Modeling updates and next steps
FY09 Work Plan

8 April 2008 1:30 pm

GCDAMP TWG Meeting, PHX

U.S. Department of the Interior
U.S. Geological Survey

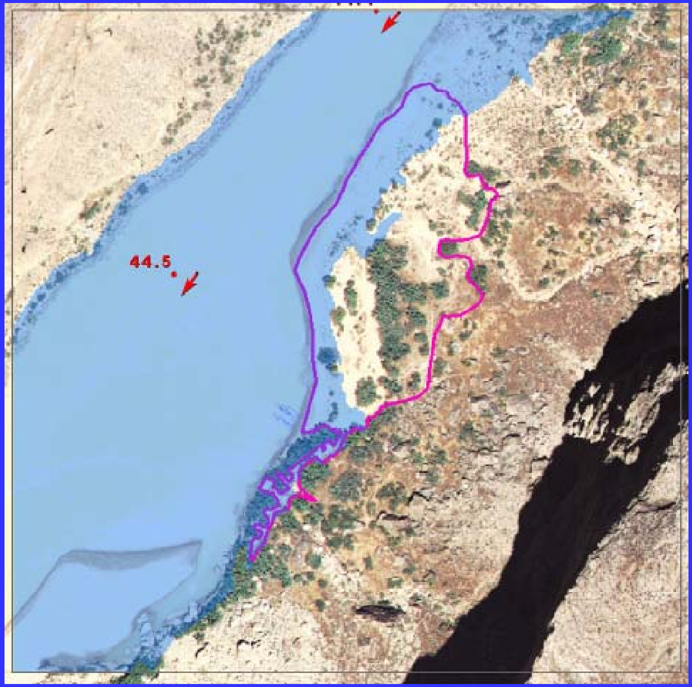
Physical modeling goals

- Develop and apply predictive models of stage and discharge
- Develop and apply predictive models of mainstem and nearshore temperature dynamics
- Develop apply predictive models of mainstem sediment transport and sandbar dynamics and stability
- Evaluate “what if” scenarios for dam operations
- Eventually, provide input to ecological models

USGS

Applications – Stage and discharge

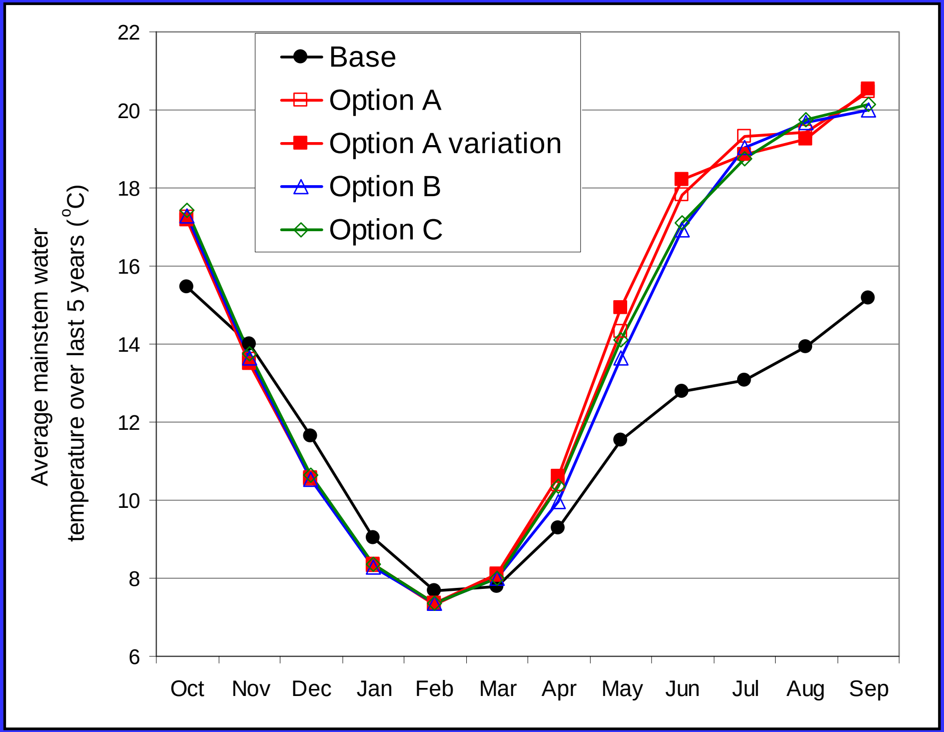
- Peak flow arrival and departure times along the river during high flow releases
- Inundation maps for campsites during high flow releases
- Estimation of inundation levels for a range of flows
- Provide hydraulic variables (velocity, cross-section area, bed shear stress) to other transport models



USGS

Applications – Temperature

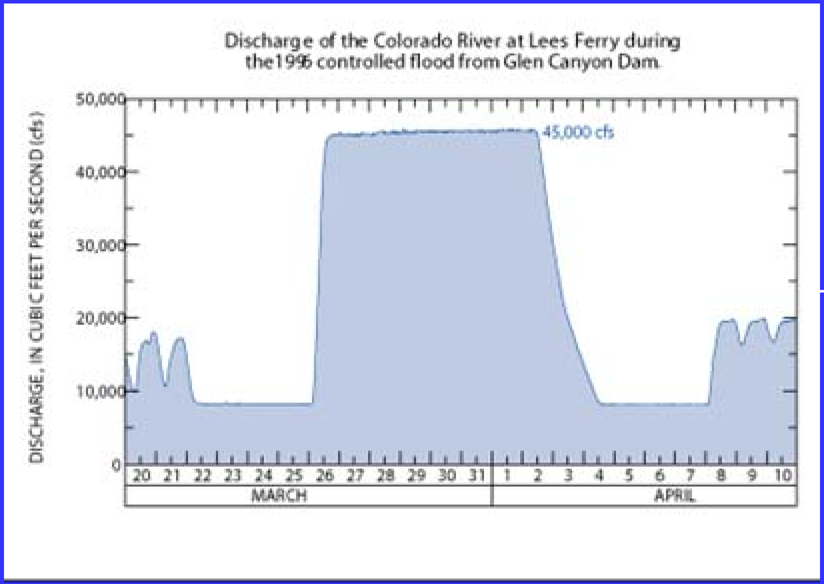
- Evaluate the effects of release temperatures and volumes (i.e. hydrology, TCD) and daily patterns (i.e. level of fluctuation) on downstream mainstem and nearshore/backwater temperature dynamics

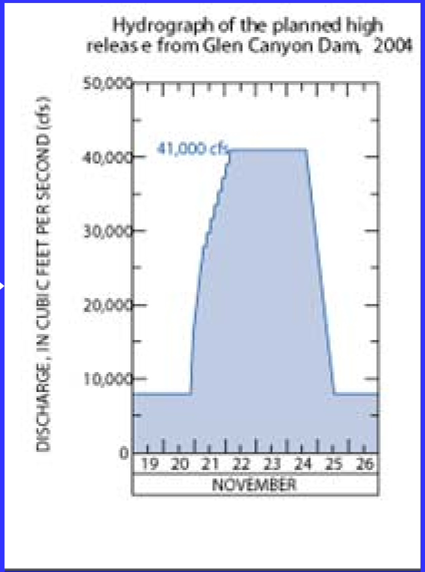


USGS

Applications – Sediment transport

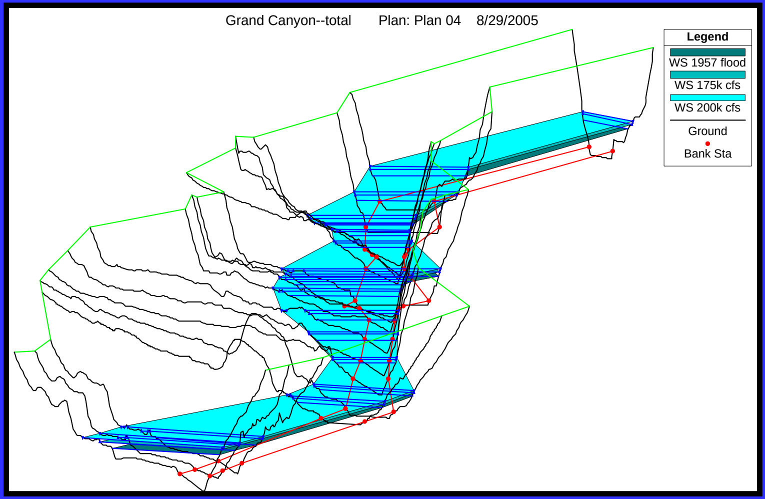
- Evaluation of the potential for a given operation to result in long-term positive mass balance of sand in Grand Canyon
- Evaluation of the effects of ramping rates on bar stability
- Design of high flow hydrographs to optimize sandbar deposition while minimizing sand export





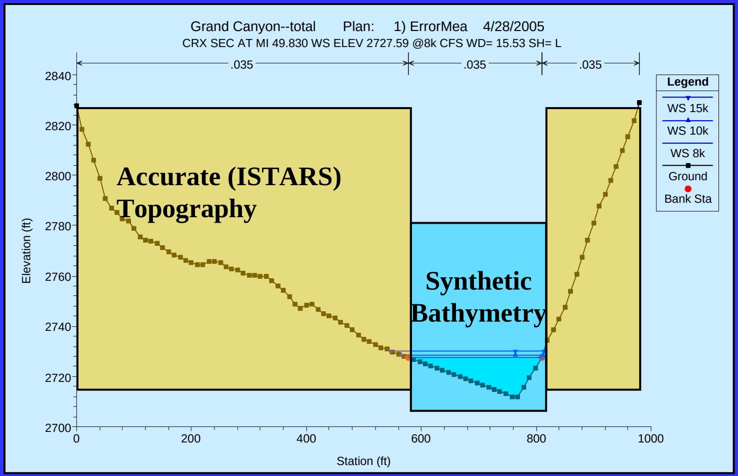
USGS

Recent progress – Stage and discharge



HEC-RAS model (steady, uniform flow) to predict stage profiles for a given discharge

USES SYNTHETIC BATHYMETRY



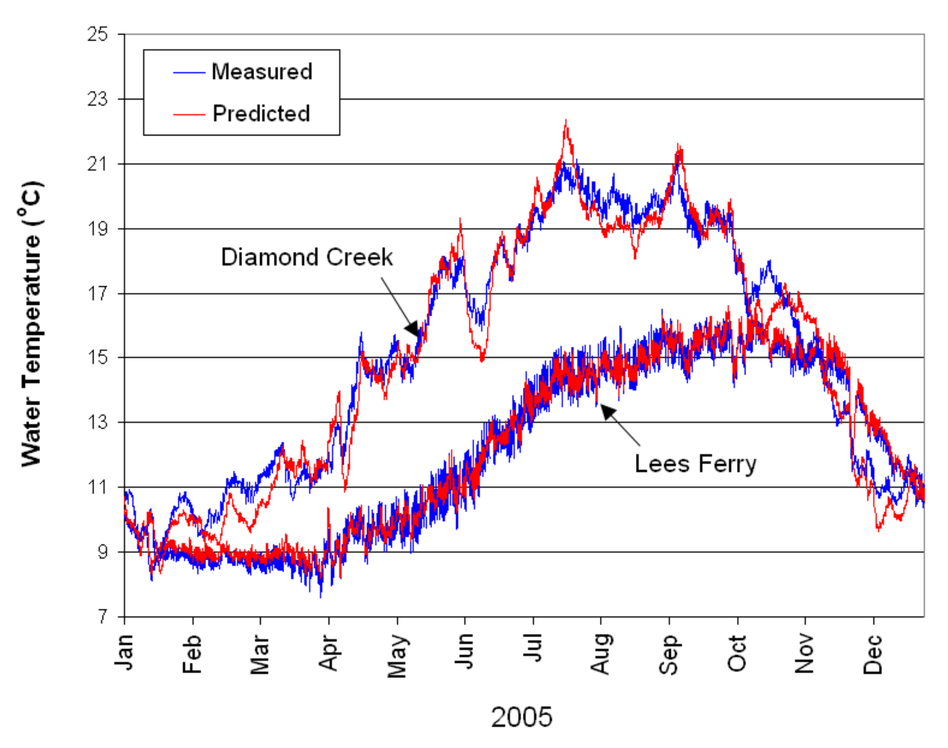
Magirl, C.S., M.J. Breedlove, R.H. Webb, and P.G. Griffiths (in USGS review). Modeling Water-Surface Elevations and Virtual Shorelines for the Colorado River in Grand Canyon, Arizona: U.S. Geological Survey Open-File Report

USGS

Recent progress – Temperature

<u>1D mainstem dynamic model</u>: Predicts hourly temperatures at any location below the dam for a given release temperature and discharge hydrograph

Model was used in SPG Options analyses



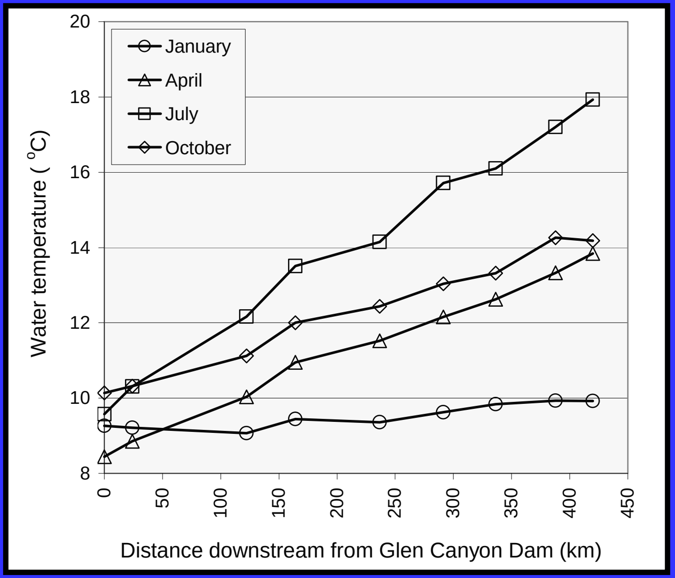
<u>Anderson, C.R., and S.A. Wright, 2007</u>. Development and application of a water temperature model for the Colorado River ecosystem below Glen Canyon Dam, Arizona. Hydrological Science and Technology , vol. 23 (1-4): Proceedings of the American Institute of Hydrology 2007 Annual Meeting and International Conference, pp. 13-26.

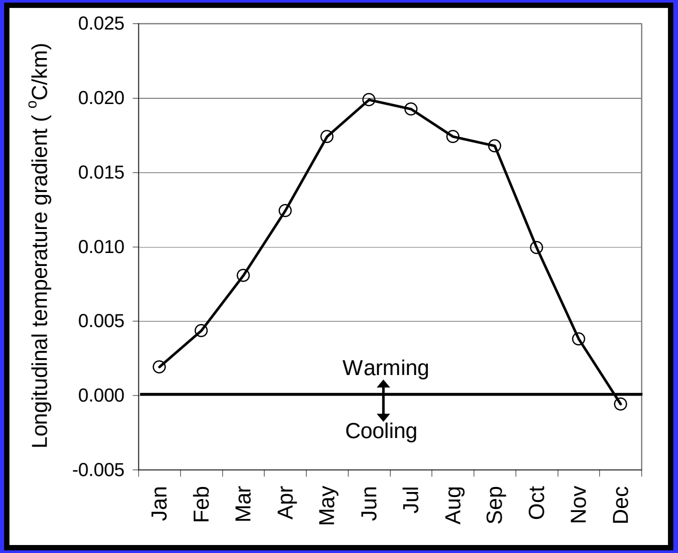
USGS

<u>Voichick, N., and Wright, S.A.,</u> 2007. Water-temperature data for the Colorado River and tributaries between Glen Canyon Dam and Spencer Canyon, Northern Arizona, 1988 – 2005, U.S. Geological Survey Data Series 251, http://pubs.usgs.gov/ds/2007/251/, 24p.

Recent progress – Temperature

<u>1D mainstem simplified model:</u>
Predicts monthly average temperatures at any location below the dam for a given release temperature and release volume



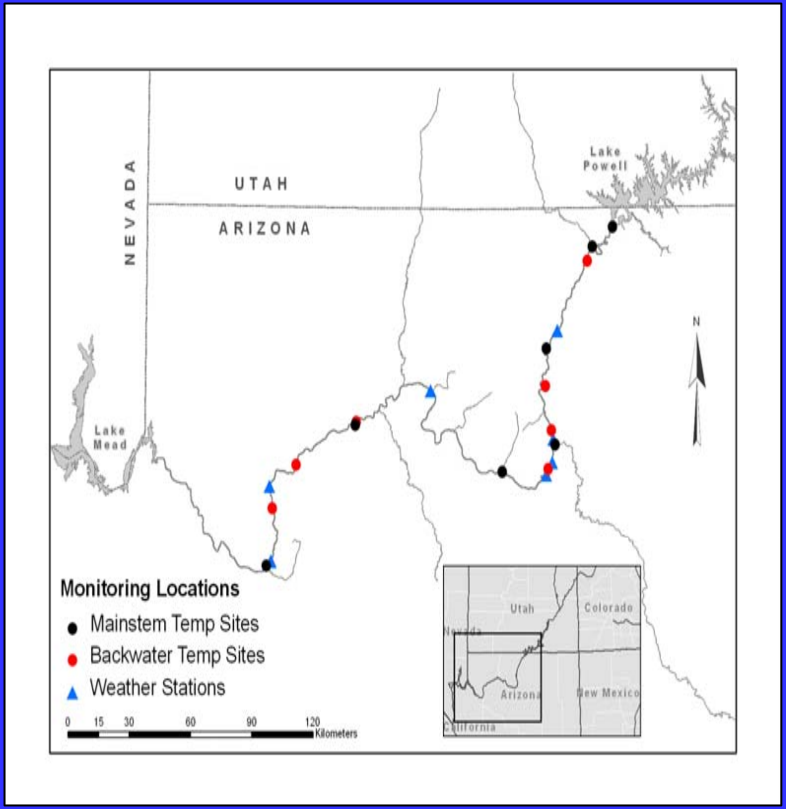


<u>Wright, S.A., Anderson, C.R., and Voichick, N.</u> (in review, pending revision). Monthly average water temperature model for the Colorado River below Glen Canyon Dam, AZ: River Research and Applications

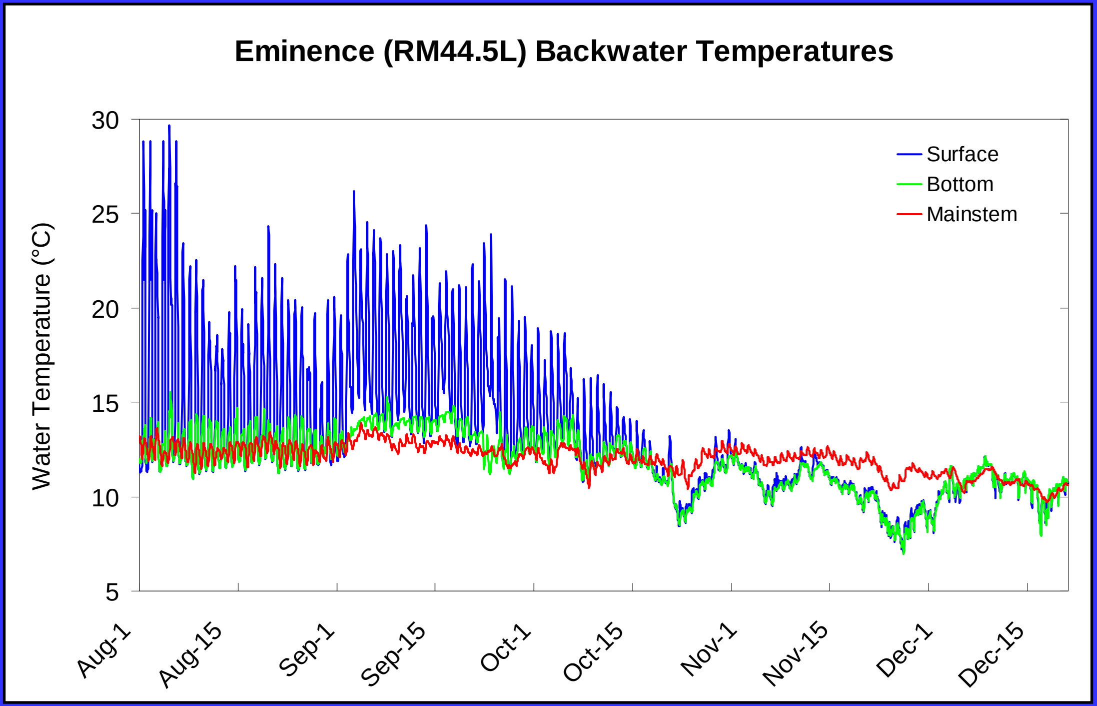
USGS

<u>Voichick, N., and Wright, S.A.,</u> 2007. Water-temperature data for the Colorado River and tributaries between Glen Canyon Dam and Spencer Canyon, Northern Arizona, 1988 – 2005, U.S. Geological Survey Data Series 251, <u>http://pubs.usgs.gov/ds/2007/251/</u>, 24p.

Recent progress – Temperature



Progress on nearshore models has been limited by lack of data – thus, we have implemented nearshore (primarily backwaters) temperature monitoring. Also using meteorological data from weather stations installed by Cultural program

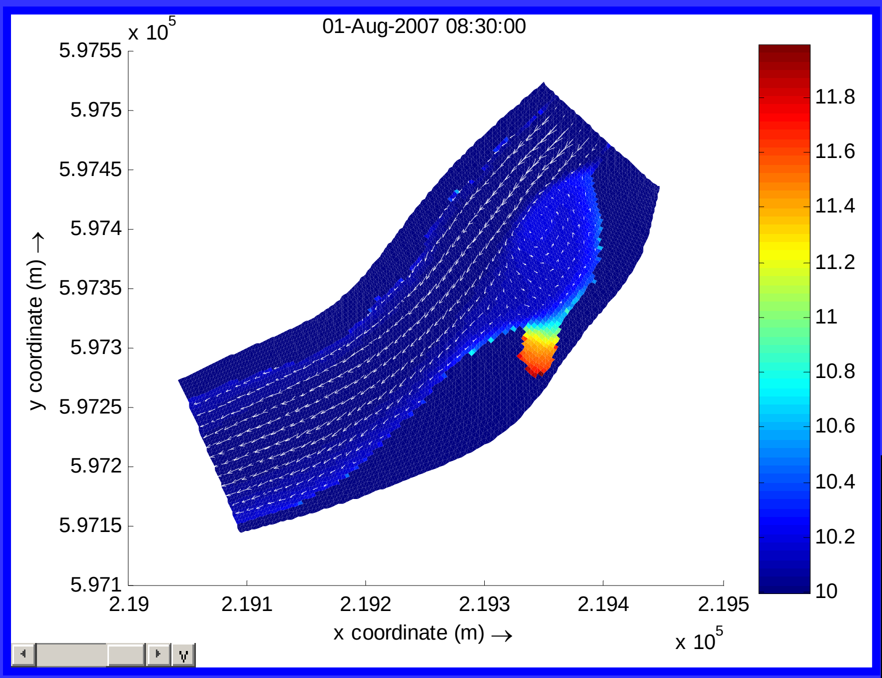


USGS

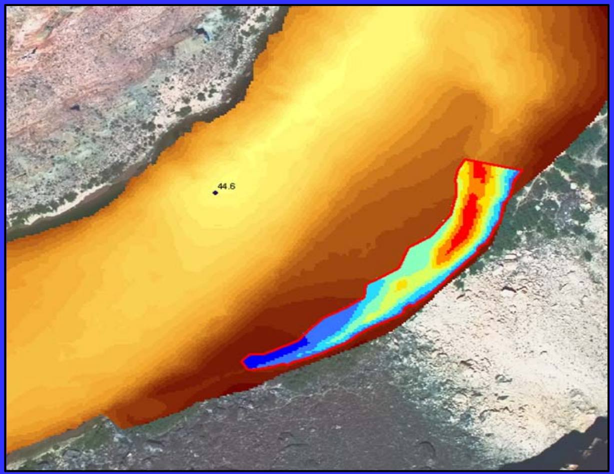
Recent progress – Temperature

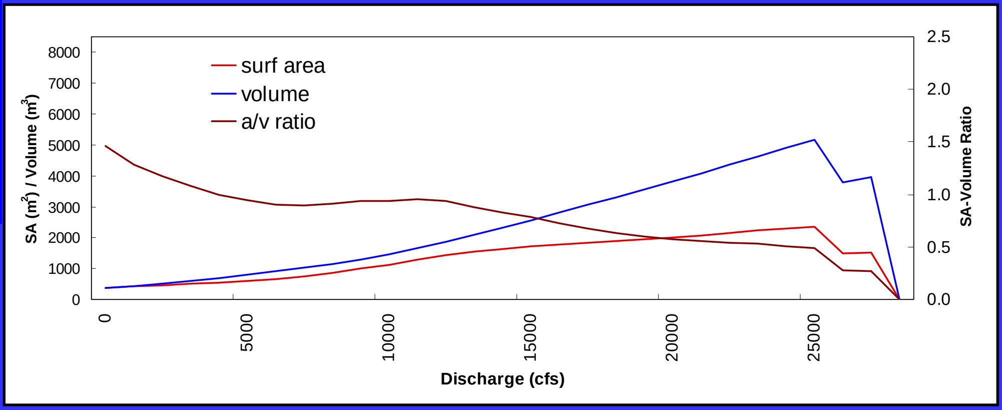
We're developing two types of nearshore temperature models

Multi-dimensional models of eddies



Well-mixed "pond" models of defined backwaters





Recent progress – Sediment transport

Sand routing model for the reach from Paria confluence to Phantom Ranch

Event-based simulations – time scales of weeks to months

Still has some calibration issues

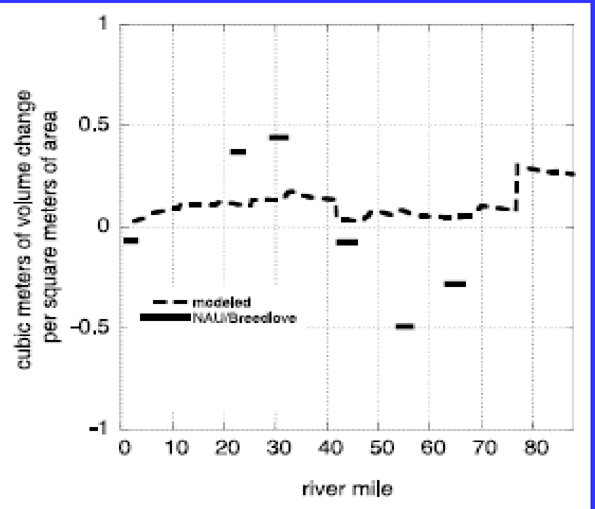


Figure 29. Model-predicted and measured change in total eddy sand volume. Both model and measurements show small changes in sand deposit thickness compared to changes that occurred during the 1996 high flow.

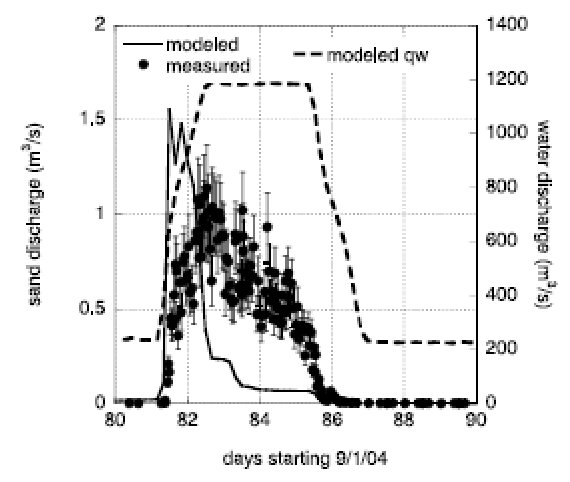


Figure 16. Model-predicted and measured sand discharge during the November 2004 experimental release at river mile 30. Error bars represent an estimated 20% error in the measurements.

Wiele, S. M., P. R. Wilcock, and P. E. Grams (2007), Reach-averaged sediment routing model of a canyon river, Water Resources Research, 43, W02425, doi:10.1029/2005WR004824.

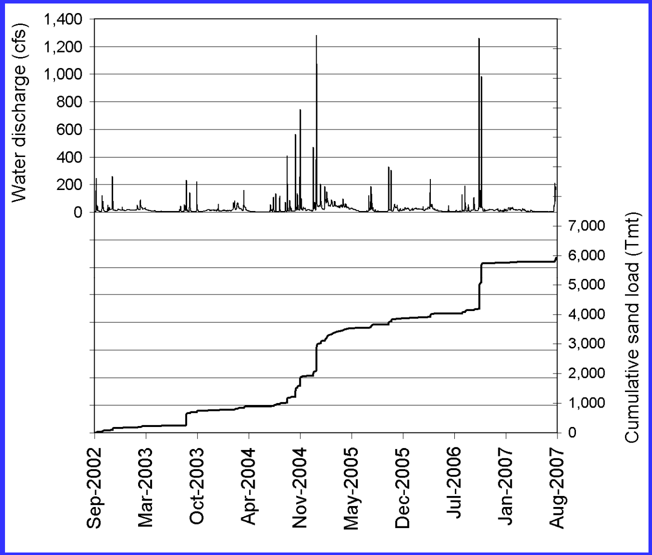
Recent progress – Sediment transport

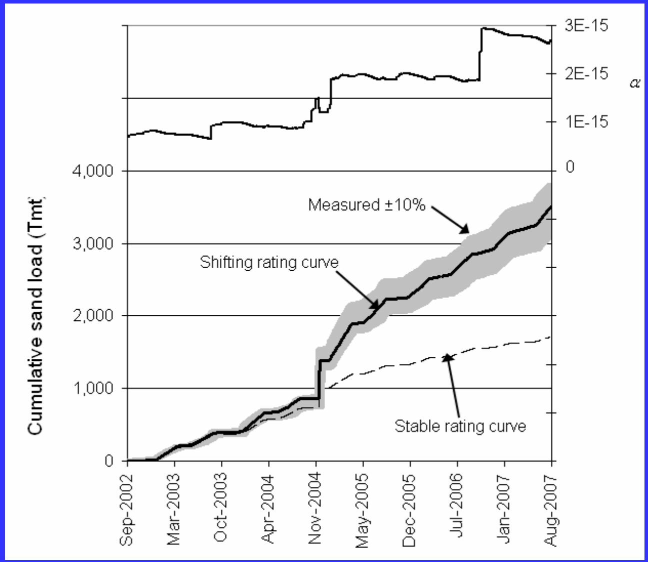
Simplified sand routing model for simulating the fate of tributary inputs over annual to decadal time scales

Shifts the relationship between sand concentration and discharge based on the supply conditions in a reach

Need to test with recent data

Wright, S.A., Topping, D.J., Rubin, D.R., and Melis, T.S. (in USGS review). Shifting suspended-sediment rating curves for supply-limited conditions, to be submitted to J. Hydraulic Engineering



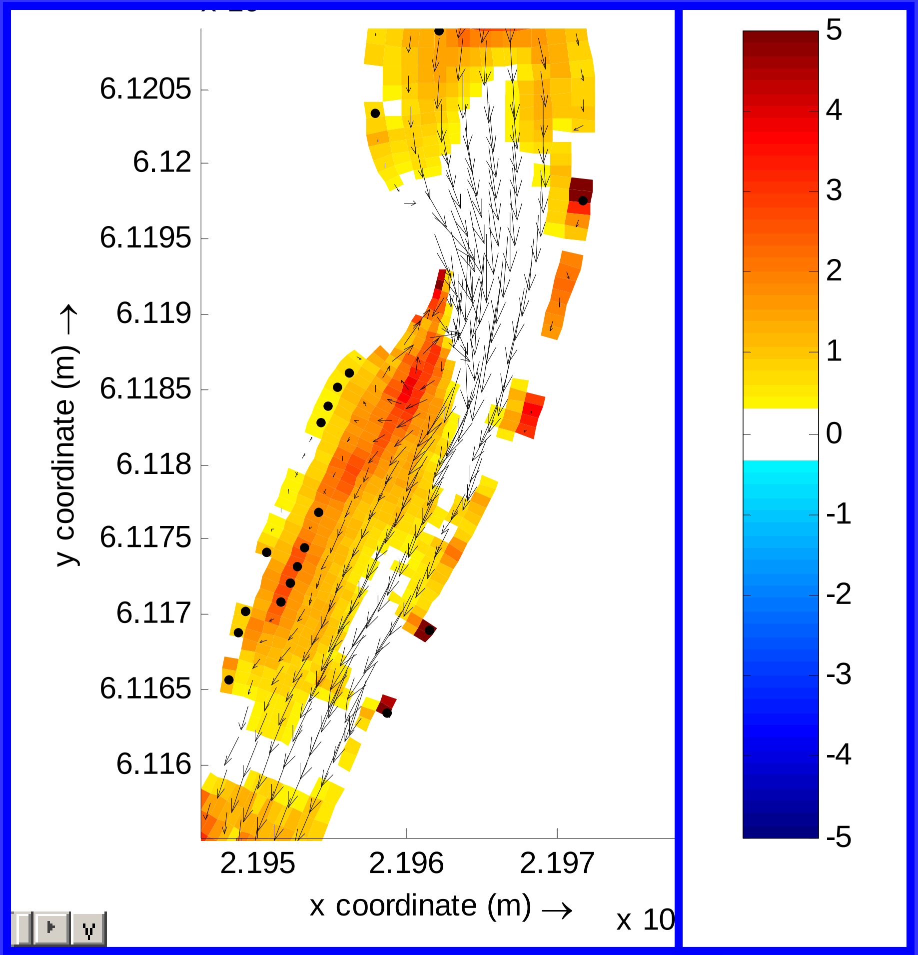


Recent progress – Sediment transport

Review panel recommended “updating” Wiele 2D eddy model (mid 90s), as new tools have become available

In the first stages of applying Delft3D model to sandbars (as well as temperature)

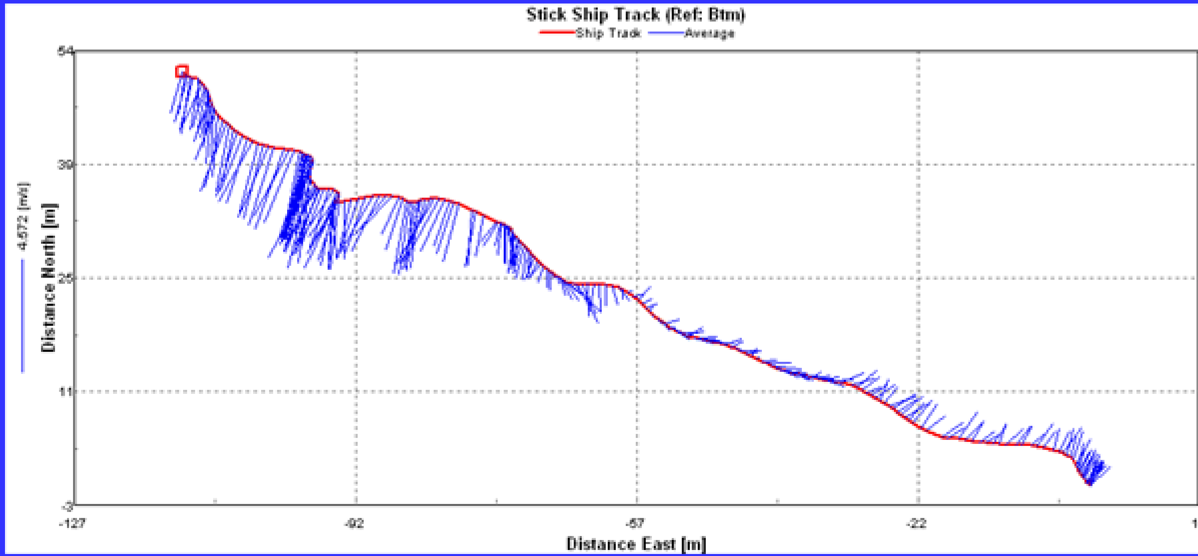
As with temperature, progress is limited by lack of data in eddies (lots of surveys, not much velocity and concentration data)

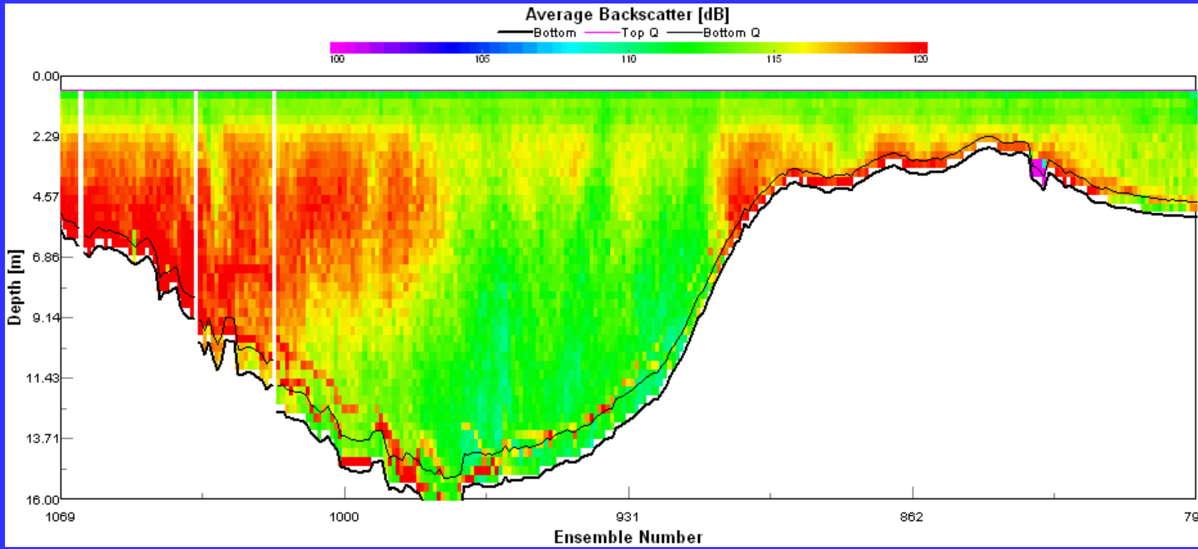


USGS

Recent progress – Sediment transport

To address this data gap, we made detailed bathymetric, velocity, and sediment measurements at Eminence and Willie Taylor during 2008 HFE





PROJECT 1B

FY09 Work plan

Task 1 - Multi-dimensional modeling of flow, temperature, and sediment transport using Delft3D*

- Calibrate hydrodynamics using velocity data from 2008 high flow
- Calibrate temperature dynamics using nearshore data
- Calibrate sediment transport using data from 2004 and 2008 high flows
- Through calibration, evaluate the complexity of model required (i.e. 2D, 3D, number of grain-sizes, turbulence model)
- Begin applications to study nearshore warming and sandbar response to high flows

USGS

* Recommended by review panel

FY09 Work plan

Task 2 - Sandbar stability modeling and experiments at Arizona State University (ramping rate studies)*

- Ongoing work led by Mark Schmeeckle to study effects of ramping rates on sandbar stability
- Physical model studies at ASU lab
- Numerical model development and applications

USGS

* Recommended by review panel

FY09 Work plan

Task 3 - Update and publish "shifting rating curve" model*

- Apply model to recent dataset (summer 2006 through March 2008) as an additional test of the algorithms
- Update manuscript as necessary and submit to Journal of Hydraulic Engineering
- Construct a simple user-interface (Excel)
- Provide support for LTEP simulations?

USGS

* Not reviewed by modeling panel, but recommended by PEP-SEDS panel

FY09 Work plan

Task 4 - Document and develop user manual for Wiele et al 1D sand routing model*

- In order to continue to improve this model (recommendation of review panel), more extensive documentation is needed
- Work with Wiele to document the code (and potentially port to other programming languages) and develop a user's manual for existing version (facilitating further calibration)

USGS

* First step toward following the review panel recommendations (continued calibration and improvement of model formulations)

FY09 Work plan

Task 5 - Begin development of integrated 1D unsteady flow and stage model*

- Our existing flow (UNSTEADY) and stage (HEC-RAS) models do not incorporate recently collected bathymetric data (UNSTEADY uses a single x-section, HEC-RAS uses synthetic bathymetry)
- We now have bathymetry for much of Marble Canyon, and Goal 8 Core Monitoring will eventually survey the entire river
- With this bathymetry, HEC-RAS can be used for unsteady flow (i.e. wave routing) and stage predictions, in a single package, with improved predictive capabilities
- This task will begin the development of this capability for reaches where bathymetry is available

* Review panel recommended updating HEC-RAS with new bathymetry

Work plan and budget

- Task 1 – Multi-dimensional modeling
  FY09 - $196,574   FY10 – continuing, potentially scaled back
- Task 2 – Sandbar stability modeling
  FY09 - $26,523   FY10 – potentially continuing, uncertain
- Task 3 – Shifting rating curve model
  FY09 - $31,419   FY10 – zero, completion in FY09
- Task 4 – Sand routing model user's manual
  FY09 - $25,129   FY10 – zero, completion in FY09
- Task 5 – Integrated 1D hydrodynamic model
  FY09 - $28,241   FY10 – continuing

Travel and publications costs: $12,100

USGS

FY09 total: $319,986
FY10 ~ 70% of FY09

Future of modeling project

- Modeling project should not be considered “over” once ongoing model developments are finished (likely in the next 2-3 years)
- Development will result in a “toolbox” of models. The “tools” require maintenance and updating, and staff who know how to use them.
- For example, as new monitoring and research flow data become available, models should incorporate improved understanding of system dynamics
- Thus, modeling project should continue in a scaled back version alongside the Core Monitoring project

USGS