

IMPACTS OF FORECAST LEAD TIMES ON RESERVOIR OPERATIONS

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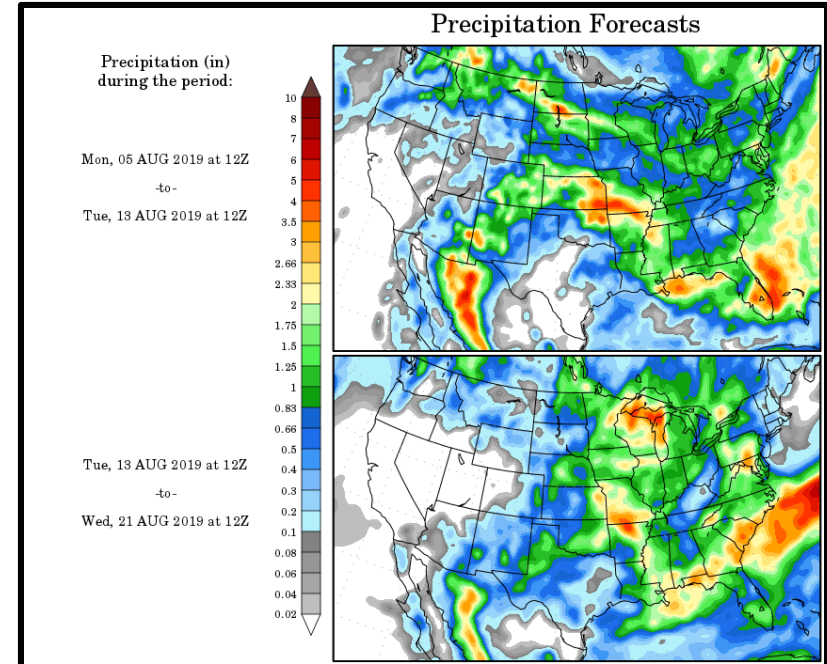
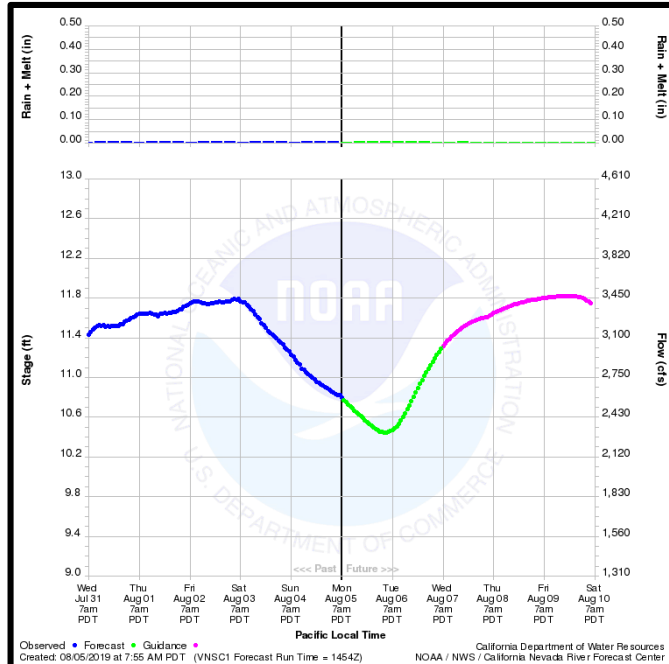


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AGENDA

- Types of forecasts used in reservoir operations
- Variations in needs forecast lead times
- Examples of forecast information with varying lead times



TYPES OF FLOOD EVENTS

Two basic types

- Rainflood events
 - Higher peaks
 - Shorter durations
- Snowmelt events
 - Lower peaks
 - Longer durations



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EXAMPLES OF FORECASTS USED

- Reservoir inflow forecasts from CNRFC
 - Deterministic
 - Ensemble
- Downstream flow forecasts from CNRFC
 - Deterministic
 - Ensemble
- Snowmelt forecasts
 - Bulletin 120 (CA)
 - CBRFC spring runoff (CO/UT)

INFLOWS



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NEEDED FORECAST LEAD TIMES VARY

- Forecast products used in operations cover wide range of time windows
- Examples of factors of forecast lead time requirements:
 - Number of reservoirs in watershed
 - Reservoir release capacity
 - Channel capacity
 - Travel times
 - Downstream local flow contributions



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EXAMPLE – PINE FLAT DAM

KINGS RIVER - PINE FLAT RESERVOIR (PFTC1)

Latitude: 36.82° N

Longitude: 119.33° W

Elevation: 615 Feet

Location: Fresno County in California

River Group: San Joaquin

Issuance Time:

Aug 06 2019 at 7:55 AM PDT

10-Day Accumulated Volume Plot

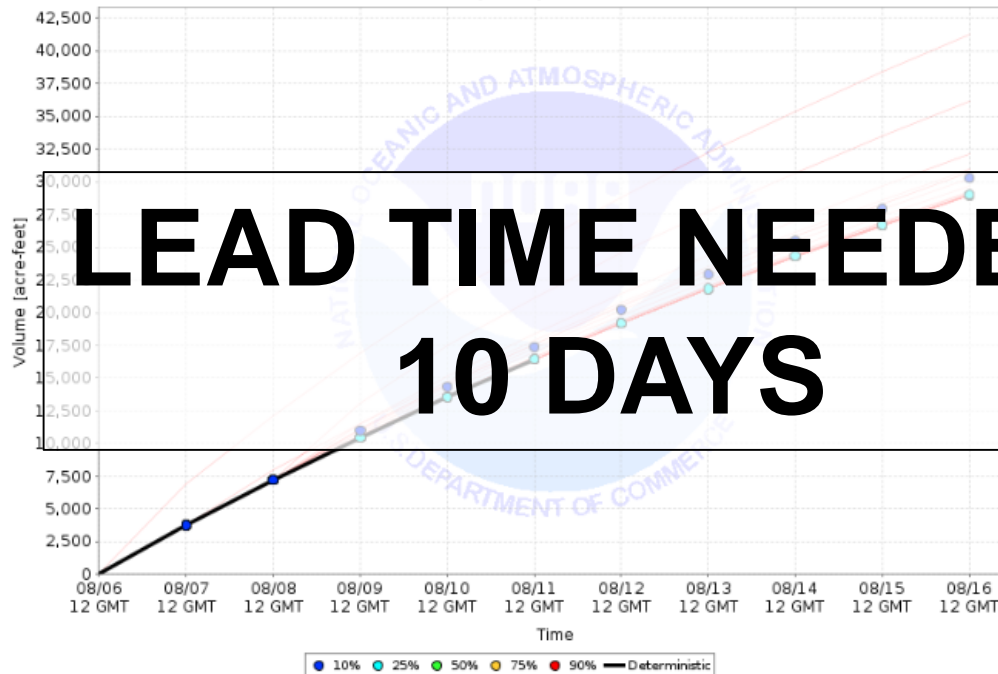
Volume Accumulation For KINGS - PINE FLAT DAM, BL

Latitude: 36.831944 Longitude: -119.32361

Forecast for the period 08/06/2019 - 08/16/2019

This is a conditional simulation based on the current conditions as of 08/06/2019

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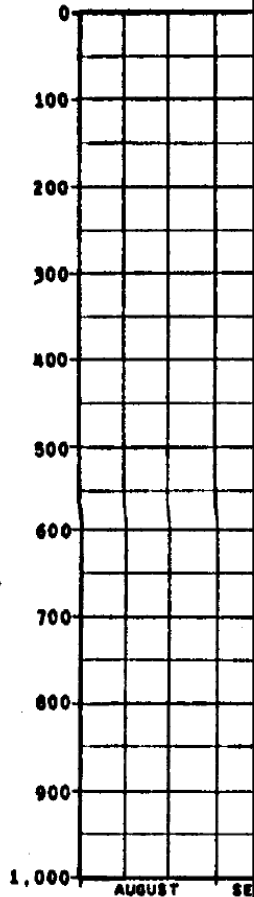


Tabular 10-Day Streamflow Volume Accumulation (1000s of Acre-Feet)

Data Updated: Aug 06 2019 at 7:57 AM PDT

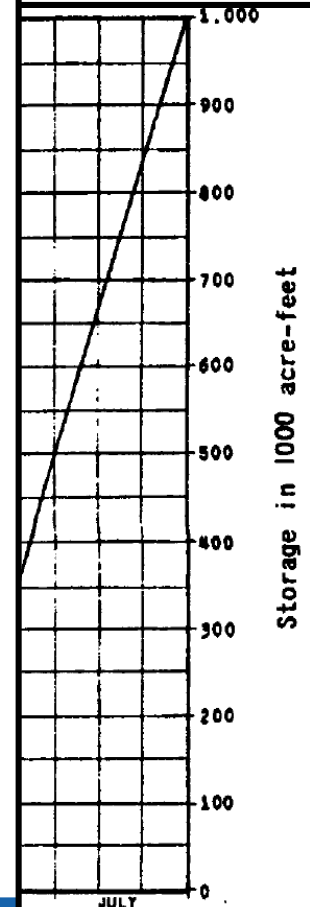
| Probability | Aug 07 | Aug 08 | Aug 09 | Aug 10 | Aug 11 | Aug 12 | Aug 13 | Aug 14 | Aug 15 | Aug 16 |
|-------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| 10% (Max) | 3.8 | 7.2 | 11.0 | 14.3 | 17.4 | 20.2 | 22.9 | 25.5 | 27.9 | 30.3 |
| 25% | 3.8 | 7.2 | 10.5 | 13.5 | 16.4 | 19.2 | 21.8 | 24.3 | 26.7 | 29.0 |
| 50% (Most Likely) | 3.8 | 7.2 | 10.5 | 13.5 | 16.4 | 19.2 | 21.8 | 24.3 | 26.7 | 29.0 |
| 75% | 3.8 | 7.2 | 10.5 | 13.5 | 16.4 | 19.2 | 21.8 | 24.3 | 26.7 | 29.0 |
| 90% (Min) | 3.8 | 7.2 | 10.5 | 13.5 | 16.4 | 19.2 | 21.8 | 24.3 | 26.7 | 29.0 |

Space in 1000 acre-feet



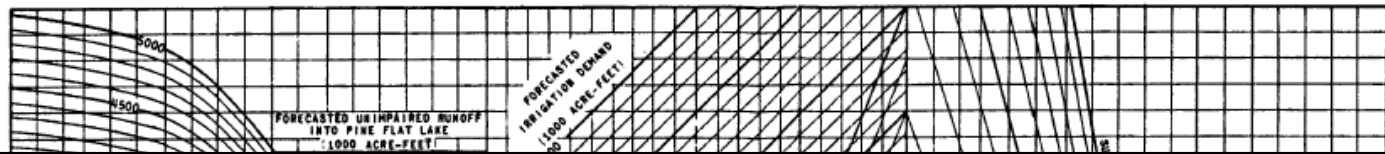
3. When wa
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Storage in 1000 acre-feet



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maximum
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EXAMPLE – PINE FLAT DAM



B-120 Water Supply Forecast Summary (continued)

Water-Year (WY) Forecast Summary and Monthly Distribution (in thousands of acre-feet):

| Watershed | Oct thru Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Water Year | 80% Probability Range | WY % Avg |
|------------------------|--------------------|-------|-------|-------|-----|-----|-----|-----|-----|---------------|-----------------------------|----------------|
| Trinity, Lewiston | 224 | 177 | 225 | 455 | 315 | 190 | 50 | 15 | 9 | 1,660 | 1,475 - 1,835 | 123% |
| Inflow to Shasta | 1,492 | 1,163 | 1,422 | 1,360 | 680 | 370 | 260 | 232 | 227 | 7,205 | 6,770 - 7,570 | 124% |
| Sacramento, Bend | 2,415 | 2,447 | 2,317 | 1,560 | 910 | 355 | 217 | 295 | 113 | 11,130 | 10,410 - 11,860 | 130% |
| Feather, Oroville | 914 | 955 | 1,173 | 1,133 | 910 | 300 | 104 | 148 | 194 | 6,255 | 5,745 - 6,710 | 142% |
| Yuba, Smartsville | 381 | 496 | 563 | 533 | 580 | 370 | 87 | 33 | 27 | 3,070 | 2,795 - 3,360 | 135% |
| American, Folsom | 425 | 702 | 704 | 772 | 499 | 440 | 100 | 23 | 17 | 3,910 | 3,610 - 4,330 | 149% |
| Cosumnes, Mich. Bar | 63 | 165 | 92 | 41 | 7 | 10 | 13 | 2 | 2 | 695 | 650 - 785 | 183% |
| Mokelumne, Pardee | 70 | 128 | 165 | 235 | 260 | 195 | 40 | 7 | 5 | 1,105 | 990 - 1,240 | 148% |
| Stanislaus, Gdw. | 144 | 217 | 278 | 356 | 390 | 255 | 79 | 17 | 8 | 1,745 | 1,610 - 1,945 | 152% |
| Tuolumne, La Grange | 199 | 344 | 365 | 450 | 580 | 540 | 200 | 33 | 15 | 2,725 | 2,515 - 3,005 | 143% |
| Merced, McClure | 95 | 226 | 183 | 255 | 320 | 240 | 55 | 15 | 6 | 1,395 | 1,280 - 1,555 | 141% |
| San Joaquin, Millerton | 144 | 211 | 236 | 403 | 550 | 570 | 237 | 65 | 28 | 2,445 | 2,180 - 2,730 | 136% |
| Kings, Pine Flat | 130 | 186 | 240 | 375 | 600 | 620 | 235 | 64 | 25 | 2,475 | 2,230 - 2,770 | 145% |
| Kaweah, Terminus | 33 | 58 | 101 | 111 | 145 | 130 | 44 | 12 | 6 | 640 | 565 - 705 | 142% |
| Tule, Success | 17 | 28 | 65 | 37 | 37 | 20 | 6 | 3 | 2 | 215 | 190 - 250 | 146% |
| Kern, Isabella | 69 | 56 | 128 | 201 | 255 | 224 | 100 | 40 | 22 | 1,095 | 985 - 1,260 | 150% |

**LEAD TIME NEEDED:
6 MONTHS**

chan
Rain
redu

Conditional Reservation Required for flood
control in Pine Flat Lake:
 $865,000 - (100,000 + 82,000 - 20,000) = 703,000 \text{ ac-ft}$

COMPUTATION OF TOTAL RELEASE FROM PINE FLAT LAKE:

Total space available for flood control . . .
 $300,000 + 100,000 + 82,000 - 20,000 = 462,000$

Supplemental release (from diagram) 2,900 cfs

Total release $3,000 + 2,900 = 5,900 \text{ cfs}$

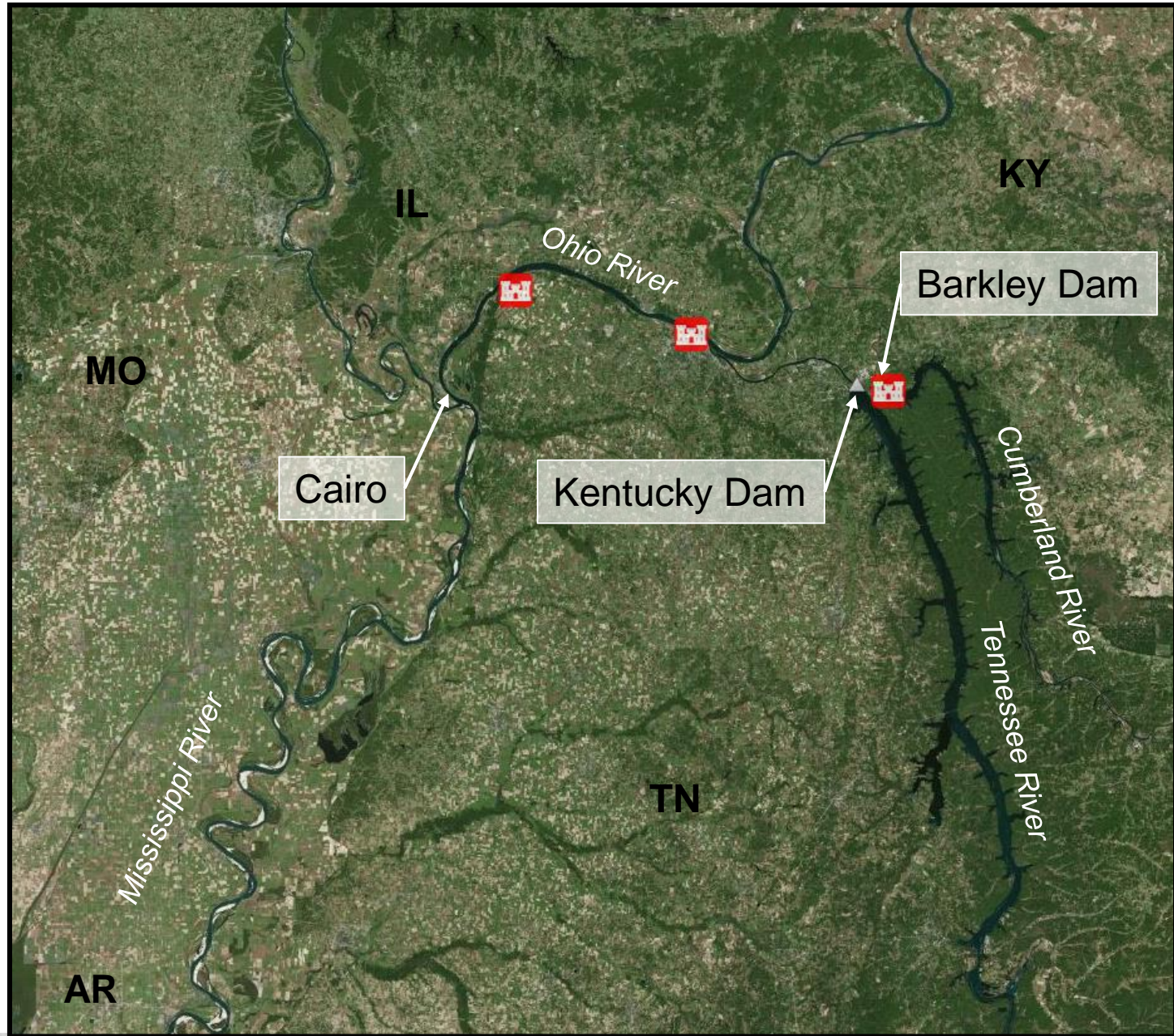
Total space required for flood control
(1000 acre-feet)

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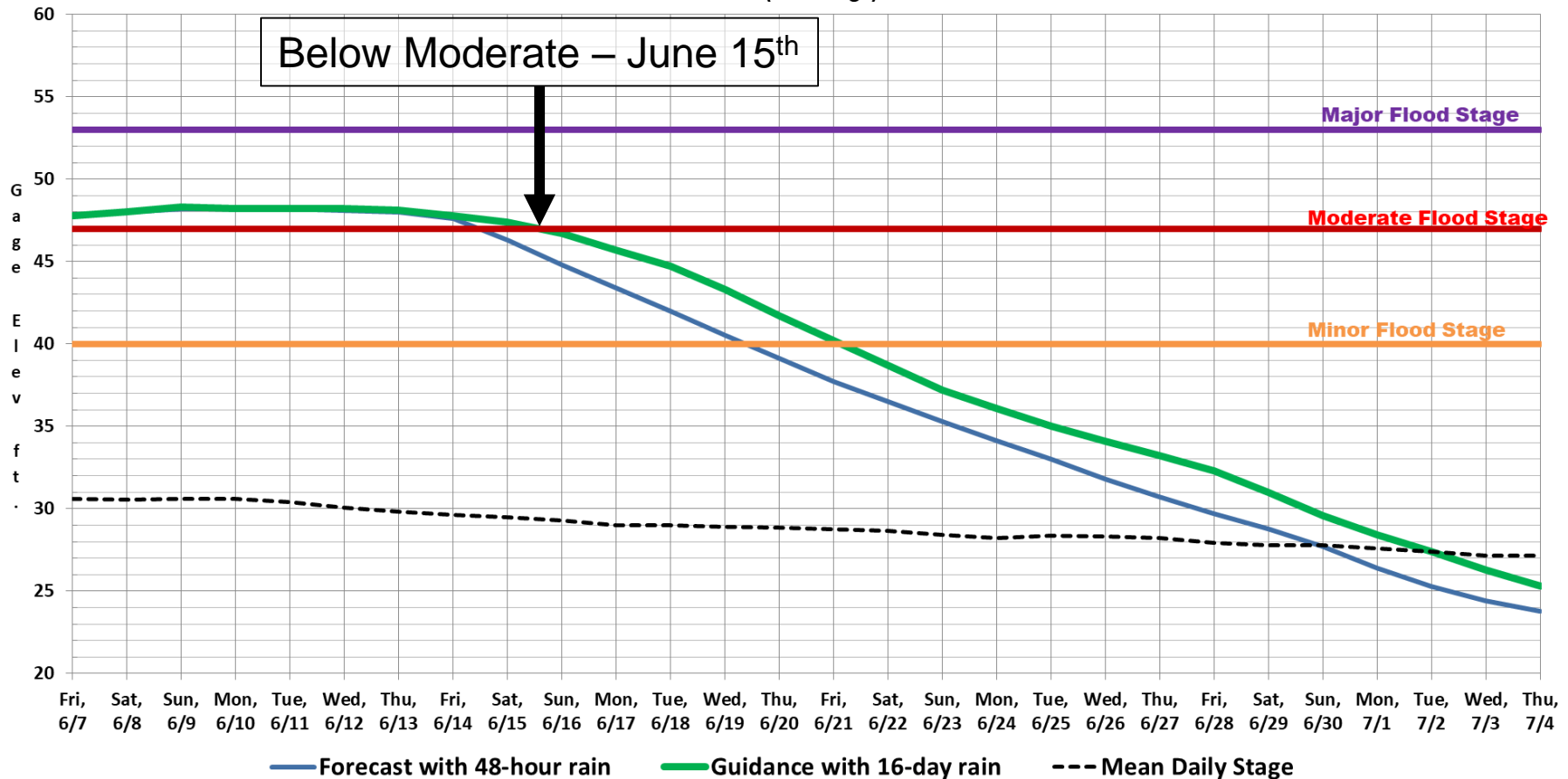
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EXAMPLE – MS/MO RIVERS FLOODING



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Lower Mississippi River
NWS Forecast 6/7-7/4
(Cairo Gage)

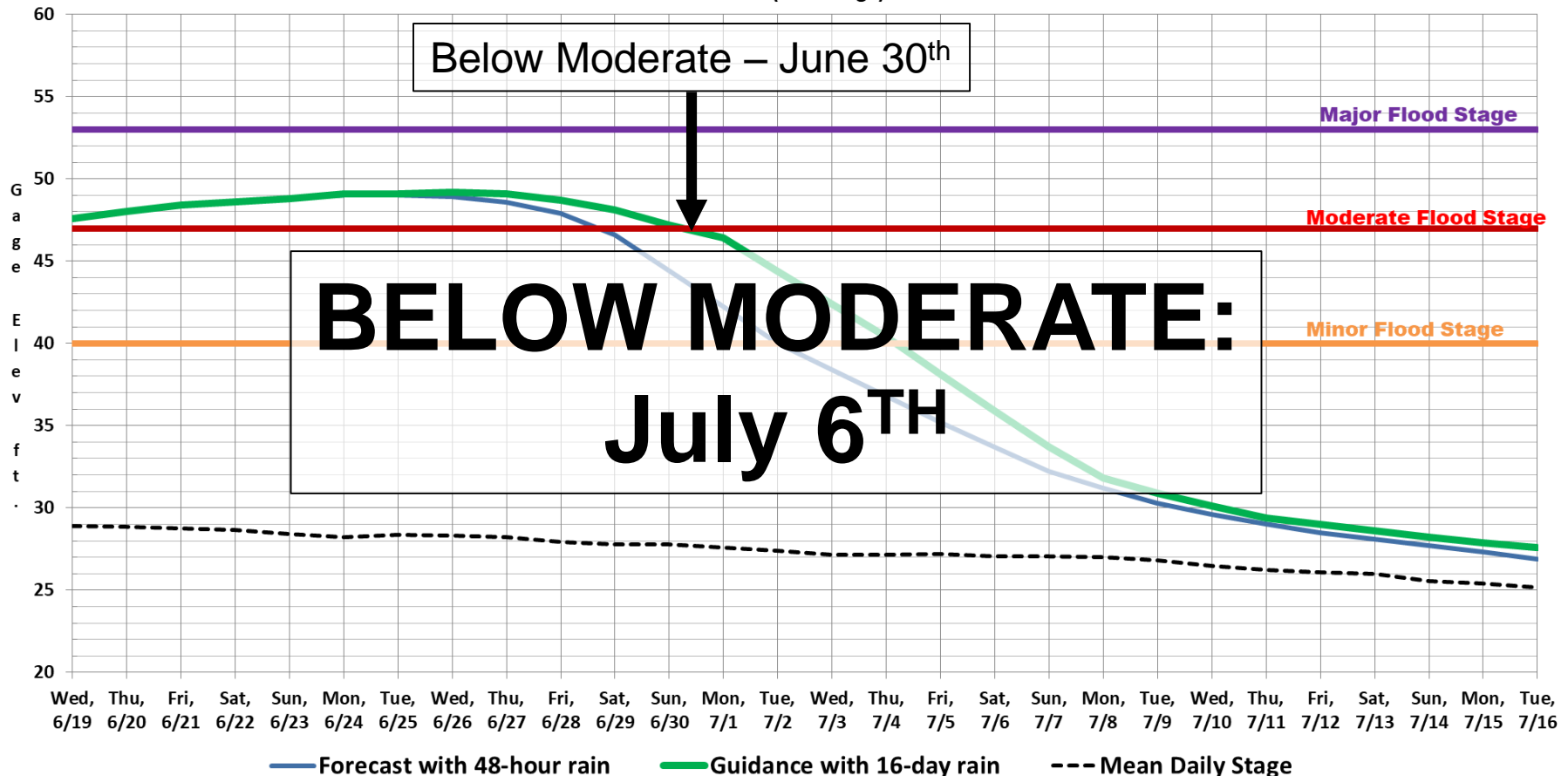


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EXAMPLE – MS/MO RIVERS FLOODING

Lower Mississippi River
NWS Forecast 6/19-7/16
(Cairo Gage)



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IF LEAD TIMES ARE INSUFFICIENT

- Operational decisions are too conservative
 - Most common result
 - Many current WCMs designed around no forecast knowledge
- Operational decisions are not conservative enough
 - Less common (so far)
 - Older WCMs based on older hydrology
 - Climate change vs. stationarity



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QUESTIONS?

