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Hydrologic and Hydraulic Modeling of the Cache River for Evaluating Alternative Restoration Measures

Mike Demissie

Laura Keefer
Illinois State Water Survey

Yanqing Lian

Elias Bekele

Laura Keefer, Fluvial Geomorphologist, has been with the Illinois State Water Survey since 1986 and working on watershed monitoring and sediment issues in the Cache River Basin since that time. Her current interests are in erosion and sedimentation processes related to stream channel adjustments to landscape changes.

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Center for Watershed Science
Illinois State Water Survey
Institute for Natural Resource Sustainability
University of Illinois
Champaign, Illinois

Funded by Illinois Nature Preserves Commission

ILLINOIS

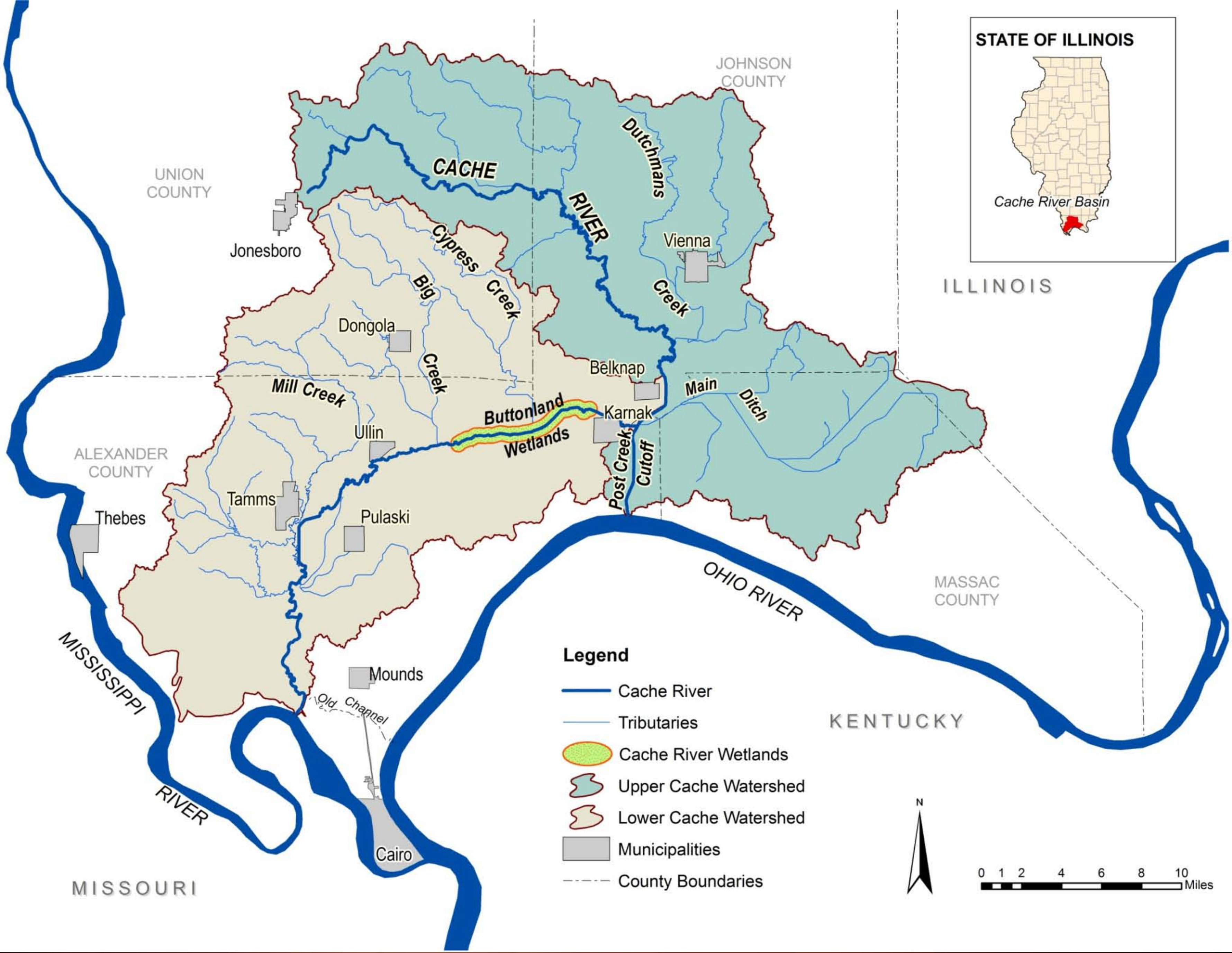
Overview

- Objectives
- Background
  - Brief review of Phase I modeling results for Lower Cache River
- Phase II project
  - Objectives
  - Background
  - Results
  - Conclusions

Objectives

- Develop the necessary hydrologic and hydraulic models to objectively evaluate benefits and potential impacts of alternative restoration measures in the Cache River watershed

- Modeling used to satisfy regulatory requirements and ensure that natural, agricultural, and social resources are not damaged by flooding induced by modifications to the river system


STATE OF ILLINOIS
Cache River Basin
ILLINOIS
JOHNSON COUNTY
UNION COUNTY
ALEXANDER COUNTY
MASSAC COUNTY
KENTUCKY
MISSOURI
MISSISSIPPI RIVER
OHIO RIVER
CACHE RIVER
Dutchmans Creek
Cypress Creek
Big Creek
Mill Creek
Buttonland Wetlands
Main Ditch
Post Creek Cutoff
Old Channel
Jonesboro
Vienna
Dongola
Belknap
Karnak
Ullin
Tamms
Thebes
Pulaski
Mounds
Cairo
Legend
Cache River
Tributaries
Cache River Wetlands
Upper Cache Watershed
Lower Cache Watershed
Municipalities
County Boundaries
N
0 1 2 4 6 8 10 Miles

Background: Phase I Project

- Hydrologic and Hydraulic models developed for Lower Cache River (Demissie et al., 2008)
  - Calibrated 5-reach model to evaluate hydrology under current flow conditions and various restoration scenarios as compared to reference/base conditions
    - Reference/base condition in Lower Cache River:
      - Controlled on east by Karnak Levee (2 x 48” culverts)
      - Controlled on west by 2 weirs (near Rt. 37 & Long Reach Rd.)
    - Current condition in Lower Cache River:
      - Breach in Karnak Levee
      - Controlled on west by 2 weirs (Rt. 37 & west of Long Reach Rd.)

Background: Phase I Project

- Phase I Results
  - Current condition exposes L. Cache River corridor to major floods (100-year + from Upper Cache and Ohio Rivers)
  - Current condition improves flood drainage for some areas during more frequent 1-, 2-, and 5-year floods
  - Installation of East Outlet Structure with 3+ 72-inch culverts in levee lowers flood elevations from base conditions for areas immediately east of structure

(continued)

Background: Phase I Project

- Phase I results
  - Diversion of some Upper Cache River flow does not increase flood elevations from base condition during 100-year floods but raise elevations for 1- and 2-year floods
    - Low and moderate flow conditions would create a slow-moving westerly flow in the Lower Cache River

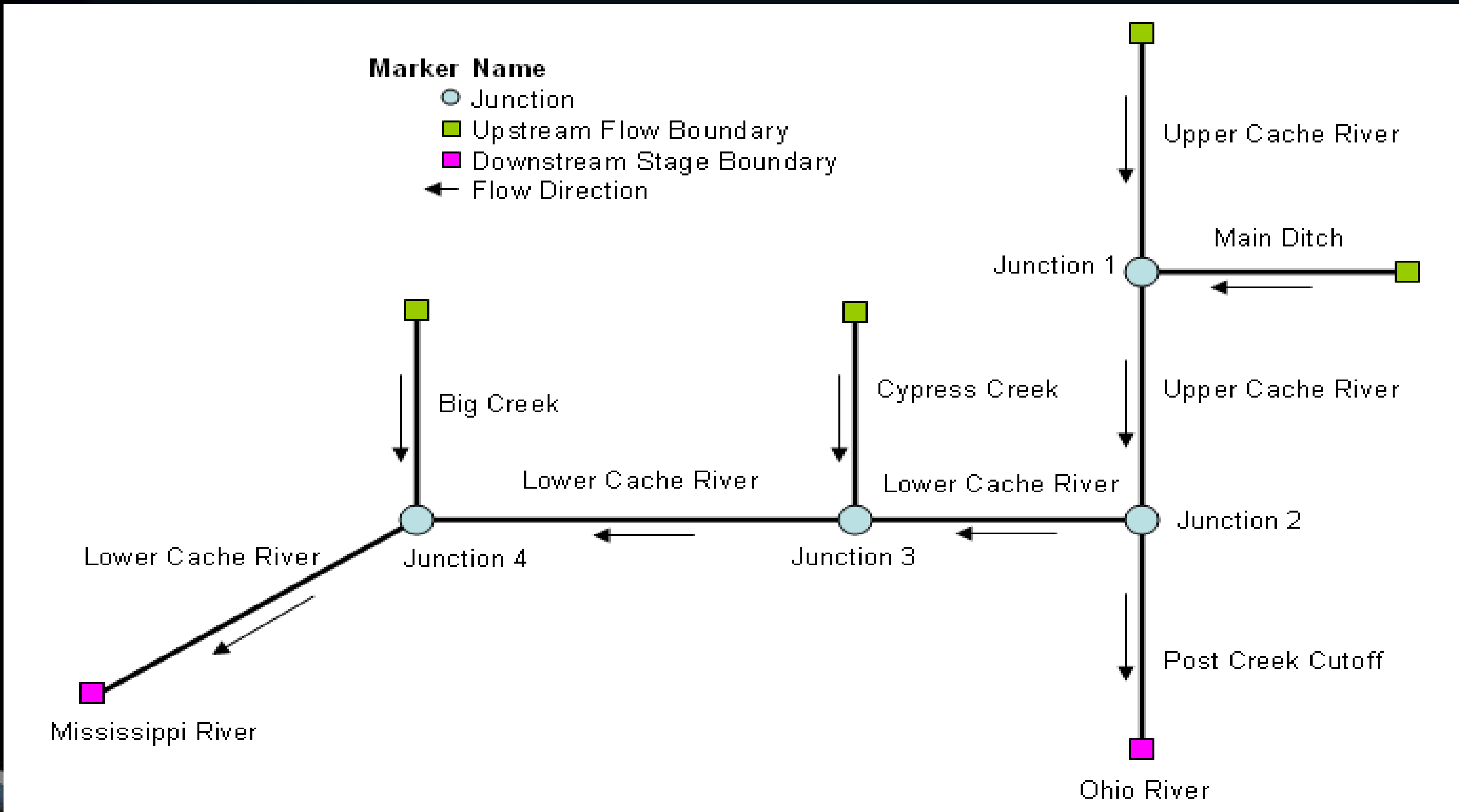
Phase II Project Objectives

- Develop Upper Cache River (UCR) hydrologic and hydraulic models to evaluate upstream impacts of in-channel weir in Forman Floodway
- Re-run Phase I hydraulic model (LCR)
  - updated in-channel cross-sections to better evaluate low and moderate flow conditions including potential inflow from UCR
- Develop LCR water budget accounting tool to evaluate alternatives for maintaining sufficient potential inflow from UCR for ecosystem sustainability
- *Model March 2008 flood*

Phase II: Background

- Developed HEC-HMS model for UCR
  - Flood hydrographs used as input to 9-reach UNET hydraulic model to simulate flood water movement through entire Cache River system and compared to observed high water elevations
  - Simulated flow dynamics between UCR, eastern segment of LCR, and Post Creek Cutoff in vicinity of Karnak Levee breach

- Schematic 9-reach model



Phase II: March 2008 Flood

- March 2008 Flood at Karnak Levee

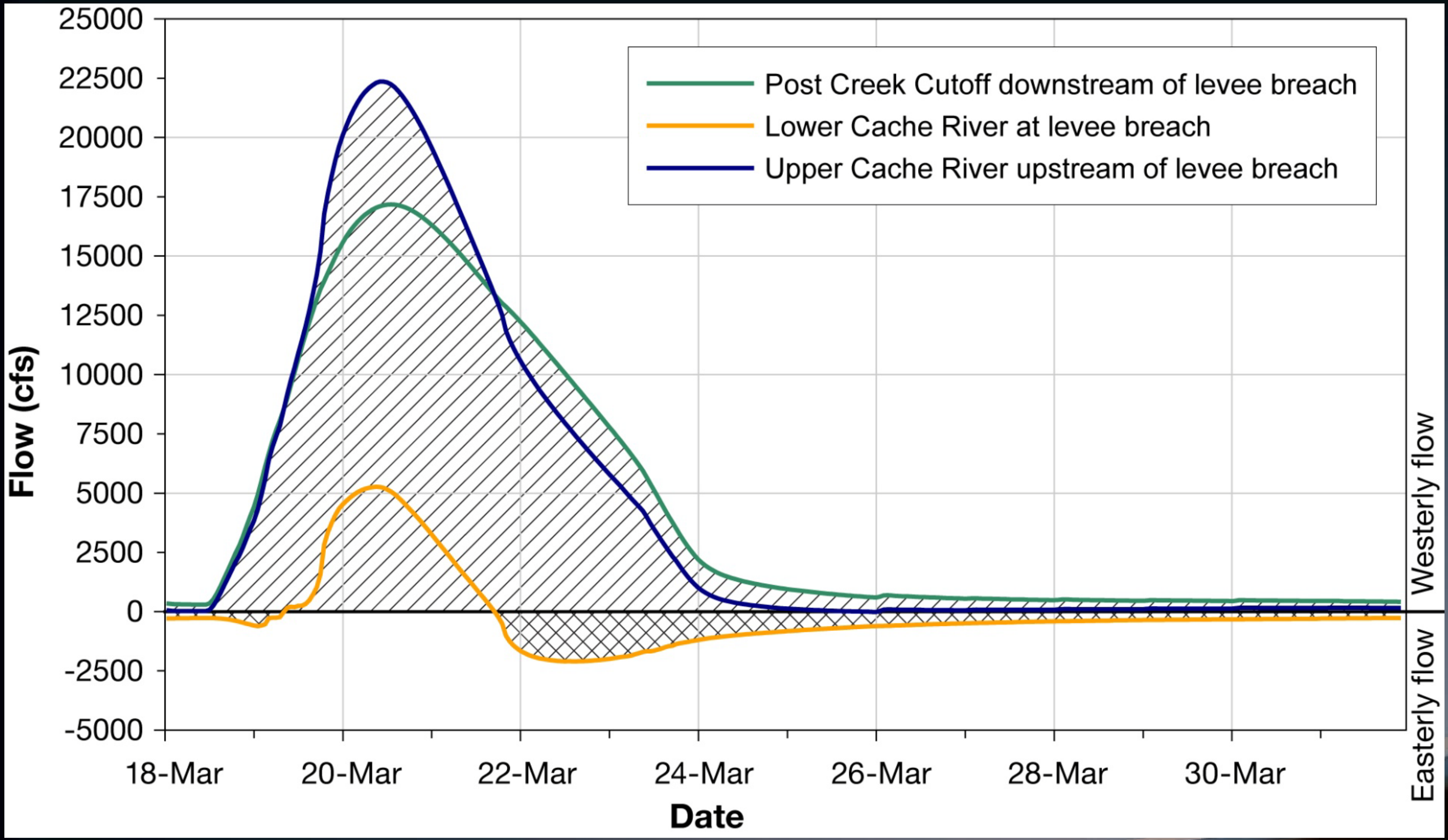


Figure 2.16. Flows in Upper and Lower Cache Rivers and in Post Creek Cutoff downstream of the breach on Karnak Levee during March 2008 flood (in Lower Cache River positive flows are westerly towards the Mississippi River, while negative flows are easterly towards Post Creek Cutoff)

Phase II: March 2008 Flood

- March 2008 Flood in Lower Cache River

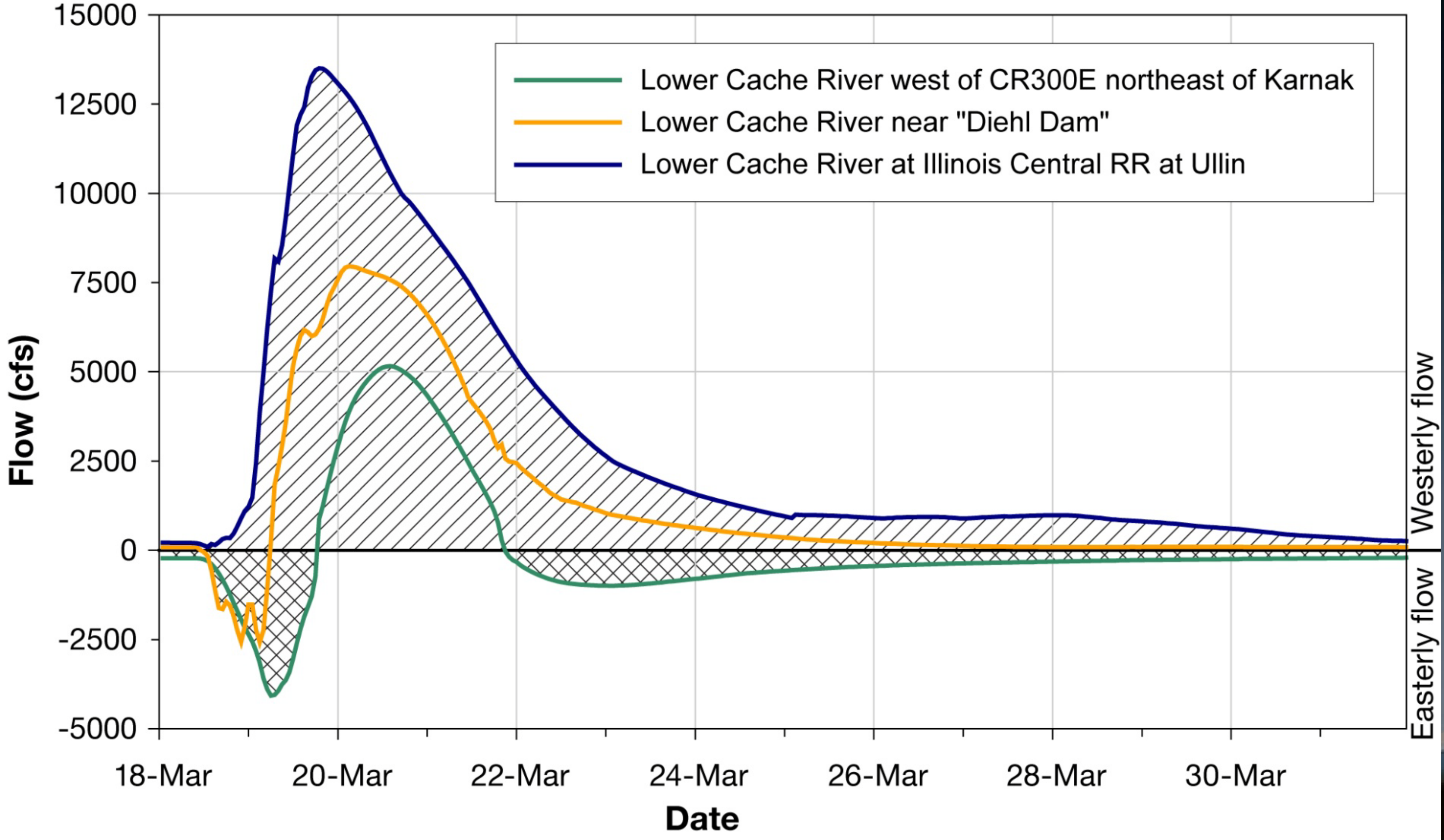
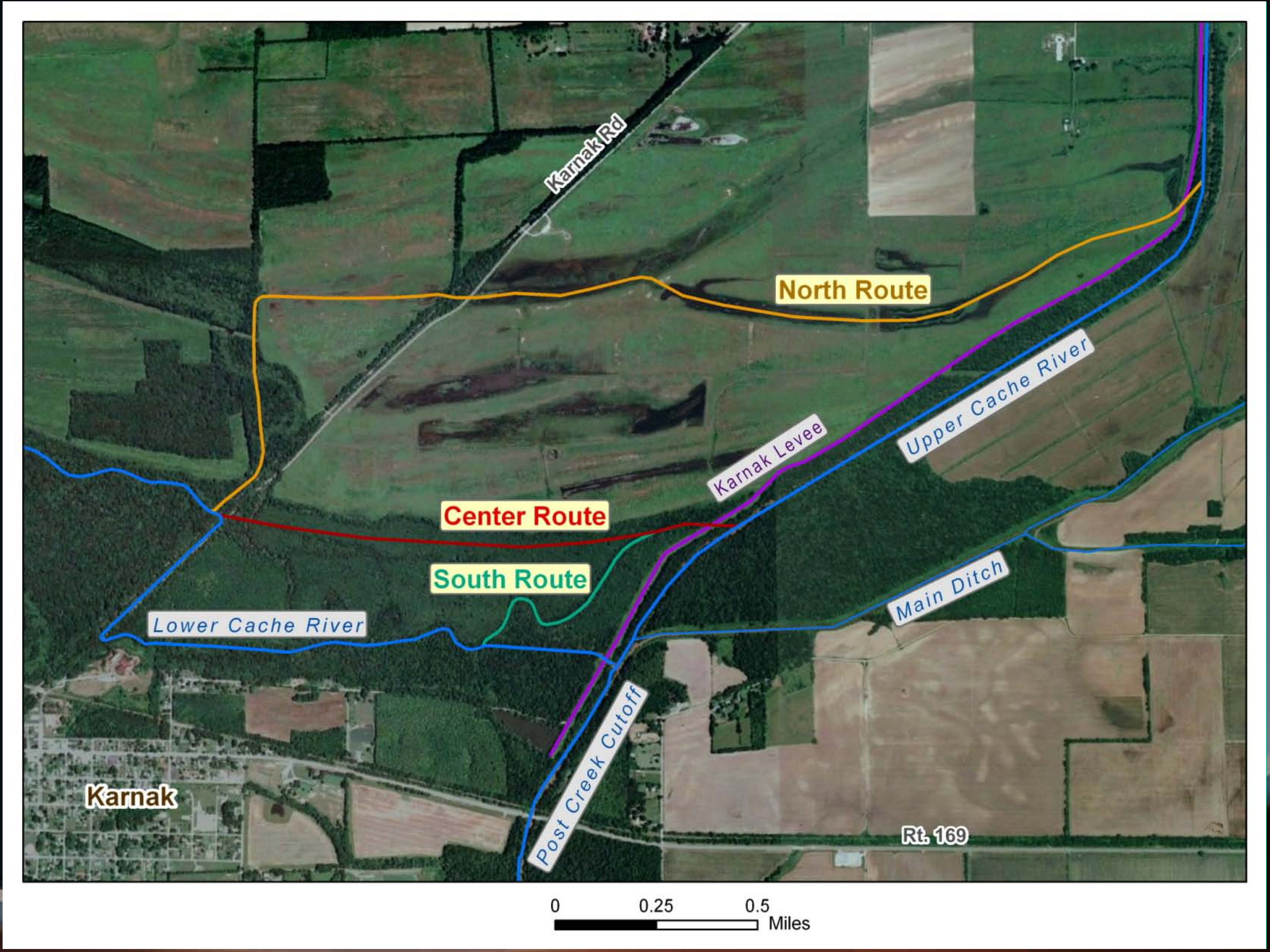


Figure 2.17. Flow hydrographs at different points in Lower Cache River during March 2008 flood (positive flows are westerly towards Mississippi River, while negative flows are easterly towards Post Creek Cutoff)

Phase II: Managed Connection

- Routes - UCR with LCR



Phase II: Managed Connection

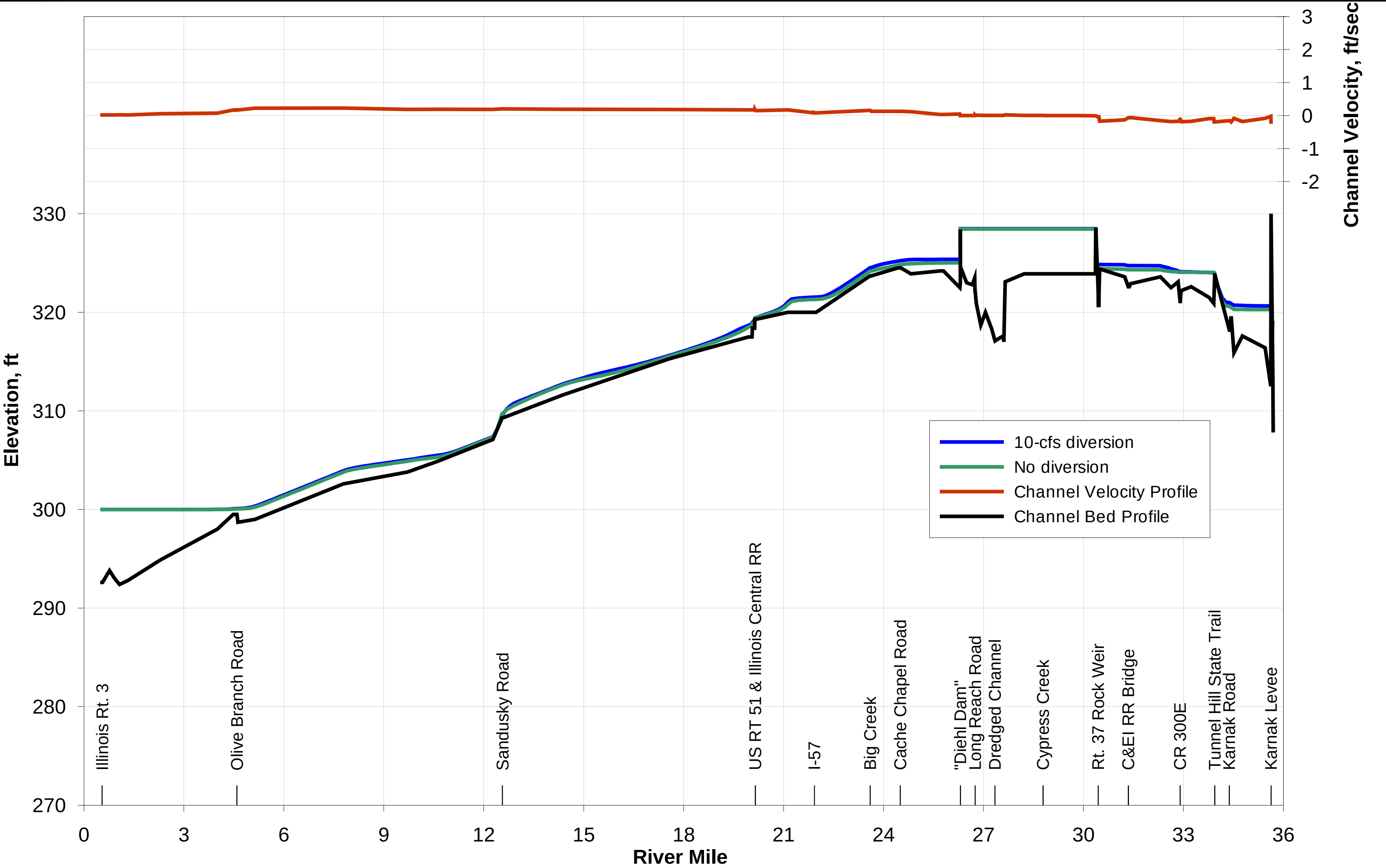
- Flow-carrying capacities

Table 3.1. Flow Splits between Post Creek Cutoff and Lower Cache River

Total diverted flow (cfs)	*Westerly Flow to the Lower Cache River*		*Easterly Flow to Post Creek Cutoff*	
	cfs	*Percent of total*	*cfs*	*Percent of total*
North Channel				
10	10	100	0	0
50	50	100	0	0
100	97	97	3	3
200	150	75	50	25
Center Channel				
10	10	100	0	0
50	50	100	0	0
100	97	97	3	3
200	186	93	28	14
South Channel				
10	10	100	0	0
50	50	100	0	0
100	96	96	4	4
200	158	79	42	21

Phase II: Managed Connection

- Impacts on LCR (Table 3.5, Demissie et al., 2008)



Phase II: Managed Connection

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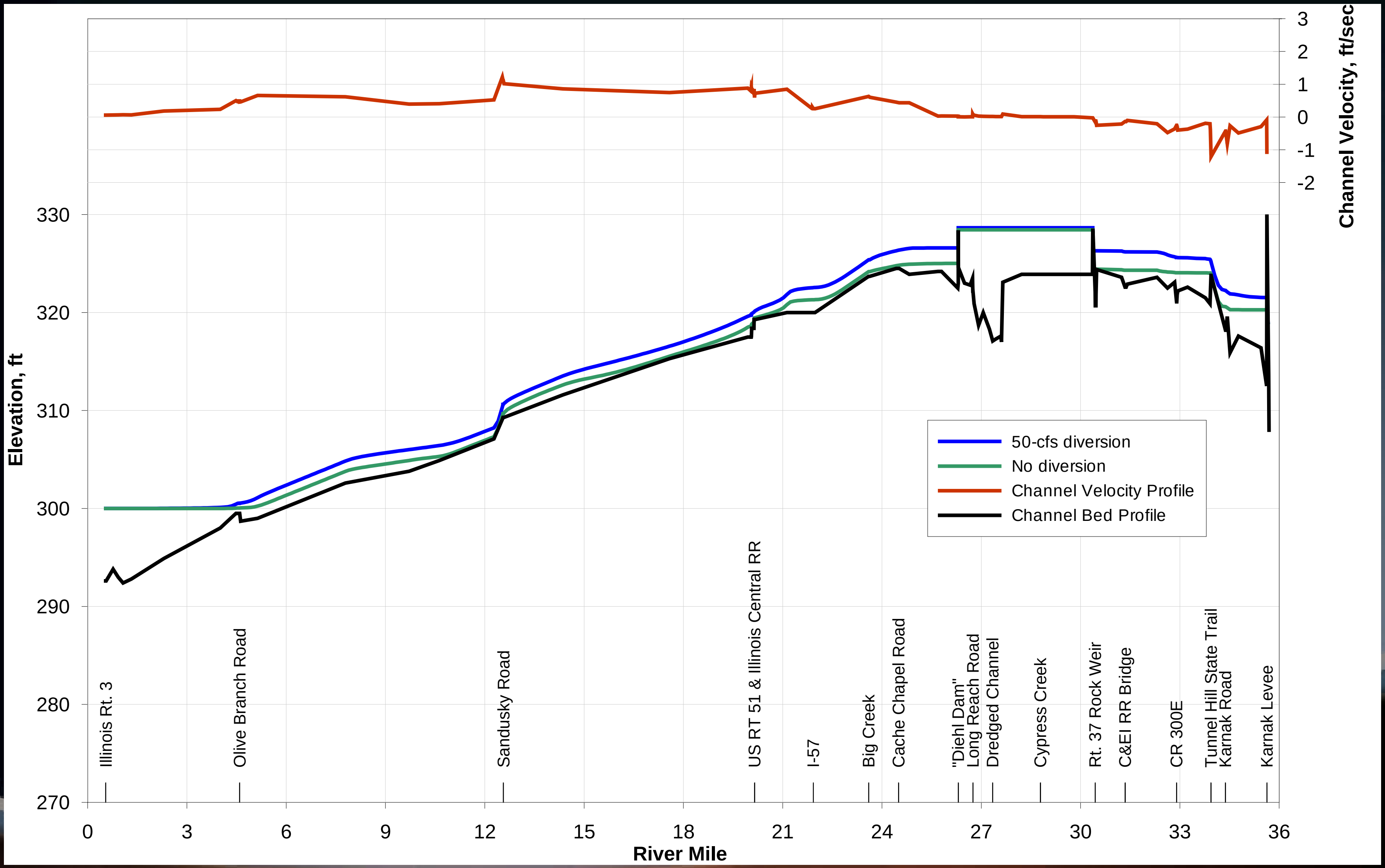

Phase II: Managed Connection

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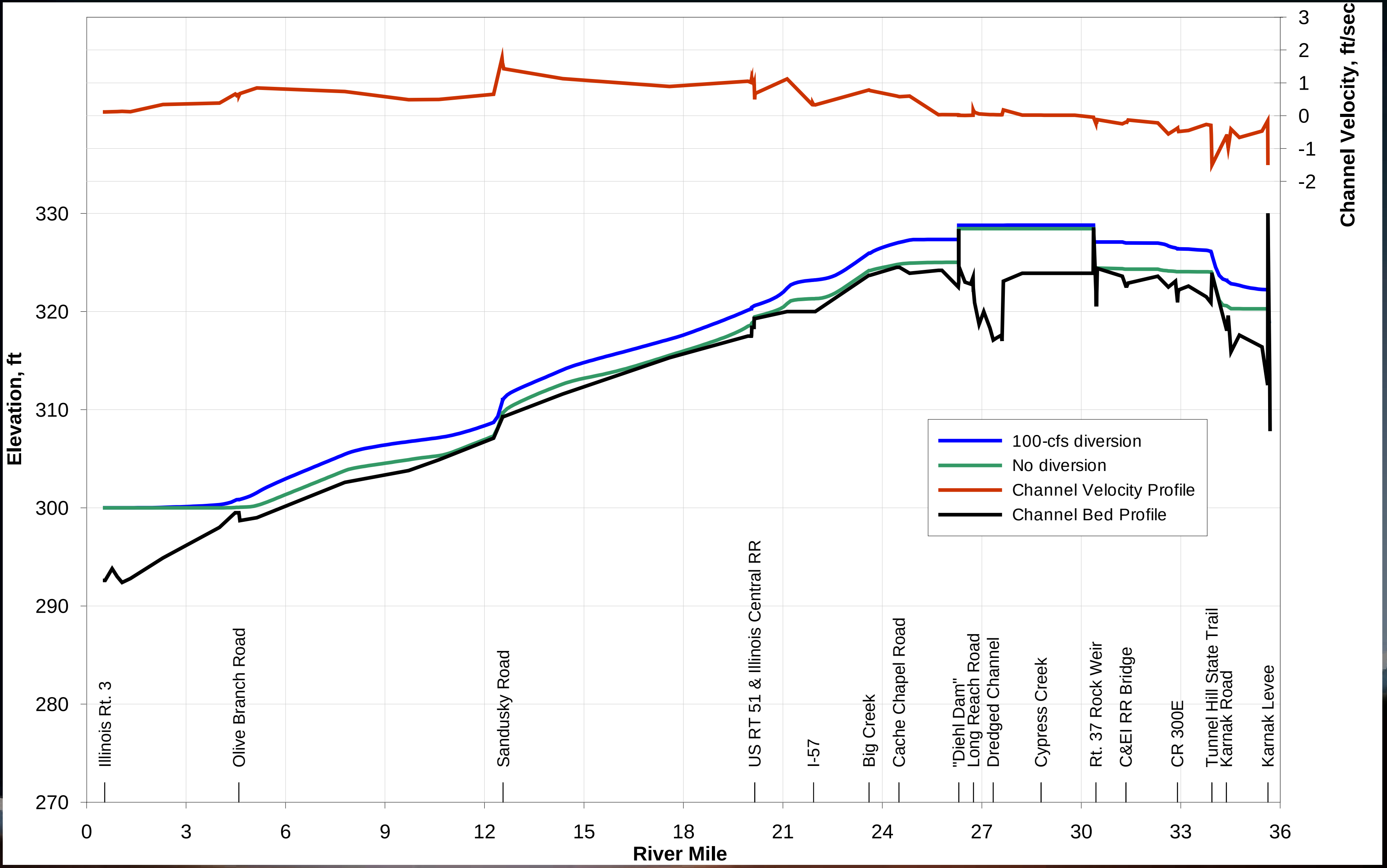
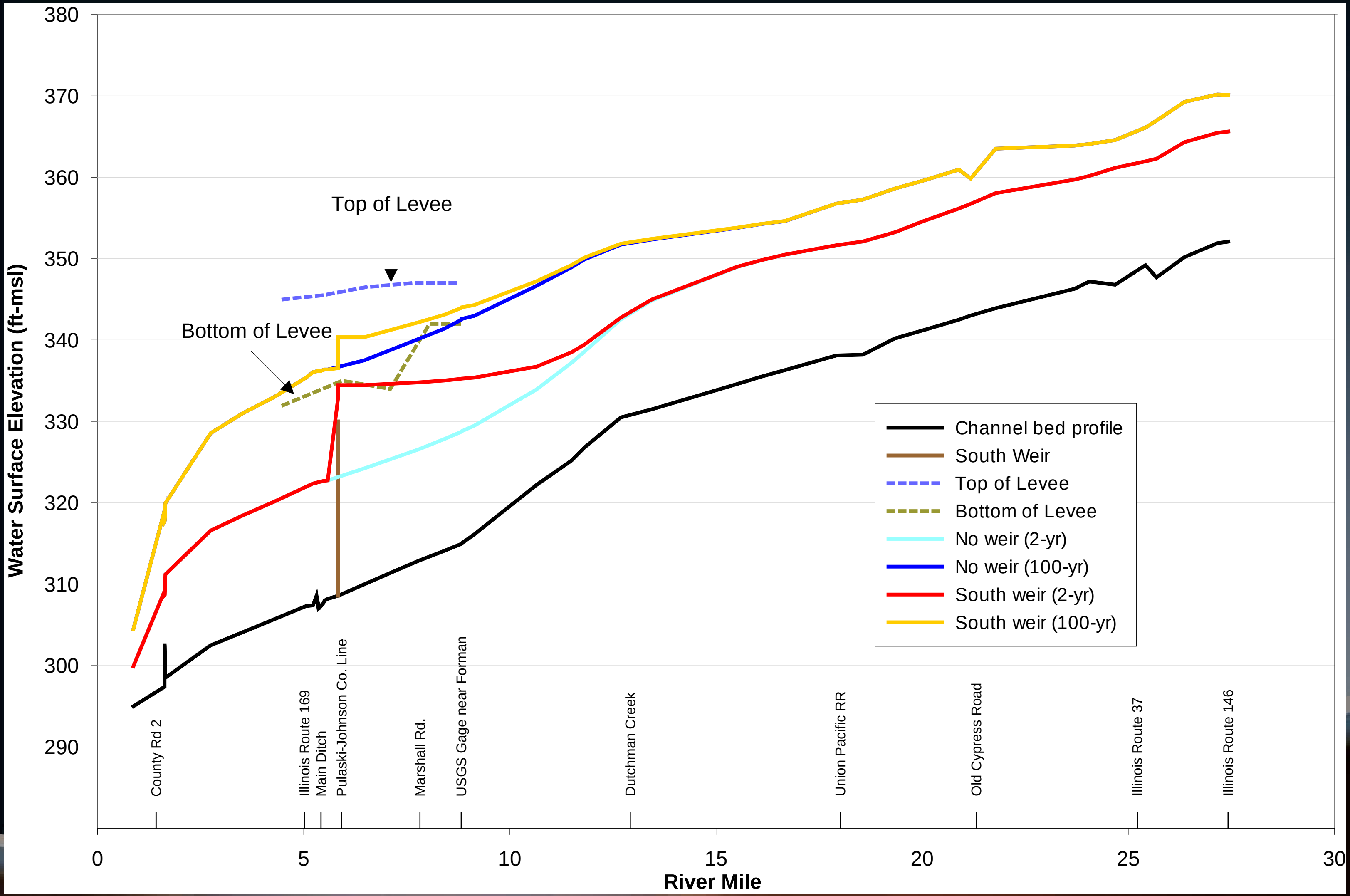


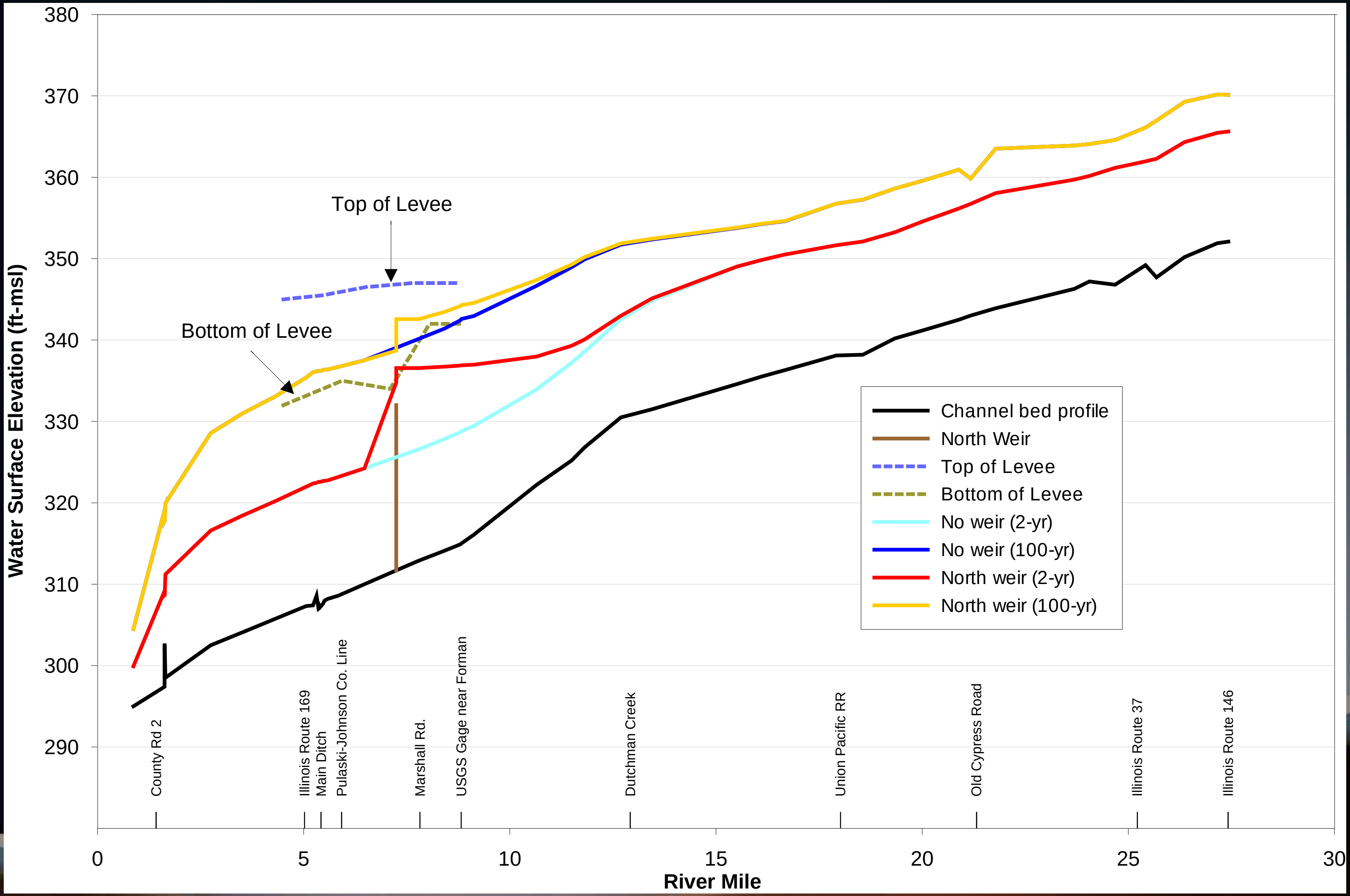
Phase II: Managed Connection

- Impacts in UCR: In-channel weirs (SOUTH: central/south)



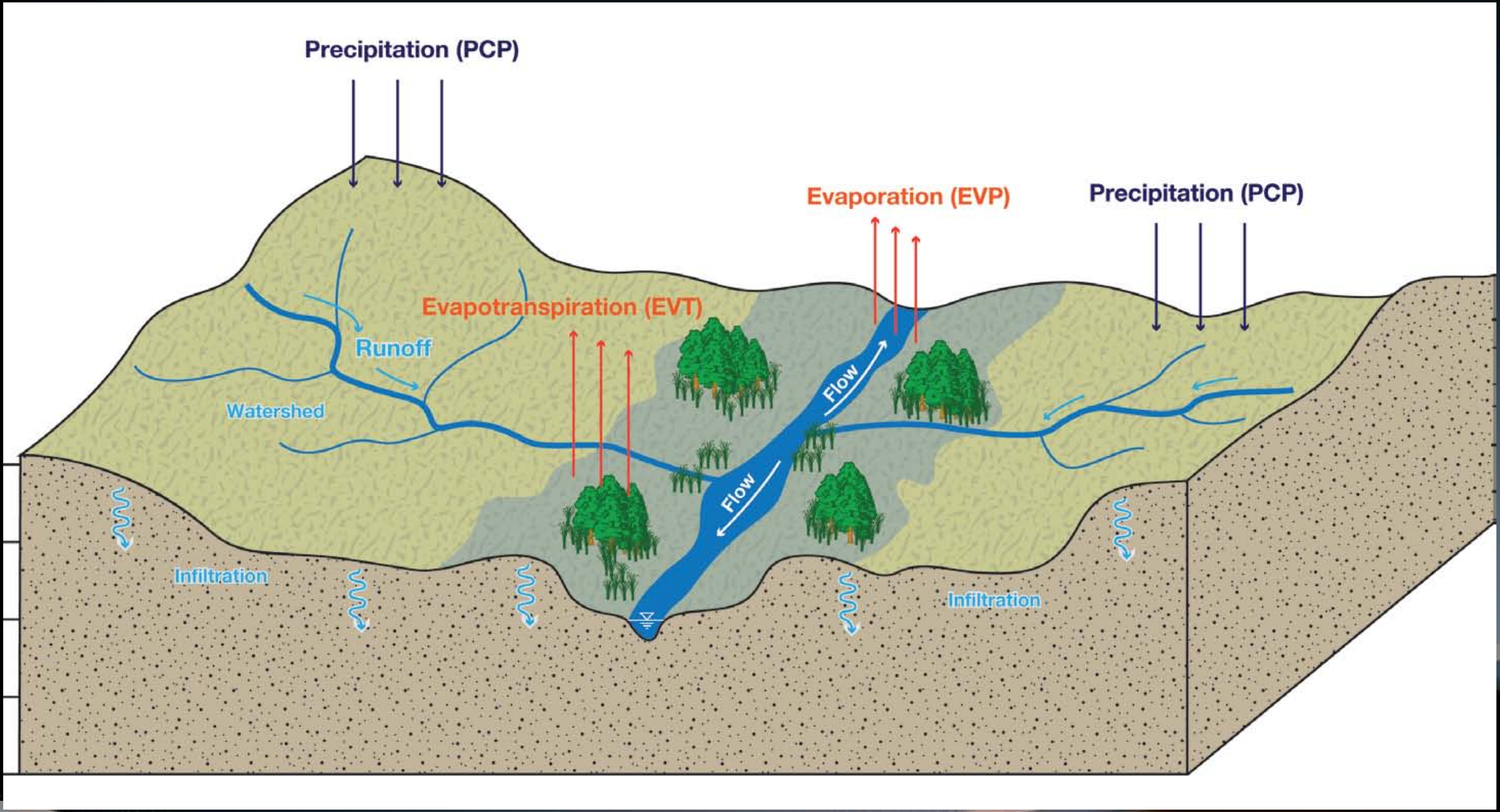
Phase II: Managed Connection

- Impacts in UCR: In-channel weirs (NORTH)



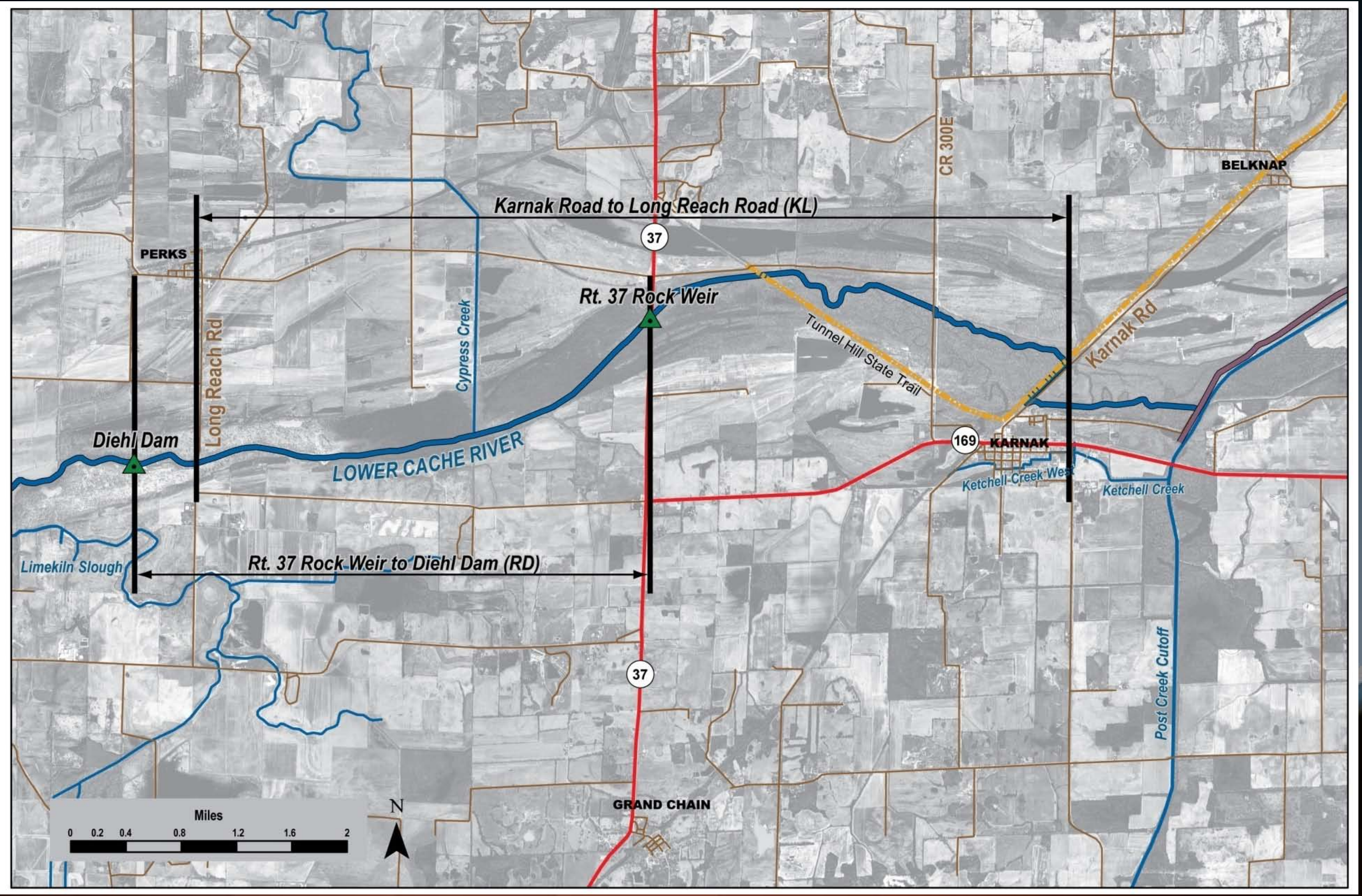
Phase II: Water Budget Tool

- Conceptual diagram



Phase II: Water Budget Tool

- Two reaches analyzed (RD and KL)

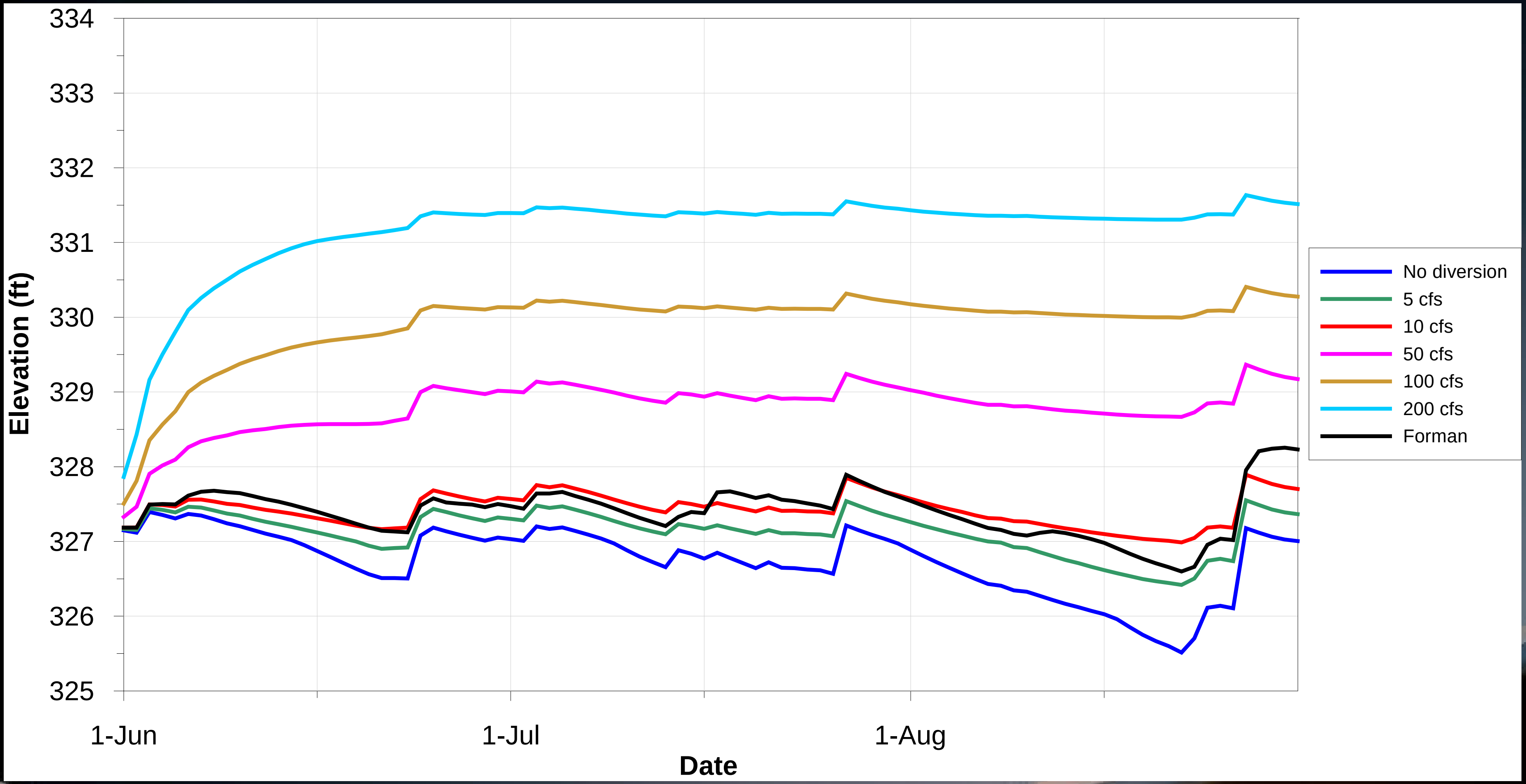


Phase II: Water Budget Tool

- Summer periods – critical time for wetland ecosystems (water availability)
  - Typical dry summer (1992)
  - Typical average summer (2000)
- Six flow conditions: existing condition and diversions for 5, 10, 50, 100, and 200 cfs
- Developed relationships between elevation and surface area/storage

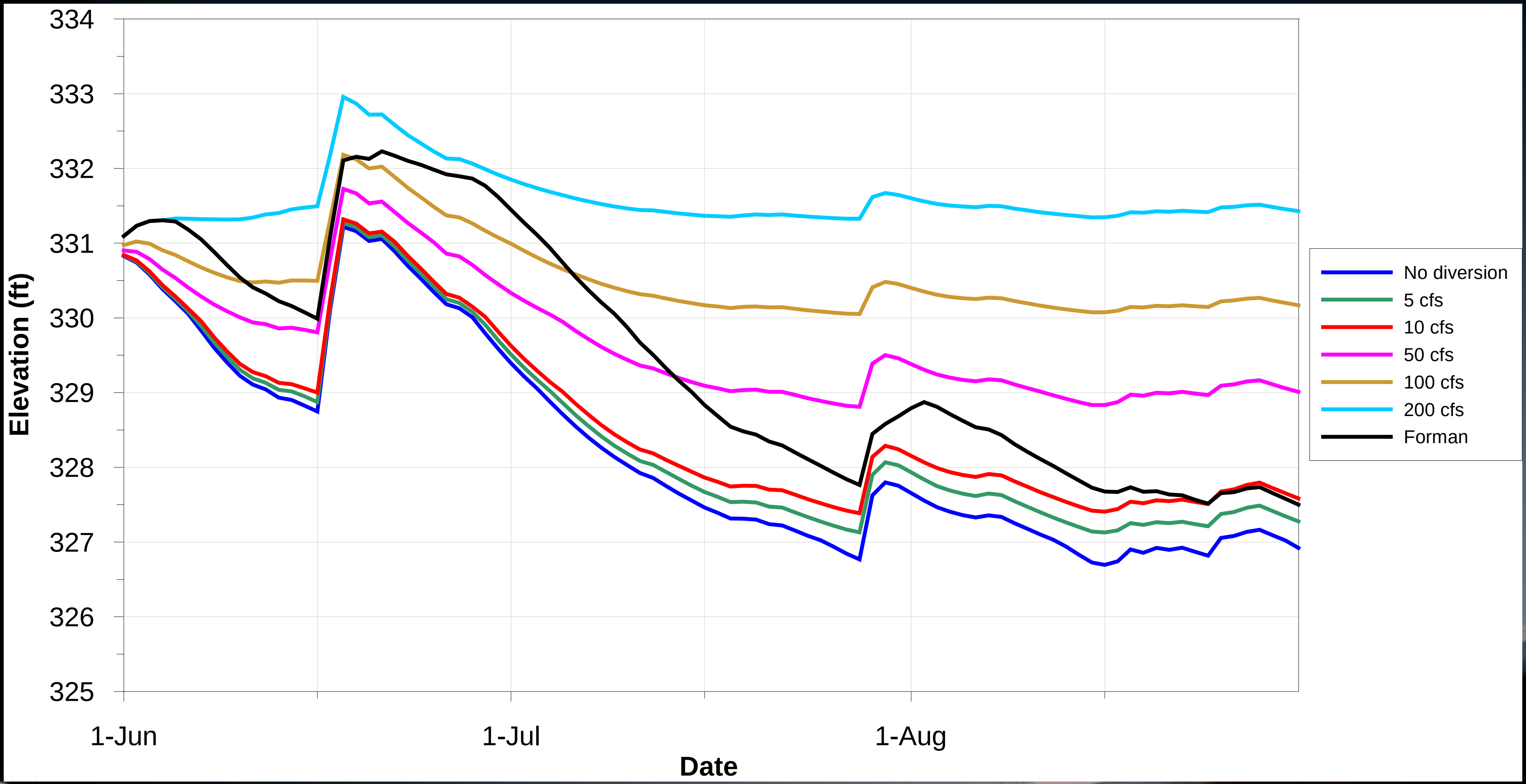
Phase II: Water budget results

- Rt. 37 and “Deihl Dam” Reach (RD): 1992 dry summer



Phase II: Water budget results

- Rt. 37 and “Deihl Dam” Reach (RD): 2000 average summer



Phase II: Conclusions

- March 2008 flood: Approximately 5200 cfs (23%) of UCR flood flows (Ohio River backwater effect) flowed in a westerly direction in LCR
- Three managed connection routes examined for flow capacities – only 200 cfs split diverted flow back to Post Creek Cutoff
- UCR in-channel weirs raise water levels for more frequent floods (10-ft) as compared to less frequent floods (3-ft)

(continued)

Phase II: Conclusions

- Water Budget
  - Flows >50 cfs show the significant improvement and prevent extremely low water levels
  - Dry period evaluation (1992) shows 10 cfs flow diversion may not be sufficient to avert drying out of floodplain all the time during major dry periods
  - Average period evaluation (2000) show more opportunity to divert UCR flow to raise low water levels in LCR

Thank you!

ISWS reports can be found in PDF format on:

http://www.isws.illinois.edu/pubs

Phase I: ISWS Contract Report 2008-01

Phase II: ISWS Contract Report 2010-06