Appendix F Quarterly Research Update Meeting and Independent Science Panel Meeting Summaries

As detailed in Section 2.3 of this report, the Independent Science Panel (ISP), Sand Studies Technical Advisory Committee (STAC), and study teams underwent an iterative process to share progress and interim findings throughout the duration of the studies. That iterative process included Quarterly Research Update Meetings and the summaries from those meetings are included in this Appendix. The meeting summaries reflect the iterative, cumulative process of understanding individual study findings in the broader context. As you review these notes, you will see how the information evolves over time.

All Meeting Summaries were prepared by the independent study coordinator and distributed to the ISP and STAC for timely review and comment. Because the independent study coordinator was not hired until Quarterly Research Update Meeting 5, there are no meeting summaries available for Meetings 1-4. In place of summaries, Agendas for those meetings are included in this Appendix.

Documents include:

- Quarterly Research Update Meeting 1 Agenda: April 29, 2021
- Quarterly Research Update Meeting 2 Agenda: August 18, 2021
- Quarterly Research Update Meeting 3 Agenda: November 3, 2021
- Quarterly Research Update Meeting 4 Agenda: February 23, 2022
- Quarterly Research Update Meeting 5 Summary: May 26, 2022
- Quarterly Research Update Meeting 6 Summary: August 17, 2022
- Quarterly Research Update Meeting 7 Summary: November 15, 2022
- Quarterly Research Update Meeting 8 Summary: January 25, 2023
- Quarterly Research Update Meeting 9 Summary: April 5, 2023

Sand Mining Studies Quarterly Meeting 1

April 29, 2021, 2:00 – 4:00 pm

Zoom: https://zoom.us/j/96856360411?pwd=SXBvcndvbUJZQmJZVUp5OHNuem9qZz09

Attendees: (based on Doodle and Calendar RSVPs)
ISP: John Largier- UC Davis, Paul Work- USGS, Bob Battalio- ESA Consulting
SFEI Team: Scott Dusterhoff, Lester McKee, Jeremy Lowe, Cristina Grosso, Jennifer Hunt, Tan Zi, Bruce Jaffe and Mathieu Marineau – USGS, Edwin Elias – Deltares
Anchor QEA: Michael MacWilliams, Aaron Bever
STAC: Tina Lau and Mike Bishop- Lehigh Hanson, Bill Buttler- Lind Marine, Jayme Ohlhaver-US Army Corps of Engineers, Sara Azat- NOAA Fisheries, and Wendy Kordesch- NOAA
BCDC: Brenda Goedon and Pascal Soumoy
SCC: Marilyn Latta and Erica Johnson

Desired outcome: The sand study contractors – SFEI, Anchor QEA and the ISP will address any remaining questions or comments about the research approach that would help the contractors get their studies underway. SCC will facilitate establishing when quarterly meetings will take place in the future. STAC, BCDC, and SCC will be allotted time for questions and to also to give brief sand study related updates.

Agenda

1. Welcome & Introductions ~5 min
   a. Review desired outcomes
   b. Consent to be recorded (or please hide video and mute mic)

2. Sand Budget/Bedform analysis (SFEI) ~45 min
   a. Brief summary of research approach ~5 min
   b. Questions / Discussion with ISP or other teams ~30 min
   STAC/BCDC/SCC Questions ~10 min

3. Sand Transport Modeling (Anchor QEA) ~45 min
   a. Brief summary of research approach ~5 min
   b. Questions / Discussion with ISP or other teams ~30 min
   c. STAC/BCDC/SCC/ Questions ~10 min

4. Logistics ~5 min
   a. Input from contractors on quarterly interval
   b. Comments on structure of meetings

5. Updates/next steps ~5 min
   a. Sand Study Coordinator
   b. Any follow-up required?
6. Adjourn Meeting

Sand Mining Studies Quarterly Meeting 2

August 18 2021, 10:00 – 12:00 pm

Zoom: https://zoom.us/j/99863619627?pwd=dEk1K3c3cGdETVI4L0M4aEh0bnNEQT09

Attendees: TBD

ISP: John Largier- UC Davis, Paul Work- USGS, David Schoellhamer-USGS Emeritus, Bob Battalio-ESA Consulting

SFEI/Deltares/USGS Team:

UT Austin/USGS Team:

STAC:

BCDC: Brenda Goeden

SCC: Erica Johnson, Marilyn Latta

Desired outcome: The UT Austin/USGS Team will be attending their first quarterly meeting and providing the STAC and ISP a brief overview of their scope as a refresher, then address any remaining questions or comments about the research approach or data needs that would help them get their studies underway. The SFEI/Deltares/USGS Team has had some work underway and will be reporting out what they have worked on thus and having discussions that will help them continue and plan for the work ahead. STAC, BCDC, and SCC will be allotted time for questions and to also to give brief sand study related updates.

Agenda

1. Welcome & Introductions ~5 min
   a. Review desired outcomes / Quick recap on where to find meeting materials
   b. Consent to be recorded (or please hide video and mute mic)

2. Stratigraphy (UT Austin/USGS) ~45 min
   a. Brief summary of research approach ~5 min
   b. Questions / Discussion with ISP or other teams ~40 min
      i. Any data needs from STAC?

3. S Sand Budget/Bedform analysis (SFEI/Deltares/USGS) ~50 min
   a. Subembayment boundaries ~ 15 mins
   b. Bathymetric change analysis (Bruce Jaffe) ~15 mins
   c. Baywide sand budget analysis (Lester McKee) ~15 mins

4. Logistics ~5 min
   a. Data Sharing
   b. Sand Study Coordinator

5. Adjourn Meeting

Sand Mining Studies Quarterly Meeting 3

November 3, 2021 from 10:00 – 12:00 pm

Zoom: https://zoom.us/j/91646982114?pwd=aERaUWowOVA3UmFpS2tsckJXUGJ6QT09

Attendees: TBD

ISP: John Largier-UC Davis, Paul Work-USGS, David Schoellhamer-USGS Emeritus, Bob Battalio-ESA Consulting, Craig Jones – Integral Consulting

SFEI/Deltares/USGS Team: Scott Dusterhoff

UT Austin/USGS Team: Matthew Malkowski

STAC:

BCDC: Brenda Goeden

SCC: Erica Johnson, Marilyn Latta

Desired outcome: The Stratigraphy (UT Austin/USGS) and Sand Budget/Bedform analysis (SFEI/Deltares/USGS) teams have been collecting and analyzing data. Both teams will provide an update on their work completed since the last quarter, % completion of each task, and their next steps (~15 minutes each). Committee members can ask each team questions about their work completed thus far. We will then move into discussion items if any.

**The Sand Transport Modeling (Anchor QEA) team has begun analyzing raw data and background info, however the bulk of their work will take place after the data hand-off from the SFEI team.*

Agenda

1. Welcome ~5 minutes
   a. Review desired outcomes / Quick recap on where to find meeting materials
   b. Consent to be recorded (or please hide video and mute mic)
2. Progress Reports ~20-40 minutes
   a. Stratigraphy (UT Austin/USGS) - Mathew Malkowski
   b. Sand Budget/Bedform analysis (SFEI/Deltares/USGS) - Scott Dusterhoff
3. Discussion ~30 minutes
   a. SFEI/Deltares/USGS
      i. Approach to sediment budget development
   b. Follow-up on data needs
4. Logistics ~5 minutes
   a. Sand Study Coordinator Update
5. Adjourn Meeting

Sand Mining Studies Quarterly Meeting 4

February 23, 2022 from 10:00 – 12:00 pm

Zoom: https://us06web.zoom.us/j/85919341785?pwd=dXhHcFNuWTAzajE0WmNSTnhRcnhkZz09

Attendees:

ISP: John Largier-UC Davis, Paul Work-USGS, David Schoellhamer-USGS Emeritus, Bob Battalio-ESA Consulting (Craig Jones – Integral Consulting was unavailable at this time)

SFEI/Deltares/USGS Team

Anchor QEA

STAC: All members welcome

Desired outcome: Sand Budget/Bedform analysis (SFEI/Deltares/USGS) team will provide an update on their work completed since the last quarter, % completion of each task, and their next steps. Committee members can ask each team questions about their work completed thus far. SFEI will be preparing to hand off data to Anchor QEA for Sand Transport modeling in Spring.

Reminder to all researchers: Please include a list of citations for all papers you are relying on to conduct your research in your draft and final synthesis reports.

Agenda

1. Welcome/updates ~10 minutes
    a. Review desired outcomes / Quick recap on where to find meeting materials
    b. Consent to be recorded (or please hide video and mute mic)
    c. State Lands Commission RFP - Chris Huitt (5 mins)
2. Progress Reports ~50 minutes
    a. Sand Budget/Bedform analysis (SFEI/Deltares/USGS) - Scott Dusterhoff
        i. Annotated Bibliography completed
        ii. Update on Task 1: Bay tributary sand supply, flood control channel sand removal, and the Bay sand budget
        iii. Update on Task 2: Sand Transport Analysis
3. Discussion ~30-50 minutes
    a. Sediment transport modeling simulation periods - Aaron Bever (20 mins)
    b. Sand deposition at San Francisco Marina entrance – Bob Battalio (20 mins)
4. Logistics ~5 minutes
    a. Follow-up on Existing Data – Cristina Groso
5. Adjourn Meeting

Sand Mining Studies Quarterly Meeting 5
Virtual Meeting (Zoom)
May 26, 2022, 1:00 – 3:00 pm

Discussion Highlights

Meeting Goals:

- Receive updates from Sand Budget/Bedform analysis (SFEI/Deltares/USGS) and Sand Transport modelling (Anchor QEA) team on –
    - Work completed this quarter
    - Percent completion of each task
- Committee member and team member interaction and information sharing

Agenda:

1. Welcome, Updates, Introductions
2. Progress Reports
    a. Anchor QEA (Sand Transport Modelling)
        i. Update on model construction
        ii. Questions, Discussion
    b. SFEI/USGS/Deltares (Sand Budget)
        i. Sources and Sinks model and Mining Area Volume analysis
        ii. Questions, Discussion
    c. Next meetings
    d. Adjourn Meeting

Action Items:

#	Item	Owner	Timeframe
1.	Share Stantec's scope of work with the ISP and STAC.	Erica Johnson	Earliest Convenience
2.	Continue review of flood control channels depositional removal database and share information about sediment removal in flood control channels with Anchor QEA.	Lester McKee/SFEI	July
3.	Convene ISP meeting to determine additional model runs for Deltares to test in SedTRAILS, noting that the SedTRAILS analysis is separate from current sand research studies and is funded entirely through the USGS.	ISP	June
4.	Review and discuss bedform mobility analysis inconsistencies for Central Bay near Angel Island to determine if any refinements are required for analysis.	Deltares and ISP	June
5.	Continue compilation of dredging data for the Bay and share the navigation dredging data with other teams for consideration	SFEI	July
6.	Members of the ISP and STAC will continue to review SFEI's technical memos.	ISP, STAC	June

Attendance:

Sand researchers, members of the Independent Science Panel (ISP), Sand Study Technical Advisory Committee (STAC), Facilitators, and Observers (full list in Attachment A).

DRAFT SUMMARY

1. WELCOME, UPDATES, AND INTRODUCTIONS

Erica Johnson (SCC) opened the session, acknowledged each attendee, and received consent to start the meeting recording.

Erica introduced the Stantec team who are coming on board as coordinators. She provided an overview of their role and scope of work, which includes technical writing support and meeting facilitation. Additional detail on Stantec's scope will be sent to the ISP and STAC.

This Quarterly Meeting of the Sand Mining Studies Program is Lesley Ewing's last. Jeremy Smith will replace her as the representative from California Coastal Commission.

Erica reviewed and confirmed the agenda with the research teams.

2. PROGRESS REPORTS

a. Anchor QEA (Sand Transport Modelling)

Anchor QEA presented an update on their progress to-date. (See presentation slides included on SharePoint website.)

They have been integrating the output from SFEI's watershed model into the sediment transport model. They will take the freshwater fluctuations and incorporate into the sediment transport model so that the tributary influxes match the watershed model. This will help balance sand budgets between the Bay and the tributaries. Anchor QEA's efforts have focused on setting things up and therefore have not yet shifted to analyzing results. Anchor QEA shared details about the construction of the sediment transport model.

Questions and Comments

Sediment yield and time-step of model

Question (Q): How Anchor QEA is handling the time series analysis for sediment yield and, particularly, the specific timestep applied in the model runs.

Answer (A): Aaron Bever replied that they are using a daily time-step for hydrology and sediment loading simulations. The watershed model output data received also use a daily time-step. Michael MacWilliams (Anchor QEA) later clarified that the hydrodynamic model runs on a 90-second time-step and the daily flow and sediment data are linearly interpolated as inputs at noon for each day in simulations.

Bedload vs suspended load data

Q: Regarding volumes, is Anchor QEA considering the bedload and suspended load, or different sand texture classes (e.g., sand, finer than sand) separately or are the data aggregated?

A: They received one value for sediment load from the watershed model output, so they are using the aggregated sand texture classes for sediment load. Additionally, of the 88 subwatershed tributaries to the Bay, previously analysis only captured about 20 due to limited available data. The current hydrodynamic model includes inputs from the 88 subwatershed tributaries to the Bay and will capture more sediment inputs than previously estimated. They also conducted a detailed analysis of the flows and sediment loads from the watershed model relative to rating curves from USGS to confirm there were no major concerns. For each, there's a sand fraction and smaller than sand fraction. Once the sediment load data are imported to the model, the sediment load may be transported as either bedload or suspended load depending on hydrodynamic conditions.

Sediment captured in flood control channels

Q: How is Anchor QEA modeling the flood control channels downstream (or seaward) from gauges? Do the watershed models account for effects of the flood control channels downstream from the gauges? Previous analyses suggested that flood control channels can have a big effect on sediment loading into the Bay based on whether the channels are trapping sediment. If the channels' effects are not currently accounted for in the watershed model, presume that some review is occurring to determine if adjustments

are required to account for effects of potential trapping of sediment in the flood control channels. A follow-up question was asked about how the watershed model data outputs for sediment budget are being reconciled for specific locations as inputs to the hydrodynamic model in effort to assure that the spatial representations within the watershed and Bay (hydrodynamical) models are correct/consistent.

A: In general, the watershed model accounts for each subwatershed draining all the way into the Bay. Hydrodynamic model analyses are being performed in a manner that assures consistency with the watershed model. SFEI provided background information about the watershed model, noting that there is some level of accounting for storage of sediment in flood control channels, particularly where geometry of the channels is well defined. SFEI analyzed depositional processes based on empirical data and noted that there are some inconsistencies in the input data time-steps (e.g., some sediment budget data are based on annual records of dredging within the flood control channels). SFEI is working to reconcile these items as they continue their sand budget analysis. Some flood control channels and their sediment storage characteristics have been quantified where geometry data are available. Sediment removal and sediment storage characteristics will also be reconciled; however, the amount of sediment removed from flood control channels is very small in comparison to the amount of sand mining and in-bay dredging. SFEI will share these data with Anchor QEA.

Uncertainty of sand grain size and implications for transport

Q: What are the implications of use of one sand size/texture class? It is important to represent different sand size/texture classes to better understand the transport mechanisms.

A: Likely that results are going to demonstrate more transport of the sand due to use of one sand size/texture class. Capacity to simulate different sand texture classes may be limited, but current analysis provides for much better understanding of sediment budgets by texture classes than previously analyzed. Understanding of the implications of use of one sand size/texture class for analysis will be important for interpretation of simulation results.

Comment: SFEI also suggested that, based on a recent literature review, the sand size/texture classifications associated to the sand being mined/removed from the Central Bay suggests that these sands are mostly transported as bedload rather than water column, so the challenge will be to simulate transport of those sands as bedload in hydrodynamic model.

Q: It's been observed that although some sediment is excavated the flood control channels, an unknown amount does make its way to the Bay. There is also a magnitude of sediment loads in the tributaries, the Yolo Bypass as an example, where massive amounts of sediment are pulled out. Are Anchor and SFEI collaborating to determine the value? What is the impact of the unknown amount of sediment on sand transport in the Bay?

A: SFEI's work has centered on quantifying sediment in the open waters of the Bay and considers inputs from the Delta (and Sacramento and San Joaquin rivers). SFEI is currently working on revised sediment supply to Bay from the Sacramento and San Joaquin rivers. Some key questions remain regarding the boundary conditions for the watershed versus hydrodynamic models and may require further reconciliation.

b. SFEI/USGS/Deltares (Sand Budget)

SFEI provided background information about their team's work on development of an updated sand budget for the Bay and sand transport study. SFEI is conducting analysis of sand supplies to the Bay from the Delta and local tributaries; USGS is conducting erosional and depositional analysis of the Bay. These two studies and associated reports will provide a contemporary understanding of the Bay's sand budget over the past 20 years. For the sand transport study, Deltares is evaluating sand movement around mining areas to understand effects of sand mining on sediment transport around the Bay.

Deltares provided an update on Task 2, the Sand Transport Study. (See presentation slides on the SharePoint.) Objectives of the study are to investigate the impact of sand mining on bedforms and sediment transport in SF Bay through: understanding bay-scale morphodynamic change; quantifying bedforms and bedform mobility in and around the mining sites; and investigations of sediment transport pathways (in collaboration with the USGS).

Deltares shared information about their investigations of Bay-scale sediment transport pathways. Their investigations utilize the Delft3D-FM community model as a base to compute flow and sediment transport. Investigations also use SedTRAILS (Sediment Transport Visualization & Lagrangian Simulator) to visualize the transport pathways across the entire Bay or for specific areas. They noted, however, that application of SedTRAILS is not a replacement of other ongoing modeling efforts, but a different approach that will help the team to integrate studies and test data-based hypotheses. The effort does not replace the model or supply volumetric information. Their analysis evaluates pathways and connections. They are still working out the methods and so not able to share results yet.

They also provided an introduction to SedTRAILS using an example from the Columbia River. By asking specific queries, they are able to unravel the tangled data results and particular transport pathways emerge. They can also reverse-engineer the origins of sand that ends up in a mining area. They can see which particles interact with the dredge sites. The tool can be used to explore many different interactions.

Questions and Comments

Seasonal transport

Q: Noting that the Coastal Commission is very concerned about sand leaving the Bay Area, they expressed appreciation for the role these simulated data will play in answering questions about transport pathways. They asked if they have observed seasonality in the transport pathways, thus suggesting that dredging or mining should occur on a seasonal basis.

A: If there is sufficient resolution of the seasonality of input conditions, they can simulate the pathways for those conditions.

Connections between models

Q: San Francisco Baykeeper expressed excitement for the study and asked how the Anchor QEA model will complement or supplement this effort and if there was some overlap in the scope.

A: While Anchor QEA's model does also simulate sediment transport, it is simulating sediment quantities and volumes. The Deltares model focuses on transport patterns and understanding the interactions of sand between different areas. Deltares' work does not yield volumetric estimates, which Anchor QEA's does. Ideally, they would use the Anchor QEA results to feed their model, but they have already found post-processing the data is challenging due to the domain size. Instead, they have applied a different solution for embedding computations into the code.

Comments:

- The effort associated with development and application of SedTRAILS for studies related to sand mining in the Bay is separate from current sand research studies and is funded entirely through the USGS.
- The USGS shared that when the model is up and running, they would like input from the ISP and from others on possible hypotheses to check. They will also take direction on which areas to track.
- BCDC suggested that SedTRAILS information should be incorporated in the synthesis to the extent possible as well as the Final Report because this seems to answer one of the key study questions. It is also bonus work connected to the work in the scope directly relevant to the main questions.

Grain size, month of study, and timeline

Q: Which grain size or size classes will they use in their SedTRAILS analysis, noting that the size withdrawn from the Bay is between .5 to 2 millimeters?

A: They'll do a sensitivity analysis to see if the pathways change based on grain size and they can adjust if they do see variation.

Q: Would there would be benefit in choosing either the same or different month of study for SedTRAILS analysis as used for Anchor QEA's sediment transport modeling?

A: The model's computational outputs are for shorter durations that can be simulated in parallel with other periods. This approach allows for isolating and comparing differences over various periods.

Q: Will the SedTRAILS study be completed by the end of the year?

A: They will be doing most of the work during summer, but it won't be finished in time for their detailed analysis. They noted, however, that they will be able to integrate information from the SedTRAILS analysis into the synthesis report, if desired.

Comment: It makes sense to evaluate sediment pathways relative to sediment budget. The team will need to consider if/how the ISP reviews the SedTRAILS analysis relative to other sand studies items.

Analyzing large regime-type events

Comment: The value of reviewing the pathways in the context of the sediment budget and suggestion that the ISP devote time to discussing it further. As scoped, the studies connect the bed changes and discharges.

Q: Specific large regime type events, such as large river discharge inputs through the Delta, large ocean waves, or storm surge from the ocean, spring tides, etc., play an important role in understanding nonlinear sand transport pathways and budgets outside of average conditions. Does the SedTRAILS analysis allow Deltares to evaluate effects of these large regime-type events on sediment pathways and budgets?

A: They will include regime-type events in their analysis.

Comments:

- Deltares requested that Bob send the questions he wants them to run, and they'll do it. The model's computational capacity is excellent, so it does not take long to test new questions. Even if a model run isn't reflective of a real condition, it does illustrate what's possible and can be educational.
- Bob suggested the ISP discuss and generate ideas to provide to the group and noted that Lesley and Jeremy are likely interested in the ocean-side results from the model.
- USGS reiterated that the SedTRAILS work is a separate add-on to current sand research studies and is funded entirely through the USGS.
- Bob clarified that additional questions/next steps could be prepared/pursued at the conclusion of their study.
- Lisa Beutler, in her role as a facilitator, observed that in a future meeting, the group can track how these efforts work together and consider how they will play together in the final report.

b. SFEI/USGS/Deltares (Sand Budget) *(continued)*

Deltares shared information about their analysis of large-scale morphodynamic change. They are using five bed-levels and polygons over the period from 1997 to 2019 to try to understand Bay-scale morphodynamic changes. Net volumetric change results, or volumetric changes relative to mining volumes, were shared from some polygons.

They also discussed the gross volumetric change analysis, or the total volumetric changes that occur, and morphodynamically active regions (bedforms). Their active bed analysis provides an estimate of the sediment volumes that are moving around in the system, noting that if sand is to be mined out, the volume change matters.

Analyses performed for simulation period 1997 to 2019 generally suggest a large scale or structural loss of sand in the system. However, additional analysis is required to understand whether or how much of the active sediment loss is attributed to mining.

Analysis allows for evaluating the extent of morphodynamically active sediments within the Bay and comparing to mining volumes. Results of bay-scale morphodynamic changes suggest sharp reductions in active bed levels between 1997 to 2008 at sand mining sites, continued reductions in active bed levels

around sand mining areas 2008 to 2019, reductions in active bed levels east of Angel Island, and increased active bed levels between 2008 and 2019 in the eastern section of Bay.

Questions and Comments

Erosion

Comment: Results show or suggest that some areas have a depleted active bed volume or not much of an active bed volume left. These areas could keep eroding further, or it may be that there is an active bed volume that does not show a net change. The results of the analyses demonstrate areas where active sand beds are eroded or eroding, as well as areas which retain sand better. These findings can be applied to the analysis of the amount of sand that moves around in the system to determine whether the relative amounts are significant or not. It was clarified that the results of the analysis are relative to the minimum bed level, which could erode further. Given a particular area of the Bay, the tool can evaluate how much is morphologically active and how that relates to the mining volume. The mined volumes are relatively large relative to the size of the active beds, however, in the context of the entire bed, the volumes are small.

Q: How were the 57 polygons determined for morphodynamic analysis?

A: The polygons are based on sedimentation and erosion patterns and the occurrence of bedforms.

Comments:

- It would be interesting to understand whether the extent of mining defines the lower limit of the active bed.
- More frequent surveys may help resolve the depth of active movement.

Bedform migration

Comment: Regarding Suisun Bay, analysis of bedform migration is challenging because there are no traceable bedforms within the mining areas. Deltares recommended a more frequent (rather than annual) sampling campaign would help inform predictions of bedform migration within the Suisun Bay lease/mining area.

Questions and Comments

Comment: The results for bedform migration within the Central Bay are not surprising, however there is hope that bedform migration may also be evaluated within the lease/sand mining area within Suisun Bay too, although it is understood that the Suisun Bay mining area is much smaller than the Central Bay lease/sand mining area. Deltares noted that they may be able to use areas near the mining sites in Suisun Bay to evaluate sediment transport rates, in addition to their sedimentation-erosion and morphodynamic analysis for Suisun Bay.

Deltares is also quantifying the bedforms and their mobility in the Central Bay. The group observed that one of the slides in the presentation shows intriguing differences between the experiential data and model output about the direction of sediment transport. Deltares will look into the inconsistency and noted that SedTRAILS analysis will support understanding of transport pathways.

Ongoing activities include estimating sand bedload by tracking individual dunes. They're preparing cross-sections and computing rates of volumetric change. Additionally, they're using a 2D sediment deposition method to estimate transport.

Comment: It will be interesting to see how the different methods address the conflicting sediment transport directions shown for Central Bay around Angel Island. Hydrodynamic conditions and currents in the area may attribute to the conflicting results.

Effects of navigation dredging

Q: Because navigation dredging activities in the Bay also remove sediment/sand, how may those activities confound the analyzed comparisons between the volumetric removal from sand mining versus morphodynamic changes? SFEI team is compiling dredging data for the Bay over the next few weeks and can share the navigation dredging data with other teams for consideration.

A: They haven't assessed that yet but could discuss the impacts from navigational dredging when they conduct the analysis and suggested further discussion on the topic.

3. NEXT MEETINGS

The sixth Quarterly Meeting (Q6) is scheduled for August 17. The Sand Budget, Transport Model, and Stratigraphy teams will share presentations. Erica distributed a SharePoint link to the group earlier where all deliverables are located.

The group discussed action items. (See Action Items on the first page.)

Topics for further discussion include exploration of model outputs, interconnections between studies, additional questions, and next steps outside the scope of the study.

Brenda inquired about the mass to volume conversion of SFEI's technical memos. Lester replied that they purposely did not convert mass to volume yet until there is consensus on the approach for the study, but they would include conversions in the final report. Brenda noted the difficulty of using the values as-is, since it is difficult to contextualize against the authorized mining volumes.

4. ADJOURN

The meeting adjourned at 3:05 p.m.

Attachment A – Attendance

SAND RESEARCHERS

Organization	Representative	Study Team
Anchor QEA	Aaron Bever Michael MacWilliams	Sand Transport Modeling
Deltares	Edwin Elias	Sand Budget and Transport
San Francisco Estuary Institute (SFEI)	Lester McKee Scott Dusterhoff	Sand Budget and Transport
U.S. Geological Survey (USGS)	Bruce Jaffe	Sand Budget, Stratigraphy

INDEPENDENT SCIENCE PANEL

Organization	Representative
Environmental Science Associates (ESA)	Bob Battalio
Integral Consulting	Craig Jones
University of California, Davis, Bodega Marine Lab	John Largier
USGS Estuarine Hydrodynamics and Sediment Transport	David Schoellhamer (Emeritus)

SAND STUDY TECHNICAL ADVISORY COMMITTEE

Organization	Representative	
Bay Keeper	Ian Wren	
Bay Conservation and Development Commission (BCDC)	Brenda Goeden Jamie Lopez	Julia Kelly Pascale Soumoy
California Coastal Commission	Jeremy Smith	Lesley Ewing
National Oceanic and Atmospheric Administration (NOAA) Fisheries	Sara Azat	
State Coastal Conservancy	Erica Johnson	Marilyn Latta
State Lands Commission	Chris Huitt	
Lehigh Hanson/ Martin Marietta	Erika Guerra Mike Bishop	Sean Riley
Lind Marine	Bill Butler	

FACILITATORS

Organization	Representative	
Stantec	Jamil Ibrahim Lisa Beutler	Marisa Perez-Reyes

OBSERVERS (Consultants to Lehigh Hanson)

Organization	Representative	
GHD Consulting Group	Aaron Holloway	Gillian Millar

Sand Mining Studies Quarterly Meeting 6
Virtual Meeting (Zoom)
August 17, 2022, 10:00am – Noon

Discussion Highlights

MEETING GOALS:

- Achieve the Independent Science Panel's (ISP) concurrence on the project team's research approach based on preliminary results
- Receive ISP feedback on any major concerns or challenges related to answering the sand management questions
- Share constructive alternatives, if any, to addressing sand management questions

ACTION ITEMS:

#	Item	Owner	Timeframe
1	Circulate San Francisco Bay Sand Transport Study Technical Memo	Erica Johnson	Aug 2022
2	Provide feedback to authors on the Technical Memo	ISP, STAC	Sep 14, 2022
3	Find opportunities for cross communication among the teams.	Teams, Erica Johnson	Ongoing
4	Assist USGS team with locating core data from Bay Bridge	Theresa Fregoso	Earliest convenience

ATTENDANCE:

ISP:

John Largier, UC Davis
Bob Battalio, ESA Consulting
John Largier, UC Davis
Craig Jones, Integral Consulting
David Schoellhamer, USGS Emeritus
Paul Work, USGS

RESEARCH TEAMS:

Stratigraphy	Matthew Malkowski and Zachary Sickmann University of Texas (UT), Austin,
Transport Modelling	Aaron Bever and Michael MacWilliams, Anchor QEA
Budget and Transport	Lester McKee and Scott Dusterhoff, SFEI
Budget and Transport	Edwin Elias, Deltares
Sand Budget / Stratigraphy	Bruce Jaffe and Theresa Fregoso, USGS

SAND STUDY TECHNICAL ADVISORY COMMITTEE:

Organization	Representative
Bay Keeper	Ian Wren
Bay Conservation and Development Commission (BCDC)	Brenda Goeden, Jamie Lopez, Julia Kelly, Pascale Soumoy
California Coastal Commission	Jeremy Smith
State Coastal Conservancy	Erica Johnson, Marilyn Latta
State Lands Commission	Chris Huitt
Lehigh Hanson/ Martin Marietta	Erika Guerra, Mike Bishop, Sean Riley
Lind Marine	Bill Butler

STUDY COORDINATORS:

Lisa Beutler and Jamil Ibrahim, Stantec

SUPPORTING MATERIALS

- The meeting chat is attached as Appendix A.

- Session PowerPoints, a time-stamped meeting transcript, and the meeting recording are also available for additional details.

DRAFT SUMMARY

1. Welcome, Updates, and Introductions

Erica Johnson (SCC) opened the session, acknowledged the attendees, reviewed the agenda and meeting goals, and noted the meeting was being recorded.

RESEARCH REPORTS

2. Sustainability of Sand Mining in San Francisco Bay - Stratigraphy Team, UT Austin & USGS

Matthew Malkowski and Zachary Sickmann (UT Austin), provided an overview of their areas of investigation including:

- Where the sand is coming from
    - Sand from the Sacramento-San Joaquin Delta (Delta) through San Francisco Bay (SF Bay)
    - Sand from the outer coast into the bay
    - Sand from local sources
- Whether the mining areas are sourced differently
- What the source distinctions are for different grain sizes
- Whether there are temporal changes reflected in the SF Bay stratigraphy

They indicated significant progress on their Tasks 1-3 and the initiation of Task 4 as follows.

- Task 1, Bathychronology (100 % complete)
- Task 2, Core sampling (100 % complete)
- Task 3, Sample processing and analysis (75% complete)
- Task 4, Data synthesis, interpretation, and report (5% complete)

Bathychronological Analysis

Bruce Jaffe (USGS) provided an overview of the core sampling and bathychronological analysis, or estimated chronology of sediment deposition based on sediment cores collected and analyzed in SF Bay. This analysis is important for establishing sedimentation patterns before and after mining or other know events. During his presentation, he illustrated the sediment gains/losses from a time series dating back to 1856 of bathymetric changes and divided the historical deposition into temporal horizons that are separated by survey dates. He then explained the analysis process and any assumptions that were made in developing conclusions.

The analysis also considered bioturbation or the extent to which the reworking of soils and sediments by animals or plants could skew the time-based analysis of the core samples.

The key takeaways from the bathychronological and cores analysis were:

1. There is variable preservation across SF Bay
    a. Some areas are net erosional
    b. Some areas showed intermittent accumulation
2. CT scans of the core samples highlighted some occurrences of bioturbation
3. Relatively few cores yielded notable sand deposits.

Petrographic Analysis

Matthew Malkowski (UT Austin) explained another of their analysis methodologies which he described as sediment “fingerprinting.” The foundation of the approach is petrographic analysis. He described how they prepared and utilized the microscopic examination of thin sections to determine the sediment’s origin and mineral composition as well as its macroscopic aspects such as texture, grain size, and evidence of alteration and/or deformation.

The team used a point-counting process to begin a quantitative characterization of sand composition and provenance. They identified 400 grains from each of 22 samples point across a range of geographies. This method will allow for comparison with well-established reference compositions and sources.

He and Zachary Sickmann (UT Austin) also explained that they have completed their planned data collection and now are in the process of developing a more refined analysis.

Detrital Zircon Provenance

Matthew continued with a discussion of their use of detrital zircon and its use in dating a specific sedimentary unit and determining its source. Zircon persists in sedimentary deposits and is a common constituent of most sands. Zircon can be dated using several modern analytical techniques.

He started by explaining the team's analysis of heavy minerals for sediment provenance. They observed heavy mineral abundances including:

- Hornblende and hypersthene (Sierra Nevada)
- Glaucophane, chert, & garnet (Franciscan Complex)
- Zircon (non-unique)

Questions and Discussion

The ISP expressed appreciation for the presentation and asked clarifying questions regarding the methodologies the team was using as well as offering some ideas for the team to consider.

The team explained that they had more to do and offered a few of their more interesting observations, including note that sand in some locations is noticeably finer.

STAC comments (see meeting chat in Appendix A for additional details) included questions about the physical locations of the sample sites. Another comment related to findings regarding the age of sands and confirming the potential sources of it. Zach explained that the majority of sampled sand is derived from volcanic activity 100 to 150 million years ago; however, its age does not represent how long the deposit had resided at the point that it was extracted from.

He was asked what else they wanted to share for zircon analysis. They replied they eventually will complete quantitative mixing analysis for zircon data. They believe it is important to have wide ranging distribution to achieve statistically meaningful representation.

For the full group discussion see the session recording from *minute 26:00 to minute 39:30.*

3. Modeling of Sand Transport in San Francisco Bay - Sand Transport Modeling Team, Anchor QEA

Aaron Bever and Michael MacWilliams (Anchor QEA) presented on their work on sediment transport modeling and sediment flux analysis. They sought to receive feedback on the analysis of model simulations and interpretation of the preliminary results. They noted results were preliminary and their model simulations not yet finished (simulations were 75% completed when this presentation was made).

The focus of sand flux maps in their presentation was on Suisun Bay and Central Bay. They will also include San Pablo Bay and South Bay in the report.

Progress Report

The team explained that Task 1, Perform Sediment Transport Modeling, was 64% complete and that they had been analyzing sediment transport model simulations and drafting some report sections. Task 2, Develop and Deliver Findings Report had just started; starting this billing period. Task 3, Coordination and Sediment Flux Analysis - with the draft exporting of subembayment bedload and suspended sand fluxes for San Francisco Estuary Institute and was 88% complete.

Incorporation of San Francisco Estuary Institute (SFEI) Watershed Model Freshwater

SFEI's watershed model allows consideration of water, fine sediment, and sand discharges from SF Bay tributaries vs. other sources. Anchor QEA used wet year analysis and critical dry year analysis – with and a

without mining scenario. They tracked sand from SF Bay tributaries as a separate sediment class. This allows for the evaluation of dispersal of sand away from the discharge locations. The 3D nature of transport may show differences in transport directions for both bedload and suspended load. The overall analysis found there was very limited dispersal over a 1-year timeframe.

Sediment Transport Model Simulations

The Anchor QEA team explained that the goal of their analysis of sediment transport model simulations was to evaluate the effects of sand mining over a year, considering wet and dry/critical years, contrasted with a without mining simulation. They also looked at the dispersal of SF Bay tributary sand and evaluated sand fluxes between embayments. They eventually plan to evaluate the predicted morphologic change relative to the observed bathymetric change.

Delta Outflows

They found that Delta flows impacted the SF Bay tributary sand fluxes and the downstream transport of sand through the Suisun Bay also increases as Delta outflow increases. When looking at cross-section sand fluxes, there was a predicted reversal in bedload transport direction at Benicia Bridge at Carquinez Strait when Delta outflow increased. They found additional changes in transport directions in low Delta outflow conditions.

For additional discussion of the simulations, including bedflow flux comparison to bedform-based flux, see the session recording from *minute 48:00 to minute 58:30.*

Predicted effects of Sand Mining

Overall, they found that, generally, sand dispersed west from mining areas with a slight eastward transport. They also found that mined sand transport was observably different in most areas in low versus high Delta flow years.

For Suisun Bay, periods of high Delta outflow were responsible for the majority of sand transport through the Suisun Bay and Carquinez Strait. In this case, mined sand dispersed westward toward Benicia Bridge at Carquinez Strait. During lower Delta outflows, sand convergence areas limit the westward impact of sand mining.

For Central Bay, sand flux is not as strongly influenced by Delta outflow. Mined sand here is dispersed throughout the Central Bay and to the Pacific Ocean through the Golden Gate. Sand flux to the Pacific Ocean through the Golden Gate is predicted to increase without mining.

A remaining study question is to determine how to evaluate year the contribution of previous year activity on current year activity.

Questions and Discussion

There were questions related to the how the total volumes were calculated and how would it be calculated into the future with continued mining through time. Michael MacWilliams explained that the sand that was mined in a given year was placed back at the start of the analysis period as a lump volume. The volume was based on actual mining amounts provided by the mining companies not the permitted volumes.

Other questions related to transport associated with density and salinity, as well as elevation and erosion.

For more details on the questions and discussion, see the meeting chat in Appendix A and the recording for the questions and answers beginning at minute 1:08:48

4. Sand Budget and Transport

Scott Dusterhoff (SFEI) from the Sand Budget and Transport Team, which includes SFEI, USGS and Deltares, provided a progress update.

Related to Task 1, Bay Sand Budget, they reported 60% complete. They are finalizing the local tributary sand supply and flood control channel storage technical memos, finishing analyses for Central Valley sand supply analysis, and continuing SF Bay-wide bathymetric change and sand erosion/deposition analysis, the

preliminary results of which they later presented. They also incorporated dredging data into the SF Bay sand budget analysis.

For Task 2, Bathymetry and Sand Transport, they reported 50% complete. They completed summarization and interpretation of recently collected bathymetric data, and developed a draft memo for ISP review that was also presented in the meeting.

Their Task 3, Information Management, was reported at 15% complete, with the compiled dredging data now input into the project database.

Progress on Within Bay Sand Sources and Sinks

Bruce Jaffe and Theresa Fregoso (USGS) continued with a discussion on sand sources and sinks. The purpose of their investigation is to answer the question, “Is the Bay a net source or sink of sand?”

Their completed and planned analysis to date includes:

- Deposition and erosion from 1980s to 2010s (completed)
- Sediment core data (95% complete)
- Estimates of percent sand in the cores (95% complete)
- Creating a 3D model of subsurface sand (0% complete)
- Combining 3D model and deposition and erosion from 1980s to 2010s to estimate the volumes of sand stored (deposition) and released (erosion) from bed (0% complete)

They also described their referenced sediment core data from SF Bay. It included:

- More than 300 cores collected in 1990 and 1991 (Anima et al., 2005)
- 186 of 1990/91 cores logged by Don Woodrow and others (series of publications and unpublished data)
- Additional cores collected and logged in 1996 (3), 2000 (28), 2006 (17), and 2016 (18)

In all, 252 cores were logged, and using the sediment core data and other research sources, they were able to extrapolate estimates of the percentages of sand. They then described their approach for developing a 3D model for estimating sand volume stored/released from a bed as well as the percent of sand within the bed.

An additional consideration was the approach for estimating anthropogenic legacy mercury (Hg) remobilization by sand volume stored/released from bed. For this analysis, they will apply the methodology used at Alviso Slough for mercury remobilization from Foxgrover et al. (2019).

They then identified some challenges for estimating sand volume stored/released from bed and how they planned to address them. The first was the requirement for extensive interpolation and extrapolation. To address this, they plan to use morphology and surface grain size to inform decisions. They also noted uncertainty analysis is a key part of an estimate of the percent of sand. Core logs include lower and upper percent of sand estimates, which they and other researchers can use to evaluate uncertainty, along with changes in percent sand composition.

Questions and Discussion

Questions and discussions for this section began at *minute 1:30:16.*

Questions included inquiries regarding potential analysis of additional core samples and the inclusion of sand at depth below a thick mud layer.

Related to sand beds, one suggestion was to look at historical maps to determine if "historical geomorphology" could help interpret subsurface layering by contrasting with recent surveys. Another suggestion was to see if there are subembayments where the data are more reliable. The thought was focusing on these could teach us about the locations with weaker data. Also, because the mass balance must reconcile, it is possible this information could be informative for learning about uncertainty.

San Francisco Bay Sand Transport Study Technical Memo 2.1

Edwin Elias (Deltares) provided a synthesis of information included in the Technical Memo referenced by Scott. The memo reports on the investigation of the impact of sand mining on bedforms and sediment transport in SF Bay, through:

- Understanding bay-scale morphodynamic change
- Quantifying bedforms and bedform mobility in and around the mining sites
- Detailed volumetric analysis of mining areas (Ring analysis)

The memo contains an inventory and summarization and interpretation of the recently collected bathymetric data in West Central Bay and Suisun Bay. Highlights and takeaways are as follows:

Central Bay

- Detailed bathymetric data is available and suitable for analysis
- Data reveals that mining has an impact on the surface
- In the timeframe of observations, mining areas do not (fully) recover
- Multibeam sonar data are suitable to determine bedform characteristics
- Sediment transport rates can only be computed in Central Bay (not Suisun Bay), and only for the period 2018-2019
- 1997 measurement may be inaccurate
- On average, 30 million cubic meters (m^3) of sediment in the active layer
- 18 million m^3 of sand mined over this period
- 2019 shows a minimum active bed content
- Mining areas appear to be net erosional

Suisun Bay

- Detailed bathymetric data are available and suitable for analysis.
- Data reveal that mining has an impact on the bed
- In the timeframe of observations, mining areas do not (fully) recover
- Mining area is net erosional
- Mining volume was 1 million cubic yards
- Larger bedforms do not occur at the mining area
- Only small bedforms can be observed (these are not suitable for transport estimates)
- Observations with a monthly (or less) frequency would be needed

Next Steps

The memo for task 2.1 is now available for the group's review. It includes the:

- Inventory of available data
- Determination of bedforms and characteristics
- Analysis of the larger scale morphodynamics, and morphodynamic change analysis

Ongoing work includes:

- A detailed analysis of the mining areas (ring analysis) with a goal to complete in September 2022.
- Determination of sediment transports from bedforms.
- Synthesis report.

Questions and discussions for this item began at *minute 1:53.* Due to time discussion was limited; however, the group was invited to email questions to Edwin.

5. General Concurrence

The group was asked to note the extent to which they had general concurrence with the direction of the study teams. With the disclaimer that the group needed to see more in writing, there was concurrence with the approaches and areas of investigation presented.

6. Next Meeting

The next meeting: Q7, will be October 26, 2022. During the next meeting, the Sand Budget and Sand Transport Modelling teams will present on results of their analyses.

Adjourn – The meeting closed at 12:05 p.m.

Appendix A – Meeting Chat

00:15:54 Bob Battalio (ESA): Bruce - can water elevation or vertical datum be added where 'depth' is used?

00:24:27 Theresa Fregoso (USGS): Do you mean change what type values are actually used? The layers can be any numbers from inputted grids.

00:26:13 Bruce Jaffe (USGS): To Bob: Yes, we could be more specific on vertical datum used in future figures.

00:31:23 Bob Battalio: Matt – did you analyze the sand placed at south Ocean Beach in 2021 (that was dredged from the offshore shipping channel)?

00:35:24 Chris Huitt (State Lands Commission): Matt, when you identify the Middle Ground Lease, which area are you referring to? The Suisun Associates lease area is identified as PRC 7781, what is the Middle Ground lease identified as? Thanks.

00:35:59 Brenda Goeden (BCDC): also, it might help us understand if it is sand from the bay or from the outer coast being deposited in the shipping channel.

00:37:20 Brenda Goeden: The Middle Ground lease is known as the Grossi Lease or TL39 - does that help Chris? I know its a private lease, so the numbering system if different from SLC lease numbers.

00:39:13 Brenda Goeden: Zack, is it appropriate to say that the majority of this sand is from 100 to 150 million years ago at this point, or is this still in process such that we can't conclude that at this time

00:41:24 Chris Huitt: Thanks Brenda, I just wanted them to identify where the samples where collected.

00:41:45 Brenda Goeden: got it, think it was on the map

00:42:10 Jeremy Smith (California Coastal Commission): Jumping off Brenda's question, these ages are of the minerals making up the sand not the age of its deposition in the bay right?

00:43:15 Bruce Jaffe: Correct Jeremy. The age is when the zircon formed.

00:44:23 Lester McKee : The sediment budget will be for the most recent 20 years - Matt - will that pose challenges for the flux question you just asked. Also, we might see some flux from the south Bay - if that happens, does that pose a challenge?

00:44:25 William Butler (Lind Marine): The samples labeled “Middleground Lease” came from sand mined from TLS39, and “Suisun Associates” from PRC7781.

00:44:48 Bruce Jaffe: The zircon forms when the molten rock cools.

00:45:25 Bruce Jaffe: It is a crystalization age.

00:46:01 Brenda Goeden: thanks! that's clear

00:46:02 Aaron Bever (Anchor QEA): The predicted sand fluxes and maps of sand flux from the 3D modeling could also provide information for the interpretation of these Zircon results.

00:47:11 Bruce Jaffe: I agree Aaron. Looking forward to looking at the modeling, SedTrails, and Zircon fingerprinting together.

00:52:04 Bob Battalio: Aaron - what were time parameters and location of watershed discharge were used, or how decided?

00:52:36 David Schoellhamer (USGS Emeritus): Was downstream boundary of watershed model collocated with the upstream boundary of the Bay model?

00:56:39 Brenda Goeden (BCDC): Aaron/Michael - was the volume of mined sand used in the model, the actual sand mined or the total permitted? just want to be clear

01:01:51 Bob Battalio (ESA): Aaron -is the divergence of bed and suspended load transport direction a result of density (salinity) ?

01:06:18 David Schoellhamer (USGS Emeritus): Gravitational circulation is logical explanation for divergent bed and suspended load at those 2 locations. Why suspended is export and bed import at both ends of Suisun bay is an interesting question I hope you can answer later

01:07:02 Paul Work (USGS): Aaron - we recently released up-looking ADCP data collected in 2004 at Benicia. This data was used to develop the model by Ganju and Schoellhamer (2006). https://www.sciencebase.gov/catalog/item/606b4a61d34edc0435c36817

01:08:28 Bob Battalio (ESA): Aaron - where there are sand flux differences, are there bed elevation changes (erosion or accretion) implied ?

01:08:58 Matthew Malkowski (UT Austin): Do you happen to know what grain size range (microns) is for the sand proxy? (Sorry if I missed this in an earlier slide.)

01:12:09 David Schoellhamer (USGS Emeritus): If you ran the model longer, would the effect of Suisun bay sand mining (the difference between with and without mining simulations) propagate further downstream?

01:12:56 Michael MacWilliams (Anchor QEA): @BobBattalio-The watershed model discharge and sand load were provided daily from the watershed model. The subwatersheds were provided as GIS files (shown on one of the slides) with the downstream point on the lowest subwatershed of each basin being the location where the wadershed inflow was mapped to the model grid.

01:15:17 Michael MacWilliams (Anchor QEA): @ DaveSchoellhamer- The above partially answers your question but yes we tried to map the location of the downstream point of the watersheds that flowed to the Bay in the watershed model to the closest face on the model grid to apply the discharge and sediment load.

01:17:33 David Schoellhamer (USGS Emeritus). I am not understanding conclusion that 'mined sand dispersed' . It is removed from the system.

01:17:40 Michael MacWilliams (Anchor QEA): @BobBattalio--there is a direct feedback between transport and bed elevation in the model at each time step (90 seconds), so flux differences also correspond to bed elevation changes.

01:17:57 Craig Jones (Integral Consulting): Are there plans to do some sensitivity around sand grain size and bedload transport parameters/model?

01:19:25 Brenda Goeden (BCDC): Wondering how you did this - total mined for the year, or mined over time, and how would it be calculated into the future with continued mining through time?

01:19:37 Mike Bishop (Lehigh Hanson/ Martin Marietta): How are you adding back the sand mined, over the time it was mined or as a lump volume at one time?

01:21:55 Michael MacWilliams (Anchor QEA): @BrendaGoeden and @Mike Bishop: The sand that was mined in a given year was placed back at the start of the analysis period as a lump volume. The volume was based on actual mining amounts provided by the mining companies not the permitted volumes.

01:23:09 Aaron Bever (Anchor QEA): @ DaveSchoellhamer- Presumably if the simulations were multiple years the effect of sand mining in Suisun Bay would propagate farther west. Conveying that is something we will consider in drafting the report.

01:25:10 Aaron Bever (Anchor QEA): @ DaveSchoellhamer- How about this wording? The sand added into the without mining scenario to represent the mined sand was predicted to be dispersed throughout Central Bay and through the Golden Gate.

01:26:38 David Schoellhamer (USGS Emeritus): this wording is clear, thank you

01:31:05 Aaron Bever (Anchor QEA): @ Craig Jones - Before starting the simulations we did some shorter simulations evaluating which bedload transport model that is included in the sediment transport model to use, factoring in assumptions in bedload transport models. The transport directions were generally consistent between the bedload transport models, while the predicted transport rates were somewhat different. We plan to acknowledge that there is not available measured bedload rates in Central Bay/Suisun Bay predicted bedload transport rates to validate the model results. Due to the amount of time needed to run the 3D sediment transport model with extra sediment classes, it wasn't feasible to run complete scenarios with multiple bedload transport models.

01:33:28 Craig Jones (Integral): Thanks Aaron! Will be good to discuss uncertainty in flux quantities at some point and how that will be incorporated into any conclusions. Nice work overall.

01:33:28 Aaron Bever (Anchor QEA): @ Mathew Malkowski - We are using a relatively fine 250 um sand for each sand (initial bed and Delta tributaries, Bay tributaries, mined sand), which is what we have used for previous studies.

01:35:17 David Schoellhamer (USGS Emeritus): No cores near Bay Bridge, I assume cores for new Bay Bridge were not useable, which is a shame.

01:36:20 Matthew Malkowski (UT Austin): Great - thanks, Aaron

01:36:28 Brenda Goeden (BCDC): looking at the example core, i am interested in the inclusion of sand at depth below a thick mud layer. This comes to mind the SFO project where the proposal included dredging a very thick mud layer to get to the sand - which was determined to be infeasible for that project. The sand mined for aggregate is all surface sand and is not anticipated to harvest sand under the mud layers. How does this analysis get included in the budget if we are not looking for sand at depth?

01:36:46 Theresa Fregoso (USGS): Cores may exist that are useable, I just need them. Still waiting on some cores

01:37:43 Craig Jones (Integral): @Bruce - Glad to see challenges explicitly listed here. First step in addressing a good plan for dealing with them. Thanks!

01:38:33 Bob Battalio (ESA): Bruce - could "historical geomorphology" be used to interpret subsurface layering and recent surveys have bed characterizations ?

01:38:59 Lester McKee (SFEI): Are there subembayments where the data are more reliable - perhaps focusing on these will teach us about the locations with weaker data? Also, the mass balance must reconcile - will total versus sand be informative for learning about uncertainty?

01:40:06 Brenda Goeden (BCDC): Aaron, regarding Matt's grain size question. You are using a larger grain size for much of Central Bay and then the smaller size for the Presidio Shoal sand, right? if not an adjustment needs to be made in the model.

01:43:41 Brenda Goeden (BCDC): great, thank you

01:53:42 Bob Battalio (ESA): Edwin - how is the depth of the active layer quantified ?

01:54:26 Lester McKee (SFEI): If the mined areas don't recover, does this match the experience of the mines? Do the mining activities move around in response? In the miners experience, can they go back to a spot every 2-3 years or 5 years? Or am I misunderstanding something? Perhaps the mined volumes are still way smaller than the material available for example.

01:54:51 Theresa Fregoso (USGS): Brenda, need to talk this over a bit more with Bruce, but I believe one result could use only information from tops of cores , top layers that have the initial sand layers. Once we hit mud, or percentage is too low of sand to be useful, layers would end. Then volumes could be calculated on those sections only. However at this moment, we don't have cores/information in the sand mining areas giving us a thickness of those sand layers. I do need a thickness to use for those sand areas, to make this all work. So suggestions on those numbers/thickness is needed. We can chat more about this offline.

01:56:48 David Schoellhamer (USGS Emeritus): Does and if so How far does the net bed loss from mining propagate from the mined area?

01:57:56 Brenda Goeden (BCDC): Thanks Teresa, i think we could perhaps come up with a layer to consider. Perhaps some of what Edwin is telling us now could help

02:00:41 William Butler (Lind Marine): With regard to your analysis of Suisun Channel, are you considering Corps maintenance dredging volumes in the channel as well?

02:00:43 Brenda Goeden (BCDC): Lester, there is no regulatory restrictions on how often the miners can visit the same site. As I understand it the miners go back to same-ish site regularly, but Mike and Bill can speak to that specifically

02:02:50 Bob Battalio (ESA): Im good with this situation - glad to have these smart folks working on the questions !

02:04:15 Paul Work (USGS): I have to sign off - nice job everyone.

02:04:36 Mike Bishop (Lehigh Hanson/ Martin Marietta): Lester - generally we mine the same area for the last 20yrs and on the whole do not see much variation in sand gradation.

Sand Mining Studies Quarterly Meeting 7
Virtual Meeting (Zoom)
November 15, 2022, 10:00am – Noon

Discussion Highlights

MEETING GOALS:

- Achieve the Independent Science Panel's (ISP) concurrence on the project team's research approach based on preliminary results
- Receive ISP feedback on any major concerns or challenges related to answering the sand management questions
- Share constructive alternatives, if any, to addressing sand management questions

ACTION ITEMS:

#	Item	Owner	Timeframe
1	Schedule ninth quarterly research meeting, to occur after all research has finished.	Erica Johnson	Early 2023
2	Provide feedback on the Sand Budget team's Mining volume analysis draft memo	ISP, STAC	12/9/2022
3	Provide feedback on the Sand Transport Modeling draft synthesis report	ISP, STAC	11/21/2022
4	Consider and respond to the Stratigraphy team's question: What should be modeled as appropriate "parent" proxies to SF Bay?	ISP, STAC	Nov/Dec 2022
5	Consider and respond to the Sand Budget and Transport team's questions: • Is the way we have handled the littoral flux at the GG bridge appropriate and is the magnitude of that flux correct? • Do you have any suggestions on the mass-volume conversion factors for sand sediment and for silt/clay sediment? • Should the budget be presented as a 20-year volume and mass or an annual average volume and mass? • At present the budget is in tabular form. Who is the ultimate target audience? For communication to that audience, what would be the best style?	ISP, STAC	12/2/2022
6	Address the questions which were posed during the Q&A session of the meeting in the modeling report to the extent possible.	Anchor QEA	Nov/Dec 2022;

ATTENDANCE:

INDEPENDENT SCIENCE PANEL (ISP):

David Schoellhamer, USGS Emeritus
Bob Battalio, ESA Consulting
Craig Jones, Integral Consulting

RESEARCH TEAMS:

Stratigraphy	Matthew Malkowski and Zack Sickmann University of Texas (UT) Austin and UT Dallas
Transport Modelling	Aaron Bever and Michael MacWilliams, Anchor QEA
Budget and Transport	Lester McKee, Scott Dusterhoff, Cristina Grosso, Jeremy Lowe SFEI
Budget and Transport	Floortje Roelvink, Deltares
Sand Budget / Stratigraphy	Bruce Jaffe and Theresa Fregoso, USGS

SAND STUDY TECHNICAL ADVISORY COMMITTEE:

Bay Conservation and Development Commission (BCDC)	Brenda Goeden, Jamie Lopez, Julia Kelly, Pascale Soumoy

State Coastal Conservancy	Erica Johnson, Marilyn Latta
State Lands Commission	Christopher Huitt
California Water Board	Jazzy Graham-Davis
Lehigh Hanson/ Martin Marietta	Erika Guerra, Mike Bishop, Sean Riley
Lind Marine	Bill Butler

STUDY COORDINATORS:

Lisa Beutler, Marisa Perez-Reyes, Stantec

OBSERVERS:

Aaron Holloway, GHD Consulting Group

SUPPORTING MATERIALS

- Meeting chat (attached as Appendix A)
- Session PowerPoints, a time-stamped meeting transcript, and the meeting recording

DRAFT SUMMARY

1. Welcome, Updates, and Introductions

Erica Johnson (SCC) opened the session, acknowledged the attendees, reviewed the agenda and meeting goals, and noted the meeting was being recorded.

RESEARCH REPORTS

2. Sustainability of Sand Mining in San Francisco Bay - Stratigraphy Team, UT Austin & USGS

Matthew Malkowski (UT Austin) and Zack Sickmann (UT Dallas) presented on how the Stratigraphy team is using detrital zircon geochronology to understand the provenance of sands in San Francisco Bay (SF Bay). Since Task 1 Bathychronology was covered extensively at the previous meeting, it was not a focus at this presentation, though Teresa Fregoso was present to answer questions. Matthew reminded the group that the scope of the Stratigraphy research team's questions include:

- Where the sand is coming from
    - Sand from the Sacramento-San Joaquin Delta (Delta) through San Francisco Bay
    - Sand from the outer coast into the bay
    - Sand from local sources
- Whether the mining areas are sourced differently
- What the source distinctions are for different grain sizes
- Whether there are temporal changes reflected in the SF Bay stratigraphy

They indicated significant progress on their Tasks 1-3 and the initiation of Task 4 as follows.

- Task 1, Bathychronology (99% complete)
- Task 2, Core sampling (99% complete)
- Task 3, Sample processing and analysis (90% complete)
- Task 4, Data synthesis, interpretation, and report (10% complete)

As part of Task 2, the team collected samples using several different techniques, including beach grabs, pistons/gravity core samples, mining grabs, and river samples. They noted that in this study, heavy mineral samples are used as a proxy for sand in general. The samples collected in Task 2 were processed and analyzed under Task 3 using detrital geochronology methods.

Using Detrital Geochronology to reconstruct sediment sources

Due to its prevalence and durability, zircon is a common constituent in most sands. Detrital zircon geochronology is a method that can be used to analyze the age at which zircon in a sample crystallized. The Stratigraphy research team can determine the provenance (source location) of sands by analyzing the age at which the detrital zircon in the sample crystallized because the time horizons for zircon crystallization in the various magmatic systems in California are known:

The most dominant magmatic system in California is the Sierra Nevada batholith, where zircon crystallized in the Cretaceous period, between 60 and 145 million years ago. There are also older populations of samples from the Jurassic period (over 150 million years ago) and younger samples from areas such as Lassen where zircon crystallized less than one million years ago. Areas closer to the coast contain various proportions of different sources. In California, the vast majority of sediments are within 300 million years old.

Matthew explained how to read the histograms that depict the results of the geochronology analysis. A feature of the histogram is the "Dmax" value. In a comparative analysis, a smaller Dmax indicates relatively similar age peaks and distributions (which suggest a similar provenance) and larger Dmax values indicating greater variability in zircon crystallization age (which suggest dissimilar provenances).

Comparing Detrital Zircon Geochronology Results for the San Francisco Bay

Matthew shared findings from the Task 3 analysis:

- There is minimal variability of samples within Suisun Bay
- The samples from the North and South Central Bay are nearly indistinguishable from one another
- The samples from the Central Bay and Outer Coast are also nearly indistinguishable from one another
- There are abundant differences between the samples from Suisun Bay and the samples from the Central Bay and Outer Coast. This difference is driven by the relative abundance of Cretaceous zircon ages in the Central Bay and Outer Coast samples
- Zircon ages in the Suisun Bay samples are also quite distinct from the Sacramento and San Joaquin River samples
- The Central Bay results appear more similar to the Sacramento and San Joaquin Rivers than Suisun Bay does

The research team concluded that there appears to be a relatively distinct provenance of sediment in the Suisun Bay as compared to other areas in SF Bay. Results from Suisun Bay suggest the sediments are not exclusively sourced from the Sacramento and San Joaquin Rivers. The results from the Central Bay are consistent with a model that includes an Outer Coast supply.

Applying a mixture model to reconstruct parent sources

The research team used a mixture model to define the "parent" sand sources based on the "child" samples that were collected in SF Bay and used an iterative process to improve its predictive capacity. Solving the mixture model is a four-step process:

- Step 1: characterize the parent distributions
- Step 2: weight the parent distributions and sum them
- Step 3: compare the model distribution against what was observed in the sample
- Step 4: iteratively refine the model to bring the prediction closer to the sample to "solve" the mixture model

The Stratigraphy wrapped up their presentation and received questions from the STAC and ISP.

Questions and Discussion

The ISP expressed appreciation for the presentation and asked clarifying questions regarding the methodologies the team was using as well as offering some ideas for the team to consider.

STAC comments (see meeting chat in Appendix A for additional details) included questions about statistical methods, relic sand, sorting mechanisms and hydrodynamic fractionating in the samples, and grain size. There was also a question about the conclusions of the analysis regarding the local sourcing and the extent to which they studied the Napa and Sonoma areas.

At the end of the Q&A session, Matthew posed a question to the ISP and STAC: What should be modeled as appropriate "parent" proxies to SF Bay? Members of the STAC and ISP should consider this question and provide thoughts. The updated slides will be distributed to the STAC.

For the full group discussion see the session recording from minute 00:37 to minute 00:41.

3. Modeling of Sand Transport in San Francisco Bay - Sand Transport Modeling Team, Anchor QEA

Aaron Bever (Anchor QEA) summarized the findings of the modeling of sand transport in SF Bay and the predicted effects of sand mining on sand transport. He mentioned that a draft of their report was provided several weeks ago.

They indicated progress on their tasks as follows:

- Task 1, Perform Sediment Transport Modeling (99% complete)
- Task 2, Develop and Deliver Findings Report (14% complete)
- Task 3, Coordination and Sediment Flux Analysis (99% complete)

Related to Task 1, Anchor QEA used the UnTRIM Bay-Delta Model to separately track sand classes from different sources. Their model evaluated scenarios in both wet (high Delta outflow) and critical (low Delta outflow) years for a "baseline"/current condition (where sand mining occurred) and a no-mining condition (which is predictive of conditions had sand mining not occurred). The sand transport team shared findings from their analysis of the model for Suisun Bay and the Central Bay.

Findings from analysis of the sand transport model in Suisun Bay:

- Mined sand is generally dispersed towards the west. There was some slight eastward transport, but largely it was westward, in the downstream direction. Over a one-year time period, the sand made it as far as Benicia Bridge and stayed within Suisun Bay.
- The predicted change in bed sand thickness without mining is small over the majority of Suisun Bay. The area of largest sand thickness change without mining is located near the mining areas. Though some of it is dispersed west, most of the effects are localized to the mining areas.
- In both the low and high flow years, there is little sand flux. The effects of sand mining diminish the further west and away from the mining areas you get.
- This all suggests that the effects of mining in Suisun Bay are fairly localized to the mining areas and don't carry downstream.

Findings from analysis of the sand transport model in the Central Bay:

- Mined sand is generally predicted to be transported between Richardson Bay, Angel Island, and San Francisco, with transport out of the Golden Gate. As with Suisun Bay, the area of largest sand thickness change is localized to where sand mining occurred.
- It is predicted that more sand would have been transported out of the Golden Gate, had sand mining not occurred, in both the low and high outflow years.
- The sand flux out of the Golden Gate was higher for the low outflow year than the high outflow year.
- Following an increase in Delta outflow, there is a predicted influx of sand into the Golden Gate.

Anchor QEA concluded their presentation and received questions from the STAC and ISP.

Questions and Discussion

The ISP expressed appreciation for the presentation and asked clarifying questions regarding the methodologies the team was using as well as offering some ideas for the team to consider.

STAC comments (see meeting chat in Appendix A for additional details) included questions about sand volume to mass, how the team modeled the added sand, whether erosion takes place in the areas of lost sand, the movement of added sands, and the expected impacts of mining to bedforms.

Michael MacWilliams offered to evaluate bathymetric change over one year for conditions of sand mining or no sand mining, to address David Schoelhamer's question.

For the full group discussion see the session recording from minute 1:05 to minute 1:18.

4. Sand Budget and Transport - SFEI, USGS, and Deltares

Scott Dusterhoff (SFEI) from the Sand Budget and Transport Team, which includes SFEI, USGS and Deltares, provided a progress update:

- Task 1 (70% complete) - The Central Valley sand supply memo, Baywide bathymetric change and sand erosion/deposition analysis and summary memo are being finalized. They are compiling the initial Baywide sediment budget and using it to determine the sand budget. Their presentation today was on this topic.
- Task 2 (70% complete) - Deltares completed the mining area volume analysis and developed a draft memo for ISP review.
- Task 3 (20% complete) – The bulk of this task (information management) will come at the very end.

As part of Task 1, Lester McKee (SFEI) shared a presentation of the Draft Sediment Budget. The questions they have for the STAC are:

1. Is the way we have handled the littoral flux at the Golden Gate bridge appropriate and is the magnitude of that flux correct?
2. Do you have suggestions on the mass-volume conversion factors for sand sediment and for silt/clay sediment?
3. Should the budget be presented as a 20-year volume and mass or an annual average volume and mass?
4. At present, the budget is in tabular form. Who is the ultimate target audience? For communication not that audience, what would be the best style?

Working from the sediment budget, SFEI presented on the sand budget. Sand inflows to SF Bay include Central Valley rivers, local tributaries, and ocean sand. Sand exits the system through outflows including sand mining, dredge disposal offshore and dredge disposal for wetland reuse, net wetland deposition, and flood control channels. Lester explained the boundary conditions, assumptions, and methods their team used, which were distributed to the STAC last week. Challenges to be worked through include:

- Spatial diversity of estuaries
- Data are a mix of volume and mass measurements, which require conversions that use estimates of bulk density. The bulk density can depend greatly based on the sources and sinks involved.
- Separating sediments such as mud from the bulk budget, to yield the sand budget
- In summary, the following unknown variables must be reconciled:
    - Sources and sinks between subembayments
    - Mass and volume
    - Total sediment, sand, and mud (silt/clay)
    - Bulk density of flux through the Golden Gate

The Whole-Bay mass budget shows that the inflows are currently less than the outflows, resulting in net negative bathymetric change and storage loss, though the Lester wouldn't ascribe cause and effect to the observation. He reminded the group that this is a total mass budget, and they'll learn a lot more when they separate out the various embayments.

Next steps include:

- Working on draft report for Central Valley sand loads.
- Developing synthesis reports for sand sources and sinks in the Bay.
- Compiling grain size for dredge data interpretation.
- Reconciling sediment budget, including subembayment scale, separating the sand sediment from the total sediment budget, and calculating mass and volume.

- Writing up a short report (Task 1.7) for review.
- Developing the database and submitting their final report.

SFEI concluded their presentation and received questions from the STAC and ISP.

Questions and Discussion

STAC comments (see meeting chat in Appendix A for additional details) included questions about the net outflows in the mass budget, fluxes out of the Golden Gate and the associated densities, changes in bathymetry, and bulk densities. There was a question about wet vs dry volumes and pre- and post-dredging surveys. Mike Bishop and Bill Butler offered to follow up with Lester to continue the discussion about bulk density.

Erica asked how Lester would like to receive input. Lester replied that email exchanges would be sufficient. Each party can give their best estimate of how to answer the questions and they will get different answers, which is fine. The group concurred with that course of action.

For the full group discussion see the session recording from minute 1:34 to minute 2:03.

5. General Concurrence

The group was asked to note the extent to which they had general concurrence with the direction of the study teams. With the disclaimer that the group needed to see more in writing, there was concurrence with the approaches and areas of investigation presented. Erica Johnson received concurrence from the group that resolving any outstanding questions from this meeting could be addressed via email exchanges.

6. Next Meeting

The next meeting: Q8, will be January 24, 2023.

Adjourn – The meeting closed at 12:10 p.m.

Appendix A – Meeting Chat

10:05:22 Bob Battalio (ESA): hi here are my questions on the anchor report, in case there is time to address:

1. Is the net transport of sand into or out of the Bay (toward the Ocean)?
2. What is the net rate or annual quantity computed ?
3. Can 1. And 2. Above be refined for:
    i. Sand grain size classes?
    ii. Mined sand sizes ?
4. Can you map the transport directions and rates across the central bay mining areas ?
5. Does sand mining in the suisun bay area reduce sand supply to the sand pablo and central bay shores (e.g. Richmond) ?
6. Do surface gravity wave processes transport sand onshore across the tidal flats to the Bay shore ?

10:18:17 Aaron Bever (Anchor QEA): Hello Bob. I'll try to provide a few quick answers.

1. Predicted net sand transport was out of the Golden Gate toward the ocean.
2. Predicted sand flux through the Golden Gate was 2.89x10^7 kg for the wet (high-outflow) year and 1.05x10^8 kg for the dry (low-outflow) year.
3. The modeling did not include multiple sand size classes, so we cannot refine for various sizes of sand.
4. Yes. Predicted transport maps with direction and relative magnitude are in the report. \
5. Over the 1-year time frames evaluated in the sediment transport modeling, there was little predicted effect of the Suisun Bay sand mining on sand transport to San Pablo Bay. So over the 1-year period, the model predictions suggest the Suisun Bay sand mining did not reduce sand supply to San Pablo Bay.
6. We have not looked into wave-induced shoreward sand transport across the tidal flats.

10:27:22 David Schoellhamer (USGS Emeritus): Dmax seems overly simple, will stats tests be used to test null hypothesis that samples are from the same population?

10:43:54 Matthew Malkowski (UT Austin): What should be modeled as appropriate ‘parent’ proxies to SF Bay?

11:06:29 Lester McKee (SFEI): I am curious what bulk density you used to estimate your bathy erosion and deposition in the model. Did you use a unique bulk density for each area of the Bay (say Suisun separate from Central Bay?

11:14:50 Brenda Goeden (BCDC): I agree with that recommendation. Since mining is continuous, it seems very relevant to extrapolate out the transport changes associated with this 1 year modeling effort. Thanks for the work!

11:20:32 Bob Battalio: I’m interested in the density because I'm more familiar with using volume in terms of cubic yards or cubic meters

11:22:04 Brenda Goeden: So my question was just a simple one regarding the sand being placed back in in the model. Was it the amount that was mined in that same year? If so, we may want to think about sand mined as max and mins, because I believe 2014 was a low mining year and 2018 may have been as well.

11:25:36 Bob Battalio: thanks Aaron for answering my questions in chat !

11:27:09 Aaron Bever: The sediment transport model used a single calibrated bulk density (porosity) for the entire domain. The density of the sand modeled was 2650 kg/m3.

11:27:24 Erica Johnson (State Coastal Conservancy): Questions from the sand budget team (I will also send as a follow-up email along with Matt’s question):

1. Is the way we have handled the littoral flux at the GG bridge appropriate and is the magnitude of that flux correct?
2. Do you have any suggestions on the mass-volume conversion factors for sand sediment and for silt/clay sediment?
3. Should the budget be presented as a 20-year volume and mass or an annual average volume and mass?
4. At present the budget is in tabular form. Who is the ultimate target audience? For communication to that audience, what would be the best style?

11:28:48 Aaron Bever: Brenda: We used the same amount of mined sand in both 2014 and 2018 to isolate the effects of different environmental conditions during the two periods.

11:30:38 Brenda Goeden: Thanks Aaron, what volume did you use?

11:31:39 Craig Jones (Integral Consulting): Diamond mining in bay sediment could be a great new business model for CA!

11:38:10 Aaron Bever: Brenda: Approximately 1.3 million yd3 total for Central and Suisun Bays

11:38:51 Brenda Goeden: So, you didn't split the volume between the two areas? Can we talk offline about this?

11:39:35 Aaron Bever: Sure. We can talk offline. We did split it between different locations based on the mining information.

11:46:59 Bob Battalio: perhaps use volume in terms of sand shoals and beaches, convert modeling to sand volume, and convert mixed sediment using percent sand.

11:47:10 Bruce Jaffe (USGS): Wet or dry density Craig?

11:48:02 Bob Battalio: its all about the beaches :) 😁

11:48:33 Erica Johnson: Looks like we might want a follow-up convo with Anchor QEA? Let's recap after SFEI

11:56:38 Craig Jones: Bruce, just to clarify the ~0.2 - 1.5 g/cm^3 density I was referring to are dry densities (mass of solids/volume). I don't want to confuse that with the wet/dry volume discussion. Just a note (that you all know well) that the overall variability of the sand vs. silt sediment bed density variability at the surface is quite large!

11:58:13 Brenda Goeden: Also, just to make sure we are on the same page. The measure from the sand barge is when the water has been drained out. Correct?

11:58:38 Brenda Goeden: Thanks Bill. Got it.

12:07:58 Lisa Beutler (Stantec): Chris - did you have a last comment?

12:09:03 Bob Battalio: thanks everyone great presentations and discussion !

12:09:21 Brenda Goeden: Agreed, thanks everyone for all the great work.

Sand Mining Studies Quarterly Meeting 8
Virtual Meeting (Zoom)
January 24, 2023, 10:00am – Noon

Discussion Highlights

MEETING GOALS:

- Achieve the Independent Science Panel's (ISP) concurrence on the project team's research approach based on preliminary results
- Receive ISP feedback on any major concerns or challenges related to answering the sand management questions
- Share constructive alternatives, if any, to addressing sand management questions

ACTION ITEMS:

#	Item	Owner
1	Distribute updated Guidelines for Final Reports based on group discussion on the requirements.	Erica Johnson
2	Distribute the Anchor QEA synthesis report to the ISP for review and comment.	
3	Distribute the Deltares synthesis report on sand transport to the ISP for review and comment.	
4	Develop and share a comprehensive list of the memos and draft reports that the ISP has reviewed to-date and are reviewing currently.	
5	The updated Schedule will be shared with the ISP and STAC.	

ATTENDANCE:

INDEPENDENT SCIENCE PANEL (ISP):

David Schoellhamer, USGS Emeritus
Bob Battalio, ESA Consulting
Paul Work, USGS
Craig Jones, Integral Consulting
John Largier, UC Davis at Bodega Marine Lab

RESEARCH TEAMS:

Stratigraphy	Zack Sickmann University of Texas (UT) Austin and UT Dallas
Transport Modelling	Aaron Bever and Michael MacWilliams, Anchor QEA
Budget and Transport	Lester McKee, Scott Dusterhoff, Cristina Grosso, SFEI
Budget and Transport	Edwin Elias, Deltares
Sand Budget / Stratigraphy	Bruce Jaffe and Theresa Fregoso, USGS

SAND STUDY TECHNICAL ADVISORY COMMITTEE:

Bay Conservation and Development Commission (BCDC)	Brenda Goeden, Jaime Lopez, Pascale Soumoy
California Coastal Commission	Jeremy Smith
NOAA Fisheries	Sara Azat
State Coastal Conservancy (SCC)	Erica Johnson
State Lands Commission	Christopher Huitt
US Army Corps of Engineers	Jayme Ohlhaver
California Water Board	Jazzy Graham-Davis
Lehigh Hanson/ Martin Marietta	Erika Guerra
Lind Marine	Bill Butler

STUDY COORDINATORS:

Jamil Ibrahim, Marisa Perez-Reyes, Stantec

OBSERVERS:

Aaron Holloway, GHD Consulting Group

SUPPORTING MATERIALS

- Meeting chat (attached as Appendix A)
- Session PowerPoints
- Time-stamped meeting transcript
- Meeting recording

SUMMARY

1. Welcome, Updates, and Introductions

Erica Johnson (SCC) opened the session, acknowledged the attendees, reviewed the agenda and meeting goals, and noted the meeting was being recorded. She also acknowledged the Stratigraphy team's absence from the meeting.

2. Final Deliverables

Erica provided clarification about guidelines for preparation of final reports, which include:

- Comparison of results and conclusions to previous studies and discuss differences, improvements, gaps, and next steps.
- Providing an estimate of uncertainty in quantitative results.
- Discussion of how results answer the sand management questions relevant to their scope of work.
- Provision of annotated bibliographies, and report credits.
- *For the Sand Budget Team only: evaluation of the data collected and description for how the data in the report should be used in future studies.

For full details on group discussion about the final deliverables, see the session recording from minute 00:02 to 00:18. Erica will update the guidelines based on discussion and recirculate the guidelines to the group.

RESEARCH REPORTS

3. Modeling of Sand Transport in San Francisco Bay – Sand Transport Modeling Team, Anchor QEA

Aaron Bever (Anchor QEA) indicated progress on their tasks as follows:

- Task 1, Perform Sediment Transport Modeling (99% complete)
- Task 2, Develop and Deliver Findings Report (75% complete)
- Task 3, Coordination and Sediment Flux Analysis (87% complete)

Under Task 1, Anchor QEA received seven sets of comments from the ISP and STAC about the sand transport modeling report which they are working to address now. Under Task 2, significant progress has been made to synthesize the sediment transport modeling results and effects of sand mining in the context of the wider literature. Anchor QEA plans to send the new synthesis to the ISP for review and comment prior to submitting the final report. The STAC emphasized the value of demonstrating radical transparency through tracking changes that are made to the report in response to comments.

For the full group discussion see the session recording from minute 00:18 to 00:29.

4. Sand Budget and Transport – SFEI, USGS, and Deltares

Scott Dusterhoff (SFEI) indicated progress on their tasks as follows:

- Task 1, Bay Sand Budget (80% complete)
- Task 2, Bathymetry and Sand Transport (90% complete)
- Task 3, Information Management (30% complete)

Related to Task 1, the USGS team is finalizing the Baywide bathymetric change and sand erosion/deposition analysis and will be developing a summary memo. Additionally, SFEI is compiling the initial Baywide sediment budget and summary memo. Related to Task 2, Deltares has developed a draft synthesis memo which will be distributed for ISP and STAC review soon. Edwin's presentation today primarily focused on summarizing the synthesis memo.

Edwin Elias (Deltares) reminded the group of the activities under the Sand Transport Study which include:

- Inventory, summary, and interpretation of recent bathymetric data for Central Bay, Suisun Channel, and Middle Ground Shoal.
- Evaluation of the directions of sand transport through various sand mining lease areas.
- Synthesis of results to understand whether sand mining is influencing sand transport, specifically the implications of bedform changes for transport and whether mining activities play a role in that effect.

The synthesis report examines findings for:

- Understanding sand transport patterns on the scale of the West Central Bay
- Local effects of mining on West Central Bay
- Local effects of mining on Suisun Channel
- Impacts of mining on Bay-scale sediment transport and exchange with the coast

The study team evaluated findings across three distinct geographic and time scales (referred to by the team as a “Scale-cascade” framework).

- Scale 1: **detailed small-scale analysis of ring polygons** analyzes a single mining event on the timescale of about a year.
- Scale 2: **lease areas and bedform analysis** evaluates mining impacts on lease and shoal areas on the timescale of about a decade.
- Scale 3: **regional analysis of morphodynamic changes** analyzes mining impacts in the context of the Bay and the overall sand budget, on the timescale of about a century.

The study focused on two sites in the Bay: the West-Central Bay and the Suisun Channel/ middle ground shoal areas. Edwin shared information about the characteristics of the bedforms in both study areas:

- In the West-Central Bay, bedforms are influenced by tides interacting with the bedrock islands and shorelines. Available bathymetric data show that mining has an impact on the surface at a regional scale, however, their study cannot conclude whether there is an overall positive or negative impact on the sand budget.
- In Suisun Channel, three bathymetric maps are available. The data reveal that the entire Suisun Channel is eroding, and mining has a particularly distinct effect on bed lowering.

Edwin reviewed the Scale-cascade scale in greater detail to explain how the three layers of analysis relate to one another and their overall study process. He then presented summarized results.

Results of mining impact analysis in West-Central Bay:

- At Scale 1, the effects of local mining show bed lowering and disappearance of the shoals. The northern mining area did not recover/ return to its natural state after the removal of sediment, however the Presidio shoal did recover once mining dropped below a certain level. Volumetric change/ recovery rates varied by region, between 14% and 141%. The areas with the lowest rates of recovery saw steeper drops in bed level. Edwin noted that analysis of the ring polygons was limited by the fact that not all the mining areas were included.
- At Scale 2, the study also evaluated the diffusive effects of mining by extending the ring analysis at set intervals. They had variable success using this method and concluded that more frequent measurements were needed to distinguish between the effects of diffusion versus naturally occurring variability.
- At Scale 3, the Point Knox shoal bedforms do not appear to be impacted by mining. In the Presidio Shoal, the results were not sufficient to suggest a strong correlation between mining and changes to the bedform.
- On a regional scale: in periods of low mining intensity, most regions show net accumulation of sediments. During periods of high mining intensity, most regions show net erosion, however Edwin noted that this is likely due to natural variations in the sediment supply since erosion also occurred in areas without mining.

Results of mining impact analysis in Suisun Channel:

- At Scale 1, mining directly results in bed lowering. The recovery rate was virtually nonexistent.
- At Scale 2, diffusion cannot be discerned from natural erosive patterns; bedform lowering is occurring irrespective of mining.
- At Scale 3, the regional scale impacts show significant losses in volume everywhere but particularly in the mined area where recovery is not occurring at all. There appears to be limited correlation between mining and recovery in other areas.

Edwin shared how tides inform large-scale sand transport patterns in the Bay. Larger bedform fields form in areas where tidal flows decelerate and deposit sediment, as is the case in the flood delta, the contraction around Angel Island, and the area exchange with South Bay. He noted that smaller scale patterns can also show areas of convergence of sand supplies.

Edwin reflected on the overall impacts of mining on Bay-scale sediment transport. For mining areas with limited recovery, there are larger impacts on local scale bed lowering, though he noted that this may not always be a disadvantage (for example, lower beds are advantageous in navigation channels). Additionally, for areas with limited recovery on the local level do not draw sediments from elsewhere in the vicinity, so there is little net effect on that local budget. Conversely, the areas with higher recovery on the local scale (such as the Presidio shoals) resulted in losses to their overall sediment budget.

Recommendations for future work:

- Process-based modeling would be helpful to understand long-term impacts of areas where effects of mining were inconclusive.
- To better understand diffusion effects, the study team recommends more detailed analysis of the individual sites. In areas where natural variability is higher (Presidio shoal), the frequency of measurements should be higher (half-year as opposed to yearly).
- The Suisun Channel is key for understanding sediment delivery from the Delta, however, it is unlikely that the individual bedforms in the Suisun Channel can be traced over the entire year because they change significantly after individual storm events. Edwin recommends focusing on a smaller subregion.

Edwin concluded that mining volume may not be the right metric to use to best understand impacts on the sediment budget. Rather, recovery rate is the most important metric for understanding the overall volume change that results from mining.

SFEI concluded their presentation and received questions from the STAC and ISP.

Questions and Discussion

Bob Battalio expressed appreciation for the diffusion analysis. He asked whether the team found density flows to be relevant for transport through the Golden Gate. Edwin replied that the answer depends on the scale. For their analysis, density flows were irrelevant. As a follow-up, Bob asked what the net sand transport rate through the Golden Gate is. Edwin replied that their study does not answer this question. It is better suited for the team studying the complete sediment budget.

Bob noted that he thinks 10-100 years is a good timeframe to study. He also reflected that the system does not appear to be stationary. One of the shoals appears to be moving in towards the Bay, but that process is occurring on a much longer timescale.

Brenda Goeden (BCDC) expressed appreciation for the various time and regional scales covered in the presentation. She noted additional sand mining surveys will be conducted this year, so more data will be available.

David Schoellhamer asked whether net losses in the local sediment budget result from an absence of a zone of convergence in the area. Edwin replied that high recovery isn't a net positive since it means that sand is coming from somewhere else in the system. Mining is still a net loss in the budget.

David asked if the draft report will be sent to the other study teams, noting that he observed similarity in their results to the SFEI team's results. He expressed interest in cross-referencing results across the studies in the synthesis report. Erica noted that all draft reports and memos are shared across study teams. This particular synthesis report will be shared this week.

Craig Jones applauded the team for contextualizing their results. He asked for Edwin to share more information about the tipping point concept. Edwin replied that bed lowering can exceed a threshold or tipping point. With more focused morphodynamic modeling, you can investigate the tipping point further. Craig thanked him for the explanation and acknowledged that it's outside the full scope of work.

Bob observed that the sand is courser in the northern, Point Knox Shoal region and finer in the Presidio area. He suggested the Point Knox Shoal may be remnant from an earlier time as opposed to the Presidio where it's assumed that sand is coming in from the ocean. Edwin agreed that the data suggests this.

John Largier asked whether their team interpreted the larger scale implications of a particular result from the 2018-19 regional scale data. Edwin replied that their analysis is observational rather than conclusive, though he noted that it's fairly unlikely that mining to the south of Angel Island influences the sediment delivery in the north and central bay.

Erica encouraged the group to read the read the report and provide comments.

For the full group discussion see the session recording from minute 00:29 to 1:55.

5. Wrap Up

Erica highlighted recent changes to the schedule, which is posted on the SharePoint and will be shared via email following the meeting. Once the research studies wrap up, Stantec will work with the ISP to develop the summary report for BCDC's Board. The schedule for those meetings is still to be determined.

Lester McKee (SFEI) asked Erica whether she imagines a role for the study teams to provide a peer review of the summary report. Bob expressed support for this idea, suggesting that it's at the very least a professional courtesy.

Bob asked if Erica could provide a comprehensive list of the reviews the ISP owes the team. Erica confirmed that she'll prepare a chart of everything they have reviewed to this point, and what they have left. Members of the study teams expressed gratitude for the ISP's reviews and comments.

6. Adjourn Meeting

The next and final meeting (Q9) is tentatively scheduled for April 5, 2023.

Adjourn – The meeting closed at 12:05.

Appendix A – Meeting Chat

10:32:17 William Butler: Agreed - track changes only!

11:36:48 Erica Johnson: Edwin's PPT is available in the shared drive in the Q8 folder

11:39:34 Bruce Jaffe: Can you please share the URL to the Q8 folder again Erica?

11:41:05 Erica Johnson: Q8 folder: https://sccca-my.sharepoint.com/:f:/g/personal/erica_johnson_scc_ca_gov/Ej5OSqo3rvJLmOgfUsS0zP4BBOgMSNUyP3pzc2nSau9Pyw?e=FhDnMB

11:45:15 Sara Azat: Erica - I only see an empty folder at this link. It may be my computer; the folder opens to an empty folder with your name as the title.

11:47:09 Brenda Goeden: HI Sara, when I open it, there's folders and documents in there.

11:47:36 Sara Azat: I think that it is the security on the computer - thanks for checking!

11:47:41 Brenda Goeden: yep

Darn cyber cops!

11:49:49 Erica Johnson: Can you try this link? I might have posted the wrong one: https://sccca-my.sharepoint.com/:f:/g/personal/erica_johnson_scc_ca_gov/Ej5OSqo3rvJLmOgfUsS0zP4BBOgMSNUyP3pzc2nSau9Pyw?e=Ynf24Q

11:50:40 Brenda Goeden: That's so interesting. I wonder if modeling could tell us when we might see a asymmetry of the tides

11:50:41 Erica Johnson: Sorry - hold on the links. I think there is some error happening where it automatically redirects to OneDrive and not the shared drive....

11:52:10 Brenda Goeden: I think you should write that down Craig

11:52:31 Craig Jones: Reacted to "I think you should w..." with

12:00:47 Bob Battalio: yes, thanks everyone - seems that we're progressing at least we're understanding the questions better :)

12:00:51 Sara Azat: Echo everyone's comments - the presentation was really great, and I really appreciate the conversation/issue of scale.

12:03:53 Craig Jones: Apologies all. I have to run. Thanks for the presentations and many cheers!

Discussion Highlights

MEETING GOALS:

- Provide update on
    - Anchor QEA synthesis section for their final report and follow-up on any questions or comments to the group.
    - SFEI key findings from their sand budget analysis and draft synthesis report.
    - Key findings from UT Austin analysis and draft stratigraphy report (reports to be circulated after the meeting).
- Begin discussion about the key findings to date of each of the studies and whether they support each other's conclusion.
- Discuss potential for further discussion with the ISP beyond the set meeting time.

ACTION ITEMS:

None to report.

ATTENDANCE:

INDEPENDENT SCIENCE PANEL (ISP):

David Schoellhamer, USGS Emeritus
Bob Battalio, ESA Consulting
Paul Work, USGS

RESEARCH TEAMS:

Stratigraphy	Matt Malkowski and Zach Sickmann, University of Texas, Austin
Transport Modelling	Aaron Bever and Michael MacWilliams, Anchor QEA
Budget and Transport	Lester McKee, Scott Dusterhoff, and Cristina Grosso, SFEI
Budget and Transport	Edwin Elias and Floortje Roelvink, Deltares
Sand Budget / Stratigraphy	Bruce Jaffe, USGS

SAND STUDY TECHNICAL ADVISORY COMMITTEE (STAC):

Bay Conservation and Development Commission (BCDC)	Brenda Goeden, Jaime Lopez, and Pascale Soumoy
Bay Keeper	Ian Wren
California Coastal Commission	Jeremy Smith
NOAA Fisheries	Sara Azat
State Coastal Conservancy (SCC)	Erica Johnson
State Lands Commission	Christopher Huitt
California Water Board	Jazzy Graham-Davis
Lehigh Hanson/ Martin Marietta	Mike Bishop

STUDY COORDINATORS:

Lisa Beutler and Marisa Perez-Reyes, Stantec

OBSERVERS:

Aaron Holloway and Gillian Millar, GHD Consulting Group

SUPPORTING MATERIALS

- Meeting chat (attached as Appendix A)
- Session PowerPoints
- Time-stamped meeting transcript
- Meeting recording

SUMMARY

1. Welcome

Erica Johnson (SCC) opened the session, acknowledged the attendees, reviewed the agenda and meeting goals, and noted the meeting was being recorded.

2. Sand Transport Modeling

Aaron Bever, of Anchor QEA, indicated progress on their tasks as follows:

- Task 1, Perform Sediment Transport Modeling (100% complete)
- Task 2, Develop and Deliver Findings Report (90% complete)
- Task 3, Coordination and Sediment Flux Analysis (90% complete)

Under Task 2, the Anchor QEA team received comments on the sediment transport modeling report from the ISP and STAC in February which have largely been incorporated in their revision. The team acknowledged the three sets of comments received so far on the synthesis section, and requested any final comments be submitted by Friday April 7. The final report will address those comments and include both a redline and clean version.

The team then provided an overview of their synthesis of the sediment transport model, in the context of the broader literature which suggested:

- Sediment transport model shows episodic westward transport of sand in Suisun Bay, with periods of elevated Delta outflow being responsible for the majority of transport toward San Pablo Bay. This result matches the wider literature.
- Modeling predicted that mining would reduce the predicted westward transport of sand, and for the one-year simulation they found that the effect wouldn't extend beyond Benicia Bridge.
- This suggests that there is either a lot of deposition occurring at Bulls Head Shoal that limits westward effects, or a longer simulation period is needed to observe lagging effects.
- For Central Bay, the effects of sand mining would reduce the predicted transport of sand out of Golden Gate. By removing that sand from the hypothesized "transport cell," there would be less sand to nourish the San Francisco Bar, and from Ocean Beach to Crissy Field. There are some uncertainties in the magnitude, and any lag effects.

Questions and Discussion

Bob Battalio asked if the team had insights about the size of the sand that is predominantly being transported, highlighting that this has been a gap in the literature. He noted that historically the sands at Ocean Beach were coarser than 0.3 mm, and the sands at Crissy Field are near 0.2 mm, but that the sand being dredged at the shipping channels past the Bar is finer, with a median size of 0.15-0.2 mm. He mentioned an example in southern Monterey Bay, where they found that the sand that was predominantly being mined was coarse and part of an ancient dune, which contributed to erosion. He suggested that working on a budget for the coarse sands specifically would be a helpful exercise in determining the effects of mining.

- Aaron reflected that the finer sands may be a result of the supply or a characteristic of the transport (e.g., may be easier to transport). Bob elaborated that coarser sands could be older, since they take longer to accumulate and tend to accumulate on the shore.

David Schoellhamer asked for the team's level of confidence in the productivity of the results, given the uncertainties associated with the potential lag times. He wondered if running the simulation for ten years as opposed to one year would produce a different result.

- Aaron replied that for Suisun, they suspect that most sands are stalled at the eastern side of Carquinez Strait, at Bulls Head Shoal, and that would be consistent with dredging logs in the area.

David encouraged Anchor QEA and the other research teams to highlight wherever results between the studies contradict or corroborate one another.

Lester McKee (SFEI) shared that their team's sediment budget analysis shows that on average, for the past 20 years, there is net movement of sediment into the Bay from the Pacific Ocean at the Golden Gate.

Jeremy Smith (California Coastal Commission) asked Aaron to expand on why uncertainties preclude their ability to draw conclusions.

- Aaron replied that it may take a long time for the effects of sand mining to propagate downstream, and those lags cannot be extrapolated.

Paul Work (USGS) suggested that the issue of not seeing an effect past Benicia Bay might have less to do with the run-time of the simulation and more to do with the size of the event being simulated. He asked if the team has run a simulation for a hypothetical, extreme event.

- Aaron replied that their team had not tried that scenario.

Bruce Jaffe (USGS) echoed Paul's suggestion urged the group to consider that for the future.

Mike Bishop (Lehigh Hanson/ Martin Marietta) confirmed that the sand they mine in the North Bay at Point Knox area is coarser and its geological makeup suggests it's from the Marin Headlands. What they see in South Bay at Presidio Shoals is a finer sand, which confirms inbound sand on the north side.

Ian Wren (Bay Keeper) shared that he isn't surprised that the one-year model couldn't show an effect from mining. He asked whether they tested the model for variable intensities of sand mining.

- Aaron replied that they didn't vary the intensity of sand mining. Michael added to this and previous points that confirm that they did model a high delta outflow year.

For full details on group discussion, see the session recording from minute 00:03 to minute 00:26.

3. Sand Budget & Transport – SFEI, USGS, and Deltares

Scott Dusterhoff (SFEI) indicated progress on their tasks as follows:

- Task 1: Bay Sand Budget – 90% complete.
    - Central Valley sand supply memo – incorporating comments.
    - Baywide bathymetric change and sand erosion/deposition analysis memo – will be out for review in mid-April, presenting results today.
    - Baywide sediment budget memo – will be out for review in mid-May, presenting results today.
- Task 2: Bathymetry and Sand Transport – 99% complete, will finalize all three memos for internal consistency.
- Task 3: Information Management – 50% complete, beginning to compile the input and output data from the technical analyses which be available in a database after all the technical studies are complete (mid to late June).

Sand Transport and Deposition Study

Bruce Jaffe (USGS) shared the results of the sand transport and deposition study. Their analysis included consideration of uncertainties associated with (1) interpretation of core logs, (2) augmenting core data with surface sediment sample data, and (3) bathymetric change analysis. He summarized the rate of change in sand volume in the bed of San Francisco Bay within the study area and concluded that sediments in the Bay are a **source** of sand, not a sink.

Sand Budget Results

Lester acknowledged the role of Bruce's team's work in preparing the updated sand budget that his team relied on. He shared information about the methods they used to convert volume to mass in their analysis, and the estimated relationship between dry bulk density and mud content using the Flemming and Delafontaine equations. They found their results (below) were largely consistent with Bob Battalio's publications.

- Preliminary results show that the Bay is net erosional (sands leaving the Bay).
- The Suisun Bay sub-embayment sediment budget shows the volume of mined sand exceeding the inflow, which is consistent with the results of the Anchor QEA transport study.
- The Central Bay receives an influx of sand from adjacent subembayments.

Lester shared considerations and questions for the group:

- Given the proximity of sand mining to the ocean, there is a question of whether it's a coincidence that the volume of mined sand is similar to the ocean supply. If sand mining were to cease, the Pacific Ocean inflow would drop.
- Although the study period is 20 years, it may not be long enough to be representative. The data is from 2000 to Present, which Lester feels is more accurate than including the 1995-1999 data (which represents a characteristically different Bay), though he looks forward to discussion on that question.

Questions and Discussion

Upon request for clarification from Bob Battalio, Lester confirmed they have the sand budget split by mining area.

Bob asked Lester to comment on the sensitivity of the max/min data and whether there might be a flow pathway, given the earlier statement by Mike Bishop that Point Knox Shoal is receiving coarse sands from Marin.

David observed that the sand budget shows inflows at the Golden Gate, but the transport team shows flows out to the Pacific. He asked Lester to comment on those different results. David also echoed Bruce's question in the chat, on bathymetry and accounting for mining in the areas of low recovery.

- Lester replied that this issue may be related to mixing scales, and pointed to Edwin's work on scale cascade which speaks further to that issue. Bruce confirmed Lester's response and added a detail about double-counting.
- Bob requested this issue be explored further, to ensure they are accounting for bed change adequately, and not double counting.

For the full group discussion see the session recording from minute 00:26 to minute 1:19.

4. Stratigraphy

Matthew Malkowski (UT Austin) indicated progress on their tasks as follows:

- Task 1: Bathychronology (100% complete)
- Task 2: Core sampling (100% complete)
- Task 3: Sample processing and analysis (95% complete) – expecting results from the lab this week
- Task 4: Data synthesis, interpretation, and report (75% complete)

Matthew reminded the group of the results of their Bathychronology study which show variable preservation across the Bay. Regarding sand size, they are mostly working with medium-size sands, though he recognized the outliers at Ocean Beach and the northern Central Bay, which are both coarser fractions.

Matthew shared results of the petrographic analysis, then moved into covering the trace element geochemistry. He noted that scandium and chromium are missing from the previous works. They use lanthium and ytterbium (La/Yb) which are relatively rare earth elements and useful for determining sediment provenance. Matthew recapped the detrital zircon provenance results, which were presented at a previous quarterly research update meeting. He shared how they feed the detrital zircon provenance results into the mixture model to match sinks (children) and sources (parents). The best fits indicate:

- Central Bay receives 100% of its sands from the outer coast.
- San Pablo Bay and Carquinez Strait are 80% Coast Ranges, 20% outer coast.
- Suisun Bay is 50% outer coast, 50% coast range.
- The Sacramento and San Joaquin Rivers are not a good fit with any region.

He augmented his comment noting, whether the "best" fit is a "good" fit is another question. His team is relatively confident in their San Pablo Bay and Carquinez Strait models, but the Suisun model is not performing well, as it's having a hard time accounting for where the 130-140 Ma zircon is coming from.

He then recapped the answers to their research questions as follows:

- Where is the sand coming from?
    - Results support an outer coast supply for Central Bay sands.
    - Suisun Bay is likely locally sourced from the Coast Ranges, or relic from gold mining.
- Are the mining areas sourced differently?
    - Yes, results suggest they are sourced differently.
- Are there source distinctions for different grain sizes?
    - For the sandstone petrography, there likely are.
    - For detrital zircon, they expect not because all the samples use the same mineral which provides consistency in the grain size.
- Are there temporal changes reflected in the SF bay stratigraphy?
    - Not from the available data.
- Do both mining areas (Central Bay and Suisan) have the same effects on sand transport pathways and associated impacts?
    - Probably not.
- Should these areas be examined separately?
    - Yes, examinations should include "separate" models.

The outstanding questions under consideration include:

- How long has the sand in Suisun and Central Bay been there?
    - Note: those results are coming soon.
- Where is the sand in Suisun Bay from?
    - Note: this remains a large, outstanding question.
- Is it a poorly defined local source, or is it relic sand from hydraulic gold mining?
    - Note: this finding may be determined by testing upstream.

Questions/Discussion

Bob asked Matthew to speak on whether their results are consistent with his own hypothesis on whether the sands are derived from the Sierras.

- Matthew confirmed that it's quite possible that most of the outer coast sand is Sierra-derived.
- Zach Sickman added that outer coast erosion seems to be contributing as well. The outer coast bears the closest resemblance to the Sacramento and San Joaquin Rivers.

The group discussed the relationship of the Sacramento and San Joaquin River sands to the outer coast. Bob asked Matthew if river sands are passing through the Central Bay and outer coast in significant amounts, or, if instead, if the sands in those areas are recirculating.

- Matt replied that they are having a hard time understanding how this could be the case, given how different the signature is in Suisun Bay.

David built on Bob's question to ask about outer coast exchange. He wondered, "Does the fact that they're similar necessarily mean that the sediment in the Central Bay came from the outer coast? Or is it possible that it's relic sand that happens to be the same as outer coast sand?"

- Matt confirmed that relic sand could be a possibility. He noted the test can't speak definitively to causality, just similarity. Matt continued by saying there appears to be a significant amount of relic sediment (of a similar signature to the Sacramento and San Joaquin River sands) on the outer shelf.

David asked whether hydraulic trapping mechanisms might account for the differences in Suisun Bay.

- Matt replied that more and more, scientists are finding that they can't rely on the assumption that sediments in rivers are well mixed, so it is difficult to exclude the possibility that sediments could become trapped for any number of years. What gives him some confidence is that dredged samples collected from miners in recent years as well as the core samples have demonstrated some spatial and temporal consistency.
- Zach added considerations related to how the system may have changed over time to be sourced from one area more predominantly than others (e.g., could have shifted to being more locally sourced over time).

Lester remarked that in their own studies, they also found high nickel and chromium signatures in an area that experienced hydraulic mining.

- Matthew confirmed that their team believes the high nickel signature comes from mafic rocks in the coastal ranges.

Jazzy asked Matthew to elaborate on how they determined the signature of the Sierra Nevadas.

- Matthew expanded on the process they used and emphasized that the Sacramento and San Joaquin River samples are a very good match for an average of the Sierra Nevada.

For the full group discussion see the session recording from minute 01:19 to 02:13.

5. Discussion

Erica invited the group to revisit unanswered questions from earlier meetings.

Bob commented to remind the group that Matt and Zach had originally proposed deeper cores, but they hadn't had the budget to accomplish that. He recommends documenting next steps to enhance broader understanding including deeper cores and longer timescales.

David shared disappointment that the studies couldn't definitively answer which direction the sand is flowing at the Golden Gate. It's something he wants to discuss further. He does have some follow up thoughts and considerations for the sand budget team he planned to send after the meeting. He asked the groups to elaborate on where they see discrepancies or areas where other studies support their conclusions.

Matthew responded to David's question, sharing that he found the sand budget results to be relatively consistent with his team's results. He's also seeing a disconnect between the two systems. Anecdotally, they were hard pressed to find sand in Carquinez Strait.

Michael added to the discussion on the question of future studies. He remarked that sediments that travel through the Delta are largely deposited in the Delta, and what makes it through are finer sands. Future studies could better understand where the Delta signature drops off.

Michael called attention to the areas where the various study teams converged in their conclusions:

- It doesn't appear that the Central Valley is a primary source of sand to the Bay system.
- Sands converge in Suisun Bay differently than the rest of the system.
- Sand transport variation exists at the Golden Gate.

Lester reiterated that the sediment budget suggests a net flux of sediment out of the Bay. However, as both Michael and Aaron's models suggest, there are times when the net flux is into the Bay. So, the question is how that averages out over the 20-year period to result in a net negative. He summarized that the model is performing well for the fine sediment fraction but is less sure for the multi-decadal scale sand fractions.

Michael added that the USGS data fluxes across Golden Gate don't suggest much about sediment transport. Aaron confirmed Michael's understanding.

Lester continued that sand makes up a larger portion of the dredged materials than was originally assumed in BCDC's 2015 work. Therefore, dredging activities for the purposes of navigation do account for some of

the sands being shifted throughout the Bay. Lester requested that Craig Jones (who was absent for this meeting, provide his thoughts on their team's technical work.

Upon request for clarification from Bob, Bruce confirmed that the bathymetric change analysis didn't include the beaches (rather, it includes up to where a ship can travel at high tide). Bob asked whether Lester's team had calculated beach volumes, noting that other studies center their sediment budgets at the beach so it would be nice to have a comparison.

Lester responded that they may have wrongly assumed that the beaches would be a small component of the budget.

Bob asked whether the model captures the bedload sediment transport, and associated uncertainties.

- Aaron replied that it's a data gap they'd like to have filled. One thing that is coming in the revised report is some sensitivity to changing the bedload formulations, though they don't have observational data.

Bob expressed interest in the quantification of uncertainty in the data with Bruce responding that some of that is included in the reports.

Bob followed up on the importance of the unanswered question of the difference between budget and transport for different sand sizes and offered considerations. Paul Work seconded Bob's comment emphasizing the need to quantify the impact of the uncertainties on the results.

Matt reflected on their team's biggest unanswered question, which is the provenance of sands in Suisun Bay. The biggest source of sand to Suisun Bay in recent history was certainly due to hydraulic mining. He felt that running down that possibility is low hanging fruit that would resolve a lot of questions.

Matt additionally reflected on the importance of the unanswered question of how sands are being transported at the Golden Gate, and that they might get some results to inform that from OSL.

Lester offered a final comment regarding the need for continued internal work to extrapolate the bathymetric change, which would drive down the amounts of sand passing through the Golden Gate.

For the full group discussion see the session recording from minute 02:14 to 02:41.

6. Wrap Up

Erica reminded the group that the study teams will be completely done with their work by the end of May, and she requested that the ISP review final reports in the mid-April to end-of-May timeframe, paying particular attention to topics of uncertainty and whether sand is predominantly coming into the Bay from a certain source, over a certain timeframe.

Following that, BCDC and their consultant will summarize the study results in a report. Meetings to determine what will be included in that report will commence in June, the purpose of which will be to determine how well the studies, taken together, answer the sand management questions.

7. Adjourn Meeting

The meeting adjourned at 12:05.

Appendix A – Meeting Chat

00:27:20 Erica Johnson: Sand Management Questions posted here ^^

00:28:46 Brenda Goeden: Of course sand mining has been going on since the 1930's, more so in recent times.

00:30:01 Bruce Jaffe: Is not the question whether the largest Sacramento/San Joaquin River discharges included in the simulations rather than how low the model is run? Were the largest discharges included in the runs?

00:30:02 Erica Johnson: There is some discussion time in agenda item 6 to loop back, however please post your question in the chat if we don't get to you by 9:30

00:32:02 Brenda Goeden: Mick hindcasted sand transport at Richmond many years ago and found a storm magnitude if that from 1997 to make it move

00:49:05 David Schoellhamer: How do Bruce's rates of sand loss in Suisun Bay compare to rate of mining?

00:56:38 Bob Battalio: Lester - I'm ok with using 1.72 t/m3 instead of my approx. est of 1.68 !

01:02:09 Bruce Jaffe: Good idea Dave. Unfortunately, the Suisun Bay bathymetry data doesn't cover enough of Suisun Bay to make an accurate comparison. Much of Suisun Bay was not resurveyed in the 2010s. See Figure 3 in Fregoso et al. (2023) available at https://pubs.er.usgs.gov/publication/ofr20231031 Also, in my short presentation I did not mention that we excluded sand mining areas and areas where humans modify bathymetry with activities such as dredging and disposal.

01:13:40 David Schoellhamer: Bathy does not include mining areas, so not in budget? Should it be, especially for mining areas with low recovery?

01:21:30 Bruce Jaffe: Mining is accounted for as another term in the budget

01:41:26 Floortje Roelvink: Update on the Deltares sand transport study; we will deliver the final reports for Task 2-1, 2-2, and 2-3 today. Many thanks to the ISP and other teams for the insightful reviews!

01:41:33 Erica Johnson: Just a reminder of the sand management questions doc here!

01:42:32 Scott Dusterhoff: Thanks for the update, Floortje!

01:42:42 Erica Johnson: Reacted to "Update on the Delt..." with 👏

01:53:15 Brenda Goeden: What is mafic?

01:55:06 Zach Sickmann: It's a geochemistry term for rocks like basalt and gabbro that have higher concentrations of elements like Ni and Cr.

01:55:51 Brenda Goeden: Thank you!

01:55:54 Erica Johnson: What is the significance of more vs less mafic?

01:58:26 Zach Sickmann: The mafic sources rocks in northern California are in the coast ranges and parts of the Sierran foothills. This would be in contrast to more "felsic" rocks from the granites and granodiorites in the main Sierra Nevada Batholith

01:58:54 Erica Johnson: Thank you!

01:59:15 Jeremy Smith: Reacted to "The mafic sources ro..." with 👍

02:02:44 Brenda Goeden: Actually, Patrick's team went out and collected box cores for that work. I was on some of the collection efforts so got to observe it firsthand - went out to Pt Reyes too.

02:13:47 Jeremy Smith: This is such interesting work. Thanks to the team for thoroughly walking through the fascinating science here.

02:14:11 Ian Wren: Agreed! Thank you.

02:19:38 Michael MacWillams: Great presentation! These results are really interesting.

02:22:01 Erica Johnson: Reposting sand management questions doc here

02:59:29 Sara Azat: Great presentations - this is a ton to digest. Thank you so much.

03:00:16 Jeremy Smith: Thank you Erica and Lisa for keeping us on track

03:04:25 Sara Azat: Can we also have a copy of the slides?