Nutrient Management Strategy

- What nutrient loads can SFB subembayments assimilate without adverse impacts?

Adverse Impacts?

- What management actions would be effective at achieving protective nutrient loads or concentrations?

Effective Management?

November 2012

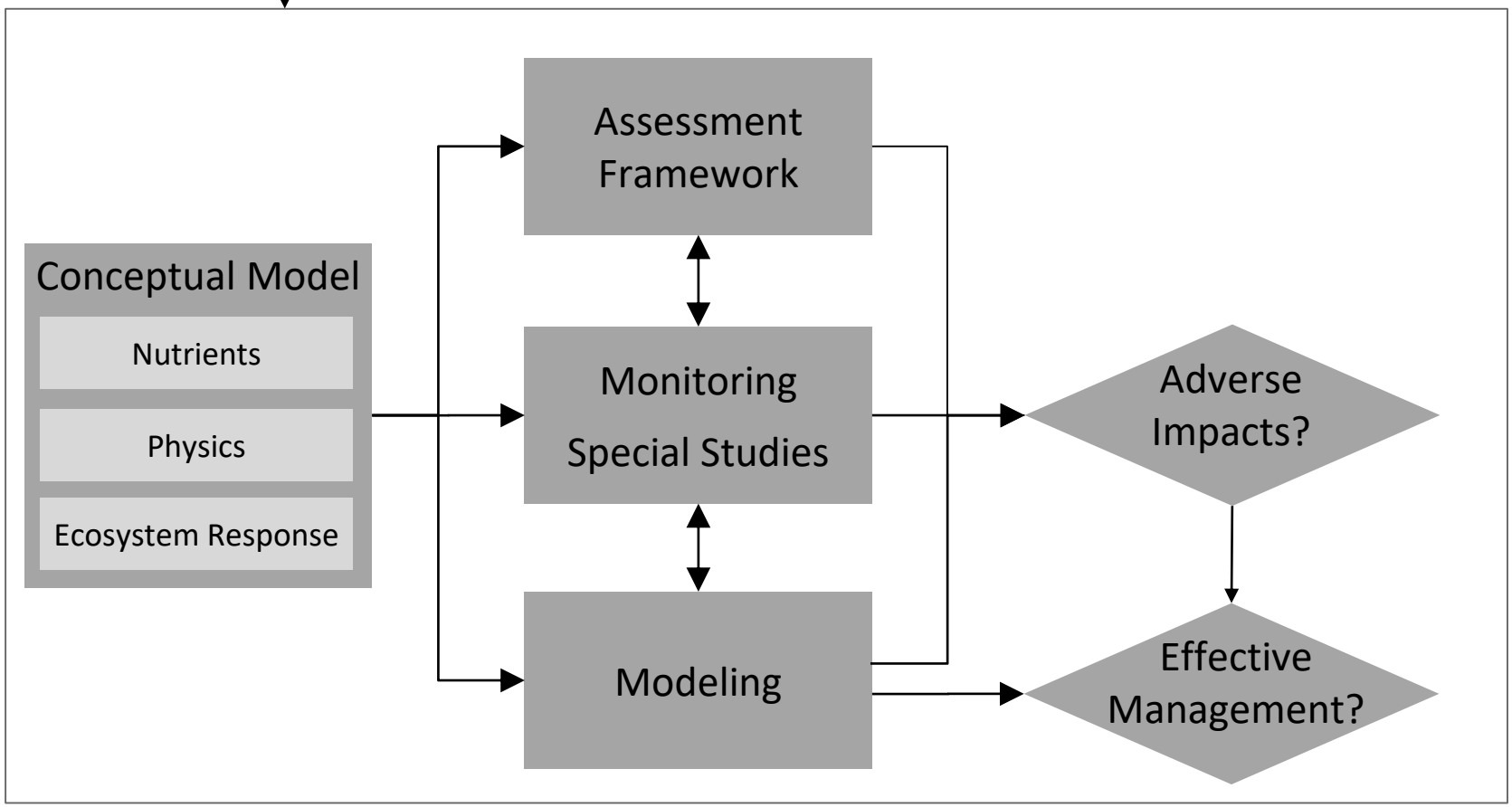
San Francisco Bay Nutrient Management Strategy

San Francisco Bay Regional Water Quality Control Board

Science Program Priorities

1. Nutrient Loads|Transformations
2. Phytoplankton Blooms & Low DO
3. HABs & Toxins
4. Coastal Ocean Impacts
5. Future Scenarios

Science Plan



November 2012

San Francisco Bay Nutrient Management Strategy

San Francisco Bay Regional Water Quality Control Board

Science Program Priorities

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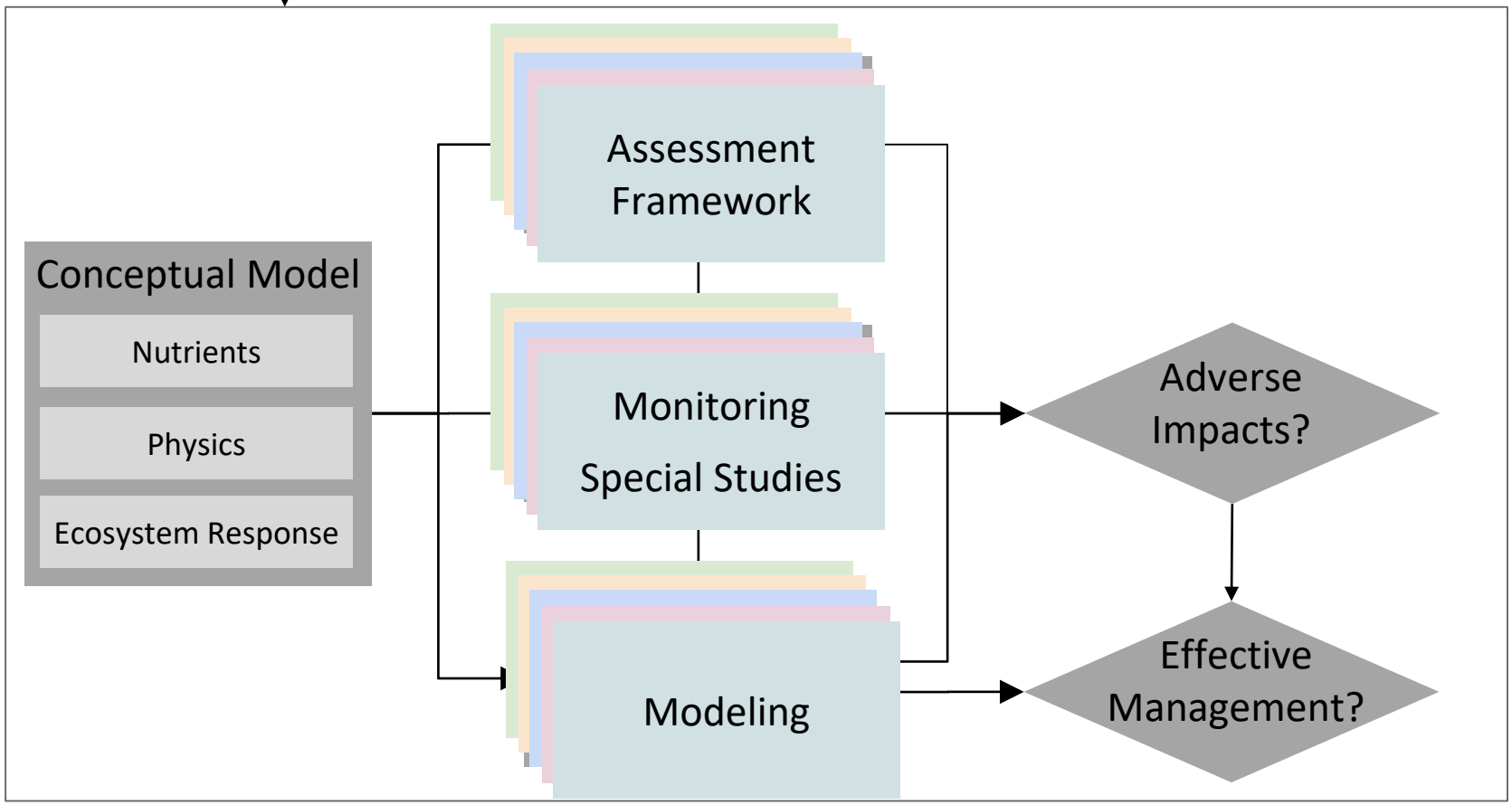
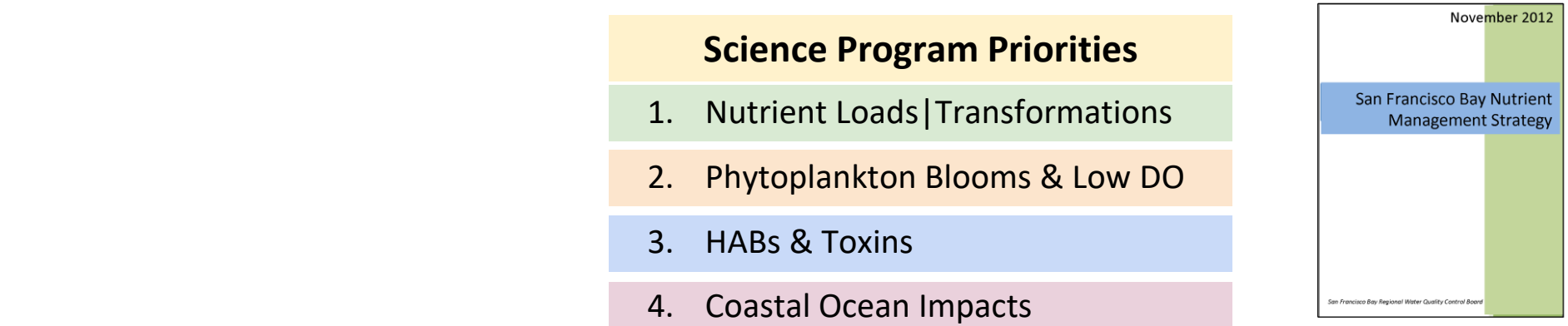
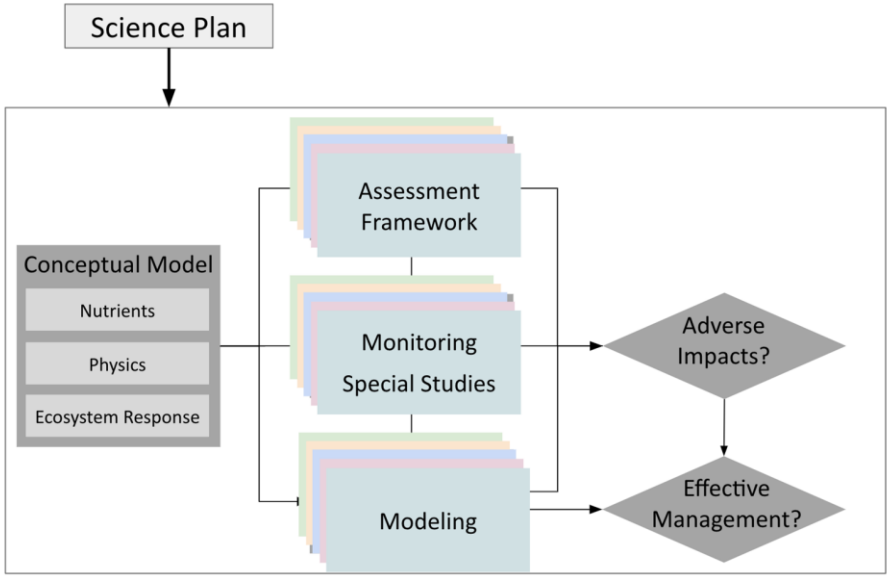
Science Plan



Science Program Priorities

1. Nutrient Loads|Transformations
2. Phytoplankton Blooms & Low DO
3. HABs & Toxins
4. Coastal Ocean Impacts
5. Future Scenarios





Major Aim going into Permit #2...
Reach agreement on the right balance between

a. Science Program Priorities
b. AF, Monitor, Studies, Modeling

Still to resolve...To obtain best most relevant info by 2024...
How should work be phased and resources allocated?

Target Resource Allocation based on Proposed Prioritization

		Total over 5yrs	%(Science)	Annual Avg
1	Nutrient sources, cycling, fate	3500		700
2	Phytoplankton, DO, openBay	3000	65	600
3	Phyto/Productivity/DO margins	2000		400
4	HABs	2500		500
5	Coastal exports	1000	35	200
6	Future Scenarios	1000		200
	Program Management	2000		400
		15000		

Total Revenue:

$12,500k: $2,200k/yr Permit + ~$300k RMP over 5 years

+$2,500k: other sources (e.g., fundraising, other partners)

$15,000k

Program Plan Approval Process

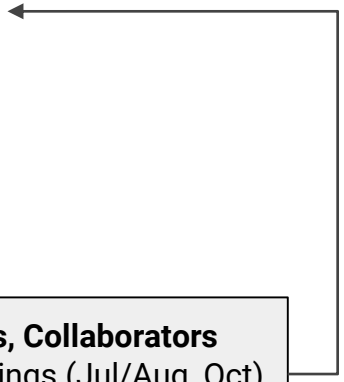
1. Early, and iterative, input from NMS SC
   - December 2018
   - March 2019

1. Alignment with Science Plan priorities
   - *Science Plan 1.0*
   - *Updated Science Plan 2.0 (2nd Permit, 2019-2024)*

1. Technical input

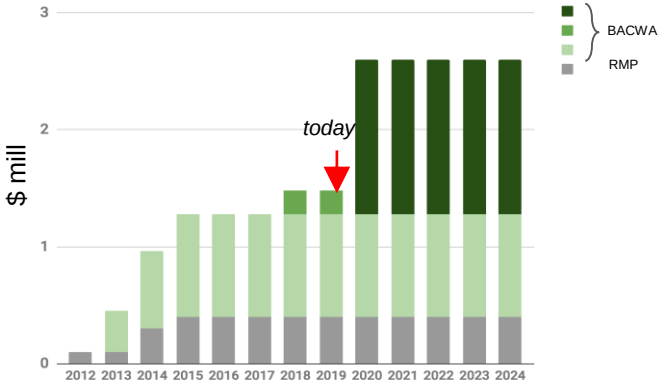
Nutrient Technical Workgroup
- Today
- Electronic (through June 5)

External Experts, Collaborators
- Upcoming meetings (Jul/Aug, Oct)



1. NMS SC Approval - June 14 2019

FY2020 Program Plan Overview



Anticipated Funding

Nutrient Permit FY2020	$2,200,000
RMP CY2020 special studies (est.; past funding: 200-500k)	$350,000
RMP CY2020 Monitoring (estimated)	$240,000
Total	**$2,790,000**

Costs

Core Program

Monitoring, Modeling:	
Ship-Based Monitoring	401,000
Mooring-sensor Monitoring	320,000
Modeling	349,000
Core Monitoring/Modeling subtotal	*$1,070,000*
Program/Project Management, Finances (15%)	354,000
Core science oversight	144,000
Core Program Total	***$1,568,000***

Projects **Total Funding Available** ***$1,222,000***

There is a ~350k gap between available funding and cost of Highest Priority projects.

Slate of Potential FY2020 Projects (see slides 5-11)

Priority Level		
	Highest	$1,579,000
	High	$1,334,000
	Medium	
	OK, already covered by other funds	

Option 1

Proj #	Brief Description	Priority	Cost		Activity						Focus Area						Opt1
					Monitor	Model	Field/Lab	A_Frmwrk	Synthesis	PrgrmCoord	chl-DO-open	chl-DO-mar	Nutrients	HABs	Future Scenarios	Coastal Exch	
C1	Ship-based sampling:	4	$401,000	$401,000	●	●	●				●	●	●	●			1
C2	Moored sensor	4	$320,000	$320,000	●	●	●				●	●	●	●			1
C3	Core Modeling:	4	$349,000	$349,000		●					●	○	●	○			1
C4a	Program/Project Management:	4	$353,907	$353,907						●							1
C4b	Science Program Coordination:	4	$143,966	$143,966						●							1
P1	HAB-toxin monitoring in bivalves:	4	$104,000	$104,000	●		●							●			1
P3	Zooplankton sampling:	4	$87,000	$87,000	●		●				●		●				1
P8	Modeling Program Planning, Model Advisory Group	4	$53,000	$53,000		●					●	●	●	○			1
P9	Developing Particle Tracking Capabilities NMS models	4	$20,000	$20,000		●					●	●	●	●			1
P14	Biogeochemical Field Studies	4	$427,000	$427,000			●				●		●				1
P15	HAB experimental study	4	$55,000	$55,000			●							●	●		1
P20	Assessment Framework Status and Work Plan	4	$35,000	$35,000				●			●	●	●	●			1
P16	Biota and DO monitoring	4	$25,000	$25,000			●	●				●					1
P27	Analysis of high-frequency DO data in sloughs/creeks of Lower South Bay	4	$60,000	$60,000					●		●	●	●				1
P28	On-going analysis of moored sensor data	4	$84,000	$84,000					●		●		●				1
P29	Analysis/interpretation of ship-based monitoring data	4	$48,000	$48,000					●		●		●	●			1
P34	Coastal Exchange	4	$200,000	$200,000		●										●	1
			$4,480,873	$2,765,873													1

Option 2

Proj #	Brief Description	Priority	Cost		Activity						Focus Area						Opt1
					Monitor	Model	Field/Lab	A_Frmwrk	Synthesis	PrgrmCoord	chl-DO-open	chl-DO-mar	Nutrients	HABs	Future Scenarios	Coastal Exch	
C1	Ship-based sampling:	4	$401,000	$401,000	●	●	●				●	●	●	●			1
C2	Moored sensor	4	$320,000	$320,000	●	●	●				●	●	●	●			1
C3	Core Modeling:	4	$349,000	$349,000		●					●	○	●	○			1
C4a	Program/Project Management:	4	$353,907	$353,907						●							1
C4b	Science Program Coordination:	4	$143,966	$143,966						●							1
P1	HAB-toxin monitoring in bivalves:	4	$104,000	$104,000	●		●							●			1
P2	Additional high-frequency sensors:	4	$92,000	$92,000	●		●				●		●				1
P3	Zooplankton sampling:	4	$45,000	$45,000	●		●				●		●				1
P4	Expand mooring program:	3	$100,000	$100,000	●		●				●		●				1
P6	Benthos monitoring:	3	$50,000	$50,000	●		●				●		●				1
P7	Nutrient Dynamics - *Source Attribution, Nutrient cycling in SFB*	4	$75,000	$75,000		●			●				●				1
P8	Modeling Program Planning, Model Advisory Group	4	$25,000	$25,000		●					●	●	●	○			1
P9	Developing Particle Tracking Capabilities NMS models	4	$20,000	$20,000		●					●	●	●	●			1
P14	Biogeochemical Field Studies	4	$200,000	$200,000			●				●		●				1
P15	HAB experimental study	4	$55,000	$55,000			●							●	●		1
P19	Trends Analysis	4	$50,000	$50,000				●	●		●		●				1
P20	Assessment Framework Status and Work Plan	4	$35,000	$35,000				●			●	●	●	●			1
P16	Biota and DO monitoring	4	$25,000	$25,000			●	●				●					1
P27	Analysis of high-frequency DO data in sloughs/creeks of Lower South Bay	4	$60,000	$60,000					●		●	●	●				1
P28	On-going analysis of moored sensor data	4	$84,000	$84,000					●		●		●				1
P29	Analysis/interpretation of ship-based monitoring data	4	$48,000	$48,000					●		●		●	●			1
P30	Annual Report, status and trends report	4	$40,000	$40,000					●		●	●	●	●			1
P34	Coastal Exchange	4	$150,000	$150,000		●										●	1
			$3,856,873	$2,825,873													1

Option 3

Proj #	Brief Description	Priority	Cost		Activity						Focus Area						Opt3
					Monitor	Model	Field/Lab	A_Frmwrk	Synthesis	PrgrmCoord	chl-DO-open	chl-DO-mar	Nutrients	HABs	Future Scenarios	Coastal Exch	
C1	Ship-based sampling:	4	$401,000	$401,000	●	●	●				●	●	●	●			1
C2	Moored sensor	4	$320,000	$320,000	●	●	●				●	●	●	●			1
C3	Core Modeling:	4	$349,000	$349,000		●					●	○	●	○			1
C4a	Program/Project Management:	4	$353,907	$353,907						●							1
C4b	Science Program Coordination:	4	$143,966	$143,966						●							1
P1	HAB-toxin monitoring in bivalves:	4	$104,000	$104,000	●		●							●			1
P2	Additional high-frequency sensors:	4	$92,000	$92,000	●		●				●		●				1
P3	Zooplankton sampling:	4	$87,000	$87,000	●		●				●		●				1
P4	Expand mooring program:	3	$150,000	$150,000	●		●				●		●				1
P6	Benthos monitoring:	3	$50,000	$50,000	●		●				●		●				1
P7	Nutrient Dynamics - *Source Attribution, Nutrient cycling in SFB*	4	$102,000	$102,000		●			●				●				1
P8	Modeling Program Planning, Model Advisory Group	4	$53,000	$53,000		●					●	●	●	○			1
P9	Developing Particle Tracking Capabilities NMS models	4	$20,000	$20,000		●					●	●	●	●			1
P12	Phytoplankton Bloom Dynamics	3	$55,000	$55,000		●					●	○	●	○			1
P14	Biogeochemical Field Studies	4	$427,000	$427,000			●				●		●				1
P15	HAB experimental study	4	$55,000	$55,000			●							●	●		1
P19	Trends Analysis	4	$100,000	$100,000				●	●		●		●				1
P20	Assessment Framework Status and Work Plan	4	$35,000	$35,000				●			●	●	●	●			1
P16	Biota and DO monitoring	4	$25,000	$25,000			●	●				●					1
P21	Fish/DO/habitat Data Analysis	4	$25,000	$25,000				●	●			●					1
P22	DO-levels, condition in LSB	3	$50,000	$50,000				●	●			●					1
P26	Fish/DO/habitat	2	$25,000	$25,000				●	●			●					1
P27	Analysis of high-frequency DO data in sloughs/creeks of Lower South Bay	4	$60,000	$60,000					●		●	●	●				1
P28	On-going analysis of moored sensor data	4	$84,000	$84,000					●		●		●				1
P29	Analysis/interpretation of ship-based monitoring data	4	$48,000	$48,000					●		●		●	●			1
P30	Annual Report, status and trends report	4	$40,000	$40,000					●		●	●	●	●			1
P31	HAB synthesis	4	$22,000	$22,000				●	●					●			1
P34	Coastal Exchange	4	$200,000	$200,000		●										●	1
			$4,330,873	$3,476,873													1

Hybrid2-3

Proj #	Brief Description	Priority	Total Project Cost	2020 Funds	2021 carryover	Activity						Focus Area					
						Monitor	Model	Field/Lab	A_Frmwrk	Synthesis	PrgrmCoord	chl-DO-open	chl-DO-mar	Nutrients	HABs	Future Scenarios	Coastal Exch
C1	Ship-based sampling:	4	$401,000	$401,000	$0	●	●	●				●	●	●	●		
C2	Moored sensor	4	$320,000	$320,000	$0	●	●	●				●	●	●	●		
C3	Core Modeling:	4	$349,000	$349,000	$0		●					●	○	●	○		
C4a	Program/Project Management:	4	$353,907	$353,907	$0						●						
C4b	Science Program Coordination:	4	$143,966	$143,966	$0						●						
P1	HAB-toxin monitoring in bivalves:	4	$104,000	$104,000	$0	●		●							●		
P2	Additional high-frequency sensors:	4	$92,000	$92,000	$0	●		●				●		●			
P3	Zooplankton sampling:	4	$87,000	$45,000	$42,000	●		●				●		●			
P4	Expand mooring program:	3	$150,000	$100,000	$50,000	●		●				●		●			
P6	Benthos monitoring:	3	$50,000	$50,000	$0	●		●				●		●			
P7	Nutrient Dynamics - *Source Attribution, Nutrient cycling in SFB*	4	$102,000	$75,000	$27,000		●			●				●			
P8	Modeling Program Planning, Model Advisory Group	4	$53,000	$25,000	$28,000		●					●	●	●	○		
P9	Developing Particle Tracking Capabilities NMS models	4	$20,000	$20,000	$0		●					●	●	●	●		
P12	Phytoplankton Bloom Dynamics	3	$55,000	$55,000	$0		●					●	○	●	○		
P14	Biogeochemical Field Studies	4	$427,000	$200,000	$227,000			●				●		●			
P15	HAB experimental study	4	$55,000	$55,000	$0			●							●	●	
P19	Trends Analysis	4	$100,000	$50,000	$50,000				●	●		●		●			
P20	Assessment Framework Status and Work Plan	4	$35,000	$35,000	$0				●			●	●	●	●		
P16	Biota and DO monitoring	4	$25,000	$25,000	$0			●	●				●				
P21	Fish/DO/habitat Data Analysis	4	$25,000	$25,000	$0				●	●			●				
P22	DO-levels, condition in LSB	3	$50,000	$50,000	$0				●	●			●				
P26	Fish/DO/habitat	2	$25,000	$25,000	$0				●	●			●				
P27	Analysis of high-frequency DO data in sloughs/creeks of Lower South Bay	4	$60,000	$60,000	$0					●		●	●	●			
P28	On-going analysis of moored sensor data	4	$84,000	$84,000	$0					●		●		●			
P29	Analysis/interpretation of ship-based monitoring data	4	$48,000	$48,000	$0					●		●		●	●		
P30	Annual Report, status and trends report	4	$40,000	$40,000	$0					●		●	●	●	●		
P31	HAB synthesis	4	$22,000	$22,000	$0				●	●					●		
P34	Coastal Exchange	4	$200,000	$150,000	$50,000		●										●
	total		$3,476,873	$3,002,873	$474,000												
	amount exceeding FY20 Revenue		$686,873	$212,873													

Science Plan 2.0: Program Priorities, 2019-2024

Focus Areas A: Complete by 2024
(65% effort)

- Nutrient cycling, transport, source attribution
- DO, chl-a deep subtidal
- DO, shallow-margin

Focus Areas B: Risky/Advanced Studies **(35% effort)**

- Mechanistic understanding of HABs
- More nuanced or advanced biotic endpoints:
  - DO / biota impacts, HAB wildlife impacts (chronic)
- Risk / future scenarios
- Coastal effects

Priority Program Areas

- Final Assessment Framework: chl-DO_deep, chl-DO_margins, HABs
- 'Basic' stable monitoring: chl-DO_deep, chl-DO_margins, HABs
- Modeling: solid on the essentials, within SFB

NMS Management Questions

1. What conditions would be considered adverse impacts or impairments?		
1.1	DO / chl in deep subtidals	
1.2	DO in shallow margin habitats	
1.3	HAB abundance, toxin abundance, Phytoplankton assemblage	
1.4	Coastal ocean	
2. Monitoring and condition assessment: Are adverse impacts impacts or impairment currently occurring?		
2.1	DO / chl in deep subtidals	
2.2	DO in shallow margin habitats	
2.3	HAB abundance, toxin abundance, Phytoplankton assemblage	
2.4	Coastal ocean	
3. How do SFB habitats respond to nutrient inputs -- dose:response?		
3.1	DO / chl in deep subtidals	
3.2	DO in shallow margin habitats	
3.3	HAB abundance, toxin abundance, Phytoplankton assemblage	
3.4	Coastal ocean	
4	Risk of Impacts under Future Scenarios (changing system behavior) (chl-a/DO, HABs)	
5. What are the contributions of individual nutrient sources to nutrient levels throughout SFB (f(space, time))?		
5.1	Magnitudes (± variability) of individual nutrient loads at point of entry (present, future)	
5.2	Magnitudes of nutrient transformations and losses within SFB, space/time variability?	
5.3	Contributions of individual nutrient sources to loads/concentrations in "subregions"?	
6. What management actions or load reductions are needed to prevent or mitigate current or future impairment?		
6.1	What reductions/changes are needed within subregions to mitigate impairments?	
6.2	What load reductions or other management actions can achieve the "local" effect(s)?	
6.3	Evaluating combinations of options: feasibility, effectiveness, cost-efficiency	

How will effort be distributed if we follow that prioritization approach?

approximate prioritization, 2019-2024

Priority level through 2024

- Highest
- High
- Moderate
- Low

Core Program

Proj #	Brief Description	Priority Level	Cost	Act_Cat 1
C1	**Ship-based sampling:** Assumes continuation of program with USGS, using the R/V Peterson on ~12 full-bay cruises and an additional ~12 South Bay cruises. This activity includes all field components of the study as well as sample analysis, including measurement of nutrients, phytoplankton taxonomy, phycotoxins, and continuation of pilot molecular measurements (sequencing) of phytoplankton assemblage and HAB detection, plus limited data management. The cost noted here ($401k) is based on proposed funding from RMP (240k; estimated) and NMS (161k; proposed).	4	$401,000	Monitor
C2	**Moored sensor** field work and data management: Servicing of the eight moored sensor stations in the South and Lower South Bay, plus the new station on South Bay shoal. Maintenance at 3 week intervals, data management. Data analysis/interpretation covered elsewhere.	4	$320,000	Monitor
C3	**Core Modeling:** Work includes ***Hydrodynamics:*** Running hydrodynamics for additional 1-3 years (2017, 2018, 2014), ***Biogeochemical model development:*** model validation for DO and Phosphorous (WY2013); continued work on sediment diagenesis model parameterization, model input/parameters sensitivity analysis; simulating biogeochemistry for 1-3 new year(s) (2017, 2018, 2014); reporting (reports, presentations); ***Tools/Maintenance:*** refinements to model grid aggregation scheme to allow for faster runs; Troubleshooting/refining code; Computing resources - internal or supercomputer time.	4	$349,000	Model
C4a	**Program Management/Coordination:** Financial management, project management, stakeholder engagement	4	$400,000	Prog Coord
C4b	**Core Science Oversight:** salary support for lead scientist (50%) effort to technical work	4	$143,966	Prog Coord

Monitoring

Proj #	Brief Description	Priority Level	Cost	Act_Cat 1
C1	**Ship-based sampling:** Assumes continuation of program with USGS, using the R/V Peterson on ~12 full-bay cruises and an additional ~12 South Bay cruises. This activity includes all field components of the study as well as sample analysis, including measurement of nutrients, phytoplankton taxonomy, phycotoxins, and continuation of pilot molecular measurements (sequencing) of phytoplankton assemblage and HAB detection, plus limited data management. The cost noted here ($401k) is based on proposed funding from RMP (240k; estimated) and NMS (161k; proposed).	4	$401,000	Monitor
C2	**Moored sensor** field work and data management: Servicing of the eight moored sensor stations in the South and Lower South Bay, plus the new station on South Bay shoal. Maintenance at 3 week intervals, data management. Data analysis/interpretation covered elsewhere.	4	$320,000	Monitor
P1	**HAB-toxin monitoring in bivalves:** This project will continue work that began in FY2016, measuring phycotoxins in naturally-occurring bivalves harvested from floating docks at ~10 locations throughout the Bay. Major project goals include: quantify phycotoxin concentrations entering biota in Central and South Bay through measurements in naturally occurring mussels; collect samples with sufficient frequency that concentrations in mussels can serve as semi-quantitative bioindicators of ambient toxin concentrations in the water column as a function of space and time. To date, this work has proven to be an informative, efficient, and cost-effective approach for characterizing how phycotoxin levels vary spatially, seasonally, and interannually.	4	$104,000	Monitor
P2	**Additional high-frequency sensors:** Augment current HF monitoring capacity by e.g., installing e.g., nitrate sensors at existing stations (Dumbarton, San Mateo, or Coyote); or by adding chl-a sensors at sites maintained by other groups (e.g., alcatraz, Exploritorium)	4	$92,000	Monitor
P3	**Zooplankton sampling**: Zooplankton are important grazers of phytoplankton, and have the potential strongly regulate phytoplankton biomass accumulation. Despite their importance, little or no zooplankton data are available for the past 30 years for regions south of San Pablo Bay substantially influence, and these data are needed for model development and calibration. In Spring 2018, we began zooplankton sampling in priority regions of SFB, in particular those that currently have no zooplankton sampling (Central, South, Lower South). Funding to date has been used to support sampling. Funding in FY20 will support the taxonomy and counting, and continued field sampling in FY2020.	4	$87,000	Monitor
P4	**Expand mooring program:** During FY20, add new (temporary) mooring stations in diverse locations to quantify variability, to inform future monitoring program design. Note: Some of this could be accomplished by relocating equipment and maintenance effort from subset of existing sites in Lower South Bay.	3	$250,000	Monitor
P5	**IFCB data analysis** An Imaging Flow Cytobot (IFCB) is now being used on USGS cruises, and between cruises is deployed at the Exploratorium pier, collecting data every 30 minutes on phytoplankton community. Funding would support a scientist to analyze and interpret IFCB data, including refining its machine-learning image classifier and characterizing spatial (cruises) and temporal (pier and cruises) variations in phytoplankton community and abundance. (Funding will support a postdoc or researcher salary).	3	$150,000	Monitor
P6	**Benthos monitoring:** Grazing by benthic filter feeders can act as a major control phytoplankton biomass accumulation in regions of SFB. To quantify benthic grazer influence on phytoplankton (e.g., for model calibration), benthic surveys are needed to estimate benthos abundance and biomass (and community composition), and how they vary over space. Currently, benthos monitoring occurs monthly in Suisun and San Pablo Bays (DWR-EMP); Although South and Lower South Bays have historic benthos data, no consistent benthos monitoring occurs there currently. This project would undertake fieldwork associated with benthic surveys, sample analysis, and reportin	3	$100,000	Monitor

Modeling

Proj #	Brief Description	Priority Level	Cost	Act_Cat 1
C3	**Core Modeling:** Work includes ***Hydrodynamics:*** Running hydrodynamics for additional 1-3 years (2017, 2018, 2014), ***Biogeochemical model development:*** model validation for DO and Phosphorous (WY2013); continued work on sediment diagenesis model parameterization, model input/parameters sensitivity analysis; simulating biogeochemistry for 1-3 new year(s) (2017, 2018, 2014); reporting (reports, presentations); ***Tools/Maintenance:*** refinements to model grid aggregation scheme to allow for faster runs; Troubleshooting/refining code; Computing resources - internal or supercomputer time.	4	$349,000	Model
P7	**Nutrient Dynamics** - ***Source Attribution:*** Quantify the proportional contributions of N and P from each POTW (and other sources) as a function of space and time. These will be provisional estimates based on best available simulations, and will be refined in subsequent years. ***Nutrient cycling in SFB:*** Spatial and temporal variations in N and P sources/fate/transport, at the subembayment-level, and causal factors, for informing assimilative capacity	4	$102,000	Model
P8	**Modeling Program Planning, Model Advisory Group:** Convene a group of local and national experts to serve as a Modeling Advisory Group, to review and inform modeling strategy, and provide technical review of modeling products	4	$53,000	Model
P9	**Developing Particle Tracking Capabilities NMS models:** Numerical tracers and particle tracking are important modeling tools used to help refine models and interpret model output. The transport and spreading over time of tracers or clusters of particles can be used to understand or quantify mixing rates, flushing rates, or residence times, and can also track or record conditions that a water parcel experiences during transit. The Deltares models do not currently have 3D particle tracking capabilities. However, the NMS has access to a well-tested particle-tracking code that has been used extensively in other Bay-Delta 3D-unstructured grid models. This project will focus on adapting that particle tracking model for use with Deltares hydrodynamic models. We anticipate that the first application of particles will be in P11a.	4	$20,000	Model
P10	**Lower South Bay Biogeochemical Modeling (Salt Ponds, Sloughs):** Although observations suggest that connections with restored salt ponds and sloughs have major influences on nutrient, phytoplankton, and dissolved oxygen concentrations in Lower South Bay, the NMS open-Bay biogeochemical model does not yet include those connections. This project will extend biogeochemical modeling into small-scale sloughs and ponds in the margins of Lower South Bay to quantify the effects of exchanges between open Bay ↔ sloughs/marshes ↔ salt ponds on LSB biogeochemistry, using the recently-developed LSB hydrodynamic model which does now simulate those slough/salt-pond connections. Work will move forward in two phases: i) Initial simulations with a simplified (highly-aggregated) version of the model, both to tune parameters and to obtain provisional quantitative estimates of the importance of the salt pond interactions (~30%); and ii) Simulations with higher-resolution model for refined estimates (70%).	3	$99,000	Model
P11	**Improving turbidity and light field estimates,** through analysis of observation data: e.g., shoal mooring turbidity data; remote sensed turbidity data; long-term DFW data	3	$75,000	Model
P12	**Phytoplankton Bloom Dynamics:** Spatial/temporal variation in phytoplankton production and factors regulating productivity and fate (stratification, light, grazing, nutrients, transport). Analogous to P05a, but focused on phytoplankton dynamics	3	$55,000	Model
P13	**Suisun-Delta Modeling:** Continuation of on-going work, with activitiesincluding: Suisun bay light field compilation; Suisun-Delta Hydrodynamic run for WY2016; Provisional biogeochemical model calibration for WY2016; and reporting (technical reports, presentations)	OK	$166,000	Model

Field / Lab Studies

Proj #	Brief Description	Priority Level	Cost	Act_Cat 1
P14	**Biogeochemical Field Studies:** Launching multi-year set of field studies to quantify important biogeochemical transformation rates to inform mechanistic understanding and calibrate models (funding for Year 1+). Work will include: Literature review for SFB and comparable systems to identify data gaps and existing data that could be applied to biogeochemical models; Convene an expert working group to provide input on the design of the field program. Field work will begin in Fall 2019, and will include: ***Water column rate measurements:*** e.g., gross primary production, nitrification, and respiration or oxygen demand. When possible, sample collection and measurements will be carried out during biweekly or monthly cruises already being conducted collaboratively between USGS and the NMS, both the sake of cost-effectiveness and to take leverage ancillary data collected during those cruises. Additional cruises will likely be needed to study conditions outside the channel. ***Sediment diagenesis/fluxes***- Sediment studies will be conducted to quantify transformation rates or fluxes between the water column and sediments, related to multiple processes, including: nitrification; denitrification; N and P fluxes to/from the sediments; and sediment oxygen demand. Sediment characteristics will also be measured to establish relationships between benthic conditions and process rates which are important for model calibration. Selection of sampling locations will be informed both by biogeochemical modeling that is underway and through interpretation of existing data for SFB, and will cover a range of habitats. ~80% of funding would support external collaborators on fieldwork, analysis, interpretation; 20% SFEI staff to participate in and coordinate project(s)	4	$427,000	Field/Lab Study
P15	**HAB experimental study:** Factors influencing Pseudo-nitszchia growth and toxicity: This project will study growth requirements of the toxic phytoplankton Pseudo-nitszchia spp (P-N). NMS funding will be combined with other recently awarded funding (OPC) to investigators at the SFSU-RTC (now called EOS) researchers. The OPC-funded work wwill examine P-N growth and toxin production as a function of temperature and salinity, with a primary focus on conditions encountered outside the Golden Gate. The NMS funding will allow the work to pursue two or more of the following: expand the ranges of (i) temperature and/or (ii) salinity to also capture relevant conditions within SFB; or iii) investigate the effects of light (light limitation), along with temperature and salinity, on growth and toxin production. SFEI staff will join the project as co-PIs and will contribute to study design and interpretation. [Project already approved by NMS-SC, Mar 2019]	4	$55,000	Field/Lab Study
P17	**Salt pond / slough biogeochemical field studies:** Evidence from NMS studies suggests that salt pond <--> slough/Bay exchange has a major local, and potentially whole-subembayment, level effect on N, C and DO cycles in LSB. Observational data are needed to quantitatively characterize processes and conditions within and salt ponds and sloughs, e.g., phytoplankton biomass, nutrients, transformations, etc. Data will be used to inform model calibration.	2	$200,000	Field/Lab Study
P18	**Mechanistic HABs field study:** Undertake targeted field study to improve understanding of HAB/toxin sources, relevant mechanisms, etc.	2	$150,000	Field/Lab Study

Assessment Framework

Proj #	Brief Description	Priority Level	Cost	Act_Cat 1
P19	**Trends Analysis:** GAM Evaluation for trend detection: In FY2019 the NMS began introducing a status and trends element to the Assessment Framework, using Generalized Additive Models (GAMs) for trend detection (SFEI, 2018). To date, GAMs have proven effective at trend detection for chl-a, using customized GAM structures evaluated by subembayment. This activity involves expert evaluation of additional parameters/indicators for a set of GAMs, to identify the most appropriate tools for long-term trend detection and writing up a technical report/manuscript	4	$100,000	Assess Frmwrk
P20	**Assessment Framework Status and Work Plan:** This project will revisit the initial Assessment Framework efforts (AF1.0; Sutula et al., 2016, 2017), with the goal of producing three main outputs: a) Revisit and clarify the goals and intended uses of a SFB Assessment Framework, including the current status (how will AF1.0 be used?) and priorities for continued AF development; b) 'Test-drive' the numeric thresholds identified in AF1.0 by assessing condition relative to those thresholds in SFB, using long-term monitoring data; c) Develop an AF WorkPlan that reflects the major goals and timelines identified in **(a)**	4	$35,000	Assess Frmwrk
P16	**Biota and DO monitoring** in Lower South Bay margins: An extensive fish surveying effort has been underway in Lower South Bay, funded currently by San Jose and previously by the salt pond restoration program, and conducted by UC-Davis researchers (Hobbs). This funding will combined with funding from San Jose, to allow for additional field work relevant to NMS goals - e.g., extending the overall study duration; targeted surveys specific to DO management questions (e.g., locations, tidal phases/stages); or supporting ancillary data collection (e.g., continuous DO in currently unmeasured locations). Specific activities / study design will be identified through discussions with UC-Davis and San Jose.	4	$25,000	Assess Frmwrk
P21	**Fish/DO/habitat Data Analysis:** This funding will support continued analysis of data collected by the UC-Davis Lower South Bay fish surveys. This work will build upon the analyses included in the 2018 DO habitat quality report, including pursue some of the recommendations/next-steps identified in that report. In addition, since that report only included data through 2016, new work will include 2+ additional years of data	4	$25,000	Assess Frmwrk
P22	**DO-levels, condition in LSB:** Further data analysis to identify options for determining protective DO conditions in Lower South Bay sloughs/margins; utilize available fisheries data, coupled with high frequency DO data, to inform relationships and assessment criteria (e.g. Virginia Province approach and others). This would be one step, requiring on-going work in subsequent years.	3	$50,000	Assess Frmwrk
P23	**Potential for low DO conditions in SFB (South Bay focus):** Over the 25+ year record when DO data were consistently measured Bay-wide, near-surface and near-bottom DO levels almost always exceeded the 5 mg/L Basin Plan standard. Under what conditions could unacceptable DO conditions develop? To explore this question, we will use hydrodynamic+biogeochemical models to identify conditions under which low DO could develop in deep subtidal habitats. For a first phase of this work, we will 'force' the biogeochemical model by adding varying magnitude blooms to simulations (concentration*area*depth), and assess the effects on DO levels. Through this approach we can identify the organic matter loading rate required (as a function of space and time) to draw down DO levels low enough to have a pronounced impact.	3	$31,000	Assess Frmwrk
P24	**Expert working group on HAB impacts:** Convene an expert panel to inform an approach to incorporating available HAB data into an Assessment Framework and review available data collected to date	2	$25,000	Assess Frmwrk
P25	**Expert working group on DO influence on habitat:** Convene an expert panel of wildlife biologists and others to inform the degree to which DO may impair resident wildlife, within the context of local and national assessment criteria (e.g. Virginia Province)	2	$25,000	Assess Frmwrk
P26	**Fish/DO/habitat** Explore additional approaches for DO-related habitat condition in LSB: This project will explore DO-related habitat from a complementary angle to prior work (2018 DO habitat report), using an emerging approach that considers both DO, T, and metabolic DO requirements (animals' DO requirements vary as a function of T and species, with DO needs increasing with increasing T).	2	$25,000	Assess Frmwrk

Synthesis

Proj #	Brief Description	Priority Level	Cost	Act_Cat 1
P27	**Analysis of high-frequency DO data in sloughs/creeks of Lower South Bay:** Complete on-going work related to interpreting DO concentrations in sloughs/creeks in LSB, to identify causal factors and estimate rates	4	$60,000	Synth
P28	**On-going analysis of moored sensor data:** e.g., GPP spatial variations; factors contributing to variations in biomass	4	$84,000	Synth
P29	**Analysis/interpretation of ship-based monitoring data:** Continue and write-up analysis/interpretations from long-term monitoring data, e.g., related to phytoplankton community, gross primary production, nutrients, etc.	4	$48,000	Synth
P30	**Annual Report, status and trends report**	4	$40,000	Synth
P31	**HAB synthesis:** complete current HAB long-term data report, expand toxin data analysis, including by providing some support for expert reviewer	4	$22,000	Synth
P33	**Deeper dive into HAB data analysis/interpretation**: Continuation of the report in P31	2	$49,000	Synth

Future Scenarios

Proj #	Brief Description	Priority Level	Cost	Act_Cat 1
P32	**Future Risks/Future Scenarios:** Develop a Work Plan for exploring Future Risks/Scenarios: workshop/goal setting; stakeholder input; expert input; planning	3	$50,000	Synth

Coastal Exchange

Proj #	Brief Description	Priority Level	Cost	Act_Cat 1
P34	**Coastal Exchange:** A sizable proportion (e.g. 50% or more, depending on season) of the nutrients that enter SFB exit via the Golden Gate to the coast ocean. The fate of those nutrients, and their effects on the GoF and coastal habitats are poorly known. Through this project, we will begin a 3-year study, teaming up with an on-going study (collaborators SCCWRP/UCLA/UCSC) to explore fate of nutrients leaving SFB and obtaining refined boundary condition estimates for nutrients entering SFB. [Project already approved by NMS-SC, Mar 2019]	4	$200,000	Model Coast