

# Analyzing ICPR's Mass Balance Report

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The Mass Balance Report can be used as an indicator for faulty initial stages, on/off settings for rating curves, and/or instabilities and should be reviewed after each routing simulation is completed.

The following information is provided to help you determine why there is not a balance of mass in your system.

## 1. Is there outflow before inflow?

If you have outflow before inflow as shown in Figure 1, and you are not doing a drawdown analysis, then your initial stages are likely set too high at one or more nodes causing flow to occur at time zero rather than later when runoff actually occurs. Unless you intend for this to occur, you will need to adjust your Initial Stage at one or more nodes.

The problematic nodes can usually be quickly found by looking at Node Graphs, One Simulation per Page, Total Outflow for all nodes. Typically, you will see outflow at time zero for the problematic nodes (Node B3 in Figure 2). Initial stages for these nodes need to be adjusted.

To correct this problem, a "static wet" condition is suggested. Setting the initial stages at elevations that would hold water back such as inverts or channel bottoms or other structures creates the static wet condition shown in Appendix "A".

Simulation	Time hrs	Inflow Volume ft <sup>3</sup>	Outflow Volume ft <sup>3</sup>	Change in Sys Storage ft <sup>3</sup>	Difference ft <sup>3</sup>	Error %
100	0.00	0.0	0.0	0.0	0.0	0.00
100	0.25	0.0	12239.2	-12239.2	0.0	-0.00
100	0.50	0.0	15208.9	-15208.9	0.0	-0.00
100	0.75	0.0	15876.0	-15876.0	0.0	-0.00
100	1.00	0.0	16137.0	-16137.0	0.0	-0.00
100	1.25	0.0	16266.5	-16266.5	0.0	-0.00
100	1.50	0.0	16341.6	-16341.6	0.0	-0.00
100	1.75	0.0	16389.1	-16389.1	0.0	-0.00
100	2.00	0.0	16421.7	-16421.7	0.0	-0.00
100	2.25	0.0	16444.6	-16444.6	0.0	-0.00
100	2.50	0.0	16461.7	-16461.7	0.0	-0.00
100	2.75	0.0	16474.9	-16474.9	0.0	-0.00
100	3.00	0.7	16485.3	-16484.6	-0.0	0.00
100	3.25	30.5	16493.9	-16463.4	-0.0	0.00
100	3.50	182.5	16501.1	-16318.7	-0.0	0.00
100	3.75	520.9	16507.3	-15986.3	-0.0	0.00
100	4.00	1127.4	16514.3	-15386.9	-0.0	0.00
100	4.25	2130.1	16537.5	-14407.4	-0.0	0.00
100	4.50	3604.3	16591.5	-12987.2	-0.0	0.00

Figure 1. Outflow before Inflow

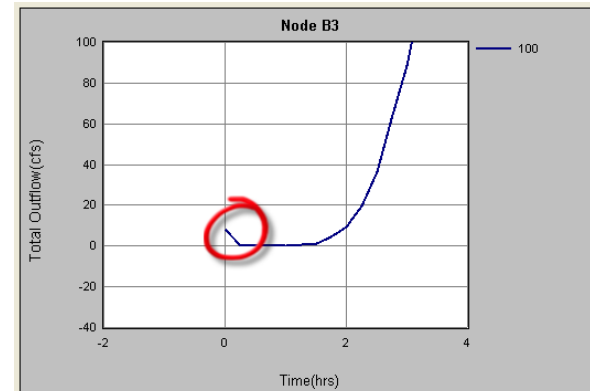


Figure 2. Outflow before Inflow Hydrograph

## 2. Is the Difference column a constant non-zero value?

If you have a condition similar to the “Difference” column shown in Figure 3, then the likely cause is a faulty initial stage. This generally happens when an initial stage at one or more node(s) is set below the bottom of a channel or pipe.

For example, if you happen to set the initial stage at a particular node below the bottom of all channel and pipe inverts connected either to the node or from it (see Figure 4), water will have to be “created” in order to fill the imaginary channel or pipe up to the true bottom elevation. The specific node(s) can usually be quickly found by going to the Node Maximum Conditions report and looking in the Max Delta Stage column for unusual values for non-stage-time nodes (see Figure 5). For example, if you have a Max Delta Stage value of 0.6’ as shown in Figure 5 for node A-045, this is the node that would be a likely candidate. The initial stage is probably 0.6’ below a channel or pipe invert at that location.

Another example is if the initial stage is set below the bottom of a pond (i.e., below the first point in the stage-area table) and a weir or drop structure is used as the outfall device. Weirs and drop structures have no storage associated with them and in cases like this, ICPR will rely entirely on the stage-area table. If this condition occurs, initial stages should be carefully checked to insure none have been placed below the point at which storage can be calculated. The exact location can usually be determined by looking at the Max Delta Z column in the Node Maximum Conditions report similar as described in the above paragraph.

Simulation	Time hrs	Inflow Volume ft3	Outflow Volume ft3	Change in Sys Storage ft3	Difference ft3	Error %
100	0.00	0.0	0.0	0.0	0.0	0.00
100	0.26	0.0	0.0	67.8	-67.8	9999.99
100	0.50	0.0	0.0	67.8	-67.8	9999.99
100	0.77	0.0	0.0	67.8	-67.8	9999.99
100	1.02	0.0	0.0	67.8	-67.8	9999.99
100	1.27	0.0	0.0	67.8	-67.8	9999.99
100	1.52	0.0	0.0	67.8	-67.8	9999.99
100	1.77	0.0	0.0	67.8	-67.8	9999.99
100	2.02	0.0	0.0	67.8	-67.8	9999.99
100	2.27	0.0	0.0	67.8	-67.8	9999.99
100	2.52	0.0	0.0	67.8	-67.8	9999.99
100	2.77	0.0	0.0	67.8	-67.8	9999.99
100	3.02	1.0	0.0	68.8	-67.8	-6763.93
100	3.27	35.4	0.0	103.2	-67.8	-191.38
100	3.52	195.5	0.0	263.3	-67.8	-34.69
100	3.77	546.7	0.0	614.5	-67.8	-12.40
100	4.02	1173.5	0.9	1240.4	-67.8	-5.78
100	4.25	2143.5	17.1	2194.2	-67.8	-3.19
100	4.50	3601.4	67.3	3601.9	-67.8	-1.92
100	4.75	5521.6	146.4	5442.9	-67.8	-1.26

Figure 3. Constant Non-Zero Value in Difference Column

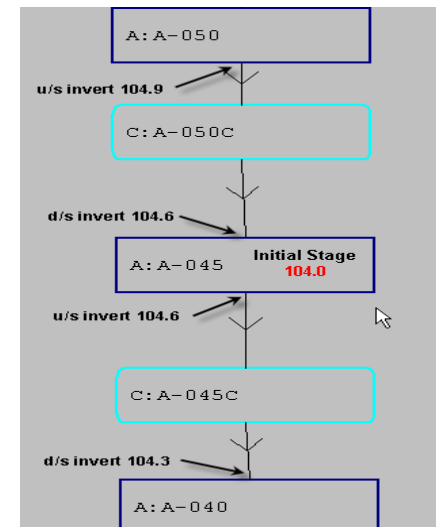


Figure 4. Node/Link Inverts

(Invert elevations and initial stage notes on this figure were added for discussion purposes and were not generated by ICPR)

Name	Simulation	Max Stage ft	Warning Max Stage ft	Max Delta Stage ft	Max Surf Area ft2	Max Inflow cfs	Max Outflow cfs
A-001	100	106.400	110.000	0.3000	5424	730.816	0.000
A-005	100	107.316	110.300	0.0050	5708	722.914	722.691
A-010	100	109.911	112.000	0.0047	6375	688.776	688.965
A-015	100	110.318	112.300	0.0045	12736	686.259	686.379
A-020	100	110.737	112.600	0.0047	24691	683.723	683.231
A-025	100	110.966	112.900	0.0050	6484	608.223	607.261
A-030	100	114.728	113.700	0.0050	35994	564.885	565.143
A-035	100	114.780	114.000	0.0049	61778	555.828	554.917
A-040	100	114.844	114.300	0.0049	47343	525.144	524.500
A-045	100	114.863	114.600	0.6000	31030	314.343	280.165
A-050	100	114.876	114.900	0.0049	9576	229.233	287.622
A-055	100	116.073	116.000	0.0031	634721	900.348	364.115
B-005	100	111.600	112.000	0.0030	23454	218.290	218.046
B-010	100	112.608	113.000	0.0035	23409	218.974	218.290
B-015	100	113.596	114.000	0.0046	23339	219.744	218.974
B-017	100	96.696	95.500	0.0027	704688	442.883	11.000
B-020	100	114.541	115.000	0.0050	11645	209.068	208.744
C-005	100	110.601	112.000	0.0050	124	49.812	49.663
C-010	100	112.356	115.000	-0.0049	123	25.476	25.481
C-015	100	114.943	116.000	-0.0026	216308	221.442	25.476

Figure 5. Node Maximum Conditions Report

### 3. Does the Difference column have varying non-zero values?

If you have a condition similar to the report shown in Figure 6, this could indicate a stability problem. The location of the problem can usually be found by looking at the Max Delta Stage values in the Node Maximum Conditions Report.

- a. If any of the Max Delta Stage values equal the maximum allowable Delta Stage (typically 1') as shown in Figure 7, set in the Routing Control data, then a stability problem has occurred. Go to the Node Maximum Conditions report for the problematic storm and search for values in the Max Delta Stage column equal to the "Max Delta Stage" set in the Routing Control data form. These are the unstable nodes. Check these nodes and any links attached to or from them.

Simulation	Time hrs	Inflow Volume ft3	Outflow Volume ft3	Change in Sys Storage ft3	Difference ft3	Error %
100Y024H	0.00	0.0	0.0	0.0	0.0	0.00
100Y024H	0.25	0.0	11165.7	-4629.8	-6535.9	58.54
100Y024H	0.50	0.0	20476.7	-4987.2	-15489.5	75.64
100Y024H	0.75	0.0	29785.6	-5309.3	-24476.3	82.17
100Y024H	1.00	0.0	39093.3	-5622.4	-33471.0	85.62
100Y024H	1.25	0.1	48400.0	-5932.4	-42467.6	87.74
100Y024H	1.50	125.9	57705.8	-6114.9	-51464.9	89.38
100Y024H	1.75	604.0	67010.6	-5943.9	-60462.6	91.05
100Y024H	2.00	1433.4	76314.5	-5420.4	-69460.7	92.76
100Y024H	2.25	3085.6	85617.5	-4073.0	-78458.9	95.06
100Y024H	2.50	5698.7	94919.6	-1763.8	-87457.2	98.02
100Y024H	2.75	9572.2	104220.9	1806.8	-96455.6	101.91
100Y024H	3.00	15515.8	113521.5	7448.2	-105454.0	107.60
100Y024H	3.25	24381.4	122822.9	16011.0	-114452.4	116.26
100Y024H	3.50	37197.9	132132.1	28516.7	-123450.9	130.04
100Y024H	3.75	54713.1	141461.4	45701.2	-132449.4	152.68
100Y024H	4.00	77365.7	150820.7	67988.2	-141443.3	192.56

Figure 6. Varying Non-Zero Difference Column

Name	Simulation	Max Stage ft	Warning Max Stage ft	Max Delta Stage ft	Max Surf Area ft2	Max Inflow cfs	Max Outflow cfs
A-001	100	106.400	110.000	0.3000	5424	730.814	0.000
A-005	100	107.316	110.300	0.0050	5708	722.913	722.690
A-010	100	109.911	112.000	1.0000	6375	688.787	688.975
A-015	100	110.318	112.300	0.0045	12736	686.272	686.390
A-020	100	110.737	112.600	0.0047	24692	683.723	683.244
A-025	100	110.966	112.900	0.0050	6484	608.222	607.260
A-030	100	114.728	113.700	0.0050	35994	564.885	565.143

Figure 7. Max Delta Stage equal Max Allowable 1'

- b. If you see in the Max Delta Stage column values a lot larger than the stability criteria (Max Delta Stage times Delta Stage Factor in the Routing Control data - typically 0.005) but not equal to the maximum allowable Delta Stage (as shown in Figure 8), then you might need to reduce the **Min Calc Time** and/or the **Delta Stage Factor** in the Routing Control data.

Name	Simulation	Max Stage ft	Warning Max Stage ft	Max Delta Stage ft	Max Surf Area ft <sup>2</sup>	Max Inflow cfs	Max Outflow cfs
A-001	025	105.899	110.000	0.3000	5078	541.791	0.000
A-005	025	106.499	110.300	0.0731	5242	532.780	532.458
A-010	025	108.591	112.000	0.0772	5588	495.764	495.238
A-015	025	109.026	112.300	0.0577	11180	484.003	485.906
A-020	025	109.437	112.600	0.0602	18999	491.951	471.751
A-025	025	109.761	112.900	0.0575	5756	402.826	448.809
A-030	025	112.521	113.700	-0.4856	7105	1700.940	364.243
A-035	025	113.952	114.000	0.1646	14767	417.142	1683.732
A-040	025	113.478	114.300	-0.1768	14364	1797.203	411.663
A-045	025	114.625	114.600	-0.1875	15904	306.199	1625.026
A-050	025	113.710	114.900	-0.1941	7076	228.024	298.691
A-055	025	115.202	116.000	0.0134	623713	688.763	208.324
B-005	025	109.781	112.000	-0.0072	12118	11.648	11.002

Figure 8. Large Max Delta Stage

- c. If in the Node Maximum Conditions report, the Max Delta Stage for all nodes is within the criteria set, then the non-zero, varying values in the Difference column of the Mass Balance report could be related to a rating curve. Check the data specified in the rating curve to verify that there is no flow through the link when it cannot physically occur (i.e. dry pond). It is helpful sometimes to set the on and off switches slightly (e.g., 0.01') above the pond bottom.

If you have a problematic rating curve linked to a node with multiple upstream links, then it is helpful to draw a sketch as shown in Figure 9. Include on the sketch the node(s) in question, all the links attached to and from these nodes, plus the nodes at the other end of these links. Then, call out the inverts and/or on/off settings for each link (both ends for pipes and channels). Indicate the elevation of the first point of the Stage-Area table for the upstream node of the rating curve link (highlighted in Figure 9), if one is used. Find the first node upstream at which storage occurs. Your rating curve(s) on/off settings need to be slightly higher than the lowest elevation of that node.

In the example shown in Figure 9, the first stage of node A-020 is at elevation 60.0 feet. The off setting of rating curve A-020R needs to be 60.01 feet and it is recommended that the on setting be even slightly higher at 60.02 feet. Another solution is to provide a little more storage below elevation 60.0 feet at node A-020.

In cases like this, the off switch might be numerically at 59.9999999 due to rounding, and the calculated bottom of the upstream node (A-020) is at 60.0000001. The off switch would never kick in and the model would continue discharging water out of nowhere. Consequently, the mass of the system will not be in balance. Making the changes to the on/off settings of the rating curve(s) as described in the previous paragraph will alleviate this problem.

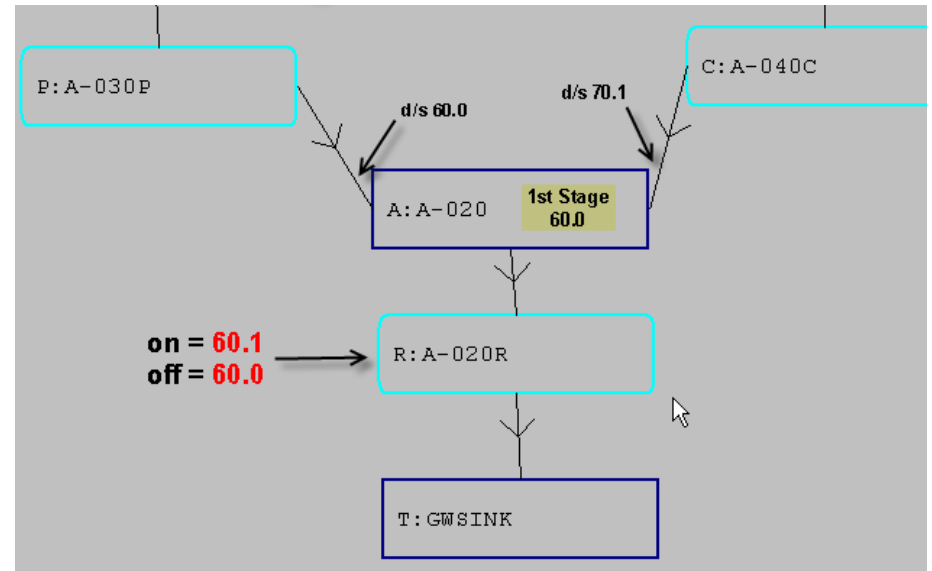
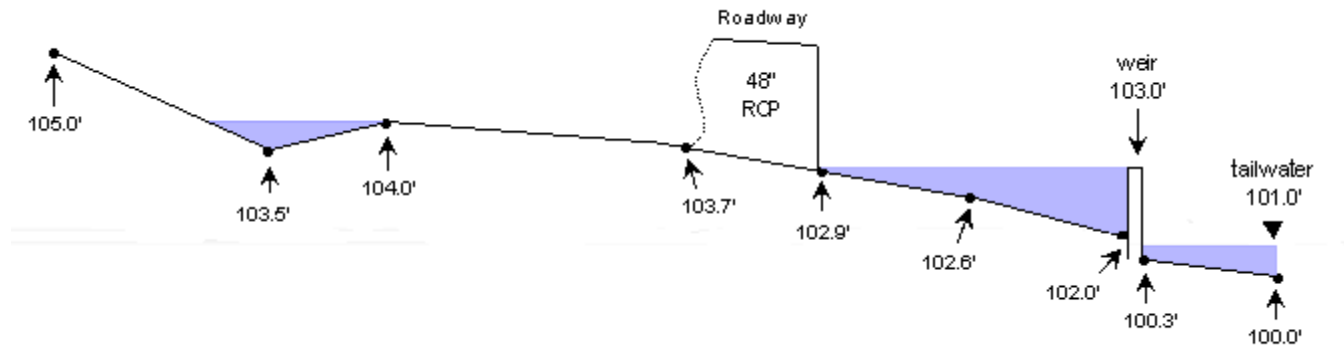


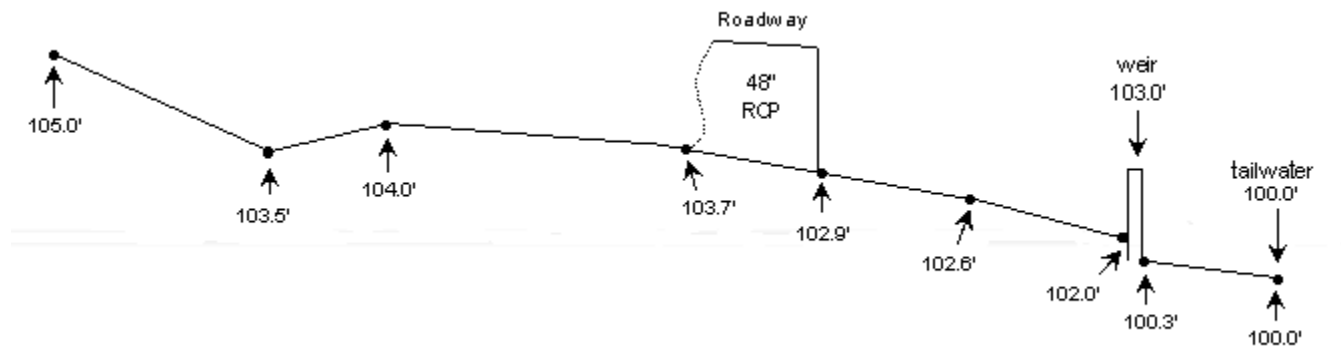
Figure 9. Rating Curve settings (before corrections) showing U/S Nodes & Links

(Invert elevations and initial stage notes on this figure were added for discussion purposes and were not generated by ICPR)

## APPENDIX "A"



**Static Wet Condition  
(nts)**



**Dry Condition  
(nts)**