Reducing Sediment Remediation Costs by Improving Sampling Accuracy

WEDA Pacific Chapter Meeting
San Francisco, California
October 2022

Presented by
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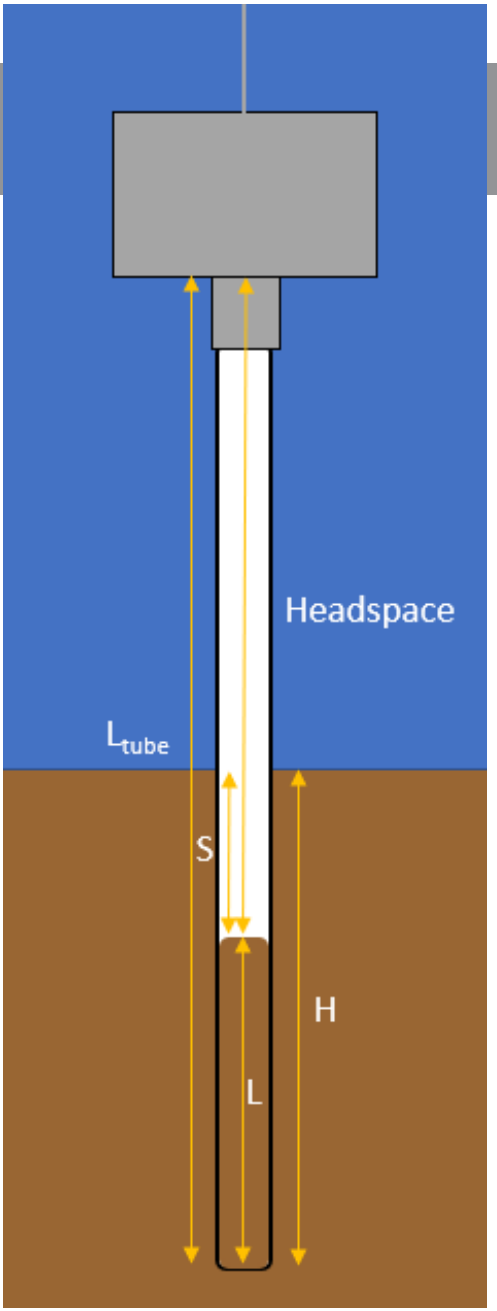
Vibracore Measurements

- Length of core tube (L_{tube}) – Headspace = recovered sediment (L)
- H is depth of penetration (field measured)
- For full penetration, H = L_{tube} and S = Headspace
- Percent Recovery (%R) = L / H * 100

- **S measurement is where uncertainty lies in conventional vibracoring!**



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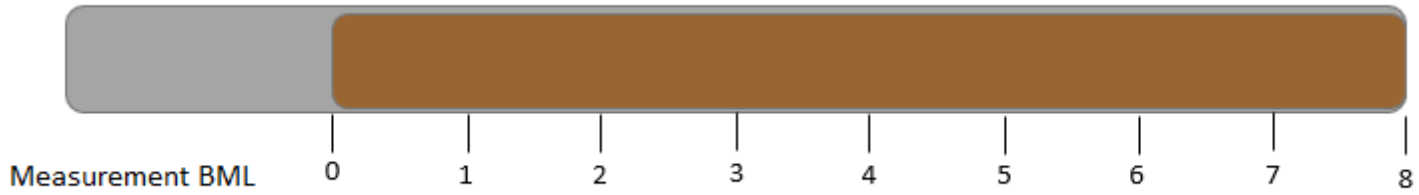
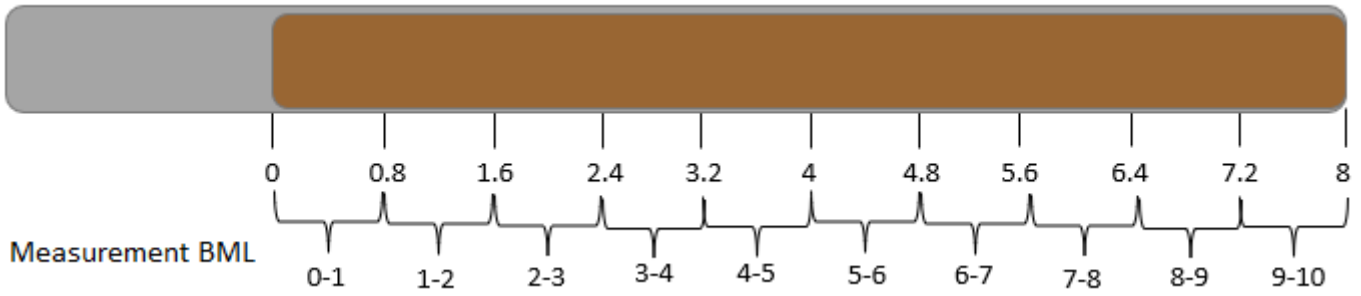
Uncertainty in Conventional Techniques

- Static Method
  - Assumes all material loss is from bottom of core upon retrieval

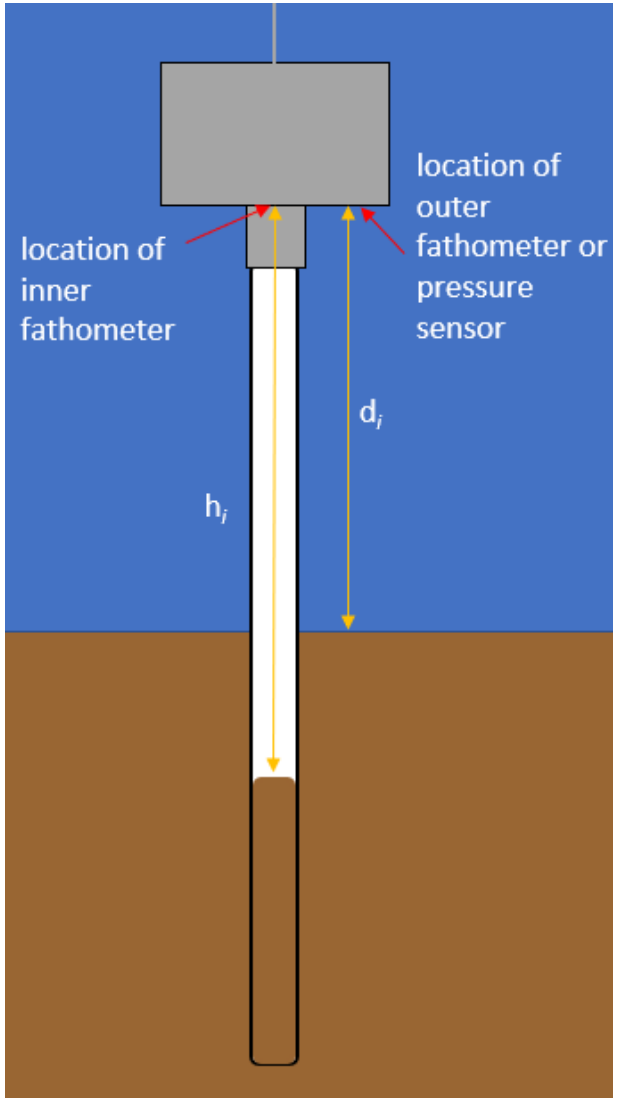


- Stretch Method
  - Assumes uniform recovery throughout drive



Vibracoring Sediment Acquisition Monitoring (V-SAM)

- Measures incremental depth to mudline inside and outside of core tube
- Incremental depth of penetration (d_i) and incremental headspace (h_i) are recorded at various stages through the drive, typically in 1’ to 3’ intervals
- At start of drive, $h_i = L_{tube}$ with adjustments for location of fathometer
- Incremental L and H are calculated from obtained values



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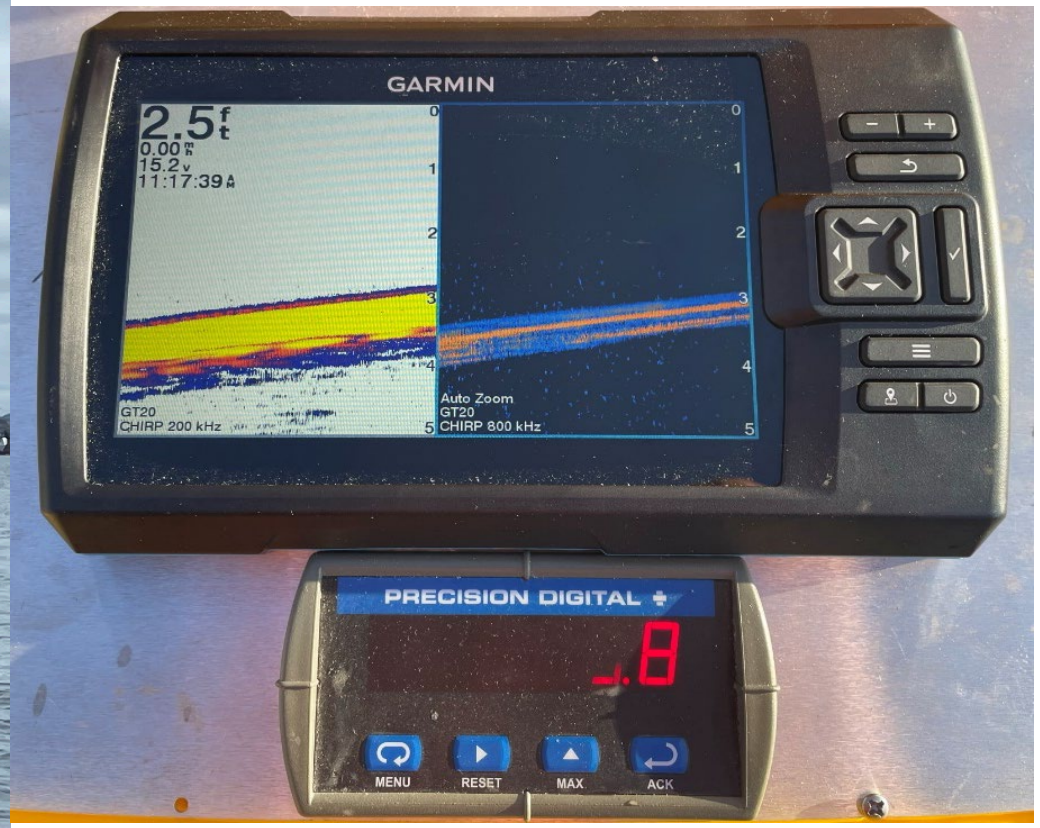
Equipment


RESEARCH


GARMIN
2.5
0.00
15.2
11:17:39
GT20
CHIRP 200 kHz
Auto Zoom
GT20
CHIRP 800 kHz
PRECISION DIGITAL
MENU
RESET
MAX
ACK

Sample Data Collected with V-SAM

Fathometer Readings		TUBE (ft.)		Increment		Core Cut Plan (ft.)	
Depth	Acquire	Drive	Acquire	% Recover	Comment	In-Situ	Core
12.1	20	0.0	0.0			HS	3.2
15	18.9	2.9	1.1	38%		0.0	0.0
18	17	5.9	3.0	63%		1.0	0.4
21	14.1	8.9	5.9	97%		2.0	0.8
24.1	10.7	12.0	9.3	110%		3.0	1.2
27.2	7.5	15.1	12.5	103%		4.0	1.8
30	4.8	17.9	15.2	96%		5.0	2.4
31.1	3.4	19.0	16.6	127%		6.0	3.1
						7.0	4.1
						8.0	5.0
						9.0	6.0
						10.0	7.1
						11.0	8.2
						12.0	9.3
						13.0	10.3
Process core? (y/n/b/x)*		y				14.0	11.4
	n	*Interpolated value*				15.0	12.4
	*	"Accepted"/"Rejected"/"Bulk Sample Only"/"No Core Recovered"				16.0	13.4
						17.0	14.3
						18.0	15.3
						19.0	16.6

Considerations for the V-SAM System

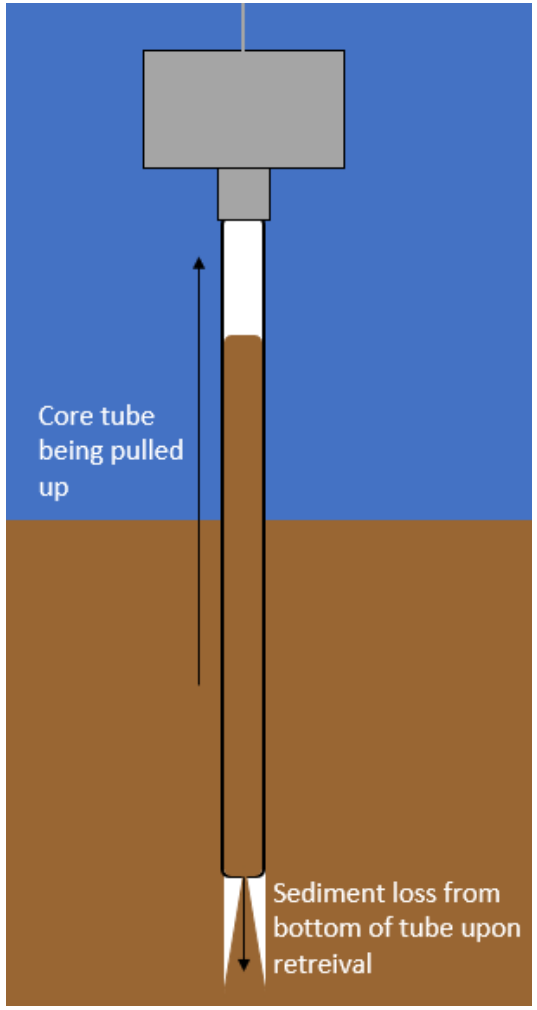
- Drive increment
- Shallow water
- Soft sediment
- Losses upon retrieval
- Instrument precision
- Percent recovery
- Uncertainty
- Acceptance criteria

Data Collection using V-SAM

- 3 projects in a riverine environment
- 140 cores collected using V-SAM
- ΔS is the difference between the final acquisition reading for headspace and the measured headspace after retrieval

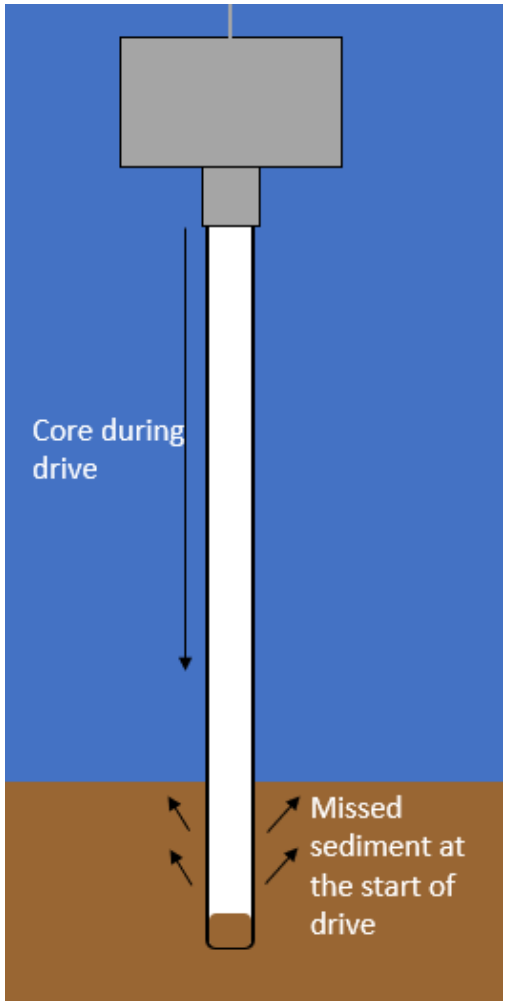
Number of Cores	Average Increment of Data Collection	Average %R, Total	Average ΔS (+/-)
140	2.2 ft	86%	0.2 ft

Observed Sediment Trends using V-SAM



- Losses from Bottom of Core Tube during Retrieval
  - Only 4 cores out of the 140 cores collected had losses out the bottom of the core greater than 6” upon retrieval
  - Maximum loss out the bottom was 1.7’
  - Average change from the final acquisition reading to the measured headspace (ΔS) was 0.2’
  - Sediment loss from the bottom of the core was not a significant trend!

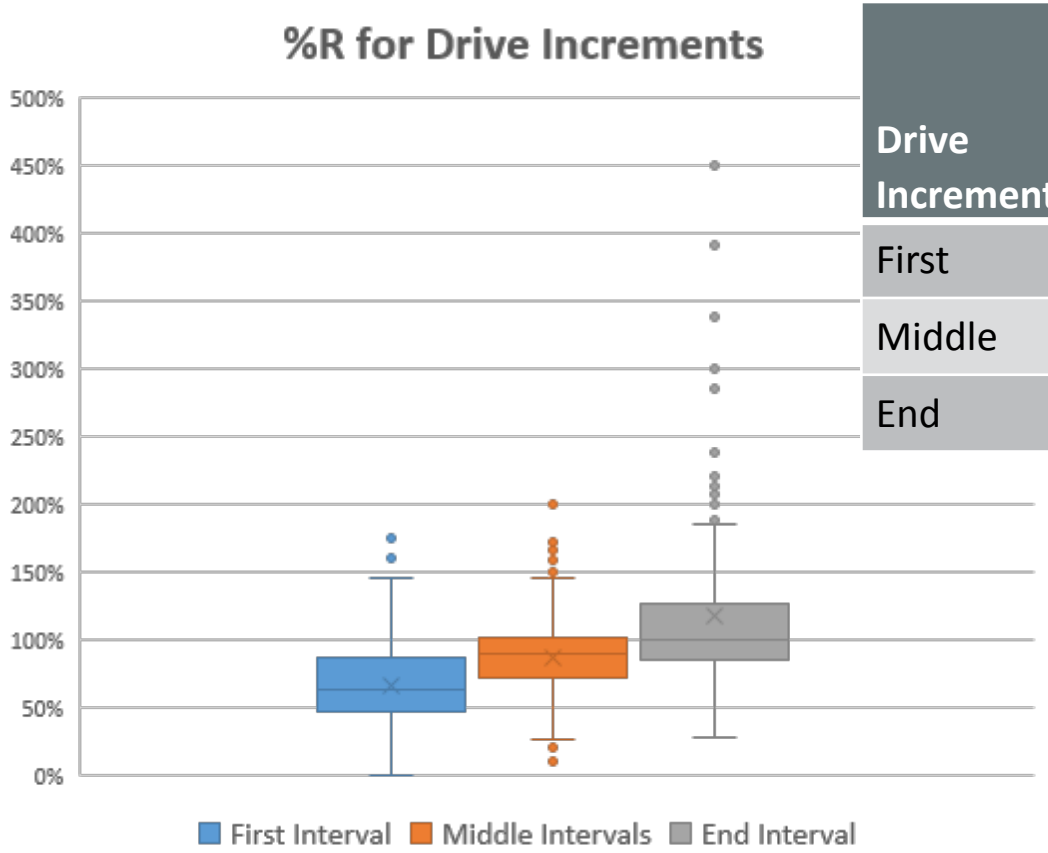
Observed Sediment Trends using V-SAM



- Missing Sediment from the Start of the Drive
  - To determine how much sediment was missed in the start of the drive, %R for the first increment was compared with %R for other intervals
  - 30% of cores had a percent recovery of less than 50% within the first increment
  - Over 40 cores missed at least 1.1 feet in the first increment of the drive
  - Some cores missed up to 5 feet of material from the start of the drive
  - Missed sediment from the start of the drive was much more significant than sediment lost from the bottom of the core!

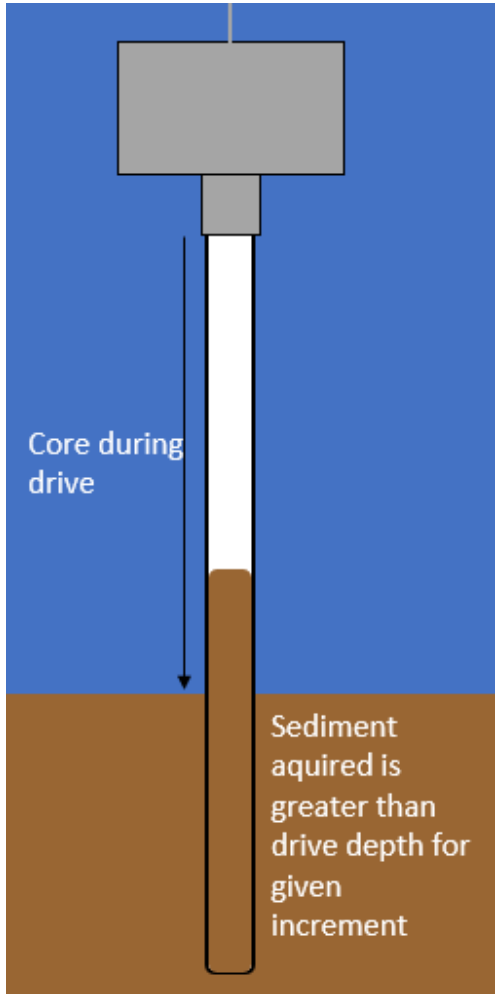
Observed Sediment Trends using V-SAM

- Missing Sediment from the Start of the Drive



Drive Increment	Average %R	Median %R	Percent of Intervals with Less Than 50% Recovery	Percent of Intervals with Greater Than 100% Recovery	Number of Samples
First	66%	63%	30%	9%	140
Middle	87%	90%	9%	25%	516
End	118%	100%	7%	47%	140

Observed Sediment Trends using V-SAM



- Increments with Greater than 100% Recovery
  - Can be an indicator of material expansion within core tube
  - Over 47% of the final increment in a drive had %R>100
  - Likely due to additional vibration at end of drive to try and "break through" refusal point
  - Can mask earlier intervals of poor recovery when using conventional methods

Drive Increment	Average %R	Median %R	Percent of Intervals with Greater Than 100% Recovery	Number of Samples
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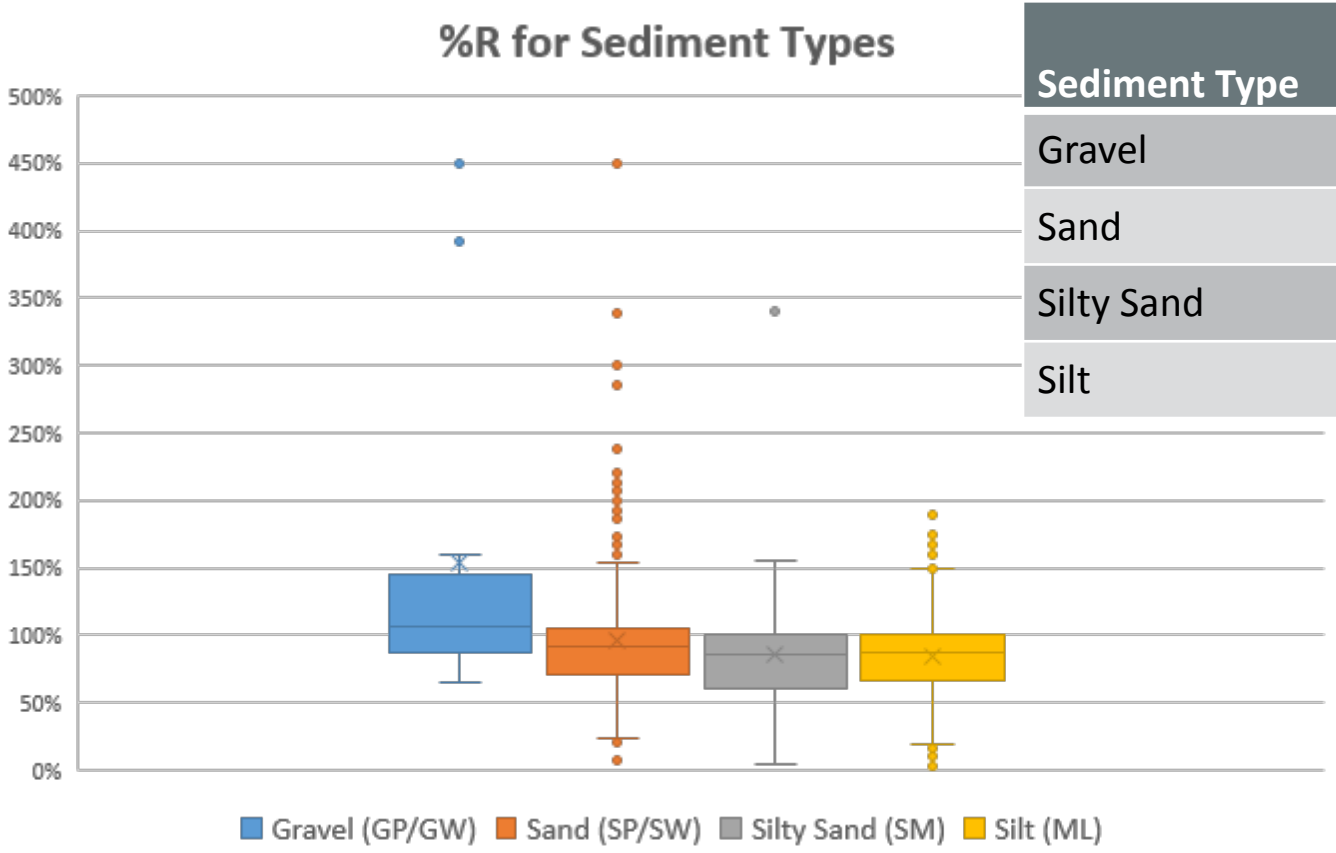
Observed Sediment Trends using V-SAM

- Percent Recovery for Different Sediment Types



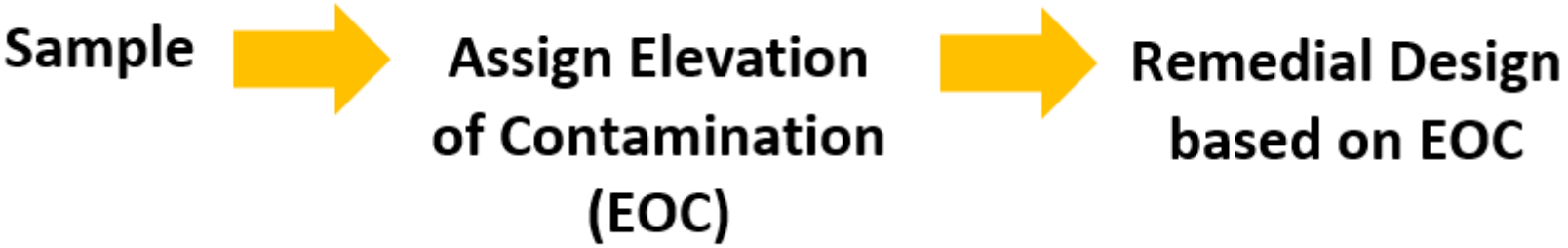
Sediment Type	Average %R	Median %R	Number of Samples
Gravel	153%	106%	13
Sand	92%	92%	251
Silty Sand	82%	85%	68
Silt	84%	87%	458

Observed Sediment Trends using V-SAM

- Percent Recovery for Different Sediment Types
  - 58% of intervals were classified as primarily silt
  - Sediment that was missed during the drive (likely soft silts) would not be accounted for and would bias the silt percent recovery high
  - Small sample size for gravel
  - Sands had an average percent recovery 8 to 10% higher than silty sands or silts

Potential Implications on Cost and Schedule

- The uncertainty associated with estimating in-situ DOC bml can limit the efficacy of precision remediation dredging, which can affect the cost, schedule, and overall success of remedial actions



Potential Implications on Cost and Schedule

- Theoretical Differences in Calculated In-Situ Sample Depth versus Using V-SAM Technology
  - In order to estimate differences in calculated in-situ sample depth bml, an *arbitrary* sample depth of 5’ using the V-SAM method was selected
  - Actual data were taken and used to calculate equivalent sample depth for each core using the Static and Stretch methods

Potential Implications on Cost and Schedule

- Theoretical Differences in Calculated In-Situ Sample Depth versus Using V-SAM Technology: EXAMPLE

Fathometer Readings		TUBE (ft.)		Increment		Core Cut Plan (ft.)	
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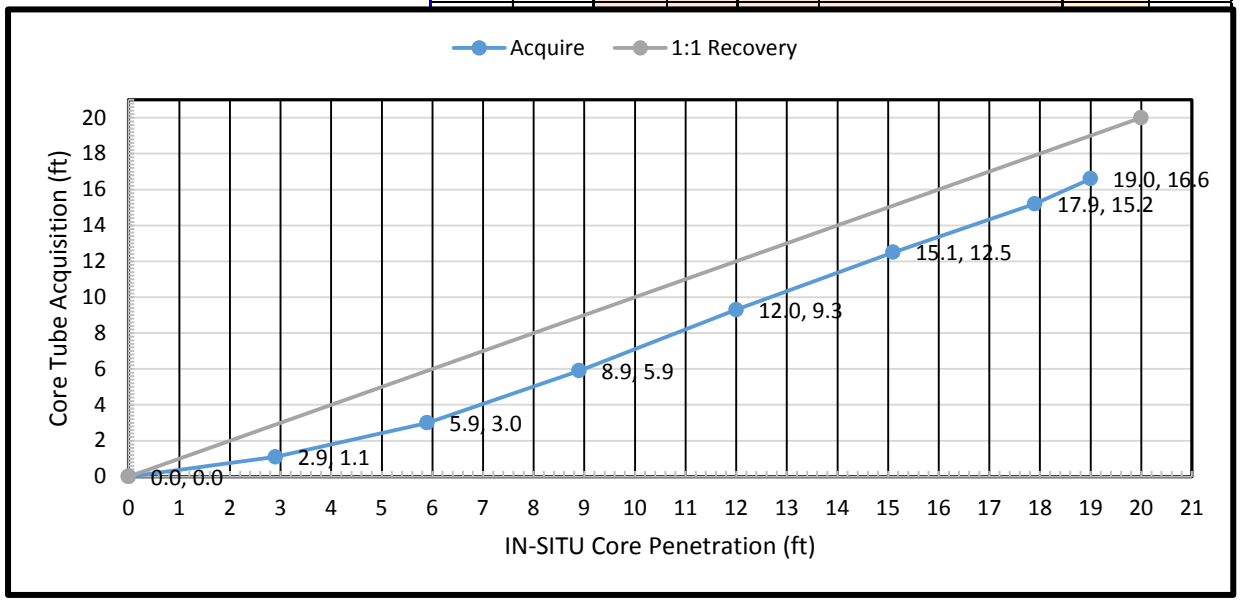

20’ core tube
3.2’ headspace
87% recovery

Deepest contaminated sample

Calculated in-situ depth (bml)

V-SAM: 5–6’ bml

Static: 2.4–3.1’ bml

Stretch: 2.8–3.3’ bml

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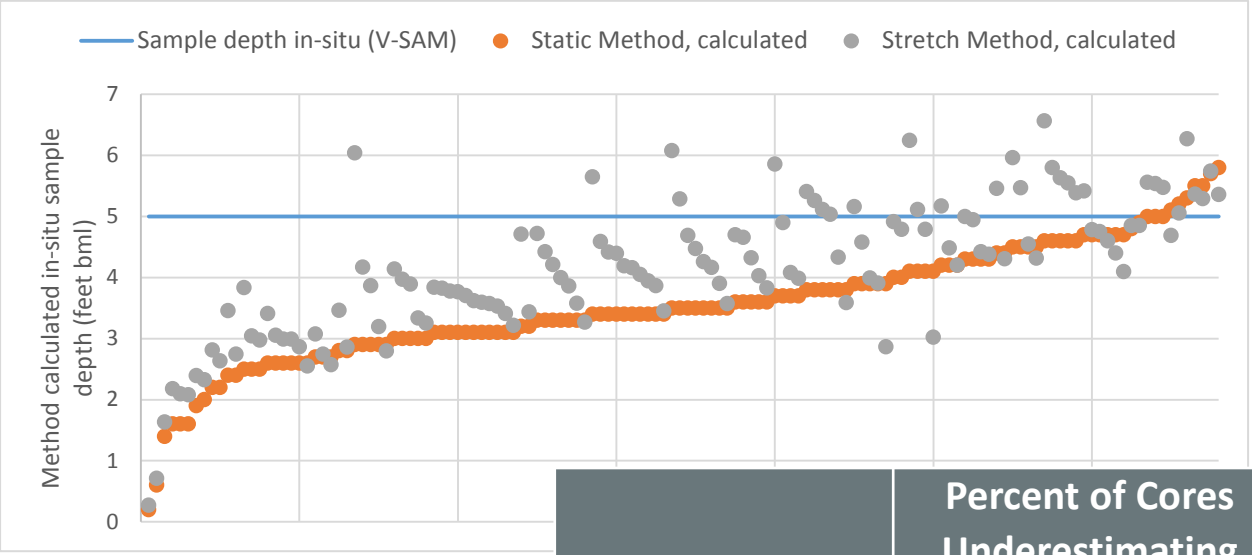
Potential Implications on Cost and Schedule

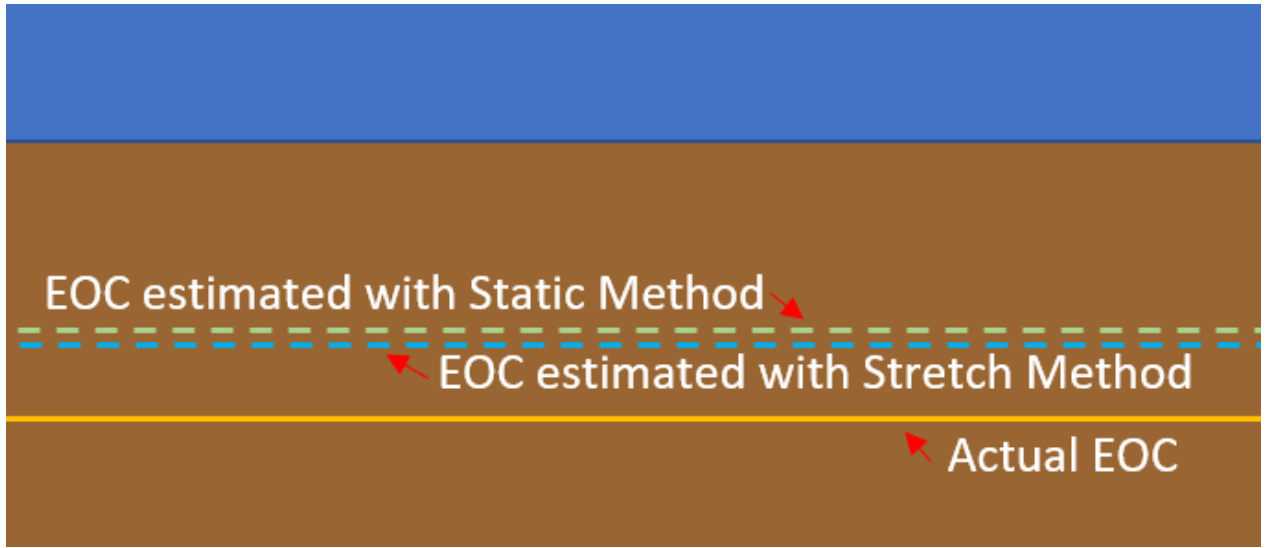
- Theoretical Differences in Calculated In-Situ Sample Depth versus Using V-SAM Technology



Method of Calculation	Percent of Cores Underestimating Sample Depth for V-SAM at 5 ft	Average Distance above V-SAM Method	Percent of Cores Overestimating Sample Depth for V-SAM at 5 ft	Average Distance Below V-SAM Method
Static Method	93%	1.6 feet	5%	0.4 feet
Stretch Method	76%	1.3 feet	23%	0.6 feet

Potential Implications on Cost and Schedule

- Theoretical Differences in Calculated In-Situ Sample Depth versus Using V-SAM Technology
- Assuming each core represents a 100'x100' area for a total area of ~ 32 acres
  - Static Method – Could result in needing to re-dredge ~77,000 CY of material, and ~1000 CY of presumed clean material would have been dredged
  - Stretch Method – Could result in needing to re-dredge ~51,000 CY, and ~ 7,000 CY of presumed clean material would be dredged



Potential Implications on Cost and Schedule

- For theoretical 32-acre project, associated costs with overdredging or having to redredge:

Cost of Overdredging					Static		Stretch
Dredging	$	31	CY	$	32,000	$	223,000
Disposal	$	111	Ton	$	184,000	$	1,300,000
			Subtotal	$	*220,000*	$	*1,520,000*
Cost of Redredging							
Re-MOB/DEMOB	$	1,000,000	LS	$	1,000,000	$	1,000,000
6" cap	$	34	CY	$	1,600,000	$	1,300,000
Resample	$	500,000	LS	$	500,000	$	500,000
			Subtotal	$	*3,100,000*	$	*2,800,000*
			Contingency (15%)	$	465,000	$	420,000
			TOTAL	$	**3,800,000**	$	**4,700,000**

- Could also end up needing to re-characterize and redesign!

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Potential Implications on Cost and Schedule

- Not to mention additional dredging that wouldn't have been budgeted for…

Unbudgeted Costs			Static	Stretch
Dredging	$ 31	CY	$ 2,000,000	$ 2,000,000
Disposal	$ 111	Ton	$ 14,000,000	$ 9,000,000
		TOTAL	**$ 16,000,000**	**$ 11,000,000**

- Could be the difference in receiving a "No Further Actions" letter from the agencies or having to go back and have on-going remediation!

Thank you

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