



Center for Advanced Decision Support for
Water and Environmental Systems (CADSWES)

UNIVERSITY OF COLORADO **BOULDER**

RiverWare Integration into Modeling Frameworks

2019 RiverWare User Group Meeting

David Neumann

Agenda

1. What are modeling frameworks
2. Four frameworks with integrated RiverWare models

What are Modeling Frameworks?

- Frameworks allow models to work together
 - Modeling different processes
 - From different agencies
 - Written in different languages
 - Have different interfaces
 - Have different data formats
- Often, the framework provides a common interface for visualization and control


Adapters

- Model integration is implemented using **adapters**
- A model adapter is the software that “bridges” between the framework and the model
 - Controls model execution
 - Communicates between the framework and models
 - May convert data to a common format

Some Modeling Frameworks

- USACE CWMS
- USACE HEC-RTS
- USACE HEC-WAT
- Deltares Delft-FEWS

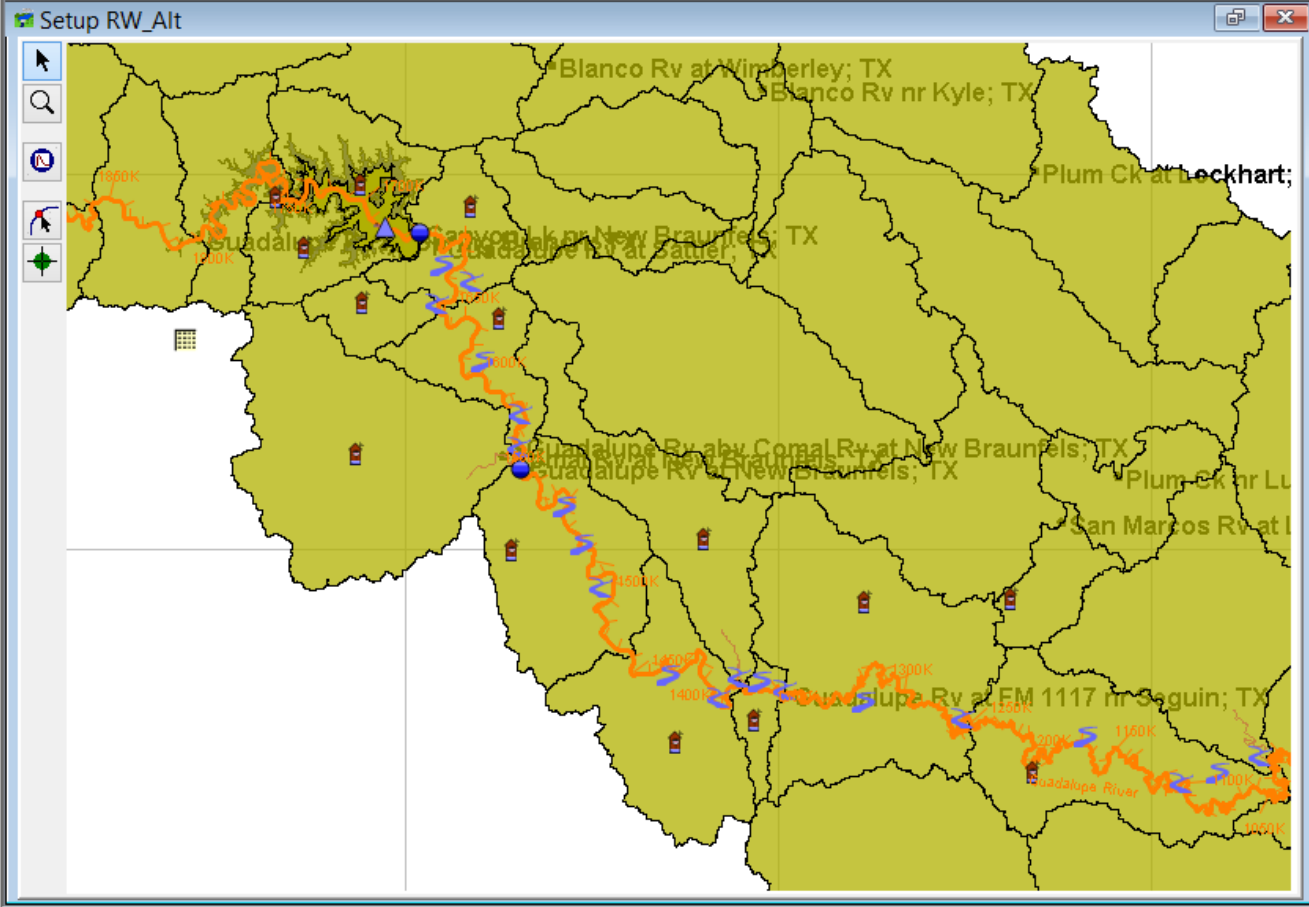
Corps Water Management System (CWMS)

- USACE modeling framework that integrates these and other models together
 - HEC MFP – Precipitation forecast
 - HEC HMS – Rainfall runoff
- 
- The RiverWare logo consists of a blue square on the left containing a white stylized 'R' that resembles a river winding to the right. To the right of the square, the word 'RIVERWARE' is written in a bold, blue, sans-serif font.
- HEC RAS – Flood inundation
 - HEC FIA – Flood Impacts Analysis
- Typically used for short-term operations



guad1424 *

- Models
 - MetVue
 - MFP
 - HMS
 - ResSim
 - RiverWare
 - RAS
 - FIA
 - Supplemental
- Stream Alignments
 - Stream Alignment
- Forecast Runs
 - norains
 - rains
 - norains_RW



File View Maps Forecast Scripts Tools Window Help

Acquisition Visualization Modeling Setup

Name: ForecastsWithRiverWare

Time Window

Time Window

Forecast Time:	17Jun2004	Time:	1000
Extract Start:	08Jun2004	Time:	1000
Start Time:	08Jun2004	Time:	1000
End Time:	26Jun2004	Time:	1000

Display Time Zone: GMT+00:00

Forecasts

- rains - W0E0R0Y0U0
 - withfutureprecip
 - HMS_AVG_ADJ
 - RW_Alt
 - Canyon
 - Guad_R120
 - Guad_R130
 - Guad_R140
 - Guad_R150
 - Guad_R170
 - Guad_R190
 - Guad_R200
 - Guad_R210

Reports - RW_Alt

Plot Dialog

SCT GuadalupeOperations

Modeling - ForecastsWithRiverWare - rains

HMS Reach Guad_R240 has no stream
 Placed HMS reach Guad_R240 on stream Guadalupe River at upstation 867984.127787668 to downstation 721041.5136512684
 HMS Reach Guad_R250 has no stream
 Placed HMS reach Guad_R250 on stream Guadalupe River at upstation 708106.252195984 to downstation 649432.4491525454
 HMS Reach SandiesCr_R010 has no stream
 Placed HMS reach SandiesCr_R010 on stream Guadalupe River at upstation 1205547.745645344 to downstation 753394.3684221575
 HMS Reach SandiesCr_R020 has no stream

File View Maps Forecast Scripts Tools Window Help

Acquisition Visualization Modeling Setup

Name: ForecastsWithRiverWare

Time Window

Forecast Time: 17Jun2004 Time: 1000

Extract Start: 08Jun2004 Time: 1000

Start Time: 08Jun2004 Time: 1000

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Display Time Zone: GMT+00:00

Forecasts

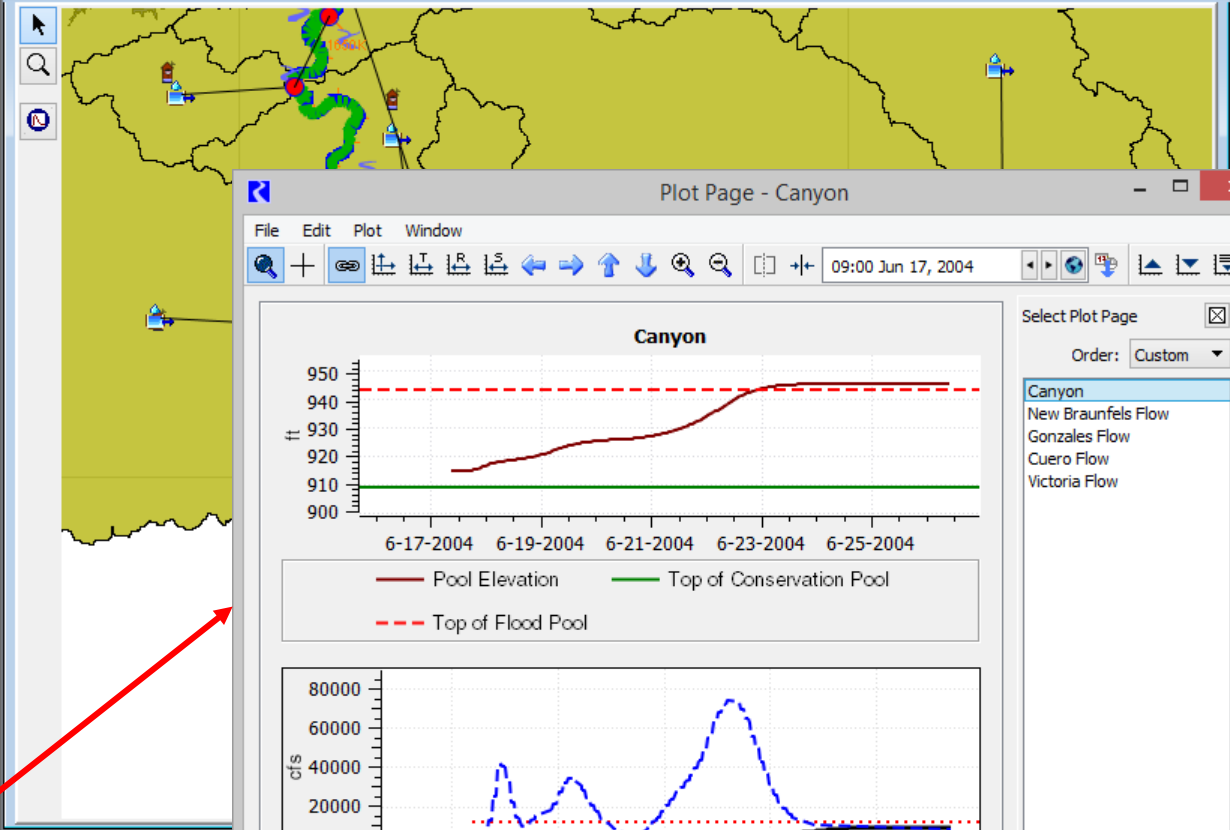
- rain - W0E0R0Y0U0
 - withfutureprecip
 - HMS_AVG_ADJ
 - RW_Alt
 - Canyon
 - Guad_R120
 - Guad_R130
 - Guad_R140
 - Guad_R150
 - Guad_R170
 - Guad_R190
 - Guad_R200
 - Guad_R210

Reports - RW_Alt

Plot Dialog

SCT GuadalupeOperations

Modeling - ForecastsWithRiverWare - rains



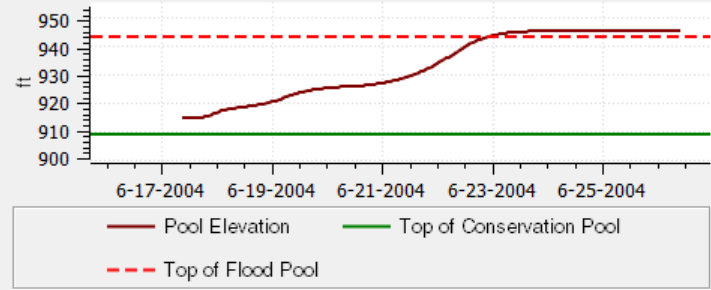
Plot Page - Canyon

File Edit Plot Window

09:00 Jun 17, 2004

Canyon

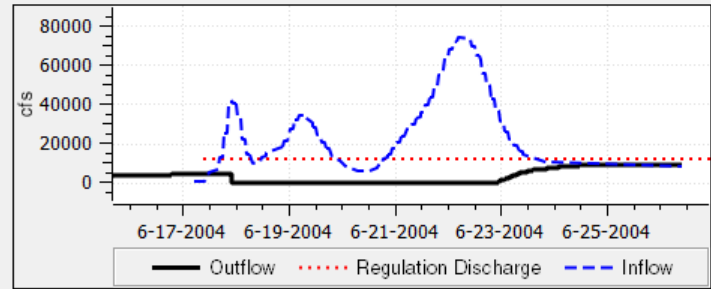
ft



6-17-2004 6-19-2004 6-21-2004 6-23-2004 6-25-2004

- Pool Elevation
- Top of Conservation Pool
- Top of Flood Pool

cfs



6-17-2004 6-19-2004 6-21-2004 6-23-2004 6-25-2004

- Outflow
- Regulation Discharge
- Inflow

Select Plot Page

Order: Custom

- Canyon
- New Braunfels Flow
- Gonzales Flow
- Cuero Flow
- Victoria Flow

Center at Date/Time

New... Edit...

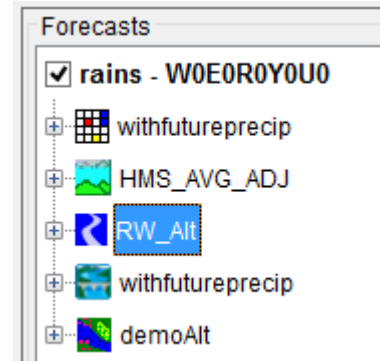
HMS Reach Guad_R240
Placed HMS reach Guad
HMS Reach Guad_R250
Placed HMS reach Guad
HMS Reach SandiesCr_
Placed HMS reach Sand
HMS Reach SandiesCr_

CWMS Interface opens these RiverWare Dialogs

- SCT
- Scripts
- RPL Sets
- Objects
- Plots
- Output Canvas
- Charts
- Workspace
- Diagnostics

CWMS “Compute”

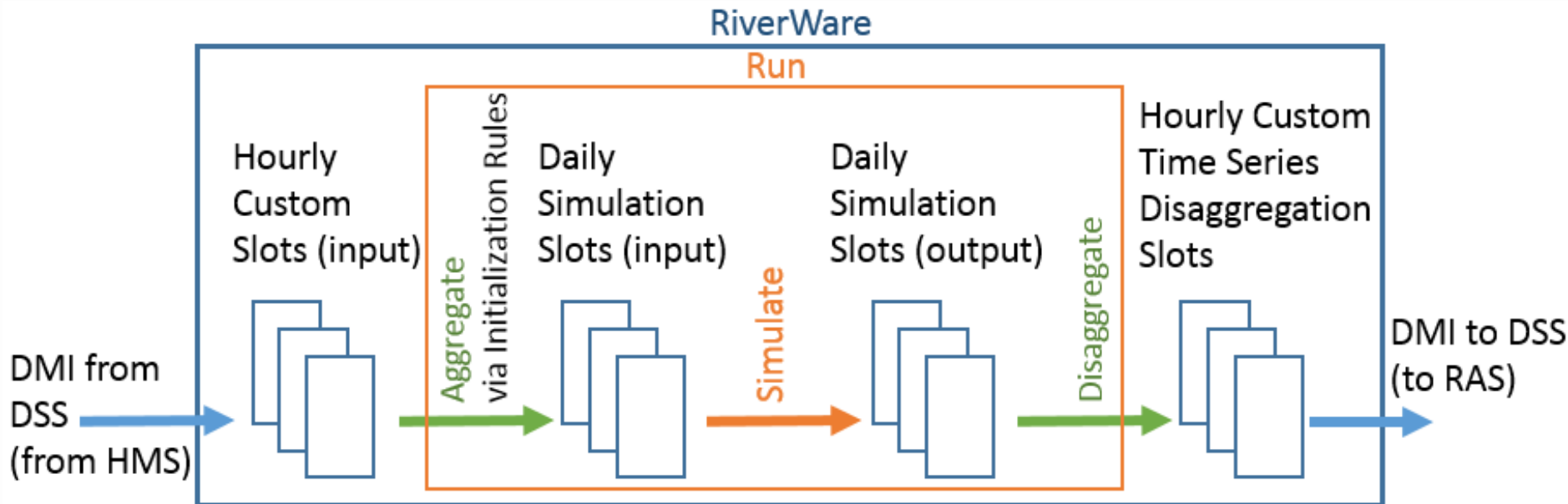
- Each model is run in sequential order
- Data is automatically loaded
 - Input data from previous model
 - Output data sent to the next model
- All models use HEC-DSS for data transfer
- RiverWare uses Database DMIs



Development Status

- Recent Enhancements
 - Show additional dialogs
 - Better messaging and error handling
 - Saving of RiverWare model
- Upcoming
 - Aggregate / disaggregate data to different time scales
 - HMS models = 1hr
 - RiverWare = 1day
 - RAS = 1hr or 6hr

Aggregation / Disaggregation



- Modifications to the CMWS RiverWare Plugin
- New RPL function to AggregateSeriesSlot
- New Time Disaggregation Series Slot

USACE HEC – RTS

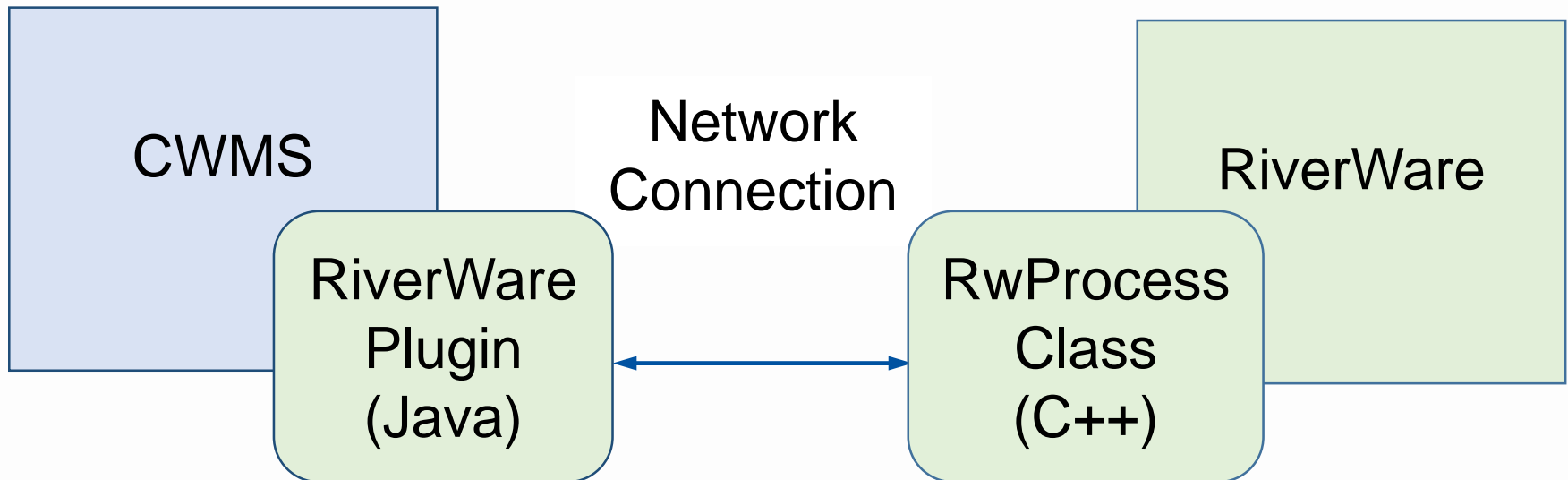
- **Real Time Simulation**
- Public version of CWMS
- CWMS RiverWare Plugin v1.0 Released
6/2019

HEC – WAT

- **Watershed Analysis Tool**
- Planning version of CWMS
- Adapter design finished in FY 2019
- Adapter implementation in FY 2020

Adapter Architecture

CWMS, HEC-RTS and HEC-WAT Plugin executes RiverWare as server, communicating with RiverWare across a network connection



Deltares Delft-FEWS

Flood Early Warning System

FEWS is a common platform and interface that

- Integrates multiple models to automate workflows
- Manages data
 - Automated data streams
 - Edit inputs
- Visualizes data and other model feedback
- Archives the models and data

FEWS Interface

File Tools Options Help

3 : Thumbnails

5 : Forecasts

6 : Data Viewer

4 : Help

9 : Buttons

Forecasts

- Test Data
 - Import test files
 - Pre-Process test data
 - Process Data
- Preparation
 - Real-Time
 - Data
 - Big10 Main
 - RTC-Tools
 - RiverWare (RBS)
 - Run model
 - SH1 Report
 - RiverWare (Opt)
 - Publish
 - SpecialPublish
 - Short Term Planning
 - Upstream Basins
 - Big10
 - Mid-Columbia
 - Lower Snake
 - Lower Columbia
 - FCRPS
 - RTC-Tools
 - Riverware (RBS)
 - Riverware (Opt)
 - Report
 - Publish

Warm state selection

Time zero: 09-18-2013 07:00

Forecast length: 09-20-2013

edit run options

PST/PDT	A	B	C
	GN_Sim (MW)	FB_Req (FT)	FB_Sim (FT)
	Chief Joseph CHJ	Chief Joseph CHJ	Chief Joseph CHJ
	RiverWare_Big10 [1]	User_Input_RT	RiverWare_Big10 [1]
Mean	775	952.8	952.6
Sum	39522	2858.5	48584.9
Min	141	952.5	951.9
Max	1300	953.5	953.7
09-18-2013 04:00	236		952.2
09-18-2013 05:00	195		952.3
09-18-2013 06:00	301		952.4
09-18-2013 07:00	432		952.2
09-18-2013 08:00	539		952.1
09-18-2013 09:00	581		952.1
09-18-2013 10:00	609		952.1
09-18-2013 11:00	534		952.2
09-18-2013 12:00	668		952.2
09-18-2013 13:00	781		952.0
09-18-2013 14:00	810		951.9
09-18-2013 15:00	819		951.9
09-18-2013 16:00	910		952.0
09-18-2013 17:00	884		952.0
09-18-2013 18:00	987		951.9
09-18-2013 19:00	1007		951.9
09-18-2013 20:00	985		951.9
09-18-2013 21:00	1023		951.9
09-18-2013 22:00	659	952.5	952.2

Chief Joseph

Power (MW)

Forebay Level (FT)

Flow (KCFPS)

Legend: [1] GN_Sim, [1] FB_Req, [1] FB_Sim, FB_Min user, FB_Max user, [1] QO_Sim, [1] QS_Sim

Big10_RiverWare_RT: [1] Run model 09-18-2013 07:00:00 PDT Current

Buttons

RTC RW-RBS RW-OPT

GCL	FB	FB R	FBMax
CHJ	dFB	FB Stable	FBMin
MidC	FB Guide	FB+FB R	dFB Up
			dFB Dn
LWG	TW	TW R	dTW Up
LGS	dTW		dTW Dn
LMN			
IHR	QI	QI R	QOMax
	QO	QO R	QOMin
MCN	QT	QT R	QSMax
JDA	QS	QS R	QSMin
TDA	QS %	QS % R	dQO Up
BON	dQO	QO+QO R	dQO Dn
	Flows	Flows R	
MCOL			
LSNK	GN	GN R	GNMin
LCOL	Cap	1% Flag	GNMax
Big10	HK		
BPA	Project Sim	Project R	Constraints
	ALL Sim	ALL R	Gen.Hours
	FedLoad	LoadAdj	ALL Load
	INC	INC Min	INC Max
	QSC Min	QSC Max	

Logs

08-04-2016 14:10:15 INFO - ***** Workflow Big10_RiverWare_RT Completed *****

08-04-2016 14:10:15 INFO - Start time: 2016-08-04 21:10:00 End time: 2016-08-04 21:10:15 TO: 2013-09-18 14:00:00 User Id:Mitch Anthony Clement

08-04-2016 14:10:15 INFO - TaskRun.Completed: Task Big10_RiverWare_RT with ID 208 completed in 14s

08-04-2016 14:10:15 INFO - TaskRun.TimeSpend:TransformationModule 2s 13% GeneralAdapter (without executables) 2s 11% SecondaryValidation 0s 2% C:\Program Files\CADSWES\RiverWare 6.9\riverware.exe 9s 61%

D:\FEWS\BPA\CADSWES\Working\2016_05_27_R2_27_1_MC_Dev\bin\riverware.exe 2s 12% database 1s 5% cache files 0s 0% database 0s 0% (0 ms/avg; 55 kB; 6.4 MB/s; 62 queries; 27 rows) loaded 0s 0% time series read 8405 (unique=2850)

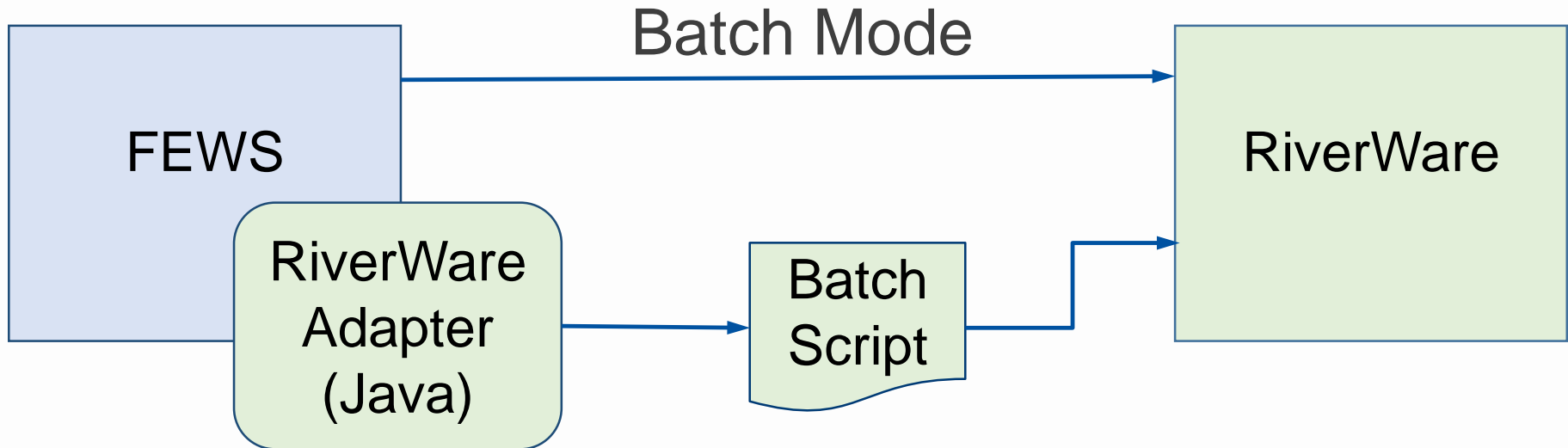
Logs 2 : Forecaster Notes

Mitch Anthony Clement

Current system time: 09-18-2013 07:00 PDT

21:13:09 GMT 15:13:09 MDT Stand alone -133.743, 42.398 0.0 MB/s 150 MB

FEWS Adapter Architecture



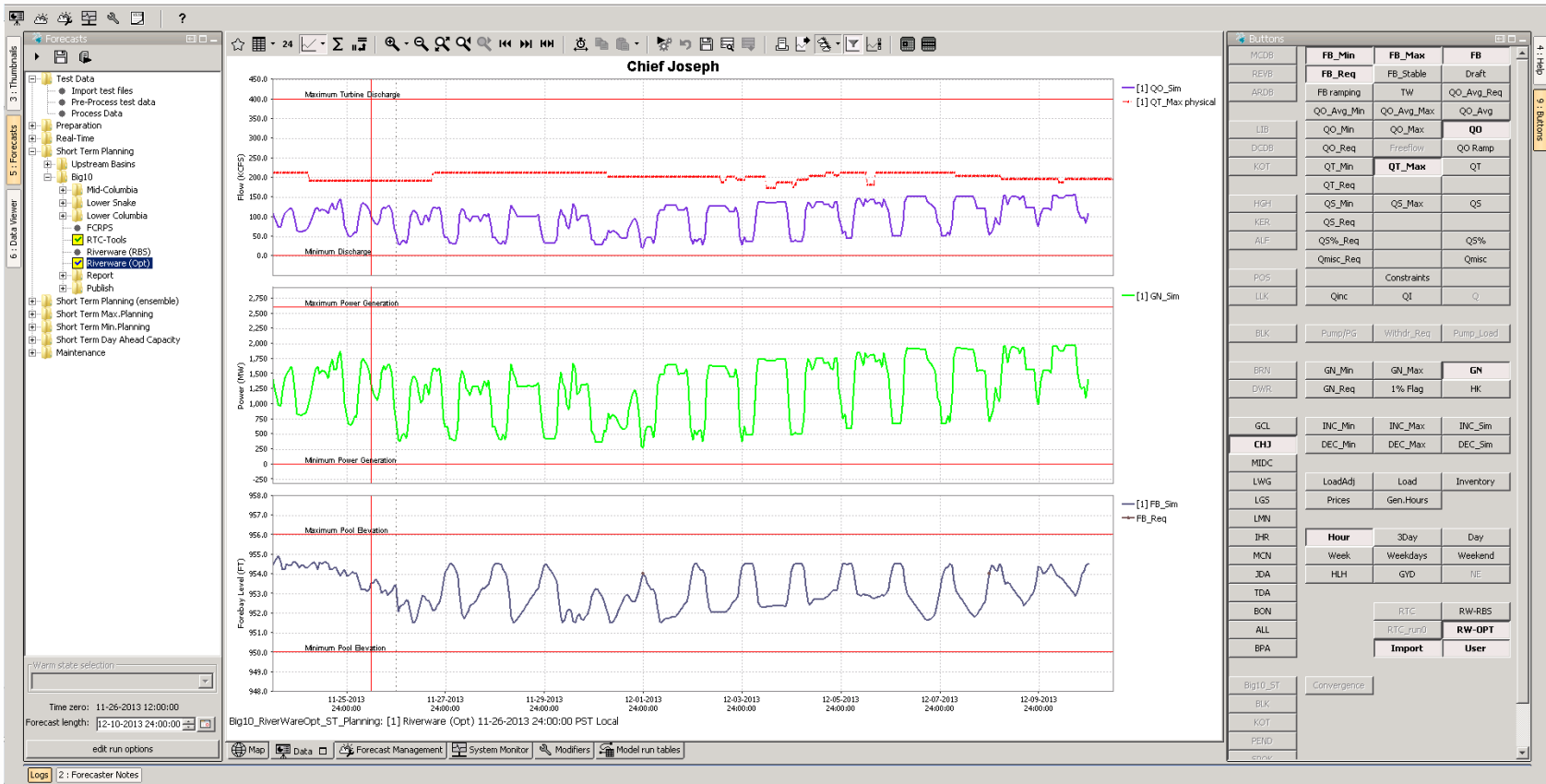
- Headless: run RiverWare in batch mode
- Interactive:
 - Batch mode sets up the run
 - Operator uses RiverWare interface
 - Sends data back to FEWS

A few FEWS Applications

- **Bonneville Power Administration**
 - Short Term Planning
 - Real Time Scheduling

FEWS Applications

Bonneville Power Administration

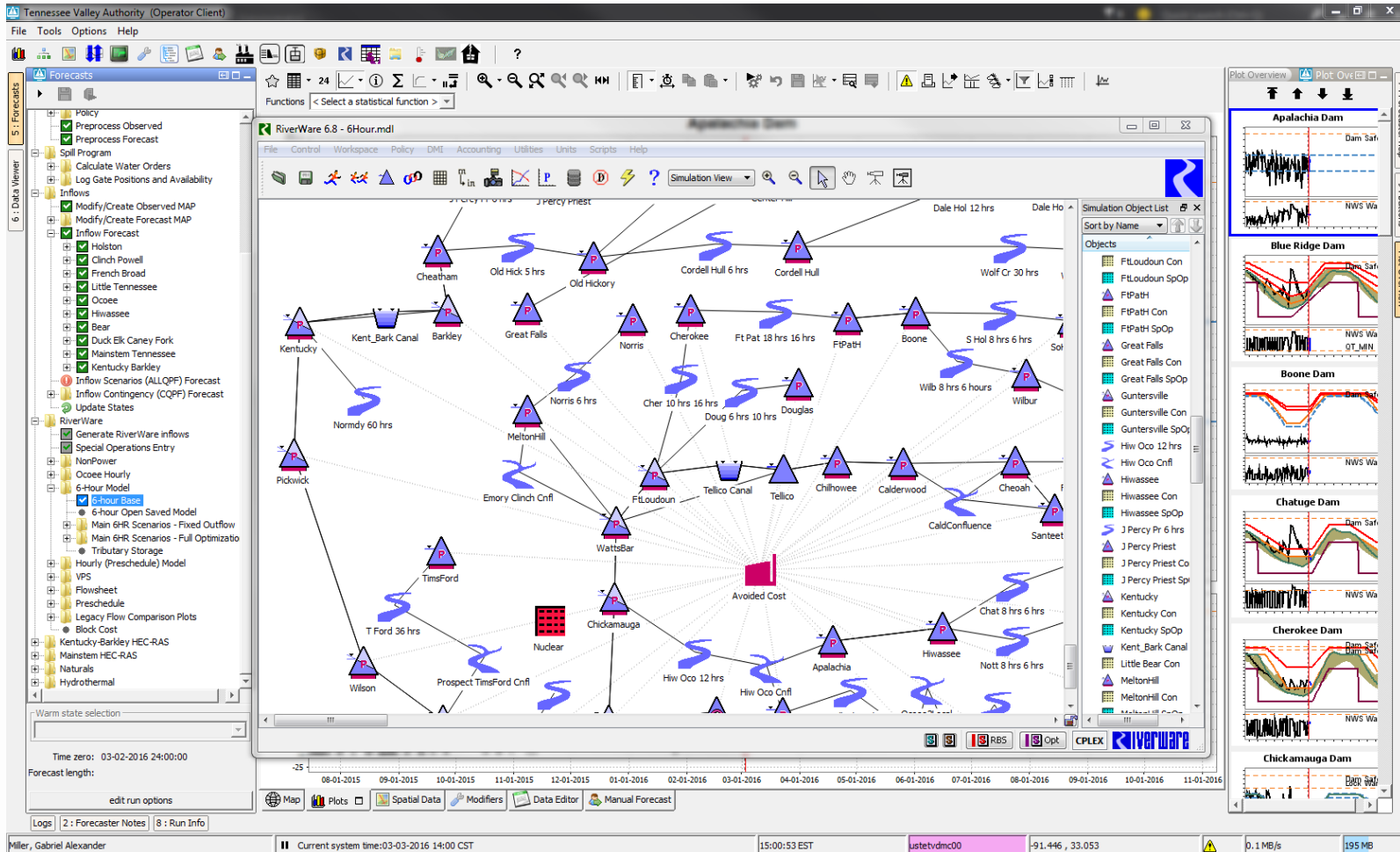


A few FEWS Applications

RiverWare in FEWS

- Bonneville Power Administration
 - Short Term Planning
 - Real Time Schedulers
- **Tennessee Valley Authority**
 - 6 Hour Model
 - Hourly Model

TVA FEWS Applications



TVA FEWS Applications

The screenshot displays the RiverWare 6.8 software interface. The main window shows a simulation model with various reservoirs and dams connected by lines. A data table is open in the foreground, showing simulation results for Douglas Energy. The table includes columns for dates from 4/29 to 5/10 and rows for various energy-related metrics.

Series Slots	4/29 Wed	4/30 Thu	5/1 Fri	5/2 Sat	5/3 Sun	5/4 Mon	5/5 Tue	5/6 Wed	5/7 Thu	5/8 Fri	5/9 Sat	5/10 Sun
Regulated spill	0.00	0.00	0.00	0.00	5.97	7.00	5.97	11.93	11.13	7.51	3.74	
Total outflow	5.66	1.50	1.47	1.45	10.12	15.92	9.31	18.02	17.23	13.66	9.95	
DOUGLAS												
Adjustment		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total inflow	7.84	2.06	0.21	0.19	0.18	0.17	0.16	0.16	0.15	0.15	0.14	
Storage	527.34	527.77	526.43	526.04	523.68	517.32	513.10	511.58	509.38	503.18	497.51	488.00
Elevation	987.44	987.47	987.37	987.34	987.16	986.66	986.33	986.21	986.04	985.54	985.09	984.64
Energy	1,336	332	316	120	509	1,261	868	336	470	1,233	1,128	1,024
6:00	230	44	118	28	429	373	588	20	20	39	20	
12:00	460	14	156	14	20	20	20	257	48	334	336	
18:00	340	118	28	53	40	40	221	20	382	820	732	
24:00	306	156	14	25	20	828	40	40	20	39	39	
Power factor	201	205	204	205	203	201	201	202	202	199	198	
Turbine discharge	6.65	1.63	1.55	0.59	2.54	6.43	4.38	1.67	2.36	6.35	5.81	
Sluice discharge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Regulated spill	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	
Total outflow	6.65	1.63	1.55	0.59	2.54	6.53	4.38	1.67	2.36	6.35	5.81	
CHATUGE												
Adjustment		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Total local	0.57	0.55	0.52	0.48	0.45	0.43	0.40	0.39	0.37	0.35	0.34	

Douglas.Energy -- (5 obscured pre-sim timesteps)
 4 values: Sum 1,336 -- Ave 334 -- Min 230 -- Max 460 -- Range 229 [MWH]

A few FEWS Applications

RiverWare in FEWS

- Bonneville Power Administration
 - Short Term Planning
 - Real Time Schedulers
- Tennessee Valley Authority
 - 6 Hour Model
 - Hourly Model
- **Idaho Power**
 - **Operations both Interactive and headless**

Thank you

