EFDC_DSI/EFDC_Explorer Modeling System

Use and Applications for Alberta

ESRD Environmental Modelling Workshop

March 2013

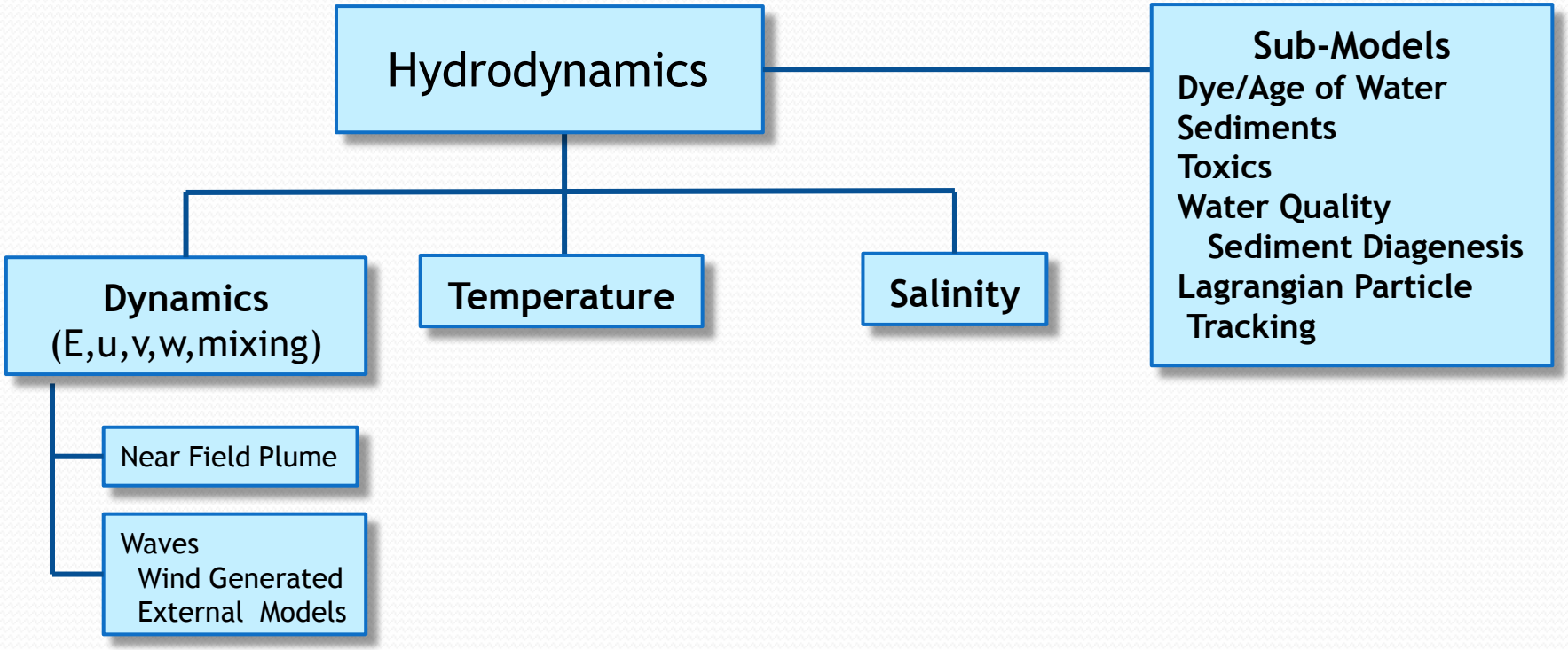
Dynamic Solutions International LLC

www.ds-intl.biz

The EFDC Model

- The Environmental Fluid Dynamics Code (EFDC) is a general-purpose hydrodynamic modeling package
- Simulates 1,2 & 3-D flow, transport, and biogeochemical processes in surface water systems (rivers, streams, lakes, estuaries, coastal waters and open ocean)
- EFDC model was originally developed at the Virginia Institute of Marine Science
- EFDC is a public domain model
- EFDC is a widely used and accepted model
- EFDC_DSI is Dynamic Solutions-International's enhanced and optimized version

EFDC Architecture



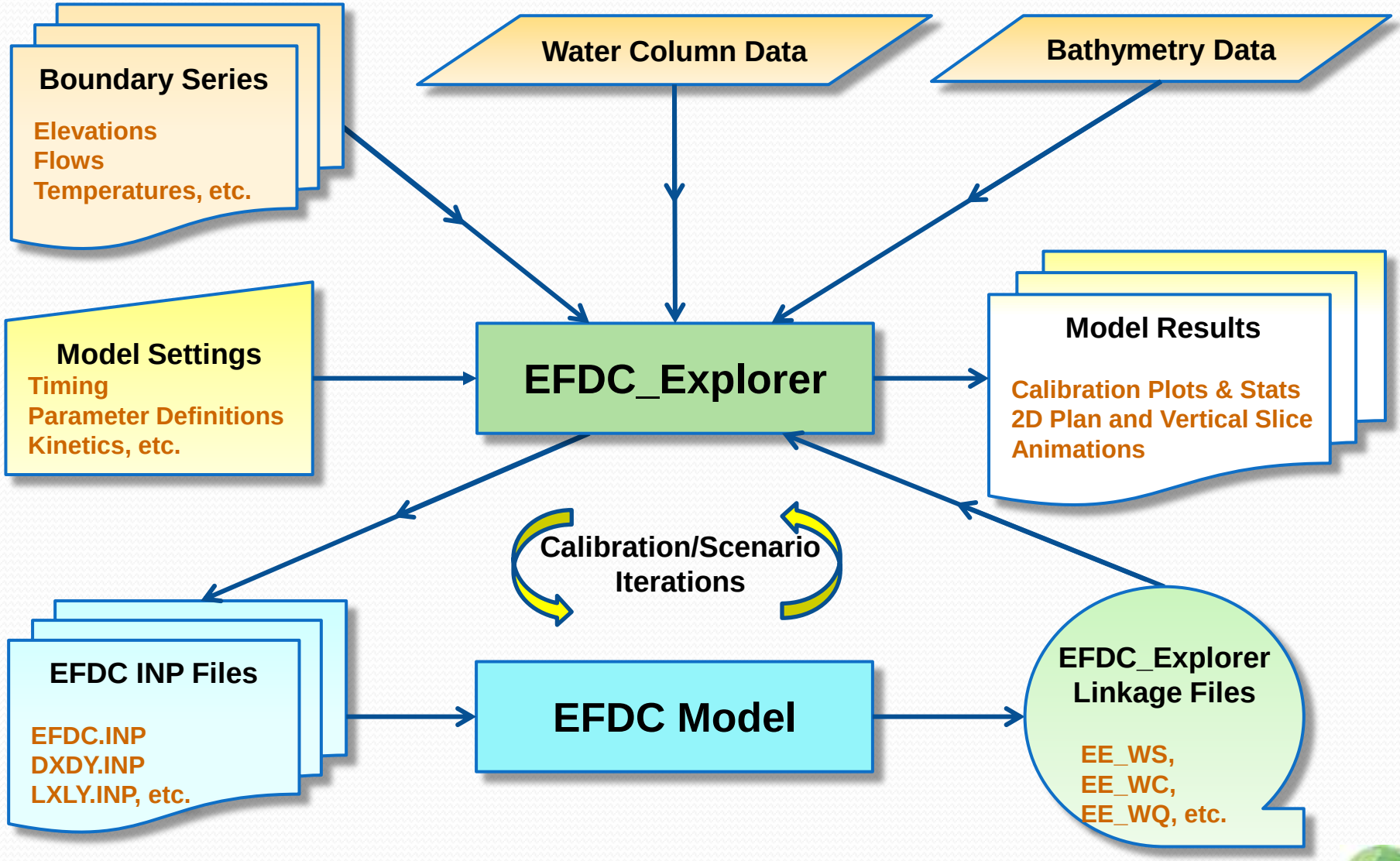
- EFDC's hydrodynamics are based on the 3D hydrostatic equations formulated in curvilinear-orthogonal horizontal coordinates and a sigma or stretched vertical coordinate system.
- EFDC is a coupled model eliminating model linkage issues

EFDC_DSI Enhancements

Dynamic Solutions-International (DSI) has developed an enhanced version the code (EFDC_DSI) which includes:

- Dynamic Memory Allocation
- Lagrangian Particle Tracking
- Improved/Simplified External Wave Model Linkage
- Internal Windwave Generation
- Added Dynamic Timestepping with WQ Model
- Age of Water/Residence Times
- Rooted Plant and Epiphyte Model (RPEM)
- OpenMP – Multi-Threading
- Upgraded all code to Fortran90 (EE7.1)

EFDC_Explorer/EFDC_DSI Modeling System



EFDC_DSI/EFDC_Explorer Uses

- Models of eutrophication and nutrient processes
- Water quality studies/planning
- Flood and inundation mapping
- Bridge scour analysis
- Oil spill tracking and planning
- Contaminated sediment/toxics analysis and planning
- Thermal discharge/impact studies and planning
- Aquatic vegetation studies
- Lakes/reservoir mixing and residence time studies
- Tailrace investigation for Hydropower
- Hydraulic structure design support

Applications in Alberta

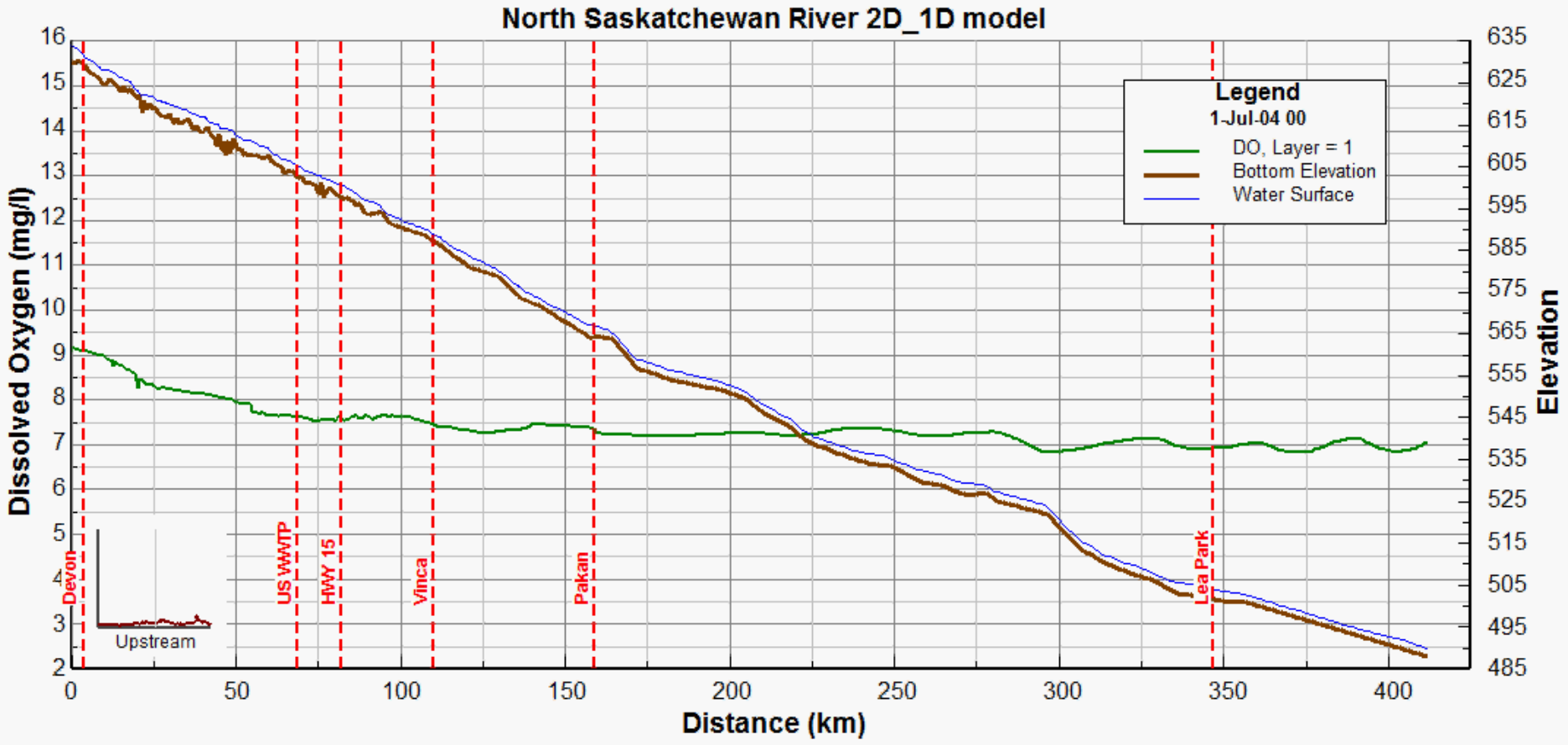
- North Saskatchewan River (NSR)
  - Water quality planning
    - 16 water quality constituents
  - DSI modified the EFDC_DSI model code to include the Rooted Plant and Epiphyte Model (RPEM)
- Lower Athabasca River (LAR)
  - DSI conducted a scoping study for hydrodynamics, water quality, sediments and toxics
  - Water quality planning
    - 15 water quality constituents
  - Contaminated sediments/toxics evaluation
    - DSI added sediment transport (4 classes)
    - DSI added toxics (24 classes)

North Saskatchewan River

- Number of Cells: 1776
- Number of Layers: 1
- Dimensions: 2D
- Duration: 1 to 10 years
- Area 9405 ha
- Length 412 km

- Processes Modeled
  - Hydrodynamics
  - Temperature
  - Water Quality: 16
  - Sed Nutrient Fluxes: Fixed
  - RPEM

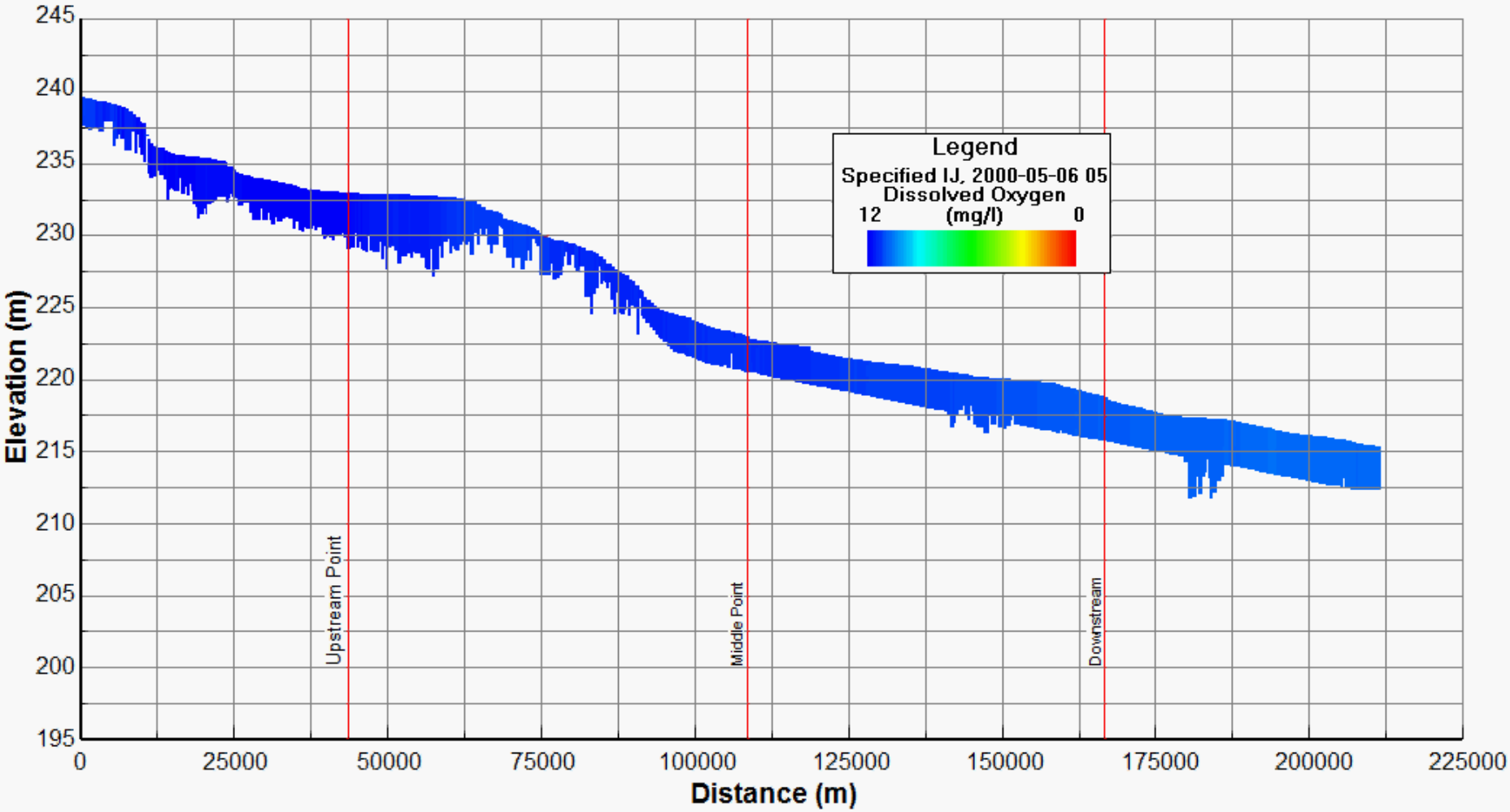
NSR Dissolved Oxygen Profile



Lower Athabasca River

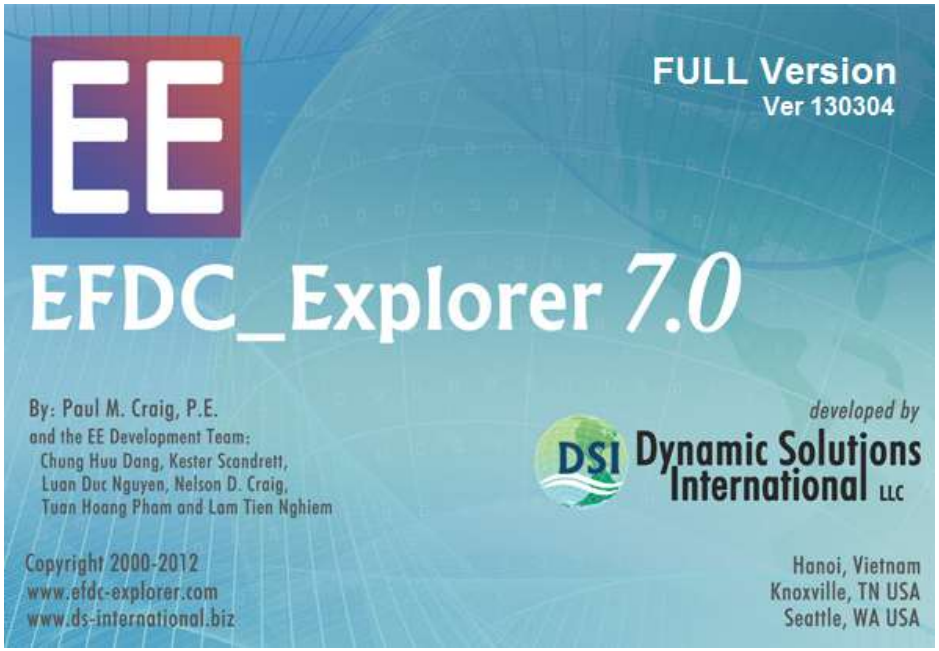
- McMurray to Old Fort
- Number of Horizontal Cells: 2257
- Number of Layers: 1
- Dimensions: 2D
- Duration: 1 to 10 years
- Area: 12,981 ha
- Length: 214 km
- Processes Modeled
  - Hydrodynamics
  - Temperature
  - Water Quality: 15
  - Sediment Nutrient Fluxes Fixed
  - Inorganic Sediments 4
  - Toxics
    - Metals 8
    - Organics 16

LAR Dissolved Oxygen Profile

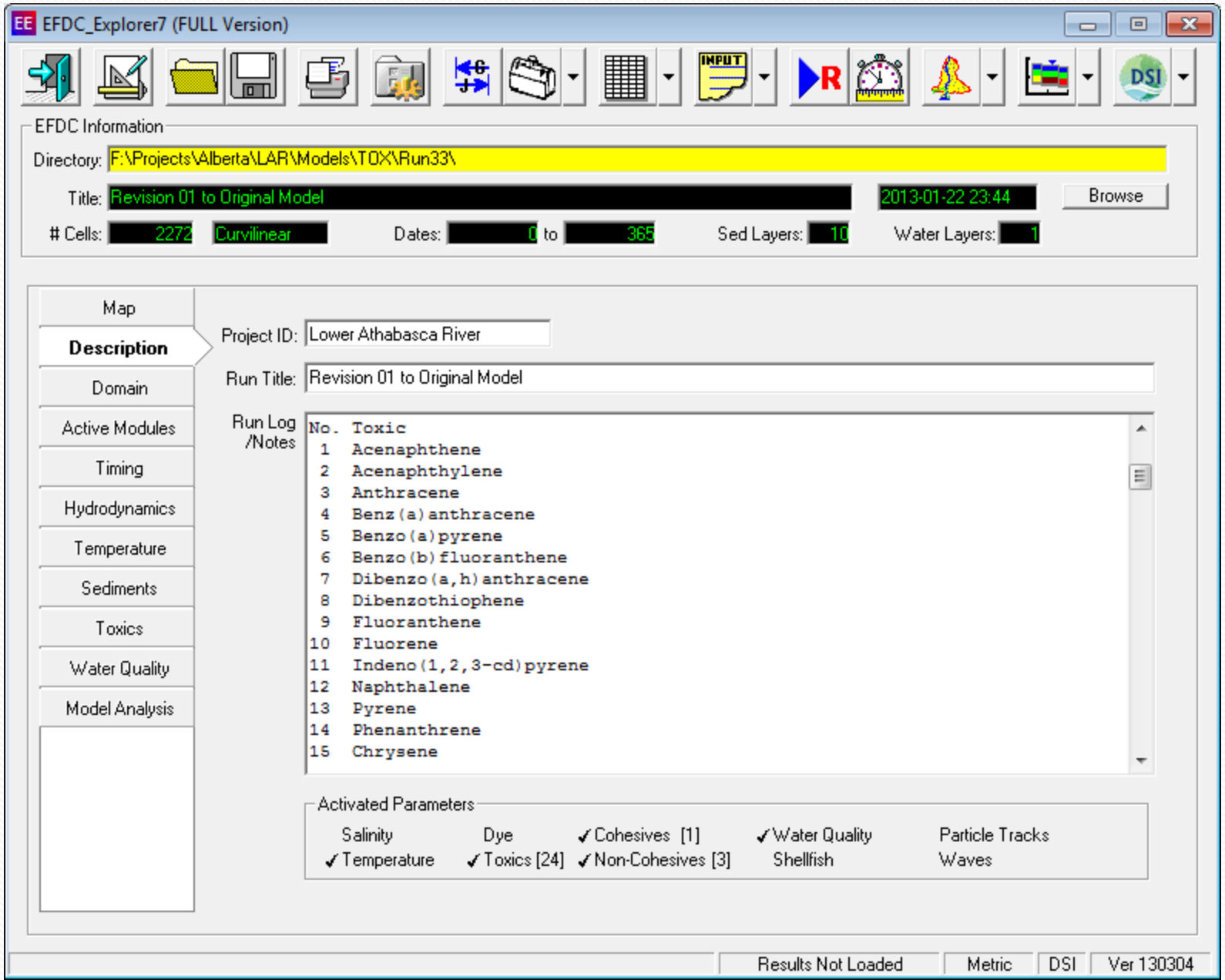


The Graphical User Interface for EFDC

EFDC_Explorer

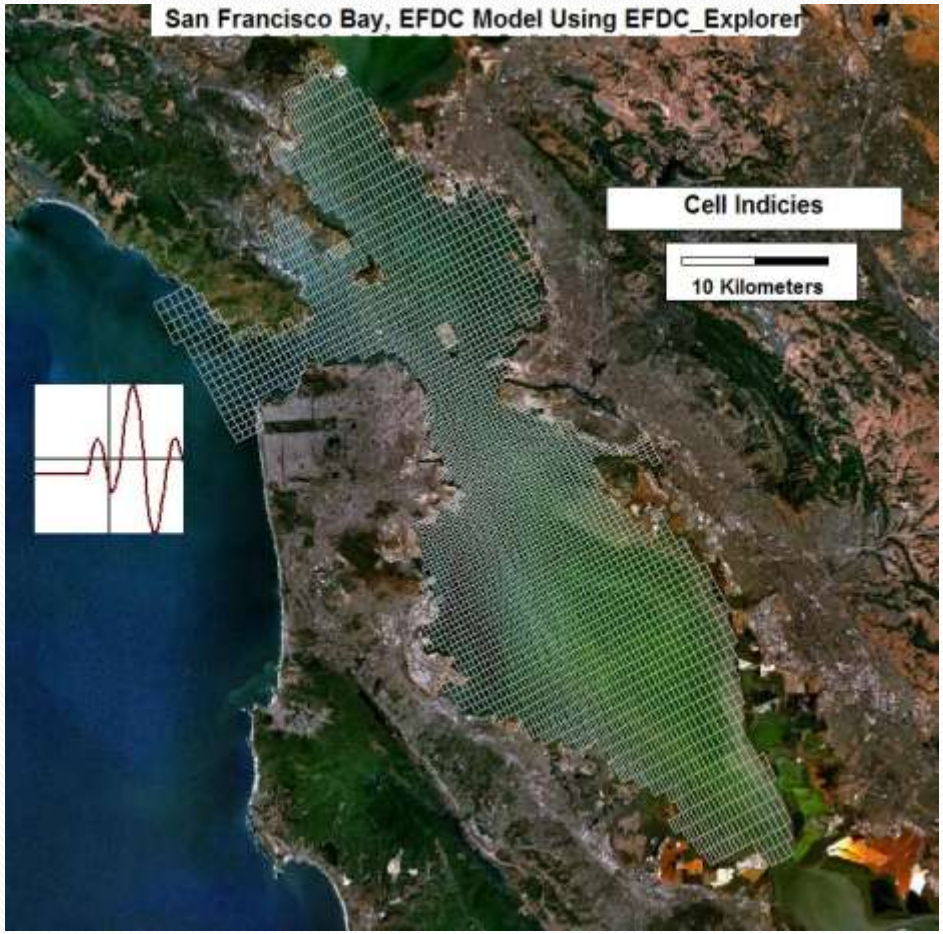


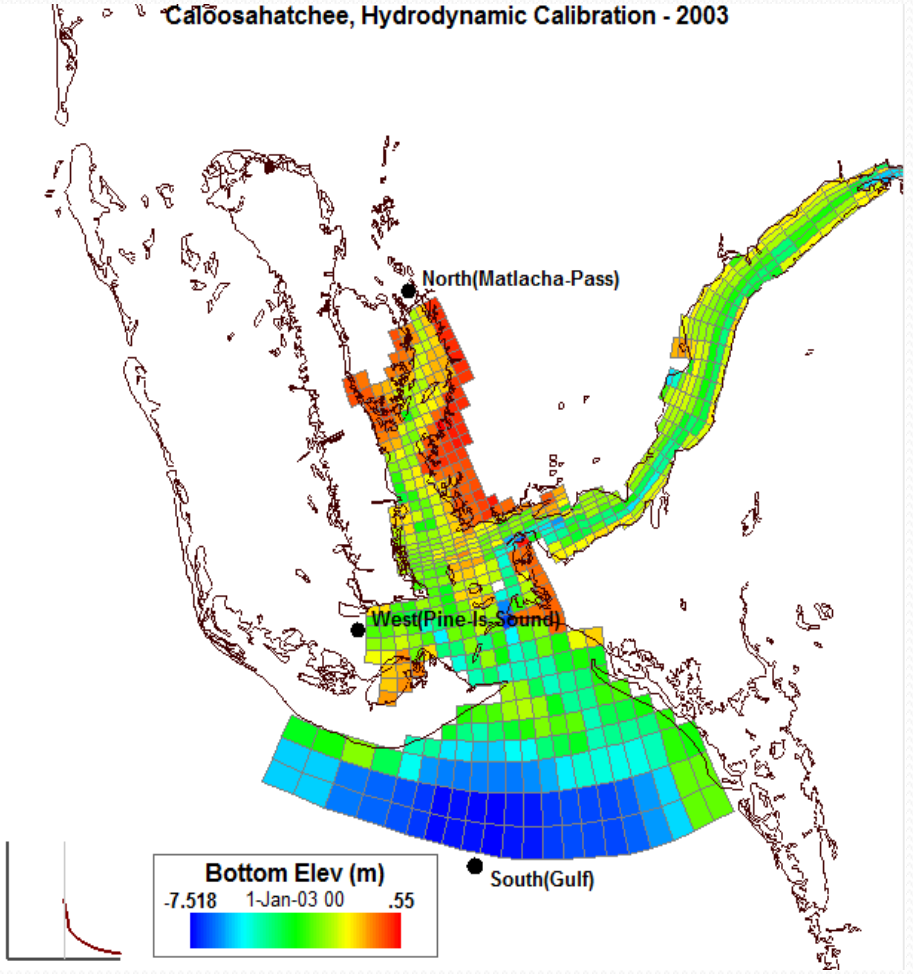
EFDC_Explorer Main Form



Example Grids

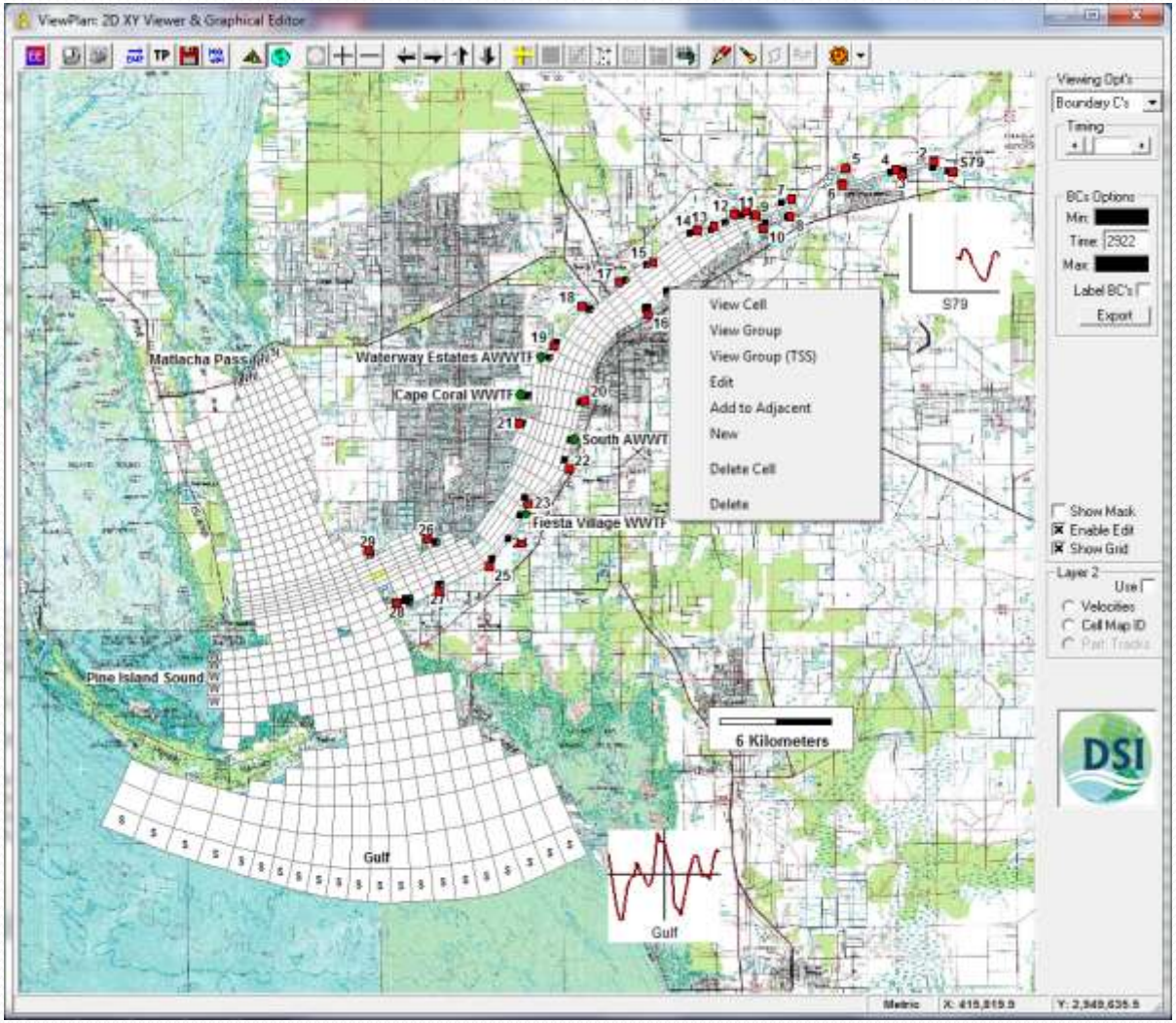
Rotated and Telescoping Cartesian Grids





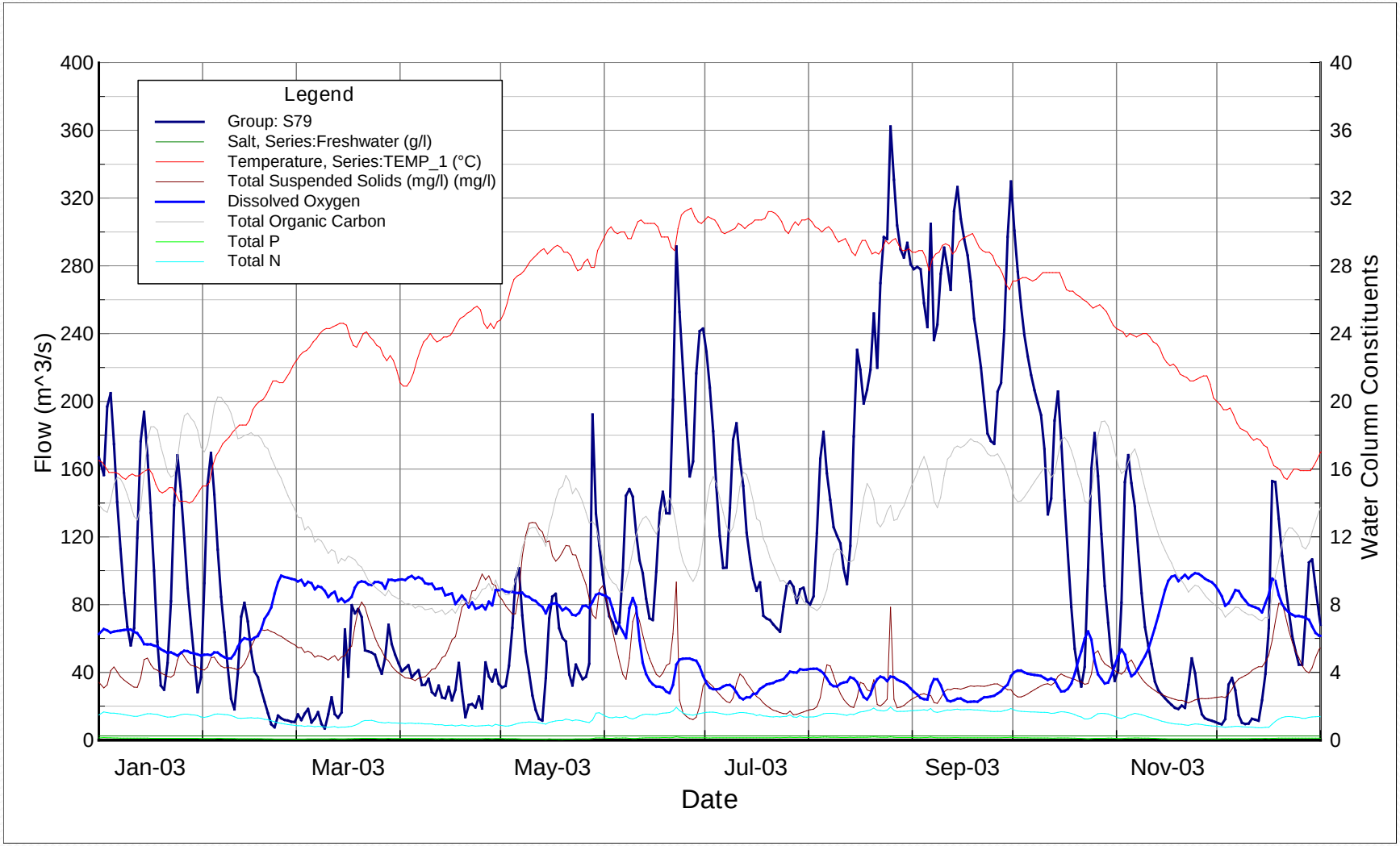
Orthogonal Curvilinear Grid

Boundary Condition Assignment



- Flow
- Withdrawal/ Return
- Open (EWNS)
- Hydraulic Structure
  - At Boundary
  - Internal
- EE Management
  - By Group

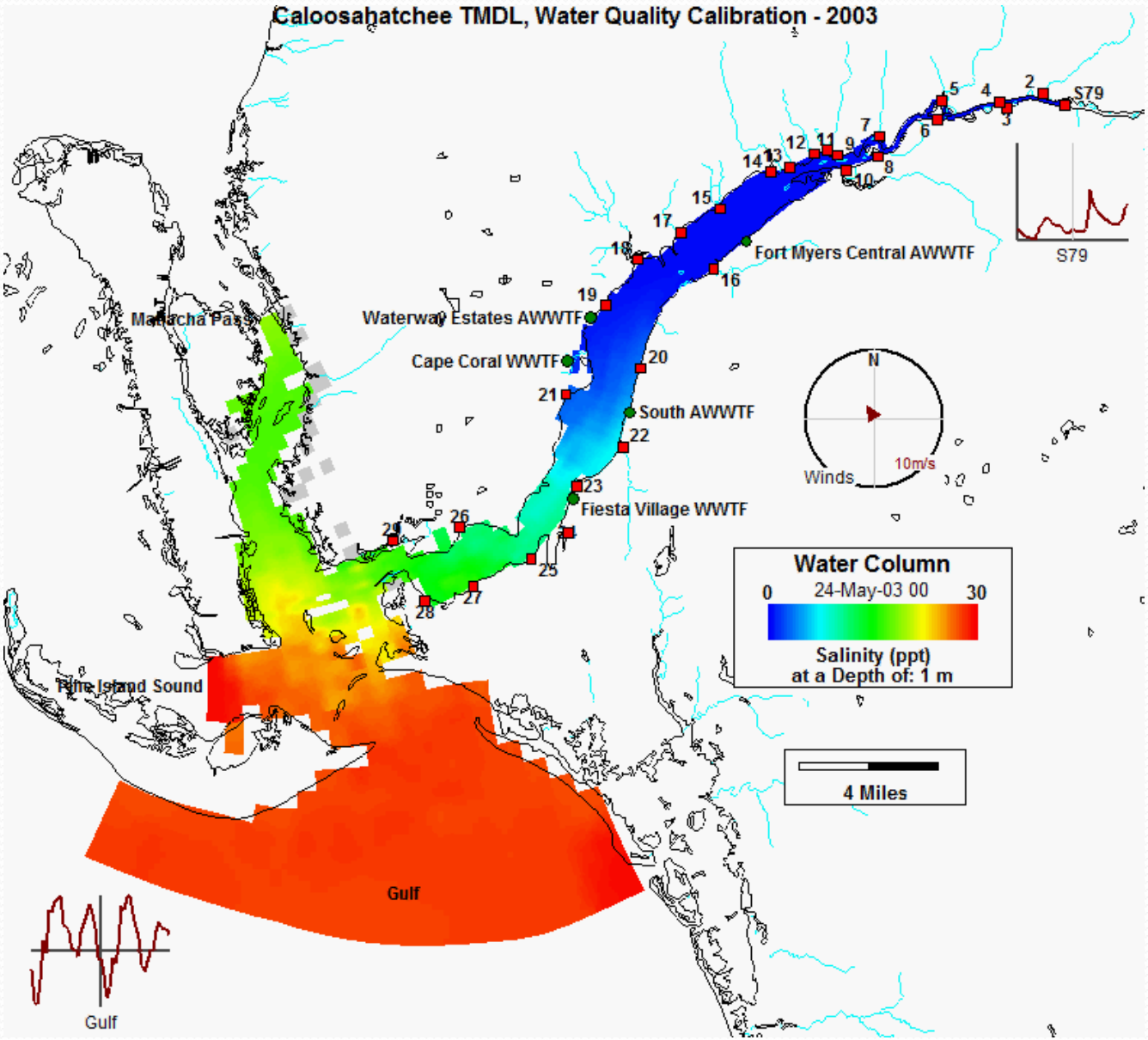
Boundary Condition Plots



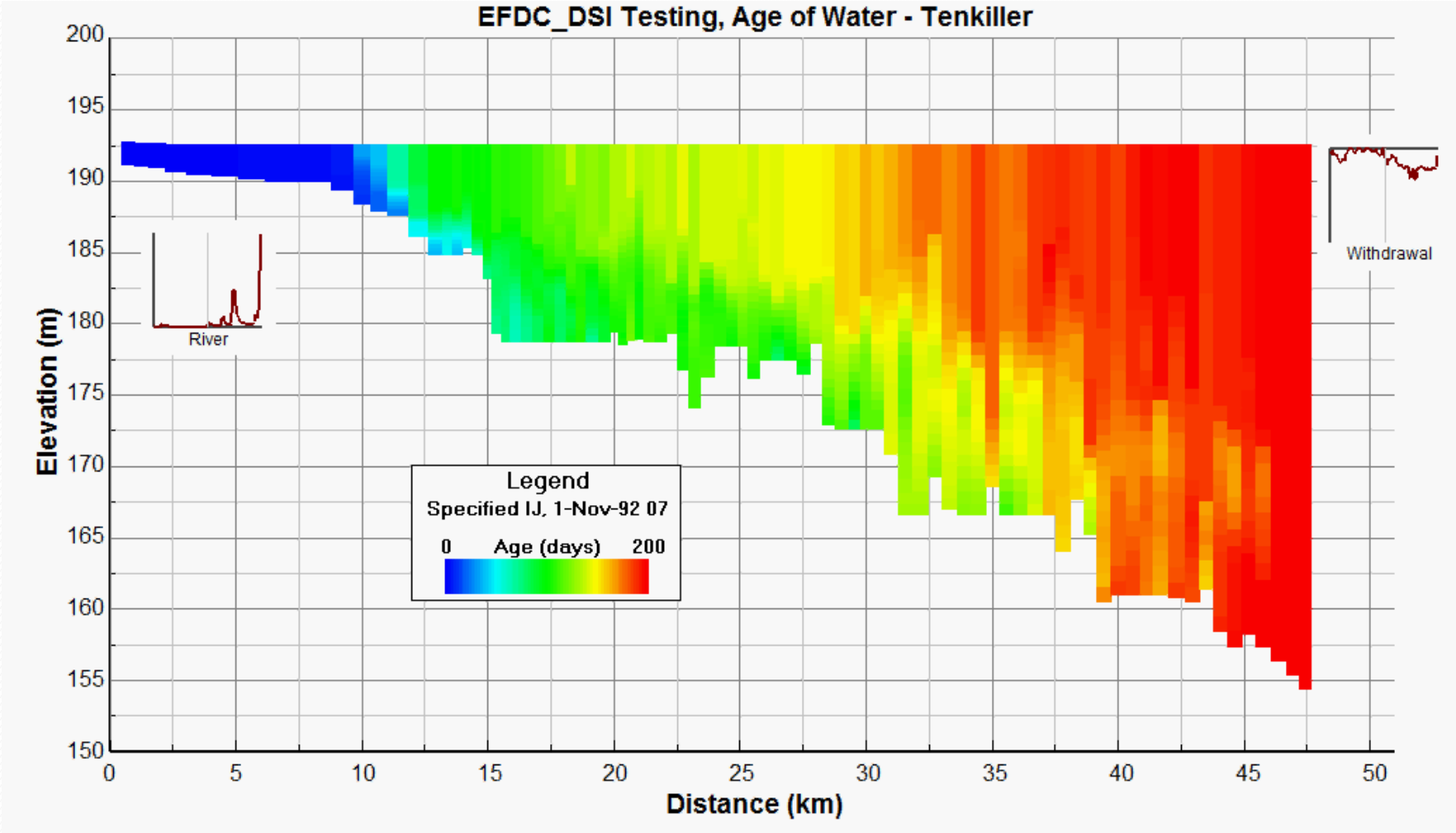
Model Calibration

- Plots
  - Time Series
  - Correlation Plots
  - Vertical Profiles
  - Plan View Overlays
- Statistics
  - Average
  - Relative
  - Absolute
  - Root Mean Square
  - Relative RMS
  - Nash-Sutcliffe
  - Model Bias
  - R-Squared (CP Only)

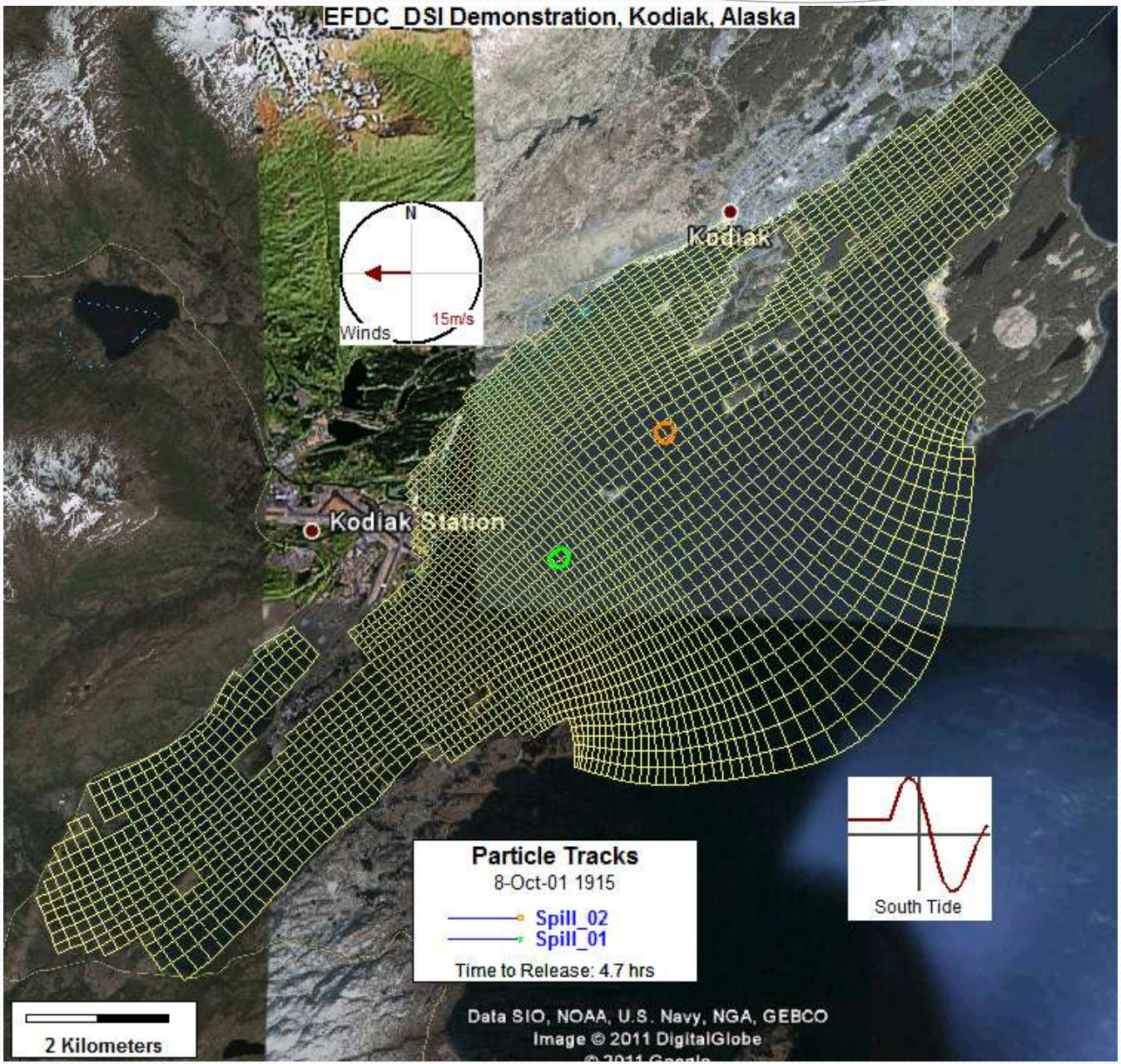
2D Plan View – Salinity



Age of Water – Reservoir



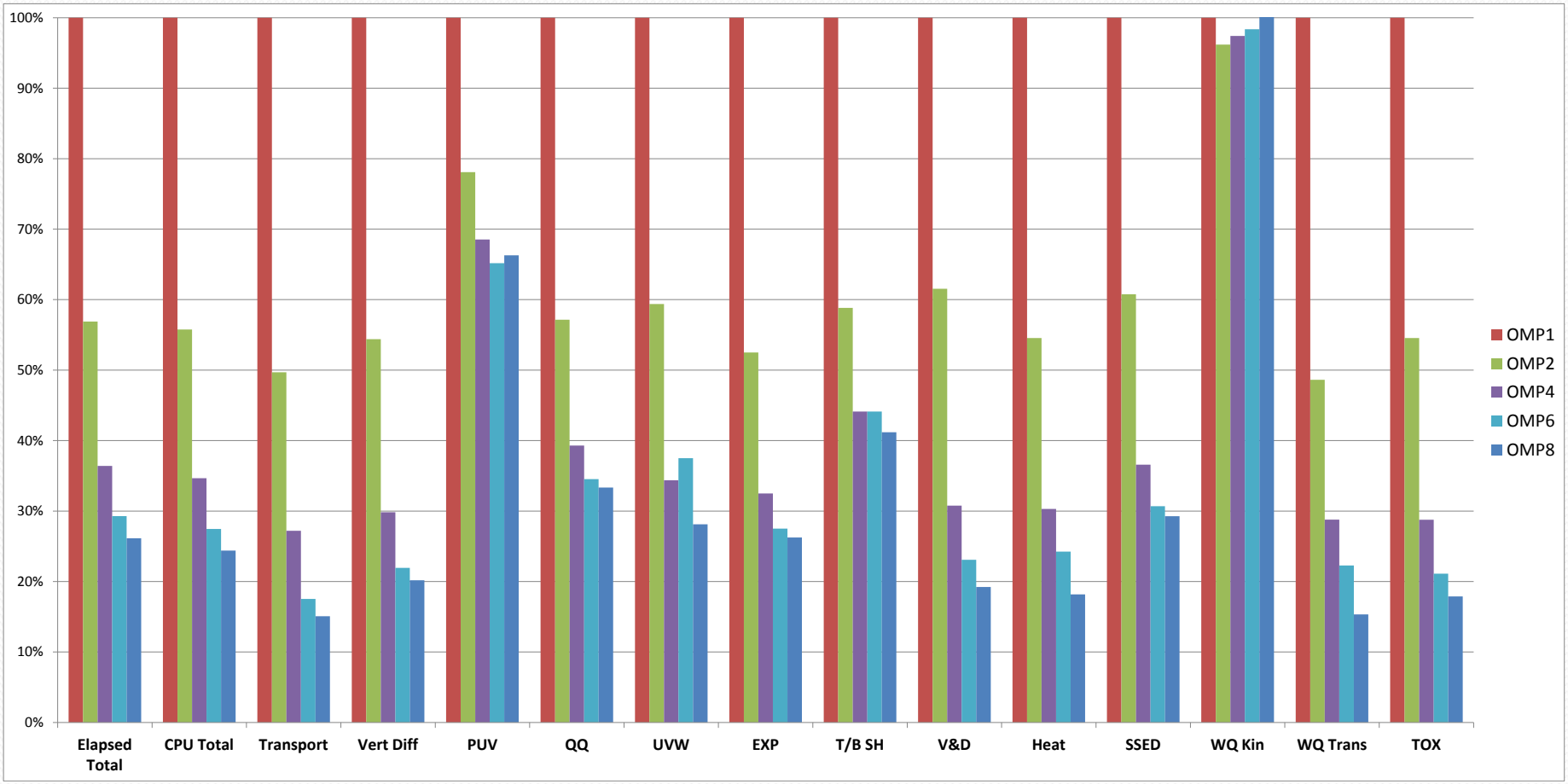
Hypothetical Oil Spill- Kodiak, AK



openMP
Multi-threaded EFDC_DSI

- Remarkably faster run times, proportional to the number of processors being used.
- Number of cores used fully configurable by the user.
- Run times up to 6 times faster on a eight core processor than the conventional single-threaded EFDC model.
- Working with Linux and Windows.

Time Saving with openMP for the Lower Athabasca Toxics Model



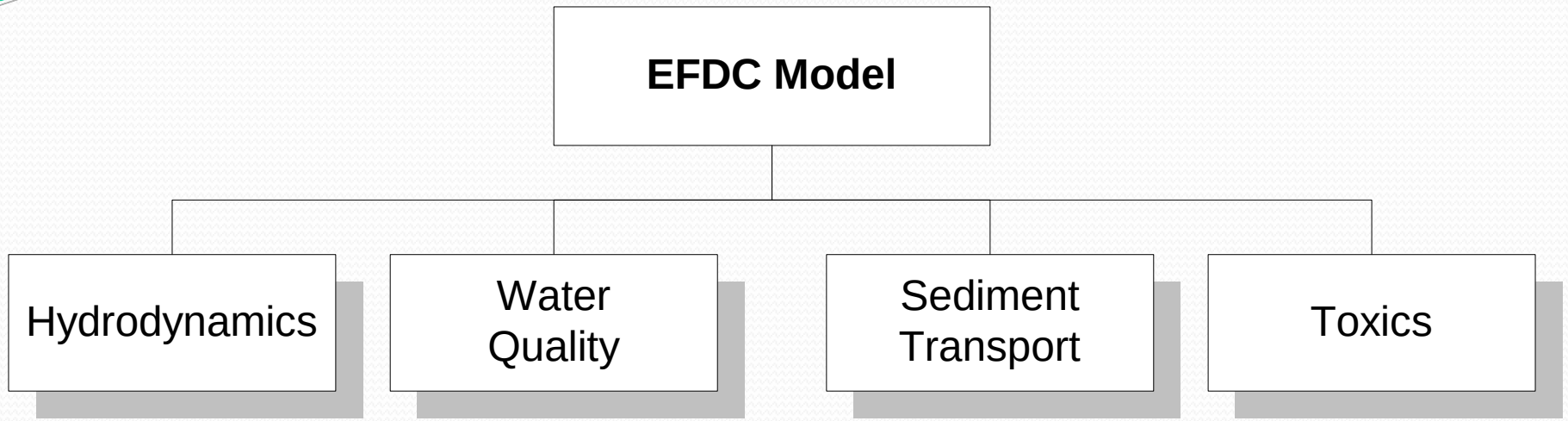
Testing and Quality Assurance

- All EFDC and EFDC_DSI features tested against text literature test cases
- Multiple example models available online for download on our website:
  - www.efdc-explorer.com
- EE has in-built pop-ups for user help, shortcut keys summaries, and a comprehensive user manual
- Pre-Run checks with more being added every month.

Recent Enhancements

- Automated calibration plots and tables
- Sediment grainsize core management tool
- Multiple Timing Frames
- Fixed depth and/or elevation extraction of model results:
  - 2D Plan view
  - Time series/calibration plots
- Write KML files for grid and model 2D fields, Read KML overlays
- Added DOC as one of the light extinction dependent variables
- Incorporated OMP for more of the sub-models
- 3D Perspective visualizations (EE7.1)

EFDC/EFDC_Explorer Packages



- 1,2,3D Capable
- Internal wind waves
- Linked to many wave models
- Vegetation
- Lagrangian Particle Tracking
- Wetting/Drying
- Dye/Age of Water

- Eutrophication
- 21 state variables
- Sediment Diagenesis

- User specified number of sediment classes
- Cohesive(s)
- Non-cohesives
- Bedload

- Metals
- Persistent organic pollutants
- 1-2-3 Phase adsorption

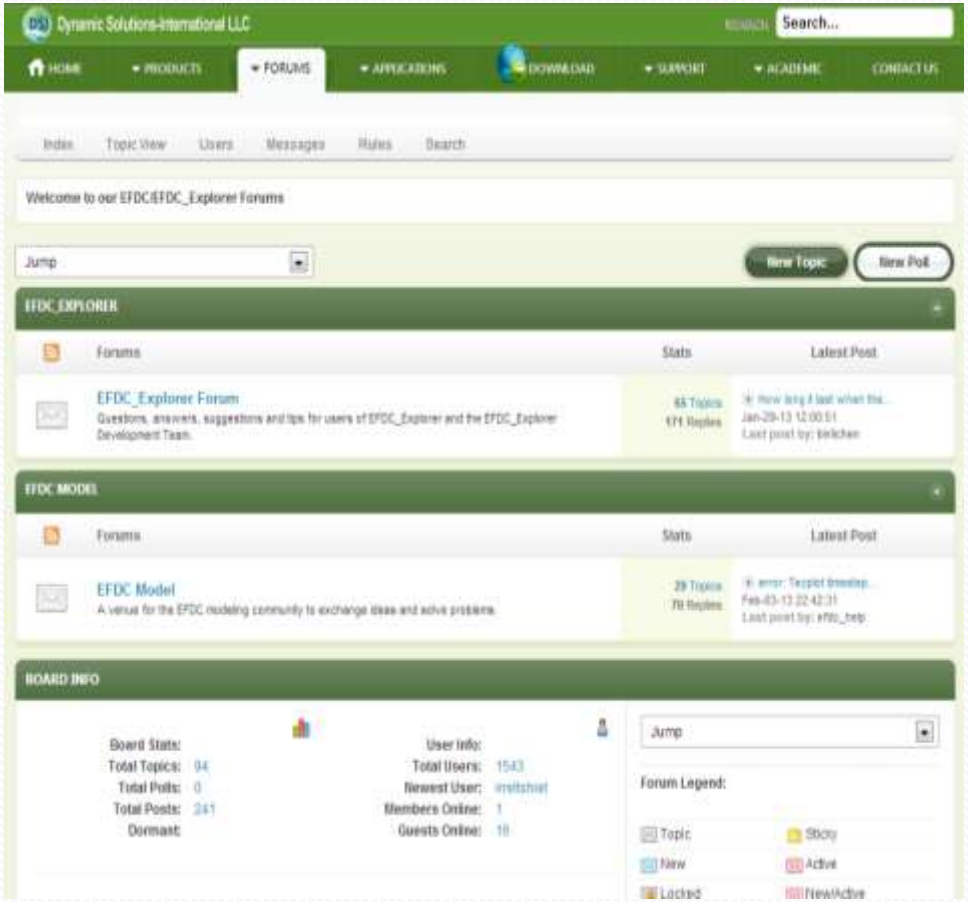
EFDC_DSI_SGL | EFDC_DSI_OMP (Optional)

EE WEB Version **EE FULL Version**

EFDC_Explorer

Web Site

www.efdc-explorer.com



EFDC_Explorer

EE User Community

www.efdc-explorer.com/forum

Contact Information

- www.ds-international.biz
- www.efdc-explorer.com
- Paul M. Craig, P.E.
  - pmcraig@ds-intl.biz
- EFDC_Explorer Development Team
  - ee_info@ds-intl.biz