Elk River Pilot Project: Hydrodynamic and Sediment Transport Model
Presentation Overview

- Modeling system overview
- Modeling domain and grid development
- Hydrodynamic model calibration and results
- Sediment transport model calibration and results
- Wrap-up
Environmental Fluid Dynamics Code (EFDC)

- EFDC is a public-domain, EPA supported, surface-water modeling system that fully integrates hydrodynamic, water quality and sediment-contaminant simulation capabilities into a single source code.
- EFDC is extremely versatile and can be used for 3, 2 and 1-dimensional simulations in rivers, estuaries, coastal regions, lakes and wetlands.
- EFDC is one of the EPA recommended models for TMDL development, and has been used in 100’s of TMDLs throughout the Country, including sediment TMDLs.
Primary Modules of EFDC Model

- Hydrodynamics
- Water Quality
- Sediment Transport
- Toxics
EFDC Sediment Transport Capabilities

- Multiple size class cohesive and non-cohesive suspended sediment transport
- Bedload transport of multiple size classes of non-cohesive sediment
- Includes sediment bed geomechanics with consolidation
- Bed morphology (scour and deposition)
EFDC Sediment Transport Model

Hydrodynamic Model → Sediment Transport Model

- Water Column
  - Cohesive
  - Noncohesive

- Sediment Bed
  - Cohesive
  - Noncohesive
Elk River Hydrodynamic and Sediment Transport Pilot Project

- Pilot scale application of EFDC to demonstrate sediment transport capability in Elk River
- Pilot reach was chosen as a portion of the Elk River with known sediment deposition issues
- Moderate amount of data available to support application of model
Model Grid Detail

- 3,505 horizontal cells
- 1 vertical layer (2D model)
- Grid resolution:
  - 1 cell for channel bed
  - 1 cell for channel bank
  - Multiple cells on floodplain
- Grid elevations from adjusted LiDAR surface
- Model forcings:
  - Flow and SSC for NF & SF Elk and tribus
  - Downstream WSE
Hydrodynamic Model Setup

Upstream BC Flows:
- 10-min Q for NF & SF Elk River (SFO Data)
- Estimated Q for tributaries

Downstream BC Stage:
- Estimated WSE from HEC-RAS model

Channel Bed Roughness:
- Roughness height \((Z_0) = 0.01\) to 0.04 m (literature values)

Vegetation Drag:
- Plant density (#/m\(^2\)), stem diameter (m), stem height (m), drag coef. (literature values)
Hydrodynamic Model Calibration

Calibration period:
- Dec 25 to 30, 2002 (Dec 2002 flood)

Calibration Strategy:
1. Adjust bottom roughness and bank vegetation drag to match observed discharge rating data at:
   - NF Elk River at Concrete Bridge (SFO data)
   - Mainstem Elk River at Steel Bridge (HRC data)
2. Adjust peak discharge values for NF & SF Elk River to match observed water surface elevations at:
   - Stage recorder data (KRW station) on NF Elk River (SFO data)
   - Dec 2002 high water mark at Red House on Mainstem Elk (K. Wrigley)
   - Dec 2002 high water mark at Steel Bridge on Mainstem Elk (HRC data)
Measured and Predicted Stage-Discharge and Stage-Velocity Relationships

Steel Bridge (Sta 509) on Mainstem Elk River

Concrete Bridge on NF Elk River
Measured and Predicted WSE

Calibration Results:

1. Measured and predicted WSE at NF Elk for stage recorder data (SFO)

2. High Water Marks

Red House (Sta_RedHouse):
- Observed = 19.4 m
- Predicted = 19.3 m

Steel Bridge (Sta 509) Silt Line:
- Observed = 19.1 m
- Predicted = 19.0 m
Results of Hydrodynamic Model Calibration

1. Semi-calibrated hydrodynamic model (calibrated to small data set)
   Calibrated to Dec 2002 flood event

2. Validation of model – still to be done
   Check against other water year flood events

3. Movie of Dec 2002 flood event
   Where’s the popcorn?
Sediment Transport Model

- Sediment transport model is work in progress
- Still working on calibration to observed deposition patterns and SSC
- We’ve made runs for WY 2003 for this workshop – but these are preliminary
Sediment Transport Model Setup

- Modeled 5 sediment classes:
  - 1 cohesive
  - 4 non-cohesive
    - Coarse silt and VF Sand
    - Fine to medium sand
    - Coarse to very coarse sand
    - Fine to medium gravel

- Modeled suspended load and bedload

- Modeled bed geomorphic change (scour and deposition)
Sediment Transport Model Input

Things we have:
• Semi-calibrated hydrodynamic model
• Measured data
  – Q, SSC, SSC sand fraction at Upstream BC
  – Bed, Bank and Floodplain material gradation, porosity, bulk density (we measured this)
  – SSC at Steel Bridge (Sta 509)

Things we did not have and assumed:
• SSC particle size distribution at Upstream BC
  – 1 cohesive ~85 to 90% of measured SSC (SFO data)
  – 4 non-cohesive ~10 to 15% of SSC applied to non-cohesive classes
  – Good thing is that we can collect this data

Adjusted through sediment calibration process:
• SSC particle gradations
• Shear stress partitioning between cohesive and non-cohesive sediment
• Bed configuration
WY 2003 Measured and Predicted SSC at Steel Bridge (Sta 509) on Mainstem Elk River
Movie clip of TSS Dec 2002 Flood

- Go to movie
Non-cohesive SSC during peak

ER_V2_CG-CBF_QSed_Run7a, Elk River Pilot Project Hydrodynamic & Sediment Transport Study

Water Column

Sediments (mg/l)
Depth Averaged
Solids Class: NonCo(1)

3.197E-18 287.9

Time 37618.105

287.9
Sediment Deposition Patterns for WY 2003
Existing Conditions
Reduced Sediment Run

- Ran model for WY 2003 with 85% reduction in all SSC
- 85% reduction provided by Adona

Results are Preliminary so interpret with Caution!
Sediment Deposition Patterns for WY 2003 with Reduced SSC (85% reduction)
Sediment Deposition Patterns for WY 2003

Existing Conditions

Reduced SSC
Difference in Deposition Patterns Between Reduced SSC and Existing Condition
Conclusions – what did we learn from the pilot project modeling effort

- Make reasonable predictions WSE, V, SSC and depositional patterns in project reach of Elk River
- Gain more confidence in results by collecting additional input and calibration data
  - In channel topography
  - Channel bed material
  - Channel obstructions
  - Vegetation patterns
  - SSC particle breakdown
  - Collection of calibration data (WSE, V, SSC, deposition) at additional locations
  - Refine estimates of peak discharge
  - In-channel measurements of sediment erosion (SedFLUME)
That’s all folks!