Real-Time Dam Fill Time and Outflow Prediction Software DAMFLOWV100

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ACKNOWLEDGMENTS

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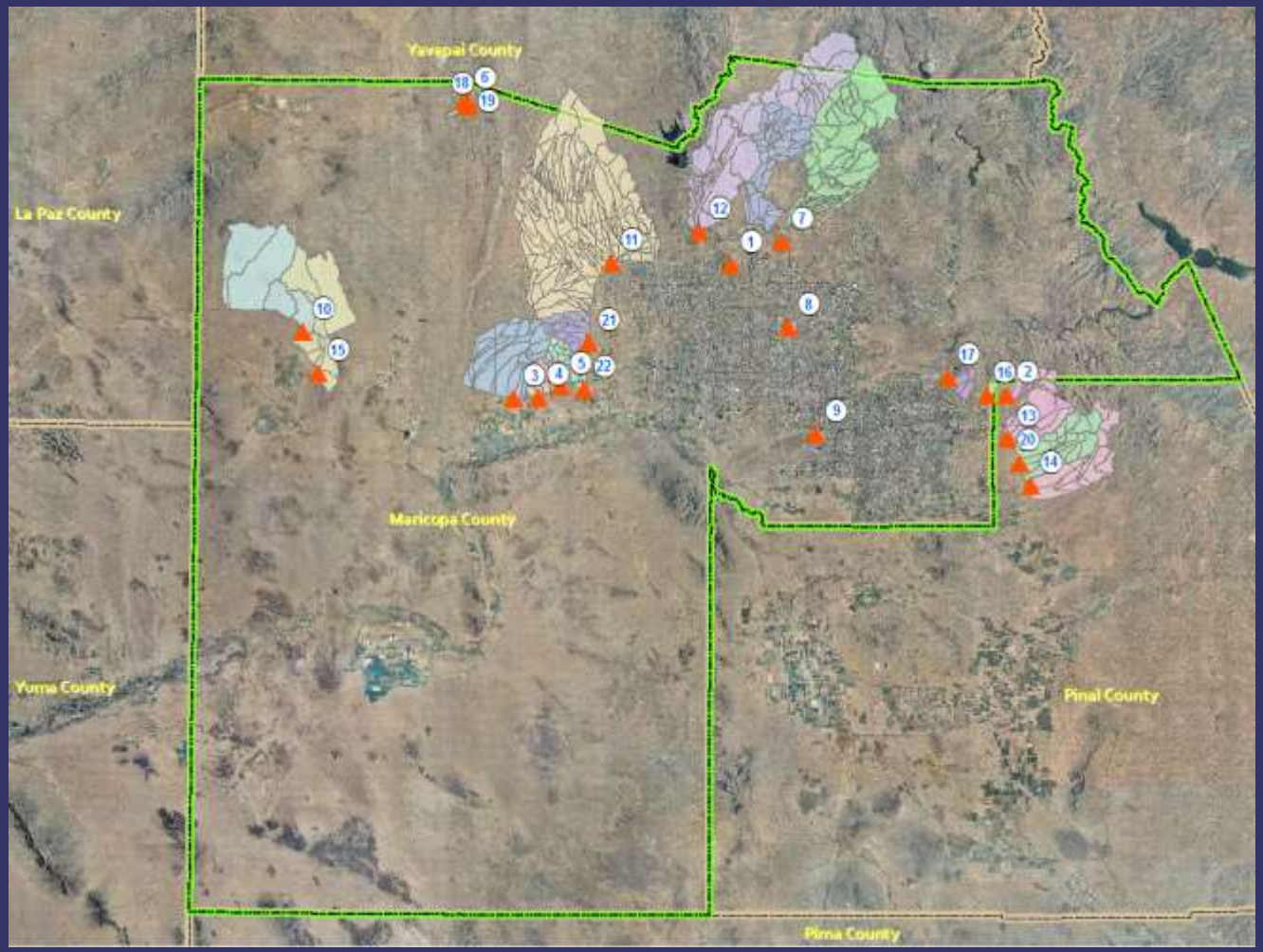
PRESENTATION OUTLINE

- Background and Objective
- Analysis Components / Modules
- Fundamentals / Theory
- Capabilities and Features
- Quick Program Overview

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

22 Flood Control District Dams



(1) Adobe Dam
(2) Apache Junction Dam
(3) Buckeye FRS #1
(4) Buckeye FRS #2
(5) Buckeye FRS #3
(6) Casandro Dam
(7) Cave Buttes Dam
(8) Dreamy Draw Dam
(9) Guadalupe FRS
(10) Harquahala FRS
(11) McMicken Dam
(12) New River Dam
(13) Powerline FRS
(14) Rittenhouse FRS
(15) Saddleback FRS
(16) Signal Butte FRS
(17) Spook Hill FRS
(18) Sunny Cove Dam
(19) Sunset Dam
(20) Vineyard FRS
(21) White Tanks FRS #3
(22) White Tanks FRS #4

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

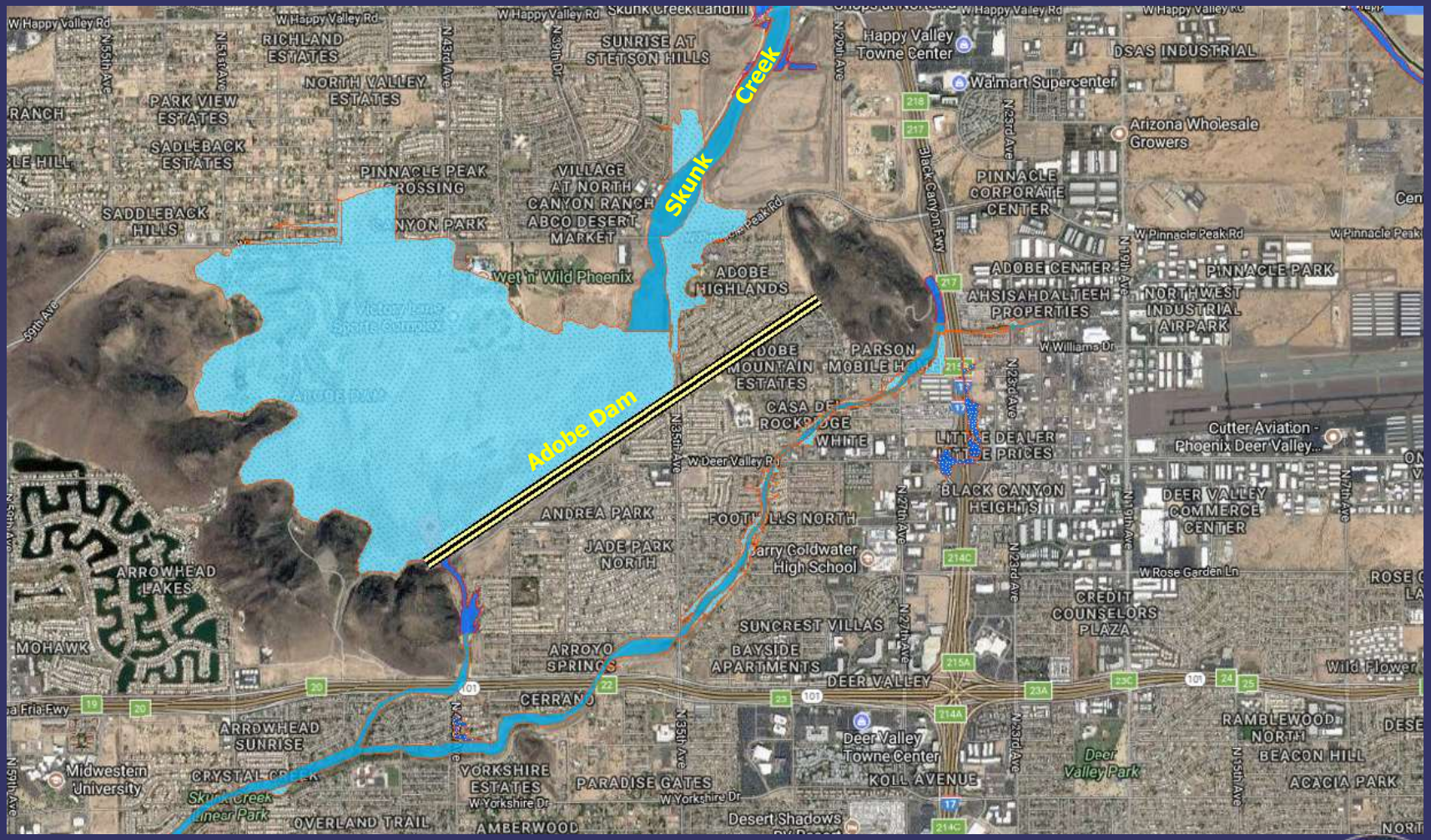
Adobe Dam Facts

Year Built:	1982
Drainage Area:	87.3 sq. mi.
Rivers:	Skunk Creek & New River
Dam Height:	65.3 ft
Dam Length:	2.1 miles
Cap. @ Spillway Crest Elev:	18,775 ac-ft
D/S Area:	Residential Area

The 2.1-mile Adobe Dam showing D/S Residential Area

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

Adobe Dam Facts



The 2.1-mile Adobe Dam showing D/S Residential Area

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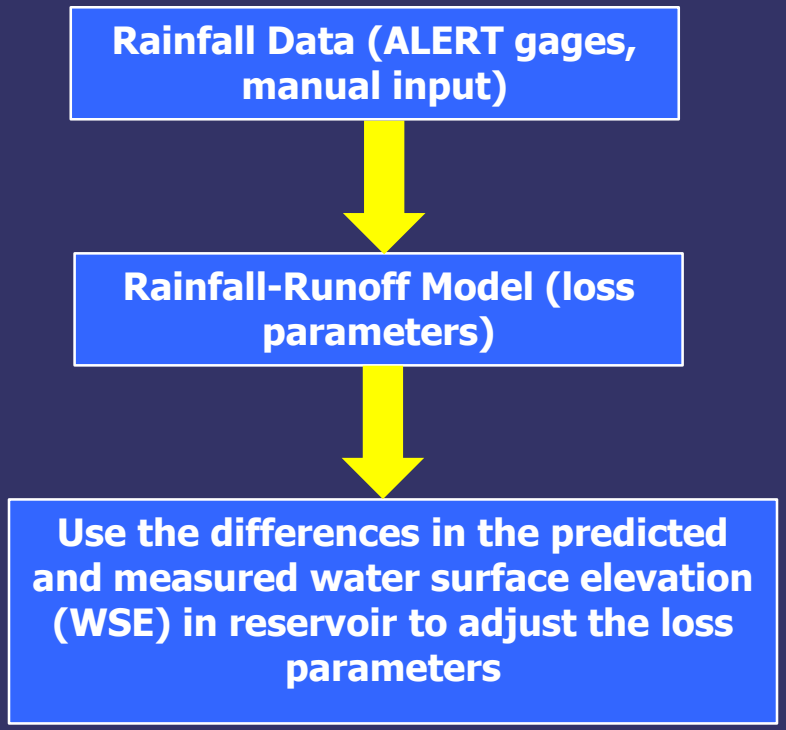
BACKGROUND AND OBJECTIVE

- Flood Modeling during Flood Exercises (EOC, AOC) since 1997
- Real-time Hydrologic and Hydraulic Modeling (with ALERT gages)
- Real-time HEC-1 Modeling for Dam Outflow Prediction for District's 22 dams (with ALERT gages)
- Real-time Rainfall-Runoff Modeling with Live Parameter Calibration for Dam Fill Time and Outflow Prediction

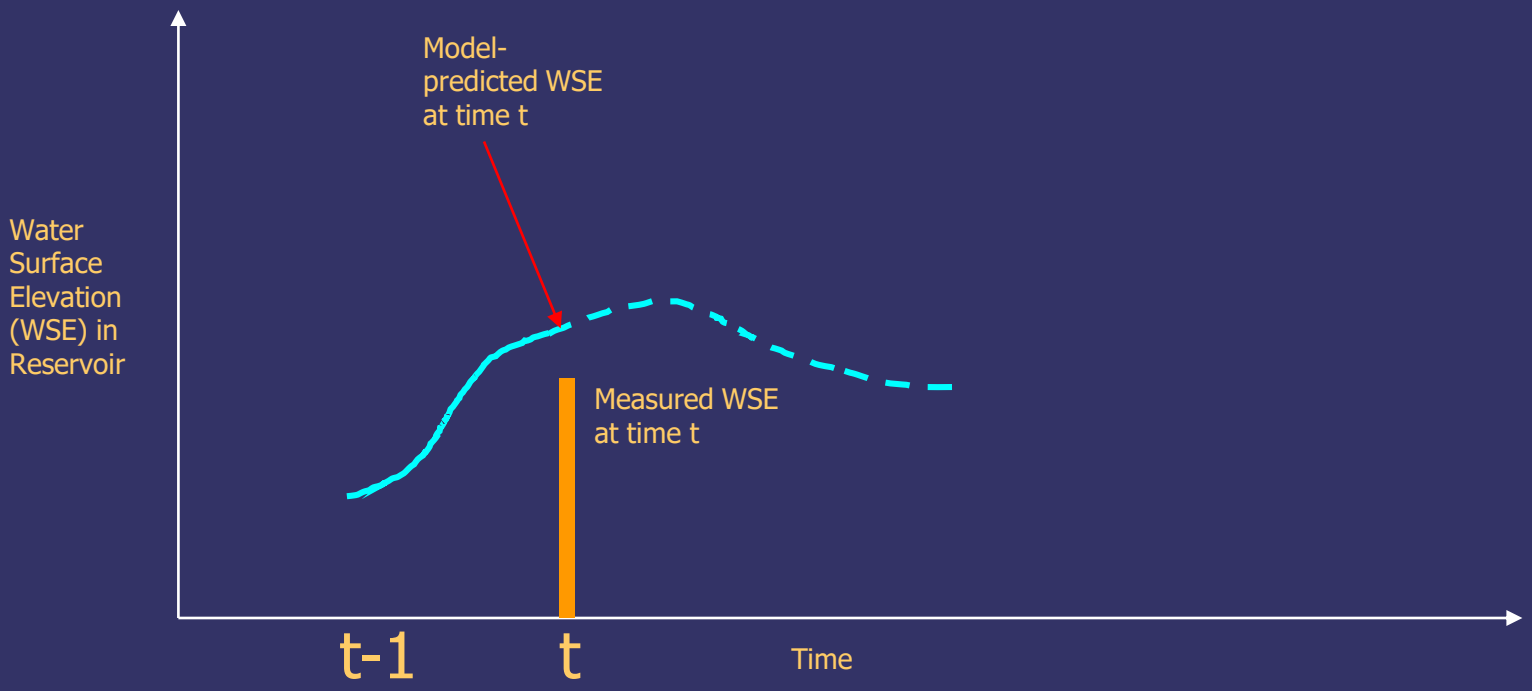
BACKGROUND AND OBJECTIVE

- Software Requirements: efficient, accuracy (through feedback for smaller time intervals), no need to use many sub-basins and Green-Ampt loss method
- 2016-2017 Strategic Initiative (FCDMC)
- Project Time Line: 7/2016-6/2017

What is parameter calibration?



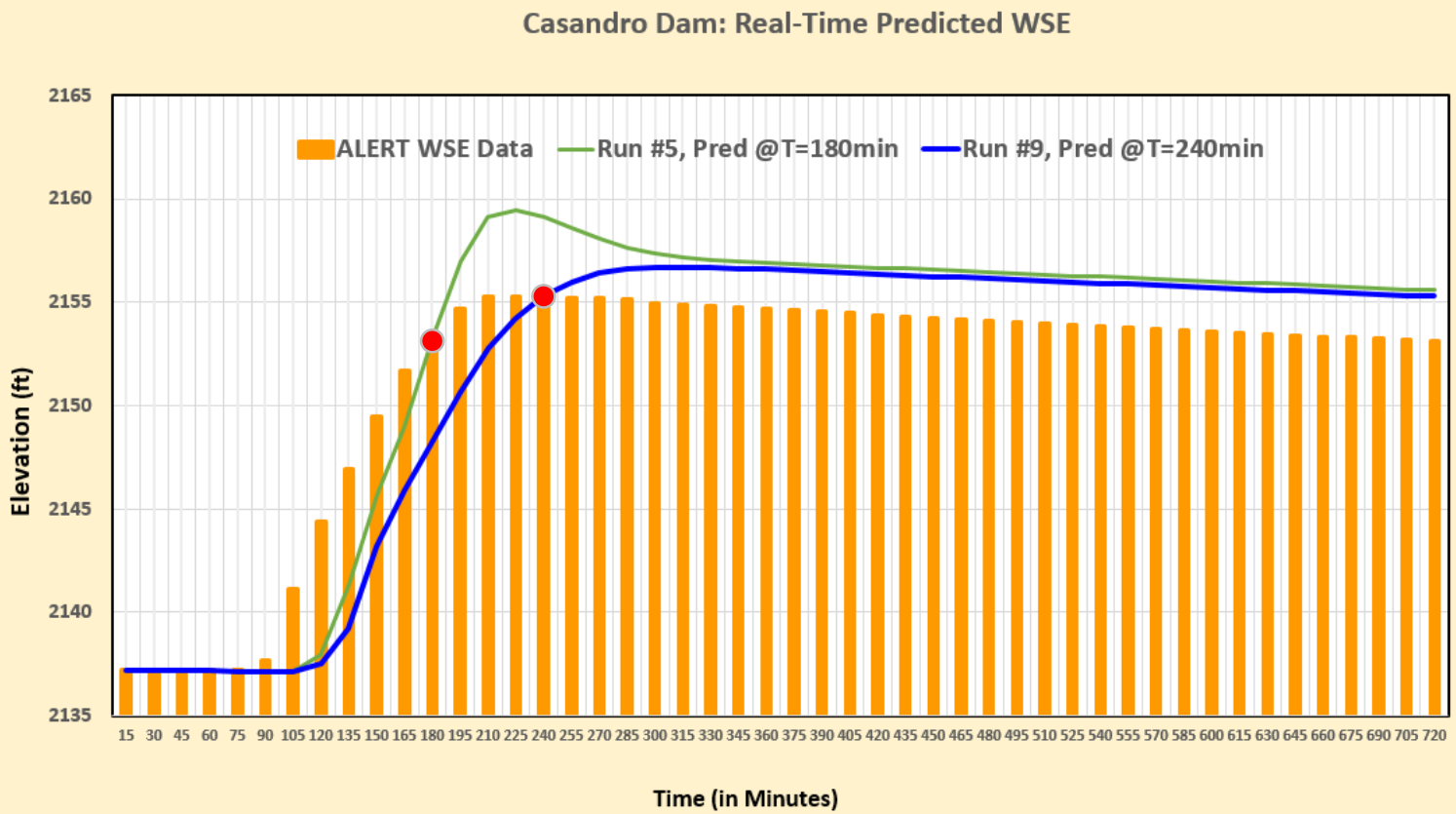
Real-time Parameter Calibration



Topic: Real-Time Dam Fill Time and Outflow Prediction Software

WSE Plot Comparison

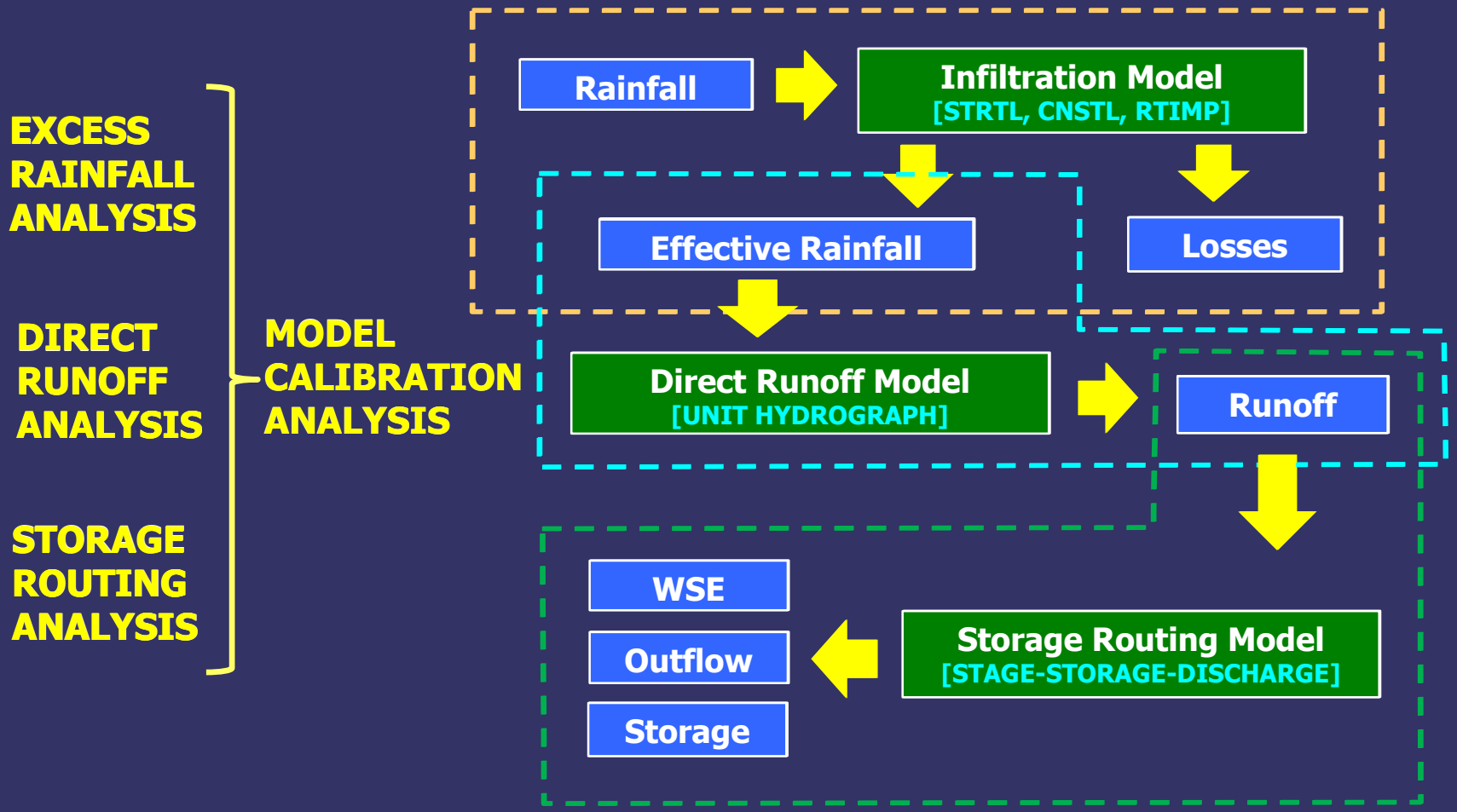
Observed Data vs Prediction Results



ANALYSIS COMPONENTS

- EXCESS RAINFALL ANALYSIS
- DIRECT RUNOFF ANALYSIS
- STORAGE ROUTING ANALYSIS
- MODEL CALIBRATION ANALYSIS

ANALYSIS COMPONENTS



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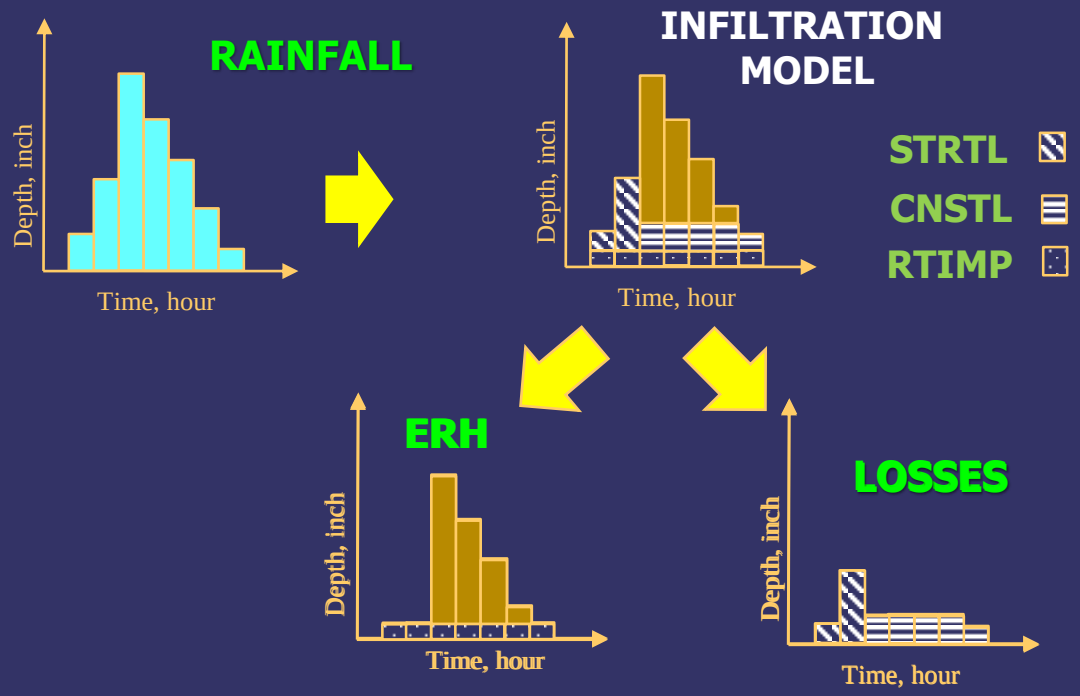
MODEL CALIBRATION ANALYSIS



EXCESS RAINFALL ANALYSIS

ANALYSIS COMPONENTS

MODEL CALIBRATION ANALYSIS

- EXCESS RAINFALL ANALYSIS
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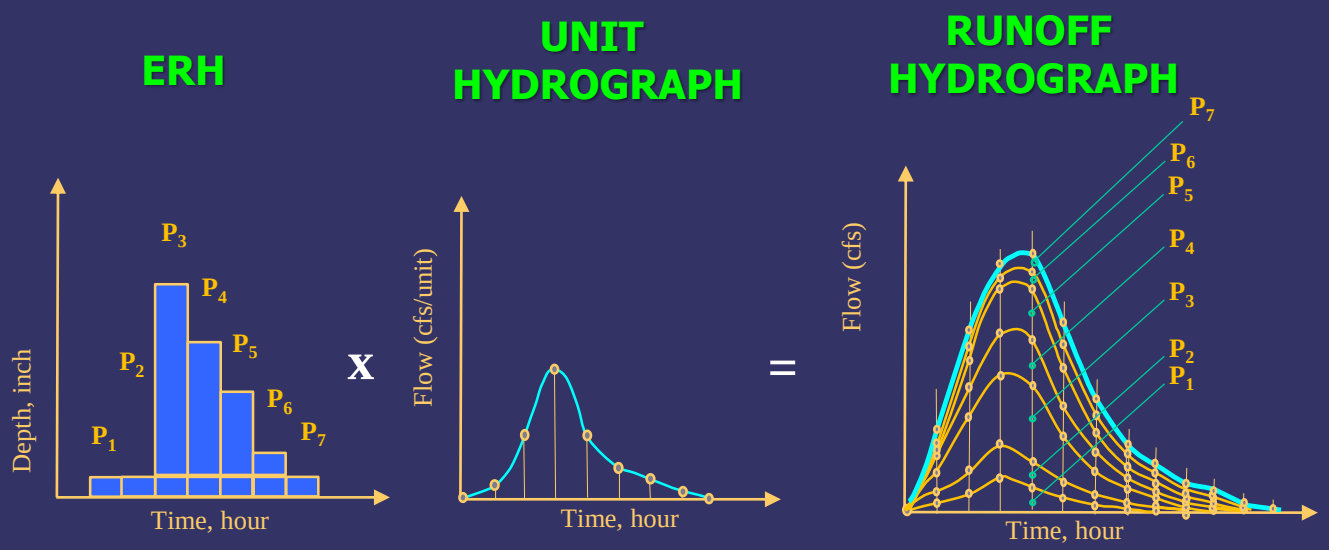


DIRECT RUNOFF ANALYSIS

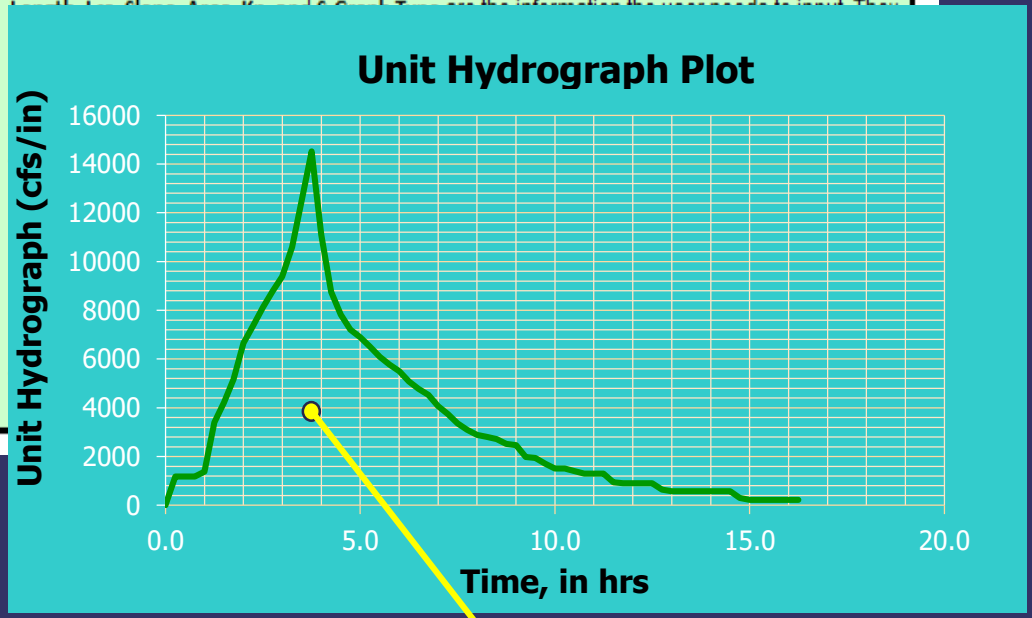
FUNDAMENTALS AND THEORY

❑ DIRECT RUNOFF ANALYSIS – UNIT HYDROGRAPH

S-GRAPH

UI Card Value Calculation (S-Graph) - Adobe Dam			
NMIN (Δt) =	15	minute	
Length (L) =	24.55	mile	
Lca =	13.02		
Slope (S) =	130.75	ft/mile	
Area (A) =	89.6	sq mile	
Area (A) =	2497904640.0	sq ft	
Kn =	0.05		
S-Graph Type =	Mountain		
Lag =	4.254	hour	
Q_{ULT} =	231286.3	cfs	
Conversion Factor =	645.33		

This sheet is used for evaluating the Unit Hydrograph. The parameters in yellow cells like **NMIN,**



Total Volume = 1 inch

FUNDAMENTALS AND THEORY

❑ DIRECT RUNOFF ANALYSIS

$$[P] \times [U] = [Q]$$

$$\begin{bmatrix} P_1 & 0 & 0 & \cdots & 0 & 0 & \cdots & 0 & 0 \\ P_2 & P_1 & 0 & \cdots & 0 & 0 & \cdots & 0 & 0 \\ P_3 & P_2 & P_1 & \cdots & 0 & 0 & \cdots & 0 & 0 \\ \cdot & & & & \cdot & & & & \cdot \\ \cdot & & & & \cdot & & & & \cdot \\ \cdot & & & & \cdot & & & & \cdot \\ P_M & P_{M-1} & P_{M-2} & \cdots & P_1 & 0 & \cdots & 0 & 0 \\ 0 & P_M & P_{M-1} & \cdots & P_2 & P_1 & \cdots & 0 & 0 \\ \cdot & & & & \cdot & & & & \cdot \\ \cdot & & & & \cdot & & & & \cdot \\ \cdot & & & & \cdot & & & & \cdot \\ 0 & 0 & 0 & \cdots & 0 & 0 & \cdots & P_M & P_{M-1} \\ 0 & 0 & 0 & \cdots & 0 & 0 & \cdots & 0 & P_M \end{bmatrix} \cdot \begin{bmatrix} U_1 \\ U_2 \\ U_3 \\ \vdots \\ U_{N-M+1} \end{bmatrix} = \begin{bmatrix} Q_1 \\ Q_2 \\ Q_3 \\ \cdot \\ \cdot \\ \cdot \\ Q_M \\ Q_{M+1} \\ \cdot \\ \cdot \\ \cdot \\ Q_{N-1} \\ Q_N \end{bmatrix}$$

[N x (N-M+1)] [(N-M+1) x 1] [N x 1]

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

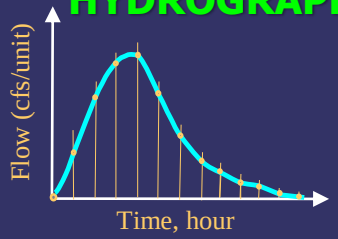
ANALYSIS COMPONENTS

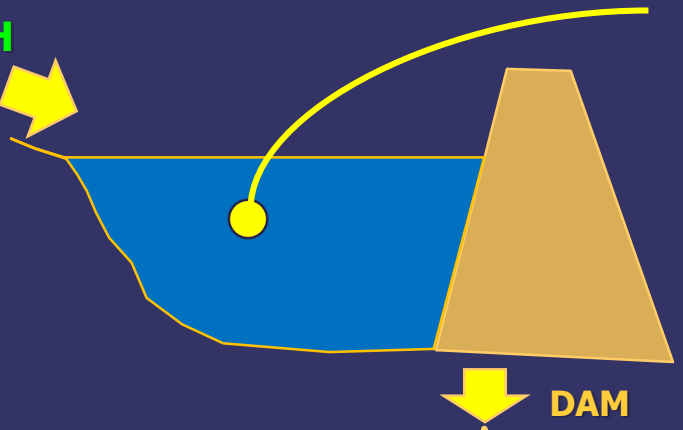
❑ STORAGE ROUTING ANALYSIS

- EXCESS RAINFALL ANALYSIS
- DIRECT RUNOFF ANALYSIS
- STORAGE ROUTING ANALYSIS

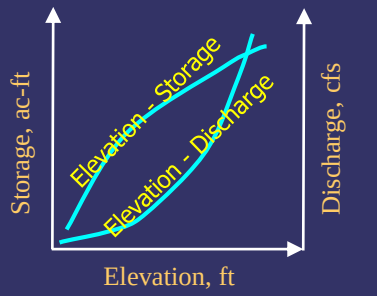
MODEL CALIBRATION ANALYSIS

INFLOW HYDROGRAPH

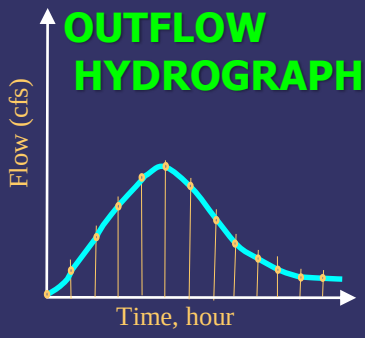




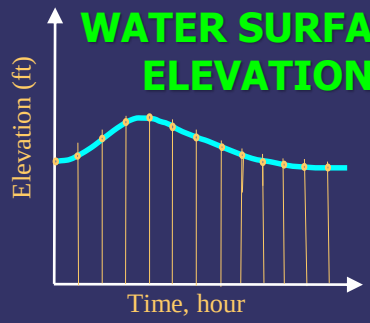
STAGE-STORAGE DISCHARGE CURVE



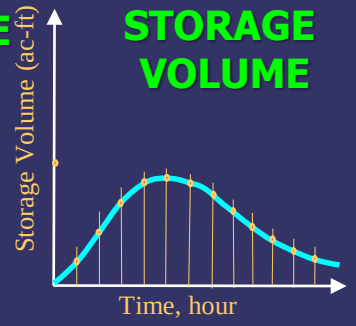
OUTFLOW HYDROGRAPH



WATER SURFACE ELEVATION



STORAGE VOLUME



STORAGE ROUTING ANALYSIS

FUNDAMENTALS AND THEORY

❑ STORAGE ROUTING ANALYSIS

$$I - Q = \frac{\partial S}{\partial t}$$

$$\frac{S_2 - S_1}{\Delta t} = \frac{I_1 + I_2}{2} - \frac{O_1 + O_2}{2}$$

$$Y = \frac{S_2 - S_1}{\Delta t} - \frac{I_1 + I_2}{2} + \frac{O_1 + O_2}{2}$$

KNOWN VARIABLES:

- Inflows (I_1, I_2)
- Outflow (O_1)
- Storage (S_1)

UNKNOWNS:

- Outflow (O_2)
- Storage (S_2)

WHERE: Y is the continuity error for the estimated elevation. The estimated elevation is adjusted until Y is less than $\pm$ 1 cfs.

FUNDAMENTALS AND THEORY

❑ LEVEL-POOL ROUTING ANALYSIS

$$Y = \frac{S_2 - S_1}{\Delta t} - \frac{I_1 + I_2}{2} + \frac{O_1 + O_2}{2}$$

$\leq$ 1.0 cfs

Known Parameters: S_1, I_1, I_2, O_1; where $S_1 = f(E_1)$ and $O_1 = f(E_1)$

Unknown Parameters: S_2, O_2

Iterative Procedure:

(1) Step 1: Make an estimate of the Water Surface Elevation, E_2.

(2) Step 2: From Rating Curve, determine S_2 and O_2 that correspond to E_2.

(3) Step 3: Using the values of S_2 and O_2, evaluate Y.

(4) Step 4: If the evaluated $Y \geq 1.0$ cfs, repeat Steps 1 to 3.
If the evaluated $Y < 1.0$ cfs, use E_2, S_2 and O_2 as the final values for the period.

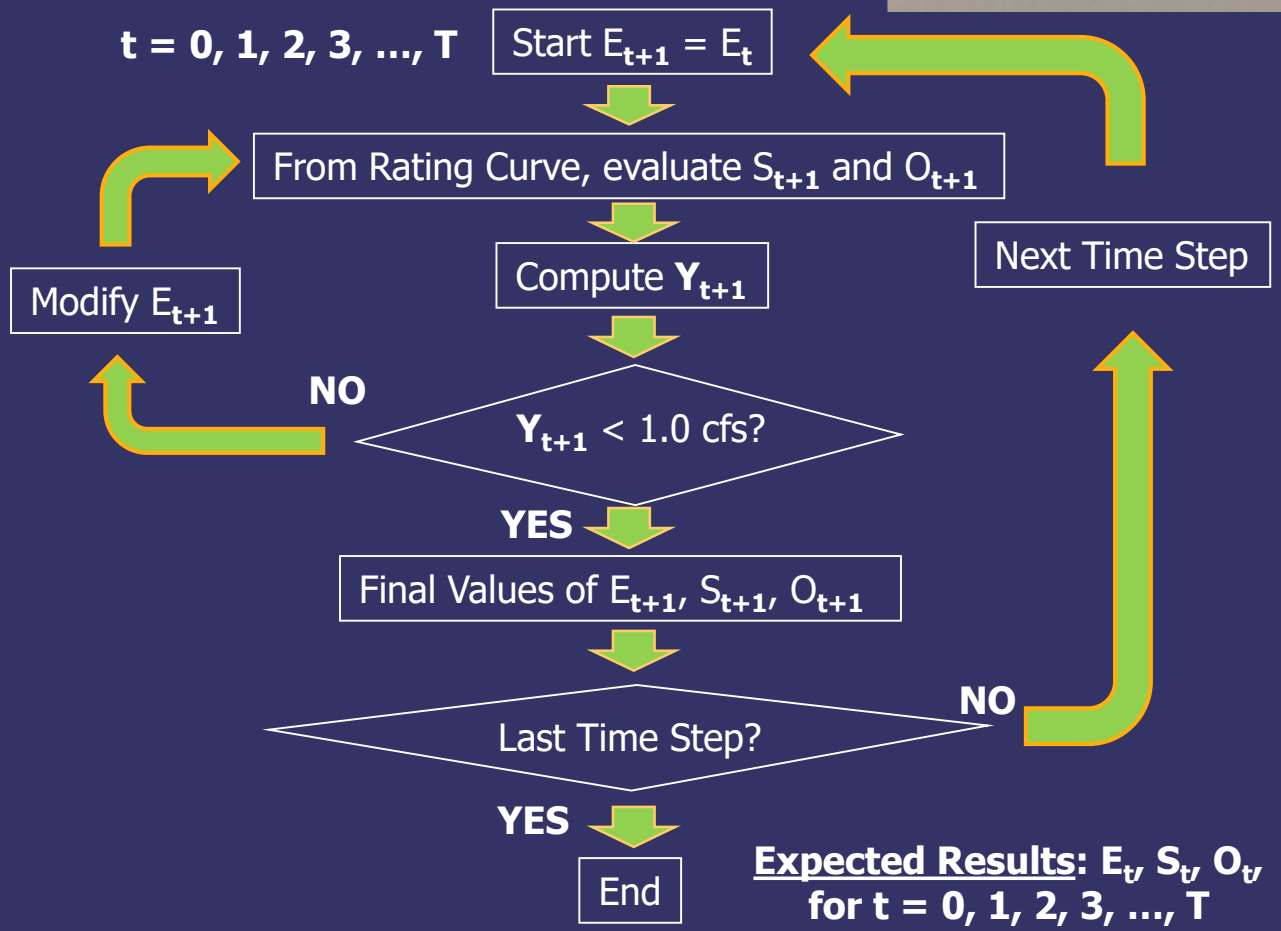
Proceed to the next period where $S_1 = S_2$ and $O_1 = O_2$.

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

FUNDAMENTALS AND THEORY

❑ STORAGE ROUTING ANALYSIS

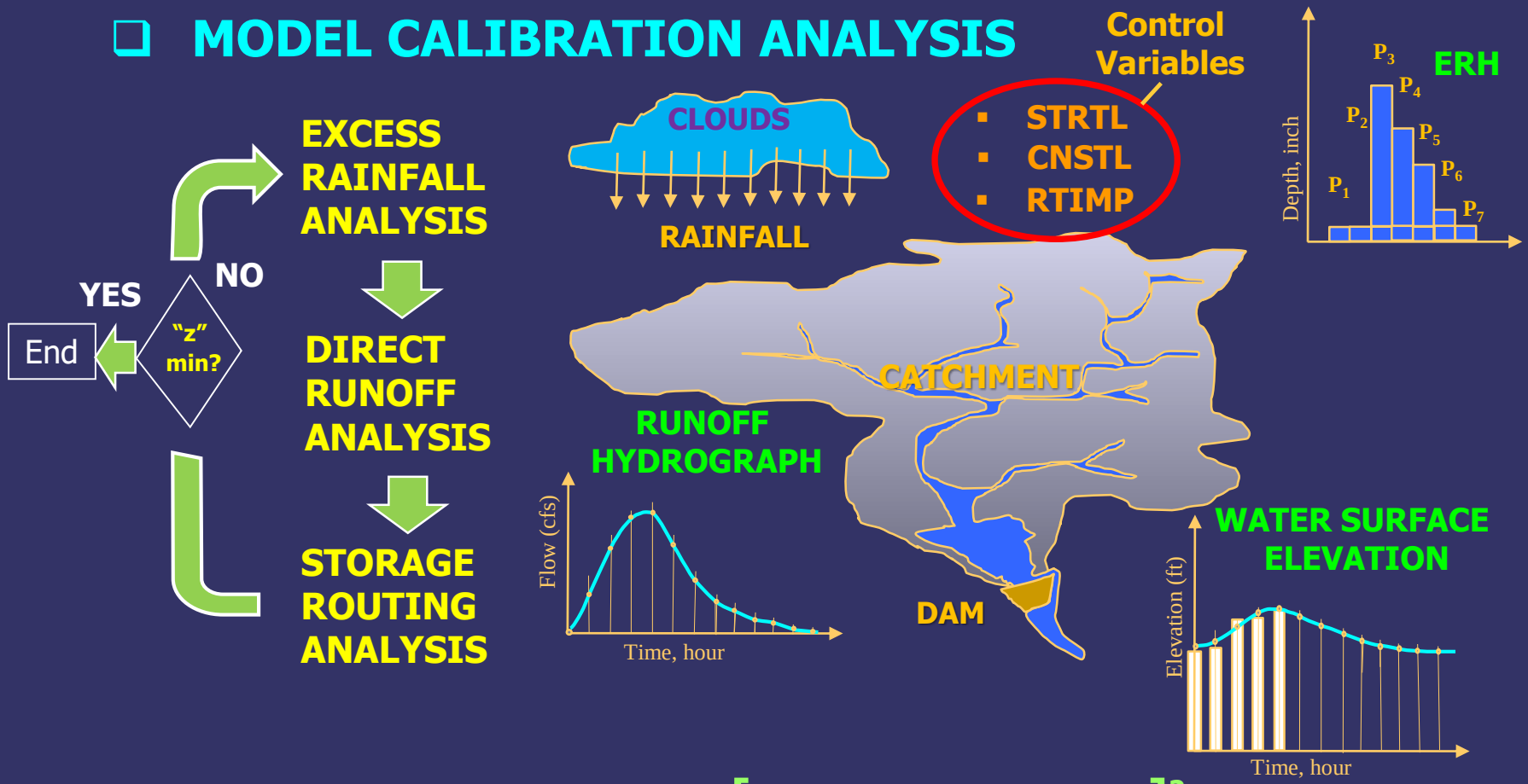
$$Y = \frac{S_2 - S_1}{\Delta t} - \frac{I_1 + I_2}{2} + \frac{O_1 + O_2}{2} \leq 1.0$$



Expected Results: E_t, S_t, O_t for t = 0, 1, 2, 3, …, T

ANALYSIS COMPONENTS

❑ MODEL CALIBRATION ANALYSIS

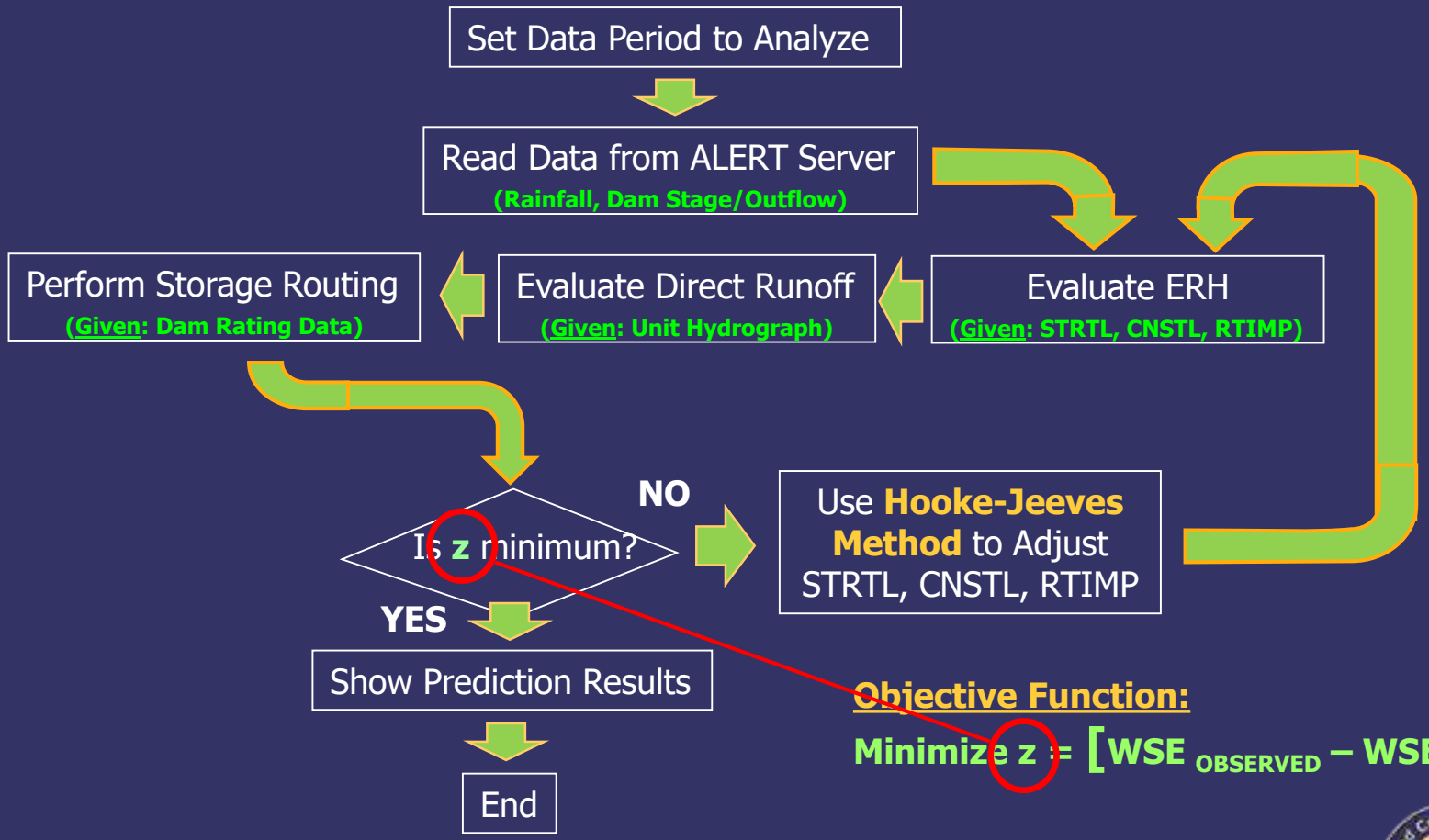


$$\text{Minimize } z = [WSE_{OBSERVED} - WSE_{MODEL}]^2$$

MODEL CALIBRATION ANALYSIS

FUNDAMENTALS AND THEORY

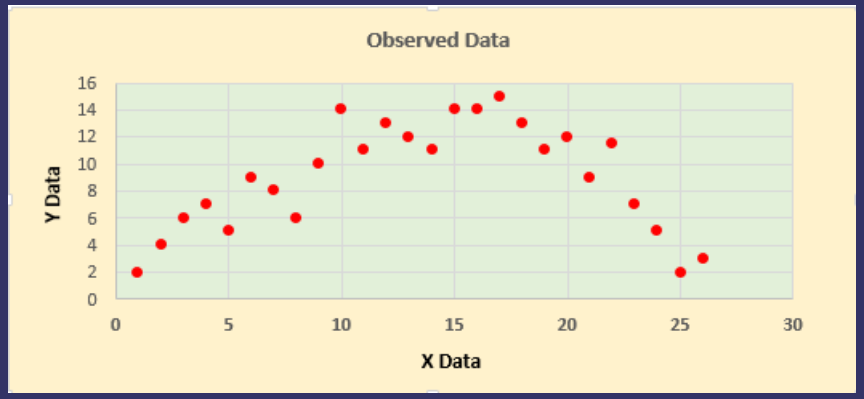
❑ CALIBRATION BY OPTIMIZATION ANALYSIS

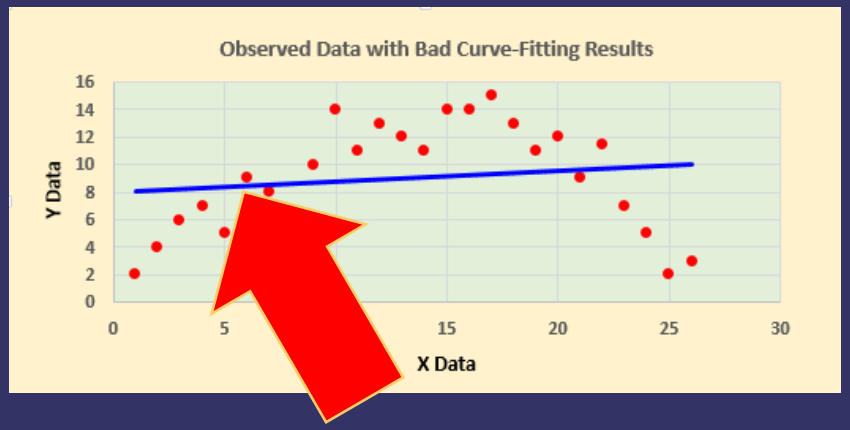


Topic: Real-Time Dam Fill Time and Outflow Prediction Software

FUNDAMENTALS AND THEORY

❑ MODEL CALIBRATION ANALYSIS





Analysis Results with "Poor" Model Parameters

Analysis Results with "Good" Model Parameters

FUNDAMENTALS AND THEORY

❑ MODEL CALIBRATION – OPTIMIZATION ANALYSIS

Objective Function:

Control Variables

State Variables

$$\text{Minimize } z = f(u, x) \quad (1)$$

$$\text{Minimize } z = [WSE_{OBSERVED} - WSE_{MODEL}]^2$$

ALERT DATA

subject to:

$$p(u, x) = 0 \quad \text{Governing Equations} \quad (2)$$

$$p_{min} \leq p(u, x) \leq p_{max} \quad \text{System Constraints} \quad (3)$$

$$u, x \geq 0 \quad \text{Non-Negativity Constraints} \quad (4)$$

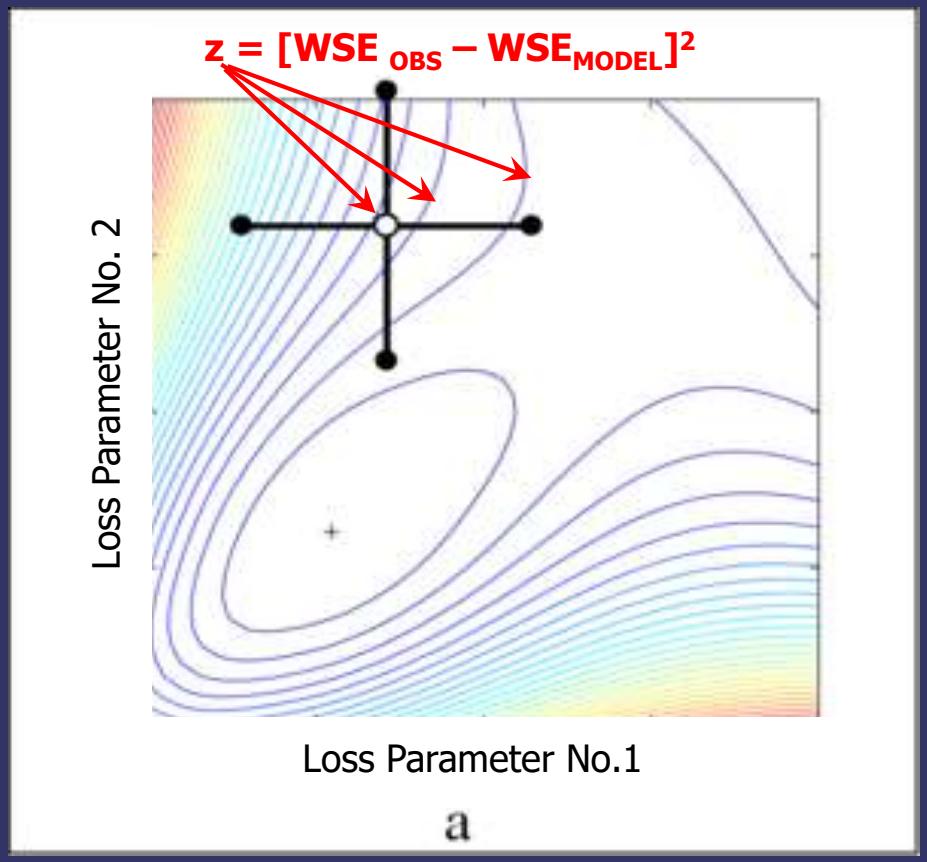
Control Variables:
Rainfall Loss Parameters

- STRTL
- CNSTL
- RTIMP

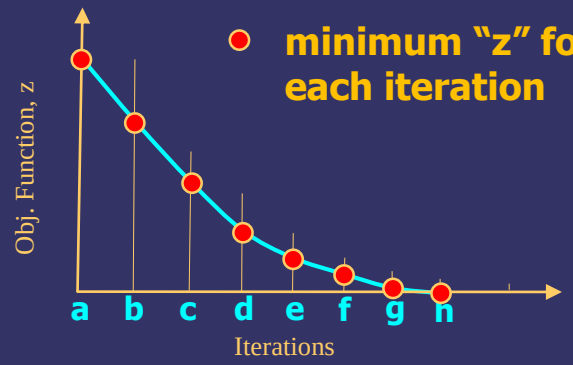
FUNDAMENTALS AND THEORY

❑ MODEL CALIBRATION – OPTIMIZATION ANALYSIS

Hooke and Jeeves Method (Direct Search Method):



- The contour lines are represented by evaluated z values.
- The algorithm starts its search from a wide area. Once the best "z" value is found, the algorithm uses that position as a base to search the neighborhood for a better solution employing a narrower search area.

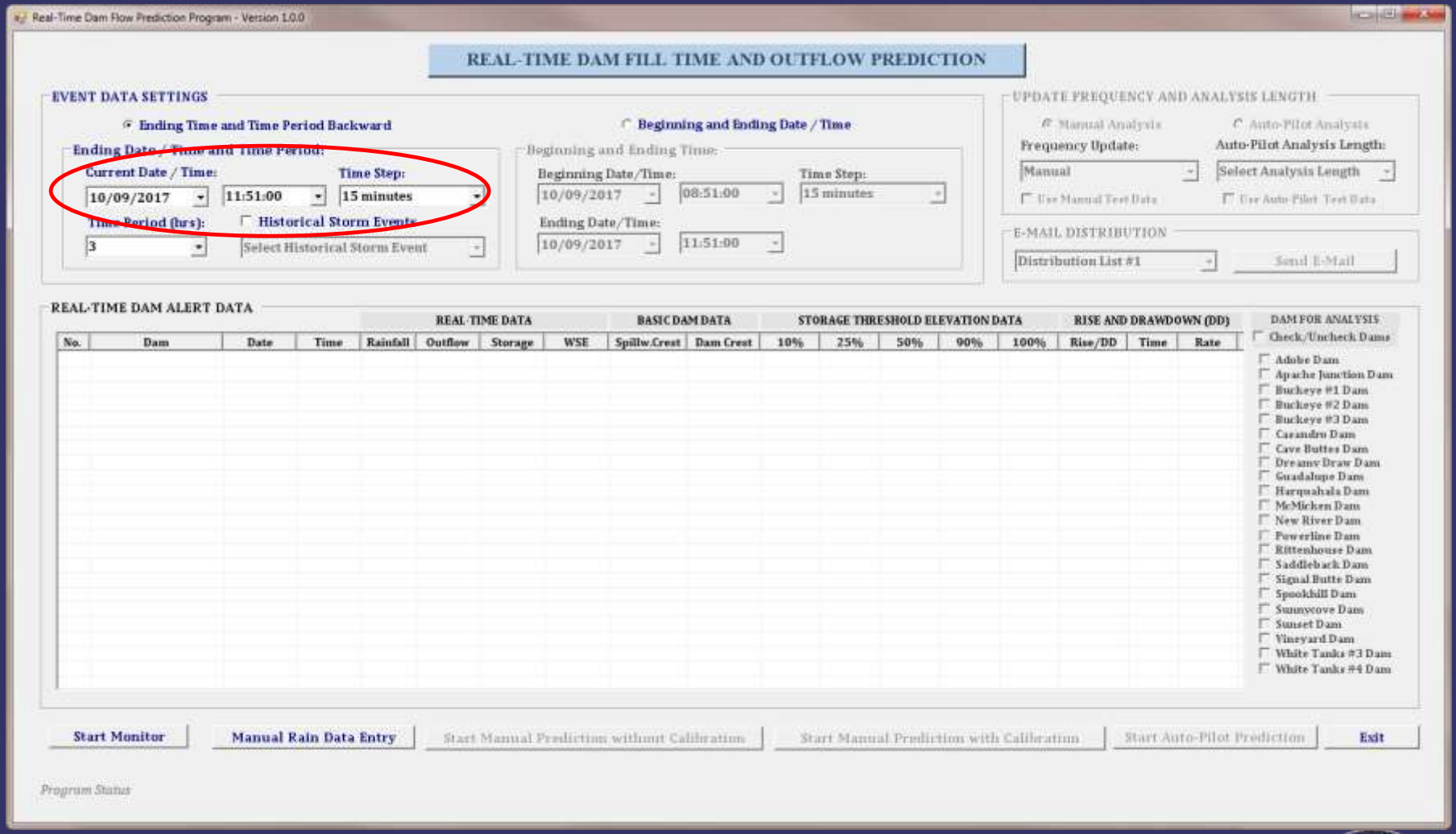


Iterative Search

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

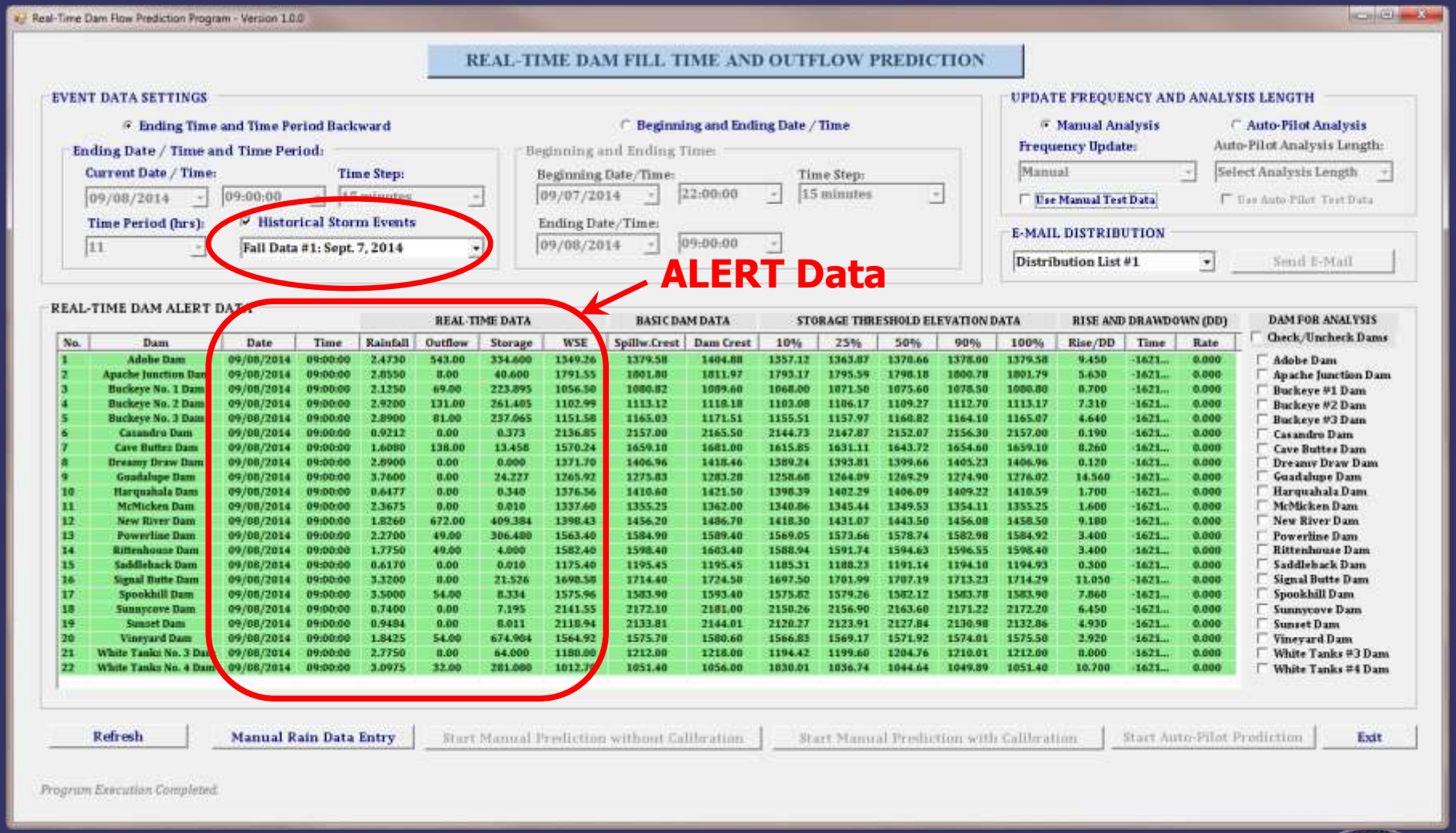
QUICK PROGRAM OVERVIEW

Topic: Real-Time Dam Fill Time and Outflow Prediction Software



Running the Software – Initially Displays the Current Date / Time

Topic: Real-Time Dam Fill Time and Outflow Prediction Software



Running the Software with Historical Storm Event

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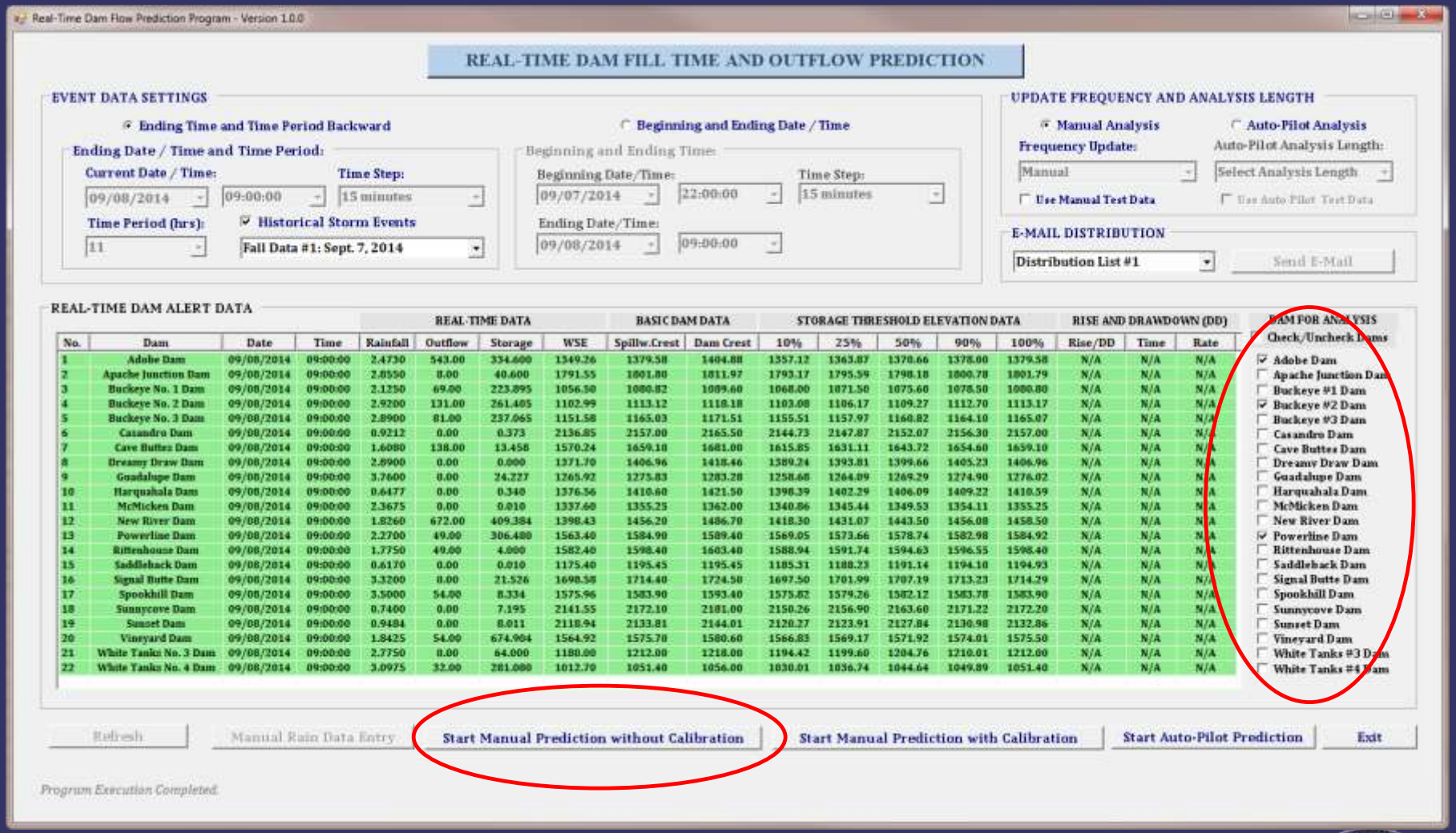

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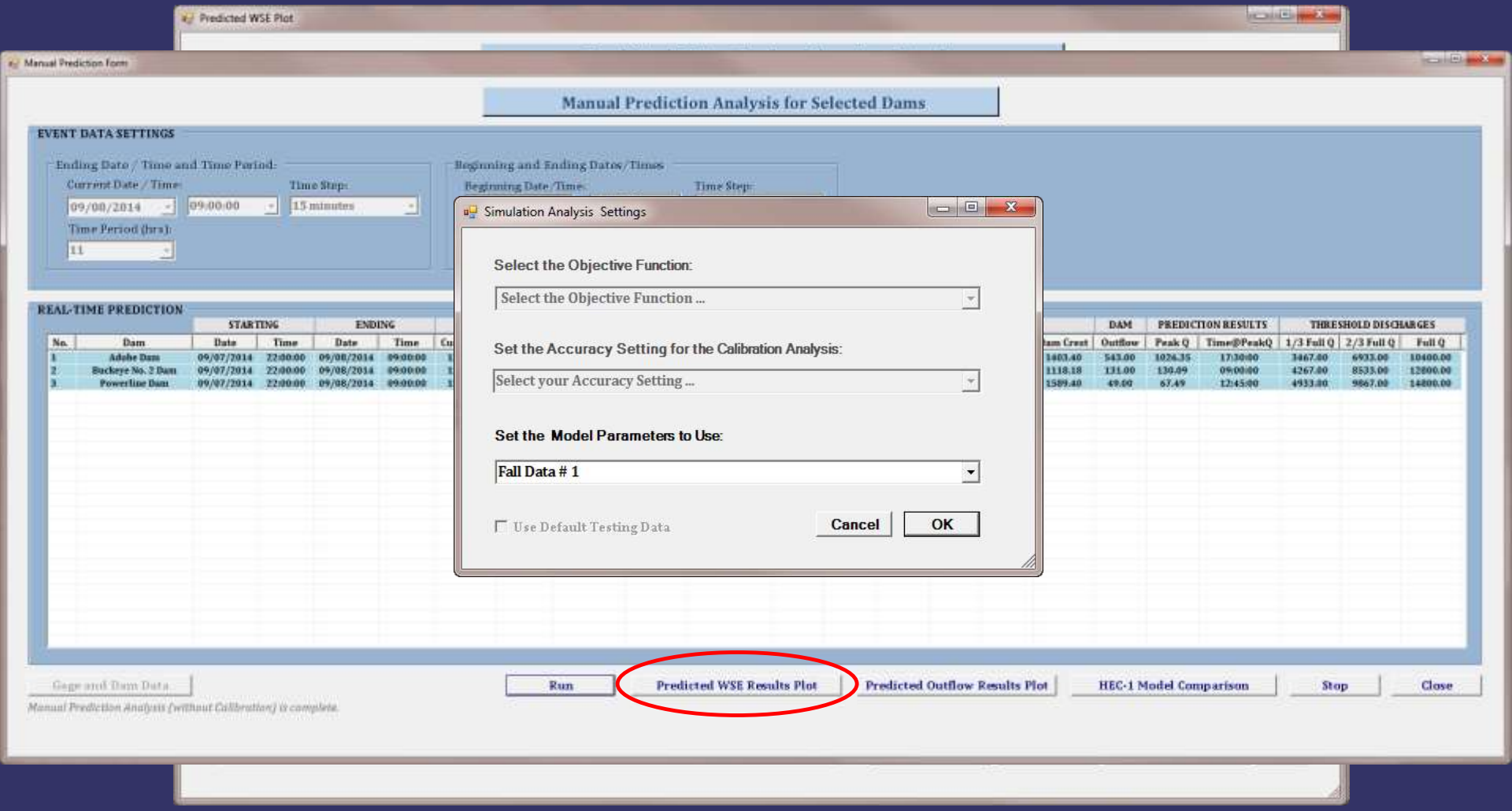

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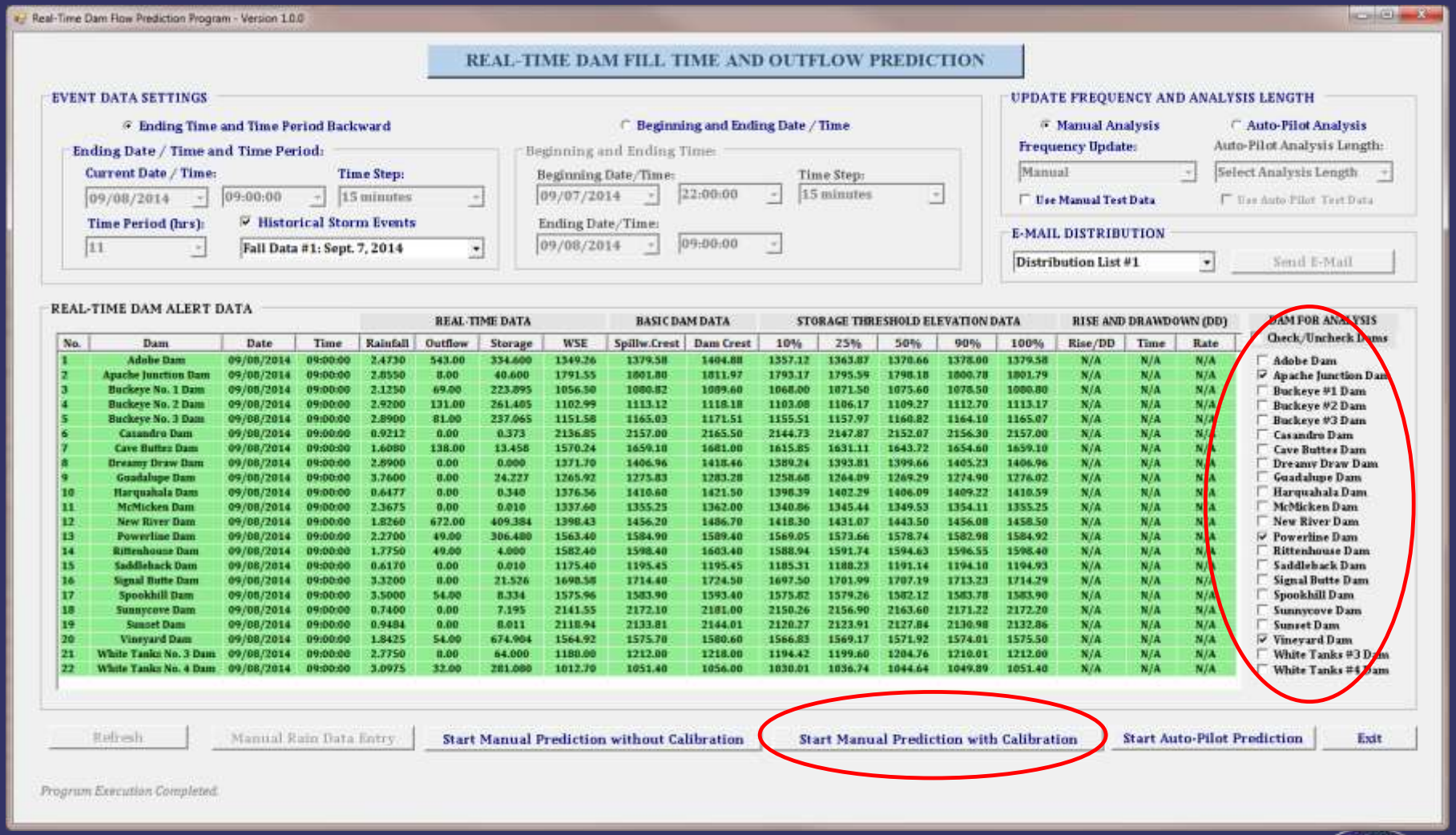

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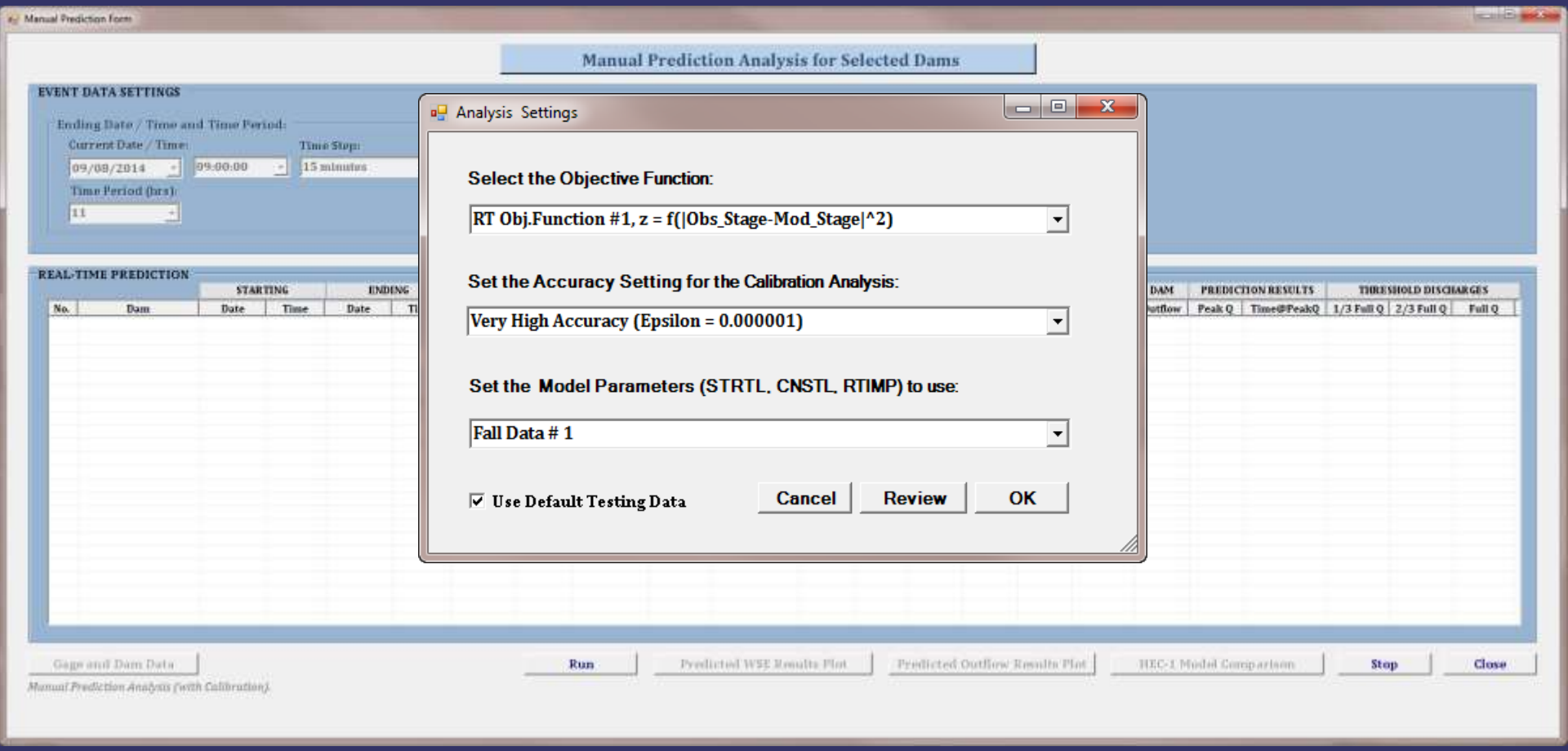

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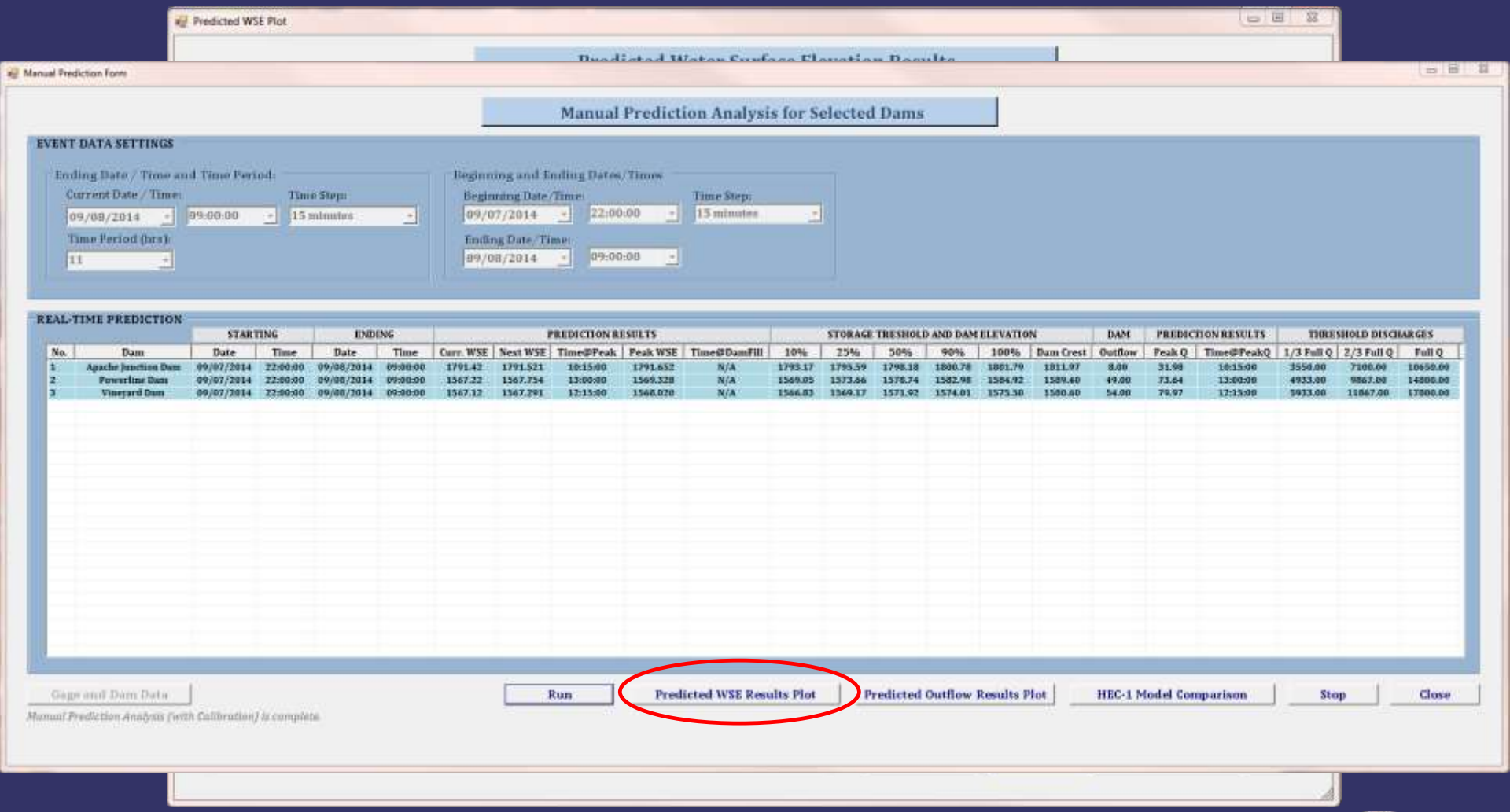

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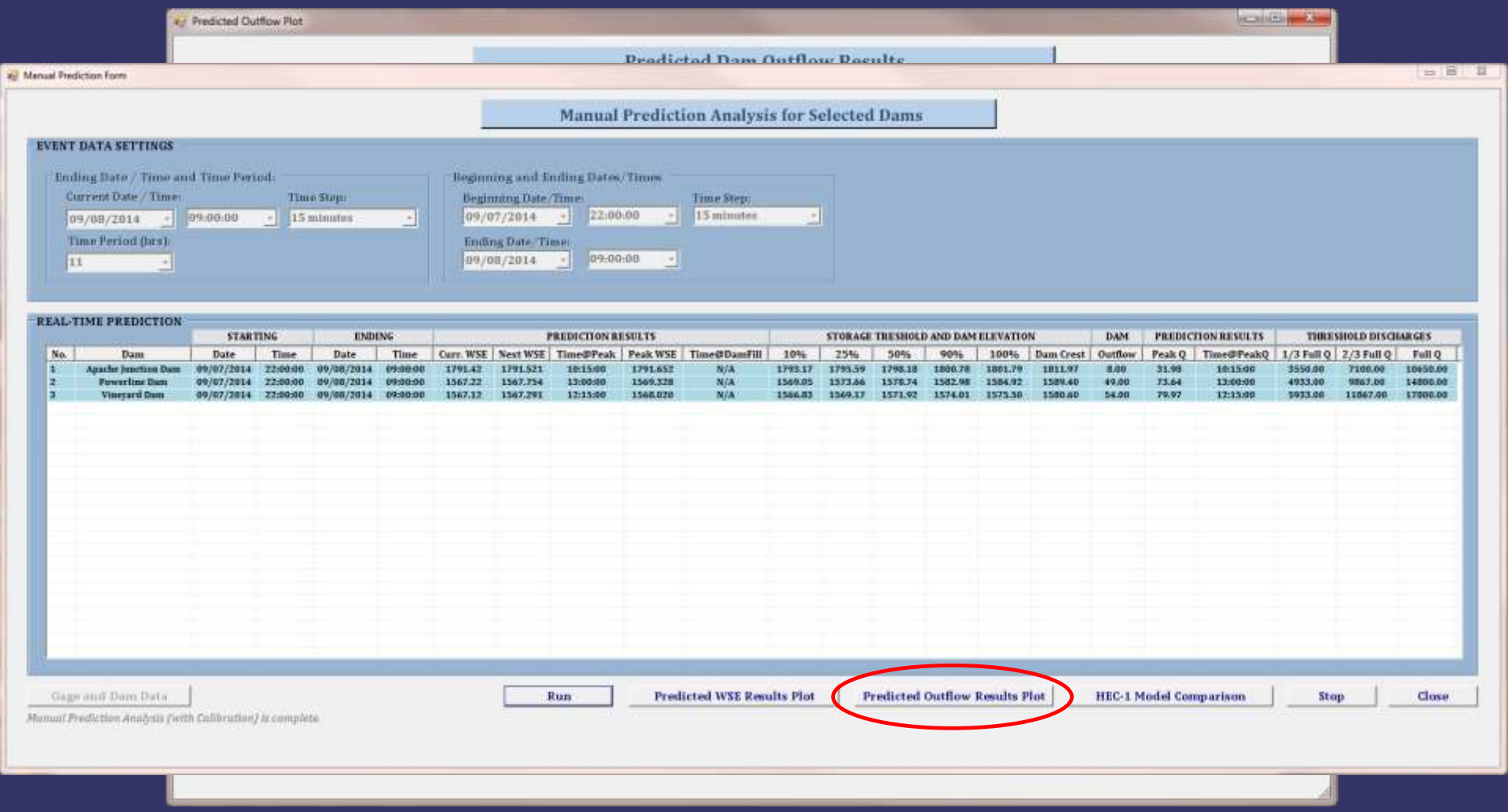

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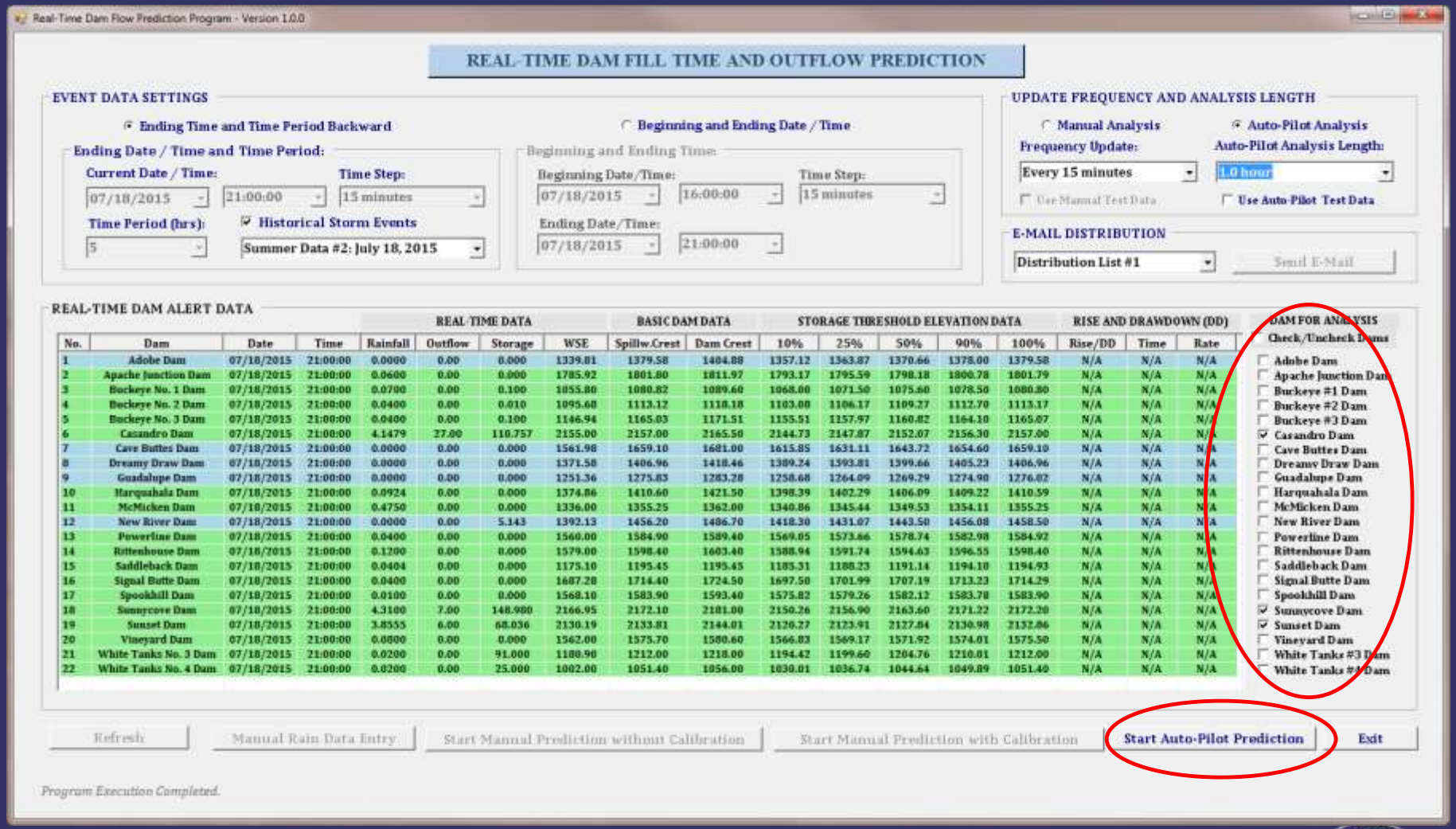

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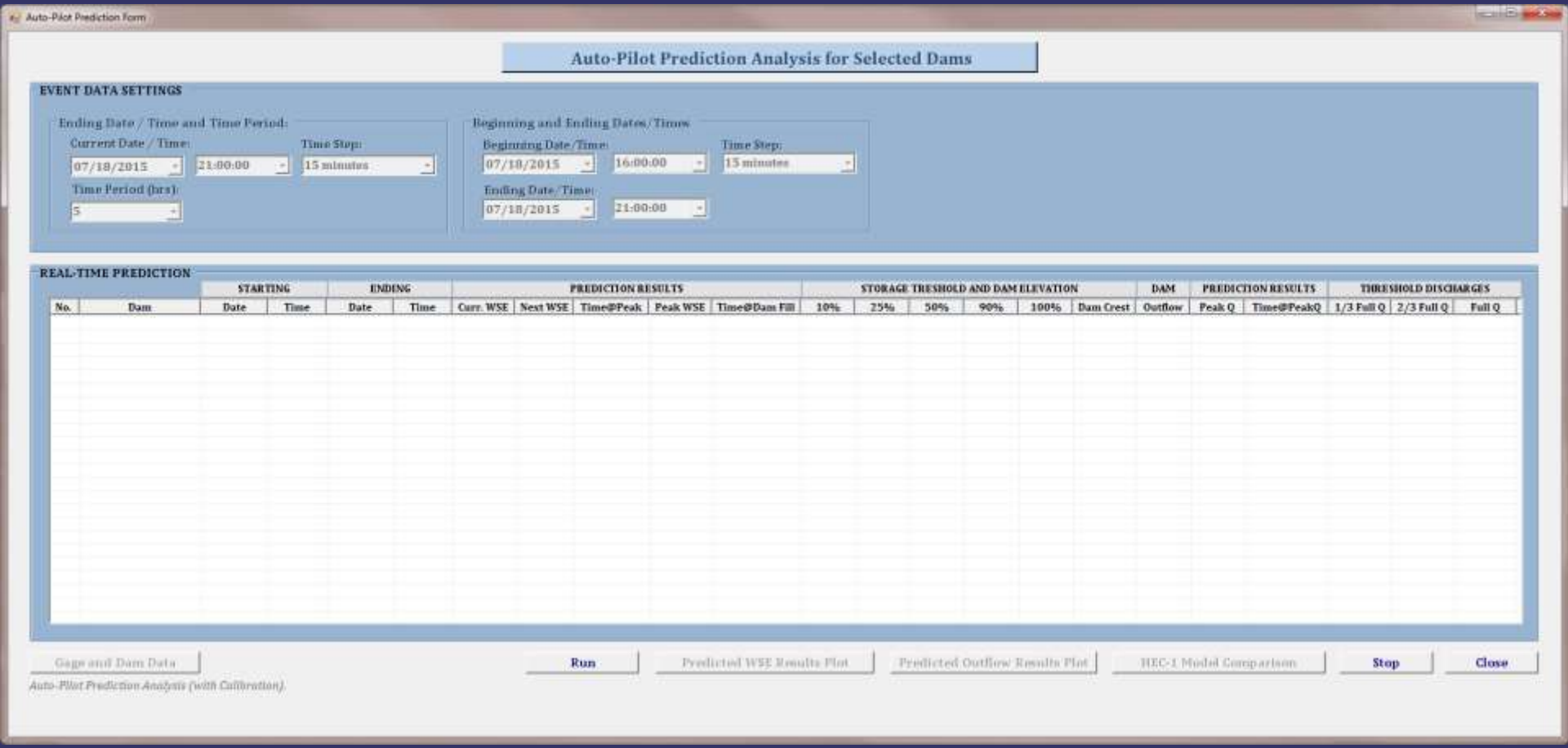

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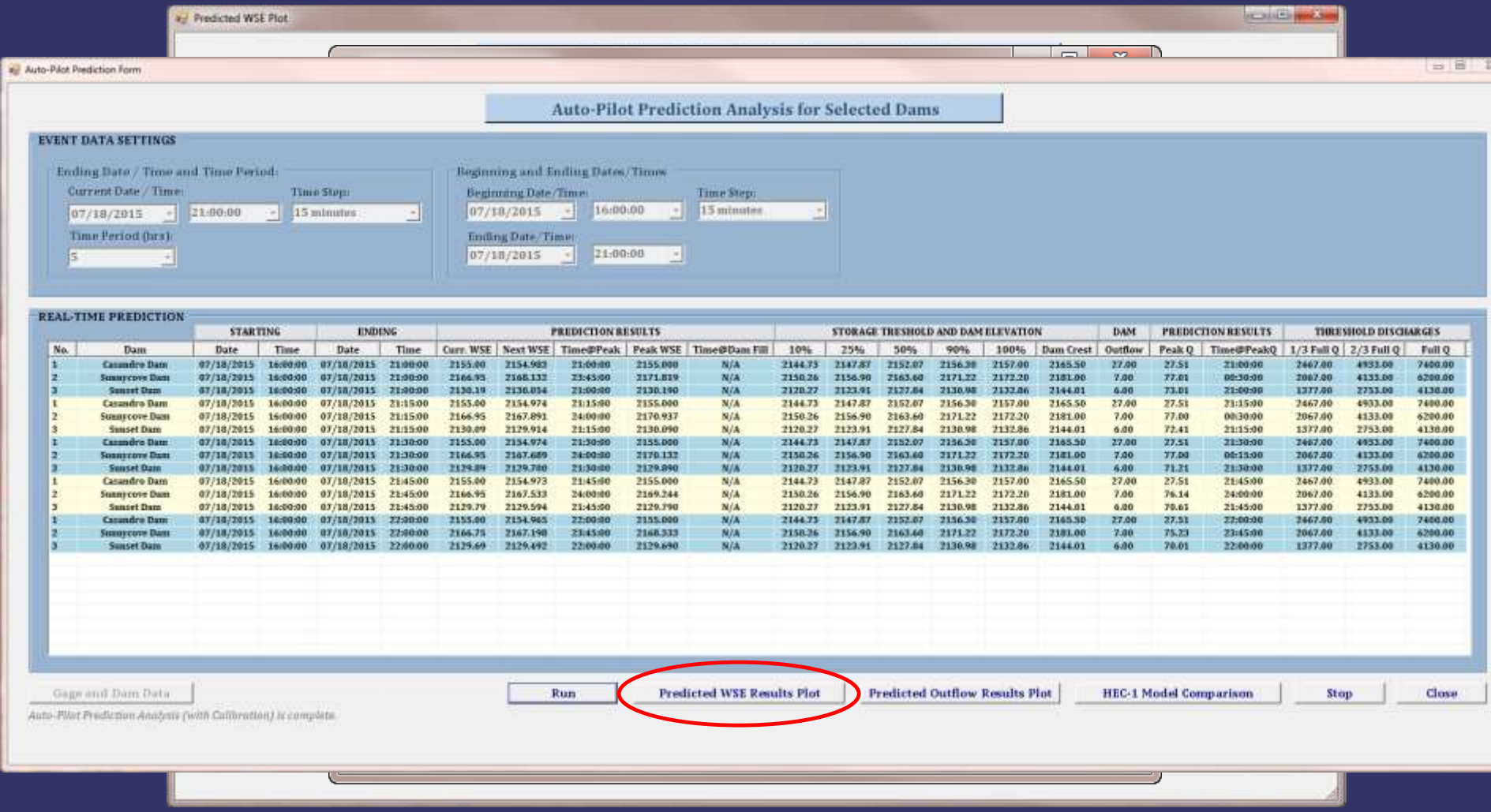
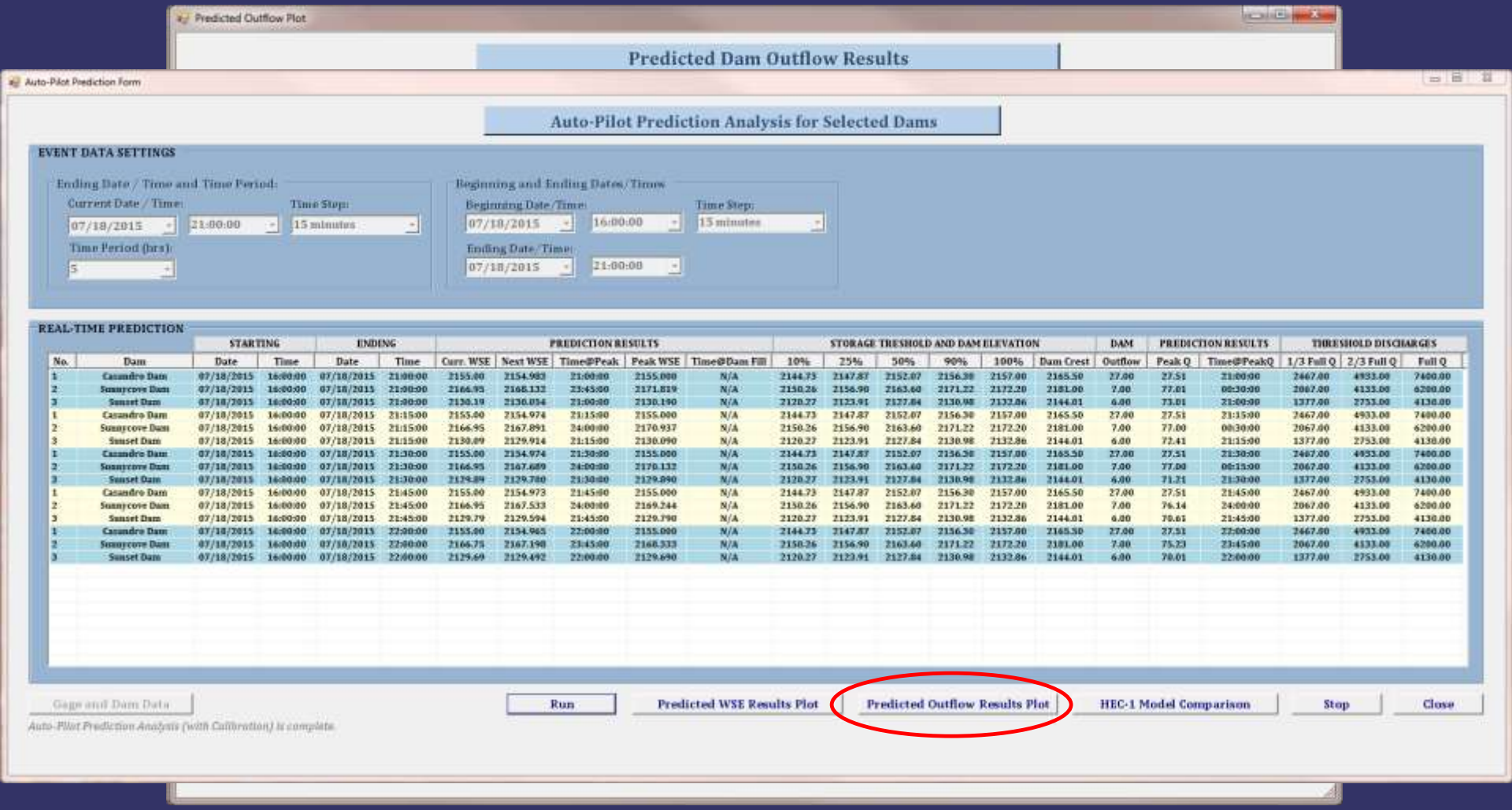


		STARTING		ENDING		PREDICTION RESULTS					STORAGE TRESHOLD AND DAM ELEVATION						DAM	PREDICTION RESULTS		THRESHOLD DISCHARGES		
No.	Dam	Date	Time	Date	Time	Curr. WSE	Next WSE	Time@Peak	Peak WSE	Time@Dam Fill	10%	25%	50%	90%	100%	Dam Crest	Outflow	Peak Q	Time@PeakQ	1/3 Full Q	2/3 Full Q	Full Q
1	Casandro Dam	07/18/2015	16:00:00	07/18/2015	21:00:00	2155.00	2154.983	21:00:00	2155.000	N/A	2144.73	2147.87	2152.07	2156.30	2157.00	2165.50	27.00	27.51	21:00:00	2467.00	4933.00	7400.00
2	Sunnycove Dam	07/18/2015	16:00:00	07/18/2015	21:00:00	2166.95	2168.132	23:45:00	2171.819	N/A	2150.26	2156.90	2163.60	2171.22	2172.20	2181.00	7.00	77.01	00:30:00	2067.00	4133.00	6200.00
3	Sunset Dam	07/18/2015	16:00:00	07/18/2015	21:00:00	2130.19	2130.034	21:00:00	2130.190	N/A	2120.27	2123.91	2127.84	2130.98	2132.86	2144.01	6.00	73.01	21:00:00	1377.00	2753.00	4130.00
1	Casandro Dam	07/18/2015	16:00:00	07/18/2015	21:15:00	2155.00	2154.974	21:15:00	2155.000	N/A	2144.73	2147.87	2152.07	2156.30	2157.00	2165.50	27.00	27.51	21:15:00	2467.00	4933.00	7400.00
2	Sunnycove Dam	07/18/2015	16:00:00	07/18/2015	21:15:00	2166.95	2167.891	24:00:00	2170.937	N/A	2150.26	2156.90	2163.60	2171.22	2172.20	2181.00	7.00	77.00	00:30:00	2067.00	4133.00	6200.00
3	Sunset Dam	07/18/2015	16:00:00	07/18/2015	21:15:00	2130.09	2129.914	21:15:00	2130.090	N/A	2120.27	2123.91	2127.84	2130.98	2132.86	2144.01	6.00	72.41	21:15:00	1377.00	2753.00	4130.00
1	Casandro Dam	07/18/2015	16:00:00	07/18/2015	21:30:00	2155.00	2154.974	21:30:00	2155.000	N/A	2144.73	2147.87	2152.07	2156.30	2157.00	2165.50	27.00	27.51	21:30:00	2467.00	4933.00	7400.00
2	Sunnycove Dam	07/18/2015	16:00:00	07/18/2015	21:30:00	2166.95	2167.689	24:00:00	2170.132	N/A	2150.26	2156.90	2163.60	2171.22	2172.20	2181.00	7.00	77.00	00:15:00	2067.00	4133.00	6200.00
3	Sunset Dam	07/18/2015	16:00:00	07/18/2015	21:30:00	2129.89	2129.780	21:30:00	2129.890	N/A	2120.27	2123.91	2127.84	2130.98	2132.86	2144.01	6.00	71.21	21:30:00	1377.00	2753.00	4130.00
1	Casandro Dam	07/18/2015	16:00:00	07/18/2015	21:45:00	2155.00	2154.973	21:45:00	2155.000	N/A	2144.73	2147.87	2152.07	2156.30	2157.00	2165.50	27.00	27.51	21:45:00	2467.00	4933.00	7400.00
2	Sunnycove Dam	07/18/2015	16:00:00	07/18/2015	21:45:00	2166.95	2167.533	24:00:00	2169.244	N/A	2150.26	2156.90	2163.60	2171.22	2172.20	2181.00	7.00	76.14	24:00:00	2067.00	4133.00	6200.00
3	Sunset Dam	07/18/2015	16:00:00	07/18/2015	21:45:00	2129.79	2129.594	21:45:00	2129.790	N/A	2120.27	2123.91	2127.84	2130.98	2132.86	2144.01	6.00	70.61	21:45:00	1377.00	2753.00	4130.00
1	Casandro Dam	07/18/2015	16:00:00	07/18/2015	22:00:00	2155.00	2154.965	22:00:00	2155.000	N/A	2144.73	2147.87	2152.07	2156.30	2157.00	2165.50	27.00	27.51	22:00:00	2467.00	4933.00	7400.00
2	Sunnycove Dam	07/18/2015	16:00:00	07/18/2015	22:00:00	2166.75	2167.198	23:45:00	2168.333	N/A	2150.26	2156.90	2163.60	2171.22	2172.20	2181.00	7.00	75.23	23:45:00	2067.00	4133.00	6200.00
3	Sunset Dam	07/18/2015	16:00:00	07/18/2015	22:00:00	2129.69	2129.492	22:00:00	2129.690	N/A	2120.27	2123.91	2127.84	2130.98	2132.86	2144.01	6.00	70.01	22:00:00	1377.00	2753.00	4130.00

Topic: Real-Time Dam Fill Time and Outflow Prediction Software



Topic: Real-Time Dam Fill Time and Outflow Prediction Software

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

PROGRAM FEATURES AND CAPABILITIES

- REAL-TIME PREDICTION ANALYSIS
- "ON-THE-FLY" MODEL CALIBRATION
- "HEC-1 ~~LIKE~~ LITE" PROGRAM
- E-MAIL NOTIFICATION FEATURE
- "AUTO-PILOT" ANALYSIS
- "MANUAL" PREDICTION ANALYSIS
- "ASK QUESTION" FEATURE

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

PROGRAM FEATURES AND CAPABILITIES

❖ REAL-TIME PREDICTION ANALYSIS

Real-Time Dam Flow Prediction Program - Version 1.0.0

REAL-TIME DAM FILL TIME AND OUTFLOW PREDICTION

EVENT DATA SETTINGS

- (•) Ending Time and Time Period Backward
- ( ) Beginning and Ending Date / Time

Ending Date / Time and Time Period:
Current Date / Time: 10/09/2017 08:29:00
Time Step: 15 minutes
Time Period (hrs): 3
[ ] Historical Storm Events
Select Historical Storm Event

Beginning and Ending Time:
Beginning Date/Time: 10/09/2017 05:29:00
Time Step: 15 minutes
Ending Date/Time: 10/09/2017 08:29:00

UPDATE FREQUENCY AND ANALYSIS LENGTH

(•) Manual Analysis ( ) Auto-Pilot Analysis
Frequency Update: Manual
Auto-Pilot Analysis Length: Select Analysis Length
[ ] Use Manual Test Data [ ] Use Auto-Pilot Test Data

E-MAIL DISTRIBUTION

Distribution List #1 — Send E-Mail

REAL-TIME DAM ALERT DATA

No.	Dam	Date	Time	Rainfall	REAL TIME DATA Outflow	Storage	WSE	BASIC DAM DATA Spillw.Crest	Dam Crest	STORAGE THRESHOLD ELEVATION DATA 10%	25%	50%	90%	100%	RISE AND DRAWDOWN (DD) Rise/DD	Time	Rate	DAM FOR ANALYSIS Check/Uncheck Dams
1	Adobe Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1339.81	1379.50	1404.88	1357.12	1363.87	1370.66	1378.00	1379.50	N/A	N/A	N/A	[ ] Adobe Dam
2	Apache Junction Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1785.92	1801.80	1811.97	1793.17	1795.59	1798.18	1800.78	1801.79	N/A	N/A	N/A	[ ] Apache Junction Dam
3	Buckeye No. 1 Dam	10/09/2017	08:29:00	0.0000	0.00	0.100	1055.80	1080.82	1089.60	1060.00	1071.50	1075.60	1078.50	1080.80	N/A	N/A	N/A	[ ] Buckeye #1 Dam
4	Buckeye No. 2 Dam	10/09/2017	08:29:00	0.0000	0.00	0.010	1095.60	1113.12	1118.18	1103.08	1106.17	1109.27	1112.70	1113.17	N/A	N/A	N/A	[ ] Buckeye #2 Dam
5	Buckeye No. 3 Dam	10/09/2017	08:29:00	0.0000	0.00	0.100	1146.94	1165.03	1171.51	1155.51	1157.97	1160.82	1164.10	1165.07	N/A	N/A	N/A	[ ] Buckeye #3 Dam
6	Casandro Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	2136.66	2157.00	2165.50	2144.73	2147.87	2152.07	2156.30	2157.00	N/A	N/A	N/A	[ ] Casandro Dam
7	Cave Buttes Dam	10/09/2017	08:29:00	0.0000	0.00	0.458	1563.89	1659.10	1681.00	1615.85	1631.11	1643.72	1654.60	1659.10	N/A	N/A	N/A	[ ] Cave Buttes Dam
8	Dreamy Draw Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1371.58	1406.96	1418.46	1389.24	1393.81	1399.66	1405.23	1406.96	N/A	N/A	N/A	[ ] Dreamy Draw Dam
9	Guadalupe Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1751.36	1275.83	1283.20	1258.68	1264.09	1269.29	1274.90	1276.02	N/A	N/A	N/A	[ ] Guadalupe Dam
10	Harquahala Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1374.86	1410.60	1421.50	1398.39	1402.29	1406.09	1409.22	1410.59	N/A	N/A	N/A	[ ] Harquahala Dam
11	McMicken Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1336.00	1355.25	1362.00	1340.86	1345.44	1349.53	1354.11	1355.25	N/A	N/A	N/A	[ ] McMicken Dam
12	New River Dam	10/09/2017	08:29:00	0.0000	30.00	8.351	1392.18	1456.20	1486.70	1418.30	1431.07	1443.50	1456.08	1458.50	N/A	N/A	N/A	[ ] New River Dam
13	Powerline Dam	10/09/2017	08:29:00	0.0000	6.00	22.995	1560.44	1584.90	1589.40	1569.05	1573.66	1578.74	1582.98	1584.92	N/A	N/A	N/A	[ ] Powerline Dam
14	Rittenhouse Dam	10/09/2017	08:29:00	0.0000	6.00	0.000	1579.44	1598.40	1603.40	1588.94	1591.74	1594.63	1596.55	1598.40	N/A	N/A	N/A	[ ] Rittenhouse Dam
15	Saddleback Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1175.10	1195.45	1195.45	1185.31	1188.23	1191.14	1194.10	1194.93	N/A	N/A	N/A	[ ] Saddleback Dam
16	Signal Butte Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1687.53	1714.40	1724.50	1697.50	1701.99	1707.19	1713.23	1714.29	N/A	N/A	N/A	[ ] Signal Butte Dam
17	Spookhill Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1568.10	1583.90	1593.40	1575.82	1579.26	1582.12	1583.78	1583.90	N/A	N/A	N/A	[ ] Spookhill Dam
18	Sunnycove Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	2135.10	2172.10	2181.00	2150.26	2156.90	2163.60	2171.22	2172.20	N/A	N/A	N/A	[ ] Sunnycove Dam
19	Sunset Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	2114.01	2133.81	2144.01	2120.27	2123.91	2127.84	2130.98	2132.86	N/A	N/A	N/A	[ ] Sunset Dam
20	Vineyard Dam	10/09/2017	08:29:00	0.0000	0.00	0.000	1562.00	1575.70	1580.60	1566.83	1569.17	1571.92	1574.01	1575.50	N/A	N/A	N/A	[ ] Vineyard Dam
21	White Tanks No. 3 Dam	10/09/2017	08:29:00	0.0000	0.00	64.000	1180.00	1212.00	1218.00	1194.42	1199.60	1204.76	1210.01	1212.00	N/A	N/A	N/A	[ ] White Tanks #3 Dam
22	White Tanks No. 4 Dam	10/09/2017	08:29:00	0.0000	0.00	25.000	1002.00	1051.40	1056.00	1030.01	1036.74	1044.64	1049.89	1051.40	N/A	N/A	N/A	[ ] White Tanks #4 Dam

Refresh | Manual Rain Data Entry | Start Manual Prediction without Calibration | Start Manual Prediction with Calibration | Start Auto-Pilot Prediction | Exit

Program Execution Completed.

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

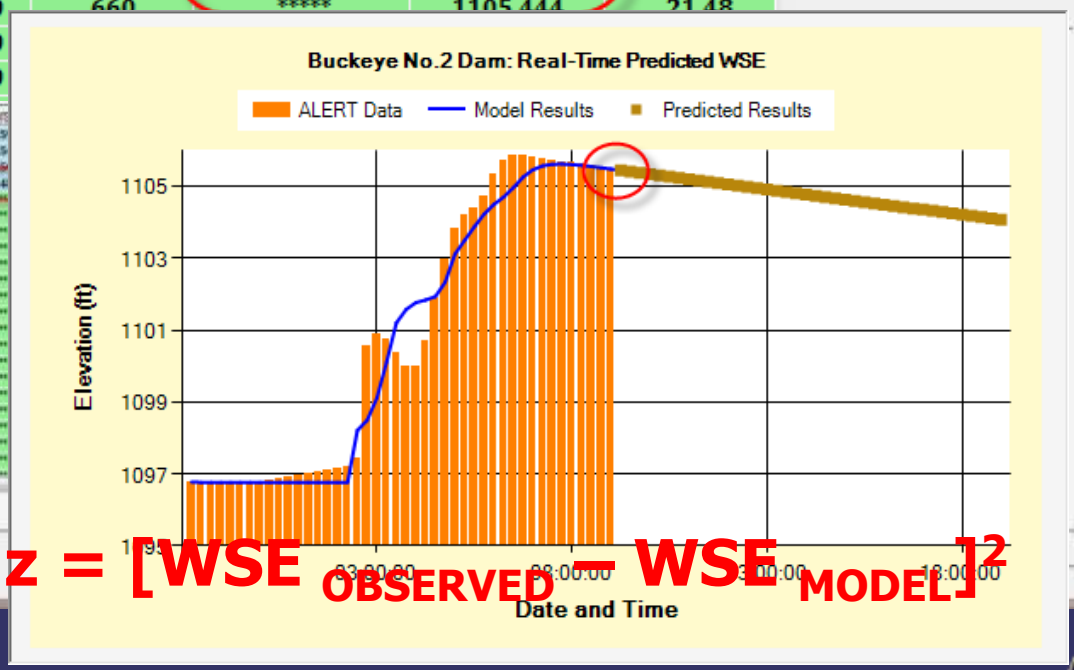
PROGRAM FEATURES AND CAPABILITIES

❖ "ON-THE-FLY" MODEL CALIBRATION

WSE Prediction Results Table

Dam Name: Buckeye No. 2 Dam

No.	Date	Time	Time (min)	ALERT WSE (ft)	Pred WSE (ft)	% Capacity
41	09/08/2014	08:15:00	600	1105.592	1105.581	22.19
42	09/08/2014	08:30:00	615	1105.546	1105.550	21.97
43	09/08/2014	08:45:00	630	1105.500	1105.516	21.75
44	09/08/2014	09:00:00	645	1105.480	1105.480	21.65
45	09/08/2014	09:15:00	660	*****	1105.444	21.48
46	09/08/2014	09:30:00				
47	09/08/2014	09:45:00				

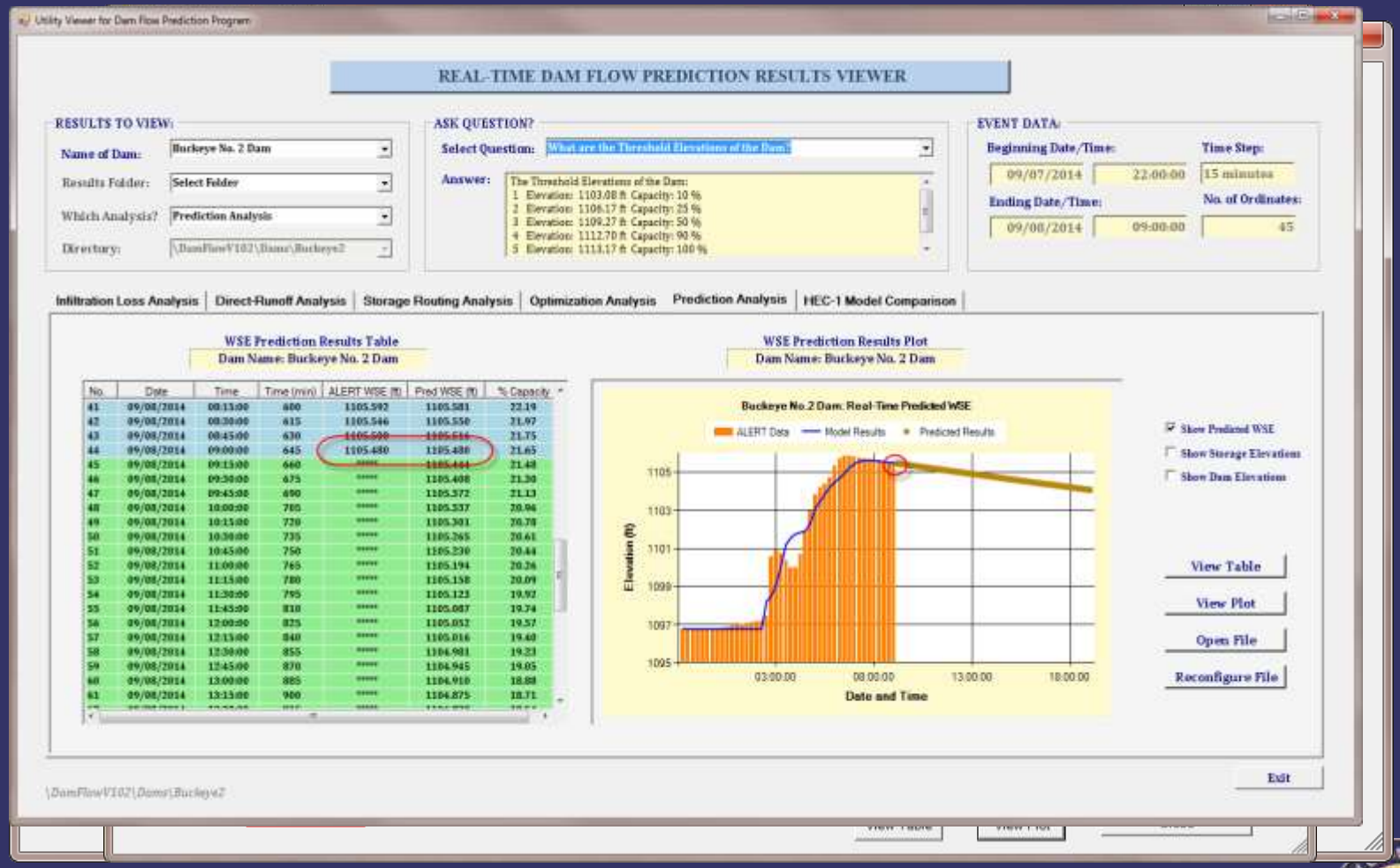


$$\text{Minimize } z = [WSE_{OBSERVED} - WSE_{MODEL}]^2$$

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

PROGRAM FEATURES AND CAPABILITIES

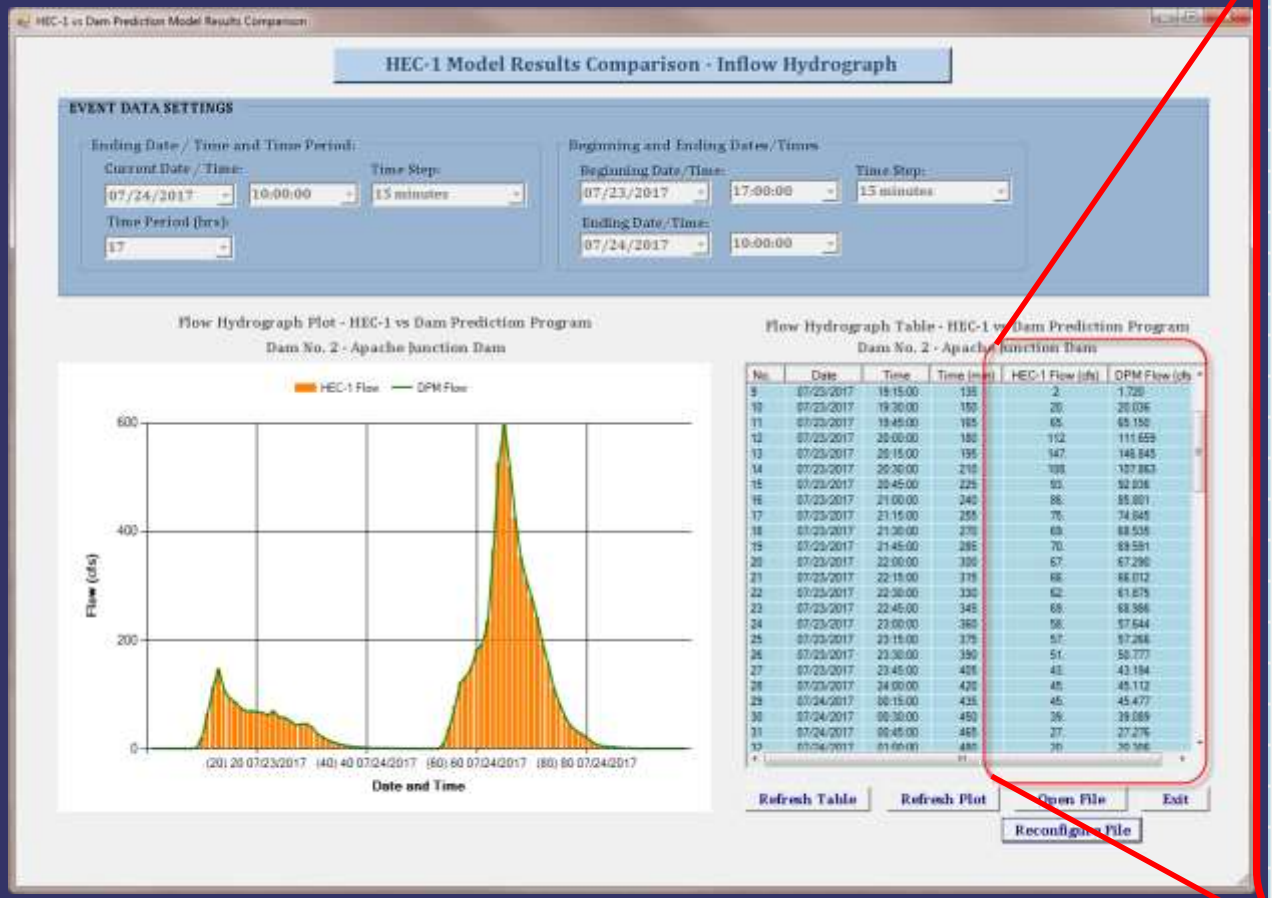
❖ "ON-THE-FLY" MODEL CALIBRATION



Topic: Real-Time Dam Fill Time and Outflow Prediction Software

PROGRAM FEATURES AND CAPABILITIES

- "HEC-1 LIKE" PROGRAM

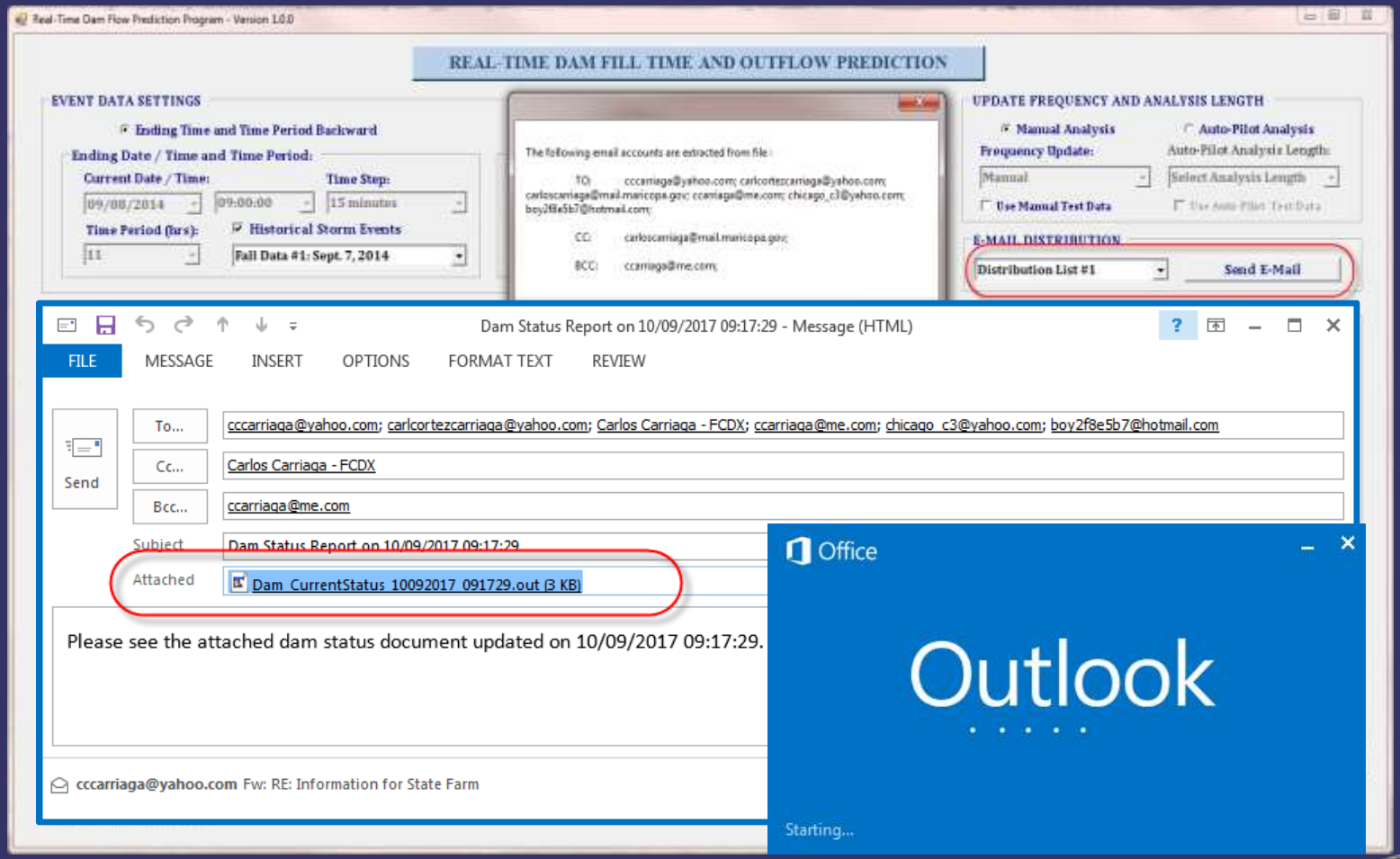


HEC-1 Flow (cfs)	DPM Flow (cfs
2.	1.720
20.	20.036
65.	65.150
112.	111.659
147.	146.845
108.	107.863
93.	92.836
86.	85.801
75.	74.845
69.	68.535
70.	69.591
67.	67.290
66.	66.012
62.	61.875
69.	68.986
58.	57.644
57.	57.266
51.	50.777
43.	43.194
45.	45.112
45.	45.477
39.	39.089
27.	27.276
20	20.306

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

PROGRAM FEATURES AND CAPABILITIES

❖ E-MAIL NOTIFICATION FEATURE



Topic: Real-Time Dam Fill Time and Outflow Prediction Software

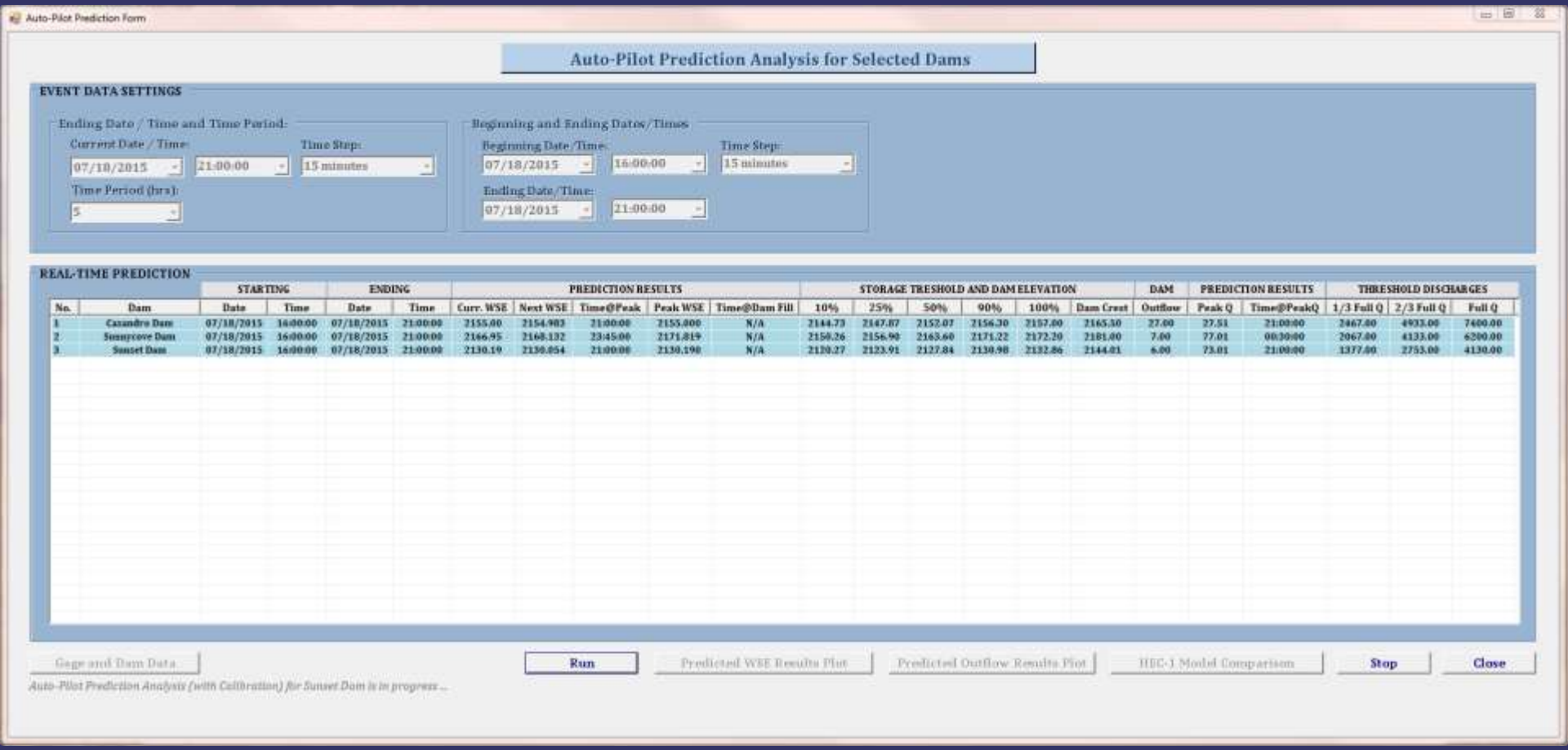
PROGRAM FEATURES AND CAPABILITIES

❖ "AUTO-PILOT" ANALYSIS

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

PROGRAM FEATURES AND CAPABILITIES

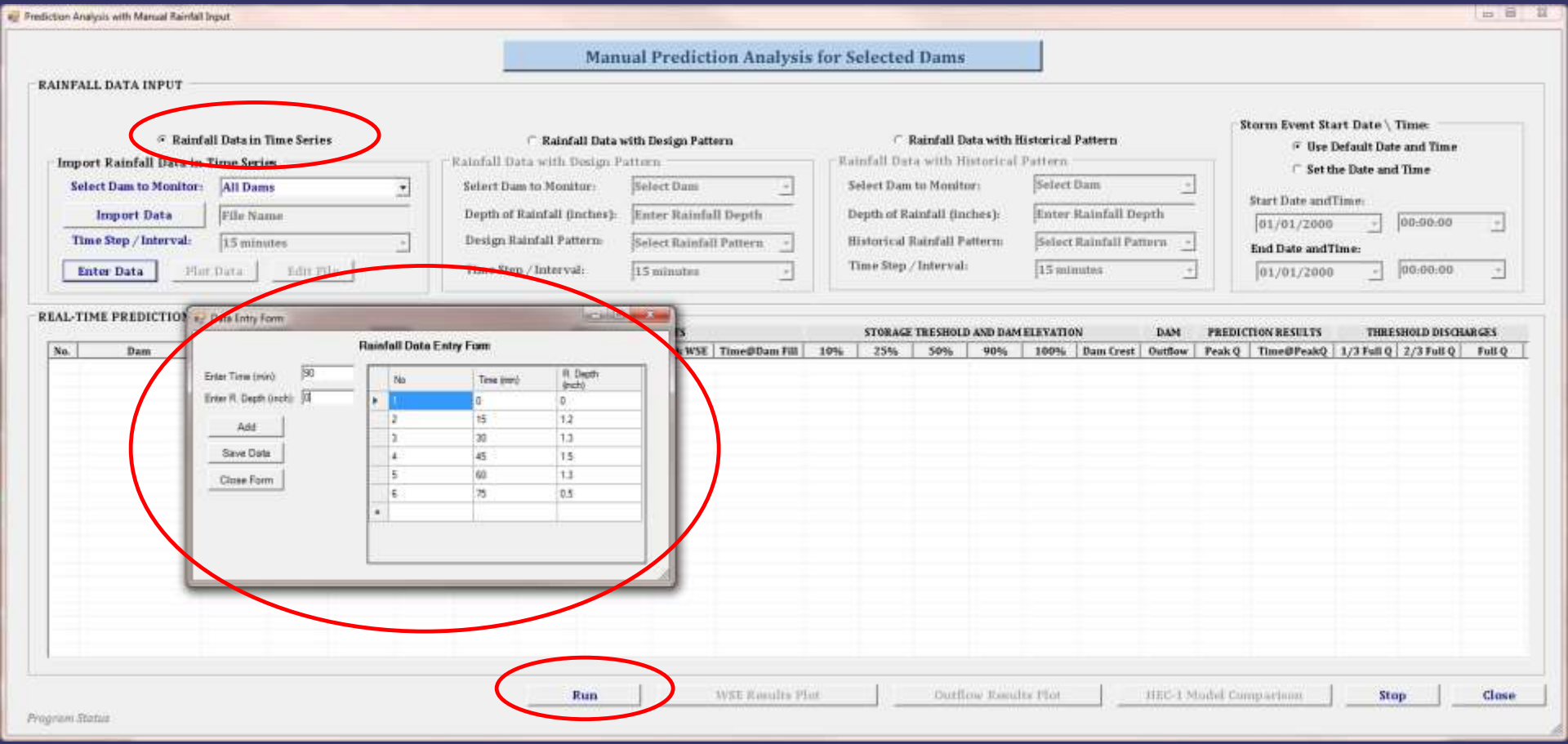
❖ "AUTO-PILOT" ANALYSIS



Topic: Real-Time Dam Fill Time and Outflow Prediction Software

PROGRAM FEATURES AND CAPABILITIES

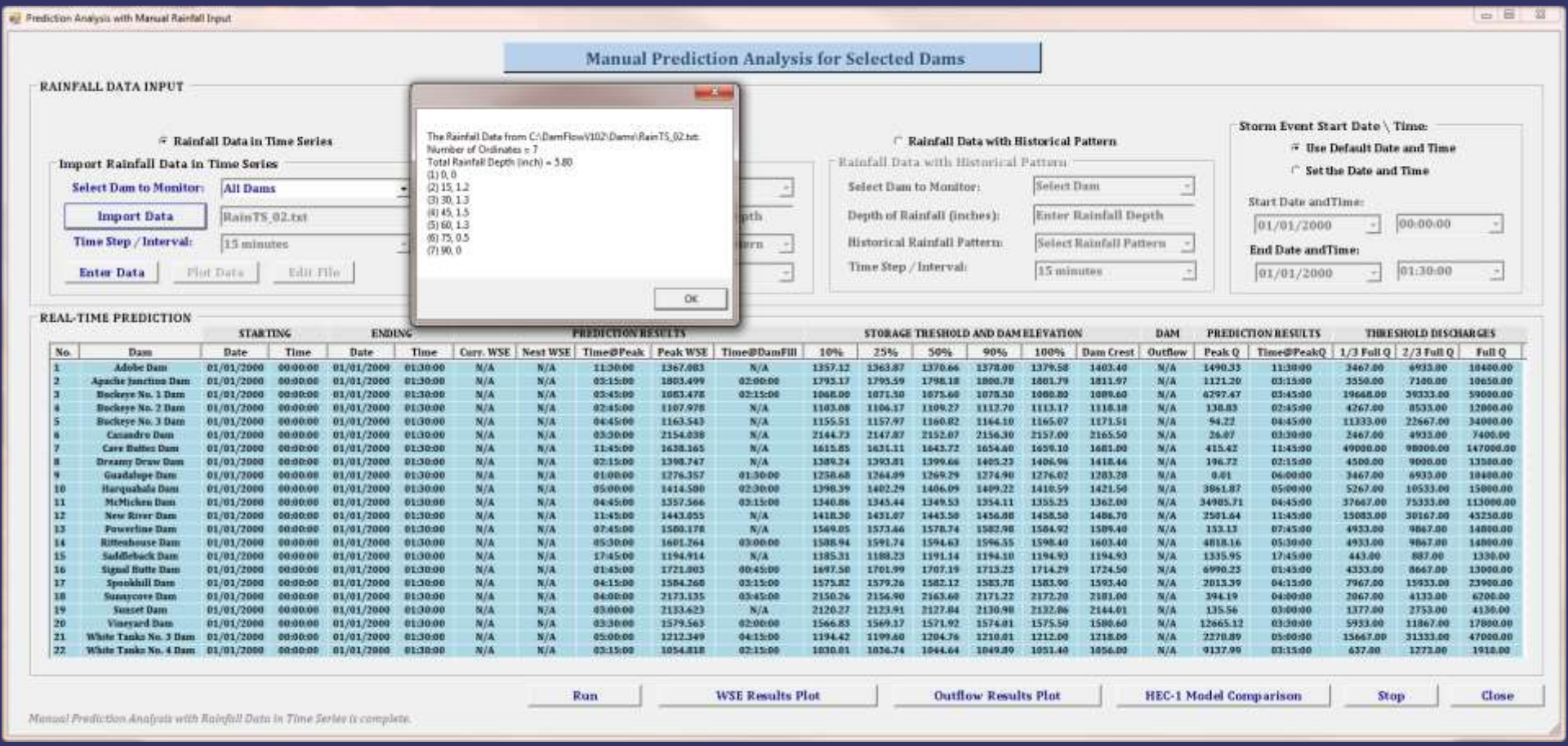
❖ "MANUAL" PREDICTION ANALYSIS



Topic: Real-Time Dam Fill Time and Outflow Prediction Software

PROGRAM FEATURES AND CAPABILITIES

❖ "MANUAL" PREDICTION ANALYSIS

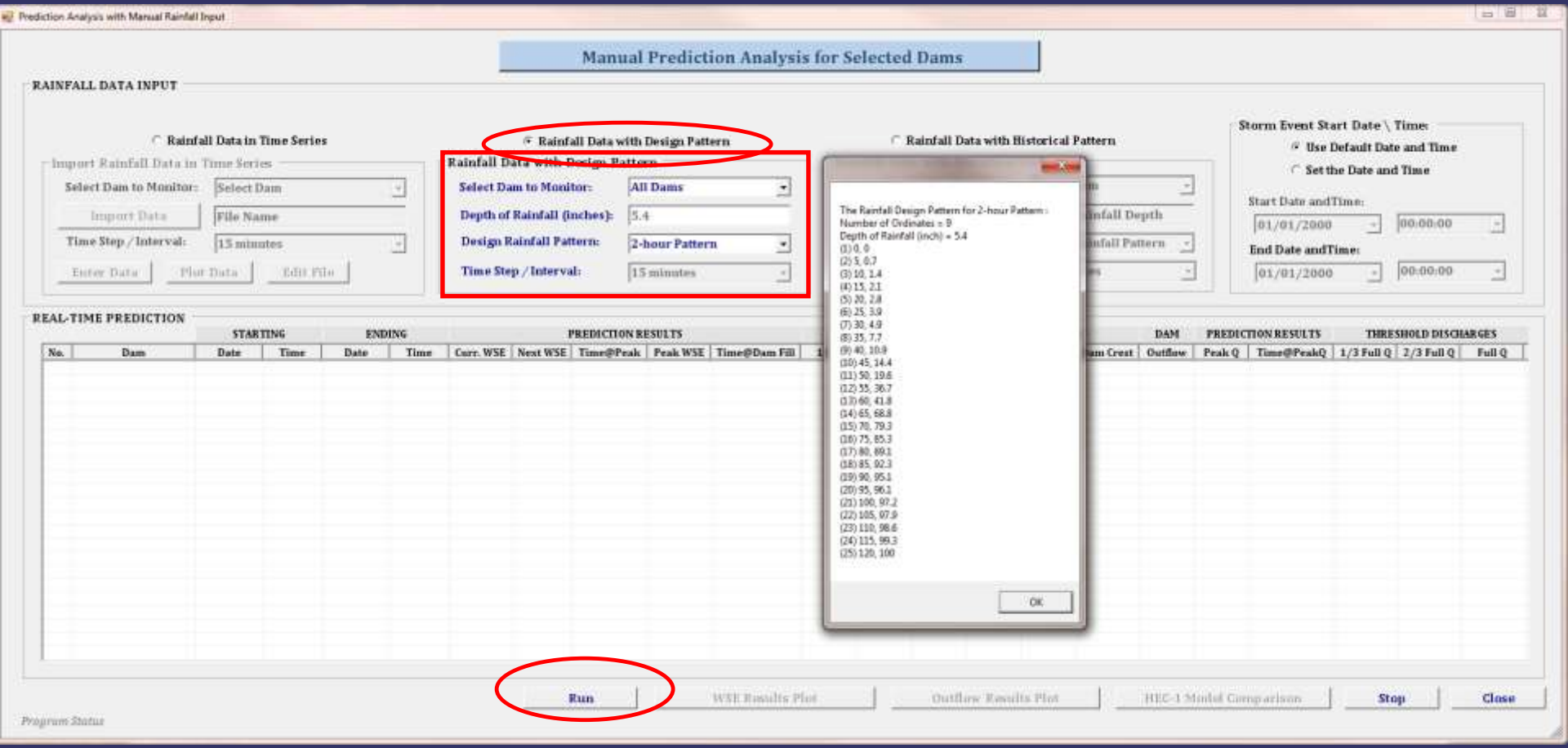


		STARTING		ENDING		PREDICTION RESULTS					STORAGE TRESHOLD AND DAM ELEVATION						DAM	PREDICTION RESULTS		THRESHOLD DISCHARGES		
No.	Dam	Date	Time	Date	Time	Curr. WSE	Next WSE	Time@Peak	Peak WSE	Time@DamFill	10%	25%	50%	90%	100%	Dam Crest	Outflow	Peak Q	Time@PeakQ	1/3 Full Q	2/3 Full Q	Full Q
1	Adobe Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	11:30:00	1367.083	N/A	1357.12	1363.87	1370.66	1378.00	1379.58	1403.40	N/A	1490.33	11:30:00	3467.00	6933.00	10400.00
2	Apache Junction Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	03:15:00	1803.499	02:00:00	1793.17	1795.59	1798.18	1800.78	1801.79	1811.97	N/A	1121.20	03:15:00	3550.00	7100.00	10650.00
3	Buckeye No. 1 Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	03:45:00	1083.478	02:15:00	1068.00	1071.50	1075.60	1078.50	1080.80	1089.60	N/A	6297.47	03:45:00	19668.00	39333.00	59000.00
4	Buckeye No. 2 Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	02:45:00	1107.978	N/A	1103.08	1106.17	1109.27	1112.70	1113.17	1118.18	N/A	138.83	02:45:00	4267.00	8533.00	12800.00
5	Buckeye No. 3 Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	04:45:00	1163.543	N/A	1155.51	1157.97	1160.82	1164.10	1165.07	1171.51	N/A	94.22	04:45:00	11333.00	22667.00	34000.00
6	Casandro Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	03:30:00	2154.038	N/A	2144.73	2147.87	2152.07	2156.30	2157.00	2165.50	N/A	26.07	03:30:00	2467.00	4933.00	7400.00
7	Cave Buttes Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	11:45:00	1638.165	N/A	1615.85	1631.11	1643.72	1654.60	1659.10	1681.00	N/A	415.42	11:45:00	49000.00	98000.00	147000.00
8	Dreamy Draw Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	02:15:00	1398.747	N/A	1389.24	1393.81	1399.66	1405.23	1406.96	1418.46	N/A	196.72	02:15:00	4500.00	9000.00	13500.00
9	Guadalupe Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	01:00:00	1276.357	01:30:00	1258.68	1264.99	1269.29	1274.90	1276.02	1283.20	N/A	0.01	06:00:00	3467.00	6933.00	10400.00
10	Harquahala Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	05:00:00	1414.580	02:30:00	1398.39	1402.29	1406.09	1409.22	1410.59	1421.50	N/A	3861.87	05:00:00	5267.00	10533.00	15800.00
11	McMicken Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	04:45:00	1357.566	03:15:00	1340.86	1345.44	1349.53	1354.11	1355.25	1362.00	N/A	34985.71	04:45:00	37667.00	75333.00	113000.00
12	New River Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	11:45:00	1443.055	N/A	1418.30	1431.07	1443.50	1456.00	1458.50	1486.70	N/A	2501.64	11:45:00	15083.00	30167.00	45250.00
13	Powerline Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	07:45:00	1500.178	N/A	1569.05	1573.46	1578.74	1582.98	1584.92	1589.40	N/A	153.13	07:45:00	4933.00	9867.00	14800.00
14	Rittenhouse Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	05:30:00	1601.264	03:00:00	1588.94	1591.74	1594.63	1596.35	1598.40	1603.40	N/A	4818.16	05:30:00	4933.00	9867.00	14800.00
15	Saddleback Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	17:45:00	1194.914	N/A	1185.31	1188.23	1191.14	1194.10	1194.93	1194.93	N/A	1335.95	17:45:00	443.00	887.00	1330.00
16	Signal Butte Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	01:45:00	1721.803	00:45:00	1697.50	1701.99	1707.19	1713.23	1714.29	1724.50	N/A	6990.23	01:45:00	4333.00	8667.00	13000.00
17	Spookhill Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	04:15:00	1584.268	03:15:00	1575.82	1579.26	1582.12	1583.78	1583.90	1593.40	N/A	2013.39	04:15:00	7967.00	15933.00	23900.00
18	Sunnycove Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	04:00:00	2173.135	03:45:00	2150.26	2156.90	2163.60	2171.22	2172.20	2181.00	N/A	394.19	04:00:00	2067.00	4133.00	6200.00
19	Sunset Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	03:00:00	2133.623	N/A	2120.27	2123.91	2127.84	2130.98	2132.86	2144.01	N/A	135.56	03:00:00	1377.00	2753.00	4130.00
20	Vineyard Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	03:30:00	1579.563	02:00:00	1566.83	1569.17	1571.92	1574.01	1575.50	1580.60	N/A	12665.12	03:30:00	5933.00	11867.00	17800.00
21	White Tanks No. 3 Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	05:00:00	1212.349	04:15:00	1194.42	1199.60	1204.76	1210.01	1212.00	1218.00	N/A	2270.89	05:00:00	15667.00	31333.00	47000.00
22	White Tanks No. 4 Dam	01/01/2000	00:00:00	01/01/2000	01:30:00	N/A	N/A	03:15:00	1054.818	02:15:00	1030.01	1036.74	1044.64	1049.89	1051.40	1056.00	N/A	9137.99	03:15:00	637.00	1273.00	1910.00

Topic: Real-Time Dam Fill Time and Outflow Prediction Software

PROGRAM FEATURES AND CAPABILITIES

❖ "MANUAL" PREDICTION ANALYSIS



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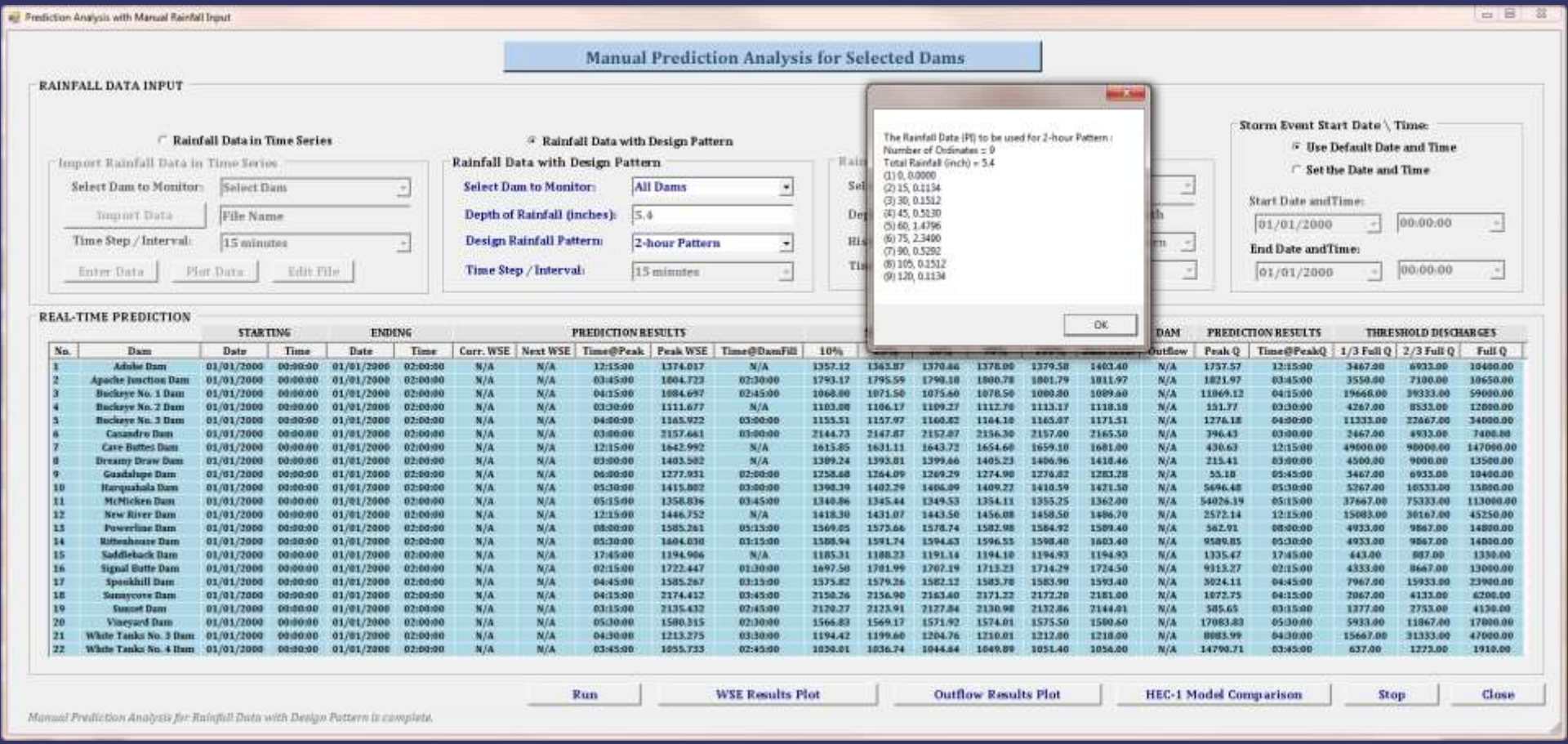
PROGRAM FEATURES AND CAPABILITIES

❖ "MANUAL" PREDICTION ANALYSIS



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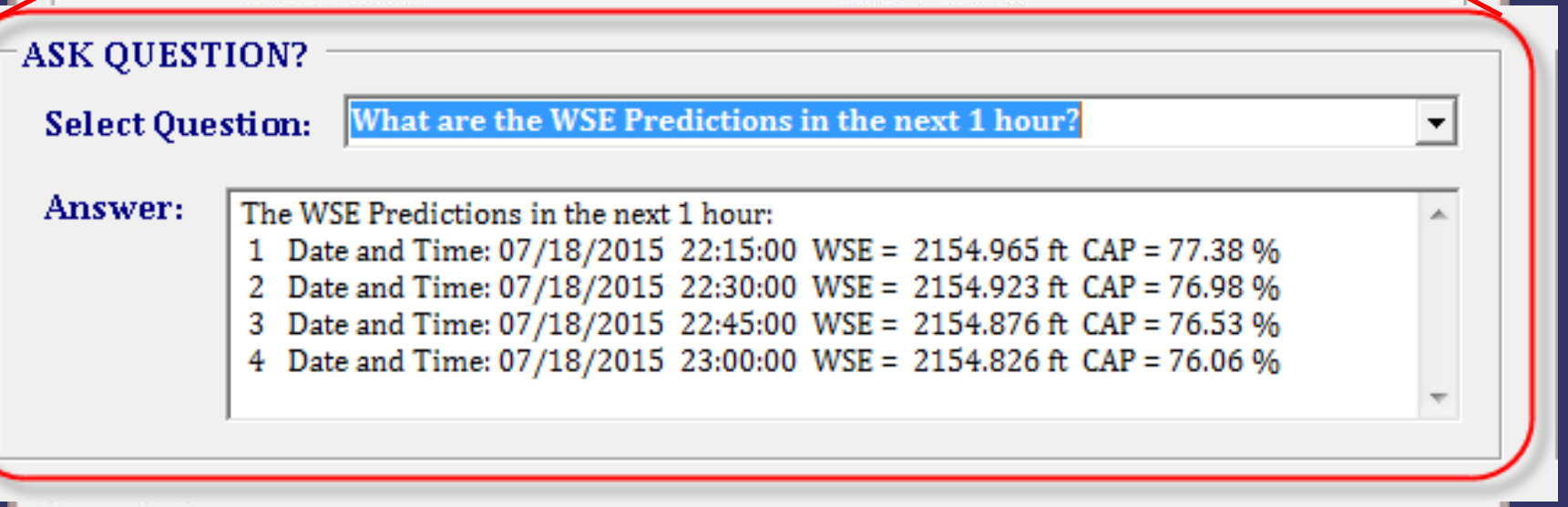
PROGRAM FEATURES AND CAPABILITIES

❖ "ASK QUESTION" FEATURE



FACTS AND FIGURES

- Number of Forms: 21
- Lines of Code: 63,845 lines
- Computer Language: C#
- IDE: MS Visual Studio 2012
- Number of Functions: 255
- Graphics: Chart Control

PROGRAM FUTURE IMPROVEMENTS

- **IMPLEMENT MULTI-THREADING**
  - PARALLEL EXECUTION OF JOBS TO RUN CONCURRENTLY
- **E-MAIL NOTIFICATION FEATURE**
  - NOTIFICATION LIST OF KEY PEOPLE AND RESPONDERS
- **VIEWER UTILITY PROGRAM**
  - TO INCLUDE MORE FUNCTIONALITIES
- **REAL-TIME ACTIVATION TOOL**
  - TOOL TO RUN 24/7 TO ACTIVATE THE SOFTWARE WHEN RAINFALL ACTIVITY IS DETERMINED.
- **"ASK QUESTION" FEATURE**
  - QUESTIONS OFTEN ASKED DURING FLOOD EMERGENCIES

Real-Time Dam Fill Time and Outflow Prediction Software

DAMFLOWV100

Thank You!!
Questions?

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