SFEI San Francisco Estuary Institute

RMP REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

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Sediment Workgroup 2026 Meeting #3

August 19, 2026

Goals for the Meeting

- Provide feedback on a sediment flux modeling location
- Discuss the Phase 1 and Phase 2 modeling proposals and determine level of stakeholder support

Agenda

Item	Time
1. Introduction & Meeting Overview	9:00 – 9:15 am
2. Discussion & Selection of Second Sediment Flux Modeling Location	9:15 – 10:00 am
3a. Presentation & Discussion of Phase 1 and Phase 2 Modeling Proposals	10:00 – 11:00 am
3b. **CLOSED DOOR SESSION** - Decision on Level of Support for Modeling Proposals	11:00 – 11:25 am
4. Report Out to Proposal Principal Investigators	11:25 - 11:30 am
Close Out & Adjourn	11:30 am

Item 2: Discussion & Selection of Second Sediment Flux Modeling Location

- Oliver Fringer received funding in 2025 for a study to model fine sediment flux at Dumbarton Br and a second x-sect location chosen with SedWG
- May 2026 Meeting - We began the conversation re: the second x-sect
- **Today** - We will discuss options and select a second x-sect location that will help address key knowledge gaps

Item 3: Presentation & Discussion of Phase 1 and Phase 2 Modeling Proposals

- Sediment Modeling Study Plan completed in early 2026 (6 Phases over 9 years, ~$7M total)
- March 2026 Meeting - Asked for Phase 1 and Phase 2 proposals (Oliver and Galen Egan)
- May 2026 Meeting - Learned that there is a discussion to fund modeling outside the regular Workgroup process, proposal discussion postponed
- **Today** - Discuss Phase 1 and Phase 2 proposals and assess stakeholder support

Update on Workgroup Activities

- Development of MQ 1 & 2 Workplan
- Update to MQ 3 - 5 Sediment Monitoring & Modeling Workplan
- 2027 Sediment Summit
- El Nino Event Monitoring
- Addition of Workgroup Advisors

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RMP Sediment Workgroup

Guiding Management Questions

1. What are the acceptable chemical levels in dredged sediment that minimize ecological impacts and maximize benefits of sediment placement in the Bay or baylands?

2a. What are the short- and long-term impacts and benefits of direct or indirect placement of dredged sediment on aquatic species and habitats?

2b. What are the impacts of hydraulic dredging on aquatic species and habitats?

2c. Will allowing more in-Bay disposal in exchange for more beneficial use have a net environmental benefit on aquatic species and habitats?

3. What are the sources, sinks, pathways and loadings of sediment and sediment-bound contaminants to and within the Bay and subembayments?

4. How much sediment is passively reaching tidal marshes and restoration projects and how could the amounts be increased by management actions?

5. What are the concentrations of suspended sediment in the Estuary and its segments?

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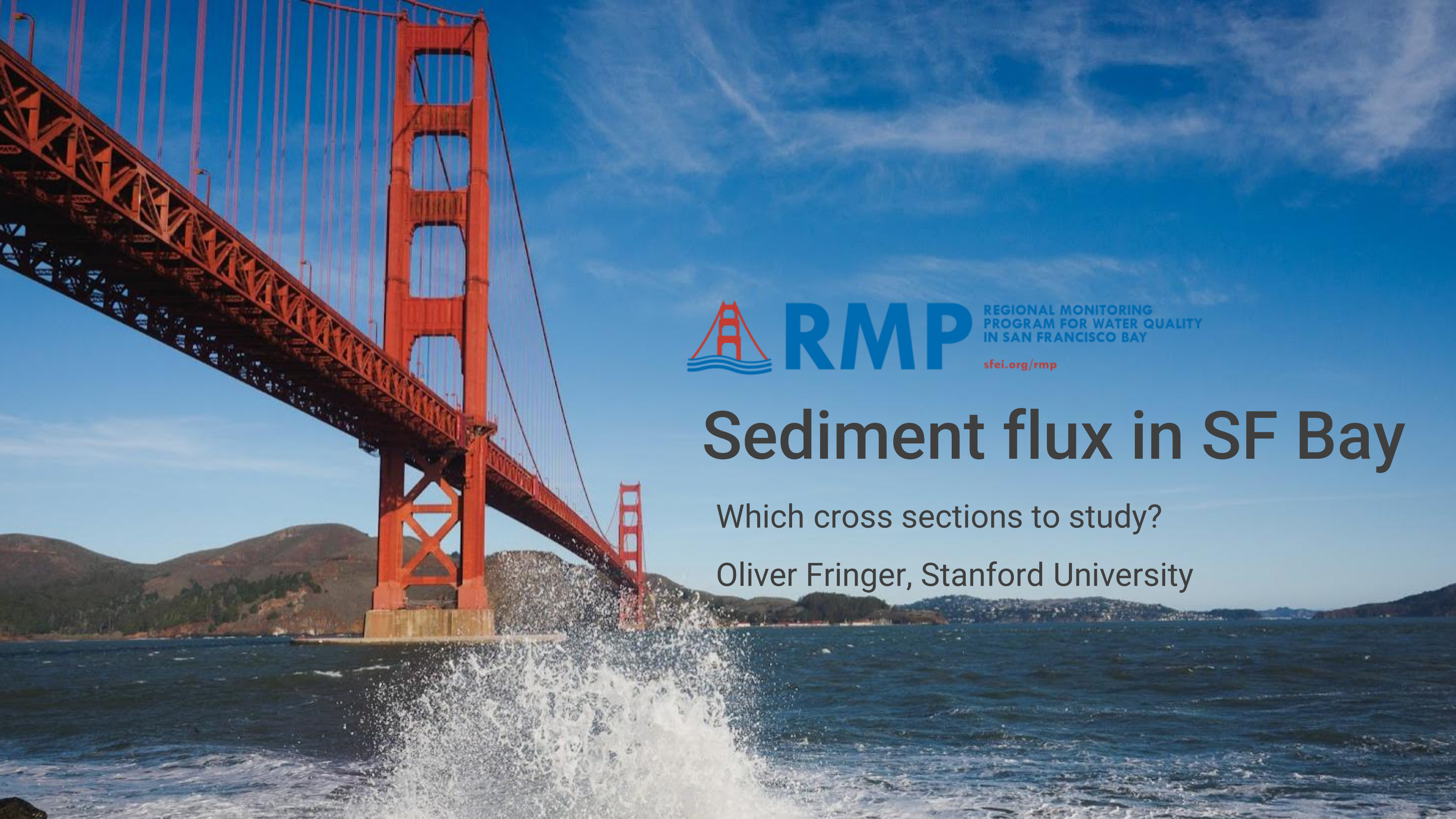

REGIONAL MONITORING PROGRAM FOR WATER QUALITY IN SAN FRANCISCO BAY

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Sediment flux in SF Bay

Which cross sections to study?

Oliver Fringer, Stanford University

Overview

Project objectives:

Task 1: Develop a community-based sediment transport model of SF Bay hosted on GitHub

Task 2: Study the physics governing the suspended sediment flux (SSF) at the Dumbarton and a second site (TBD) in SF Bay.

Project timeline: Total 2 years; started Jan 1, 2026 (3 month delay)

This presentation:

1. Project timeline and objectives

2. Discussion of second site to study suspended sediment flux

Project tasks and timeline

Note:

- Project delay of three months 10/1/25→1/1/26 (Agreement not finalized until 11/21/25).
- Additional three-month delay: Devin Dollery paternity leave spring 2026.

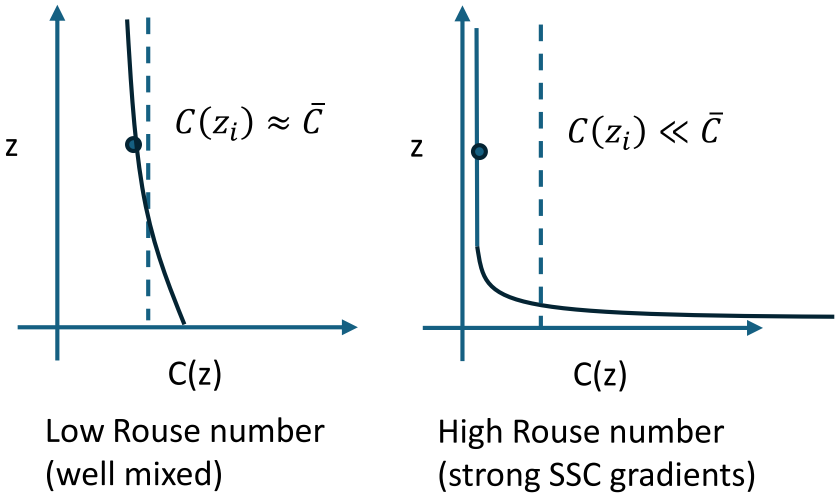
Deliverable	Original due date	New due date
Task 1: Community-based sediment transport model		
Task 1a: A full-bay DFlow-FM calibrated sediment transport model with waves (SWAN) + sediment (Delwaq)	July 2026	October 2026
Task 1b: A report and paper outlining the model implementation and its calibration.	July 2026	October 2026
Task 1c: A GitHub repository to share the model online for community use.	September 2027	December 2027
Task 2: Suspended sediment flux		
Task 2a: A report outlining the errors and possible improvements to methods to compute the sediment flux from field observations.	December 2026	March 2027
Task 2b: A report and paper on modeling and analysis of the physical factors impacting the sediment flux across the Dumbarton Narrows and one other transect in SF Bay.	September 2027	December 2027
Presentations to the Sediment Workgroup	**May 2026 (complete)** May 2027	

Motivation for studying the suspended sediment flux

- The suspended sediment flux is a key metric dictating sediment transport pathways in SF Bay
    - Indicates the potential for marshes to keep up with sea-level rise
    - Salt pond restoration projects in lower South Bay rely on a sediment supply
    - Useful for:
        - Computing average erosion/deposition in embayments.
        - Quantifying seasonal trends and impacts of different physical processes on sediment transport.
        - Model validation.
- Few modeling studies have quantified the physical drivers of the suspended sediment flux in estuaries like SF Bay.
    - Very difficult to measure
    - Few if any studies quantitatively compare observed and 3d-modeled cumulative flux (e.g. over a water year)

Project goals: Sediment flux analysis

1. Develop more accurate methods to infer the flux from limited observations
   a) How can we accurately relate high-frequency point measurements to infrequent cross-sectional averages (i.e. the index method of Livsey et al. 2019)?
   b) What is the impact of the cross-sectional variability on the flux?
   c) What instrument locations give the most accurate measure of the flux?
   d) What is the uncertainty in computing the flux with instruments?



Relationship of point measurement to depth average is sensitive to depth of measurement z_i and Rouse number $Ro = w_s/\kappa u_*$

2. What are the physical processes dictating the flux?

a) Relative contributions of the tidal residual and wind-driven circulation? Effect of spring-neap variability?

b) Effect of baroclinic circulation?

c) Channel-shoal exchange processes?

d) Effects of particle size distribution and erosion and flocculation/settling parameterizations?

e) Effects of wind-wave resuspension and seasonal variability of the wave direction and magnitude?

f) Relative contribution of local streams?

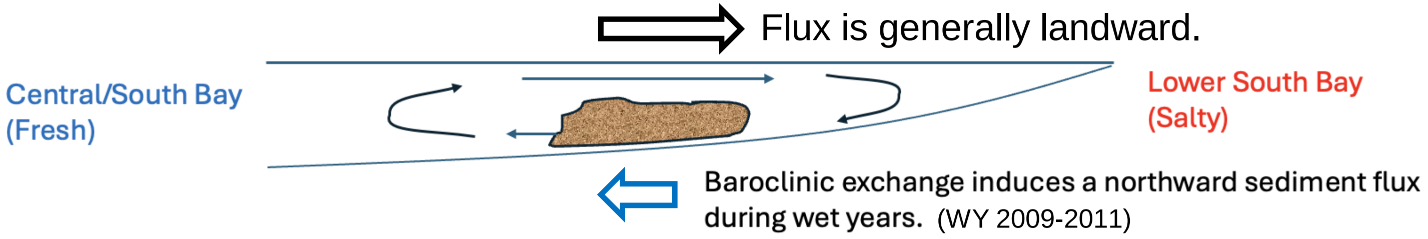
3. How do these processes impact the different components of the flux? Dyer (1974):

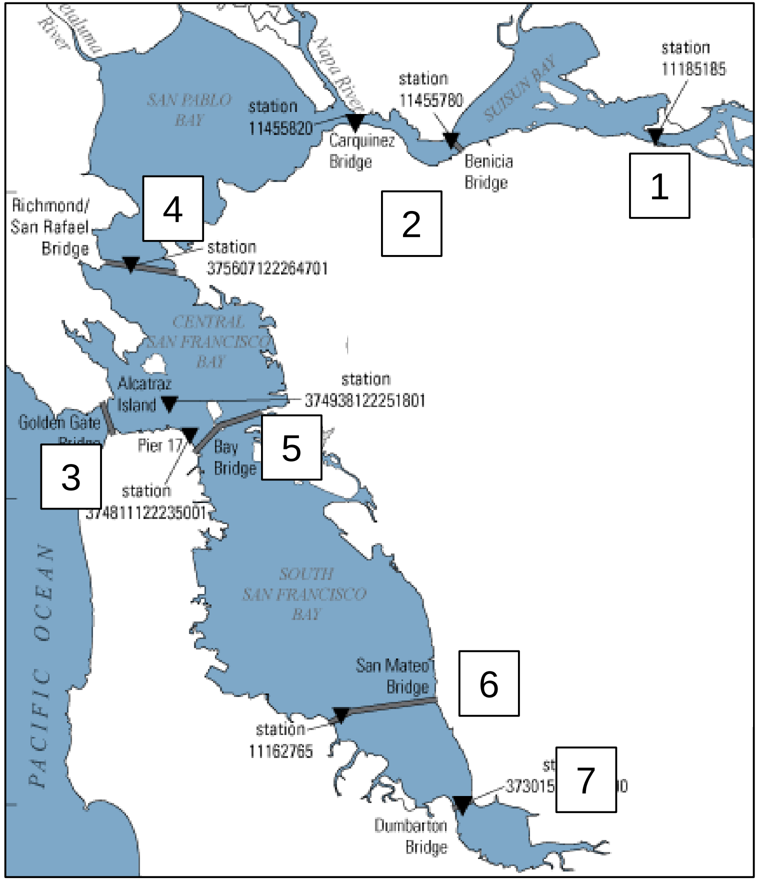
$$F_s = \overline{uHC} = \underbrace{\bar{u}\bar{C}\bar{H}}_{\text{Mean}} + \underbrace{\overline{\boldsymbol{u'C'}}\,\bar{\boldsymbol{H}}}_{\text{Dispersive}} + \underbrace{\overline{u'H'}\,\bar{C}}_{\text{Stokes drift}}$$

→ Because of the proposed detailed analysis, the study is limited to two sites even though a 3D model can easily compute the flux at all sites in SF Bay.

Why focus on the Dumbarton Bridge?

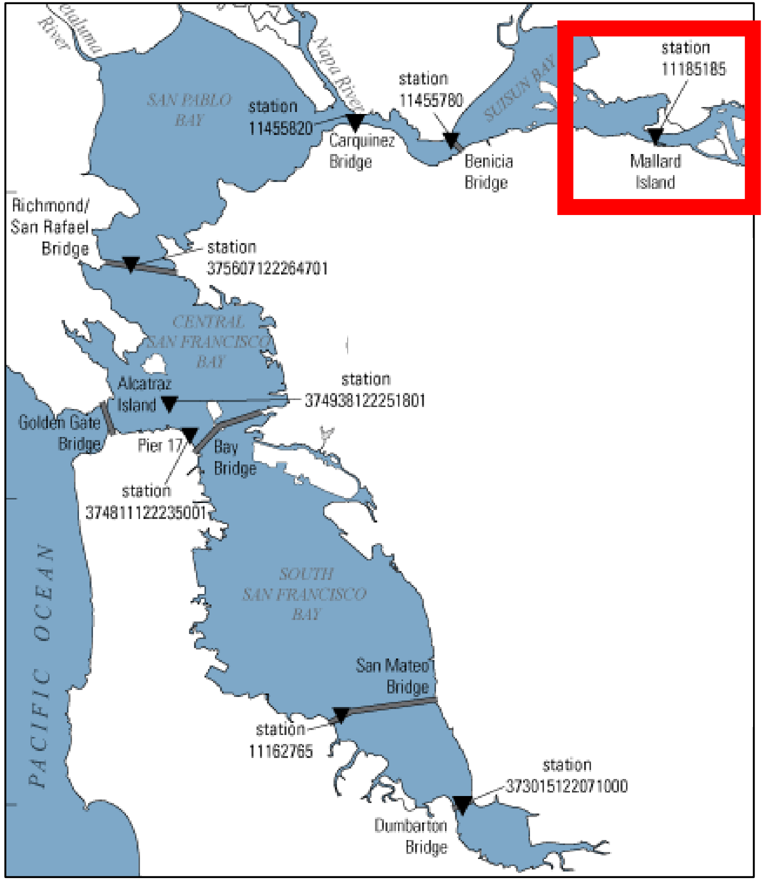
- The Dumbarton Bridge cross section has been extensively studied with observations (Shellenbarger et al. 2013; Livsey et al. 2019, 2020) and models (Bever and MacWilliams 2013; White 2019; Van Gijzen 2020).
  - General agreement that the flux is landward (into lower South Bay)
  - Modeling studies have not focused on understanding of governing physical processes
- Opportunity to build on past conceptual frameworks.
  - e.g. Livsey et al. (2020): Landward flux in WY 2009-2011 was lower than average because 2009-2011 was wetter (baroclinic flux drives sediment northward).





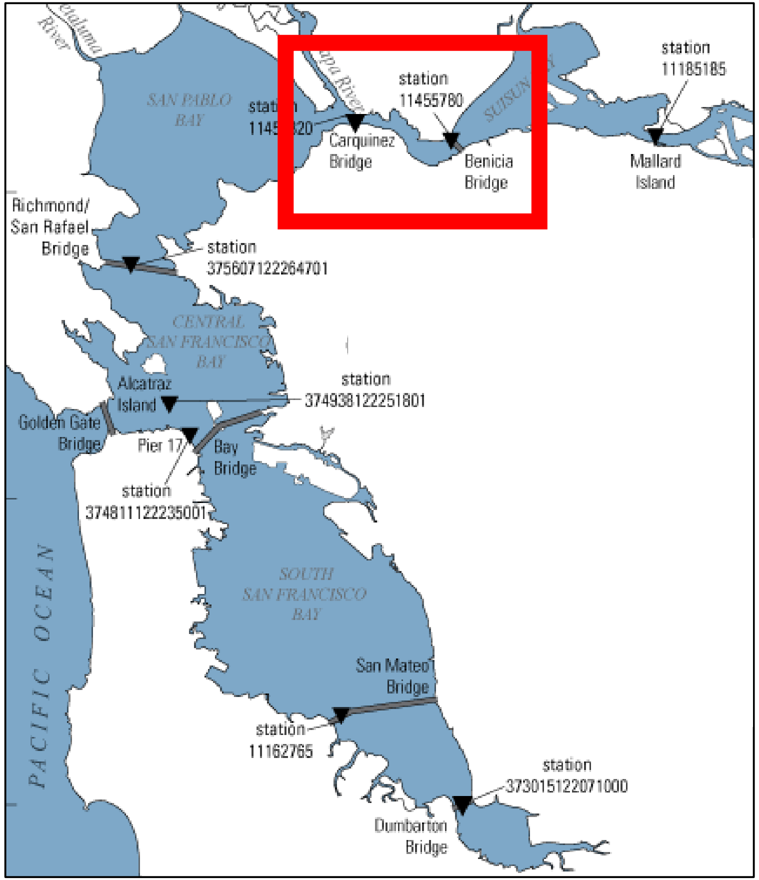
Which additional transect?

1. Mallard Island
2. Carquinez Bridge/Benicia Bridge
3. Golden Gate Bridge
4. Richmond/San Rafael Bridge
5. Bay Bridge
6. San Mateo Bridge
7. Dumbarton Bridge (this study)



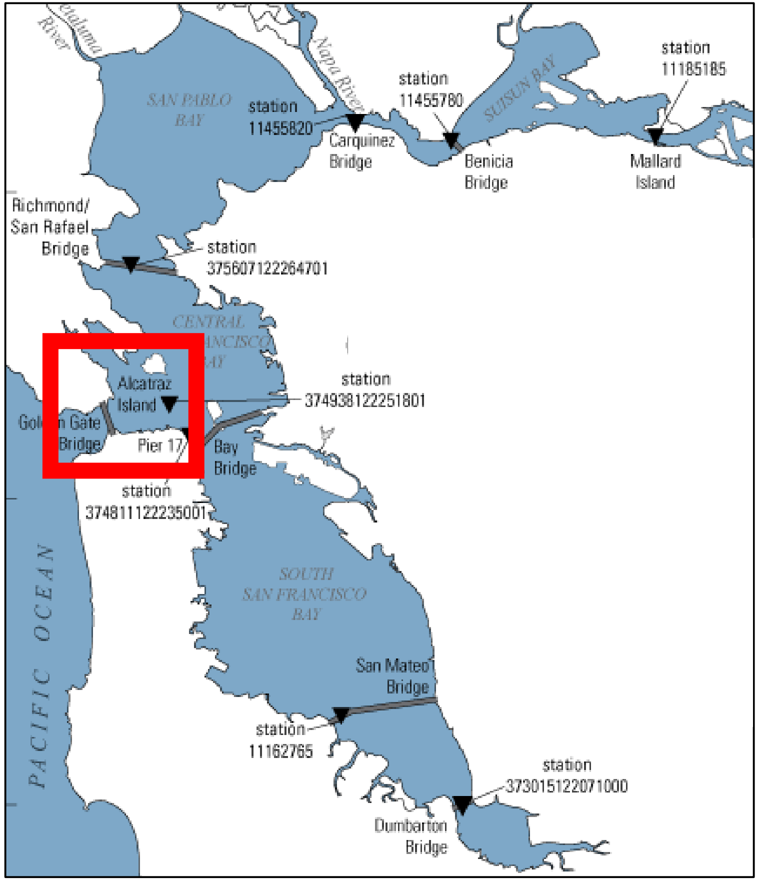
Transect: Mallard Island

- **Continuous monitoring station?** Yes
- **Previous literature:** McKee et al. (2006):
    - SSC observations at Mallard Island, split into advective+dispersive loads + DAYFLOW.
        - 1.2 Mt/year advective load into Bay during WY 1995-2003
        - 0.24 Mt/year (20%) dispersive load landward
    - Sediment delivery is strongly event-driven: The January 1997 flood accounted for 1.2 Mt (~11% of entire nine-year load).
- **Key issues for modeling:**
    - Measure of sediment supply to SF Bay.
    - Not a good candidate because proposed model does not include Delta.



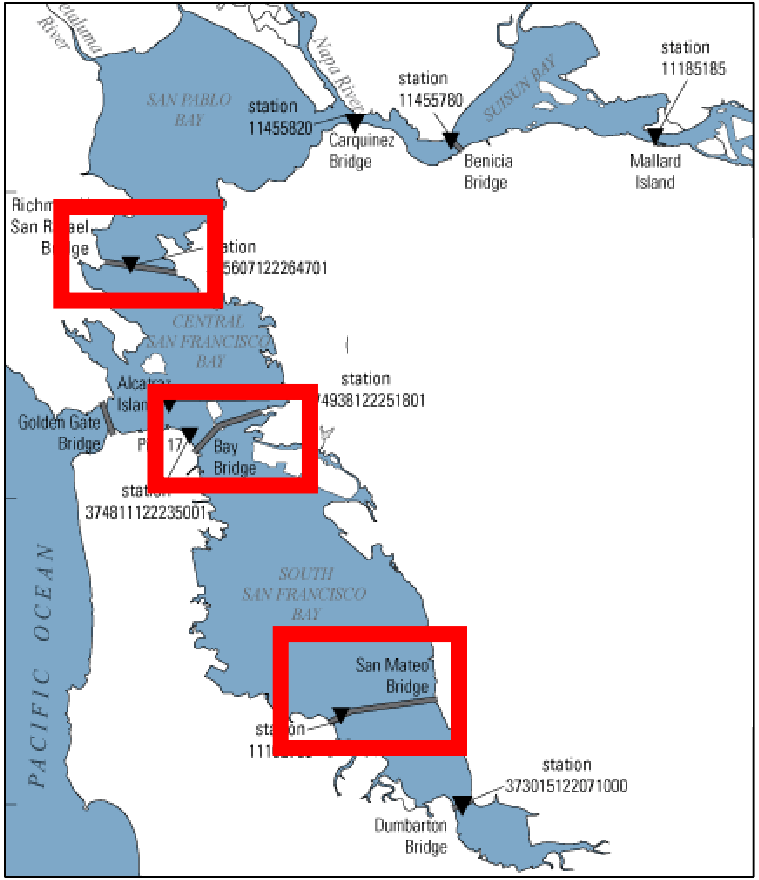
Transect: Carquinez/Benicia Bridge

- **Continuous monitoring station?** Yes (Carquinez and Benicia)
- **Previous literature:** Ganju and Schoellhamer (2006):
  - Cross-sectional measurements over 2 days + index method using Benicia station. Estimated advective, dispersive, and Stokes drift fluxes.
  - High flows: Advective and dispersive flux seaward
    Low flows: Dispersive flux landward, driven by gravitational circulation and high SSC in San Pablo Bay.
  - Stokes drift flux always landward.
- **Key issues for modeling:**
  - Could verify decomposition of fluxes and accuracy of the index method.
  - Rich interaction of different physical processes (gravitational circulation + Stokes drift).
  - Could relate physical processes to extensive literature on salt flux.
  - Flux depends largely on estimate of inflows from Delta.



Transect: Golden Gate Bridge

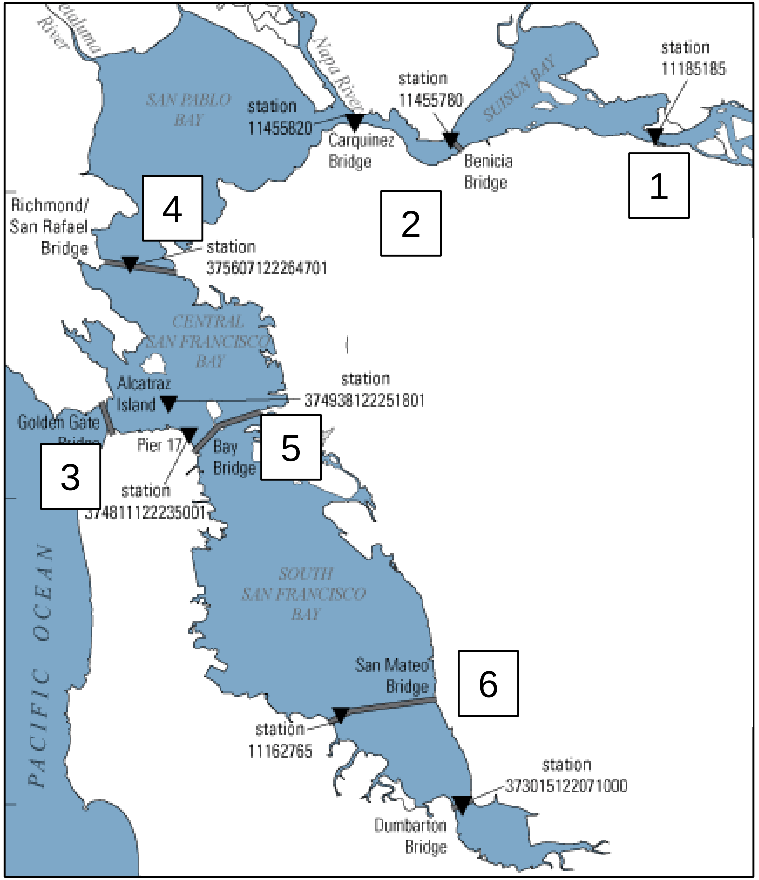
- **Continuous monitoring station?** No (Alcatraz surrogate)
- **Previous literature:**
  - Anchor QEA, L.L.C. (2021):
    - Observations (1 tidal cycle) + 3D model.
    - Surrogate relating Alcatraz SSC to GG SSF.
  - Erikson et al. (2013):
    - Observations (~2 tidal cycles) + 2D model.
    - Surrogate relating Alcatraz SSC to GG SSF.
  - Both studies show that transect data over one or two tidal cycles is not enough to validate the flux.
- **Key issues for modeling:**
  - Flux is largely due to remote rather than local sources.
  - Key measure of SF Bay sediment budget.
  - No continuous monitoring; 3D modeling could optimize field study and further evaluate Alcatraz as a surrogate.



Transect: Richmond/San Rafael Bridge, Bay Bridge, San Mateo Bridge

- **Continuous monitoring station?** Yes except for Bay Bridge (Pier 17 is a surrogate)
- **Previous literature:**
  Many previous studies compute the SSF at these transects to estimate sediment budgets, although they do not validate the flux or perform a detailed analysis (e.g. Anchor QEA, L.L.C. 2021, Van Gijzen 2020).
- **Key issues for modeling:**
  - Difficult to validate 3d model due to lack of cross-sectional measurements.
  - Very wide cross sections:
    - Likely interesting physics associated with lateral variability.
    - Point measurements less representative of cross-sectional variability.
    - Surrogates or index method less reliable.
  - Could evaluate potential for a flux observational study with 3D model.

Summary



Site	Continuous monitoring?	Past studies	Key issues
Golden Gate Bridge (3)	Surrogate (Alcatraz)	Anchor QEA, L.L.C. (2021), Erikson et al. (2013) Observations (~2 tidal cycles) + 2D model; Surrogate relating Alcatraz SSC to GG SSF.	• SSF is largely due to remote rather than local sources. • Key measure of SF Bay sediment budget. • No continuous monitoring; 3D modeling could optimize field study and further evaluate surrogates.
Carquinez Bridge/Benicia Bridge (2)	Yes	Ganju and Schoellhamer (2006): Observations over 2 days + index method. Surrogates relating flow, salinity Gradient, and Benicia SSC to advective, dispersive, Stokes drift SSF.	• .Could verify decomposition of fluxes using index method. • Rich interaction of different physical processes (gravitational circulation + Stokes drift). • Could relate physical processes to extensive literature on salt flux. • Flux depends largely on estimate of inflows from Delta.
Mallard Island (1)	Yes	McKee et al. (2006), Observations estimating advective + dispersive SSF.	• Measure of sediment supply to SF Bay. • Not a good candidate because model does not include Delta.
San Mateo Bridge (6) Bay Bridge (5) Richmond/San Rafael Bridge (4)	Yes (Pier 17 is surrogate for Bay Bridge)	No focused studies.	• Difficult to validate 3d model due to lack of cross-sectional measurements. • Very wide cross sections. • Could propose flux observational study with 3D model.

Modeling can help inform:

- Accuracy of surrogates and/or index method.
- Placement of instrumentation to improve accuracy of flux estimates with observations.

Questions?

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Cohesive sediment transport modeling for SF Bay

Galen Egan[1] and Oliver Fringer[2]

1 Department of Geosciences, Princeton University

2 Dept of Civil and Environmental Engineering, Stanford University

Overview

- (1 min) Sediment Modeling Study Plan (Fringer)
- (5 min) The need for cohesive sediment transport modeling in SF Bay (Fringer)
- (5 min) Data assimilation methods (Egan)

- (10 min) Phase 1: 1DV Modeling (Egan)
- (15 min) Discussion

- (10 min) Phase 2: 3D Modeling (Fringer)
- (15 min) Discussion

Sediment modeling study plan

"A study plan to improve parameterizations of erosion and settling to advance sediment transport modeling for San Francisco Bay", by Oliver Fringer, Rachel Allen, Allie King, and Jessie Lacy. http://web.stanford.edu/~fringer/study_plan

6 Phases

- Phase 1: Past observations with new 1DV modeling (Egan/Allen)
- Phase 2: Past observations with new 3D modeling (Fringer)

- Phases 3 and 4: Design and conduct a combined observational (Phase 3) and modeling (Phase 4) study to infer erosion and settling parameters

- Phases 5 and 6: Design and conduct a combined observational (Phase 5) and modeling (Phase 6) study of SSF at the Dumbarton Narrows

Suspended sediment advection-diffusion equation

Sediment transport models discretize the suspended sediment advection-diffusion equation for multiple size classes $i = 1, 2, \dots, N_s$

$$\frac{\partial C_i}{\partial t} + u\frac{\partial C_i}{\partial x} - w_{s,i}\frac{\partial C_i}{\partial z} = \frac{\partial}{\partial z}\left(\kappa_T \frac{\partial C_i}{\partial z}\right)$$

Rate + Advection – Settling = Vertical turbulent mixing

Boundary condition at bed:

$$\left(-\kappa_T \frac{\partial C_i}{\partial z}\right) = E - w_{s,i} C_{i,bed}$$

Flux from/to bed = Erosion - deposition

- Hydrodynamics models do a good job of predicting horizontal transport and vertical turbulent mixing in response to tides, winds, waves, baroclinic circulation, etc…
- Models are still lacking in their ability to predict erosion and settling.

Fixed size-class sediment transport models of SF Bay

Model	# Size Classes	Reference
Delft3D	2	Allen et al. (2021)
SUNTANS	2	Chou et al. (2017)
UnTRIM + Sedimorph	4	MacWilliams et al. (2015)
UnTRIM + Sedimorph	5	Anchor QEA, L.L.C. (2021)
SCHISM+SED3D	3	Wang et al. (2021)
Dflow-FM	2	Van Gijzen (2020), White (2019), Gostic (2018)

- Models can reasonably predict low-frequency variability of the SSC; generally underpredict peaks in tidally-driven or wave-driven SSC.
- Parameter set is not unique! (Allen et al. 2021); Options if modeled SSC is too low:
  - Increase erodibility parameter
  - Decrease critical shear stress
  - Decrease settling velocity
- Size classes (and hence settling velocities) are tuned to match observations of SSC. Account for errors in other parameters.
- All models use fixed bed properties that are either tuned or based on core samples.

Status of the current state of the art

Anchor QEA 2021 Report (MacWilliams) on sediment transport modeling in SF Bay with UnTRIM + SediMorph:

"The major simplifications made in this application were:"

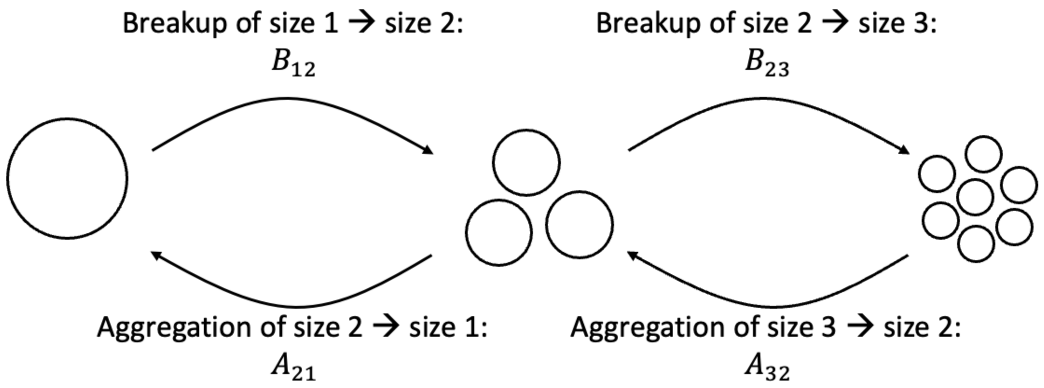
- Discrete set of sediment classes with constant sediment parameters.
- No model for aggregation and breakup of sediment particles.
- Simple treatment of the seabed.

Some of the effects of these simplifications:

- Decreased peak SSC during energetic periods because flocs do not disaggregate and resuspend more easily.
- Underestimation of sediment flux from channels and onto mudflats.
- Increased SSC at the start of spring tides owing to a lack of consolidation during the preceding neap tide.

Proposed work: Cohesive sediment transport

- Use FLOCMOD model of Verney et al. (2011) to simulate aggregation and breakup of multiple cohesive sediment size classes:

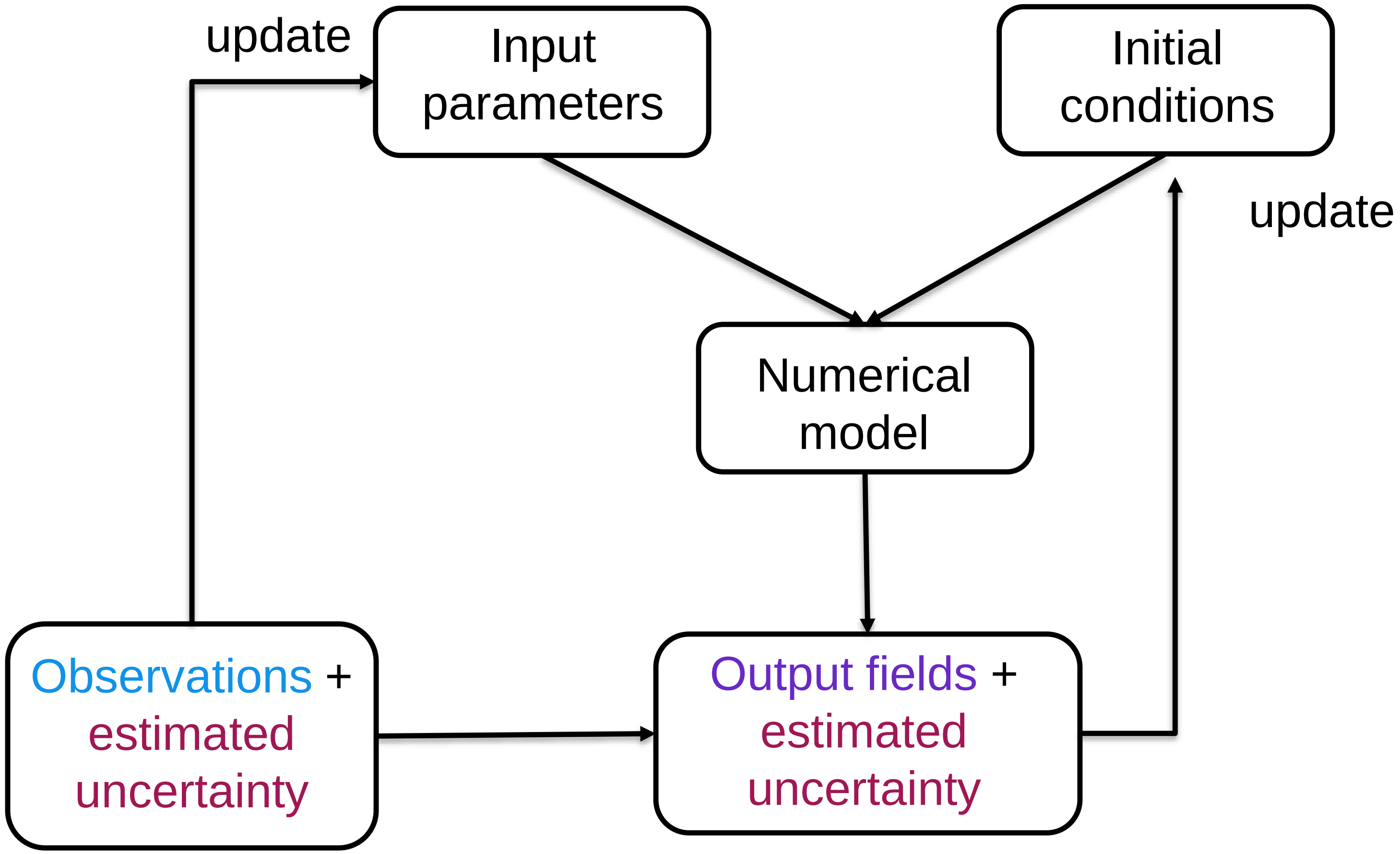


$$\frac{\partial C_1}{\partial t} + \cdots = -B_{12} + A_{21}$$
$$\frac{\partial C_2}{\partial t} + \cdots = +B_{12} - A_{21} - B_{23} + A_{32}$$
$$\frac{\partial C_3}{\partial t} + \cdots = +B_{23} - A_{32}$$

→ Requires many size classes and additional parameters related to aggregation and breakup in response to turbulent shear rate, suspended sediment concentration, and fractal dimension.

- Use the model of Sanford (2008) to represent consolidation and swelling of bed in response to erosion/deposition.
- Infer the many parameters using data assimilation.

Data Assimilation

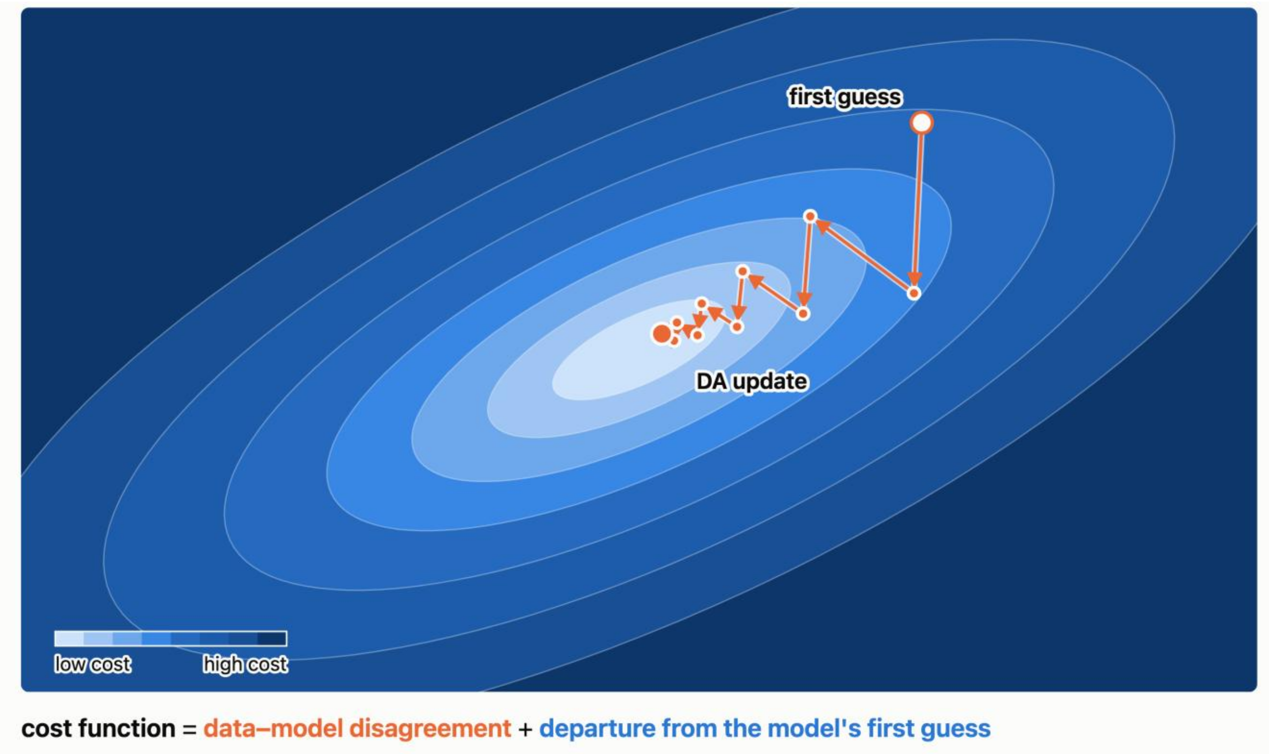


- Methods for combining numerical model output, observations, and uncertainties of each to better estimate modeled quantities and unknown input parameters

Data Assimilation for Sediment Transport Modeling

- Updating model state, e.g., the suspended sediment concentration field
  - Improved initialization
  - Adjustments to model output
- Setting input parameters, e.g., floc yield strength, critical shear stress, fractal dimension, …
  - Updates are automatic and optimal given the available data
- Comparisons across time and space
  - Improvement over subjective tuning procedures, which can make it difficult to compare calibrated parameter values between study sites

Adjoint Methods

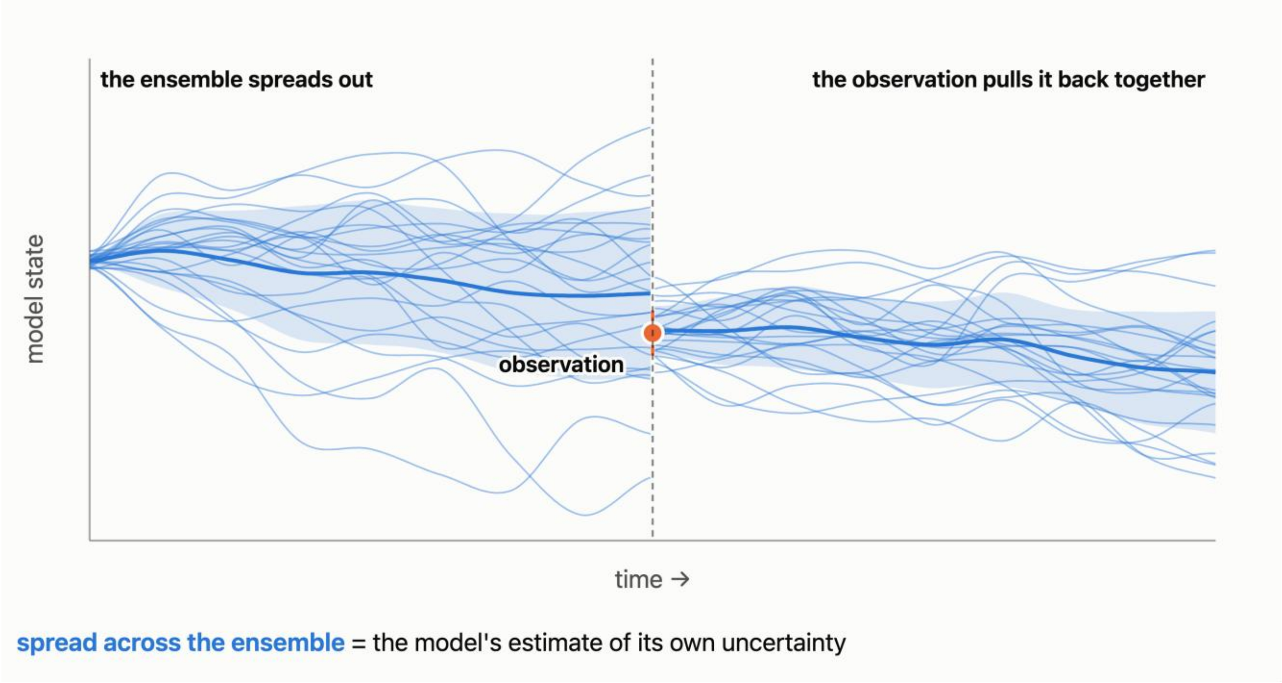


- Model uncertainty prescribed in advance, with updates based on an iterative cost function minimization

- High upfront implementation cost: requires hand-coding derivatives (Jacobian) of the numerical model and all parameterizations

Wang et al., 2018

Ensemble Kalman Filter



- Model uncertainty calculated on the fly from an ensemble of simulations (i.e., Monte Carlo approach)

- Easier to implement, but high ongoing computational cost

Evensen, 1994

Project Goals: Phases 1 & 2

Develop and validate **data-assimilative numerical models for cohesive sediment transport** in SF Bay

Management Questions: Phases 1 & 2

MQ3: What are the sources, sinks, pathways, and loadings of sediment and sediment-bound contaminants to and within the Bay and subembayments?

3.3: What are the main sediment transport processes and pathways within subembayments?

MQ5: What are the concentrations of suspended sediment in the Estuary and its subembayments?

5.2: How does bed erodibility vary around the Bay in relation to physical factors such as texture, tides, and waves, and biotic factors such as phytobenthos and bioturbation?

5.3: How do flocculation processes and floc sizes vary throughout the Bay in relation to SSC, water column depth, tides, wind, and other drivers, and how do these influence settling velocity?

5.4: What are the concentrations and fluxes of suspended sediment in nearshore areas over tidal cycles, spring and neap tides, and seasonally?

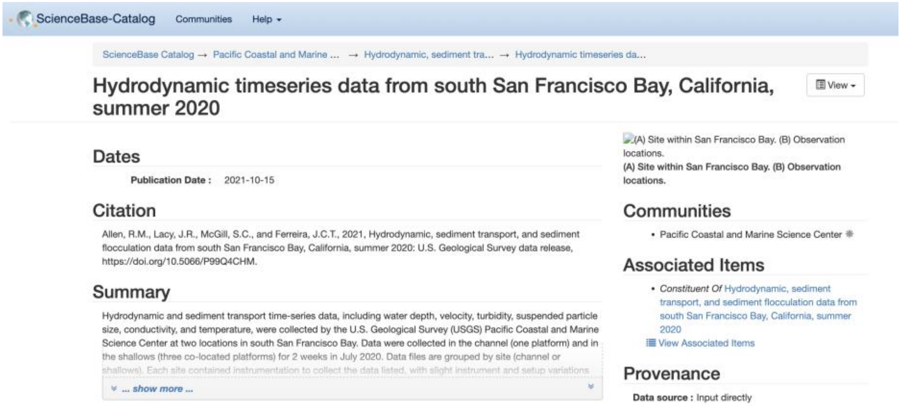
Phase 1 Study Proposal

- Overarching Goal: Implement a data-assimilative 1D Vertical (1DV) numerical sediment transport model, validated against existing SF Bay observations

1A
  - Task 1: Curate and QA/QC existing SF Bay Datasets (07/2027)
  - Task 2: Develop non-assimilative 1DV model code (02/2028)
  - Task 3: Report + publication on model development and validation (07/2028)

1B
  - Task 4: Add data assimilation to 1DV model (02/2029)
  - Task 5: Report + publication on DA methods and validation (07/2029)
  - Task 6: Report + publication comparing assimilation-informed model parameters across time and study sites (12/2029)

Task 1: SF Bay Datasets


ScienceBase-Catalog Communities Help

ScienceBase Catalog → Pacific Coastal and Marine ... → Hydrodynamic, sediment tra... → Hydrodynamic timeseries da...

Hydrodynamic timeseries data from south San Francisco Bay, California, summer 2020

View

Dates

Publication Date : 2021-10-15

Citation

Allen, R.M., Lacy, J.R., McGill, S.C., and Ferreira, J.C.T., 2021, Hydrodynamic, sediment transport, and sediment flocculation data from south San Francisco Bay, California, summer 2020: U.S. Geological Survey data release, https://doi.org/10.5066/P99Q4CHM.

Summary

Hydrodynamic and sediment transport time-series data, including water depth, velocity, turbidity, suspended particle size, conductivity, and temperature, were collected by the U.S. Geological Survey (USGS) Pacific Coastal and Marine Science Center at two locations in south San Francisco Bay. Data were collected in the channel (one platform) and in the shallows (three co-located platforms) for 2 weeks in July 2020. Data files are grouped by site (channel or shallows). Each site contained instrumentation to collect the data listed, with slight instrument and setup variations

... show more ...

(A) Site within San Francisco Bay. (B) Observation locations.

(A) Site within San Francisco Bay. (B) Observation locations.

Communities

- Pacific Coastal and Marine Science Center

Associated Items

- *Constituent Of* Hydrodynamic, sediment transport, and sediment flocculation data from south San Francisco Bay, California, summer 2020

View Associated Items

Provenance

Data source : Input directly

Allen et al., 2021 (www.sciencebase.gov)

- Minimum requirements: water level, tidal velocity, wave height, salinity, temperature, and SSC
- Range of environments: channels, flats, marsh fringes
- Deliverable (July 2027): datasets hosted in an open-source repository and used to validate 1DV and 3D model

Task 2: 1DV Modeling

- Suspended sediment transport assuming horizontal homogeneity: 1DV (Phase 1) and 3D (Phase 2) modeling will use exactly the same equations and parameterizations except for horizontal advection in 3D model.

$$\frac{\partial C_i}{\partial t} - w_{s,i}\frac{\partial C_i}{\partial z} = \frac{\partial}{\partial z}\left(\kappa_T \frac{\partial C_i}{\partial z}\right) - \boxed{u\frac{\partial C_i}{\partial x}}$$

3D Model only

- The vertical turbulent eddy-diffusivity, κ_T, will be computed with the General Ocean Turbulence Model (GOTM; Umlauf and Burchard, 2003, 2005a), in response to currents, waves, vertical stratification, bottom stress, etc…
- Deliverable (Feb 2028): source code hosted on Github

Parameterizations in the 1DV model

Table S2. Variables associated with the floc model FLOCMOD as implemented in ROMS/CSTMS, listed in order of appearance in the sediment.in input file.

Symbol in Text	*Model Variable Name in FLOCMOD*	*Description*	*Typical or Default Value*	*Units*
	l_ADS	Enable differential settling	F	True/False
	l_ASH	Enable shear aggregation	T	True/False
D_p	f_dp0	Primary particle size	4e-6	m
	f_dmax	Maximum particle size	Not used	m
	f_nb_frag	Number of fragments by shear erosion	2	-
α	f_alpha	Flocculation efficiency (range: 0 – 1)	0.35	-
β	f_beta	Shear fragmentation rate (0 – 1)	0.15	-
	f_ater	Ternary breakup: 0.5; Binary: 0.0	0.0	-
	f_ero_frac	Fraction of shear fragmentation term transferred to shear erosion (0 – 1)	0.0	-
	f_ero_nbfrag	Number of fragments induced by shear erosion	2.0	-
	f_ero_iv	Fragment size class	1	-
	f_collfragparam	Fragmentation rate for collision-induced breakup	0.01	-
	f_clim	Min. concentration below which floc processes are not calculated	0.001	kg / m^3
	l_testcase	Set G values to Verney et al. (2011) values	F	True/False
	MUD_FRAC_EQ	Fractional size class distribution for cohesive sediment in bed		NNS values; sum must be unity.
	t_dfloc	Time scale for floc evolution in the bed	200.0	s

- Flocculation: FLOCMOD
    - Models exchange of particles among size classes by shear- and collision-driven aggregation and breakup
- Bed evolution and erosion
    - Models the evolution of particle size distribution, bulk density, critical shear stress over multiple bed layers as a function of time and bioturbation
- Lots of parameters to specify!

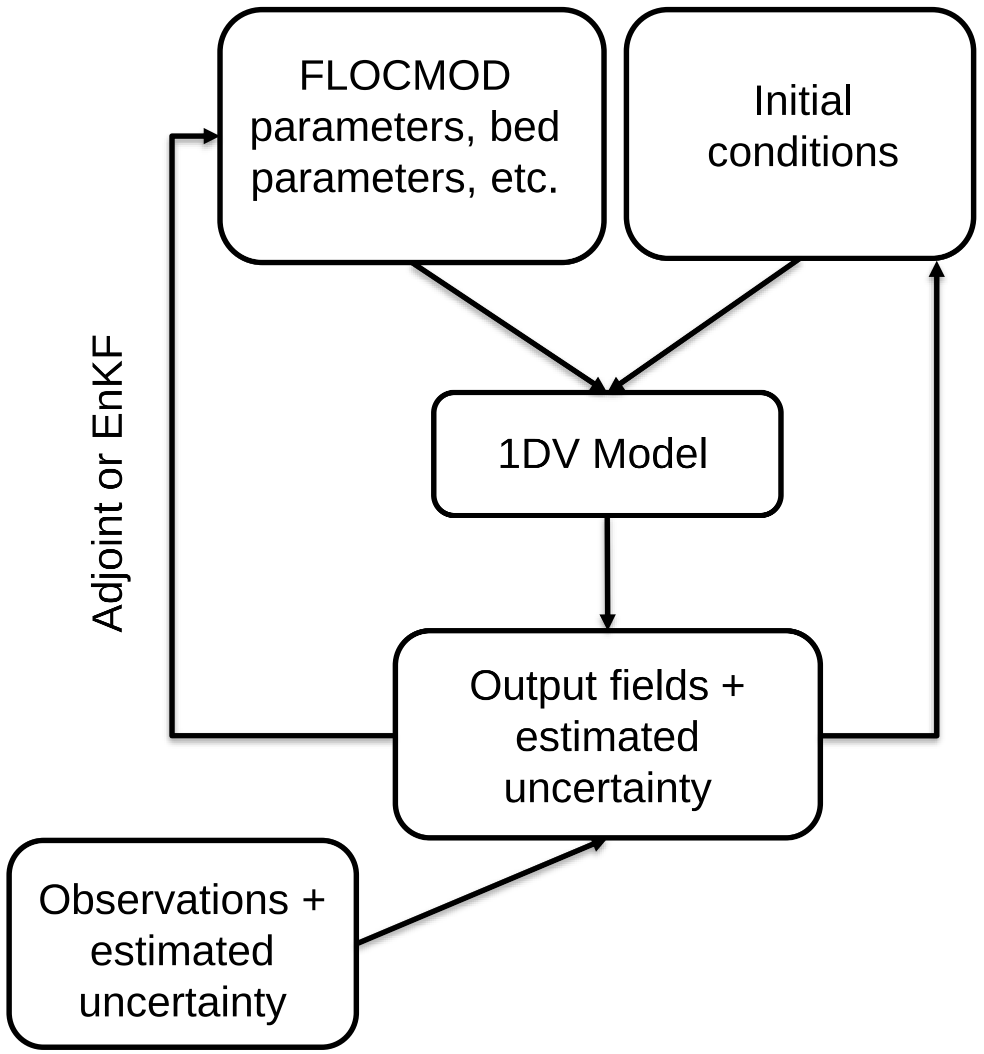
Verney et al., 2011, Sherwood et al., 2018

Task 3 (Paper/Report): 1DV Model Development + Validation

- Deliverable (July 2028): Technical report and submitted journal publication detailing:
  - Development of the 1DV model
  - Validation/comparison against multiple field datasets
- Will include discussion of conditions that the 1DV model struggles to resolve

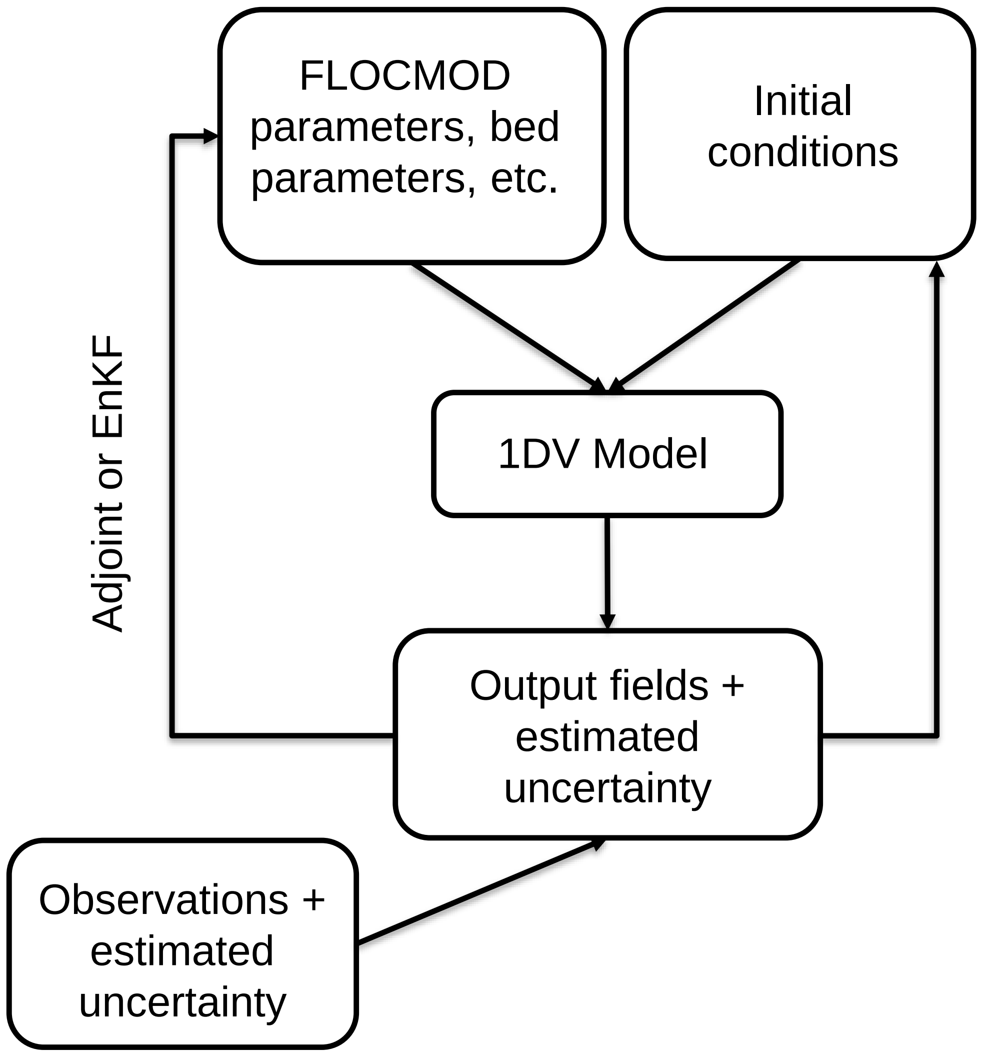
3.3: What are the main sediment transport processes and pathways within subembayments?

Task 4: 1DV Model with Data Assimilation



- Primary research effort: implement and test adjoint and ensemble Kalman filter data assimilation approaches
  - Will compare upfront and ongoing complexity in terms of code maintenance and computational costs
- Final implementation will enable objective, data-driven parameter estimation
- Deliverable (Feb 2029): source code hosted on Github

Task 5 (Paper/Report): 1DV + DA Development



- Deliverable (July 2029): Technical report and submitted journal publication describing:
  - Development and testing of the data assimilation system
  - Comparison of the adjoint and ensemble Kalman filter methods

Task 6 (Paper/Report): Applying 1DV + DA to field sites

5.2: How does bed erodibility vary around the Bay in relation to physical factors such as texture, tides, and waves, and biotic factors such as phytobenthos and bioturbation?

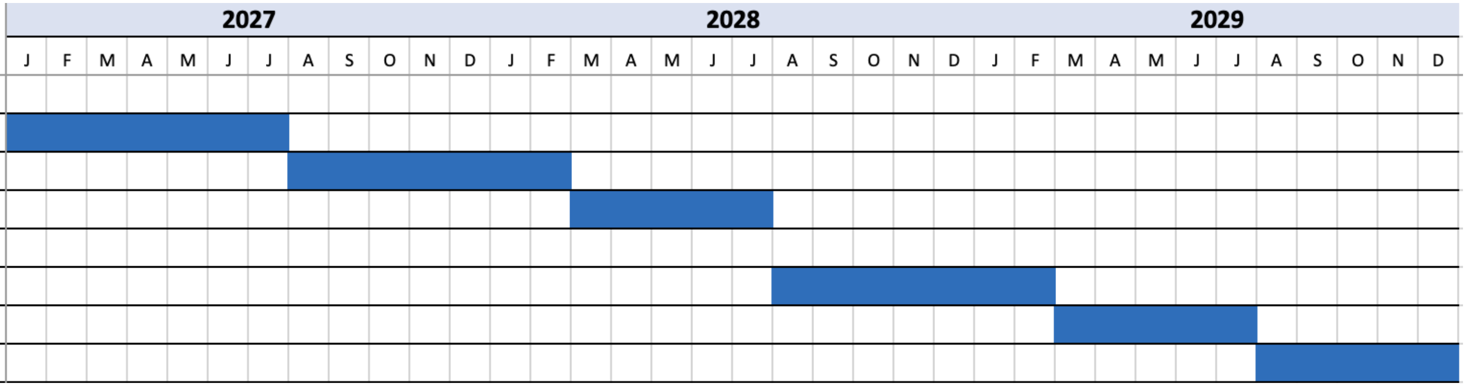
5.3: How do flocculation processes and floc sizes vary throughout the Bay in relation to SSC, water column depth, tides, wind, and other drivers, and how do these influence settling velocity?

5.4: What are the concentrations and fluxes of suspended sediment in nearshore areas over tidal cycles, spring and neap tides, and seasonally?

- Deliverable (Dec 2029): Technical report and submitted journal publication comparing:
    - Predictive skill of assimilative versus non-assimilative 1DV model over various time scales
    - Optimal input parameter values at each of the study sites
    - Relationships between parameter values and resulting suspended sediment concentration and particle size distributions across study sites

Phase 1 Budget: 3 Year Timeline

Deliverable	Cost	Due
<u>Phase 1a</u>		
Task 1. QA/QC'd dataset	$ 65,372	July 2027
Task 2. 1DV model code	$ 76,267	February 2028
Task 3. Paper: model dev. + validation	$ 54,477	July 2028
<u>Phase 1b</u>		
Task 4. 1DV model w/ DA code	$ 76,267	February 2029
Task 5. Paper: 1DV + DA dev.	$ 54,476	July 2029
Task 6. Paper: applying 1DV + DA to field sites	$ 65,372	December 2029
<u>Other Direct Costs</u>		
Materials, travel, and publications	$ 15,000	
<u>Indirect Costs</u>		
25% of Total Modified Direct Costs	$ 91,038	
GRAND TOTAL	**$ 498,269**	



- PI Egan: 1 month/year
- PI Allen: 2 weeks/year
- Full-time postdoctoral scholar

Phase 1 Discussion
(15 minutes)

Phase 2 Study Proposal

RMP

Overarching Goal: Develop a 3D sediment transport model that accurately simulates cohesive sediment transport processes in SF Bay.

2A Fixed size classes

- Task 1: Software to compute offline sediment transport (04/2027)
- Task 2: Calibrated offline sediment transport model (07/2027)

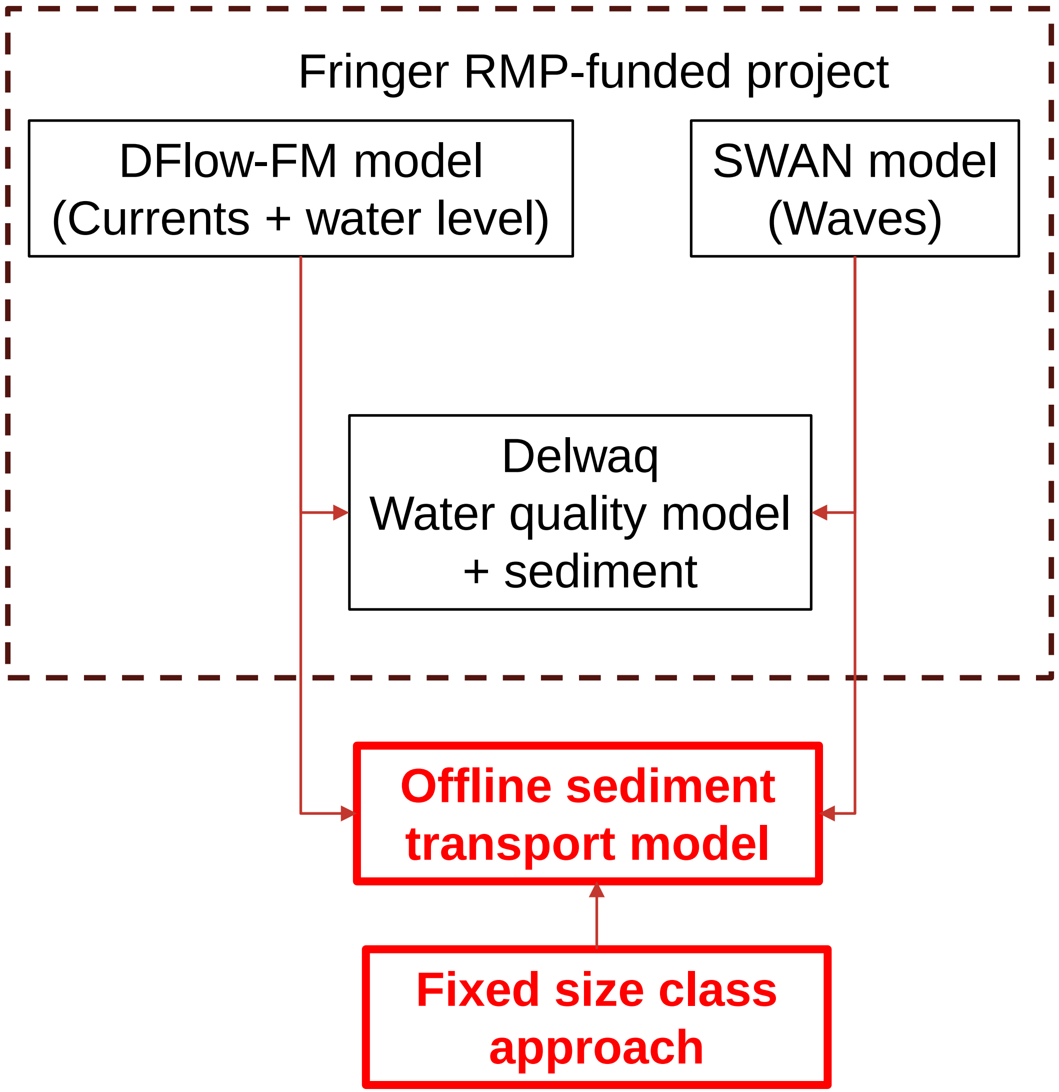
2B: Cohesive modeling

- Task 3: Software to compute sediment transport with the FLOCMOD approach (02/2028)
- Task 4: Calibrated FLOCMOD software with traditional tuning approach (07/2028)
- Task 5: Technical report and peer-reviewed publication (07/2028)

2C: Data assimilation

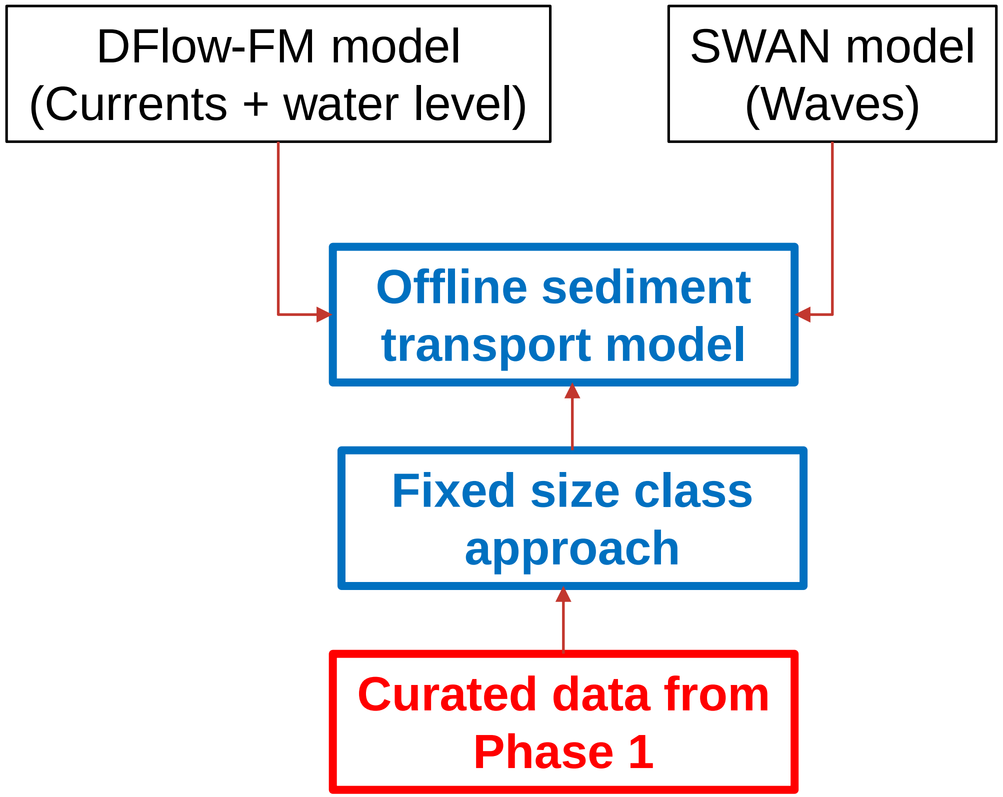
- Task 6: Data assimilation with fixed size classes (12/2029)
- Task 7: Technical report and peer-reviewed publication (12/2029)
- Task 8: Data assimilation with FLOCMOD (12/2030)
- Task 9: Technical report and peer-reviewed publication (12/2030)

Task 1: Offline sediment transport model



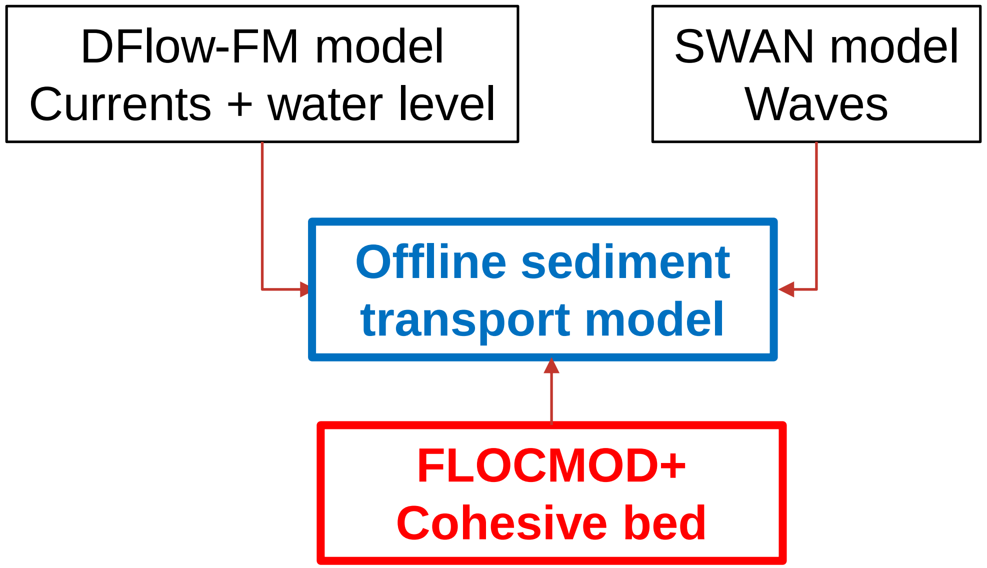
- Fringer's RMP-funded project:
  - Existing DFlow-FM model from previous RMP-funded projects → community-based github repository
  - Add SWAN wave model
  - Implement sediment transport in Delwaq model
- Task 1: Replace Delwaq with more efficient, in-house sediment transport model
- Deliverable (April 2027): Offline sediment transport modeling software with fixed size class approach.

Task 2: Calibrated offline sediment transport model



- Use data from phase 1 to calibrate offline sediment transport model.
- Deliverable (July 2027): Calibrated offline sediment transport model.

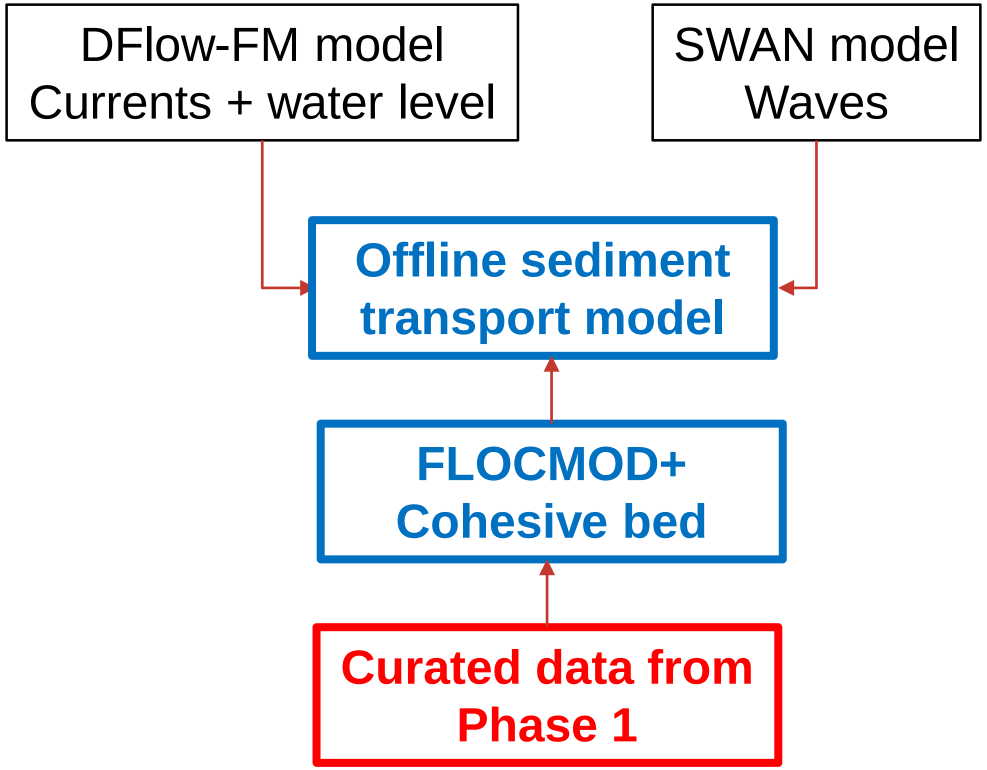
Task 3: Develop 3D FLOCMOD and cohesive bed routines



- Add FLOCMOD and cohesive bed routines to offline sediment transport code.
  - Incorporate variable size classes and flocculation/breakup routines as well as cohesive bed properties.
  - Will work closely with Egan/Allen to ensure same parameterizations as 1DV model.

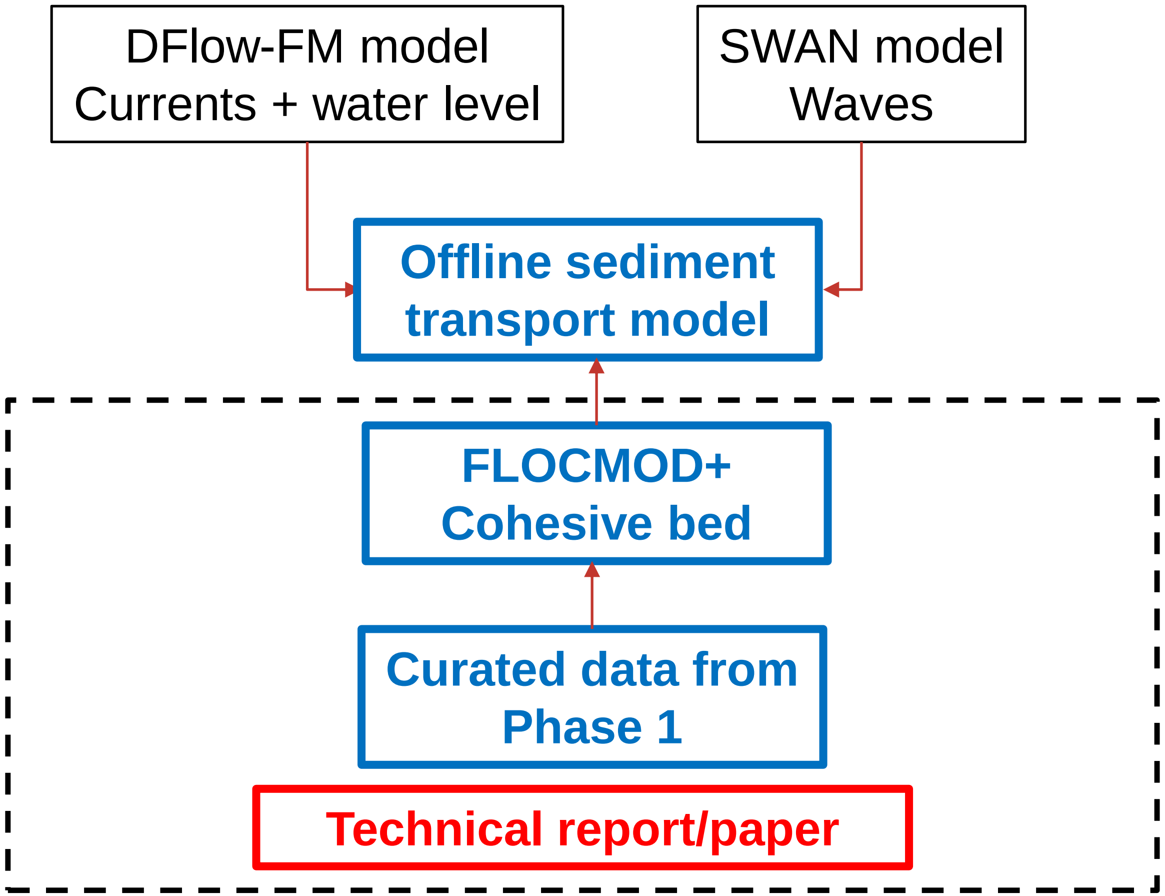
- Deliverable (Feb 2028):
  - FLOCMOD+cohesive bed source code hosted on github.
  - **Coincides with Phase 1, Task 2 deliverable (1DV model code).**

Task 4: Calibrated 3D FLOCMOD model



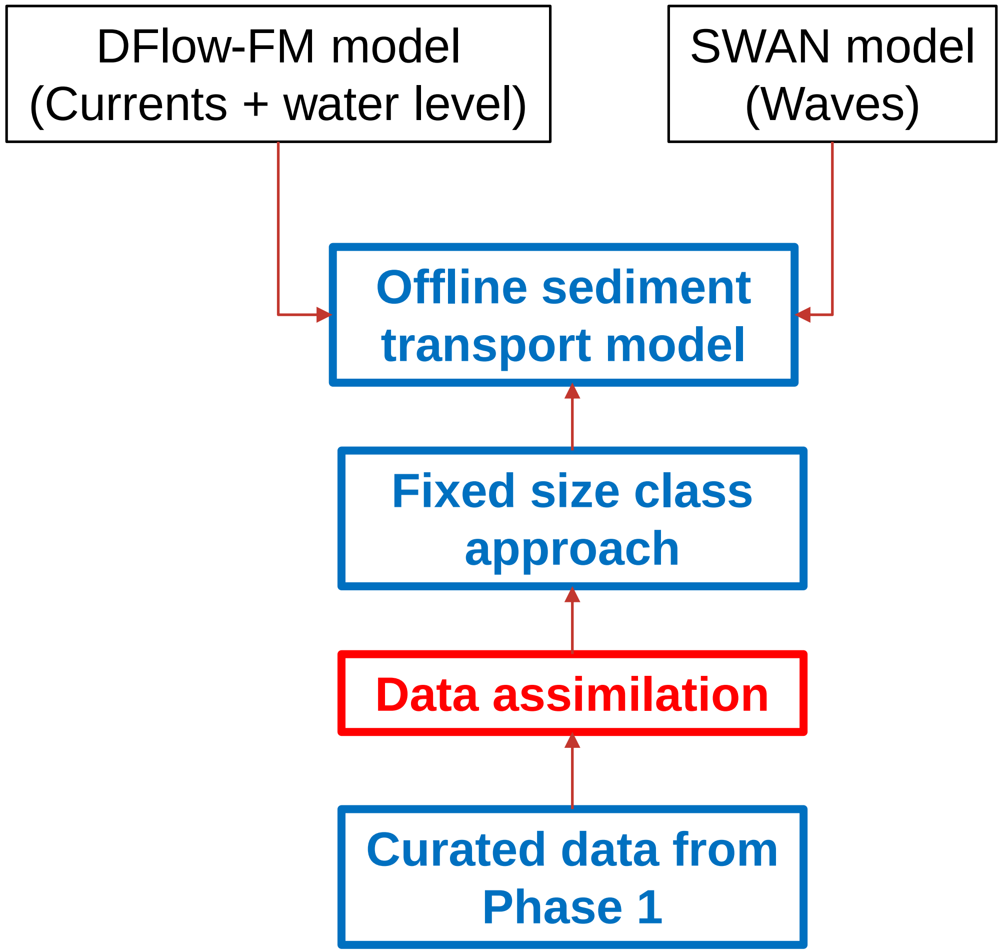
- Calibrate FLOCMOD + cohesive routines
  - Calibrate using traditional calibration methods (i.e. not data assimilative)
  - Use curated data from Egan/Allan Phase 1
  - Will use parameters suggested from Egan/Allen and previous studies (e.g. flocculation/breakup rates, bed properties)
- Deliverable (July 2028):
  - Calibrated FLOCMOD+cohesive bed source code hosted on github
  - **Coincides with Phase 1, Task 3 deliverable date (Report/paper on calibrated 1DV model with no data assimilation).**

Task 5: Technical report and paper on calibrated 3D FLOCMOD model



- Deliverable (July 2028): Technical report/paper on FLOCMOD + cohesive sediment transport modeling in SF Bay
  - Offline sediment transport model
  - Compare FLOCMOD and cohesive bed parameters to those based on fixed size class approach (Tasks1/2).
  - Advantages/disadvantages when compared to traditional, fixed size class approach

Task 6: Data assimilation applied to traditional fixed size class approach

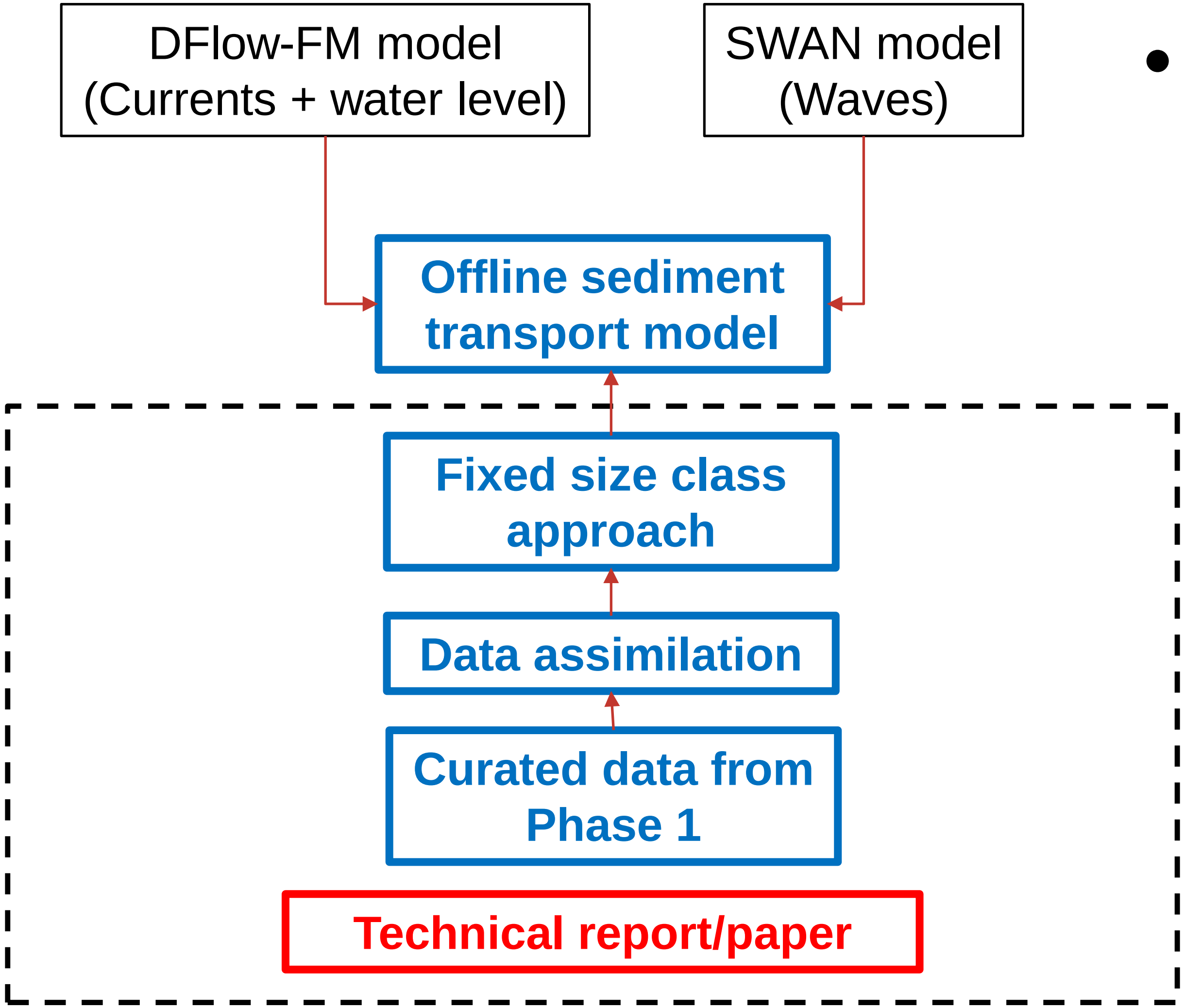


- Primary research effort: Develop and test data assimilation techniques
  - Apply to fixed size-class approach from Tasks 1 and 2.
  - Develop 3D ensemble Kalman filter and adjoint codes in offline sediment transport model and compare efficiency of both methods.
  - Key is to focus on assimilation methods with simplified sediment model, following Wang et al. (2018).

- Will use ideas/methods from Phase 1, Tasks 4/5/6 (Feb/July/December 2029).

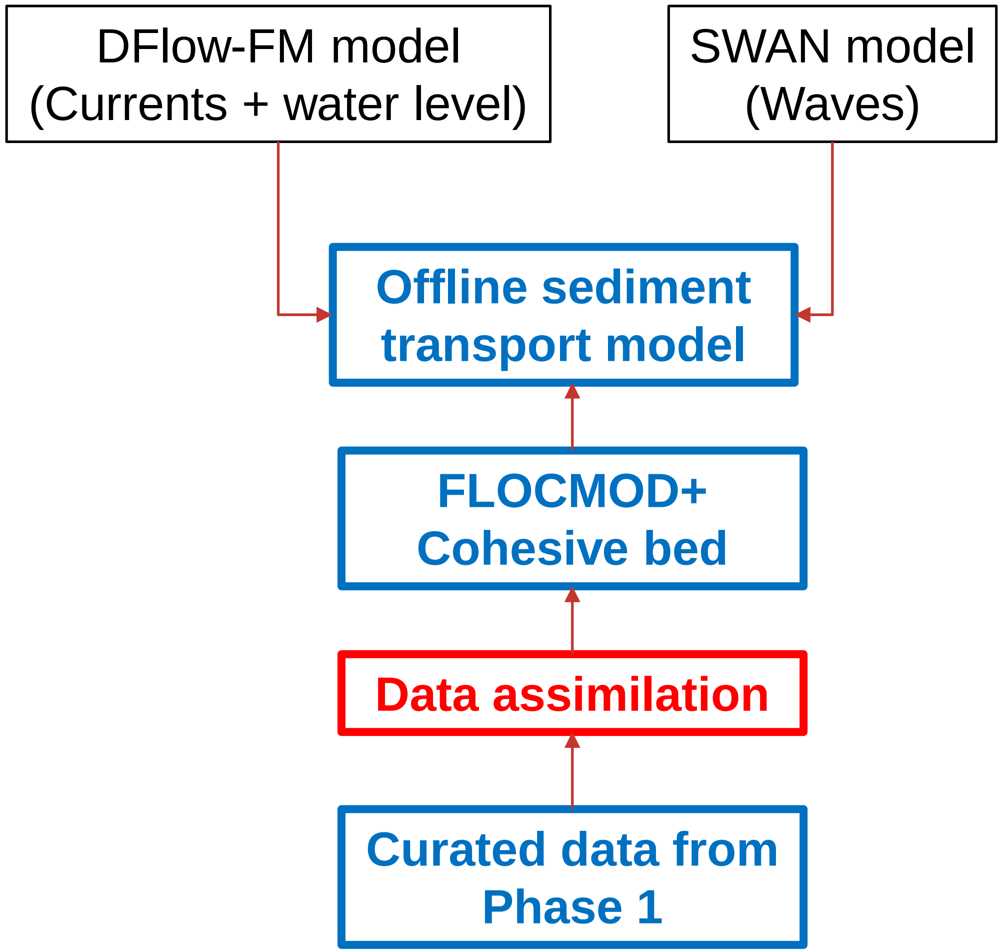
- Deliverable (December 2029):
  - Data assimilation codes hosted on github.

Task 7: Technical report on data assimilation for SF Bay sediment transport model



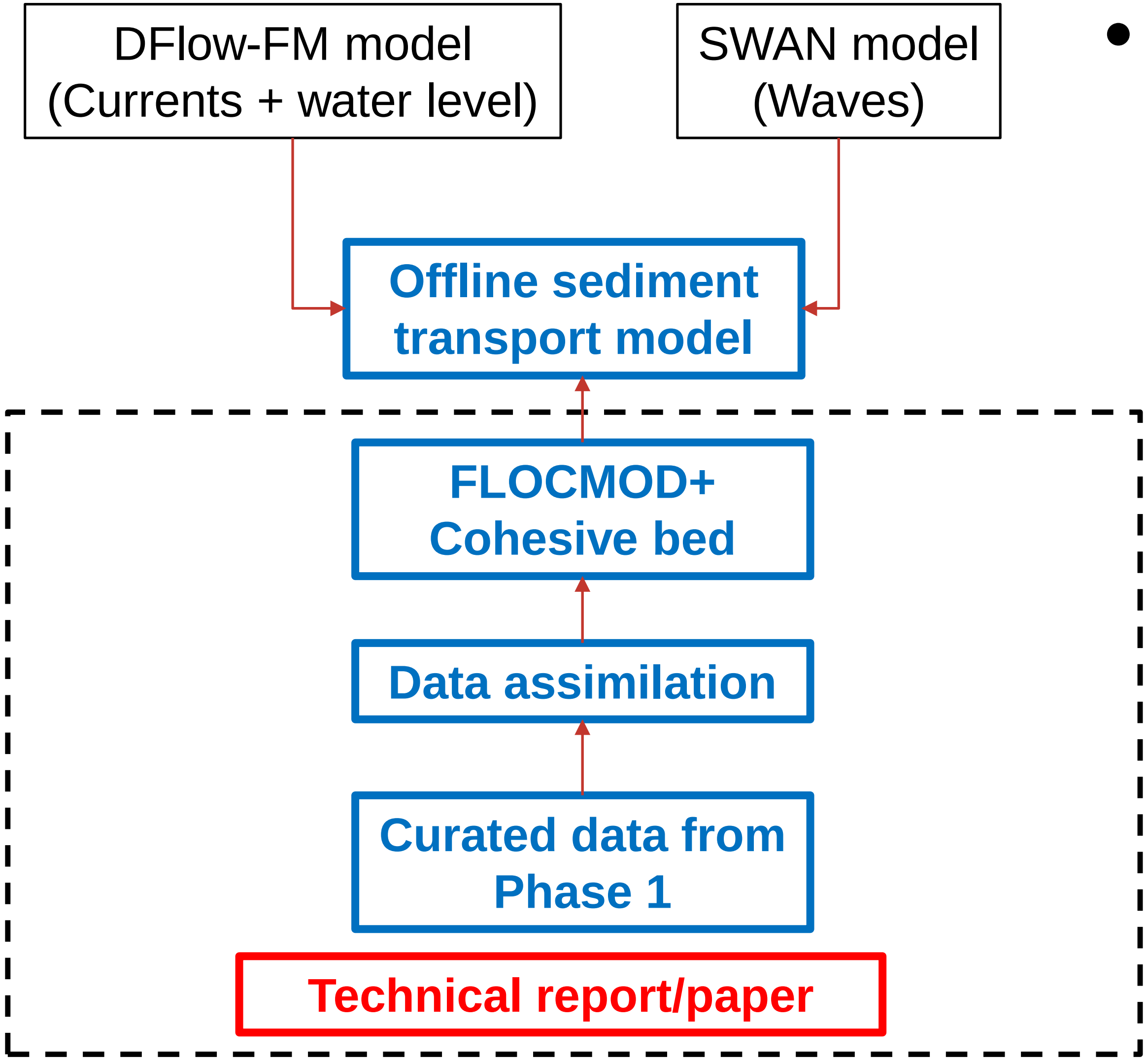
- Deliverable (December 2029): Technical report and paper outlining data assimilation applied to SF Bay sediment transport modeling
  - Focus on implementation and comparison of data assimilation techniques (adjoint vs EnKF)
  - Compare parameters derived from data assimilation to ad-hoc tuning approach (Tasks 1/2).
  - Compare accuracy of data assimilation approach to traditional ad-hoc tuning approach.

Task 8: Data assimilation applied to cohesive sediment transport model



- Primary research effort: Data assimilation applied to cohesive sediment transport modeling
  - Apply to cohesive modeling methods from Task 4.
  - Employ assimilation techniques developed during Task 6.
  - Key is to focus on cohesive methodology from Task 4 with knowledge of assimilation methods gained from Task 6.
- Will use ideas/methods from Phase 1, Tasks 4/5/6 (July 2029/December 2029).
- Deliverable (December 2030):
  - Data assimilation codes applied to cohesive sediment transport hosted on github.

Task 9: Technical report on SF Bay cohesive sediment transport modeling with data assimilation



- Deliverable (December 2030): Technical report and paper on cohesive sediment transport modeling in SF Bay with data assimilation
  - Outline cohesive sediment transport model.
  - Discuss data assimilation methodology.
  - Compare to three approaches:
    - Ad-hoc tuning with fixed size classes (Tasks 1/2)
    - ad-hoc tuning with cohesive sediment transport physics (Tasks 4/5)
    - data assimilation with fixed size classes (Tasks 6/7)
  - Compare to parameters obtained from 1DV modeling
  - Discuss overall advantages and limitations of cohesive sediment transport physics and data assimilation.

Phase 2 budget and 4-year timeline

Relevant Phase 1 Tasks	Task	Cost	Due	2027	2028	2029	2030
	Task 1: Software to compute offline sediment transport	$ 66,275	Apr 2027				
Task 1 (Curated data)	Task 2: Calibrated offline sediment transport model	$ 49,706	Jul 2027				
Task 2 (1DV model code)	Task 3: Software to compute sediment transport with the FLOCMOD approach	$ 116,975	Feb 2028				
Task 3 (1DV report/paper)	Task 4: Calibrated FLOCMOD software with traditional tuning approach	$ 42,664	Jul 2028				
	Task 5: Technical report and peer-reviewed publication	$ 42,664	Jul 2028				
Tasks 4-6 (1DV data assimilation codes and reports/papers)	Task 6: Data assimilation with fixed size classes	$ 225,951	Dec 2029				
	Task 7: Technical report and peer-reviewed publication	$ 35,156	Dec 2029				
	Task 8: Data assimilation with FLOCMOD	$ 198,101	Dec 2030				
	Task 9: Technical report and peer-reviewed publication	$ 54,315	Dec 2030				
	Direct costs						
	Equipment	$ 4,620					
	Travel	$ 27,720					
	Publications	$ 13,860					
	GRAND TOTAL	$ 878,009					

- PI Fringer: ½ month/year
- Full-time postdoctoral scholar

By sub-phase	
Expense	**Cost**
Phase 2a: Fixed size classes (Labor + Laptop)	$ 120,601
Phase 2b: Cohesive modeling (Labor + 1 pub. + 1 conf.)	$ 216,164
Phase 2c: Data assimilation (Labor + 2 pubs. + 2 conf.)	$ 541,244
GRAND TOTAL	$ 878,009

By year	
Year 1	$ 203,445
Year 2	$ 218,650
Year 3	$ 224,793
Year 4	$ 231,121
GRAND TOTAL	$ 878,009

Phase 2 Discussion
(15 minutes)