RIVERWARE FLOOD CONTROL METHODS ARKANSAS RIVER BASIN



US Army Corps of Engineers Tulsa District



TODAY'S DISCUSION

- System/Project Features: Arkansas River
- Need for period of record (POR) basin simulation model
- Transition to RiverWare, brief history
- New flood control methods in RiverWare
- Future work

Tulsa District:

- 50 flood control lakes
- 12 Section-7 lakes
- 18 lakes with gated spillways
- 8 COE Hydropower
- 3 NonFederal Hydropower

A.A....

• 5 Navigation Locks





CONSERVATION POOL



storage

INACTIVE POOL

DAM



inflow



ORIGIN OF INFLOW

- Seasonal Rainfall Spring/Fall
- Frontal Systems
- Remnants of Tropical Systems
- Snow Pack Insignificant

RUNOFF

- Few Hours to Several Days
- Single to Multiple Events

Frequency of Filling





ARKANSAS RIVER BASIN: PROJECT FLOOD CONTOL %



NEED FOR POR SIMULATION & PLANNING MODEL

- Statistical Analysis
- Alternative operations
- Reallocation of storages
- Recreation Investment
- M&I Dependability
- Hydropower
- Navigation
- Environmental Issues

EXISTING POR SIMULATION MODEL - SUPER

- Southwest Division COE Districts have been using a system planning model for 30 years - "Super".
 Development/Expert (Ronald L. Hula) SWD Corps, Retired.
- "Super Program" application has been accepted by SWPA/DOE, State Water Distr's, navigation, others.
- Districts have limited ability to use/revise program.
- Retiree is temporarily on contract.

GOAL OF FLOOD CONTROL OPERATION

Surcharge Operation: Prevent overtopping and loss of control

Drain flood pool quickly as possible without causing downstream flooding, if possible

Give priority to reservoirs based on their "fullness"

Leave sets of reservoirs controlled by a KEY control point as balanced as possible

Flooding at control point does occur as a result of: Surcharge releases Local runoff added to prior releases Convergence

TRANSITION FROM SUPER TO RIVERWARE

- 1999 Southwest Division lead effort to investigate existing simulation models.
- 1999 2000: Determination that RiverWare has potential to meet SWD COE needs. Simulation and Rules Training
- Spring 2000: Preliminary RiverWare investigation/evaluation
- 2001 2004: Flood control logic transferred from old Super program to RiverWare by CADWES with new methods
- Currently Using old program with assistance of author
- Developing RiverWare models

SIMULATION WITH RIVERWARE:

 Sub-Basin Configuration: Pre-Defined Rules of Operation/Simulation

- Reservoir Object: Balance Level Definition
- Control Point Object: Local Flow With Forecast, Regulation Method, List of Regulating Reservoirs
- Key Control Point Definition
- Stream Routing
- Evacuate Flood Control Storage In A Way To Achieve System Balance







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Inflow = Upstream routed releases



Total Inflow = Inflow + Deterministic Local + Diversion Return + Canal Outflow = Surcharge Release + Flood Control Release + Turbine



Inflow = Upstream Routed Release

• Outflow = Step Response Routing Method

Inflow = Upstream routed releases



Total Inflow = Inflow + Deterministic Local + Local Peaking

Total Discharge = Total Inflow + Diversion

Inflow = Outflow

- 0 ×

16 BALANCE LEVELS

 Zero storage
 Bottom conservation
 Bottom power pool
 50% conservation
 100% conservation pool
 5 Nypically not used

9 10% Flood control 10 30% Flood control 11 50% Flood control 12 70% Flood control 13 90% Flood control 14 100% Flood control **15 Top surcharge** 16 Top of dam

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CONTROL POINT OBJECT

Uncontrolled local flow

Routed upstream releases

• Regulation method (Key Control Point)

Space hydrograph for releases

CONTROL POINT REGULATION METHODS

Channel regulation
 Current level regulation
 Future level regulation
 System percent full regulation

Misc applications: Stage control Sag operation Flood exception Regulation recession



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Category	Method		NONE	NONE	NONE
 Flood Control Local Inflow Calculation Generate Forecast Inflows Include Locals in Outflow Regulation Discharge Stage Control Over Forecast Sag Operation Regulation Recession Key Control Point Balancing Key Control Point Reservoir Balance Period Balance Iterations M Temp Balance Level M Temp Share 	Operating Level Balancing Forecast Local Inflows Geometric Recession Locals Not Included in Outflow Channel Regulation Stage Control Fixed Over Forecast None None Operating Level Balancing	0 1 2 3 4 5 6 7 8 9 10 11 12 13 14	0.0443 0.1706 0.2680 0.2351 0.1437 0.0747 0.0356 0.0161 0.0070 0.0030 0.0030 0.0012 0.0004 0.0002 0.0000	0.0144 0.0740 0.1654 0.2168 0.1961 0.1402 0.0876 0.0503 0.0273 0.0142 0.0072 0.0035 0.0017 0.0007 0.0007 0.0003	0.3158 0.4322 0.1592 0.0587 0.0216 0.0080 0.0029 0.0011 0.0004 0.0001 0.0000 0.000 0.00
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Council Grove			
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OK	Apply	Reset	Cancel
		57.	



Open Object - Commerce		
File Edit View Slot Account		and the second second
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Selected Method: Channel Regulation		Channel Regulation
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🔲 Open Object - Hulah Outflow

File Edit View Slot Account

Object Name: Hulah O	utflow					Cur	rent	Me	etho			
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Selected Method: Reservoir C	Current Level Regulation	<u> </u>	[0	-				
Category	Method					and a second	000	10000	0.00			
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PI Level Regulation T	able					00	·	AN TO	A COL			
- ERegulation Reserv	Edit Slot: Hulah	outflow.	evel Rea	ulation Tal	ble							
Stage Control Inte	File Row Column	View					_					
W Variable Regulatio	Level Regulation Table											
	Units: N	Units: NONE										
		1000.00	1000.00	1000.01	1999.99	2000.00	3999.99	4000.00	6499.99			
Emp Regulation	0:00 January 1	5.00	8.00	8.99	9.00	9.99	10.00	10.99	11.00			
Stage Control Over Forec- Sag Operation Regulation Recession												
End of the second se	Interpolate C Annual Period, Irreg	Lookup gular Interva	al									

Current Level Regulation Method

	-	~

Discharge 1 cfs

6500.00

16.00

6500.00

14.00

Open Object - John Redmond Outflow	v					2. Ca		1. 2. C	
e Edit View Slot Account					0-0	Pro al	0.0-	0 0 0 C	0 0 00
Object Name: John Redmond Outflo lots Methods Accounts elected Method: Reservoir Future Level R	w egulation	<u> </u>			Fut	ure L	evel Meth	Regulod	lation
Category	Method								A
Flood Control Local Inflow Calculation Regulation Discharge	Operatin No Loca Reservo	g Level Balancing I Inflow ir Future Level Regula	tion		200				2000
···· 📴 Level Regulation Table ···· 📃 Regulation Reservoirs		Edit Slot: John File Row Column	Redmond View	Outflow.Lo	evel Regu	lation Tab	le		
WFuture Level Tolerance WFuture Level Iterations PBStage Control Intervals		Units: N	IONE		Level	Regulation	Table		
Variable Regulation Intervals			1000.00		4000.00		44000.00		Discharge 1 cfs
		0:00 January 1	1999.99	2000.00	4999.99	5000.00 8.50	11999.99	12000.00	12000.00
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Stage Control Over Forecast Sag Operation Regulation Recession Key Control Point Balancing Flooding Exception	Stage Co None None None None	ontrol Fixed Over Fored	cast						

File Row Column View



Percent Full Regulation Table

Discharge 1 cfs

	20000.00	40000.00	75000.00	75000.01	125000.00	125000.01	150000.00	150000.00
0:00 January 2	0.00	0.07	0.09	0.18	0.19	0.40	0.40	1.00
0:00 February 16	0.00	0.07	0.09	0.18	0.19	0.40	0.40	1.00
0:00 March 2	0.00	0.03	0.05	0.10	0.11	0.40	0.40	1.00
0:00 May 16	0.00	0.03	0.05	0.10	0.11	0.40	0.40	1.00
0:00 June 16	0.00	0.11	0.13	0.18	0.19	0.40	0.40	1.00
0:00 September 16	0.00	0.11	0.13	0.18	0.19	0.40	0.40	1.00
0:00 October 2	0.00	0.07	0.09	0.18	0.19	0.50	0.50	1.00
0:00 November 2	0.00	0.07	0.09	0.18	0.19	0.50	0.50	1.00
0:00 December 2	0.00	0.07	0.09	0.18	0.19	0.50	0.50	1.00
0:00 December 16	0.00	0.07	0.09	0.18	0.19	0.40	0.40	1.00

Interpolate C Lookup Annual Period, Irregular Interval



Sag Regulation Method



 RiverWare 4.5.1 - RWDEM02005

 Model _Control _Workspace Policy Accounting _DMI _Utilities Help

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 Workspace Policy Accounting _DMI _Utilities Help

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 Workspace Policy Accounting _DMI _Utilities Help

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TANDEM SOLVING

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Balancing

Fillup

Pass through

RECENT EFFORTS BY CADSWES

- Completion of flood control logic & methods
- Scope DMI & RW integration into HEC-CWMS
- Assessment of COE hydropower approach
- Critical dependable pool and stream yield analysis using RW Batch Mode with RCL
- Multi-cycle periodic slot
- Flood control user guide

FLOOD CONTROL TESTING BY CADSWES

- RiverWare test results are very close to Super
- RiverWare generally releases more than Super
- Super storage slightly greater than RiverWare, total system difference very small
- Differences in flood control releases on one reservoir are made up for in another reservoir, total balance level very close
- Balance achieved by RiverWare is neither better nor worse on average than Super
- 61-year daily POR flood control run takes 2.6 hrs on Pentium 4 (4.3GHz with 1G RAM): 21 Reservoirs, 50 CP's

16 BALANCE LEVELS

1 Zero storage **2** Bottom conservation **3 Bottom power pool** 4 50% conservation **5** 100% conservation pool 6-8 Typically not used¹

10% Flood control 9 10 30% Flood control 11 50% Flood control 12 70% Flood control 13 90% Flood control 14 100% Flood control **15 Top surcharge** 16 Top of dam

CORPS USE WITH RIVERWARE

- Super to RW by Tulsa, Ft Worth, & Little Rock COE Distr's
- HEC-CWMS
- Real time evacuation of flood storage TAPER program used in Tulsa
- Water supply accounting
- Other COE Districts?

CORPS RIVERWARE BASINS

- Arkansas River
- Red River
- White River
- Brazos River
- Trinity River

Others: Kansas River, Upper Rio Grande

FUTURE WORK WITH CADSWES

- Balance Depletion Method of conservation pools
- DSS, Database, and DMI functionality
- RiverWare interaction with HEC-CWMS
- Performance issues
- Corps Hydropower and QFISH methods
- Statistical post processing analysis on Slots
- Input comparison tool

SUPER

R.I.P

RIVERWARE FLOOD CONTROL METHODS

Questions?

