FLOOD RISK MANAGEMENT – PLANNING CENTER OF EXPERTISE (FRM-PCX)

FRM-PCX WEBINAR SERIES #4

SEA LEVEL CHANGE (SLC) TOOLS AND BEST PRACTICES FOR FRM STUDIES
(ON-DEMAND VIDEO TRAINING MODULE)

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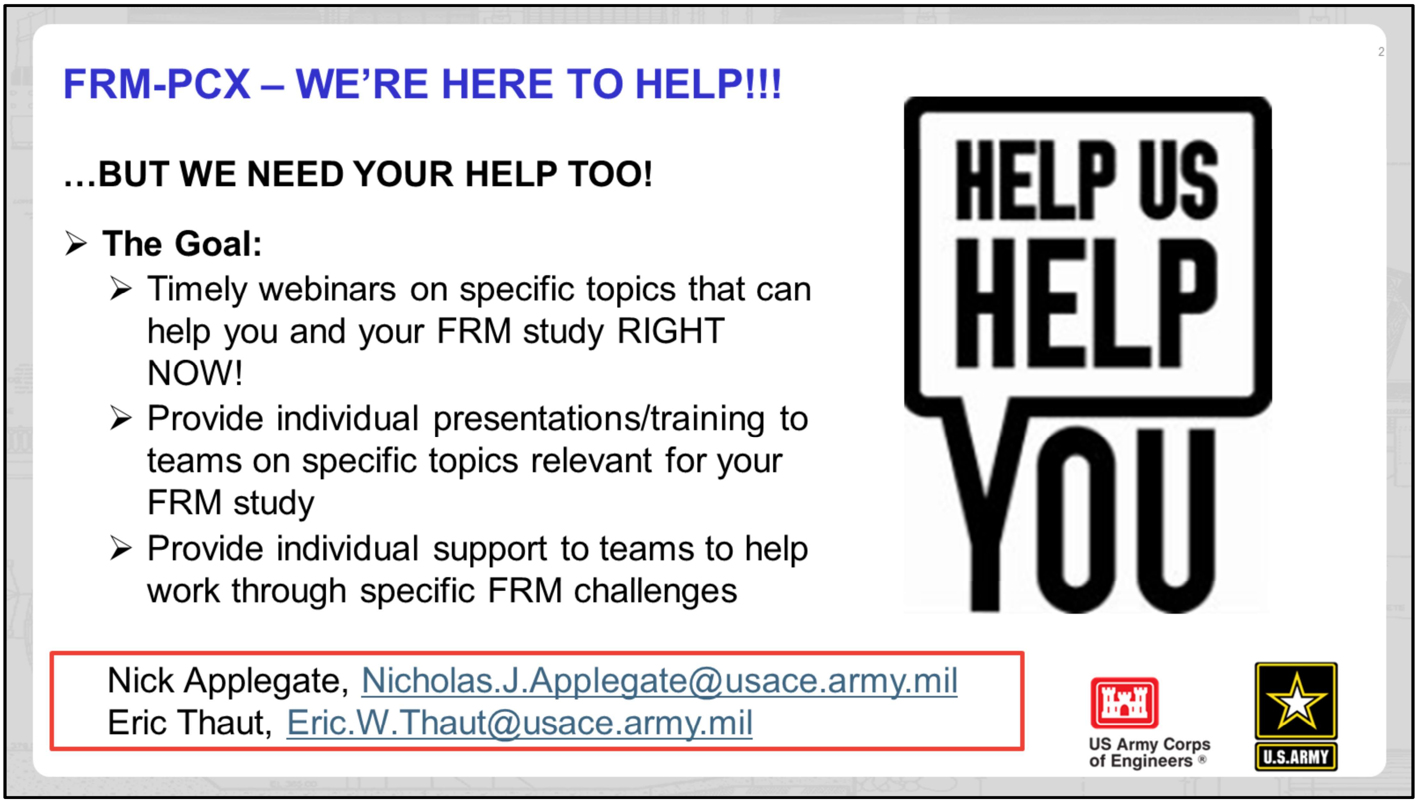

- **WE NEED YOUR HELP!!!**

- We need you to reach out and ask for help.
- And tell us what your challenges are!
- We can provide advice and assistance free-of-charge either and/or find the right SME to help.

- **Here's our goal…**
    - ➢ Timely webinars on specific topics that can help you and your FRM study RIGHT NOW!
    - ➢ Provide individual presentations/training to teams on specific topics relevant for your FRM study
    - ➢ Provide individual support to teams to help work through specific FRM challenges
        - ➢ I'm in a newly created position with the PCX to do just this! You don't need to provide me a labor charge code! Please reach out, invite me to a meeting, or even just run some of your recent decisions, assumptions or results by me to make sure we aren't missing anything.

➢ Please reach out to either myself or the Deputy Director with any questions.

PRESENTATION SUMMARY – SLC FOR INLAND FRM PLANNING

- What is SLC?
- Why is SLC important for FRM Studies?
- SLC Overview – Policy and Guidance
- SLC Tools and How/When to use them
- Economic analysis with SLC

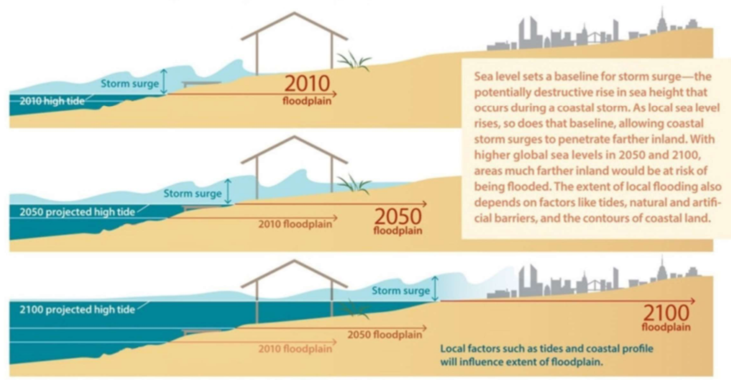

Image adapted from Union of Concerned Scientists 2013; www.ucsusa.org/sealevelrisescience

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- Policy
- Adaptation to change…doesn't matter why it's changing, we know its changing

EXECUTIVE SUMMARY OF SLC TOOLS AND BEST PRACTICES FOR INLAND FRM

- **The "so-what"**: Sea level will continue changing into the very far future
  - USACE projects must perform as intended/communicated anyway
- Several FRM impacts from sea level change
  - Flowline
  - Sedimentation
  - Shift in governing design condition
- Best practices:
  - Datums; Total water levels
  - "When, not if"
- **Policy**: USACE sea level guidance uses scenario projections. Plan Form must:
  - (1) Formulate under one scenario, then check performance under the other two, **OR**
  - (2) Evaluate all alternatives under all scenarios
- **Step 1**: Use Tools very early to gather data in the study area to inform formulation and scoping
  - Sea Tracker
  - Curve Calculator
- **Step 2**: Choose the most appropriate policy compliant plan form approach for your study (see above)
  - For inland FRM, consider starting with Option 1, but be ready to move to Option 2 if new data gathered requires it
- **Step 3**: Economic Analysis
  - Utilize sensitivity analysis wherever possible
  - Look at the most extreme scenarios first to assess impacts
  - Use solid and defendable qualitative reasoning where possible to limit modeling

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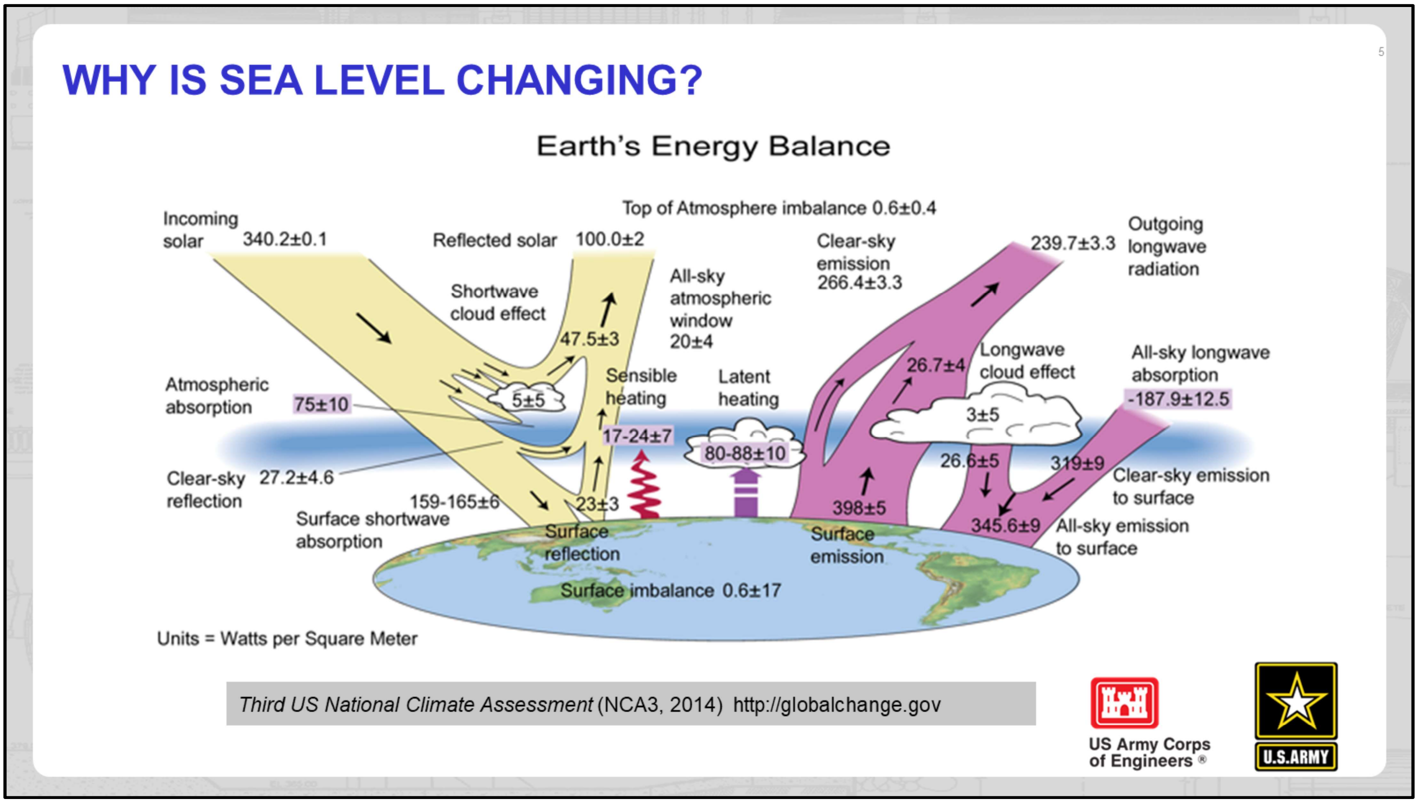
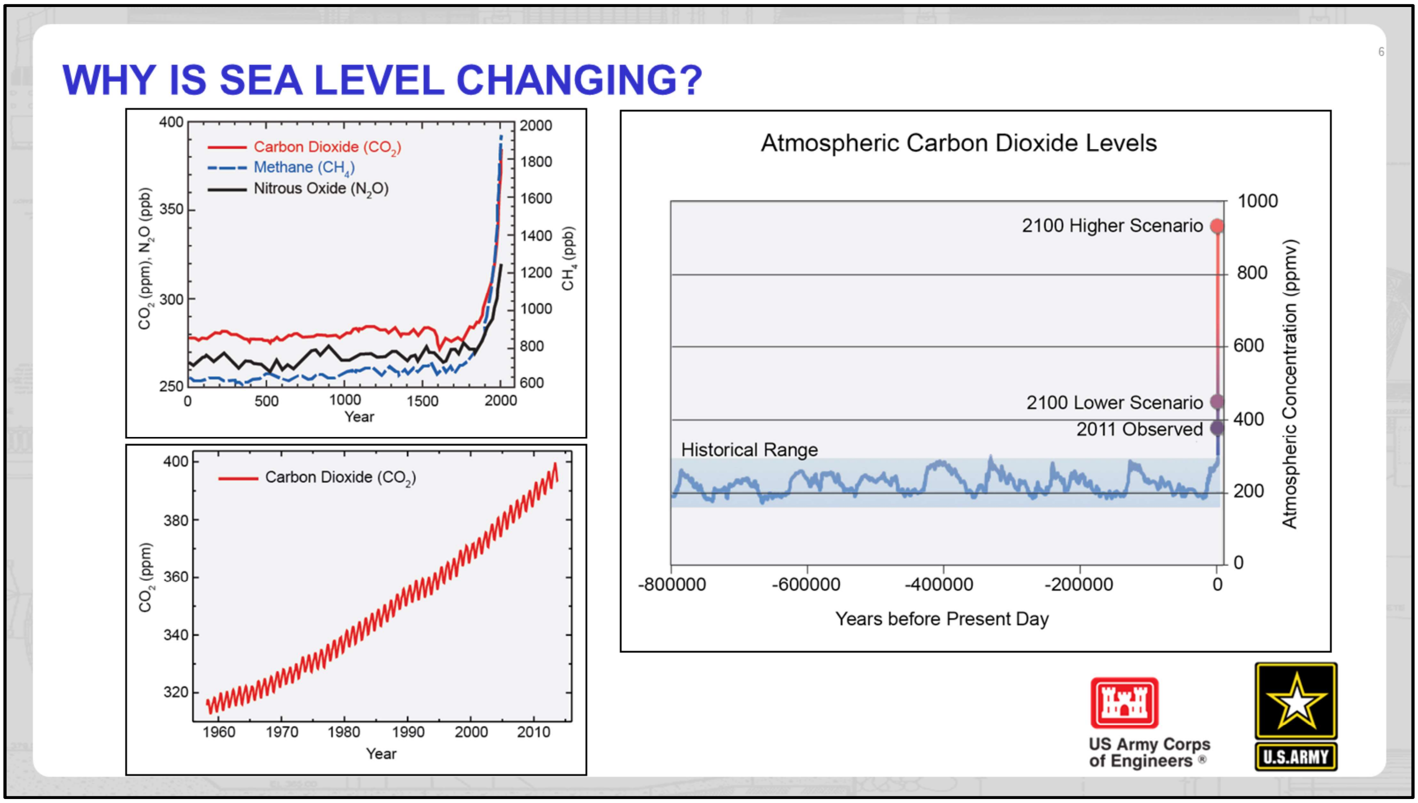


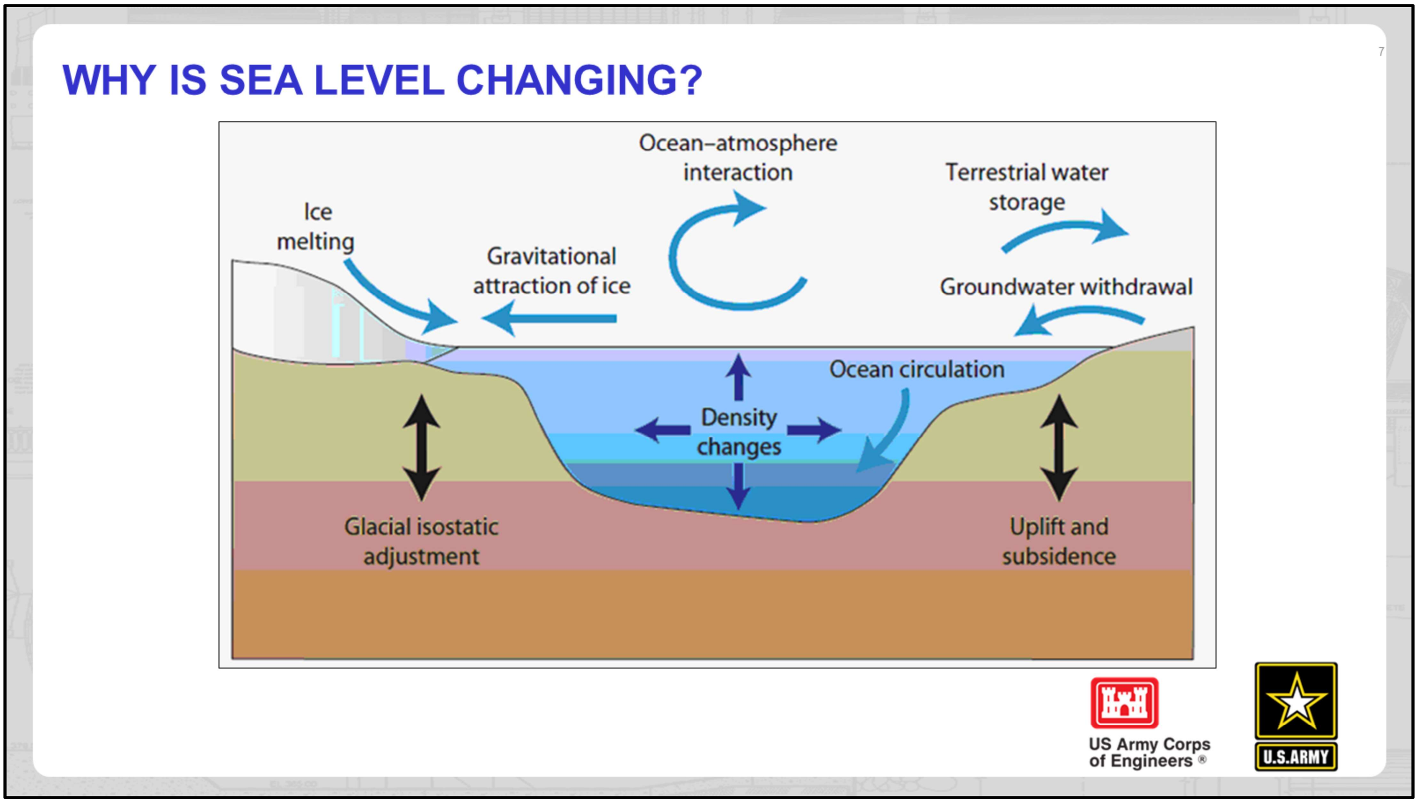
- **There are many components to the energy balance of the Earth.** Longwave radiation, shortwave radiation, sensible heat, latent heat, absorption and re-emission.
  - But it all boils down to the **overall balance**, the excess or deficit, that determines whether the climate will change or stay in a dynamic equilibrium
  - The Earth's energy budget is presently out of balance **by about 0.6 W/m^2**. That might not sound like much compared to a 100 watt light bulb, but of course, the Earth has a lot of square meters.
  - **Human burning of fossil fuels has enhanced the greenhouse effect and made the energy going out ever so slightly less than the energy going in, causing the atmosphere to warm.**

- USACE **climate adaptation policy** is actually agnostic about the cause of the warming, although the science is pretty settled on the causes by now. (USACE, and the DoD, have other policies about climate **mitigation**, but that's not the topic of this webinar).
  - No matter **why** the climate is changing, **it is changing.** And for USACE projects to perform as intended, our designs must incorporate that change



- The concentration of heat-trapping gases in the atmosphere like carbon dioxide, methane, and nitrous oxide **has increased dramatically and recently**.
    - CO_2 concentrations have increased about **25% just since 1960**.
    - Concentrations are **well above even the uncertainty in measurements** from the last several hundred thousand years

- The climate consequences of these changes in greenhouse gases **will take centuries to millennia to play out**.
    - Therefore **we have high confidence** that the changes won't be reversed anytime soon, like on the scale of a USACE project lifecycle.

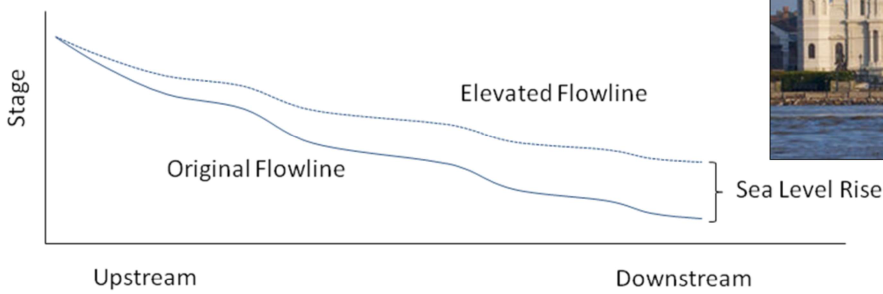


- **Three main processes** are responsible for the majority of sea level change:
    - Thermosteric effect, as **water expands when warmed**
    - **Melting of terrestrial ice sheets** such as the Greenland ice sheet and the Eastern and Western Antarctic ice sheets.
    - **Local land uplift or subsidence**, which affects *apparent* sea level at a location on the coast

- Other effects may have **local importance**, such as changes in ocean currents and changes in the Earth's gravity field (geoid) due to redistribution of ice mass.
    - But in most areas these effects are relatively minor compared to the first three

EFFECT OF SEA LEVEL CHANGE ON FRM PROJECTS

- Increasing a river's downstream boundary (the sea) increases the river height proportionally
- Effect decreases with distance upstream
- Effect also reduced with higher river discharge



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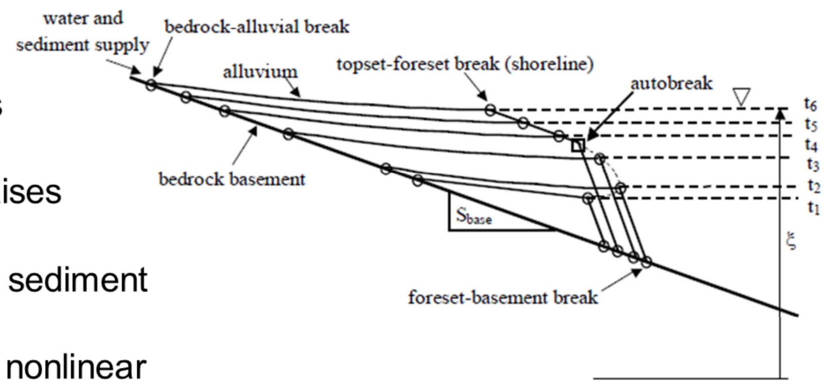
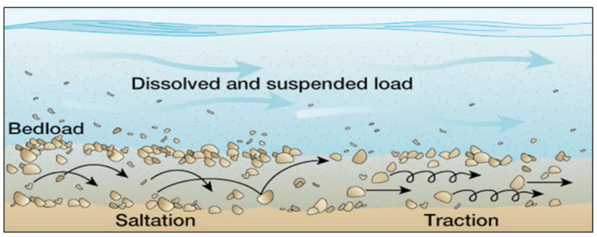
- The most significant effect of sea level in FRM studies is the effect of the **change in downstream boundary** due to sea level change
- Raising the downstream boundary raises the river level for a given discharge rate
    - But the good news for FRM is that this effect is decreased at the high flows that are of greatest interest for FRM studies. This may mean the FRM projects are relatively insensitive to sea level change, though this assumption must be tested
    - The effect is also reduced with distance away from the coast
    - Some FRM infrastructure such as flood bypasses may actually perform *better* under future conditions with higher sea level, at least for a while
    - It is not unusual for net benefits to be higher with higher sea level due to the FWOP being worsened. In many cases the economically optimal sea level for FRM projects is above the USACE high scenario (not that we have any control over it)

EFFECT OF SEA LEVEL CHANGE ON FRM PROJECTS

- Change in sea level changes river's sediment transport
- Can result in shoaling that raises flood heights
- Both location and quantity of sediment can be affected
- Effects may be complex and nonlinear





Parker, Gary, and Tetsuji Muto. "1D numerical model of delta response to rising sea level." *Proceedings, International Conference on Civil and Environmental Engineering (ICCEE-2004)*, Hiroshima University, Japan, July 27 to 28, 2004.

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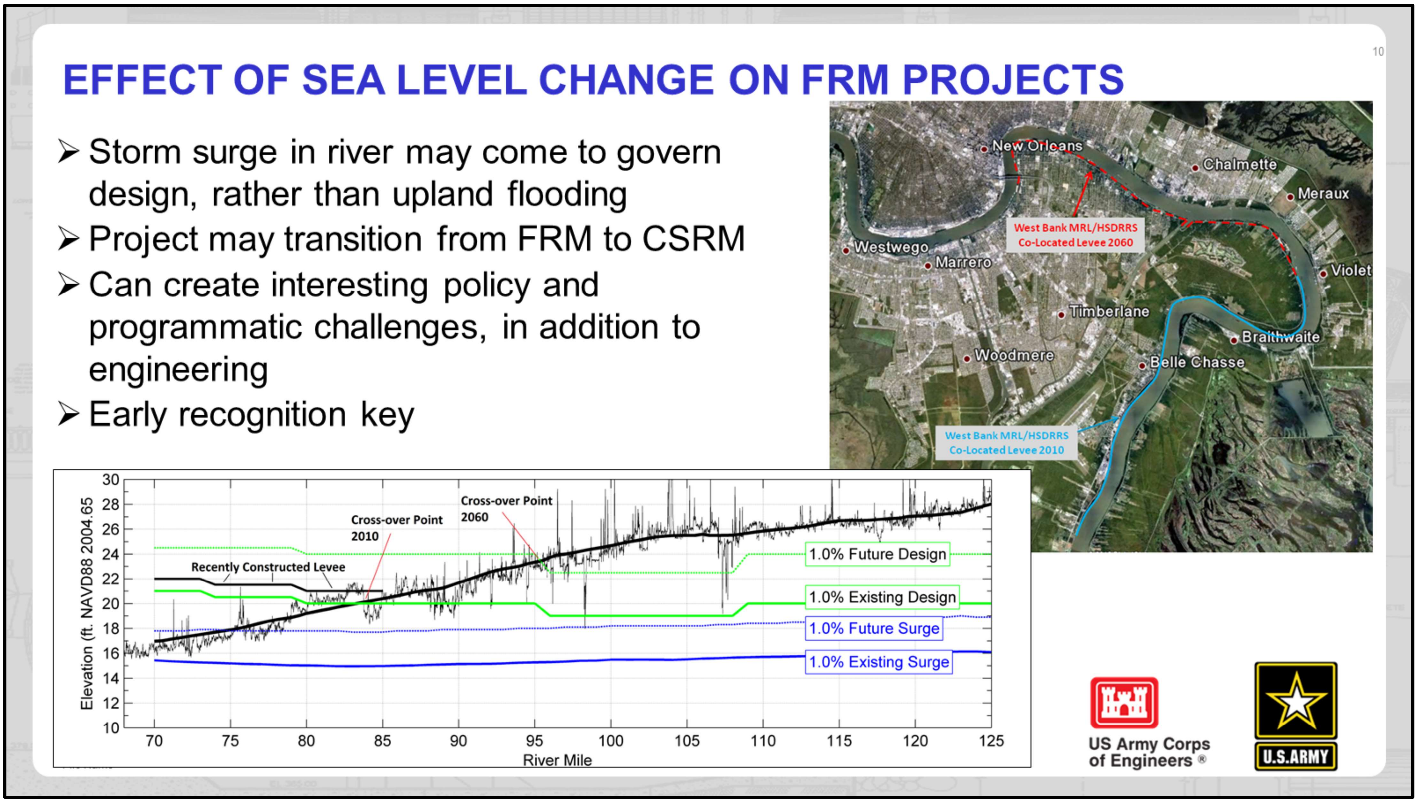
- Changes in **sedimentation patterns** are another important effect of sea level change
  - These may be complex, nonlinear, and hard to model
  - Shoaling areas can raise flood elevations and correspondingly increase flood risk
- Paradoxically, areas of scouring may develop upstream of the depositional areas, which could threaten levee stability. Fluvial geomorphology is complicated.



- As sea levels rise, storm surges are enhanced nonlinearly
    - This is due to reduced bottom friction and depth-limited waves being less limited (much of what is commonly called “storm surge” in everyday speech is actually wave setup)
- For FRM project areas affected by storm surges at their downstream extents, surges may come to govern design over river floods
    - As sea levels change, the point where the two designs “cross over” will move upstream
- This is a large scale programmatic impact and should be considered and communicated upward very early

FUTURE WITHOUT-PROJECT CONDITION SCENARIO(S) (FWOP)

- Single most important scenario!
  - Basis of comparison for alternatives
- Primarily a qualitative effort for initial iterations
  - Identify data gaps and where to focus gathering additional data for quantitative analysis

- Assumptions – trends, actions by others
  - Will FRM problems get worse or better without Federal action?
  - *How might sea level change impact the future?*
- May have more than one future without project scenario
  - Best practice is to identify **one** "most-likely" FWOP to identify TSP and then compare back to other possible FWOPs.

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- The single most important scenario that we will forecast and compare against our alternatives.
- Qualitative in initial planning iterations and scoping phase
- Primarily based on existing information
- Becomes more quantitative in later iterations when moving towards the TSP.
- Quantitative incorporation of Climate Change in FWOP need prior approval from Climate Preparedness and Resilience (see slide 12)

- There's a great deal of uncertainty in the future, so we can't predict it perfectly. Therefore, there's multiple different future realities that we have to think about.
  - However, to the best of our ability we want to narrow these possibilities because the Future Without Project is the baseline to define our problem and the baseline that we compare all alternatives to. So, the more possible futures you have, the more evaluations and comparisons you have to do.
  - Make reasonable assumptions, that you can document and get buy-off from the vertical chain and review team throughout the process for significant assumptions.
  - Climate Change will require us to look qualitatively at projecting potential future impacts
  - Sea Level Change requires a quantitative assessment us to look at multiple future's at least in terms of doing a sensitivity analysis. More detail to come…

FORECASTING

- What is a forecast?
  - Potential future reality
  - Period of Analysis (50 years) vs. Project Life (50+ years)
- Why do we forecast?
  - Anticipate future conditions
  - Understand benefits of the project
  - Identify & adapt to changes
- Uncertainty
  - Uncertainty in the rate of SLC change (But not in SLC itself!)
  - Different approaches for different inputs
  - Embrace it, document it and communicate it!

- **Some typical forecasts in FRM**:
  - HH&C
    - Climate change
  - Hydraulics
    - Roughness, infiltration, runoff
  - Economics
    - Population, development, land use, risk
  - Environmental
    - Habitat quality/quantity

- **Projections for Sea Level Change**:
  - 3 USACE SLC Curves
  - State/local trends/predictions?

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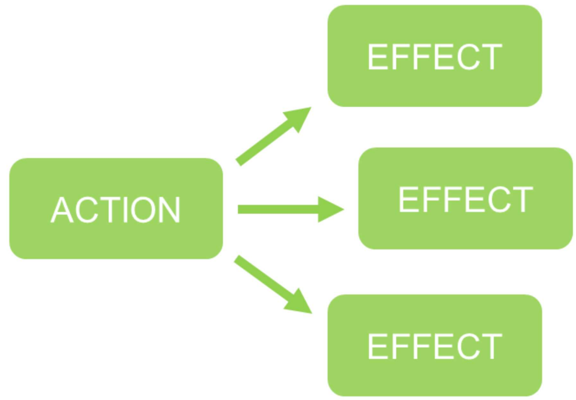
- **Period of Analysis** = The time horizon for project benefits, deferred installation costs, and OMRR&R costs. Use the same period of analysis for all alternative plans.
  - Doesn't have to be full 50 years, future year can be more reasonable based on development plans, etc. And than truncated. Just need to document why these assumptions were made and why they are reasonable.
    - Base Year vs. Future Year
- **Project Life** = how long we think proposed projects will last and perform.
  - In terms of Climate Change and SLC we are concerned about how the project performs over the project life, not just the period of analysis.

We need to be transparent about our assumptions and convey to decision-makers what the risk is to our decision should any of these conditions prove to be different than our forecasts and projections.

FUTURE WITH PROJECT SCENARIO(S)

- Most likely future condition if a plan of action is taken
  - Hydrology, Hydraulics, Economics, Geotech, Environmental
  - Will there be downstream or upstream impacts?
  - What is the residual risk?
  - *How robust and adaptive is the plan to an uncertain future?*
- Purpose of the with-condition scenario is provide the narrative for evaluating the plan's effects
- Different with-condition for each plan
- Account for changes and uncertainty in the with condition scenarios
  - SLC is happening, but at what rate?
- Document assumptions along the way and TELL YOUR STORY!



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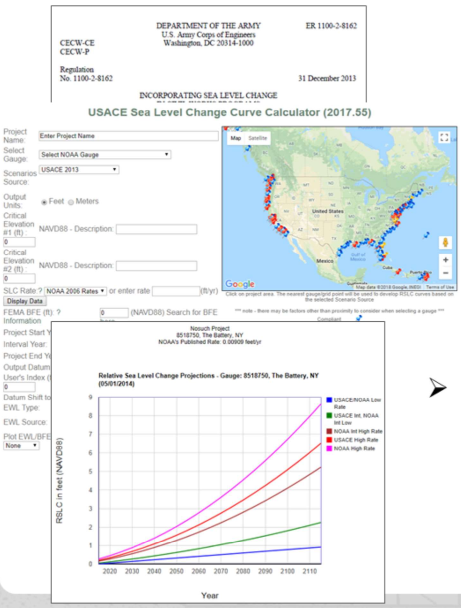
- We want to look at how the with project scenarios perform considering the range of SLC rates of change over time.

PLANNING WITH UNCERTAINTY – SEA LEVEL CHANGE

Sea Level Change
ER1100-2-8162



Requirements:

- If SLC is applicable for your study area, options:
  - (1) Formulate under one SLC scenario, with sensitivity for the others

    OR
  - (2) Evaluate all Alts vs. all three USACE SLC scenarios

- The Goal:
  - Bracket the plausible futures
  - Show robustness and adaptive capacity
  - Document assumptions, methods and results

- USACE Tools!:
  - https://www.usace.army.mil/corpsclimate/Public_Tools_Dev_by_USACE/sea_level_change/

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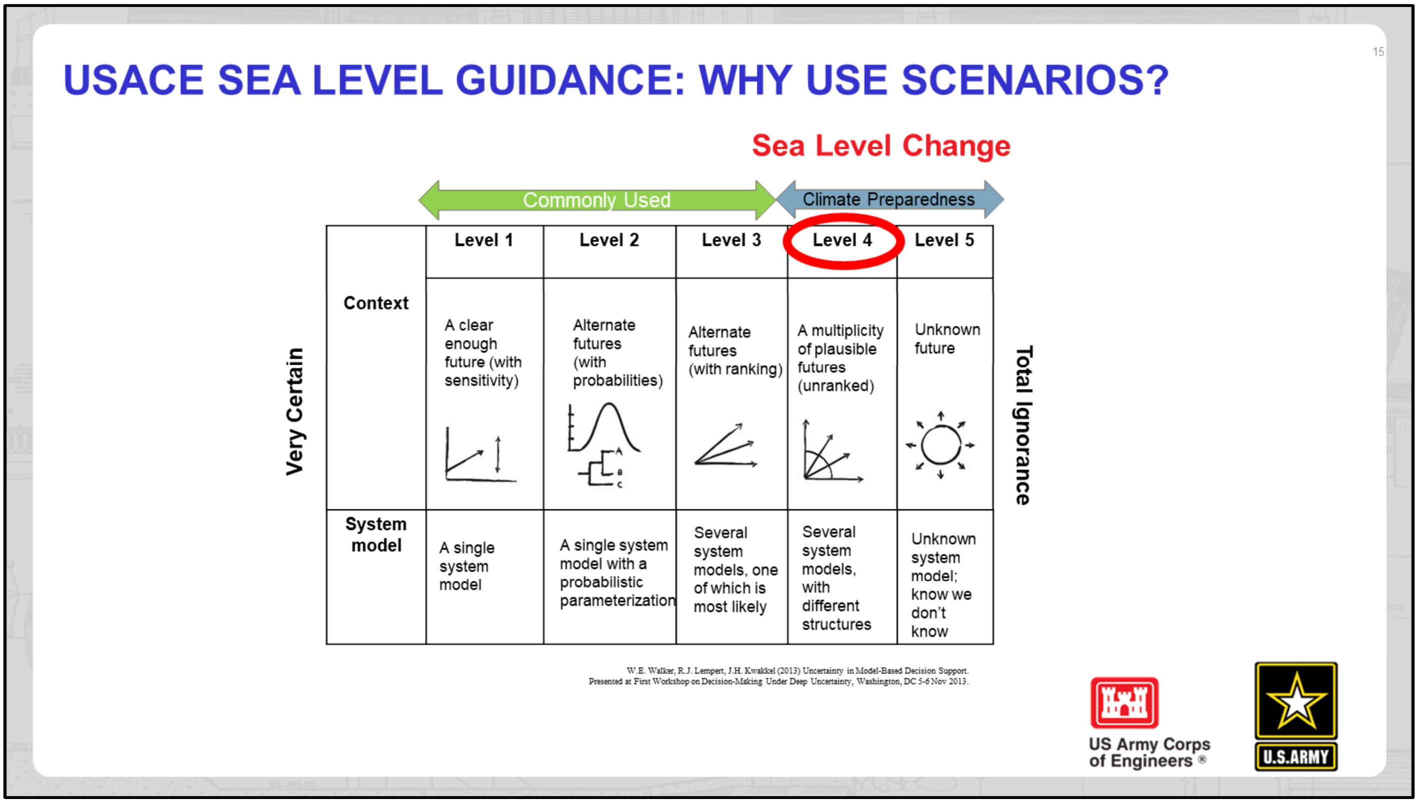
- If anyone asks how to find out if they are subject to sea level change, the rule is that if your area is tidally influenced, you are (including downstream boundaries). If you don’t know if you're tidally influenced, a typical rule of thumb is that you're safe if you're more than 50 miles from the coast or more than 50 feet NAVD88 above sea level. As always, be sure to vet these assumptions vertically and get buy off.

- There are two options outlined in paragraph 6.d. (page 3 of the PDF) of ER 8162. You can (1) formulate under one scenario (typically the intermediate) and then evaluate performance of the identified TSP under the other two to document how long you can reasonably expect it to perform, or (2) evaluate all alternatives against all scenarios. The most common approach for inland FRM is (1), unless your study area proves to be highly sensitive to the rates of SLC. In these cases, many times the highest b/c ratio is achieved under the high sea level scenario, so teams want to show that number but don't want to be accused of cherry-picking that scenario, which is the kind of thing OMB looks for. Also, they want to show that they wouldn't have chosen a different alternative if they had used a different scenario (in practice, the winner usually wins under all three scenarios).

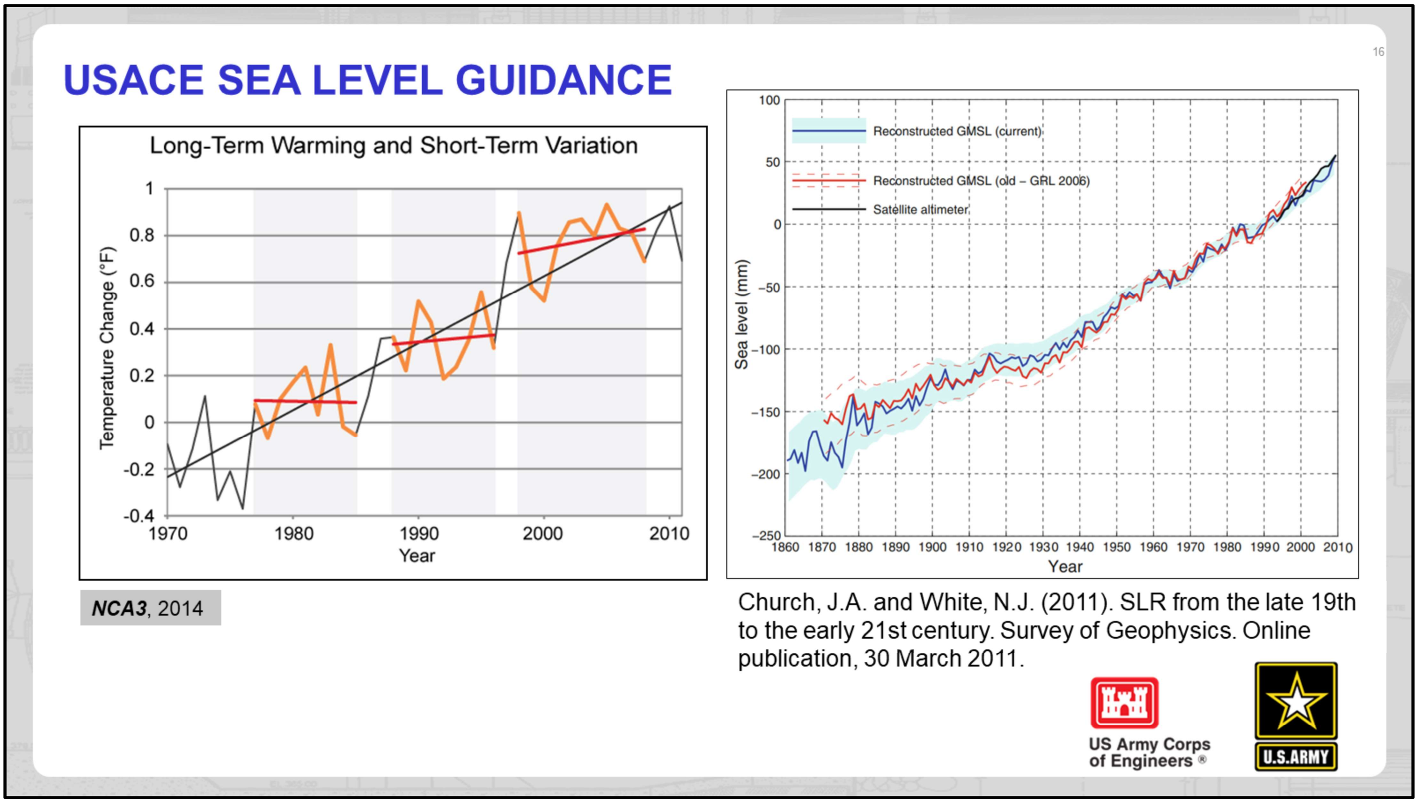
- If a team wants to use approach (1) then they should show in the report that either the "local conditions and plan performance are not highly sensitive to the rate of SLC" per the ER or that they would get the same answer if they had gone and looked at all scenarios against all alternatives. There are a few ways do make that case but typically they either show that all alternatives are equally sensitive to sea level so the same alternative wins under all three, or that some of the other alternatives can be eliminated for some other reason so there is no need to model them.

- One last thing I sometimes mention that seems to help people understand: the scenarios are there to bracket to plausible future, so you actually only need the low and high scenarios to do that. The intermediate is really just there as a convenience. Our policy is that our projects will perform for their full intended design life despite the fact that there is uncertainty in future conditions. The low and high rates define the envelope so we can ensure that is true.

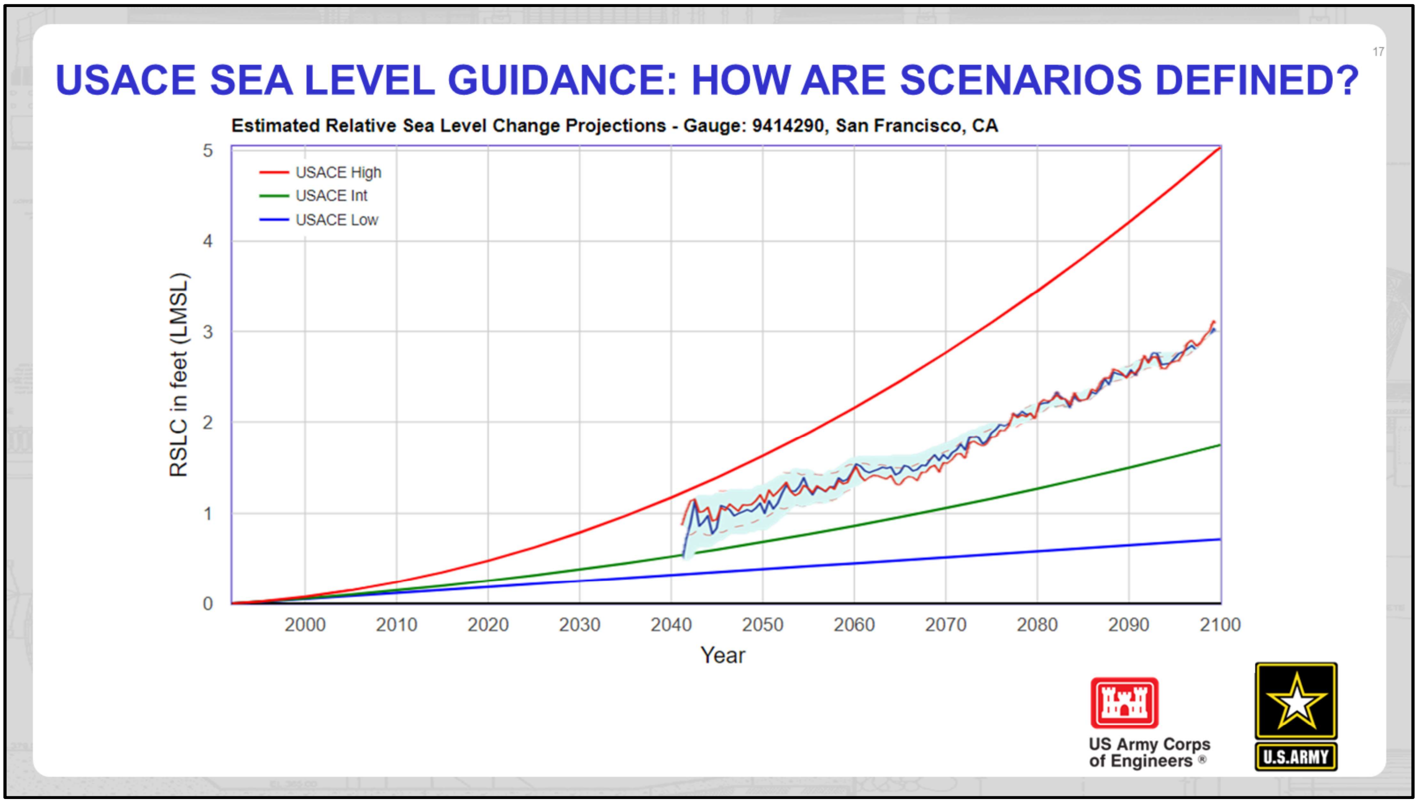
- 2 USACE Tools!
  - The curve calculator and the SeaTracker. Again, you aren't required to use them but why wouldn't you - they make nice report-quality graphs and tables suitable for copy/paste and the reviewer is going to see something that s/he recognizes. It's just easier for everyone.



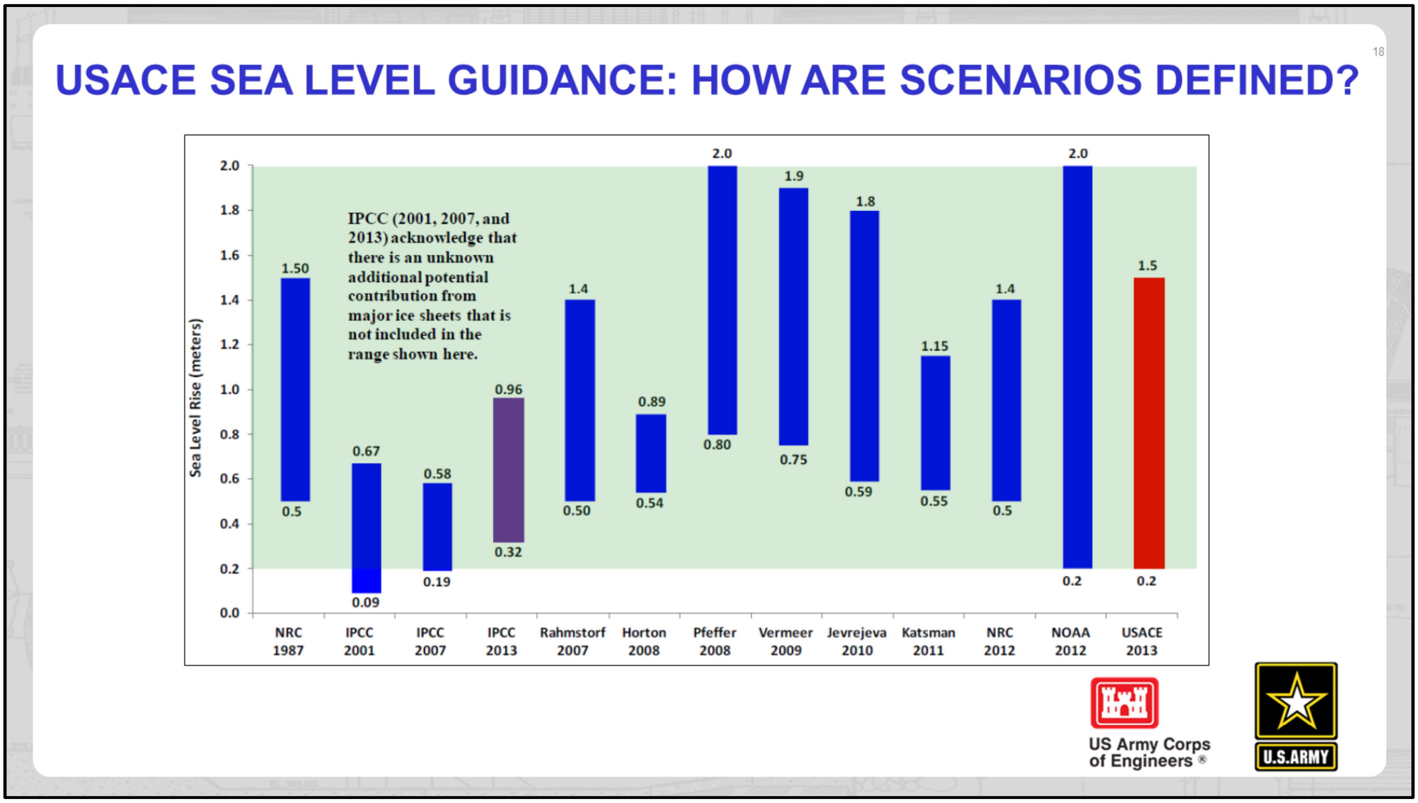
- Different approaches to uncertainty make sense depending on the level of confidence in the change and the consequences of being wrong.
- We typically use a single forecast or a probabilistic system to describe uncertainty, but unfortunately with climate change we aren't yet confident enough in the science to do that
    - Instead we use scenarios, which are not ranked and are all considered equally likely
    - Someday the science will strengthen to the point that we can use level 1-3 approaches, and at that time we will adjust guidance
    - We don't want to be overly precise where we can't also be accurate



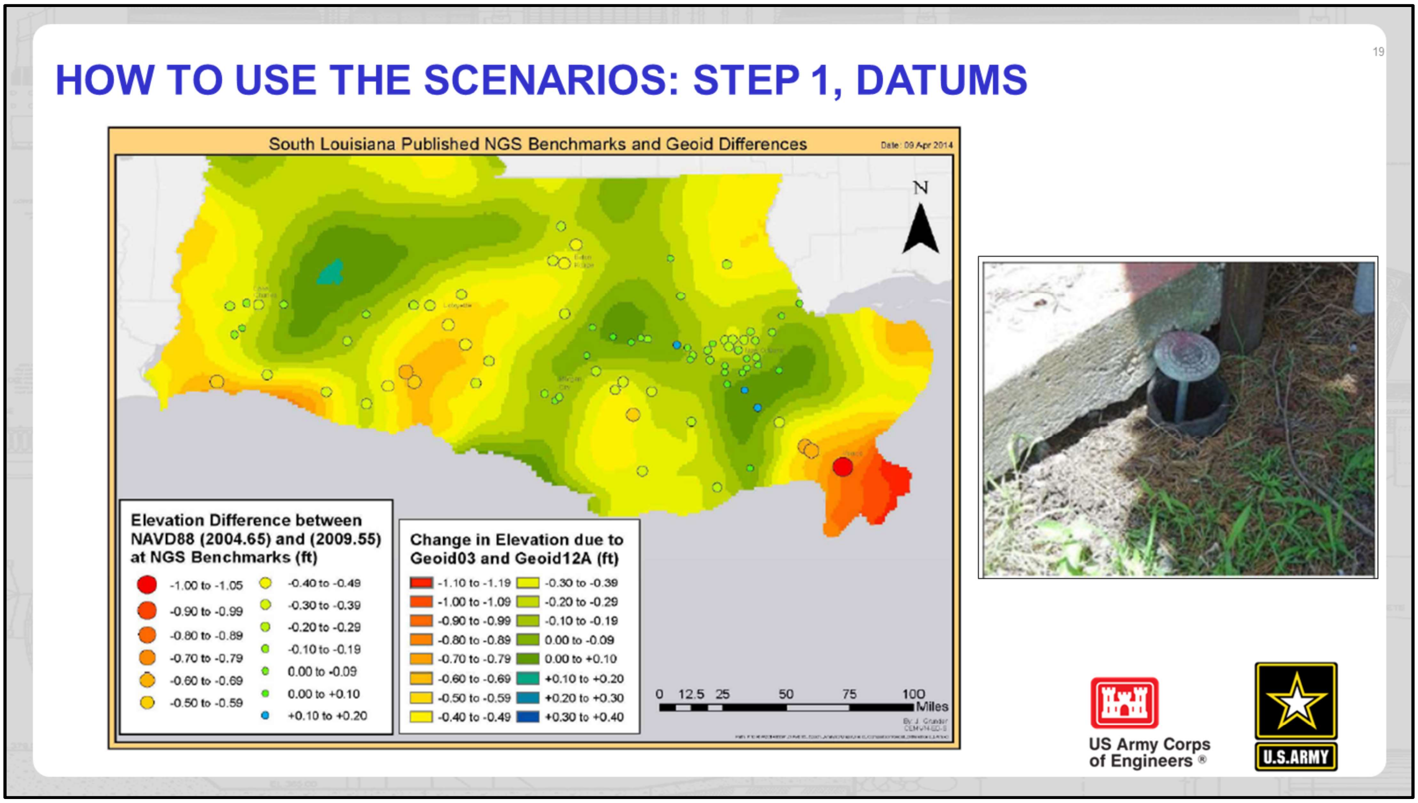
- In contrast to other climate changes like increased frequency of floods or storms, we have **high confidence** in how sea level will change: mostly, **it's going up**.
  - That doesn't mean it will go up every year, though. Temperature (left) and sea level (right) have historically increased in fits and starts. Periods of slower rise are followed by faster periods.
- USACE policy **brackets the range of the reasonably plausible future conditions** but does not attempt to forecast those conditions exactly.



- The three USACE scenarios for future sea level are **NOT** storylines; none of them will actually happen! They are used to **bracket the range** of reasonably plausible future conditions
- The Low and High scenarios create an **envelope of conditions**, somewhere within which we expect the true conditions to exist
- The Intermediate scenario does not form part of the envelope; it is just provided as a guide or a middle value so that we have consistency across projects
- Local land movement and regional effects are incorporated into the curves for a given tidegage. The historic rate of change forms the Low curve, and the acceleration factors for uncertainty are added on to create the Intermediate and High curves.



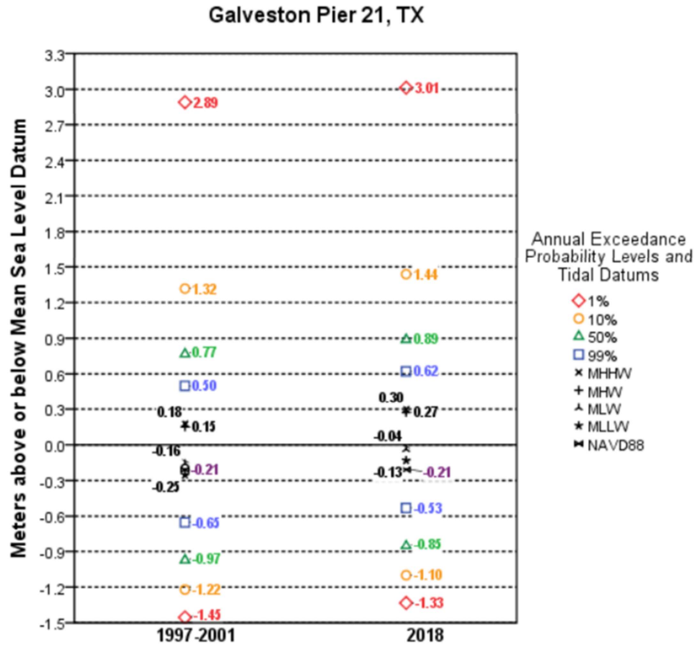
- The three curves were computed by **backing into polynomial equations** that would yield global sea level rise values of 0.2, 1.0, and 1.5 meters by the year 2100.
- Those values were determined based on a review of the available scientific literature
- The uncertainty in future sea level change rate is due in part to uncertainty in future emission rates for greenhouse gases, but is largely due to geophysical uncertainty regarding the behavior of melting ice sheets. We don't know how fast the ice will break apart, and this means we aren't sure how fast the sea will rise.
    - But we are sure that it will rise, sooner or later. This is why we describe our approach as "when, not if."



The first step in applying sea level scenarios is to ensure the usage of consistent datums. If the land elevation and sea level aren't measured from the same basis, then the sea level scenarios won't be applied correctly. In this slide we see differences of over a foot in different epochs of the same datum (NAVD88) due to different geoid models (gravity surfaces) used in the two epochs. Clearly this kind of difference is critical to construction of FRM infrastructure such as levees. On the right we see the effects of subsidence, where the land surface has sunken over time but the survey benchmark has remained relatively fixed. This would also be an important consideration when comparing sea level change to a land surface.

Aligning land surveys with sea level in time may require adjusting sea level or land elevations to some common year. This is typically done by adjusting elevations according to the USACE Low scenario (the historic rate).

HOW TO USE THE SCENARIOS: STEP 1, DATUMS



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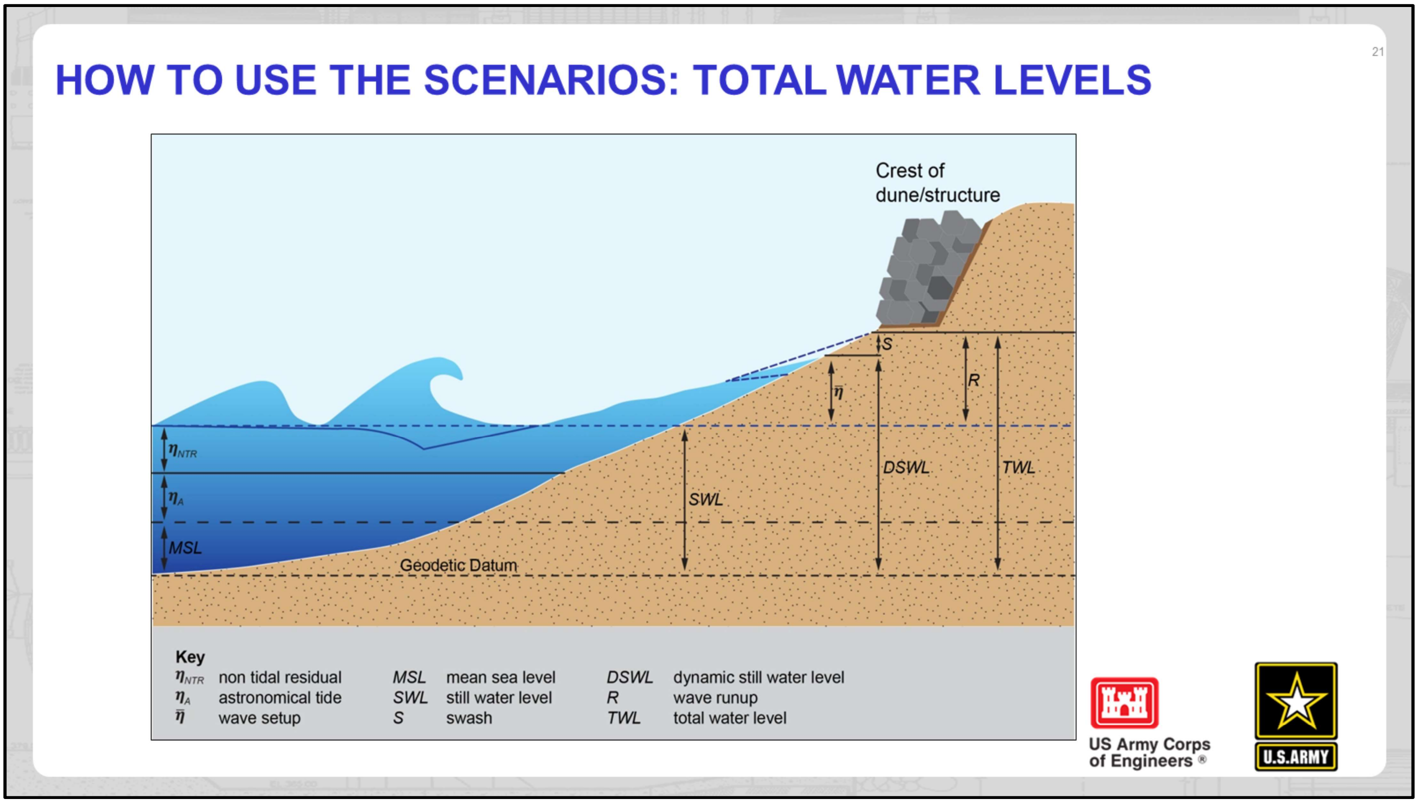
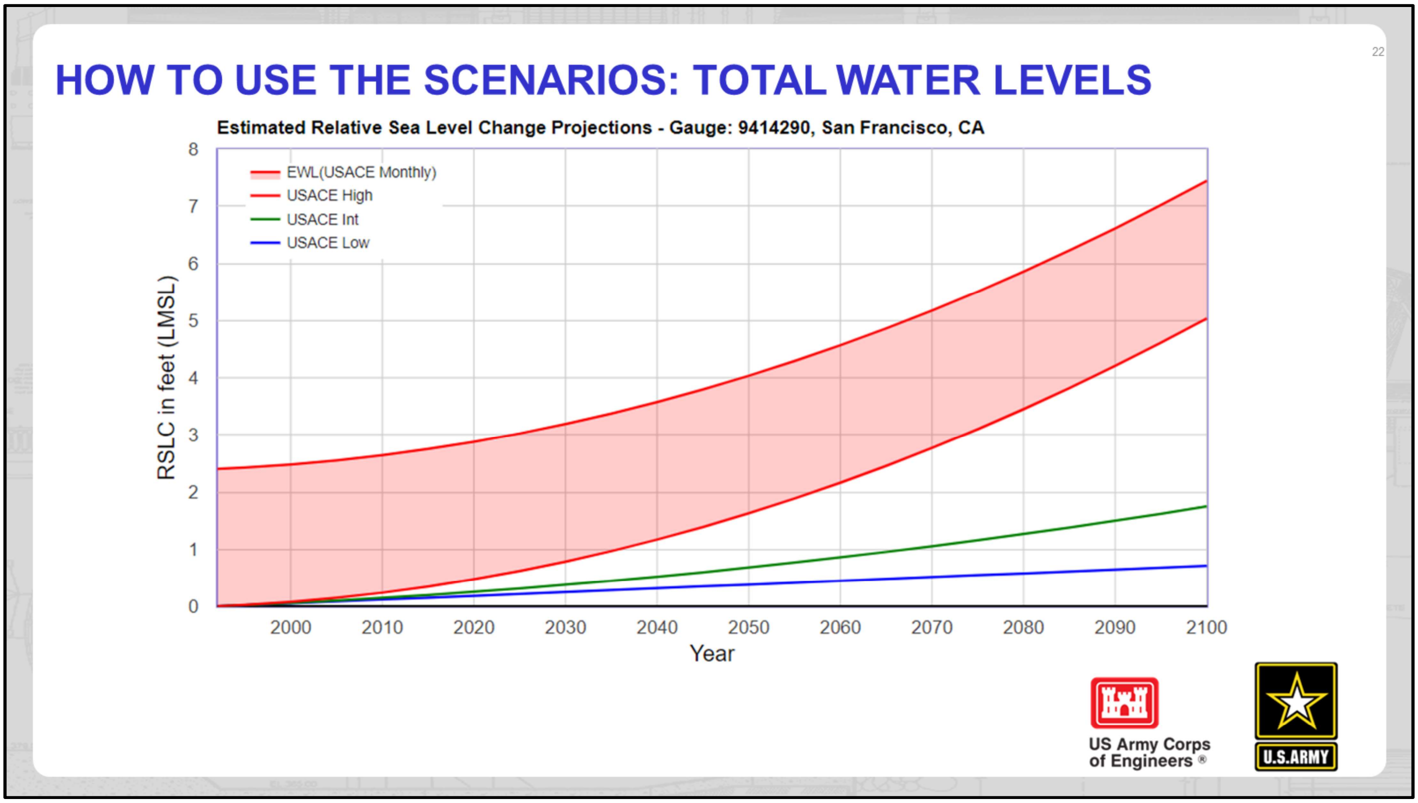
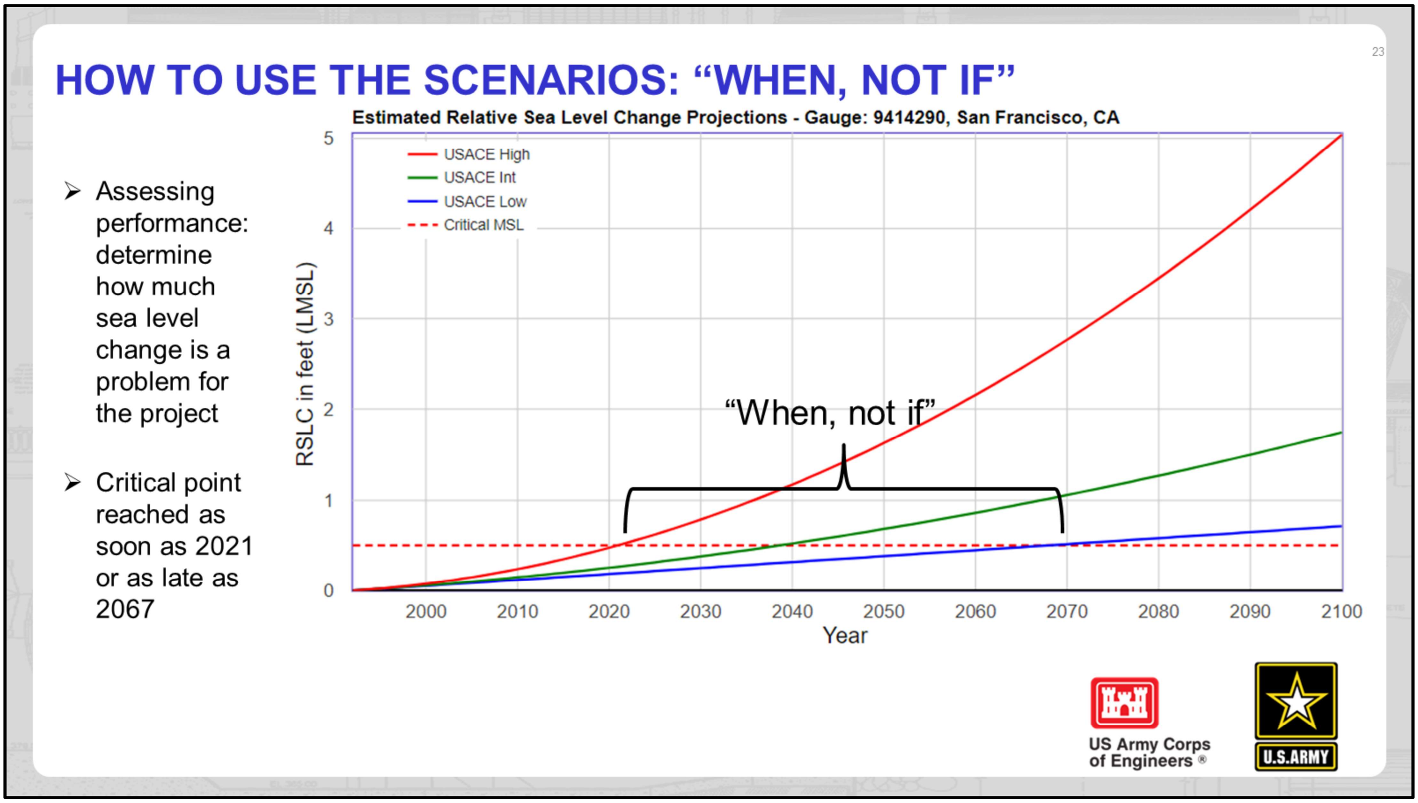
The most recent National Tidal Datum Epoch spanned from 1983-2001, making the year 1992.5 the midpoint of the epoch and therefore the year that pertains to "sea level" as we know it for most gages. But this is not always the case; NOAA may publish sea level for different time periods based on data availability or changes in local conditions. Here we see a gage where sea level was computed based on data from 1997-2001 (i.e. centered on 1998.5), yet there is still a noticeable difference when that computed level is extrapolated forward to the year 2018.



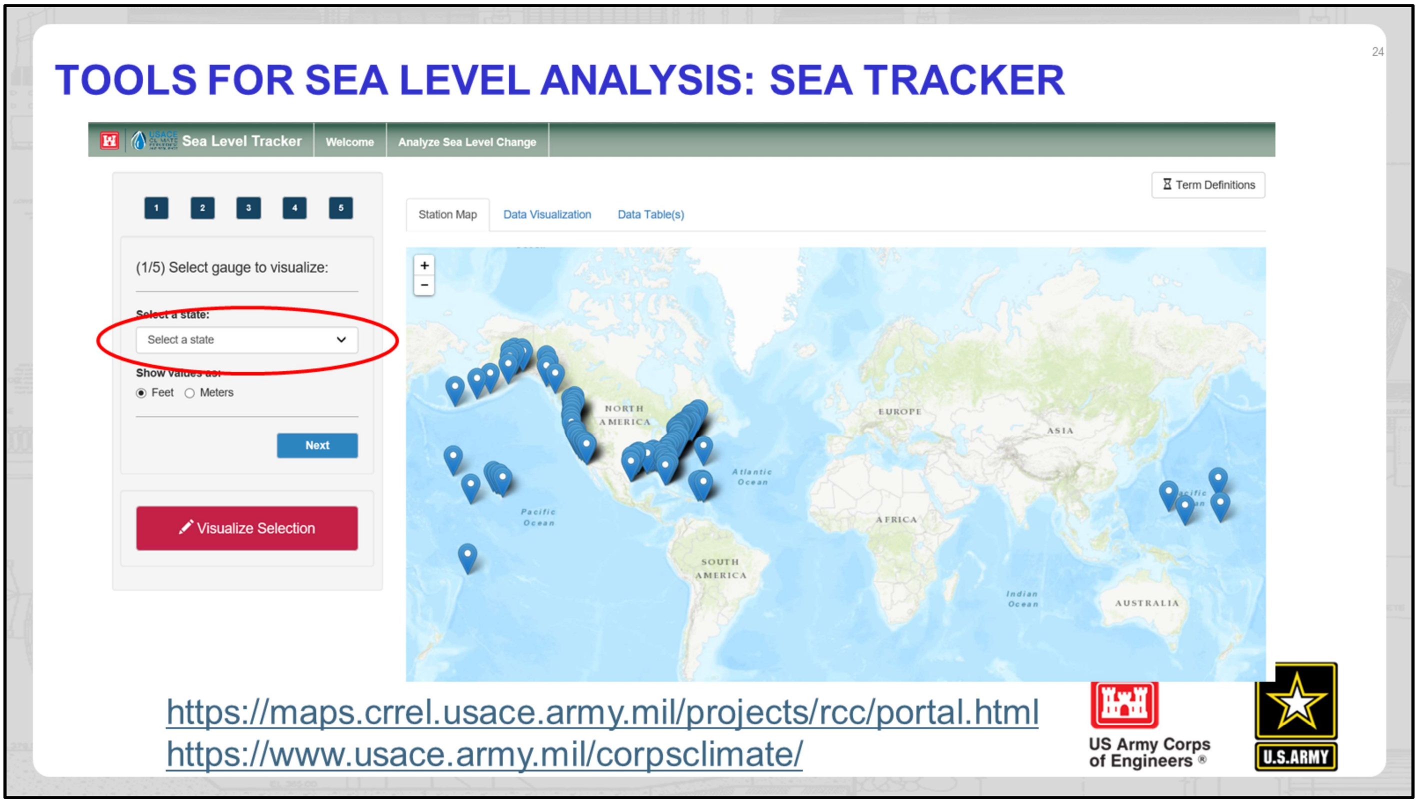
Mean sea level is not the forcing water level for most (any?) FRM projects. Other processes like tides, storm surges, wave runup/setup, and of course river flow also contribute to the water level at a levee or other FRM project element. Not all processes may apply to all projects; for example, wave action may be small on rivers with little width for wind fetch and without large ships to create wakes. But it remains important to remember that sea level is not the end of the analysis, it is the beginning.



- The USACE sea level curve calculator allows total water levels to be superimposed on top of scenarios for a quick screening level view of water levels at a the gage site. Here the monthly average high water is shown on top of the High scenario at the San Francisco tidegage. This functionality may not be appropriate for FRM projects far from the tidegage site, but still illustrates the concept of total water levels being higher than mean sea levels.

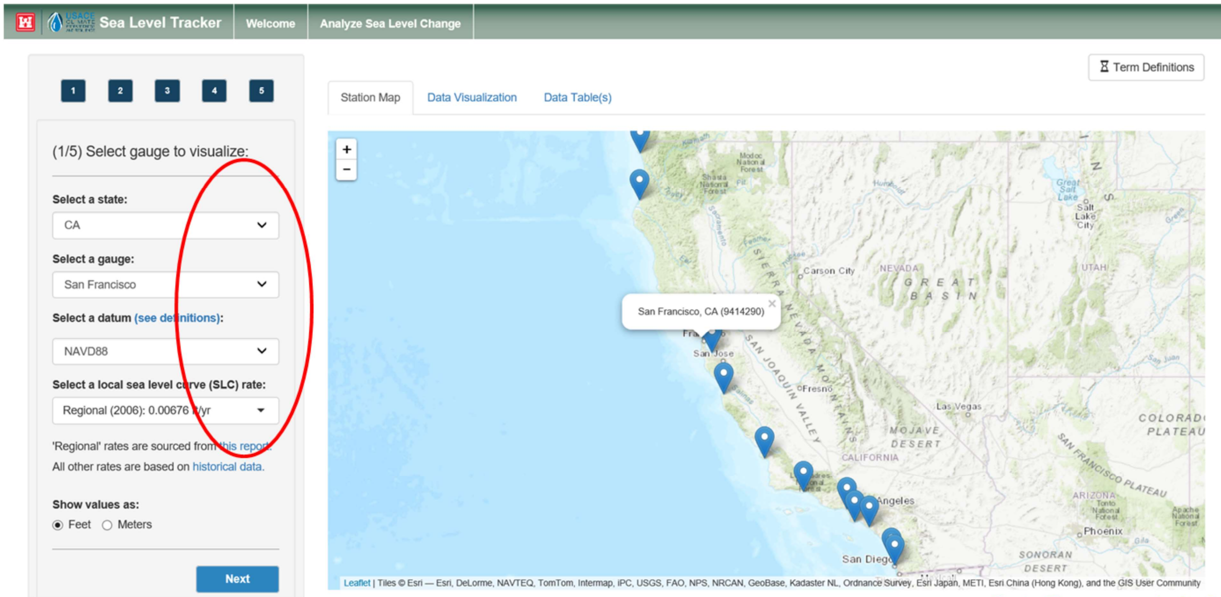


- In most cases, the most effective way to employ the USACE sea level scenarios is in a "when, not if" context, assessing uncertainty in the timing of impacts ("horizontally") rather than as an uncertain condition in some fixed future year ("vertically"). This approach allows potential project impacts and adaptation pathways to be bracketed in time. When formulating alternatives it is most helpful to think about when the project area may be affected by water overcoming local landforms. When assessing the performance of a given alternative this approach points to the dates when the project may be expected to non-perform and/or be damaged. In most cases it is not economical to build projects that are so robust as to perform over their entire design lives and the full range of future sea levels, so we employ adaptable designs instead. The "when, not if" approach tells us when adaptation actions are likely to be needed.
- Non-adaptable designs built only for present conditions are not policy compliant. Per the USACE climate adaptation policy statement, adaptation is not optional. Such designs do not "outcompete" adaptable ones on cost – they don't perform!
- Note that performance means different things for different projects. In FRM performance means reducing risk, but whether risk is to be reduced to some level or by some amount depends on the project



- The CPR CoP has created two web tools to help make sea level analyses easier, faster, cheaper, and more consistent than simply requiring teams to do all analyses from scratch. The Sea Tracker tool helps with observing sea level changes in the past, and will be demonstrated first. The sea level curve calculator will be shown afterward.
- The first of the two URLs at the bottom of the page will take you to the portal for all CPR CoP tools, including Sea Tracker. The second URL is the public-facing website for USACE climate activities and hosts the CPR tools that are open to the public, including Sea Tracker.
- The Sea Tracker has too many capabilities to demonstrate them all here, so you are encouraged to explore the tool and associated user guide. The simple analysis shown here starts with selecting a tidegage from the map or the pulldown list.

TOOLS FOR SEA LEVEL ANALYSIS: SEA TRACKER



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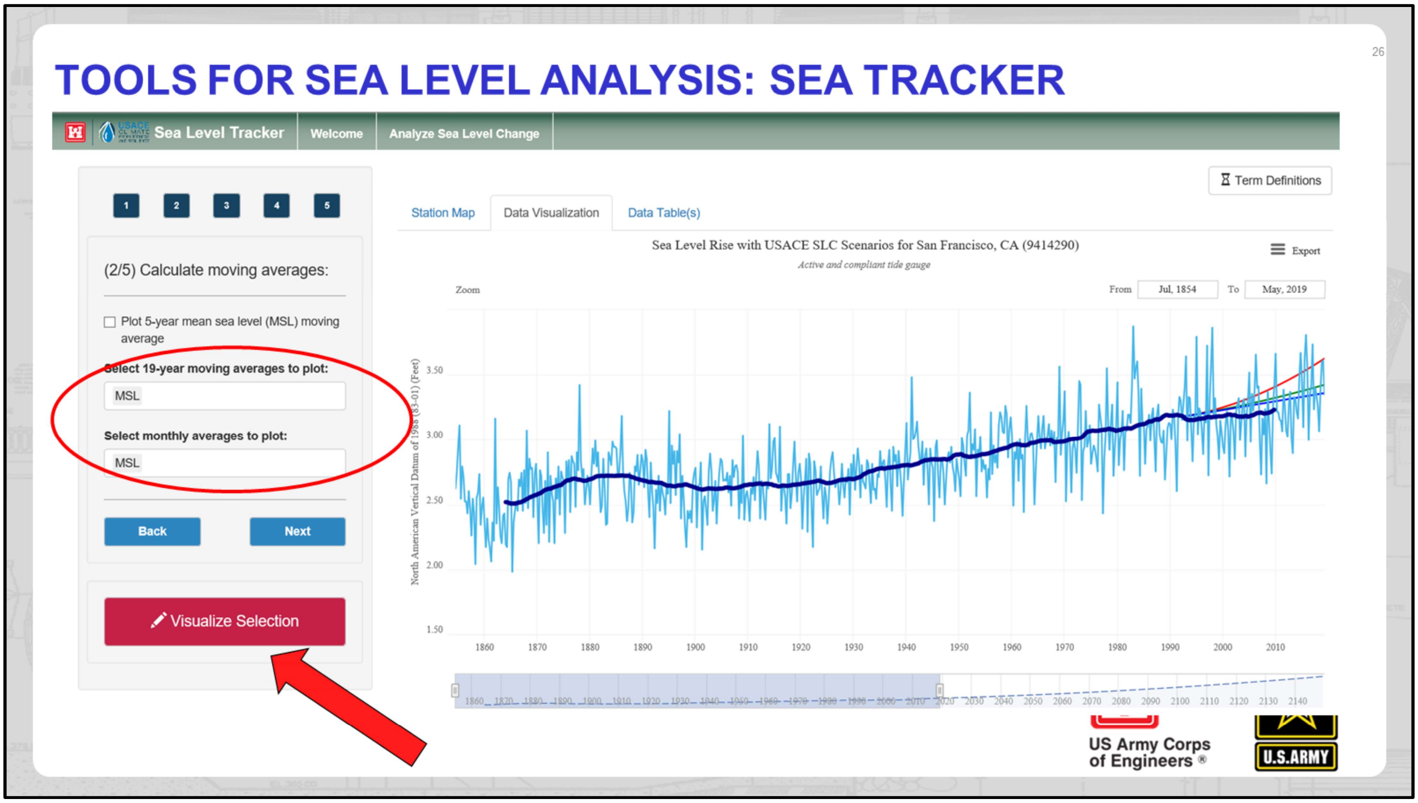
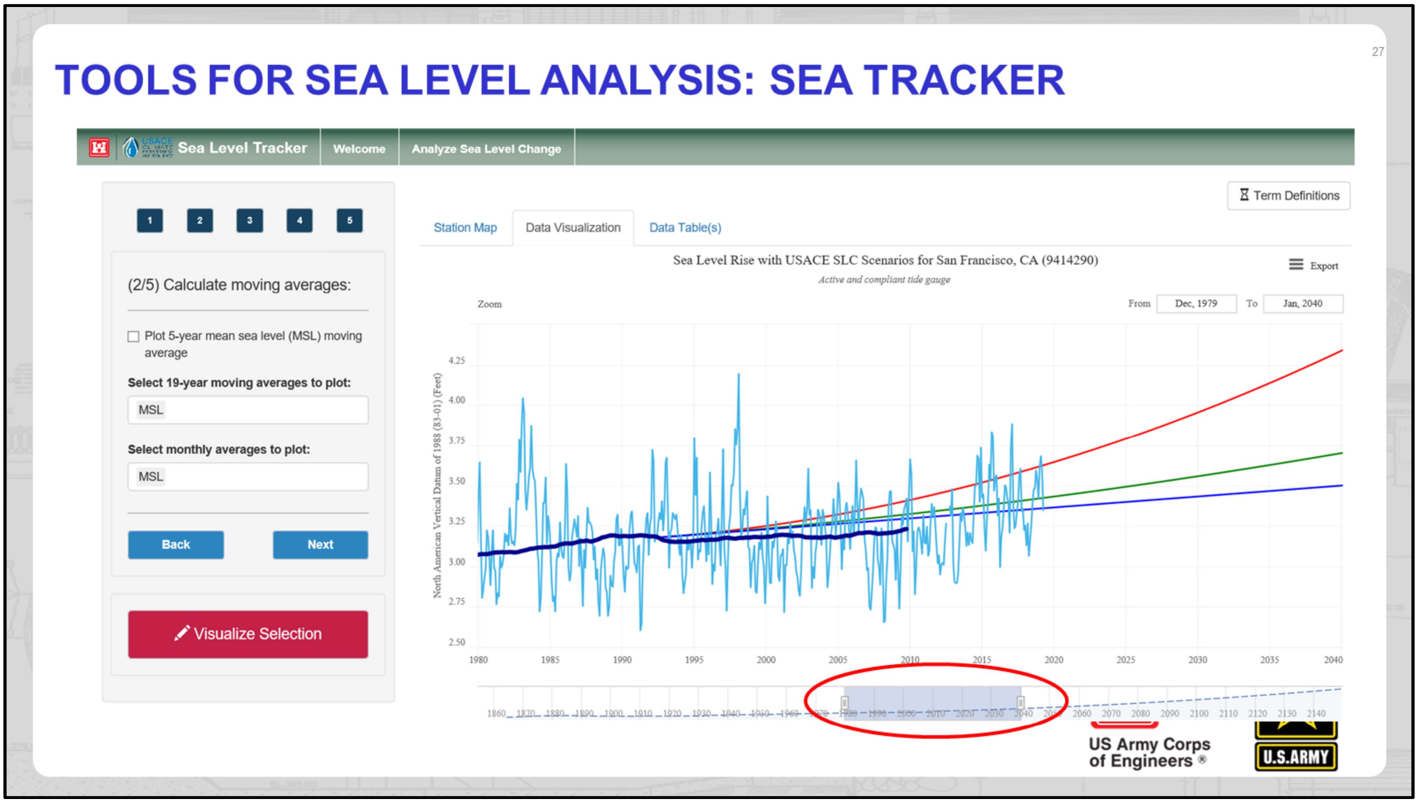
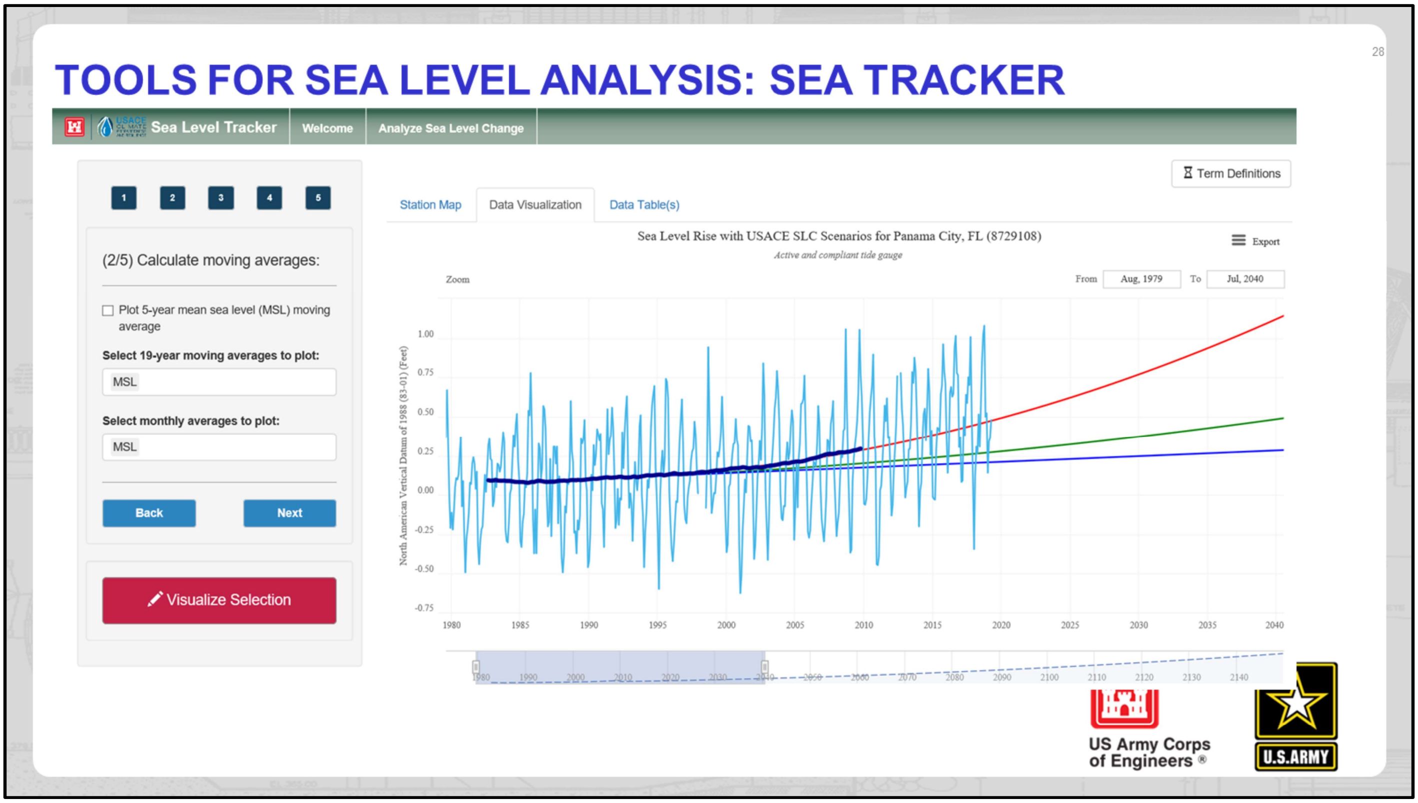
- After choosing a state, the user can select a gage, a terrestrial datum, and a period of analysis for past sea level change



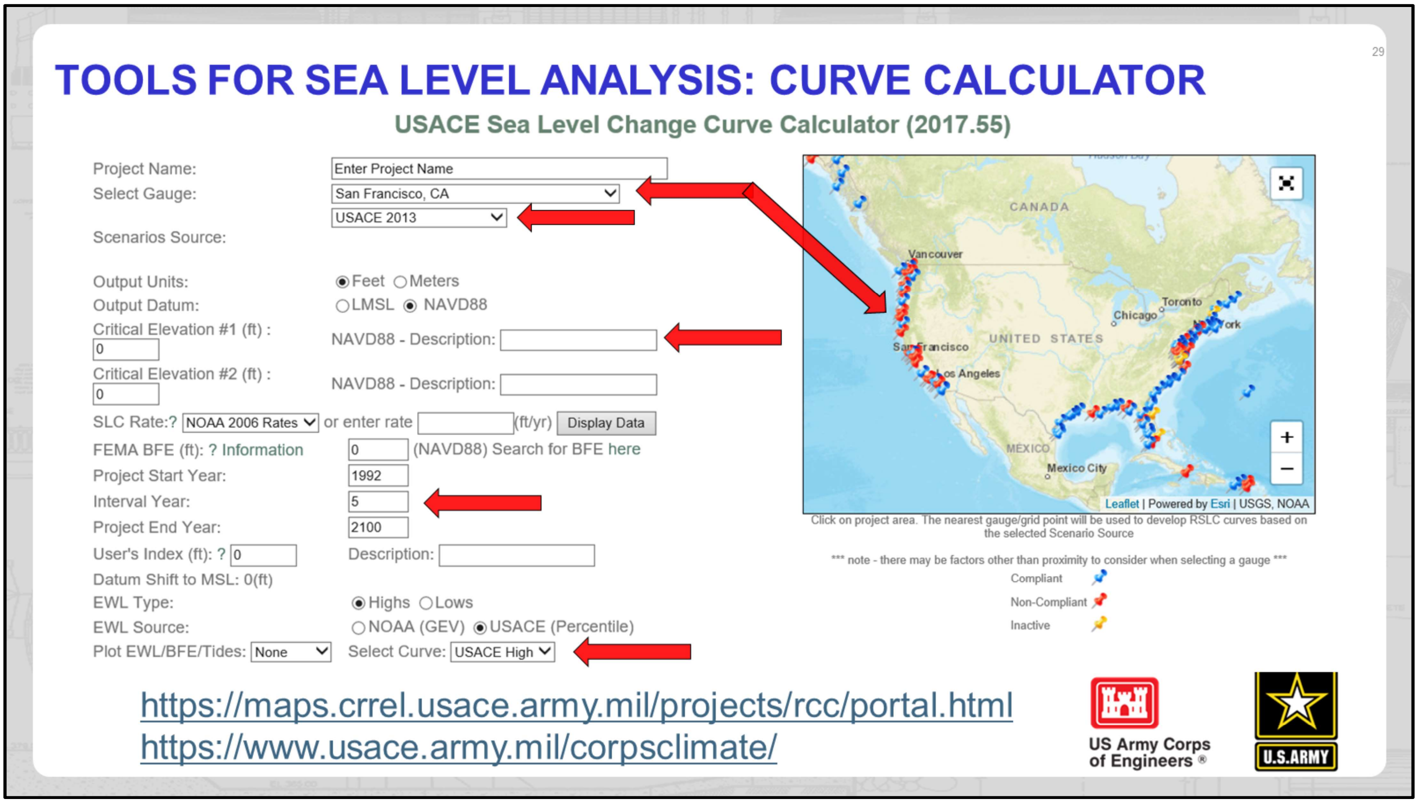
- Many different water level datums and quantiles can be plotted in the Sea Tracker. Here we will examine mean sea level using the standard 19-year moving window as well as the monthly average water levels. The three sea level scenarios are also shown for comparison.
- We see that the monthly variability dominates the trend in sea level and the difference between the three curves. Sometimes we get overly focused on mean sea level scenarios, when inter- and intra-annual variability already makes water levels change more in a month or two than the average may change for many years!
- We can also see that sea level has gone through cycles of faster and slower changes, but that it still rises overall in the long run



- The slider bar at the bottom of the page allows us to zoom in on a time period of interest
- Here we see the 19-year moving average sea level at San Francisco has been trending below the USACE Low scenario since the early 1990s. Does that mean that sea level has stopped, or that projects here should only use the Low curve? NO! Remember that sea level rises in fits and starts – it might be slow for awhile and then speed up again. Even though we might be lower than the Low right now, by policy we still consider the range from Low to High to represent the best estimate of reasonably plausible future conditions for planning purposes. The three scenarios are not highly differentiated in the near term, so we can't use a difference of inches to choose which curve is "best" for a study. Instead we use the "when, not if" approach.
- We *may* use the findings here to decide to assess another scenario in addition to the USACE scenarios, but we can't replace our scenarios with new ones based on past data. Recall that local land movement and regional effects are already incorporated into the curves.



- Whereas the running average sea level in San Francisco is presently lower than the Low curve, the opposite is true in Panama City Beach, where the observed sea level is higher than the High scenario, at least for now. We still consider the three curves our best representation of future conditions until the next guidance update.
- When new sea levels are published in the next few years, the new curves will incorporate the latest updated observed conditions.



- The second tool shown today is the curve calculator, which is the first tool created by CPR CoP. It makes sea level analysis fast and easy, and creates familiar plots and tables for the benefit of technical and policy compliance reviewers.
- The calculator has many capabilities but I will focus on just a few. The top arrow shows how to select a gage for analysis by either clicking on the map or choosing from the pulldown menu.
- The second arrow shows where you can choose which scenarios to assess. USACE 2013 is the set required by ER 8162 but other scenarios developed by NOAA and other can be investigated as well.
- The third arrow points where to input a critical elevation for “when, not if” analysis. This elevation will appear on the curve plot and will generate a table of impact timing.
- The fourth arrow indicates where the project start and end data can be adjusted, along with the interval in the output table
- The bottom arrow shows where extreme total water levels can be added to the mean sea level curves

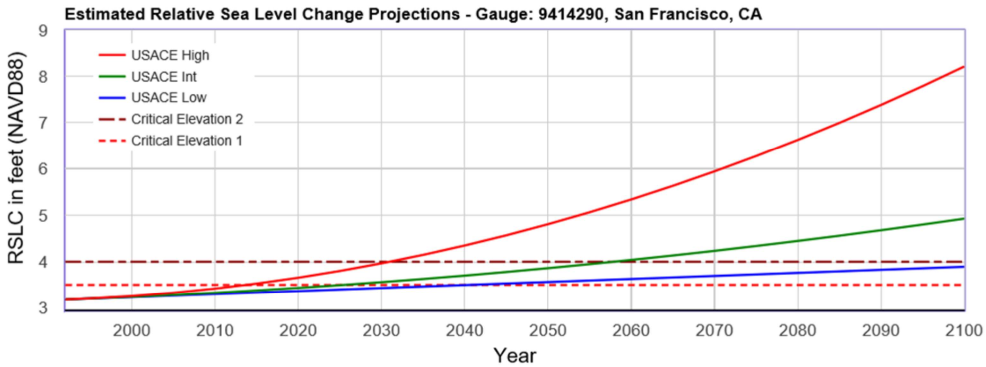
TOOLS FOR SEA LEVEL ANALYSIS: CURVE CALCULATOR

30

9414290, San Francisco, CA
NOAA's 2006 Published Rate: 0.00659 feet/yr
All values are expressed in feet relative to NAVD88

Year	USACE Low	USACE Int	USACE High
1992	3.18	3.18	3.18
1995	3.20	3.20	3.20
2000	3.23	3.24	3.26
2005	3.27	3.28	3.33
2010	3.30	3.33	3.42
2015	3.33	3.38	3.53
2020	3.37	3.43	3.66
2025	3.40	3.49	3.80
2030	3.43	3.56	3.97
2035	3.46	3.63	4.15
2040	3.50	3.70	4.35
2045	3.53	3.78	4.57
2050	3.56	3.86	4.81
2055	3.60	3.95	5.07
2060	3.63	4.04	5.34
2065	3.66	4.14	5.64
2070	3.69	4.24	5.95
2075	3.73	4.34	6.28
2080	3.76	4.45	6.63
2085	3.79	4.56	7.00
2090	3.83	4.68	7.39
2095	3.86	4.80	7.79
2100	3.89	4.93	8.22

Print Table



Curve Intersections	Critical Elevation #1 (yr)	Critical Elevation #2 (yr)	BFE (yr)
USACE High	2013	2030	N/A
USACE Int	2025	2057	N/A
USACE Low	2040	2116	N/A

Print Intersections Table

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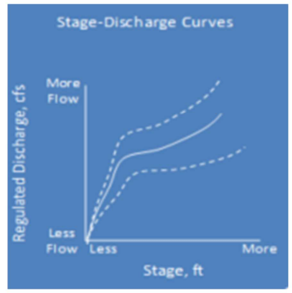
- Here we see the output after having selected the San Francisco tidegage and critical elevations of 3.5 and 4.0 feet NAVD88
- The plot and table can be printed or cut and pasted directly into a project report
- The intersection table shows that the first critical elevation may be exceeded as early as the year 2013 (note that we have uncertainty even about *present* sea level!) or as late as 2040. This time bracket helps inform adaptability in formulation and adaptation actions in performance evaluation.

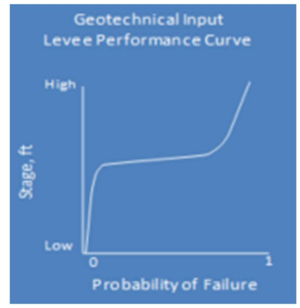
ECONOMIC ANALYSIS WITH SLC

<u>**3 primary technical disciplines affected by SLC:**</u>

- **Hydraulics**
  - Flow-stage relationship
  - Frequency-stage relationship



- **Geotech**
  - Frequency-failure relationship



- **Economics**
  - Stage-damage relationship
  - Frequency-damage relationship
  - Project performance

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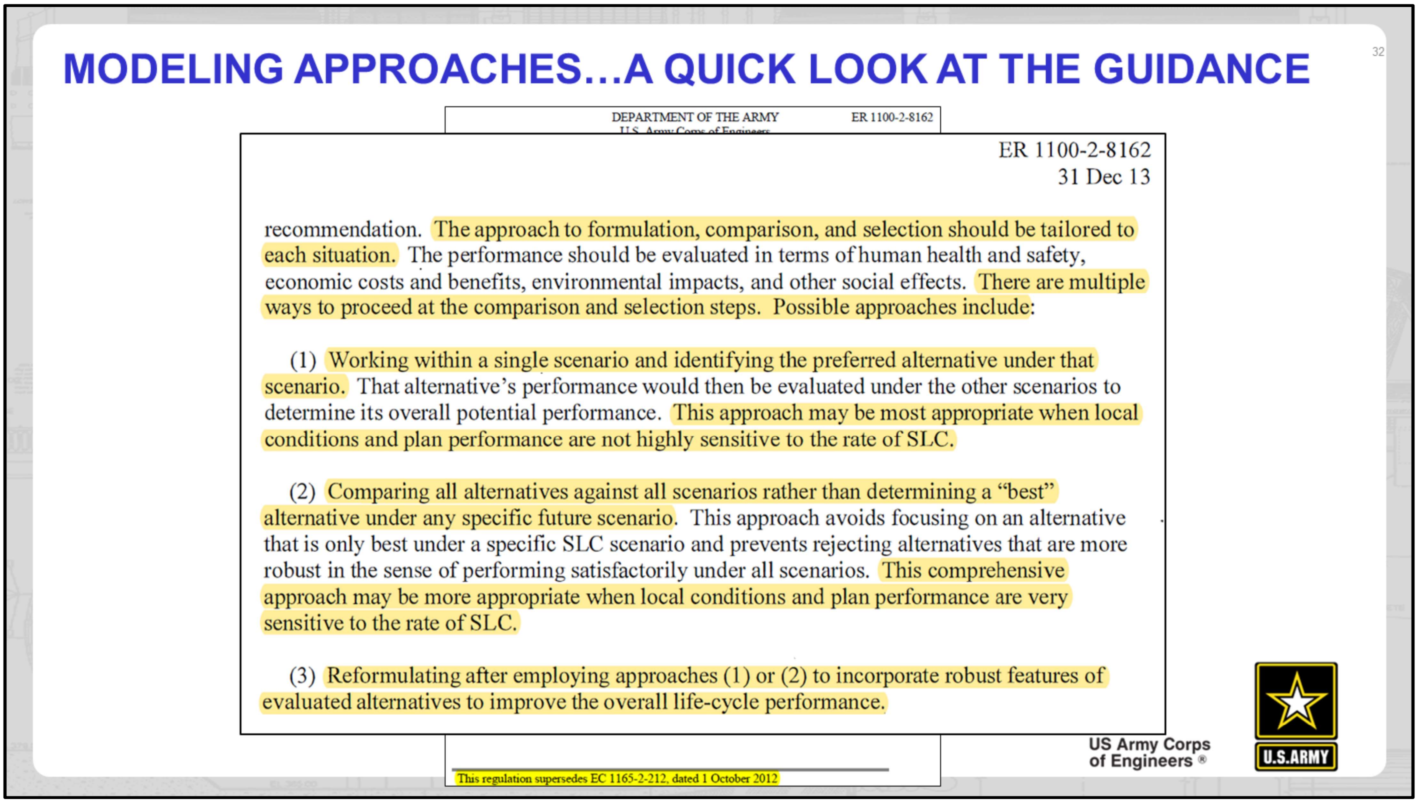
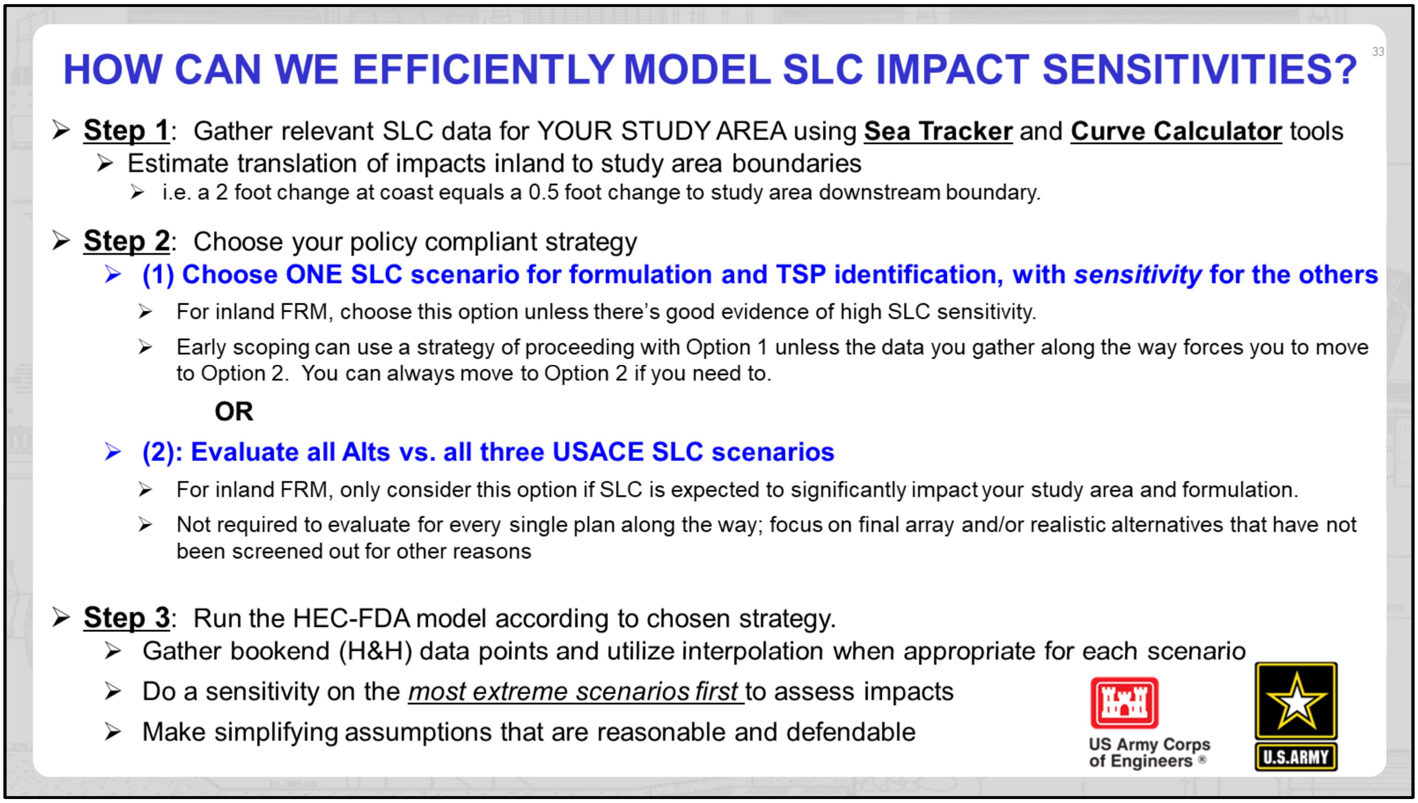
- Changes to the flow-stage and/or frequency-stage curves due to climate change will roll into Geotech and Economics as well. But the trigger for the change comes from the H&H.

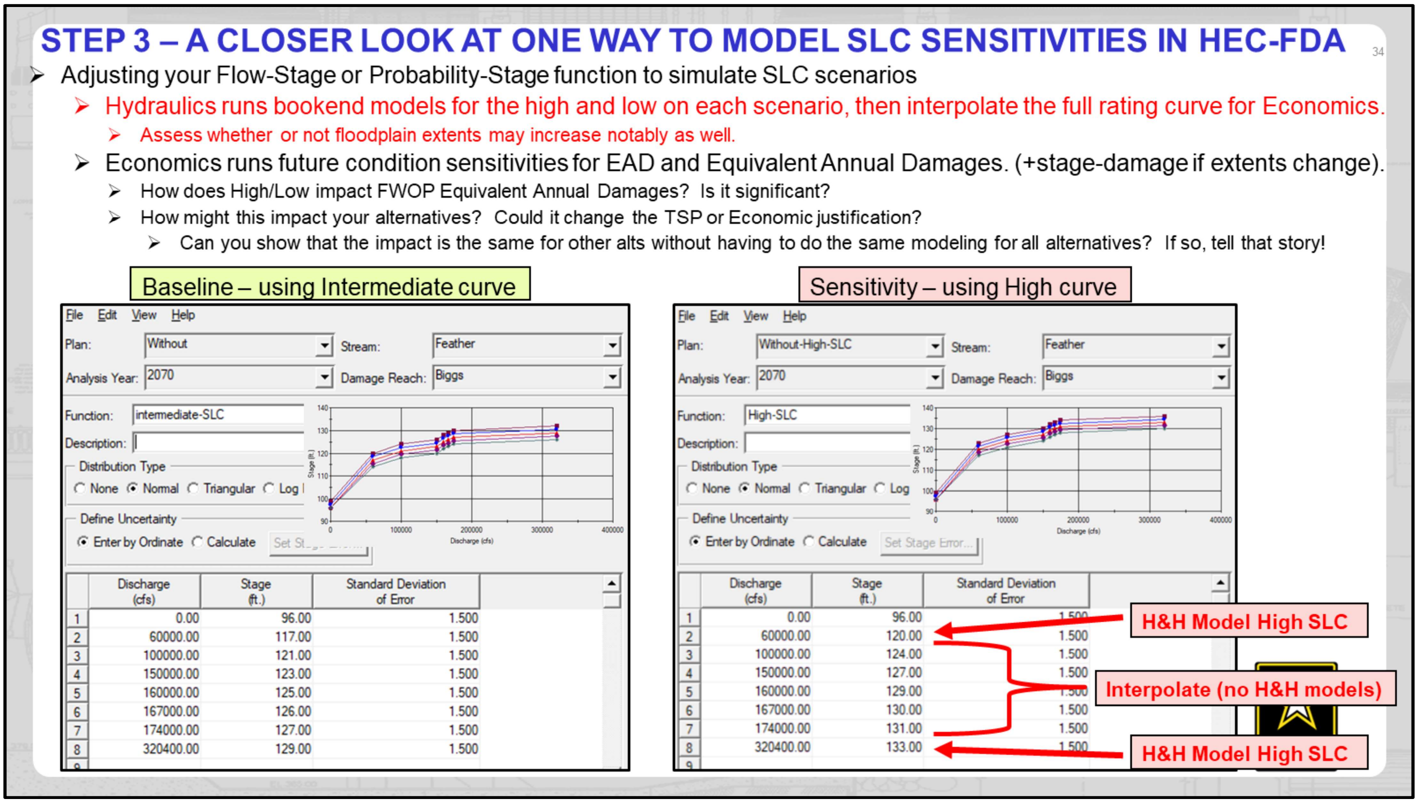


- Some excerpts from the guidance.
  - Note the hints at when to use each scenario
    - For Scenario 1: "This approach may be the most appropriate when local conditions and plan performance are not highly sensitive to the rate of SLC."
    - For Scenario 2: "This comprehensive approach may be more appropriate when local conditions and plan performance are very sensitive to the rate of SLC."



Slide is fairly detailed and self explanatory here:

- Step 1: Use reasonable approaches to assess the potential sensitivity to your study area (and the downstream boundary conditions to SLC.
    - Look at upstream translation of increases.
    - Start with the high curve. If it's not sensitive to the high curve, then it's not going to be sensitive to the others.
- Step 2: Choose the right option for your study area
- Step 3: Find efficient and effective ways to run HEC-FDA for either full analysis or sensitivities.
    - Again, focus on the most extreme scenarios first and work your way to the others if it proves sensitive.
    - Gather endpoint data and utilize interpolation where possible.



- Graphics show an example of adjusting the rating curve in HEC-FDA to run a sensitivity on the High SLC scenario.
  - Model the endpoints and then do linear interpolation in-between. Then re-run Expected Annual Damages for the future condition and Equivalent Annual Damages.
    - Also need to consider if the floodplain extents are changing and if so, then the stage-damage curve will need to be re-run before the Equivalent annual damages.
      - This would entail updated floodplains or again running the endpoint floodplains and making some simplifying (but reasonable) assumptions to save model run times.
  - This is one way to do it, but there are other possibilities. Contact the FRM-PCX for additional ideas and strategies.
- Also need to check project performance statistics as part of the sensitivity. How does plan performance change over time?
  - Is there a trigger point when it stops performing and if so, what are the date ranges that it might occur based on the different SLC curves?
    - Use the Curve Calculator Tool!

EXECUTIVE SUMMARY OF SLC TOOLS AND BEST PRACTICES FOR INLAND FRM

- **The "so-what"**: Sea level will continue changing into the very far future
  - USACE projects must perform as intended/communicated anyway
- Several FRM impacts from sea level change
  - Flowline
  - Sedimentation
  - Shift in governing design condition
- Best practices:
  - Datums; Total water levels
  - "When, not if"
- **Policy**: USACE sea level guidance uses scenario projections. Plan Form must:
  - (1) Formulate under one scenario, then check performance under the other two, **OR**
  - (2) Evaluate all alternatives under all scenarios
- **Step 1**: Use Tools very early to gather data in the study area to inform formulation and scoping
  - Sea Tracker
  - Curve Calculator
- **Step 2**: Choose the most appropriate policy compliant plan form approach for your study (see above)
  - For inland FRM, consider starting with Option 1, but be ready to move to Option 2 if new data gathered requires it
- **Step 3**: Economic Analysis
  - Utilize sensitivity analysis wherever possible
  - Look at the most extreme scenarios first to assess impacts
  - Use solid and defendable qualitative reasoning where possible to limit modeling

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- What if the local sponsor or other stakeholder wants to assess their own sea level scenarios? This is specifically allowed in the guidance per ER 8162, though it might be hard to find (it's in paragraph B-4.a.). Additional scenarios may be assessed **in addition to** the USACE scenarios, not as a replacement for them. Please contact a CPR SME or your policy compliance reviewer if you have questions.

QUESTIONS / FEEDBACK?

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  - 916-557-6711, Nicholas.J.Applegate@usace.army.mil
- **Will Veatch** (MVN, Climate Preparedness and Resiliency)
  - *504-862-2858, William.C.Veatch@usace.army.mil*

Please contact us with:
- Questions?
- Comments?
- More/less helpful than a live webinar?
- Recommendations for improvement?

FRM-PCX POC's:
- **Eric Thaut**, *Deputy Director*
- **Nick Applegate**, *National Tech Specialist (Economic and Risk Analysis)*
- Regional Managers:
  - **Karen Miller** *(LRD/NAD)*
  - **Michelle Kniep** *(MVD/SAD)*
  - **Charyl Barrow** *(NWD/POD)*
  - **Sara Schultz** *(SPD/SWD)*

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