# Forecasting Inflows for Jamestown and Pipestem Reservoirs – Spring 2009

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21 Jan 2010

US Army Corps of Engineers
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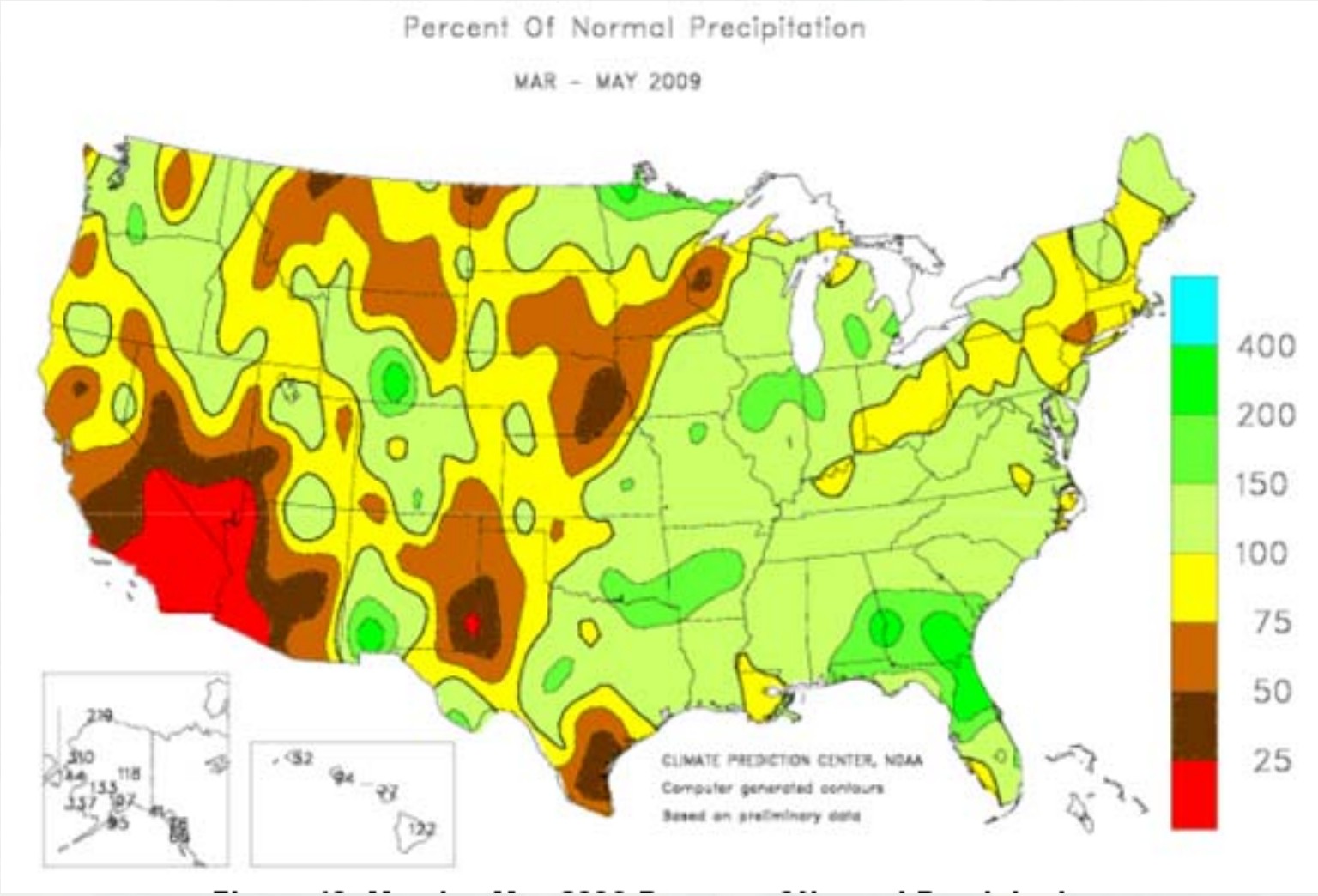
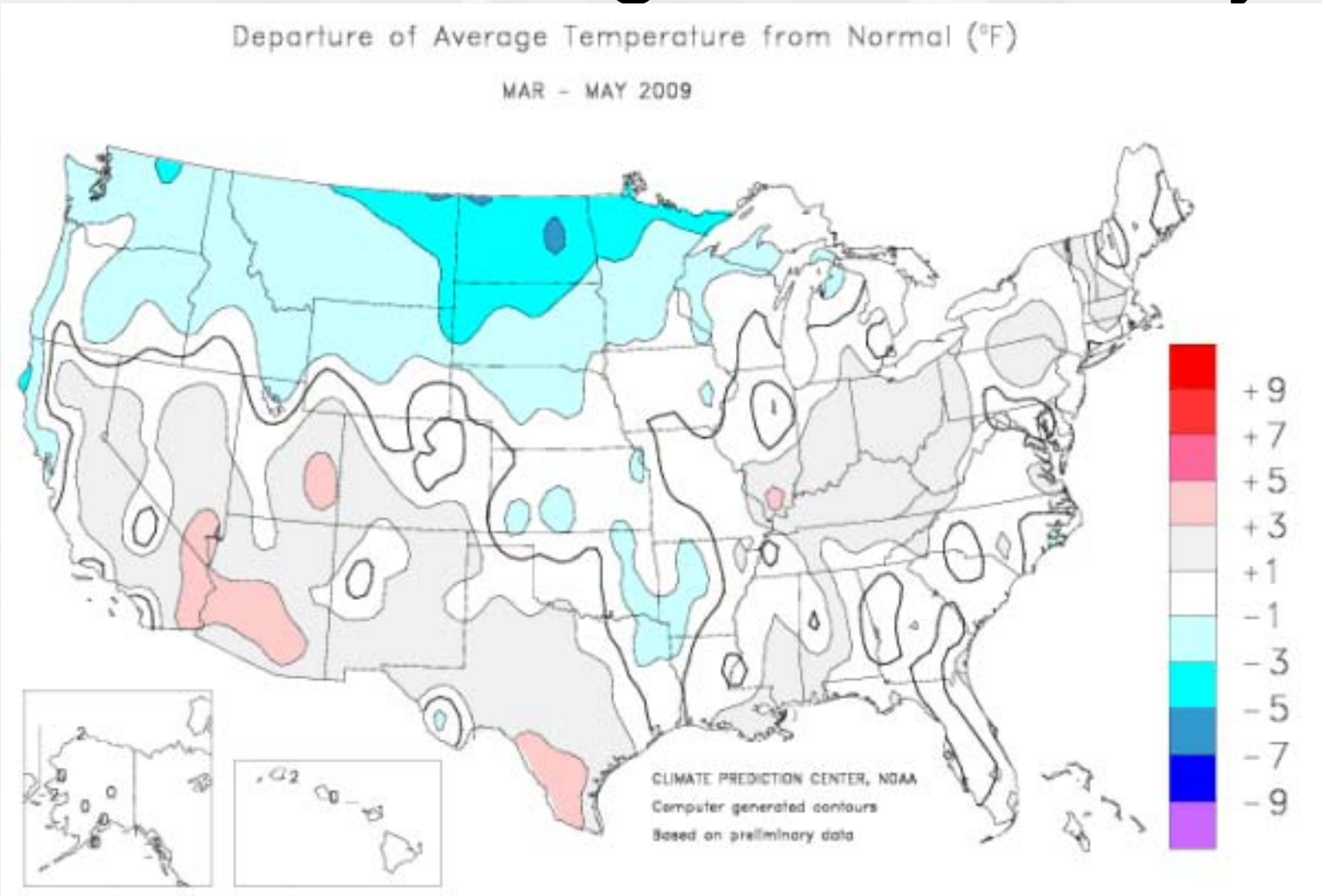
# Presentation Overview

- Meteorological summary
- Summary of forecasting methods
- Summary of results
- Lessons learned
- Questions

# Meteorological Summary



# Meteorological Summary



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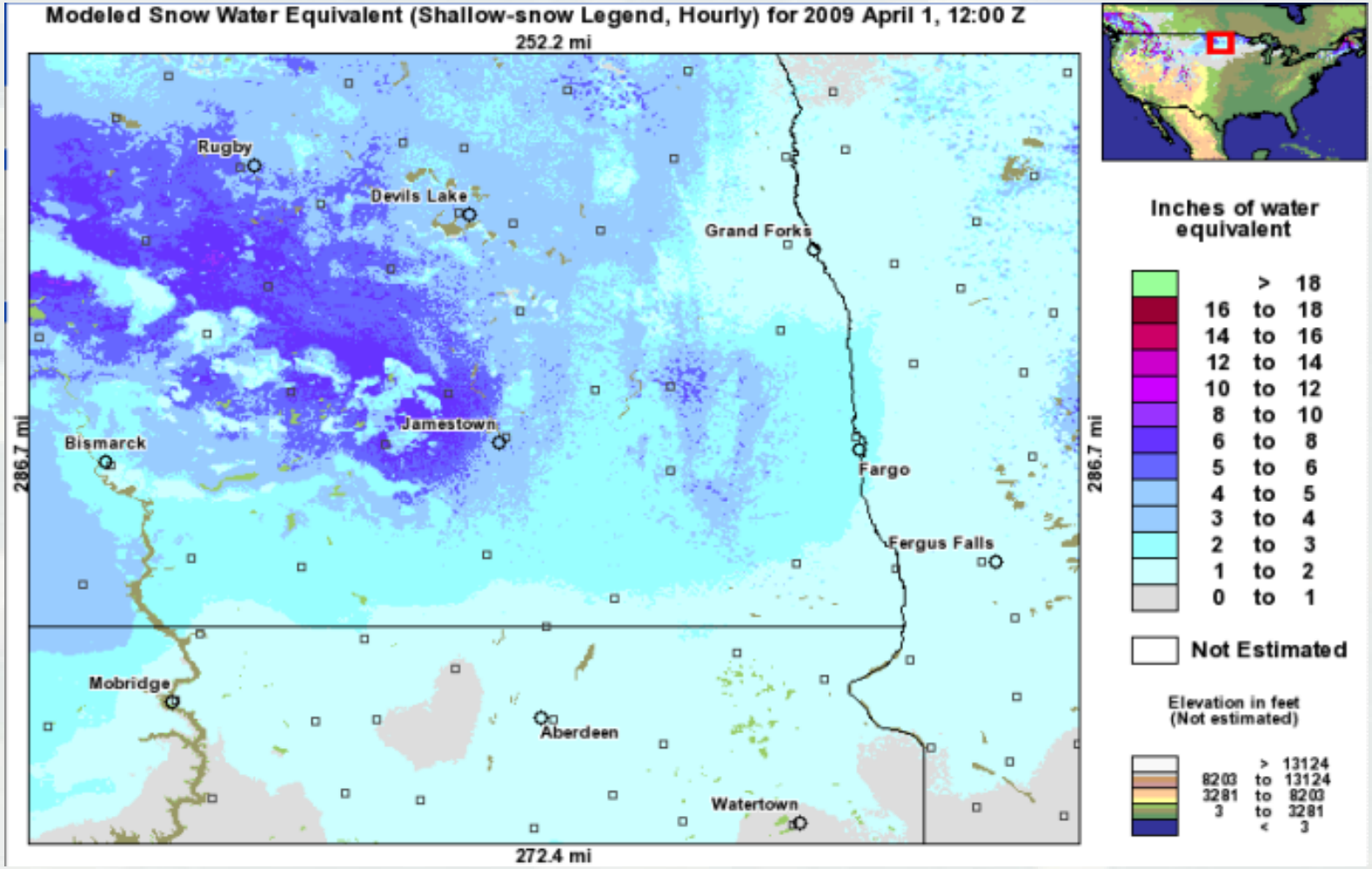
# Meteorological Summary



# Short-term Reservoir Forecasts

- Calculated an estimated snow water equivalent above the reservoirs
- Unit hydrograph developed using collected data from 1997 snowmelt event
- Data placed into rainfall/runoff models (HEC-1, HEC-HMS) to generate inflow hydrographs
  - Two hydrographs created for each reservoir
- Inflows placed into HEC-ResSim to model different reservoir operating scenarios



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# Short-term Reservoir Forecasts

- Pipestem Forecasts
  - Based on 1997, 75% of snowmelt transferred into reservoir (HEC-1)
  - Calibrated HEC-HMS model with built-in snowmelt routine
- Jamestown Forecasts
  - Based on 1997, 65% of snowmelt transferred into reservoir (HEC-1)
  - Second forecast created assuming 50% of snowmelt transferred into reservoir (HEC-1)



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# Short-term Reservoir Forecasts

| Date | SWE | Depth | Density | High Temp | Low Temp | Ave Temp | DegDays | MeltRate | Rain | Snow | Melt | Total P | .75*P | .65*P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-Apr-09 | 4.41 | 14 | 0.315 | 33 | 26 | 29.5 | 0.0 | 0.076 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2-Apr-09 | 4.41 | 14 | 0.315 | 33 | 12 | 22.5 | 0.0 | 0.076 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-Apr-09 | 4.41 | 14 | 0.315 | 34 | 13 | 23.5 | 0.0 | 0.076 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4-Apr-09 | 4.41 | 13 | 0.339 | 32 | 21 | 26.5 | 0.0 | 0.081 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5-Apr-09 | 4.41 | 13 | 0.339 | 30 | 19 | 24.5 | 0.0 | 0.081 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6-Apr-09 | 4.41 | 13 | 0.339 | 33 | 17 | 25.0 | 0.0 | 0.081 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7-Apr-09 | 4.41 | 13 | 0.339 | 36 | 15 | 25.5 | 0.0 | 0.081 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8-Apr-09 | 4.41 | 11 | 0.401 | 37 | 26 | 31.5 | 0.0 | 0.096 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 9-Apr-09 | 4.41 | 10 | 0.441 | 39 | 22 | 30.5 | 0.0 | 0.106 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 10-Apr-09 | 4.41 | 10 | 0.441 | 43 | 23 | 33.0 | 1.0 | 0.106 | 0.00 | 0.00 | 0.11 | 0.11 | 0.08 | 0.07 |
| 11-Apr-09 | 4.30 | 9 | 0.478 | 48 | 28 | 38.0 | 6.0 | 0.115 | 0.00 | 0.00 | 0.69 | 0.69 | 0.52 | 0.45 |
| 12-Apr-09 | 3.61 | 8 | 0.452 | 53 | 33 | 43.0 | 11.0 | 0.108 | 0.26 | 0.00 | 1.19 | 1.45 | 1.09 | 0.94 |
| 13-Apr-09 | 2.42 | 5 | 0.484 | 57 | 39 | 48.0 | 16.0 | 0.116 | 0.00 | 0.00 | 1.86 | 1.86 | 1.39 | 1.21 |
| **14-Apr-09** | 0.56 | 1.5 | 0.374 | 61 | 38 | 49.5 | 17.5 | 0.090 | 0.00 | 0.00 | 0.56 | 0.56 | 0.42 | 0.37 |
| 15-Apr-09 | 0.00 | 0.01 | 0.000 | 59 | 36 | 47.5 | 15.5 | 0.000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Snowmelt Spreadsheet**

```
KKPISTBF
BA  0.0
ZR=QI A=PIPESTEM DAM B=PIST C=FLOW-IN F=0.80 RECESSION
*
KKPISTRO
KM RUNOFF FROM PIPESTEM CR. ABOVE PIPESTEM DAM
BA   594
PB   .00
PI   .00      .00      .00      .00      .00
UI   264      414     2294     3464     2754     2154     1054      854      754      654
UI   554      504      454      404        0        0        0
ZW A=PIPESTEM DAM B=PIST C=FLOW-IN FORE F=SCENARIO 1
*
* FIRST PI CARD BEGINS APRIL 26, 2009
*
KKPISTIN
KM
HC     2
ZW A=PIPESTEM DAM B=PIST C=FLOW-IN COMB F=SCENARIO 1
* *
* ***************************************************************
*
*
KK  PIST
RS     1    ELEV  1491.8
SV  7921    9511   11362   13483   15869   18515   21400   24503   27817   31337
SV 35058   38975   43085   47391   51901   56621   61572   72230   84019  146880
SE  1440    1442    1444    1446    1448    1450    1452    1454    1456    1458
SE  1460    1462    1464    1466    1468    1470    1472    1476    1480  1496.3
SQ     0    1400    1400    1400    1400    1400    3036    5205    7807   10843
SQ 15108   19446   24578   30217
SE  1440  1442.7    1480  1481.1  1496.6    1497  1497.5    1498  1498.5    1499
SE1499.5    1500  1500.5    1501
ZW A=PIPESTEM DAM B=PIST C=STAGE F=SCENARIO 1
ZW A=PIPESTEM DAM B=PIST C=FLOW-OUT F=SCENARIO 1
```

# Long-term Reservoir Forecasts

- Evaluated three options for the long-term operations of the models
- Routed reservoir outflows downstream through LaMoure, ND; Columbia, SD; and Huron, SD
- Reservoir inflows developed by applying recession coefficients determined by studying the 1997 snowmelt event, then used average daily inflow
  - Pipestem – 0.80; Jamestown – 0.90



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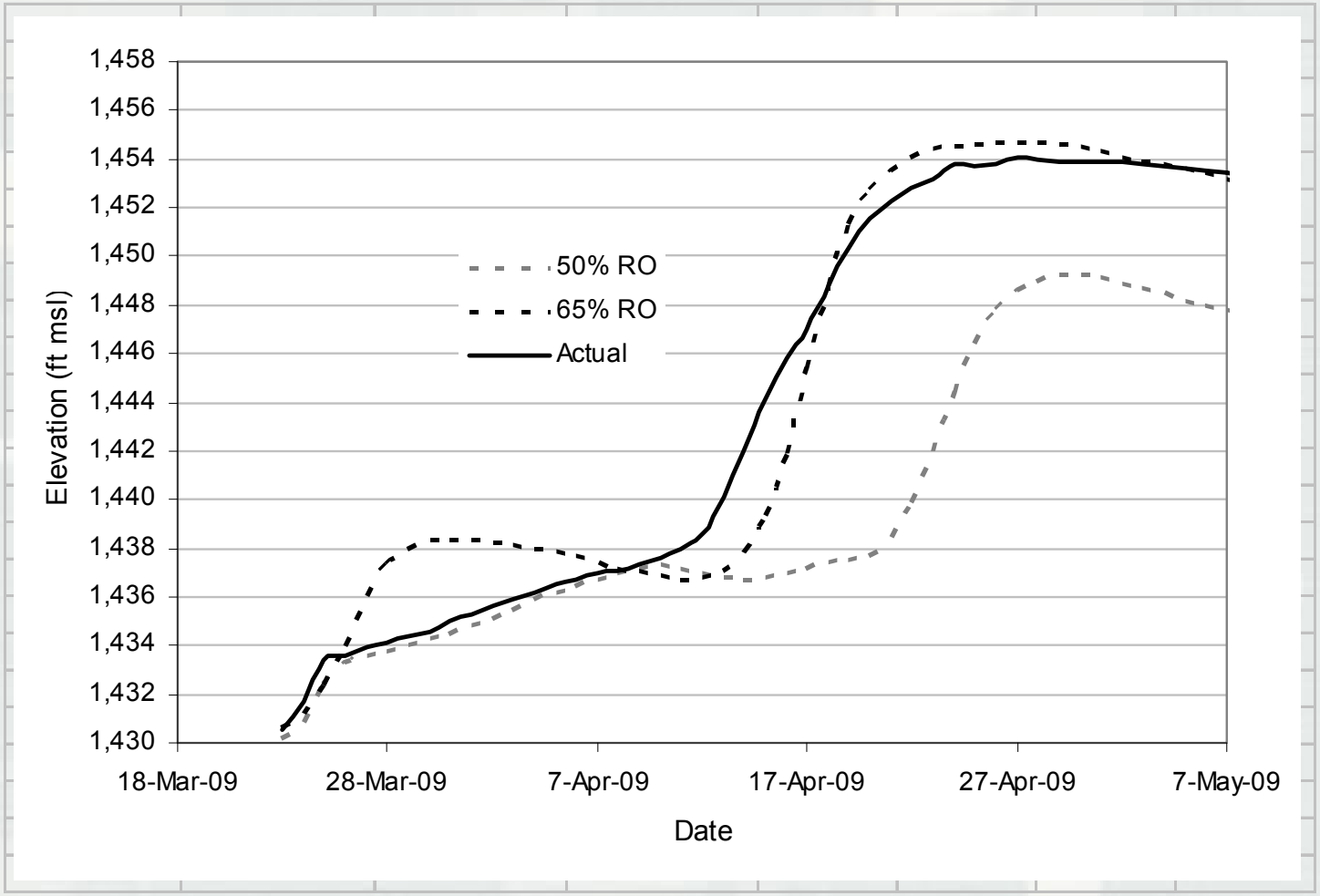
# Long-term Reservoir Forecasts

- Option 1: Maintain combined release at 3200 cfs (1800 cfs out of Jamestown, 1400 cfs out of Pipestem) until all flood control storage is evacuated in early July.
- Option 2: Maintain combined release of 3200 cfs (1800 cfs out of Jamestown, 1400 cfs out of Pipestem) until late May, and then reduce combined release to 1800 cfs, with all storage being evacuated by late July.
- Option 3: Reduce combined release to 1800 cfs immediately, which would temporarily increase pool levels, and then results in all flood storage being evacuated by late August.

# Results – Short-term Forecasts Jamestown Reservoir – Elevation




**Forecast Performed: 4-14-09**



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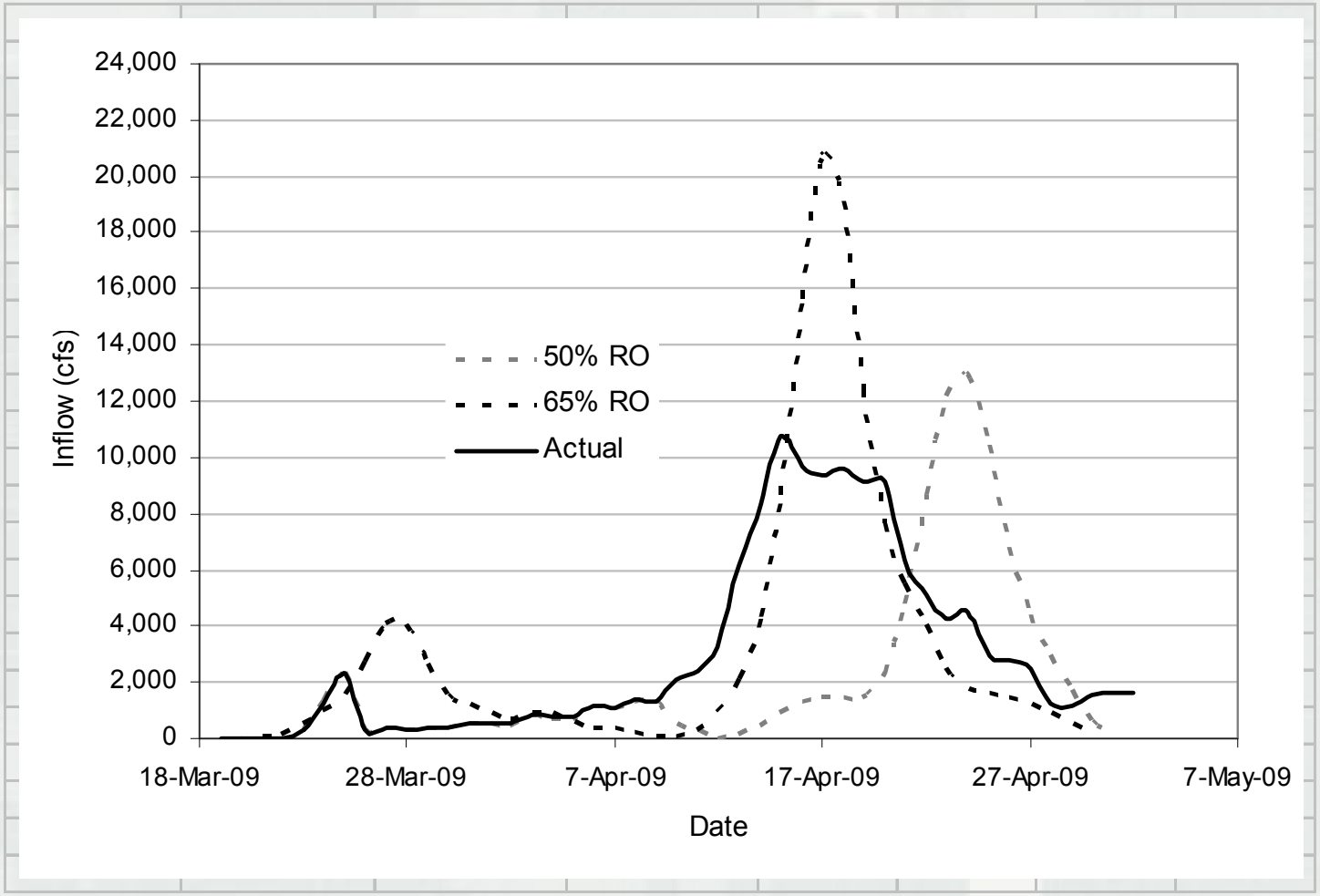
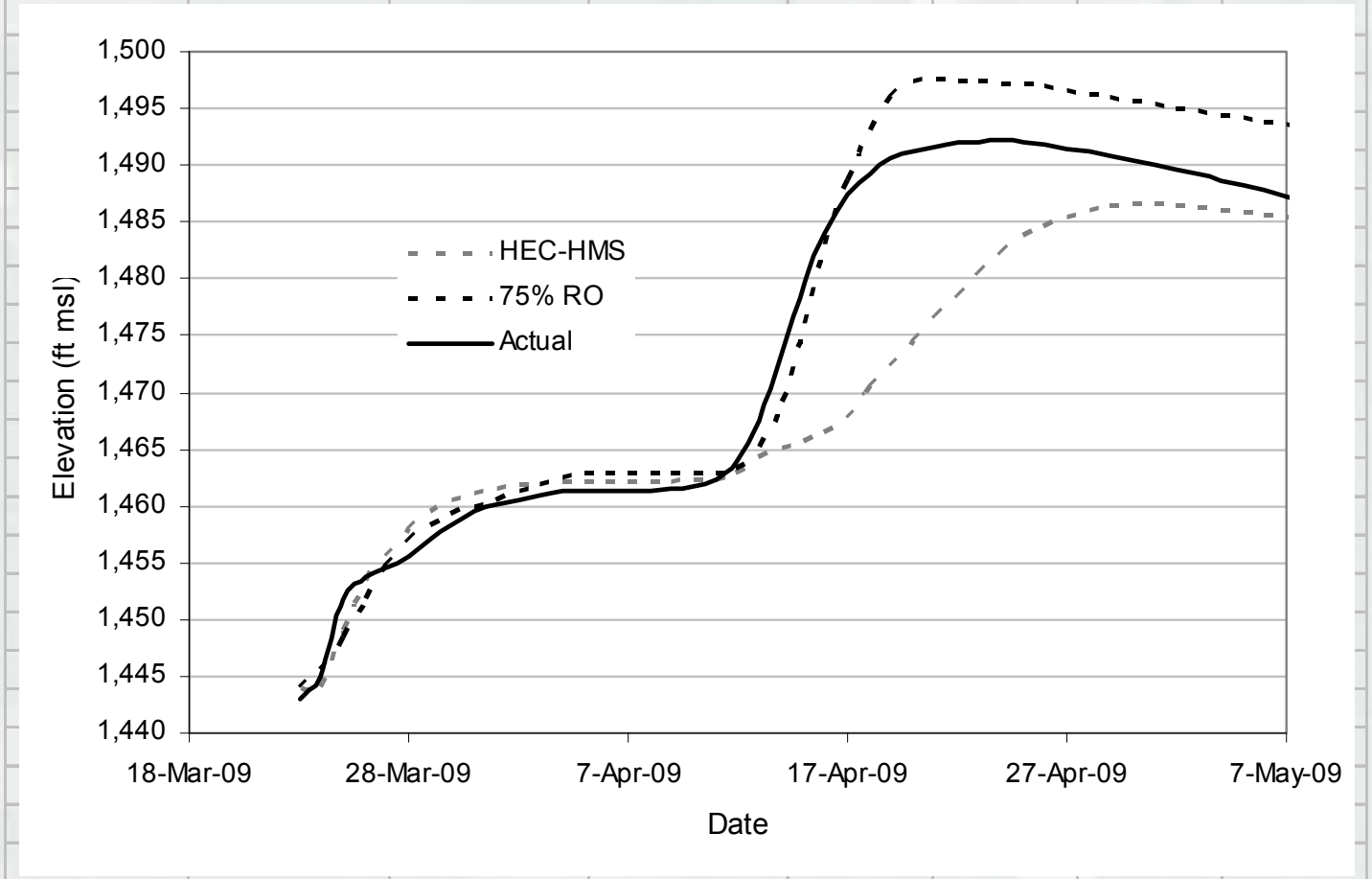
# Results – Short-term Forecasts Jamestown Reservoir – Inflow



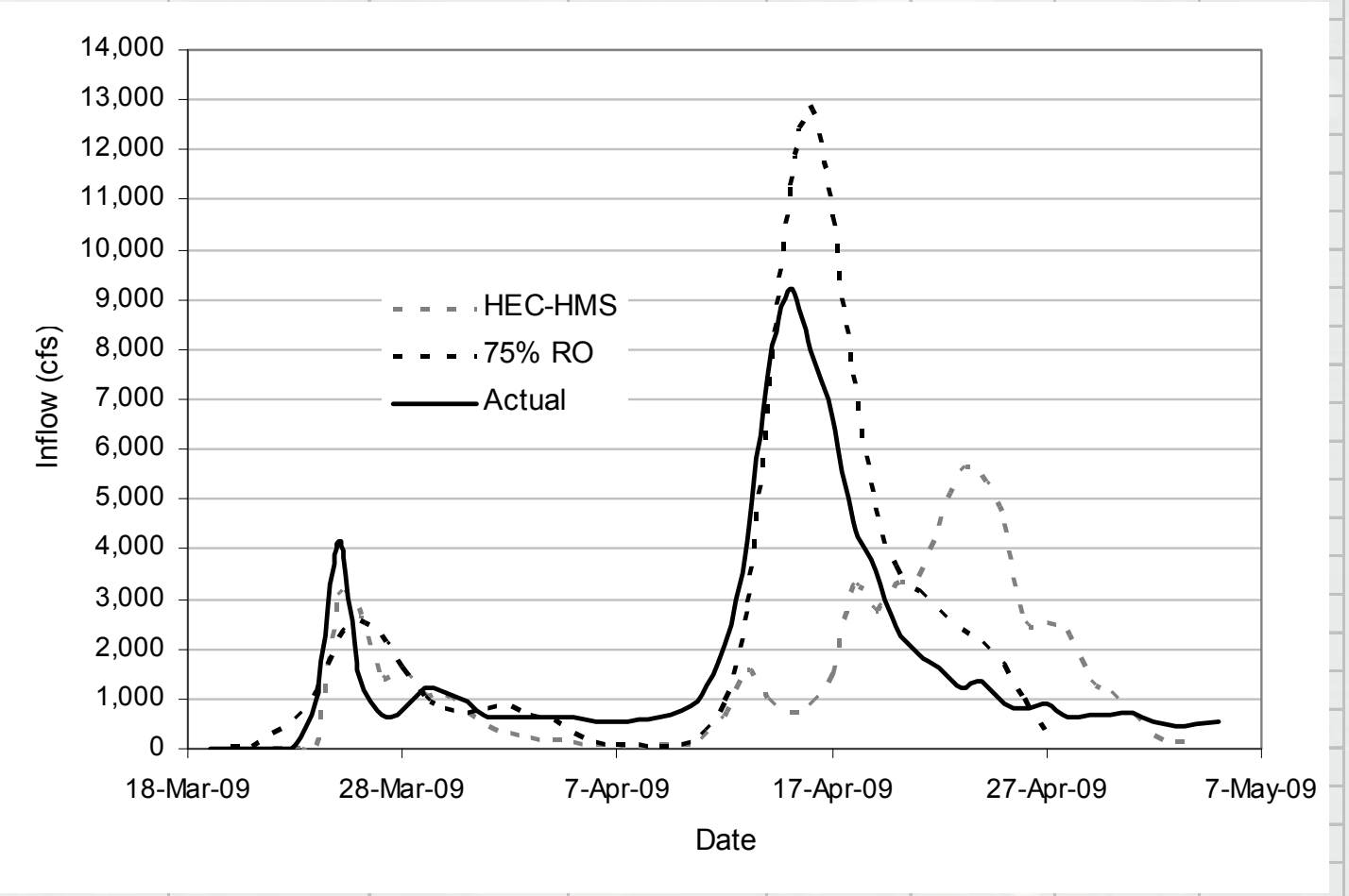

**Forecast Performed: 4-14-09**

# Results – Short-term Forecasts Pipestem Reservoir – Elevation




**Forecast Performed: 4-14-09**

# Results – Short-term Forecasts Pipestem Reservoir – Inflow




**Forecast Performed: 4-14-09**



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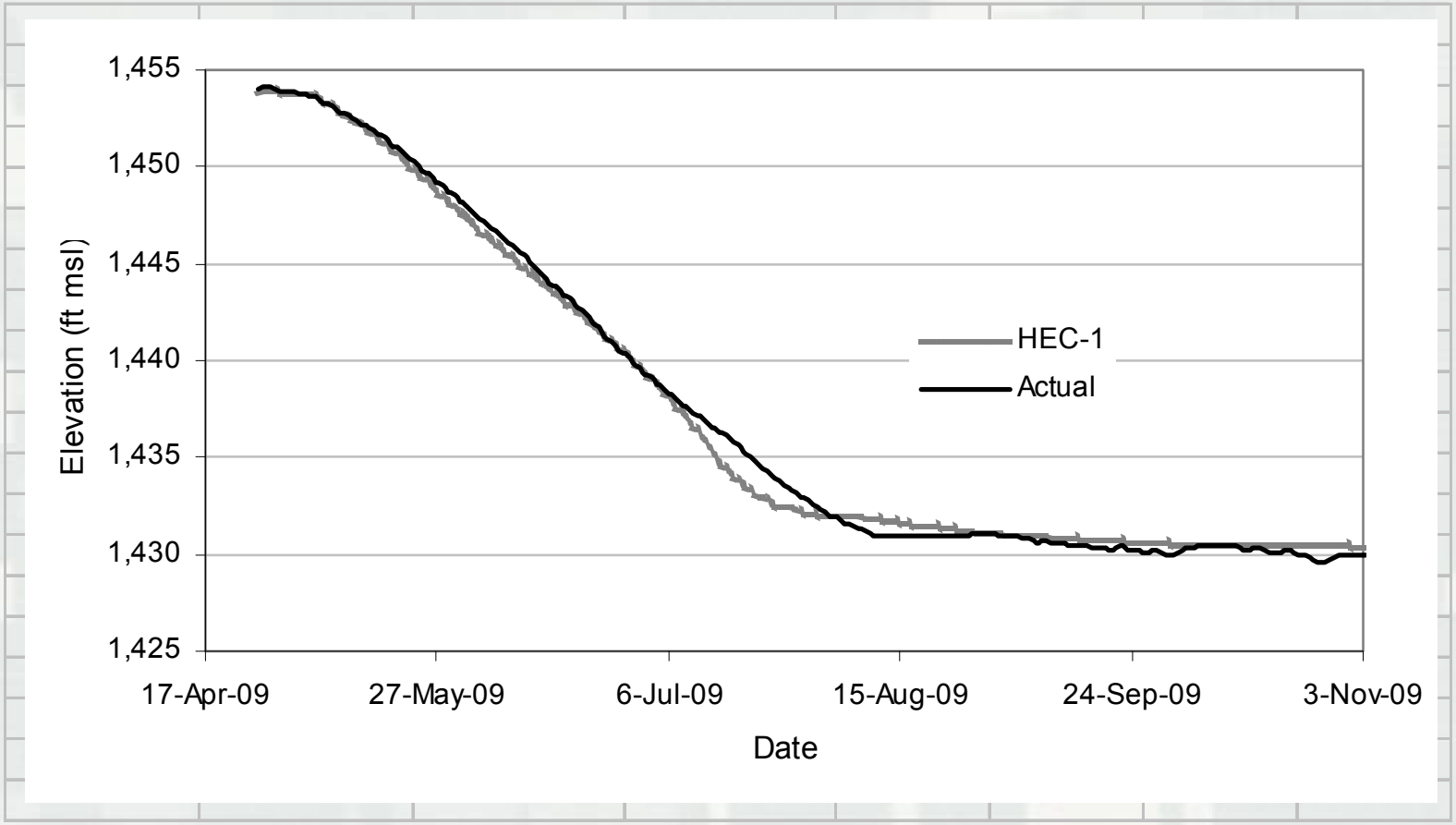
# Results – Long-term Forecasts Jamestown Reservoir – Elevation



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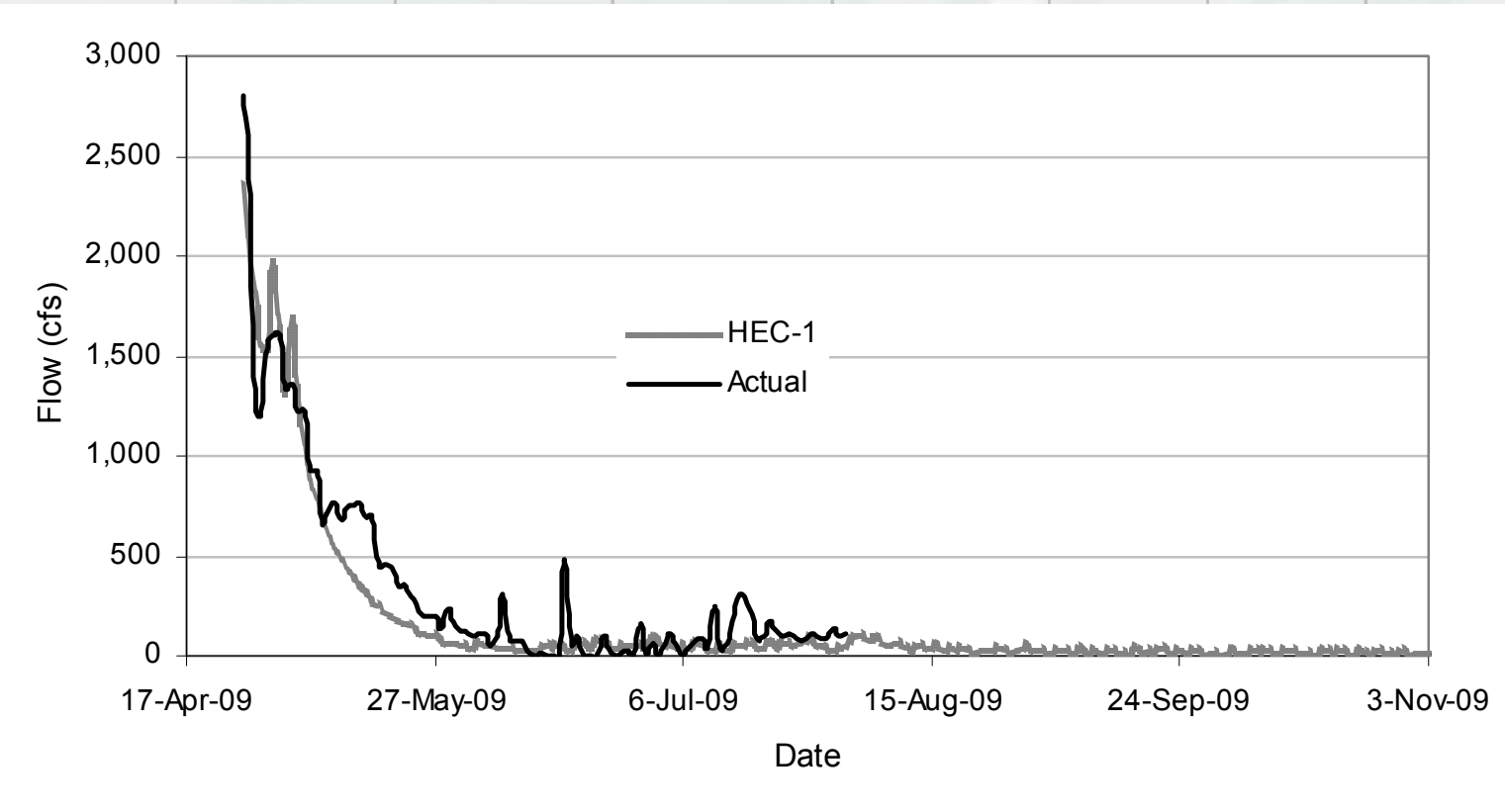




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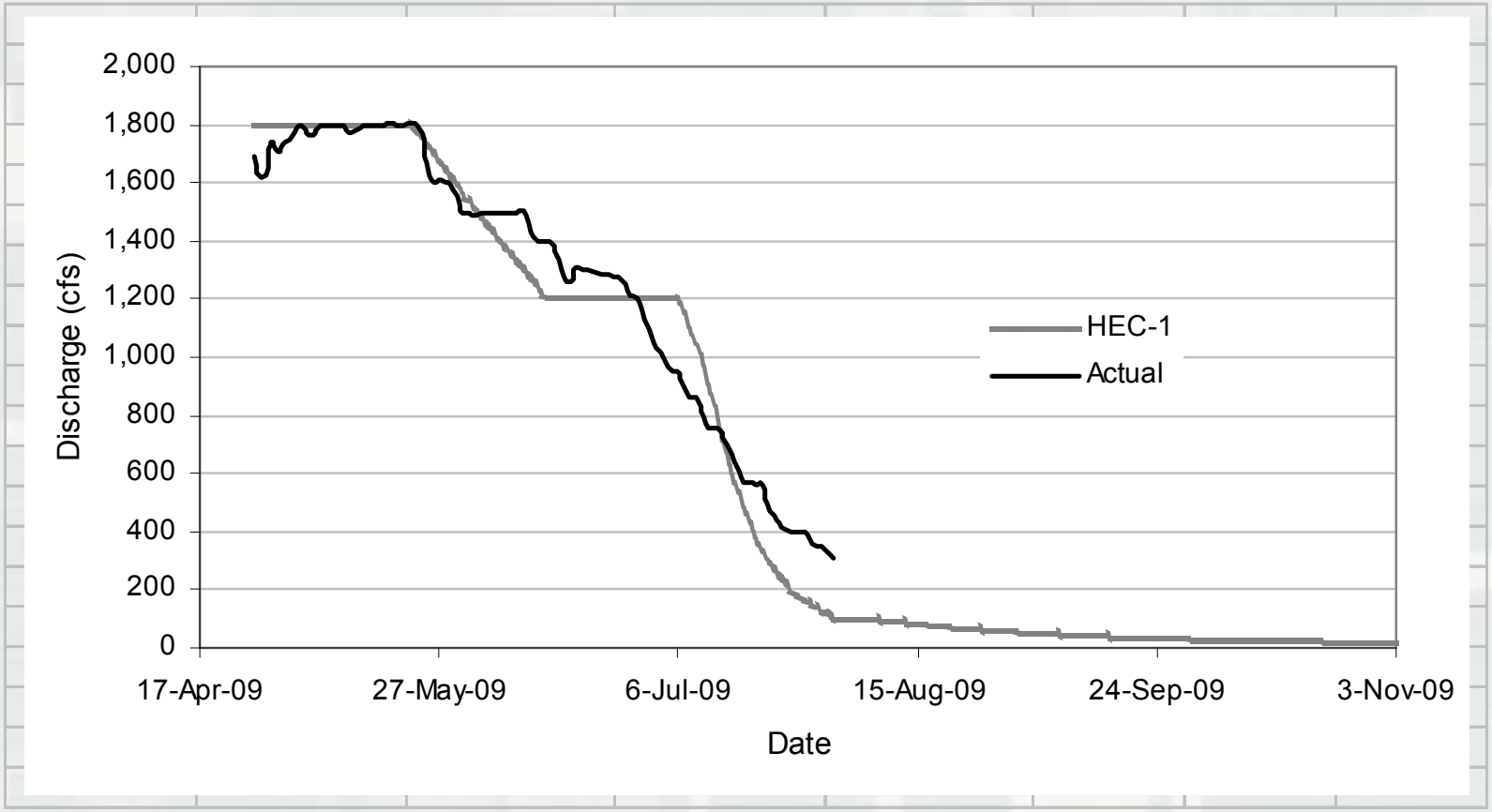
# Results – Long-term Forecasts Jamestown Reservoir – Outflow



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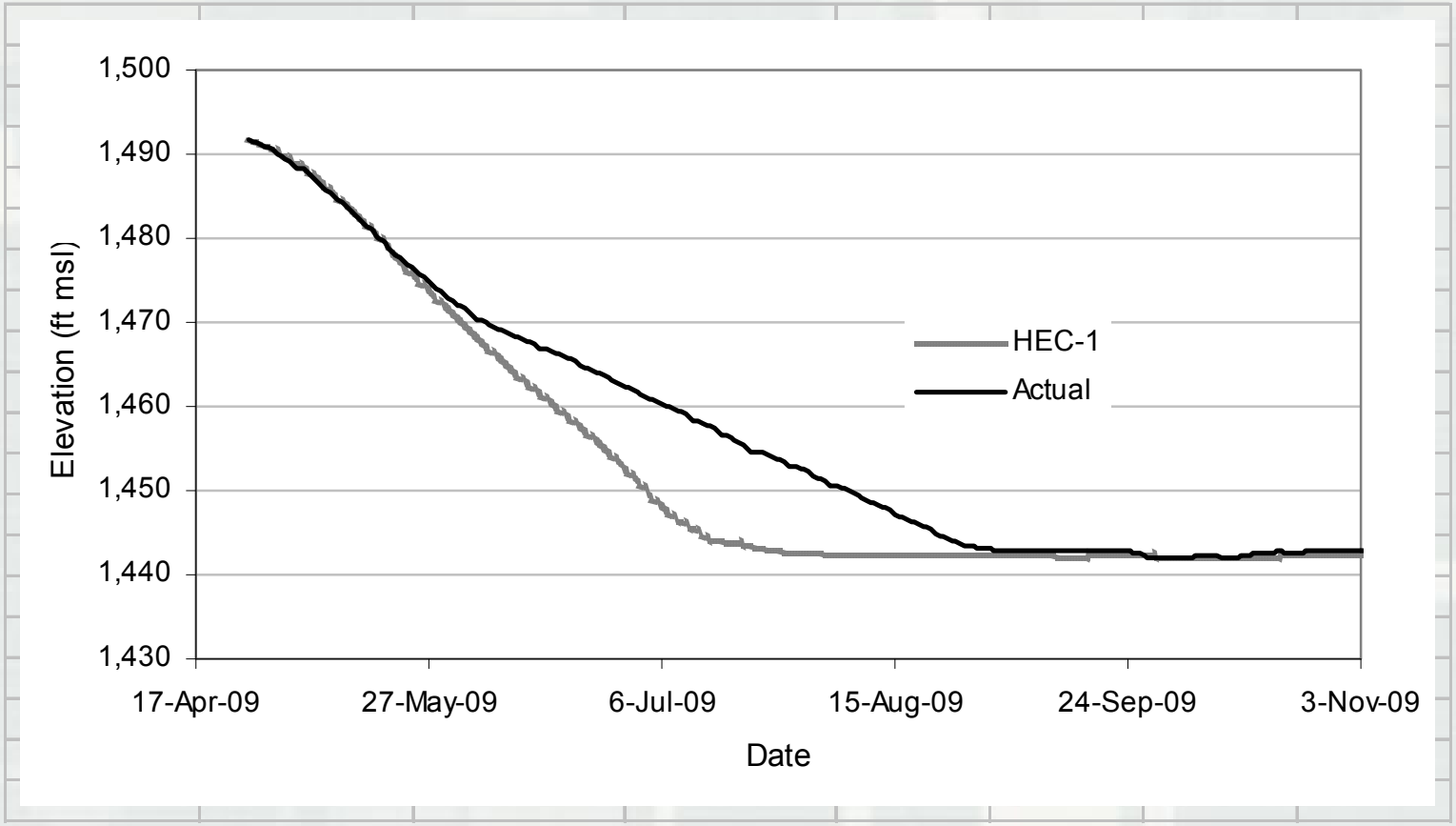
# Results – Long-term Forecasts Pipestem Reservoir – Elevation



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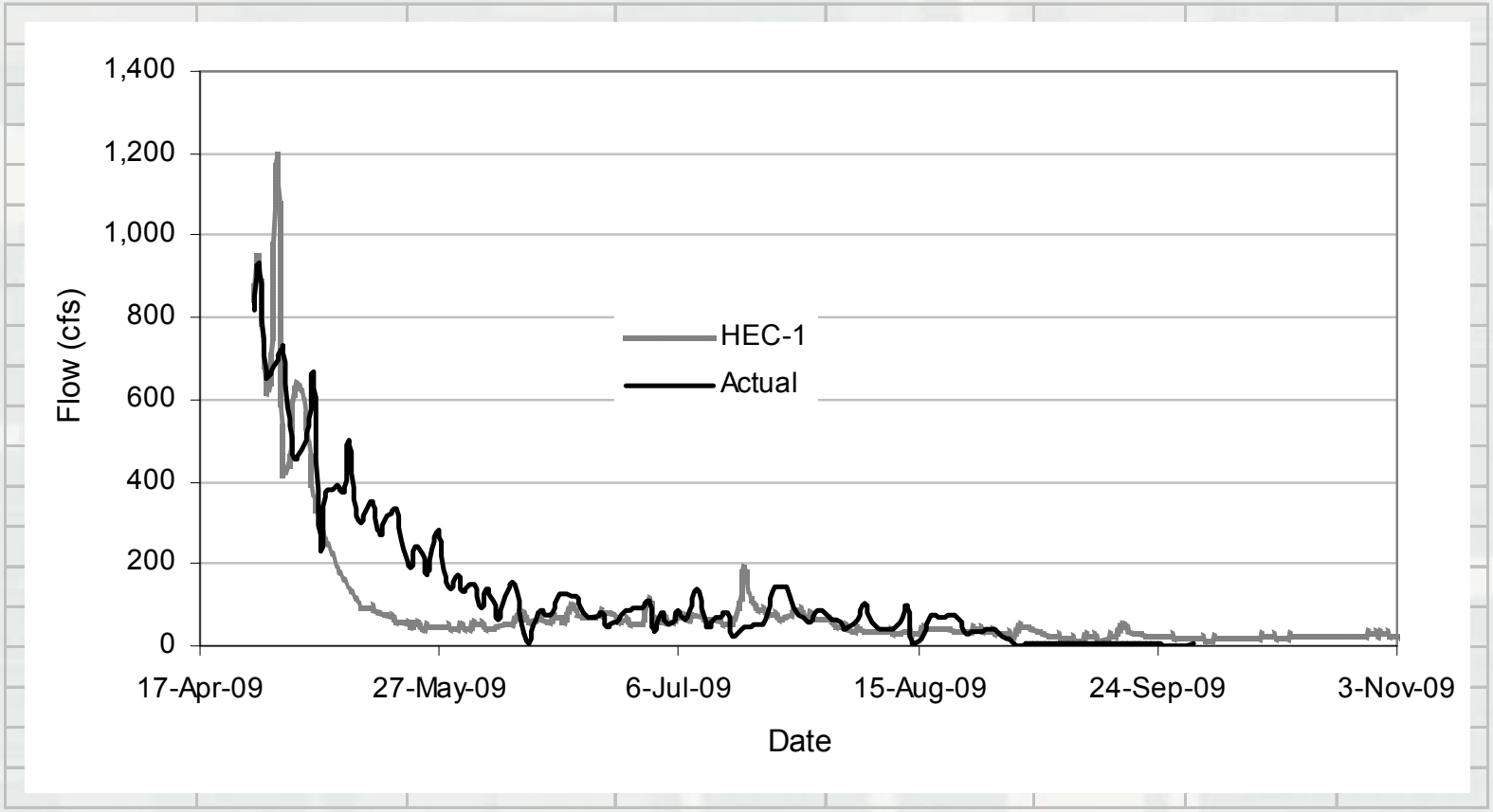
# Results – Long-term Forecasts Pipestem Reservoir – Inflow



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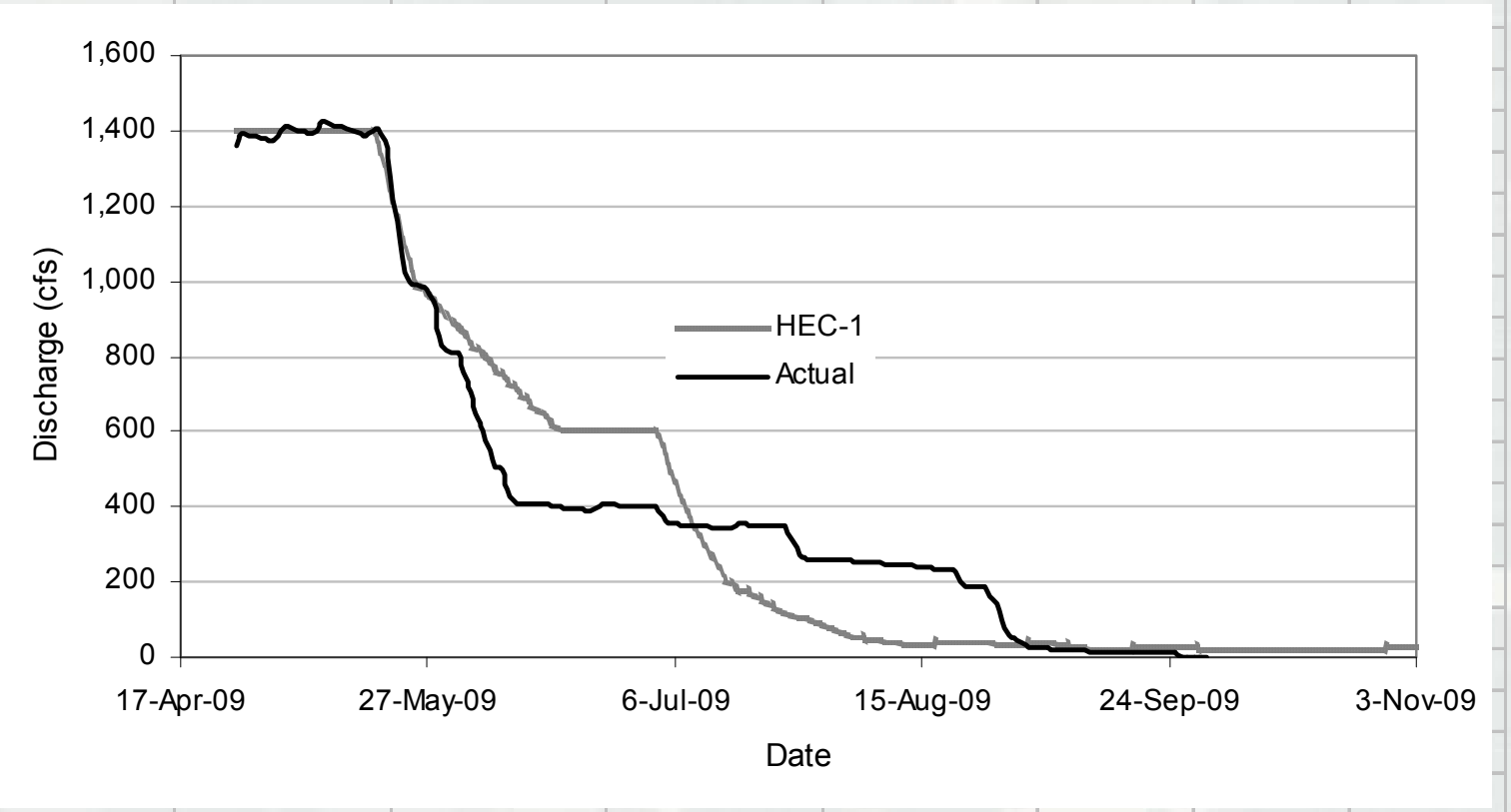
# Results – Long-term Forecasts Pipestem Reservoir – Outflow



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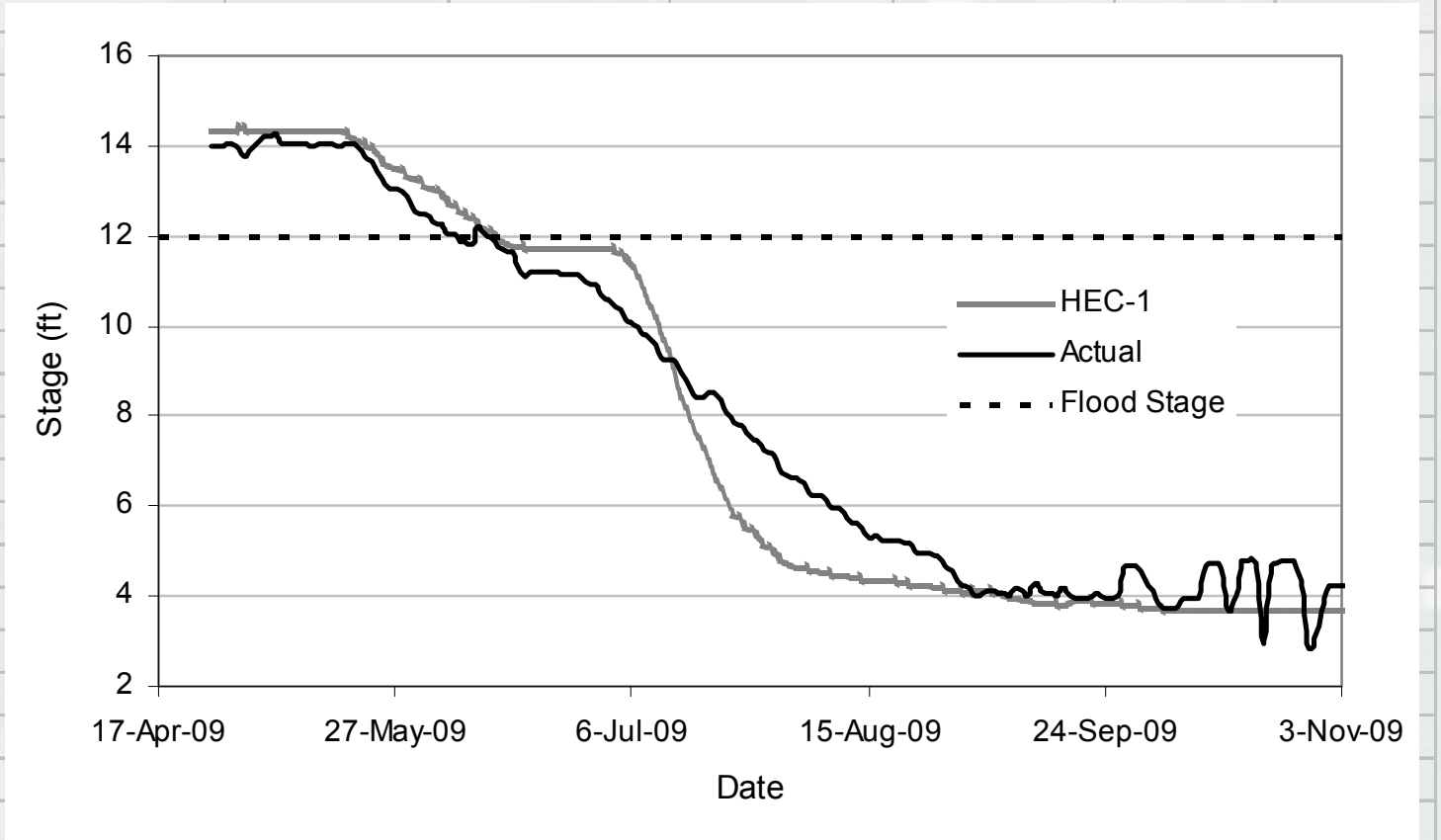
# Results – Long-term Forecasts Jamestown – Stage



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# Additional Products

- City of Jamestown interior drainage analysis
- Jamestown reservoir wind-wave analysis
- Evaluation of reservoir storage
- Precipitation vs. runoff curves for Jamestown and Pipestem reservoirs

# Lessons Learned

- HEC-1 was preferred model due to ease of use and reliable results
- Calibrated HEC-HMS model under-predicted runoff
- HEC-ResSim was useful in evaluating complex reservoir operations
- HEC-ResSim required experienced user during flood emergencies