Climate Safe Infrastructure Working Group

Meeting #3

San Francisco

Bay Area Metro Center, Oholone Room

375 Beale Street, San Francisco, CA 94105

Tuesday, March 13, 2018

10am – 4pm

Agenda

Time	Agenda Item
10:00-10:30am	Welcome, Intros, Review of progress to date & Charge for Mtg. #3
10:30-11:00am	N. Diffenbaugh: Understanding, Reducing & Estimating Uncertainty
11:00-12:00pm	Panel Discussion: Planning for, Deciding despite & Managing Uncertainty
12:00-12:30pm	Extracting Preliminary Lessons
12:30-1:30pm	Lunch
1:30-2:30pm	Working Through Specific Examples: Information Needs & Barriers to Use
2:30-3:00pm	Extracting Additional Lessons
3:00-3:45pm	Selecting Appropriate Engineering Designs in the Face of Uncertainty
3:45-4:00pm	Wrap-up: Review, Next Steps
4:00	Adjourn

AB 2800 (Quirk): Purpose

Examine how to integrate scientific data concerning projected climate change impacts into state infrastructure engineering, including oversight, investment, design, and construction.

AB 2800 (Quirk):
Scope of Assessment and Recommendations

The working group shall consider and investigate, at a minimum, the following issues:

(1) The current informational and institutional barriers to integrating projected climate change impacts into state infrastructure design.

(2) The critical information that engineers responsible for infrastructure design and construction need to address climate change impacts.

(3) How to select an appropriate engineering design for a range of future climate scenarios as related to infrastructure planning and investment.

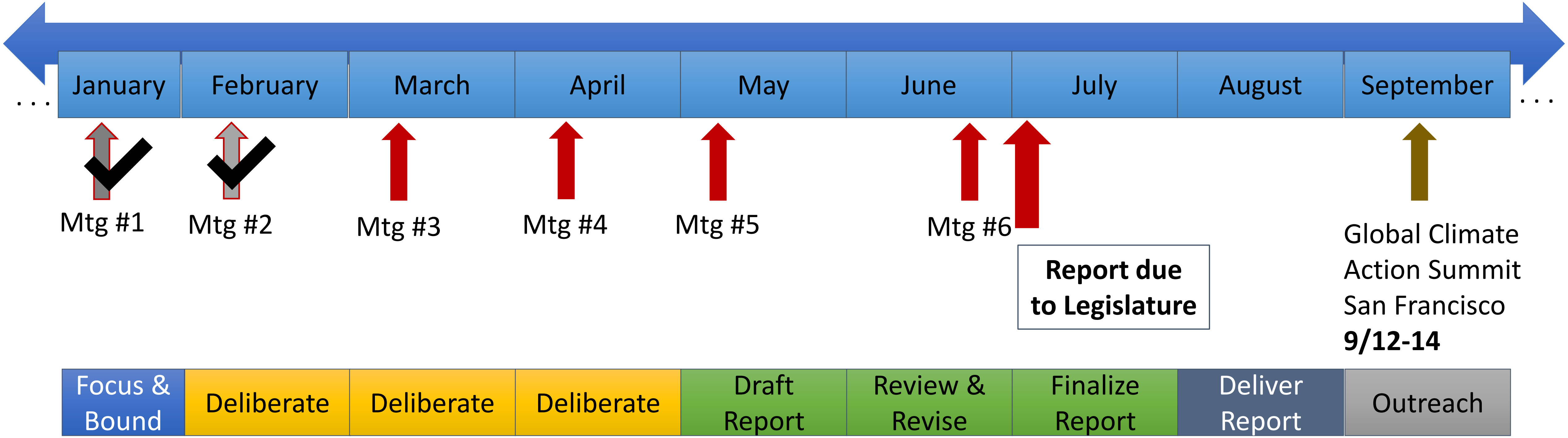
AB 2800 (Quirk): Additional Scope of Recommendations

(A) Integrating scientific knowledge of projected climate change impacts into state infrastructure design.

(B) Addressing critical information gaps identified by the working group.

(C) A platform or process to facilitate communication between climate scientists and infrastructure engineers.

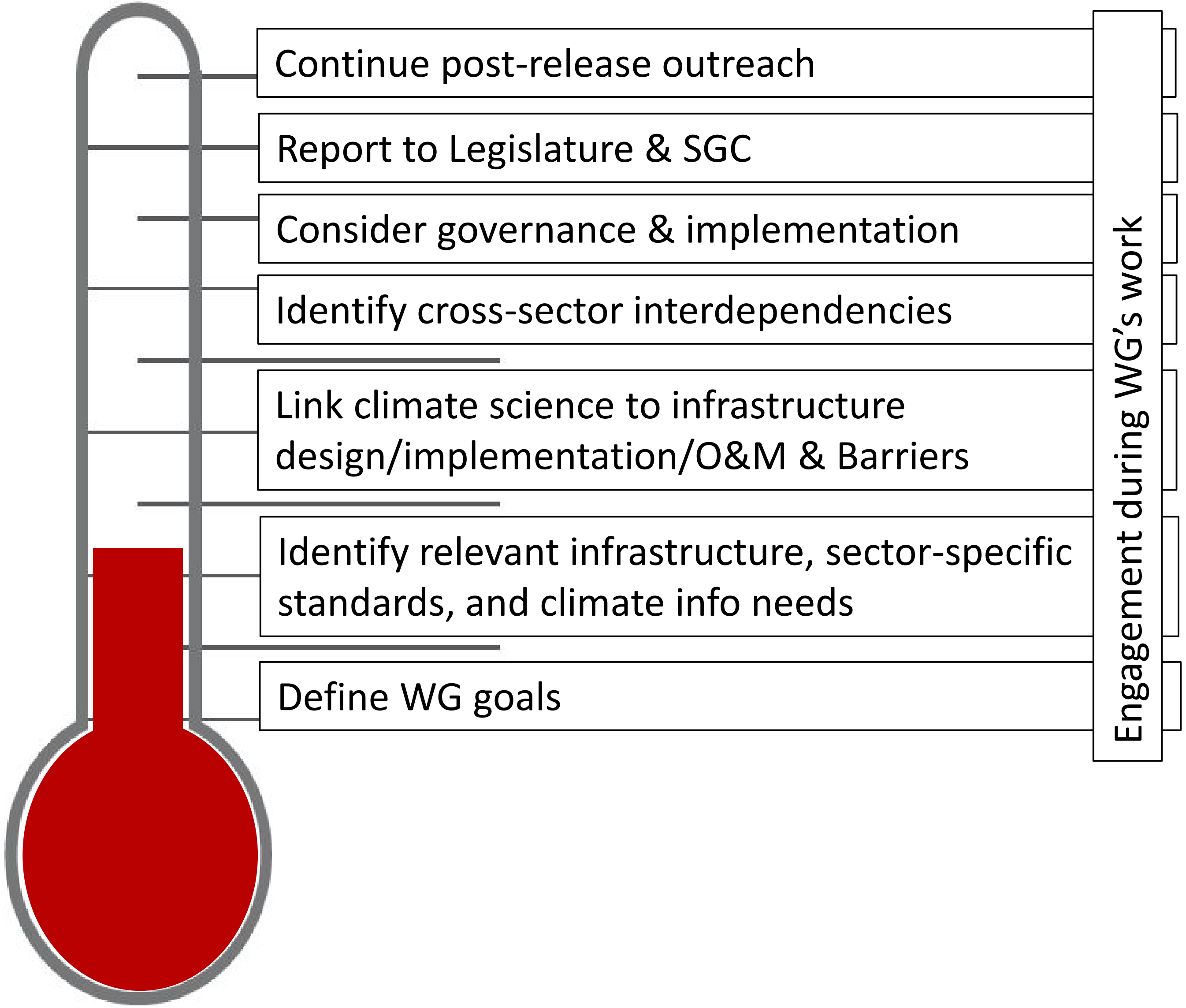
Project Timeline



Meeting Dates, Locations, Topics & Tasks

Mtg	Dates	Locations	Topics and Tasks
~~1~~	~~1/18~~	~~Sacramento~~	~~Determine project goals; WG structure and process~~
~~2~~	~~2/12~~	~~Los Angeles~~	~~Identify relevant infrastructure, sector-specific infrastructure standards, climate-sensitivity, information needs~~
3	**3/13**	**San Francisco**	**Linking forward-looking climate science and impacts information with standards, codes, certifications throughout infrastructure life cycle, identify barriers to information use and potential ways to overcome them**
4	4/11	Sacramento	Sector-specific design standards and cross-sector interdependencies
5	5/9	San Diego	Governance of setting/changing design standards; non-standard strategies to ensure climate-safe infrastructure; deliberation of draft report; agree on refinement needs
6	6/20	Sacramento	Agree on final report revisions; delivery and outreach/promotion; project debrief

Measuring progress



The Arc of Our Work: The Forward Look

Meeting 1

- Goal setting
- Rules of engagement

Meeting 2

- Identify, prioritize climate-sensitive infrastructure;
- Agree on definitions
- Prioritize relevant standards, codes, guidelines;
- Identify information needs

Meeting 3

- **Connect engineers' information needs with climate science;**
- **Identify barriers to information use, solutions**
- **Work through concrete examples**

Meeting 4

- Refine information needs when considering cross-sector interdependencies
- Refine prioritization
- Consider comprehensive approaches to climate-safe infrastructure

Working Backwards from the Final Product

- Meeting 1
- Meeting 2
- Meeting 3
- Meeting 4
- Meeting 5
- Meeting 6

A Set of Project Findings

- The **infrastructure considered** in the work of the WG
- **Opportunities for state to affect how and where infrastructure is built**
- **Opportunities for integrating science into infrastructure design**
- **Critical information needs of infrastructure engineers** to address CC impacts.
- **Critical information gaps**
- **Informational and institutional barriers** to integrating projected climate change impacts into state infrastructure design
- **Ways to select an appropriate engineering design** for a range of future climate scenarios as related to infrastructure planning and investment.

A Set of Recommendations

- **Policy recommendations** of how to encourage forward-looking infrastructure planning and design
- **Procedural recommendations** to affect climate-safe infrastructure development process (from planning, design, approval, construction to monitoring)
- **Principles** to guide infrastructure development, maintenance, repair to build equitable, climate-resilient infrastructure
- **Available tools and information sources** to use
- **Recommendations on how to lower/overcome barriers** to information use
- **Research recommendations** to fill information gaps
- **Recommendations on capacity building/professional development**

Today's Focus

- Meeting 1
- Meeting 2
- Meeting 3
- Meeting 4
- Meeting 5
- Meeting 6

A Set of Project Findings

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Charge for Meeting #3:

- **Task 1**: Assess possibilities and limits for linking forward-looking climate science and impacts information with standards, codes, certifications throughout infrastructure life cycle
- **Task 2**: Identify information gaps/research needs
- **Task 3**: Identify barriers to information use and possible ways to work around or overcome them
- **Task 4**: Explore approaches to select appropriate engineering designs in light of a range of different climate futures

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Response to Identified Information Needs: *Understanding, Reducing & Estimating Uncertainty*

Noah Diffenbaugh, Ph.D.
Stanford University
CSIWG Member

- Meeting #2 compilation of
  - Types of infrastructure
  - Types of climate information currently used/needed in future
- What climate science can and can't do at this time
- What is in the works and what will remain elusive

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The Core of the Challenge

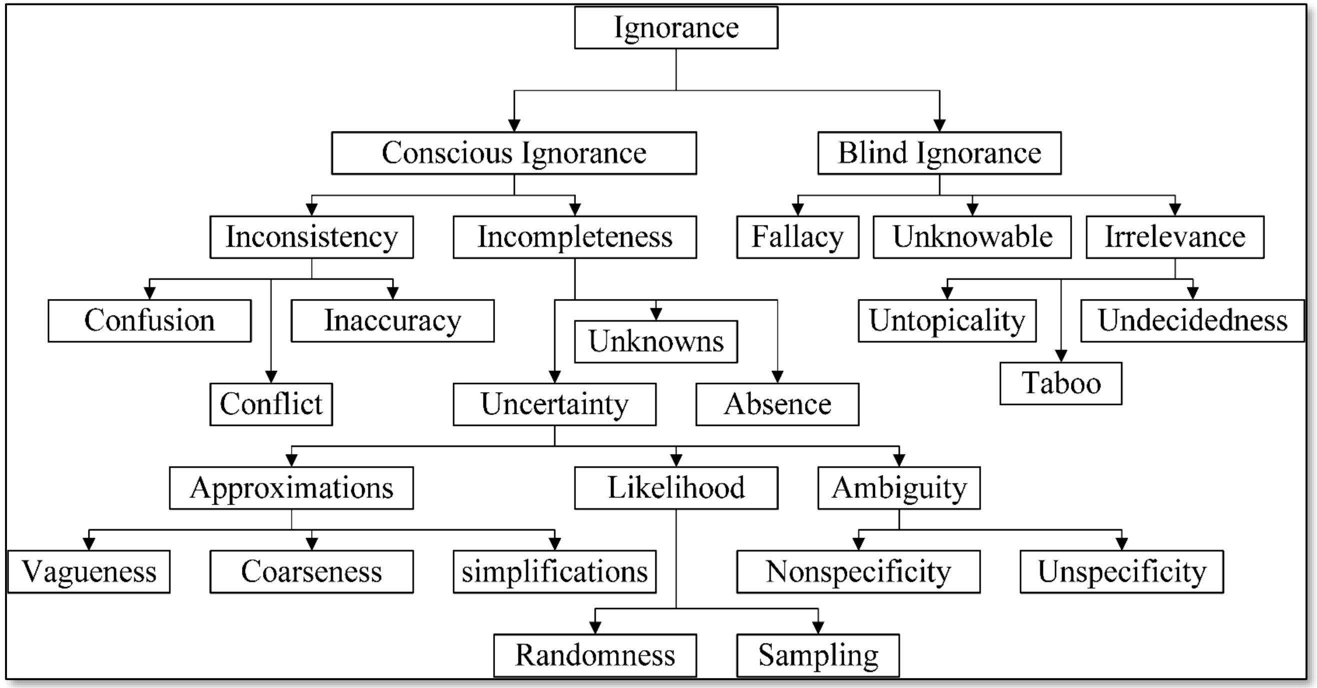
What happens when you ask an engineer to design to a number that can’t be given?

- Not one number but range of possible values
- Available probabilities are conditional on emission pathways
- Some aspects known so incompletely that probabilities can’t be given at all

Charge to Panel:
Planning for, Deciding despite & Managing Uncertainty

Give an example of when you were asked to build/design/upgrade infrastructure taking climate change impacts into account

- How did you choose "what number" to build to?
- How did you deal with missing or uncertain information?
- What challenges did you encounter along the entire pathway to a decision?
- How did you overcome these challenges?
- What helped?



Source: B.M. Ayyub (2015), *Journal of Risk and Uncertainty in Engineering*, ASME

Panel Discussion

Steve Reel, M.Eng.
Project Manager
Port of San Francisco

John Thomas, P.E.
City Engineer
City of San Francisco

Kit Batten, Ph.D.
Climate Resilience Chief
PG&E

Bob Battalio, P.E.
Chief Engineer
ESA Associates

Nate Kaufman, M.A.
Landscape Architect
Living Edge Adaptation Project

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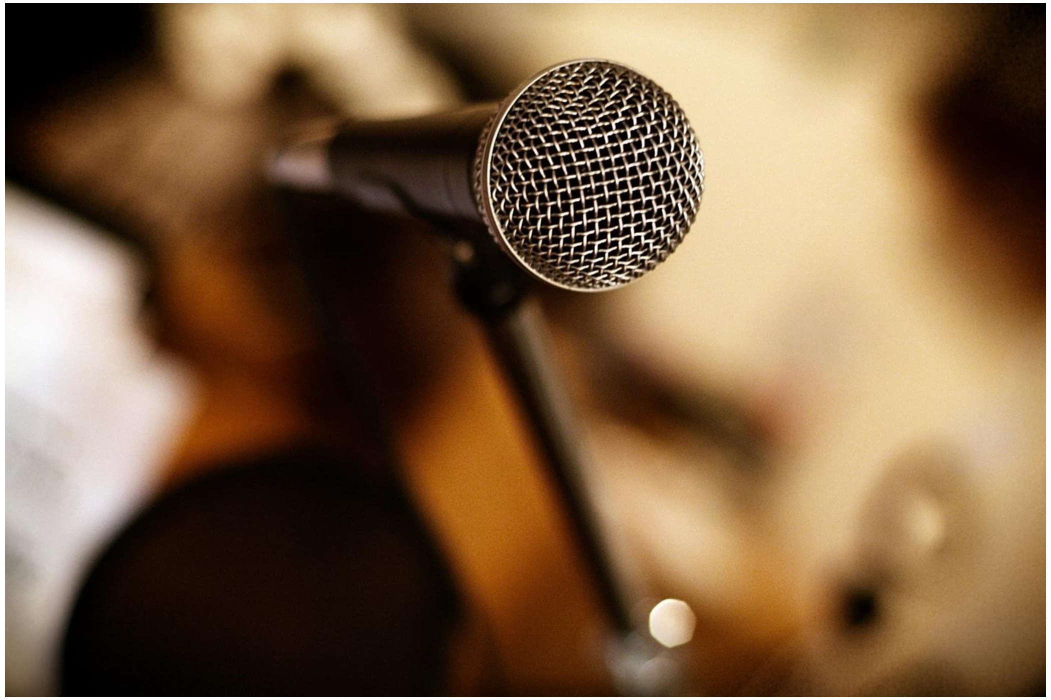
Brief Exercise

What did you hear about…

1. What the most challenging uncertainties were?
2. What the barriers were to planning/deciding/acting in the face of them?
3. What helped to overcome them?

Opportunity for Public Comment



Lunch

12:30-1:30pm

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Working Through a Couple of Examples

Energy Efficient AC Units
(Martha Brook, CEC)

Highway 37 Improvement
(*Gurdeep Bhattal, DOT*)

EXPOSURE TO CLIMATE STRESSORS

CURRENT STANDARDS, REGULATIONS, CODES, GUIDELINES

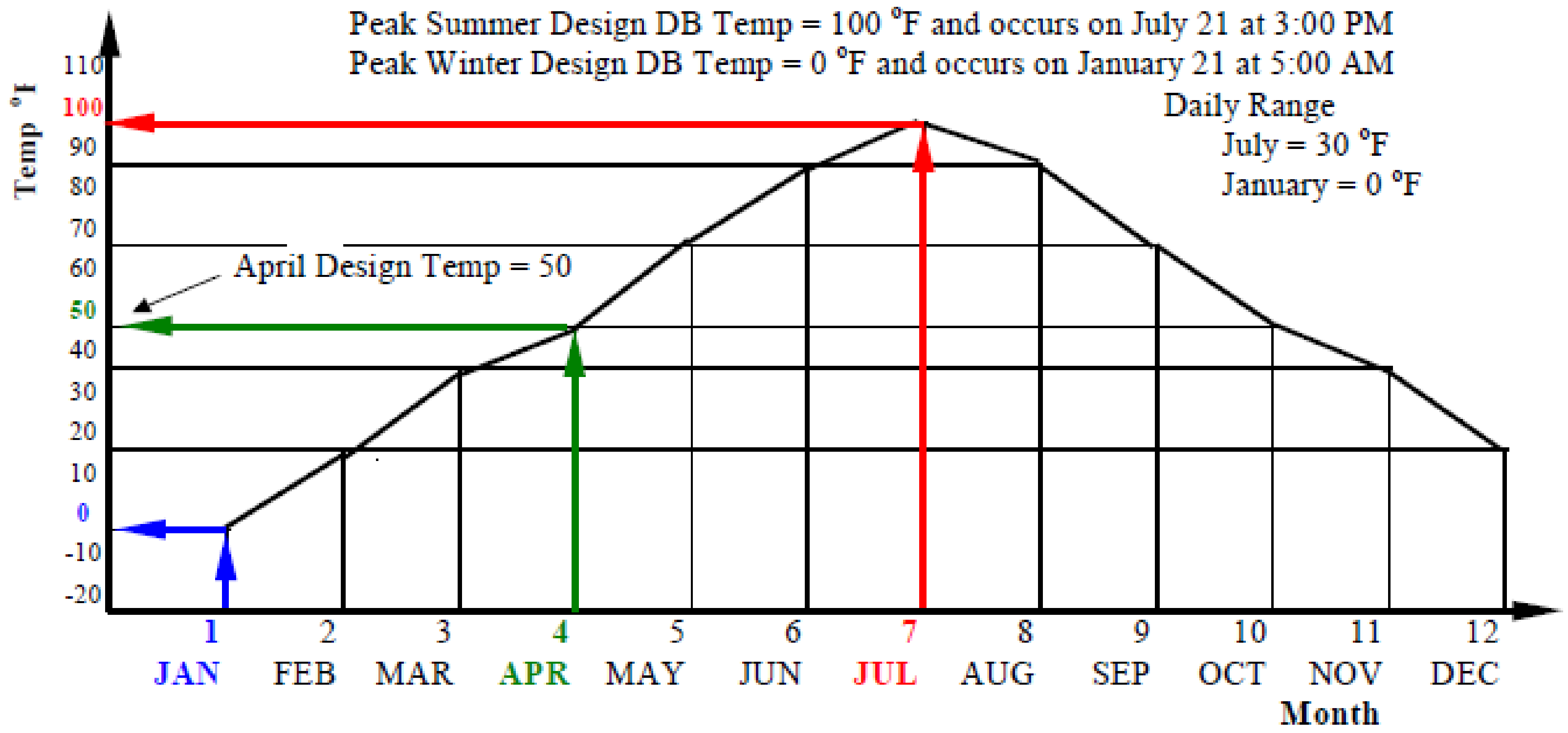
NEEDED CHANGES

INFORMATION FOR PLANNING, DESIGN, BUILDING, OPERATION ETC.

BARRIERS TO USING FORWARD-LOOKING CLIMATE INFORMATION

WORK-AROUNDS

Weather Data for Building System Design



1. Exposure to climate stressors

A. Relevant weather parameters

- Outdoor temperatures, solar radiation, wind speed / direction
- Diurnal and seasonal patterns

B. Impacts of climate change

- Extreme temperatures
- Changes in diurnal and seasonal temperature patterns
- Humidity, wind, solar radiation changes – magnitudes & patterns

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2. Current Standards, etc. for Design

- ASHRAE Handbooks (Guidelines)
  - Design day outdoor temperatures
  - ASHRAE Std 55: Indoor design temperature and humidity conditions for general comfort
  - Building heating & cooling load calculations & HVAC system sizing procedures
- Title-24, Part 6 (CA Building Energy Efficiency Standards)
  - Requirements for load calcs & HVAC sizing procedures, consistent with ASHRAE
  - Hourly & design day weather data used to model building energy use – part of code compliance process
- US DOE Appliance Energy Efficiency Standards
  - Equipment test procedures include specific seasonal and extreme temperature/humidity levels (e.g. SEER and EER)

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2. Design Standards/Guidelines – frequency of updates

- ASHRAE Handbooks (Guidelines)
  - Standards & Handbooks update scope & frequency driven by volunteer participation in ASHRAE committees – so “it depends”
- Title-24, Part 6 (CA Building Energy Efficiency Standards)
  - Updated on triennial cycle: 2017, 2020, 2023, …
- US DOE Appliance Energy Efficiency Standards
  - Politically dependent – so “not much lately”

2. Design Standards/Guidelines – historical reference period

- Hourly weather data: last 10 years
- Design Day temperature data: last 50 years?

3. Needed Changes:
Future-ize weather data

- Design day temperature data
- Hourly weather data (temperature, humidity, solar radiation, wind, etc.)

3. Needed Changes:
Establish additional equipment performance test conditions that capture future weather expectations (e.g. more extreme temps)

- Title-24 could require full performance curve information be used for HVAC sizing & energy use calcs

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4. Information used; information needed

Location	Elevation	Latitude	Winter	Summer					
	Feet	Degrees North	Heating 99% Dry Bulb	Cooling 1% Dry Bulb	Coincident Wet Bulb	Design Grains 55% RH	Design Grains 50% RH	Design Grains 45% RH	Daily Range (DR)
Merced-Castle AFB	188	37	32	97	69	-9	-2	4	H
Modesto	97	37	30	98	68	-16	-9	-3	H
Monterey	162	36	38	71	61	-7	0	6	M
Mount Shasta	3543	41	21	88	61	-33	-26	-20	H
Mountain View, Moffet NAS	34	37	39	84	65	-9	-2	4	M
Napa	33	38	32	96	68	-12	-5	1	H
Needles AP	983	34	33	110	71	-18	-11	-5	H
Oakland AP	6	37	36	80	63	-12	-5	1	M
Oceanside	28	33	43	80	68	13	20	26	L
Ontario IAP	952	34	38	98	70	-5	2	8	H
Oxnard	7	34	41	79	68	-6	1	7	M
Palmdale AP	2542	34	24	98	67	-31	-24	-18	H
Palm Springs	462	33	35	110	66	-24	-17	-11	H
Pasadena	864	34	35	95	69	-11	-4	2	H
Paso Robles	837	35	29	98	69	-21	-14	-8	H
Petaluma	87	38	29	90	67	-13	-6	0	H
Pomona CO	934	34	30	99	69	-12	-5	1	H
Red Bluff	342	40	32	102	69	-17	-10	-4	H
Redding AP	502	40	31	102	67	-27	-20	-14	H
Redlands	1571	34	33	99	69	-12	-5	1	H
Richmond	55	38	36	80	63	-12	-6	1	M
Riverside-March AFB	1533	33	36	98	68	-16	-9	-3	H
Sacramento AP	95	38	32	97	68	-14	-7	-1	H

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4. Information used; information needed

A. Climate data used in building system design

- See slide 3

B. Uncertainties

- Yes. Generally handled with application of “safety factors” – e.g. oversizing HVAC equipment by x%
- Building industry needs to get much better at including uncertainty into design decisions

C. Availability of forward-looking data

- No, need to translate climate change models ->> hourly & design day weather statistics

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5. Barriers

A. Rules preventing use of forward-looking data

- US DOE sets test conditions for equipment efficiency ratings; states cannot require different tests for “federally covered products”

B. Other barriers

- Need future data in standard design day and hourly weather formats
- Lack of precedent, standards, guidelines
- Risk aversion

Highway-37, Counties of Marin, Sonoma,& Solano

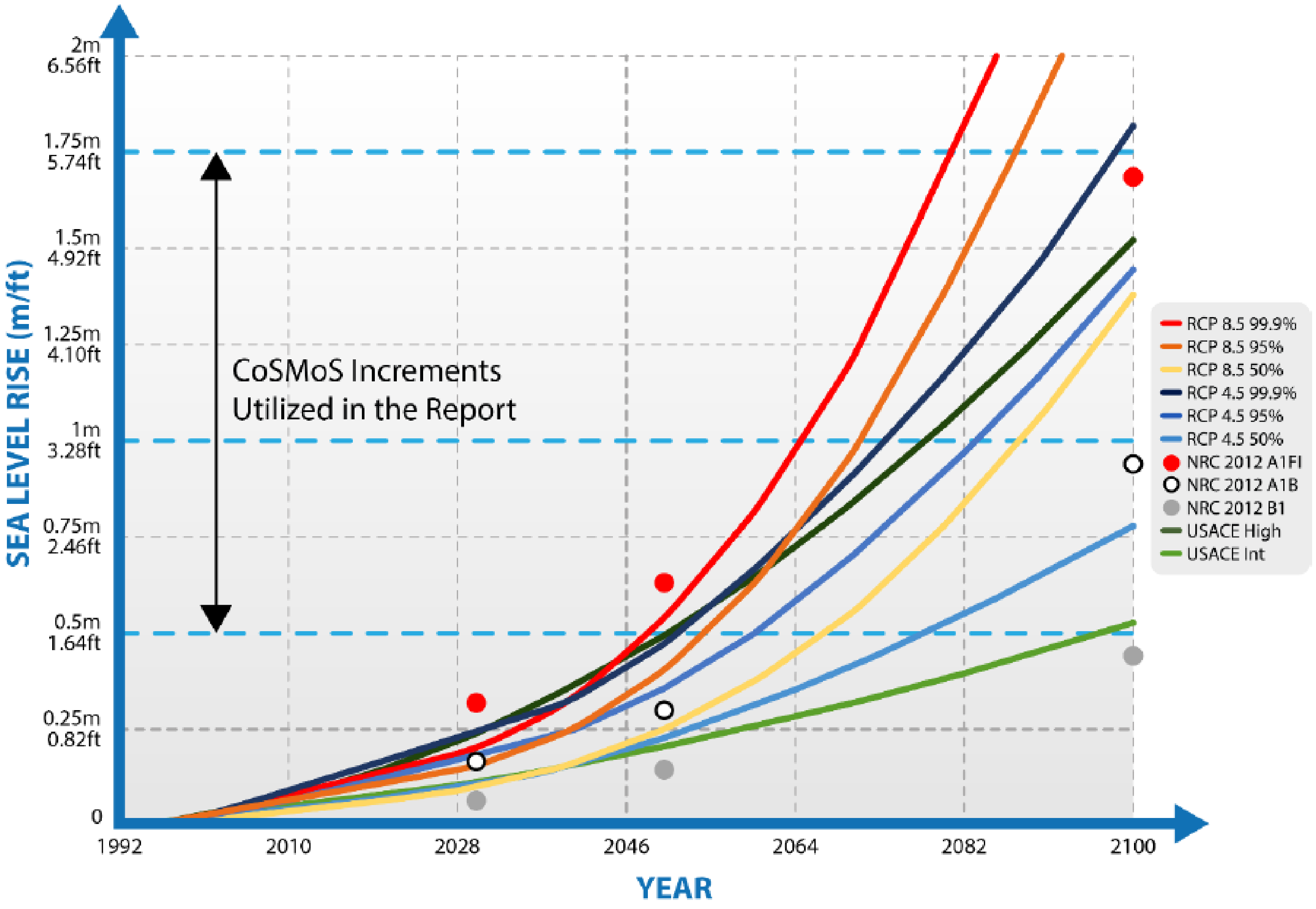
Assume the Highway is to be widened from 2 lanes to 4.

- Vulnerability Assessment identified Hwy-37 is expected to be impacted by SLR, Temperatures, Precipitation, Storm Surge
- For SLR the COSMOS model was selected
- Service life of the highway is assumed to be 50-years
- Determine SLR for Year 2070

SLR MODELS

- US Army Corps of Engineers (USACE)
- National Research Council
- Scripps
- Coastal Storm Modeling System (CoSMoS)

FIGURE 5: AVERAGE SEA LEVEL RISE PROJECTIONS: GAUGES LOCATED IN DISTRICT 4



DATA VARIATIONS

Variation between Models

Variation within models RCP 4.5 to 8.5 ranges from 2.5-feet to 6.5 feet

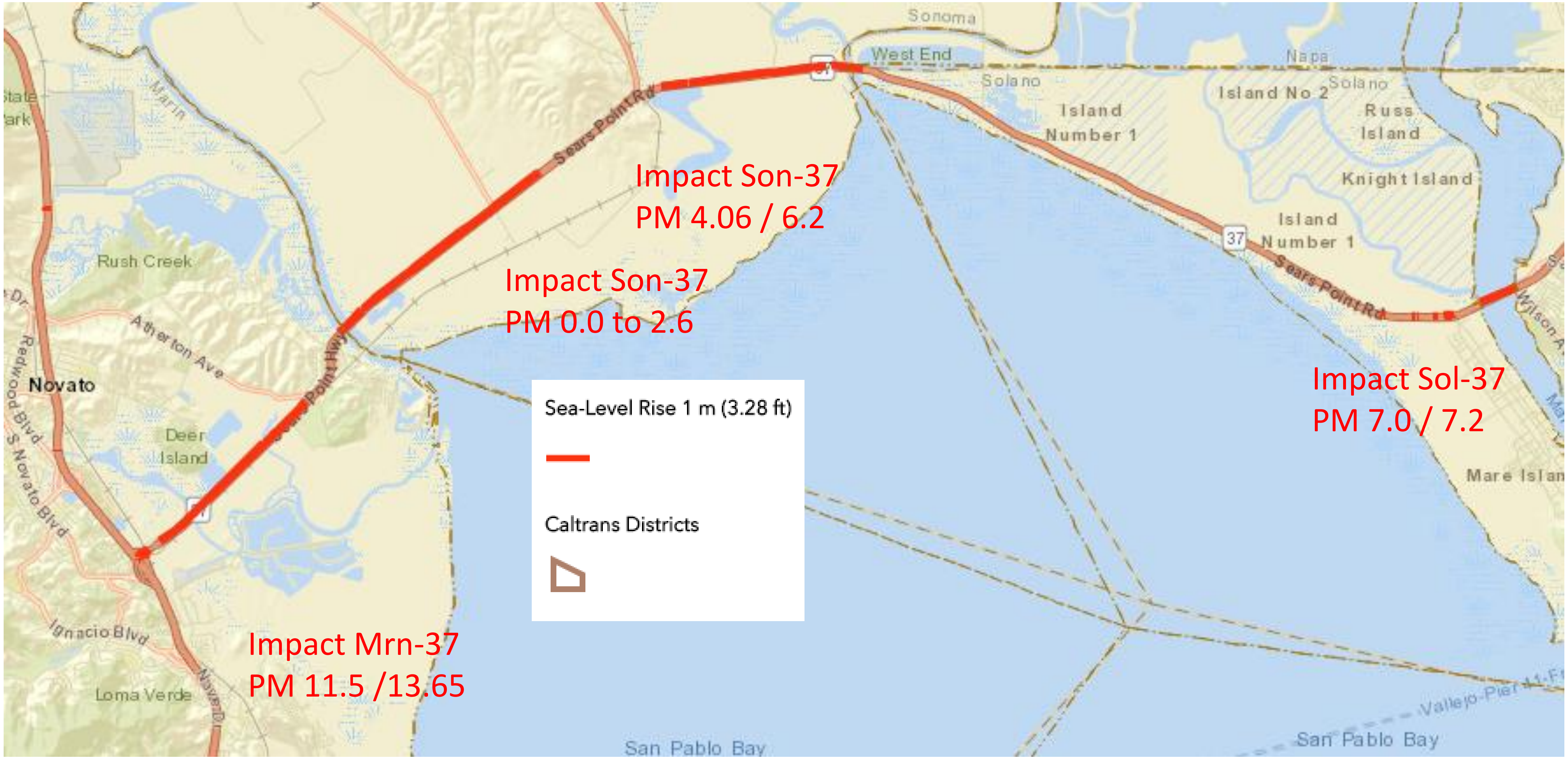
DRAWBACKS OF DATA VARIATIONS

Design Costs multiply as more conservative values are selected
Project costs increase several fold as more conservative SLR values are selected
Environmental mitigation costs multiply with higher estimates of SLR


121
37
Exposed Roadway
Inundated Land

SEA LEVEL RISE 1-m (3.28-ft) segments impacted

Use Low Probability/High Estimate SLR (RCP 8.5)



Storm Surge plus 1-m (3.28-ft) SLR

Storm Surge impacts on bridges

Asphalt Pavement Typical Service Life is 20-years.

32 Global Climate Models (GCM) were downscaled by Localized Constructed Analogs (LOCA) methodology

California State agencies selected 10 models for use. 4 Representative Concentration Pathways (RCP) were developed to reflect assumed GHG emission scenarios

RCP 2.6 assumes global annual GHG emissions will peak in the next few years and then begin to decline
RCP 4.5 assumes global annual GHG emissions will peak around 2040 and then begin to decline
RCP 6.0 assumes global annual GHG emissions will peak around 2080 and then start to decline
RCP 8.5 assumes that high GHG emissions will continue increasing steadily to the end of the century.

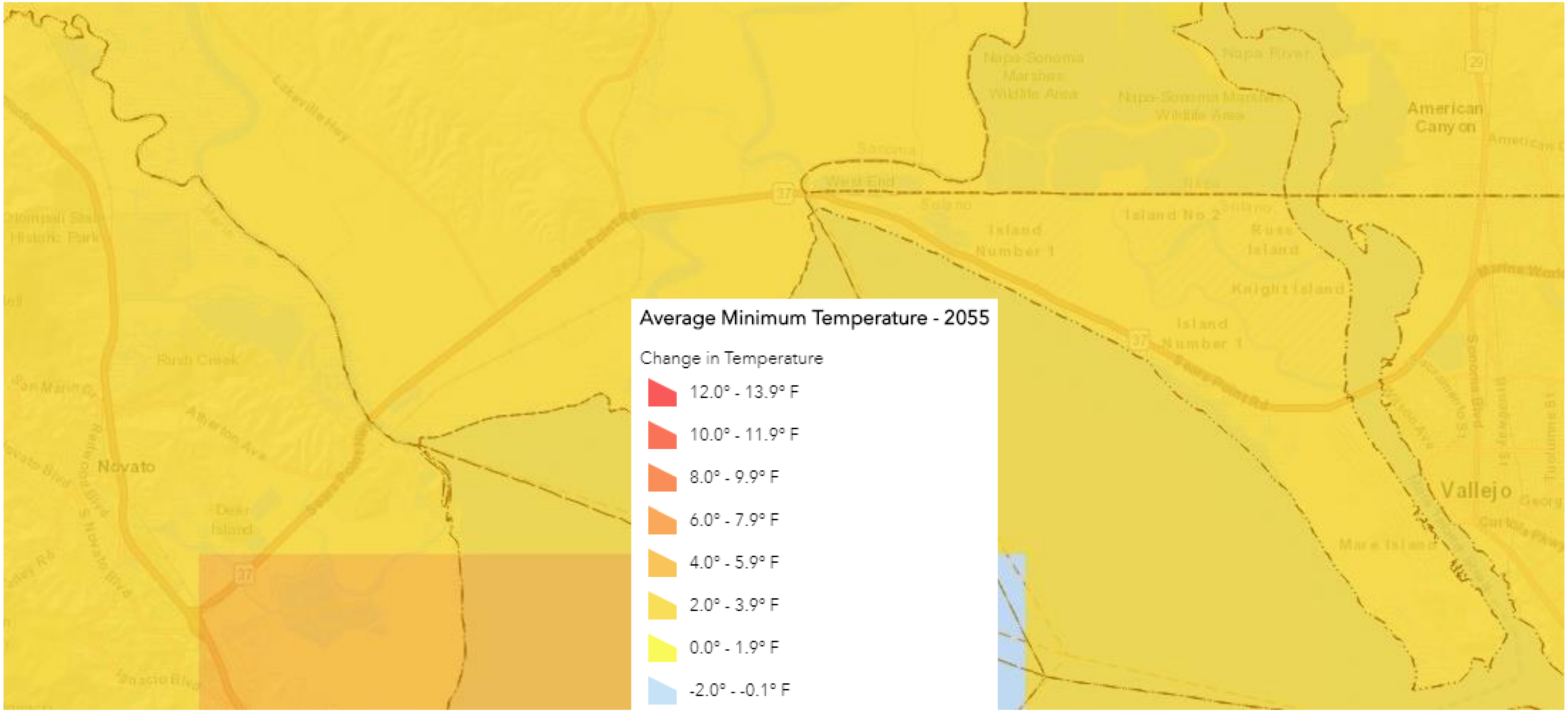
Localized Constructed Analogs (LOCA) developed by Scripps for 30-year period temperatures, 2025, 2055 and 2085. Use temperatures for 2055 for evaluating pavement materials

Data Variations

RCP assumptions reflect large variations in data. RCP data needs to be consolidated to a single assumption which can be used for design purposes.

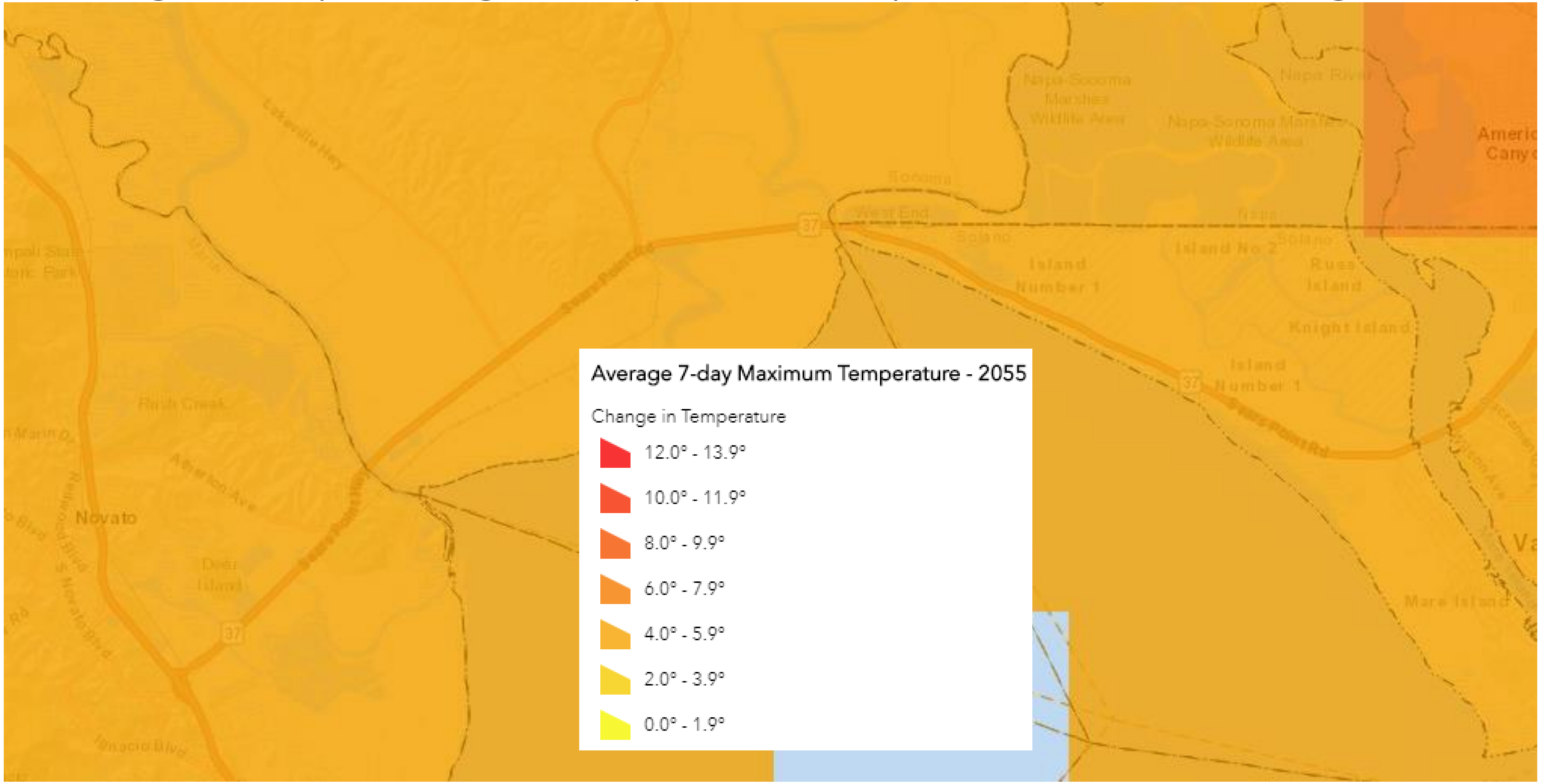
Average Minimum Temperature – 2055

Average minimum temperature expected to be 3.5^0 F higher

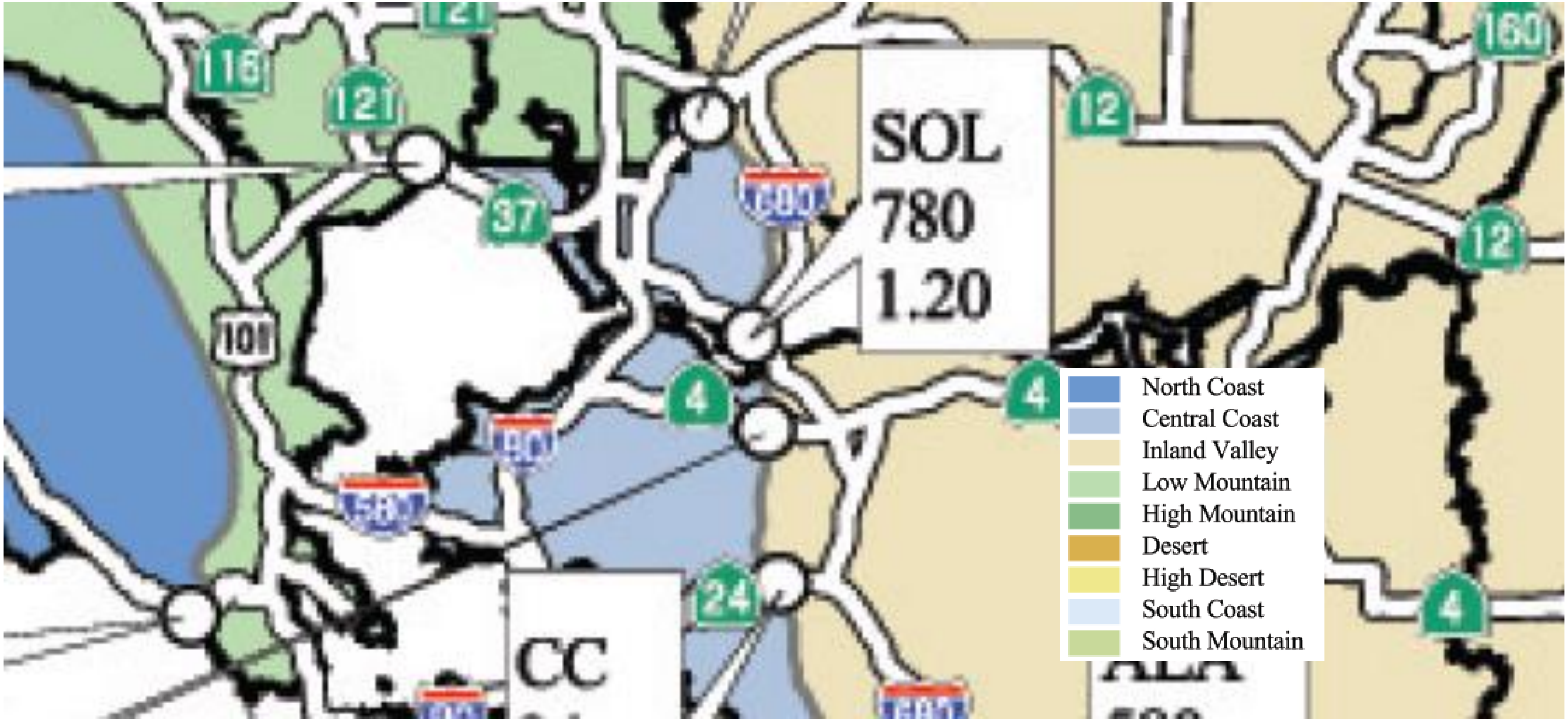


Average 7-day Maximum Temperature – 2055

Average 7-day average temperature expected to be 5^0 F higher



Caltrans Pavement Climate Regions



HISTORICAL PRECIPITATION DATA

NOAA Atlas 14 used for runoff calculations. Historical rainfall data estimated for time periods ranging from 5 minutes through 60 days.

PF tabular | PF graphical | Supplementary information | Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**1.39** (1.24-1.57)	**1.70** (1.51-1.94)	**2.15** (1.91-2.45)	**2.52** (2.22-2.90)	**3.06** (2.58-3.66)	**3.49** (2.88-4.28)	**3.96** (3.17-4.99)	**4.45** (3.44-5.81)	**5.16** (3.80-7.06)	**5.72** (4.06-8.15)
10-min	**0.996** (0.888-1.13)	**1.22** (1.09-1.39)	**1.54** (1.36-1.75)	**1.81** (1.58-2.08)	**2.20** (1.85-2.63)	**2.51** (2.06-3.07)	**2.84** (2.27-3.58)	**3.19** (2.47-4.16)	**3.70** (2.73-5.06)	**4.10** (2.91-5.84)
15-min	**0.800** (0.712-0.908)	**0.984** (0.876-1.12)	**1.24** (1.10-1.41)	**1.46** (1.28-1.68)	**1.77** (1.49-2.12)	**2.02** (1.66-2.48)	**2.29** (1.83-2.89)	**2.57** (1.99-3.36)	**2.98** (2.20-4.08)	**3.31** (2.35-4.71)
30-min	**0.558** (0.498-0.634)	**0.686** (0.610-0.780)	**0.864** (0.766-0.984)	**1.02** (0.892-1.17)	**1.23** (1.04-1.47)	**1.41** (1.16-1.73)	**1.59** (1.27-2.01)	**1.79** (1.39-2.34)	**2.07** (1.53-2.84)	**2.30** (1.63-3.28)

FORWARD LOOKING PRECIPITATION DATA

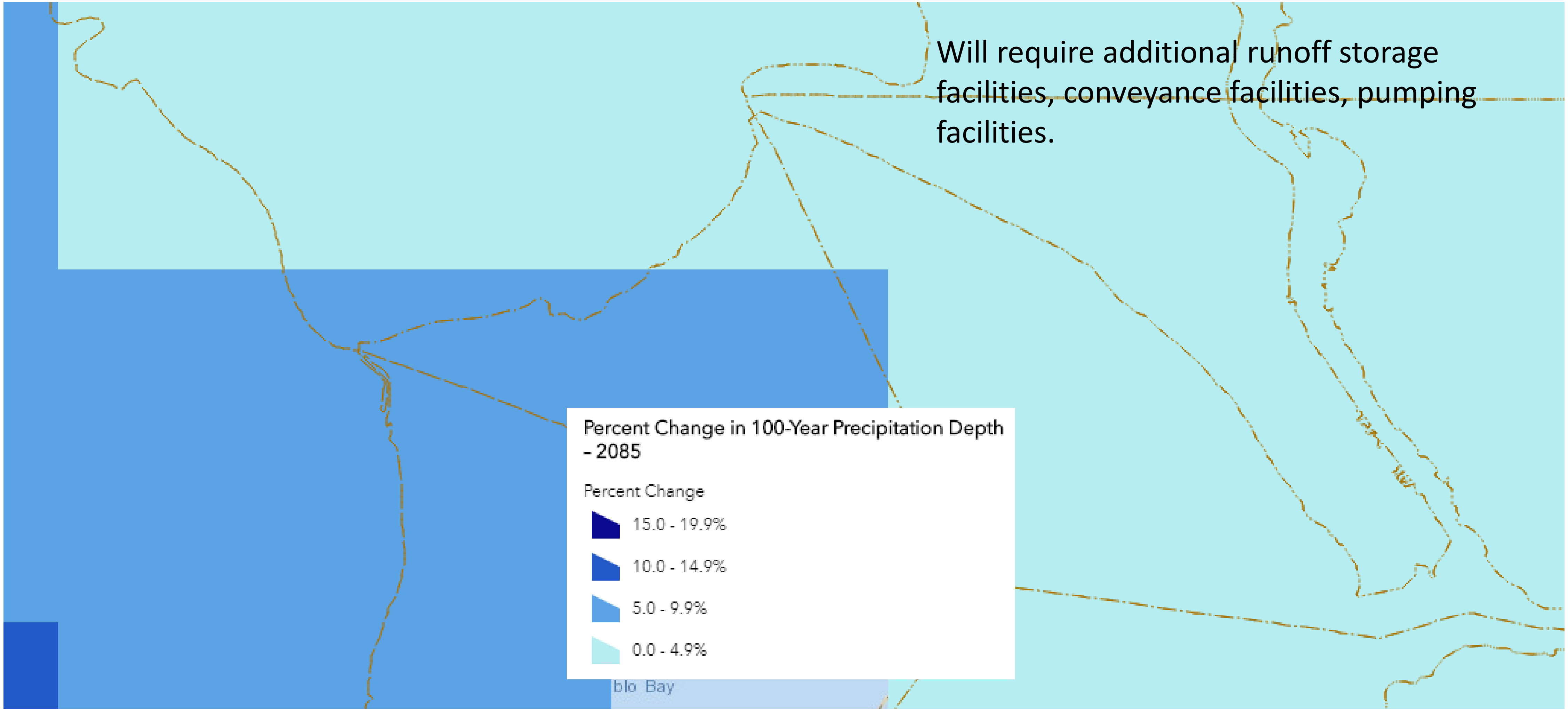
Data estimated for RCP 4.5 and 8.5 emission scenarios over 3 time periods 2025, 2055 and 2085. Models analyzed to determine magnitude of rainfall depth for a 100-year storm event.

ADDITIONAL DATA NEEDS

Percentage increase in precipitation in NOAA Atlas 14 for various time intervals and projected time periods

Percent Change in 100-yr Precip depth- 2085

Marin/Sonoma 6 % increase, Sonoma/Solano 4% increase



Alternative 1 Raise Roadway profile by 4-ft

Armor sea-side of embankment to act as a levee

Expected overtopping of highway at existing elevation

Roadway elevated with armored embankment

Advantages and Disadvantages

Advantages

- Roadway elevated above the projected sea level
- Areas on the land side protected from sea

Disadvantages

- Additional runoff storage, conveyance and pumping facilities
- Potential ecological systems imbalance
- Additional structures for preventing flooding of existing low lying areas

Alternative-2 Build a Viaduct

Alternative 3 Realign Highway on levee along the coast

Work in Sector Break-Out Groups

Infrastructure Example ______________________________

- **EXPOSURE TO CLIMATE STRESSORS: (Brief recap or summary)**
  A. What aspects of weather/climate affect the use, functionality, performance of this infrastructure?

  B. How might climate change affect these parameters?

- **CURRENT STANDARDS, REGULATIONS, CODES, GUIDELINES:**
  A. Which specific standards, regulations, codes, and/or guidelines are in use in CA and must be complied with to build, operate or maintain this infrastructure?

Stage in infrastructure development/use	**Which codes, standards, regulations, guidelines apply in this case? (be specific)**	**Frequency of updates of standards etc.**	**Historical reference period used to set or apply standards**
Initial design			
Operation			
Maintenance			
Repair/rebuilding after disaster/ disruption (if applicable)			
Decommissioning			

- **NEEDED CHANGES:**
  A. What changes would need to happen to accommodate climate change in existing standards codes and guidelines etc.?

- **INFORMATION FOR PLANNING, DESIGN, BUILDING, OPERATION ETC.:**
  A. What type of climate information is currently being used/would be needed in the future?

  B. Are there any uncertainties in current information? If so, how is that handled?

  C. Is the desired forward-looking information available in the format needed?

- **BARRIERS TO USING FORWARD-LOOKING CLIMATE INFORMATION:**

Are there any **rules or regulations** that prevent or forbid the use of forward looking information?	What are some potential work-arounds/ways to overcome these barriers?
Are there any **other barriers** that prevent, delay, or inhibit the use of forward looking information? (for examples see below)	What are some potential work-arounds/ways to overcome these barriers?

Possible barriers to think about (but not be limited to): spatial/temporal resolution of information, information format, lack of access to data, infrequency of updates of information, risk aversion among information users, lack of concern, lack of understanding, disbelief in science, lack of precedent/examples, cost increases, lack of mandate, lack of influence over process, professional liability concerns, professional reputation, disagreement on alternatives, political challenges, lack of accountability, lack of clarity on targets/goals, lack of performance standards, etc.

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Reporting Back and Lessons

What did you hear about…

1. What needs to change?
2. The toughest barriers?
3. The most promising ways to overcome them?

Opportunity for Public Comment

Agenda

Time	Agenda Item
10:00-10:30am	Welcome, Intros, Review of progress to date & Charge for Mtg. #3
10:30-11:00am	N. Diffenbaugh: Understanding, Reducing & Estimating Uncertainty
11:00-12:00pm	Panel Discussion: Planning for, Deciding despite & Managing Uncertainty
12:00-12:30pm	Extracting Preliminary Lessons
12:30-1:30pm	Lunch
1:30-2:30pm	Working Through Specific Examples: Information Needs & Barriers to Use
2:30-3:00pm	Extracting Additional Lessons
3:00-3:45pm	Selecting Appropriate Engineering Designs in the Face of Uncertainty
3:45-4:00pm	Wrap-up: Review, Next Steps
4:00	Adjourn

Selecting Appropriate Engineering Designs in Light of Uncertain Climate Futures

"How to select an appropriate engineering design for a range of future climate scenarios as related to infrastructure planning and investment."

Debrief

Insights about accounting for an uncertain future throughout the infrastructure life cycle?

Opportunity for Public Comment

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Review of the Day

We Recommend…

National Academies of Science, Engineering & Medicine
Board on Environmental Change and Society
March 1, 2018 Seminar

“Communities in Harm's Way: Addressing Environmental Change and Extreme Weather Events”

http://sites.nationalacademies.org/DBASSE/BECS/DBASSE_184748
(Slides will be posted)

ADAPTIVE ENGINEERING IN THE FACE OF UNCERTAINTY

Decision-scaling: A Decision Analytic Approach to Using Climate Information
Casey Brown, PhD, PE from University of Massachusetts
https://vimeo.com/15776471

Managing Risk and Uncertainty for Water and the Environment (Introduction to decision-scaling and eco-engineering decision-scaling (EEDS))
http://agwaguide.org/about/EEDS/index.html#welcome

Next Webinar – March 21, 2018

Mobilizing the Future: Infrastructure Challenges and Opportunities in the TRANSPORTATION Sector

Gurdeep Bhattal, P.E.
Caltrans

James Deane, AIA, CDT, LEED AP, PMP
High-Speed Rail Authority

Cris Liban, Ph.D., P.E.
L.A. Metro

And Another Webinar – March 22, 2018

Rushing toward the Future: Infrastructure Challenges and Opportunities in the WATER Sector

John Andrew, P.E.
Dept. of Water Resources

Kate White, Ph.D., P.E.
Lead, Climate Preparedness and Resilience Community of Practice
US Army Corps of Engineers

Amir Aghakouchak, Ph.D., P.E.
UC-Irvine

Next Steps

We Will

- Continue webinar series
- Prepare meeting summary notes
- Prepare Meeting #4 (Sacramento)
- Finalize key definitions
- [to be added over the course of the CSIWG meeting]
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You Will

- Send in travel receipts
- Make travel arrangements for April meeting (Davis/Sacramento)
- Attend and contribute to Webinar series
- Complete infrastructure homework in greater detail
- [to be added over the course of the CSIWG meeting]
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Be in touch!

- To sign up to the Climate-Safe Infrastructure listserv…
- To stay up to date on CSIWG developments…
- To ask questions or send comments…

Email: Elea Becker-Lowe at Elea.Beckerlowe@resources.ca.gov or at climatesafeinfrastructure@resources.ca.gov

… and she will direct the inquiry accordingly.


Meeting #3 of the Climate-Safe Infrastructure Working Group • San Francisco • March 13, 2018
Toward Climate-Safe Infrastructure
CALIFORNIA RE
Thank you!