# HEC-HMS

*Hydrologic Modeling System*

# HEC-HMS (Hydrologic Modeling System)

**Purpose**:

1. ***Rainfall-Runoff model, water quality***

2. **Decision making:** used for both (1) real-time operation OR (2) long term planning

**Model characteristics:**

1. **Type of model:** Simulates the hydrologic cycle given different precipitation/temp inputs: runoff, infiltration, ET, water quality, snow pack, simple reservoir flows, can be modeled as a lumped model or spatially distributed (gridded)

2. **How can we view this model?**

   - **Spatially:** two dimensions (map interface)

   - **Resolution**: User/need dependent, organized at the basin level – basins can range from the drainage area for a small town to the entire Mekong River basin

   - **Time period:** User/need dependent, can be run for event-based analysis or for n-year simulation (time step generally minutes to hours)

# Impact:
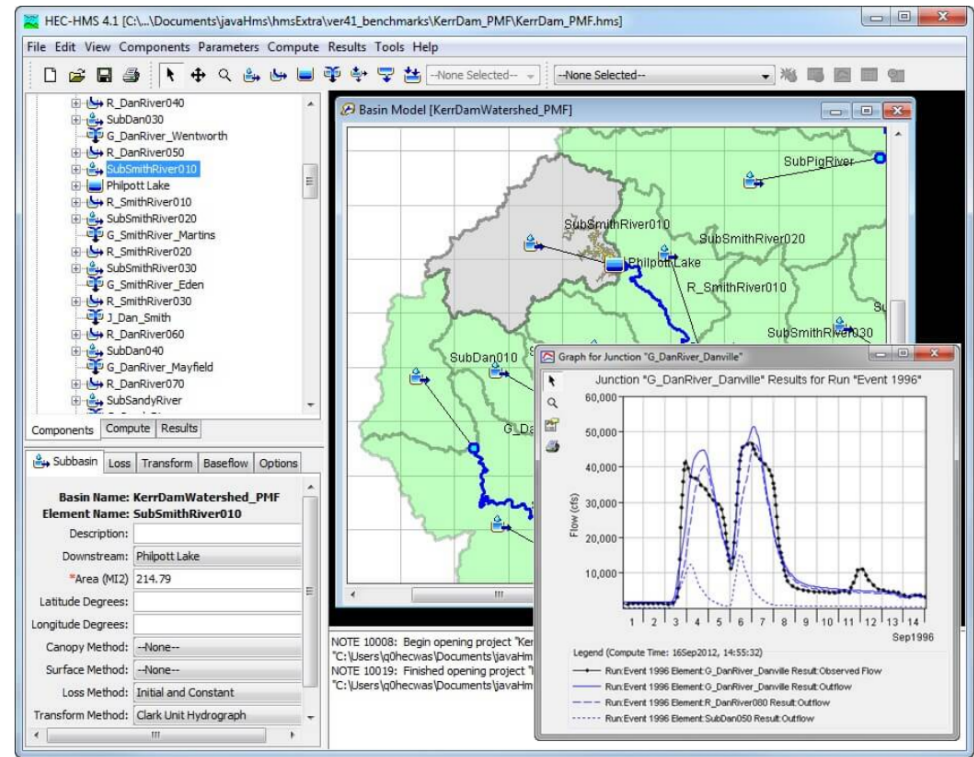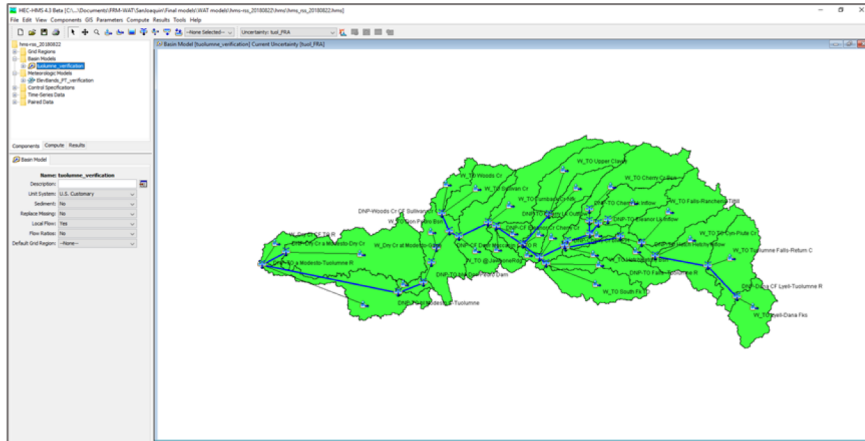


- **Natural:** Simulates flow/water quality impacts of changes in basin land cover (e.g., forested vs. urban), can explore impacts of changes in precip/temp on flows/water quality/snow.

- **Social:** Can simulate inflows to reservoirs based on different weather regimes, development scenarios

- **Gov./Inst:** Can test/support policies related to land development/zoning

- **Mekong:** Useful for evaluating impacts of different weather (precip/temp) regimes and land development plans throughout Mekong Basin

# Result and Implications

- **EXAMPLE result**: Hourly inflows to reservoirs, monthly snow pack by subbasin, monthly subbasin infiltration volume
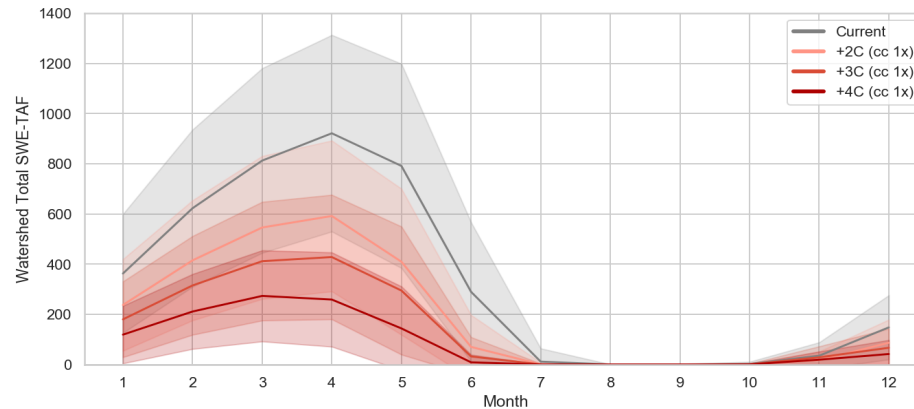


- HEC-HMS can be used to forecast stream flows for real-time operations (input to HEC-ResSim), can be used in a planning context for developing hydrology for drought or extreme events for operations or dam safety studies.

- HEC-HMS can be used to inform policy prescription/change related to land development, climate change impacts on runoff/water quality, etc.
  - E.g., Impacts of deforestation on dry season flows and sediment loading in the mainstream Mekong River

- A single joint HMS model can be created for the Mekong River Basin

# HEC-ResSIM

*Reservoir System Simulation*

# HEC-ResSim (Reservoir System Simulation)

**Purpose**:

1. *Reservoir Operations*

2. **Decision making:** used for both (1) real-time operation and (2) long term planning real-time operation

**Model characteristics:**

1. **Type of model:** Simulates regulated flows from one or more reservoirs for multiple purposes; simple and complex systems

2. **How can we view this model?**
   - **Spatially:** Two dimensions (map interface)
   - **Resolution:** User defined and problem specific (single reservoir to large reservoir system)
   - **Time period:** User defined and problem specific (hours to years)

# Impact:

- **Natural:** It is used for environmental flows and examining impact of operations on flow regimes / habitat needs, etc,

- **Social:** Supports operations and planning for Flood, Water Supply, Hydropower, and Recreation.

- **Gov/Inst:** It is can be used with HEC-WAT to analyze operational alternatives using risk analysis approach for trans-boundary negotiations (e.g. Columbia River Treaty)

- **Gov/Inst:** Government water policies are simulated and tested / applied.

- **Mekong:** Useful for integrated operations and evaluation of mainstream and tributary reservoirs throughout the Mekong.
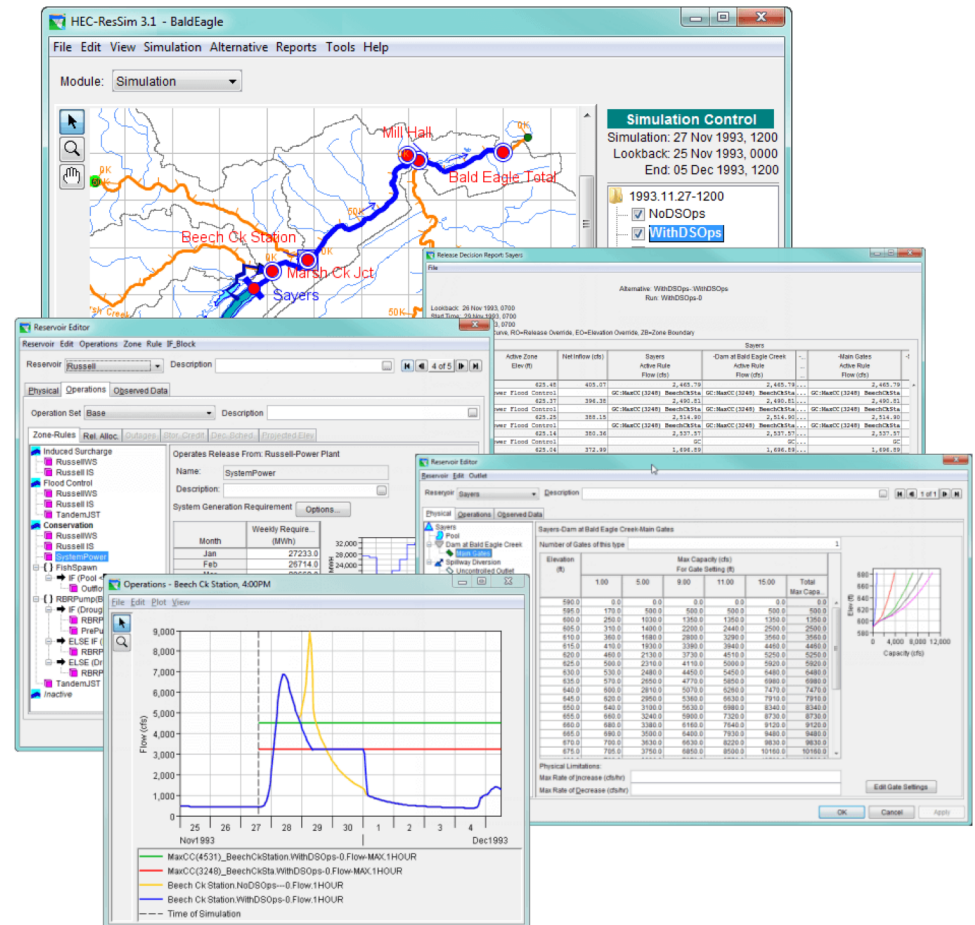
# Result and Implications

- **Example Result:** Model output can reflect reservoir water/sediment levels and outflows associated with different operational alternatives.

impacts of reservoir sedimentation in the Mekong on hydropower generation and reservoir sustainability (SIM through Ministry of Energy and Mines, Lao PDR)
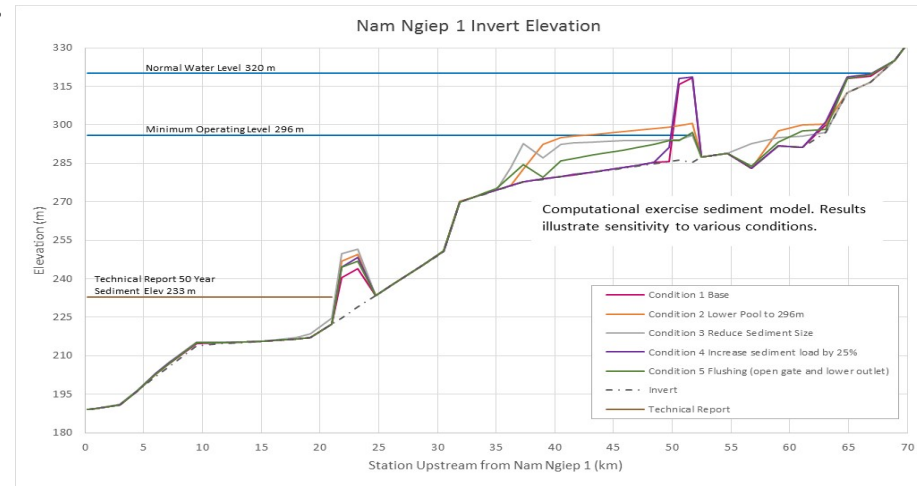


- ResSim can be used for operations and decision support including real-time and longer-term. Can use HEC-HMS to generate streamflow forecasts to be input into ResSIM.

- ResSim can support examining the shared benefits of coordinated operations of Mekong dams.
  - For example, coordinated regional or system operations to enhance resilience to droughts, or to sustain tidal flows into Tonle Sap.

- ResSim is used for the examination of operational alternatives to make recommendations for individual projects and system operations. Theses results can be used to develop, inform, or adjust policy.

- A single ResSim model can be created for the Mekong River System.

# HEC-RAS

*River Analysis System*

# HEC-RAS (River Analysis System)

**Purpose**:

1. **One and two dimensional River Hydraulics**

2. **Decision making:** used for both (1) long term planning OR (2) real-time operation

**Model** **characteristics:**

1. **Type of model:** simulates river velocities, stages, profiles, inundation area, flow / flood depths, sediment transport and deposition, water quality, dam break analysis

2. **How can we view this model?**
   - **Spatially:** one or two dimensions (map interface), some 3D visualizations
   - **Resolution**: User/need defined.
   - **Time period:** User/need defined (usually encompassing storm events of interest but flow time series are also simulated and can extend to decades)

# Impact:
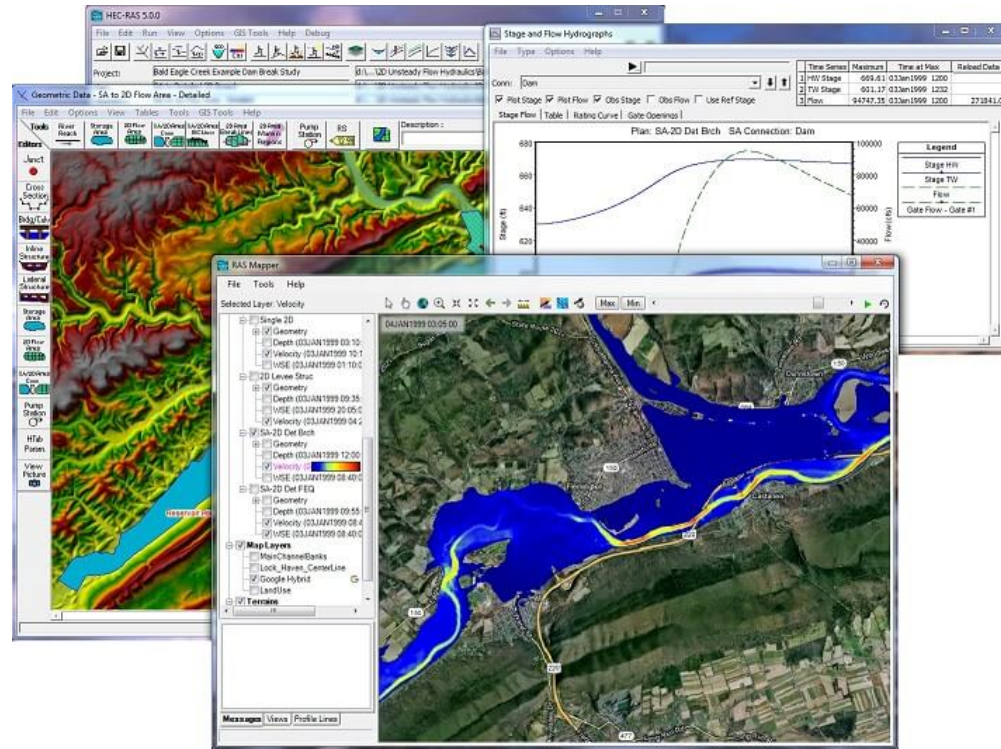


- **Natural:** Used to evaluate plans for ecosystem restoration or sustainability by linking with HEC-EFM (establishing ecosystem flow regimes), and habitat suitability (sediment balance)

- **Social:** Used to evaluate plans to reduce economic, cultural, critical infrastructure losses, as well as reduce loss of life.

- **Gov./Inst:** Used to inform strategies and policies related flood risk reduction and ecosystems

- **Mekong:** Can and does support Mekong challenges in sediment and flood risk management

# Result and Implications

- **EXAMPLE result**: Inundation boundaries and depth maps are viewed and used for consequence estimates but also great way to inform public of risk
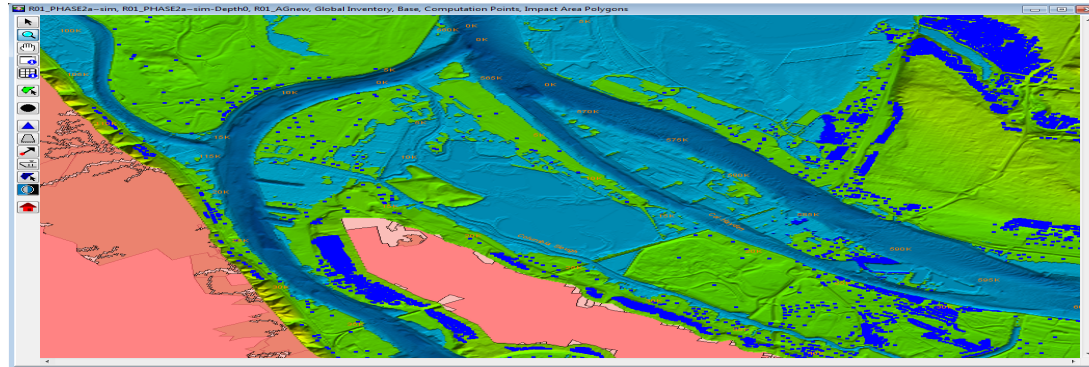


- HEC-RAS can be used to inform policy prescription/change related to flood risk, designing flow regimes, and sediment management
    - E.g. Flows from reservoir operations upstream in Mekong River with a tidal downstream effects can be used to prescribe operations for needed Tonle Sap flows and inundation.

- HEC-RAS models have been and can be created for the various reaches of Mekong River Basin, the tributaries, and even be integrated into a single model.
    - E.g, HEC-RAS was used to evaluate flood inundation due to Indian Ocean cyclones in Myanmar. (LMI with Ministry of Agriculture, Livestock, and Irrigation (MOALI).

# HEC-FIA / HEC-FDA

*Flood Impact Analysis / Flood Damage Reduction Analysis*

# HEC-FIA / HEC-FDA

Flood Impact Assessment / Flood Damage Reduction Analysis

**Purpose**:

1. **Identify consequences from a flood event and evaluate risk of different alternatives**

2. **Decision making:** used for long term planning

**Model characteristics:**

1. **Type of model:** Event damages, expected annual damages, consequences (losses to structures and their contents, agricultural losses, and expected life loss).

2. **How can we view this model?**

   - **Spatially:** one and two dimensional, Maps, tables and curves

   - **Resolution**: user/needs defined

   - **Time period:** FIA is an event-based model that can process unsteady hydraulic data, FDA analyzes steady state (flood peak only) probabilistic exceedance functions.

# **Impact**:
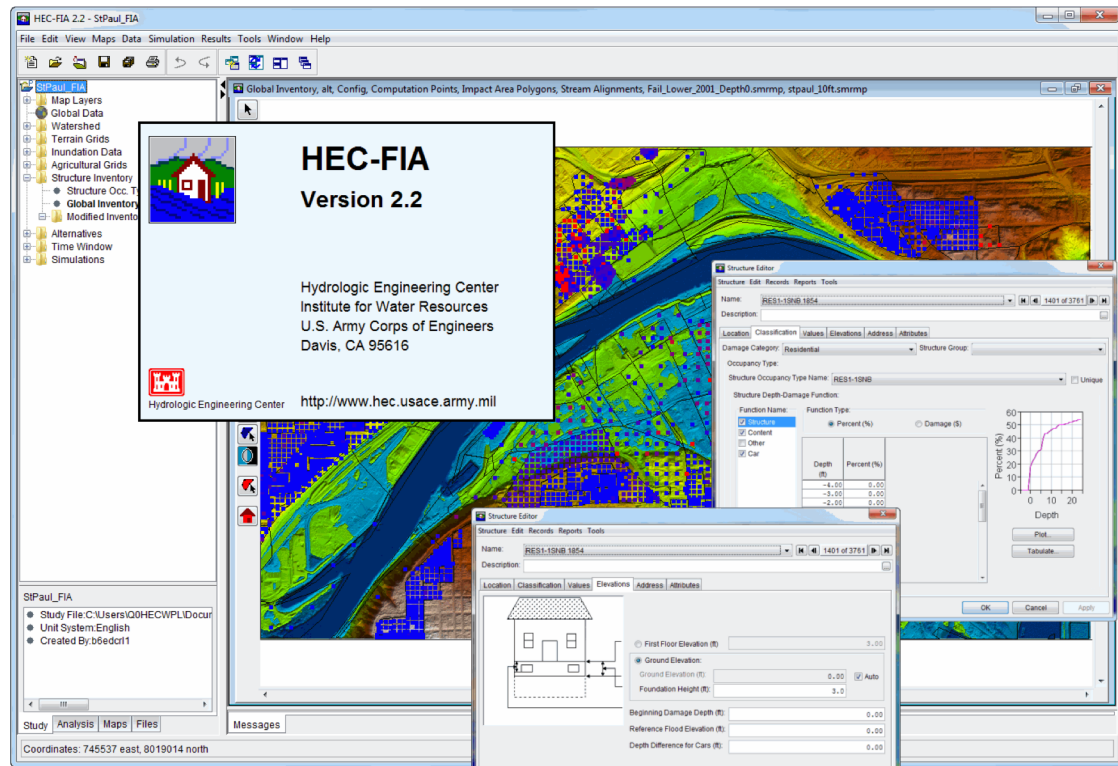


- **Natural:** It is used to estimate agricultural losses, and might be extended to other natural environment purposes

- **Social:** Used to evaluate plans to reduce economic, cultural, critical infrastructure losses, as well as reduce loss of life.

- **Gov./Inst:** Used to justify/recommend strategies and policies related flood risk reduction

- **Mekong:** It could be used for the social and economic analysis of beneficial or damaging flooding in the Mekong.

# Result and Implications

- **EXAMPLE result**:

Expected Annual

Damages to Structures
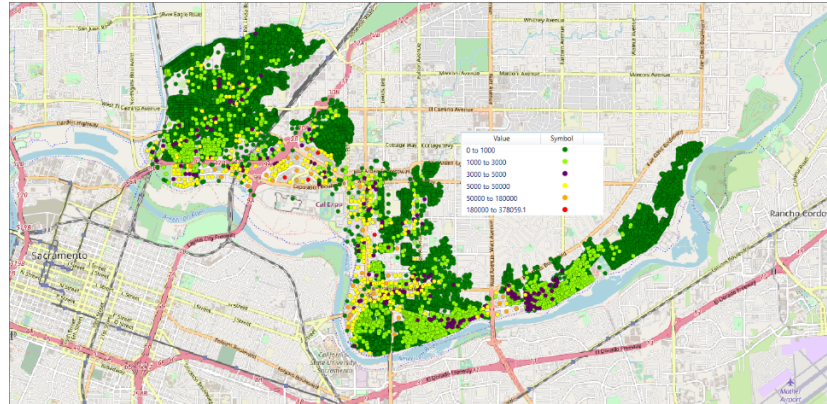


- HEC-FIA/FDA can be used to inform policy prescription/change related to flood risk
  - E.g. Quantify flood risk reduction from reservoir operations.
- HEC-FIA/FDA could be applied in the Mekong

# HEC-RTS / HEC-WAT

*Real-Time Simulation / Watershed Analysis Tool*

# HEC-RTS / HEC-WAT

*Real Time Simulation / Watershed Analysis Tool*

**Purpose**:

1.  **Model Integration Tools** – Links input metrological or stream flow data to multiple water resource models including **hydrologic, reservoir operations, hydraulic** (flood depths), and **economic** flood damages/life loss estimation models

2.  **Decision making:** HEC-WAT for (1) planning and long-term simulation, HEC-RTS for (2) real-time operation

Model characteristics:

1.  **Type of model:** Both HEC-WAT and HEC-RTS are frameworks that link multiple HEC models together to simulate rainfall-runoff processes (HEC-HMS), reservoir operations (HEC-ResSIM), downstream flood depths (HEC-RAS), and economic impacts (HEC-FIA). HEC-WAT is of a planning tool, set up for long-term simulations of historical/projected climate (for multiple purposes). HEC-RTS links to current precip/temp forecasts to inform real-time reservoir operations (generally for flood).

2.  **How can we view this model?**
    *   **Spatially:** two-three dimensions (map interface, HEC-RAS does allow some 3D visualization of channel flow/stage)
    *   **Resolution**: User/need dependent
    *   **Time period:** User/need dependent (generally HEC-RTS focused on near future, hours to days/weeks; HEC-WAT focused on long-term system performance). The input data time steps are daily or sub-daily
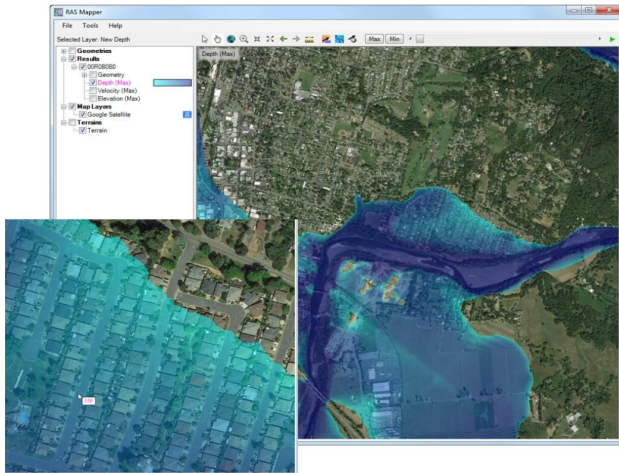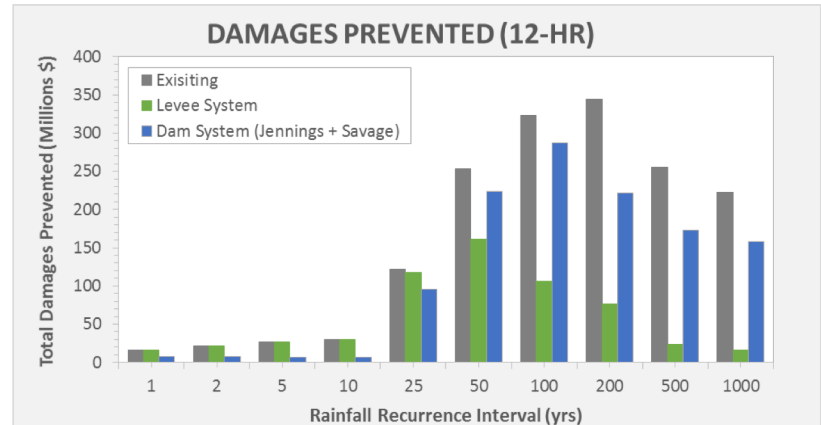
# Impact:

**HEC-RTS**
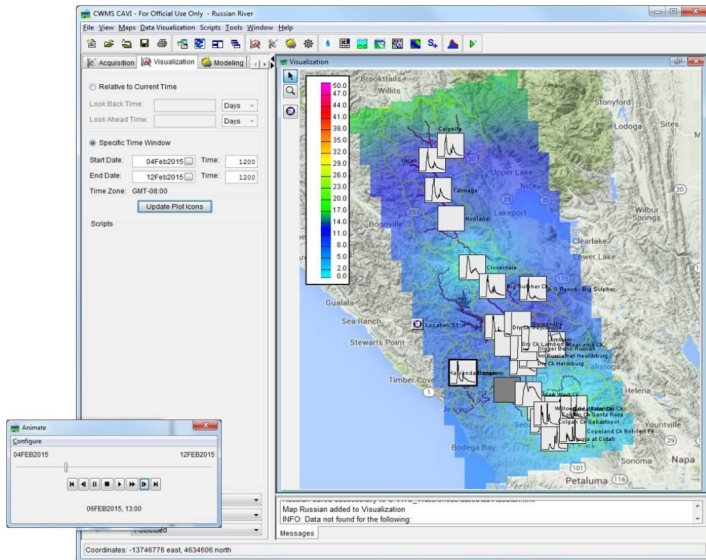


**HEC-WAT**
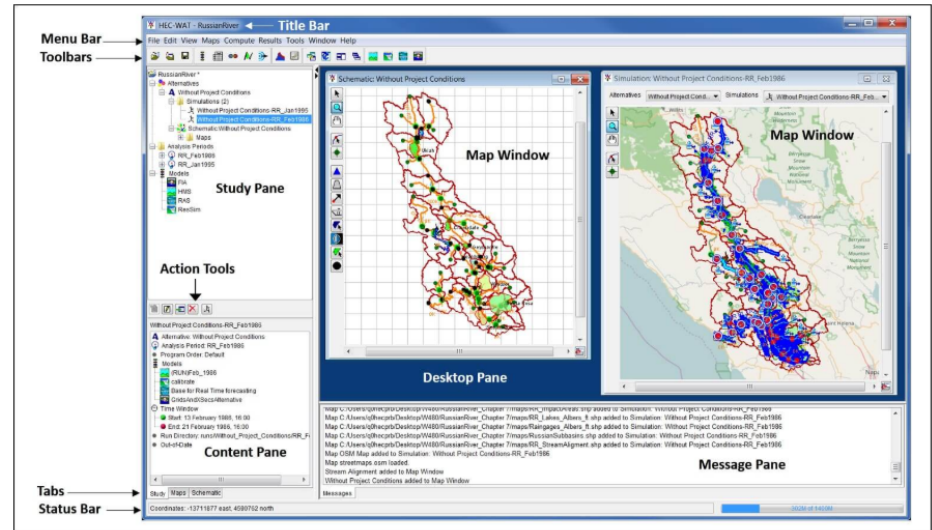


- **Natural:** RTS (can forecast in real-time e-flows, habitat flooding), WAT (long-term impacts on frequency/magnitude of e-flows / habitat flooding / water quality of different development/operation alternatives)

- **Social:** RTS (can forecast in real-time potential high flows/flooding in populated areas), WAT (long-term impacts on flooding / drought frequency/magnitude of different development/operation alternatives)

- **Gov/Inst:** RTS (support real-time flood/drought response, evacuation, emergency actions), WAT (can support land development/reservoir operation policy evaluation/updates/changes)

- **Mekong:** RTS (support real-time flood/drought forecasting and coordinating operations in response to an evolving event), WAT (support planning and evaluation of alternatives for ecosystem restoration, flood and drought risk management, sediment management, etc.)

# Result and Implications

- **EXAMPLE results:** HMS (reservoir inflows, snow pack, infiltration volumes), ResSIM (reservoir outflows, pool levels), RAS (channel flows, stages), FIA (flood event damages, life loss)

**HEC-WAT**



- **HEC-WAT** is used to inform policy prescription/change related to land development, climate change impacts on runoff/water quality, reservoir operations. **HEC-RTS** is used to inform decisions in real-time related to floods (and can be used for droughts)

  - WAT – Joint operations of reservoir system in Lower Mekong Basin for drought/flood management + Land development policies

  - RTS – Reservoir operations/emergency response actions during flood events in the Lower Mekong Basin

- Single joint HEC-WAT and HEC-RTS models can be created for the Mekong River Basin