, portions of the planning area are found to be subject to current and future sea level rise impacts.

Step 3.1: Map the coastal resources (in this case the wetland, development, and wastewater treatment facility) for the range of time periods and sea level rise projections.

Step 3.2

a. **Exposure**

- *Wetland:* The wetland is highly exposed to flooding and inundation from sea level rise. By the year 2030, portions of the wetland will trap sediment at a rate such that the elevation keeps pace with sea level rise. By 2050, a portion of the wetland will become inundated and converted to open water, and by 2100 the entire area will be converted to open water. The wetland will be completely lost by this time period if it is not able to move inland.
- *Bluff-top Residential Development:* Houses in the residential development are not exposed to sea level rise impacts in 2030. However, a high rate of retreat along the fronting beach and bluff will put front-line houses in danger of being undermined by the year 2050, and the entire development may be lost by 2100.
- *Wastewater Treatment Facility:* Given that the wastewater treatment plant is set back somewhat from the water, it will not be exposed to impacts from sea level rise until 2050. By 2050, however, portions of the infrastructure will be exposed to impacts from elevated water levels due to 100-year storm events and El Niño occurrences. By 2100, significant portions of the facility will be exposed to flooding as the surrounding area is eroded and inundated.

b. **Sensitivity**

- *Wetland:* The wetland has high sensitivity to changes in sea level because its functioning is highly-dependent on local physical parameters such as water flow, tidal fluctuation, sediment supply, and water quality. Although it currently has good sediment supply, good water quality, and a number of other characteristics, small changes in sea level rise by 2050 may alter the function of the wetland. In addition, there are concerns that beyond 2050 the wetland will not be able to keep up with accelerated sea level rise, thus increasing sensitivity to further changes in sea level.
- *Bluff-top Residential Development:* The residential development has moderate to high sensitivity to longer-term sea level rise changes. By 2050, the front-line houses will no longer be safe enough for occupancy. Moreover, infrastructure such as roads, sewage systems, and power networks may be damaged as the bluff-face erodes.
- *Wastewater Treatment Facility:* The facility is moderately sensitive to sea level rise. Flooding and erosion from sea level rise could cause damage of the facility, pumps and

other equipment, but the facility was initially built to withstand a high degree of storm and related impacts.

c. **Adaptive Capacity**

- *Wetland:* Unlike many wetlands in the State of California, this particular wetland has a moderate-high adaptive capacity because it has the ability to both accumulate sediment and grow upwards, and, given that the land upland of the wetland is preserved as open space, it can migrate inland. However, by 2050, a part or all of the existing wetland area could be converted to open water if the wetland is not able to migrate inland or accumulate sediment at a rate that keeps pace with sea level rise. In this case, for example, a public trail will need to be relocated to allow inland migration of the new intertidal zone. Additionally, adaptive capacity may be reduced if pollution increases (*e.g.*, as a result of damage to adjacent development) and disrupts the normal functioning of the wetland.
- *Bluff-top Residential Development:* The residential development has a moderate adaptive capacity. As houses become threatened over time, a scenario of managed retreat would allow houses to be removed incrementally and eventually be relocated to safer areas. The feasibility of managed retreat can depend upon lot sizes, ownership patterns, land use restrictions in the safer areas, and the availability of public or private financing. In addition, a protective structure such as a seawall would minimize threats to the residence due to erosion, though if the development is protected by shoreline structures, the fronting beach will eventually be lost.
- *Wastewater Treatment Facility:* The wastewater treatment facility has a very low adaptive capacity. It is large and has expensive infrastructure so it cannot be elevated, and relocation is costly and difficult. In order to be protected in its current location, new structures will need to be built.

d. **Consequences**

- *Wetland:* In many situations, the loss of wetland area is a high risk since wetlands provide flood protection, water quality enhancement, and essential habitat for fish and bird species. However, in this case, wetland migration is not restricted by inland development, so the risks for this wetland are slight to moderate, depending upon the suitability of the inland area for establishment of wetland plants and potential changes in water temperature and water quality. In the short term, the wetland will likely continue to function at normal levels. However, if it eventually can't keep up with sea level rise or if there are barriers to migration, loss of the habitat will result in a loss of important ecosystem services.
- *Bluff-top Residential Development:* The housing development has medium to high risk through 2100. The option to either relocate houses or protect them with a seawall means that they could continue to exist. Importantly, a system of managed retreat will allow for the continued existence of the fronting beach and all of its social, economic, and environmental benefits, whereas the construction of a seawall will result in the loss of the beach and these benefits.

- *Wastewater Treatment Facility:* Given its low adaptive capacity and high sensitivity to higher levels of sea level rise, the wastewater treatment facility is at high risk. Loss or damage to the facility could result in serious social, economic, and environmental consequences. Flooding of the facility and surrounding areas will cause damage to infrastructure and loss of facility function. This could lead to discharge of untreated sewage, which would have adverse impacts to water quality and could impair the health of nearshore ecosystems. Sea level rise could also cause outflow pipes to back up with seawater, leading to inland flooding and additional water quality problems. However, efforts to protect the structure may have unintended consequences including loss of surrounding habitat areas.

e. **Land Use Constraints (discussed further in Step 4)**

- *Wetland:* The high adaptive capacity of the wetland means that minimizing risk to this resource may be accomplished by ensuring that there is space available for it to move into. Land use policies designed to protect areas inland of the current wetland area will be necessary.
- *Bluff-top Residential Development:* The area in question will eventually become incompatible with the current use. Development will not begin to be exposed to sea level rise impacts until 2050, but it is important to start planning now about how best to address the risks to the houses. Managed retreat would necessitate identifying feasible locations into which houses could be moved or a plan to abandon and remove houses. Such a plan might include a Transfer of Development Rights program in which homes are encouraged in less hazardous areas. If a managed retreat strategy is not in place, existing structures may qualify for shoreline protection. Shoreline protection would likely exacerbate beach erosion, degrade public access, impair shoreline habitat, and alter visual character.
- *Wastewater Treatment Facility:* The biggest risk in this scenario is to the wastewater treatment facility. It should be determined how likely it is that the facility will be able to be protected throughout the rest of its expected lifespan under even the highest sea level rise scenarios. It may be that the wastewater treatment facility becomes an incompatible use under future conditions. If so, plans should be made to relocate at-risk portions of the facility, as feasible, or to phase out the facility.

Note that this is a simplified example used to demonstrate the process described in Step 3. Decisions about how to address various challenges presented by sea level rise will be more complex than those illustrated above and may require prioritizing the different resources based on Coastal Act requirements taking into account the goals and circumstances of the community and the various characteristics of each resource. An understanding of the exposure, sensitivity, adaptive capacity, consequences, and land use constraints for the particular resources and scenarios will need to be kept in mind as planners move into Step 4 to identify possible adaptation strategies. Updated LCP policies and ordinances should be considered to support strategy implementation over the long term.

Step 4 – Identify LCP adaptation strategies to minimize risks

Whether as part of a new LCP or as part of an amendment to update an existing LCP, coastal planners should work with the Coastal Commission and relevant stakeholders at all steps, but particularly to evaluate potential options and adaptation strategies to address the sea level rise impacts identified in Step 2 and the risks to coastal resources identified in Step 3. Planners will then develop new or revised land use designations, policies, standards, or ordinances to implement the adaptation strategies in the LCP.

An LCP as certified by the Commission should already have land use policies, standards, and ordinances to implement Coastal Act Chapter 3 policies, including policies to avoid and mitigate hazards, and to protect coastal resources. However, in older LCPs, many of these policies may not address changing conditions adequately enough to protect coastal resources over time as sea level rises. Similarly, policies to protect resources and address coastal hazards may not reflect new techniques that can be utilized to adaptively manage coastal resources in a dynamic environment. As such, the LCP should be evaluated to identify the land use designations, policies, or ordinances that need to be amended. An LCP update may need to include a variety of adaptation measures depending on the nature and location of the vulnerability. In addition, local governments may need to add new “programmatic” changes to address sea level rise, such as transfer of development credit programs, regional sediment management programs, or a land acquisition program.

In Steps 1-3, planners will have analyzed several possible sea level rise scenarios, and this analysis will have revealed valuable information about areas and specific coastal resources that are especially vulnerable to sea level rise hazards under possible scenarios. The results should show areas that are particularly resilient to future change and trigger points at which sea level hazards will become particularly relevant to certain areas. Step 3d (identifying the *Consequences* of sea level rise impacts) and Step 3e (considering the *Land use constraints*) will be particularly useful in thinking through what resources are particularly vulnerable and what the local priorities may be.

In Step 4, planners should weigh information from the previous steps, keeping in mind the hazard avoidance and resource protection policies of the Coastal Act, and begin identifying, choosing, and/or developing adaptation strategies to be included in a new or updated LCP. The options available to minimize risks from sea level rise are dependent upon the specifics of the local community, and will vary widely depending on whether the area is an urban, fully-developed waterfront, or a rural, undeveloped coastline. In undeveloped areas, the options may be clear: strictly limit new development in sea level rise hazard zones.

However, in urban areas, sea level rise can present unprecedented challenges, and the options are less clear. The Coastal Act allows for protection of certain existing structures. However, armoring can pose significant impacts to coastal resources. To minimize impacts, innovative, cutting-edge solutions will be needed, such as the use of living shorelines to protect existing infrastructure, restrictions on redevelopment of properties in hazardous areas, managed retreat, partnerships with land trust organizations to convert at risk areas to open space, or transfer of development rights programs. Strategies will need to be tailored to the specific needs of each

community based on the resources at risk, should be evaluated for resulting impacts to coastal resources, and should be developed through a public process, in close consultation with the Coastal Commission and in line with the Coastal Act.

Adaptation strategies should be selected based upon the local conditions, the results of the scenario-based analysis, and Coastal Act requirements, taking into account the particular goals of the local community. If certain adaptation strategies should be implemented when conditions reach pre-identified trigger points, those caveats should be included in the LCP. Similarly, LCP adaptation policies should be developed and implemented in such a way as to be flexible and adaptive enough that they can be changed or updated as conditions change or if sea level rise impacts are significantly different than anticipated. Additionally, many adaptation strategies should be implemented in a coordinated way through both the LCP and individual CDPs. For example, current land uses that will conflict with future conditions may be amended through updated zoning designations in an LCP. In turn, zoning designations could carry out specific policies or requirements regarding new development or redevelopment that need to be addressed in a CDP to ensure that projects are resilient over time. Planners are encouraged to work with Coastal Commission staff to ensure compliance with the Coastal Act and to coordinate and share information with other local partners including those in charge of emergency management, law enforcement, and related services, and those identified in [Figure 10](#) as applicable and feasible.

A key issue that should be addressed in the LCP is the evaluation of strategies to minimize hazards related to existing development. Under the Coastal Act, certain improvements and repairs to existing development are exempt from CDP requirements. Non-exempt improvements and any repairs that involve the replacement of 50% or more of a structure, however, generally require a CDP and must conform to the standards of the relevant Local Coastal Program or Coastal Act.³³ Redevelopment, therefore, should minimize hazards from sea level rise. For existing structures currently sited in at-risk locations, the process of redeveloping the structure may require the structure to be moved or modified to ensure that the structure and coastal resources are not at risk due to impacts from sea level rise. As described in Guiding Principle 6, sequential renovation or replacement of small portions of existing development should be considered in total. LCPs should include policies that specify that multiple smaller renovations that amount to alteration of 50% or more of the original structure should require a Coastal Development Permit, and require that the entire structure to be brought into conformance with the standards of the Local Coastal Program or Coastal Act.³⁴

³³ Section § 13252(b) of the Commission’s regulations states that “unless destroyed by natural disaster, the replacement of 50 percent or more of a single family residence, seawall, revetment, bluff retaining wall, breakwater, groin or any other structure is not repair and maintenance under Coastal Act Section 30610(d) but instead constitutes a replacement structure requiring a Coastal Development Permit.”

³⁴ In addition, for existing structures located between the first public road and the sea or within 300 feet of the inland extent of a beach, improvements that increase the height or internal floor area by more than 10% normally require a CDP. (Cal. Code Regs., tit. 14, §§13250(b)(4), 13253(b)(4).) Depending upon the location of the structure, smaller improvements may also require a CDP. (Cal. Code Regs., tit. 14, §§ 13250(b), 13253(b).)

General Adaptation Strategies:

[Chapter 7](#) describes a number of adaptation policies and strategies and is organized by resource type to allow users to easily identify the types of policies that may be relevant to local resource vulnerabilities. However, there are a number of adaptation strategies or related actions that apply to a variety of resources or that may be generally useful when adopting or updating an LCP. Some of these adaptation strategies and actions are broadly described below.

- **Update resource inventory and maps:** An important first step for addressing sea level rise hazards and vulnerabilities in a new or updated LCP will be to compile a set of maps that clearly show the current locations of the range of coastal resources present in an LCP jurisdiction (*e.g.*, beaches and public accessways; agricultural land, wetlands, ESHA, and other coastal habitats; energy, wastewater, transportation, and other critical infrastructure; and archaeological and paleontological resources), as well as existing land use designations, and hazard areas. It may also be helpful to map possible future conditions based on the analysis done in Steps 1-3. Doing so will help planners begin to identify possible land use and zoning changes and other adaptation strategies that will be necessary to meet hazard avoidance and resource protection goals.
- **Update land use designations and zoning ordinances:** One of the most common methods of regulating land use is through zoning designations and ordinances, and updating these policies is one of the most fundamental ways of responding to sea level rise impacts. Planners may address particular vulnerabilities and local priorities by updating land use designations and zoning ordinances to protect specific areas and/or resources. For example, areas that are particularly vulnerable to sea level rise impacts can be designated as hazard zones and specific regulations can be used to limit new development and/or to encourage removal of existing development in such zones. Similarly, open areas can be designated as conservation zones in order to protect and provide upland areas for wetland and habitat migration or for additional agricultural land.
- **Update siting and design standards:** Updated siting and design standards may go hand in hand with updated land use designations and zoning ordinances in that specific standards may be required for development or projects in certain zones. For example, development in hazard zones may require additional setbacks, limits for first floor habitable space, innovative stormwater management systems, special flood protection measures, mitigation measures for unavoidable impacts, relocation and removal triggers and methodologies, and so on.
- **Establish methods to monitor local changes from sea level rise:** Add policies that establish actions to conduct long-term sea level rise monitoring and research on areas of key uncertainties, areas sensitive to small changes in sea level rise, or areas with high sea level rise risk.
- **Research and data collection:** Support research to address key data gaps and better utilize existing information. Local governments may find it useful to collaborate with local, regional, and state partners to pursue new research to better understand the factors controlling sea level rise, baseline shoreline conditions, ecosystem responses to sea level rise, potential impacts and vulnerabilities, and the efficacy of adaptation tools. Related efforts may include monitoring programs designed to track trends in local shoreline

change, flooding extent and frequency, or water quality. Monitoring of the results of various adaptation strategies and protective structures could be included as part of a Coastal Development Permit for projects in hazard zones.

- **Outreach and education:** Education and outreach efforts involve formal instruction and provision of information to stakeholders, and can help generate support for planning and action implementation. It is important to coordinate with partners and include all relevant stakeholders in these processes, particularly those that are typically isolated, such as low-income or underserved communities. For many people, sea level rise is a new issue. Information on sea level rise science and potential consequences may motivate stakeholders to take an active role in updating the LCP for sea level rise issues, or in the vulnerability and risk assessment efforts. Additionally, education efforts regarding the risks of sea level rise as well as possible adaptation strategies may encourage people to take proactive steps to retrofit their homes to be more resilient or to choose to build in less hazardous areas.

As stated above, a more extensive and detailed list of possible adaptation strategies can be found in [Chapter 7](#). The list should neither be considered a checklist from which all options need to be added to an LCP, nor is it an exhaustive list of all possible adaptation strategies. Sea level rise adaptation is still an evolving field and decision makers will need to be innovative and flexible to respond to changing conditions, new science, and new adaptation opportunities. The important point is to analyze current and future risks from sea level rise, determine local priorities and goals for protection of coastal resources and development, and identify what land use designations, zoning ordinances, and other adaptation strategies can be used to meet those goals within the context of the Coastal Act.

Expected outcomes from Step 4: Identified sections of the LCP that need to be updated, a list of adaptation measures applicable to the LCP, and new policies and ordinances to implement the adaptation measures.

Step 5 – Draft updated or new LCP for certification with the Coastal Commission

Once potential adaptation strategies have been identified, LCP policies that address sea level rise should be incorporated into a new LCP or LCP amendment. For jurisdictions with a certified LCP, adaptation measures will be implemented through development of amendments to the certified LCPs. For jurisdictions that currently do not have a certified LCP, the sea level rise policies will be part of the development of a new LCP. In areas without a certified LCP, the Coastal Commission generally retains permitting authority, and the standard of review for development is generally Chapter 3 of the California Coastal Act.

As noted in Step 4, sea level rise has the potential to affect many types of coastal resources in an LCP planning area/segment, and it is likely that policies throughout the LCP will need to be revised or developed to address impacts from sea level rise. Two major types of updates to the LCP will likely be needed to address sea level rise:

1. New or revised policies/ordinances that apply to all development in the planning area. For example, policies such as “All new development shall be sited and designed to minimize risks from sea level rise over the life of the structure.”
2. Updated land use and zoning designations, as well as programs to facilitate adaptive community responses, to reduce risks to specific coastal resources. For example, the LCP could modify the zoning of undeveloped land located upland of wetlands from residential to open space in order to provide the opportunity for wetlands to migrate inland, and protect wetlands for the future.

Local government staff should work closely with Coastal Commission staff and relevant stakeholders, including ensuring there is opportunity for public input, to develop the new LCP or LCP amendments. Once the updates and plans are complete, local governments will submit to the Commission for certification. The Commission may either certify or deny the LCP or LCP amendment as submitted, or it may suggest modifications. If the Commission adopts suggested modifications, the local government may adopt the modifications for certification or refuse the modifications and resubmit a revised LCP for additional Commission review. For more information on updating LCPs, see <https://www.coastal.ca.gov/rflg/>.

Expected outcomes from Step 5: Certified/updated LCP with policies and land use designations that address sea level rise and related hazards and ensure protection of coastal resources to the maximum extent feasible.

Step 6 – Implement LCP and monitor and revise as needed

Upon certification of the updated LCP, sea level rise adaptation strategies will be implemented through the certified implementing ordinances and related processes and actions (e.g., local review of CDPs, proactive action plans). Additionally, an important component of successful adaptation is to secure funds for implementation, regularly monitor progress and results, and update any policies and approaches as needed. Sea level rise projections should be re-evaluated and updated as necessary.

- **Secure resources for implementation:** There are a number of different sources of funds available to help local governments implement adaptation strategies. For example, the Coastal Commission, the Ocean Protection Council, and the Coastal Conservancy have grant programs designed to support local adaptation efforts (see [Chapter 1](#) for additional details on each of these programs).

As described previously there may also be overlap between LCP planning and Local Hazard Mitigation planning. FEMA’s Hazard Mitigation Assistance (HMA) grant programs provide significant opportunities to reduce or eliminate potential losses to State, Indian Tribal government, and local assets through hazard mitigation planning and project grant funding. Currently, there are three programs: the [Hazard Mitigation Grant Program \(HMGP\)](#); [Pre-Disaster Mitigation \(PDM\)](#); and [Flood Mitigation Assistance](#)

(FMA)³⁵. Cal OES administers the HMA and FMA programs. More information can be found at <http://www.caloes.ca.gov/cal-oes-divisions/recovery/disaster-mitigation-technical-support/404-hazard-mitigation-grant-program> or the FEMA HMA Web site at <https://www.fema.gov/hazard-mitigation-assistance>.

A list compiled by Cal OES of additional funding options for hazard mitigation can be found in [Appendix E](#). The Commission recognizes that funding opportunities are constantly evolving, that demand for funding is increasing, and that there is a significant need for the development of additional funding opportunities.

- **Identify key resources to monitor:** Certain species can be indicators of whether sea level rise is affecting an ecosystem. For instance, the presence of certain plant species can indicate the salinity of soils. Also, monitoring plans should reflect the outcome of the scenario-based analysis of sea level rise. Some adaptation measures might be earmarked for implementation when a certain amount of sea level rise (or a particular sea level rise impact) occurs. Monitoring programs should ensure that these triggers are recognized and responded to at the appropriate time.
- **Periodically Update LCPs:** Local governments should try to review their vulnerability and risk assessments on a regular basis as significant new scientific information becomes available and propose amendments as appropriate. Given the evolving nature of sea level rise science, policies may need to be updated as major scientific advancements are made, changing what is considered the best available science. Modify the current and future hazard areas on a five to ten year basis or as necessary to allow for the incorporation of new sea level rise science, monitoring results, and information on coastal conditions. Regular evaluation of LCPs is important to make sure policies and adaptation strategies are effective in reducing impacts from sea level rise.

Expected outcomes from Step 6: Plan to monitor the LCP planning area for sea level rise and other impacts and for effectiveness of various adaptation strategies that are implemented; plan to revise the LCP when conditions change or science is updated.

This six-step process discussed in this chapter is illustrated in the flowchart below ([Figure 12](#)). Notice that the process is circular. Because sea level rise science will be refined and updated in the future, planners should periodically repeat this six-step process to update and improve their LCPs.

For additional resources and examples of ways to incorporate sea level rise into the LCP, see [Appendix C](#).

³⁵ Each HMA program was authorized by separate legislative action, and as such, each program differs slightly in scope and intent.

Planning Process for Local Coastal Programs and Other Plans



Figure 12. Flowchart for addressing sea level rise in Local Coastal Programs and other plans

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Chapter 6

Addressing Sea Level Rise in Coastal Development Permits

Development in the coastal zone generally requires a Coastal Development Permit (CDP).³⁶ In areas of retained jurisdiction and areas without a certified Local Coastal Program (LCP), the Commission is generally responsible for reviewing the consistency of CDP applications with the policies of Chapter 3 of the Coastal Act (Public Resources Code Sections 30200-30265.5).³⁷ In areas with a certified LCP, the local government is responsible for reviewing the compliance of CDP applications with the requirements of the certified LCP and, where applicable, the public access and recreation policies of the Coastal Act. Certain local government actions on CDP applications are appealable to the Commission. On appeal, the Commission also applies the policies of the certified LCP and applicable public access and recreation policies of the Coastal Act.³⁸ The Commission and local governments may require changes to the project or other mitigation measures in order to assure compliance with Coastal Act policies or LCP requirements by both minimizing risks to the development from coastal hazards and avoiding impacts to coastal resources.

The Coastal Act, the LCP, and the CDP Application cover the broad range of information and analyses that must be addressed in a CDP application. This CDP guidance focuses only on sea level rise and those conditions or circumstances that might change as a result of changing sea level. It does not address other Coastal Act or LCP requirements.

Adopting or updating LCPs as recommended in this Guidance should facilitate subsequent review of CDPs. LCPs can identify areas where close review of sea level rise concerns is necessary and where it is not. If kept up to date, they can also provide information for evaluation at the permit stage and specify appropriate mitigation measures for CDPs to incorporate.

Sea level rise will be important for some, but not all, of the projects reviewed through the CDP process. Locations currently subject to inundation, flooding, wave impacts, erosion, or saltwater intrusion will be exposed to increased risks from these coastal hazards with rising sea level and will require review for sea level rise effects. Locations close to or hydraulically connected to these at-risk locations, will themselves be at risk as sea level rises and increases the inland extent

³⁶ Coastal Act Section 30106 defines "Development" to be, "on land, in or under water, the placement or erection of any solid material or structure; discharge or disposal of any dredged material or of any gaseous, liquid, solid, or thermal waste; grading, removing, dredging, mining, or extraction of any materials; change in the density or intensity of use of land, including, but not limited to, subdivision pursuant to the Subdivision Map Act (commencing with Section 66410 of the Government Code), and any other division of land, including lot splits, except where the land division is brought about in connection with the purchase of such land by a public agency for public recreational use; change in the intensity of use of water, or of access thereto; construction, reconstruction, demolition, or alteration of the size of any structure, including any facility of any private, public, or municipal utility; and the removal or harvesting of major vegetation other than for agricultural purposes, kelp harvesting, and timber operations which are in accordance with a timber harvesting plan submitted pursuant to the provisions of the Z'berg-Nejedly Forest Practice Act of 1973 (commencing with Section 4511)."

³⁷ The Commission retains CDP jurisdiction below mean high tide and on public trust lands.

³⁸ Local governments may assume permitting authority even without a fully certified LCP (*see* Public Resources Code, §§ 30600(b), 30600.5), but only the City of Los Angeles has done so. Any action on a CDP application by a local government without a fully certified LCP may be appealed to the Commission. (Public Resources Code, § 30602.)

of these hazards. The following box provides some of the general situations for which sea level rise will need to be included in the project analysis.

General Situations when sea level rise should be considered in the project analysis include when the project or planning site is:

- Currently in or adjacent to an identified floodplain
- Currently or has been exposed to flooding or erosion from waves or tides
- Currently in a location protected by constructed dikes, levees, bulkheads, or other flood-control or protective structures
- On or close to a beach, estuary, lagoon, or wetland
- On a coastal bluff with historic evidence of erosion
- Reliant upon shallow wells for water supply

Many of the projects reviewed through the CDP application process already examine sea level rise as part of the hazards analysis. Such examination will need to continue, and these guidelines offer direction and support for a thorough examination of sea level rise and its associated impacts based on current climate science, coastal responses to changing sea level, and consequences of future changes.

To comply with Coastal Act Section 30253 or the equivalent LCP section, projects will need to be planned, located, designed, and engineered for the changing water levels and associated impacts that might occur over the life of the development. In addition, project planning should anticipate the migration and natural adaptation of coastal resources (beaches, access, wetlands, *etc.*) due to future sea level rise conditions in order to avoid future impacts to those resources from the new development. As LCPs are updated to reflect changing conditions and to implement sea level rise adaptation strategies, it will be important that CDPs are also conditioned and approved in ways that similarly emphasize an adaptive approach to addressing sea level rise hazards. Such coordination between LCP and CDP adaptation policies and strategies will help ensure that coastal development and resources are resilient over time.

Steps for Addressing Sea Level Rise in Coastal Development Permits

The steps presented in [Figure 13](#) and described in more detail below, provide general guidance for addressing sea level rise in the project design and permitting process for those projects where sea level rise may contribute to or exacerbate hazards or impact coastal resources.

1. Establish the projected sea level rise range for the proposed project

2. Determine how sea level rise impacts may constrain the project site

3. Determine how the project may impact coastal resources over time, considering sea level rise

4. Identify project alternatives to both avoid resource impacts and minimize risks to the project

5. Finalize project design and submit permit application

Figure 13. Process for addressing sea level rise in Coastal Development Permits

The goal of these steps is to ensure that projects are designed and built in a way that minimizes risks to the development and avoids impacts to coastal resources in light of current conditions and the changes that may arise over the life of the project. Many project sites and proposed projects may raise issues not specifically contemplated by the following guidance steps or the permit filing checklist at the end of this section. It remains the responsibility of the project applicant to adequately address these situations so that consistency with the Coastal Act and/or LCP may be fully evaluated. There are many ways to evaluate and minimize the risks associated with sea level rise, and the Commission understands that different types of analyses and actions will be appropriate depending on the type of project or planning effort.

Throughout the CDP analysis, applicants are advised to contact planning staff (either at the Commission or the local government, whichever is appropriate) to discuss the proposed project, project site, and possible resource or hazard concerns. The extent and frequency of staff coordination may vary with the scale of the proposed project and the constraints of the proposed project site. Larger projects and more constrained sites will likely necessitate greater coordination with local government and Commission staff.

Use scenario-based analysis

This process recommends using various sea level rise scenarios for the analysis of possible resource changes and site risks associated with sea level rise. Given the uncertainty about the magnitude and timing of future sea level rise, a scenario-based analysis will examine the consequences of a range of situations rather than basing project planning and design upon one sea level rise projection.

One approach for scenario-based analysis is to start with the highest possible sea level rise. If a developable area can be identified that has no long-term resource impacts, and is at no or low-risk from inundation, flooding, and erosion, then there may be no benefit to undertaking additional analysis for sea level rise and the project can continue with the rest of the analyses that are part of the Coastal Act or LCP (such as impacts to coastal habitats, public access, and scenic and visual qualities, and other issues unrelated to sea level rise).

If the site is constrained under a high sea level rise scenario, analysis of other, lower sea level rise amounts can help determine thresholds for varying impacts to coastal resources and types and extent of site constraints that need to be considered during project planning. The analysis of lower and intermediate sea level rise projections are used to better understand the timing and probability of the constraints. For further description of scenario-based analysis, see [Chapter 3](#) of this Guidance.

Step 1 – Establish the projected sea level rise range for the proposed project

A projected sea level rise range should be obtained from the best available science, such as the [2018 OPC SLR Guidance](#) or an equivalent resource. These projections should cover the expected life of the proposed project, as the ultimate objective will be to assure that the project is safe from coastal hazards, without the need for shoreline protection or other detrimental hazard mitigation measures, as long as it exists.

- **Define Expected Project Life:** The expected project life will help determine the amount of sea level rise to which the project site could be exposed while the development is in place. Importantly, the point of this step is not to specify exactly how long a project will exist (and be permitted for), but rather to identify a project life time frame that is typical for the type of development in question so that the hazard analyses performed in subsequent steps will adequately consider the impacts that may occur over the entire life of the development.

Some LCPs include a specified design life for new development. If no specified time frame is provided, a more general range may be chosen based on the type of development. For example, temporary structures, ancillary development, amenity structures, or moveable or expendable construction may identify a relatively short expected life such as 25 years or less. Residential or commercial structures will likely be around for some time, so a time frame of 75 to 100 years may be appropriate. A longer time frame of 100 years or more should be considered for critical infrastructure like bridges or industrial facilities. Resource protection or enhancement projects such as

coastal habitat conservation or restoration projects should also consider longer time frames of 100 years or more, as these types of projects are typically meant to last in perpetuity.³⁹

- **Determine Sea Level Rise Range:** Using the typical project life identified above, the project analysis should identify a range of sea level rise projections based on the best available science that may occur over the life of the project. At present, the 2018 OPC SLR Guidance is considered to be the best available science ([Table 6](#); [Appendix G](#)), though an equivalent resource may be used provided that it is peer-reviewed, widely accepted within the scientific community, and locally relevant⁴⁰.

As explained in Chapter 3, the 2018 OPC SLR Guidance recommends evaluating different scenarios depending on the type of project and the level of risk associated with the development type. These projections scenarios include:

1. *Low risk aversion scenario:* may be used for projects that would have limited consequences or have a higher ability to adapt, such as sections of unpaved coastal trail, public accessways, and other small or temporary structures that are easily removable and would not have high costs if damaged.
2. *Medium-high risk aversion scenario:* should be used for projects with greater consequences and/or a lower ability to adapt such as residential and commercial structures.
3. *Extreme risk aversion (H++):* should be used for projects with little to no adaptive capacity that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts should that level of sea level rise occur. In the Coastal Commission’s jurisdiction, this could include new wastewater treatment plants, power stations, highways, or other critical infrastructure.

In general, the Coastal Commission recommends taking a precautionary approach by evaluating the higher sea level rise projections, such as the medium-high risk aversion scenario, for most development. For critical infrastructure, development with a very long project life (e.g., 100 years or greater), or assets that have little to no adaptive capacity, that would be irreversibly destroyed or significantly costly to repair, and/or would have considerable public health, public safety, or environmental impacts, the analysis should consider the “extreme risk aversion” scenario. If constraints are identified with the higher sea level rise scenario(s), a lower sea level rise scenario and/or one or more intermediate

³⁹ Determining an anticipated life for restoration activities or other related projects is somewhat more complex than for typical development projects because these activities are typically meant to exist in perpetuity. As such, assessing sea level rise impacts may necessitate analyzing multiple different time frames, including the present, near future, and very long term depending on the overall goals of the project. For restoration projects that are implemented as mitigation for development projects, an expected project life that is at least as long as the expected life of the corresponding development project should be considered.

⁴⁰ More detailed refinement of sea level rise projections is not considered necessary at this time, as variations from the nearby tide gauges will often be quite small, and may be insignificant compared to other sources of uncertainty. However, the Coastal Commission recognizes that other studies exist with localized data, for example those completed in the Humboldt Bay region, which may also be appropriate for use.

scenarios may also be used to develop a broader understanding of the overall risk sea level rise poses to the site or proposed development. These values should each be carried forward through the rest of the steps in this chapter.

Table 6. Sea Level Rise Projections for the San Francisco Tide Gauge⁴¹ (OPC 2018)

Projected Sea Level Rise (in feet): <i>San Francisco</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.8	1.0
2040	0.8	1.3	1.8
2050	1.1	1.9	2.7
2060	1.5	2.6	3.9
2070	1.9	3.5	5.2
2080	2.4	4.5	6.6
2090	2.9	5.6	8.3
2100	3.4	6.9	10.2
2110*	3.5	7.3	11.9
2120	4.1	8.6	14.2
2130	4.6	10.0	16.6
2140	5.2	11.4	19.1
2150	5.8	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

⁴¹ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Expected outcomes from Step 1: A proposed or expected project life and corresponding range of sea level projections—including the high, the low, and one or more intermediate sea level rise projections—that will be used in the following analytic steps.

Step 2 – Determine how physical impacts from sea level rise may constrain the project site

The Coastal Act requires that development minimize risks from coastal hazards. Sea level rise can both present new hazards and exacerbate hazards that are typically analyzed in CDP applications. In this step, project applicants determine the types and extent of sea level rise impacts that may occur now and into the future.

As described in [Chapter 3](#) of the Guidance, impacts associated with sea level rise generally include erosion, inundation, flooding, wave impacts, and saltwater intrusion. An assessment of these impacts is often required as part of a routine hazards assessment or the safety element of the LCP. Therefore, information in the local LCP can provide an initial determination of potential hazards for the project in question, if available. However, proposed development will often need a second, site-specific analysis of hazards to augment the more general LCP information.

Analyze relevant sea level rise impacts for each sea level rise scenario.

A CDP application for new development in a hazardous area should include reports analyzing the anticipated impacts to a project site associated with each sea level rise scenario identified in Step 1. Generally, the analyses pertinent to sea level rise include geologic stability, erosion, flooding/inundation, wave runup, and wave impacts, and these analyses are described in detail below. Depending on the site, however, different analyses may be required. Applicants should work with planning staff (Coastal Commission or local government staff) to perform a pre-application submittal consultation to determine what analyses are required for their particular project. Analysis of those hazards that will not be altered by sea level rise (such as the location of faults, fire zones, *etc.*) should be undertaken at the same time as the assessment of sea level rise affected hazards so a complete understanding of hazard constraints can be used for identification of safe or low-hazard building areas. After the submission of the CDP application, any additional analyses that are required will be listed in an application filing status review letter.

The professionals who are responsible for technical studies of geologic stability, erosion, flooding/inundation, wave runup, and wave impacts should be familiar with the methodologies for examining the respective impacts. However, the methodologies do not always adequately examine potential impacts under rising sea level conditions, as established by best available science. [Appendix B](#) goes through the various steps for incorporating the best available science on sea level rise into the more routine analyses, which are summarized below. The analyses should be undertaken for each of the sea level rise scenarios identified in Step 1.

- **Geologic Stability:** The CDP should analyze site-specific stability and structural integrity without reliance upon existing or new protective devices (including cliff-

retaining structures, seawalls, revetments, groins, buried retaining walls, and caisson foundations) that would substantially alter natural landforms along bluffs and cliffs. Geologic stability can include, among others, concerns such as landslides, slope failure, liquefiable soils, and seismic activity. In most situations, the analyses of these concerns will be combined with the erosion analysis (below) to fully establish the safe developable area.

- **Erosion:** Both bluff erosion and long-term shoreline change will increase as the time period increases. Thus, some estimate of project life is needed to determine expected bluff and shoreline change, and to fully assess the viability of a proposed site for long-term development. The CDP application should include an erosion analysis that establishes the extent of erosion that could occur from current processes, as well as future erosion hazards associated with the identified sea level rise scenarios over the life of the project. If possible, these erosion conditions should be shown on a site map, and the erosion zone, combined with the geologic stability concerns, can be used to help establish locations on the parcel or parcels that can be developed without reliance upon existing or new protective devices (including cliff-retaining structures, seawalls, revetments, groins, buried retaining walls, and caissons) that would substantially alter natural landforms along bluffs and cliffs.
- **Flooding and Inundation:** The CDP application should identify the current tidal datum and include analysis of the extent of flooding or inundation that potentially could occur from the identified sea level rise scenarios, and under a range of conditions that could include high tide, storm surge, water elevation due to El Niños, Pacific Decadal Oscillations, a 100-year storm event, and the combination of long-term erosion and seasonal beach erosion. If possible, this information and resulting flood zones should be shown on a site map.
 - **Flood Elevation Certificate:** If a site is within a FEMA-mapped 100-year flood zone, building regulations, in implementing the federal flood protection program, require new residences to have a finished floor elevation above Base Flood Elevation (BFE; generally 1 ft).⁴² The CDP application should include a flood elevation certificate prepared by a registered land surveyor, engineer, or architect, demonstrating that the finished floor foundation of the new structure will comply with the minimum FEMA guidelines and building standards. However, at this time, the Flood Certificate does not address sea level rise related flooding. In addition, designing to meet FEMA requirements may be in conflict with other resource constraints, such as protection of visual resources, community character, and public access and recreation. Thus, in general, a certificate is not adequate to

⁴² FEMA’s proposed “[Revised Guidelines for Implementing Executive Order 11988, Floodplain Management](#)” (released for public review and comment on January 30, 2015) will modify the Federal Flood Risk Management Standard, in compliance with EO 13960, to address the need for federal agencies to include climate change considerations in floodplain management. It recommends that the elevation and flood hazard area be established by (i) using climate-informed science, (ii) adding 2 feet (for non-critical actions) or 3 feet (for critical actions) of freeboard to the Base Flood Elevation, or (iii) including the area subject to the 0.2% annual chance of flood. These Revised Guidelines could lead to future changes in the elevation required for Flood Elevation Certificates for new development.

address Coastal Act and LCP standards for demonstrating that future flood risk or other impacts to coastal resources have been minimized.

- **Wave Runup and Wave Impacts:** Building upon the analysis for flooding, the CDP application should include analysis of the wave runup and impacts that potentially could occur over the anticipated life of the project from a 100-year storm event, combined with the identified sea level rise scenarios, and under a range of conditions that could include high tide, storm surge, water elevation due to El Niño events, Pacific Decadal Oscillations, and the combination of long-term erosion and seasonal beach erosion. If possible, this information and resulting wave runup zones should be shown on a site map or site profile.
- **Other Impacts:** Any additional sea level rise related impacts that could be expected to occur over the life of the project, such as saltwater intrusion should be evaluated. This may be especially significant for areas with a high groundwater table such as wetlands or coastal resources that might rely upon groundwater, such as agricultural uses.

Expected outcomes from Step 2: Detailed information about the sea level rise related impacts that can occur on the site and changes that will occur over time under various sea level rise scenarios. High risk and low risk areas of the site should be identified. The scenario-based analyses should also provide information on the potential effects of sea level rise, such as coastal erosion, that could occur over the proposed development life, without relying upon existing or new protective devices.

Step 3 – Determine how the project may impact coastal resources, considering the influence of sea level rise upon the landscape over time

The Coastal Act requires that development avoid impacts to coastal resources. Sea level rise will likely cause some coastal resources to change over time, as described in Chapters [3](#) and [4](#). Therefore, in this step, applicants should analyze how sea level rise will affect coastal resources now and in the future so that alternatives can be developed in Step 4 to minimize the project’s impacts to coastal resources throughout its lifetime.

This section discusses only those resources that might change due to rising sea level or possible responses to rising sea levels. As in Step 2, each sea level rise scenario (high, low, and intermediate values) should be carried through this step. A complete CDP application will need to assess possible impacts to all coastal resources – including public access and recreation, water quality, natural resources (such as ESHA and wetlands), agricultural resources, natural landforms, scenic resources, and archaeological and paleontological resources. Analysis of those resources that will not be affected by sea level rise should be undertaken at the same time as the assessment of the sea level rise affected resources so a complete map of resource constraints can be used for identification of a resource-protective building area.

3.1 Analyze coastal resource impacts and hazard risks for each sea level rise scenario

Analysis of resource impacts will require information about the type and location of the resources on or in proximity to the proposed project site and the way in which the proposed project will affect such resources initially and over time. The following discussion of each resource will help identify the key impacts to each that might result from either sea level rise or the proposed development. If coastal resources will be affected by sea level rise, such as changes to the area and extent of a wetland or riparian buffer, these changes must be considered in the analysis. Much of the following discussion recommends analysis of impacts from current and future inundation, flooding, erosion, and from the ways in which the project proposes to address such impacts. [Appendix B](#) provides guidance on how to undertake this analysis and includes lists of suggested resources that can provide data, tools, or other resources to help with these analyses. This analysis should be repeated for each sea level rise scenario identified in Step 1. Also, it may be important for local planners to coordinate and share information with other local partners – including those in charge of emergency management, law enforcement, and related services – in order to identify risks and vulnerabilities. Information on the following coastal resources is included. To skip to a section, click on the links below:

- New Development (addressed in Step 2, above)
- [Public Access and Recreation](#)
- [Coastal Habitats](#)
- [Natural Landforms](#)
- [Agricultural Resources](#)
- [Water Quality and Groundwater](#)
- [Scenic Resources](#)

Public Access and Recreation: Public access and recreation resources include lateral and vertical public accessways, public access easements, beaches, recreation areas, public trust lands,⁴³ and trails, including the California Coastal Trail. These areas may become hazardous or unusable during the project life due to sea level rise and/or due to the proposed project.

Approaches to identify potential risks to public access and recreation include:

- Identify all public access locations on or near the proposed project site and, if possible, map these resources in relation to the location of the proposed project. The analysis should also identify existing public trust areas in relation to the proposed project
- Determine whether any access locations or public trust lands will be altered or impacted by sea level rise and/or the proposed project for the identified sea level rise scenarios. Such impacts could result from flooding, inundation, or shoreline erosion, or from proposed project elements. At a minimum, establish the extent of likely and/or possible changes to public access and recreation and to public trust lands.

⁴³ The State Lands Commission has oversight of all public trust lands and many local governments are trustees of granted tidelands. The State Lands Commission or other appropriate trustee should be contacted if there is any possibility that public trust lands might be involved in the proposed project. As a general guide, public trust lands include tide and submerged lands as well as artificially filled tide and submerged lands.

- If any access locations will be altered by sea level rise and/or the proposed project, map or otherwise identify the potential changes to the location of these access resources for the identified sea level rise scenarios.
- Identify whether there are locations on the proposed project site that can support development without encroachment onto the existing or future locations of these access locations, and without impacts otherwise to public access and recreation. Overlay with development constraints (fault zones, landslides, steep slopes, property line setbacks, *etc.*) and with other coastal resource constraints.

Coastal Habitats (ESHA, wetlands, *etc.*): Coastal habitats, especially those that have a connection to water, such as beaches, intertidal areas, and wetlands, can be highly sensitive to changes in sea level. Ways to identify potential resource impacts associated with the project include:

- Identify all coastal habitats and species of special biological or economic significance on or near the proposed project site and, if possible, map these resources in relation to the location of the proposed project.
- Determine whether any coastal habitats will be altered or affected by sea level rise and/or the proposed project over the proposed life of the project. Such impacts could result from flooding, inundation, shoreline erosion, or changes to surface or groundwater conditions (see discussion below on water quality). At a minimum, use the identified sea level rise scenarios to establish the extent of likely and/or possible changes to coastal habitats.
- If any coastal habitats will be altered by sea level rise and/or the proposed project, map or otherwise identify potential changes to the location of these coastal resources for the identified sea level rise scenarios.
- Identify locations of the proposed project site that can support development without encroachment onto the existing or future locations of these coastal habitats, and without other impacts to coastal habitats. Overlay with development constraints (fault zones, landslides, steep slopes, property line setbacks, *etc.*) and with other coastal resource constraints.

Natural Landforms: Natural landforms can include coastal caves, rock formations, bluffs, terraces, ridges, and cliffs. Steps to identify natural landforms at risk include:

- Identify all natural landforms on or near the proposed project site and, if possible map these resources in relation to the location of the proposed project.
- Determine whether any natural landforms will be altered or impacted by sea level rise and/or the proposed project for the identified sea level rise scenarios. Such impacts could result from flooding, inundation or shoreline erosion. At a minimum, use the identified sea level rise scenarios to establish the zone of likely and/or possible changes to natural landforms.
- If any natural landforms will be altered by sea level rise and/or the proposed project, map or otherwise identify the likely changes to location of these coastal resources for the identified sea level rise scenarios.

- Identify locations of the proposed project site that can support development without encroachment onto the existing or future locations of these natural landforms and without other impacts to such landforms. Bluffs and cliffs can often require additional analysis for slope stability to determine the setback from the eroded bluff face that can safely support development. Overlay with development constraints (fault zones, landslides, steep slopes, property line setbacks, *etc.*) and with other coastal resource constraints.

Agricultural Resources: Agricultural resources may be affected by sea level rise through changes to surface drainage and the groundwater table. Other changes can result from flooding, inundation or saltwater intrusion. If agricultural lands are protected by levees or dikes, they can be affected by changes to the stability or effectiveness of these structures. Steps to identify risks to agricultural resources include:

- Identify whether the proposed project site is used for or zoned for agricultural uses, contains agricultural soils, or is in the vicinity of or upstream of lands in agricultural use.
- Identify surface water drainage patterns across the site or from the site to the agricultural use site.
- If any drainage patterns are closely linked to and potentially influenced by the elevation of sea level, examine changes in drainage patterns with rising sea level on the proposed site or the agricultural use site.

Water Quality and Groundwater: Sea level rise may cause drainages with a low elevation discharge to have water back-ups. It may also cause a rise in the groundwater table. Both of these changes could alter on-site drainage and limit future drainage options. If the proposed site must support an on-site wastewater treatment system, or if drainage and on-site water retention will be a concern, consider the following, as appropriate:

- Identify surface water drainage patterns across the site.
- Examine changes with rising sea level of any drainage patterns that are closely linked to and likely influenced by the elevation of sea level. At a minimum, use the identified sea level rise scenarios to establish the zone of likely changes to drainage patterns.
- Identify the elevation of the groundwater table. Since groundwater can fluctuate during periods of rain and drought, attempt to identify the groundwater zone.
- Estimate the likely future elevation of the groundwater zone, due to sea level rise. At a minimum, use the identified sea level rise scenarios to establish the zone of likely changes to groundwater.
- Evaluate whether changes in groundwater will alter the proposed site conditions.

Scenic Resources: Visual and scenic resources include views to and along the ocean and scenic coastal areas. Development modifications to minimize risks from sea level rise could have negative consequences for scenic resources, including creating a structure that is out of character with the surrounding area, blocks a scenic view, or alters natural landforms. Steps to identify impacts to scenic resources, including any impacts from possible adaptation measures, include:

- Identify all scenic views to and through the proposed project site from public vantage points such as overlooks, access locations, beaches, trails, the Coastal Trail, public roads, parks, and if possible, map these views and view lines in relation to the location and maximum allowable elevation of the proposed project.
- Identify locations of the proposed project site that can support development and avoid or minimize impacts to scenic views from current and future vantage points. Overlay with development constraints (fault zones, landslides, steep slopes, property line setbacks, etc.) and with other coastal resource constraints.

3.2 Synthesize and assess development and resource constraints

After completing the detailed analysis of each coastal resource, the applicant should summarize the potential resource impacts under each sea level rise scenario identified in Step 1. This set of results, when combined with potential impacts to those coastal resources not affected by sea level rise, should give the applicant valuable information about the degree of risk posed to each coastal resource and to the development itself. If practical, for each sea level rise scenario, applicants should produce a constraints map illustrating the location and the extent of resource impacts that could occur over the life of the development. Based on the analysis of resource impacts and potential hazard risks over the life of the development, the applicant should develop an overlay identifying the development and resource constraints.

3.3 Identify areas suitable for development

The final part of this step is to identify the locations of the project site that could support some level of development without impacts to coastal resources and without putting the development at risk.

Expected outcomes from Step 3: Upon completing this step, the applicant should have detailed information about the types of coastal resources on the project site and the level of risk that sea level rise poses to each resource under each sea level rise scenario, including resource locations and the extent of resource impacts that could occur over the life of the proposed project. This step should also provide an overlay of all development and resource constraints, and clearly identify the locations on the proposed project site that could support some level of development without impacts to coastal resources and without putting the development at risk.

Step 4 – Identify project alternatives that avoid resource impacts and minimize risks to the project

By this step, applicants should have developed a set of factors based on the sea level rise hazards identified in Step 2, potential resource impacts identified in Step 3, and other site conditions (such as archaeological resources or fault lines) to identify the buildable areas that avoid both risk from coastal hazards and impacts to coastal resources. Hazard and resource avoidance is usually the preferred option, and, in many cases, applicants may find that the site is safe from sea level rise hazards for all the identified sea level rise scenarios and no further identification of project alternatives would be necessary in order to address sea level rise concerns.

For some cases, the site constraints may require consideration of project alternatives that fit with the available buildable area, without the use of protective structures. In these cases, one of the alternatives may be to replace what was initially being considered for the site. In other cases, development that is safe from hazards and is resource protective may be possible if certain adaptation strategies are used to modify the project over time and as the potential hazard areas increase or move closer to the project. For these cases, the possible adaptation pathways would be included as part of the proposed project, along with necessary monitoring and triggers for implementing the adaptation options. In still other cases, hazard minimization may be the only feasible option for development on hazard constrained-sites. In all cases, projects must be sited and designed to address all applicable Coastal Act and LCP requirements, including any new requirements within LCPs that have been updated to adapt to sea level rise.

The results from the analysis of sea level rise scenarios should factor into the decisions made in this step. In particular, after looking at the results from Steps 2 and 3 as a whole, applicants can better decide the project changes, types of adaptation strategies, and design alternatives that would be most appropriate given the degree of risk posed by possible sea level rise and how long the development might be free from risk. The applicant also might identify triggers (*e.g.*, a certain amount of sea level rise) when certain adaptation measures should be implemented to reduce risk and/or impacts to coastal resources.

Importantly, land divisions and lot line adjustments in high hazard areas can change hazard exposure and should therefore be undertaken only when they can be shown to not worsen or create new vulnerability. In particular, no new lots or reconfigured lots with new development potential should be created if they cannot be developed without additional shoreline hazard risks.

Strategies to Avoid Resource Impacts and Minimize Risks

The best way to minimize risks to development and coastal resources is to avoid areas that are or will become hazardous as identified by the sea level rise scenarios analysis in the previous steps. Such avoidance often includes changes to the proposed project to bring the size and scale of the proposed development in line with the capacity of the project site. However, if it is not feasible to site or design a structure to completely avoid sea level rise impacts, the applicant may need to modify or relocate the development to prevent risks to the development or to coastal resources. Some changes, such as the use of setbacks, may be necessary at the outset of the project. Other changes, such as managed retreat or added floodproofing, may be useful as adaptive strategies that can be used after the initial project completion. Considerations involved in choosing and designing an appropriate adaptation strategy may include those listed below. See [Chapter 7](#) for more information on specific adaptation measures. For a list of guidebooks, online clearinghouses, and other sea level rise adaptation resources, see [Appendix C](#).

- **Assess Design Constraints:** Determine whether there are any significant site or design constraints that might prevent future implementation of possible sea level rise adaptation measures. Some project locations may be constrained due to lot size, sea level related hazards, steep slopes, fault lines, the presence of wetlands or other ESHA, or other constraints such that no safe development area exists on the parcel. Ideally, such parcels would be identified during the LCP vulnerability analysis, and the land use and zoning

designations would appropriately reflect the constraints of the site. However, in some cases development may need to be permitted even if it cannot avoid all potential hazards. As stated above, care should be taken in these cases to avoid resource impacts and minimize risks as much as possible by developing and implementing a sea level rise adaptation plan for the proposed development. In creating this plan, it is important to identify any design constraints that will limit the ability to implement adaptation strategies in the future, as described below.

- **Identify Adaptation Options:** Identify possible adaptation strategies (such as those found in [Chapter 7](#)) for the proposed project, and evaluate each adaptation option for efficacy in protecting the development. Also, evaluate the consequences from each proposed adaptation measure to ensure it will not have adverse impacts on coastal and sensitive environmental resources, including visual impacts and public access.

For example, an option that is often considered for sea level rise is to elevate the development or the structures that are providing flood protection. However, elevated structures will change the scenic quality and visual character of the area. Also, elevation of the main development may be of little long-term utility to the property owner if the supporting infrastructure, such as the driveways, roads, utilities or septic systems are not also elevated or otherwise protected. Elevation of existing levees or dikes can provide flood protection for an area of land and all the development therein. However, the foundation of the levee or dike must have been designed to support the additional height or else it may have to be expanded and the increased footprint of the foundation could have impacts on intertidal area, wetlands, or other natural resources. Thus, the long-term options for adaptation should be considered as part of any permit action, to ensure that current development decisions are not predetermining resource impacts in the future.

- **Utilize Adaptation Pathways:** “Adaptation pathways” refers to a planning approach in which planners consider multiple possible futures and analyze the robustness and flexibility of various adaptation options across those multiple futures. In the context of sea level rise planning, if the likelihood of impacts is expected to increase with rising sea level, it may be necessary to design the initial project for some amount of sea level rise but to also include design flexibility that will allow future project changes or modifications to prevent impacts if the amount of sea level rise is more than anticipated in the initial design. Changes and modifications could include the use of foundation elements that will allow for building relocations or removal of portions of a building as it is threatened or reserving space to move on-site waste treatment systems away from eroding areas or areas that will be susceptible to a rising water table or increased flooding.
- **Develop Project Modifications:** Highly constrained sites may not be able to support the amount of development that an applicant initially plans for the site. Even a small building footprint may be at risk from flooding or erosion under high sea level rise scenarios. In such cases, it will be important to work closely with the appropriate planning staff to develop a project option that can minimize hazards from the identified sea level rise scenarios for as long as possible, and then incrementally retreat once certain triggers are met. Some examples of triggers could be that erosion is within some distance of the

foundation, or monthly high tides are within some distance of the finished floor elevation. The time period for relocation or removing the structure would be determined by changing site conditions but relocation would most likely occur prior to the time period used in Step 1 to determine long-term site constraints.

- **Plan for Monitoring:** Develop a monitoring program or links to other monitoring efforts to ensure that the proposed adaptation measures will be implemented in a timely manner. Following a monitoring protocol and requirements for evaluating sea level rise impacts to coastal habitats over time can help to identify the triggers that would lead to revising project life, other project modifications or additional adaptation efforts.

Expected outcomes from Step 4: This step may involve an iterative process of project modifications and reexamination of impacts, leading to one or more alternatives for the project site. The alternative that will minimize risks from coastal hazards and avoid or minimize impacts to coastal resources should be identified. Possible adaptation options could be identified and analyzed, if appropriate. If the site is very constrained, modifications to the expected project life might be suggested.

Step 5 – Finalize project design and submit CDP application

After Step 4, the applicant should have developed one or more project alternatives and identified a preferred alternative. The alternatives should include adaptation strategies to minimize impacts if hazards cannot be avoided entirely. The CDP application step involves the following:

- 1. Work with the planning staff to complete the CDP application.** Depending upon the proposed project and extent of prior interactions with the planning staff, the initial submittal may be the first time the planner has been provided with information about the general project or the preferred alternative. Once a proposed project is submitted, the coastal planner will need to become familiar with the project location, area around the project site, the proposed actions and the studies and analyses that have been undertaken in support of the application. The planner will review the application for completeness to ensure that there is sufficient information to analyze the project for all appropriate LCP or Coastal Act Chapter 3 policies. If analysis for sea level rise concerns is needed, the planner will also check that analyses for sea level rise risks have been included in the submittal. Much of the information developed in Steps 1-4 will be useful for the application process. The Suggested Filing Checklist for CDP Applications (located at the end of this chapter) covers the typical information that might be included in a CDP application necessary for planning review of the sea level rise aspects of the proposed project. Applicants who are unfamiliar with the permit process should consult the local government website, Coastal Commission website, or contact the appropriate district office for instructions on how to complete a CDP application.

The review of an application might involve an iterative process, wherein planning staff requests more information about the proposed project, project alternatives, analysis of the hazards or identification of potential resource impacts to help in the review for

compliance with the LCP or the Coastal Act. At the same time, planning staff may request that some of the technical staff review the submitted material to ensure that there is sufficient information in all technical information and analyses to support a decision on the proposed project. This process may be repeated until the application provides the studies, analysis and project review necessary for planning review.

- 2. Submit a complete CDP application.** Once a complete application has been accepted, the planning staff will do a more thorough review and analysis of the potential hazards and resource impacts associated with the proposed project. Ideally, the planner will have requested all necessary project information at the filing stage. In some instances, additional information may be needed after the application has been accepted. This is normally limited to clarifications of some of the information or further details about some of the possible, but not preferred alternatives. During this stage in the CDP application process, the planner may identify necessary project modifications that were not part of the initial application, or identify various conditions that will be needed if the project is to be approved. [Chapter 7](#) includes many of the possible project modifications and permit conditions that might be used to address sea level rise concerns and potential resource impacts.

During the project analysis, the planning staff will review all submitted material, discussing the proposed project with other staff members, and obtaining further technical review. Working with their supervisors and managers, they will also develop a staff recommendation and prepare a staff report that supports the proposed recommendation. Please consult the Coastal Commission website (<http://www.coastal.ca.gov/cdp/cdp-forms.html>) or contact your district office for instructions on how to complete a CDP application.

- 3. Permit action.** Once the proposed project has been through planning review and a staff recommendation has been prepared, the proposed project will be brought to hearing before either the local planning commission or the California Coastal Commission. The outcome of the hearing process will be project approval, approval with conditions, or denial. Based on the regulatory decision, the project may be constructed, or additional modifications and condition requirements may have to be met.
- 4. Monitor and revise.** CDP approvals may include conditions that require monitoring. Applicants should monitor the physical impacts of sea level rise on the project site, provide reports and updates to planning staff and introduce adaptive changes to the project in accordance with the permit and permit conditions.

Expected outcomes from Step 5: This step, combined with supporting documentation from the previous steps, should provide a basis for evaluating the proposed project's hazard risks and impacts that can result from sea level rise. Such an analysis will provide one of the bases for project evaluation and complements the other resource evaluations and analyses that are part of a complete CDP application.

Planning Process for Coastal Development Permits

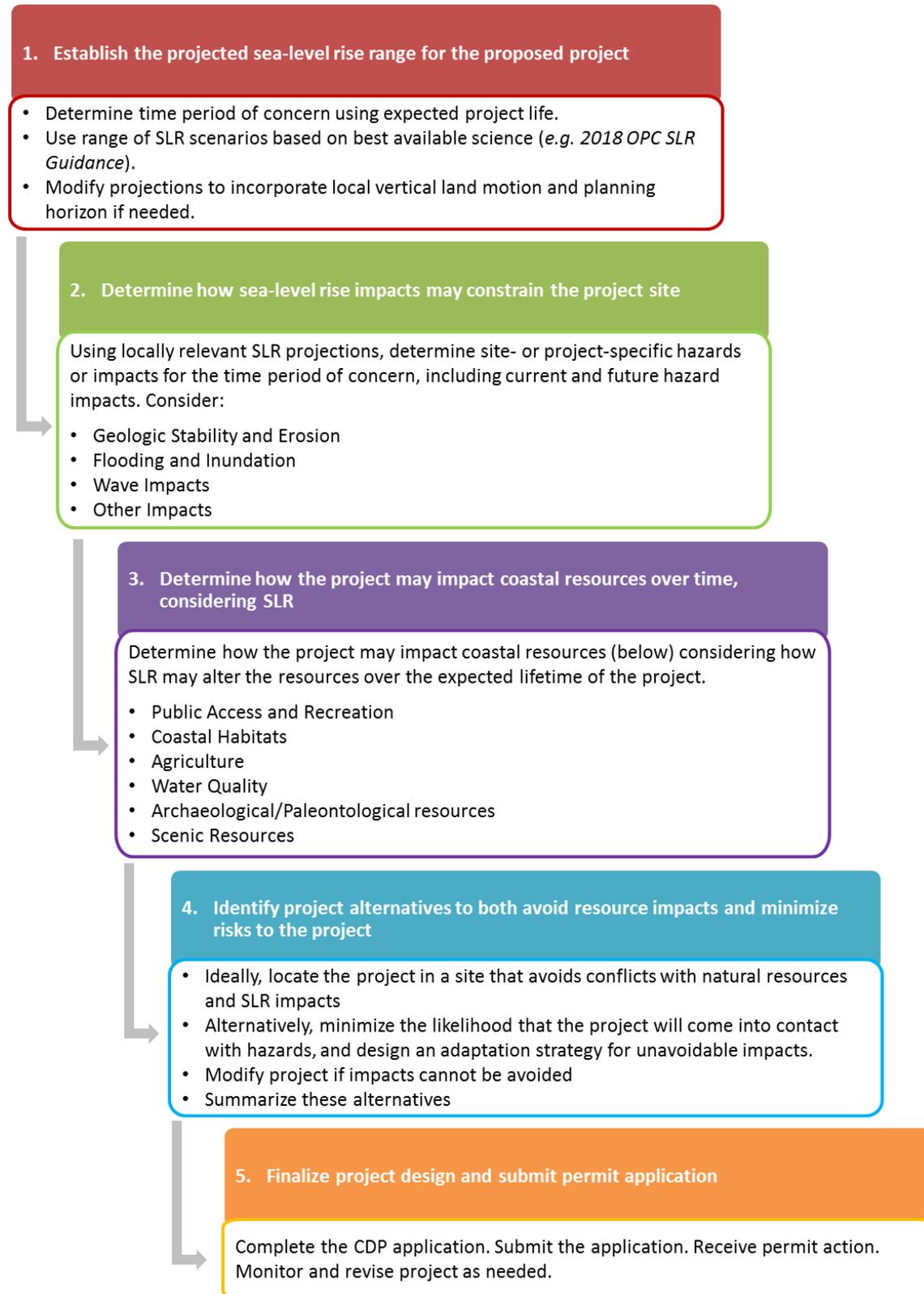


Figure 14. Flowchart for steps to address sea level rise in Coastal Development Permits

Suggested Filing Checklist for Sea Level Rise Analysis

- Proposed/Expected Project Life
- Sea Level Rise Projections used in Impacts Analyses
- Impacts Analyses (possibly from Vulnerability Assessment)
 - Structural and Geologic Stability
 - Identify current tidal datum
 - Perform Geotechnical Report and Erosion Analysis
 - Identify blufftop setback and safe building area
 - Show setback, safe building area and proposed project footprint (site maps)
 - Erosion Amount over Expected Project Life
 - Perform Coastal Processes Study and Erosion Analysis
 - Quantify total erosion amount for proposed project site
 - Show retreat along with proposed project footprint (site maps)
 - Flooding and Inundation Risks
 - Perform Coastal Processes Study and Wave Runup Analysis
 - Quantify flood elevation and flooding extent
 - Show flood extent with proposed project footprint (site map)
 - Show flood elevation on site profile, with proposed project elevation
 - Provide Flood Certificate if in FEMA designated 100-year Flood Zone
 - Tipping points for sea level rise impacts, specific to proposed project site
- Impacts to coastal resources (possibly from Environmental Assessment) for current conditions and changes due to sea level rise and related impacts
 - Public Access and Recreation
 - Show access resources and future changes (site maps)
 - Water Quality, surface and groundwater
 - Provide surface drainage patterns and runoff and future changes (site maps)
 - Provide zone of groundwater elevation
 - Coastal Habitats
 - Provide wetland delineation, ESHA determination, if appropriate
 - Provide boundary determinations or State Lands review, if appropriate
 - Show all coastal habitats and future changes (site maps)
 - Agricultural Resources
 - Show agricultural resources and future changes (site maps)
 - Natural Landforms
 - Show all natural landforms and future changes (site maps)
 - Scenic Resources
 - Show views from public access and future changes due to access changes
 - Overlay all coastal resources to establish areas suitable for development (site maps)
- Analysis of Proposed Project and Alternatives
 - Provide amount(s) of sea level rise used in project planning and design
 - Provide analysis of the proposed project and alternatives
 - Identify proposed current and future adaptation strategies
 - Show avoidance efforts (site map)
 - Identify hazard minimization efforts that avoid resource impacts (site maps)

Example for Addressing Sea Level Rise in Coastal Development Permits

To illustrate the process described in this chapter for how to address sea level rise in the CDP process, consider three example projects: a wetland restoration project, a new bluff-top residential development with a fronting beach, and a new wastewater treatment facility. These three examples will follow each of the recommended CDP steps, showing how the guidance could be applied in specific situations. Note that these are simplified examples used to demonstrate the process described in this chapter. Decisions about how to address various challenges presented by sea level rise will be more complex than those illustrated below, and the Coastal Commission encourages applicants to coordinate with staff as necessary and feasible throughout the process.

Step 1: Establish the projected sea level rise range for the proposed project

- *Wetland Restoration Project:* Sea level rise projection ranges should be chosen based on the goals of the project. For example, if wetland restoration efforts are intended as mitigation for a development project, the lifetime for the wetland restoration should be, at a minimum, the lifetime of the development project. For wetland restoration projects in which the desired outcome is the protection of the wetland in perpetuity, sea level rise ranges should be projected over a minimum of 100 years, with consideration of the intervening years as well as the even longer term for ongoing adaptive management.
- *Bluff-top Residential Development:* The lifetime of the project is assumed to be at least 75 years, unless the LCP specifies a different time period. High, low, and intermediate sea level rise projection ranges are established, appropriate for the proposed area over the assumed 75-year project life.
- *Wastewater Treatment Facility:* Wastewater treatment facilities are normally critical infrastructure. For this example, a minimum life of 100 years is assumed, unless the LCP specifies a different time period. High, low, and intermediate sea level rise projections ranges are established, appropriate for the proposed area over the assumed 100-year or longer project life.

Step 2: Determine how impacts from sea level rise may constrain the project site

- *Wetland Restoration Project:* Current topography of the wetland area is mapped, current barriers to inland migration are identified, and an analysis of erosion and flooding potential (and subsequent effects to wetland extent) is performed for various sea level rise scenarios. Potential changes to groundwater are evaluated. Potential changes in sediment flows or other physical properties as a result of changing conditions are examined. It is determined that in this case, open space exists behind the wetland to allow for inland migration over time.
- *Bluff-top Residential Development:* The average long-term beach and bluff retreat rate, erosion rate due to various sea level rise scenarios, and erosion potential from 100-year storms and other extreme events are determined. Beach and bluff erosion will vary with sea level rise rates. The geologic stability of the bluff over the life of the development is analyzed assuming that no protective structure (such as a seawall) either exists or will be built.

- *Wastewater Treatment Facility:* Erosion and flooding potential over the lifetime of the facility under both a low and a worst-case scenario sea level rise projection are analyzed, as are current and future wave runoff and storm impacts for 100-year storms. The geologic stability of the site over the life of the facility is analyzed assuming that no protective structure either exists or will be built. Potential damage to infrastructure (for example corrosion due to saltwater intrusion) is examined.

Step 3: Determine how the project may impact coastal resources, considering the influence of sea level rise upon the landscape over time

- *Wetland Restoration Project:* Coastal resources present in the proposed project site are mapped and sea level rise impacts to these resources are analyzed over the lifetime of the project. It is unlikely that the project will have any adverse impacts on coastal resources. Barriers to wetland migration are examined and it is determined in this case that enough open space currently exists to allow for the wetland to migrate inland over time. The few barriers that exist can be modified in the future, if necessary. This will allow for continued maintenance of habitat area and ecosystem services.
- *Bluff-top Residential Development:* Maps are developed that identify scenic viewsheds, the bluff extent, and adjacent coastal habitats including the fronting beach, and descriptions of each are provided. Opportunities for public access are identified. Impacts to each of these resources as a result of sea level rise are analyzed, as are impacts that would result from the development project. It is determined that the development has the potential to result in the loss of a fronting beach if a protective structure is installed. However, development setbacks are designed to ensure that no such structure is planned over the lifetime of the development under any sea level rise scenario.
- *Wastewater Treatment Facility:* Maps are developed that identify coastal resources in the area and impacts to these resources resulting from sea level rise are analyzed. As with the bluff-top development, any protective structure would have detrimental effects to the fronting beach, but no such structure is determined to be necessary. Any potential impacts to adjacent habitat areas or to water quality as a result of damage to infrastructure (for example sewage outflow or backup of seawater into the system) are examined under the range of sea level rise projections for the life of the facility.

Step 4: Identify project design alternatives that avoid resource impacts and minimize risks to the project

- *Wetland Restoration Project:* In this example, there are no concerns related to detrimental impacts to coastal resources as a result of this project. Natural barriers will be removed through grading and contouring of the land to ensure that the wetland has the ability to migrate inland with sea level rise and that hydrologic function will be maintained. Inland areas are protected into the future to ensure the space will be open for migration. Additionally, a plan is included to monitor changes in sea level, sediment dynamics, and overall health of the wetland so that adaptive management options can be applied as needed.

- *Bluff-top Residential Development:* The optimal site for a bluff-top residential development is one that avoids the hazards identified in Step 2 and impacts to coastal resources identified in Step 3 over the life-time of the project. If the proposed site does not avoid risks, alternative locations on the project sites should be identified and examined. If no such location exists, efforts should be made to minimize hazards and impacts to resources, or the project should be denied. Minimization efforts may include: building with an extra setback from the bluff-face, developing a managed retreat plan, and designing buildings to be easily relocated. If the safe building envelope will not be sufficient for a reasonable-sized building, local governments could consider allowing reduced setbacks on portions of the site located away from the bluff face (e.g., side or front yard setbacks), reduced off-street parking, additional height on safe portions of the site, or other development that doesn't require shore protection. No seawall is planned as such a device would result in the loss of the fronting beach. A plan to monitor rates of erosion at various places along the bluff as well as any impacts to adjacent resources is developed, and erosion rates/scenarios that would trigger the need for retreat are identified.
- *Wastewater Treatment Facility:* The optimal site for a wastewater treatment facility is one that avoids the hazards identified in Step 2 and impacts to coastal resources identified in Step 3 over the life-time of the project. If the proposed site does not avoid risks, alternative sites should be identified and examined. If no such site exists, efforts should be made to minimize hazards and impacts to resources. Minimization efforts may include: building the facility further back from the beach, elevating outflow pipes, and adding one-way valves to prevent backflow of sea-water into the system. A plan to monitor erosion rates along the beach as well as wave and storm impacts and any impacts to coastal resources caused by the facility is developed.

Step 5: Finalize project design and submit CDP application

- *Wetland Restoration Project:* The best site and design option is chosen and presented to the Commission or local government for the permit process. Application includes likely options for adaptive management to maintain wetlands and key monitoring needed to examine ongoing wetland function.
- *Bluff-top Residential Development:* The best site and design option is chosen and presented to the Commission or local government for the permit process. Application includes analyses of hazard and resource risks and any plans for adaptive project designs and proposed monitoring.
- *Wastewater Treatment Facility:* The best site and design option is chosen and presented to the Commission or local government for the permit process. Application includes analyses of hazards and resource risk and plans for site monitoring.

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Chapter 7

Adaptation Strategies

Chapters 5 and 6 provide guidance on the sequential processes for addressing sea level rise in Local Coastal Programs (LCPs) and Coastal Development Permits (CDPs). This chapter describes some of the specific adaptation strategies to consider in these planning and development review processes. Given the range of impacts that could occur as a result of sea level rise, and the uncertainties surrounding projections of sea level rise over the lifetimes of many coastal projects, communities, planners, coastal managers and project applicants will need to use adaptation strategies to effectively address coastal hazard risks, and protect coastal resources over time.

As described in Chapters [5](#) and [6](#), adaptation strategies should be chosen based on the specific risks and vulnerabilities of a region or project site and the applicable Coastal Act and LCP requirements, with due consideration of local priorities and goals. Adaptation strategies may involve modifications to land use plans, regulatory changes, project modifications, or permit conditions that focus on avoidance or minimization of risks and the protection of coastal resources.

Some adaptation strategies may require land use plans or proposed projects to anticipate longer-run impacts now, such as assuring that critical infrastructure is built to last a long time without being put in danger, or rezoning hazardous areas as open space. Other adaptation strategies may build adaptive capacity into the plan or project itself, so that future changes in hazard risks can be effectively addressed while ensuring long-term resource protection. In most cases, especially for LCP land use and implementation plans, multiple adaptation strategies will need to be employed. For projects, adaptation strategies may be addressed through initial siting and design and through conditions that provide for specific adaptation over time.

The next sections provide an overview of the general categories of adaptation options, followed by a description of various specific adaptation strategies organized by type of coastal resource, as outlined in Chapter 3 of the California Coastal Act.

The adaptation options described in this chapter are intended to provide guidance for potential LCP and permitting strategies. Not all strategies listed here will be appropriate for every jurisdiction, nor is this an exhaustive list of options. However, as described in Chapters 5 and 6, all local governments and all project applicants should analyze the possible effects of sea level rise and evaluate how the strategies in this chapter, or additional supplemental strategies, could be implemented in LCPs or CDPs to minimize the adverse effects of sea level rise.

GENERAL ADAPTATION CATEGORIES

There are a number of options for how to address the risks and impacts associated with sea level rise. Choosing to “do nothing” or following a policy of “non-intervention” may be considered an adaptive response, but in most cases, the strategies for addressing sea level rise hazards will require proactive planning to ensure protection of coastal resources and development. Such proactive adaptation strategies generally fall into three main categories: protect, accommodate, and retreat.

For purposes of implementing the Coastal Act, no single category or even specific strategy should be considered the “best” option as a rule. Different types of strategies will be appropriate in different locations and for different hazard management and resource protection goals. The effectiveness of different adaptation strategies will vary across both spatial and temporal scales. In many cases, a hybrid approach that uses strategies from multiple categories will be necessary,

and the suite of strategies chosen may need to change over time. As discussed later in the document, the legal context of various options will also need to be considered in each situation and ultimately, adaptive responses will need to be consistent with the Coastal Act. Nonetheless, it is useful to think about the general categories of adaptation strategies to help frame the consideration of land use planning and regulatory options in specific communities and places along the coast.

Protect: Protection strategies refer to those strategies that employ some sort of engineered structure or other measure to defend development (or other resources) in its current location without changes to the development itself. Protection strategies can be further divided into “hard” and “soft” defensive measures or armoring. “Hard” armoring refers to engineered structures such as seawalls, revetments, and bulkheads that defend against coastal hazards like wave impacts, erosion, and flooding. Such armoring is a fairly common response to coastal hazards, but it can result in serious negative impacts to coastal resources, particularly as sea level rises. Most significantly, hard structures form barriers that impede the ability of natural beaches and habitats to migrate inland over time. If they are unable to move inland, public recreational beaches, wetlands, and other habitats will be lost as sea level continues to rise. This process is commonly referred to as “passive erosion,” which is the narrowing of beaches due to the fact that the back of the beach on an eroding shoreline has been fixed in place (Flick *et al.* 2012). Other detrimental impacts may include negative visual impacts or interference with other ecosystem services.



Figure 15. Photo depicting passive erosion. (Left) Passive erosion in front of a revetment at Fort Ord, illustrating the loss of beach where the development prevents the shoreline from migrating landward. The beach continues to migrate inland on either side of the revetment. (Right) Recovery of the beach following removal of the revetment and blufftop structure. (Source: [California Coastal Records Project](#)).

“Soft” armoring refers to the use of natural or “green” infrastructure like beaches, dune systems, wetlands, and other systems to buffer coastal areas. Strategies like beach nourishment, dune management, or the construction of “living shorelines” capitalize on the natural ability of these systems to protect coastlines from coastal hazards while also providing benefits such as habitat, recreation area, more pleasing visual impacts, and the continuation or enhancement of ecosystem services. The engineering of green infrastructure is a somewhat newer concept in some cases, and because of this, the effectiveness of different strategies in different types of environments is not necessarily well-known or tested. In cases in which natural infrastructure might not be

completely effective or may not be preferred, a hybrid approach using both hard and natural infrastructure could be considered. As described in Principle 10 of this Guidance and in the [Safeguarding California](#) plan (CNRA 2014), priority should be given to options that protect, enhance, and maximize coastal resources and access, including giving full consideration to innovative nature-based approaches such as living shoreline techniques or managed/planned retreat. Although the Coastal Act clearly provides for potential protection strategies for “existing development”, it also directs that new development be sited and designed to not require future protection that may alter a natural shoreline.

Accommodate: Accommodation strategies refer to those strategies that employ methods that modify existing developments or design new developments to decrease hazard risks and thus increase the resiliency of development to the impacts of sea level rise. On an individual project scale, these accommodation strategies include actions such as elevating structures, retrofits and/or the use of materials meant to increase the strength of development, building structures that can easily be moved and relocated, or using extra setbacks. On a community-scale, accommodation strategies include any of the land use designations, zoning ordinances, or other measures that require the above types of actions, as well as strategies such as clustering development in less vulnerable areas or requiring mitigation actions to provide for protection of natural areas even as development is protected. As with protection strategies, some accommodation strategies could result in negative impacts to coastal resources. Elevated structures may block coastal views or detract from community character; pile-supported structures may, through erosion, develop into a form of shore protection that interferes with coastal processes, blocks access, and, at the extreme, results in structures looming over or directly on top of the beach.



Figure 16. Photo depicting “managed retreat” and restoration. Surfers' Point Managed Shoreline Retreat project in which the parking lot was moved back and beach area was restored. (Aerial composite by Rick Wilborne (February 28, 2013); photo courtesy of Surfrider Foundation)

Retreat: Retreat strategies are those strategies that relocate or remove existing development out of hazard areas and limit the construction of new development in vulnerable areas. These strategies include land use designations and zoning ordinances that encourage building in more resilient areas or gradually removing and relocating existing development. Acquisition and buy-out programs, transfer of development rights programs, and removal of structures where the right to protection was waived (*i.e.*, via permit condition) are examples of strategies designed to encourage managed retreat.

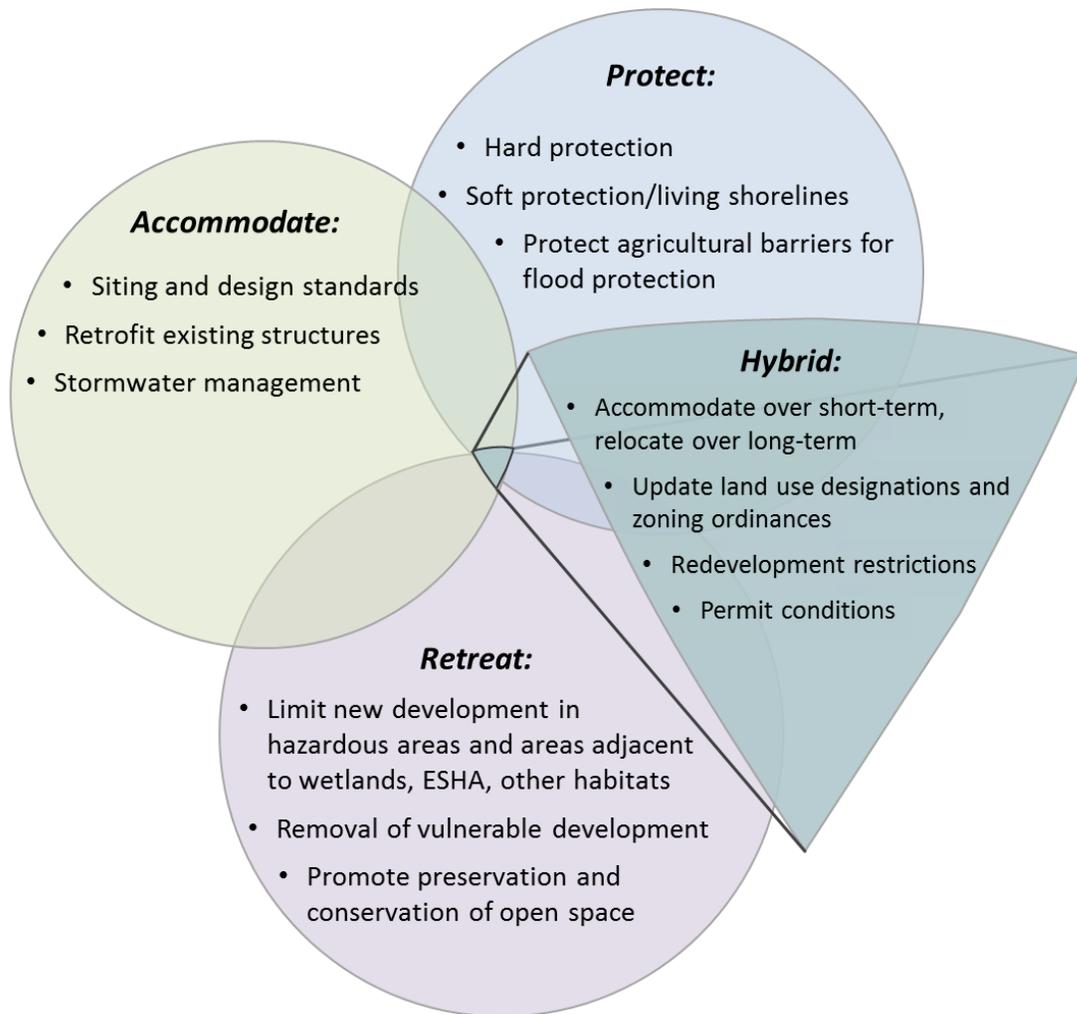


Figure 17. Examples of general adaptation strategies

SPECIFIC ADAPTATION STRATEGIES

The following sections, organized by category of coastal resource, present measures that local governments and coastal planners should consider including in their LCPs or individual CDPs. The purpose of this organization is to allow coastal managers and project applicants to easily find strategies that will help address the specific resource vulnerabilities identified in Steps 1-3 of the LCP and CDP processes laid out in Chapters [5](#) and [6](#). In the development of LCP policies, local governments should use adaptation measures that best implement the statewide resource protection and hazard policies of the Coastal Act at the local level given the diverse geography and conditions of different areas.

As part of identifying adaptation strategies, local governments should carefully examine the potential impacts to coastal resources that could occur from various adaptation strategies. Some adaptation strategies will need to be implemented incrementally over time as conditions change, and many strategies will need to be implemented through both the LCP and CDP to be effective. For each issue area, there is a description of potential impacts that could occur due to sea level rise and a list of adaptation tools or actions to minimize impacts. To skip to a topic, click on the links below.

- A. [Coastal Development and Hazards](#)
- B. [Public Access and Recreation](#)
- C. [Coastal Habitats, ESHA, and Wetlands](#)
- D. [Agricultural Resources](#)
- E. [Water Quality and Supply](#)
- F. [Archaeological and Paleontological Resources](#)
- G. [Scenic and Visual Resources](#)

The lists in these sections should be considered neither checklists from which all options need to be used, nor exhaustive lists of all possible adaptation strategies. Sea level rise adaptation is an evolving field, and policy language, cost considerations, effectiveness of various strategies, and other topics are continuing to be developed. Planners, applicants, and partners will need to think creatively and adaptively respond to changing conditions, new science, and new adaptation opportunities, and the Coastal Commission will continue to support and collaborate on these efforts.

Additionally, sea level rise planning may involve a number of trade-offs among various competing interests, and no single adaptation strategy will be able to accomplish all planning objectives. Economic and social implications of various adaptation options will likely play into the planning process at the local level. The important point is to analyze current and future risks from sea level rise, determine local priorities and goals for protection of coastal resources and development in light of Coastal Act requirements, and identify what land use designations, zoning ordinances, and other adaptation strategies can be used to meet those goals.

A. Coastal Development and Hazards

The Coastal Act requires that new development be sited and designed to be safe from hazards and to not adversely impact coastal resources (Coastal Act Sections 30235 and 30253). The main goals that relate to hazards and coastal development are:

- Update land use designations, zoning maps, and ordinances to account for changing hazard zones
- Include sea level rise in hazard analyses and policies
- Plan and locate new development to be safe from hazards, not require protection over its entire lifespan, and be protective of coastal resources
- Incorporate sea level rise adaptation into redevelopment policies
- Encourage the removal of development that is threatened by sea level rise
- Use “soft” or “natural” solutions as a preferred alternative for protection of existing endangered structures
- Limit bluff and shoreline protective devices to protect existing endangered structures
- Require special considerations for critical infrastructure and facilities
- Protect transportation infrastructure

[Chapter 3](#) of the Guidance covers the impacts to coastal development that might result from sea level rise. Certified LCPs should already have policies and standards to assure that coastal development is safe over its anticipated lifetime and that it does not adversely impact other coastal resources. However, LCP policies and standards may need to be updated in light of new knowledge and to consider sea level rise hazards. Adaptation options have been developed to support the development goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Update land use designations, zoning maps, and ordinances to account for changing hazard zones

A.1 Establish mapped hazard zones or overlays: Update land uses and zoning requirements to minimize risks from sea level rise in identified hazard zones or overlay areas. For example, limit new development in current and future sea level hazard zones and encourage removal of existing development when threatened.

A.1a **Identify zones that require a more rigorous sea level rise hazards analysis:** Specify areas where a closer analysis of sea level rise is necessary at the permit application stage to avoid or minimize coastal hazards and impacts to coastal

resources. Ensure that the most up-to-date information on sea level rise is incorporated in such analyses.

Goal: Include sea level rise in hazard analyses and policies

A.2 Update policies to require sea level rise to be included in hazard analyses and management plans: LCP policies should include requirements to analyze projected sea level rise. Consider specific projection scenarios to be analyzed. (See [Chapter 3](#) of the Guidance for a description of scenario planning.) LCPs could also specify which analyses are required for various types of projects/development (see Step 2 of Chapters [5](#) and [6](#) or [Appendix B](#) for suggested analyses).

- A.2a **Site-specific evaluation of sea level rise:** Update policies, ordinances, and permit application requirements to include a required site-specific evaluation of coastal hazards due to sea level rise over the full projected life of any proposed development. Analyses should be conducted by a certified Civil Engineer or Engineering Geologist with expertise in coastal processes.
- A.2b **Incorporate wave runup zones and sea level rise in coastal flood hazard maps:** Develop coastal flood maps that include areas that will be subject to wave action and flooding due to sea level rise. These maps may be able to rely upon existing flood maps, such as the FEMA Flood Insurance Rate Maps, for current flood areas and base conditions, but should be augmented to include future conditions, including sea level rise, likely to occur through the life of proposed new development.
- A.2c **Incorporate sea level rise into calculations of the Geologic Setback Line:** Update geotechnical report requirements for establishing the Geologic Setback Line (bluff setback) to include consideration of bluff retreat due to sea level rise in addition to historic bluff retreat data, future increase in storm or El Niño events, and any known site-specific conditions. The report should be completed by a licensed Geotechnical Engineer or an Engineering Geologist.
- A.2d **Include sea level rise in wave runup, storm surge, and tsunami hazard assessments⁴⁴:** Sea level rise should be included in wave runup analyses, including storm event and tsunami hazard assessments. This should include evaluating tsunami loads/currents on maritime facilities and coastal structures. Since tsunami wave runup can be quite large, sea level rise projections of only a few inches may not have a large impact on these assessments. However, for time periods or scenarios where sea level rise projections are large (perhaps 1 ft or more), it would be appropriate to include sea level rise because it could change the results to a significant degree.

⁴⁴ Tsunami evacuation maps are based upon current sea level conditions and they will need to be updated with changes in sea level.

A.3 Establish shoreline management plans to address long-term shoreline change due to sea level rise: Create policies that require a management plan for priority areas that are subject to sea level rise hazards, and incorporate the plan into the larger LCP if applicable. Similar to an LCP, shoreline management plans generally include the short and long term goals for the specified area, the management actions and policies necessary for reaching those goals, and any necessary monitoring to ensure effectiveness and success. Incorporate strategies necessary to manage and adapt to changes in wave, flooding, and erosion hazards due to sea level rise.

Goal: Plan and locate new development to be safe from hazards, not require protection over its entire lifespan, and be protective of coastal resources

A.4 Limit new development in hazardous areas: Restrict or limit construction of new development in zones or overlay areas that have been identified or designated as hazardous areas to avoid or minimize impacts to coastal resources and property from sea level rise impacts.

A.5 Cluster development away from hazard areas: Concentrate development away from hazardous areas. Update any existing policies that cluster development to reflect additional hazard zones due to sea level rise.

A.5a **Concentration of development/smart growth:** Require development to concentrate in areas that can accommodate it without significant adverse effects on coastal resources. This strategy is applicable for community wide planning through an LCP, but may also apply to CDPs for subdivisions or for larger developments involving large or multiple lots.

A.5b **Transfer of Development Rights programs (TDR):** Restrict development in one area (“sending area”) and allow for the transfer of development rights to another area more appropriate for intense use (“receiving area”). LCPs can establish policies to implement a TDR program to restrict development in areas vulnerable to sea level rise and allow for transfer of development rights to parcels with less vulnerability to hazards. A TDR program can encourage the relocation of development away from at-risk locations, and may be used in combination with a buy-out program.

A.6 Develop adequate setbacks for new development: Ensure structures are set back far enough inland from the beach or bluff edge such that they will not be endangered by erosion (including sea level rise induced erosion) over the life of the structure, *without the use of a shoreline protective device*. When used to address future risk, setbacks are normally defined by a measurable distance from an identifiable location such as a bluff edge, line of vegetation, dune crest, or roadway. Establish general guidance and criteria for setbacks in LCPs that consider changes in retreat due to sea level rise. Require detailed, site-specific analyses through LCPs and CDPs to determine the size of the setback, taking into consideration sea level rise and establish the expected life of the

structure (for example, the time period over which the setback should be effective).



Figure 18. Photo depicting a development setback in Pismo Beach. (Source: [California Coastal Records Project](#))

- A.7 Limit subdivisions in areas vulnerable to sea level rise:** Prohibit any new land divisions, including subdivisions, lot splits, lot line adjustments, and/or certificates of compliance that create new beachfront or blufftop lots unless the lots can meet specific criteria that ensure that when the lots are developed, the development will not be exposed to hazards or pose any risks to protection of coastal resources.
- A.8 Update development siting, code, and design standards to avoid, minimize, or reduce risks from coastal hazards and extreme events:** Establish and implement building codes and standards for building siting and construction that avoid or minimize risks from flooding and erosion and increase resilience to extreme events within sea level rise hazard zones. Such standards and applicable building code provisions should be included in LCPs as additional development controls in areas that are identified in the LCP as hazard areas, and applied in specific projects through a CDP.
- A.8a Update flood protection measures to incorporate both FEMA and Coastal Act requirements:** Require new development located in areas subject to current or future flood/wave action to be sited and designed to be capable of withstanding such impacts in compliance with both FEMA and Coastal Act requirements. For example, ensure that implementation of adaptation measures such as elevation of habitable areas, break-away walls, *etc.* will be consistent with both LCP and FEMA provisions.

- A.8b **Limit basements and first floor habitable space:** Where applicable, in areas likely to be subject to current or future flood/wave action, revise residential building standards to prohibit habitable space at elevations subject to wave/flood risk. Specifically address potential impacts of basements on long-range adaptation options such as landward relocation or removal.
- A.8c **Evaluate impacts from flood protection measures:** Require new development that must be located in areas likely subject to current or future flood/wave action or elevated groundwater to evaluate potential impacts to adjacent or nearby properties from all proposed structural flood protection measures to ensure that these measures will not create adverse direct and/or cumulative impacts either on-site or off-site.

A.9 Analyze options for removal when planning and designing new development: Design options should not place an undue burden on future property owners or coastal resources. For new development in high hazard areas or resource-constrained areas where managed retreat might be an appropriate option at some time in the future, ensure that foundation designs or other aspects of the development will not preclude future incremental relocation or managed retreat. Foundation and building elements, such as deepened perimeter foundations, caissons or basements, may be difficult to remove in the future, or their removal may put adjacent properties at risk. Alternative design options should be considered, and employed if site conditions allow.

- A.9a **Develop a plan to remove or relocate structures that become threatened:** Require new development authorized through a CDP that is subject to wave action, erosion, or other hazards to be removed or relocated if it becomes threatened in the future.
- A.9b **Identify triggers for incremental removal of structures on constrained lots:** When a lot is not large enough to accommodate development that avoids coastal hazards for the expected life of the development, develop a project option that minimizes hazards from the identified sea level rise scenarios for as long as possible, and then requires incremental retreat once certain triggers are met.

Triggers for relocation or removal of the structure would be determined by changing site conditions such as when erosion is within a certain distance of the foundation; when monthly high tides are within a certain distance of the finished floor elevation; when building officials prohibit occupancy; or when the wetland buffer area decreases to a certain width.
- A.9c **Avoid shoreline protection for new development:** Require CDPs for new development in hazardous locations to include as a condition of approval a waiver of rights to future shoreline protection that would substantially alter natural landforms or cause other adverse coastal resource impacts.
- A.9d **Limit the use of foundations or basements that can interfere with coastal processes:** In locations where foundation or building elements, such as deepened perimeter foundations, caissons or basements may be exposed to wave action through rising sea level or erosion, require analysis of less extensive foundation or building options.

- A.9e **Develop triggers for foundation and structure removal:** If no less damaging foundation alternatives are possible, ensure that the foundation design allows for incremental removal as the foundation elements become exposed, and develop pre-established triggers, for example when the bluff edge or shoreline comes within a certain distance of the foundation, for incremental or complete removal that will avoid future resource impacts.



Figure 19. Photo depicting eroding bluff and exposed caissons in Encinitas, CA. (Photograph by Lesley Ewing)

- A.10 Ensure that current and future risks are assumed by the property owner:** New development should be undertaken in such a way that the consequences from development in high hazard areas will not be passed on to public or coastal resources. Recognize that over time, sea level rise will cause the public trust boundary to move inland. Establish standards, permit conditions, and deed restrictions that ensure that current and future risks are assumed by the property owner. Consider policies that would encourage or require property owners to set aside money, such as in the form of a bond, as a contingency if it becomes necessary to modify, relocate, or remove development that becomes threatened in the future.
- A.11 Real estate disclosure:** Require sellers of real estate to disclose permit conditions related to coastal hazards, or property defects or vulnerabilities, including information about known current and potential future vulnerabilities to sea level rise, to prospective buyers prior to closing escrow.

Goal: Incorporate sea level rise adaptation into redevelopment policies

A.12 Avoid the expansion or perpetuation of existing structures in at-risk locations: On an eroding shoreline, the seaward portions of an existing structure may become threatened as the setback or buffer zone between the structure and the mean high tide line or bluff edge is reduced due to erosion of the beach or bluff. When the seaward portion of the structure no longer meets the standards or setback that would be required for new development, it becomes a “non-conforming” structure for purposes of redevelopment policies and regulations. The following should be considered, as consistent with the Coastal Act, FEMA policies, and other relevant standards, to address existing non-conforming development to avoid the need for shoreline or bluff protective devices and associated impacts to coastal resources.

- A.12a **Update non-conforming structure policies and definitions:** Develop policies and regulations to define non-conforming development in the area between the sea and the first coastal roadway or other known hazard zones to avoid perpetuating development that may become at risk and require a new protective device or extend the need for an existing protective device.
- A.12b **Limit redevelopment or upgrades to existing structures in at risk locations:** Use redevelopment policies or regulations to limit expansions, additions, or substantial renovations of existing structures in danger from erosion. Require removal of non-conforming portions of the existing structure, when possible, when a remodel or renovation is proposed.
- A.12c **Limit foundation work within the geologic setback area:** To facilitate removal of non-conforming portions of an existing structure, use LCP regulations and CDPs to limit new or replacement foundations or substantial improvements, other than repair and maintenance, to the existing foundation when located seaward of the Geologic Setback line. Approve significant new foundation work only when it is located inland of the setback line for new development and when it will not interfere with coastal processes in the future.
- A.12d **Limit increases to existing non-conformities:** Use LCP regulations and CDPs to allow non-exempt repair and maintenance and modifications only if they do not increase the size or degree of non-conformity of the existing structure. For shoreline or blufftop development, any decrease in the existing non-conforming setback would increase the degree of non-conformity.
- A.12e **Limit additions to non-conforming structures:** Use LCP regulations and CDPs to acknowledge that additions to existing structures should be considered new development that must conform to the standards for new development including but not limited to avoiding future protective devices. Consider limitations on the size of additions unless non-conforming portions of the structure are removed.
- A.12f **Address existing protection of non-conforming structures:** Use LCP regulations and CDP conditions to put current and future property owners on notice that if there is currently shoreline or bluff protection for an existing structure, the structure is likely at-risk and improvements to that structure in its current location may be limited. Also, consider acknowledging that any rights to

retain the existing protective device(s) apply only to the structure that existed at the time the protective device was constructed or permitted.

A.13 Redevelopment of existing structures: Define “redevelopment” as, at a minimum, replacement of 50% or more of an existing structure. Other options that may be used to define what constitutes redevelopment or a replacement structure could include 1) limits on the extent of replacement of major structural components such as the foundation or exterior walls, or 2) improvements costing more than 50% of the assessed or appraised value of the existing structure. The redevelopment definition should take into consideration existing conditions and pattern of development, potential impacts to coastal resources, and the need for bluff or shoreline protective devices if the structure remains in its current, non-conforming location.

A.13a **Require redevelopment to meet the standards for new development:** Use LCPs and CDPs to require that renovations meeting the threshold for redevelopment should not be approved unless the entire structure meets the standards for new development, including but not limited to a waiver of right to protection. Specify that if any existing non-conforming elements are permitted to remain, those non-conforming elements are not subject to rights to protection pursuant to Coastal Act Section 30235.

A.13b **Include cumulative improvement or additions to existing structures in the definition of redevelopment:** Use LCP regulations to acknowledge that demolition, renovation, or replacement of less than 50% (or less) of an existing structure constitutes redevelopment when the proposed improvements would result cumulatively in replacement of more than 50% of the existing structure from an established date, such as certification of the LUP.

A.14 Remove existing shoreline protective devices: On properties with existing shoreline protective devices, use regulations to require removal of the protective device when the structure requiring protection is redeveloped or removed. If removal is not possible, require a waiver of any rights to retain the protective device to protect any structure other than the one that existed at the time the protective device was constructed or permitted.

Goal: Encourage the removal of development that is threatened by sea level rise

A.15 Use Rolling Easements: The term “rolling easement” refers to the policy or policies intended to allow coastal lands and habitats including beaches and wetlands to migrate landward over time as the mean high tide line and public trust boundary moves inland with sea level rise. Such policies often restrict the use of shoreline protective structures (such as the “no future seawall” limitation sometimes used by the Commission), limit new development, and encourage the removal of structures that are seaward (or become seaward over time) of a designated boundary. This boundary may be designated based on such variables as the mean high tide line, dune vegetation line, or other dynamic line or legal requirement. Despite the term “rolling easements,” not all of the strategies related to rolling easements actually involve the use of recorded easements.

- A.16 Develop an incentive program to relocate existing development at risk:** Provide incentives to relocate development out of hazardous areas and to acquire oceanfront properties damaged by storms, where relocation is not feasible. Consider creating a relocation fund through increased development fees, *in lieu* fees, or other funding mechanisms.
- A.17 Transfer of Development Rights programs (TDR):** See Strategy A.5b above.
- A.18 Acquisition and buyout programs:** Acquisition includes the acquiring of land from the individual landowner(s). Structures are typically demolished or relocated, the property is restored, and future development on the land is restricted. Such a program is often used in combination with a TDR program that can provide incentives for relocation. Undeveloped lands are conserved as open space or public parks. LCPs can include policies to encourage the local government to establish an acquisition plan or buyout program to acquire property at risk from flooding or other hazards.

Goal: Use “soft” or “natural” solutions as a preferred alternative for protection of existing endangered structures

- A.19 Require the use of green infrastructure as a preferred alternative:** Under appropriate shoreline conditions, require or encourage development to use “soft” or “natural” solutions or “living shorelines” as an alternative to the placement of hard shoreline protection in order to protect development or other resources and to enhance natural resource areas. Examples of soft solutions include vegetative planting, dune restoration, and sand nourishment.
- A.19a Establish a beach nourishment program and protocols:** New policies may be needed to address increased demand or need for beach nourishment with sea level rise. Policies within an LCP may identify locations where nourishment may be appropriate; establish a beach nourishment program and protocols for conducting beach nourishment; establish criteria for the design, construction, and management of the nourishment area; and/or establish measures to minimize adverse biological resource impacts from deposition of material, such as sand compatibility specifications, timing or seasonal restrictions, and identification of environmentally preferred locations for deposits. Beach nourishment programs should also consider how nourishment options may need to change over time as sea level rises.
- A.19b Dune management:** Establish management actions to maintain and restore dunes and natural dune processes. Dunes provide buffers against erosion and flooding by trapping windblown sand, storing excess beach sand, and protecting inland areas, and they also provide habitat. This is likely most effective for areas with some existing dune habitat and where there is sufficient space to expand a foredune beach for sand exchange between the more active (beach) and stable (dune) parts of the ecosystem. LCPs can identify existing dune systems and develop or encourage management plans to enhance and restore these areas,

including consideration of ways that the system will change with rising sea level. CDPs for dune management plans may need to include periodic reviews so the permitted plans can be updated to address increased erosion from sea level rise, and the need for increased sand retention and replenishment.



Figure 20. Photo depicting dune restoration at Surfer's Point, Ventura. (Photograph courtesy of Surfrider Foundation)

- A.19c **Regional Sediment Management (RSM) programs:** Develop a Regional Sediment Management (RSM) program including strategies designed to allow the use of natural processes to solve engineering problems. To be most effective, RSM programs include the entire watershed, account for effects of human activities on sediment, protect and enhance coastal ecosystems, and maintain safe access to beaches for recreational purposes. LCPs can support development of an RSM program and its implementation, and the program should be periodically updated to address on-going changes from sea level rise. Natural boundaries for RSM may overlap within several LCPs, so regional cooperation may be needed for best implementation. Individual actions such as a beach nourishment project would be accomplished through a CDP. Many coastal RSM programs have already been developed and can be used as a resource. See the *Coastal Sediment Management Workgroup website* (and [Appendix C](#)) for more information.
- A.19d **Maintenance or restoration of natural sand supply:** Adjustment of the sediment supply has been one of the ways natural systems have accommodated

changes from sea level. Maintenance or restoration of sediment involves identifying natural sediment supplies and removing and/or modifying existing structures or actions that impair natural sand supply, such as dams or sand mining. LCPs could include policies and implementing standards that support nature-based responses to sea level rise by maintaining and restoring natural sand supply. Where applicable, develop policies and standards to prohibit sand mining, regulate sand replenishment, and promote removal of dams or the by-passing of sand around dams. Plans should take into consideration changes in sand supply due to sea level rise and may identify and designate high priority areas for restoring natural processes. These actions and policies can also be implemented through a Regional Sediment Management (RSM) program.

- A.19e **Beneficial reuse of sediment through dredging management:** Dredging involves the removal of sediment from harbor areas to facilitate boat and ship traffic or from wetland areas for restoration. Dredging management actions and plans may need to be updated to account for elevated water levels. Policies can be developed with an LCP and/or carried out through a CDP to facilitate delivery of clean sediment extracted from dredging to nearby beaches or wetland areas where needed. Beneficial reuse of sediment in this way can be coordinated through a Regional Sediment Management (RSM) program and/or through coordination with other jurisdictions.

Goal: Allow bluff and shoreline protective devices only to protect existing endangered structures

- A.20 Use hard protection only if allowable and if no feasible less damaging alternative exists:** “Hard” coastal protection is a broad term for most engineered features such as seawalls, revetments, cave fills, and bulkheads that block the landward retreat of the shoreline. In some cases, caissons and pilings may also be considered hard shoreline protective devices. Due to adverse effects on shoreline sand supply and beach area available for public use, such protective devices should be avoided when feasible. Under current law, shoreline protection for existing structures in danger from erosion may be allowed if coastal resource impacts are avoided or minimized and fully mitigated where unavoidable.

- A.20a **Retention of existing shoreline protection:** On intensely developed, urbanized shorelines, if the removal of armoring would put existing development at risk and not otherwise result in significant protection or enhancement of coastal resources, it may be appropriate to allow properly designed shoreline armoring to remain for the foreseeable future, subject to conditions that provide for potential future removal in coordination with surrounding development. However, the proper short term responses, longer term adaptation measures, and mitigation of on-going resource impacts should be determined through updated context-specific LCP planning and consideration of the existing rights and responsibilities of development in the area (see strategies A.21 – A.25).

A.21 Require monitoring of the structure: Require periodic monitoring of the shoreline protective device to examine for structural damage, excessive scour, or other impacts from coastal hazards and sea level rise. Ensure that the structures remain within the initial footprint and that they retain functional stability.

A.22 Conditional approval of shoreline protective device: Use LCP regulations and permit conditions to require monitoring of impacts to shoreline processes and beach width both at the project site and the broader area and/or littoral cell as feasible, and provide for such actions as removal or modification of armoring in the future if it is no longer needed for protection or if site conditions change.

A.22a **Limit the authorization of shoreline protective devices to the development being protected:** Use LCP regulations and CDP conditions to require permits for bluff and shoreline protective devices to expire when the currently existing structure requiring protection is redeveloped, is no longer present, or no longer requires a protective device, whichever occurs first. Prior to expiration of the permit, the property owner should apply for a Coastal Development Permit to remove the protective device, or to modify or retain it if removal is not feasible at that time.

A.22b **Require assessment of impacts from existing pre-Coastal Act or permitted shoreline armoring:** Use LCP regulations and permit conditions to specify that expansion and/or alteration of a pre-Coastal Act or legally permitted bluff or shoreline protective device requires a new CDP and the review should include an assessment of changes to geologic site and beach conditions including but not limited to, changes in beach width relative to sea level rise, implementation of any long-term, large scale sand replenishment or shoreline restoration programs, and any ongoing impacts to public access and recreation from the existing device.

A.22c **Reassess impacts and need for existing armoring over time:** Use LCP regulations and CDPs to provide for reassessment of the impacts from protective devices at specific trigger points, including when substantial improvement or redevelopment of the structure requiring protection is proposed, or when existing armoring is being modified or expanded. Reassessment should consider the effect any significant improvement to a structure requiring protection will have on the length of time the protective device will remain, and if the existing armoring is still required, acknowledge that it is authorized to protect the existing structure only. The CDP review should assess existing site conditions and evaluate options to modify, replace, or remove the existing device in a manner that would eliminate or mitigate any identified impacts that may be occurring on public access and recreation, scenic views, sand supply, and other coastal resources, if feasible.

A.23 Require mitigation for impacts of shoreline protective devices: For unavoidable public resource impacts from shoreline structures permitted under the Coastal Act, require mitigation of resource impacts over the life of the structure as a condition of approval for the development permit. For example, require landowners to pay mitigation fees and/or complete other mitigation actions for the loss of sandy beach and other

adverse impacts on public access and recreation due to shoreline protection devices. Importantly, mitigation measures should be planned in such a way that sea level rise will not impair their efficacy over time. Other mitigation measures could include acquisition of other shoreline property for public recreational purposes, construction of public access and recreational improvements along the shoreline, and/or easements to protect lateral access along the shoreline in areas where seawalls eliminate sandy beach.

A.23a **Reassess mitigation over time as necessary:** Impacts of shoreline structures, including to shoreline and sand supply, public access and recreation, ecosystem values, and other relevant coastal resources, should be fully mitigated. Where reassessment of an approved structure is authorized, phasing of necessary mitigation may be appropriate.

A.24 Limit retention of existing shore protection: On lots with existing pre-Coastal Act or permitted armoring, consider requiring a waiver of rights to retain such protection for any structures other than the structure that existed at the time the armoring was constructed or permitted.

A.25 Removal of shoreline protection structures: The removal of shoreline protection structures can open beach or wetland areas to natural processes and provide for natural responses to sea level rise. LCPs can specify priority areas where shoreline protection structures should be removed if they are no longer needed or in a state of great disrepair, including areas where structures threaten the survival of wetlands and other habitats, beaches, trails, and other recreational areas. Once these priority areas have been identified, assessment of potential re-siting of structures and removal of armoring could be required by a CDP as redevelopment occurs.

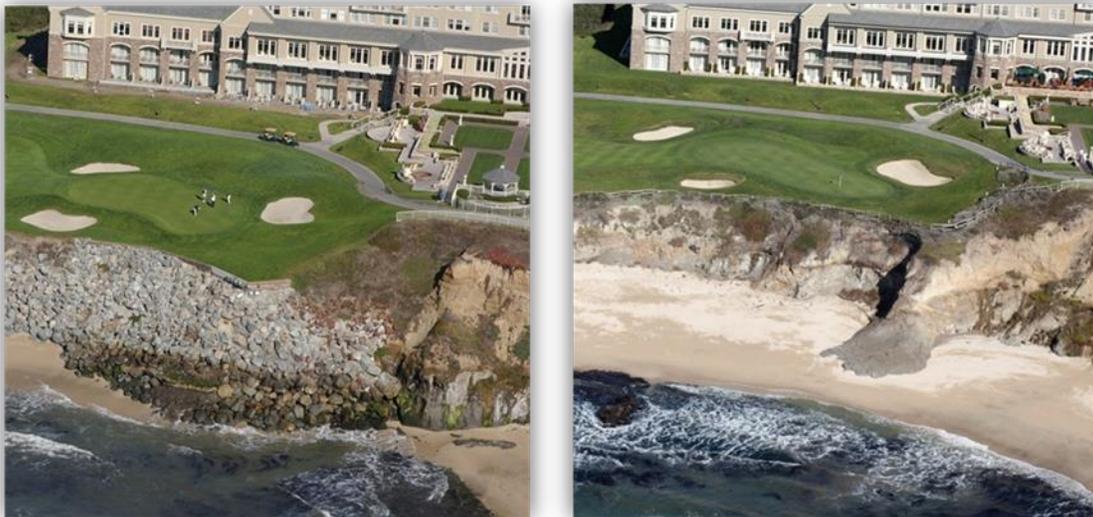


Figure 21. Photo depicting removal of shoreline protective structure. Removal of rock revetment restores access and allows natural bluff erosion at the Ritz Carlton in Half Moon Bay. (Source: [California Coastal Records Project](#))

A.25a **Remove shoreline protective structures located on public lands:** Over time, sea level rise will cause the public trust boundary to move inland. If the structures

as originally approved were located on uplands but that land becomes subject to the public trust in the future, the State Lands Commission or any local government or other entity acting as trustee for public trust lands could require the structures to be removed. The Commission or local governments could approve permit conditions to ensure permittees obtain authorization to retain or remove structures if they ever become located on public trust lands. Removal might also be accomplished through non-regulatory means such as offering incentives for removal to property owners or by incorporating removal of public structures into Capital Improvement Plans.

Goal: Require special considerations for critical infrastructure and facilities

A.26 Plan ahead to preserve function of critical facilities: Addressing sea level rise impacts to critical facilities and infrastructure will likely be more complex than for other resources and may require greater amounts of planning time, impacts analyses, public input, and funding. To address these complexities, establish measures that ensure continued function of critical infrastructure, or the basic facilities, service, networks, and systems needed for the functioning of a community. Programs and measures within an LCP could include identification of critical infrastructure that is vulnerable to SLR hazards, establishment of a plan for managed relocation of at-risk facilities, and/or other measures to ensure functional continuity of the critical services provided by infrastructure at risk from sea level rise and extreme storms. Repair and maintenance, elevation or spot-repair of key components, or fortification of structures where consistent with the Coastal Act may be implemented through CDPs.

A.26a **Develop or update a long-term public works plan for critical facilities to address sea level rise:** Develop a long-term management plan to address the complexities of planning for sea level rise that incorporates any potential maintenance, relocation, or retrofits and structural changes to critical facilities to accommodate changes in sea level, and obtain Coastal Commission certification.

A.27 Apply high sea level rise projections for siting and design of critical facilities: Given the planning complexities, high costs, and potential impacts resulting from damage, there is reason to be particularly cautious when planning and designing new critical facilities and/or retrofitting existing facilities. Ensure that critical facilities are designed to function even if the highest projected amounts of sea level rise occur and that sites with hazardous materials are protected from worst-case scenario sea level rise impacts.

A.27a **Design coastal-dependent infrastructure to accommodate worst case scenario sea level rise:** Include policies that would require proposals and/or expansion plans to address sea level rise for coastal dependent infrastructure that must necessarily be sited in potentially hazardous areas, such as industrial, energy, and port facilities. Such facilities should be designed to withstand worst case future impacts while minimizing risks to other coastal resources through initial siting, design, and/or inclusion of features that will allow for future adaptation.

A.28 Site and design wastewater disposal systems to avoid risks from sea level rise:

Wastewater treatment and disposal systems are particularly challenging in that they are often located in areas that will be impacted by sea level rise. Ensure that these systems are not adversely affected by the impacts of sea level rise over the full life of the structure and ensure that damage to these facilities would not result in impacts to water quality or other coastal resources. Avoid locating new facilities in hazardous areas if possible. If complete avoidance is not possible, minimize elements of the system that are in hazardous areas (for example, locate the main facility on higher ground and only place pump stations in potentially hazardous areas), and design any facilities in hazardous areas to withstand worst-case scenario sea level rise impacts.

Goal: Protect transportation infrastructure

A.29 Identify priorities for adaptation planning and response: Carry out vulnerability analyses to identify chronic problem areas that are highly subject to erosion, wave impacts, flooding, or other coastal hazards or that maybe become so in the near future. Coordinate with Caltrans and local public works/transportation agencies to address high priority areas and increase monitoring efforts of chronic problem areas.

A.30 Add policies to address impacts to transportation routes: If transportation facilities are at risk from sea level rise, coordinate with Caltrans and local public works/transportation agencies to establish new alternative transportation routes or a plan to ensure continued alternative transportation and parking is available that allows for continued access to beaches and other recreation areas.

A.30a Integrate LCP/land use planning processes with transportation planning processes: Updates and changes to LCPs and other land use planning efforts should be jointly planned, evaluated, and implemented with Coordinated System Management Plans, Regional Transportation Plans, and other transportation planning efforts to ensure that long-term land use and access goals and needs are aligned.

A.31 Allow for phased implementation of realignment and relocation projects: In some cases it may be necessary to make incremental changes in transportation networks so that access to and along the coast can be maintained while also addressing coastal hazards over the long-term. For example, a phased approach may allow for interim shoreline protection to maintain an existing road alignment while future realignment plans are evaluated and pursued. Such phased approaches should be coordinated with Caltrans and local public works/transportation agencies and aligned with long-term LCP planning and adaptation goals. Individual projects will be implemented through CDPs.



Figure 22. Photo depicting planned retreat for major public infrastructure. The Piedras Blancas Highway 1 Realignment will move nearly 3 miles (5km) of Highway 1 500 ft (152 m) inland. (Source: [California Coastal Records Project](#))

A.32 Plan and design transportation systems to accommodate anticipated sea level rise impacts: Ensure that transportation networks are designed to function even if the highest projected sea level rise amounts occur. Efforts to realign, retrofit, and/or protect infrastructure should be coordinated with Caltrans, local public works/transportation agencies, and LCP planning efforts, and individual projects will be implemented through CDPs.

A.32a **Retrofit existing transportation infrastructure as necessary:** In instances where relocation is not an option, repair damage and/or retrofit existing structures to better withstand sea level rise impacts. For example, use stronger materials, elevate bridges or sections of roadways, and build larger or additional drainage systems to address flooding concerns.

A.32b **Build redundancy into the system:** Provide alternate routes, as possible, to allow for access to and along the coast in instances in which sections of roadways may become temporarily impassible as a result of coastal hazards. Ensure that alternate route information is provided to residents and visitors to coastal areas.

A.33 Incorporate sea level rise considerations into Port Master Plans and other port activities: Ensure that ports and related infrastructure are designed to function given anticipated sea level rise. In some cases, this may mean initially designing structures to accommodate projected sea level rise impacts. Other options may include planning for and ensuring capacity for future adaptive actions.

A.33a **Retrofit existing port infrastructure as necessary:** Given the coastal-dependent nature of many port structures, it may not be feasible to site or relocate development to avoid hazards. In these instances it may be more appropriate to include efforts to accommodate and withstand sea level rise during actions to

repair or retrofit existing structures. Options may include using more robust designs or materials or elevating structures.

- A.33b **Minimize resource impacts that may result from future use of shoreline protective structures:** If existing, coastal-dependent port structures require shoreline protective structures, minimize resource impacts as feasible and consistent with Chapter 3 and/or Chapter 8 of the Coastal Act, as applicable, by encouraging inland expansion of protective devices rather than further fill of coastal waters.
- A.33c **Ensure that linkages to overland transportation networks are able to adapt to sea level rise impacts:** Coordinate with relevant stakeholders to ensure that linkages between port infrastructure and overland transportation networks will be resilient to future sea level rise impacts.
- A.33d **Ensure that lessees and other parties understand sea level rise risks and vulnerabilities:** Coordinate with lessees and other stakeholders to ensure that they understand the risks associated with development in hazard areas as well as the responsibilities that come with such development.

B. Public Access and Recreation

One of the highest priorities in the Coastal Act is the mandate to maximize public access and recreational opportunities to and along the coast. The main goals and Coastal Act policies (Sections 30210, 30220, 30221, 30213) that relate to public access and recreation are to:

- Maximize public access and recreational use by protecting beaches and other coastal areas suitable for such use
- Protect lower cost visitor and recreational facilities and accessways

[Chapter 3](#) of the Guidance covers the impacts to public access and recreation that might result from sea level rise or the interaction of sea level rise with development patterns. Certified LCPs should already have policies and standards to assure that existing public access and visitor serving amenities are protected and that maximum public access is both planned for and provided with new development when warranted. However, LCP policies and standards may need to be updated to consider sea level rise hazards. Adaptation options have been developed to support the access goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Maximize public access and recreational use by protecting beaches and other coastal areas

B.1 Incorporate sea level rise into a comprehensive beach management strategy: Update or develop a new comprehensive beach management strategy to address loss of beach areas, including loss of lateral access, or changes in beach management due to sea level rise. Establish a program to minimize loss of beach area through, as may be appropriate, a beach nourishment program; restoring sand and sediment supply to the littoral cell; removal, adjustments, or maintenance to shoreline protection structures; use of man-made structures such as terminal groins or artificial reefs to retain sediment; or other actions.

B.1a Develop a sediment management and sand replenishment strategy: Identify natural sediment supplies and remove and/or modify existing structures or actions that impair natural sand supply, such as dams or sand mining. LCPs could include policies and implementing standards that support nature-based responses to sea level rise by maintaining and restoring natural sand supply. Where applicable, develop policies and standards to prohibit sand mining, regulate sand replenishment, and promote removal of dams or the by-passing of sand around dams. Plans should take into consideration changes in sand supply due to sea level rise. These actions and policies can also be implemented through a Regional Sediment Management (RSM) program.

- B.2 Plan ahead to replace loss of access and recreation areas:** Identify replacement opportunities or otherwise plan ahead for how to replace recreation areas and accessways that will be lost due to inundation or damage associated with sea level rise. An LCP could designate and zone lands for this through, for example, a phased overlay or other regulatory measures that ensure that access and recreational areas are available in the future. Local governments may choose to provide additional incentives to encourage creation of new recreation areas or opportunities. Such incentives could include grant for protection new recreation areas or tax breaks for recreation related businesses.
- B.2a **Protect existing open space adjacent to the coast:** Plan for future coastal recreational space and parkland by protecting open space adjacent to coastal habitats so that beaches and other habitats can migrate or so that there is open space available as parkland or other areas are lost.
- B.2b **Plan for removal of structures that limit inland migration of beaches:** Seawalls and other development adjacent to beaches and other coastal habitats will impede the ability of these habitats to migrate inland and will therefore result in the inundation and eventual loss of these areas. Consideration should be given to removing and relocating these structures to ensure that beaches and other habitats are able to persist over time. Additional detail on removal of structures can be found above in the “Coastal Development and Hazards” section of this chapter.

Goal: Protect lower cost visitor and recreational facilities and accessways

- B.3 Site and design access sites and facilities to minimize impacts:** Add policies that require public access sites, segments of the CCT, and recreation and visitor-serving facilities to be sited and designed to avoid impacts from sea level rise, while maximizing public access and recreation opportunities. Examples of siting and design standards for development can be found in section A. Where facilities can be safely sited for the near term but future impacts are likely, require an adaptive management plan detailing steps for maintenance, retrofitting, and/or relocation.
- B.3a **Require mitigation of any unavoidable impacts:** For unavoidable impacts to public access or recreation from shoreline armoring or other development, require mitigation of impacts through the addition of new public access, recreation opportunities, visitor-serving accommodations, or Coastal Trail segments, or payment of fees to fund such improvements. Importantly, mitigation measures should be planned in such a way that, if possible, sea level rise will not impair their efficacy over time.
- B.4 Plan ahead to replace loss of visitor-serving and recreational facilities:** Develop a plan to replace any visitor-serving facilities that are lost due to impacts from sea level rise, maximizing continued provision of affordable options and an appropriate mix of accommodations over time. For example, an LCP could include standards to re-site existing visitor-serving and recreational facilities when they become impacted by sea

level rise and/or could identify and zone for future areas to be reserved for these functions.

B.5 Add requirements for retrofit/relocation of public access and recreation sites at risk:

The LCP can add policies that require all new public access and recreation areas, sections of the CCT, visitor- serving accommodations, or related recreation facilities to be retrofitted or relocated if they become threatened from erosion, flooding, or inundation. For new facilities and public access sites, the CDP conditions of approval can specify how maintenance, retrofit, or relocation will take place. Policies and plans should be designed to be adaptive so that retrofits and or/relocations are implemented as sea level rise impacts occur.

B.5a Retrofit or relocate recreation and visitor-serving facilities: Consider options to retrofit existing recreation and visitor-serving facilities to better accommodate sea level rise impacts. Such retrofits could include use of different building materials and/or relocating facilities.

B.5b Retrofit or relocate vertical accessways: Consider options to retrofit existing accessways to reduce impacts from sea level rise. Such retrofits could include using different materials that can better withstand impacts, or re-orienting the layout or other features of accessways to lessen damage and other impacts. Also begin to plan for and identify triggers and options for relocating accessways over time as conditions change.

B.5c Retrofit or relocate sections of the Coastal Trail: Use boardwalks, bridges, and/or other design features to ensure continuity of the CCT in sections that are vulnerable to SLR hazards. Some sections may need to be relocated over time. An LCP could identify vulnerable sections of the CCT and establish a phased approach to relocate sections of the trail in such a way that is consistent with provisions of the Coastal Act and ensures that the CCT remains within sight, sound, or smell of the sea.

Goal: Foster efforts to better understand impacts of sea level rise

B.6 Support research on impacts to recreation and public access: Changes in sea level will affect wave conditions and sediment transport, but additional research is needed to understand how these changes will affect specific conditions for surfing and other recreation activities. While such research programs may be outside the scope of individual local jurisdictions, statements of support for the local issues that need to be addressed can help guide research agendas at the regional state or federal level. Or, such needs can serve to guide grant applications to undertake the needed projects within a jurisdiction. To the extent possible, add policies to promote research on sea level rise impacts to recreational activities like surfing or other coastal recreational uses in the LCP jurisdiction.

C. Coastal Habitats, ESHA, and Wetlands

The Coastal Act provides for the protection of both land and marine habitats. It mandates that ESHA and marine resources shall be protected against significant disruption of habitat value and shall be maintained, enhanced, and restored as feasible (Sections 30230, 30233, 30240, 30240(a), 30240(b)). The main goals and Coastal Act policies that relate to coastal habitats are to:

- Protect, enhance, and restore sensitive habitats
- Avoid significant disruption to sensitive habitats
- Avoid significant impacts to habitats from adjacent development
- Manage sediment in ways that benefit habitats

[Chapter 3](#) of the Guidance covers the impacts to coastal habitats and resources that might result from sea level rise or the interaction of sea level rise with development patterns. Certified LCPs should already have policies and standards to ensure that ESHA, wetlands, and other coastal habitats and resources are protected to the maximum extent feasible. However, LCP policies and standards may need to be updated to consider sea level rise hazards. Adaptation options have been developed to support the habitat protection goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Protect, enhance, and restore sensitive habitats

- C.1 Open space preservation and conservation:** Preserve land for its ecological or recreational value. This may involve limiting or prohibiting development and any uses that conflict with ecological preservation goals. LCPs can establish transfer of development rights programs to offset reduced development potential and can develop open space management plans that evaluate and consider the impacts of sea level rise, extreme events, and other climate change impacts. LCPs can establish open space and conservation areas through land use designations and zoning, redevelopment restrictions, acquisition and easement programs, and setback and buffer requirements.
- C.1a **Update policies to provide for new or restored coastal habitat:** Update policies to require new coastal habitat to be provided or for degraded areas to be restored to account for the expected loss of existing habitat that will occur when development blocks the necessary upland migration due to sea level rise. Use an adaptive management approach where applicable. Encourage policies that provide for conservation or restoration of multiple habitat types.
- C.1b **Identify areas for public acquisition:** New or updated LCPs can establish a program to partner with state, federal, and non-profit organizations to acquire and protect natural resource areas for public use, including areas that could serve as

refugia for species impacted by sea level rise, or areas that could be appropriate sites for coastal habitat creation or restoration.

- C.1c **Establish conservation easements or other development restrictions to protect habitat:** Establish a formalized program to identify, acquire, and manage areas appropriate for some form of conservation protection. Easements or other strategies may be used to limit or restrict development on portions of a lot parcel that are most vulnerable to SLR impacts. The program might develop standard agreements to be used for easements and identify the entities that could hold the easements. A conservation easement program could be established on a community wide basis through an LCP and implemented on a parcel by parcel basis through individual CDPs.
- C.1d **Require open space protection as a component of new development located adjacent to coastal habitats:** The LCP can require permit conditions for new development in certain areas that buffers around natural resource areas be protected through a conservation easement, deed restrictions, or other comparable mechanism.
- C.1e **Use Rolling Easements:** See Strategy A.15 above.
- C.1f **Transfer of Development Rights programs (TDR):** See Strategy A.5b above.

Goal: Avoid significant disruption to habitats

- C.2 **Use ecological buffer zones and/or increase the size of buffers:** Buffer zones are intended to protect sensitive habitats from the adverse impacts of development and human disturbance. An important aspect of buffers is that they are distinct ecologically from the habitat they are designed to protect. LCPs can establish requirements for ecological buffers and provide guidance on how to establish or adjust these buffers to accommodate sea level rise. CDPs should require buffers to be designed, where applicable, to provide “habitat migration corridors” that allow sensitive habitats and species to migrate inland or upland as sea level rises.
 - C.2a **Consider sea level rise buffer zones:** Update buffer zone policies to allow room for coastal habitats to migrate with changes in sea level. The size of the buffer needed to allow for migration will vary depending on the individual wetland or habitat type, as well as site-specific features such as natural or artificial topography and existing development. For instance, in flat areas, a larger buffer may be needed, but in steep areas, a smaller buffer may be acceptable.
- C.3 **Avoid impacts to Marine Protected Areas:** Recognize the importance of the State’s network of marine protected areas (MPAs) in protecting the diversity and abundance of marine life. Understand that planning and permitting decisions made on land could have impacts on these areas, particularly as conditions change with sea level rise, and avoid disruptions to these habitats as feasible and applicable.
- C.4 **Protect specific ESHA functions:** Environmentally Sensitive Habitat Areas (ESHA) are areas that are critically important for the survival of species or valuable for maintaining

biodiversity. These areas can include nursery grounds, spawning areas, or highly diverse areas. Where at risk from sea level rise, the LCP should establish measures to ensure the continued viability of the habitat areas, such as protection of migration zones, habitat corridors, and other applicable adaptation strategies, as listed below. ESHA that is not at risk from sea level rise should also be afforded special protection in the LCP to serve as refugia.

- C.4a **Protect wildlife corridors, habitat linkages, and land upland of wetlands to allow habitat migration:** Preserve open areas that are adjacent to wetlands to allow for migration of these habitats as sea levels rise.
- C.4b **Protect refugia areas:** Protect refugia, or areas that may be relatively unaltered by global climate change and thus can serve as a refuge for coastal species displaced from their native habitat due to sea level rise or other climate change impacts.
- C.4c **Promote increased habitat connectivity to allow species movement:** Connectivity refers to the degree to which the landscape facilitates animal movement and other ecological flows. Roads, highways, median barriers, fences, walls, culverts, and other structures can inhibit movement of animals. Develop LCP policies that will enable identification of important animal movement corridors. Develop regulations to protect these corridors for present and future conditions, taking into account habitat shifts from climate change. In LCPs and through CDPs, require that new structures such as highways, medians, bridges, culverts, and other development are designed to facilitate movement of animals.
- C.4d **Facilitate wetland and other habitat migration:** Reserve space for a “habitat migration corridor” or areas into which wetlands and other habitats could migrate as sea level rise induced inundation of existing wetland areas occurs. In the LCP, identify potential habitat migration corridors. These areas could be reserved for this purpose in an LCP through land acquisition, use designations, zoning buffers, setbacks, conservation easement requirements, and clustering development. LCPs should also consider developing a plan for acquisition of important habitat migration corridors.

Goal: Avoid significant impacts to habitats from adjacent development

- C.5 **Limit new development in areas adjacent to wetlands, ESHA, and other coastal habitats:** Restrict the construction of new development in areas that are adjacent to wetlands, ESHA, and other coastal habitats in order to preserve buffers and open areas to allow for habitat migration.
 - C.5a **Cluster development away from coastal habitats:** Existing LCPs will likely have policies that already require clustering of development. To address sea level rise, these policies might need to be updated to include clustering development away from land where wetlands and other coastal habitats could migrate with sea level rise.

- C.5b **Limit subdivisions:** Update subdivision requirements to require provision for inland migration of natural resource areas or to require lots to be configured in a way that allows such migration. Lot line adjustments may sometimes be appropriate if they facilitate locating physical development further away from hazards or sensitive resources.



Figure 23. Photo depicting the preservation and conservation of open space along an urban-rural boundary. North end of Pismo Beach from 1972 (left) to 2002 (right). (Source: [California Coastal Records Project](#))

Goal: Manage sediment in ways that benefit habitats

- C.6 **Identify opportunities for Regional Sediment Management:** Sediment supplies will be important for the long-term sustainability of many beaches and wetland areas. Strategies to maintain or restore natural sediment supplies and to coordinate sediment removal efforts with opportunities for reuse can provide multiple benefits to coastal ecosystems. See Strategy A.19c above for more detail on RSM programs.
- C.6a **Restore natural sediment sources to wetlands:** Restoration of natural hydrodynamic systems will help to ensure the ability of wetlands to persist with sea level rise by ensuring that sediment is available for wetland accretion. Such actions may include restoring natural channels in streams and waterways that have been armored or channelized. Organizing and coordinating such efforts may be accomplished through a Regional Sediment Management Plan.
- C.6b **Identify opportunities for beneficial reuse of sediment to support wetland restoration:** Consider facilitating the delivery of clean, dredged sediment to areas where former wetlands have subsided or to areas where existing wetlands are or may become sediment-limited as sea levels rise.

Goal: Incorporate sea level rise into habitat management actions

- C.7 **Include sea level rise in site-specific evaluations:** Update policies to require site-specific biological evaluations and field observations of coastal habitat to include an evaluation of vulnerability to sea level rise where appropriate. Such an evaluation should consider both topographic features as well as habitat and species sensitivities (for example, sensitivity to inundation and saltwater intrusion).

- C.8 Incorporate sea level rise in restoration, creation, or enhancement of coastal habitats:** Update policies to require site-specific biological evaluations and field observations of coastal habitat to include an evaluation of vulnerability to sea level rise. Such an evaluation should consider both topographic features as well as habitat and species sensitivities (for example, sensitivity to inundation and saltwater intrusion). Habitat restoration, creation, or enhancement projects should be designed to withstand impacts of sea level rise and adapt to future conditions. As applicable, the LCP should contain policies to ensure restoration and management techniques account for future changes in conditions. CDPs for restoration projects should incorporate sea level rise and provisions to ensure habitats can adapt with changing future conditions.
- C.9 Update habitat management plans to address sea level rise:** Add policies stating that the effects of sea level rise should be addressed in management plans for coastal habitats. For example, plans should evaluate the full range of sea level rise impacts to coastal habitats, and develop a strategy for managing coastal habitats given changing sea level rise conditions. Existing management plans may need to be updated to add new monitoring and restoration requirements to address sea level rise. The strategies listed below are examples of strategies that could be included in habitat management plans.
- C.9a Use an adaptive management approach in ecosystem management, restoration, or design:** Habitat management plans and/or other habitat projects should establish an adaptive management approach, with clearly defined triggers for adaptive actions. Such an approach would allow for and ensure that coastal habitats are able to migrate and transition with changes in sea level.



Figure 24. Photo depicting habitat protection at Salinas River State Beach. Dunes are roped off to protect Snowy Plover nesting habitat. (Source: [California Coastal Records Project](#))

C.10 Pursue strategies to protect ecosystem function under a range of future sea level rise or climate change scenarios: The LCP and/or habitat management plans can recommend coastal habitat management strategies that strive to protect ecosystem function in the future. Strategies include protecting a wide range of ecosystem types, protecting refugia, protecting wildlife and habitat corridors, and establishing methods to monitor ecosystem change over time.

C.10a **Update monitoring requirements for coastal habitats:** As part of the LCP and/or habitat management plans, consider establishing a monitoring protocol and requirements for evaluating sea level rise impacts to coastal habitats over time. Such a protocol would also help identify triggers at which additional adaptation options are necessary.

D. Agricultural Resources

Agriculture is a priority use within the Coastal Act, which mandates that the maximum amount of prime agricultural land shall be protected and maintained (Sections 30231, 30241, 30242). The main goals and Coastal Act policies that relate to agriculture are to:

- Protect the maximum amount of prime agricultural land
- Limit conversion of lands suitable for agriculture to non-agricultural uses
- Minimize impacts to water quality that could result from agricultural practices
- Promote water conservation efforts

[Chapter 3](#) of the Guidance describes the impacts to agricultural resources that may result from sea level rise. Certified LCPs should already have policies and standards to ensure that agricultural resources are protected to the maximum extent feasible. However, LCP policies and standards may need to be updated to address sea level rise hazards. Adaptation options have been developed to support the agricultural protection goals of the Coastal Act through both LCP policies and CDP conditions, and the following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Protect the maximum amount of prime agricultural land

D.1 Identify and designate areas suitable for agricultural production to replace agricultural production areas that could be lost to sea level rise: Identify any non-sensitive open or developed areas, both within and outside of the Coastal Zone, which could potentially be used to replace agricultural land that is lost to sea level rise. Update LCP designations and/or policies to protect these identified areas for agricultural production and, as applicable, to provide for their conversion to agricultural use. Encourage and support regional coordination as feasible and applicable.

D.1a Establish SLR-specific agricultural protection program: Establish a formal program to identify, acquire, incentivize, and manage areas appropriate for new/renewed agricultural use and/or for protection of current and/or future agricultural uses. Such program should target key areas and properties where agricultural conversion threats are highest, and should dovetail with existing agricultural protection programs. Easements and other legal restrictions may be used as part of such program to help limit or restrict development in areas where agricultural land and production are most vulnerable to sea level rise impacts. The program might develop standard language and/or legal documents that can be used for easements or other property restrictions. The program should be flexible enough to be able to be implemented on both a large scale (*e.g.*, through LCP policies and programs) as well as on a smaller scale (*e.g.*, through the CDP process).

D.2 Protection, maintenance, and adaptation of dikes and levees: Repairing and maintaining existing flood barriers such as dikes and levees may be a cost-effective way to continue to protect agricultural areas. While some repair and maintenance activities are exempt from the need for a CDP, the repair and maintenance exemption does not apply to repair and maintenance work that is located within an ESHA, within any sand area, within 50 feet of the edge of a coastal bluff or ESHA, or within 20 feet of coastal waters. LCPs could identify opportunities for these kinds of actions and ensure that they are appropriately permitted, with consideration to the environmental protection and restoration goals of the Coastal Act. While landowners have the right to repair and maintain existing legal levees in their current configurations, the Commission and local governments administering LCPs have the authority to regulate, via the CDP process, the proposed methods of repair and maintenance. To raise, reconfigure, enlarge, or widen levees is not repair and maintenance and requires a Coastal Development Permit. Such activities may not be consistent with the Coastal Act or certified LCP, such as in cases involving wetland fill impacts. However, where there are opportunities to restore marine resources and the biological productivity of wetlands and estuaries, it may be possible to permit a dike/levee reconstruction project that provides for substantial restoration.

Goal: Limit conversion of lands suitable for agriculture to non-agricultural uses

D.3 Limit conversion of agricultural land to other developed land uses: Develop policies to assure maximum environmentally feasible protection of rural agricultural land, open space, and other coastal resources, including areas that may be considered non-prime agricultural land at this time. Anticipate areas that could become more difficult to farm and identify strategies to avoid or mitigate the potential impacts.

Goal: Minimize impacts to water quality that could result from agricultural practices

D.4 Include sea level rise in water quality protection policies: Where needed, coordinate with regional water quality control boards to add policies to reduce water pollution from runoff should agricultural lands become flooded or inundated due to sea level rise.

D.4a Minimize water quality impacts from flooding of agricultural lands: Agricultural practices that are designed to minimize water quality impacts, such as those designed to minimize runoff, may need to be updated or enhanced to ensure water quality protection if sea level rise results in more frequent flooding of agricultural lands.

D.4b Add policies to address saltwater intrusion: Add policies to protect water supply for priority coastal agriculture, including policies to address saltwater intrusion, such as limits on groundwater withdrawal or diversification of water supplies. Strategies to pump freshwater and/or highly treated wastewater into aquifers to reduce saltwater intrusion should be minimized in areas with limited freshwater resources.

Goal: Promote water conservation efforts

- D.5 Maximize water conservation to protect priority agricultural water supplies:** Saltwater intrusion and other climate change impacts may result in reduced water availability. LCP policies should be updated to establish or enhance standards related to water conservation and/or to identify opportunities for water recycling, dual plumbing systems, and the like. For more information on options such as relocating wells and reducing pumping in sensitive aquifers, see the following section on Water Quality and Water Control Management.
- D.6 Identify alternate water sources for agriculture:** Establish a program to identify alternate water sources for agriculture.

E. Water Quality and Supply

The main water quality protection policy of the Coastal Act requires minimizing the adverse effects of wastewater discharges, runoff, and groundwater depletion in order to protect the biological productivity and quality of coastal waters, as described in Section 30231. The main goals related to water quality include:

- Control runoff and stormwater pollution
- Minimize adverse effects of wastewater discharges and entrainment
- Prevent depletion of groundwater supplies from saltwater intrusion
- Improve long-term water quality through research

[Chapter 3](#) of the Guidance covers the impacts to coastal waters from increased runoff, wastewater discharge and saltwater intrusion into groundwater sources from sea level rise. Adaptation options have been developed to limit the amount of pollutants that enter coastal waters through runoff or discharges.

Goal: Control runoff and stormwater pollution

E.1 Update water quality Best Management Practices (BMPs): Evaluate and update BMPs to account for changes in water quality and supply issues due to sea level rise, as applicable. Updates could include practices to provide greater infiltration/inflow of rainwater, increased stormwater capture and/or water recycling programs, the use of low impact development, improved maintenance procedures for public sewer mains, policies to address impaired private sewer laterals, and other proactive measures.

E.2 Include sea level rise in stormwater management plans and actions: Control the amount of pollutants, sediments, and nutrients entering water bodies through precipitation-generated runoff. LCPs should include sea level rise and extreme storms in stormwater management plans and actions. CDPs for stormwater infrastructure should consider sea level rise.

E.2a Increase capacity of stormwater infrastructure: Actions to reduce impacts from higher water levels could include widening drainage ditches, improving carrying and storage capacity of tidally-influenced streams, installing larger pipes and culverts, adding pumps, converting culverts to bridges, creating retention and detention basins, and developing contingency plans for extreme events. Encouraging and supporting these types of efforts upstream may also be important.

E.2b Use green stormwater infrastructure to the maximum extent feasible: Employ natural, on-site drainage strategies to minimize the amount of stormwater that flows into pipes or conveyance systems. These strategies include low impact development, green roofs, permeable pavements, bioretention (*e.g.*, vegetated

swales, rain gardens) and cisterns. LCPs can include policies that require green infrastructure be used whenever possible *in lieu* of hard structures. Incorporate sea level rise and extreme storms into the design.

- E.2c **Retrofit existing development with inadequate stormwater infrastructure:** Identify and prioritize development in low-lying or other at-risk areas with inadequate stormwater infrastructure and take steps to retrofit these systems to better accommodate sea level rise driven changes. Retrofits should incorporate the green infrastructure options detailed in strategy E.2c above as applicable.

Goal: Minimize adverse effects of wastewater discharges and entrainment

- E.3 Add policies to address water quality risks from wastewater treatment plants, septic systems, and ocean outfalls:** Consider establishing a program to retrofit, relocate, or eliminate ocean outfalls and other wastewater infrastructure deemed at risk. Alternatives include modifications to outfall lines, the use of green infrastructure, and redesign of waste and stormwater systems.

- E.3a **Update siting and design policies:** Add policies to ensure that new ocean outfalls, wastewater treatment facilities, and other facilities that could negatively impact water quality if flooded or inundated, are sited and designed to minimize impacts from sea level rise. Avoid construction of new stormwater outfalls and direct stormwater to existing facilities with appropriate treatment and filtration where feasible. Where new outfalls cannot be avoided, plan, site, and design stormwater outfalls to minimize adverse impacts on coastal resources, including consolidation of existing and new outfalls where appropriate. Consolidate new and existing outfalls where appropriate.
- E.3b **Retrofit, relocate, or eliminate outfalls deemed "at risk":** An ocean outfall is a pipeline or tunnel that discharges municipal or industrial wastewater, stormwater, combined sewer overflows, cooling water, or brine effluents from desalination plants to the sea. LCPs should identify areas where sea level rise could affect flow of wastewater from outfalls and lead to backup and inland flooding, and plans should be made to retrofit, relocate, or eliminate these outfalls to prevent damage and impacts to water quality. Additionally, CDPs for new ocean outfalls should consider sea level rise in the design.
- E.3c **Reduce or find alternatives for septic systems in hazardous areas:** Flooding, inundation, and changing groundwater dynamics may result in impacts to septic systems, which rely on leach fields for dispersal of wastewater, that could cause water quality impairments. Options to reduce the potential for these impacts by redesigning or eliminating septic systems in hazardous areas should be identified. New development that will rely on septic systems should be limited in hazardous areas.

Goal: Prevent depletion of groundwater supplies from saltwater intrusion

E.4 Groundwater Management: Plan and coordinate monitoring, operation, and administration of a groundwater basin or portion of a groundwater basin with the goal of fostering long-term sustainability of the resource. The LCP can add policies that specify limits or establish other standards for the use of groundwater and sensitive aquifers. These policies should be made in accordance with other regional water planning efforts, such as Integrated Regional Water Plans as well as relevant state water policies. CDPs involving the use of groundwater should address groundwater management issues.

- E.4a **Add policies to address saltwater intrusion into aquifers:** Consider adding policies that establish a long-term strategy for addressing saltwater intrusion in aquifers, including limiting development that would use sensitive aquifers as applicable. For some areas of the state, additional information is needed on the site-specific impacts of sea level rise on aquifers. For these areas, the LCP could identify the local information needs and promote the establishment of a research program to increase understanding of the vulnerability of coastal aquifers.
- E.4b **Limit groundwater extraction from shallow aquifers:** Groundwater extraction from shallow aquifers can increase susceptibility to saltwater intrusion. Regulating development to limit or prevent extraction and avoid overdraft from vulnerable aquifers can reduce the impacts of saltwater intrusion and preserve fresh groundwater supplies. LCPs or CDPs can add restrictions to the use of aquifers susceptible to saltwater intrusion and can encourage measures to recharge shallow aquifers that are depleted.
- E.4c **Relocate wells and water intake facilities:** Identify opportunities to relocate wells and water intake facilities away from hazards and/or areas where saltwater intrusion may be a problem.
- E.4d **Restrict development of new wells in sensitive areas:** Require new water wells to be sited away from areas where saltwater intrusion could occur.
- E.4e **Limit development that relies on vulnerable water supplies:** Limit or restrict new development in areas that are dependent on water supplies that are or will become susceptible to saltwater intrusion.
- E.4f **Ensure adequate long term water supplies:** When siting and designing new development, ensure that adequate and sustainable water sources are available for the lifetime of the development and suitable for the intended use of the development, considering potential impacts of sea level rise and saltwater intrusion upon groundwater supplies.

Goal: Improve long-term water quality through research

E.5 Identify research and monitoring needs to more precisely understand local issues:

Research programs may be established to analyze the particular local challenges related to water quality and supply as a result of sea level rise. Opportunities for innovative solutions to these challenges should be identified.

E.5a Clearly define areas at risk: The LCP should include an updated inventory of potential pollutant sources due to sea level rise, including toxic waste sites, ocean outfalls and wastewater treatment facilities at risk of inundation, as well as aquifers and wells at risk of saltwater intrusion. Policies may also be added to prioritize low-lying contaminated sites for remediation and restoration.

F. Archaeological and Paleontological Resources

The Coastal Act provides for the protection of archaeological and paleontological resources, stating in Section 30244 that:

“Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.”

[Chapter 3](#) of the Guidance discusses the impacts to archaeological and paleontological resources that might result from sea level rise. Certified LCPs should already have policies and standards to ensure that these resources are protected to the maximum extent feasible, however, such policies and standards may need to be updated to consider sea level rise hazards. The following strategies cover a range of options for addressing the identified goals of the Coastal Act.

Goal: Protect archaeological and paleontological resources

- F.1 Add policies to protect archeological and paleontological resources from sea level rise:** Add policies to require site-specific evaluation of potential sea level rise impacts to archeological and paleontological resources on a development site. The LCP can also add requirements that a monitoring program and plan be established as a condition of approval for development located on a site with artifacts vulnerable to sea level rise. Adaptation or protection strategies used may depend on the significance of the archaeological resources in question.
- F.1a **Consult with relevant tribes for guidance:** If resources are at risk, the appropriate entity or Native American tribe(s) should be contacted to develop a coordinated management plan for artifacts. See, for example, the [California Natural Resources Agency Final Tribal Consultation Policy](#) for additional guidance.
- F.1b **Coordinate with the State Historic Preservation Officer (SHPO):** In line with the provisions of the Coastal Act, work with the State Historic Preservation Officer to identify actions to protect archaeological and paleontological resources.

G. Scenic and Visual Resources

The scenic value of the coast is a resource of public importance. As noted in Section 30251 of the Coastal Act, development shall be sited and designed to:

“Protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural landforms...and to restore and enhance visual quality in visually degraded areas.”

As stated in [Chapter 3](#) of the Guidance, some options to address rising sea levels, such as elevating structures or utilizing seawalls or bluff retention devices, have the potential to alter or degrade the visual character of an area. Certified LCPs should already have policies and standards to ensure scenic and visual resources are protected to the maximum extent feasible, but these may need to be updated to consider sea level rise hazards. Coastal regions with scenic overlays or designated scenic corridors, or those areas designated as scenic in the California Coastal Preservation and Recreation Plan in particular should pay close attention to actions that could be used to minimize risks to development. The following adaptation options address some of the methods for protecting the scenic qualities of the coast.

Goal: Protect views to and along the ocean and scenic coastal areas

G.1 Establish design standards to protect visual resources: Update and/or add design standards to ensure that adaptation measures protect visual resources while minimizing hazards. Adaptation strategies such as shoreline armoring or elevation techniques should be designed such that the visuals are subordinate to, and in character with, the surrounding visual resources of an area.

G.1a **Establish standards for the use of caissons or other means of elevating structures:** Ensure that the use of caissons or other elevation techniques do not result in negative visual impacts. Develop policies regarding where elevation of structures may be allowable, and establish standards guiding the use of these techniques. Ensure that the appearance of caissons will not detract from the scenic character of an area if or when they become visible as a result of erosion or other processes.

G.1b **Maintain height limitations in scenic areas:** Avoid modifications to height limits in scenic areas and provide for options to modify roof-lines or elevate the lowest flood elevation for flood protection in a manner that is consistent with scenic character. In some cases it may be appropriate to update height limitations to allow for elevation in response to sea level rise hazards. However, such decisions will require trade-offs and will need to strike a balance in terms of adapting to sea level rise and protecting visual resources and community character in line with the requirements of the Coastal Act.

- G.1c **Develop or redevelop property to be safe from hazards without impairing scenic resources:** Emphasize the use of adaptation strategies that will not impact visual resources. Such strategies may include short-term retrofits with plans for longer term relocation or removal.
- G.1d **Establish new scenic communities:** Designate areas with significant visual resources that could be negatively impacted by adaptation responses (*e.g.*, due to seawalls or “spider” homes) as scenic communities with special protections. Establish standards in LCPs to specifically protect visual resources in these areas.



Figure 25. Photo depicting protection of visual resources and public access. A seawall visually blends in with the natural bluff while surfing access is also provided at Pleasure Point, Santa Cruz (2013). (Source: [California Coastal Records Project](#))



Chapter 8

Legal Context of Adaptation Planning

Land use law is dynamic and must be interpreted and applied based on case-specific factors at the time of decision. Nonetheless, sea level rise and adaptation planning raise a number of important legal issues that coastal managers should consider as they develop and apply adaptation strategies.

This section includes discussion of the legal contexts for addressing:

- Seawalls and other shoreline protective devices
- The public trust boundary
- Potential private property takings issues

SEAWALLS AND OTHER SHORELINE PROTECTIVE DEVICES

Section 30235 of the Coastal Act provides that seawalls and other forms of construction that alter natural shoreline processes “shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply.” Despite other Coastal Act provisions that could often serve as the basis for denial of shoreline protective devices (for example, new development requiring shoreline protection can also conflict with Coastal Act policies requiring protection of public access and recreation, coastal waters and marine resources, natural landforms, and visual resources), the Coastal Commission has interpreted Section 30235 as a more specific overriding policy that requires the approval of Coastal Development Permits for construction intended to protect coastal-dependent uses⁴⁵ or existing structures if the other requirements of Section 30235 are also satisfied.⁴⁶ The Commission thus will generally permit a shoreline protective device if (1) there is an existing structure, public beach, or coastal-dependent use that is (2) in danger from erosion; and (3) the shoreline protection is both required to address the danger (the least environmentally-damaging, feasible alternative) and (4) designed to eliminate or mitigate impacts on sand supply.

In contrast to Section 30235, Coastal Act Section 30253 requires that “new development...assure stability and structural integrity, and neither create nor contribute significantly to erosion...or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs.” The Commission has long applied this policy to implement appropriate bluff-top and shoreline setbacks for new development. Such setbacks are based on an assessment of projected erosion and related hazards at the site for the life of the proposed development and help ensure that seawalls and other protective devices that could lead to adverse impacts would not be necessary in the future.

⁴⁵ Coastal-dependent uses are those that require a site on, or adjacent to, the sea to be able to function at all. (Public Resources Code, § 30101.)

⁴⁶ Some commenters argue that because shoreline armoring often conflicts with Coastal Act policies other than Section 30235, the Commission should evaluate proposed armoring under the conflict resolution provisions of the Act. (See Public Resources Code, § 30007.5, 30200(b).) Because the conflict resolution provisions require the Commission to resolve the conflict in a manner which on balance is the most protective of significant coastal resources, this approach could result in the more frequent denial of shoreline armoring, especially when it is intended to protect residential development or other uses that the Coastal Act does not identify as priority uses.

Additionally, from its earliest days, the Commission has also required that landowners “assume the risks” of developing along shoreline and coastal bluffs where risks of coastal hazards are present. Since at least the late 1990s, the Commission has approved many new developments with required deed restrictions that specifically prohibit any future construction of shoreline protection for these developments. These deed restrictions require that property owners waive any rights that may exist for a shoreline structure under Section 30235 and thus internalize the risks of building in an inherently hazardous location. This, in turn, will protect shoreline areas with natural resources or other access, recreational, or scenic value, including as required by Section 30253. If and when the approved development is threatened by erosion and becomes uninhabitable, these deed restrictions prevent the construction of a shoreline protective device and require property owners to remove the development, as well as clean up any debris that may result from erosion undermining the development.⁴⁷

Read together, the most reasonable and straight-forward interpretation of Coastal Act Sections 30235 and 30253 is that they evince a broad legislative intent to allow shoreline protection for development that was in existence when the Coastal Act was passed, but avoid such protective structures for new development now subject to the Act. In this way, the Coastal Act’s broad purpose to protect natural shoreline resources and public access and recreation would be implemented to the maximum extent when new, yet-to-be-entitled development was being considered, while shoreline development that was already entitled in 1976 would be “grandfathered” and allowed to protect itself from shoreline hazards if it otherwise met Coastal Act tests even if this resulted in adverse resource impacts. Such grandfathering of existing conditions is common when new land use and resource protection policies are put in place, and the existing development becomes “non-conforming.”

Even still, in the case of Coastal Act Section 30235, existing development is only entitled to shoreline protection if it is in fact in danger, and the proposed shoreline protection is the least environmentally-damaging alternative to abate such danger. It may be that in certain circumstances existing development can be modified or feasibly relocated, or that other non-structural alternatives such as reducing blufftop irrigation or pursuing beach replenishment, may effectively address the risk to the development without the need for a shoreline protective device.

In practice, implementing Sections 30235 and 30253 has been challenging because many urban areas are made up of both developed and undeveloped lots. In addition, many developments in existence in 1976 have since been “redeveloped” through renovations, remodeling, additions, and complete demolition and rebuild. The reality of effective shoreline management is that the Coastal Act and LCPs must address and be applied to a wide variety of physical and legal circumstances that may not be addressed by a simple application of the clean Coastal Act distinction between existing development that may be entitled to shoreline protection and new development that is not. In some urban areas, for example, one may find intermingled shoreline developments that pre-date the Coastal Act, both with and without shoreline protection, post-Coastal Act developments approved by the Coastal Commission or local governments pursuant to an LCP that theoretically won’t need shoreline protection (though some may have it), and

⁴⁷ This legal instrument is not an easement but it does provide for “planned retreat” into the future as a site erodes. Once a development is removed, a site may have potential for new development if it is once again set back and restricted against future shoreline protection device construction.

developments that may have pre-dated the Coastal Act but that were redeveloped pursuant to a coastal development permit. Moreover, some of the post-Coastal Act developments may have conditions that prohibit shoreline protection while adjacent properties may be eligible for or have a protective device because they pre-date the Act.

For purposes of implementing this Guidance, it is important that local governments, property owners, development applicants, and others take full advantage of available legal tools to mitigate hazards and protect resources, but to do so in way that considers the specific legal context and circumstances of LCP updates and individual development decisions in context and on a case-by-case basis. For example, although the Coastal Act does not explicitly define what qualifies as an “existing structure” for the purposes of Section 30235, how this term is interpreted in specific cases and through LCPs may be critical to the success of an adaptation strategy over the long-run.

The Commission has relatively infrequently evaluated whether structures built after 1976 should be treated as “existing” and thus entitled to shoreline protection pursuant to Section 30235. When it has, the shoreline protection being proposed to protect the structure has often also been identified as necessary to protect adjacent pre-Coastal Act structures.⁴⁸ In a few instances, however, the Commission has treated structures built after 1976 as existing structures entitled to shoreline protection even if no adjacent pre-Coastal Act structure also needed protection. Nonetheless, going forward, the Commission recommends the rebuttable presumption that structures built after 1976 pursuant to a coastal development permit are not “existing” as that term was originally intended relative to applications for shoreline protective devices, and that the details of any prior coastal development approvals should be fully understood before concluding that a development is entitled to shoreline protection under Section 30235.

As mentioned, in order to find new development consistent with Section 30253 or related LCP requirements and to limit the potential proliferation of armoring to protect newly approved structures, the Commission has long used setbacks, assumption of risk conditions and, over the last 15-20 years, generally required that applicants proposing new development in hazardous shoreline locations waive any rights under Section 30235 (or related LCP policies) to build shoreline protection for the proposed new development. Notably, no appellate decision addresses whether the term “existing structures” in this context includes only structures built prior to the Coastal Act or instead includes structures in existence at the time the Commission acts on an application for shoreline protection, or otherwise addresses the interplay between 30235 and 30253.

LCP updates are an opportunity to clarify how the distinction between existing and new development will be applied in specific areas, and some LCP’s have already done so. For example, local governments have sometimes specified a date by which a structure must have been constructed in order to qualify as an “existing structure” for the purpose of evaluating whether it may be eligible for shoreline protection. In Marin County, the Local Coastal Program

⁴⁸ For example, CDP A-3-CAP-99-023-A1, *Swan and Green Valley Corporation Seawall*. In this situation, repairs to maintain a seawall fronting the pre-coastal Swan Residence could only be undertaken by encroachment onto the adjacent property, Green Valley Corporation; however, the Green Valley Corporation development had been approved with a condition to prohibit any future shore protection.

policy that implements Section 30235 specifies that existing structures are those that existed on the date the LCP was originally adopted (May 13, 1982). LCPs can also codify the prohibition on shoreline protective devices for new development, such as the following provision from the San Luis Obispo County North Coast Area Plan standard:

***Seawall Prohibition.** Shoreline and bluff protection structures shall not be permitted to protect new development. All permits for development on blufftop or shoreline lots that do not have a legally established shoreline protection structure shall be conditioned to require that prior to issuance of any grading or construction permits, the property owner record a deed restriction against the property that ensures that no shoreline protection structure shall be proposed or constructed to protect the development, and which expressly waives any future right to construct such devices that may exist pursuant to Public Resources Code Section 30235 and the San Luis Obispo County certified LCP.⁴⁹*

The distinction between existing and new development inherent in the Coastal Act is often directly raised by proposals for redevelopment as well. This Guidance thus deals directly with potential approaches for managing shoreline hazards and protecting coastal resources as shorelines are redeveloped (see [Chapter 7](#), Strategy A.13). Most recently, the Commission approved a Land Use Plan for the City of Solana Beach that includes many policies designed to address the existing residential development pattern along the high, eroding bluffs of the City. Although further elaboration is yet to come through the City's work on the Implementation Plan, the Solana Beach LUP is a good example of an effort to pragmatically address the need to mitigate the risks to residential development, provide for some redevelopment potential while moving the line of new development inland, avoid and minimize new bluff protection and seawalls, and perhaps remove protective devices in the future to minimize impacts to natural landforms and to protect the beach for long-term public use.

Local governments and other shoreline managers should also take into account that although a public agency may not deny a Coastal Development Permit for a shoreline protective device that meets all of the tests under Section 30235 and equivalent LCP policies, this does not limit the authority of public agencies to refuse to allow construction of shoreline protective devices pursuant to some authority other than the Coastal Act. For example, if a private property owner requests permission from a public agency to build a structure on that agency's property (such as a local or State park or public beach) to protect adjacent private property, the public agency would generally have the authority as the landowner not to agree to the encroachment. Similarly, agencies that are trustees of public trust lands (such as the State Lands Commission and Port Districts) have the authority to prohibit structures that are not consistent with public trust uses and prioritized public trust needs, values, and principles. Public trust uses include maritime commerce, navigation, fishing, boating, water-oriented recreation, and environmental preservation and restoration, but do not typically include non-water dependent uses such as residential or general commercial and office uses. Thus, trustee agencies have the authority to refuse to allow, or to require removal of, shoreline armoring located on public trust lands, including if that armoring unreasonably interferes with public trust uses.

⁴⁹ Community-wide standard 15C.

Approval of a Coastal Development Permit for shoreline armoring under Section 30235 may be unavoidable in certain circumstances. Nonetheless, the construction of shoreline armoring will often cause impacts inconsistent with other Coastal Act requirements, including Section 30235's requirement that a shoreline protective device be the least-environmentally damaging, feasible alternative for addressing shoreline hazards. For example, as discussed above, Section 30253(b) prohibits *new development* from in any way requiring the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs. Shoreline protective devices can also adversely affect a wide range of other coastal resources and uses that the Coastal Act protects. They often impede or degrade public access and recreation along the shoreline by occupying beach area or tidelands, by reducing shoreline sand supply, and by fixing the back of the beach, ultimately leading to the loss of the beach. Shoreline protection structures thus raise serious concerns regarding consistency with the public access and recreation policies of the Coastal Act. Such structures can fill coastal waters or tidelands and harm marine resources and biological productivity in conflict with Sections 30230, 30231, and 30233. They often degrade the scenic qualities of coastal areas and alter natural landforms in conflict with Section 30251. Finally, by halting shoreline erosion, they can prevent the inland migration of intertidal habitat, salt marshes, beaches, and other low-lying habitats that rising sea levels will inundate.

Even when an agency approves a Coastal Development Permit for shoreline armoring, the agency has the authority to impose conditions to mitigate impacts on shoreline sand supply and to minimize adverse impacts on other coastal resources. (See *Ocean Harbor House Homeowners Assn. v. California Coastal Comm.* (2008) 163 Cal.App.4th 215, 242; Public Resources Code, §30607.)⁵⁰ Any approved shoreline structure, therefore, must avoid or mitigate impacts that are inconsistent with Coastal Act policies.

Because of the wide range of adverse effects that shoreline protective devices typically have on coastal resources, this Guidance recommends avoidance of hard shoreline armoring whenever possible. This can entail denying development in hazardous locations, allowing only development that is easily removable as the shoreline erodes, or requiring new development to be set back far enough from wave runup zones or eroding bluff edges so that the development will not need shoreline armoring during its anticipated lifetime. The Commission's practice when reviewing proposed development in shoreline locations that are potentially vulnerable to shoreline erosion, wave runup, or inundation has been to require applicants to waive rights to shoreline protective devices in the future, and, more recently, to require relocation and/or removal should such development become endangered in the future. See [Chapter 7: Adaptation Strategies](#) for further details regarding alternatives to the use of hard armoring structures.

PUBLIC TRUST BOUNDARY

The State of California acquired sovereign ownership of all tidelands and submerged lands and beds of navigable waterways upon its admission to the United States in 1850. The State holds and manages these lands for the benefit of all people of the State for statewide purposes consistent with the common law Public Trust Doctrine ("public trust"). The public trust ensures that title to sovereign land is held by the State in trust for the people of the State. Public trust

⁵⁰ Indeed, as noted above, 30235 itself clarifies that even when approvable, such structures should be designed to eliminate or mitigate any adverse impacts on local shoreline sand supply.

uses include maritime commerce, navigation, fishing, boating, water-oriented recreation, visitor-serving facilities and environmental preservation and restoration. Non-water dependent uses such as residential and general office or commercial uses are generally inconsistent with public trust protections and do not qualify as public trust uses.

In coastal areas, the landward location and extent of the State's sovereign fee ownership of these public trust lands are generally defined by reference to the ordinary high water mark (Civil Code §670), as measured by the mean high tide line (*Borax Consolidated v. City of Los Angeles* (1935) 210 U.S. 10); these boundaries remain ambulatory, except where there has been fill or artificial accretion. More specifically, in areas unaffected by fill or artificial accretion, the ordinary high water mark and the mean high tide line will generally be the same. In areas where there has been fill or artificial accretion, the ordinary high water mark (and the state's public trust ownership) is generally defined as the location of the mean high tide line just prior to the fill or artificial influence. It is important to note that such boundaries may not be readily apparent from present day site inspections (*Carpenter v. City of Santa Monica* (1944) 63 C. A. 2nd 772, 787).

The mean high tide line is the intersection of the shoreline with the elevation of the average of all high tides calculated over an 18.6-year tidal epoch. This property line is referred to as “ambulatory” for two reasons: first, gradual changes to the shoreline due to factors such as variations in the height and width of sandy beaches, shoreline erosion or accretion, and uplift or subsidence of land can change the location of where the mean high tide line meets the shoreline. Second, the elevation of the mean high tide line itself changes over time and is likely to increase at an accelerating rate in the future due to sea level rise. Over time, sea level rise will continue to gradually cause the public trust boundary to move inland. Boundaries between publicly-owned waterways and adjoining private properties (referred to as *littoral* along lakes and seas and *riparian* along rivers and streams) have always been subject to the forces of nature and property boundary law reflects these realities.

Accelerating sea level rise will likely lead to more disputes regarding the location of property boundaries along the shoreline, since lands that were previously landward of the mean high tide line have become subject to the State's ownership and protections of the public trust. These disputes, in turn, will affect determinations regarding what kinds of structures and uses may be allowed or maintained in areas that, because of sea level rise, either are already seaward of the mean high tide line, are likely to become seaward of the mean high tide line in the future, or would be seaward of the mean high tide line if it were not for artificial alterations to the shoreline.

California case law does not explicitly address how shoreline structures such as seawalls that artificially fix the shoreline temporarily and prevent inland movement of the mean high tide line affect property boundaries, if at all. The Ninth Circuit Court of Appeals, however, has interpreted federal common law as allowing the owner of tidelands to bring a trespass action against a neighboring upland property owner who built a revetment that prevented the natural inland movement of the mean high tide line. The court ruled that the actual property boundary was where the mean high tide line would have been if the revetment were not there and that the owner of the tidelands could require the upland owners to remove the portions of the revetment

that were no longer located on the upland owners' properties. (*United States v. Milner* (9th Cir. 2009) 583 F.3d 1174, 1189-1190.)

POTENTIAL PRIVATE PROPERTY TAKINGS ISSUES

The United States and California constitutions prohibit public agencies from taking private property for public use without just compensation. Section 30010 of the Coastal Act similarly prohibits public agencies implementing the Coastal Act from granting or denying a permit in a manner that takes or damages private property for public use without payment of just compensation. The classic "takings" scenario arises when a public agency acquires title to private property in order to build a public facility or otherwise devote the property to public use. In 1922, however, the United States Supreme Court ruled that regulation of private property can constitute a taking even if the regulation does not involve acquisition of title to the property. As Justice Oliver Wendell Holmes stated, "while property may be regulated to a certain extent, if regulation goes too far it will be recognized as a taking," (*Pennsylvania Coal Co. v. Mahon* (1922) 260 U.S. 393, 415.)

Courts have struggled in the 90 years since then to give agencies and property owners a more definite sense of exactly when a regulation "goes too far." The Supreme Court has identified three basic categories of takings that can occur in the context of land use regulation. Different legal standards apply depending on what kind of taking is at issue. (See, generally, *Lingle v. Chevron USA, Inc.* (2005) 544 U.S. 528).

The most straightforward test applies to what is variously called a categorical, total, *per se*, or "Lucas" takings, which occurs when a regulation deprives an owner of all economically beneficial use of the property. (See *Lucas v. South Carolina Coastal Council* (1992) 505 U.S. 1003). An agency that completely deprives a property owner of all economically beneficial use of the property will likely be found liable for a taking unless background principles of nuisance or property law independently restrict the owner's intended use of the property. Courts have generally been very strict about when they apply this test. If any economically beneficial use remains after application of the regulation, even if the value of that use is a very small percentage of the value of the property absent the regulatory restriction, a *Lucas* taking has not occurred.

Where a regulation significantly reduces the value of private property but does not completely deprive the owner of all economically beneficial use, the multi-factor "*Penn-Central*" test applies (*Penn Central Transportation Co. v. City of New York* (1978) 438 U.S. 104). This test has no set formula, but the primary factors include the economic impact of the regulation, the extent to which the regulation interferes with distinct, reasonable investment-backed expectations, and the character of the governmental action. When evaluating the character of the governmental action, courts consider whether the regulation amounts to a physical invasion or instead more generally affects property interests through a program that adjusts the burdens and benefits of economic life for the common good. Whether a regulation was in effect at the time an owner acquired title is also a relevant factor, but is not by itself dispositive. (See *Palazzolo v. Rhode Island* (2001) 533 U.S. 606, 632-633 (O'Connor, J., concurring)). Because this test takes such a wide range of factors into account, caselaw does not provide clear guidance about the situations in which a regulation is likely to qualify as a "*Penn-Central*" taking. A *Penn-Central*

claim is unlikely to succeed, however, unless the plaintiff can establish that the regulation very substantially reduces the value of the property.

The third category of takings claims applies to “exactions,” that is, government permitting decisions that require a property owner either to convey a property interest or to pay a mitigation fee as a condition of approval. (See *Nollan v. California Coastal Comm.* (1987) 483 U.S. 825; *Dolan v. City of Tigard* (1994) 512 U.S. 374; *Koontz v. St. Johns River Water Management Dist.* (2013) 133 S.Ct. 2586). Under the *Nollan/Dolan* line of cases, the agency must establish a “nexus” between the condition requiring a property interest or payment and the effects of the project that that property interest or payment is mitigating. That property interest or payment must also be roughly proportional to the impact that it is intended to mitigate. In California, the *Ocean Harbor House* case is a good example of a shoreline structure impact mitigation requirement that was found by the courts to meet the relevant standards of nexus and proportionality.

Various recommendations of this Guidance may potentially give rise to takings concerns. Because the determination of whether a particular regulation may in some circumstances be applied in a way that constitutes a taking is so fact-intensive and context-specific, this Guidance cannot provide a simple set of parameters for when agencies should either allow exceptions to a land use regulation or consider purchasing a property interest. That said, land use restrictions that prevent all economically beneficial use of the entirety of a property⁵¹ are vulnerable to *Lucas* takings claims unless those uses would qualify as a nuisance or are prohibited by property law principles such as the public trust doctrine. Agencies can minimize the risk of these claims by allowing economically beneficial uses on some of the property and by exploring whether legal doctrines regarding nuisance, changing shoreline property lines, or the public trust independently allow for significant limitations on the use of the property. Establishing a transferrable development rights program for properties that are subject to significant development restrictions may also minimize potential exposure to takings claims.

Where a proposed development would be safe from hazards related to sea level rise in the near future, but cannot be sited so as to avoid those risks for the expected life of the structure, agencies may consider allowing the structure, but requiring removal once it is threatened. Property owners may argue that they have a right to protect threatened structures even if they have waived rights to shoreline protection under the Coastal Act, but a recent federal court of appeal ruling casts significant doubt on the existence of any common law right to attempt to fix an ambulatory shoreline boundary through artificial structures such as seawalls (see *United States v. Milner* (9th Cir. 2009) 583 F.3d 1174, 1189-1190).

If an agency is contemplating requiring property owners to dedicate open space easements or other property interests or requiring the payment of fees to mitigate project impacts, the agency should be careful to adopt findings explaining how requiring the property interest or payment is

⁵¹ What qualifies as the entirety of a property can also be the subject of dispute. The property will normally include all legal lots on which the proposed development would be located, but can also include other lots that are in common ownership and adjacent to, or in close proximity with, the lots that would be developed. (See *Norman v. United States* (Fed. Cir. 2005) 429 F.3d 1081, 1091; *District Intown Properties Limited Partnership v. District of Columbia* (D.C. Cir. 1999) 198 F.3d 874, 880.)

both logically related to mitigating an adverse impact of the project and roughly proportional to that impact. Legislatively adopting rules that establish the exact criteria for determining when to require these exactions and, if so, their magnitude, may also reduce an agency's exposure to takings claims.⁵² With respect to mitigation fees, California cities and counties should also comply with applicable requirements of the Mitigation Fee Act (Government Code, §66000 *et seq.*).

⁵² The California Supreme Court has ruled that courts should be more deferential towards agencies when reviewing fees imposed pursuant to legislatively enacted rules of general applicability than when reviewing fees imposed on an ad hoc basis. (*Ehrlich v. City of Culver City* (1996) 12 Cal.4th 854, 881.) The rationale is that fees imposed pursuant to rules of general applicability that involve little discretion are less likely to impose disproportionate burdens on property owners than fees determined on an ad hoc basis.



Chapter 9

Next Steps

CURRENT AND FUTURE COASTAL COMMISSION EFFORTS:

The Commission has a [Strategic Plan](#) for 2013-2018 (2013a) that identifies many action items that the Commission or partner organizations plan to take to address the challenges of sea level rise and climate change. The first priority in the Strategic Plan is for the Commission to adopt Sea Level Rise Policy Guidance for use in Local Coastal Program (LCP) planning and project design (Action 3.1.1), and this Guidance reflects significant progress toward accomplishing this task. The objectives and action items from the Strategic Plan related to sea level rise and climate change are presented within the following pages.

The Commission is also involved in a number of other efforts that meet the climate change planning goals laid out in its Strategic Plan. These include efforts related to the Commission's normal operating business, such as ongoing coordination with local government partners and other agencies, as well as specially funded projects designed to meet specific needs. Several of these efforts that are currently underway or that staff identified as next steps during the completion of this Guidance document are listed below. The Commission anticipates that these items will be completed over the next two to five years, in coordination with other relevant partners and research institutions, as staff capacity and funding allows.

1. **Continue an active program of public outreach on sea level rise.** The Commission will strive to provide public information about sea level rise issues through public workshops, the Commission's website, meetings, outreach, and our public education program. The Commission will work to enhance efforts to coordinate with low-income and underserved populations and communities.
2. **Develop methods for quantifying impacts to coastal resources from shoreline armoring projects.** The Coastal Commission staff has initiated a Project of Special Merit (funded by NOAA) to build upon the Commission's existing efforts to mitigate for the adverse impacts of shoreline development projects to public access and recreation by working with beach ecologists and a valuation economist to develop a method to quantify impacts to biological resources and beach ecology. The final product is anticipated to be a set of guidelines to use in assessing the impacts of proposed shoreline armoring projects and a method(s) for calculating the full value of recreational and ecological loss resulting from installation of shoreline armoring projects (where they may be approved as consistent with the Coastal Act).
3. **Adopt policy guidance and model ordinance language for resilient shoreline residential development in hazardous areas affected by sea level rise.** Under another NOAA-funded Project of Special Merit, the Coastal Commission will conduct a statewide survey to characterize physical shoreline conditions for residential areas along the coast. Informed by this assessment, staff will identify and analyze policy and legal issues for development and redevelopment in hazardous areas, factoring in sea level rise projections that will change shoreline conditions over time. Working collaboratively with local governments, staff will use the policy and legal analysis to develop policy guidance and model ordinance language. The project will build upon this Guidance and is consistent with the Coastal Commission's Strategic Plan goals.

4. **Enhance coordination and planning efforts related to developing adaptation strategies for critical infrastructure.** Addressing sea level rise impacts to critical infrastructure is particularly complex and will require greater amounts of planning time, stakeholder input, and funding. The Commission will support planning efforts in a number of ways including, for example:
 - a. Providing guidance or participating in working groups that examine managed retreat of critical infrastructure, including when to consider managed retreat rather than continue with repairs and maintenance in light of sea level rise.
 - b. Coordinating closely with Caltrans to address transportation issues. Planning efforts may include integrating LCP planning and regional transportation planning processes; coordinating and supporting phased approaches for realignment projects; and identifying priorities for adaption response.
 - c. Coordinating with port and harbor authorities and other relevant stakeholders to address vulnerabilities specific to ports, harbors, fisheries, and navigation, and to develop and enhance adaptation strategies that are particularly applicable for coastal-dependent infrastructure and other port needs.
 - d. Coordinating with the State and Regional Water Quality Control Boards to consider vulnerability issues related to water supply and wastewater capacity infrastructure in California.

5. **Consider producing additional guidance documents, including:**
 - a. Broader climate change guidance addressing other climate change impacts to the coastal zone.
 - b. One-page fact sheets on some adaptation measures such as green infrastructure and conservation easements.
 - c. Guidance on the use of ‘living shorelines’, dune management, beach nourishment, and so on for California, including an assessment of areas or coastal situations where these strategies could be effective, what they need to succeed, monitoring requirements, and maintenance.
 - d. Guidance for how to address impacts to critical infrastructure, assets and resources that cross jurisdictional boundaries, and ports, harbors and other coastal-dependent resources.

6. **Implement the Coastal Commission’s responsibilities under other state efforts and legislation.**
 - a. Governor Brown’s April 2015 [Executive Order B-30-15](#) states that state agencies shall take climate change into account in their planning and investment decisions, and employ full life-cycle cost accounting to evaluate and compare infrastructure investments and alternatives. The order requires agencies to ensure that priority is given to actions that build climate preparedness and reduce greenhouse gas emissions, provide flexible and adaptive approaches, protect the state's most vulnerable

- populations, and promote natural infrastructure solutions. The Coastal Commission will continue to integrate these principles into its planning and regulatory work.
- b. [AB2516](#), authored by Assemblymember Gordon and approved in September 2014, established a *Planning for Sea Level Rise Database* that is anticipated to be available online in early 2016. The database will provide the public with an educational tool from which to learn about the actions taken by cities, counties, regions, and various public and private entities to address sea level rise. The Coastal Commission will contribute data to this effort, including information about grant-funded LCP updates.
 - c. The Coastal Commission will also participate in the implementation of the 2014 [Safeguarding California](#) plan, along with the Ocean Protection Council's 2014 [Resolution on the Implementation of the Safeguarding California Plan](#). Key principles are and will continue to be incorporated into Coastal Commission work, including protection of California's most vulnerable populations the integration of risk reduction with emissions reductions, and the development of metrics and indicators of progress on efforts to reduce climate risk.

Coastal Commission Strategic Plan 2013-2018 Excerpts Actions Related to Sea Level Rise and Climate Change

GOAL 1: Maximize Public Access and Recreation

Objective 1.1 – Enhance Public Access through Updated Beach Access Assessment and Constraints Analysis

Actions:

- 1.1.5 Identify locations where access may be limited or eliminated in the future due to sea level rise and increased storm events and begin planning for other options such as new vertical accessways to maintain maximum beach access (see also Action 3.2.1).

Objective 1.4 – Expand the California Coastal Trail System through Enhanced Planning and Implementation

Actions:

- 1.4.4 Identify locations of the CCT that might be at risk from rising sea level and increased storm events and begin planning for trail relocations or other alternatives to insure continued functionality of the CCT (see also Action 3.2.1).

GOAL 3: Address Climate Change through LCP Planning, Coastal Permitting, Inter-Agency Collaboration, and Public Education

Objective 3.1 – Develop Planning and Permitting Policy Guidance for Addressing the Effects of Climate Change on Coastal Resources

Actions:

- 3.1.1 Adopt general sea level rise (SLR) policy guidance for use in coastal permitting and LCP planning, and amendments based on best available science, including the final report

from the National Research Council of the National Academy of Science entitled *Sea-Level Rise for the Coasts of California, Oregon, and Washington* (June 2012).

- 3.1.2 Based on the general SLR policy guidance, identify and develop specific regulatory guidance for addressing coastal hazards, including recommendations for analytic methods for accounting for SLR and increased storm events in project analysis, standards for redevelopment and development in hazard zones (*e.g.*, bluff top and flood zones), buffers for coastal wetlands, and policies for shoreline structure design and impact mitigation.
- 3.1.3 Develop a work program to produce policy guidance for coastal permitting and LCPs, to account for other climate change related impacts and adaptation planning including wetland, marine and terrestrial habitat protection, habitat migration, risk of wildfires, water supply and groundwater protection.
- 3.1.4 Provide public information and guidance through workshops, presentations to local government, *etc.* Assist local governments with interpretation of scientific or other technical information related to climate change and sea level rise that could be of use in adaptation planning.
- 3.1.5 Contribute to relevant state-wide efforts on climate change and adaptation as a member of the State's Climate Action Team – Coast and Ocean Working Group.
- 3.1.6 Coordinate with Natural Resources Agency, Office of Planning and Research, California Governor's Office of Emergency Services (Cal OES) and others to provide consistent guidance on climate change in updating general plans, hazard mitigation plans and other planning documents used by local governments.
- 3.1.7 Coordinate with the State Lands Commission to address sea level rise and shoreline change and implications for the management of public trust resources.

Objective 3.2 – Assess Coastal Resource Vulnerabilities to Guide Development of Priority Coastal Adaptation Planning Strategies

Actions:

- 3.2.1 Conduct a broad vulnerability assessment of urban and rural areas to identify priority areas for adaptation planning, such as community development, public infrastructure, public accessways, open space or public beaches at risk from sea level rise. Identify and participate in on-going vulnerability assessments and adaptation planning efforts as feasible.
- 3.2.2 Work with CalTrans and other public agency partners to assess and address roadway, rail, and other transportation infrastructure vulnerabilities, particularly along Highway One and other coastal roads and highways.
- 3.2.3 Work with the Department of Water Resources, State Water Resources Control Board, and local agencies to assess and address water and wastewater treatment plant vulnerabilities along the coast.
- 3.2.4 Work with the Conservancy, California Department of Fish and Game [*sic*], US Fish and Wildlife, and other partners to assess the vulnerability of wetlands and other sensitive habitat areas. Identify habitats that are particularly vulnerable climate change and/or

habitats that may be important for future habitat migration (*e.g.*, wetland transitional areas).

- 3.2.5 Work with the Coastal Observing Systems, researchers, and others to identify and develop baseline monitoring elements to better understand and monitor changes in coastal conditions related to sea level rise and other climate change impacts.
- 3.2.6 With the Conservancy and OPC, develop and implement a competitive grant program to provide funding to selected local governments to conduct vulnerability assessments and/or technical studies that can be used to assess a community's risks from climate change and inform updates to LCPs.

ADDITIONAL RESEARCH NEEDS

Additional research is needed to more fully understand and prepare for sea level rise. The research needs are directed toward research institutions at academic, state, federal, and local levels. The Commission will strive to collaborate with and support research related to sea level rise science and adaptation, including with the efforts and ongoing work of the [California Climate Change Research Plan](#).

1. **Modeling.** Sea level rise science is an evolving field, and new science is expected to change and refine our understanding of the dynamics of sea level rise and its associated impacts to both natural and built environments. As such, there is a continual need for models to be developed, updated, and refined to ensure that we continue to have the best understanding of sea level rise-related impacts as possible. In some cases, the modelling capabilities already exist, but there is a need for such modelling to be applied to local areas to understand specific localized impacts. Several topics in particular that are in need of better or more refined modeling include:
 - a. Fluvial dynamics as they relate to and interact with rising sea levels
 - b. Habitat evolution models (*e.g.*, SLAMM) that project future locations of wetlands and other coastal habitats
 - c. The interaction of other climate change-related impacts with the impacts of sea level rise (*e.g.*, changing precipitation patterns, increased frequency and/or intensity of storms)
2. **Improved estimates of local vertical land motion.** Several independent processes – glacial isostatic rebound, groundwater withdrawals, plate movements and seismic activity – influence vertical land motion. Current guidance on sea level projections adjusts for large-scale vertical land motion north and south of Cape Mendocino. These adjustments do not properly address locations that are moving differently from the region, such as Humboldt Bay. A peer-reviewed methodology is needed to determine:
 - a. Instances when it will be important to modify the regional sea level rise projections for local vertical land motion
 - b. Types of existing information on land motion (*e.g.*, tide gauge records, satellite data, land-based GPS stations) that provide the best estimates of local land trends

- c. A procedure for adjusting state or regional sea level rise projections for sub-regional or local conditions
 - d. Additional data that are needed to implement this procedure
3. **Baseline data and monitoring systems.** Baseline monitoring data are needed for coastal and nearshore waters, beaches, bluffs, dune systems, nearshore reefs, tide pools, wetlands, and other habitat areas to better understand these systems, monitor trends, and detect significant deviations from historic conditions that may be related to sea level rise and other aspects of climate change. Better storm event monitoring data are also needed to support refinements and calibration of models used to project and analyze impacts.

A system for monitoring and tracking the cumulative impacts of projects in the coastal zone, including both new development and any adaptation strategies, is needed to better understand the impacts of development in the face of sea level rise and the efficacy of various adaptation methods. Monitoring systems may be needed at a variety of scales, including at the local, regional, and state level.

4. **Methods for estimating change in erosion rates and shoreline change due to future sea level rise.** There is a need for a peer-reviewed methodology for estimating change in erosion rates due to sea level rise for bluffs, beaches, and other shorelines exposed to erosion. An improved understanding of future erosion rates is necessary to better evaluate projects affected by such erosion, including in terms of calculating an appropriate setback distance.
5. **Analysis of sea level rise impacts to coastal access and recreation.** To improve public access planning efforts, more information is needed about how sea level rise could affect public access areas and recreation throughout the state, including changes to waves and surfing, and the potential economic costs of these impacts. Additional information about how these changes will affect lower-income populations and underserved communities is particularly important.

Many currently accessible beach areas have the potential to become inaccessible due to impacts from sea level rise. Shoreline armoring and emerging headlands could isolate connected beaches with sea level rise, which will block lateral access. Rising sea level will also tend to constrict beaches that are prevented from migrating landward by shoreline armoring and development. Some blufftop trails will become inaccessible as segments of trail are lost to erosion. In addition, changes in beach conditions and sediment dynamics due to sea level rise could affect waves and surfing, as can the rise itself by potentially ‘drowning out’ surf spots combined with the lack of space available for these spots to move (*e.g.*, where new ‘tripping’ elements can be encountered in the right depth of water to create surfable waves). Research on the specifics of these impacts will help the Commission and others understand the details of the potential impacts to coastal access and recreation.

6. **Methods to evaluate impacts to coastal resources from shoreline protection.** Research is needed to develop and improve methods to evaluate and mitigate for the adverse impacts to recreation, public access and beach ecology from shoreline armoring projects. This information will be used to determine a set of mitigation options that may be considered for use when evaluating individual permit applications to offset anticipated losses to beach

ecology and resources caused by shoreline armoring projects. The Coastal Commission staff is currently working on developing resource valuation guidelines as part of a Project of Special Merit (see Coastal Commission Effort #2).

7. **Analysis of sea level rise impacts to wetlands and strategies for preserving wetlands throughout the state.** Additional research is needed to assess the vulnerability of wetlands and other sensitive habitat areas to climate change, and to identify adjacent areas that may be important for future habitat migration (*e.g.*, wetland transitional areas). Further work is also needed to develop management strategies that are adaptable to local wetland conditions and sea level rise impacts, such as the following:
 - a. Methodologies for establishing natural resource area buffer widths in light of sea level rise
 - b. Approaches for identifying and protecting migration corridors
 - c. Guidance for increasing wetland sediment supply and retention
 - d. Techniques for developing an adaptive wetland restoration plan
 - e. Monitoring criteria
8. **Assessment of coastal habitat functions in light of sea level rise and other climate change impacts.** It is necessary to develop a better understanding of the value and benefits that intact natural habitats provide, especially as they relate to increasing coastal resiliency to sea level rise. In addition, further research is needed to identify the coastal habitats that are most likely to experience adverse impacts from sea level rise and extreme storms, and what the associated loss of ecosystem services will mean for coastal populations. Research is also needed to identify strategies to ameliorate the vulnerabilities.
9. **Potential effects of sea level rise on groundwater and coastal aquifers.** Additional research is needed to quantify the potential effect of sea level rise on freshwater aquifers located along the California coast, and the degree to which sea level rise could lead to new incidences of intrusion. Research should include: (a) an evaluation of the potential incidence and severity of saltwater intrusion at the scale of individual aquifers, under various sea level rise scenarios, (b) criteria to use when deciding if saltwater intrusion requires mitigation or response and (c) identification of strategies to address the impacts rising groundwater and saltwater intrusion have on agriculture.
10. **Analysis of non-environmental factors that influence sea level rise adaptation.** As suggested in a number of places throughout this Guidance, there are factors beyond just environmental concerns that will influence sea level rise planning. Such factors include environmental justice/social equity, economic, and legal considerations, among others. Understanding how these social concerns interact with environmental vulnerabilities will be important when assessing adaptation planning opportunities and challenges.



Glossary

The following terms were collected from the 2009 [California Climate Change Adaptation Strategy](#)⁵³, the [Intergovernmental Panel on Climate Change Third Assessment Report](#)⁵⁴, the Coastal Commission’s Beach Erosion and Response (BEAR) document,⁵⁵ and the [California Coastal Act](#), unless otherwise noted. Some of these definitions are not used in the text of the report, but are included as a resource on coastal-related adaptation issues.

Adaptation: Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which minimizes harm or takes advantage of beneficial opportunities.

Adaptation Pathway: A planning approach addressing the uncertainty and challenges of climate change decision-making. It enables consideration of multiple possible futures, and allows analysis/exploration of the robustness and flexibility of various options across those multiple futures.⁵⁶

Adaptive capacity: The ability of a system to respond to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, and to cope with the consequences.⁵⁷

Adaptive management: Involves monitoring the results of a management decision, and updating actions as needed and as based on new information and results from the monitoring.

Ambulatory (*as used in public trust boundaries*): Moveable, subject to change, or capable of alteration.⁵⁸

Aquifer: An underground layer of porous rock, sand, or other earth material containing water, into which wells may be sunk.

Armor: To fortify a topographical feature to protect it from erosion (*e.g.*, constructing a wall to armor the base of a sea cliff), or to construct a feature (*e.g.*, a seawall, dike, or levee) to protect other resources (*e.g.*, development or agricultural land) from flooding, erosion, or other hazards.

Atmosphere-Ocean General Circulation Models (or Atmosphere-Ocean General Climate Models; ACGOM): Three-dimensional global models that dynamically link ocean density, circulation, and sea level using wind stress, heat transfer between air and sea, and freshwater fluxes as critical variables. (See also *General Circulation Models*)

Baseline (or Reference): Any datum against which change is measured. It might be a “current baseline,” in which case it represents observable, present-day conditions. It might also be a

⁵³ CNRA 2009

⁵⁴ IPCC 2001

⁵⁵ Many of these definitions were extracted from: USACE 2002, Griggs and Savoy 1985 and Flick 1994.

⁵⁶ Ocean Protection Council 2018

⁵⁷ Willows and Connell 2003

⁵⁸ *West's Encyclopedia of American Law* 2008

“future baseline”, which is a projected future set of conditions excluding the driving factor of interest (*e.g.*, how would a sector evolve without climate warming). It is critical to be aware of what change is measured against which baseline to ensure proper interpretation. Alternative interpretations of the reference conditions can give rise to multiple baselines.⁵⁹

Beach: The expanse of sand, gravel, cobble or other loose material that extends landward from the low water line to the place where there is distinguishable change in physiographic form, or to the line of permanent vegetation. The seaward limit of a beach (unless specified otherwise) is the mean low water line.

Beach nourishment: Placement of sand and/or sediment (*e.g.*, beneficial re-use of dredged sediment) on a beach to provide protection from storms and erosion, to create or maintain a wide(r) beach, and/or to aid shoreline dynamics throughout the littoral cell. The project may include dunes and/or hard structures as part of the design.

Bluff (or Cliff): A scarp or steep face of rock, weathered rock, sediment and/or soil resulting from erosion, faulting, folding or excavation of the land mass. The cliff or bluff may be a simple planar or curved surface or it may be step-like in section. For purposes of (the Statewide Interpretive Guidelines), “cliff” or “bluff” is limited to those features having vertical relief of ten feet or more and “seacliff” is a cliff whose toe is or may be subject to marine erosion.

Bluff top retreat (or Cliff top retreat): The landward migration of the bluff or cliff edge, caused by marine erosion of the bluff or cliff toe and subaerial erosion of the bluff or cliff face.

Caisson: A supporting piling constructed by drilling a casing hole into a geologic formation and filling it with reinforcing bar and concrete; used for foundations. (See also *Piling*)

Climate change: Any long-term change in average climate conditions in a place or region, whether due to natural causes or as a result of human activity.

Climate variability: Variations in the mean state of the climate and other statistics (*e.g.*, standard deviations, the occurrence of extremes) on all temporal and spatial scales beyond that of individual weather events.

Coastal-dependent development or use: Any development or use which requires a site on, or adjacent to, the sea to be able to function at all.⁶⁰

Coastal-related development: Any use that is dependent on a coastal-dependent development or use.⁶¹

Coastal resources: A general term used throughout the Guidance to refer to those resources addressed in Chapter 3 of the California Coastal Act, including beaches, wetlands, agricultural

⁵⁹ Moser 2008

⁶⁰ Public Resources Code § 30101

⁶¹ Public Resources Code § 30101.3

lands, and other coastal habitats; coastal development; public access and recreation opportunities; cultural, archaeological, and paleontological resources; and scenic and visual qualities.

Development: On land, in or under water, the placement or erection of any solid material or structure; discharge or disposal of any dredged material or of any gaseous, liquid, solid, or thermal waste; grading, removing, dredging, mining, or extraction of any materials; change in the density or intensity of use of land, including, but not limited to, subdivision pursuant to the Subdivision Map Act (commencing with Section 66410 of the Government Code), and any other division of land, including lot splits, except where the land division is brought about in connection with the purchase of such land by a public agency for public recreational use; change in the intensity of use of water, or of access thereto; construction, reconstruction, demolition, or alteration of the size of any structure, including any facility of any private, public, or municipal utility; and the removal or harvesting of major vegetation other than for agricultural purposes, kelp harvesting, and timber operations which are in accordance with a timber harvesting plan submitted pursuant to the provisions of the Z'berg-Nejedly Forest Practice of 1973 (commencing with Section 4511).⁶²

Ecosystem-Based Management (EBM): An integrated approach to resource management that considers the entire ecosystem, including humans, and the elements that are integral to ecosystem functions.⁶³

Ecosystem services: Benefits that nature provides to humans. For example, plants, animals, fungi and micro-organisms produce services or goods like food, wood and other raw materials, as well as provide essential regulating services such as pollination of crops, prevention of soil erosion and water purification, and a vast array of cultural services, like recreation and a sense of place.⁶⁴

Emissions scenarios: Scenarios representing alternative rates of global greenhouse gas emissions growth, which are dependent on rates of economic growth, the success of emission reduction strategies, and rates of clean technology development and diffusion, among other factors.⁶⁵

Environmentally Sensitive [Habitat] Area (ESHA): Any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.⁶⁶

Erosion: The wearing away of land by natural forces; on a beach, the carrying away of beach material by wave action, currents, or the wind. Development and other non-natural forces (*e.g.*,

⁶² Public Resources Code § 30106

⁶³ NOC 2011

⁶⁴ Hassan *et al.* 2005

⁶⁵ Bedsworth and Hanak 2008

⁶⁶ Public Resources Code § 30107.5

water leaking from pipes or scour caused by wave action against a seawall) may create or worsen erosion problems.

Eustatic: Refers to worldwide changes in sea level.

Feasible (as used in “least environmentally damaging feasible alternative”): Capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors.⁶⁷

Flood (or Flooding): Refers to normally dry land becoming temporarily covered in water, either periodically (e.g., tidal flooding) or episodically (e.g., storm or tsunami flooding).⁶⁸

General Circulation Models (or General Climate Models; GCM): A global, three-dimensional computer model of the climate system which can be used to simulate human-induced climate change. GCMs are highly complex and they represent the effects of such factors as reflective and absorptive properties of atmospheric water vapor, greenhouse gas concentrations, clouds, annual and daily solar heating, ocean temperatures and ice boundaries. The most recent GCMs include global representations of the atmosphere, oceans, and land surface.⁶⁹ (See also *Atmospheric-Ocean General Circulation Models*)

Green infrastructure: Refers to the use of vegetative planting, dune management, beach nourishment or other methods that mimic natural systems to capitalize on the ability of these systems to provide flood and erosion protection, stormwater management, and other ecosystem services while also contributing to the enhancement or creation of natural habitat areas.

Greenhouse gases (GHGs): Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, carbon dioxide, methane, nitrous oxide, ozone, chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride.⁷⁰

Hard protection: A broad term for most engineered features such as seawalls, revetments, cave fills, and bulkheads that block the landward retreat of the shoreline. (See also *Revetment, Seawall, Shoreline protective devices*)

Impact assessment: The practice of identifying and evaluating the detrimental and beneficial consequences of climate change on natural and human systems.

Inundation: The process of dry land becoming permanently drowned or submerged, such as from dam construction or from sea level rise.⁷¹

⁶⁷ California Coastal Act § 30108

⁶⁸ Flick *et al.* 2012

⁶⁹ NASA Earth Observatory Glossary

⁷⁰ UNFCCC 2004

⁷¹ Flick *et al.* 2012

Local Coastal Program (LCP): A local government's (a) land use plans, (b) zoning ordinances, (c) zoning district maps, and (d) within sensitive coastal resources areas, other implementing actions, which, when taken together, meet the requirements of, and implement the provisions and policies of, this division at the local level.⁷²

Mean sea level: The average relative sea level over a period, such as a month or a year, long enough to average out transients such as waves and tides. Relative sea level is sea level measured by a tide gauge with respect to the land upon which it is situated. (See also *Sea level change/sea level rise*)

Mitigation (as used in climate science): A set of policies and programs designed to reduce emissions of greenhouse gases.⁷³

Mitigation (as used in resource management): Projects or programs intended to offset impacts to resources.

Monitoring: Systematic collection of physical, biological, chemical, or economic data, or a combination of these data on a project in order to make decisions regarding project operation or to evaluate project performance.

Passive erosion: The process whereby erosion causes the shoreline to retreat and migrate landward of any hardened structures that have fixed the location of the back beach therefore resulting in the gradual loss of beach in front of the hardened structure.

Permit: Any license, certificate, approval, or other entitlement for use granted or denied by any public agency which is subject to the provisions of this division.⁷⁴

Piling (or Pile): A long, heavy timber or section of concrete or metal driven or drilled into the earth or seabed to serve as a support or protection. (See also *Caisson*)

Potential impacts: All impacts that may occur given a projected change in climate, including impacts that may result from adaptation measures.

Public Trust Lands: All lands subject to the Common Law Public Trust for commerce, navigation, fisheries, recreation, and other public purposes. Public Trust Lands include tidelands, submerged lands, the beds of navigable lakes and rivers, and historic tidelands and submerged lands that are presently filled or reclaimed and which were subject to the Public Trust at any time.⁷⁵ (See also *Tidelands, Submerged lands*)

⁷² Public Resources Code § 30108.6

⁷³ Luers and Moser 2006

⁷⁴ Public Resources Code § 30110

⁷⁵ Public Resources Code § 13577

Radiative forcing: Radiative forcing is a measure of the influence a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and is an index of the importance of the factor as a potential climate change mechanism. In [the IPCC] report radiative forcing values are for changes relative to pre-industrial conditions defined at 1750 and are expressed in Watts per square meter (W/m^2).⁷⁶

Redevelopment: At a minimum, replacement of 50% or more of an existing structure. LCPs may also consider including limits on the extent of replacement of major structural components such as the foundation or exterior walls, or improvements costing more than 50% of the assessed or appraised value of the existing structure.

Revetment: A sloped retaining wall; a facing of stone, concrete, blocks, rip-rap, *etc.* built to protect an embankment, bluff, or development against erosion by wave action and currents. (See also *Hard protection, Seawall, Shoreline protective devices*)

Risk: Commonly considered to be the combination of the likelihood of an event and its consequences – *i.e.*, risk equals the probability of climate hazard occurring multiplied the consequences a given system may experience.⁷⁷

Scenario-based analysis: A tool for developing a science-based decision-making framework to address environmental uncertainty. In general, a range of plausible impacts based on multiple time scales, emissions scenarios, or other factors is developed to inform further decision-making regarding the range of impacts and vulnerabilities.⁷⁸

Sea level: The height of the ocean relative to land; tides, wind, atmospheric pressure changes, heating, cooling, and other factors cause sea level changes.

Sea level change/sea level rise: Sea level can change, both globally and locally, due to (a) changes in the shape of the ocean basins, (b) changes in the total mass of water and (c) changes in water density. Factors leading to sea level rise under global warming include both increases in the total mass of water from the melting of land-based snow and ice, and changes in water density from an increase in ocean water temperatures and salinity changes. Relative sea level rise occurs where there is a local increase in the level of the ocean relative to the land, which might be due to ocean rise and/or land level subsidence.⁷⁹ (See also *Mean sea level, Thermal expansion*)

Sea level rise impact: An effect of sea level rise on the structure or function of a system.⁸⁰

⁷⁶ IPCC 2007

⁷⁷ Burton *et al.* 2004

⁷⁸ NOAA 2010

⁷⁹ IPCC 2007

⁸⁰ PCGCC 2007

Seawall: A structure separating land and water areas, primarily designed to prevent erosion and other damage due to wave action. It is usually a vertical wood or concrete wall as opposed to a sloped revetment. (See also *Hard protection, Revetment, Shoreline protective devices*)

Sediment: Grains of soil, sand, or rock that have been transported from one location and deposited at another.

Sediment management: The system-based approach to the management of coastal, nearshore and estuarine sediments through activities that affect the transport, removal and deposition of sediment to achieve balanced and sustainable solutions to sediment related needs.

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate-related stimuli. The effect may be direct (*e.g.*, a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (*e.g.*, climatic or non-climatic stressors may cause people to be more sensitive to additional extreme conditions from climate change than they would be in the absence of these stressors).

Shore protection: Structures or sand placed at or on the shore to reduce or eliminate upland damage from wave action or flooding during storms.

Shoreline protective devices: A broad term for constructed features such as seawalls, revetments, riprap, earthen berms, cave fills, and bulkheads that block the landward retreat of the shoreline and are used to protect structures or other features from erosion and other hazards. (See also *Hard protection, Revetment, Seawall*)

Still water level: The elevation that the surface of the water would assume if all wave action were absent.

Storm surge: A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes the rise in water level due to atmospheric pressure reduction as well as that due to wind stress.

Submerged lands: Lands which lie below the line of mean low tide.⁸¹ (See also *Public Trust Lands, Tidelands*)

Subsidence: Sinking or down-warping of a part of the earth's surface; can result from seismic activity, changes in loadings on the earth's surface, fluid extraction, or soil settlement.

Tectonic: Of or relating to the structure of the earth's crust and the large-scale processes that take place within it.

Thermal expansion: An increase in water volume in response to an increase in temperature, through heat transfer.

⁸¹ Public Resources Code § 13577

Tidal prism: The total amount of water that flows into a harbor or estuary and out again with movement of the tide, excluding any freshwater flow.

Tidal range: The vertical difference between consecutive high and low waters. The Great Diurnal Range is the difference between mean higher high water and mean lower low water; the Mean Range of tide is the difference in height between mean high water and mean low water.⁸²

Tidelands: Lands which are located between the lines of mean high tide and mean low tide.⁸³
(See also *Public Trust Lands, Submerged lands*)

Transfer of Development Rights (TDR): A device by which the development potential of a site is severed from its title and made available for transfer to another location. The owner of a site within a transfer area may retain property ownership, but not approval to develop. The owner of a site within a receiving area may purchase transferable development rights, allowing a receptor site to be developed at a greater density.⁸⁴

Tsunami: A long period wave, or seismic sea wave, caused by an underwater disturbance such as an earthquake, submarine landslide, or subaerial landslide (slope failure from land into a water body). Tsunamis can cause significant flooding in low-lying coastal areas and strong currents in harbors. (Commonly misnamed a *Tidal wave*)

Vulnerability: The extent to which a species, habitat, ecosystem, or human system is susceptible to harm from climate change impacts. More specifically, the degree to which a system is exposed to, susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, as well as of non-climatic characteristics of the system, including its sensitivity, and its coping and adaptive capacity.

Vulnerability assessment: A practice that identifies who and what is exposed and sensitive to change and how able a given system is to cope with extremes and change. It considers the factors that expose and make people or the environment susceptible to harm and access to natural and financial resources available to cope and adapt, including the ability to self-protect, external coping mechanisms, support networks, and so on.⁸⁵

Wave: A ridge, deformation, or undulation of the surface of a liquid. On the ocean, most waves are generated by wind and are often referred to as wind waves.

Wave height: The vertical distance from a wave trough to crest.

Wave length (or Wavelength): The horizontal distance between successive wave crests or between successive troughs of waves.

⁸² NOAA 2013

⁸³ Public Resources Code § 13577

⁸⁴ Cal OPR 1987

⁸⁵ Tompkins *et al.* 2005

Wave period: The time for a wave crest to traverse a distance equal to one wavelength, which is the time for two successive wave crests to pass a fixed point.

Wave runup: The distance or extent that water from a breaking wave will extend up the shoreline, including up a beach, bluff, or structure.



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Appendix A

Sea Level Rise Science and Projections for Future Change

DRIVERS OF SEA LEVEL RISE

The main mechanisms driving increases in *global* sea level are: 1) expansion of sea water as it gets warmer (thermal expansion) and, 2) increases in the amount of water in the ocean from melting of land-based glaciers and ice sheets as well as human-induced changes in water storage and groundwater pumping (Chao *et al.* 2008; Wada *et al.* 2010; Konikow 2011).¹ The reverse processes can cause global sea level to fall.

Sea level at the *regional and local levels* often differs from the average global sea level.² Regional variability in sea level results from large-scale tectonics and ocean and atmospheric circulation patterns. The primary factors influencing local sea level include tides, waves, atmospheric pressure, winds, vertical land motion and short duration changes from seismic events, storms, and tsunamis. Other determinants of local sea level include changes in the ocean floor (Smith and Sandwell 1997), confluence of fresh and saltwater, and proximity to major ice sheets (Clark *et al.* 1978; Perette *et al.* 2013).

Over the long-term, sea level trends in California have generally followed global trends (Cayan *et al.* 2009; Cayan *et al.* 2012). However, global projections do not account for California's regional water levels or land level changes. California's water levels are influenced by large-scale oceanographic phenomena such as the El Niño Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO), which can increase or decrease coastal water levels for extended periods of time. [Figure A-1](#) shows how El Niño and La Niña events have corresponded to mean sea level in California in the past. California's land levels are also affected by plate tectonics and earthquakes. Changes to water as well as land levels are important factors in regionally down-scaled projections of future sea level. It follows that the sea level rise projections specific to California are more relevant to efforts in the coastal zone of California than projections of global mean sea level.

¹ Large movements of the tectonic plates have been a third major mechanism for changes in global sea level. The time periods for plate movements to significantly influence global sea level are beyond the time horizons used for even the most far-reaching land-use decisions. Plate dynamics will not be included in these discussions of changes to future sea level.

² For further discussion of regional sea level variations and regional sea level rise projections, see Yin *et al.* 2010, Slangen *et al.* 2012, and Levermann *et al.* 2013, as examples.

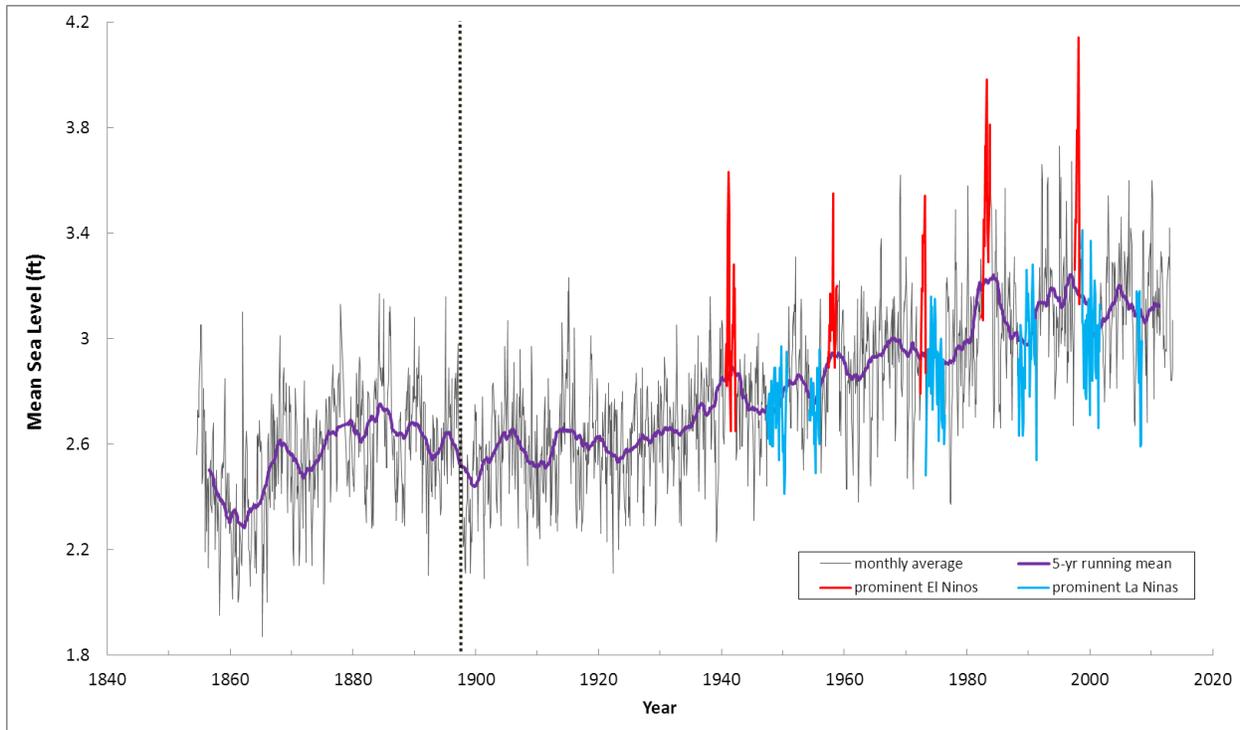


Figure A-1. Variations in monthly mean sea level at Fort Point, San Francisco, 1854 to 2013. Mean sea level heights (in ft) are relative to mean lower low water (MLLW). Purple line represents the 5-year running average. Note that the monthly mean sea level has varied greatly throughout the years and that several of the peaks occurred during strong El Niño events (red highlight). Periods of low sea level often occurred during strong La Niña events (blue highlight). The current “flat” sea level condition can also be seen in the 5-year running average. (Sources: NOAA CO-OPS data, Station 9414290, <http://tidesandcurrents.noaa.gov/> (sea level); NOAA Climate Prediction Center, <http://www.elnino.noaa.gov/> (ENSO data))

APPROACHES FOR PROJECTING FUTURE GLOBAL SEA LEVEL RISE

This section provides an overview of some of the more well-known approaches that have been used to project sea level changes and their relevance to California. [Appendix B](#) will cover how these projections can be used to determine water conditions at the local scale.

There is no single, well-accepted technique for projecting future sea level rise. Understanding future sea level rise involves projecting future changes in glaciers, ice sheets, and ice caps, as well as future groundwater and reservoir storage. Two subjects in particular present challenges in sea level rise modeling. First, future changes to glaciers, ice sheets, and ice caps are not well understood and, due to the potential for non-linear responses from climate change, they present many difficulties for climate models (Overpeck 2006; Pfeffer *et al.* 2008; van den Broecke *et al.* 2011; Alley and Joughin 2012; Shepherd *et al.* 2012; Little *et al.* 2013). Second, the actual magnitudes of the two human-induced changes – pumping of groundwater and storage of water in reservoirs – are poorly quantified, but the effects of these activities are understood and can be modeled (Wada *et al.* 2010). Despite these challenges, sea level rise projections are needed for many coastal management efforts and scientists have employed a variety of techniques to model sea level rise, including:

1. Extrapolation of historical trends;
2. Modeling the physical conditions that cause changes in sea level;
3. Empirical or semi-empirical methods; and
4. Expert elicitations

There are strengths and weaknesses to each approach, and users of any sea level rise projections should recognize that there is no perfect approach for anticipating future conditions. This section provides users of the Guidance document with a general understanding of several of the most widely used sea level rise projection methodologies and their respective advantages and disadvantages. [Figure A-2](#) provides a visual summary of several of the more commonly cited projections of future global and regional sea level rise.

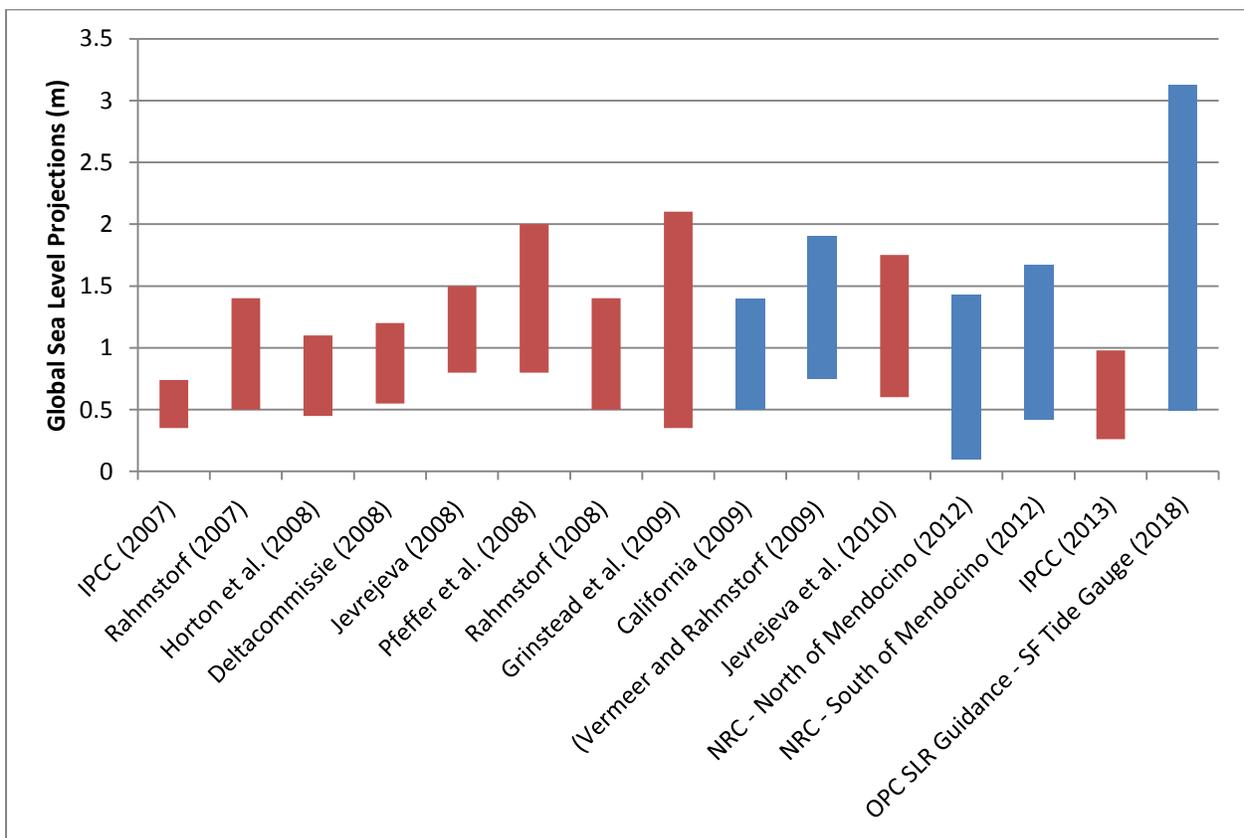


Figure A-2. Sea level rise projections for year 2100 from scientific literature. Graphic summary of the range of average sea level rise (SLR) projections by end of century (2090–2100) from the peer-reviewed literature as compared to the recent National Research Council report for California, Oregon and Washington. The light blue shaded boxes indicate projections for California. Ranges are based on the IPCC scenarios, with the low range represented by the B1 scenario (moderate growth and reliance in the future on technological innovation and low use of fossil fuels) and the high part of the range represented by the A1FI scenario (high growth and reliance in the future on fossil fuels). Details on the methods used and assumptions are provided in the original references.

Extrapolation of Historical Trends

Extrapolation of historical trends in sea level has been used for many years to project future changes in sea level. The approach assumes that there will be no abrupt changes in the processes that drive the long-term trend, and that the driving forces will not change. However, drivers of climate change and sea level rise, such as radiative forcing, are known to be changing, and this method is no longer considered appropriate or viable in climate science.

A recent modification to the historical trend method discussed above has been to estimate rates of sea level rise during the peak of the last interglacial (LIG) period (~125,000 years before present, when some drivers of sea level rise were similar to those today)³ and use these as proxy records to project sea level rise rates to the 21st Century. For example, Katsman *et al.* (2011) and Vellinga *et al.* (2008) used the reconstructed LIG record of sea level change (from Rohling *et al.* 2008) to reconstruct sea level rise rates during rapid climate warming, and applied these rates to estimate sea level at years 2100 and 2200. Similarly, Kopp *et al.* (2009) used sea level rise rates inferred from the LIG to estimate a range of sea level rise for Year 2100 between 1-3 ft (0.3-1 m). Compared to traditional historical trend extrapolation, this modified approach has the advantage of including the dynamic responses of ice sheets and glaciers to past global climates that were significantly warmer than the present, but is limited by the large uncertainties associated with proxy reconstructions of past sea level.

Physical Models

Physical climate models use mathematical equations that integrate the basic laws of physics, thermodynamics, and fluid dynamics with chemical reactions to represent physical processes such as atmospheric circulation, transfers of heat (thermodynamics), development of precipitation patterns, ocean warming, and other aspects of climate. Some models represent only a few processes, such as the dynamics of ice sheets or cloud cover. Other models represent larger scale atmospheric or oceanic circulation, and some of the more complex General Climate Models (GCMs) include atmospheric and oceanic interactions.

Physical models of sea level changes account for the thermal expansion of the ocean and the transfer of water currently stored on land, particularly from glaciers and ice sheets (Church *et al.* 2011). Currently, coupled Atmosphere-Ocean General Circulation Models (AOGCMs) and ice sheet models are replacing energy-balance climate models as the primary techniques supporting sea level projections (IPCC 2013). Ocean density, circulation and sea level are dynamically connected in AOGCMs as critical components of the models include surface wind stress, heat transfer between air and sea, and freshwater fluxes. AOGCM climate simulations have recently been used as input for glacier models (Marzeion *et al.* 2012) which project land-water contributions to sea level.

The Intergovernmental Panel on Climate Change (IPCC) is one of the main sources of peer-reviewed, consensus-based modeling information on climate change. The IPCC does not undertake climate modeling, but uses the outputs from a group of climate models that project

³ During the last interglacial, global mean temperature was 1-2°C warmer than the pre-industrial era (Levermann *et al.* 2013), while global mean sea level was likely 16.4-29.5 ft (5-9 m) above present mean sea level (Kopp *et al.* 2009; Dutton and Lambeck 2012; Levermann *et al.* 2013).

future temperature, precipitation patterns, and sea level rise, based on specific emission scenarios. Early in the 1990s, the IPCC developed basic model input conditions to ensure comparable outputs from the various models. The IPCC initially developed scenarios of future emissions, based on energy development, population and economic growth, and technological innovation. Four families of scenarios (A1, A2, B1, and B2) and subgroups (A1B, A1FI, A1T) were developed and used for climate and sea level rise projections for early IPCC reports (1990, 1995, 2001, 2007). IPCC used 4 new scenarios for the [5th Assessment Report](#) (AR5) in 2013, based on Representative Concentration Pathways (RCPs) that are different greenhouse gas concentration trajectories. These trajectories bear similarities to, but are not directly comparable to the earlier emission scenarios. Projections in IPCC AR5 (2013) differ from the earlier IPCC projections due to improvements in climate science, changes due to the new scenarios, and changes in the models to accommodate the new inputs, with improvements in climate science and model capabilities driving the bulk of the changes.

One finding of the earlier 2007 IPCC report called for improved modeling of ice dynamics. Focused research on ice dynamics to improve the ability of climate models to address the scale and dynamics of change to glaciers, ice sheets, and ice caps was subsequently undertaken (*e.g.*, Price *et al.* 2011; Shepherd *et al.* 2012; Winkelmann *et al.* 2012; Bassis and Jacobs 2013; Little *et al.* 2013). Recent modeling results presented in the AR5 (IPCC 2013) reflect the scientific community's increased understanding in, as well as advances in modeling of the impacts of glacier melting and ocean thermal expansion on sea level change. AR5 scenarios reflect a greater range of global sea level rise (28-98 cm) based on improved modelling of land-ice contributions.

Semi-Empirical Method

The semi-empirical method for projecting sea level rise is based on developing a relationship between sea level and some factor (a proxy) – often atmospheric temperature or radiative forcing – and using this relationship to project changes to sea level. An important aspect for the proxy is that there is fairly high confidence in models of its future changes; a key assumption that is made by this method is that the historical relationship between sea level and the proxy will continue into the future. One of the first projections of this kind was based on the historical relationship between global temperature changes and sea level changes (Rahmstorf 2007). This semi-empirical approach received widespread recognition for its inclusion of sea level rise projections. These projections looked at the temperature projections for two of the previous IPCC (2007) emission scenarios that span the likely future conditions within the report's framework – B1, an optimistic, low-greenhouse gas emission future, and A1FI, a more “business-as-usual” fossil fuel intensive future.⁴ The Rahmstorf 2007 sea level rise projections were used in the California 2009 *Climate Change Scenarios Assessment* (Cayan 2009).

Since the initial semi-empirical projections for future sea level rise (Rahmstorf 2007), other researchers have published different projections based on the IPCC scenarios, using different

⁴ When the IPCC began examining climate change, the available models used a broad range of inputs. In an attempt to evaluate the different model outputs based on the different model characteristics rather than the inputs, the IPCC developed a number of standard greenhouse gas emission scenarios. These scenarios are described in *Response Strategies Working Group III* (IPCC 1990). In general, the B1 scenario projects the lowest temperature and sea level increases and the A1FI projects the highest increases.

data sets or best-fit relationships.⁵ Notably, Vermeer and Rahmstorf (2009) prepared a more detailed methodology that includes both short-term responses and longer-term responses between sea level rise and temperature. These 2009 projections of sea level rise were used in the *Interim Guidance on Sea Level Rise* (OPC 2010) and the California 2012 *Vulnerability and Assessment Report* (Cayan 2012).

There are also several new semi-empirical sea level rise projections based on scenarios other than those developed by the IPCC. For instance, Katsman *et al.* (2011) use a “hybrid” approach that is based on one of the newer radiative forcing scenarios and empirical relationships between temperature change and sea level. Future projections were then modified to include contributions from the melting of major ice sheets based on expert judgment⁶. This yields what they call “high end” SLR projections for Years 2100 and 2200 under several emissions scenarios.

Zecca and Chiari (2012) produced semi-empirical sea level rise projections based on their own scenarios of when fossil fuel resources would be economically exhausted. Though based on a different set of assumptions about human behavior/choices, in terms of global temperature and radiative forcing, the scenarios do not differ greatly from the IPCC scenarios. The results are identified as being “lower bound” sea level rise projections for high, medium, low fuel use scenarios, and “mitigation” (extreme and immediate action to replace fossil fuel use) scenarios. The report then provides projections for the 2000-2200 time period.

Expert Elicitation

Expert elicitation is one of the newer methods that have been used for projecting or narrowing ranges of future sea level rise. Using expert judgment has been an important aspect of scientific inquiry and the scientific method. The method of expert elicitation is a formalized use of experts in climate science and sea level change to help either narrow uncertainty for sea level projections, or to help with specifying extremes of a range. The elicitation method normally begins with experts refining model output information. One of the first attempts to use expert elicitation for sea level rise was a study by Titus and Narayanan (1996), when it was thought there was only 1% probability that sea level would exceed 3.3 ft (1 m) by Year 2100. In 2011, the Arctic Monitoring and Assessment Programme Report (AMAP 2011) surveyed the climate literature to construct a range of estimates of sea level rise by the year 2100, and then used a panel of experts to decide on a smaller, more plausible range. Not surprisingly, the projections supported by the AMAP experts fell right in the middle of the range shown in [Figure A-2](#). Bamber and Aspinall (2013) used a statistical analysis of a large number of expert estimates to

⁵ Semi-empirical projections of sea level rise using relationships between water level and radiative forcing such as those from Grinsted *et al.* (2009), Jevrejeva *et al.* (2010), Katsman *et al.* (2011), Meehl *et al.* (2012), Rahmstorf *et al.* (2012), Schaeffer *et al.* (2012), and Zecca and Chiari (2012) have shown general agreement with the projections by Vermeer and Rahmstorf (2009). The Grinsted *et al.* projections have a wider range than those of Vermeer and Rahmstorf, while the Jevrejeva *et al.* projections are slightly lower. All semi-empirical methods project that sea level in Year 2100 is likely to be much higher than linear projections of historical trends and the projections from the 2007 IPCC.

⁶ Expert judgment has long been part of the scientific process. Expert elicitation, which is a formalized process for using expert judgment, has grown in importance and is discussed as a separate approach for projecting future sea level rise.

develop their projected range of future sea level, projecting sea level rise by 2100 ranging from 1–4.3 ft (0.33–1.32 m), under one of the intermediate AR5 scenarios (RCP 4.5).

Horton *et al.* (2014) surveyed experts in sea level science, based upon published papers, to develop a probabilistic assessment of long-term sea level rise (by the years 2100 and 2300), assuming two very different scenarios. Under one scenario, aggressive efforts would limit greenhouse gas concentrations that would cause global temperature to increase slightly until about 2050 when it would slowly drop (AR5’s RCP 3 scenario). Under the other scenario, temperatures would continue to increase through to 2300 (AR5’s RCP 8.5 scenario). Experts determined that it is likely that sea level rise could remain below 3.3 ft (1 m) for the low emission scenario (RCP 2.6), but that the likely range of future sea level rise for the high emission scenario (RCP 8.5) could be 6.6-9.8 ft (2-3 m).

Kopp *et al.* (2014) have combined detailed process modeling, community assessments and expert elicitation to assign probability distributions of local sea level rise through 2200 for identified communities around the world. Under the high concentration scenario, RCP 8.5, Kopp *et al.* estimate the “maximum physically possible rate of sea level rise” to be 8.2 ft (2.5 m) for the year 2100. This study also finds that sea level rise along the Pacific Coast of the US is close to the global average, and the likely range of sea level is 2-3.3 ft (0.6-1.0 m) by the year 2100 at San Francisco, under the high concentration scenario. In contrast, in areas of high subsidence such as Galveston, Texas, the likely range of sea level in by 2100 ranges from 3.3 to 5 ft (1.0-1.5 m). And, at many of the localities that were examined, including San Francisco, the current 1-in-10 year flooding event is likely to occur every other year by 2100 (five times more frequently) due to sea level rise; the frequency of the 1-in-100 year event is expected to double by the year 2100 with sea level rise.

Coastal communities cannot ignore sea level rise in long-term planning, permitting and project design. The four different approaches to projecting future sea level rise all have varying strengths and weaknesses. As noted earlier in this section, projections, like models, will not be completely accurate, but they are important tools for evaluation nonetheless⁷. The most commonly cited projections provide future sea level as a range, as a way to allow for many of the uncertainties that are part of future climate change. Often, projections of sea level rise rely upon multiple approaches. For example, the 2012 National Research Council (NRC) report was developed through expert judgment that combined information from both physical models and semi-empirical projections.

⁷ George E.P. Box, mathematician and statistician is quoted as saying, “Essentially all models are wrong, but some are useful.”

BEST AVAILABLE SCIENCE ON SEA LEVEL RISE

Global Projections of Sea Level Rise

The best available science on *global* sea level rise projections is currently the IPCC *Fifth Assessment Report: Climate Change 2013* (AR5) released in September 2013. The new report now projects a more rapid sea level rise than the *Fourth Assessment* (AR4) released in 2007. By Year 2100, the AR5 projects global sea level to be more than 50% higher (26-98 cm) than the old projections (18-59 cm) when comparing similar emission scenarios and time periods. The increase in AR5 sea level projections results from improved modelling of land-ice contributions. Substantial progress in the assessment of extreme weather and climate events has also been made since the AR4 as models now better reproduce phenomena like the El Niño-Southern Oscillation (ENSO; IPCC 2013).

National Projections of Sea Level Rise

The [third National Climate Assessment](#) (NCA) was released in May 2014 (Melillo *et al.*), and includes the current best-available science on climate change and sea level rise *at the national scale*.⁸ The sea level rise projections in the NCA were informed by the 2012 NOAA report titled [Global Sea Level Rise Scenarios for the United States National Climate Assessment](#) (Parris *et al.*). This report provides a set of four scenarios of future global sea level rise, as well as a synthesis of the scientific literature on global sea level rise. The NOAA Climate Program Office produced the report in collaboration with twelve contributing authors.⁹ The report includes the following description of the four scenarios of sea level rise by the year 2100:

- **Low scenario:** The lowest sea level change scenario (a rise of 8 in (20 cm)) is based on historical rates of observed sea level change.
- **Intermediate-low scenario:** The intermediate-low scenario (a rise of 1.6 ft (0.5 m) is based on projected ocean warming.
- **Intermediate- high scenario:** The intermediate-high scenario (a rise of 3.9 ft (1.2 m)) is based on projected ocean warming and recent ice sheet loss.
- **High scenario:** The highest sea level change scenario (a rise of 6.6 ft (2 m)) reflects ocean warming and the maximum plausible contribution of ice sheet loss and glacial melting.

The Parris *et al.* (2012) report recommends that the highest scenario be considered in situations where there is little tolerance for risk. It also provides steps for planners and local officials to modify these scenarios to account for local conditions. These steps are intended for areas where local sea level rise projections have not been developed. For California, the 2018 OPC SLR Guidance report (below) provides scenarios that have been refined for use at the local level, and the Coastal Commission recommends using the OPC projections rather than the global or national scenarios.

⁸ Note that the 4th National Climate Assessment is due to be released in late 2018. <https://www.globalchange.gov/nca4>

⁹ Authors include NOAA, NASA, the US Geologic Survey, the Scripps Institution of Oceanography, the US Department of Defense, the US Army Corps of Engineers, Columbia University, the University of Maryland, the University of Florida, and the South Florida Water Management District.

California-Specific Projections of Sea Level Rise and Best Available Science

The State of California has long-supported the development of scientific information on climate change and sea level rise to help guide planning and decision-making. For example, the State helped support the development of the 2012 National Research Council (NRC) report, [*Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*](#), which provided an examination of global and regional sea level rise trends and projections of future sea level. This report was then incorporated into the Ocean Protection Council's 2013 *State Sea-Level Rise Guidance*, and was considered the best available science on sea level rise for California.

More recently, and in response to the release of new scientific studies related to sea level rise, Governor Brown directed the OPC to synthesize recent science on sea level rise and incorporate findings into updates to the State Guidance. In April 2017, a working group of OPC's Science Advisory team (comprised mainly of climate researchers at various academic institutions in California and throughout the country) released a report titled [*Rising Seas in California: An Update on Sea-Level Rise Science*](#). The report highlighted seven key findings:

1. *Scientific understanding of sea level rise is advancing at a rapid pace.* Sea level rise projections have increased substantially over the last few years, particularly for late in the 21st century and under high emissions scenarios, due to our evolving understanding of the dynamics of ice sheet loss. However, there is still significant uncertainty regarding these processes.
2. *The direction of sea level change is clear.* Coastal California is already experiencing the impacts of rising sea levels, and impacts will increase in the future.
3. *The rate of ice loss from the Greenland and Antarctic ice sheets is increasing.* Ice sheet loss will soon overtake thermal expansion of seawater as the primary driver of rising sea levels. Due to a variety of ocean circulation dynamics, ice loss from Antarctica, and particularly West Antarctica, has an outsized impact on California compared to the rest of the world ([Figure A-3](#)). Continued research on this dynamic is critical for accurately projecting future sea level rise along our coast.
4. *New scientific evidence has highlighted the potential for extreme sea level rise.* Recent research (e.g., DeConto and Pollard, 2016; Sweet et al., 2017) has found that, if greenhouse gas emissions are not curtailed, glaciological processes could cross thresholds that lead to rapidly accelerating and effectively irreversible ice loss. The probability of this extreme scenario is currently unknown, but its consideration is important. Significant reductions in greenhouse gas emissions may reduce the likelihood of this extreme scenario, but does not completely eliminate the risk. Importantly, it is difficult to determine if the world is on the track for extreme and irreversible ice loss for some time because the processes that drive extreme ice loss in the later part of the century or beyond are different than those that are driving ice loss now.

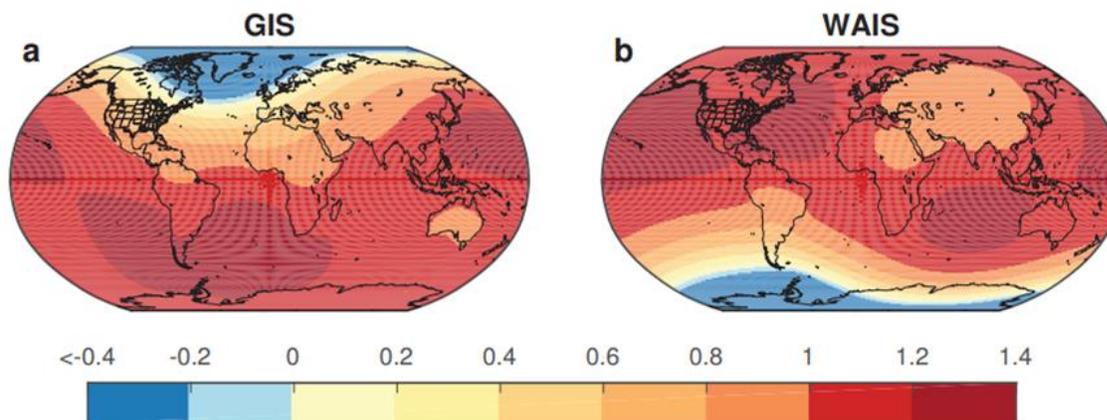


Figure A-3. Sea level ‘fingerprints’ resulting from the distribution of ice and water around the Earth and ensuing gravitational and rotational effects. The maps depict the relative response of sea-level to the loss of ice mass from (a) Greenland Ice Sheet (GIS) and (b) West Antarctic Ice Sheet (WAIS). The color bar represents the fractional departure of relative sea level rise from that expected given the ice contribution to global mean sea level. For example, when ice is lost from the Greenland Ice Sheet the relative effect on the US West Coast is 75% of the sea-level rise expected from the water volume added to the ocean. By comparison, when ice is lost from the West Antarctic Ice Sheet the US West Coast experiences 125% of sea-level rise from that expected from the water volume added (*from Griggs et al. 2017*).

5. *Probabilities of specific sea-level increases can inform decisions.* A probabilistic approach to sea level rise projections, combined with a clear articulation of the implications of uncertainty and the decision support needs of affected stakeholders, is the most appropriate approach for use in a policy setting.

The OPC Scientific Working Group utilized a comprehensive probability approach based on Kopp et al. (2014) that estimates both a comprehensive probability distribution and the likelihood of extreme ‘tail’ outcomes. It is important to note that probabilistic projections do not provide probabilities of occurrence of sea level rise, but rather probabilities that the ensemble of climate models used to estimate contributions of sea level rise (from thermal expansion, ice sheet loss, oceanographic conditions etc.) will predict a certain amount of sea level rise.

Note that the probabilistic projections do not consider the H++ extreme ice loss scenario. The extreme ice loss studies were not included in the inputs to the model ensemble, which means the probability distributions may be an underestimate.¹⁰

6. *Current greenhouse gas emissions policy decisions are shaping our coastal future.* Before 2050, differences in SLR projections under different emissions scenarios are minor. After 2050, SLR projections increasingly depend on the trajectory of greenhouse

¹⁰ The 4th California Climate Assessment developed projections that present a broader range of SLR estimates than the Rising Seas science report and the 2018 OPC SLR Guidance. Both programs’ projections are based on estimates of contributions to SLR from primary sources using different methods, including model projections and expert input. However, the 4th Assessment incorporates the findings from the recent studies regarding the potential for rapid loss of Antarctic ice sheets (which results in the H++ scenario of about 10ft. of SLR by 2100) into its probabilistic projections whereas the OPC reports do NOT include this possibility in the probabilistic projections, as explained above.

gas emissions. If greenhouse gas emissions are not curtailed worldwide, we will see significantly higher rates of sea level rise during the second half of the century.

7. *Waiting for scientific certainty is neither a safe nor prudent option.* Taking action today to assess vulnerabilities and identify and implement adaptation strategies will prevent much greater losses than will occur if action is not taken. Taking a precautionary approach that considers high and extreme scenarios is critical for safeguarding the people and resources of coastal California.

This scientific information was incorporated into OPC's [State Sea-Level Rise Guidance: 2018 Update](#). The OPC Guidance includes projection tables for 12 tide gauges along the California coast for each decade from 2030 to 2150. OPC further recommends utilizing three different projection scenarios to guide planning, permitting, investment, and other decisions based on the type of project, its ability to cope with or adapt to sea level rise, and the consequences to the environment and the project associated with sea level rise. The projection table for the San Francisco tide gauge is provided below ([Table A-1](#)), and tables for other California tide gauges are presented in [Appendix G](#). The 2018 OPC SLR Guidance (along with the foundational Rising Seas science report) is currently considered best available science on sea level rise for the State of California.

The Coastal Commission recommends that the low, medium-high, and extreme risk aversion scenarios from the OPC 2018 Sea-Level Rise Guidance be considered in all relevant local coastal planning and coastal development permitting decisions.

Table A-1. Sea Level Rise Projections for the San Francisco Tide Gauge¹¹ (OPC 2018)

Projected Sea Level Rise (in feet): <i>San Francisco</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.8	1.0
2040	0.8	1.3	1.8
2050	1.1	1.9	2.7
2060	1.5	2.6	3.9
2070	1.9	3.5	5.2
2080	2.4	4.5	6.6
2090	2.9	5.6	8.3
2100	3.4	6.9	10.2
2110*	3.5	7.3	11.9
2120	4.1	8.6	14.2
2130	4.6	10.0	16.6
2140	5.2	11.4	19.1
2150	5.8	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹¹ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

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Appendix B

Developing Local Hazard Conditions Based on Regional or Local Sea Level Rise Using Best Available Science

This Appendix provides technical information regarding how to determine local hazard conditions for sea level rise planning efforts. This process is described more broadly as Steps 1-3 in Chapters 5 and 6 in this document, and includes determining a range of sea level rise projections and analyzing the physical effects and possible resource impacts of sea level rise hazards.

Water level varies locally, so this analysis must be performed on a regional or site specific basis, and applicants and planners should prioritize obtaining data or conducting research at the correct geographical scale. The 2018 OPC Sea-Level Rise Guidance is considered the best available science on California's regional sea level rise, and the Commission recommends using it when sea level rise projections are needed. Equivalent resources may be used by local governments and applicants provided that the resource is peer-reviewed, widely accepted within the scientific community, and locally relevant.⁹⁷

Much of the research by the Intergovernmental Panel on Climate Change (IPCC) and others has focused on global and regional changes to mean sea level. However, the coast is formed and changed by local water and land conditions. Local tidal range influences where beaches, wetlands and estuaries will establish; waves and currents are major drivers of shoreline change; and storms and storm waves are often the major factors causing damage to coastal development. It is local conditions that influence beach accretion and erosion, storm damage, bluff retreat, and wetland function.

Local water levels along the coast are affected by local land uplift or subsidence, tides, waves, storm waves, atmospheric forcing, surge, basin-wide oscillations, and tsunamis. Some of these factors, such as tides and waves, are ever-present and result in ever-changing shifts in the local water level. Other drivers, such as storms, tsunamis, or co-seismic uplift or subsidence, are episodic but can have important influences on water level when they occur. The following section discusses these factors in the context of sea level rise and how to incorporate them into planning and project analysis.

In most situations, high water will be the main project or planning concern. For wetlands, the intertidal zone between low and high tides will be of concern, while in some special situations, such as for intake structures, low water might be the main concern. In situations where low water is the concern, current low water is likely to be the low water planning condition and there may be no need to factor future sea level rise into those project or planning situations. In most other situations, hazards analyses will need to account for sea level rise. The following box identifies some of the key situations in which it may be important for coastal managers and applicants to consider sea level rise during project review.

⁹⁷ This appendix is written in such a way that it complements the materials from the 2012 NRC Report and the 2018 OPC SLR Guidance, which is currently considered the best available science on sea level rise in California. As new reports are issued in the future, Commission staff will assess whether they should be considered the best available science and update the approaches or terminology in this Appendix accordingly.

General situations needing sea level rise analysis include when the project or planning site is:

- Currently in or adjacent to an identified floodplain
- Currently or has been exposed to flooding or erosion from waves or tides
- Currently in a location protected from flooding by constructed dikes, levees, bulkheads, or other flood-control or protective structures
- On or close to a beach, estuary, lagoon, or wetland
- On a coastal bluff with historic evidence of erosion
- Reliant upon shallow wells for water supply

For situations where future sea level conditions will be important for the analyses of hazards or resource impacts, the following sections are provided as guidance for determining local hazards. [Figure B-1](#) shows the general progression for going from global sea level projections to the possible consequences or impacts that can result from local water levels.

The following information provides guidance on using temporally- and regionally-appropriate sea level rise projections to determine future tidal elevations and inundation, future still water, future shoreline change and erosion, potential flooding, wave impacts and wave runup, and flooding from extreme events⁹⁸.

Most of these analyses must occur sequentially. Sea level rise is used to determine changes in tidal conditions, and tidal conditions are combined with future surge, El Niño Southern Oscillation (ENSO) events, and Pacific Decadal Oscillations (PDOs) to estimate local still water. Changes in the frequencies of still water levels will in turn affect erosion rates, and the amount of erosion will affect future wave impacts, runup and flooding.

To be consistent with other sections, these different efforts are presented as Steps, with a discussion of how to accomplish each and the expected outcome. Depending upon the planning or project concerns and required analysis, it may not be necessary to proceed step-by-step and readers should use their judgment as to which items are relevant to their concerns. For example, if the concern is about runup on a non-erosive slope due to an increase in the still water level of 5.5 ft (1.7 m), the guidance on wave runup analysis may be all that is necessary.

⁹⁸ Importantly, the 2018 OPC SLR Guidance includes projections tables for 12 tide gauges throughout California, and for every 10 years from 2030 to 2150. As such, adjusting the projections to account for more localized conditions or specific years is likely unnecessary. This is a change from the 2012 NRC report, which included projections for north and south of Cape Mendocino and for only three time periods. Thus, sections within this Appendix that pertained to developing temporally- and spatially-adjusted projections (including mathematic interpolation methods) have largely been removed in the 2018 update.

- Step 1 – Develop temporally- and spatially-appropriate sea level rise projections
- Step 2 – Determine tidal range and future inundation
- Step 3 – Determine still water level changes from surge, El Niño events and PDOs
- Step 4 – Estimate beach, bluff, and dune change from erosion
- Step 5 – Determine wave, storm wave, wave runup, and flooding conditions
- Step 6 – Examine potential flooding from extreme events

A Note on Hydrodynamic Models versus “Bathtub Fill” Models

It is important to be aware of the differences between a so-called “bathtub fill” model and hydrodynamic models, and the related pros and cons of each for analysis of sea level rise impacts. In general, “bathtub fill” refers to those models that analyze flooding or inundation based solely on elevation. In other words, if sea level is projected to rise 3 ft (1 m), thereby increasing flooding/inundation from a current elevation of +10 ft (3 m) to +13 ft (4 m), these models will, in general, flood everything below the +13 ft (4m) elevation. The modeling does not take into consideration whether the new flood areas are connected to the ocean, nor does it consider how the changes to the water level will change wave propagation or overtopping of flood barriers. This is a significant oversimplification of the processes involved in flooding, but it provides value in allowing individuals to gain a broad view of the general areas that could be impacted by sea level rise without requiring a great deal of technical information.

Conversely, hydrodynamic modeling takes into account the details of local development patterns and the characteristics of waves and storms, and can therefore provide a much better understanding of local sea level rise impacts than is possible from “bathtub fill” models. In particular, hydrodynamic models take into account factors that alter flooding and inundation patterns and impacts. Such factors may include the extent and orientation of development – for example, roadways and linear features that tend to channelize water flows, and buildings or flood barriers that can block and divert flows – as well as the conditions that contribute to flooding and inundation, such as wave conditions, flow velocities, the extent of overtopping, and so on. Although the initial development of the modeling grid that is used to depict the community development patterns can be quite time-consuming to create and the model output will change with differing grid designs (Schubert and Sanders 2012), once the grid is developed, hydrodynamic modeling can be used to better characterize areas of flooding and to distinguish areas of concentrated flooding from those areas that may experience small amounts of flooding only during peak conditions (Gallien *et al.* 2011, 2012).

Significantly, many of the analyses described in this Appendix are the kinds of analyses that go beyond “bathtub fill” modeling to include the hydrodynamic factors that help to specify the more location-specific impacts for which planners should prepare.

From Global Sea-Level Rise to Local Consequences

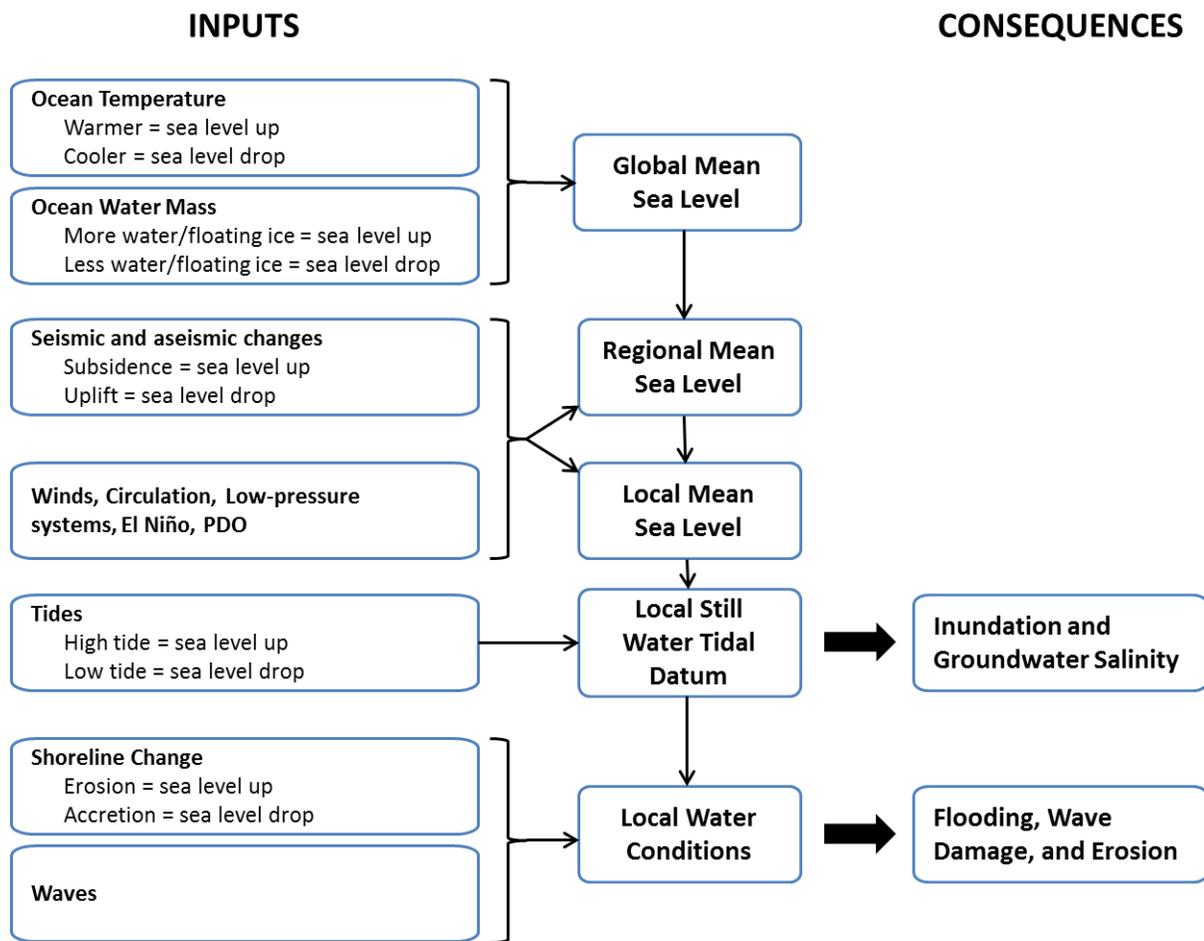


Figure B-1. General process for translating global sea level rise to local consequences

Step 1 – Develop temporally- and spatially-appropriate sea level rise projections

a. Identify the nearest tide gauge

The 2018 OPC Sea-Level Rise Guidance contains projection tables for 12 tide gauges along the California coast in order to account for localized trends in relative sea level rise, related mainly to different rates of vertical land motion. The 12 tide gauges are mapped in Appendix 2 of the OPC Guidance (and copied in [Appendix G](#) here). OPC directs users to identify the nearest tide gauge to the project or planning site and to use the associated projection table in planning and permitting. In some cases it may be appropriate to interpolate between two tide gauges (if the project site is equidistant between tide gauges) or to use more locally-specific scientific data, if available. In many cases, though, the differences among projections (either between two tide gauges or from more localized data) are likely to be small, and therefore may be insignificant compared to overall uncertainty in modeling and/or future greenhouse gas emissions scenarios.

b. Determine appropriate planning horizon or expected project life and identify relevant sea level rise projections

The first step in a sea level rise analysis is to determine the appropriate planning horizon based on the expected life of the project. The longer the life of a project or planning horizon, the greater the amount of sea level rise the project or planning area will experience.

Local governments should select their planning horizons to evaluate a broad range of planning concerns. Planning horizons could address the 20-year time period that is typical for *General Plan* updates as well as the long-range planning that is necessary for infrastructure and new development. The 20-year planning horizon may help identify areas within the coastal zone that are now or will soon be vulnerable to sea level rise related hazards as an aid for focusing adaptation planning on the areas of greatest need. Local Coastal Program (LCP) planning will likely use multiple planning horizons and undertake hazards analyses for multiple time periods, multiple sea level rise projections, or both.

At the project level, the LCP may provide insight into the time period that should be considered for the expected project life. At present, LCPs typically provide only a single standard (if any) for the expected life of a structure or development, such as 50, 75, or 100 years. Future LCPs and LCP Amendments (LCPAs) may find it useful to provide greater guidance on expected project life, with differentiations among major development or use classifications. For example, a general range may be chosen based on the type of development such that temporary structures, ancillary development, amenity structures, or moveable or expendable construction should identify a relatively short expected life of 25 years or less. Residential or commercial structures, which will be around longer, should choose a time frame of 75 to 100 years to consider. A longer time frame of 100 years or more should be considered for critical infrastructure like bridges or industrial facilities or for resource protection or enhancement projects that are typically meant to last in perpetuity.

For projects with long lead times, the analysis of impacts from sea level rise should use the projections for the time period when the development will be in use, rather than the current

period because the trajectory of future sea level rise is not expected to be linear. For example, a project built today will experience less sea level rise over a 50-year lifetime (about 1.9 feet under the “medium-high risk aversion” scenario at the San Francisco tide gauge) than the same project if it were built in the year 2050 (about 5 feet under the “medium-high risk aversion” scenario at the San Francisco tide gauge). Thus, it is important to understand the anticipated project life of a structure and the associated planning horizon before starting an analysis for sea level rise concerns.

As explained in Chapters [5](#) and [6](#), the point of this step is not to specify exactly how long a project will exist (and be permitted for), but rather to identify a project life timeframe that is typical for the type of development in question so that the hazard analyses performed in subsequent steps will adequately consider the impacts that may occur over the entire life of the development.

Once the appropriate planning/project horizon has been identified, the associated projection for that time period can be identified using the projection tables from the 2018 OPC SLR Guidance. These tables include projections for each decade from 2030 to 2150.

As explained elsewhere in this Guidance, project characteristics (including its ability to withstand or adapt to different sea level rise amounts and the consequences associated with underestimating the amount of sea level rise that occurs) should guide users in choosing which scenario to assess for a particular planning horizon. As general guidance, the Coastal Commission continues to recommend that planners or project applicants take a precautionary approach by evaluating higher sea level rise amounts (for example, the medium-high risk aversion scenario for most development, or the extreme risk aversion scenario for critical infrastructure).

Step 2 – Determine tidal range and future inundation

One of the most basic examinations of changing sea level conditions has been to determine the new intersection of mean sea level or other tidal datums⁹⁹ with the shoreline. This is a basic “bathtub” analysis since it looks only at the expansion of areas that will be inundated (*i.e.*, regularly submerged under water) or subject to tidal or wave action. For example, future subtidal levels would be the current subtidal limit plus projected regional mean sea level rise. Future intertidal zones would be bounded by the future higher high tide level (current higher high water plus projected regional sea level rise) and future lower low tide levels (current lower low water plus projected regional sea level rise).¹⁰⁰ For some projects, such as wetland restoration, the identification of future inundation zones may be the only sea level analysis needed for project evaluation. However, if the shoreline is eroding, the location of this elevation would need to also incorporate the rate of erosion. So, if the shoreline is expected to erode due to increased wave attack, not only will the intertidal zone move up in elevation, it will be both higher than and inland of the current zone.

Future Water Elevation = Current Tidal Datum + Projected Sea Level Rise

OR

Future Water Location = Intersection of Future Water Elevation with Future Shore Location

Future water location will extend to the new inundation elevation on the future shoreline. On beaches with a gradual slope, this can move the inundation location significantly inland, based on the geometric conditions of the beach. (This type of analysis is often called the Bruun Rule). On a stable beach with a slope of 1:X (Vertical:Horizontal), every foot of vertical sea level rise will move the inundation area horizontally X feet inland. For a typical 1:60 beach, every foot of sea level would move the inundation zone inland by 60 ft. If the beach is eroding, the loss due to erosion will add to the loss resulting from inundation.

[Figure B-2](#) shows the influence of tides and sea level rise on low-wave energy beaches. [Table B-1](#) provides some useful resources for inundation studies. Local Tidal Elevations are available from tide gauges maintained by NOAA. Where there are no nearby gauges, NOAA recommends the VDatum software.

⁹⁹ Tidal datums are based on the latest National Tidal Datum Epoch (NTDE) published by NOAA and are the mean of the observed sea levels over a 19-year period. The latest published epoch is 1983-2001. This tidal epoch can be considered equivalent to the year 2000 baseline for the **OPC** projections.

¹⁰⁰ Historical trends of high and low tide have changed differently than mean sea level (Flick *et al.* 2003). Based on historical trends, the changes to various tidal elements are likely to track closely with, but not identically with, changes to mean sea level. The future variability of changes to the tidal components, compared with changes to mean sea level will normally fall within the uncertainty for sea level rise projections and can be disregarded in almost all situations. As this phenomenon of tidal change is better understood and can be modeled, it may be appropriate in the future to include the changes in tidal components into the analysis of inundation and various water level projections.

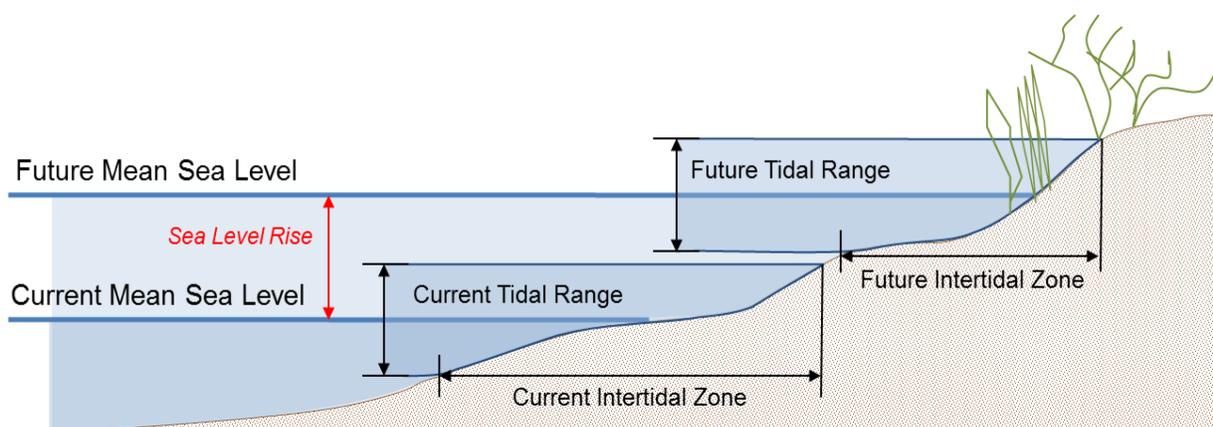


Figure B-2. Sea level rise and changes to tide range and intertidal zone. (Source: L. Ewing, 2013).

Table B-1. General Resources for Inundation Studies

Resource	Description	Link
Aerial Photographs	Useful for general information on shoreline trends; ortho-rectified photos can help quantify trends.	California Coastal Records Project, www.californiacoastline.org ; Huntington Library; Local Libraries
LIDAR	Fairly detailed topography providing GIS layers for current conditions and comparable with LIDAR data sets for temporal changes.	NOAA Digital Coast, http://coast.noaa.gov/digitalcoast/data/coastallidar
Topographic Maps	Useful for basemaps to overlay site changes; often not at a scale to distinguish small changes in inundation or tidal action.	USGS Map Center, http://www.usgs.gov/pubprod/maps.html
NOAA Sea Level Rise and Coastal Flooding Impacts Viewer	Useful to show changes in water level location if there are no changes in the land due to erosion.	NOAA Digital Coast, https://coast.noaa.gov/digitalcoast/tools/slr.html
NOAA Tidal Data	Measured and predicted tidal components for locations along the open coast and in bays.	NOAA Center for Operational Oceanographic Products and Services, http://tidesandcurrents.noaa.gov/
NOAA Technical Report NOS 2010-01: Technical Considerations for use of Geospatial Data in Sea Level Change Mapping and Assessment	Provides technical guidance to agencies, practitioners, and decision makers seeking to use geospatial data to assist with sea level change assessments.	NOAA National Ocean Service http://www.tidesandcurrents.noaa.gov/publications/tech_rpt_57.pdf

VDatum Software	A Vertical Datum Transformation program that allows users to transform geospatial data among various geoidal, ellipsoidal and tidal vertical datums.	NOAA National Ocean Service, https://vdatum.noaa.gov/
Cal-Adapt – Exploring California’s Climate	Represents inundation location and depth for the San Francisco Bay, the Sacramento-San Joaquin River Delta and California coast resulting from different increments of sea level rise coupled with extreme storm events. Incorporates real, time series water level data from past (near 100 year) storm events to capture the dynamic effect of storm surges in modeling inundation using a three dimensional hydrodynamic model (per Radke et al., 2017).	http://cal-adapt.org/tools/slr-calflod-3d/
Estimating Sea Level for Project Initiation Documents	Provides guidance on converting tidal datums and predicting future sea levels.	Caltrans Office of Land Surveys, http://www.dot.ca.gov/hq/row/landsurveys/SurveysManual/Estimating_Sea_Level_v1.pdf

Outcome from Step 2: Provide information on the projected changes to the tidal range and future zones of inundation. For locations without any influence from erosion, storm surge, or wave energy, the identification of new inundation areas may be sufficient for project analysis and planning efforts. This projected new inundation area may also be useful for anticipating the likely migration of wetlands and low-energy water areas or as input for analysis of changes to groundwater salinity. For most open coast situations, this information will be used to inform further project planning and analysis that examines erosion, surge and storm wave conditions.

Step 3 – Determine still water changes from surge, El Niño events, and PDOs

Estimates of surge, El Niño, and PDO water elevation changes are developed primarily from historical records. There are no state-wide resources for this information, although it may be included in some Regional Sediment Management Plan studies. General guidance on water level changes that can be expected from surge, El Niño events, and PDOs is provided in [Table B-2](#).

The remaining discussion provides general information on some of these phenomena. It is provided to acquaint readers to the main issues associated with each phenomenon. Readers with a strong background in ocean-atmospheric conditions may want to skim or skip the rest of this section.

The Pacific Ocean is a complex system. Sea level in the Pacific Ocean responds to multiple oceanic and atmospheric forcing phenomena, occurring with different intensities and at different temporal and spatial scales. Some phenomena may reinforce each other, while others may act in opposition, reducing the net effect. Scientists and researchers are attempting to identify the various signals from the multiple phenomena, but these are nascent sciences and there is still much we need to learn.

Regional water levels can be influenced by surge as well as by high and low pressure systems. Surge is a short-term change in water elevation due to high wind, low atmospheric pressure, or both. It is most often associated with East Coast and Gulf Coast hurricanes that can cause up to 15 or 20 ft (4-6 m) or more of short-term water level rise over many miles of the coast. Along the West Coast, storm surge tends to be much smaller, and is rarely a coastal hazard, except in enclosed bays. In southern California, it rarely exceeds 1 ft (0.3 m) and in central California, it rarely exceeds 2 ft (0.6 m). Surge becomes a concern as one of several cumulative factors that cause a temporary rise in sea level. Each rise may be small, but when surge occurs during high tides and/or in combination with storms, it increases the threat of coastal flooding, wave impacts, and erosion.

Two of the more recognized phenomena that affect water temperature in the Pacific are the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). ENSO cycles, which occur on inter-annual timescales (approximately 2-7 years), not only involve ocean-basin-spanning changes in sea surface temperature (SST) and in the depth of the mixed layer in the Equatorial Pacific, but also drive changes in ocean conditions and atmospheric circulation at higher latitudes. El Niño events result in the transfer of warm surface waters into the normally cool eastern equatorial Pacific, resulting in elevated SST and water levels along much of the west coast of the Americas. El Niños also tend to increase the strength and frequency of winter low pressure systems in the North Pacific. These events can persist for months or years at a time, and strongly influence local and regional sea level. For example, the pulse of warm water from the large 1982-83 El Niño caused water levels along California to be elevated by approximately 0.4-0.7 ft (0.12-0.21 m) for many months, with short-term water elevation peaks up to approximately 1 ft (0.3 m; Flick 1998). The opposite phase of ENSO, characterized by unusually cool SSTs and lower water elevations along the eastern Pacific margin, are called La Niña events. Between El Niños and La Niñas are periods of neutral SST and water elevation changes.

The PDO is an ENSO-like pattern of SST and atmospheric variability occurring over multiple decades. In contrast to ENSO, the PDO is more strongly expressed in the North Pacific than in the tropics. The positive or warm phase of the PDO is associated with unusually warm surface water throughout the eastern North Pacific (along the western US coast), while the negative or cool phase PDO is associated with colder than normal waters. As with the ENSO effects, the warm phase PDO has tended to cause elevated sea levels in the eastern Pacific and along the California coast, while the cool phase of the PDO tends to lower sea level in this region.

The PDO has basin-wide influence. Elevated water levels in one part of the Pacific are often accompanied by lowered water levels elsewhere. The cool phase PDO can result in a drop of water level along the eastern Pacific (western US Coast) and a rise in water level along the western Pacific. Recently, sea level along the western Pacific has been rising about three times

faster than the global mean sea level rise rate, due in part to the PDO (Bromirski *et al.* 2011; Merrifield 2011). This does not mean the eastern Pacific will experience sea level rise that is three times faster than the global mean sea level rise when there is the next shift in the PDO, but does show that the PDO can have a major influence on basin-wide and regional sea level. The above discussion of El Niño and the PDO may suggest that they are well-understood phenomena, with easily anticipated changes in sea level. However, it is important to note that El Niños have varying strengths and intensities, resulting in different sea changes from one event to the next. Also, changes in regional mean sea level along the eastern Pacific have not always shown a strong connection to the PDO cycles. An apparent jump in regional mean sea level occurred after the mid-1970s shift to the warm phase of the PDO, yet the expected continued rise in sea level along the West Coast seems to have been suppressed by other forces. Tide gauge records for the Washington, Oregon, and California coasts have shown no significant inter-annual rise in sea level from 1983 to 2011 (Cayan *et al.* 2008; Bromirski *et al.* 2011; NOAA 2013). Bromirski *et al.* (2011, 2012) postulate that persistent alongshore winds have caused an extended period of offshore upwelling that has both drawn coastal waters offshore and replaced warm surface waters with cooler deep ocean water. Both of these factors could have caused a drop in sea level, canceling out the sea rise that would otherwise be expected from a warm phase PDO signal.

Water level changes from surge, atmospheric forcing, El Niño events and the PDO can occur in combination. The water elevation changes from each factor may be only about 1 ft (0.3 m) or less, but each can cause changes in the water level over a time period of days, months, or a few years – far more rapidly than sea level rise. In combination, they can potentially cause a significant localized increase in water level.

When high water conditions occur in combination with high tides, and with coastal storms, the threat of coastal flooding, wave impacts and erosion also increases. These conditions can be additive, as shown in [Figure B-3](#). Also, these changes in water level will continue to be important to the overall water level conditions along the California coast and they need to be examined in conjunction with possible changes due to regional sea level rise.

As stated earlier, estimates of surge, El Niño and PDO water elevation changes are developed primarily from historical records. There are no state-wide resources for this information, although it may be included in one of the Regional Sediment Management Plans, available for many coastal areas (see <http://www.dbw.ca.gov/csmw/>). General guidance on water level changes, surge, and El Niño events is provided in [Table B-2](#).

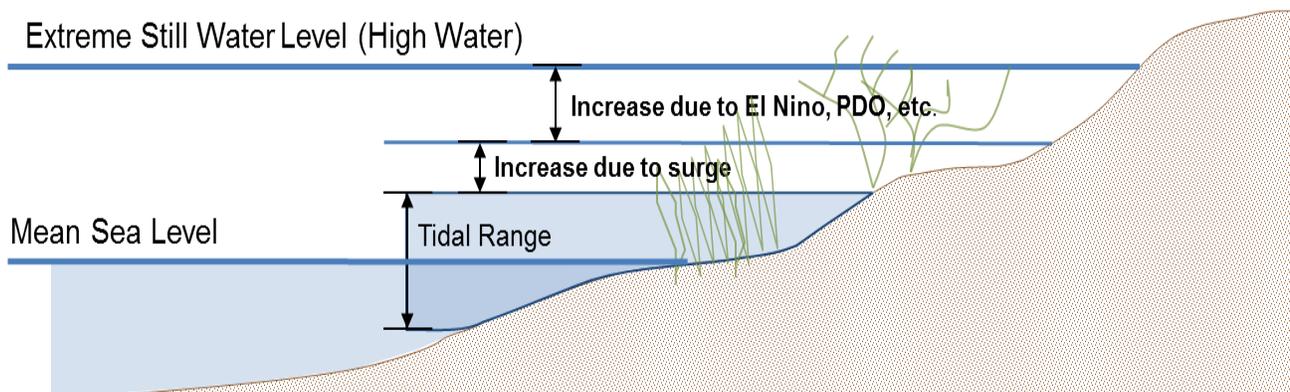


Figure B-3. Changes to extreme still water level due to surge, El Niño events, and PDOs. (Source: L. Ewing, 2013).

Table B-2. General Resources for Determining Still Water Elevation, Surge, El Niño events, and PDOs

Resource	Description	Link
NOAA Sea Level Rise and Coastal Flooding Impacts Viewer	Displays potential future sea levels within wetland areas, and provides visualizations for various amounts of sea level rise. For bays and estuaries, it also provides information on inland areas with the potential to flood if existing barriers to water connectivity are removed or overtopped. Communicates spatial uncertainty of mapped sea level rise, overlays social and economic data onto sea level rise maps, and models potential marsh migration due to sea level rise. Maps do not include any influence of beach or dune erosion.	NOAA Digital Coast, https://coast.noaa.gov/digitalcoast/tools/slr.html
Pacific Institute Sea Level Rise Maps	Downloadable PDF maps showing the coastal flood and erosion hazard zones from the 2009 study. Data are overlaid on aerial photographs and show major roads. Also available are an interactive online map and downloadable maps showing sea level rise and population and property at risk, miles of vulnerable roads and railroads, vulnerable power plants and wastewater treatment plants, and wetland migration potential.	http://www.pacinst.org/reports/sea_level_rise/maps/ For the 2009 report “The Impacts of Sea Level Rise on the California Coast” visit: http://pacinst.org/publication/the-impacts-of-sea-level-rise-on-the-california-coast/
Cal-Adapt – Exploring California’s Climate	Represents inundation location and depth for the San Francisco Bay, the Sacramento-San Joaquin River Delta and California coast resulting from different increments of sea level rise coupled with extreme storm events. Incorporates real, time series water level data from past (near 100 year) storm events to capture the dynamic effect of	http://cal-adapt.org/tools/slr-calflod-3d/

	storm surges in modeling inundation using a three dimensional hydrodynamic model (per Radke et al., 2017).	
Regional Sediment Management Plans	Plans for regions of the state to identify how governance, outreach and technical approaches can support beneficial reuse of sediment resources within that region without causing environmental degradation or public nuisance.	http://www.dbw.ca.gov/csmw/

Outcome from Step 3: Provide estimates of water elevations that can result from surge, El Niño events, and PDOs. When combined with the sea level changes to the tidal range, developed in Step 4, these can provide information on the extreme still water level. For most open coast situations, this information will be used to inform further project analysis and planning that examines erosion, surge and storm conditions.

Step 4 – Estimate beach, bluff, and dune change from erosion

Predictions of future beach, bluff, and dune erosion are complicated by the uncertainty associated with future waves, storms and sediment supply. As a result, there is no single specific accepted method for predicting future beach erosion. At a minimum, projects should assume that there will be inundation of dry beach and that the beach will continue to experience seasonal and inter-annual changes comparable to historical amounts. When there is a range of erosion rates from historical trends, the high rate should be used to project future erosion with rising sea level conditions (unless future erosion will encounter more resistant materials, in which case lower erosion rates may be used). For beaches that have had a relatively stable long-term width, it would be prudent to also consider the potential for greater variability or even erosion as a future condition. For recent studies that provide some general guidance for including sea level rise in an evaluation of bluff and dune erosion, see, for example, Heberger *et al.* (2009) or Revell *et al.* (2011). Other approaches that recognize the influence of water levels in beach, bluff, or dune erosion can also be used. [Table B-3](#), at the end of this section, provides some resources that can be used for projecting future erosion.

The following sections discuss specific concerns associated with beach, bluff and dune erosion and are provided to acquaint readers to the main issues associated with each system. Readers with a strong background in coastal systems may want to skim or skip the rest of this section.

Beach Erosion

Beach erosion and accretion occur on an on-going basis due to regular variability in waves, currents and sand supply. The movement of sand on and off of beaches is an ongoing process. Along the California coast, periods of gradual, on-going beach change will be punctuated by rapid and dramatic changes, often during times of large waves or high streamflow events.

The overall dynamics of beach change have been described many times.¹⁰¹ Sand moves on and off shore as well as along the shore. Normal sources of sand to a beach are from rivers and streams, bluff erosion or gullies, and offshore sand sources. Sand leaves a beach by being carried downcoast by waves and currents, either into submarine canyons or to locations too far offshore for waves to move it back onto shore. Beaches are part of the larger-scale sediment dynamics of the littoral cell, and in very simple terms, beaches accrete if more sand comes onto the beach than leaves and beaches erode if more sand leaves than is added. Changes in sand supply are a major aspect of beach change.

Beach changes are often classified as being either seasonal or long-term/inter-annual changes. Seasonal changes are the shifts in beach width that tend to occur throughout the year and are usually reversible. During late fall and winter, beaches tend to become narrower as more high energy waves carry sand away from the beach and deposit it in offshore bars. This is later followed by beach widening as gentler waves again bring sand landward, building up a wider dry-sand summer beach. These changes are considered seasonal changes, and if the beach widths return to the same seasonal width each year, then the beach experiences seasonal changes but no long-term or inter-annual changes. If the seasonal beach widths become progressively wider or narrower, these changes become long-term or inter-annual change, and suggest a long-term beach change trend – accretion if the beach is widening and erosion if the beach is narrowing.

If development is at or near beach level, erosion of the beach can expose the development to damage from waves, flooding, and foundation scour. Additionally, waves that hit the coast bring with them vegetation, floating debris, sand, cobbles, and other material which can act like projectiles, adding to the wave forces and flood damage.

At present, approximately 66% of the California beaches have experienced erosion over the last few decades, with the main concentration of eroding beaches occurring in southern California (Hapke *et al.* 2006). This erosion has been due to a combination of diminished sand supplies and increased removal of sand by waves and currents. With rising sea level, beach erosion is likely to increase due to both increased wave energy¹⁰² that can carry sand offshore or away from the beach, and to decreased supply of new sediments to the coast.¹⁰³

There are several factors that will contribute to the effects of sea level rise on seasonal and inter-annual beach change. There will be the changes to the beach due to inundation by rising water levels, as shown in [Figure B-4](#) (see the discussion on inundation earlier in this Appendix for more information on how to determine this change). If the beach cannot migrate inland to accommodate these changes, then the inundation will result in a direct loss or erosion of beach width. This will result in a narrower seasonal beach as well as inter-annual loss of beach.

¹⁰¹ See for example, Bascom 1980, Komar 1998, and Griggs *et al.* 2005.

¹⁰² In shallow water, wave energy is proportional to the square of the water depth. As water depths increase with sea level rise, wave energy at the same location will likewise increase.

¹⁰³ Many parts of the developed coast are already experiencing drops in sand supplies due to upstream impoundments of water and sediment, more impervious surfaces, and sand mining.

Seasonal and inter-annual beach conditions will also be affected by changes to waves and sediment supply. Since waves are sensitive to bottom bathymetry, changes in sea level may change the diffraction and refraction of waves as they approach the coast, thereby changing the resulting mixture of beach-accreting and beach-eroding waves. However, the influence of climate change (not just rising sea level) on wave conditions, through changes in wave height, wave direction, storm frequency, and storm intensity, will likely be far more significant than the slight changes from bathymetric changes. In addition, changing precipitation patterns will modify the amount and timing of sediment delivery to the beach.

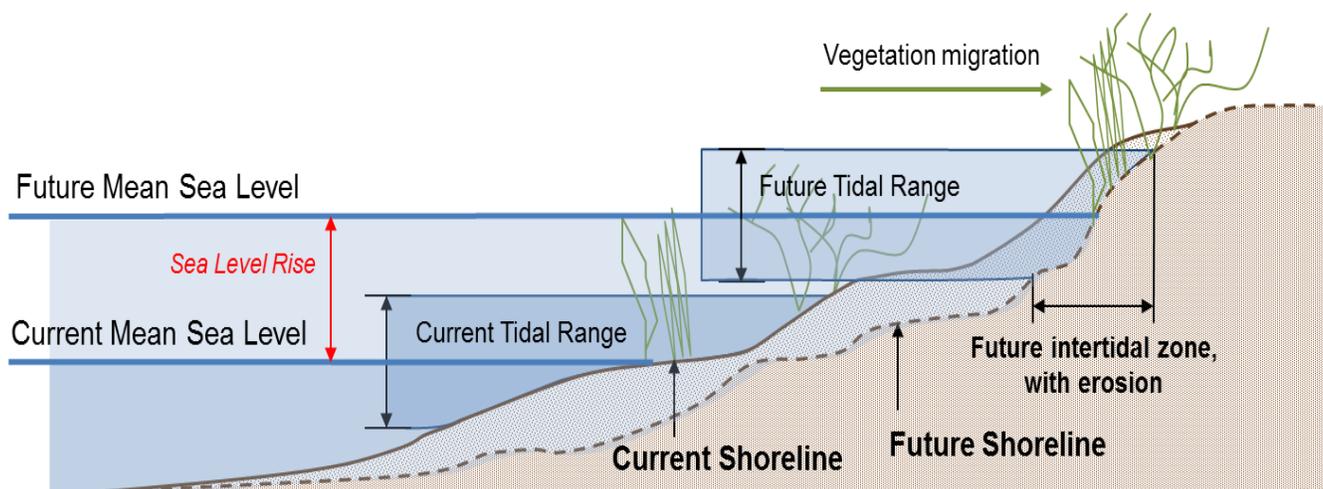


Figure B-4. Changes to the intertidal zone with sea level rise and erosion, without wave impacts. (Source: L. Ewing, 2013).

Bluff Erosion

A second type of erosion occurs on coastal bluffs.¹⁰⁴ There is no fully-accepted methodology for estimating future bluff erosion with sea level rise. Guidance for coastal analysts in Hawaii is to assume erosion will increase as a proportion of historical erosion (Hwang 2005). One approach used in the past by the Commission has been to apply one of the higher rates of historical erosion to represent average future trends. A more process-based methodology, used in the Pacific Institute study of erosion due to rising sea level, is to correlate future erosion rates of bluffs with a higher still water level that will allow waves to attack the bluff more frequently (Heberger *et al.* 2009; Revell *et al.* 2011). This approach assumes that all bluff erosion is due to wave impacts and that erosion rates will change over time as the beach or bluff experiences more frequent or more intense wave attack. Such an approach should be considered for examining bluff erosion with rising sea level. Other approaches that recognize the influence of water levels in beach, bluff, or dune erosion can also be used.

¹⁰⁴ Bluffs can be built or expanded during interglacial cycles or following seismic uplift. Many of the marine terraces that are visible along the California coast are remnants of past beach areas that have been uplifted to become bluffs and cliffs. However, natural bluff rebuilding is a millennial or multi-millennial process, and it will not occur during the time periods over which most development projects are evaluated.

Bluff retreat occurs via many different mechanisms. Landslides, slumps, block failures, gullies, and rilling are examples of bluff retreat. At the most basic level, bluff retreat or collapse occurs when the forces leading to collapse of the bluff face are stronger than the forces holding the bluff in place. Forces causing bluff retreat can include earthquakes, wind, burrowing animals, gravity, rain, surface runoff, groundwater, and sheet flow. Coastal bluffs have the added factor of wave attack. Resistance to collapse is mainly a characteristic of the bluff material. For example, granitic bluffs like those along the Big Sur coast retreat at a much slower rate than the soft sandstone and marine terrace bluffs of Pacifica.

Coastal bluff erosion can occur throughout the year, but it often occurs during or after storm periods, when the dry beach will be narrow or non-existent. When coastal bluffs are fronted by wide sand beaches, most waves break on the beach face and the beaches protect the bluffs from direct wave attack. When the beach is narrow, there is less buffering of the wave energy and waves can break directly against the bluffs. A general depiction of bluff retreat with rising sea level is provided in [Figure B-5](#).

Bluff retreat is often episodic – the bluff may be stable for a number of years and then retreat by tens of feet in a few hours or a few days. If the changes to a bluff are examined through endpoint analysis (*i.e.*, looking first at the initial position of the bluff and then at the position of the bluff sometime in the future), researchers can determine the amount of retreat that has occurred during the time from the initial to final positions. This gives information on an average retreat rate that has occurred, but provides no insight about the conditions leading to the retreat, the size of retreat, frequency of retreat events, or the progression of retreat and no retreat. The average retreat rates can give some indication of likely future changes, but they provide little information about when the next retreat episode might occur or how large it might be.

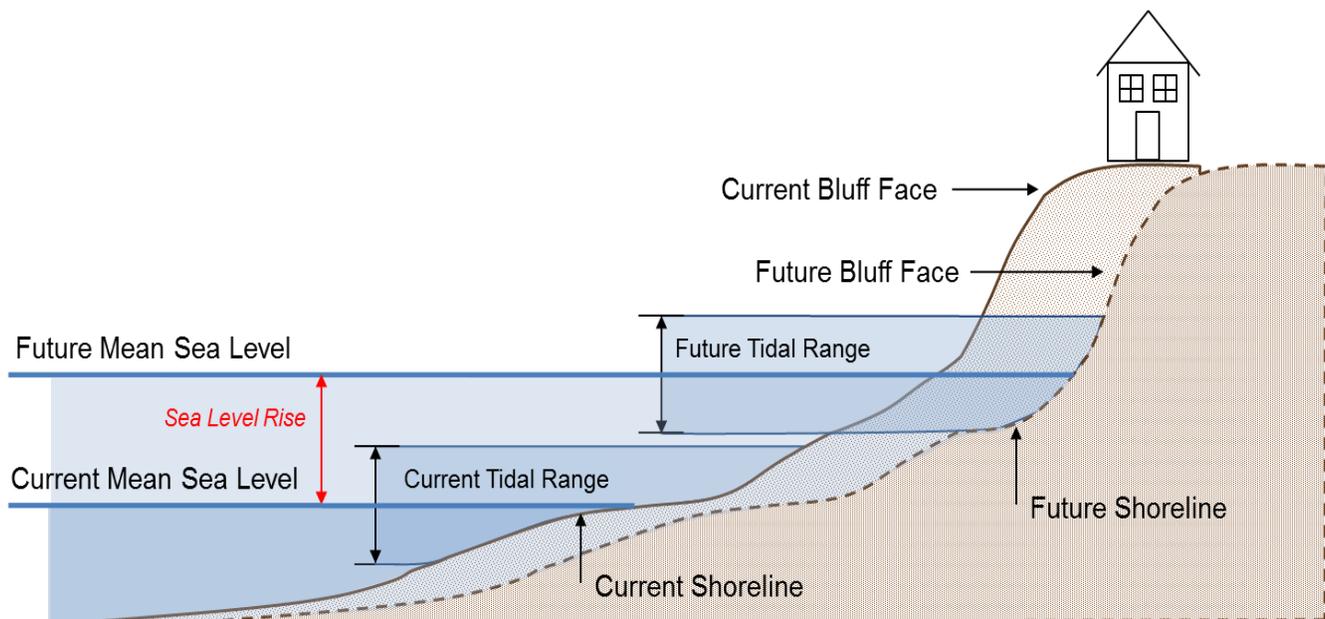


Figure B-5. Bluff erosion with changes in sea level. (Source: L. Ewing, 2013).

Dune Erosion

Just as there is no fully-accepted methodology for estimating changes to beach or bluff erosion with sea level rise, there is no fully-accepted methodology for dune erosion. A methodology somewhat similar to that for bluff erosion has been developed for dunes (Heberger *et al.* 2009; Revell *et al.* 2011), and such an approach should be considered for examining dune erosion with rising sea level. Other approaches that recognize the influence of water levels in beach, bluff, or dune erosion may also be used.

Dune erosion occurs when the waves break at or near the dunes, pulling sediment out of the dune. This process deposits sand onto the beach or in the nearshore area, but can result in short-term dune retreat. If sand is not returned to the dunes following these periods of short-term retreat, the sand losses will contribute to long-term dune erosion. Damage will occur to development located on dunes when the dune retreats back to the location of development, either through reversible, short-term retreat or long-term erosion.

For individual cases, determinations of future retreat risk are based on the site-specific conditions and professional analysis and judgment. However, the lack of information about the contributions of all the erosive forces to dunes and the beach-dune interactions makes it challenging to anticipate future changes to coastal dune retreat due to rising sea level and increased wave forces. As with beaches and bluffs for most situations, historical conditions provide a lower limit for future dune *retreat*, or the upper limit of dune *advance* for those sites that are now experiencing accretion or quasi-stability. Projections of future erosion should either: 1) use the high range of historical erosion; 2) develop a sea level rise influenced erosion rate, as done by Heberger *et al.* (2009) or Revell *et al.* (2011); or, 3) develop another approach that considers shoreline changes that are likely to occur under rising sea level conditions.

Table B-3. General Resources for Information on Beach, Bluff and Dune Erosion

Resource	Description	Link
Aerial Photographs	Useful for general information on shoreline trends; ortho-rectified photos can help quantify trends.	California Coastal Records Project, www.californiacoastline.org ; Huntington Library; Local Libraries
LIDAR	Fairly detailed topography that can provide GIS layers for current conditions and is comparable with LIDAR data sets for temporal changes.	NOAA's Digital Coast, http://coast.noaa.gov/digitalcoast/data/coastallidar
USGS National Assessment of Shoreline Change with GIS Compilation of Vector Shorelines	Statewide inter-annual beach and bluff erosion; GIS shorelines available for sandy shorelines & cliff edge, showing historical changes for long-term (70 to 100 years) and short-term (25 to 50 years). No projections of future erosion rates available.	Sandy Shorelines – Open File Report 2006-1219, http://pubs.usgs.gov/of/2006/1219 , and GIS Data in Open File 2006-1251, http://pubs.usgs.gov/of/2006/1251 ; Bluff Shorelines – Open File Report 2007-1133, http://pubs.usgs.gov/of/2007/1133 , and GIS Data in Open File 2007-1251, http://pubs.usgs.gov/of/2007/1112

Regional Sediment Management Studies	Summaries of seasonal and long-term erosion studies	CSMW Website, http://dbw.ca.gov/csmw/default.aspx ; California Beach Erosion Assessment Survey, http://dbw.ca.gov/csmw/library.aspx
US Army Corps of Engineers, Coast of California Studies	Summaries of seasonal and long-term erosion studies	Studies for many regions are available through an internet search (addresses are too numerous to list here)
Beach Profiles and Surveys	Detailed beach or bluff changes with time	NOAA’s Digital Coast, https://coast.noaa.gov/digitalcoast/tools/ US Army Corps of Engineers; Regional Beach Studies; University Studies
The Impacts of Sea Level Rise on the California Coast (Pacific Institute Report)	Expected changes to bluff position over time for sea level rise of 4.6 ft (1.4 m) from 2000 to 2100 for California coast from Oregon border through Santa Barbara County.	Pacific Institute Website, http://www.pacinst.org/reports/sea_level_rise/maps/
CoSMoS	Currently available for Point Arena to the Mexico border, with a statewide expansion anticipated in 2018/2019. The Coastal Storm Modeling System (CoSMoS) is a dynamic modeling approach that allows detailed predictions of coastal flooding due to both future sea level rise and storms, and integrated with long-term coastal evolution (i.e., beach changes and cliff/bluff retreat)	https://walrus.wr.usgs.gov/coastal_processes/cosmos/ http://data.pointblue.org/apps/ocof/cms/
TNC Coastal Resilience	An online mapping tool showing potential impacts from sea level rise and coastal hazards designed to help communities develop and implement solutions that incorporate ecosystem-based adaptation approaches. Available statewide with more detailed modelling for Monterey Bay, Santa Barbara, Ventura, and Santa Monica.	http://maps.coastalresilience.org/california/

***Outcome from Step 4:** Provide projections of future long-term beach, bluff or dune erosion that takes into account sea level rise. For locations without any influence from storm surge, or wave energy, the identification of the extent of beach, bluff or dune erosion may be sufficient for project analysis and planning efforts. This projected new erosion area may also be useful for anticipating the appropriate setback distance for otherwise stable land forms (If slope stability is a concern, refer to Commission guidance on setbacks (<http://www.coastal.ca.gov/W-11.5-2mm3.pdf>)). For most open coast situations, this information will be used to inform further project analysis and planning that examines erosion, surge and storm conditions.*

Step 5 – Determine wave, storm wave, wave runup, and flooding conditions

The main concerns with waves, storm waves, and runup are flooding and damage from wave impacts. Flooding is the temporary wetting of an area by waves, wave runup, surge, atmospheric forcing (such as water elevation during El Niño events) and, at river mouths, the combination of waves and river flows. Wave impacts occur when high-energy waves, often associated with storms, reach backshore areas or development. Coastal flooding and wave impacts are worst when they coincide with high water level events (high tide plus high inundation). As sea level rises, inundation will move inland, and so will flooding and wave impacts. Beach erosion will aggravate these conditions and add to the inland extent of impacts.

Flooding

In most situations, factors that result in high water conditions, such as tides, surge, El Niño events, and PDOs, should be used to determine flood levels and flood areas, as shown below. If the area is exposed to storm waves, these forces should be examined as well.

Future Flooding Level = Higher High Tide + Sea Level Rise + Surge + Forcing + Wave Runup

Flooding Areas = Flooding + Seasonal Eroded Beach + Long-Term Beach Erosion

Waves

Waves, like tides, cause constant changes to the water levels that are observed at the coast. The rhythmic lapping of waves on the beach during summer can be one of the joys of a beach visit. At other times of the year, waves can increase in size and energy and damage or destroy buildings, and cause erosion of bluffs and cliffs. Routine ocean waves are generated by wind blowing across the surface of the water and can travel far from their source, combining with waves generated from other locations to produce the rather erratic and choppy water levels that are seen in most of the ocean. As waves move into shallow water and approach land, they are strongly modified by the offshore bathymetry. They take on a more uniform appearance, aligning somewhat parallel to the shoreline through processes of refraction and diffraction. During most of the year, moderate short-period waves break once they are in water depths of approximately 1.3 times the wave height.

Wave impacts depend greatly upon storm activity – both the intensity and the duration of the storm. Normally projects have used design wave conditions comparable to the 100-year event. For critical infrastructure or development with a long life expectancy, it may be advisable to use a greater design standard, such as a 200-year or 500-year event. It may be suitable for some proposed projects to adjust design waves or the frequency of high energy waves to analyze the consequences of worsening wave impacts.

Waves also vary greatly with bathymetry; offshore reefs and sand bars can cause waves to break far from the coast and greatly reduce the energy of the waves that come onshore. Therefore, changes in offshore water depths can alter the nature of nearshore wave propagation and

resultant onshore waves. For areas with complex offshore bathymetry, wave impact changes due to rising sea level may need to be examined in the context of both offshore and nearshore conditions.

Wave impacts to the coast, to coastal bluff erosion and inland development, should be analyzed under the conditions most likely to cause harm. Those conditions normally occur in winter when most of the sand has moved offshore leaving only a reduced dry sand beach to dissipate wave energy (this seasonal change in beach width is often referred to as short-term or seasonal erosion). On beaches that will experience long-term erosion, trends expected to occur over the entire expected life of the development should also be considered. Just as the beach conditions to analyze should be those least likely to protect from damage over the life of the development, the water level conditions considered should also be those most likely to contribute to damage over the life of the development. Waves that cause significant damage during high tide will be less damaging during low tide; all other things being equal, waves will cause more inland flooding and impact damage when water levels are higher. Since water levels will increase over the life of the development due to rising sea level, the development should be examined for the amount of sea level rise (or a scenario of sea level rise conditions) that is likely to occur throughout the expected life of the development. Then, the wave impact analysis should examine the consequences of a 100-year design storm event using the combined water levels that are likely to occur with high water conditions and sea level rise, as well as a long-term and seasonally eroded beach.

Eroded Beach Conditions = Seasonal Erosion + Long-Term Erosion*

High Water Conditions = High Tide + Relative Sea Level Rise* + Atmospheric Forcing

Wave Conditions = 100-year Design Storm + High Water + Eroded Beach

* The time period for both long-term erosion and relative sea level rise will be at least as long as the expected life of the development.

The remaining discussion provides general information about waves, the California wave climate, and coastal flooding. It is provided to acquaint readers to the main issues associated with waves and coastal flooding. Readers with a strong background in waves or coastal processes may want to skim or skip the rest of this section.

Storm Waves

During storm conditions, winds can transfer large amounts of energy into waves, increasing wave height, length, and period. Energy transfer to waves depends upon three conditions: the wind energy that is available to be transferred to the water (intensity); the length of time over which the wind blows (duration); and the area over which the wind blows (the fetch). As any of these conditions increases, the energy in the waves will increase, as will the energy that these waves bring to the coastline. Coastal scientists separate waves that are generated far from the coast (swell) from waves that are locally generated (seas). Storms in the mid-Pacific can cause

storm-like wave conditions along the coast, even when there are no storms in the area. Likewise, a local storm can cause storm waves along one part of the coast while waves in other sections of the coast may be fairly mild.

Some of the worst storm wave conditions occur when there are intense storms along a large portion of the coast and when this large, distantly generated swell combines with local seas. The 1982/83 El Niño has been cited often as one of the more damaging storm seasons in recent times. In late January 1983, waves from a distant storm combined with locally generated waves and the highest tides of the year. This one storm caused substantial damage along much of the California Coast. The coast was not able to recover before a series of storms in February and March caused additional damage. The full 1982/83 El Niño storm season resulted in damage to approximately 3,000 homes and 900 businesses and destruction of 33 buildings. Damages exceeded \$100 million to structures and \$35 million to public recreational infrastructure (in 1982 dollars; Flick 1998).

Wave Runup

Wave runup, as depicted in [Figure B-6](#), is the distance or extent to which water from a breaking wave will spread up the shoreline. Much of the wave energy will dissipate during breaking, but wave runup can also be damaging. The runup water moves quickly and can scour or erode the shoreline areas (including the beach), damage structures, and flood inland areas.

Damage from waves and wave runup may increase in the future, due both to rising sea level and to changes in storm intensity and frequency. Waves will break farther landward when water levels are higher. Therefore, increased water levels due to tides, surge, ENSO or PDO variability, or sea level rise will enable more wave energy to reach the beach, back shore, or inland development. The higher water levels do not change the waves. Rather, higher water levels change the point of impact, the extent of runup, and the frequency of wave impact. In locations where high waves now hit the coast, that frequency will increase; in locations where high waves rarely hit the coast, exposure to wave impacts will increase. Increased exposure to wave impacts or wave runup can cause a greater risk of flooding, erosion, bluff failure, and/or damage to development. But, since the focusing of wave energy is strongly influenced by offshore bathymetry, locations of wave exposure may also change with rising sea level and modifications in wave propagation might result from future differences in water depths.

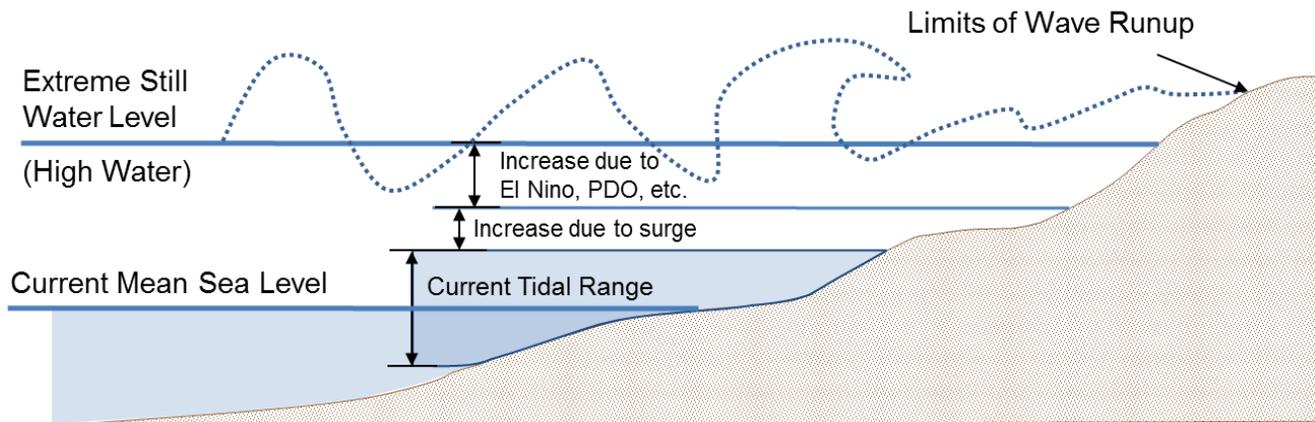


Figure B-6. Wave runup combined with extreme still water (High Water). (Source: L. Ewing, 2013).

Summary

Coastal flooding is a significant problem now and it will increase with rising sea level. At present, about 210,000 people in California are living in areas at risk from a 100-year flood event (Heberger *et al.* 2009). A rise in sea level of 55 in (1.4 m) with no change in development patterns or growth along the coast could put 418,000 to 480,000 people at risk from a 100-year flood (Cooley *et al.* 2012). An additional fraction of the California population that relies on critical infrastructure located in potentially hazardous areas is also vulnerable and increases in storm intensity or in the density of development in flood-prone areas will increase the number of people at risk from flooding.

The frequency and intensity of high wave events depends upon the storm conditions that generate the waves. There is less consistency in the output of climate models related to projections of future storm conditions than there has been for temperature projections. A recent report on coastal flooding from years 2000 to 2100 for the California coast has found that “storm activity is not projected to intensify or appreciably change the characteristics of winter nearshore wave activity of the twenty-first century” (Bromirski *et al.* 2012, p. 33). This continuation of current storm conditions is not, however, an indication that storms will not be a problem in the future. Storm damage is expected to continue, and, if sea level rise by the end of the twenty-first century reaches the high projections of about 55 in (1.4 m), “coastal managers can anticipate that coastal flooding events of much greater magnitude than those during the 1982-83 El Niño will occur annually.” (Bromirski *et al.* 2012, p. 36)

For most situations, the 100-year storm event should be used as the design storm. This is equivalent to a storm with a 1% annual probability of occurrence. However, most development does not last one year and this probability of occurrence grows over time such that there is a 22% probability of occurrence during a 25-year period and over 53% probability that this storm will occur at least once during a 75-year period. Even so, the 100-year storm event, like the 100-year flood event, is often used as a design standard for development. However, for structures with a very long projected life or for which storm protection is very critical, a larger, 200-year or 500-year event might be appropriate.

[Table B-4](#) lists many of the resources that are available for finding regional or state-wide information on waves and flooding. Local communities may have records of major erosion episodes or flood events as well.

Table B-4. General Resources for Flooding and Wave Impacts

Resource	Description	Link
CDIP (Coastal Data Information Program)	Current and historical information on wind, waves, and water temperature, wave and swell models and forecasting. As of 2013, there are 19 active stations along the California coast.	http://cdip.ucsd.edu/
Flood Insurance Rate Maps (FIRMs)	FEMA is updating coastal flood maps. Existing FIRMs are based on 1980s topography; flooding includes seasonal beach change but not long-term erosion. Maps do not include sea level rise. Inclusion of a site shows a flood hazard; but exclusion does not necessarily indicate a lack of flood hazard.	FEMA Flood Map Service Center, https://msc.fema.gov/portal
FEMA Flood Hazard Mapping Guidance	<i>Subsection D.2.8</i> provides guidance for calculating wave runup and overtopping on barriers. There are special cases for steep slopes and where runup exceeds the barrier or bluff crest.	https://www.fema.gov/media-library/assets/documents/13948
Regional Sediment Management Studies	Some studies show elements of beach flooding and wave impacts.	http://dbw.ca.gov/csmw/default.aspx
Cal-Adapt – Exploring California’s Climate	Represents inundation location and depth for the San Francisco Bay, the Sacramento-San Joaquin River Delta and California coast resulting from different increments of sea level rise coupled with extreme storm events. Incorporates real, time series water level data from past (near 100 year) storm events to capture the dynamic effect of storm surges in modeling inundation using a three dimensional hydrodynamic model (per Radke et al., 2017).	http://cal-adapt.org/tools/slr-calflod-3d/
US Army Corps of Engineers, Coastal Engineering Manual	Detailed information on all aspects of deep-water wave transformation, shoaling, runup, and overtopping.	https://www.publications.usace.army.mil/USACE-Publications/Engineer-Manuals/
European Overtopping Manual	Descriptions of available methods for assessing overtopping and its consequences. Provides techniques to predict wave overtopping at seawalls, flood embankments, breakwaters and other shoreline structures facing waves. Supported by web-based programs for the calculation of overtopping discharge and design details.	http://www.overtopping-manual.com/

<p>CoSMoS</p>	<p>Currently available for Point Arena to the Mexico border, with a statewide expansion anticipated in 2018/2019. The Coastal Storm Modeling System (CoSMoS) is a dynamic modeling approach that allows detailed predictions of coastal flooding due to both future sea level rise and storms, and integrated with long-term coastal evolution (i.e., beach changes and cliff/bluff retreat)</p>	<p>https://walrus.wr.usgs.gov/coastal_processes/cosmos/ http://data.pointblue.org/apps/ocof/cms/</p>
<p>TNC Coastal Resilience</p>	<p>An online mapping tool showing potential impacts from sea level rise and coastal hazards designed to help communities develop and implement solutions that incorporate ecosystem-based adaptation approaches. Available statewide with more detailed modelling for Monterey Bay, Santa Barbara, Ventura, and Santa Monica.</p>	<p>http://maps.coastalresilience.org/california/</p>

Outcome from Step 5: Provide projections of future flooding and wave impacts resulting from waves, storm waves and runoff, taking into account sea level rise.

Step 6 – Examine potential flooding from extreme events

Extreme events¹⁰⁵, by their very nature, are those beyond the normal events that are considered in most shoreline studies. Examples of extreme events that might occur along the California coast include:

- An individual storm with an intensity at or above the 100-year event
- A series of large, long-duration storms during high tides
- A local storm that coincides with the arrival of distant swell and high tides
- Rapid subsidence, as might happen along the Northern California coast during a Cascadia Subduction Zone earthquake
- Global sea level rise greater than that projected to occur by 2100, when combined with a large storm during normal tides

Planning and project analysis need to consider and anticipate the consequences of these outlier events. In many situations, this assessment might be a qualitative consideration of consequences that could happen if an extreme event does occur. Analysis of the consequences of extreme events presents opportunities to address some of those potential impacts through design and adaptation.

¹⁰⁵ In its report on *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, the IPCC defines extreme events as “a facet of climate variability under stable or changing climate conditions. They are defined as the occurrence of a value or weather or climate variable above (or below) a threshold value near the upper (or lower) ends (“tails”) of the range of observed values of the variable” (IPCC 2012).

In California, there may be some worsening of extreme precipitation and inland flooding from projected changes to atmospheric rivers, narrow bands of concentrated moisture in the atmosphere. In general, however, future extremes are likely to be comparable to the extremes of today, but with the added influence of sea level rise. Extreme storm waves or floods can be addressed with the guidance provided earlier, except that the extreme storm conditions would be used. For tsunamis it is recommended that, for most situations, the appropriate projection of sea level rise be added to the currently projected inundation level from tsunamis. This will provide a close approximation for future inundation from extreme tsunamis. If a detailed analysis of future tsunami impacts is needed, the analysis should be conducted by someone experienced in modeling tsunami waves.

Tsunamis

Tsunamis are large, long-period waves that can be generated by submarine landslides, subaerial landslides (slope failures from land into a water body), large submarine earthquakes, meteors, or volcanic eruptions. They are rare events, but can be extremely destructive when they occur. The extent of tsunami damage will increase as rising water levels allow tsunami waves to extend farther inland. Thus the tsunami inundation zone will expand inland with rising sea level. There has been no research that suggests that climate change will increase the intensity or frequency of seismically-generated tsunamis. However, the number and size of coastal subaerial landslides may increase because of increased coastal erosion due to sea level rise, which in turn may increase the potential for tsunamigenic landslides along the California coast (Highland 2004; Walder *et al.* 2003).

The detailed changes to the inundation zone with rising sea level need to be determined by modeling; however, modeling of long-waves, such as tsunamis, is a specialized area of coastal engineering, and will not be covered in this general Guidance. For most situations, it will be sufficient to get information on possible inundation from the most recent tsunami inundation maps (currently on the Department of Conservation website, http://www.conservation.ca.gov/cgs/geologic_hazards/Tsunami/Inundation_Maps/Pages/Statewide_Maps.aspx). The California Geological Survey and California Governor's Office of Emergency Services are creating new tsunami inundation maps based on probabilistic tsunami hazard analysis (CPTHAWG 2015). As a rough approximation, the change to the tsunami inundation level can be estimated as equal to the change in water elevation due to sea level; a 1-ft rise in sea level could be assumed to result in a 1-ft rise in the inundation elevation. However, in many places, particularly shallow bays, harbors, and estuaries, the change in tsunami inundation zone is likely to scale non-linearly with sea level rise and require careful modeling. California Geological Survey is also working to evaluate the impact of sea level rise with numerical tsunami modeling to verify that an additive approach (tsunami height + SLR) is the appropriate method for integrating SLR and tsunami inundation together. In areas with high tsunami hazards, or where critical resources are at risk, a site-specific analysis of sea level rise impacts on tsunami hazards is crucial, and someone experienced in modeling tsunami waves should be consulted.

Summary

Many different factors affect the actual water levels that occur along the coast and resulting hazards. In California, waves and tides have the largest routine effect on water levels. Tsunamis

may have a very large, but infrequent effect on water levels. Sea level rise will affect water levels all along the coast. Until the mid-century, tides and storms are expected to have the biggest effects on local water levels, with sea level rise being a growing concern. After Year 2050, sea level rise is expected to become increasingly influential on water levels and in contributing to damages to inland areas from flooding, erosion and wave impacts. [Table B-5](#) provides a general characterization of all the factors that can affect local water levels, with general estimates of their range and frequency of occurrence.

Outcome from Step 6: Projections of potential flooding from extreme events including rapid subsidence, extreme precipitation, and tsunamis.

Table B-5. Factors that Influence Local Water Level Conditions

Factors Affecting Water Level	Typical Range for CA Coast (ft)	Typical Range for CA Coast (m)	Period of Influence	Frequency
Tides	3 – 10	1 – 3	Hours	Twice daily
Low pressure	1.5	0.5	Days	Many times a year
Storm Surge	2 – 3	0.6 – 1.0	Days	Several times a year
Storm Waves	3 – 15	1 – 5	Hours	Several times a year
El Niño events (within the ENSO cycle)	<1.5	< 0.5	Months - Years	2 – 7 years
Tsunami waves	20 – 50 (max) 3 – 10 (typical)	6 – 15 (max) 1 – 3 (typical)	Minutes, Hours, Days	Infrequent but unpredictable
Historical Sea Level, over 100 years	0.7	0.2	Ongoing	Persistent
OPC Sea Level Projections 2000 – 2050 (SF tide gauge; see also App. G)	1.1 – 2.7	0.3 – 0.8	Ongoing	Persistent
OPC Sea Level Projections 2000 – 2100 (SF tide gauge; see also App. G)	3.4 – 10.2	1.0 – 3.1	Ongoing	Persistent

Note that all values are approximations. The conversions between feet and meters have been rounded to maintain the general ranges and they are not exact conversions. *Sources:* Flick 1998; OPC 2018; Personal communications from Dr. Robert Guza (Scripps Institution of Oceanography), Dr. William O'Reilly (Scripps Institution of Oceanography and University of California, Berkeley), and Rick Wilson, California Geological Survey; and professional judgment of staff.

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Appendix C

Resources for Addressing Sea Level Rise

This section contains lists of sea level rise viewers, guidebooks, guidance documents, and state agency-produced resources, and data clearing houses related to sea level rise. These resources will be particularly relevant for informing Steps 1-6 of the LCP planning process ([Chapter 5](#)). Tables include:

- [Table C-1](#) – Sea Level Rise Mapping Tools.
This may be particularly relevant for Steps 1-3.
- [Table C-2](#) – Sea Level Rise Data and Resource Clearinghouses.
This may be particularly relevant for Steps 1-4.
- [Table C-3](#) – Adaptation Planning Guidebooks.
This may be particularly relevant for Steps 1-3.
- [Table C-4](#) – Resources for Assessing Adaptation Measures.
This may be particularly relevant for Step 4.
- [Table C-5](#) – Examples of Sea Level Rise Vulnerability Assessments in California.
This may be particularly relevant for Steps 1-3.
- [Table C-6](#) – California Climate Adaptation Plans that Address Sea Level Rise.
This may be particularly relevant for Steps 1-4.
- [Table C-7](#) – California State Agency Resources

Table C-1. Sea Level Rise Mapping Tools

Tool	Description	Link
Statewide		
NOAA Digital Coast Sea Level Rise and Coastal Flooding Impacts Viewer	Displays potential future sea levels with a slider bar. Communicates spatial uncertainty of mapped sea level rise, overlays social and economic data onto sea level rise maps, and models potential marsh migration due to sea level rise. Maps do not include any influence of beach or dune erosion.	https://coast.noaa.gov/digitalcoast/tools/slr.html
Cal-Adapt – Exploring California’s Climate	Represents inundation location and depth for the San Francisco Bay, the Sacramento-San Joaquin River Delta and California coast resulting from different increments of sea level rise coupled with extreme storm events. Incorporates real, time series water level data from past (near 100 year) storm events to capture the dynamic effect of storm surges in modeling inundation using a three dimensional hydrodynamic model (per Radke et al., 2017).	http://cal-adapt.org/tools/slr-calflod-3d/
Climate Central Surging Seas	Overlays sea level rise data with socio-economic information and ability to analyze property values, population, socio-economic status, ethnicity, and income or areas at risk. Can compare exposure across the whole state or selected county.	http://sealevel.climatecentral.org/ssrf/california
Pacific Institute Sea Level Rise Maps (Heberger <i>et al.</i> 2009)	Downloadable PDF maps showing the coastal flood and erosion hazard zones from the 2009 study. Data are overlaid on aerial photographs and show major roads. Also available are an interactive online map and downloadable maps showing sea level rise and population and property at risk, miles of vulnerable roads and railroads, vulnerable power plants and wastewater treatment plants, and wetland migration potential.	http://www.pacinst.org/reports/sea_level_rise/maps/ For the 2009 report <i>The Impacts of Sea-Level Rise on the California Coast</i> , see: http://pacinst.org/publication/the-impacts-of-sea-level-rise-on-the-california-coast/

<p>Sea Level Affecting Marshes Model (SLAMM)</p>	<p>Simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term sea level rise. Map distributions of wetlands are predicted under conditions of accelerated sea level rise, and results are summarized in tabular and graphical form.</p>	<p>http://www.warrenpinnacle.com/prof/SLAMM</p>
<p>Coastal Storm Modeling System (CoSMoS); tool hosted by Our Coast Our Future</p>	<p>Currently available for Point Arena to the Mexico border, with a statewide expansion anticipated in 2018/2019. The Coastal Storm Modeling System (CoSMoS) is a dynamic modeling approach that allows detailed predictions of coastal flooding due to both future sea level rise and storms, and integrated with long-term coastal evolution (i.e., beach changes and cliff/bluff retreat)</p>	<p>https://walrus.wr.usgs.gov/coastal_processes/cosmos/ http://data.pointblue.org/apps/ocof/cms/</p>
<p>TNC Coastal Resilience</p>	<p>An online mapping tool showing potential impacts from sea level rise and coastal hazards designed to help communities develop and implement solutions that incorporate ecosystem-based adaptation approaches. Available statewide with more detailed modelling for Monterey Bay, Santa Barbara, Ventura, and Santa Monica.</p>	<p>http://maps.coastalresilience.org/california/</p>
<p>Humboldt Bay Sea Level Rise Adaptation Project</p>	<p>This project is a multi-phased, regional collaboration. Phase I produced the <i>Humboldt Bay Shoreline Inventory, Mapping, and Sea Level Rise Vulnerability Assessment</i> which describes current shoreline conditions and vulnerabilities under the current tidal regime. Phase II included hydrodynamic modeling to develop vulnerability maps of areas surrounding Humboldt Bay vulnerable to inundation from existing and future sea levels. Phase II produced the <i>Humboldt Bay Sea Level Rise Modeling Inundation Mapping Report</i> and the <i>Humboldt Bay Sea Level Rise Conceptual Groundwater Model</i>.</p>	<p>All reports are available at: http://humboltdbay.org/humboldt-bay-sea-level-rise-adaptation-planning-project</p>

Table C-2. Sea Level Rise Data and Resource Clearinghouses

Resource	Description	Link
California State Adaptation Clearinghouse	Hosted by the OPR Integrated Climate Adaptation and Resiliency Program (ICARP), a centralized source of information that provides the resources necessary to guide decision makers at the state, regional, and local levels when planning for and implementing climate adaptation projects to promote resiliency to climate change in California.	http://opr.ca.gov/clearinghouse/adaptation/ or https://resilientca.org/
California Climate Commons	Offers a point of access to climate change data and related resources, information about the science that produced it, and the opportunity to communicate with others about applying climate change science to conservation in California.	http://climate.calcommons.org/
Climate Adaptation Knowledge Exchange (CAKE)	Provides an online library of climate adaptation case studies and resources, plus ways to connect with an online climate adaptation community/network.	http://www.cakex.org/
Ecosystem Based Management Tools Network Database	Provides a searchable database of tools available for climate adaptation, conservation planning, sea level rise impact assessment, <i>etc.</i>	http://www.ebmtools.org/about_ebm_tools.html
Climate.Data.gov	Recently launched federal government data portal that includes a number of data sets on climate change, including sea level rise impacts.	http://www.data.gov/climate/
NOAA Digital Coast	This NOAA-sponsored website is focused on helping communities address coastal issues. The Digital Coast provides coastal data, tools, training, and information from reputable sources.	http://coast.noaa.gov/digitalcoast/

Table C-3. Adaptation Planning Guidebooks

Title	Description	Link
<p>Scanning the Conservation Horizon (National Wildlife Federation 2011)</p>	<p>Designed to assist conservation and resource professionals to better plan, execute, and interpret climate change vulnerability assessments.</p>	<p>https://www.nwf.org/~/media/pdfs/global-warming/climate-smart-conservation/nwfscanningtheconservationhorizonfinal92311.ashx</p>
<p>Adapting to Sea Level Rise: A Guide for California's Coastal Communities (Russell and Griggs 2012)</p>	<p>Intended to assist California's coastal managers and community planners in developing adaptation plans for sea level rise that are suited to their local conditions and communities.</p>	<p>http://seymourcenter.ucsc.edu/OOB/Adapting%20to%20Sea%20Level%20Rise.pdf</p>
<p>California Adaptation Planning Guide (APG) (Cal EMA/CNRA 2012)</p>	<p>Provides guidance to support regional and local communities in proactively addressing the unavoidable consequences of climate change. Includes a step-by-step process for local and regional climate vulnerability assessment and adaptation strategy development.</p>	<p>http://resources.ca.gov/climate/safeguarding/local-action/</p>
<p>Preparing for Climate Change: A Guidebook for Regional and State Governments (Snover <i>et al.</i> 2007)</p>	<p>Assists decision makers in a local, regional, or state government prepare for climate change by recommending a detailed, easy-to-understand process for climate change preparedness based on familiar resources and tools.</p>	<p>http://cses.washington.edu/db/pdf/snoveretalgb574.pdf</p>
<p>Adapting to Climate Change: a Planning Guide for State Coastal Managers (NOAA 2010)</p>	<p>Guide offers a framework for state coastal managers to follow as they develop and implement climate change adaptation plans in their own states.</p>	<p>https://coast.noaa.gov/czm/media/adaptationguide.pdf</p>

<p>Using Scenarios to Explore Climate Change: A Handbook for Practitioners (NPS 2013)</p>	<p>Describes the five-step process for developing multivariate climate change scenarios taught by the Global Business Network (GBN). Detailed instructions are provided on how to accomplish each step. Appendices include a hypothetical scenario exercise that demonstrates how to implement the process and some early examples of how national parks are using climate change scenarios to inform planning and decision making.</p>	<p>http://www.nps.gov/subjects/climatechange/upload/CCScenariosHandbookJuly2013.pdf</p>
<p>Scenario Planning for Climate Change Adaptation: A Guidance for Resource Managers (Moore <i>et al.</i> 2013)</p>	<p>Step-by-step guide to using scenarios to plan for climate change adaptation for natural resource managers, planners, scientists, and other stakeholders working at a local or regional scale to develop resource management approaches that take future climate change impacts and other important uncertainties into account.</p>	<p>http://scc.ca.gov/files/2013/07/Scenario_planning_17july2013_FINAL-3.pdf</p>

Table C-4. Resources for Assessing Adaptation Measures

Resource	Description	Link
General		
<p>Georgetown Climate Center’s Climate Adaptation Toolkit – Sea Level Rise and Coastal Land Use</p>	<p>Explores 18 different land-use tools that can be used to preemptively respond to the threats posed by sea level rise to both public and private coastal development and infrastructure, and strives to assist governments in determining which tools to employ to meet their unique socio-economic and political contexts.</p>	<p>http://www.georgetownclimate.org/resources/adaptation-tool-kit-sea-level-rise-and-coastal-land-use</p>
<p>What Will Adaptation Cost? (ERGI 2013)</p>	<p>“This report provides a framework that community leaders and planners can use to make more economically informed decisions about adapting to sea level rise and storm flooding. The four-step framework can be used to perform a holistic assessment of costs and benefits of different adaptation approaches across a community, or to focus in on select infrastructure. The report also discusses the expertise needed at each step in the process.”</p>	<p>https://coast.noaa.gov/data/digitalcoast/pdf/adaptation-report.pdf</p>
<p>Center for Ocean Solutions: Adaptation in Action: Examples from the Field</p>	<p>Provides case studies of various adaptation strategies including overlay zones, non-conformities, setbacks, buffers, development conditions, shoreline protection devices, managed retreat, capital improvement programs, acquisition programs, conservation easements, rolling easements, tax incentives, transfer development rights, and real estate disclosures.</p>	<p>http://www.centerforoceansolutions.org/sites/default/files/Application%20of%20Land%20Use%20Practices%20and%20Tools%20to%20Prepare.pdf</p>

<p>Combatting Sea Level Rise in Southern California: How Local Government Can Seize Adaptation Opportunities While Minimizing Legal Risk (Herzog and Hecht 2013)</p>	<p>Identifies how local governments can harness legal doctrines to support aggressive, innovative strategies to achieve successful sea level rise adaptation outcomes for Southern California while minimizing legal risk. Broadly outlines likely sea level rise impacts in Southern California, and evaluates the risks and opportunities of potential protection, accommodation, and retreat adaptation strategies that local governments could deploy.</p>	<p>http://www.law.ucla.edu/~/media/Files/UCLA/Law/Pages/Publications/CEN_EM_PUB%20Combatting%20Sea-Level%20Rise.ashx</p>
<p>Strategies for Erosion-Related Impacts</p>		
<p>Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay</p>	<p>Provides a technical evaluation of various erosion mitigation measures, conducts a cost benefit analysis of some of the more promising measures, and includes recommendations for addressing coastal erosion in Southern Monterey Bay. The report is intended to be relevant for other areas of California as well.</p>	<p>https://montereybay.noaa.gov/research/techreports/tresapwa2012.html</p>
<p>Rolling Easements</p>		
<p>Rolling Easements- A Primer (Titus 2011)</p>	<p>Examines more than a dozen different legal approaches to rolling easements. It differentiates opportunities for legislatures, regulators, land trusts, developers, and individual landowners. Considers different shoreline environments (<i>e.g.</i>, wetlands, barrier islands) and different objectives (<i>e.g.</i>, public access, wetland migration)</p>	<p>http://papers.risingsea.net/rolling-easements.html</p>
<p>No Day at the Beach: Sea Level Rise, Ecosystem Loss, and Public Access Along the California Coast (Caldwell and Segall 2007)</p>	<p>Provides a description of sea level rise impacts to ecosystems and public access, strategies to address these impacts, and case study examples of rolling easement strategies for the California coast.</p>	<p>http://scholarship.law.berkeley.edu/cgi/viewcontent.cgi?article=1833&context=elq</p>

Natural Resources		
PRBO Climate Smart Conservation	Lists science-based, climate-smart conservation planning and management tools and methods, including restoration projects designed for climate change and extremes.	http://www.pointblue.org/priorities/climate-smart-conservation/
US Forest Service System for Assessing Vulnerability of Species- Climate Change Tool	Quantifies the relative impact of expected climate change effects for terrestrial vertebrate species.	http://www.fs.fed.us/rm/g rassland-shrubland-desert/products/species-vulnerability/savs-climate-change-tool/
The Nature Conservancy: Reducing Climate Risk with Natural Infrastructure report	Presents a series of nine case studies in which natural, “green” infrastructure was successfully used to mitigate climate impacts. The economic costs and benefits of the green infrastructure are compared with traditional “gray” approaches.	http://www.nature.org/our-initiatives/regions/northamerica/unitedstates/california/ca-green-vs-gray-report-2.pdf
CDFW Essential Habitat Connectivity Project	“The California Department of Fish and Wildlife and the California Department of Transportation (Caltrans) commissioned a team of consultants to produce a statewide assessment of essential habitat connectivity by February of 2010, using the best available science, datasets, spatial analyses, and modeling techniques. The goal was to identify large remaining blocks of intact habitat or natural landscape and model linkages between them that need to be maintained, particularly as corridors for wildlife.”	https://www.wildlife.ca.gov/Conservation/Planning/Connectivity
CDFW Areas of Conservation Emphasis tool	Provides a mapping tool and reports on the best available statewide, spatial information on California's biological richness, including species diversity, rarity, and sensitive habitats, as well as recreational needs and opportunities throughout the state, including fishing, hunting and wildlife-viewing.	http://www.dfg.ca.gov/bio/geodata/ace/

Table C-5. Examples of Sea Level Rise Vulnerability Assessments in California

Title	Description	Link
Humboldt Bay Sea Level Rise Adaptation Planning Project	Multiphase project to assess vulnerability of Humboldt Bay shoreline and adjacent areas to sea level rise and coastal hazards.	http://humboldt-bay-sea-level-rise-adaptation-planning-project
Marin Ocean Coast Sea Level Rise Vulnerability Assessment (2018)	Assesses vulnerability of Marin County’s ocean coastal areas to sea level rise, specifically evaluating 5 SLR and storm scenarios through approximately 2100. Findings are organized both by asset type and community.	https://www.marincounty.org/depts/cd/divisions/planning/csmart-sea-level-rise/csmart-publications-csmart-infospot
San Francisco Sea Level Rise Existing Data and Analyses Technical Memorandum (2016)	Summarizes existing data and analyses of SLR vulnerability within the Coastal Zone and lays the foundation for San Francisco’s proposed LCP amendment.	http://default.sfplanning.org/plans-and-programs/local_coastal_prgm/20160506.SFLCP_SLR_Tech_Memo.FINAL.pdf
Plan Half Moon Bay Sea Level Rise Vulnerability Assessment (2016)	Identifies the primary vulnerabilities within Half Moon Bay and sets forth next steps that the City and other involved agencies may take to further assess and address these vulnerabilities.	http://nebula.wsimg.com/0849a308eececc2c58ce202e2851bade?AccessKeyId=06ACEAA5216D33A5C3B0&disposition=0&alloworigin=1
City of Monterey Final Sea Level Rise and Vulnerability Analyses, Existing Conditions and Issues Report (2016)	Provides a science-based assessment of climate change vulnerabilities that includes extensive field data gathering, and compilation of existing data and information.	https://www.monterey.org/Portals/0/Policies-Procedures/Planning/WorkProgram/LCP/16_0316_FINAL_Monterey_ExistingConditions_wAppendixA_WEB.pdf
City of Pacific Grove Climate Change Vulnerability Assessment (2015)	Provides an evaluation of potential significant impacts of climate change for the city’s coastal zone with an emphasis on how anticipated climate change may affect people, resources, and infrastructure along the coast.	http://www.cityofpacificgrove.org/sites/default/files/general-documents/local-coastal-program/pg-lcp-final-vulnerability-assessment-011515.pdf
City of Morro Bay Community Vulnerability and Resilience Assessment (2017)	Provides a best estimate of likely future conditions, based on local demographic projections and the most recently available scientific projections of future climate conditions, given current trends.	http://www.morrobayca.gov/DocumentCenter/View/10676/Final-Draft--Revised-Community-Vulnerability-and-Resilience-Assessment-3-6-17?bidId=

<p>City of Goleta Coastal Hazards Vulnerability Assessment and Fiscal Impact Report (2015)</p>	<p>Provides a science-based assessment that includes extensive field data gathering, compilation of existing data and information, and the participation of stakeholders such as citizens, business owners, local organizations, and community leaders. Enhances community planning by identifying coastal hazards and associated vulnerabilities that are in balance with fiscal resources.</p>	<p>https://www.conservationgateway.org/ConservationPractices/Marine/crr/library/Documents/GoletaCoastalVulnerability.pdf</p>
<p>City of Oxnard Sea Level Rise Atlas (2016)</p>	<p>Maps and identifies areas and assets at risk to existing and future conditions, including sea level rise.</p>	<p>http://nebula.wsimg.com/64b81b1805381307f1e6492bf187b6d9?AccessKeyId=D91312DA8FC16C8BCDB9&disposition=0&alloworigin=1</p>
<p>County of San Diego Climate Change Vulnerability Assessment (2017)</p>	<p>Identifies the primary threats from a changing climate facing the unincorporated areas of San Diego county, and its vulnerability to these threats.</p>	<p>https://www.sandiegocounty.gov/content/dam/sdc/pds/advance/cap/publicreviewdocuments/PostBOSDocs/CAP%20Appendix%20D%20-%20Climate%20Change%20Vulnerability%20Assessment.pdf</p>
<p>City of Imperial Beach Sea Level Rise Assessment (2016)</p>	<p>Identifies vulnerabilities from sea level rise and coastal hazards; a range of adaptation strategies including tradeoffs and economics; and recommends strategies over time that are politically digestible and economically feasible.</p>	<p>http://www.imperialbeachca.gov/vertical/sites/%7B6283CA4C-E2BD-4DFA-A7F7-8D4ECD543E0F%7D/uploads/100516_IB_Sea_Level_Rise_Assessment_FINAL.pdf</p>
<p>Santa Barbara Sea Level Rise Vulnerability Study (Russell and Griggs 2012)</p>	<p>Assesses the vulnerability of the City of Santa Barbara to future sea level rise and related coastal hazards (by Years 2050 and 2100) based upon past events, shoreline topography, and exposure to sea level rise and wave attack. It also evaluates the likely impacts of coastal hazards to specific areas of the City, analyzes their risks and the City's ability to respond, and recommends potential adaptation responses.</p>	<p>http://www.energy.ca.gov/2012publications/CEC-500-2012-039/CEC-500-2012-039.pdf</p>

<p>City of Santa Cruz Climate Change Vulnerability Assessment (Griggs and Haddad 2011)</p>	<p>Delineates and evaluates the likely impacts of future climate change on the city of Santa Cruz, analyzes the risks that these hazards pose for the city, and then recommends potential adaptation responses to reduce the risk and exposure from these hazards in the future.</p>	<p>http://seymourcenter.ucsc.edu/OOB/SCClimateChangeVulnerabilityAssessment.pdf</p>
<p>Developing Climate Adaptation Strategies for San Luis Obispo County: Preliminary Vulnerability Assessment for Social Systems (Moser 2012)</p>	<p>Describes the likely impacts of climate change on the resources and social systems of San Luis Obispo County, and assesses key areas of vulnerability. Sea level rise is identified as a major source of risk to fishing, coastal tourism, coastal development, and infrastructure.</p>	<p>http://www.energy.ca.gov/2012publications/CEC-500-2012-054/CEC-500-2012-054.pdf</p>
<p>Monterey Bay Sea Level Rise Vulnerability Study (Monterey Bay National Marine Sanctuary and PWA ESA; In progress)</p>	<p>Will assess potential future impacts from sea level rise for the Monterey Bay region. The project will estimate the extent of future coastal erosion in Monterey Bay due to accelerated sea level rise and evaluate areas subjected to coastal flooding by inundation from wave action and/or storm surges. The project will update and refine existing Monterey Bay coastal hazard zones maps (erosion and flooding).</p>	<p>Project scope and grant details: http://scc.ca.gov/webmaster/ftp/pdf/scbb/2012/1201/20120119Board03D_Monterey_Bay_Sea_Level_Rise.pdf</p>
<p>Sea Level Rise Vulnerability Study for the City of LA (Adapt LA) (USC Sea Grant 2013)</p>	<p>This report provides a summary of the initial research on the potential impacts of sea level rise and associated flooding from storms for coastal communities in the City of L.A. The study concentrates on the City's three coastal regions: Pacific Palisades from Malibu to Santa Monica; Venice and Playa del Rey; and San Pedro, Wilmington and the Port of Los Angeles.</p>	<p>http://dornsife.usc.edu/uscseagrant/la-slrl/</p>

* See also the Coastal Commission's [LCP Grant website](#) for a status chart of sea level rise work completed by grantees (updated on an approximately quarterly basis).

Table C-6. California Climate Adaptation Plans that Address Sea Level Rise

Title	Description	Link
Marin Ocean Coast Sea Level Rise Adaptation Report (2018)	Presents near-, medium-, and long-term options to accommodate, protect against, or retreat from the threats of SLR and extreme events and is intended to inform Marin County’s Local Coastal Program (LCP), coastal permitting, and other county goals related to SLR preparation.	https://www.marincounty.org/depts/cd/divisions/planning/csmart-sea-level-rise/csmart-publications-csmart-infospot
Morro Bay Sea Level Rise Adaptation Strategy Report (2018)	Presents adaptation strategies for three sites within the City, selected to represent the general exposure of a type of hazard or asset.	http://www.morro-bay.ca.us/DocumentCenter/View/11753/Sea-Level-Rise-Adaptation-Report-January-2018
Adapting to Rising Tides (ART) Project	The ART project is a collaborative planning effort led by the San Francisco Bay Conservation and Development Commission to help SF Bay Area communities adapt to rising sea levels. The project has started with a vulnerability assessment for a portion of the Alameda County shoreline.	http://www.adaptingtorisingtides.org/
Santa Cruz Climate Adaptation Plan	An update to the 2007 Hazard Mitigation Plan, the adaptation plan includes strategies and best available science for integrating climate change impacts into City of Santa Cruz operations.	Complete plan is available: http://www.cityofsantacruz.com/home/showdocument?id=23644
San Diego Bay Sea Level Rise Adaptation Strategy	The strategy provides measures to evaluate and manage risks from sea level rise and other climate change impacts, and includes a vulnerability assessment of community assets at risk, and broad recommendations to increase resilience of these assets.	http://icleiusa.org/wp-content/uploads/2015/08/San-Diego-Sea-Level-Rise.pdf

* See also the Coastal Commission’s [LCP Grant website](#) for a status chart of sea level rise work completed by grantees (updated on an approximately quarterly basis).

Table C-7. California State Agency Resources

Agency	Document	Description and Link
California Natural Resources Agency	<i>Safeguarding California Plan: 2018 Update (2018)</i>	An update to the 2014 Safeguarding document: http://resources.ca.gov/docs/climate/safeguarding/update2018/safeguarding-california-plan-2018-update.pdf
	<i>Safeguarding California from Climate Change (2014)</i>	An update to the 2009 <i>California Climate Adaptation Strategy</i> : http://resources.ca.gov/docs/climate/Final_Safeguarding_CA_Plan_July_31_2014.pdf
	<i>California Climate Adaptation Strategy (2009)</i>	Summarizes climate change impacts and recommends adaptation strategies across seven sectors: Public Health, Biodiversity and Habitat, Oceans and Coastal Resources, Water, Agriculture, Forestry, and Transportation and Energy: http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf
Office of the Governor	<i>Executive Order S-13-08 (2008)</i>	This 2008 Executive Order required the CA Natural Resources Agency to develop a statewide climate adaptation strategy, and requested that the National Academy of Sciences convene an independent scientific panel to assess sea level rise in California. http://www.climatechange.ca.gov/state/executive_orders.html
	<i>Executive Order B-30-15 (2015)</i>	This 2015 Executive Order established an interim greenhouse gas reduction target of 40 percent below 1990 levels by 2030 to expand upon the targets already included in AB32 and emphasized the need for adaptation in line with the actions identified in the <i>Safeguarding California</i> document. http://gov.ca.gov/news.php?id=18938
Governor’s Office of Planning and Research	<i>Defining Vulnerable Communities in the Context of Climate Adaptation</i>	Resource guide developed by the Integrated Climate Adaptation and Resiliency Program (ICARP) as a starting point for practitioners to use when first considering how to define vulnerable communities in an adaptation context. http://opr.ca.gov/planning/icarp/vulnerable-communities.html
California Ocean Protection Council (and the Coasts &	<i>State of California Sea-Level Rise Guidance: 2018 Update (2018)</i>	Provides guidance for incorporating sea level rise projections into planning and decision making. Updated to include <i>Rising Seas</i> science, 2018: http://www.opc.ca.gov/updating-californias-sea-level-rise-guidance/

Oceans Climate Action Team, or CO-CAT)	<i>Rising Seas in California: An Update on Sea-Level Rise Science</i>	Provides a synthesis of the state of the science on sea-level rise and forms the scientific foundation for the updated OPC SLR Guidance. http://www.opc.ca.gov/webmaster/ftp/pdf/docs/rising-seas-in-california-an-update-on-sea-level-rise-science.pdf
	<i>Resolution on Implementation of the Safeguarding California Plan for Reducing Climate Risks (2014)</i>	Resolves that OPC staff and the State Coastal Leadership Group on SLR will develop an action plan to implement the <i>Safeguarding California</i> plan. http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20140827/Item5 OPC Aug2014 Exhibit 1 Safeguarding Resolution ADOPTED.pdf
	<i>Resolution on Sea Level Rise (2011)</i>	Recognizes that state agencies should address SLR through various actions such as the consideration of SLR risks in decision making, investment of public funds, stakeholder engagement, state SLR guidance updates, etc. http://www.opc.ca.gov/webmaster/ftp/pdf/docs/OPC SeaLevelRise Resolution Adopted031111.pdf
	<i>California State Sea-Level Rise Guidance Document (2013)</i>	Provides guidance for incorporating sea level rise projections into planning and decision making for projects in California. Updated to include NRC projections March 2013: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013 SLR Guidance Update FINAL1.pdf
	<i>Climate Change Policy (2010)</i>	Includes policies on 1) consideration of climate change in project evaluation, 2) consideration of sea level rise impacts in vulnerability assessments, 3) collaboration to support adaptation strategies, and 4) encouragement of adaptation strategies in project applications mitigation and adaptation: http://scc.ca.gov/2009/01/21/coastal-conservancy-climate-change-policy-and-project-selection-criteria/
California Coastal Conservancy	<i>Project Selection Criteria (2011)</i>	Adds sea level rise vulnerability to project selection criteria: http://scc.ca.gov/2009/01/21/coastal-conservancy-climate-change-policy-and-project-selection-criteria/

	Guidance for addressing climate change in CA Coastal Conservancy projects (2012)	Includes the following steps: 1) conduct initial vulnerability assessment, 2) conduct more comprehensive vulnerability assessment, 3) reduce risks and increase adaptive capacity, and 4) identify adaptation options: http://scc.ca.gov/2013/04/24/guidance-for-grantees
San Francisco Bay Conservation and Development Commission (BCDC)	<i>Climate Change Bay Plan Amendment</i> (2011)	Amends <i>Bay Plan</i> to include policies on climate change and sea level rise. Policies require: 1) a sea level rise risk assessment for shoreline planning and larger shoreline projects, and 2) if risks exist, the project must be designed to cope with flood levels by mid-century, and include a plan to address flood risks at end of century. Assessments are required to “identify all types of potential flooding, degrees of uncertainty, consequences of defense failure, and risks to existing habitat from proposed flood protection devices”: http://www.bcdc.ca.gov/proposed_bay_plan/bp_amend_1-08.shtml
	<i>Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline</i> (2011)	Provides the background staff report identifying vulnerabilities in the Bay Area’s economic and environmental systems, as well as the potential impacts of climate change on public health and safety. The report provides the basis for all versions of the proposed findings and policies concerning climate change: http://www.bcdc.ca.gov/BPA/LivingWithRisingBay.pdf
California Department of Transportation (Caltrans)	<i>Estimating Sea Level for Project Initiation Documents</i> (2012)	Provides guidance on converting tidal datums and predicting future sea levels. http://www.dot.ca.gov/hq/row/landsurveys/SurveyManual/Estimating_Sea_Level_v1.pdf

	<p><i>Guidance on Incorporating Sea Level Rise</i> (2011)</p>	<p>Provides guidance on how to incorporate sea level rise concerns into programming and design of Caltrans projects. Includes screening criteria for determining whether to include SLR and steps for evaluating degree of potential impacts, developing adaptation alternatives, and implementing the adaptation strategies: http://www.dot.ca.gov/ser/downloads/sealevel/guide_incorp_slr.pdf</p>
	<p><i>Addressing Climate Change in Adaptation Regional Transportation Plans: A Guide for MPOs and RTPAs</i> (2013)</p>	<p>Provides a clear methodology for regional agencies to address climate change impacts through adaptation of transportation infrastructure: http://www.dot.ca.gov/hq/tpp/offices/orip/climate_change/documents/FR3_CA_Climate_Change_Adaptation_Guide_2013-02-26.pdf</p>
	<p><i>District-wide Vulnerability Assessments</i> (2018, ongoing)</p>	<p>Caltrans is currently in the process of completing climate change and sea level rise vulnerability assessments for each of its Districts. http://www.dot.ca.gov/transplanning/ocp/vulnerability-assessment.html</p>
<p>Cal OES</p>	<p><i>California Multi-Hazard Mitigation Plan</i> (Draft SHMP 2018)</p>	<p>The California (CA) State Hazard Mitigation Plan (SHMP) represents the state’s primary hazard mitigation guidance document - providing an updated analysis of the state’s historical and current hazards, hazard mitigation goals and objectives, and hazard mitigation strategies and actions. The plan represents the state’s overall commitment to supporting a comprehensive mitigation strategy to reduce or eliminate potential risks and impacts of disasters in order to promote faster recovery after disasters and, overall, a more resilient state: http://www.caloes.ca.gov/for-individuals-families/hazard-mitigation-planning/state-hazard-mitigation-plan</p>
<p>State Lands Commission</p>	<p>Application for Lease of State Lands</p>	<p>Requires assessment of climate change risks, and preference is given to projects that reduce climate change risks: http://www.slc.ca.gov/Forms/LMDApplication/LeaseApp.pdf</p>

California State Parks	Sea level rise guidance (<i>in development</i>)	Will provide guidance to Park staff on how to assess impacts to parklands.
Groups of state agencies	California Climate Change Center's 3 rd Assessment	Explores local and statewide vulnerabilities to climate change, highlighting opportunities for taking concrete actions to reduce climate-change impacts: http://climatechange.ca.gov/climate_action_team/reports/third_assessment/
	<i>California Climate Adaptation Planning Guide (APG)</i>	Provides a decision-making framework intended for use by local and regional stakeholders to aid in the interpretation of climate science and to develop a systematic rationale for reducing risks caused, or exacerbated, by climate change (2012): http://resources.ca.gov/climate/safeguarding/local-action/

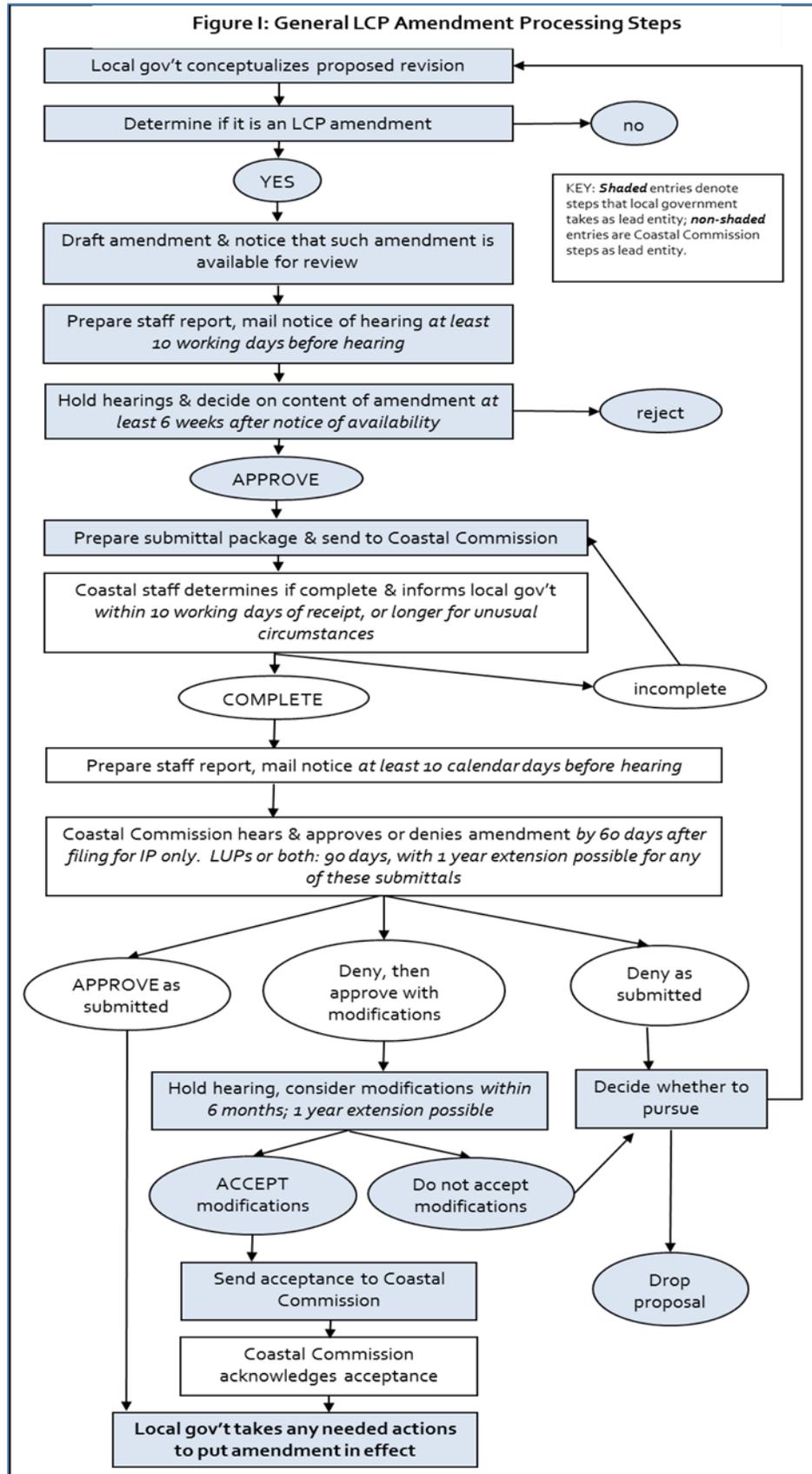
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Appendix D

General LCP Amendment Processing Steps and Best Practices

Sea level rise is one of many topics that should be addressed in a Local Coastal Program (LCP) or LCP amendment. The Coastal Commission offers a [Local Coastal Program \(LCP\) Update Guide](#) that outlines the broad process for amending or certifying an LCP, including guidance for both Land Use Plans and Implementation Plans. It addresses major Coastal Act concerns, including public access, recreation and visitor serving facilities, water quality protection, ESHA and natural resources, agricultural resources, new development, archaeological and cultural resources, scenic and visual resources, coastal hazards, shoreline erosion and protective devices, energy and industrial development, and timberlands. Therefore, this *Sea Level Rise Policy Guidance* should be used in conjunction with the LCP Update Guide to perform complete LCP amendments or certifications. The following figure depicts the general LCP amendment process.



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Appendix E

Funding Opportunities for LCP Planning and Implementation

Project Implementation Funds

The following table includes a list of grant funding available for implementation of sea level rise adaptation projects and programs. Much of this information was compiled by the [Governor's Office of Emergency Services](#) (Cal OES).

Grant Name	Agency	Purpose	Contact
Proposition 1 & Proposition 84 Competitive Grant Programs	Ocean Protection Council	Funding from Prop 1 is intended to fund projects that provide more reliable water supplies, restore important species and habitat, and develop a more resilient and sustainably managed water system (water supply, water quality, flood protection, and environment) that can better withstand inevitable and unforeseen pressures in the coming decades. Proposition 84 funds may be used for a wide range of purposes including scientific research, adaptive management, and conservation of marine resources.	OPC http://www.opc.ca.gov/category/funding-opportunities/
Proposition 68 Funds Proposition 1 Grants Climate Ready Grants	California Coastal Conservancy	Proposition 68 grants for a variety of purposes including creating parks, protecting coastal forests and wetlands, and climate adaptation Proposition 1 Grants for multi-benefit ecosystem and watershed protection and restoration projects. Climate Ready Grants are focused on supporting planning, project implementation and multi-agency coordination to advance actions that will increase the resilience of coastal communities and ecosystems	Coastal Conservancy http://scc.ca.gov/2018/10/10/proposition-68-draft-guidelines/ http://scc.ca.gov/grants/proposition-1-grants/ http://scc.ca.gov/climate-change/climate-ready-program/
SB 1 Adaptation Planning Grants	Caltrans	Support actions at the local and regional level to advance climate change adaptation efforts on the state transportation system	Caltrans http://www.dot.ca.gov/hq/tpp/grants.html

Proposition 68	Ocean Protection Council	Provide funding for projects that plan, develop, and implement climate adaptation and resiliency projects, including projects that assist coastal communities with adaptation to sea level rise. These funds can also support technical assistance and community access projects.	Ocean Protection Council (<i>website to come</i>)
Hazard Mitigation Grant (HMG) Program	Administered by: Cal OES Funded by: US Department of Homeland Security, Federal Emergency Management Agency (FEMA)	Provides grants to states and local governments to implement long-term hazard mitigation measures after a major disaster declaration. The purpose of the HMGP is to reduce the loss of life and property due to natural disasters and to enable mitigation measures to be implemented during the immediate recovery from a disaster.	Cal OES http://www.caloes.ca.gov/ca-l-oes-divisions/recovery/disaster-mitigation-technical-support/404-hazard-mitigation-grant-program FEMA https://www.fema.gov/hazard-mitigation-grant-program
Flood Mitigation Assistance (FMA) Program	Administered by: Cal OES Funded by: US Department of Homeland Security, Federal Emergency Management Agency (FEMA)	Provides grants to assist states and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the NFIP.	Cal OES http://www.caloes.ca.gov/ca-l-oes-divisions/hazard-mitigation/pre-disaster-flood-mitigation FEMA https://www.fema.gov/flood-mitigation-assistance-program
Public Assistance (PA) Program	US Department of Homeland Security, Federal Emergency Management Agency (FEMA)	To provide supplemental Federal disaster grant assistance for debris removal, emergency protective measures, and the repair, replacement, or restoration of disaster-damaged, publicly owned facilities and the facilities of certain Private Non-Profit (PNP) organizations. The PA Program also encourages protection of these damaged facilities from future events by providing assistance for hazard mitigation measures during the recovery process.	FEMA https://www.fema.gov/public-assistance-local-state-tribal-and-non-profit
Community Development Block Grant (CDBG) Program	US Department of Housing and Urban Development	Program works to ensure decent affordable housing, to provide services to the most vulnerable in our communities, and to create jobs through the expansion and retention of businesses.	HUD http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs

Watershed Surveys and Planning	US Department of Agriculture, Natural Resource Conservation Service	To provide planning assistance to Federal, state and local agencies for the development or coordination of water and related land resources and programs in watersheds and river basins.	NRCS http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wsp/
Watershed Protection and Flood Prevention	US Department of Agriculture, Natural Resource Conservation Service	To provide technical and financial assistance in planning and executing works of improvement to protect, develop, and use of land and water resources in small watersheds.	NRCS http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/
Land and Water Conservation Fund Grants	US Department of the Interior, National Park Service	To acquire and develop outdoor recreation areas and facilities for the general public, to meet current and future needs.	NPS http://www.nps.gov/lwcf/index.htm
SBA Disaster Loan Program	US Small Business Administration	SBA provides low-interest disaster loans to businesses of all sizes, private non-profit organizations, homeowners, and renters. SBA disaster loans can be used to repair or replace the following items damaged or destroyed in a declared disaster: real estate, personal property, machinery and equipment, and inventory and business assets.	SBA https://www.sba.gov/content/disaster-loan-program
Clean Water Act Section 319 Grants	US Environmental Protection Agency	To implement state and tribal non-point source pollution management programs, including support for non-structural watershed resource restoration activities.	EPA https://www.epa.gov/nps/319-grant-program-states-and-territories
Flood Control Works/ Emergency Rehabilitation	US Department of Defense, Army Corps of Engineers	To assist in the repairs and restoration of public works damaged by flood, extraordinary wind, wave or water action.	USACE http://www.usace.army.mil/Missions/EmergencyOperations/NationalResponseFramework/FloodControl.aspx
Emergency Streambank and Shoreline Protection	US Department of Defense, Army Corps of Engineers	To prevent erosion damages to public facilities by the emergency construction or repair of streambank and shoreline protection works (33 CFR 263.25)	USACE http://www.mvr.usace.army.mil/BusinessWithUs/OutreachCustomerService/FloodRiskManagement/Section14.aspx
Small Flood Control Projects	US Department of Defense, Army Corps of Engineers	To reduce flood damages through small flood control projects not specifically authorized by Congress.	USACE www.usace.army.mil See also: https://www.cfda.gov/index?s=program&mode=form&tab=core&id=2216ee03c69db437c431036a5585ede6



Appendix F

Primary Coastal Act Policies Related to Sea Level Rise and Coastal Hazards

Legislative Findings Relating to Sea Level Rise

Section 30006.5 of the Coastal Act states (Legislative findings and declarations; technical advice and recommendations) states (emphasis added):

The Legislature further finds and declares that sound and timely scientific recommendations are necessary for many coastal planning, conservation, and development decisions and that the commission should, in addition to developing its own expertise in significant applicable fields of science, interact with members of the scientific and academic communities in the social, physical, and natural sciences so that the commission may receive technical advice and recommendations with regard to its decisionmaking, especially with regard to issues such as coastal erosion and geology, marine biodiversity, wetland restoration, the question of sea level rise, desalination plants, and the cumulative impact of coastal zone developments.

Public Access and Recreation

Section 30210 of the Coastal Act (Access; recreational opportunities; posting) states:

In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resource areas from overuse.

Section 30211 of the Coastal Act (Development not to interfere with access) states:

Development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization, including, but not limited to, the use of dry sand and rocky coastal beaches to the first line of terrestrial vegetation.

Section 30212 of the Coastal Act (New development projects) states:

(a) Public access from the nearest public roadway to the shoreline and along the coast shall be provided in new development projects except where: (1) it is inconsistent with public safety, military security needs, or the protection of fragile coastal resources, (2) adequate access exists nearby, or (3) agriculture would be adversely affected. Dedicated accessway shall not be required to be opened to public use until a public agency or private association agrees to accept responsibility for maintenance and liability of the accessway.

Section 30214 of the Coastal Act (Implementation of public access policies; legislative intent) states:

(a) The public access policies of this article shall be implemented in a manner that takes into account the need to regulate the time, place, and manner of public access depending on the facts and circumstances in each case including, but not limited to, the following:

- (1) Topographic and geologic site characteristics.*
- (2) The capacity of the site to sustain use and at what level of intensity.*

(3) The appropriateness of limiting public access to the right to pass and repass depending on such factors as the fragility of the natural resources in the area and the proximity of the access area to adjacent residential uses.

(4) The need to provide for the management of access areas so as to protect the privacy of adjacent property owners and to protect the aesthetic values of the area by providing for the collection of litter.

(b) It is the intent of the Legislature that the public access policies of this article be carried out in a reasonable manner that considers the equities and that balances the rights of the individual property owner with the public's constitutional right of access pursuant to Section 4 of Article X of the California Constitution. Nothing in this section or any amendment thereto shall be construed as a limitation on the rights guaranteed to the public under Section 4 of Article X of the California Constitution.

(c) In carrying out the public access policies of this article, the commission and any other responsible public agency shall consider and encourage the utilization of innovative access management techniques, including, but not limited to, agreements with private organizations which would minimize management costs and encourage the use of volunteer programs.

Section 30220 of the Coastal Act (Protection of certain water-oriented activities) states:

Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.

Section 30221 of the Coastal Act (Oceanfront land; protection for recreational use and development) states:

Oceanfront land suitable for recreational use shall be protected for recreational use and development unless present and foreseeable future demand for public or commercial recreational activities that could be accommodated on the property is already adequately provided for in the area.

Section 30223 of the Coastal Act (Upland areas) states:

Upland areas necessary to support coastal recreational uses shall be reserved for such uses, where feasible.

Wetlands and Environmentally Sensitive Resources

Section 30231 of the Coastal Act (Biological productivity; water quality) states in part:

The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored...

Section 30233 of the Coastal Act (Diking, filling or dredging; continued movement of sediment and nutrients) states:

(a) The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects, and shall be limited to the following:

Section 30240 of the Coastal Act (Environmentally sensitive habitat areas; adjacent developments) states:

(a) Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.

(b) Development in areas adjacent to environmentally sensitive habitat areas and parks and recreation areas shall be sited and designed to prevent impacts which would significantly degrade those areas, and shall be compatible with the continuance of those habitat and recreation areas.

Coastal Act Section 30121 defines “Wetland” as follows:

"Wetland" means lands within the coastal zone which may be covered periodically or permanently with shallow water and include saltwater marshes, freshwater marshes, open or closed brackish water marshes, swamps, mudflats, and fens.

The California Code of Regulations Section 13577(b) of Title 14, Division 5.5, Article 18 defines “Wetland” as follows:

(1) Measure 100 feet landward from the upland limit of the wetland. Wetland shall be defined as land where the water table is at, near, or above the land surface long enough to promote the formation of hydric soils or to support the growth of hydrophytes, and shall also include those types of wetlands where vegetation is lacking and soil is poorly developed or absent as a result of frequent and drastic fluctuations of surface water levels, wave action, water flow, turbidity or high concentrations of salts or other substances in the substrate. Such wetlands can be recognized by the presence of surface water or saturated substrate at some time during each year and their location within, or adjacent to, vegetated wetlands or deep-water habitats. For purposes of this section, the upland limit of a wetland shall be defined as:

(A) the boundary between land with predominantly hydrophytic cover and land with predominantly mesophytic or xerophytic cover;

(B) the boundary between soil that is predominantly hydric and soil that is predominantly nonhydric; or

(C) in the case of wetlands without vegetation or soils, the boundary between land that is flooded or saturated at some time during years of normal precipitation, and land that is not.

(2) For the purposes of this section, the term “wetland” shall not include wetland habitat created by the presence of and associated with agricultural ponds and reservoirs where:

(A) the pond or reservoir was in fact constructed by a farmer or rancher for agricultural purposes; and

(B) there is no evidence (e.g., aerial photographs, historical survey, etc.) showing that wetland habitat pre-dated the existence of the pond or reservoir. Areas with drained hydric soils that are no longer capable of supporting hydrophytes shall not be considered wetlands.

In addition, Coastal Act Section 30107.5 defines “Environmentally sensitive area” as follows:

"Environmentally sensitive area" means any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.

Agricultural and Timber Lands

Section 30241 of the Coastal Act (Prime agricultural land; maintenance in agricultural production) states:

The maximum amount of prime agricultural land shall be maintained in agricultural production to assure the protection of the areas' agricultural economy, and conflicts shall be minimized between agricultural and urban land uses...

Section 30242 of the Coastal Act (Lands suitable for agricultural use; conversion) states:

All other lands suitable for agricultural use shall not be converted to nonagricultural uses unless (1) continued or renewed agriculture use is not feasible, or (2) such conversion would preserve prime agricultural land or concentrate development consistent with Section 30250. Any such permitted conversion shall be compatible with continue agricultural use on surrounding lands.

Section 30243 of the Coastal Act (Productivity of soils and timberlands; conversions) states:

The long-term productivity of soils and timberlands shall be protected, and conversions of coastal commercial timberlands in units of commercial size to other uses or their division into units of noncommercial size shall be limited to providing for necessary timber processing and related facilities.

Archaeological and Paleontological Resources

Section 30244 of the Coastal Act (Archaeological or paleontological resources) states:

Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.

Marine Resources

Section 30230 of the Coastal Act (Marine resources; maintenance) states:

Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

Section 30231 of the Coastal Act (Biological productivity; water quality) states:

The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored through, among other means, minimizing adverse effects of waste water discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface waterflow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.

Section 30233 of the Coastal Act (Diking, filling or dredging; continued movement of sediment and nutrients) states:

(a) The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects...

(d) Erosion control and flood control facilities constructed on watercourses can impede the movement of sediment and nutrients that would otherwise be carried by storm runoff into coastal waters. To facilitate the continued delivery of these sediments to the littoral zone, whenever feasible, the material removed from these facilities may be placed at appropriate points on the shoreline in accordance with other applicable provisions of this division, where feasible mitigation measures have been provided to minimize adverse environmental effects. Aspects that shall be considered before issuing a Coastal Development Permit for these purposes are the method of placement, time of year of placement, and sensitivity of the placement area.

Section 30234 of the Coastal Act (Commercial fishing and recreational boating facilities) states:

Facilities serving the commercial fishing and recreational boating industries shall be protected and, where feasible, upgraded. Existing commercial fishing and recreational boating harbor space shall not be reduced unless the demand for those facilities no longer exists or adequate substitute space has been provided. Proposed recreational boating facilities shall, where feasible, be designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry.

Section 30234.5 of the Coastal Act (Economic, commercial, and recreational importance of fishing) states:

The economic, commercial, and recreational importance of fishing activities shall be recognized and protected.

Coastal Development

Section 30250 of the Coastal Act (Location; existing developed area) states:

(a) New residential, commercial, or industrial development, except as otherwise provided in this division, shall be located within, contiguous with, or in close proximity to, existing developed areas able to accommodate it or, where such areas are not able to accommodate it, in other areas with adequate public services and where it will not have significant adverse effects, either individually or cumulatively, on coastal resources. In addition, land divisions, other than leases for agricultural uses, outside existing developed areas shall be permitted only where 50 percent of the usable parcels in the area have been developed and the created parcels would be no smaller than the average size of surrounding parcels.

(b) Where feasible, new hazardous industrial development shall be located away from existing developed areas.

(c) Visitor-serving facilities that cannot feasibly be located in existing developed areas shall be located in existing isolated developments or at selected points of attraction for visitors.

Section 30251 of the Coastal Act (Scenic and visual qualities) states:

The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas...

Section 30253 the Coastal Act (Minimization of adverse impacts) states in part:

New development shall do all of the following:

(a) Minimize risks to life and property in areas of high geologic, flood, and fire hazard.

(b) Assure stability and structural integrity, and neither create nor contribute significantly to erosion, geologic instability, or destruction of the site or surrounding area or in any way require the construction of protective devices that would substantially alter natural landforms along bluffs and cliffs...

Section 30235 of the Coastal Act (Construction altering natural shoreline) states:

Revetments, breakwaters, groins, harbor channels, seawalls, cliff retaining walls, and other such construction that alters natural shoreline processes shall be permitted when required to serve coastal-dependent uses or to protect existing structures or public

beaches in danger from erosion, and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Existing marine structures causing water stagnation contributing to pollution problems and fishkills should be phased out or upgraded where feasible.

Section 30236 of the Coastal Act (Water supply and flood control) states:

Channelizations, dams, or other substantial alterations of rivers and streams shall incorporate the best mitigation measures feasible, and be limited to (1) necessary water supply projects, (2) flood control projects where no other method for protecting existing structures in the flood plain is feasible and where such protection is necessary for public safety or to protect existing development, or (3) developments where the primary function is the improvement of fish and wildlife habitat.

Ports

Section 30705 of the Coastal Act (Diking, filling or dredging water areas) states:

(a) Water areas may be diked, filled, or dredged when consistent with a certified port master plan only for the following: ...

(b) The design and location of new or expanded facilities shall, to the extent practicable, take advantage of existing water depths, water circulation, siltation patterns, and means available to reduce controllable sedimentation so as to diminish the need for future dredging.

(c) Dredging shall be planned, scheduled, and carried out to minimize disruption to fish and bird breeding and migrations, marine habitats, and water circulation. Bottom sediments or sediment elutriate shall be analyzed for toxicants prior to dredging or mining, and where water quality standards are met, dredge spoils may be deposited in open coastal water sites designated to minimize potential adverse impacts on marine organisms, or in confined coastal waters designated as fill sites by the master plan where such spoil can be isolated and contained, or in fill basins on upland sites. Dredge material shall not be transported from coastal waters into estuarine or fresh water areas for disposal.

Section 30706 of the Coastal Act (Fill) states:

In addition to the other provisions of this chapter, the policies contained in this section shall govern filling seaward of the mean high tide line within the jurisdiction of ports:

(a) The water area to be filled shall be the minimum necessary to achieve the purpose of the fill.

(b) The nature, location, and extent of any fill, including the disposal of dredge spoils within an area designated for fill, shall minimize harmful effects to coastal resources, such as water quality, fish or wildlife resources, recreational resources, or sand transport systems, and shall minimize reductions of the volume, surface area, or circulation of water.

(c) The fill is constructed in accordance with sound safety standards which will afford reasonable protection to persons and property against the hazards of unstable geologic or soil conditions or of flood or storm waters.

(d) The fill is consistent with navigational safety.

Section 30708 of the Coastal Act (Location, design and construction of port related developments) states:

All port-related developments shall be located, designed, and constructed so as to:

(a) Minimize substantial adverse environmental impacts.

(b) Minimize potential traffic conflicts between vessels.

(c) Give highest priority to the use of existing land space within harbors for port purposes, including, but not limited to, navigational facilities, shipping industries, and necessary support and access facilities.

(d) Provide for other beneficial uses consistent with the public trust, including, but not limited to, recreation and wildlife habitat uses, to the extent feasible.

(e) Encourage rail service to port areas and multicompany use of facilities.

Public Works Facilities

According to Coastal Act Section 30114, public works facilities include:

(a) All production, storage, transmission, and recovery facilities for water, sewerage, telephone, and other similar utilities owned or operated by any public agency or by any utility subject to the jurisdiction of the Public Utilities Commission, except for energy facilities.

(b) All public transportation facilities, including streets, roads, highways, public parking lots and structures, ports, harbors, airports, railroads, and mass transit facilities and stations, bridges, trolley wires, and other related facilities. For purposes of this division, neither the Ports of Hueneme, Long Beach, Los Angeles, nor San Diego Unified Port District nor any of the developments within these ports shall be considered public works.

(c) All publicly financed recreational facilities, all projects of the State Coastal Conservancy, and any development by a special district.

(d) All community college facilities.

Greenhouse Gas Emissions Reduction

Section 30250(a) of the Coastal Act (Location, existing developed areas states) in part:

(a) New residential, commercial, or industrial development, except as otherwise provided in this division, shall be located within, contiguous with, or in close proximity to, existing developed areas able to accommodate it or, where such areas are not able to accommodate it, in other areas with adequate public services and where it will not have

significant adverse effects, either individually or cumulatively, on coastal resources. In addition, land divisions, other than leases for agricultural uses, outside existing developed areas shall be permitted only where 50 percent of the usable parcels in the area have been developed and the created parcels would be no smaller than the average size of surrounding parcels.

Section 30252 of the Coastal Act (Maintenance and enhancement of public access) states:

The location and amount of new development should maintain and enhance public access to the coast by (1) facilitating the provision or extension of transit service, (2) providing commercial facilities within or adjoining residential development or in other areas that will minimize the use of coastal access roads, (3) providing nonautomobile circulation within the development, (4) providing adequate parking facilities or providing substitute means of serving the development with public transportation, (5) assuring the potential for public transit for high intensity uses such as high-rise office buildings, and by (6) assuring that the recreational needs of new residents will not overload nearby coastal recreation areas by correlating the amount of development with local park acquisition and development plans with the provision of onsite recreational facilities to serve the new development.

Section 30253(d) of the Coastal Act (Minimization of adverse impacts) states in part:

New Development shall:

(d) Minimize energy consumption and vehicle miles traveled....



Appendix G

Sea Level Rise Projections for 12 California Tide Gauges

Map of Tide Gauge Locations



Figure G-1. Map of tide gauge locations (from OPC 2018)

Table G-1. Sea Level Rise Projections for the Crescent City Tide Gauge¹⁰⁶ (OPC 2018)

Projected Sea Level Rise (in feet): <i>Crescent City</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.3	0.5	0.8
2040	0.4	0.9	1.4
2050	0.7	1.5	2.3
2060	0.9	2.1	3.3
2070	1.2	2.8	4.5
2080	1.6	3.7	5.9
2090	2.0	4.7	7.4
2100	2.5	5.9	9.3
2110*	2.5	6.2	11.0
2120	3.0	7.4	13.1
2130	3.4	8.7	15.3
2140	3.9	10.1	17.8
2150	4.4	11.6	20.6

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹⁰⁶ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-2. Sea Level Rise Projections for the North Spit Tide Gauge¹⁰⁷ (OPC 2018)

Projected Sea Level Rise (in feet): North Spit			
	Probabilistic Projections (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.7	1.0	1.2
2040	1.1	1.6	2.0
2050	1.5	2.3	3.1
2060	1.9	3.1	4.3
2070	2.4	4.0	5.6
2080	2.9	5.1	7.2
2090	3.5	6.2	8.9
2100	4.1	7.6	10.9
2110*	4.3	8.0	12.7
2120	4.9	9.4	15.0
2130	5.5	10.9	17.4
2140	6.2	12.5	20.1
2150	6.8	14.1	23.0

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹⁰⁷ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-3. Sea Level Rise Projections for the Arena Cove Tide Gauge¹⁰⁸ (OPC 2018)

Projected Sea Level Rise (in feet): Arena Cove			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.7	1.0
2040	0.7	1.2	1.6
2050	1.0	1.8	2.6
2060	1.3	2.5	3.7
2070	1.7	3.3	5.0
2080	2.2	4.3	6.4
2090	2.6	5.4	8.0
2100	3.1	6.7	9.9
2110*	3.2	7.0	11.6
2120	3.8	8.2	13.9
2130	4.3	9.7	16.2
2140	4.8	11.1	18.7
2150	5.4	12.6	21.5

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹⁰⁸ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-4. Sea Level Rise Projections for the Point Reyes Tide Gauge¹⁰⁹ (OPC 2018)

Projected Sea Level Rise (in feet): <i>Point Reyes</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.6	0.8	1.0
2040	0.8	1.3	1.8
2050	1.1	2.0	2.8
2060	1.5	2.7	3.9
2070	1.9	3.5	5.2
2080	2.4	4.6	6.7
2090	2.9	5.6	8.3
2100	3.5	7.0	10.3
2110*	3.6	7.3	12.0
2120	4.2	8.6	14.3
2130	4.7	10.1	16.6
2140	5.3	11.5	19.2
2150	5.9	13.1	22.0

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹⁰⁹ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-5. Sea Level Rise Projections for the San Francisco Tide Gauge¹¹⁰ (OPC 2018)

Projected Sea Level Rise (in feet): <i>San Francisco</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.8	1.0
2040	0.8	1.3	1.8
2050	1.1	1.9	2.7
2060	1.5	2.6	3.9
2070	1.9	3.5	5.2
2080	2.4	4.5	6.6
2090	2.9	5.6	8.3
2100	3.4	6.9	10.2
2110*	3.5	7.3	11.9
2120	4.1	8.6	14.2
2130	4.6	10.0	16.6
2140	5.2	11.4	19.1
2150	5.8	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹¹⁰ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-6. Sea Level Rise Projections for the Monterey Tide Gauge¹¹¹ (OPC 2018)

Projected Sea Level Rise (in feet): Monterey			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.8	1.0
2040	0.8	1.2	1.7
2050	1.1	1.9	2.7
2060	1.4	2.6	3.8
2070	1.8	3.4	5.1
2080	2.3	4.4	6.6
2090	2.8	5.5	8.2
2100	3.3	6.9	10.1
2110*	3.4	7.2	11.8
2120	4.0	8.5	14.0
2130	4.5	9.9	16.4
2140	5.1	11.3	18.9
2150	5.7	12.9	21.8

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹¹¹ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-7. Sea Level Rise Projections for the Port San Luis Tide Gauge¹¹² (OPC 2018)

Projected Sea Level Rise (in feet): <i>Port San Luis</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.7	1.0
2040	0.7	1.2	1.6
2050	1.0	1.8	2.6
2060	1.3	2.5	3.7
2070	1.7	3.3	5.0
2080	2.1	4.3	6.4
2090	2.6	5.3	8.0
2100	3.1	6.7	9.9
2110*	3.2	7.0	11.6
2120	3.7	8.2	13.8
2130	4.3	9.6	16.2
2140	4.8	11.1	18.7
2150	5.4	12.6	21.5

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹¹² Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-8. Sea Level Rise Projections for the Santa Barbara Tide Gauge¹¹³ (OPC 2018)

Projected Sea Level Rise (in feet): <i>Santa Barbara</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.4	0.7	1.0
2040	0.7	1.1	1.6
2050	1.0	1.8	2.5
2060	1.3	2.5	3.6
2070	1.7	3.3	4.9
2080	2.1	4.3	6.3
2090	2.6	5.3	7.9
2100	3.1	6.6	9.8
2110*	3.2	6.9	11.5
2120	3.7	8.2	13.7
2130	4.2	9.5	16.0
2140	4.8	11.0	18.6
2150	5.3	12.6	21.4

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹¹³ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-9. Sea Level Rise Projections for the Santa Monica Tide Gauge¹¹⁴ (OPC 2018)

Projected Sea Level Rise (in feet): <i>Santa Monica</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.8	1.0
2040	0.8	1.2	1.7
2050	1.1	1.9	2.6
2060	1.4	2.6	3.8
2070	1.8	3.4	5.1
2080	2.3	4.4	6.5
2090	2.8	5.5	8.1
2100	3.3	6.8	10.0
2110*	3.5	7.2	11.7
2120	4.0	8.5	14.0
2130	4.5	9.8	16.3
2140	5.1	11.3	18.9
2150	5.7	12.9	21.7

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹¹⁴ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-10. Sea Level Rise Projections for the Los Angeles Tide Gauge¹¹⁵ (OPC 2018)

Projected Sea Level Rise (in feet): <i>Los Angeles</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.5	0.7	1.0
2040	0.7	1.2	1.7
2050	1.0	1.8	2.6
2060	1.3	2.5	3.7
2070	1.7	3.3	5.0
2080	2.2	4.3	6.4
2090	2.7	5.3	8.0
2100	3.2	6.7	9.9
2110*	3.3	7.1	11.5
2120	3.8	8.3	13.8
2130	4.3	9.7	16.1
2140	4.9	11.1	18.7
2150	5.4	12.7	21.5

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹¹⁵ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-11. Sea Level Rise Projections for the La Jolla Tide Gauge¹¹⁶ (OPC 2018)

Projected Sea Level Rise (in feet): <i>La Jolla</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.6	0.9	1.1
2040	0.9	1.3	1.8
2050	1.2	2.0	2.8
2060	1.6	2.7	3.9
2070	2.0	3.6	5.2
2080	2.5	4.6	6.7
2090	3.0	5.7	8.3
2100	3.6	7.1	10.2
2110*	3.7	7.5	12.0
2120	4.3	8.8	14.3
2130	4.9	10.2	16.6
2140	5.4	11.7	19.2
2150	6.1	13.3	22.0

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹¹⁶ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.

Table G-12. Sea Level Rise Projections for the San Diego Tide Gauge¹¹⁷ (OPC 2018)

Projected Sea Level Rise (in feet): <i>San Diego</i>			
	Probabilistic Projections (in feet) (based on Kopp et al. 2014)		H++ Scenario (Sweet et al. 2017)
	Low Risk Aversion	Medium-High Risk Aversion	Extreme Risk Aversion
	<i>Upper limit of "likely range" (~17% probability SLR exceeds...)</i>	<i>1-in-200 chance (0.5% probability SLR exceeds...)</i>	<i>Single scenario (no associated probability)</i>
2030	0.6	0.9	1.1
2040	0.9	1.3	1.8
2050	1.2	2.0	2.8
2060	1.6	2.7	3.9
2070	2.0	3.6	5.2
2080	2.5	4.6	6.7
2090	3.0	5.7	8.3
2100	3.6	7.0	10.2
2110*	3.7	7.5	12.0
2120	4.3	8.8	14.3
2130	4.9	10.2	16.6
2140	5.4	11.7	19.2
2150	6.1	13.3	22.0

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al., 2014). Use of 2110 projections should be done with caution and acknowledgement of increased uncertainty around these projections.*

¹¹⁷ Probabilistic projections for the height of sea level rise and the H++ scenario are presented. The H++ projection is a single scenario and does not have an associated likelihood of occurrence. Projections are with respect to a baseline year of 2000 (or more specifically, the average relative sea level over 1991-2009). Table is adapted from the 2018 OPC SLR Guidance to present only the three scenarios OPC recommends evaluating. Additionally, while the OPC tables include low emissions scenarios, only high emissions scenarios, which represent RCP 8.5, are included here because global greenhouse gas emissions are currently tracking along this trajectory. The Coastal Commission will continue to update best available science as necessary, including if emissions trajectories change.



Appendix H

Coastal Commission Contact Information

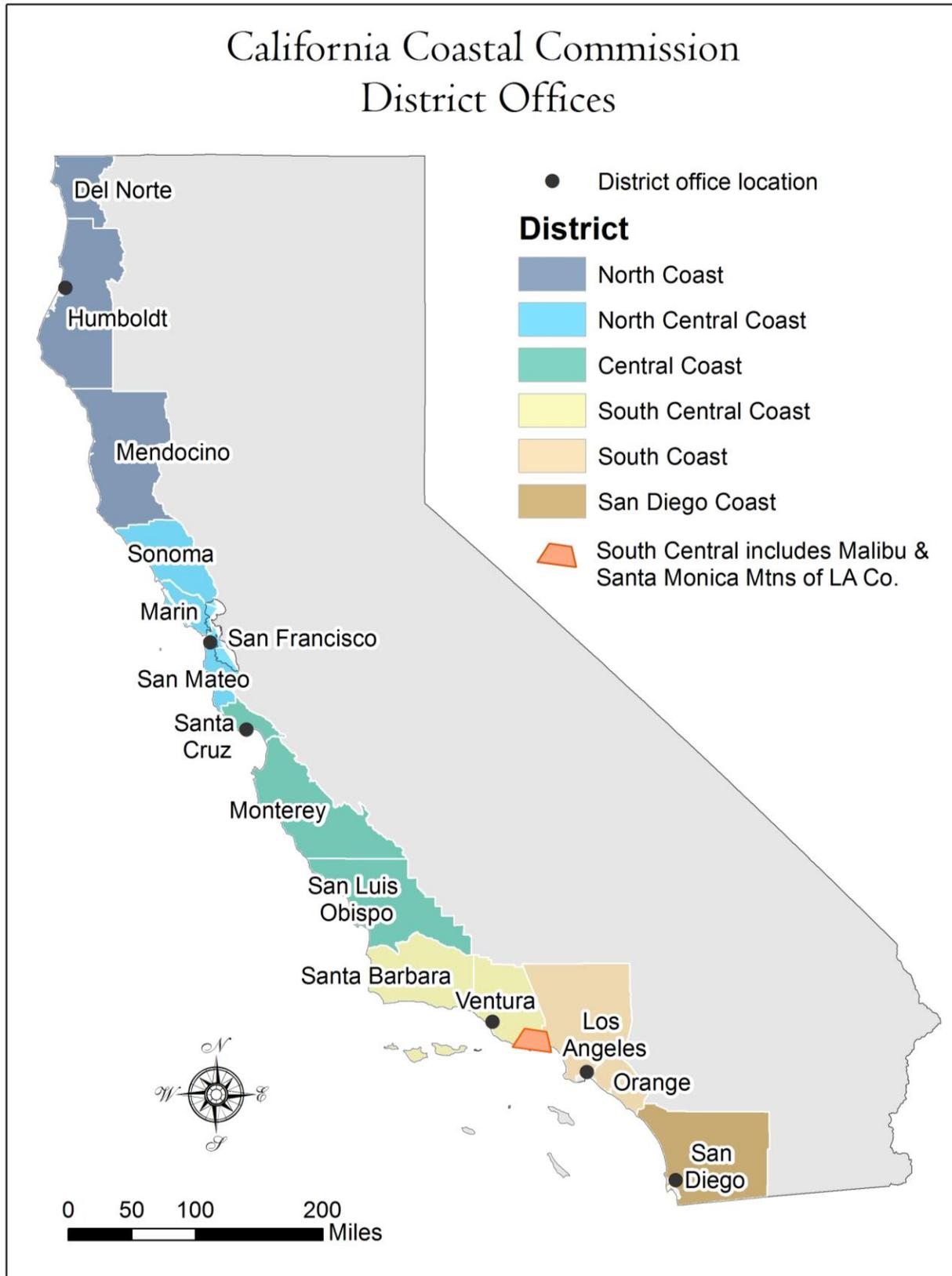


Figure H-1. Location of Coastal Commission Offices

COASTAL COMMISSION DISTRICT OFFICE CONTACT INFORMATION

North Coast (Del Norte, Humboldt, Mendocino Counties)
(707) 826-8950

Headquarters and North Central Coast (Sonoma, Marin, San Francisco, San Mateo Counties)
(415)-904-5200

Central Coast (Santa Cruz, Monterey, San Luis Obispo Counties)
(831) 427-4863

South Central Coast (Santa Barbara and Ventura Counties, and the Malibu portion of Los Angeles County)
(805) 585-1800

South Coast (Los Angeles (except Malibu) and Orange Counties)
(562) 590-5071

San Diego (San Diego County)
(619) 767-2370

COASTAL COMMISSION STAFF SEA LEVEL RISE TEAM

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How High Will Seas Rise? Get Ready for Seven Feet

As governments, businesses, and homeowners plan for the future, they should assume that the world's oceans will rise by at least two meters – roughly seven feet – this century. But far too few agencies or individuals are preparing for the inevitable increase in sea level that will take place as polar ice sheets melt.

BY ROB YOUNG AND ORRIN PILKEY • JANUARY 14, 2010

The reports from the Intergovernmental Panel on Climate Change (IPCC) are balanced and comprehensive documents summarizing the impact of global warming on the planet. But they are not without imperfections, and one of the most notable was the analysis of future sea level rise contained in the latest report, issued in 2007.

Given the complexities of forecasting how much the melting of the Greenland and West Antarctic ice sheets will contribute to increases in global sea level, the IPCC chose not to include these giant ice masses in their calculations, thus ignoring what is likely to be the most important source of sea level rise in the 21st century. Arguing that too little was understood about ice sheet collapse to construct a mathematical model upon which even a rough estimate could be based, the IPCC came up with sea level predictions using thermal expansion of the oceans and melting of mountain glaciers outside the poles. Its results were predictably conservative – a maximum of a two-foot rise this century – and were even a foot lower than an earlier IPCC report that factored in some melting of Greenland's ice sheet.

The IPCC's 2007 sea level calculations – widely recognized by the academic community as a critical flaw in the report – have caused confusion among many in the general public and the media and have created fodder for global warming skeptics. But there should be no confusion about the serious threat posed by rising sea levels, especially as evidence has mounted in the past two years of the accelerated pace of melting of the Greenland and West Antarctic ice sheets.



Getty Images

Most climate scientists believe melting of the Greenland Ice Sheet will be one of the main

The message for the world's leaders and decision makers is that sea level rise is real and is only going to get worse. Indeed, we make the case in our recent book, *The Rising Sea*, that governments and coastal managers should assume the inevitability of a seven-foot rise in sea level. This number is not a prediction. But we believe that seven feet is the most prudent, conservative long-term planning guideline for coastal cities and communities, especially for

drivers of sea level rise during this century.

the siting of major infrastructure; a number of academic studies examining recent ice sheet dynamics have

suggested that an increase of seven feet or more is not only possible, but likely. Certainly, no one should be expecting less than a three-foot rise in sea level this century.

In the 20th century, sea level rise was primarily due to thermal expansion of ocean water. Contributions of melting mountain glaciers and the large ice sheets were minor components. But most climate scientists now believe that the main drivers of sea level rise in the 21st century will be the melting of the West Antarctic Ice Sheet (a potential of a 16-foot rise if the entire sheet melts) and the Greenland Ice Sheet (a potential rise of 20 feet if the entire ice cap melts). The nature of the melting is non-linear and is difficult to predict.

The continued development of many low-lying coastal areas is foolhardy and irresponsible.

Seeking to correct the IPCC's failure to come up with a comprehensive forecast for sea level increase, a number of state panels and government committees have produced sea level rise predictions that include an examination of melting ice sheets. For example, sea level rise panels in Rhode Island and Miami-Dade County have concluded that a minimum of a three- to five-foot sea level rise should be anticipated by 2100. A California report assumes a possible 4.6-foot rise by 2100, while the Dutch assume a 2.5-foot rise by 2050 in the design of their tidal gates.

Given the growing consensus about the major sea level rise on the way in the coming century or two, the continued development of many low-lying coastal areas – including much of the U.S. east coast – is foolhardy and irresponsible.

Who is at risk?

Rising seas will be on the front lines of the battle against changing climate during the next century. Our great concern is that as the infrastructure of major cities in the industrialized world becomes threatened, there will be few resources left to address the dramatic impacts that will be facing the citizens of the developing world.

The ramifications of a major sea level rise are massive. Agriculture will be disrupted, water supplies will be salinized, storms and flood waters will reach ever further inland, and millions of environmental refugees will be created – 15 million people live at or below three feet elevation in Bangladesh, for example. Governments, especially those in the developing world, will be disrupted, creating political instability.

The most vulnerable of all coastal environments are deltas of major rivers, including the Mississippi.

The most vulnerable of all coastal environments are deltas of major rivers, including the Mekong, Irrawaddy, Niger, Ganges-Brahmaputra, Nile, and Mississippi. Here, land subsidence will combine with global sea level rise to create very high rates of what is known as “local, relative sea level rise.” The rising seas will displace the vast majority of people in these delta regions. Adding insult to injury, in many parts of Asia the rice crop will be decimated by rising sea level – a three-foot sea level rise will eliminate half of the rice production in Vietnam – causing a food crisis coincident with the mass migration of people.

The Mississippi Delta is unique because it lies within a country with the financial resources to fight land loss. Nevertheless, we believe multibillion-dollar engineering and restoration efforts designed to preserve communities on the Mississippi Delta are doomed to failure, given the magnitude of relative sea level rise expected. Former Secretary of the Interior Bruce Babbitt said in 2008 that it was an “ineluctable fact” that within the lifespan of some people alive today, “the vast majority of that land will be underwater.” He also faulted federal officials for not developing migration plans for area residents and for not having the “honesty and compassion” to tell Louisiana residents the “truth”: Someday, they will have to leave the delta. The city of New Orleans can probably be protected into the next century, but only at great expense and with little guarantee that future storms like hurricane Katrina will not inundate the city again.

Pacific and Indian Ocean atoll nations are already being abandoned because of the direct and indirect effects of sea level rise, such as saltwater intrusion into groundwater. In the Marshall Islands, some crops are being grown in abandoned 55-gallon oil drums because the ground is now too salty for planting. New Zealand is accepting, on a gradual basis, all of the inhabitants of the Tuvalu atolls. Inhabitants of Carteret Atoll have all moved to Papua, New Guinea. The forward-looking government of the Maldives recently held a cabinet meeting underwater to highlight the ultimate fate of their small island nation.

The world’s major coastal cities will undoubtedly receive most of the attention as sea level rise threatens infrastructure. Miami tops the list of most endangered cities in the world, as measured by the value of property that would be threatened by a three-foot rise. This would flood all of Miami Beach and leave downtown Miami sitting as an island of water, disconnected from the rest of Florida. Other threatened U.S. cities include New York/Newark, New Orleans, Boston, Washington, Philadelphia, Tampa-St Petersburg, and San Francisco. Osaka/Kobe, Tokyo, Rotterdam, Amsterdam, and Nagoya are among the most threatened major cities outside of North America.

Preserving coastal cities will require huge public expenditures, leaving smaller coastal resort communities to fend for themselves. Manhattan, for example, is likely to beat

out Nags Head, North Carolina for federal funds, a fact that recreational beach communities must recognize when planning a response to sea level rise.

Twelve percent of the world's open ocean shorelines are fronted by barrier islands, and a three-foot sea level rise will spell doom for development on most of them – save for those completely surrounded by massive seawalls.

The next century of rising sea level need not be an economic disaster.

Impacts in the United States, with a 3,500-mile long barrier island shoreline extending from Montauk Point on Long Island to the Mexican border, will be huge. The only way to preserve the barrier islands themselves will be to abandon them so that they may respond naturally to rising sea level. Yet, most coastal states continue to allow massive, irresponsible development of the low-lying coast.

Ironically, low-elevation Florida is probably the least prepared of all coastal states. Hundreds of miles of high rises line the state's shoreline, and more are built every year. The state pours subsidies into coastal development through state-run insurance and funding for coastal protection. If a portion of those funds were spent adapting to sea level rise rather than ignoring it, Florida might be ready to meet the challenge of the next century. Let's hope the state rises to the challenge.

Despite the dire facts, the next century of rising sea level need not be an economic disaster. Thoughtful planning can lead to a measured retreat from vulnerable coastal lowlands. We recommend the following:

Immediately prohibit the construction of high-rise buildings and major infrastructure in areas vulnerable to future sea level rise. Buildings placed in future hazardous zones should be small and movable – or disposable.

Relocation of buildings and infrastructure should be a guiding philosophy. Instead of making major repairs on infrastructure such as bridges, water supply, and sewer and drainage systems, when major maintenance is needed, go the extra mile and place them out of reach of the sea. In our view, no new sewer and water lines should be introduced to zones that will be adversely affected by sea level rise in the next 50 years. Relocation of some beach buildings could be implemented after severe storms or with financial incentives.

Stop government assistance for oceanfront rebuilding. The guarantee of recovery is perhaps the biggest obstacle to a sensible response to sea level rise. The goal in the past has always been to restore conditions to what they were before a storm or flood. In the United States, hurricanes have become urban renewal programs. The replacement houses become larger and larger and even more costly to replace again in

the future. Those who invest in vulnerable coastal areas need to assume responsibility for that decision. If you stay, you pay.

Get the Corps off the shore. The U.S. Army Corps of Engineers, more or less by default, is the government agency in charge of much of the planning and the funding for the nation's response to sea level rise. It is an agency ill-suited to the job. Part of the problem is that the engineers' "we can fix it" mentality is the wrong mindset for a sensible approach to responding to changing sea level.

Local governments cannot be expected to take the lead. The problems created by sea level rise are international and national, not local, in scope. Local governments of coastal towns (understandably) follow the self-interests of coastal property owners and developers, so preservation of buildings and maintaining tax base is inevitably a very high priority. In addition, the resources needed to respond to sea level rise will be far beyond those available to local communities.

Responding to long-term sea level rise will pose unprecedented challenges to the international community. Economic and humanitarian disasters can be avoided, but only through wise, forward-looking planning. Tough decisions will need to be made regarding the allocation of resources and response to natural disasters. Let us hope that our political leadership can provide the bold vision and strong leadership that will be required to implement a reasoned response.



Rob Young, left, is director of the Program for the Study of Developed Shorelines at Western Carolina University. Orrin Pilkey is James B. Duke Professor Emeritus in the Duke University Division of Earth and Ocean Science. They are the authors of *The Rising Sea*, published by Island Press. **MORE** →

Lemos, June

From: Annemarie <aweibel@mcn.org>
Sent: Monday, September 9, 2019 4:59 PM
To: Lee, Will; Morsell-Haye, Jessica; Norvell, Bernie; Albin-Smith, Tess; Peters, Lindy; Miller, Tabatha; Lemos, June
Subject: Adopting MND for the Fort Bragg 2019 Housing Element & Resolution item 7A, 9-9-19

To city council members,
I am objecting to the approval of the MND & Resolution for item 7A.

The primary problem as I see it is that the MND does not actually analyze much of anything and attempts to defer meaningful analysis until individual housing projects are developed in the future.

This is very concerning to me because the current "project" is the housing element itself. Even CDFW submitted comments that suggested that the MND was inadequate because it failed to analyze the effect of all the potential new housing on the City's water supply.

Also very concerning is the lack of climate change and sea-level rise analysis relating to the water supply. Are we just going to keep pumping lots of water from our local salmon spawning streams like Hare Creek or keep pumping from the Noyo River while the ocean is rising?

I attended the recent presentation with the city's water studies and was amazed to find out that we had that much of a cushion as far as water is concerned. When the Hare Creek mall was actively pursued we were told that we had 1% left for the mall & the Avalon Hotel & Conference Center.

I understand that we have a bit more water in reserve now, but the reservoir is not new water.

It seems foolish to just brush off the City's water model and ignore the fact that sea levels are expected to rise, which will make it difficult for Fort Bragg to continue to rely on our three water sources. How would it look if the ocean would be just one meter higher do to ocean rising?

Would it not be difficult to keep using water from the Noyo River? We could easily run out of water between July and October.

How can we have enough water for additional housing or other development if we don't have enough water for our current developments?

Why did the City not include any studies predicting sea-level rise in their water model?

It seems to me that further studies are needed before the Council considers this MND for the housing element.

Thank you for your consideration,
Annemarie Weibel
CACLU
citizens for appropriate coastal land us
9-9-19

PUBLIC COMMENT

TO: FORT BRAGG CITY COUNCIL

FROM: HOUSING FOR FORT BRAGG

SUBJECT: ITEM 7A, HOUSING ELEMENT PUBLIC HEARING

DATE: SEPTEMBER 9, 2019

Housing for Fort Bragg (HFFB) submits this public comment encouraging the Fort Bragg City Council to refrain from adopting the Mitigated Negative Declaration or the housing element under consideration tonight its meeting (Item 7A on the agenda). HFFB objects to the Mitigated Negative Declaration and the housing element as inadequate as discussed in other public comments. Please direct staff to bring Item 7A back at a future meeting after the documents have been revised to meet requirements and address community concerns and objections. Trying to address our local housing crisis is too important to not get right.