West Bay Diversion Evaluation

Geomorphic Assessment

Peer Review Oct. 20, 2009

Charlie Little

ERDC Coastal & Hydraulics Laboratory

Vicksburg, MS

West Bay Diversion Task #2: Geomorphic Assessment

Objective: Conduct a geomorphic assessment of the lower Mississippi River (Belle Chasse to East Jetty) to investigate causes of observed shoaling in Pilottown Anchorage Area, with emphasis on evaluating long term trends in river morphology due to hydrology, sedimentation and channel maintenance activities as well as diversion construction.

Geomorphic Assessment Tasks

- Geometric Data Analysis
- Gage/Discharge/Sediment Data Analysis
- Dredge Record Assessment
- Historic Event/Timeline Analysis
- Integration of Analyses/Interpretation

Geometric Data Analysis Hydrographic Surveys

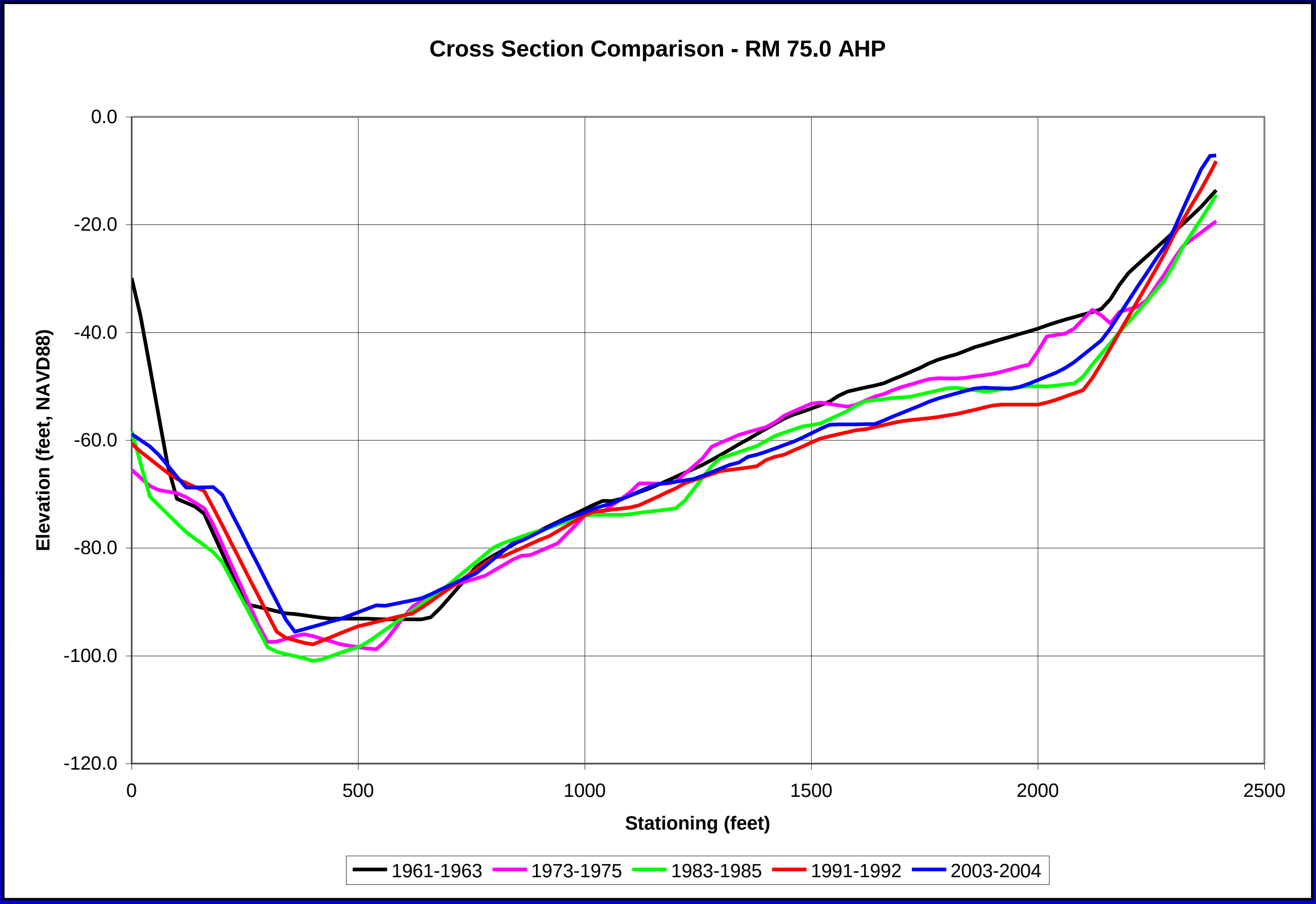
- Comprehensive Mississippi River hydrographic surveys
  - 1961-1963
  - 1973-1975
  - 1983-1985
  - 1991-1992
  - 2003-2004
- MVN channel condition surveys
  - Yearly 1990-2008 (October)
  - Event specific (1997 & 2008 floods, Hurricane Katrina)
- All survey data elevations corrected to NAVD88 vertical datum

Geometric Data Analysis: Cross Section Comparisons

- 31 total cross sections were established, with a cross section located at the ends and mid-points of each reach.
- Cross sections were used with the TINs for each survey to “cut” the sections and extract the bathymetric data. Cross section location is consistent for all surveys.
- Cross section data from each survey were plotted to illustrate changes in channel dimensions with time and to qualitatively determine trends.
- Cross sections upstream of Venice represent comprehensive hydrographic surveys only.

Geometric Data Analysis: Cross Section Locations

Geometric Data Analysis: Cross Section Comparisons



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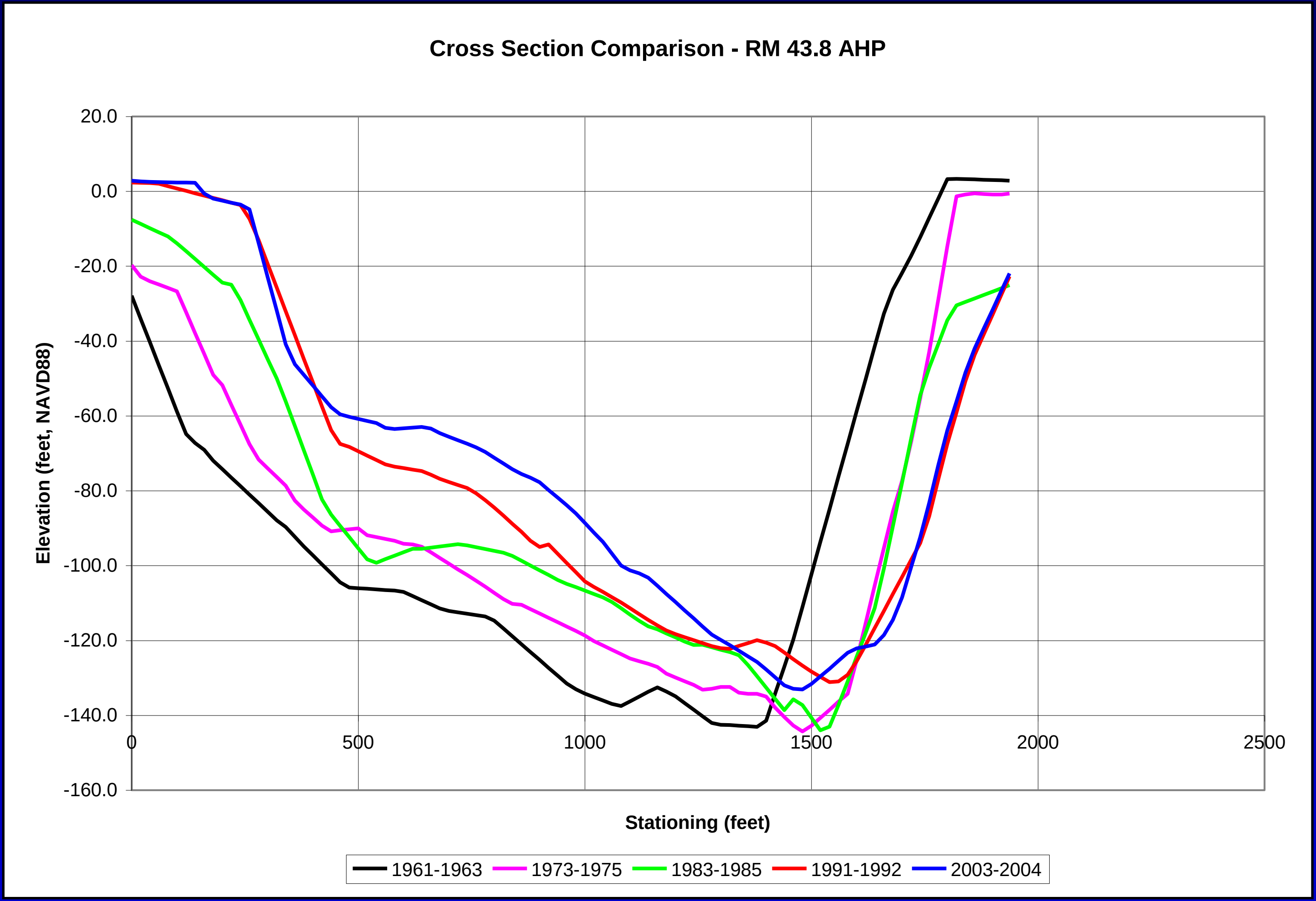
Geometric Data Analysis: Cross Section Comparisons



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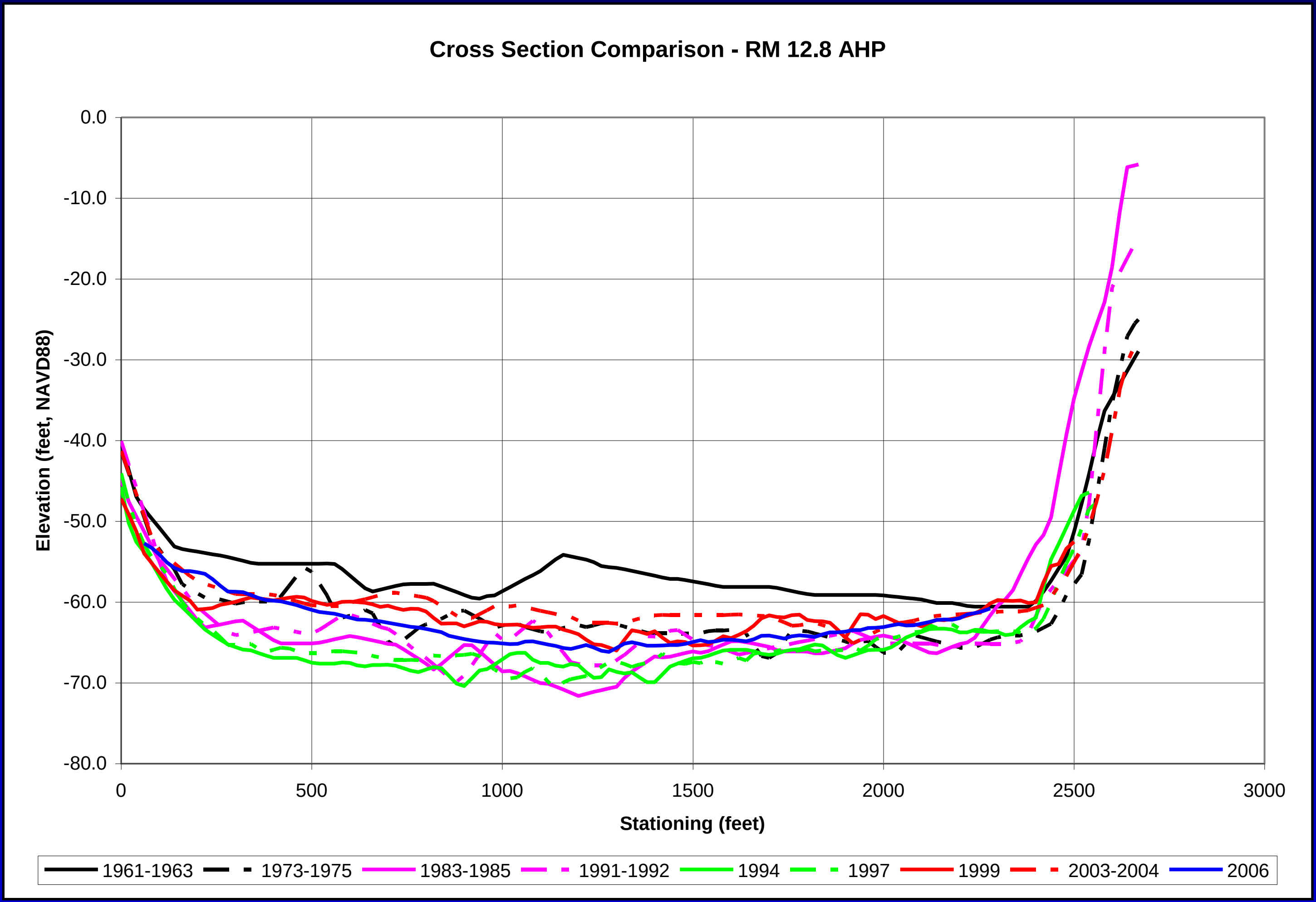

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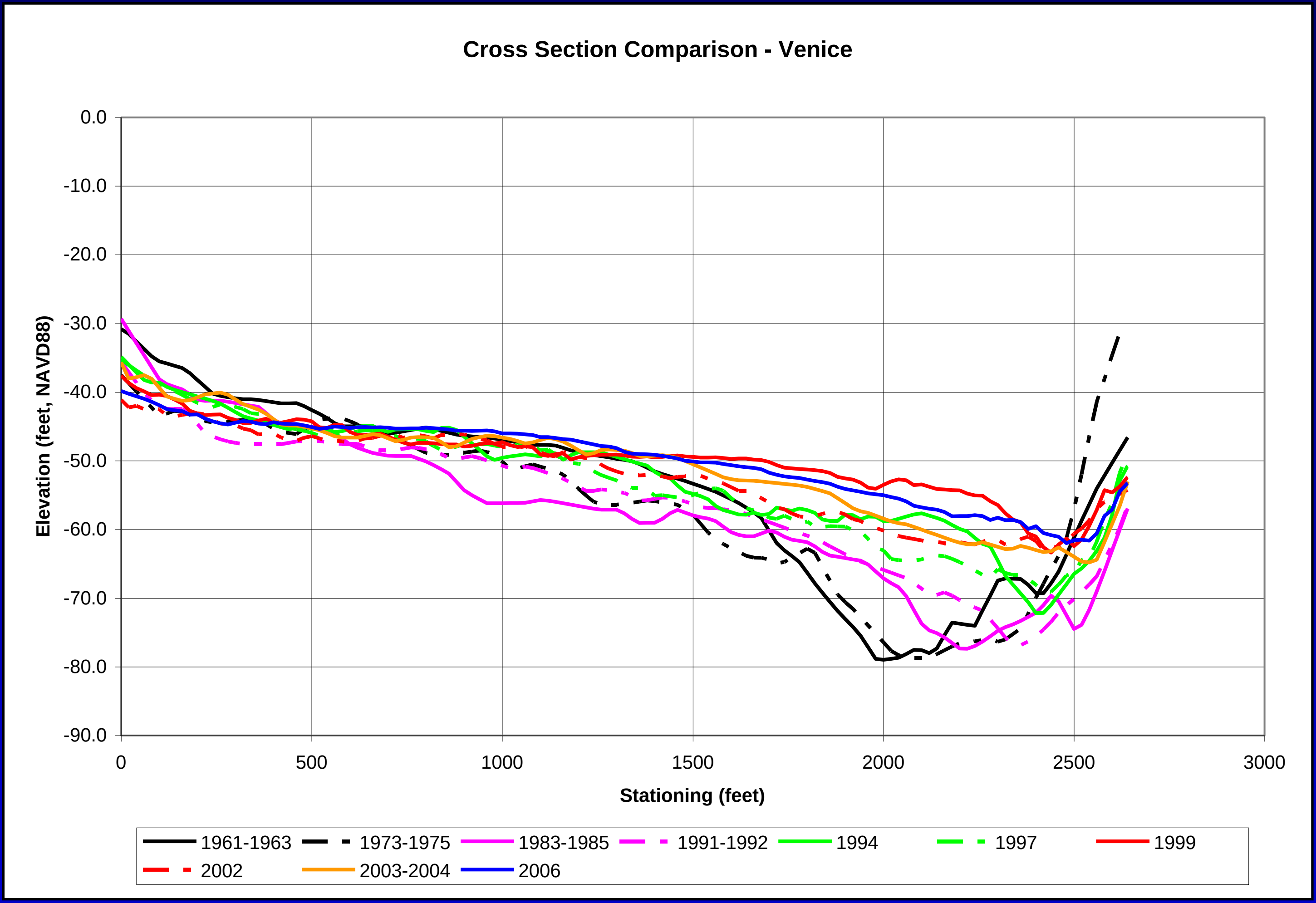

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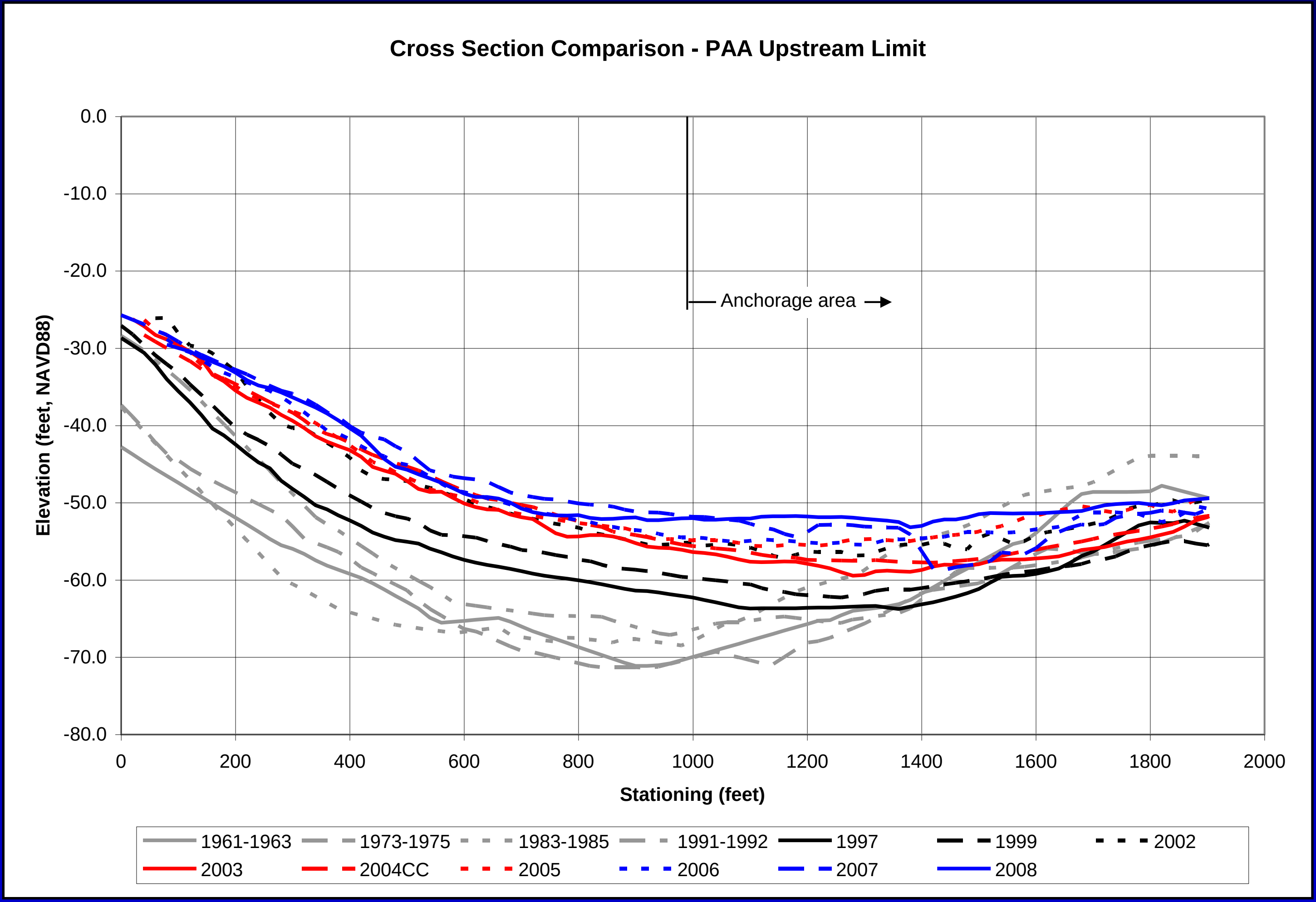
Geometric Data Analysis: Cross Section Comparisons



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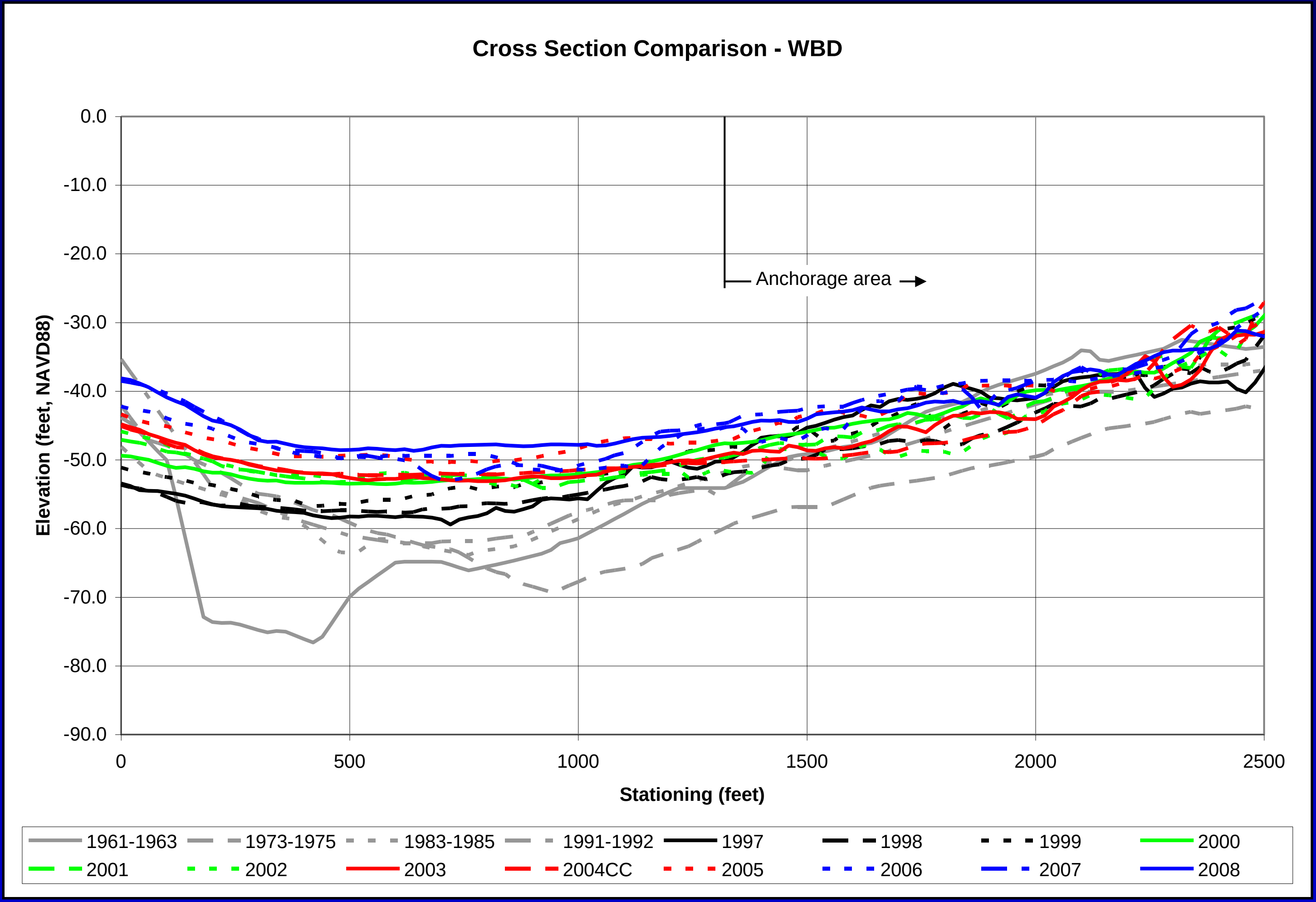
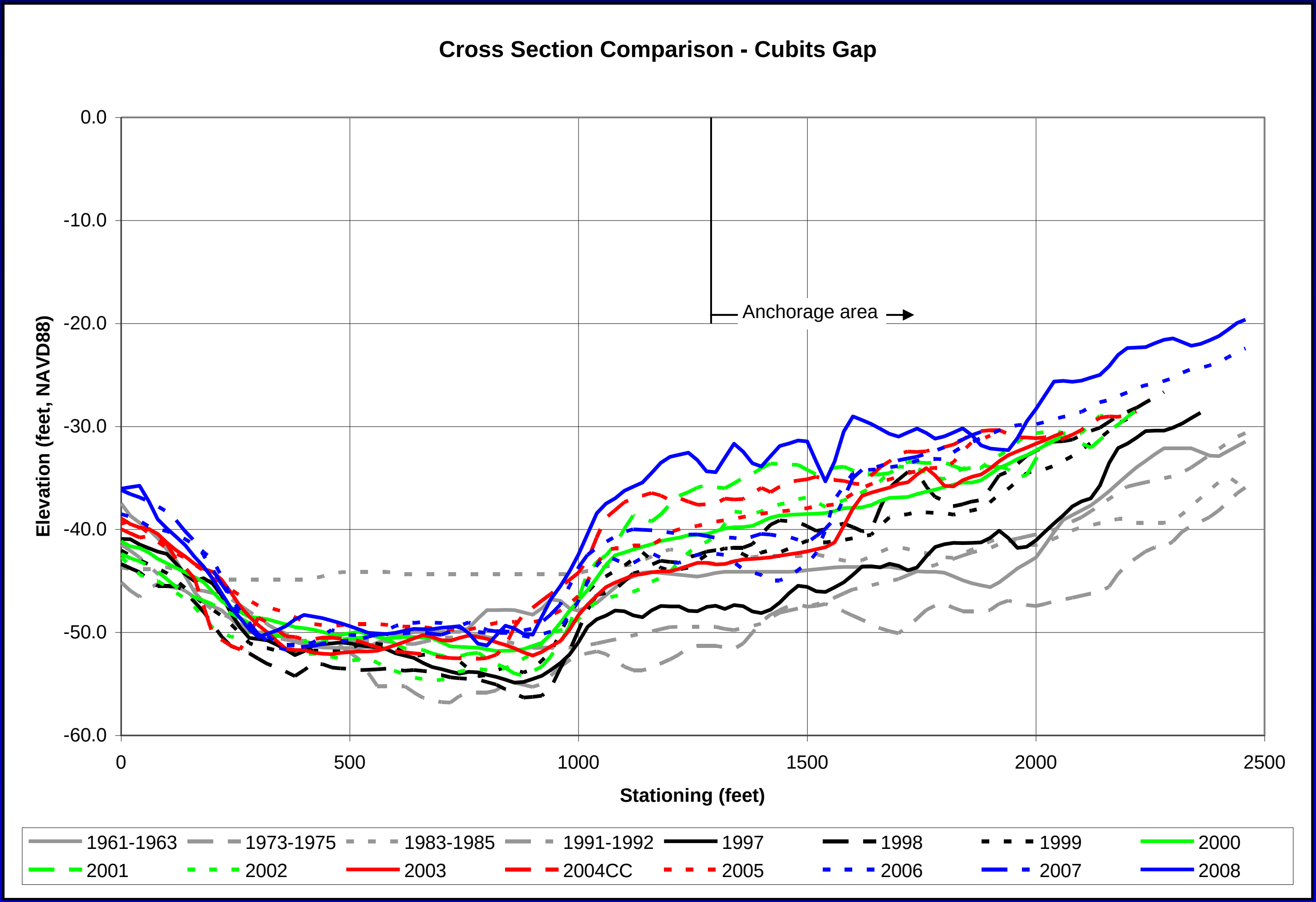
Geometric Data Analysis: Cross Section Comparisons



Geometric Data Analysis: Cross Section Comparisons



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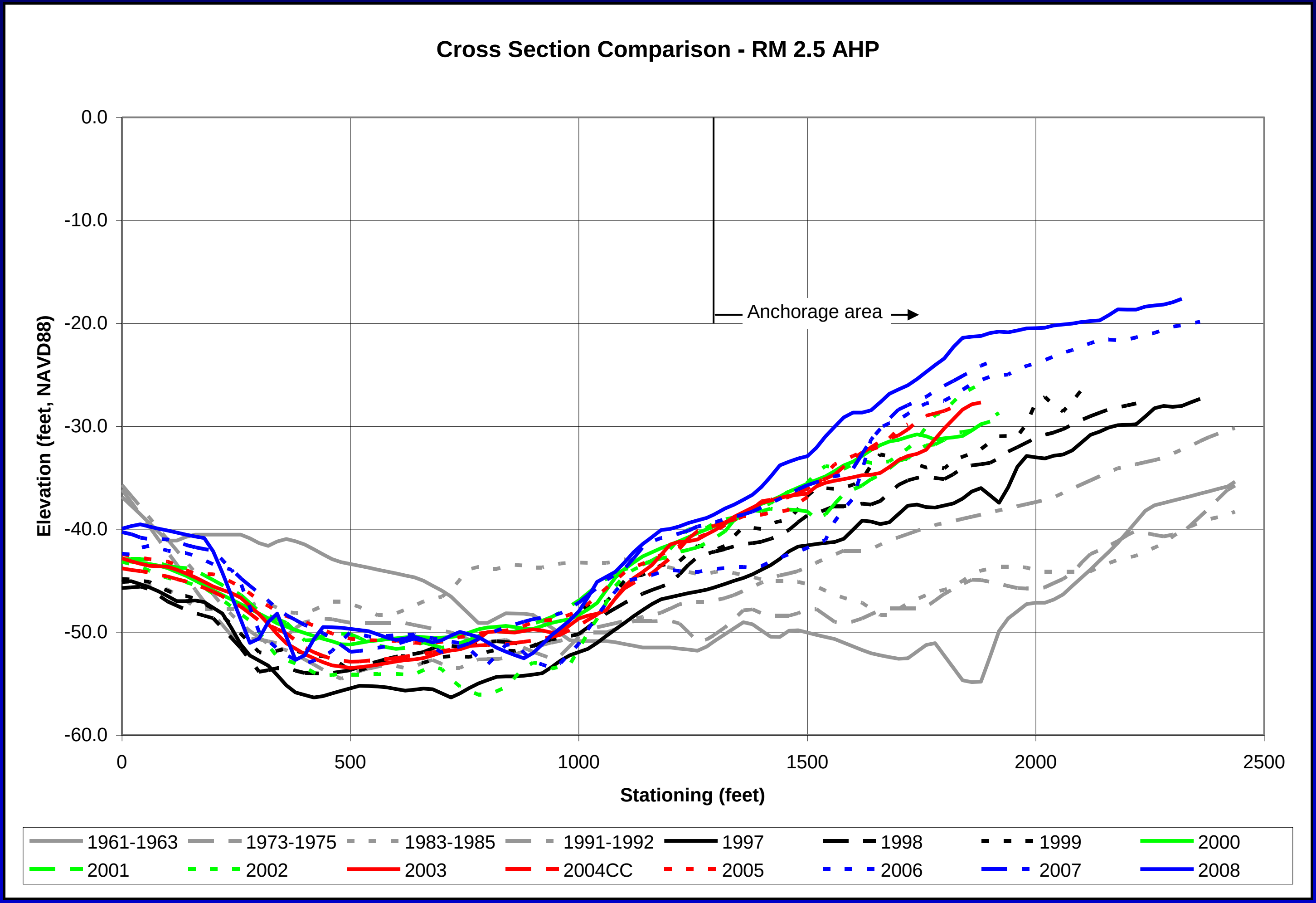
Geometric Data Analysis: Cross Section Comparisons



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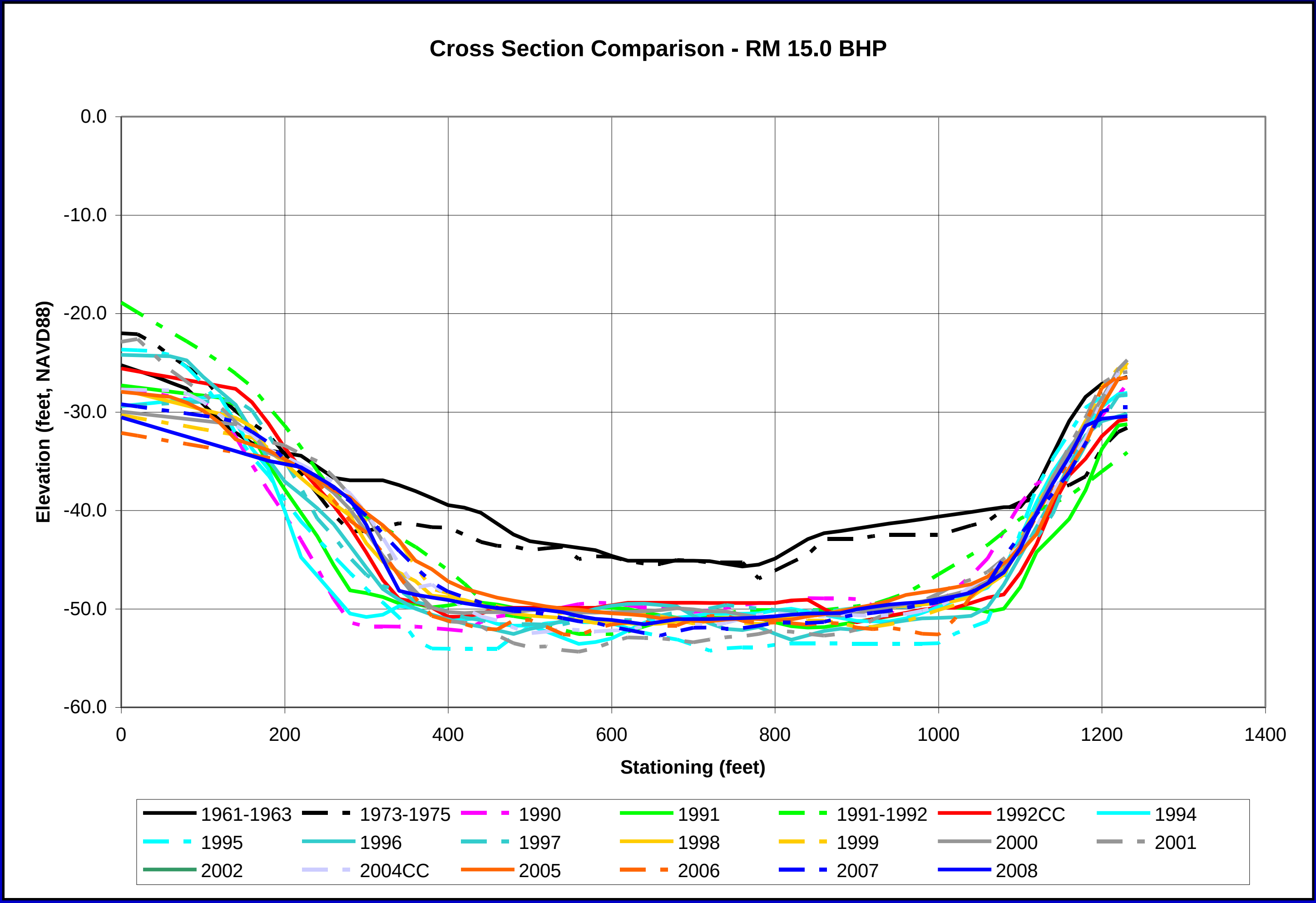
Geometric Data Analysis: Cross Section Comparisons



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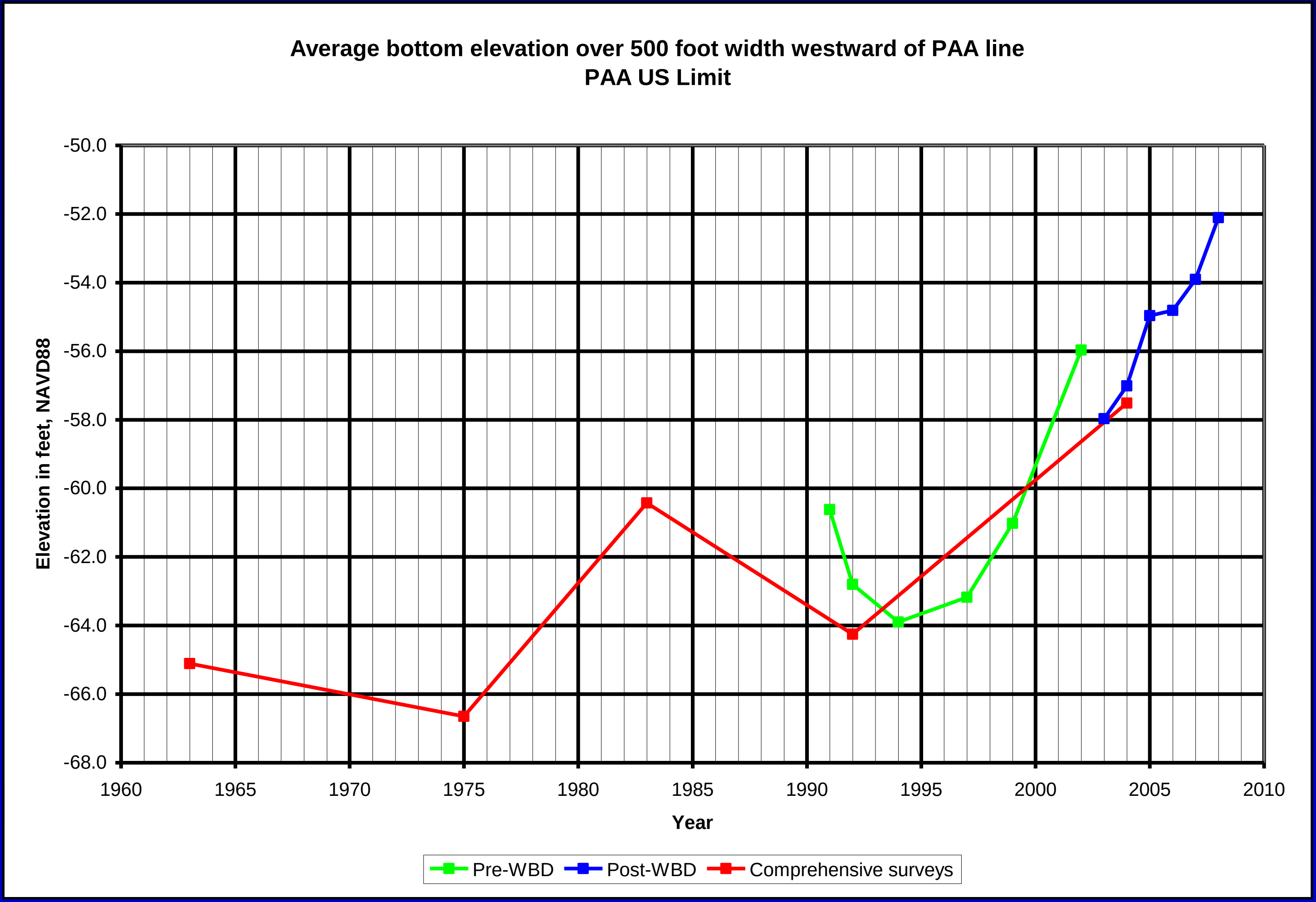
Geometric Data Analysis: Average Bed Elevation Change

- To quantify the change in bed elevation with time, an average bed elevation was determined for each survey.
- The average channel bed elevation was determined over a portion of the cross section 500 feet westward of the PAA line.
- Average channel bed elevations from each survey were plotted to illustrate trends in bed elevation change and to generally quantify the rates of change.
- This analysis was conducted only for the cross sections within the PAA.

Geometric Data Analysis: Average Bed Elevation Change



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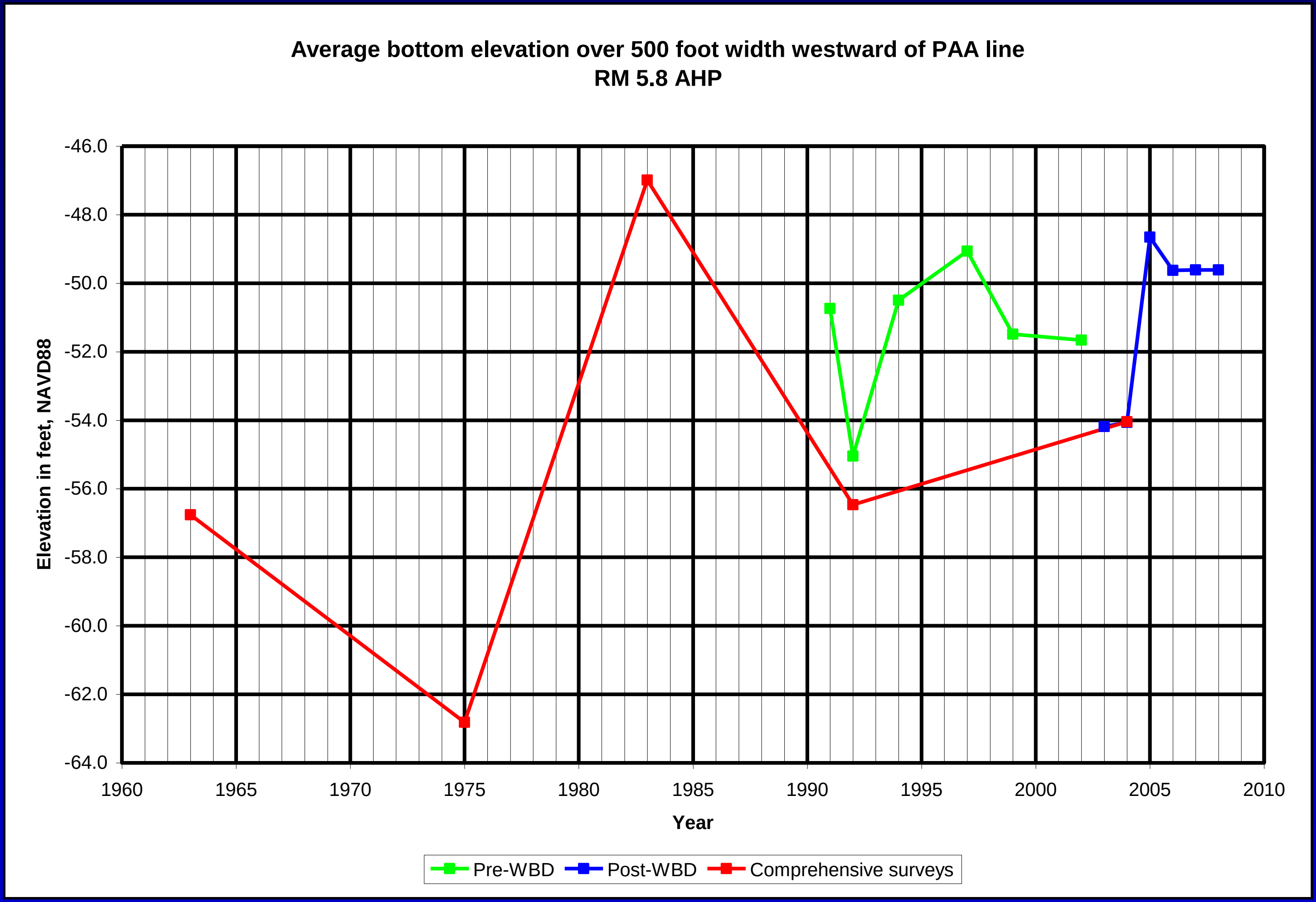

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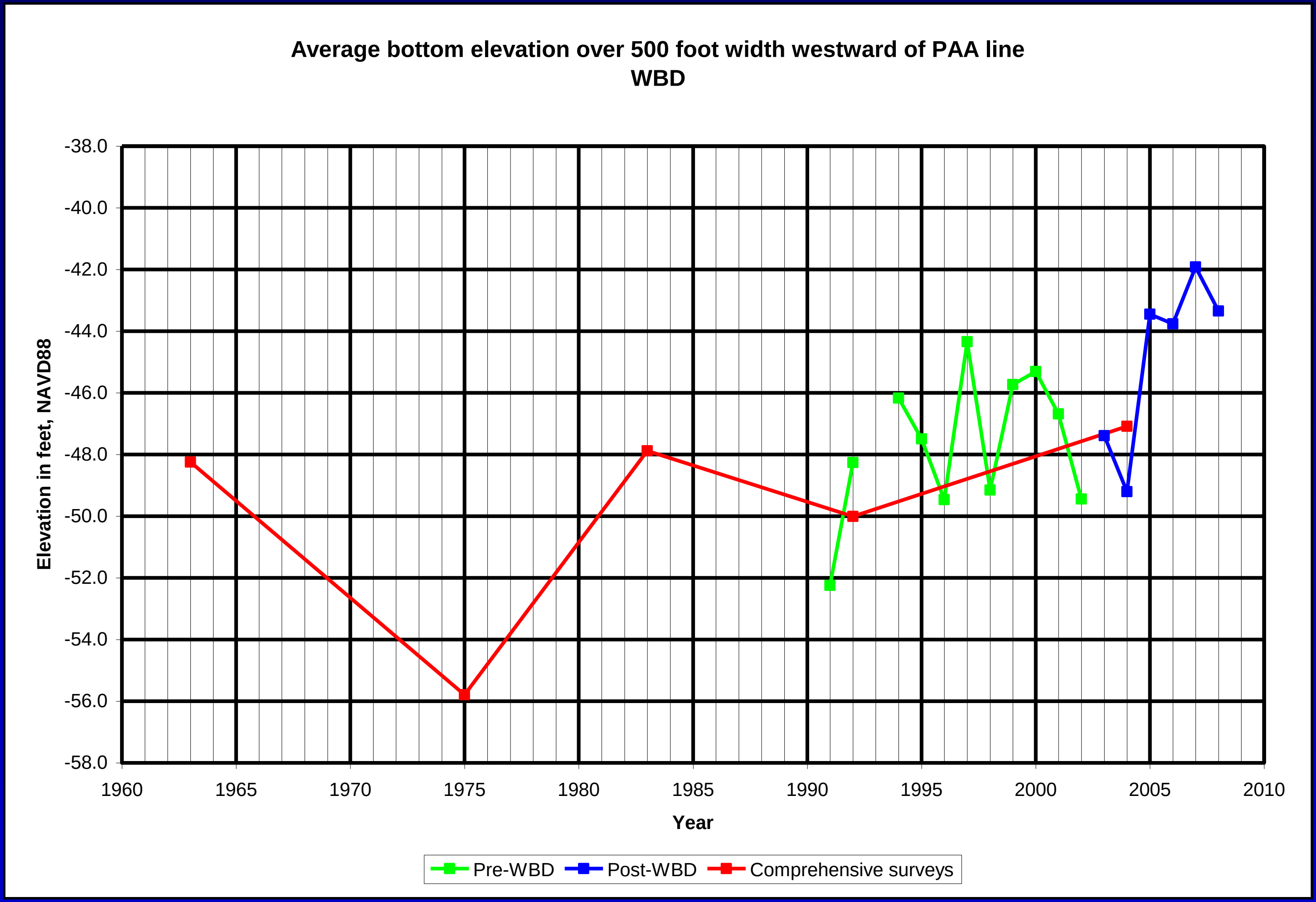

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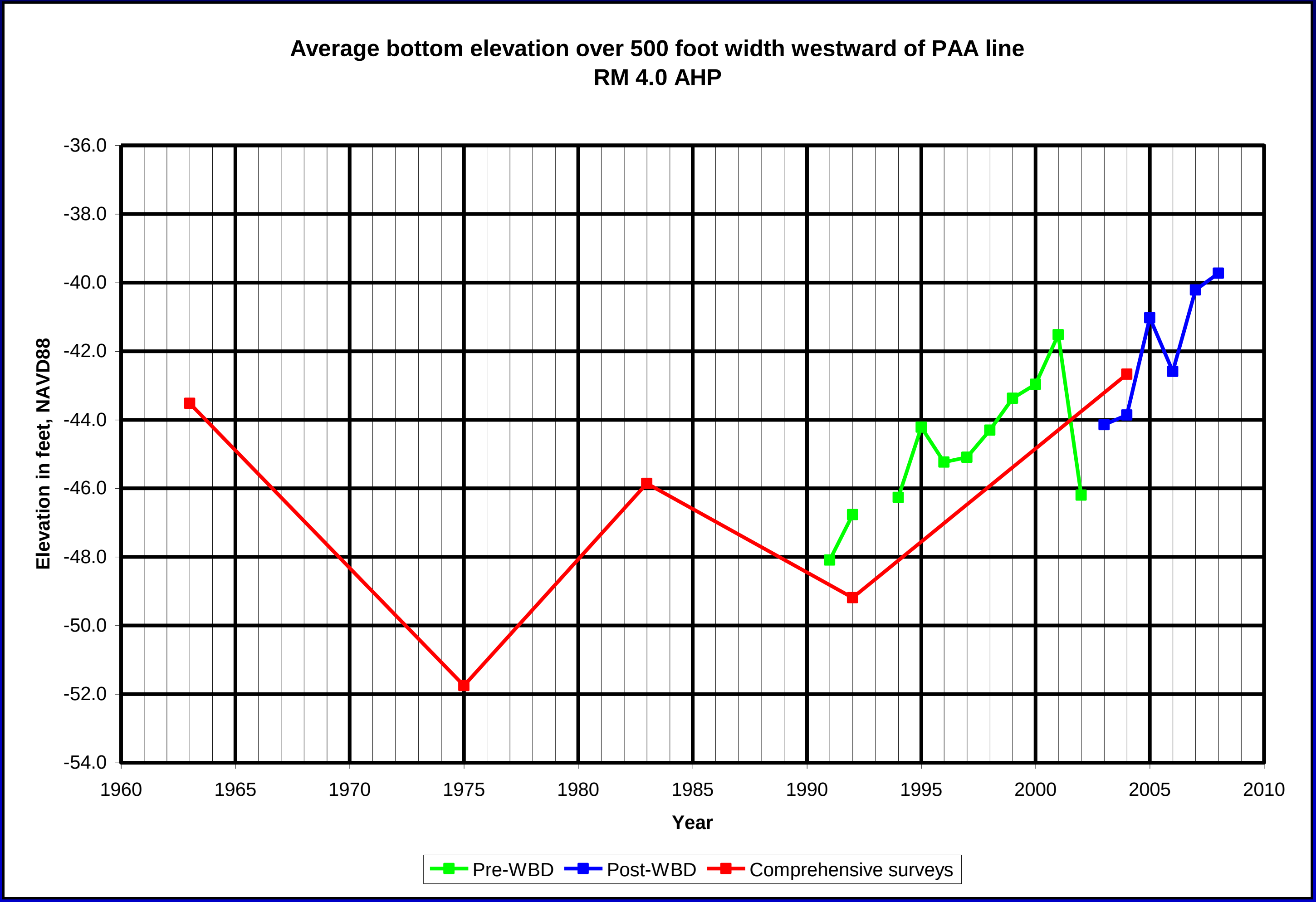

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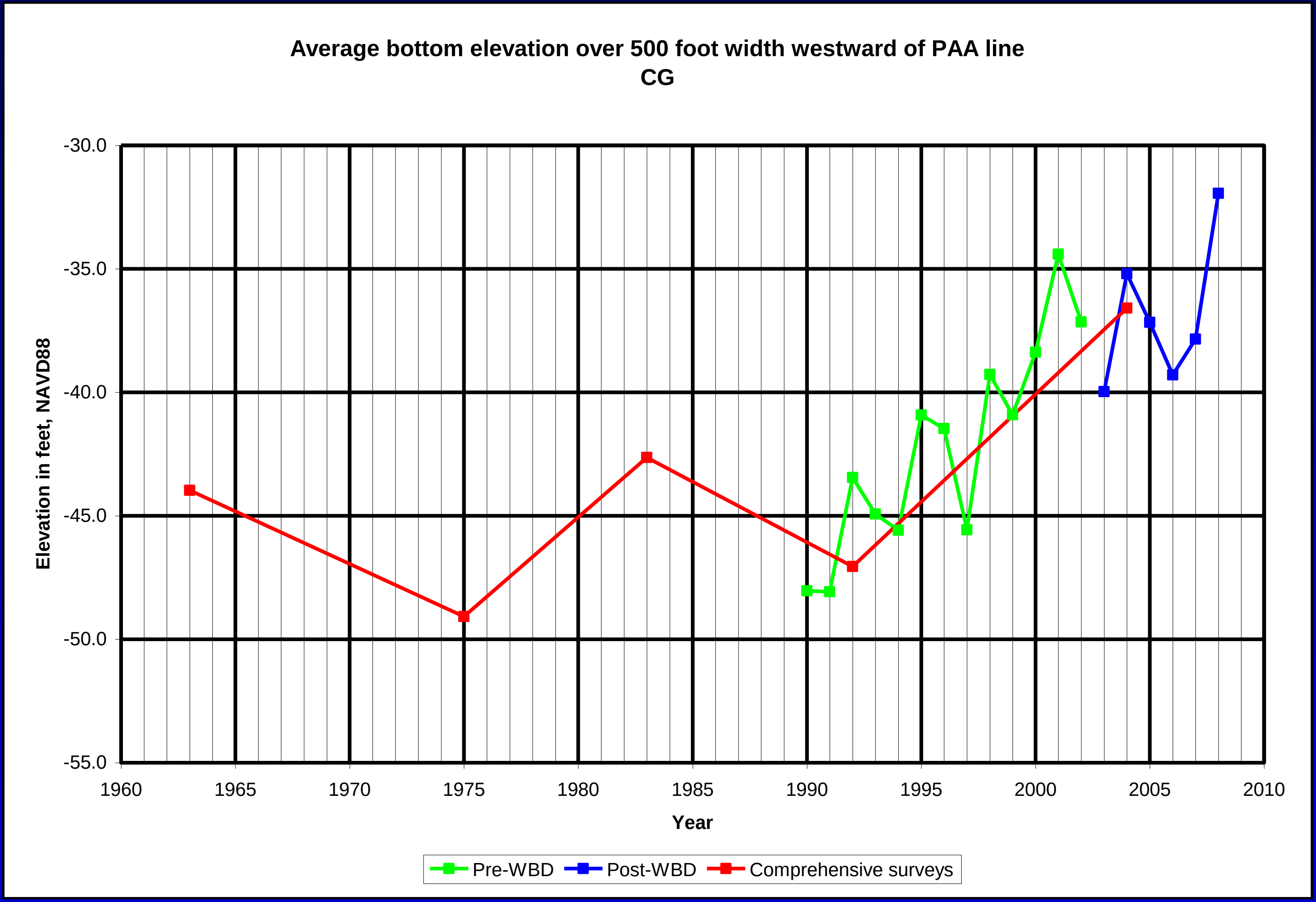

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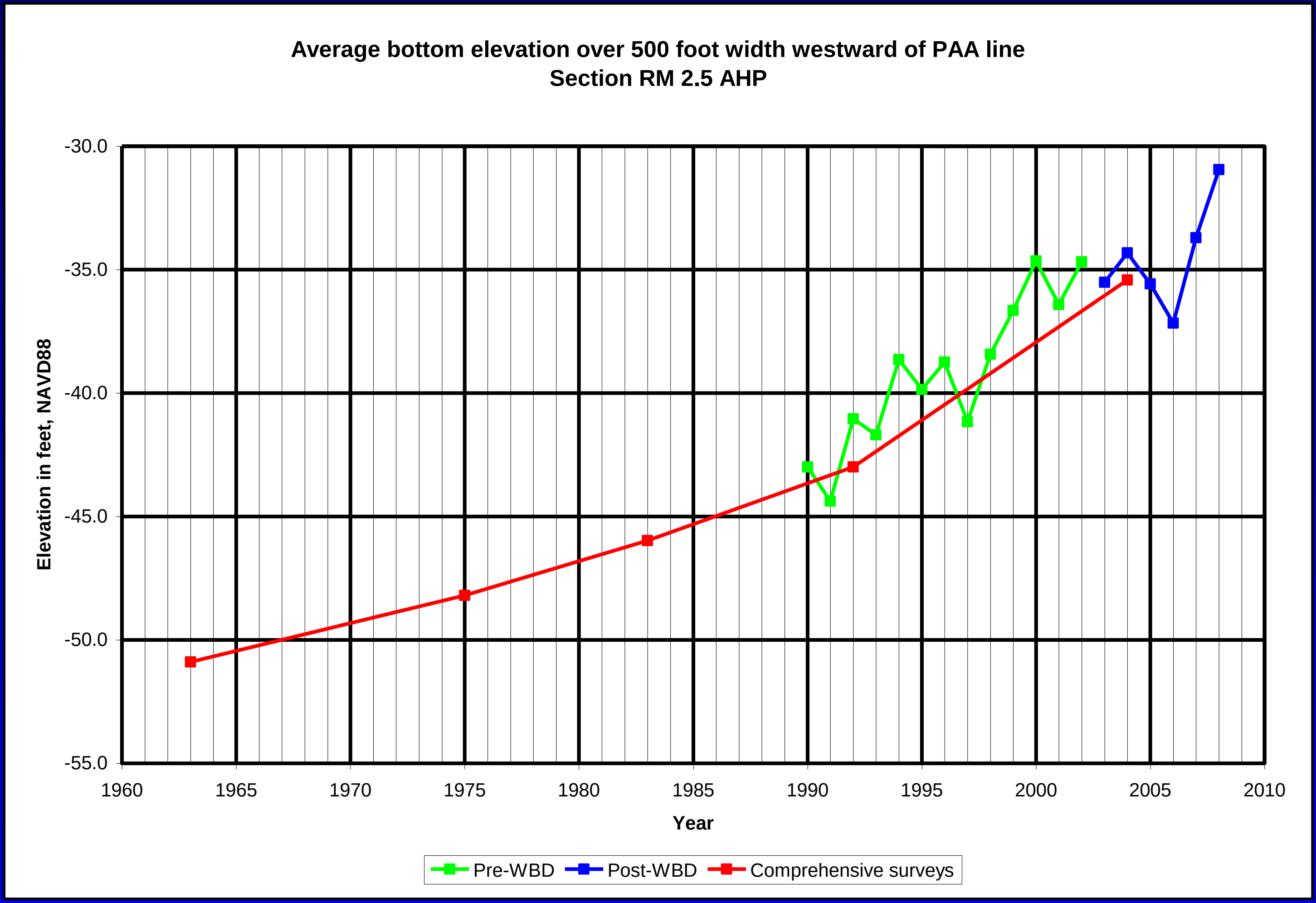

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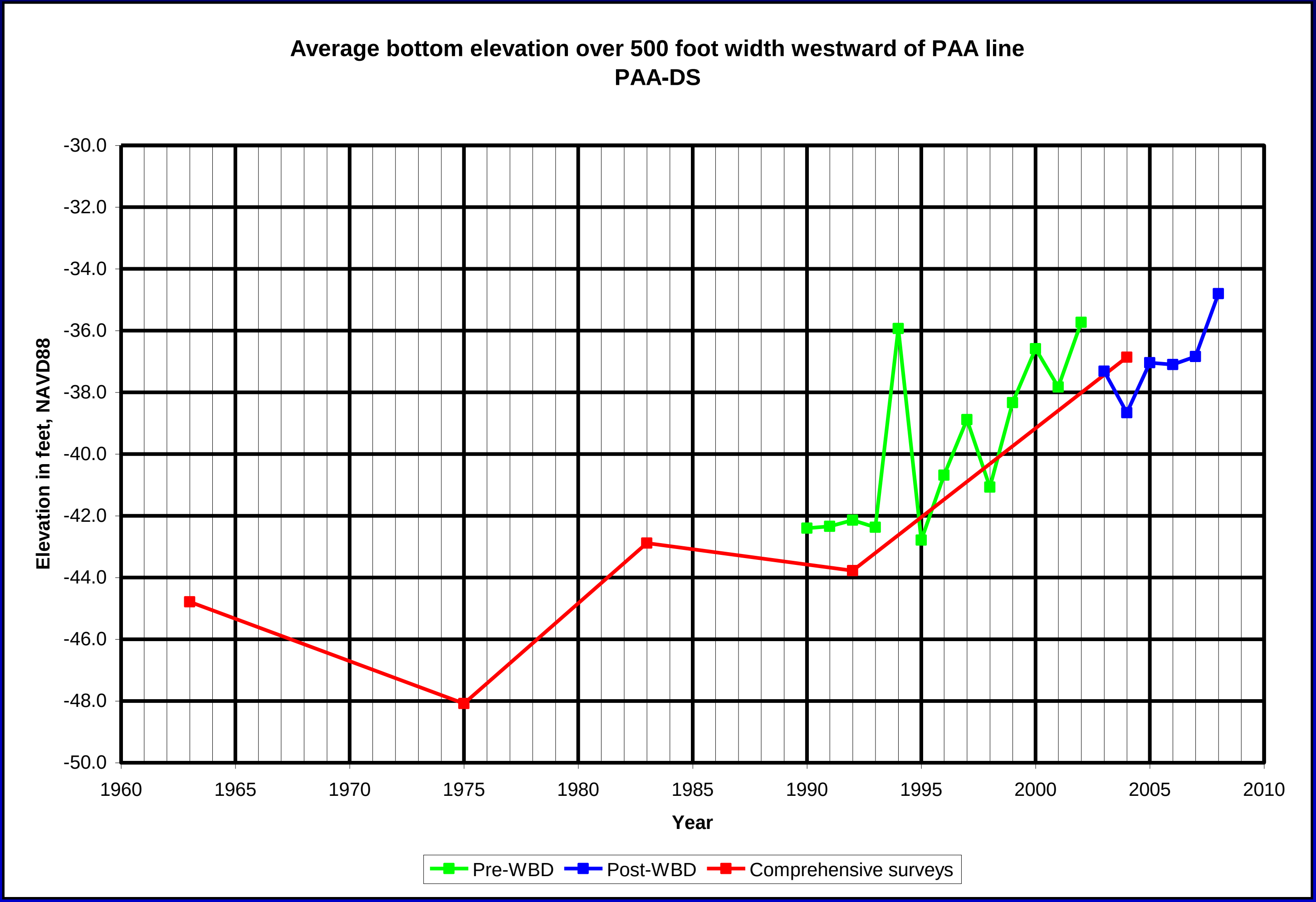
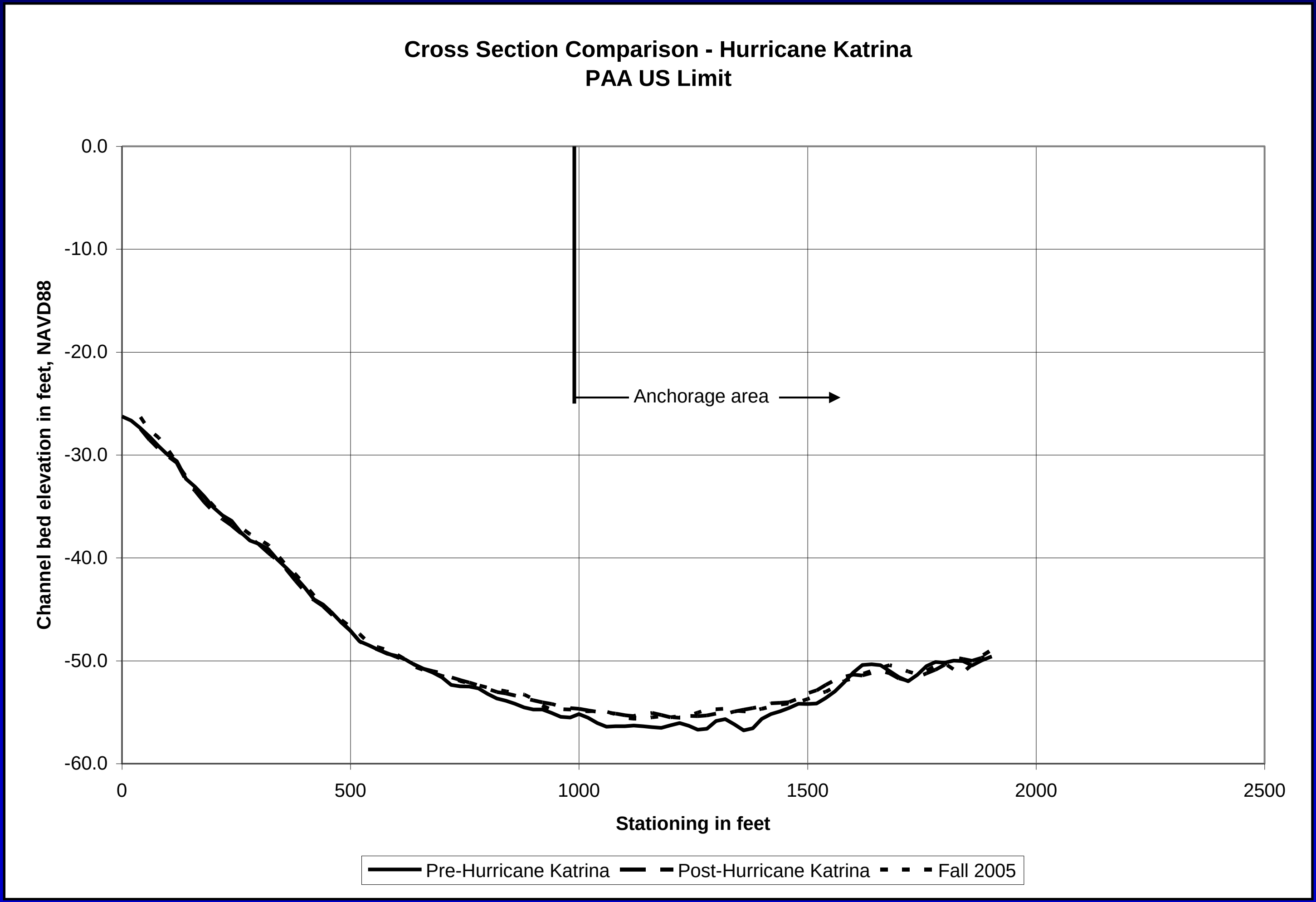


Geometric Data Analysis: Cross Section Comparison – Hurricane Katrina



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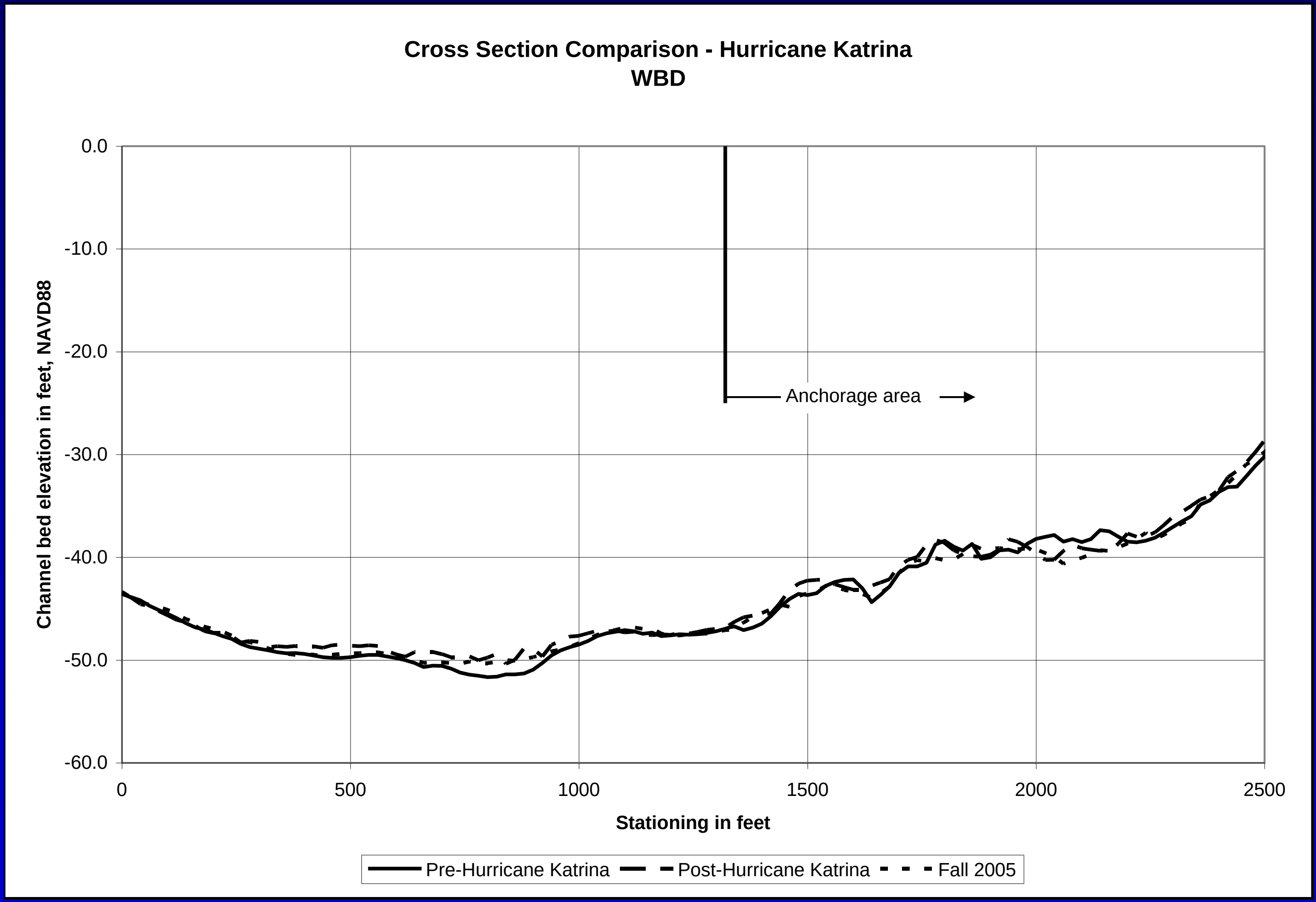

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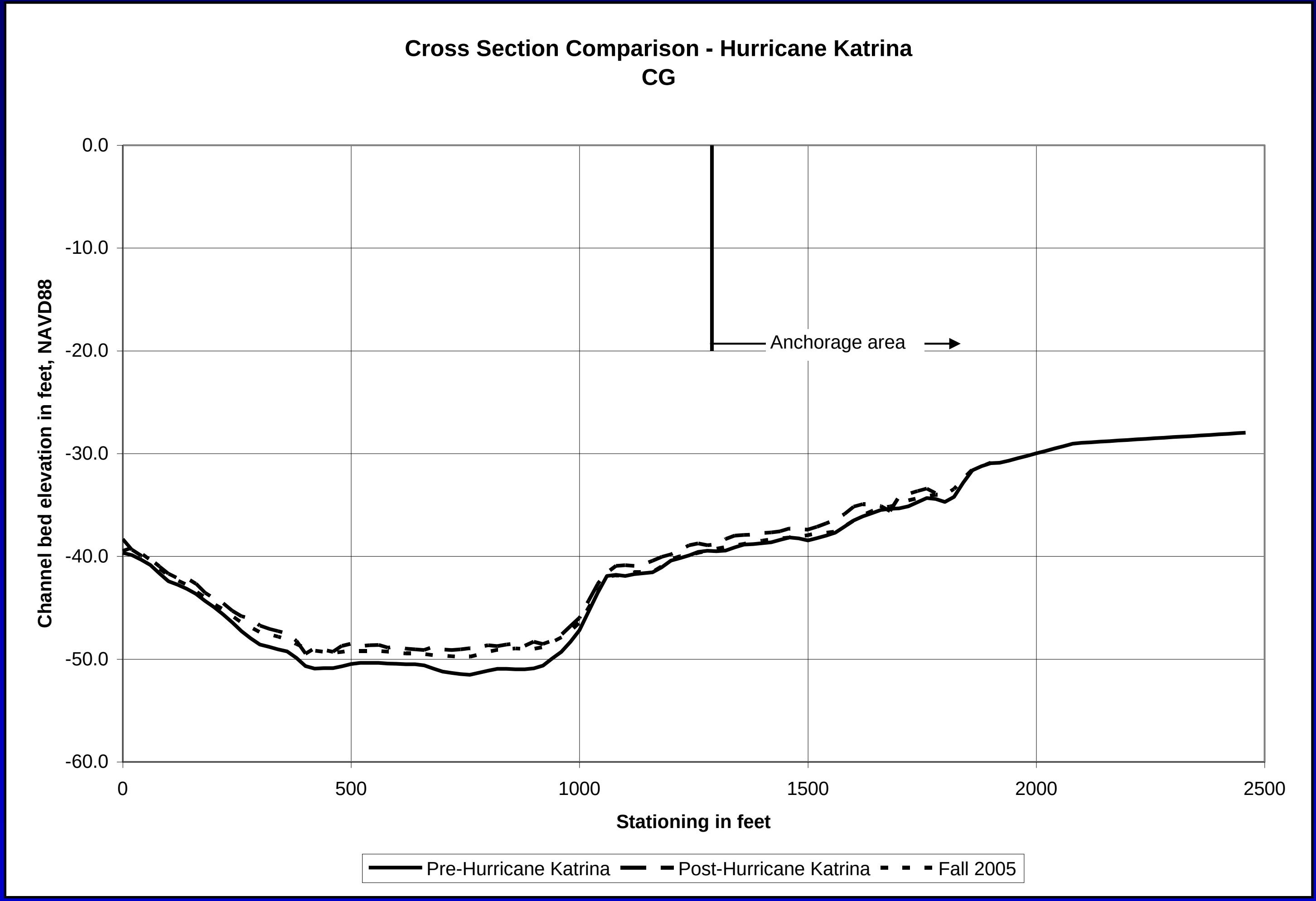

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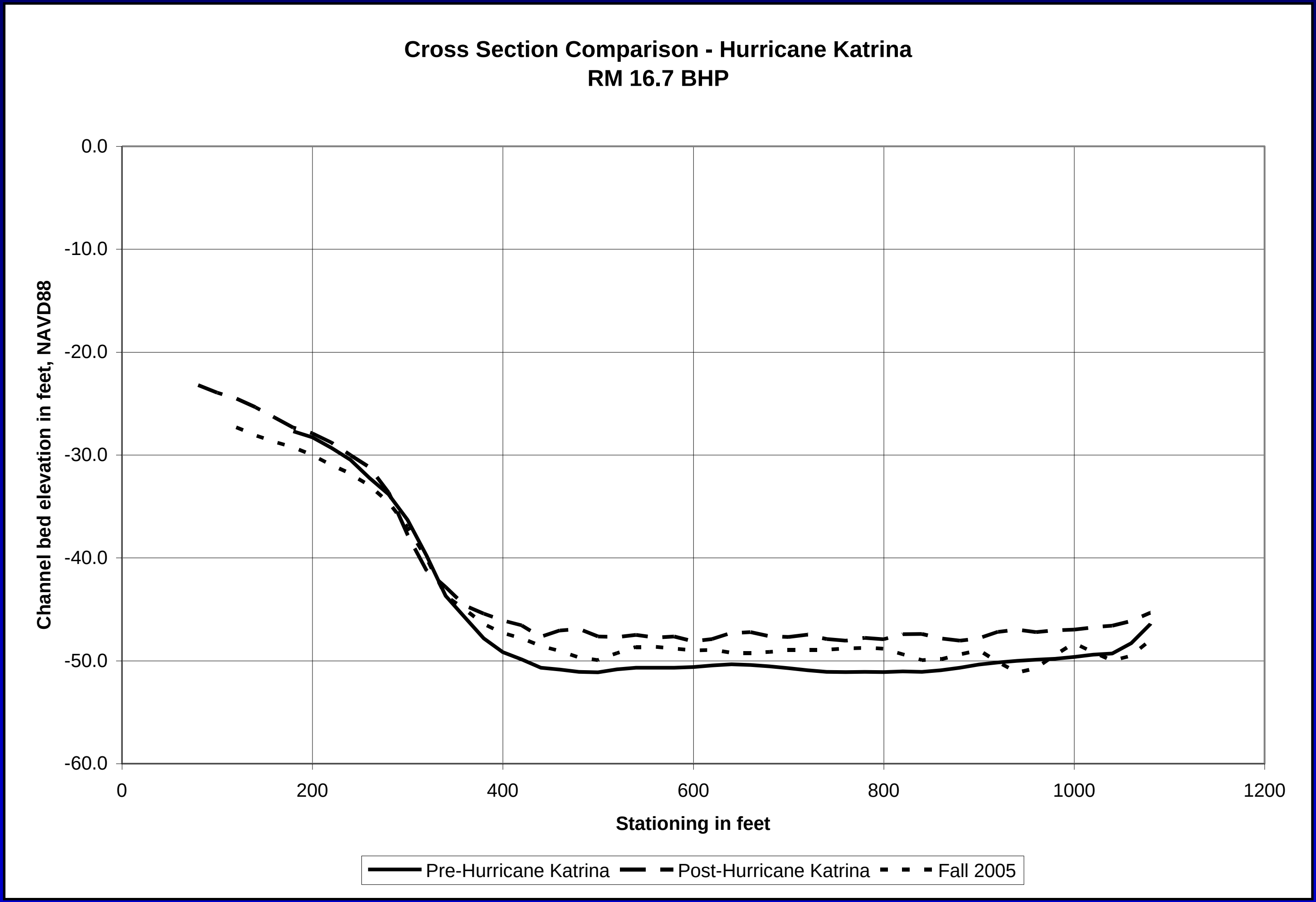

Geometric Data Analysis: Volumetric Computations

- Reach “polygons” were established to computed volumetric change (15 in river channel and 6 in PAA).
- River channel polygons extend to approximately the -20 foot contour. PAA polygons extend approximately 500 feet westward from the PAA line.
- Volume of each reach polygon was computed for all surveys, and the annual change in volume was computed.
- The incremental volumes were divided by the area of the polygon to computed an average annual bed change for the volume.

Geometric Data Analysis: Reach Locations

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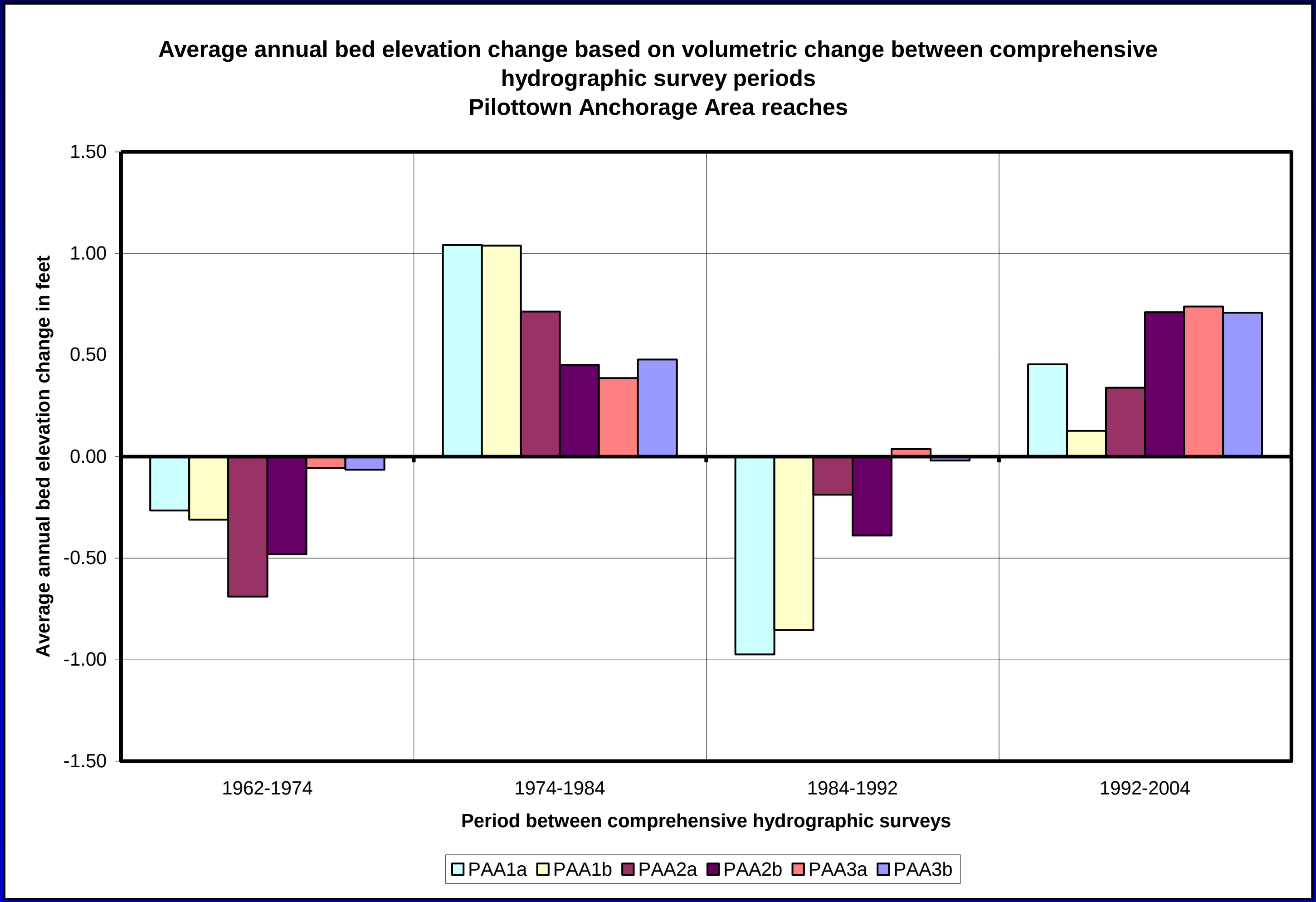
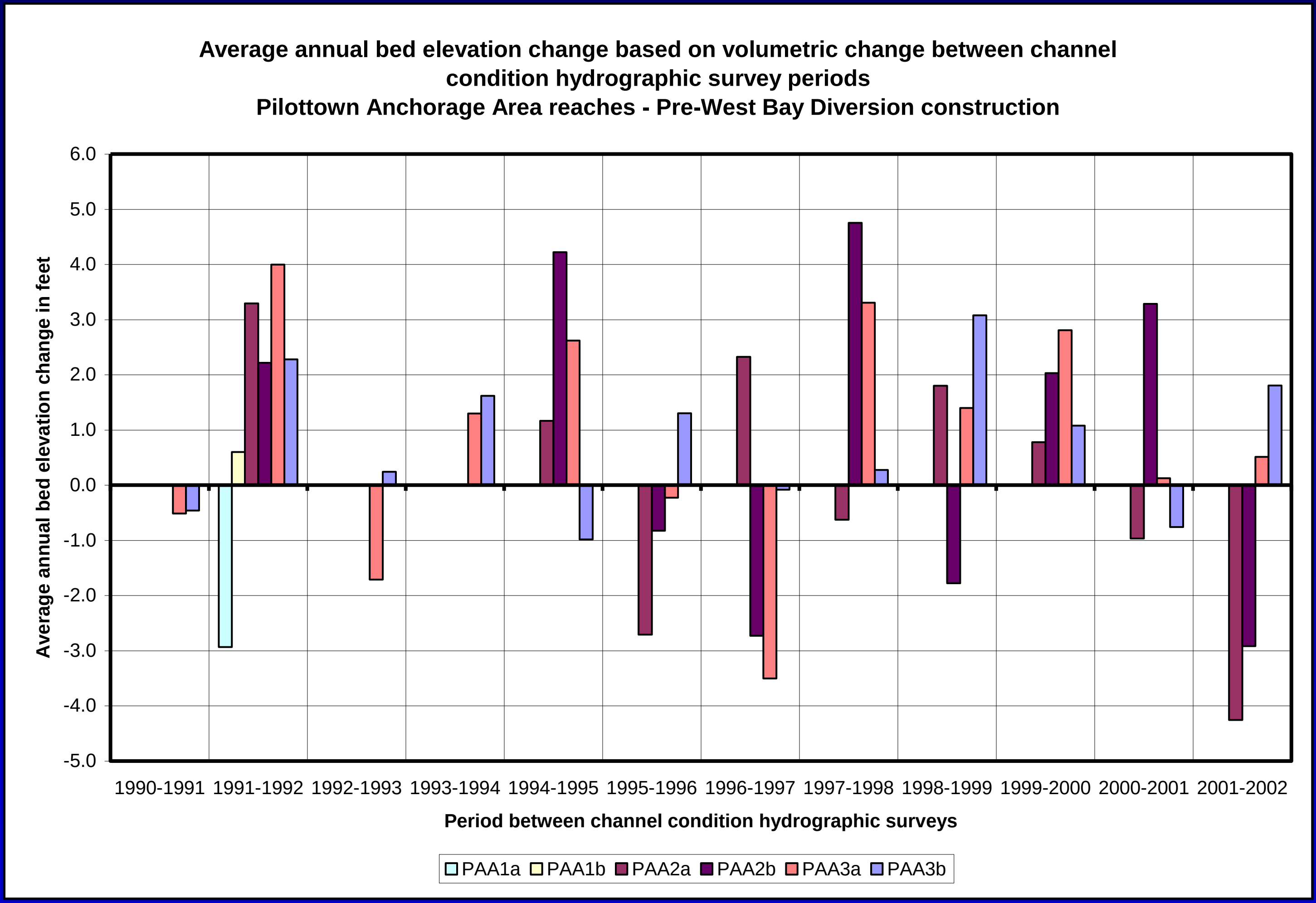
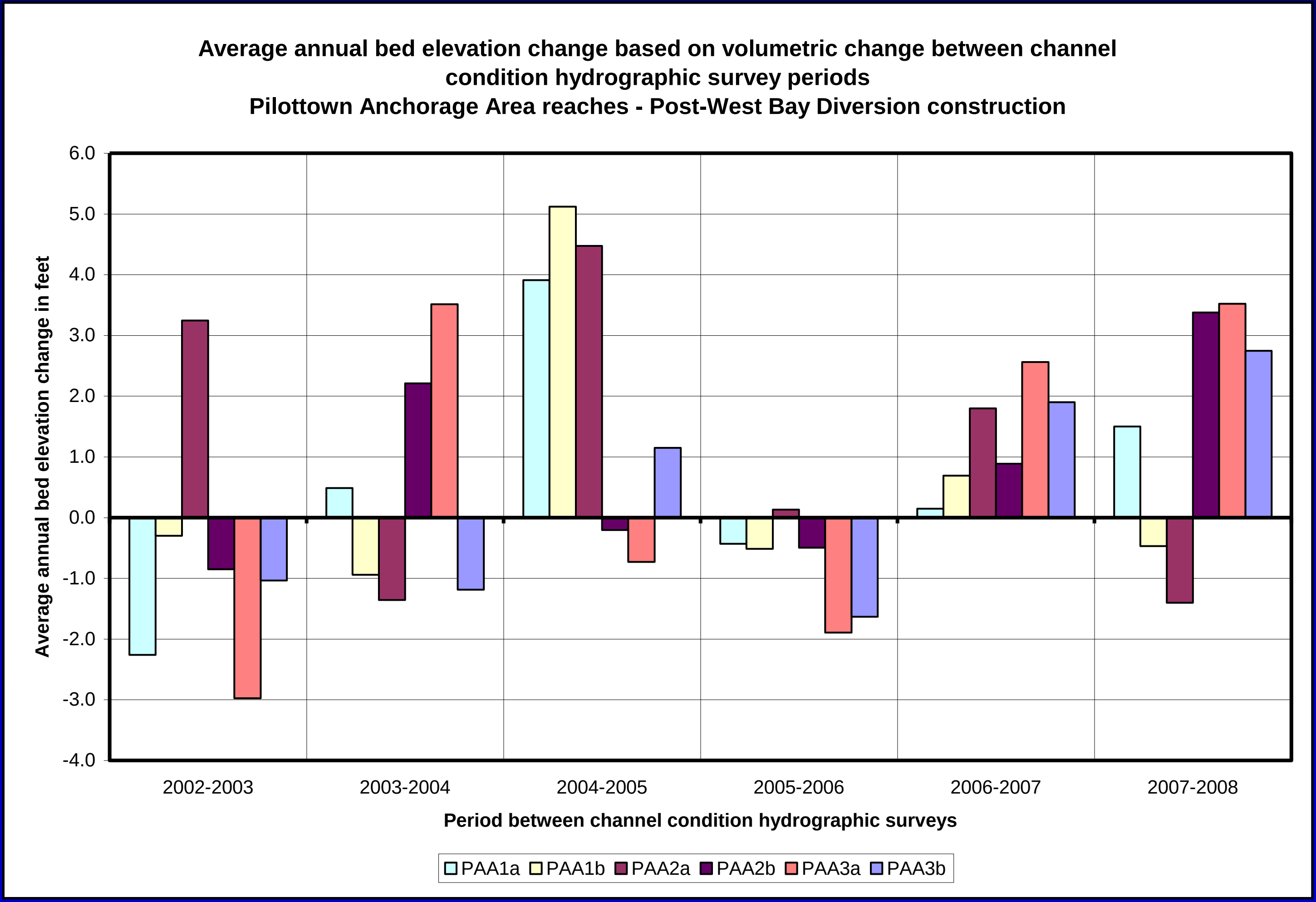
Geometric Data Analysis: Volumetric Computations



Geometric Data Analysis: Volumetric Computations



Geometric Data Analysis: Volumetric Computations



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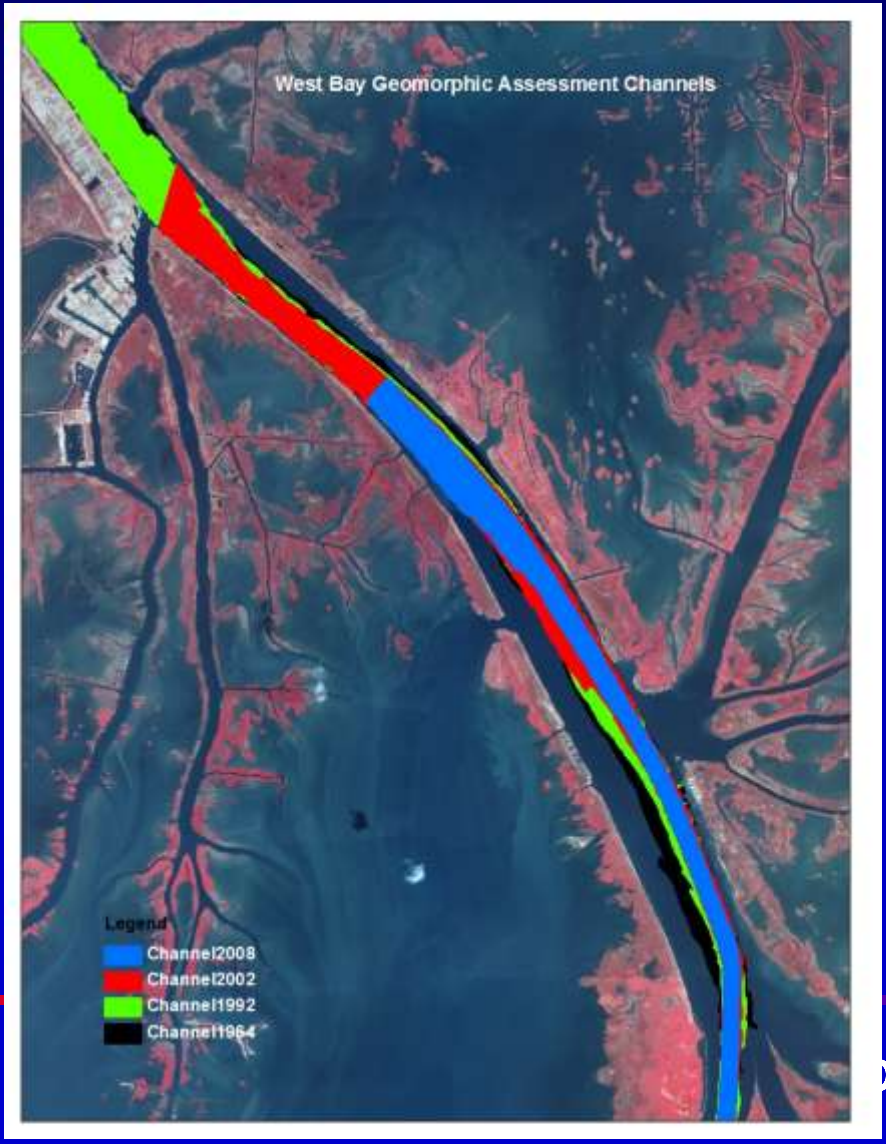
Geometric Data Analysis: Channel Pattern Analysis

- Polygons were developed for the appropriate navigation channel depth for all surveys.
- The channel polygons were plotted to qualitatively determine any trends in channel pattern.
- The width of the channel polygon was measured at each cross section location to determine any trends in channel width. (This analysis is still ongoing)

Geometric Data Analysis: Channel Pattern Analysis



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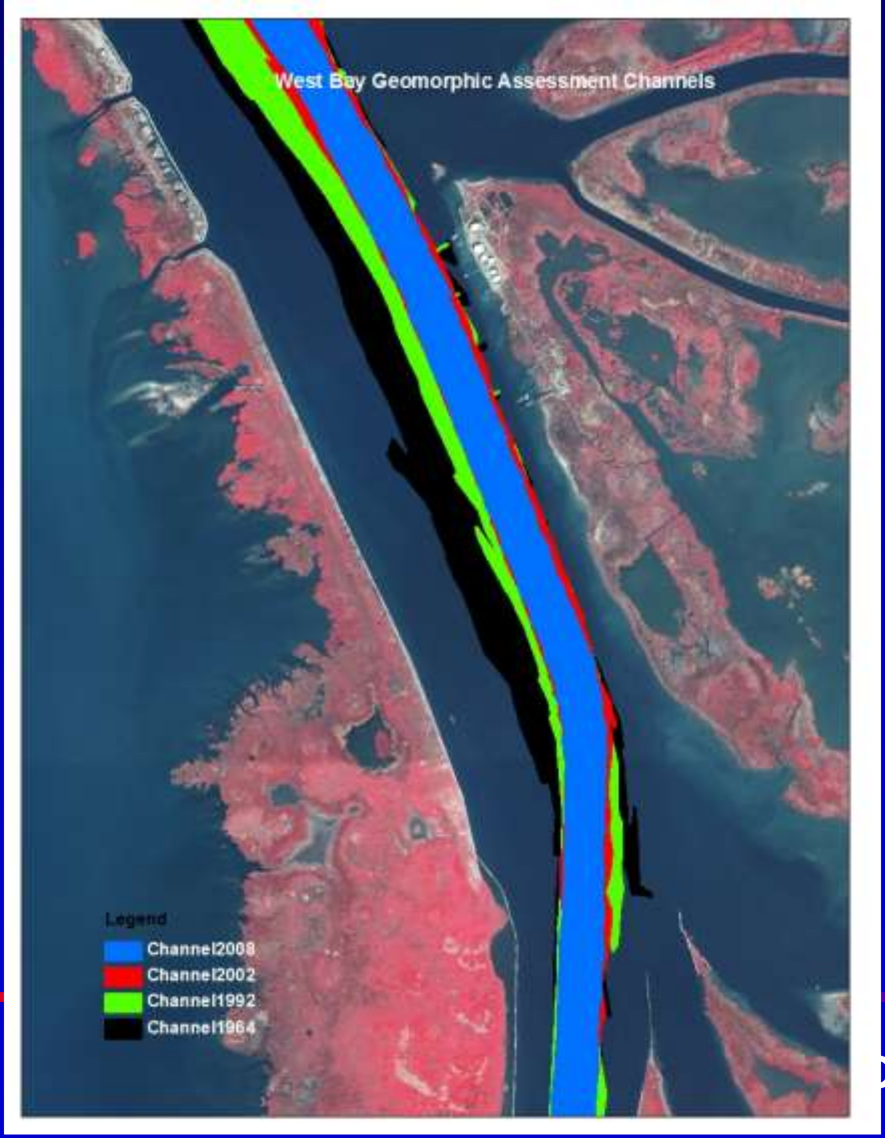

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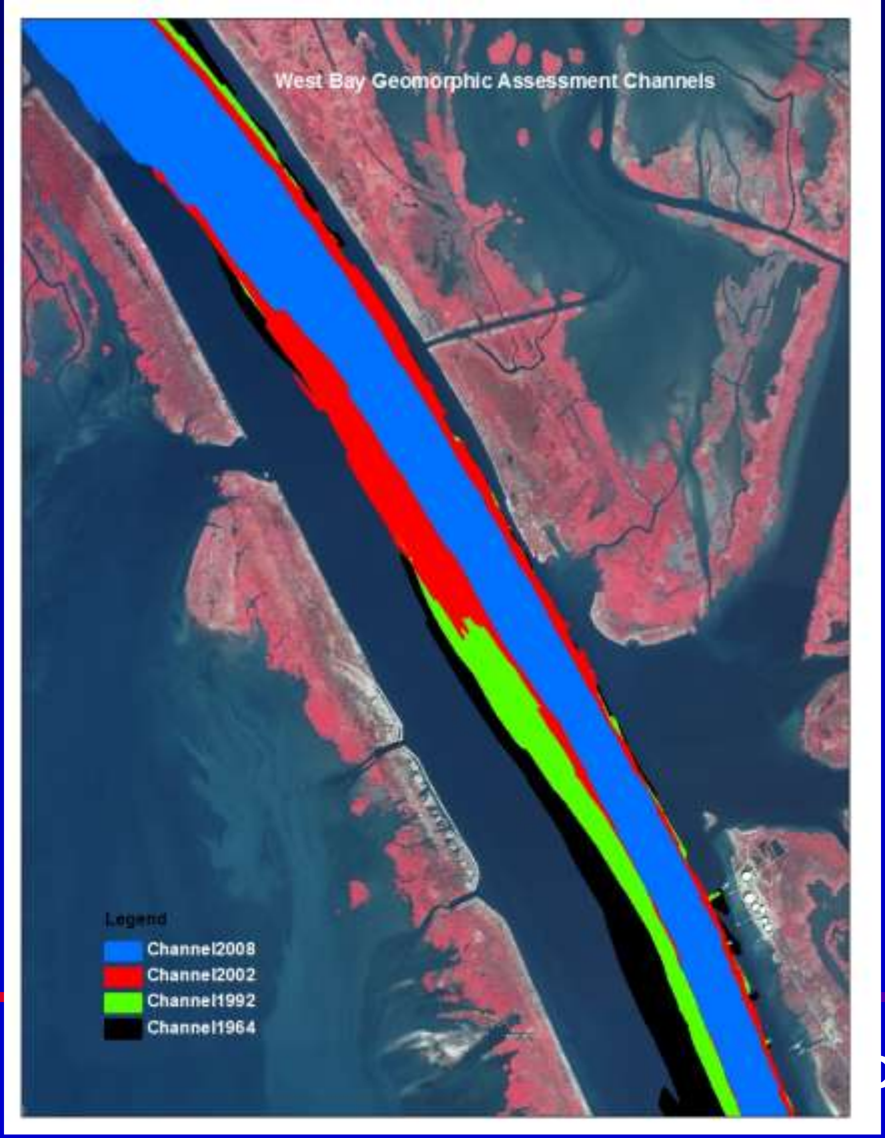
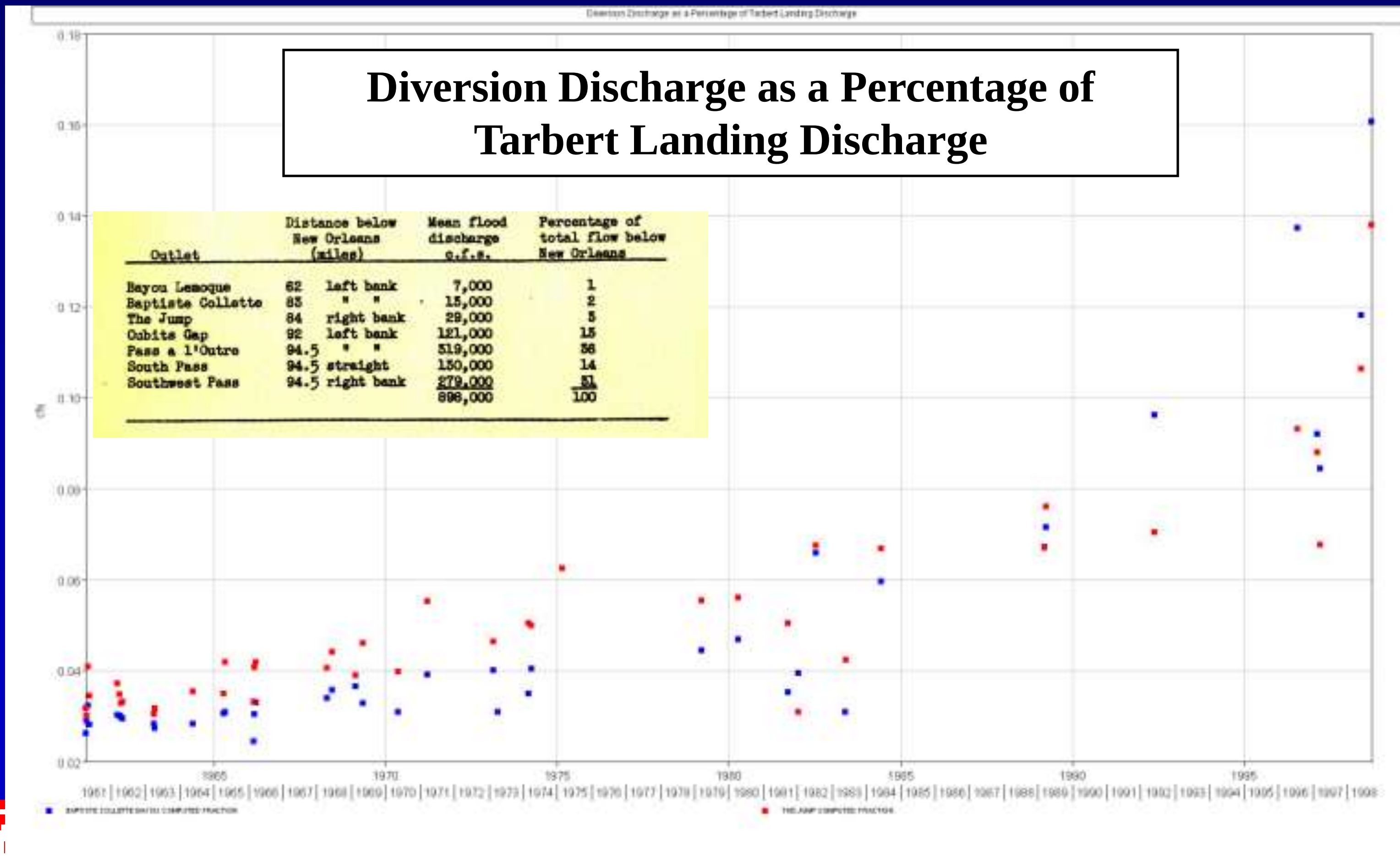
Geometric Data Analysis: Channel Pattern Analysis

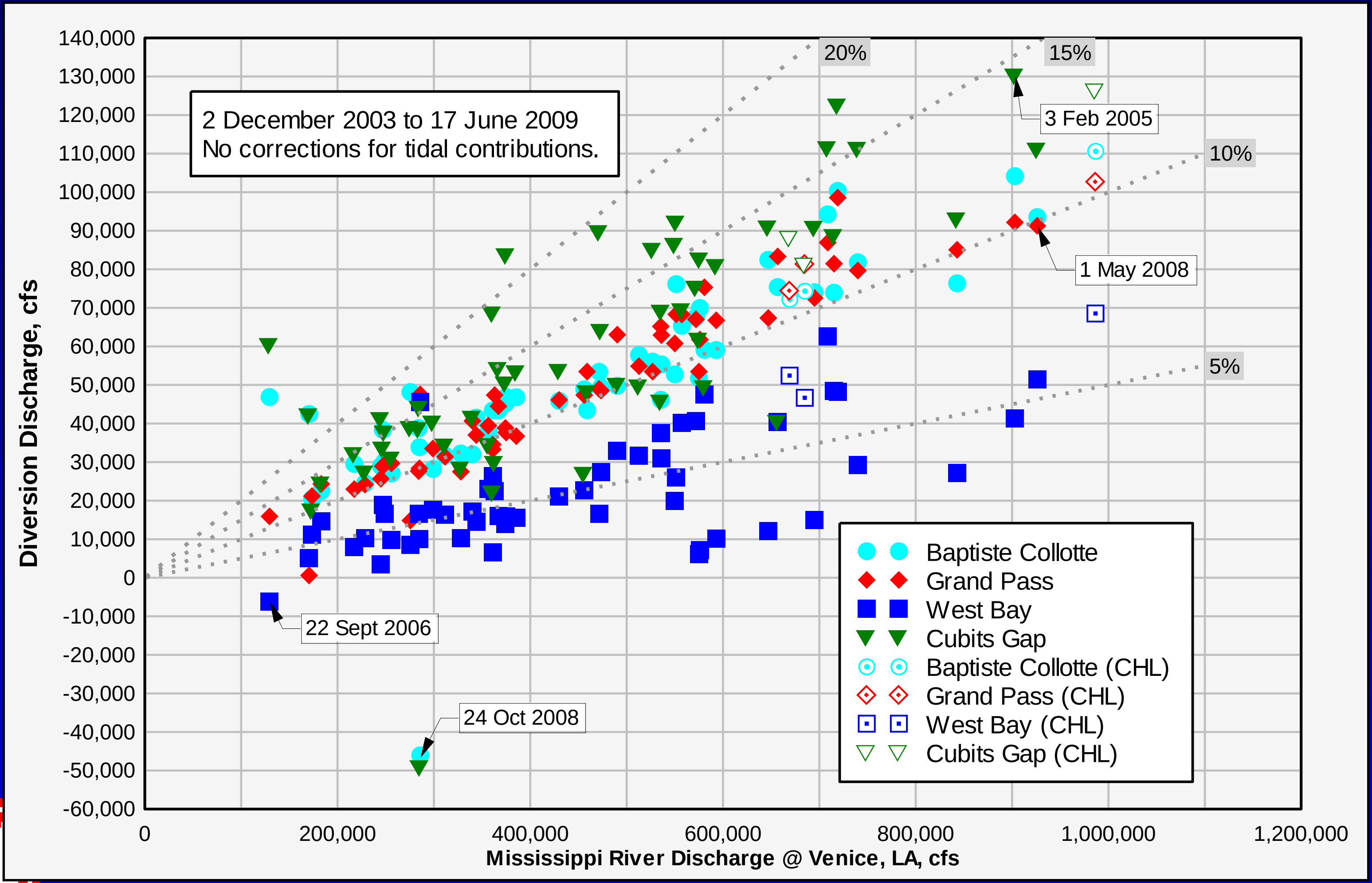


Gage/Discharge/Sediment Data Analysis



Outlet	Distance below New Orleans (miles)		Mean flood discharge c.f.s.	Percentage of total flow below New Orleans
Bayou Lamoque	62	left bank	7,000	1
Baptiste Collette	83	" "	15,000	2
The Jump	84	right bank	29,000	5
Cubits Gap	92	left bank	121,000	15
Pass a l'Outre	94.5	" "	319,000	36
South Pass	94.5	straight	130,000	14
Southwest Pass	94.5	right bank	279,000	31
			898,000	100

Gage/Discharge/Sediment Data Analysis



Dredge Data Analysis

Questions/Discussion

West Bay Diversion Evaluation
1-Dimensional Modeling
Peer Review

Webinar
20 October 2009

Freddie Pinkard
ERDC - CHL

Actions Taken
Continued Development of Model Input Requirements

1. **Analyze ERDC Collected Data / Compare With MVK Model Input / Revise Input As Required**
   - Flow Distribution At Diversions / Distributaries
   - Sediment Concentration Ratios Between Diversions / Distributaries And The River
   - Bed Material Gradations From RM 19.6 to RM -18
2. **Develop Downstream Boundary Condition**
   - Daily 8:00 AM Stage At Grand Isle, East Point Gage
     - Rectify Datum Issues

Actions Taken
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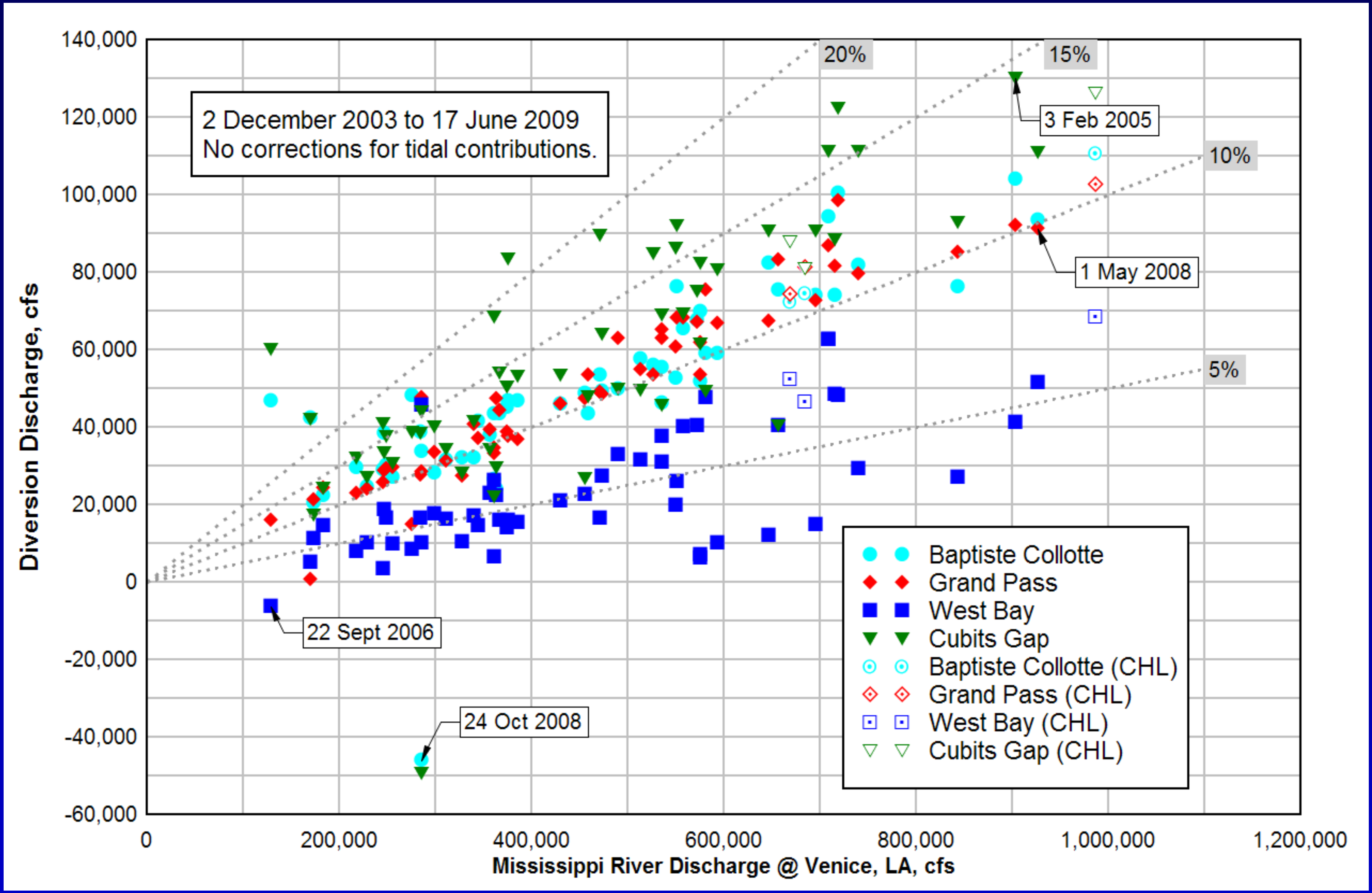

Flow Distribution At Diversions / Distributaries

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Actions Taken
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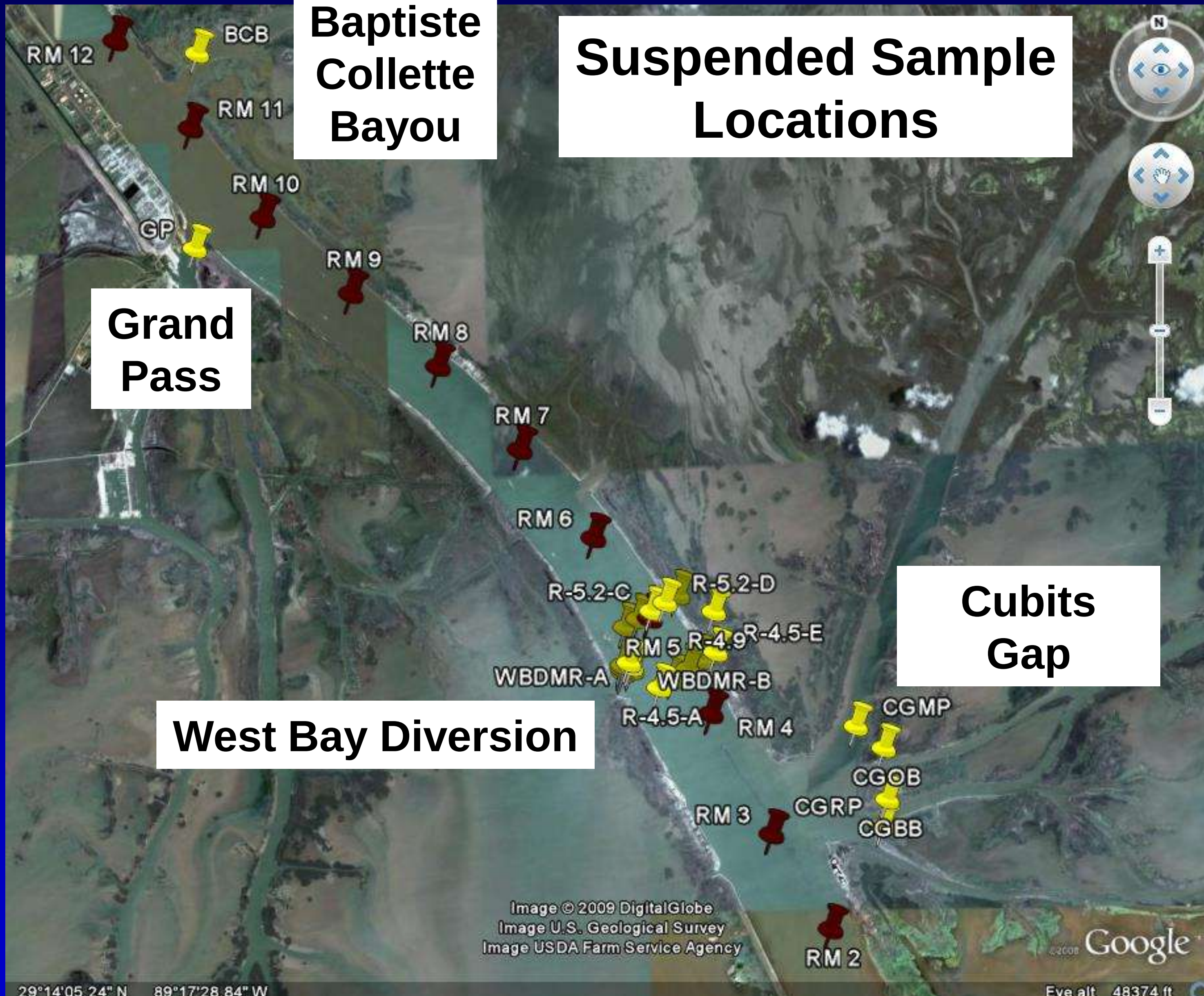
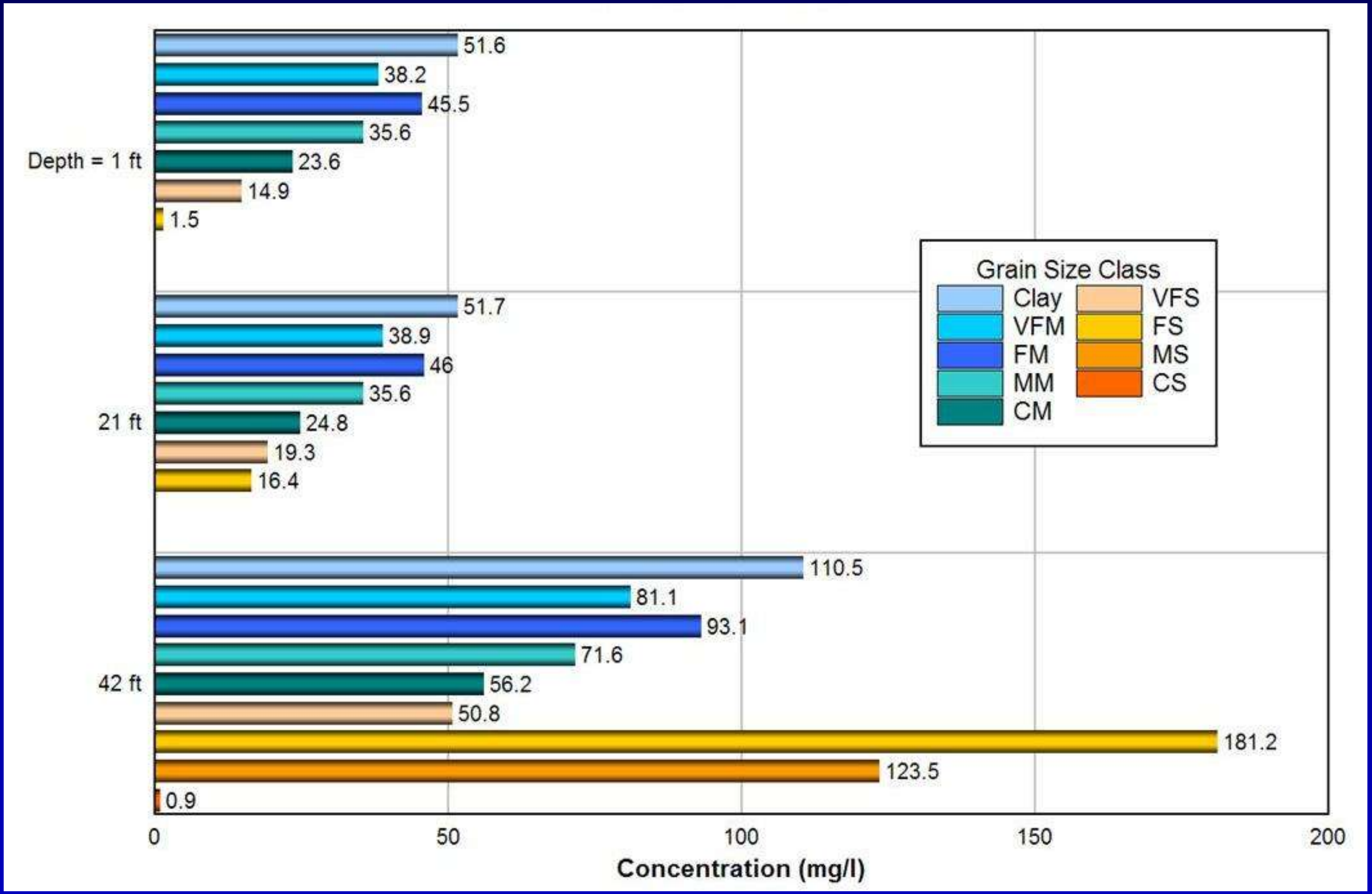
Suspended Sample Locations





Baptiste Collette Bayou
Sediment Concentrations By Grain Size
29 May 2009 Q = 110,000 cfs

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Actions Taken
Continued Development of Model Input Requirements

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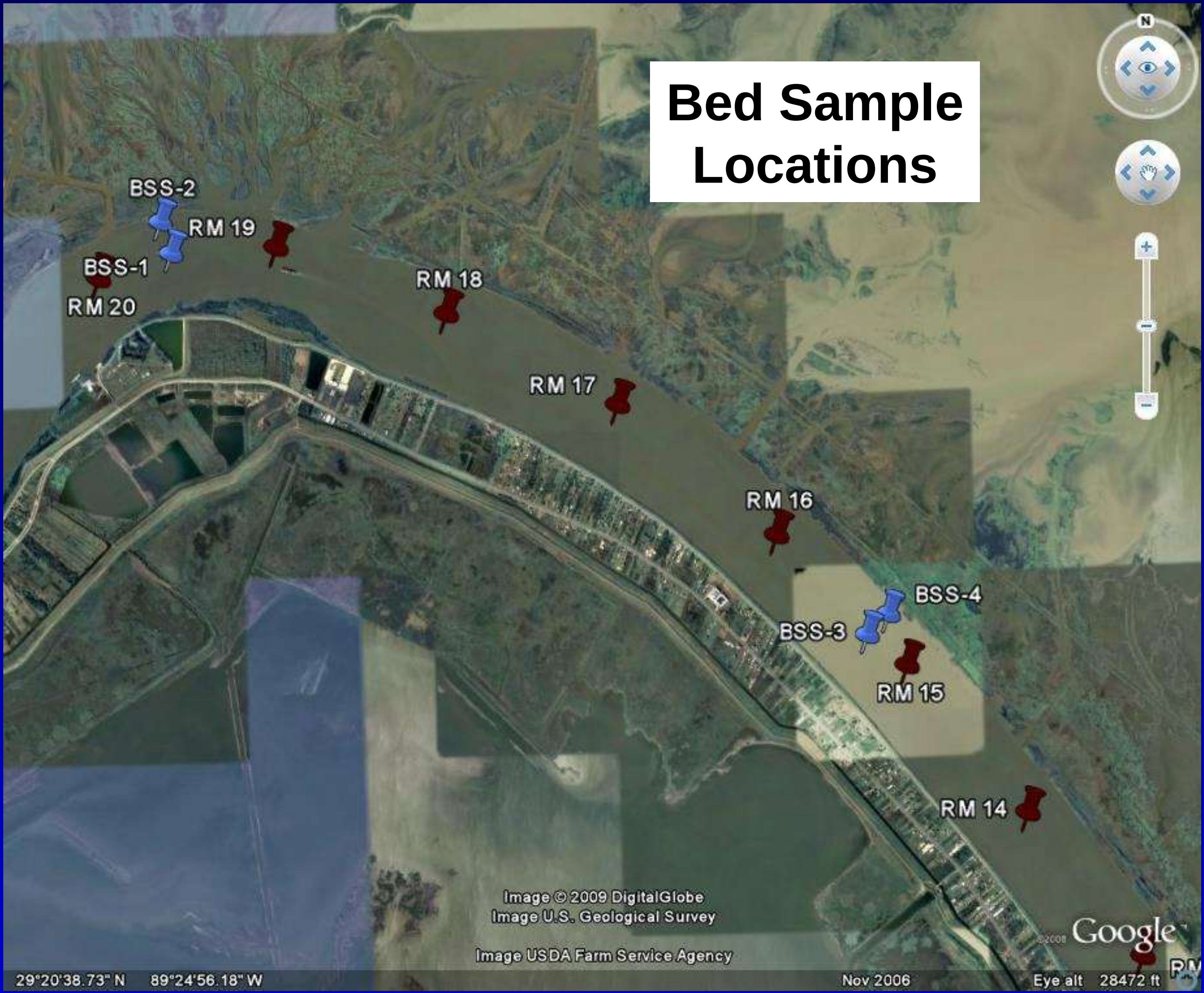
Bed Sample Locations



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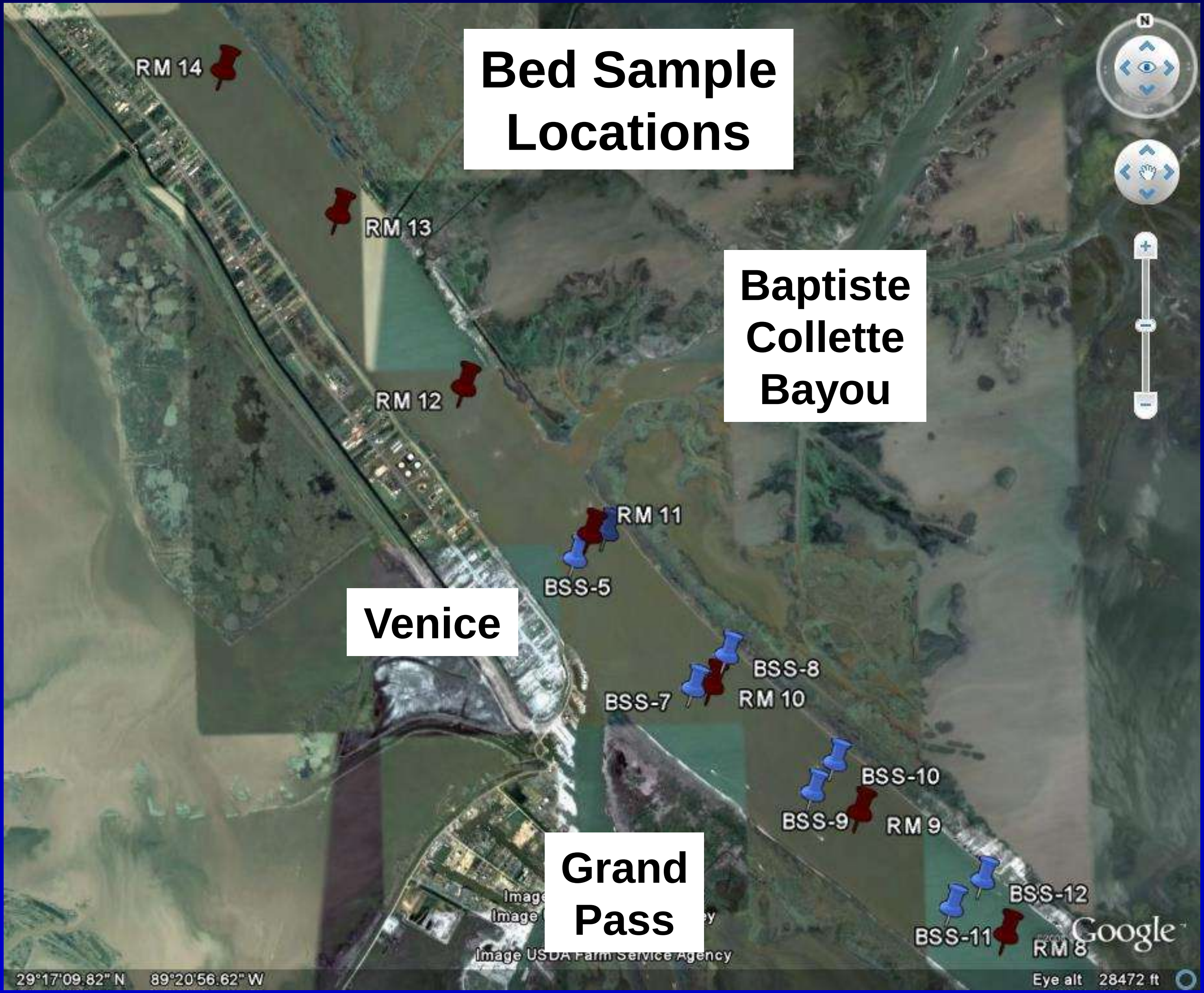

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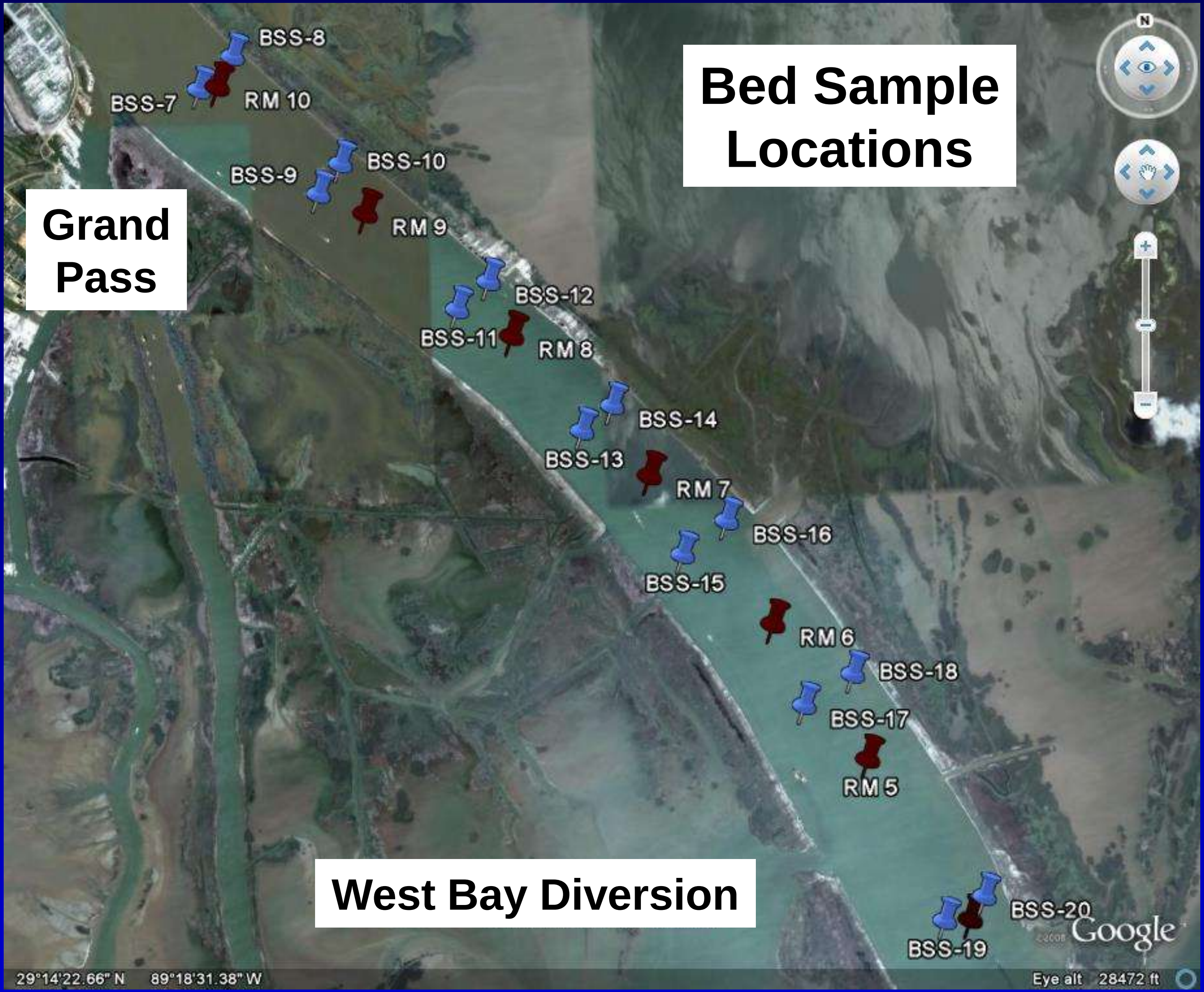
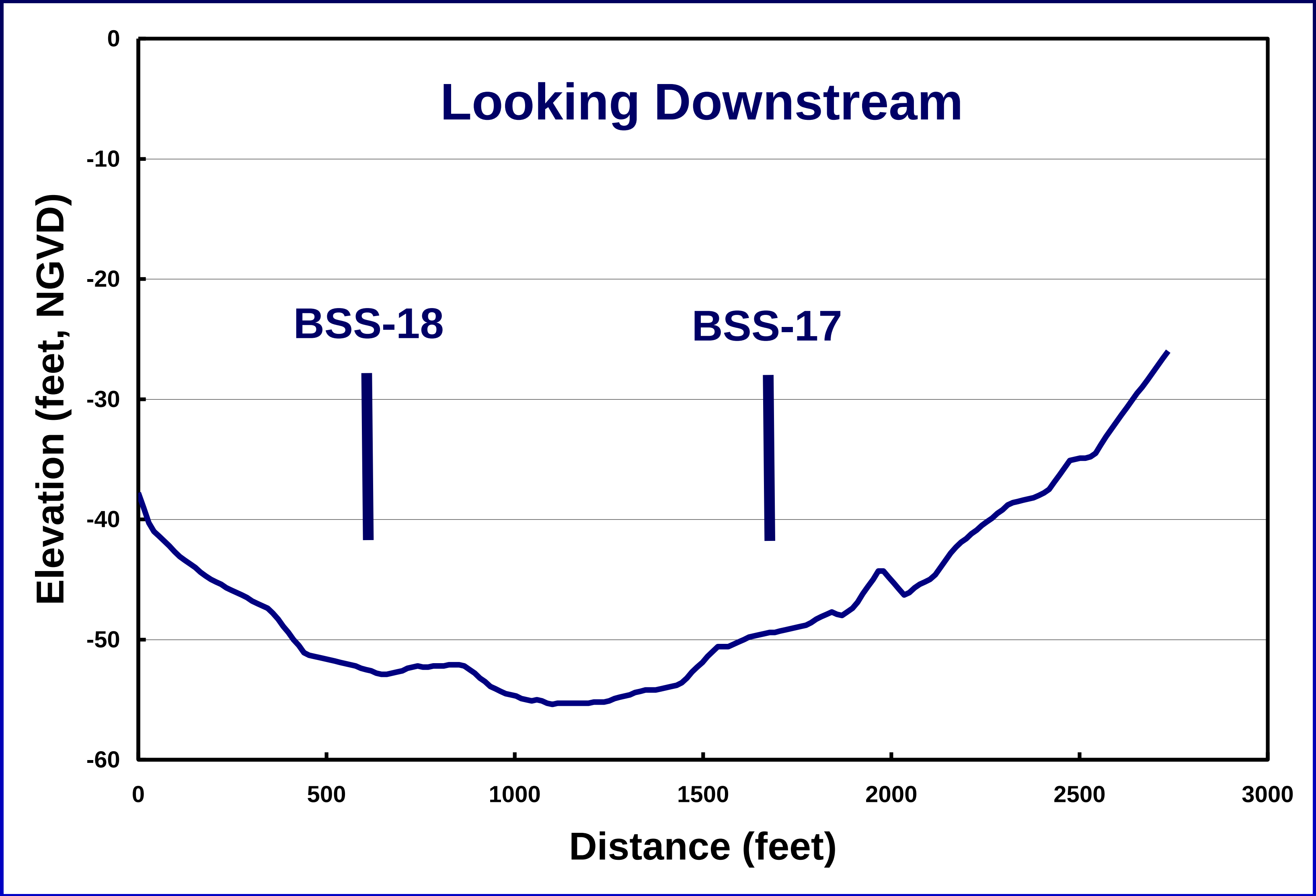

Bed Sample Locations
Grand Pass
West Bay Diversion
BSS-8
BSS-7
RM 10
BSS-10
BSS-9
RM 9
BSS-12
BSS-11
RM 8
BSS-14
BSS-13
RM 7
BSS-16
BSS-15
RM 6
BSS-18
BSS-17
RM 5
BSS-20
BSS-19
Google
29°14'22.66" N 89°18'31.38" W
Eye alt 28472 ft



River Mile 5.5 Bed Sample Locations

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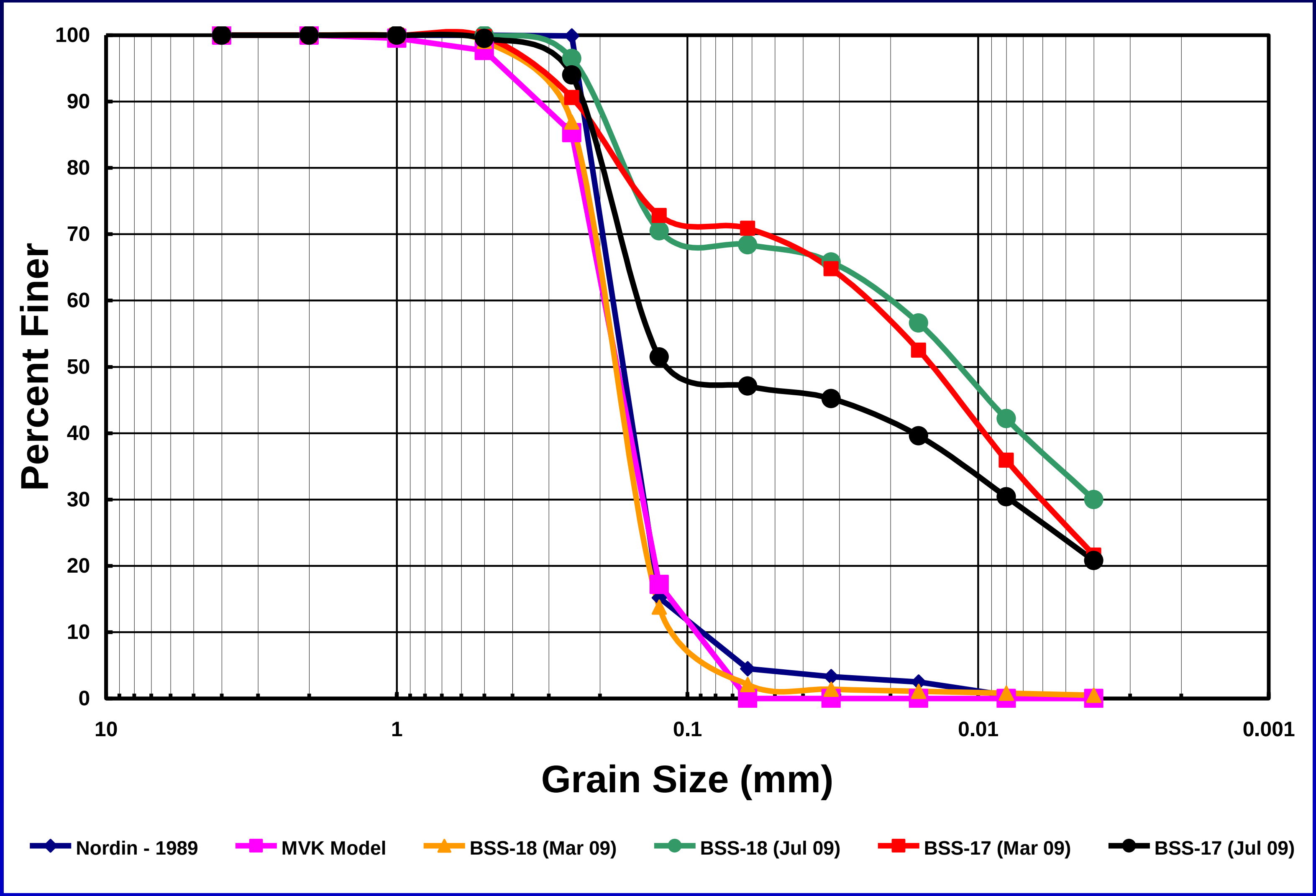

River Mile 5.5 Bed Material Gradations

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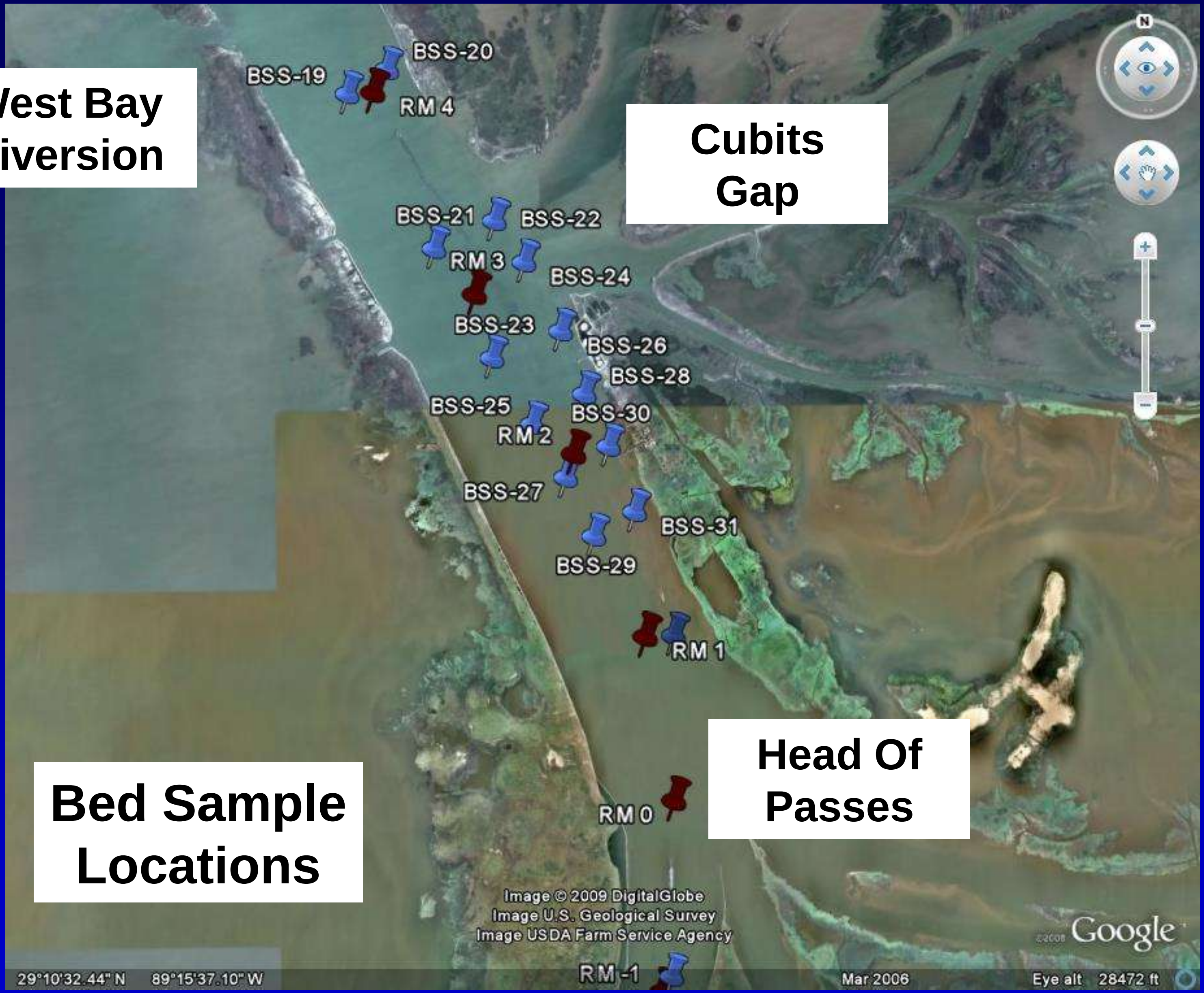
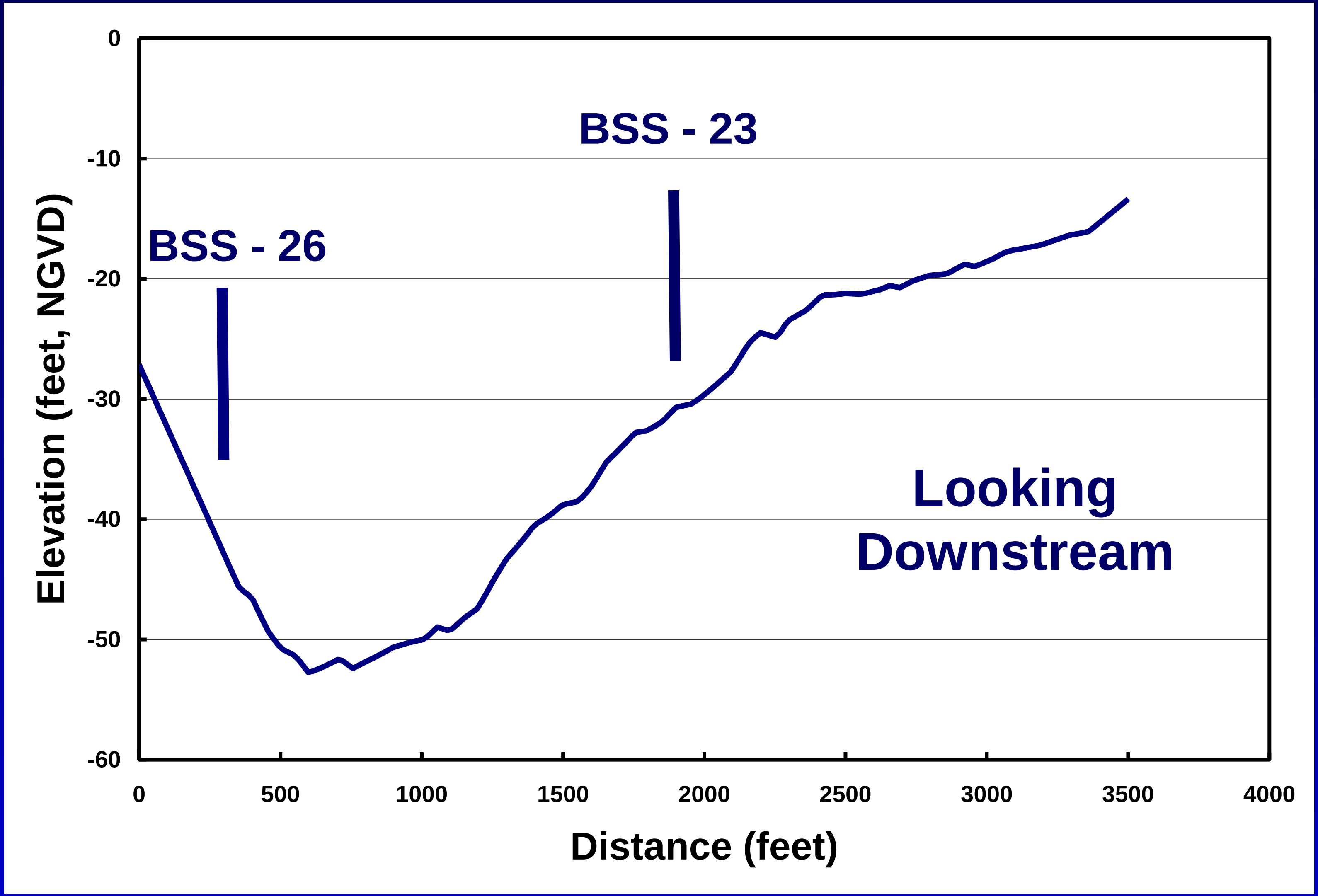


West Bay Diversion
Cubits Gap
Bed Sample Locations
Head Of Passes
BSS-19
BSS-20
RM 4
BSS-21
BSS-22
RM 3
BSS-24
BSS-23
BSS-26
BSS-28
BSS-25
BSS-30
RM 2
BSS-27
BSS-31
BSS-29
RM 1
RM 0
RM -1
Image © 2009 DigitalGlobe
Image U.S. Geological Survey
Image USDA Farm Service Agency
Google
29°10'32.44" N
89°15'37.10" W
Mar 2006
Eye alt 28472 ft



River Mile 2.5 Bed Sample Locations

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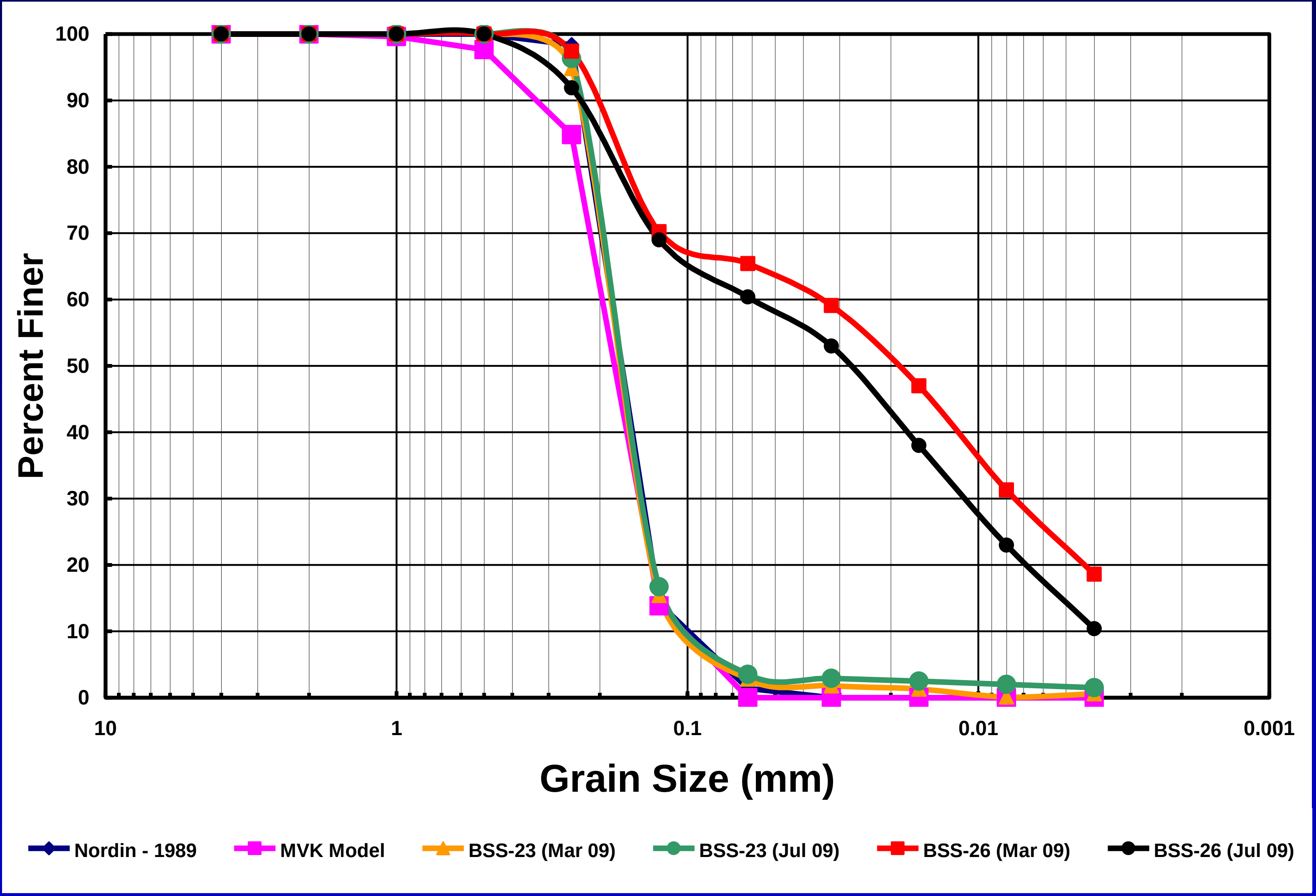

River Mile 2.8 – 2.46 Bed Material Gradations

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Actions Taken
Continued Development of Model Input Requirements

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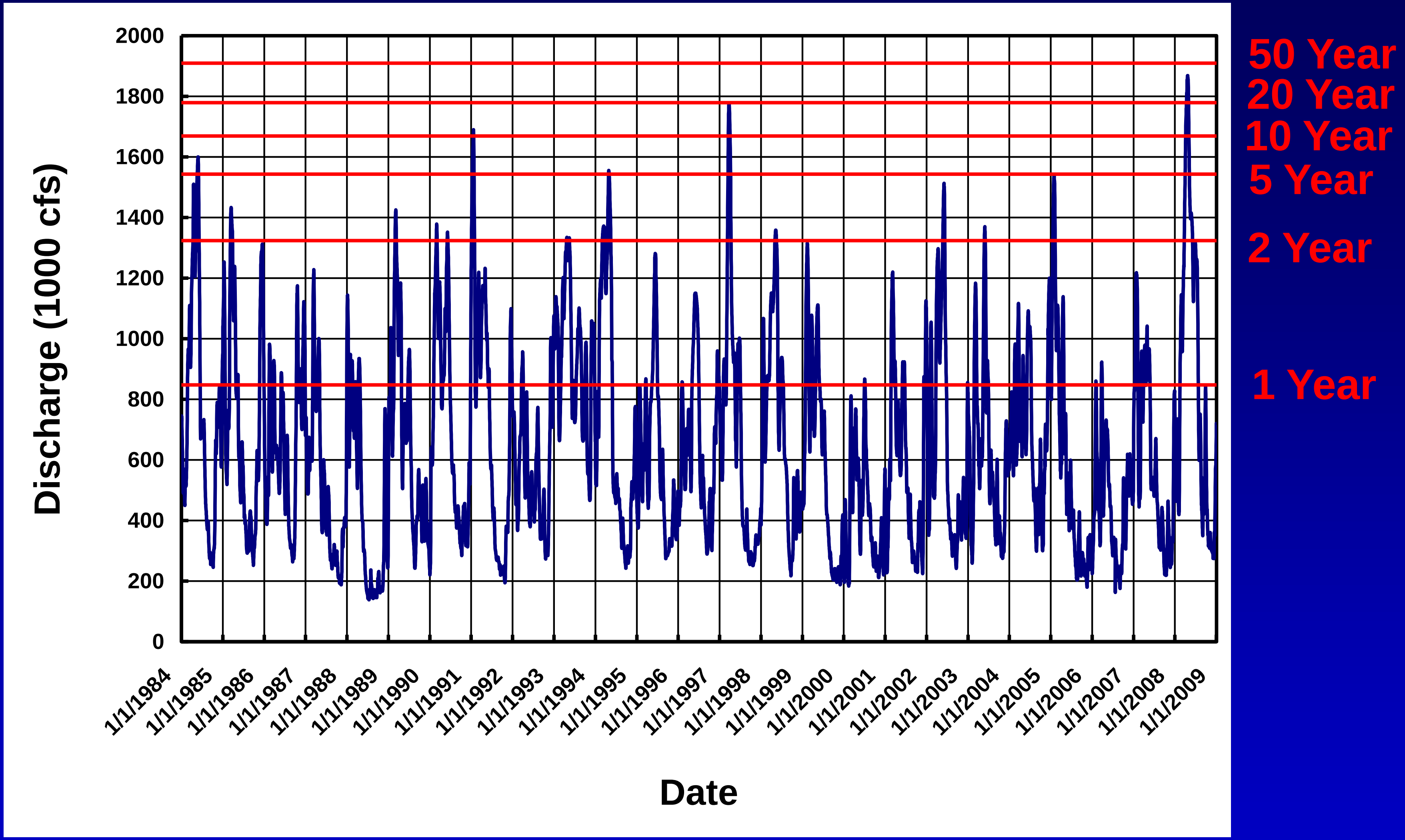
2. Develop Downstream Boundary Condition
   - Daily 8:00 AM Stage At Grand Isle, East Point Gage
     - Rectify Datum Issues

Actions Taken

3. Check Model Calibration As Input Parameters Are Revised

4. Develop Typical Discharge Hydrograph And Corresponding Downstream Boundary Conditions

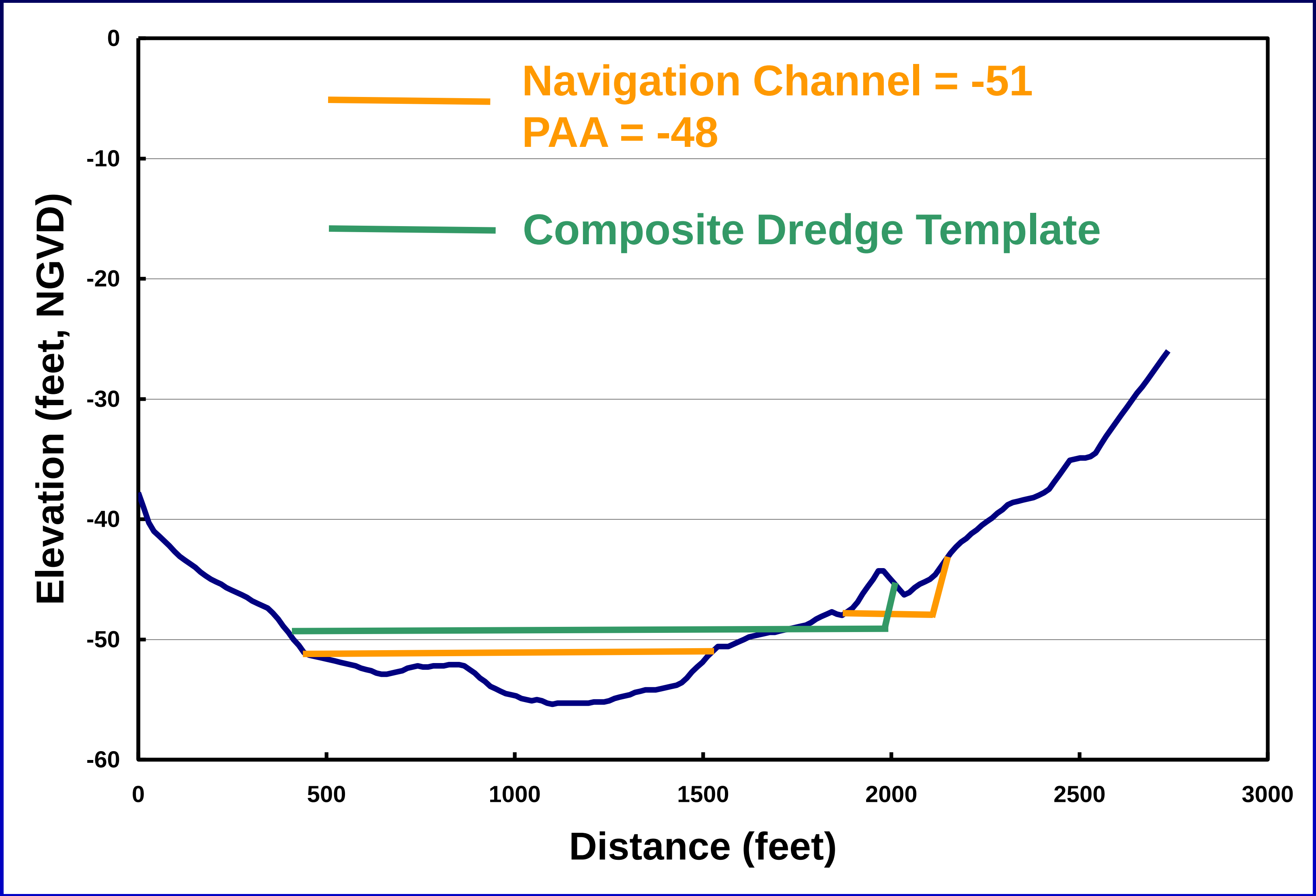
- Daily Discharge Hydrograph At Vicksburg, MS for 1984 – 2008 Period Of Record
- Daily 8:00 AM Stage At Grand Isle, East Point Gage For 1984 – 2008 Period Of Record



Typical Discharge Hydrograph
Vicksburg, MS 1984 - 2008

Next Steps

1. Final Model Calibration Check Once Model Input Has Been Finalized
2. Determine 50 Year Subsidence And Sea Level Rise Rates And Incorporate Into The Model
3. Make Without West Bay Diversion and With No Dredging 50 Year Simulation Run
4. Develop Appropriate Dredging Template
5. Make Without West Bay Diversion But With Dredging 50 Year Simulation Run



River Mile 5.5 Dredging Template

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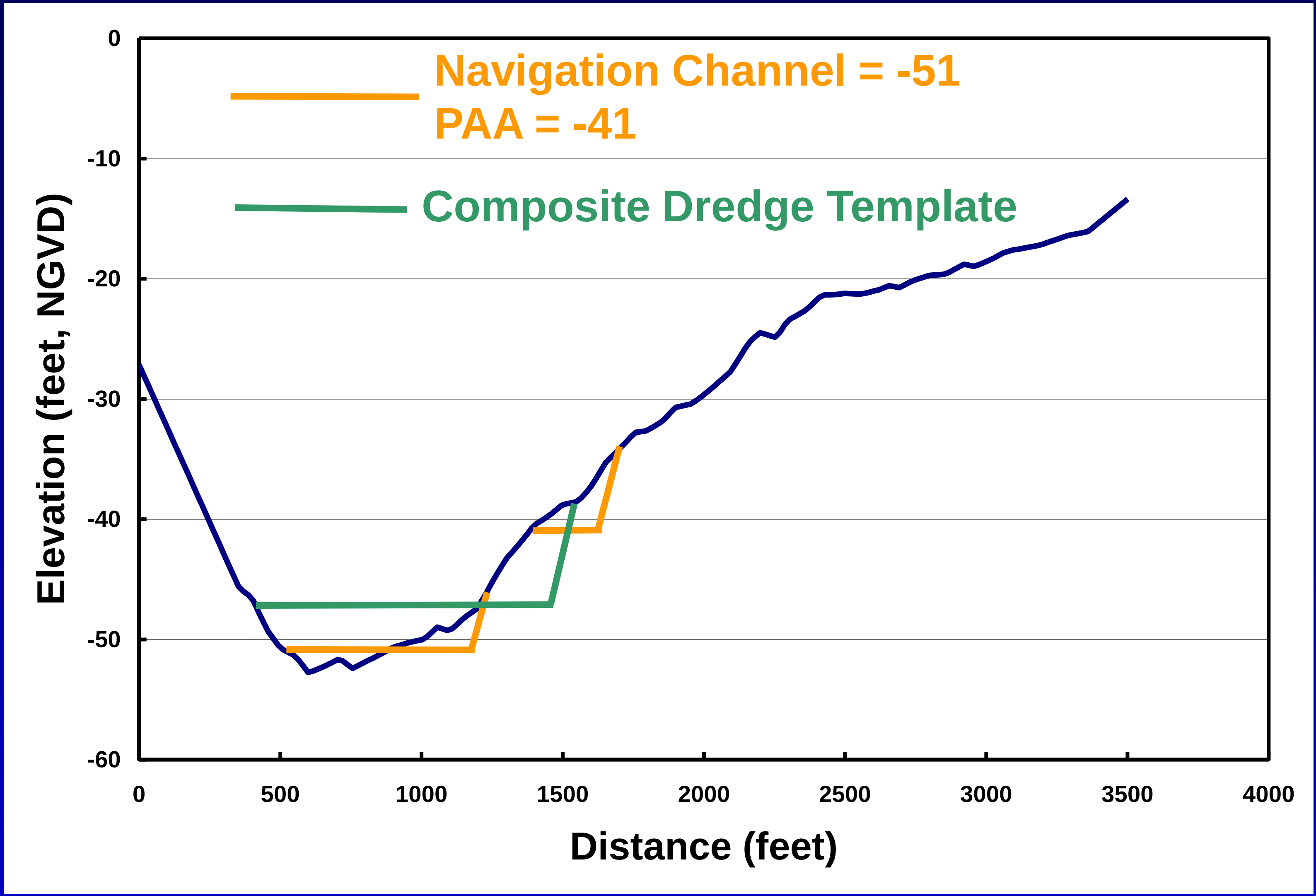

River Mile 2.5 Dredging Template

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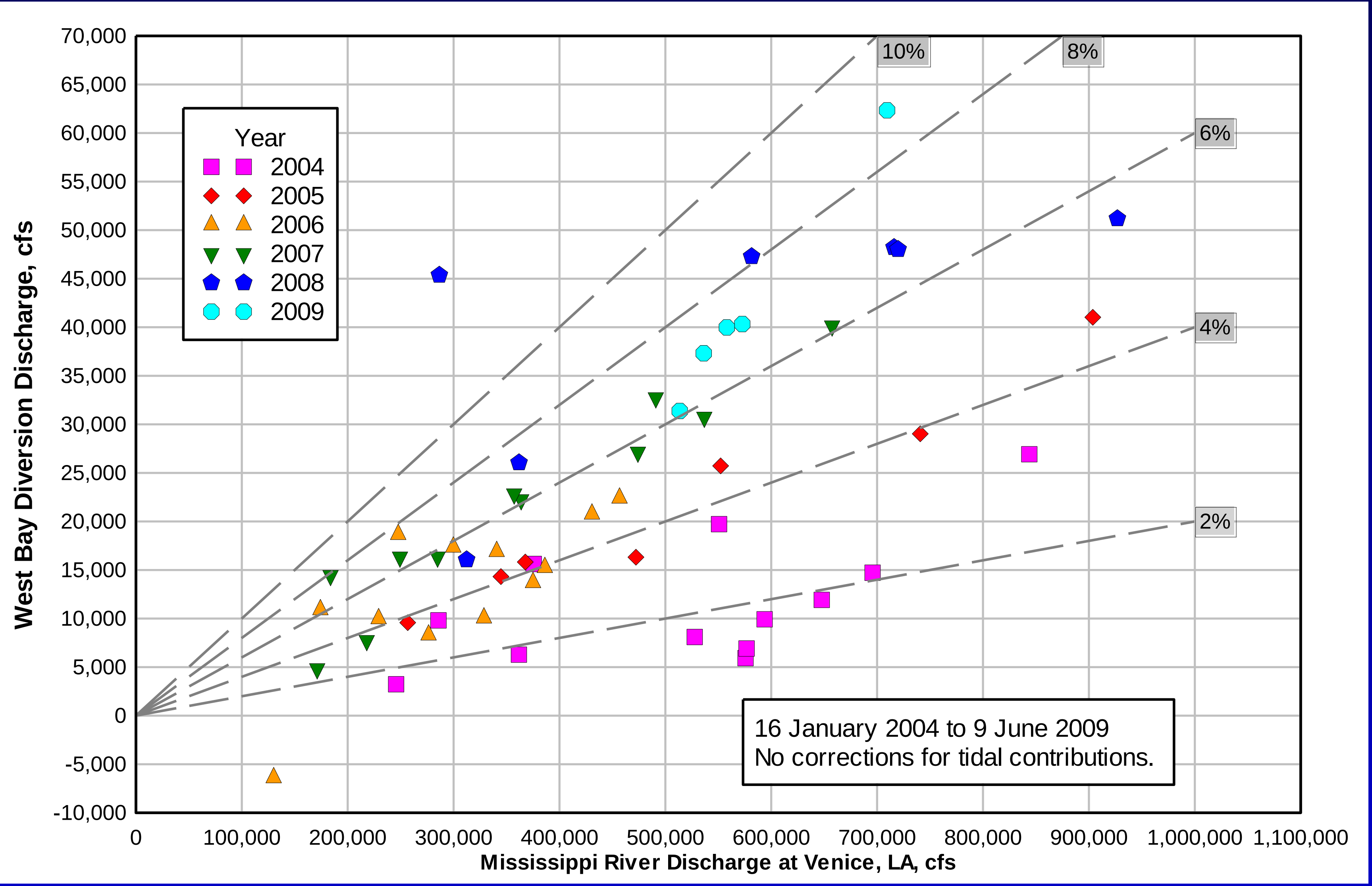
Next Steps

6. Insert West Bay Diversion Into the Model (Discharge And Sediment Concentration Diversion Ratios)
7. Make With West Bay Diversion And No Dredging 50 Year Simulation Run
8. Make With West Bay Diversion And With Dredging 50 Year Simulation Run
9. Compare Sediment Deposition Locations And Quantities And Dredging Locations And Quantities Through The Pilottown Anchorage Area Reach For The Four 50 Year Simulation Runs

Sensitivity Analyses
(12 Month Effort)

- Future Flows (Typical Hydrograph)
- Future Development of West Bay Diversion
- Different Transport Functions
- Impact of Different Diversions / Distributaries



Annual Flow Distribution At West Bay Diversion

West Bay Diversion Evaluation
1-Dimensional Modeling

West Bay Sediment Diversion Work Plan
Task 1 : Data Collection and Analysis

October 20th 2009

Thad Pratt CEERD-HF-FM

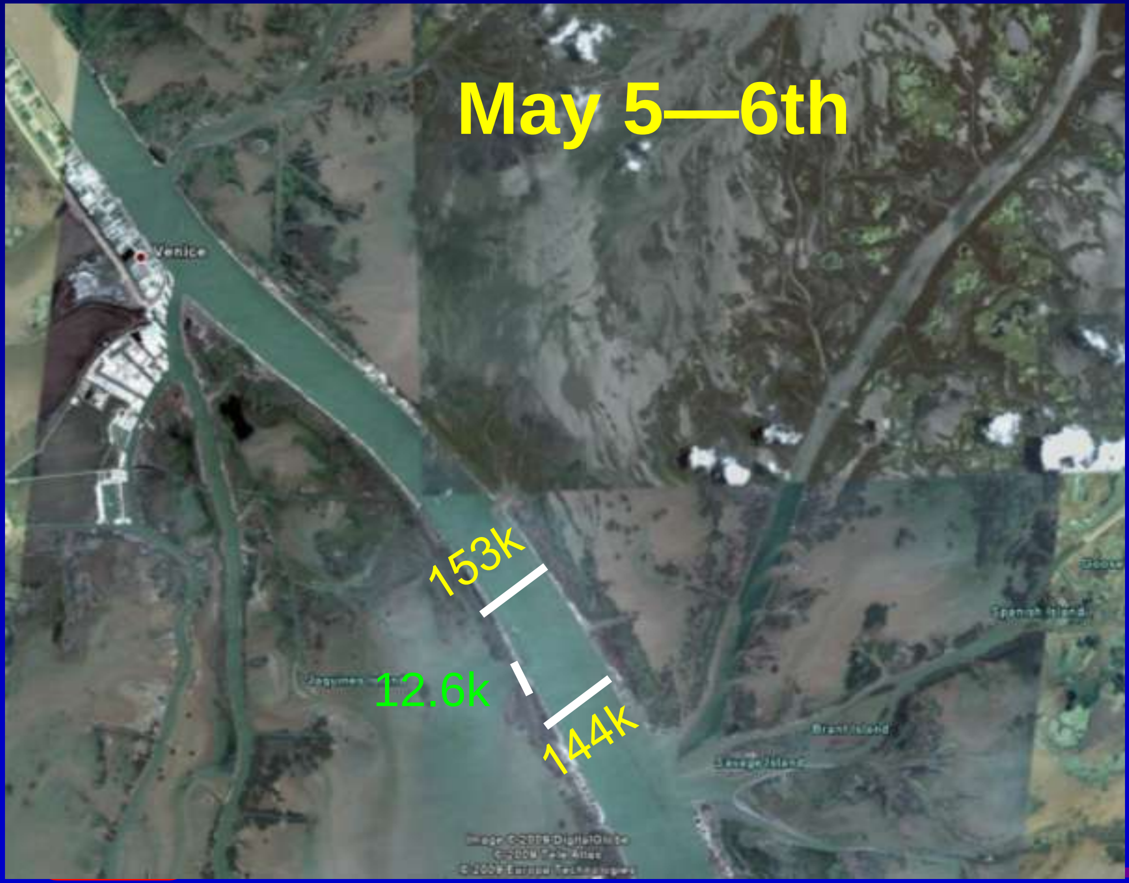
Data Collection Trips

- Data collection Trip 1, March 9-12, 22-23 April, 5-6 May, 2009: Multi-beam and hydrodynamic (ADCP) surveys, bed samples and suspended sediment samples.
- Data collection Trip 2, 27-31 May, 2009: Hydrodynamic surveys, suspended sediment samples and additional bed material samples from below Cubit's Gap to Southwest Pass Jetties.
- Data collection Trip 3, June 15-18, 2009: Hydrodynamic surveys and suspended sediment samples.
- Data collection Trip 4, July 21-23, 2009: Hydrodynamic surveys, suspended sediment samples, and bed load samples.
- Additional Multi-beam survey, August 2009
- Data Collection Trip 5, September 23-24, 2009: Hydrodynamic surveys, suspended sediment samples and bed material samples.

Q and Sediment Flux for Venice to below Cubit's Gap

Line	Total Q (ft^3/s)	Sed Flux (Tons/Day)	M2
R-2.6	444,000	108 K	133 K
R-2.8-RB	3,600	0.47 K	.8 K
R-3.5-RB	2,300	0.4 K	.4K
R-5.2	518,000	128 K	140K
R-6.5-LB	4,700	0.4 K	.7K
R-6.4-RB	1,700	0.2 K	.4K
R-12.1	685,600	170 K	191K
WBD	51,500	24 K	25k
GP	81,000	27 K	50 k
BCB	74,000	18 K	22 k

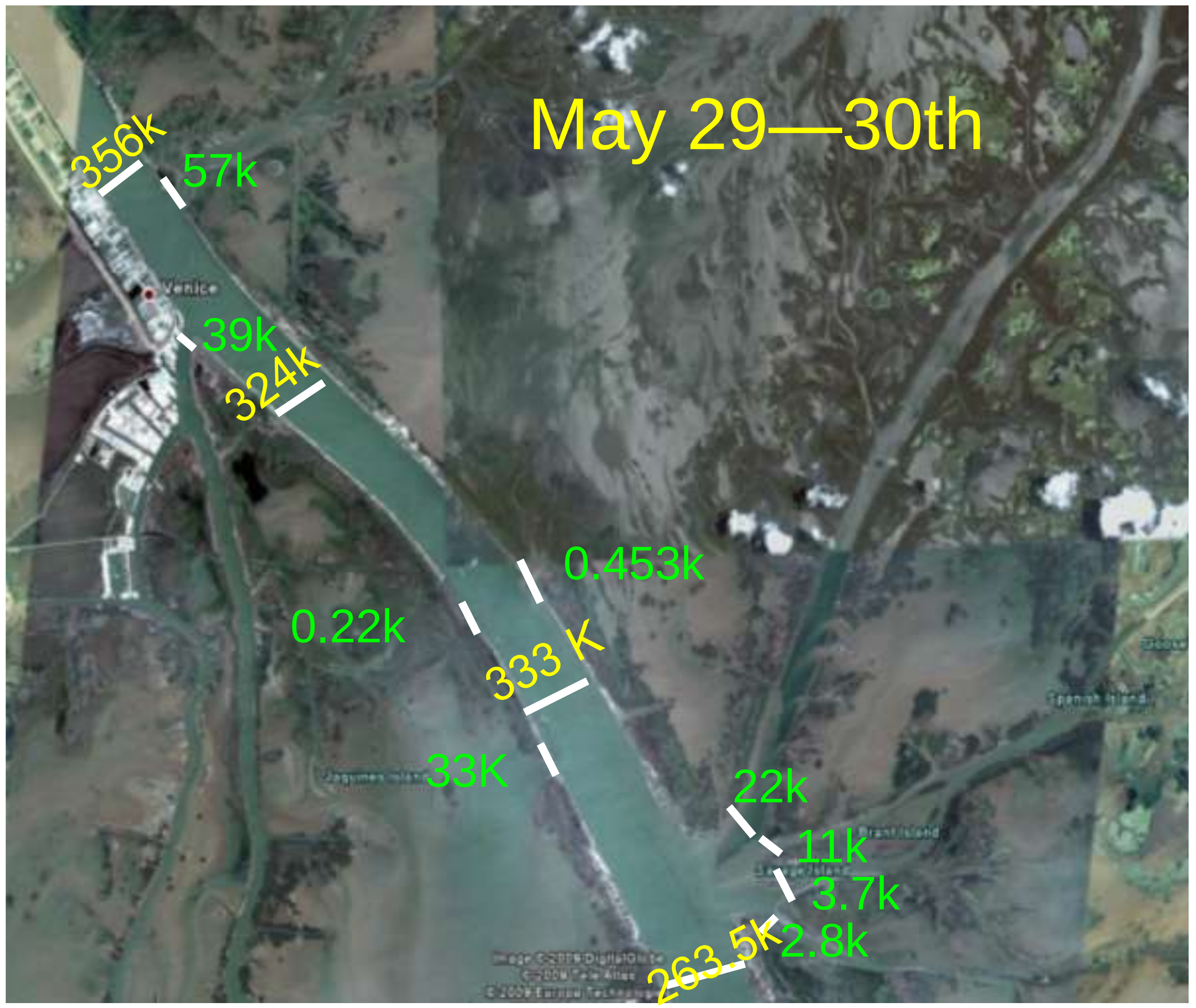
Q and Sediment Flux Around the Diversion Cut



Line	Total Q (ft³/s)	Sed Flux (Tons/Day)	M2
R-5.2	504,000*	153.0 K	162.0 K
WBD	42,000*	12.6 K	13.1 K
R-4.5	454,000*	144.0 K	148.0 K

* Multiple Transects Averaged

Q and Sediment Flux form Venice to below Cubit's Gap

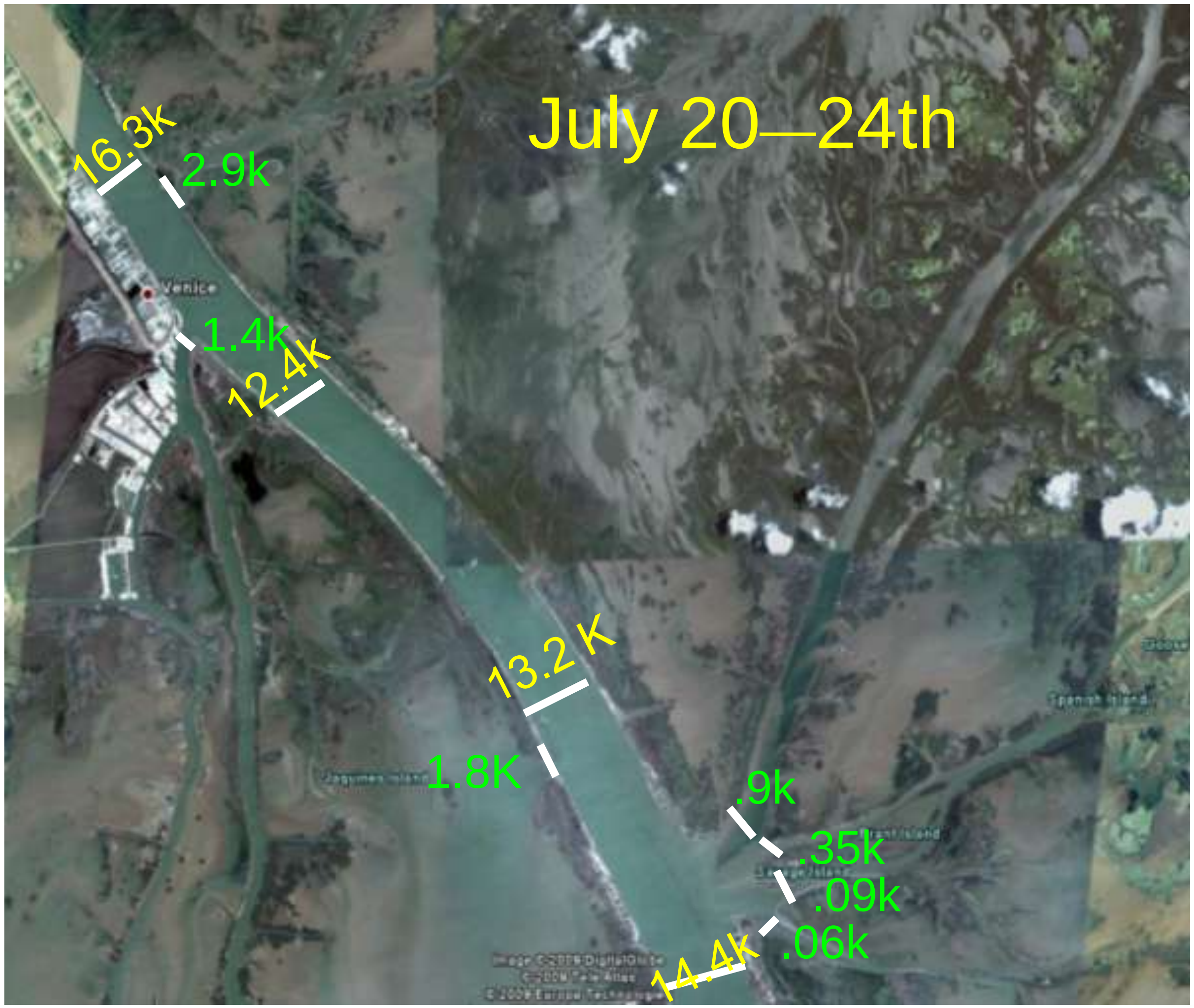


Line	Total Q (ft^3/s)	Sed Flux (Tons/Day)	M2
R-2.6	563,100	263.5K	276K
R-2.8-RB	1,375	.157K	.1K
R-3.5-RB	2,300	.09K	.1K
R-4.5	675,500	325K	333 K
R-5.2	794,400	333.5K	355 K
R-6.5-LB	7,000	0.453K	.5 K
R-6.4-RB	2,400	0.22K	.3 K
R-9.5	795,000	324K	337 K
R12.1	1,003,813	356K	428 K
CGRP	11,000	2.8K	3.8 K
CGBB	33,200	11K	14.8 K
CGOP	17,500	3.7K	4.0 K
CGMP	72,000	22K	28 K
WBD	721,000	33K	34 K
GP	104,600	39K	44K
BCB	114,000	57K	50 K

Q and Sediment Flux form Venice to below Cubit's Gap

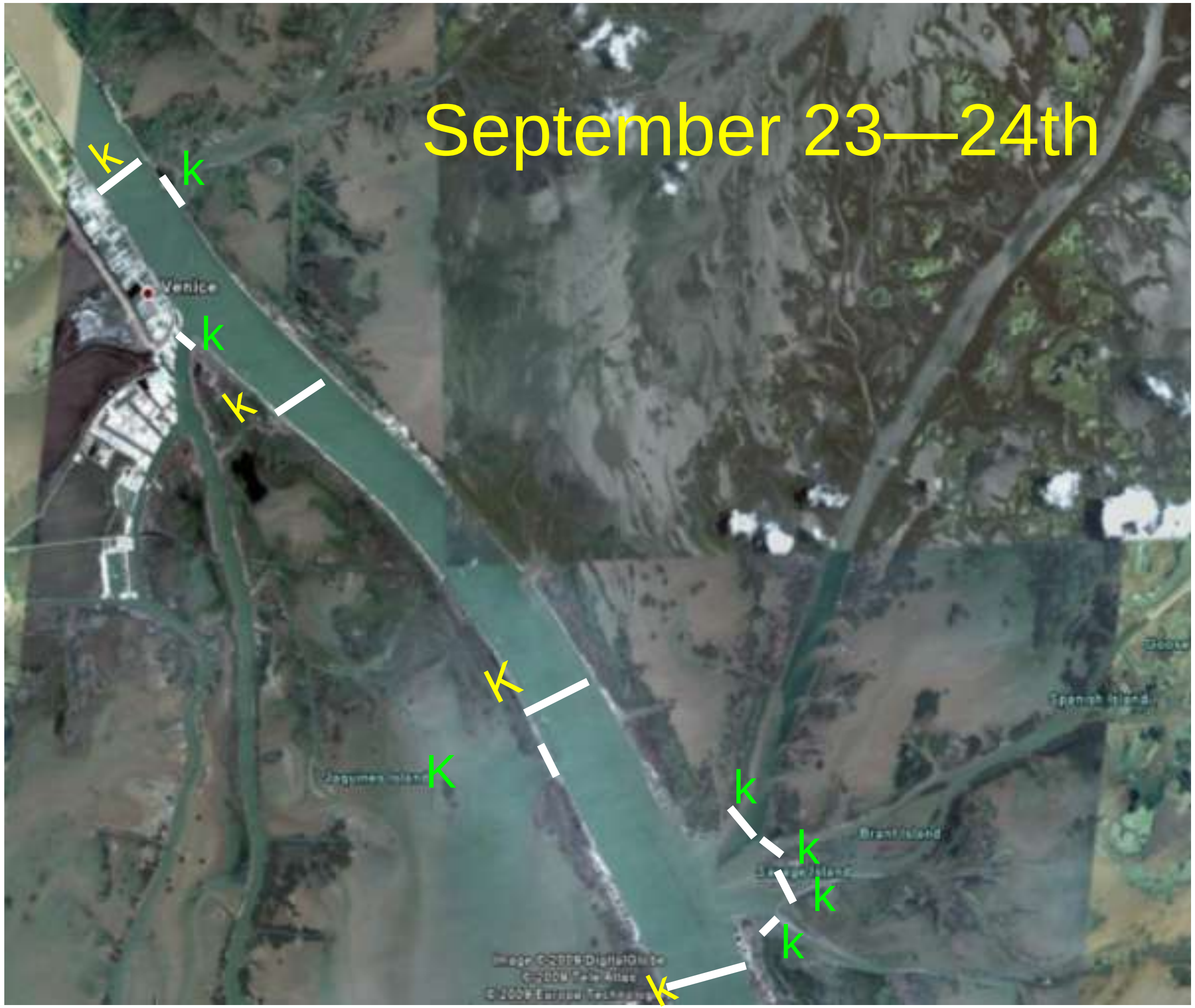
Line	Total Q (ft^3/s)	Sed Flux (Tons/Day)	M2
R-2.6	385,500	104 K	101 K
R-5.2	568,000	145.9K	171 K
R-6.5-LB	4,300	0.115 K	.175 K
R-6.4-RB	600	0.003 K	0 K
R-12.1	698,500	191 K	200.0 K
CGRP	7,300	0.79 K	1.1 K
CGBB	21,000	2.4 K	3.4 K
CGOP	9,000	0.9 K	1.1 K
CGMP	50,000	5.7 K	8.6 K
WBD	51,500	14.3 K	16.0 K
GP	74,300	11.9 K	15.7 K
BCB	72,100	23.4 K	18.0 K

Q and Sediment Flux form Venice to below Cubit's Gap



Line	Total Q (ft^3/s)	Sed Flux (Tons/Day)	M2
R-2.6	269,000	14.4 K	14.3 K
R-4.5	222,000	10.6 K	9.4 K
R-5.2	245,000	13.2 K	13.4 K
R-9.5	195,000	12.4 K	11.5 K
R12.1	238,000	16.3 K	14.2 K
CGRP	2,600	.09 K	.1 K
CGBB	5,600	.35 K	.37 K
CGOP	2,400	.06 K	.07 K
CGMP	24,000	.9 K	1.0 K
WBD	28,000	1.8 K	1.5 K
GP	29,000	1.4 K	1.7K
BCB	51,000	2.9 K	7.9 K

Q and Sediment Flux form Venice to below Cubit's Gap

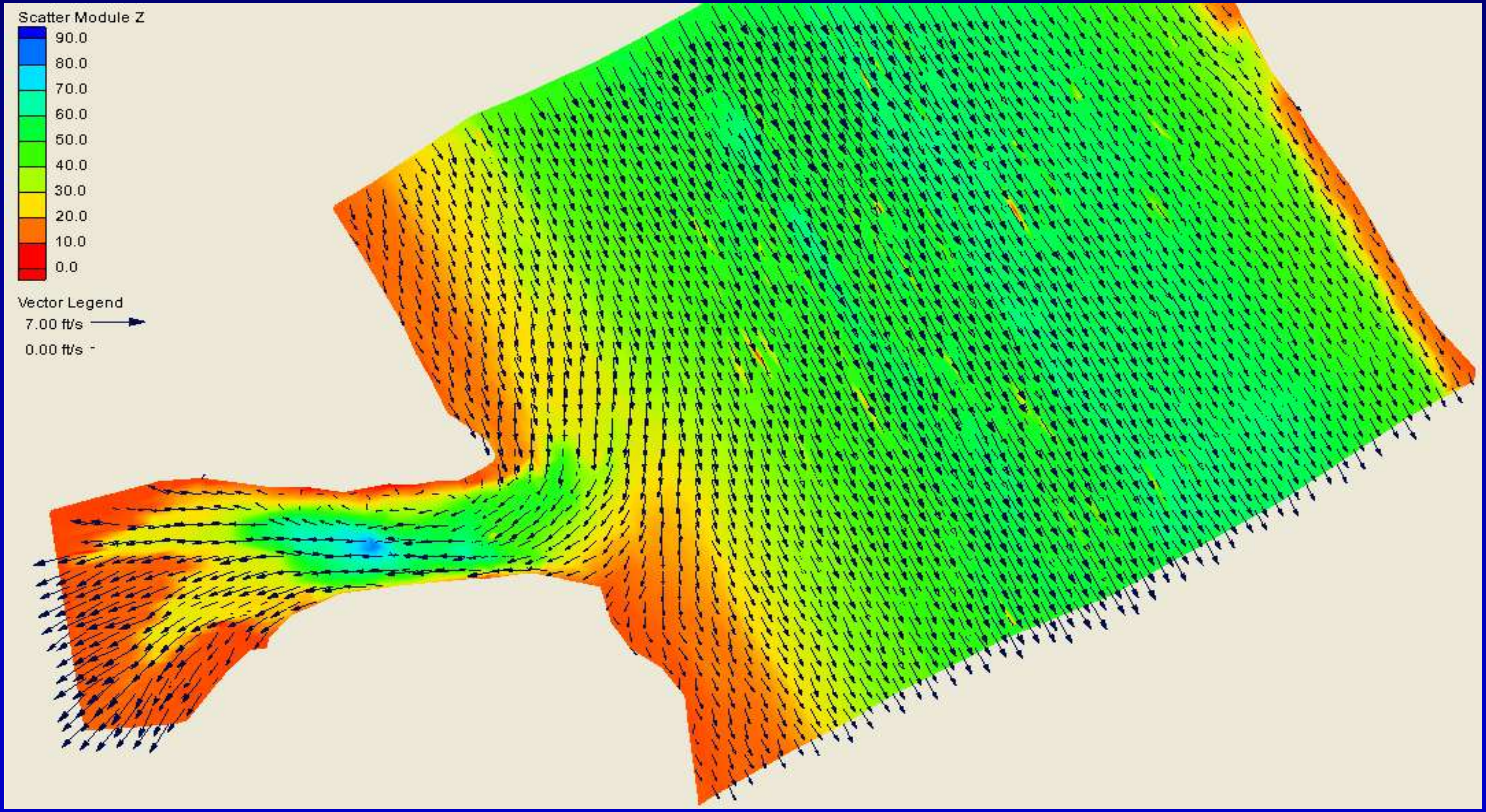


Line	Total Q (ft^3/s)	Sed Flux (Tons/Day)	M2
R-2.6	168,000		
R-4.5	201,000		
R-5.2	229,000		
R-9.5	254,000		
R12.1	330,000		
CGRP	3,200		
CGBB	7,900		
CGOP	1,000		
CGMP	16,000		
WBD	25,000		
GP	49,000		
BCB	19,000		

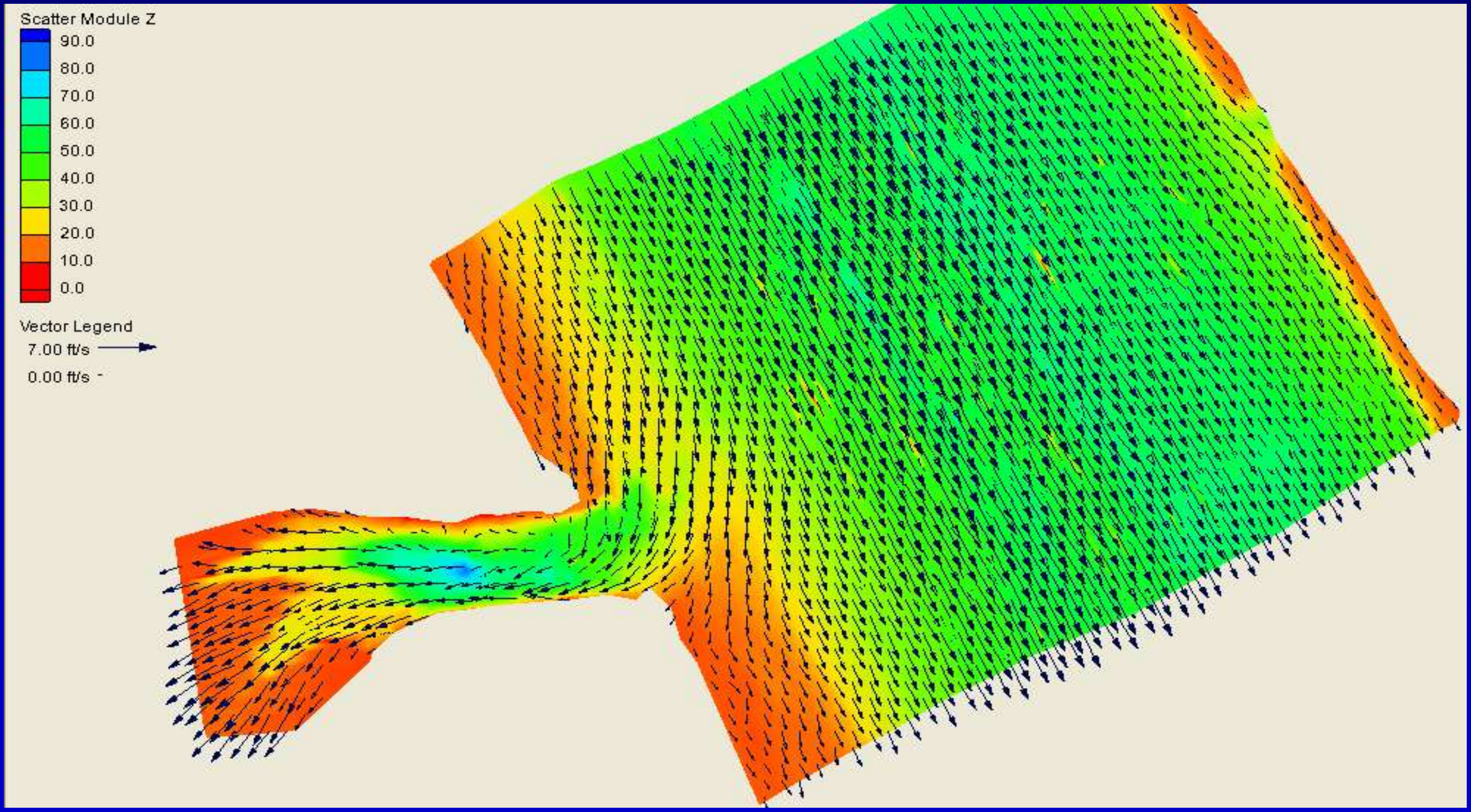
Size Classification for TSM Samples/ Depth

WBDMR-A											
Depth (ft)	% Sand	%Silt	%Clay	% very fine silt	% fine silt	%med silt	%coarse silt	%very fine sand	% fine sand	%med sand	%coarse sand
1	2.289825	71.905	25.79425	18.75	22.335	18.28	12.54	2.2885	0.001325	0	0
7.5	13.13675	65.0125	21.85775	16.16	19.38	16.25	13.2225	9.756	3.294	0.08675	0
15	16.54952	62.685	20.76175	15.635	18.7675	15.4475	12.835	11.3425	5.07725	0.129771	0
22.5	29.57163	52.101	18.32263	13.0825	15.455	12.88375	10.67975	10.446	5.605	2.7235	10.79713
30	14.89658	63.7725	21.31225	15.83	19.095	15.43	13.4175	12.855	2.041575	0	0

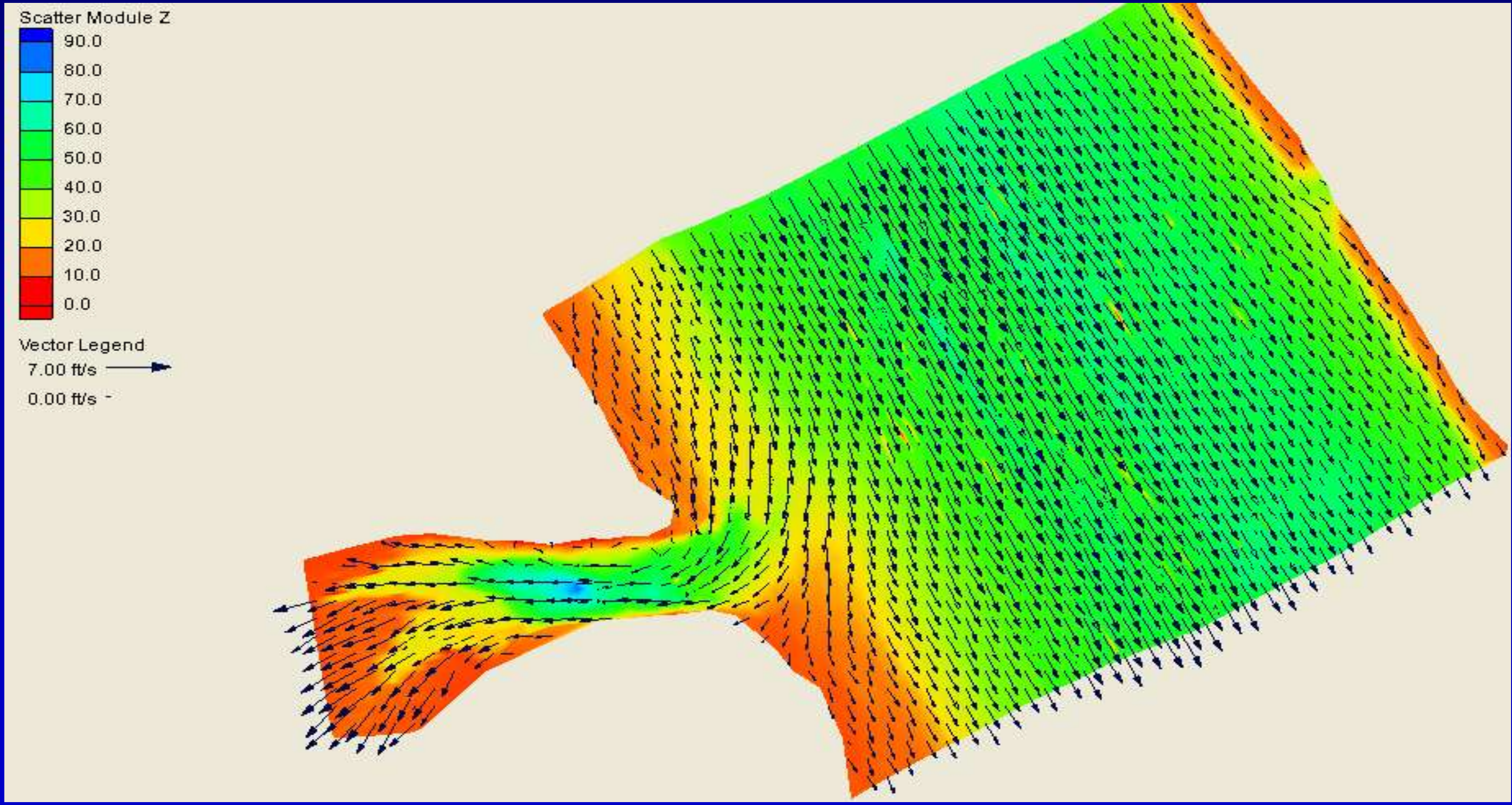
West Bay Diversion Depth Averaged Velocities April 2009



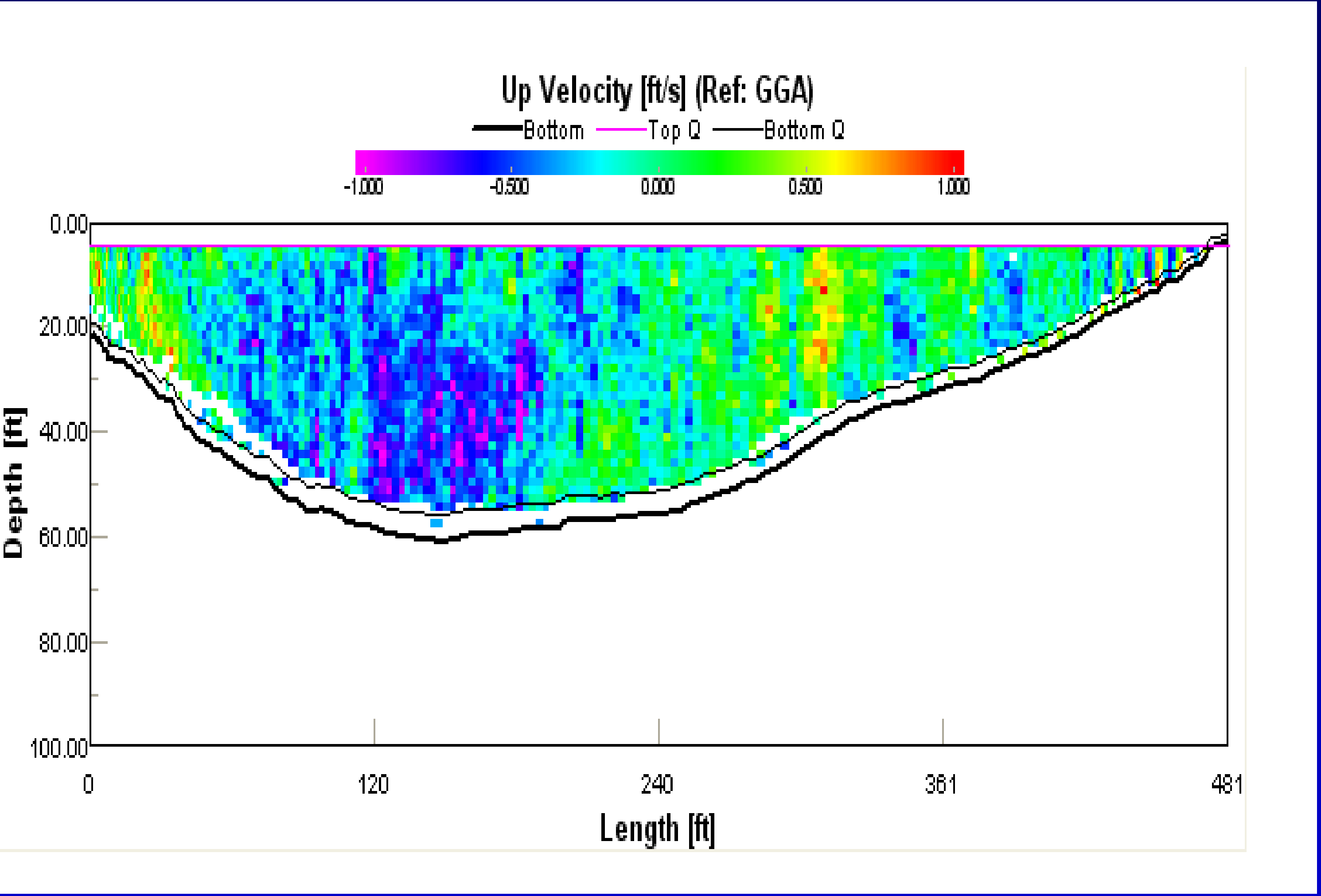
West Bay Diversion Surface Velocity April 2009



West Bay Diversion Bottom Velocity April 2009



Vertical Velocity Distribution within West Bay Diversion



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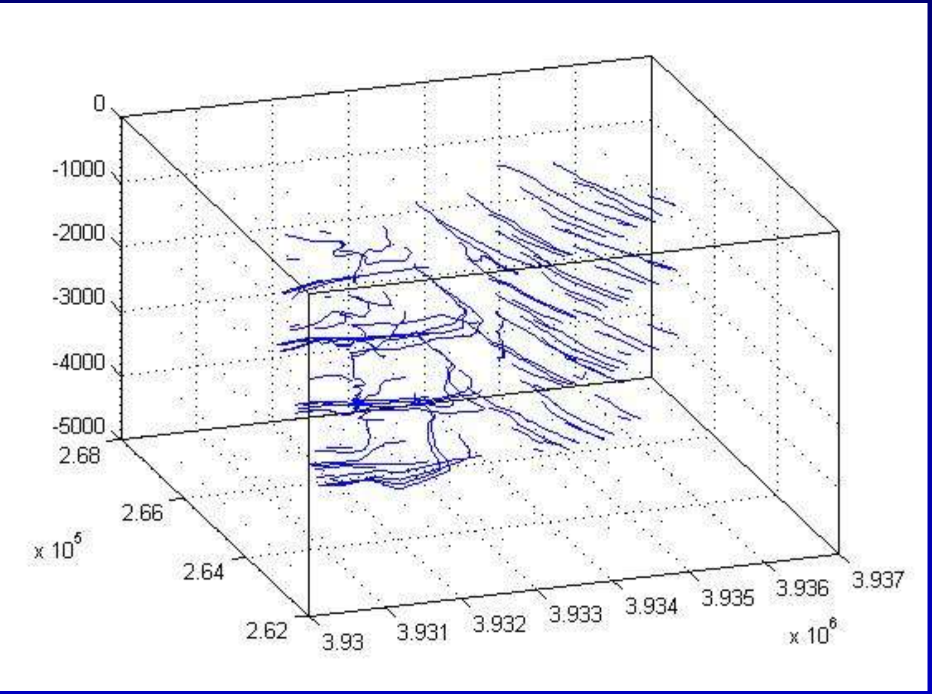
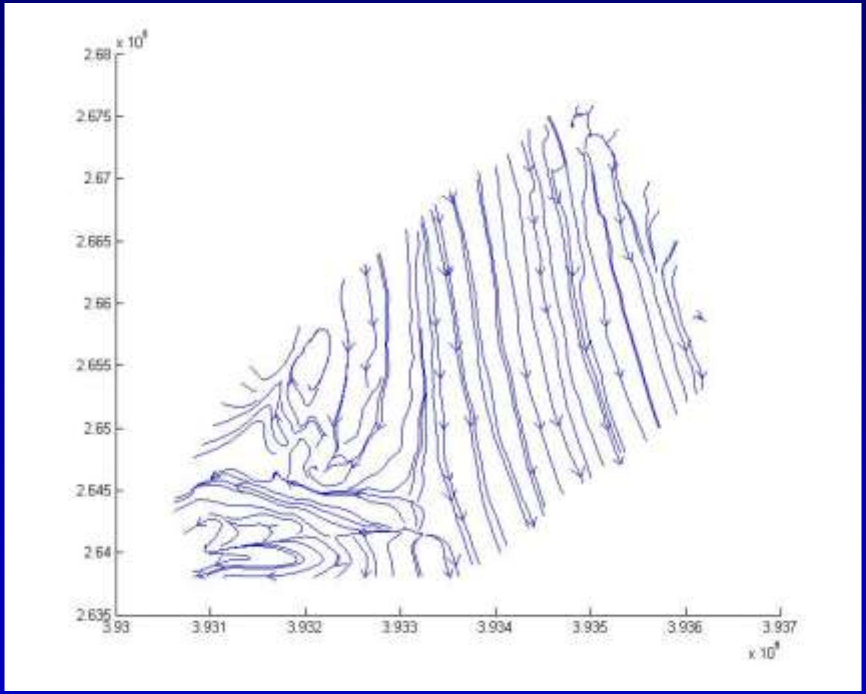
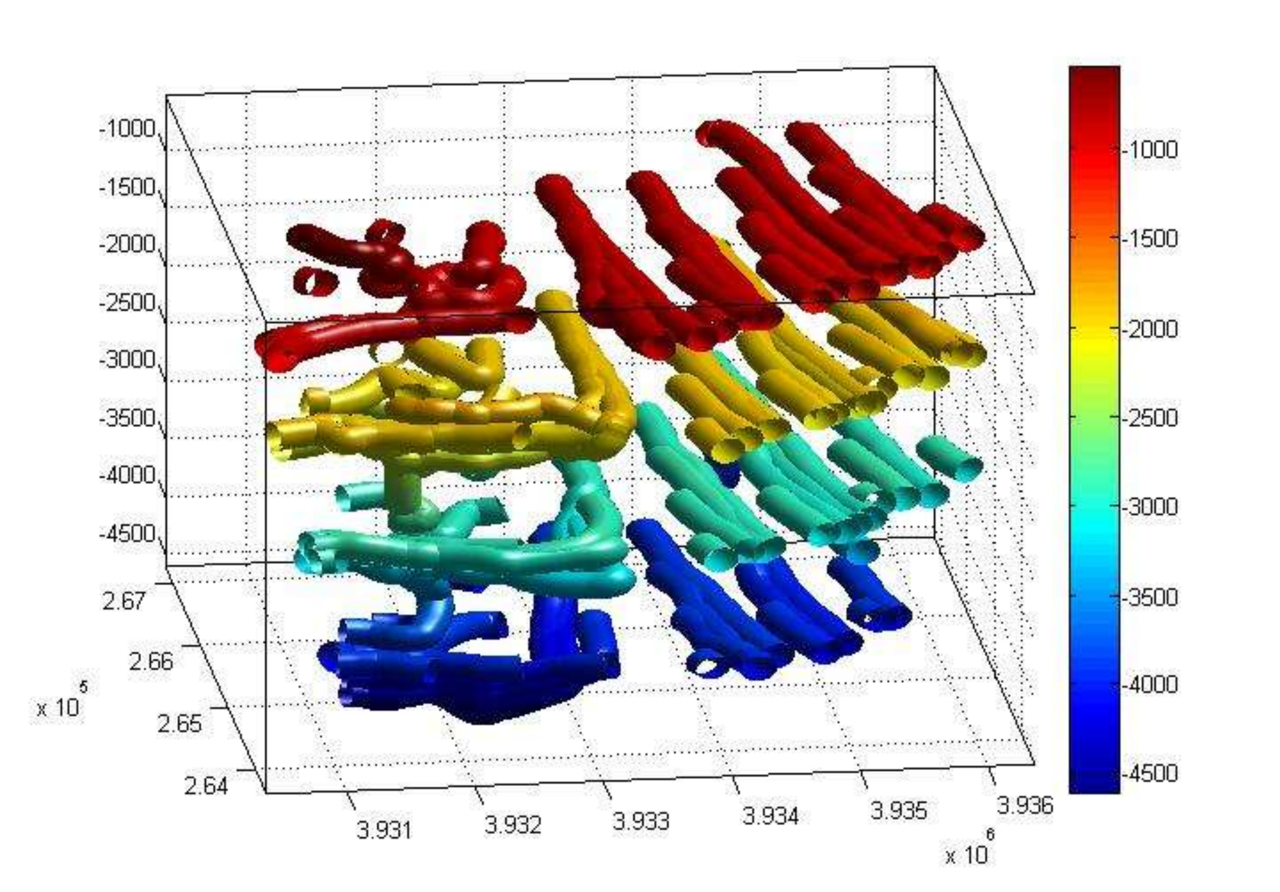
3D Particle Tracking





3D Particle Tracking



Observations

- ~45% Total Discharge is lost to the multiple cuts from Venice to below Cubit's Gap
- Bed material grain size in anchorage range from 0-800 microns
- Suspended sediment concentrations range from 50-350 mg/l in the vertical
- Grain size in suspended sediments range from 0-100 microns w/ mean size at surface 8-9 microns and w/ mean grain size 1 foot above bed ~15 microns

Sensitivity and Uncertainty

Sources of Uncertainty

There are multiple sources of uncertainty associated with the present effort

- Uncertainty in the simplifying assumptions used in the analysis (e.g. hydrostatic assumption, focus on high and median flows, etc.)
- Uncertainty in the physical process descriptions (i.e. entrainment rate, bedload flux, etc.)
- Uncertainty in the accuracy of the observations (both for model validation and for boundary condition specification)
- Uncertainty in the reliability of the observations (where historical data is not available for comparison to recent observations)
- Uncertainty in the future conditions (i.e. stochastic description of boundary conditions, trends such as relative sea level rise, etc.)

Sensitivity Analysis

- Identify the potential impact of various uncertainties, i.e., specific model inputs and assumptions, on the model outputs being used for decision making.
- Where sufficient data is available to quantify the uncertainty in a significant model input, a formal uncertainty analysis can quantify the impact.
- Where sufficient data is not available, estimates based on professional judgment can provide a qualitative assessment of the uncertainty.

Addressing Uncertainty

Uncertainty can be formally addressed in many ways, but each method will exhibit a similar set of basic tests

- Uncertainty in the simplifying assumptions can be addressed though analytical and/or numerical quantification of the relative impacts of these assumptions
- Uncertainty in the physical process descriptions can be addressed though analytical and/or numerical investigation of the use of alternative process descriptions
- Uncertainty in the accuracy of the observations can be addressed though numerical sensitivity analysis, with perturbations derived from known statistical properties of boundary conditions and/or statistical analyses of observation (provided sufficient observations are available)
- Uncertainty in the future conditions can be addressed through multiple realizations of results associated with stochastic descriptions of boundary condition variability and trends.

Addressing Uncertainty

For this study we propose to address uncertainty formally on the 12 month effort only. In the 6 month effort, we will include some discussion of qualitative aspects of model sensitivity.

- Uncertainty in the simplifying assumptions (12 month effort)
- Uncertainty in the physical process descriptions (12 month effort)
- Uncertainty in the accuracy of the observations (12 month effort)
- Uncertainty in the future conditions (12 month effort – limited sensitivity analysis in 1D model)

Addressing Uncertainty

Note that it is important to constrain discussions of uncertainty to matters that are relevant to the specific problem being addressed.

So, for example, uncertainty in future conditions is not relevant to the question of how much Anchorage are shoaling has been induced by West Bay TO DATE.

Patterns of Sediment Deposition in the West Bay Receiving Basin

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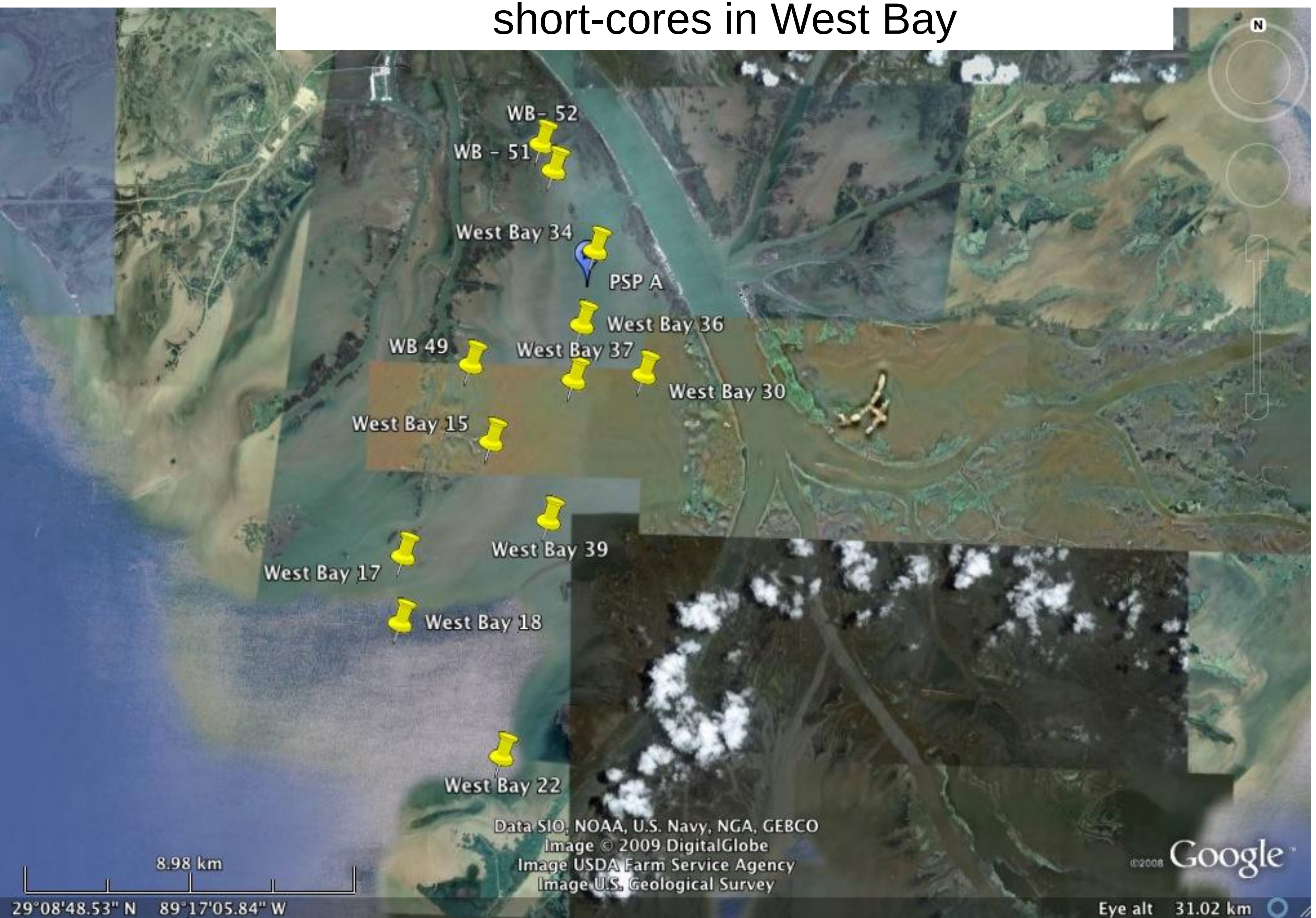
Technical Questions

- What what was the spatial arrangement of recently deposited in September, 2009?
- How does this recent history of sediment deposition compare with longer term (decadal and centenial) patterns of sediment deposition?

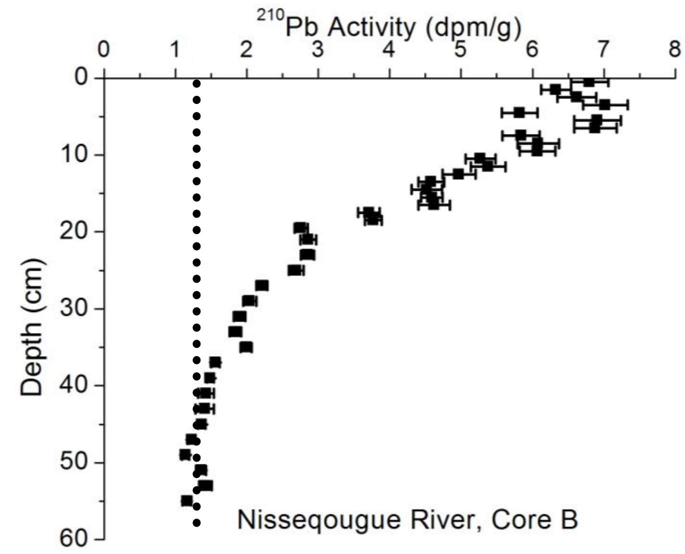
We collected eight long cores and additional short-cores in West Bay

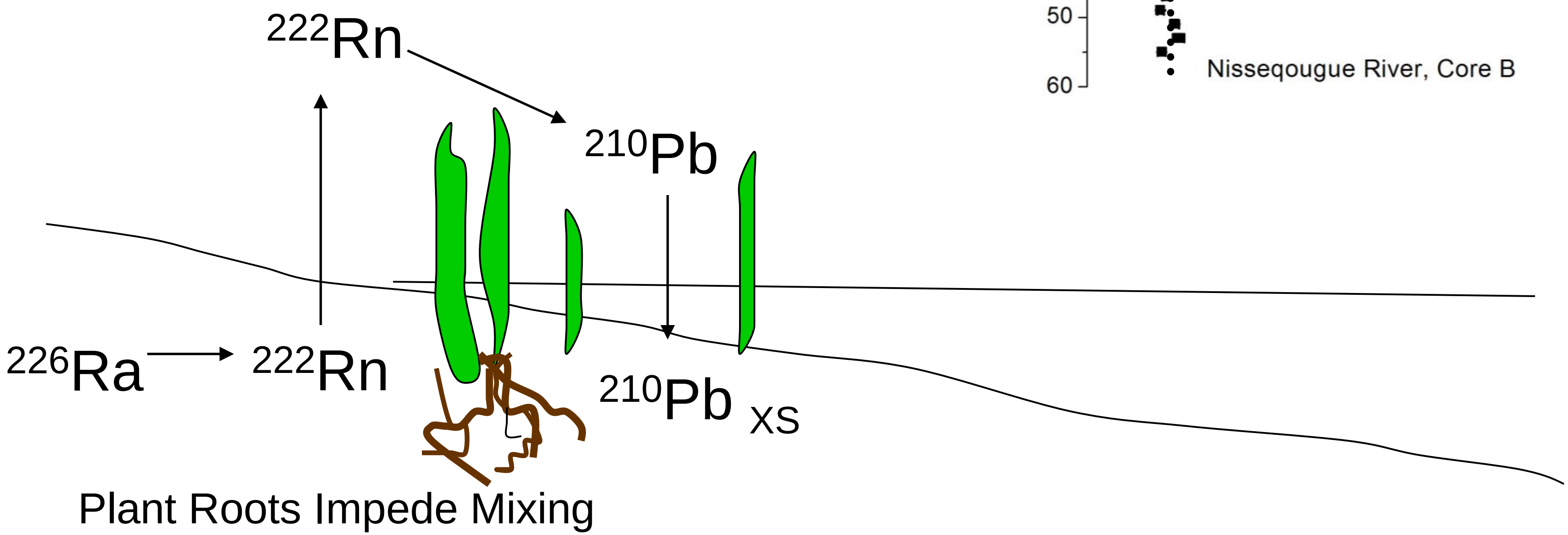


^{7}Be Analysis

- ^{7}Be is produced in the upper atmosphere when the sun's rays interact with N and C atoms.
- ^{7}Be is delivered to Earth's surface via wet and dry deposition.
- Chemically, ^{7}Be is particle reactive, which makes it an ideal tracer of recent sediment dynamics.
- Physically, ^{7}Be has a short half life (53.3 days), which makes it an ideal tracer of recent geological activity.

^{210}Pb Pathways in a Salt Marsh





^{210}Pb ← ^{222}Rn ← ^{226}Ra

(Supported)

Schedule of Work

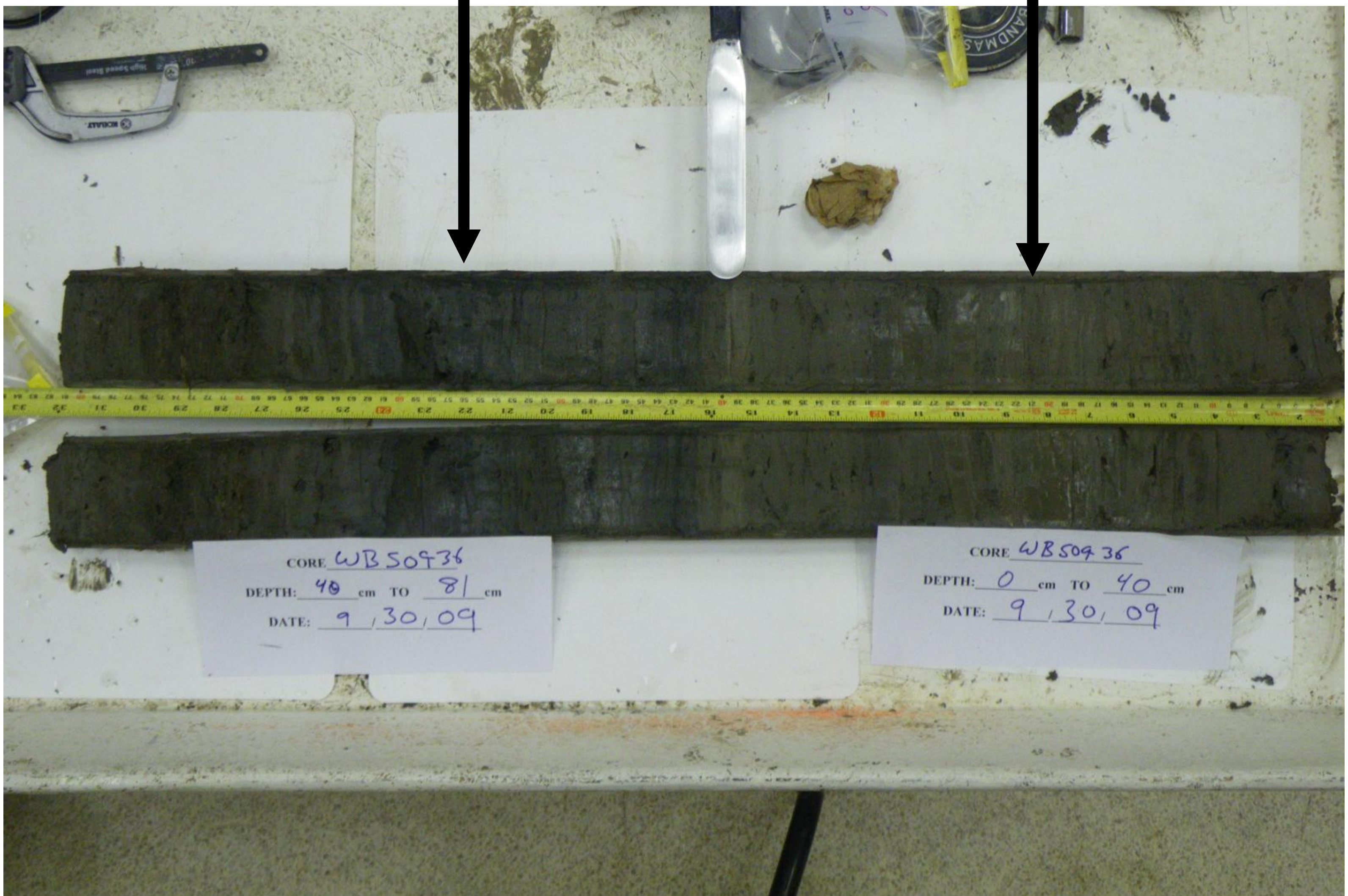
- Sediment cores were collected on September 20, and 22, 2009.
- Cores were x-radiographed and cut into sections 1 - 2 cm sections, as determined by x-radiographs.
- Cores are being counted for radioisotope analysis at Tulane University, the University of Texas, Austin and Louisiana State University.
- Our goal is to count all cores for ^{7}Be within 1 half life (53 days).
- Core analysis will continue through March, 2010, and will include ^{210}Pb and ^{137}Cs analysis.

West Bay, Core 36

Organic sediments most likely relict marsh

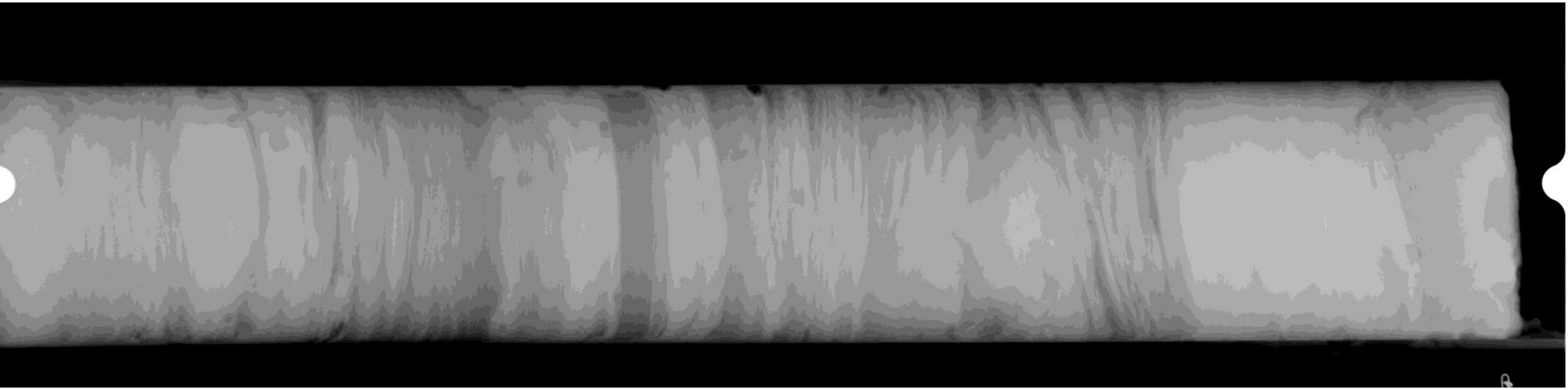
Mineral sediments, some laminated

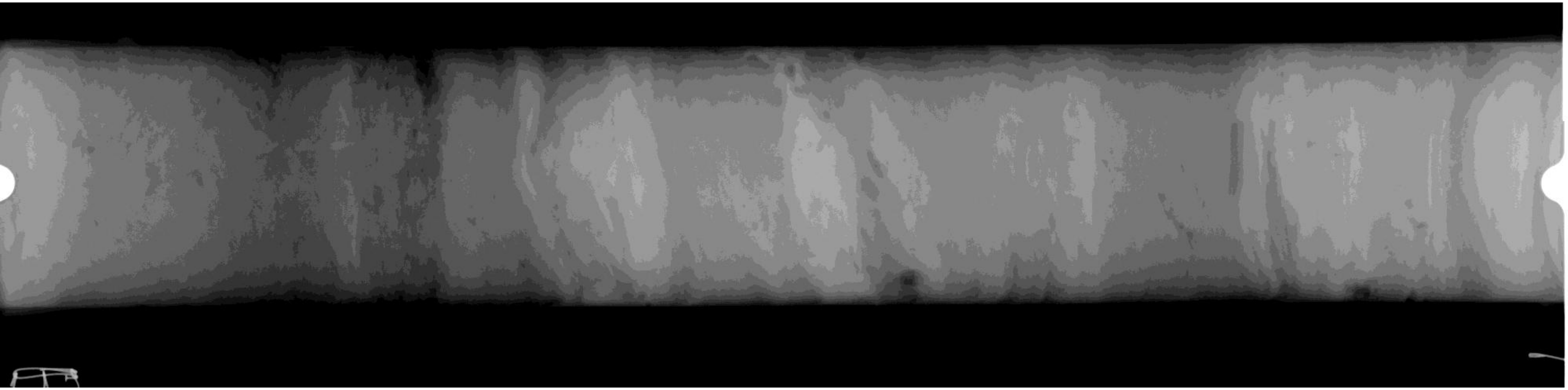
Depth



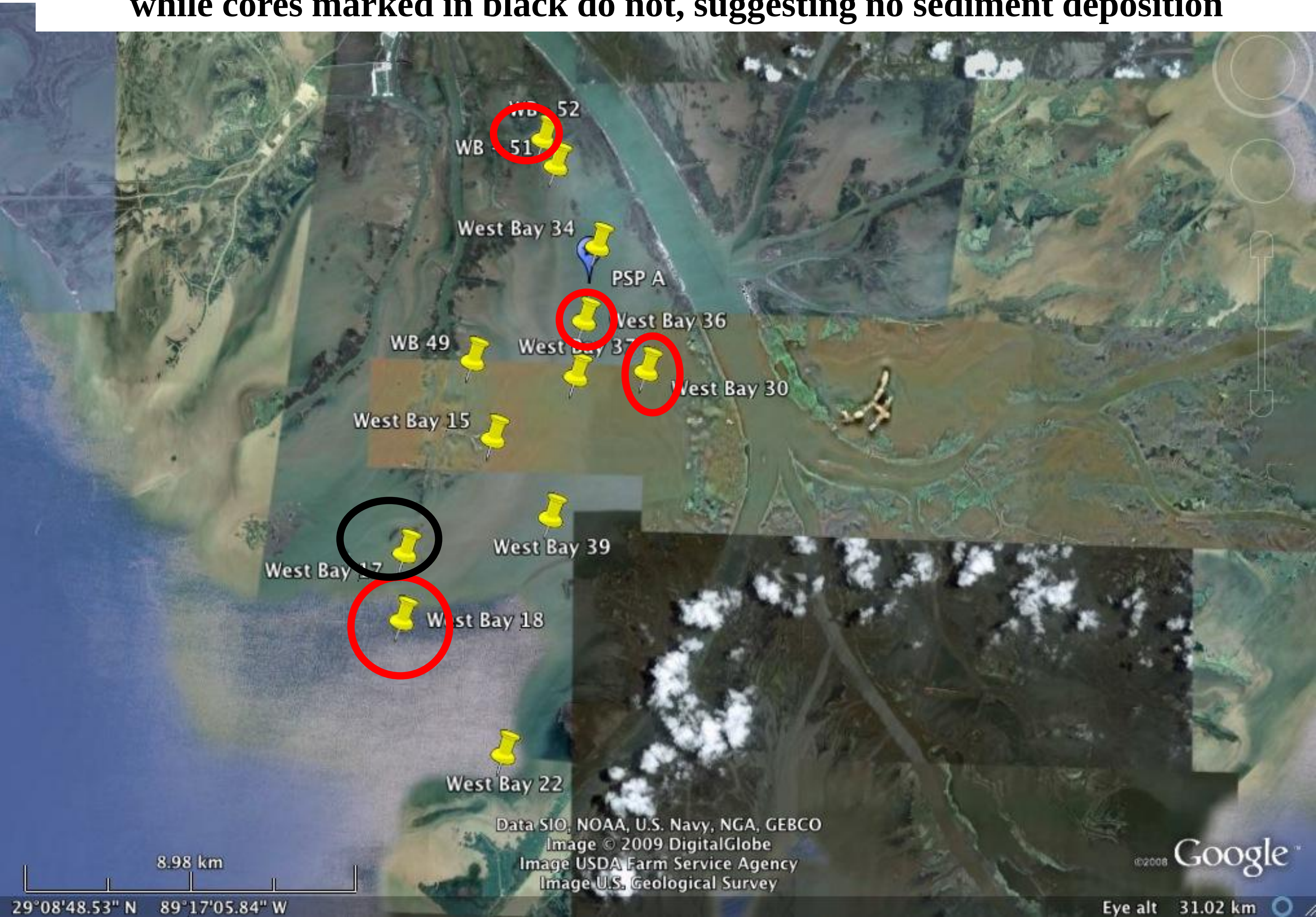
Surface

X- radiograph of West Bay, core 36, collected 9/09





Cores marked in red have detectable ^{7}Be, suggesting active sediment deposition, while cores marked in black do not, suggesting no sediment deposition



Preliminary Findings

Visual inspection of sediment cores from West Bay suggests that marshes have been submerged and buried. This is consisted with work by Wells and Coleman indicating a sub-delta chronology in West Bay.

^{7}Be data suggest some seasonal-scale sediment deposition in West Bay

X-radiograph data show buried sediment horizons, suggesting that burial may exceed reworking in West Bay.

Seasonal scale patterns in sediment deposition are being compared to long-term sediment deposition rates that are being determined using ^{210}Pb and ^{137}Cs.


Many Thanks
Mead Allison
Ashley Barker
Kristen Butcher
Dan Duncan
Barb Kleiss
Charlie Milan
Harry Roberts
Kelly Williams
Brian Vosberg