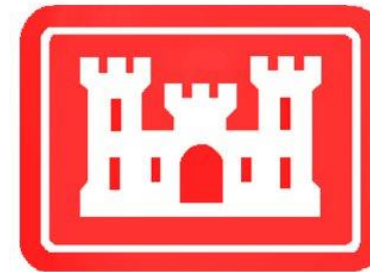


Benefits Modeling with RiverWare and Corps Water Management System (CWMS) in Tulsa District

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Samantha Palmason
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30 August 2023



**US Army Corps
of Engineers**®
Tulsa District

2019 Flooding Near the Arkansas, Neosho, Verdigris Rivers Confluence

Image from News on 6 and ADS



Why Model Flood Damages Reduced?

Yearly reporting required by Congress on flood damages reduced.

Provide regulated and unregulated datasets for studies and planning projects.

Visualize extents of flooding with and without projects using latest calibrated hydraulic models.

Structure by structure damage assessment using the latest National Structure Inventories (NSI).

Uses Cropland Data Layers (CropScape) to determine Agricultural Flood Damages reduced.

Legacy process uses depth-damage curves developed in the 60's and 70's which is time and recourse intensive to update.

How has Tulsa District modeled H&H outputs for flood damages reduced in the past?

1990's-2016: PC version of Hydrologic Engineering Center (HEC) 1

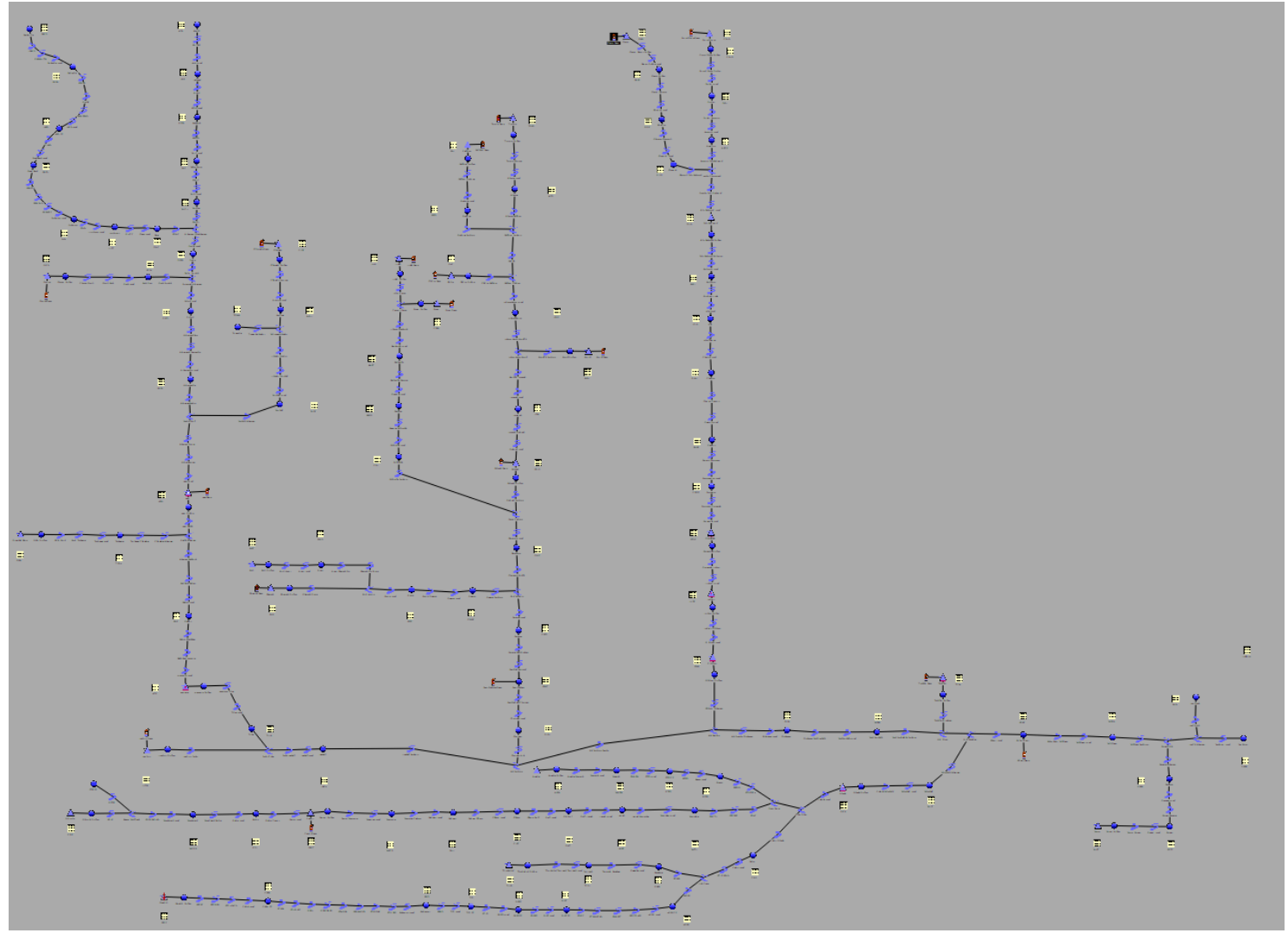
2016-2023: HEC-1 converted to RiverWare

2023-future: RiverWare with results then used in CWMS

How Tulsa District models Benefits Currently

- 6-hour timestep model run for each separate flood event.
 - Run models throughout the year to check for times when unregulated flow are above regulating.
- Use only post event observed data from all stream and dam gages.
- Run observed data through a “Locals” script in RiverWare to calculate incremental locals for each non-headwater gage.
 - Simple routing model that takes routed flow from upstream and observed flow at the gage to subtract what the local flow for that drainage area is.
- Export locals to DSS and clean negative flows out.
- Import observed and locals through the “Unregulated” script in RiverWare.
 - Turn off all reservoir methods to only pass inflow.
 - Input headwater observed data and local inflows below.
 - The Unregulated script generate plots and tables of regulated “observed” vs unregulated flow and stage.
 - Final step of the script is to generate the report to send to our economist.
- District Economist takes RiverWare data and applies to older damage curves to convert from stage-flow to dollar amount of damages reduced.
- End of each fiscal year data is sent to Congress.

Current RiverWare Modeling Layout – Arkansas River



Current Modeling Snapshots

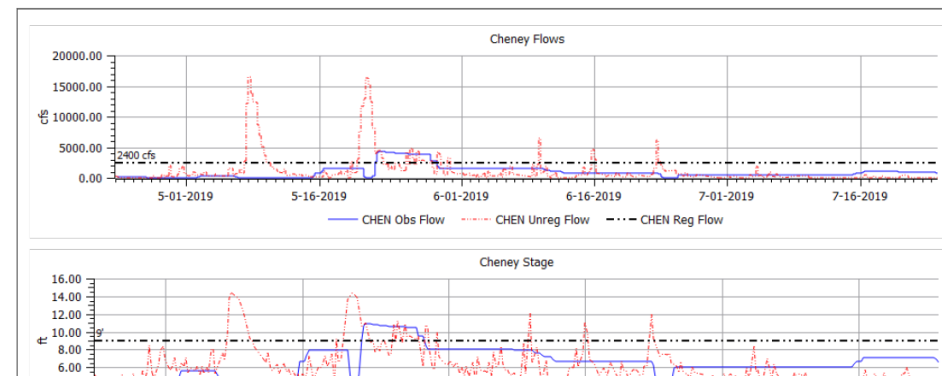
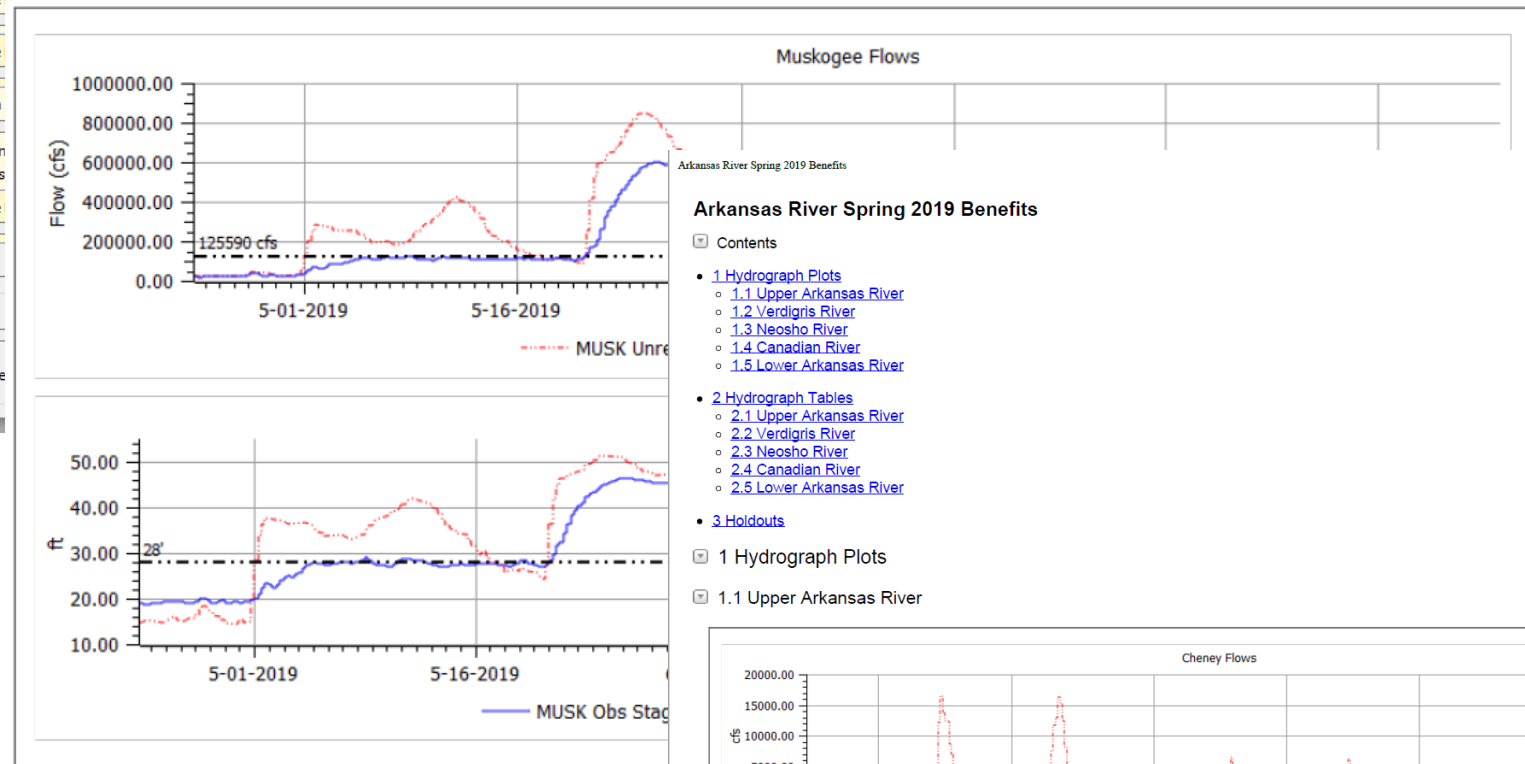
Local Calcs

- Clear values set by the **Locals DMI**
- Clear values set by the **Unregulated DMI**
- Set Disable Reservoir Processes to None
- Set Dummy Reaches to Calculate Local Inflows
- Set the run range to: **<unspecified> -- <unspecified>**
Use Start Date: ...
Use End Date: ...
- Execute the **Unregulated DMI**
- Execute the **Locals DMI**
- Execute run

Unregulated

- Clear values set by the **Locals DMI**
- Clear values set by the **Unregulated DMI**
- Set Calumet_EIReno.Inflow's flags to Output in the range: **Start Timestep - 1 Timesteps -- Start Timestep - 1 Timesteps**
- Set Reservoirs to Pass Inflows
- Set Dummy Reaches to Solve Outflow
- Execute the **Unregulated DMI**
- Execute run

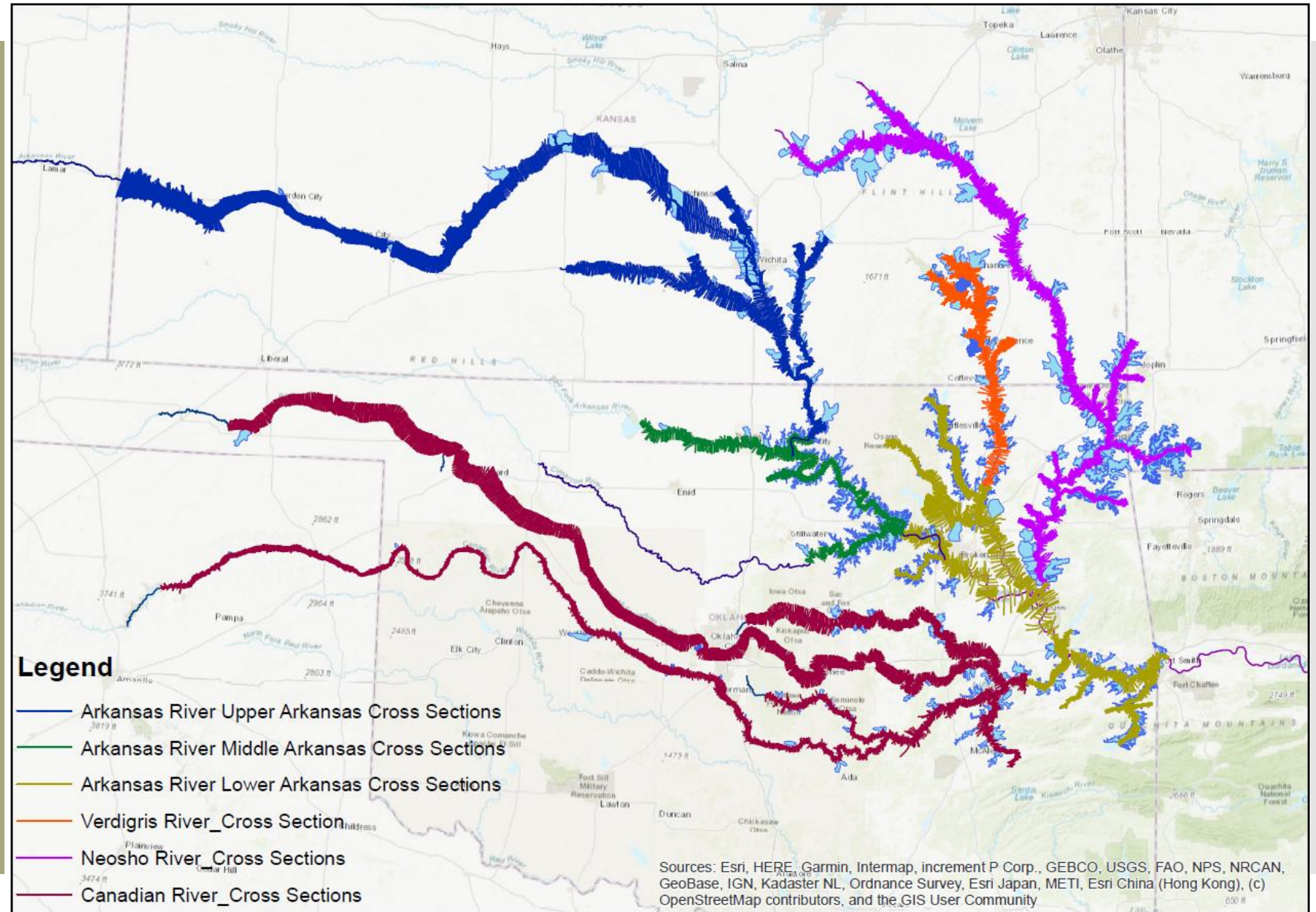
Execution
Run not s
Status: script not e



Work In Progress Benefits Modeling in RiverWare and CWMS

- Utilize RiverWare to calculate locals using a 1-hour timestep and “holdouts” for project distribution.
- RiverWare output is applied to the CWMS suite of modeling to compute flood damages reduced
 - HEC-Control and Visualization Interface (CAVI) connects the CWMS models through forecast alternatives and data extraction capabilities.
 - Data results are imported from standalone HEC-DSS-Vue file output from RiverWare to forecast.dss file used for the flood damage reduced forecast alternative
 - Hydrology outputs from Riverware are boundary conditions for HEC-River Analysis System (RAS)
 - RAS results then passed into HEC-Flood Impact Analysis (FIA) for the economic analysis
- RAS used to create mapping, depth, timing datasets.
- FIA contains land use and structure information to estimate damages.

CWMS RAS and FIA Model Extents for Flood Damages Reduced



CAVI Example

Forecast Run Editor

Forecast Run

Name	Key	Description
Canton RAS Only	-----C0--	This only contains the RAS extents for the CA...
Eufaula RAS Only	-----E0E0--	This only contains the RAS extents for the EU...
Bridgeport RAS Only	-----B0--	This only contains the RAS extents for the BR...
Canadian River System Model (no inlines)	-----S0--	This contains all flows and elevations from L...
Regulated Canadian River System	-----S0S0S0	Regulated model for the entire Canadian Riv...
Canadian FDR	R0U0S0	

Name: Canadian FDR

Description:

Models

Program Order: FDR

Key: R0U0S0

RAS: R:Canadian_System_FDR_Regulated

RAS: U:Canadian_System_FDR_Unregulated

FIA: S:Damages Only

CWMS CAVI - Controlled Unclassified Information - Canadian_Basin

File View Maps Forecast Scripts Tools Window Help

Acquisition Visualization Modeling Setup

Modeling - Canadian FDR May 2022 - Canadian FDR

Name: Canadian FDR May 2022

Time Window

Forecast Time: 14May2022 Time: 0000

Extract Start: 04May2022 Time: 0000

Start Time: 04May2022 Time: 0000

Epd Time: 16May2022 Time: 2400

Display Time Zone: GMT

Forecasts

- Canadian FDR - R0U0S0
- Canadian_System_FDR_Regulated
- Canadian_System_FDR_Unregulated
- Damages Only

Actions - Canadian FDR - R0U0S0

- Compute
- Open CAVI Dashboard
- Display in Map
- Save To Base
- Replace from Base
- Post

Force Recompute
 Run Post after Successful Compute

Actions Reports Scripts Icon Layers Workflow Team

Messages Extract

Forecast Run Editor

Forecast Run

Name	Key	Description
Verdigris River 88 thru RAS	V0V0--	
Verdigris River 88 thru FIA	V0V0V0	
Verdigris River 29 thru ResSim	E0----	
VERD FDR Reg WL	--A0A0	
VERD FDR Reg WOL	--C0B0	
VERD FDR Unreg WL	--B0C0	
VERD FDR Unreg WOL	--D0D0	

Name: VERD FDR Reg WL

Description:

Models

Program Order: Default

Key: --A0A0

ResSim:

RAS: A:Verdigris_FDR_REG_WLevee

FIA: A:Verdigris_REG_WLevee

CWMS CAVI - Controlled Unclassified Information - VerdigrisBasin

File View Maps Forecast Scripts Tools Window Help

Acquisition Visualization Modeling Setup

Modeling - WY22_Mar_Apr_Reg - VERD FDR Reg WL

Name: WY22_Mar_Apr_Reg

Time Window

Forecast Time: 24Mar2022 Time: 0000

Extract Start: 23Mar2022 Time: 0000

Start Time: 23Mar2022 Time: 0000

Epd Time: 16Apr2022 Time: 2400

Display Time Zone: GMT

Forecasts

- VERD FDR Reg WL --A0A0
- Verdigris_FDR_REG_WLevee
- Verdigris_REG_WLevee
- VERD FDR Reg WOL --C0B0
- Verdigris_FDR_REG_WOUT_Levee
- Verdigris_REG_WOUTLevee

Reports

- Compute Log
- Forecast DSS File
- Extract Report

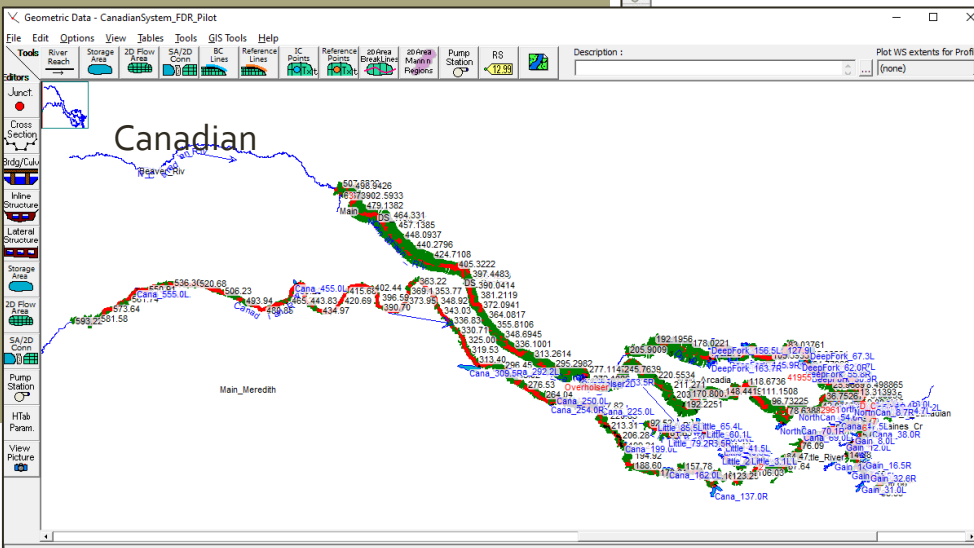
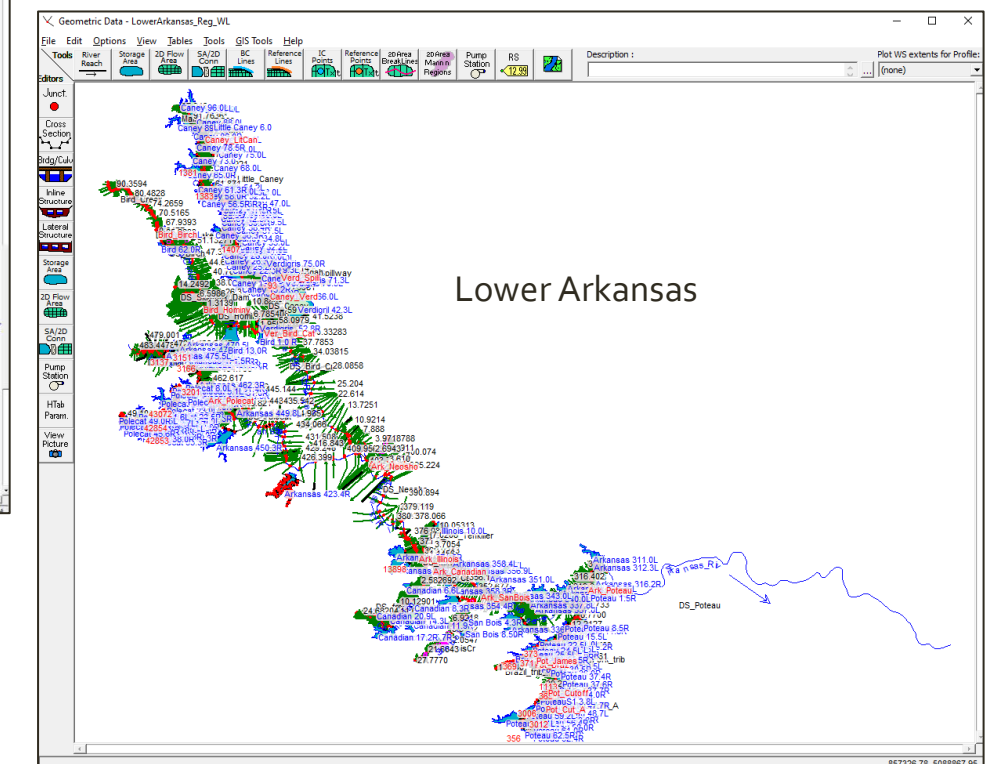
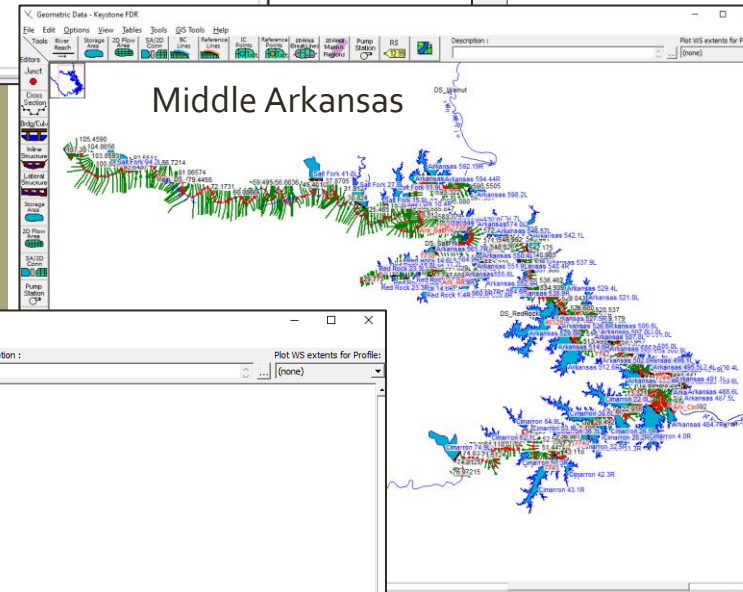
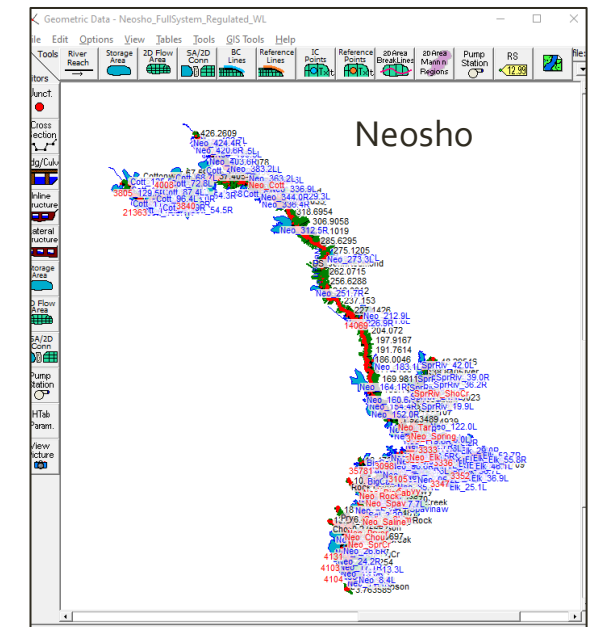
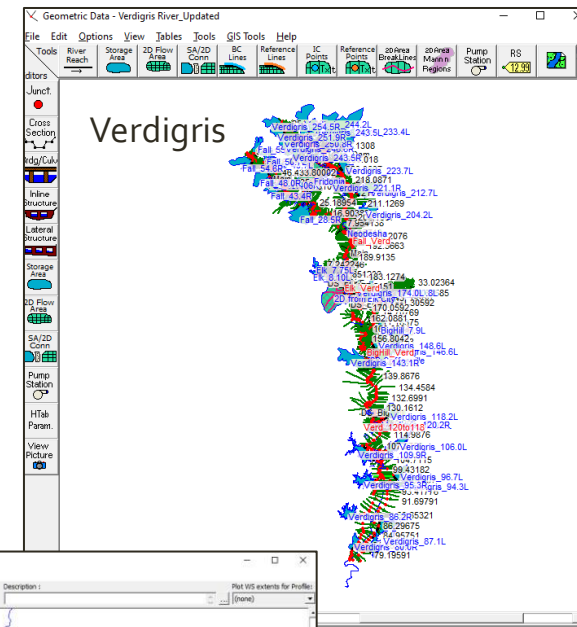
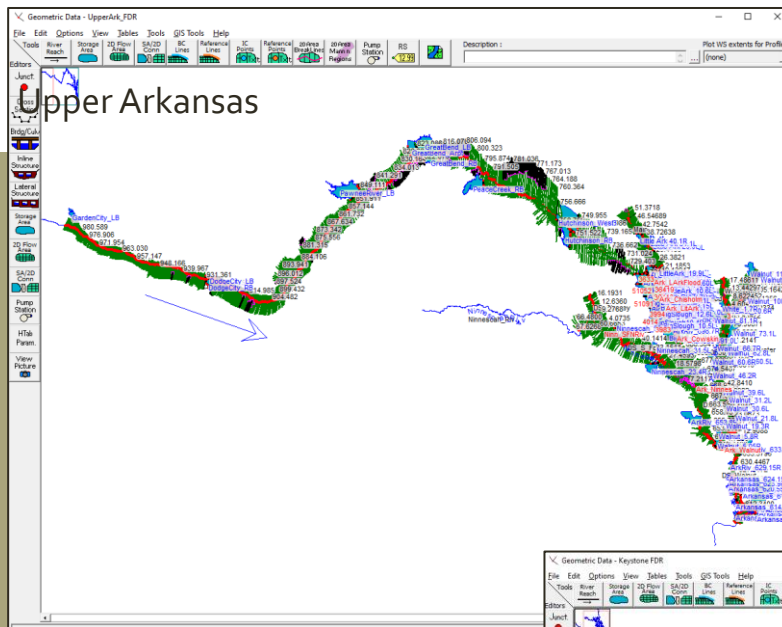
Force Recompute
 Run Post after Successful Compute

Actions Reports Scripts Icon Layers Workflow Team

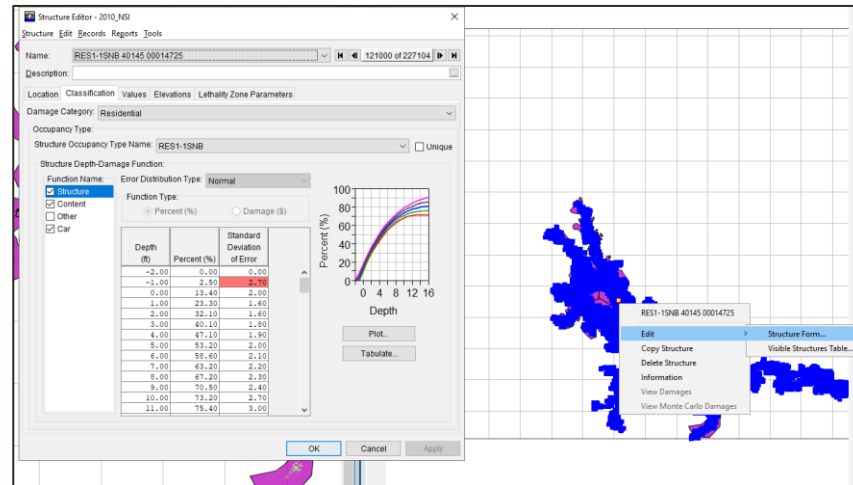
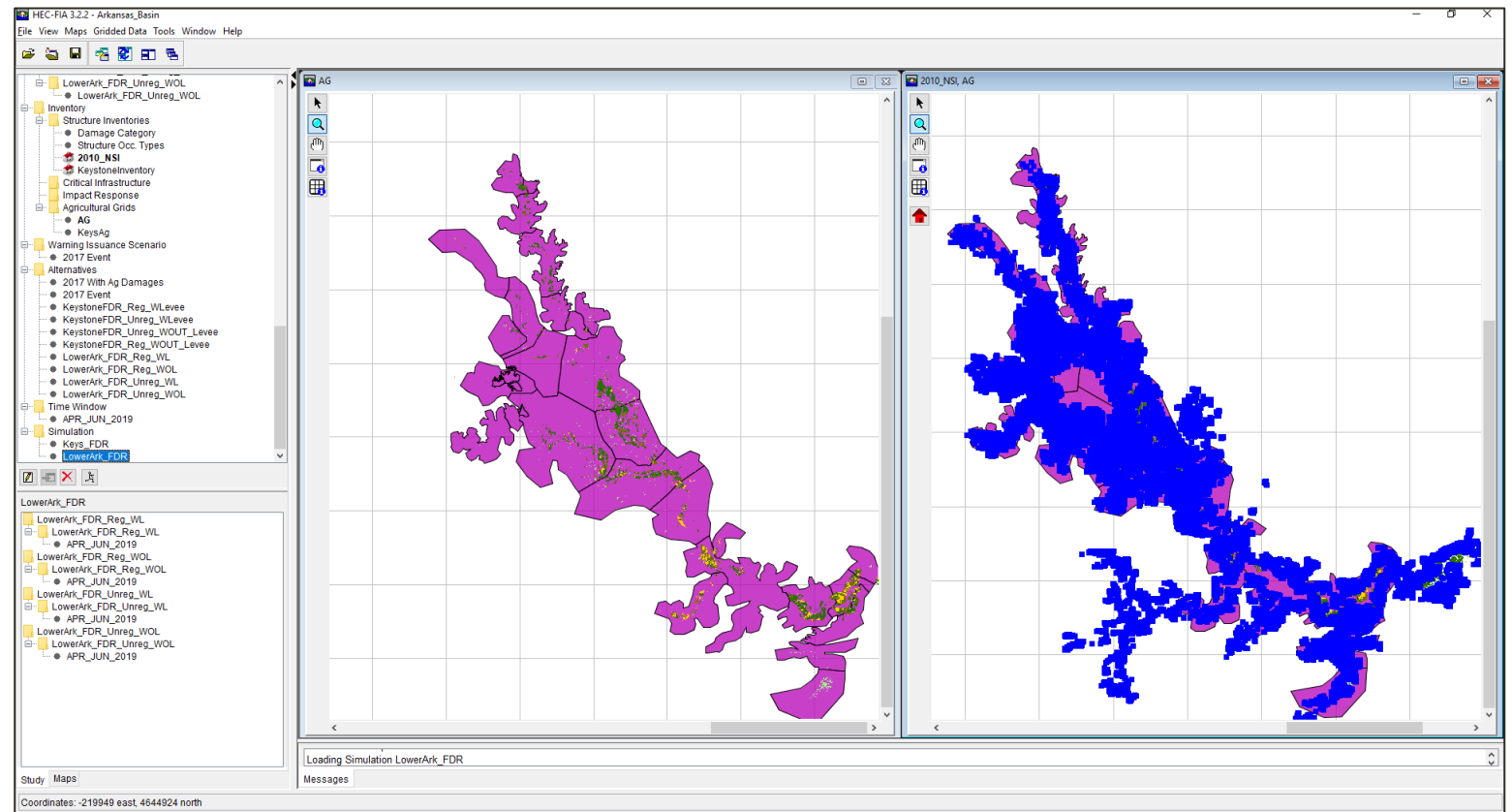
Messages Extract

Coordinates: -718535 east 3442803 north

RAS Example



FIA Example



Crop Loss Editor

Crop: Alfalfa

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fixed	0.73	\$10.73	\$10.73	\$10.73	\$10.73	\$10.73	\$10.73	\$10.73	\$10.73	\$10.73	\$10.73
Variable	0.00	\$24.70	\$69.08	\$5.35	\$20.21	\$20.21	\$20.21	\$11.40	\$11.40	\$13.69	\$1.00
Variable	0.00	\$24.70	\$69.08	\$5.35	\$20.21	\$20.21	\$11.40	\$11.40	\$13.69	\$1.00	\$1.00
Variable	0.00	\$24.70	\$69.08	\$5.35	\$20.21	\$20.21	\$11.40	\$11.40	\$13.69	\$1.00	\$1.00

Substitute Crop: Alfalfa

Harvest Date	Harvest Cost	Yield	Unit	Unit Price	% Loss from Late Plant
31may	\$122.19	3.0	Ton	\$101.59	10.0

Number of Days	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.0	0.0	0.0	0.0	0.0	12.0	9.0	9.0	4.0	0.0	3.0	0.0	0.0
2.0	0.0	0.0	0.0	0.0	12.0	9.0	9.0	4.0	0.0	3.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	12.0	9.0	9.0	4.0	0.0	3.0	0.0	0.0
4.0	0.0	0.0	0.0	0.0	12.0	9.0	9.0	4.0	0.0	3.0	0.0	0.0
5.0	27.0	27.0	27.0	27.0	75.0	59.0	44.0	44.0	44.0	36.0	27.0	27.0

Add Duration

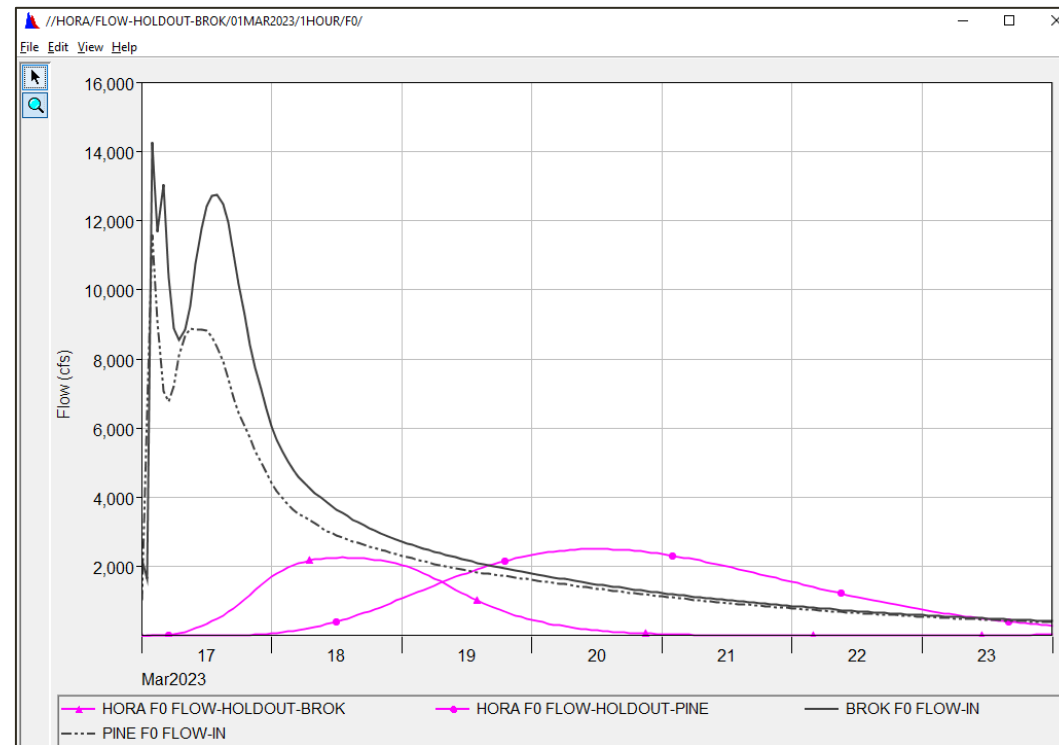
Plot Tabulate OK Cancel

Improvements of New Modeling Methods

- By switching to hourly modeling better results on start/end times and peaks of any flooding.
- Uses most current inventory data for economic analysis (structure and agricultural damages)
- Better understanding of impacts on individual locations due to ability to map entire flood in RAS versus using a static table of depth vs damage for an entire reach for current methods.

Work Currently Underway

- Compute Reservoir Holdouts in RiverWare
 - Currently – Using RiverWare computed volumes to compute percent holdout for reservoirs contributing to each damage reach.
 - In Progress – Single Reservoir routing to determine holdouts flows for damage reaches. Holdout record from RiverWare is used as FIA impute to compute percent holdout applied for each reservoir for the damage reach.



What Are Holdouts, and Why We Use Them

- When determining how to allocate flood damages reduced to each flood control project USACE uses “Holdouts” as a way to apportion these percentages.
- Anytime a reservoir inflow is greater than an outflow during a flood event this incremental storage is accumulated as a holdout for that project and is used for accounting and allocating benefits.
- Our legacy method accumulated all of the incremental volume holdouts and reported a single total volume which was then used to apportion reservoir benefits to downstream gages.
- With CWMS we will be using routed holdouts to better dynamically attribute the benefits based on timing and flood mapping.



Questions?