TENNESSEE VALLEY AUTHORITY

River System Overview

Duck River Symposium 2022

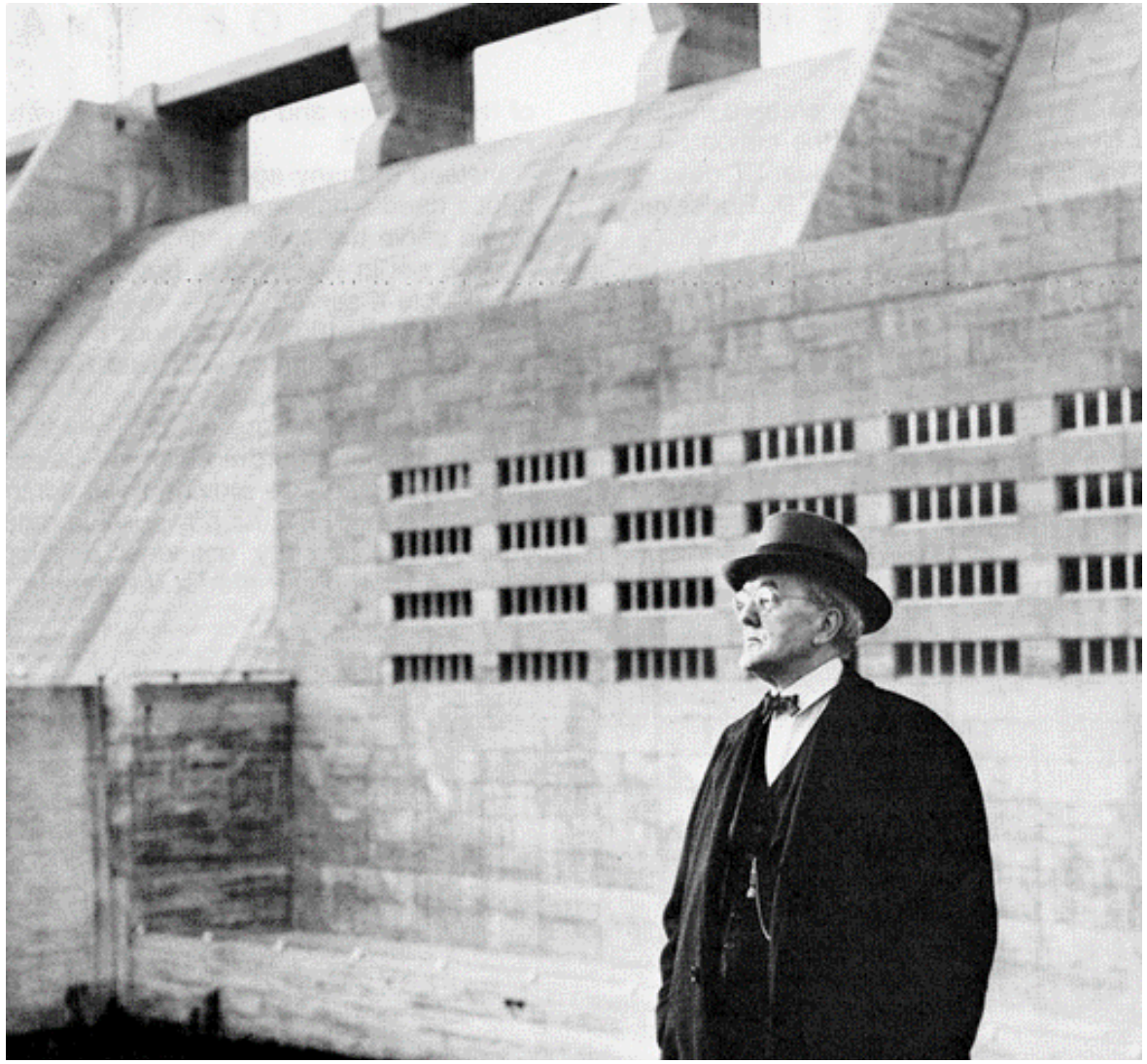
Jenny Sharkey, River Forecast Center
Amanda Turk, River Management

(information only)

Integrated Resource Management

River system assigned multipurpose role through TVA Act in 1933.

(section 9a) …to regulate the stream flow primarily for the purposes of promoting navigation and controlling floods. So far as may be consistent with such purposes, …for the generation of electric energy…



“Father of TVA,” Senator George Norris

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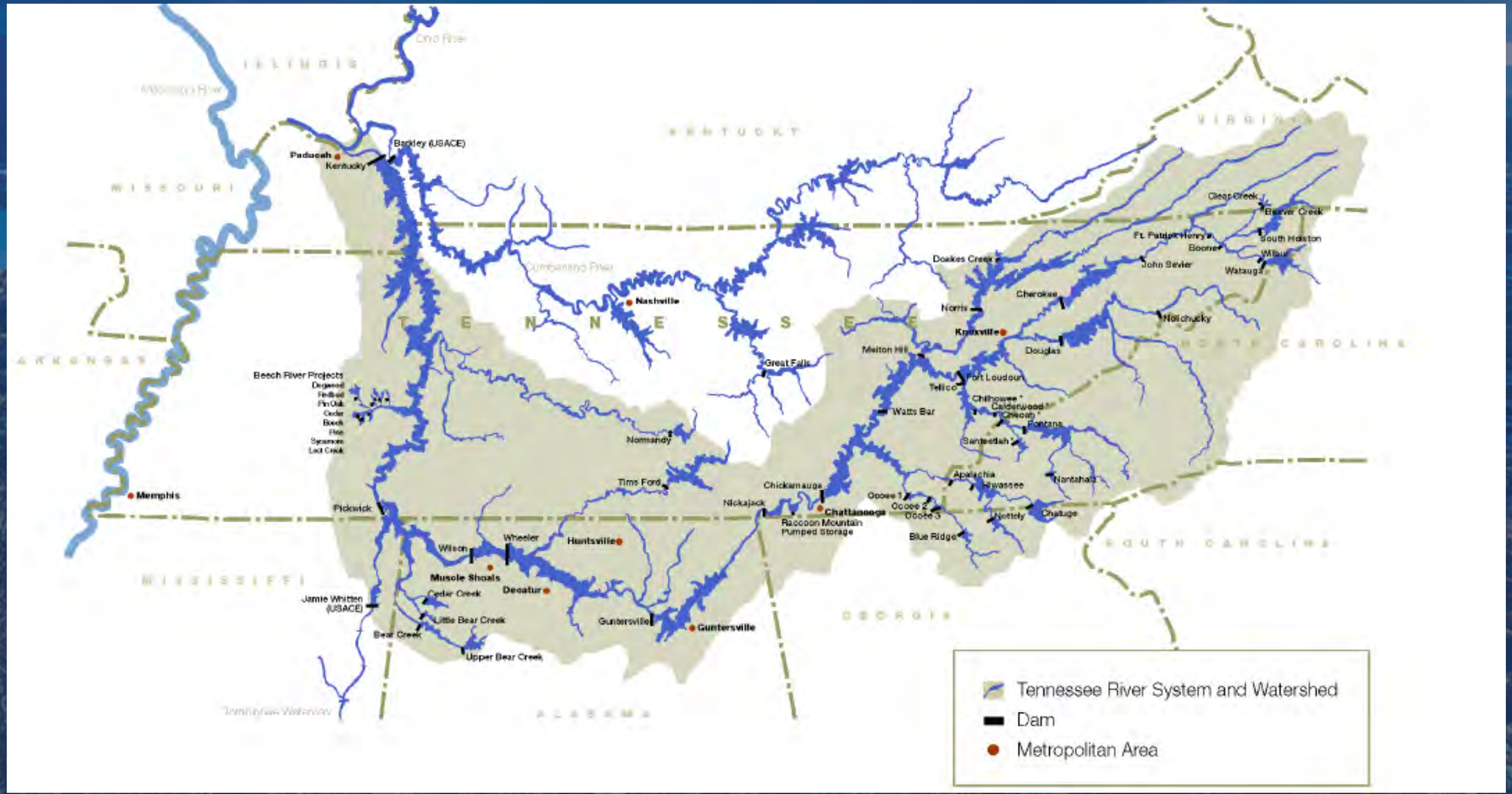
Ohio River
ILLINOIS
Mississippi River
KENTUCKY
VIRGINIA
MISSOURI
Barkley (USACE)
Paducah
Kentucky
Cumberland River
Nashville
TENNESSEE
Clear Creek
Beaver Creek
Ft. Patrick Henry
Boone
South Holston
Wilbur
John Sevier
Watauga
Douglas Creek
Cherokee
Norris
Knoxville
Douglas
Melton Hill
Great Falls
Fort Loudoun
Tellico
Chilhowee
Calderwood
Chilcoa
Fontana
Watts Bar
Santeetlah
Nantahala
Apalachia
Hiwassee
Ocoee 1
Ocoee 2
Ocoee 3
Nottely
Chatuge
Blue Ridge
Chickamauga
Nickajack
Chattanooga
Raccoon Mountain
Pumped Storage
Normandy
Tims Ford
Beech River Projects
Dogwood
Redbud
Pin Oak
Cedar
Beech
Pine
Sycamore
Lost Creek
Memphis
Pickwick
Wilson
Wheeler
Huntsville
Muscle Shoals
Decatur
Cedar Creek
Jamie Whitten
(USACE)
Little Bear Creek
Bear Creek
Upper Bear Creek
Guntersville
Guntersville
MISSISSIPPI
GEORGIA
SOUTH CAROLINA
ALABAMA
Tennessee River System and Watershed
Dam
Metropolitan Area

Integrated Tennessee River System Management

Navigation

Flood Damage Reduction

Power Generation

Water Supply

Recreation

Water Quality

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River Forecast Center

- Staffed day and night
- Issue 2 - 4 river forecasts per day
- Model and scheduling of non-power reservoirs (such as Normandy)
- Coordinate and schedule hourly generation schedules with system schedulers
- Monitor water levels in real-time
- Provide data management, modeling and dissemination
- Provide stakeholder notifications
- Coordinate operations with U.S. Army Corps of Engineers

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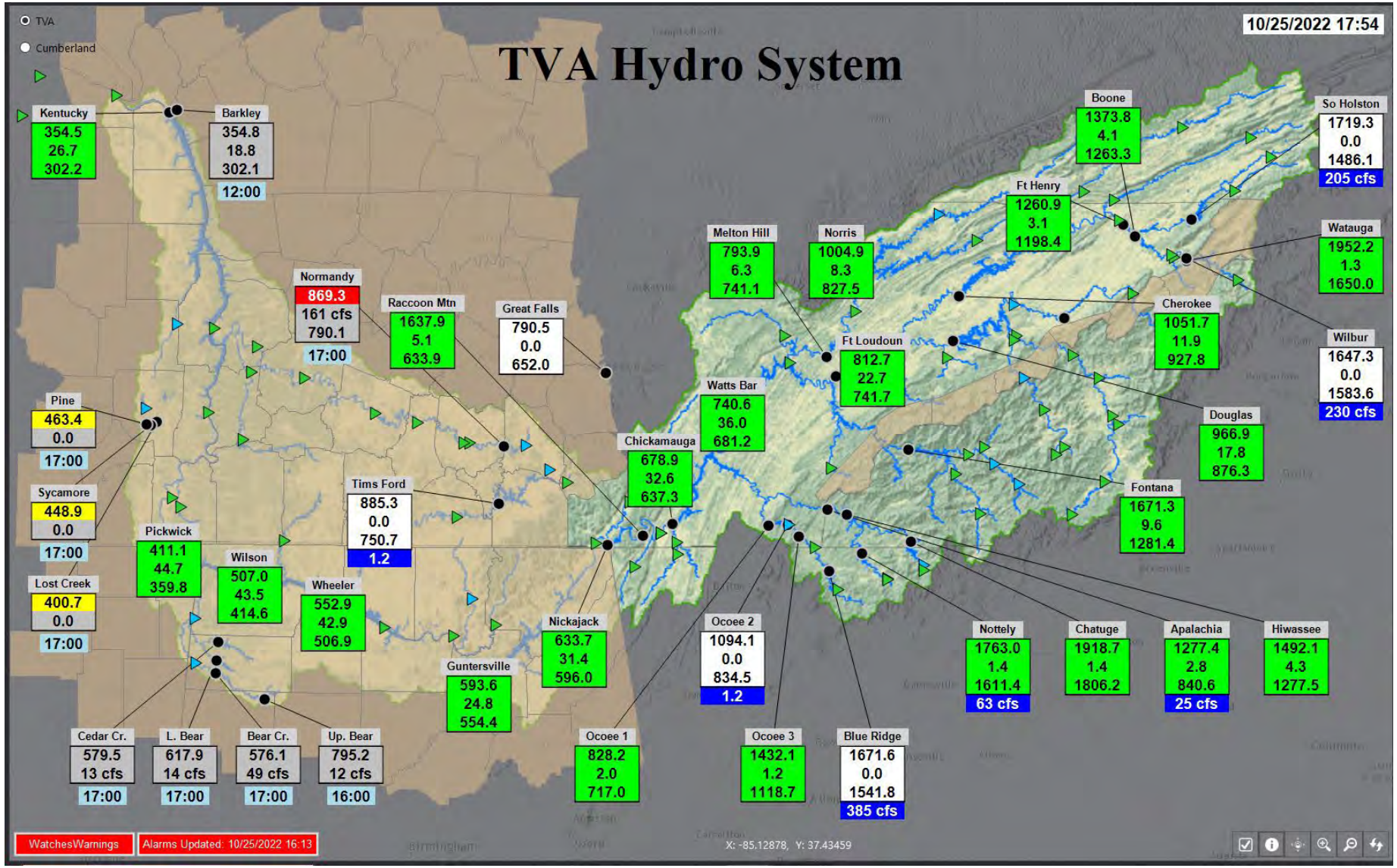
Real Time Data – NWS Advisories, Watches, and Warnings



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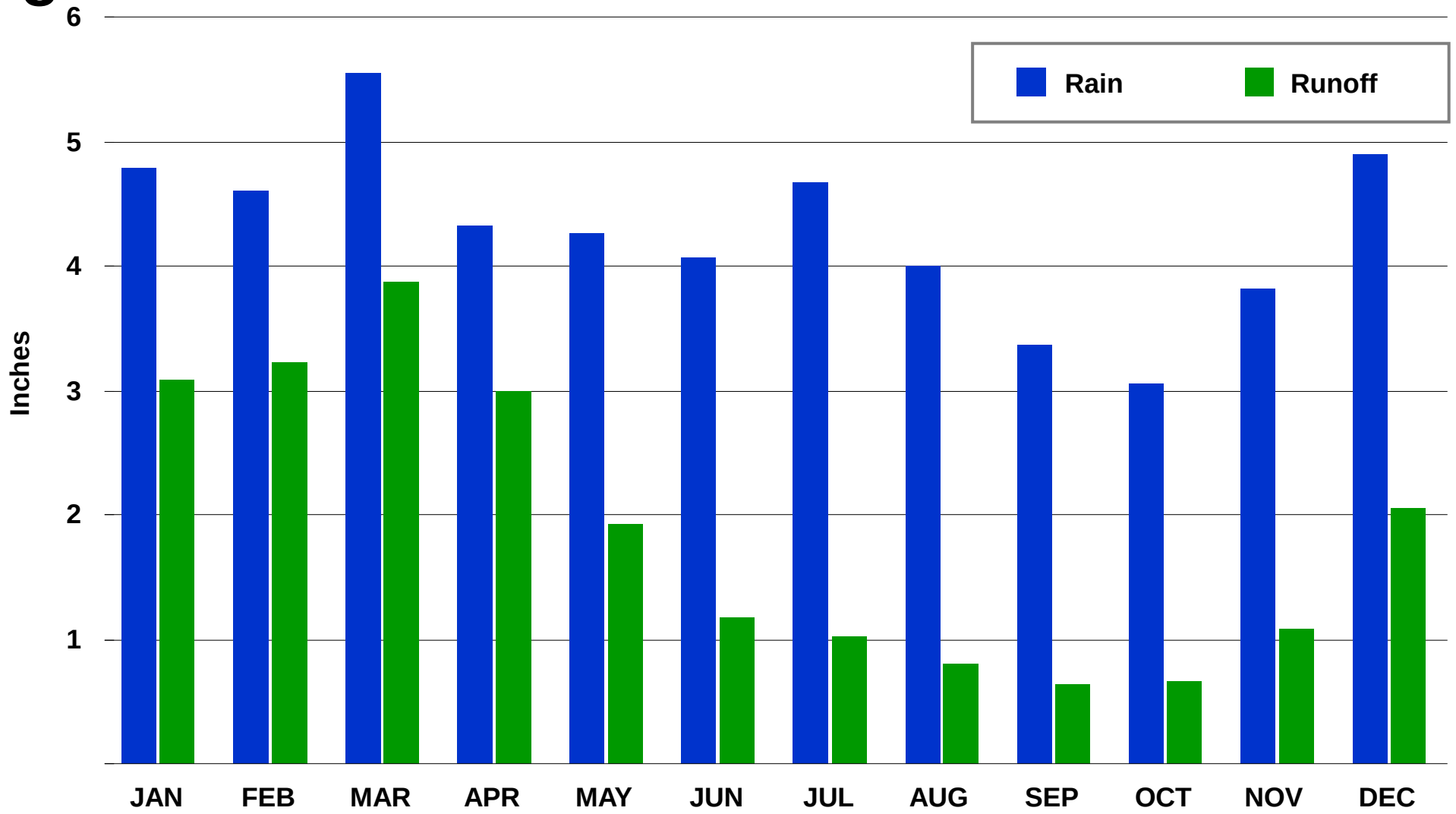
Average Annual Rainfall and Runoff



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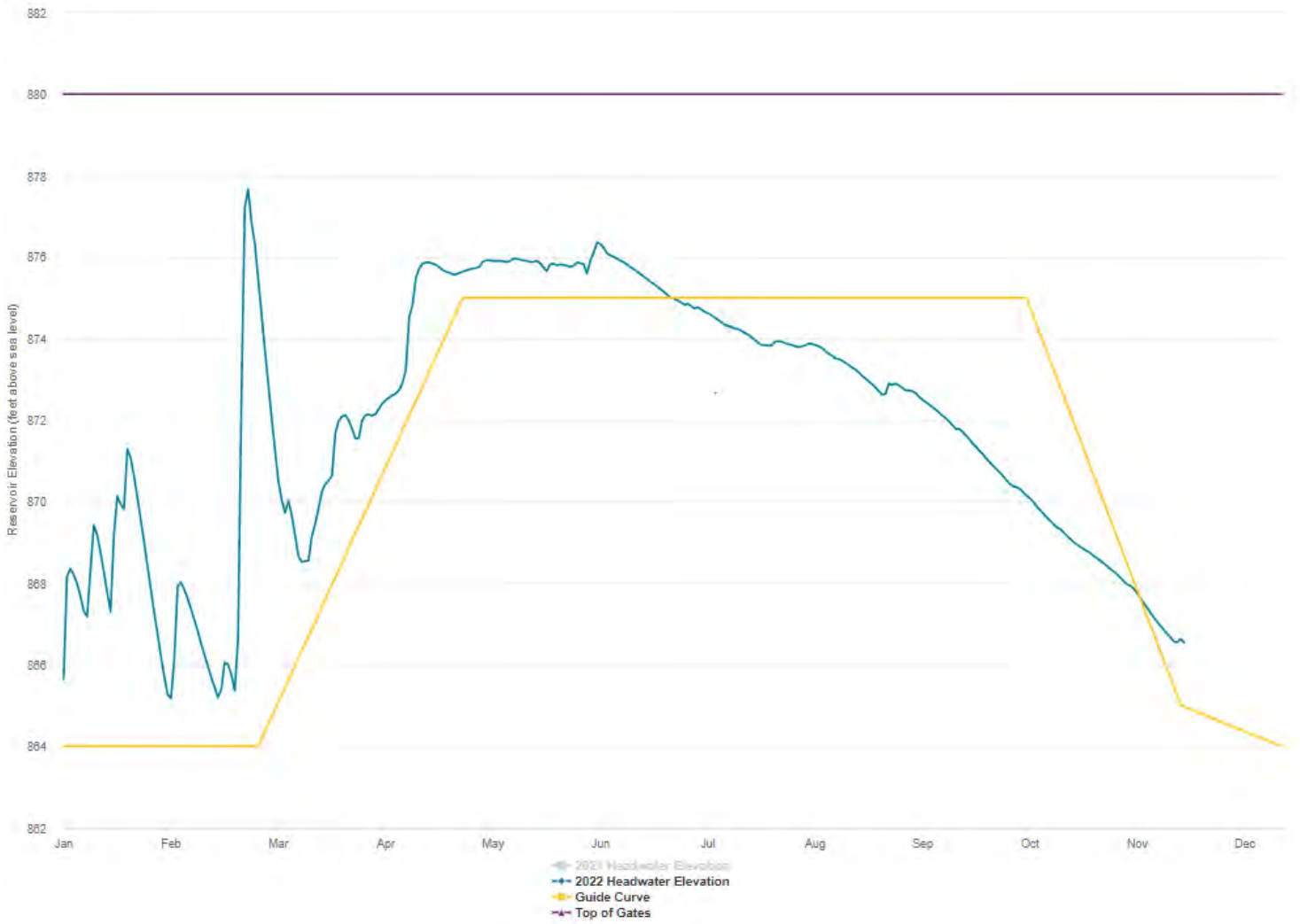
Normandy Operating Guide



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Types of Dams

Tributary Storage (Norris)

Main River (Fort Loudoun)

Tributary Run-of-River (Melton Hill)

Tributary Non-Power (Upper Bear)

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Normandy Dam - Purposes and Background

Purposes:

- Flood protection for communities downstream of Normandy Dam along the Duck River, such as Shelbyville
- Recreation
- Water supply
- Water quality to support aquatic habitat along the Duck River

Background:

- Normandy Dam serves a drainage area of 195 square miles.
- The January 1 flood guide elevation provides just over 4.5 inches (runoff) of flood storage space to the top-of-gates elevation of 880’.

Integrated Tennessee River System Management

Navigation

Flood Damage Reduction

Power Generation

Water Supply

Recreation

Water Quality

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Integrated Tennessee River System Management

Flood Damage Reduction

Water Supply

Recreation

Water Quality

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Flood Control

- Store water in the reservoir to reduce flood levels downstream along the Duck River.
- Provide flood forecasting information to National Weather Service and local Emergency Management Agencies.
- Issue notifications to Bedford Co. to close off parking areas for public safety.
- Since 1976, the operation of Normandy Dam has averaged $600,000 in averted damages.
- TVA averted $1M in damages in February 2019.

Flooding May 2003 - Water is near 3 feet deep at the gas station. Photo: Eugene Nichols, Bedford County EMA

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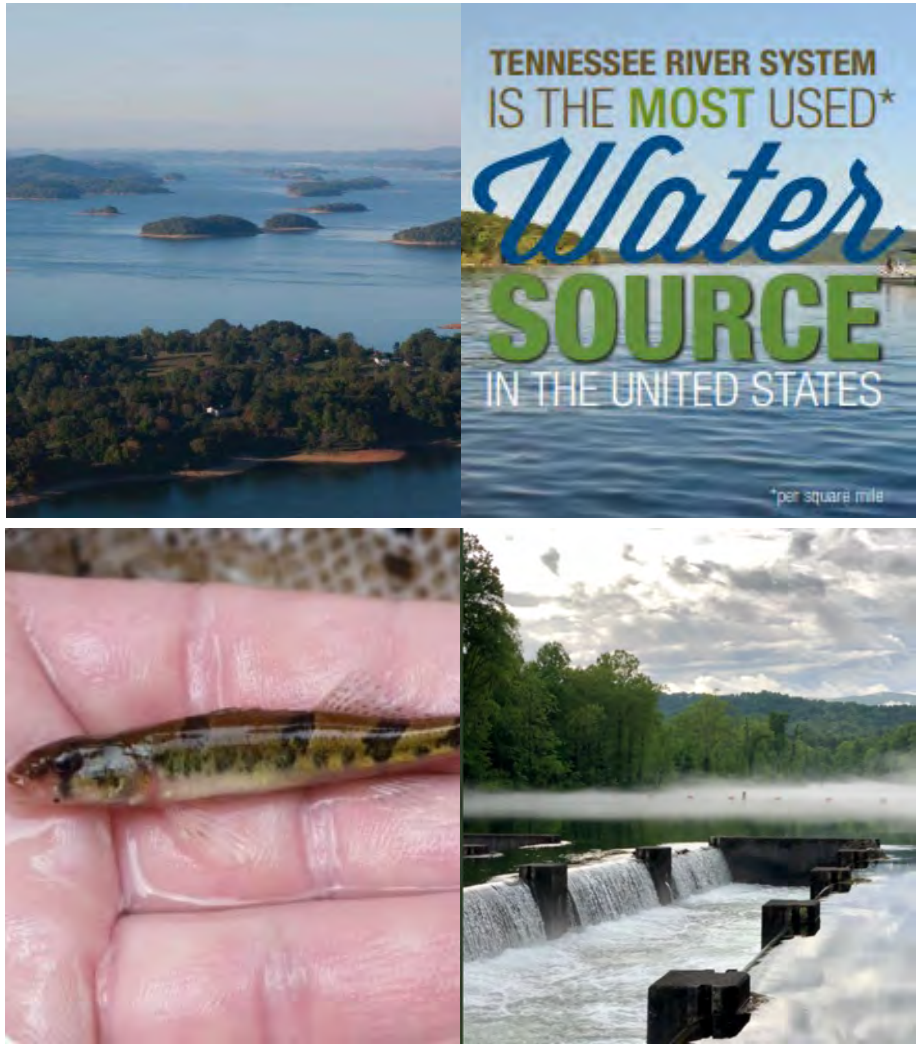
Water Supply

- Over 700 water intakes
  - 10 intakes rely on Normandy Dam
- Process water for industry, municipal, and irrigation
- Drinking water for nearly 5.2 million people
  - 250,000 rely on Normandy Dam
- Provide minimum depth for intakes



Water Quality

- Temperature monitoring and dissolved oxygen enhancement (forebay aeration diffuser system)
- Adaptive management for threatened and endangered species (Consultation with USFWS)
- Minimum flow for downstream habitat

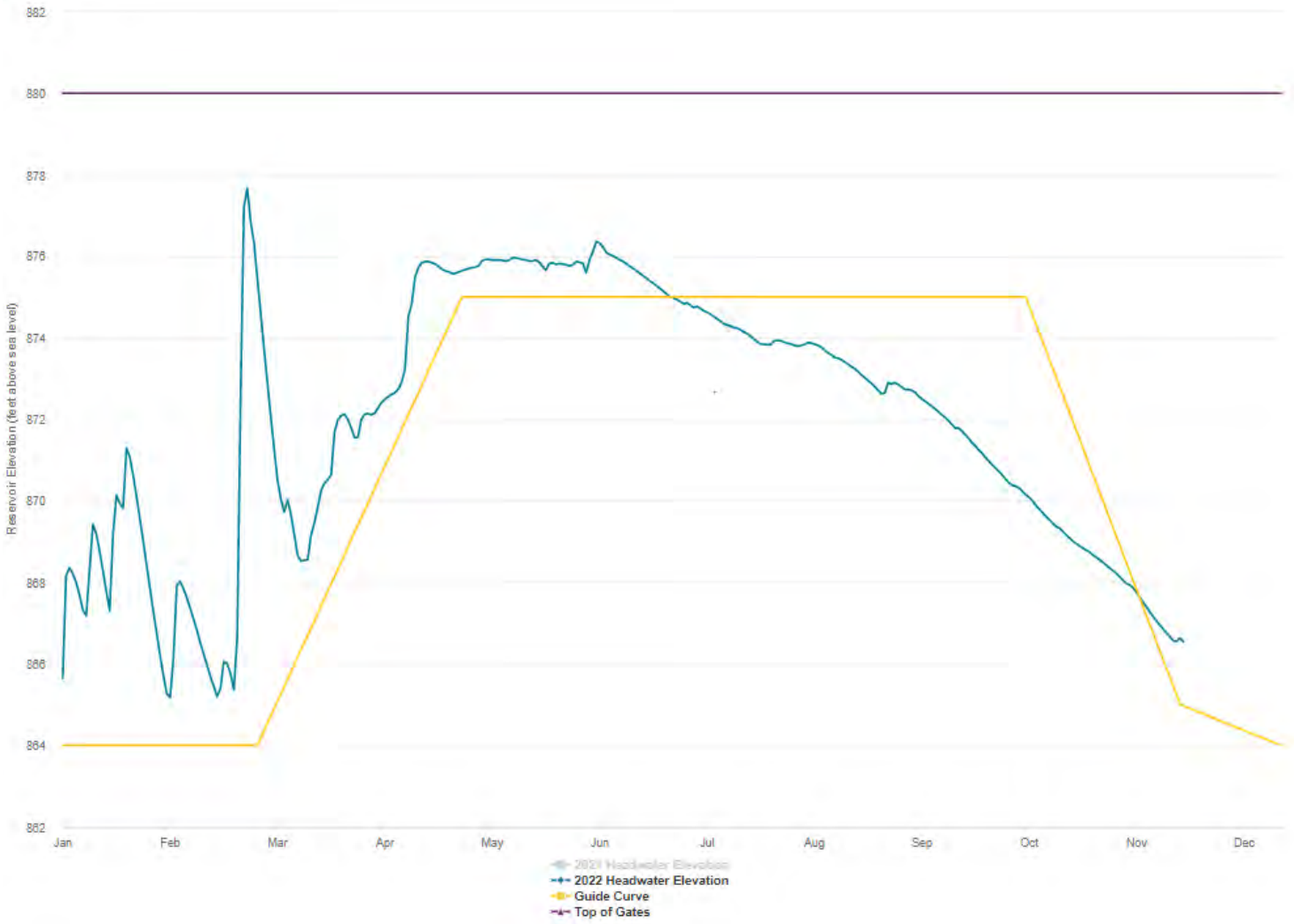
Recreation

- Lake levels managed to help enhance areas for public benefit (marinas, campgrounds, private and public shorelines)
- The Duck River watershed is one of the most biologically diverse river systems in the nation.
- Over 500 species of fish, insects and other aquatic life inhabit the ecosystem, including two species of mussels – the Cumberland monkeyface and birdwing pearly – on the endangered species list
- Economic boost locally and regionally – (about $11.9 billion per year across the entire Tennessee Valley)

Normandy Operating Guide

Operating Constraints

- Minimum Flows at Shelbyville
- Normandy Dam Minimum Flow
- Limited flood storage at summer pool
- Lag time from the dam to Shelbyville is 18 hours
- Accuracy of the weather forecast



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Normandy Dam – Operational Challenges

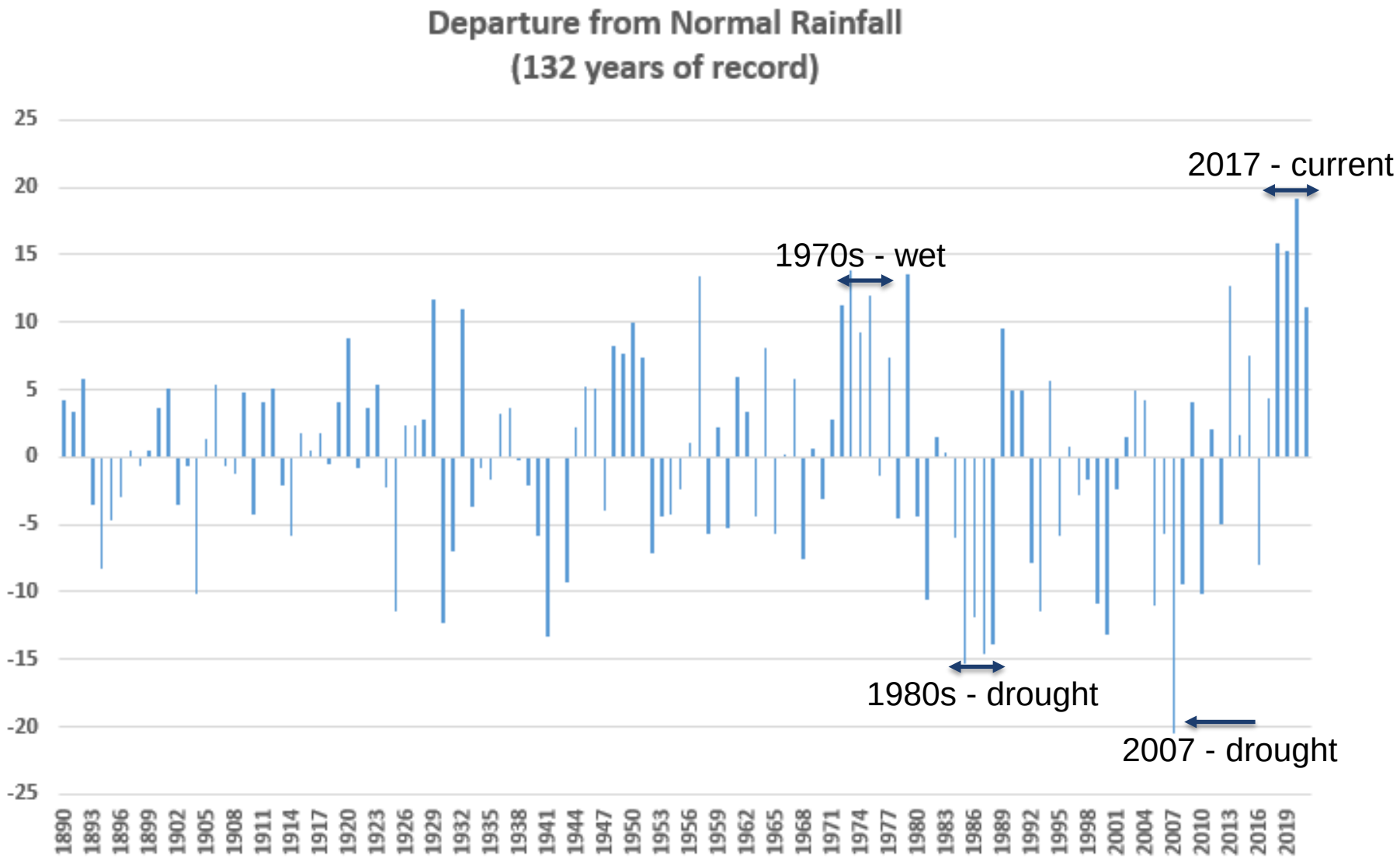
Flood Events

- The January 1 flood guide elevation provides just over 4.5 inches (runoff) of flood storage space to the top-of-gates elevation of 880’.
- Timing of reducing releases and beginning to hold back runoff in the reservoir is challenging due to the lag time to Shelbyville.

Droughts

- Minimum flow requirements for water supply and water quality have evolved over timed to be a good steward of the natural resource while maximizing the benefits to the area.
- It can be challenging to meet the minimum flow requirements and be as efficient as possible due to the long lag time to Shelbyville and the variability in the weather forecast.

Period of Record – Departure from Normal



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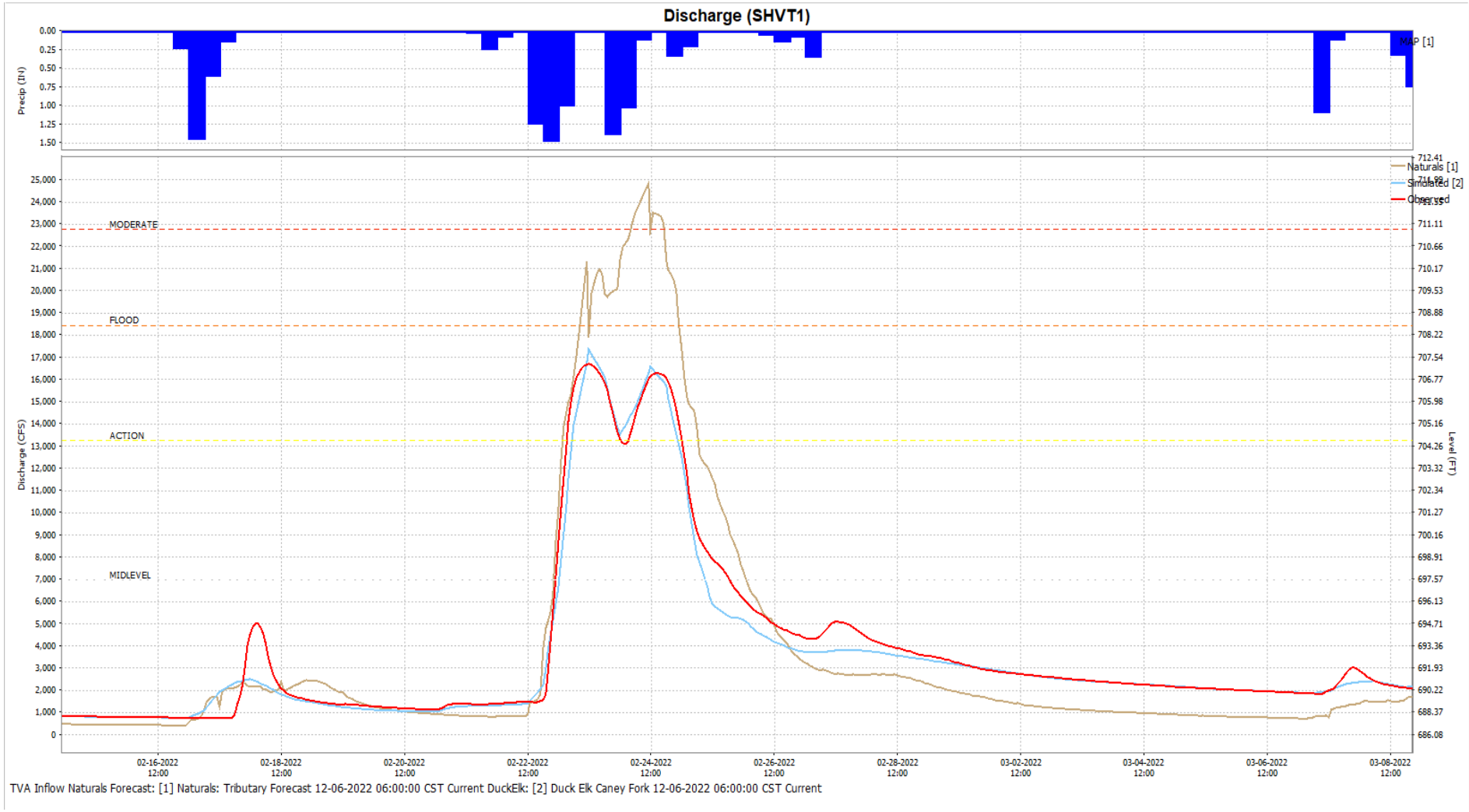
Shelbyville Flows vs Naturals Model – Flood Operations



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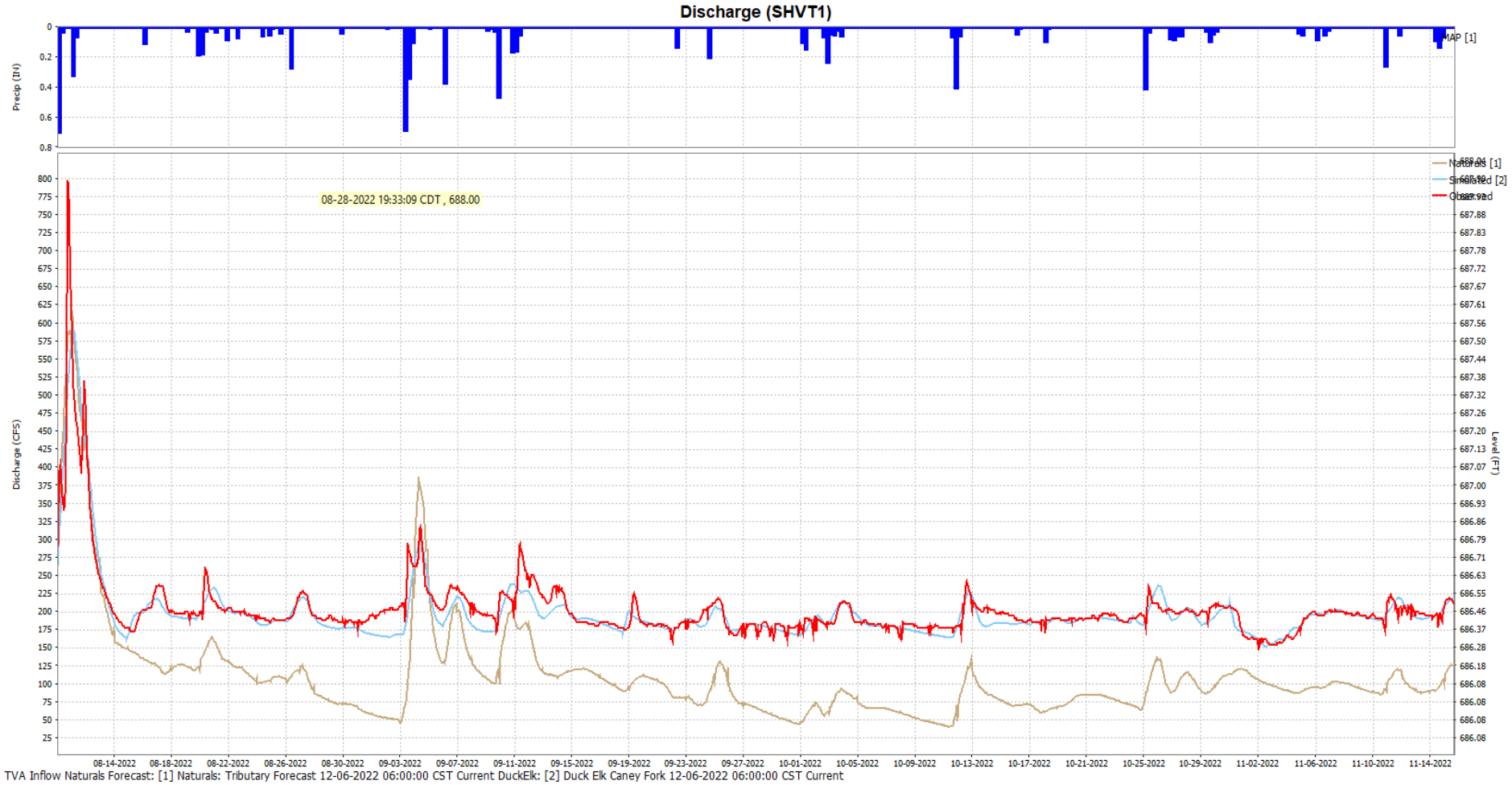
Shelbyville Flows vs Naturals Model – Drought Operations



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Summary

- TVA’s management of Normandy Dam and the Tennessee River system is a balancing act, driven by weather, operating policy, and stakeholder feedback and engagement.
- The integrated reservoir system provides a host of benefits, and the priority of those benefits can vary season to season.
- Rainfall extremes have been challenging but also allow us to highlight the benefits the system provides.
- Active and continuous stakeholder engagement is a critical part of maintaining partnerships, building public trust, and obtaining feedback.

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Questions?

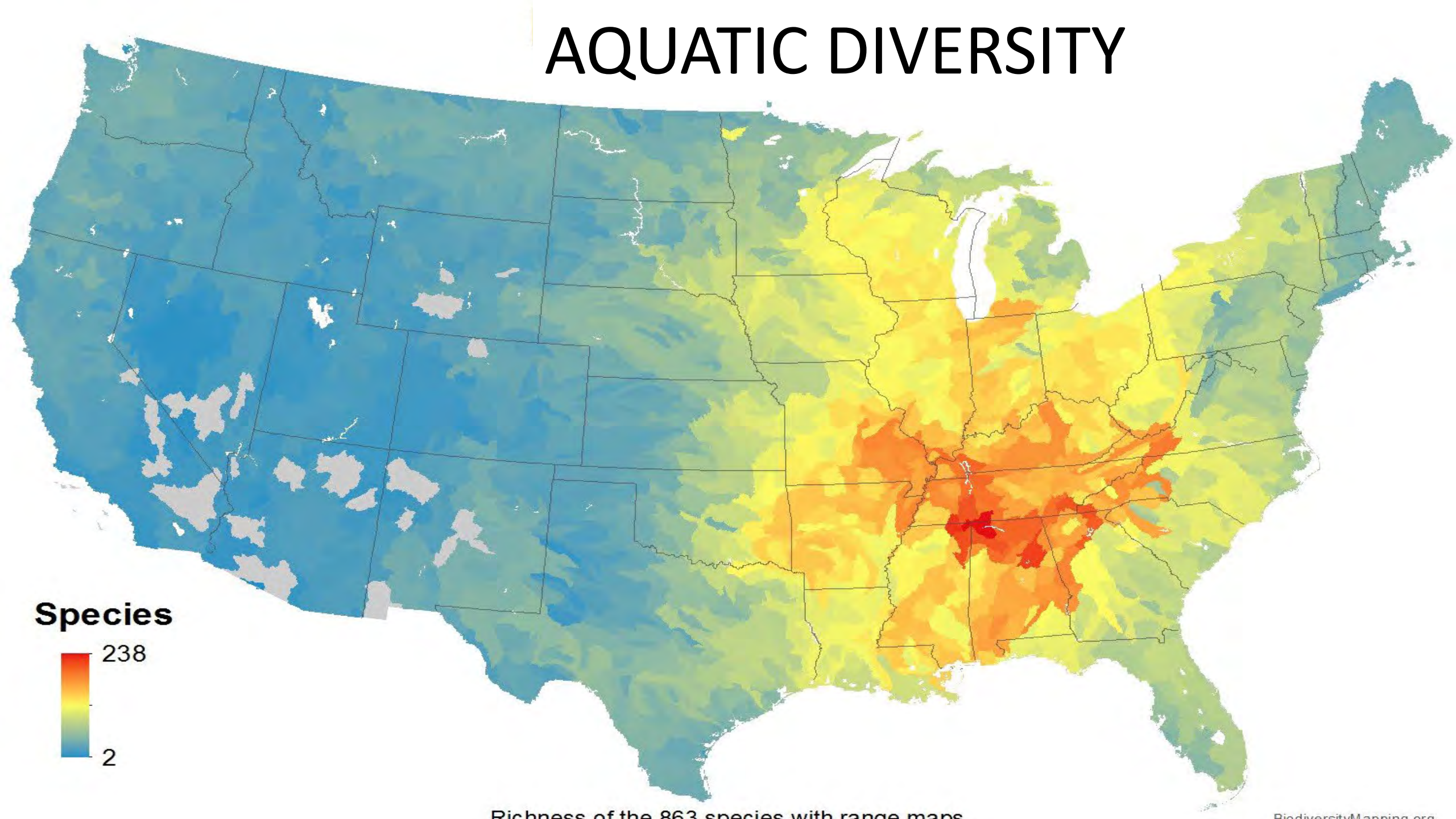
Development and Implementation of Instream Flow Requirements to Preserve the Biotic Integrity and Resilience of the Duck River

Amanda Rosenberger, *USGS/TTU Cooperative Fishery Research Unit*

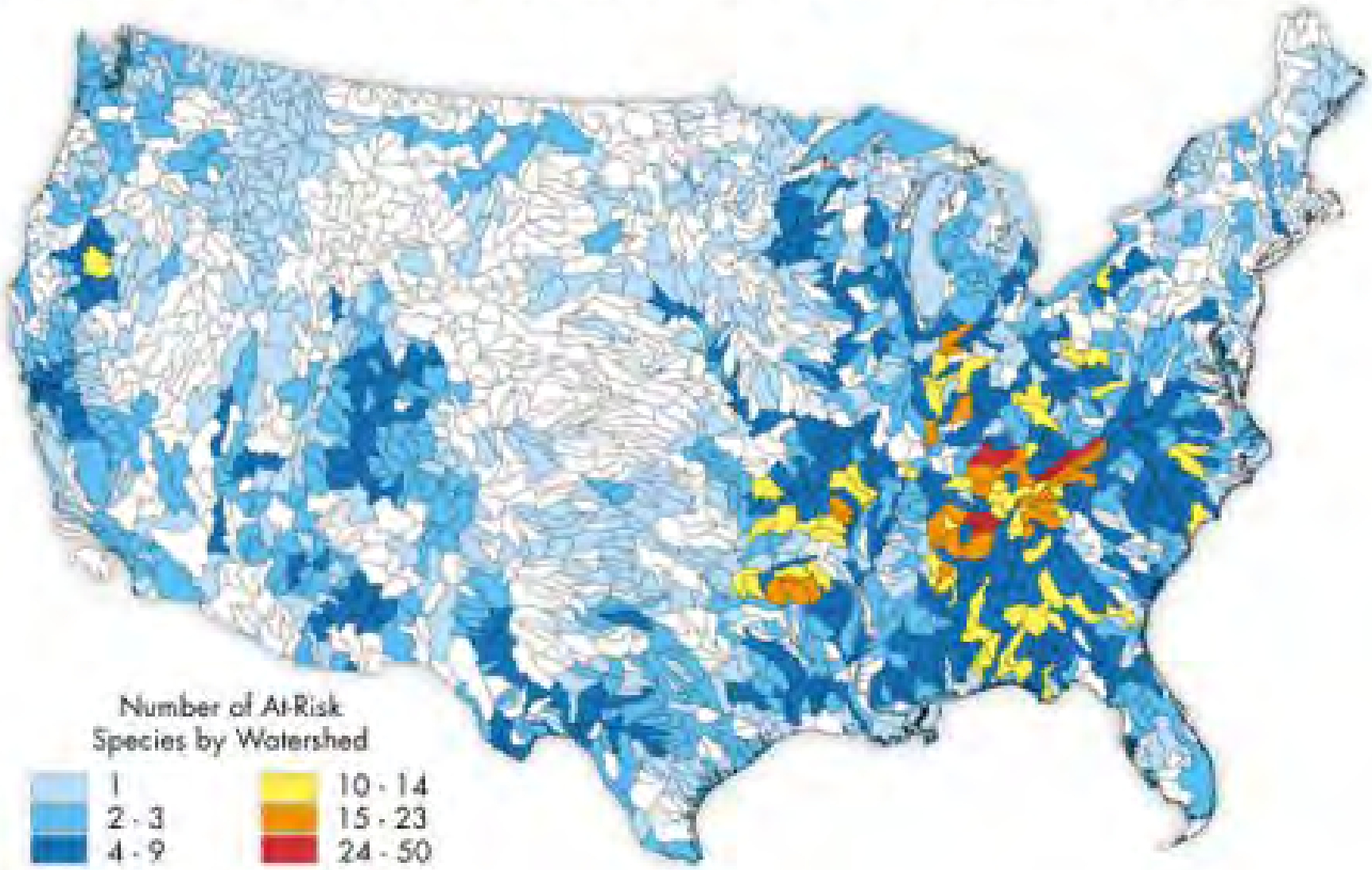
It takes a village..

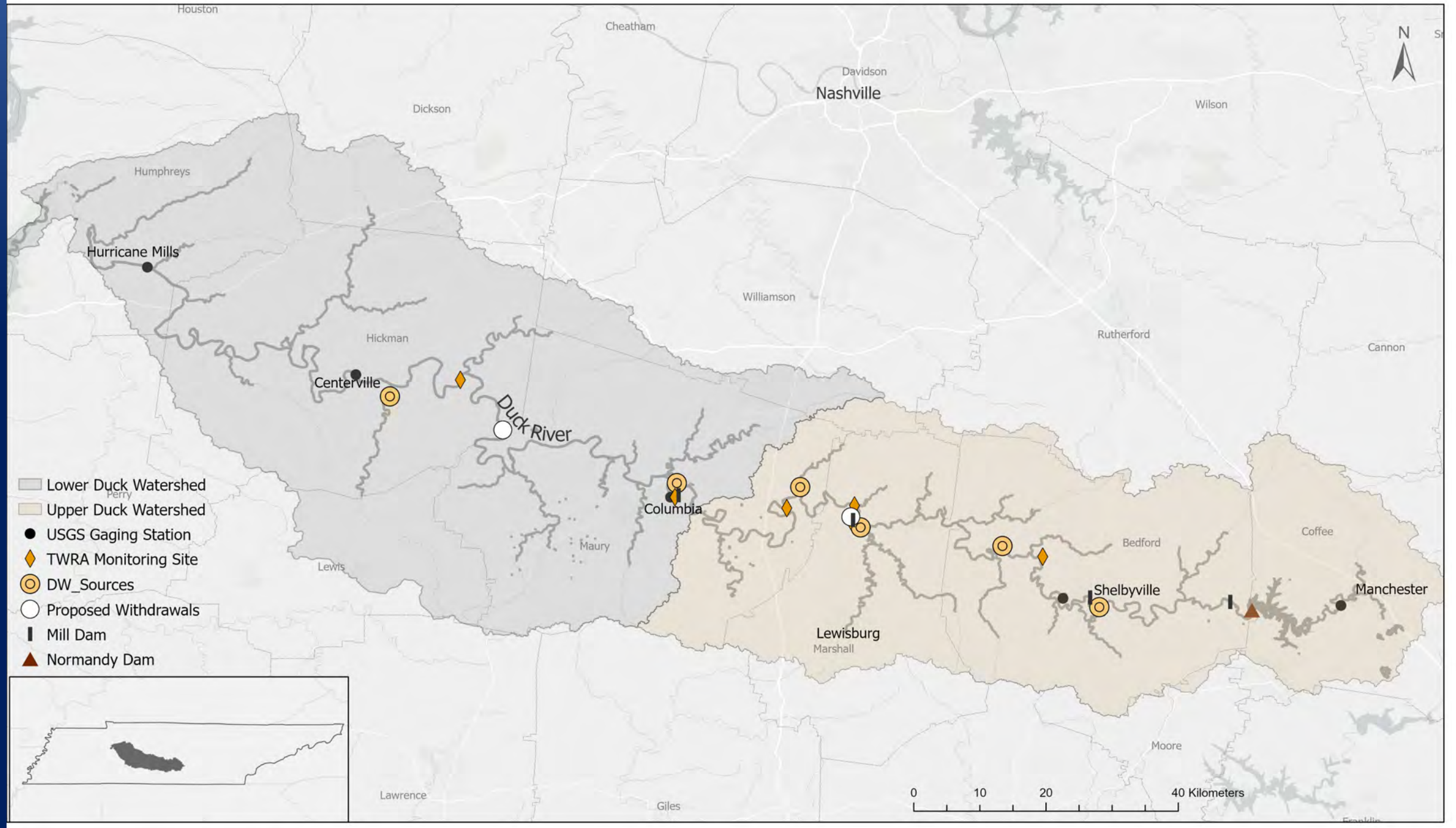
- Kristin Irwin Womble, M.S.
- Alfred Kalyanapu, Ph.D.
- Brett Connell, James Parham, Ph.D TRUTTA
- Gerry Dinkins, UT Curator
- Agency Cooperators: FWS, TDEC, TWRA

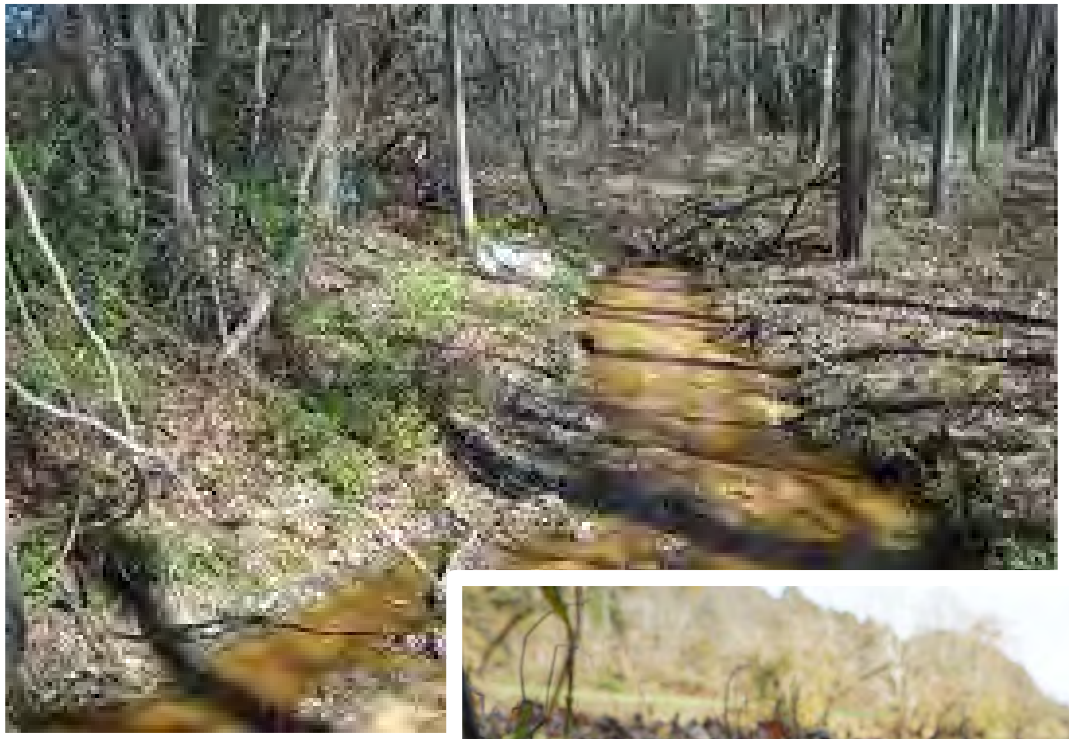
AQUATIC DIVERSITY



Hot Spots for At-Risk Fish and Mussel Species




Houston
Cheatham
Davidson
Nashville
Dickson
Wilson
Humphreys
Hurricane Mills
Williamson
Hickman
Rutherford
Cannon
Centerville
Duck River
Columbia
Perry
Maury
Lewis
Bedford
Coffee
Shelbyville
Manchester
Lewisburg
Marshall
Moore
Lawrence
Giles
Franklin
N
Lower Duck Watershed
Upper Duck Watershed
USGS Gaging Station
TWRA Monitoring Site
DW_Sources
Proposed Withdrawals
Mill Dam
Normandy Dam
0
10
20
40 Kilometers




With Mussels- Clean Water
No Mussels- Dirty Water

Duck River Development Agency

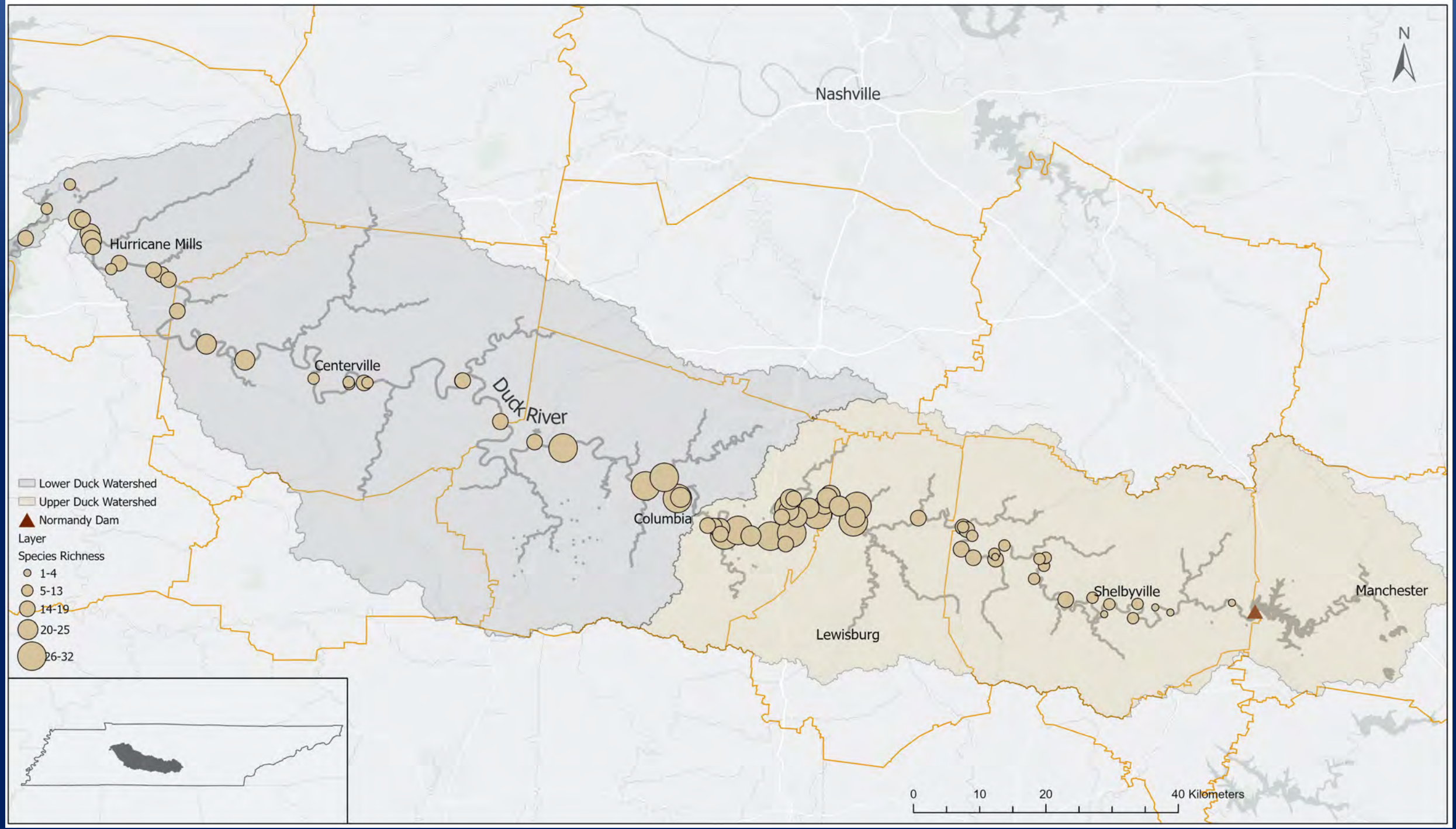
TN Department of Environment & Conservation

TENNESSEE WILDLIFE RESOURCES AGENCY

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

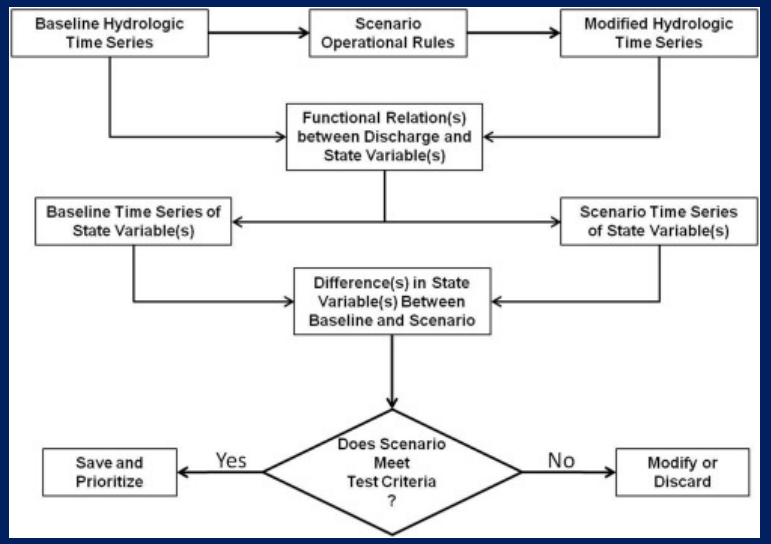
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

TVA


N
Nashville
Hurricane Mills
Centerville
Duck River
Columbia
Lewisburg
Shelbyville
Manchester
Lower Duck Watershed
Upper Duck Watershed
Normandy Dam
Layer
Species Richness
1-4
5-13
14-19
20-25
26-32
0
10
20
40 Kilometers

WATER USE PLANNING TOOL

- Needs to be collaborative, multi-agency
- Needs to be biologically relevant, flexible
- Needs to incorporate human and ecosystem needs
- Needs to show gaps and help us anticipate problems



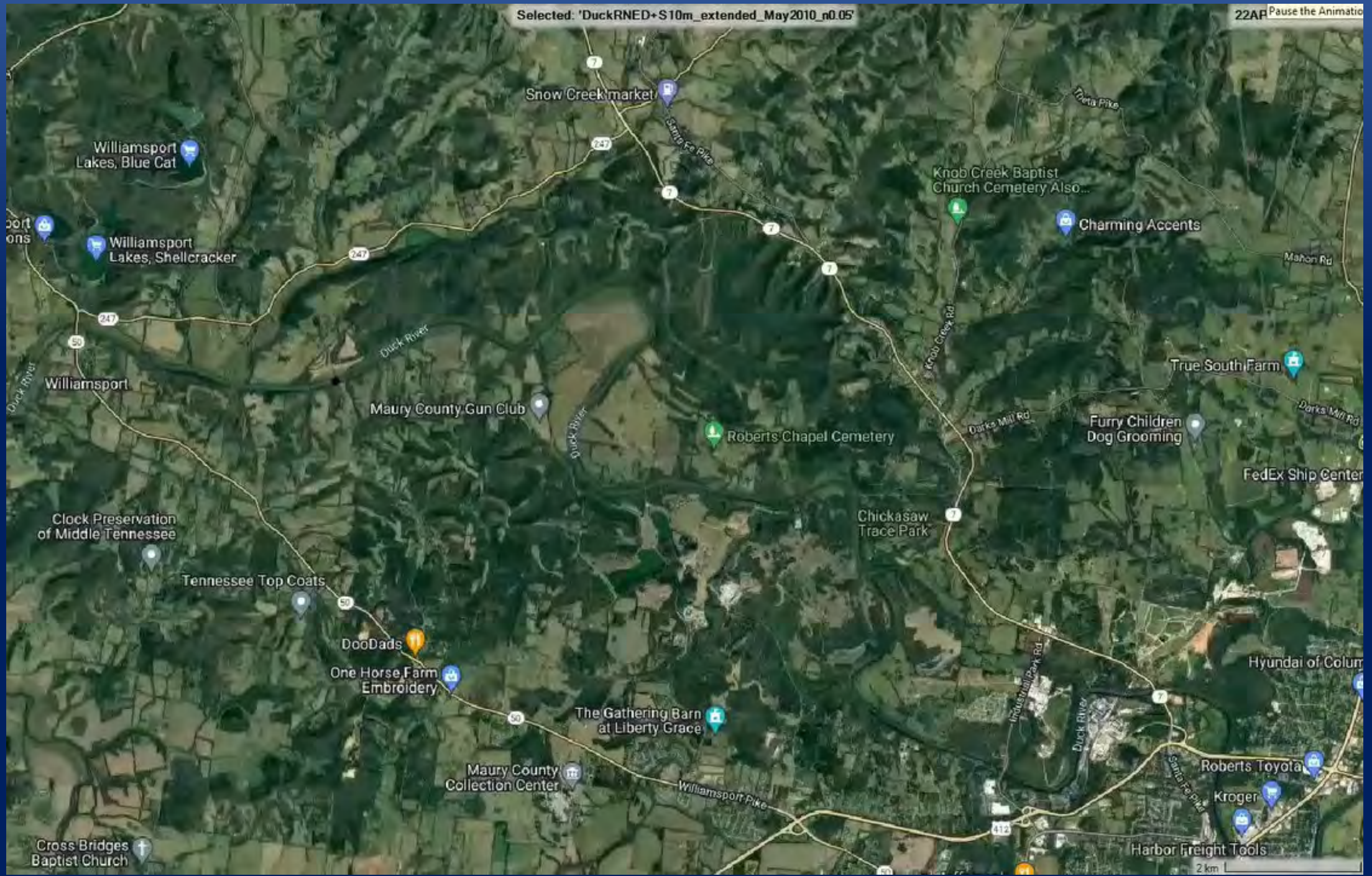
RESEARCH NEEDS AND STEPS

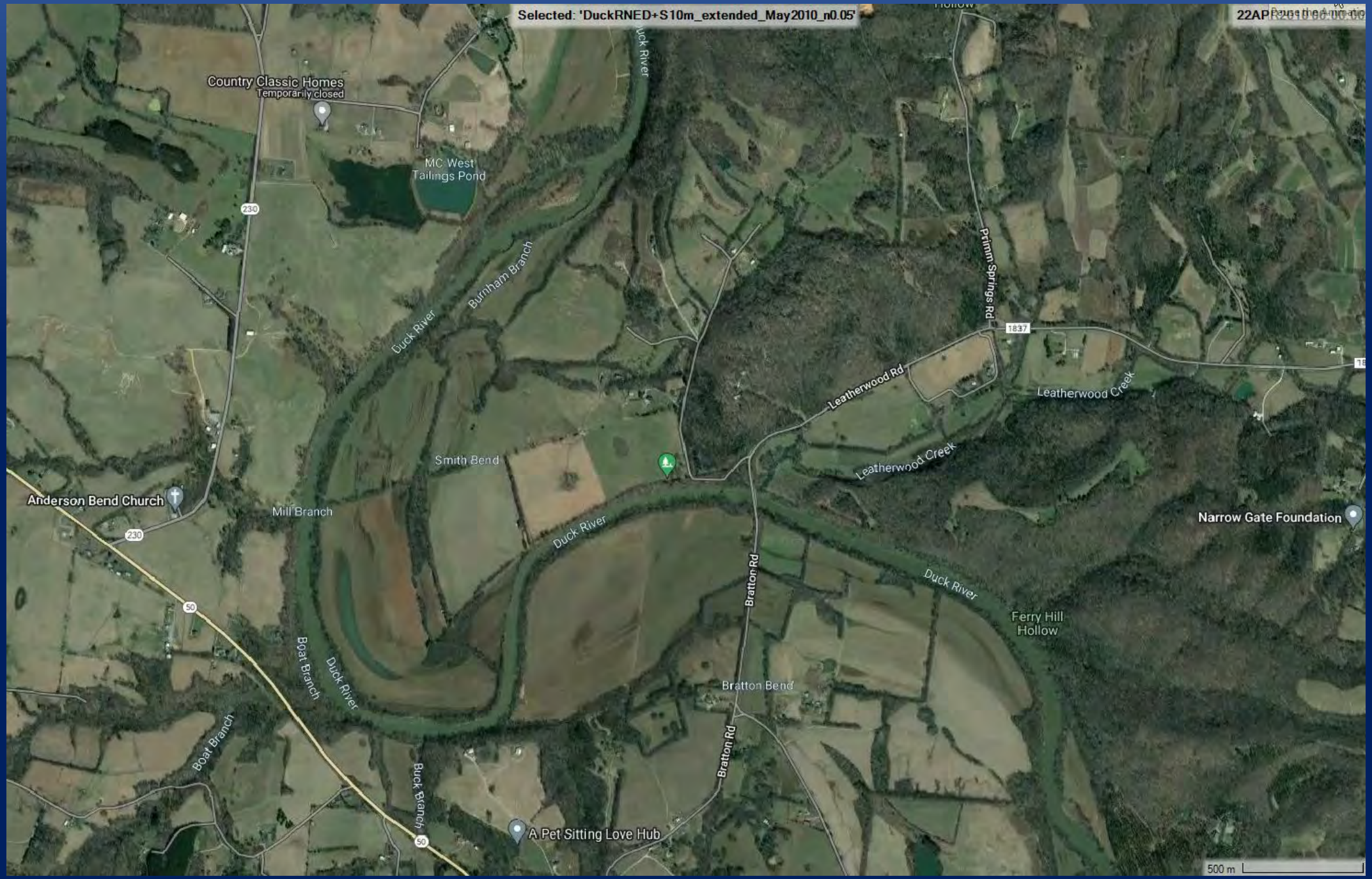
- Provide baseline data on the Duck River system – ON IT!! (or proposed)
  - Database of living resources
  - Distribution modeling, identification of gaps in monitoring
  - Summarize and fill in the gaps for biota (fish, mussels)
  - Longitudinal assessment of habitat (partially completed, proposed)
  - Hydrology, instream flow, and water quality (proposed)
  - Extent of permitted AND unpermitted water withdrawals in the system

RESEARCH NEEDS AND STEPS (CONT)

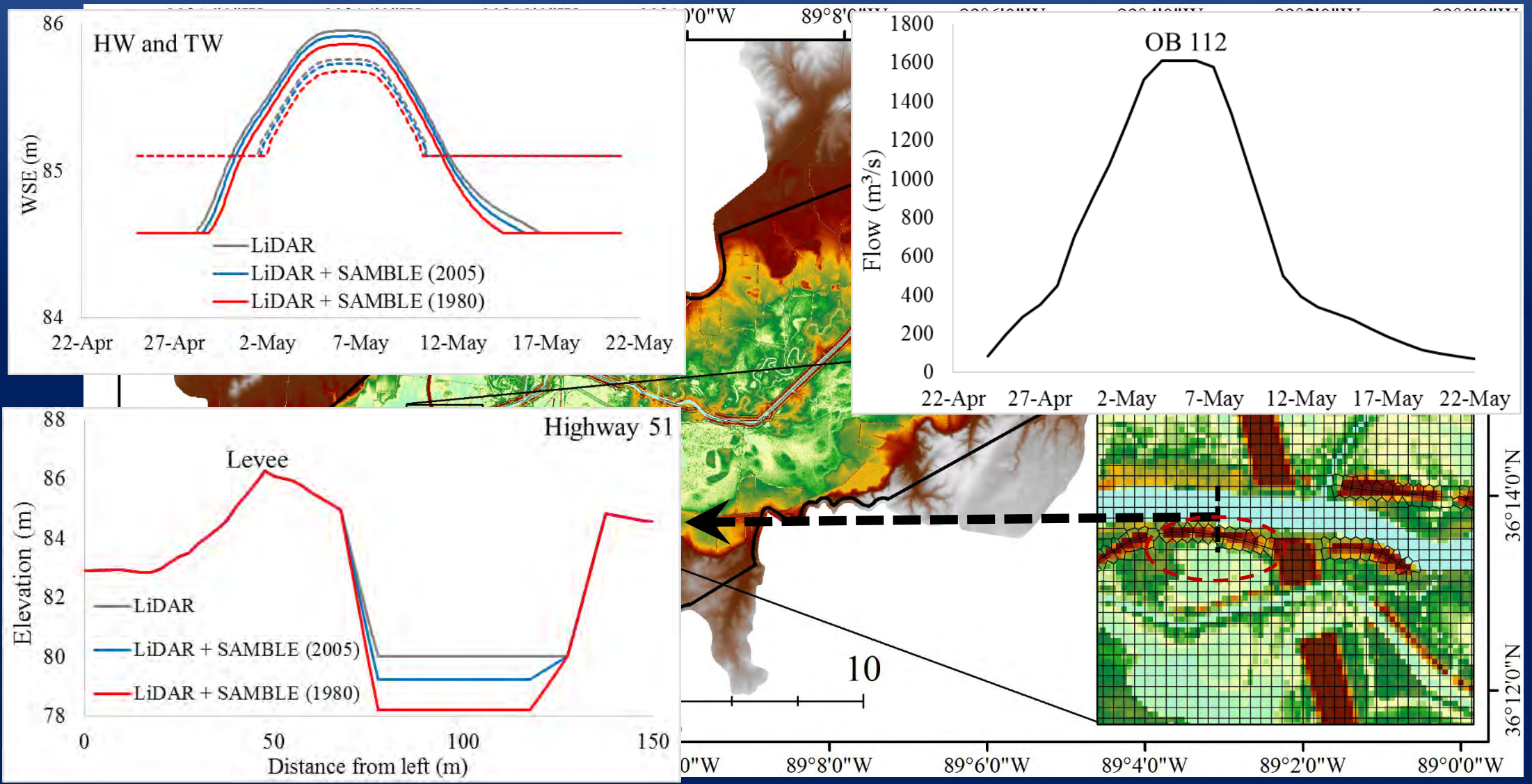
- Provide Models of Habitat in Different Flow Scenarios
  - 2-D and 3-D models, but with emphasis on low flows
  - Determine relationship between flows and physical processes
  - Determine water quality consequences of low flows
  - Estimate population response to hydrologic changes in the Duck river (TWRA)

Tools for picturing the Duck River as the dynamic system this is! Not just wetted width, but a supplier of water, sediment, ecosystem services, and biological services!


Selected: 'DuckRNED+S10m_extended_May2010_n0.05'
22AP
Pause the Animatio
Snow Creek market
Williamsport Lakes, Blue Cat
Williamsport Lakes, Shellcracker
Knob Creek Baptist Church Cemetery Also...
Charming Accents
Mahon Rd
Knob Creek Rd
Duck River
Williamsport
Maury County Gun Club
Roberts Chapel Cemetery
Darks Mill Rd
True South Farm
Furry Children Dog Grooming
FedEx Ship Center
Chickasaw Trace Park
Clock Preservation of Middle Tennessee
Tennessee Top Coats
DooDads
One Horse Farm Embroidery
The Gathering Barn at Liberty Grace
Maury County Collection Center
Williamsport Pike
Industrial Park Rd
Hyundai of Colum
Roberts Toyota
Kroger
Harbor Freight Tools
Cross Bridges Baptist Church
Santa Fe Pike
Theta Pike
2 km


Selected: 'DuckRNED+S10m_extended_May2010_n0.05'
Country Classic Homes
Temporarily closed
MC West
Tailings Pond
Duck River
Burnham Branch
Duck River
Primm Springs Rd
1837
Leatherwood Rd
Leatherwood Creek
Leatherwood Creek
Smith Bend
Anderson Bend Church
Mill Branch
Duck River
Narrow Gate Foundation
Bratton Rd
Duck River
Ferry Hill
Hollow
Boat Branch
Duck River
Bratton Bend
Boat Branch
Buck Branch
Bratton Rd
A Pet Sitting Love Hub
500 m

Example: 2D Hydrodynamic Model



RESEARCH NEEDS AND STEPS (CONT)

- Ecological and Environmental Consequences of Instream Flow Alteration

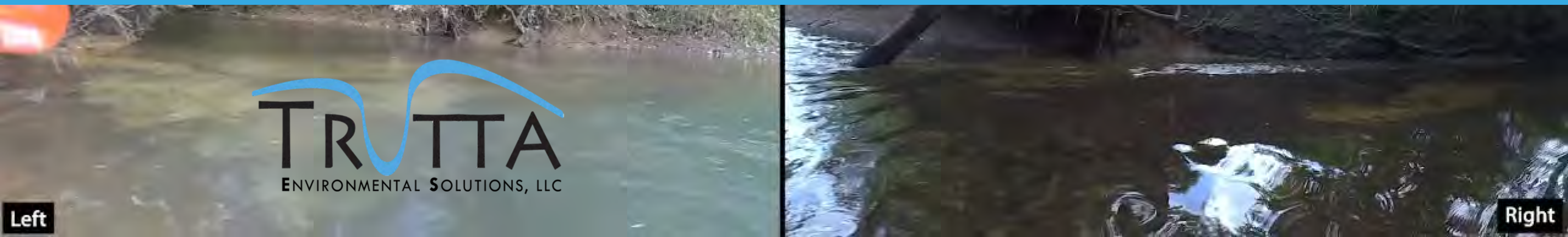
PUTTING RESEARCH INTO ACTION

- DECISION SUPPORT TOOL
  - Water withdrawal assessment process
  - Future analysis scenarios
  - Identification of systemic vulnerabilities
  - Incorporate human needs and vulnerabilities

HIGH DEFNITION STREAM SU

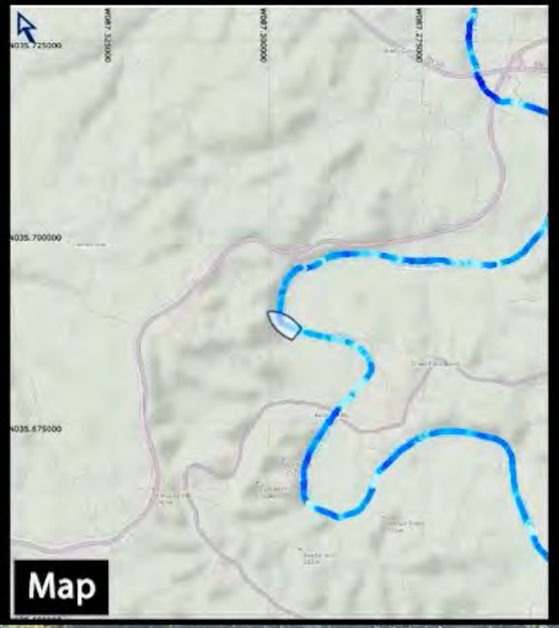
A Fast, Affordable and Flexible Method to Document River Conditions and Support Management Actions

Prepared by James Parham, Ph.D.
Trutta Environmental Solutions



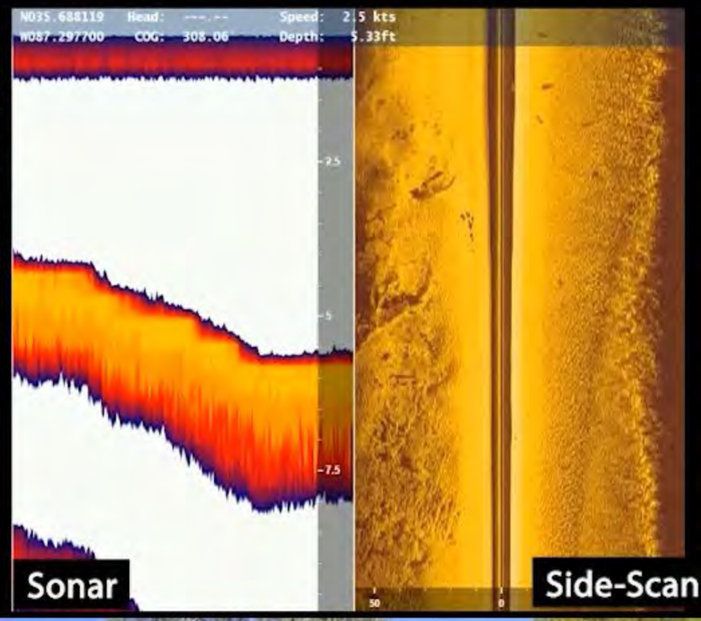
High Definition Stream Survey

TruttaSolutions.com



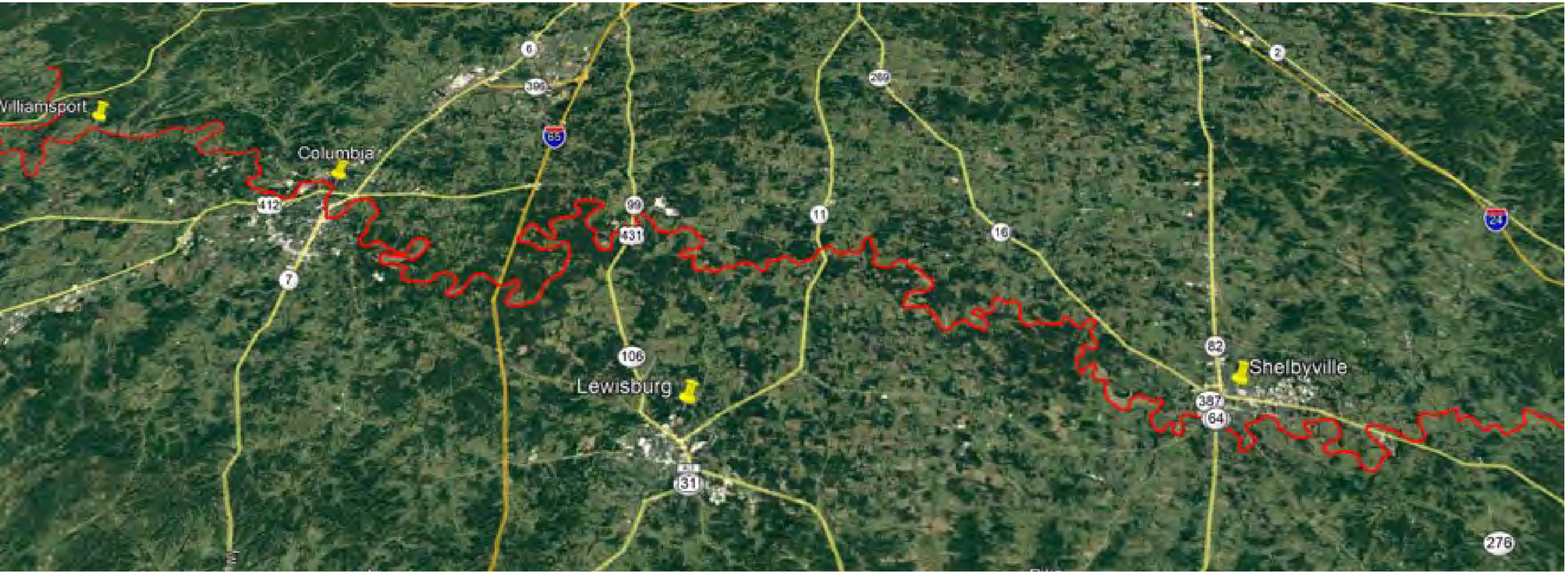
Duck River, TN

Kettle Mills Rd Bridge to Hwy 50 Bridge



Fast Inventory and Assessment

Duck River, TN 155 MILES, 250 XS, 2 SURVEYORS, 10 DAYS



TN Department of Environment & Conservation

CPWS
Columbia Power & Water Systems

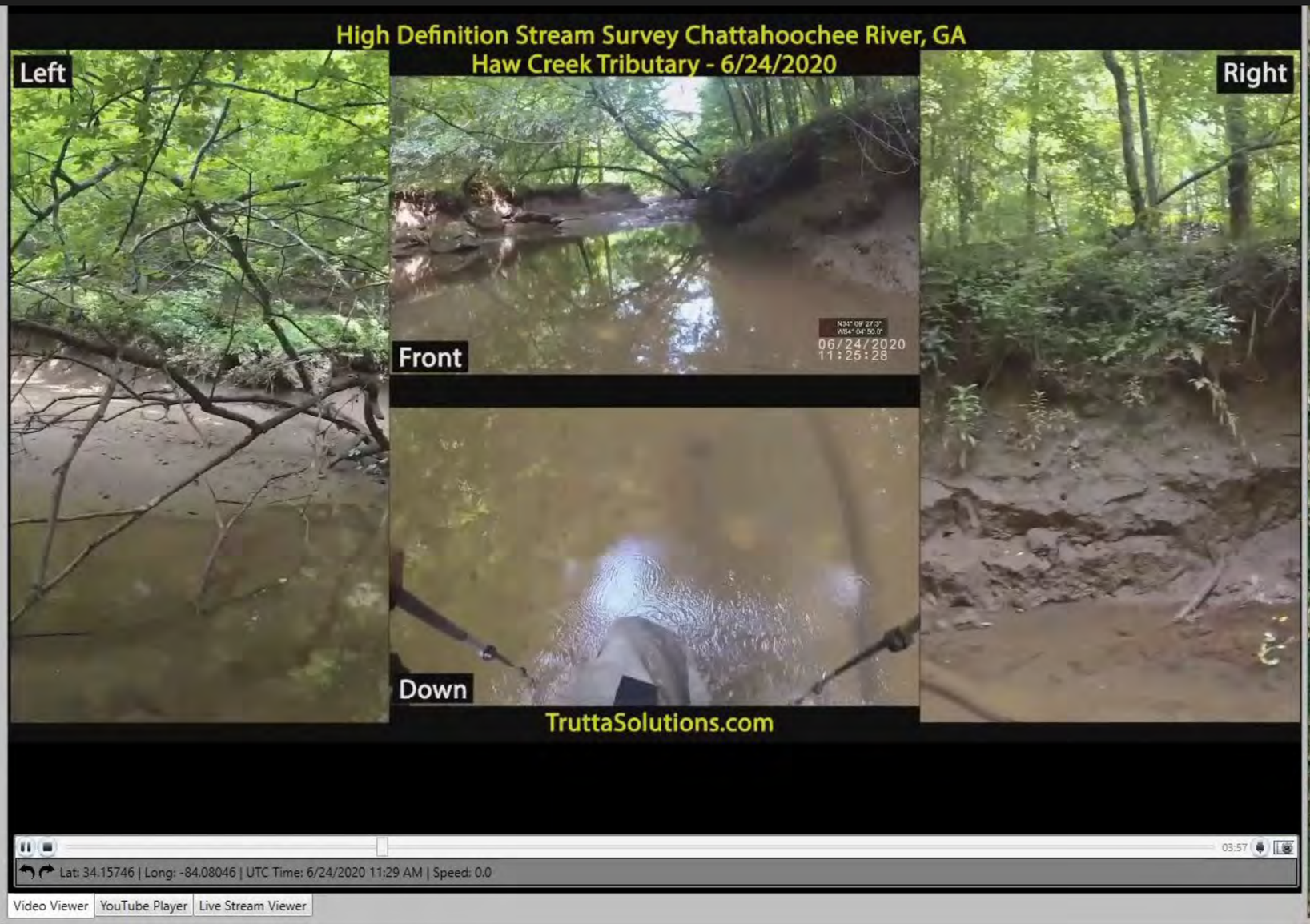
DUCK RIVER AGENCY

South Central Tennessee Development District

O'BRIEN & GERE

spatial metadata embedded in video:

works in arcgis, qgis &remote geosystems geotagger

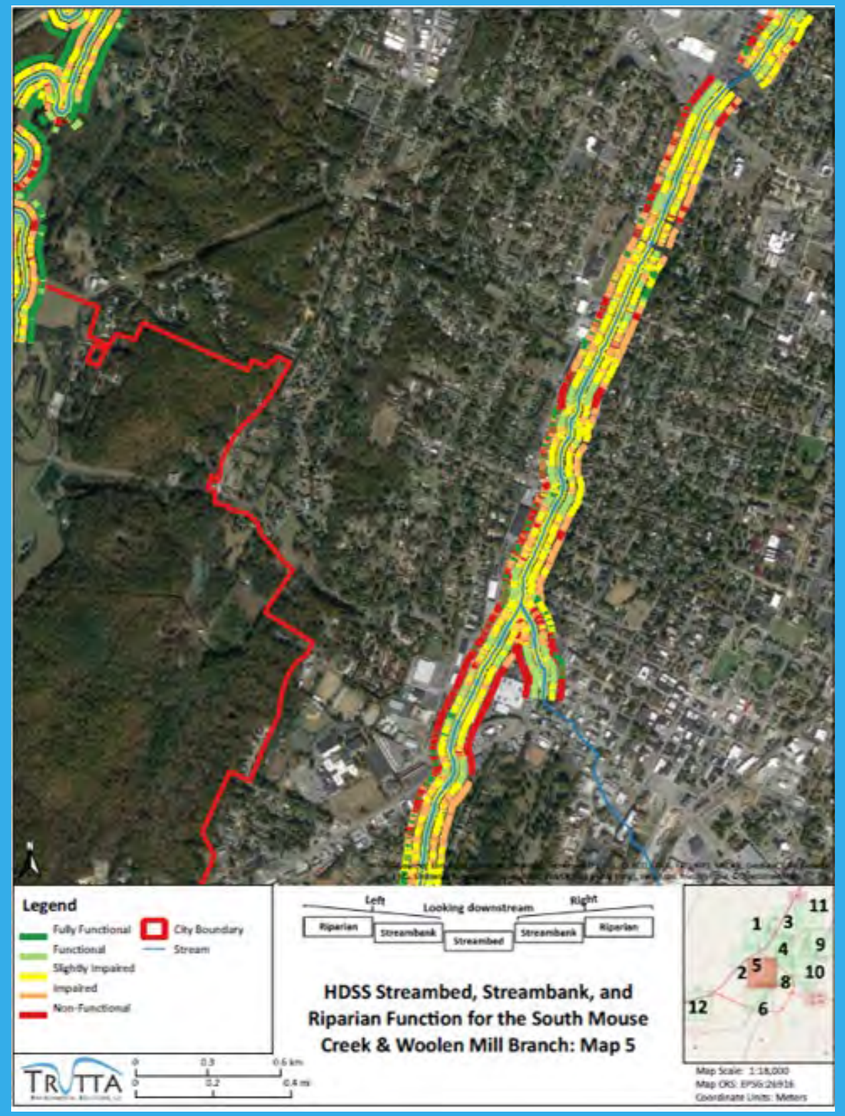


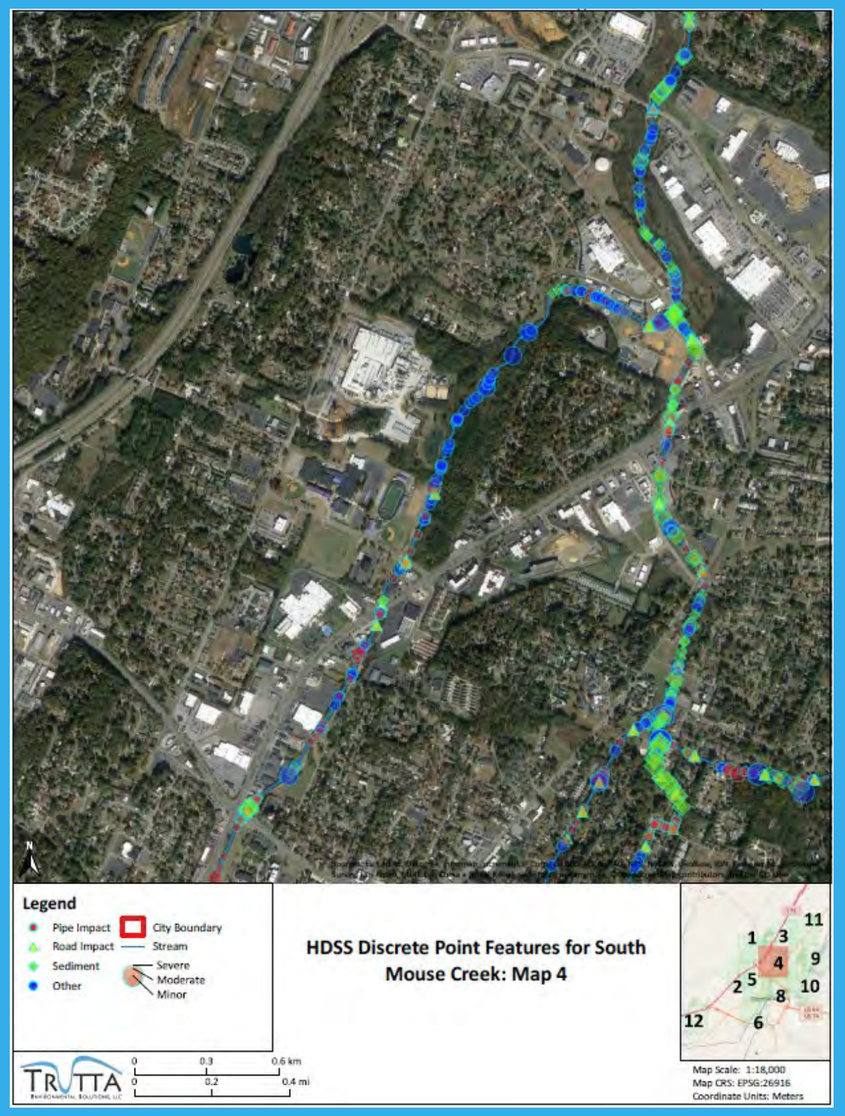
habitat data linked in gis

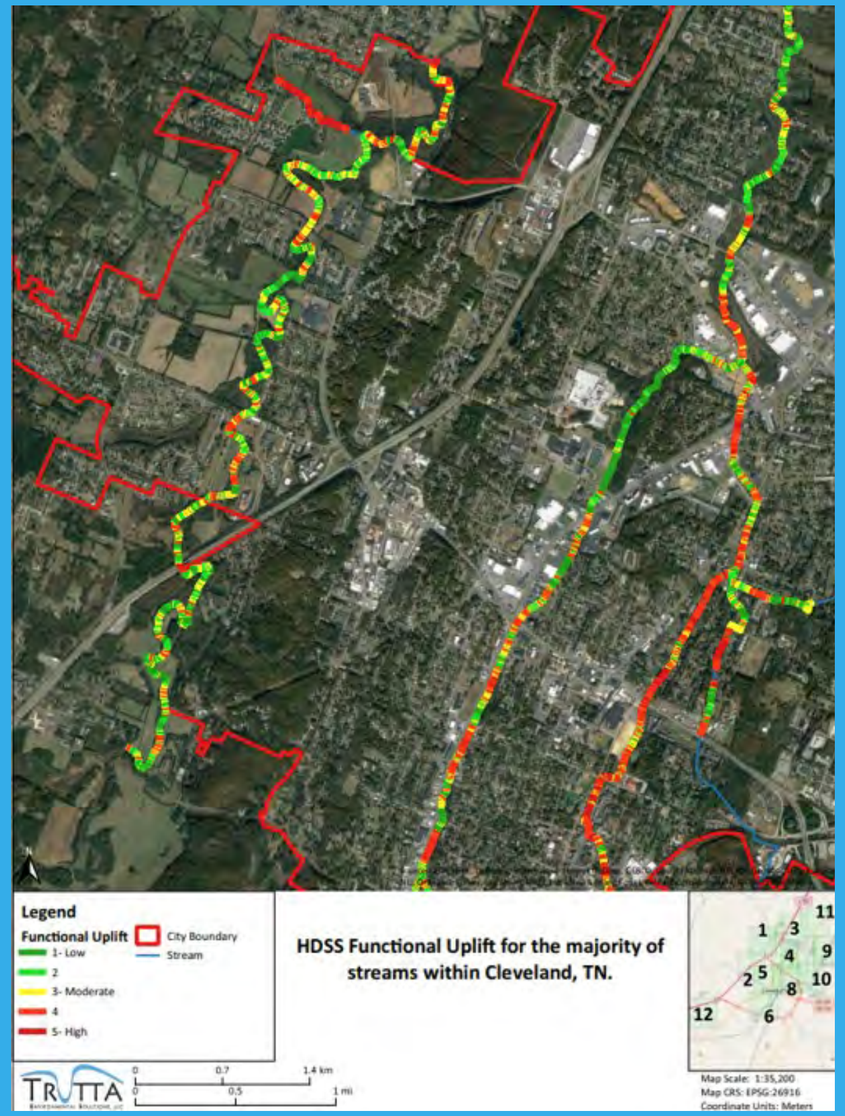
time, location &condition scores

maps showing habitat condition:

Continuous data, point data & combined data







how do we collect data?

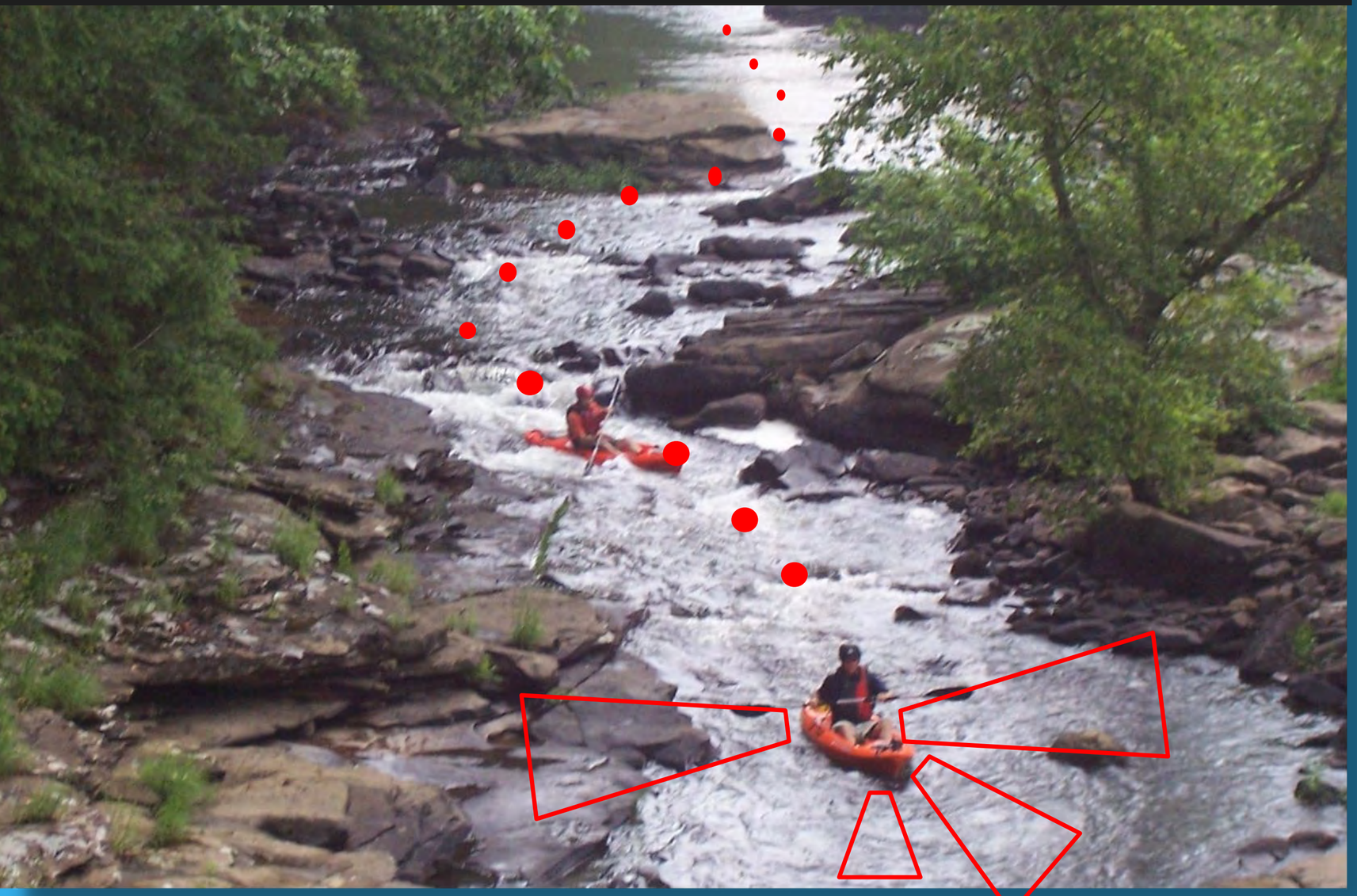
BACKPACK

KAYAK

INFLATABLE BOAT

COMING SOON:
DRONES

what data do we collect?



Side Video/LiDAR
- Left & Right Streambank
- Riparian
- Floodplain Access
- Infrastructure

Front Video
- Habitat Type
- Canopy Cover

Down Video & Sonar
- Depth
- Side-scan imagery
- Substrate Type
- Embeddedness

Water Quality Sensor
- DO, pH, Temp, etc.

Acoustic Doppler Current Profiler
- Bathymetry
- Discharge
- Transects

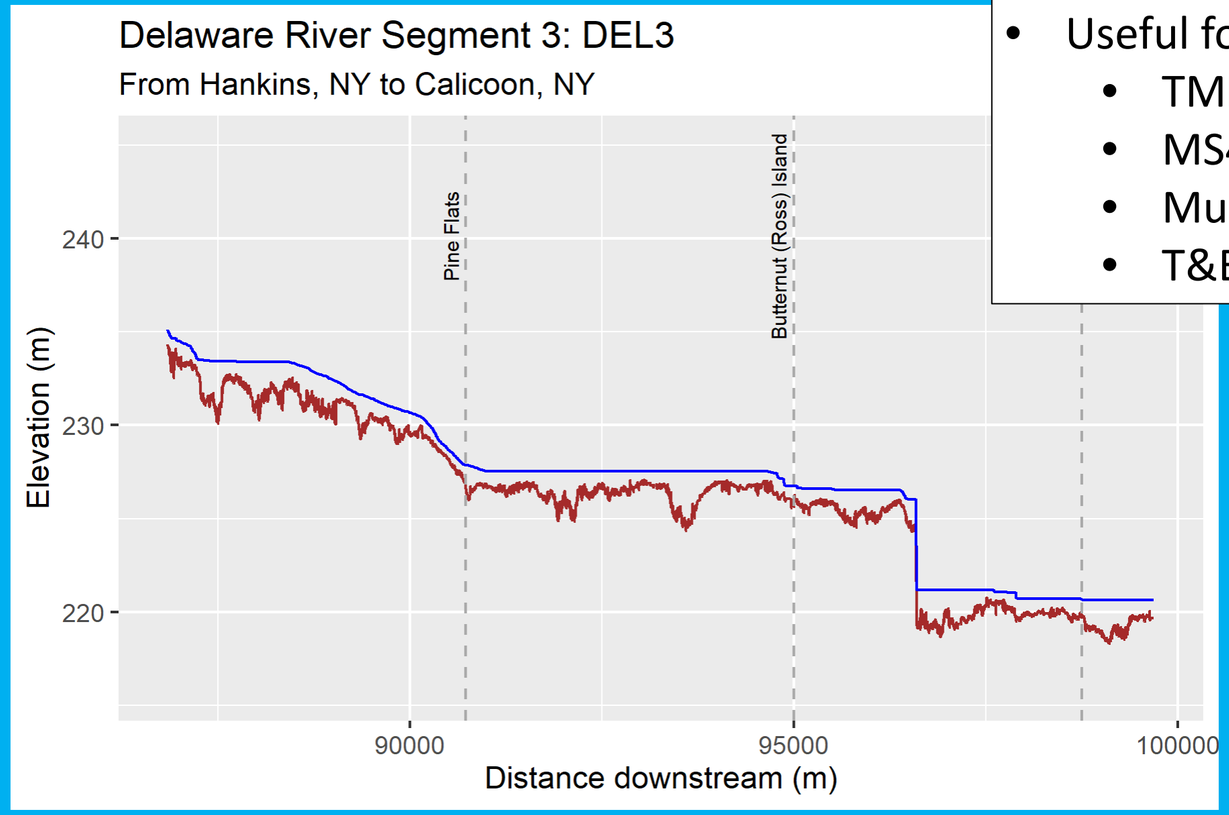
Water Grab Samples
- eDNA

GPS

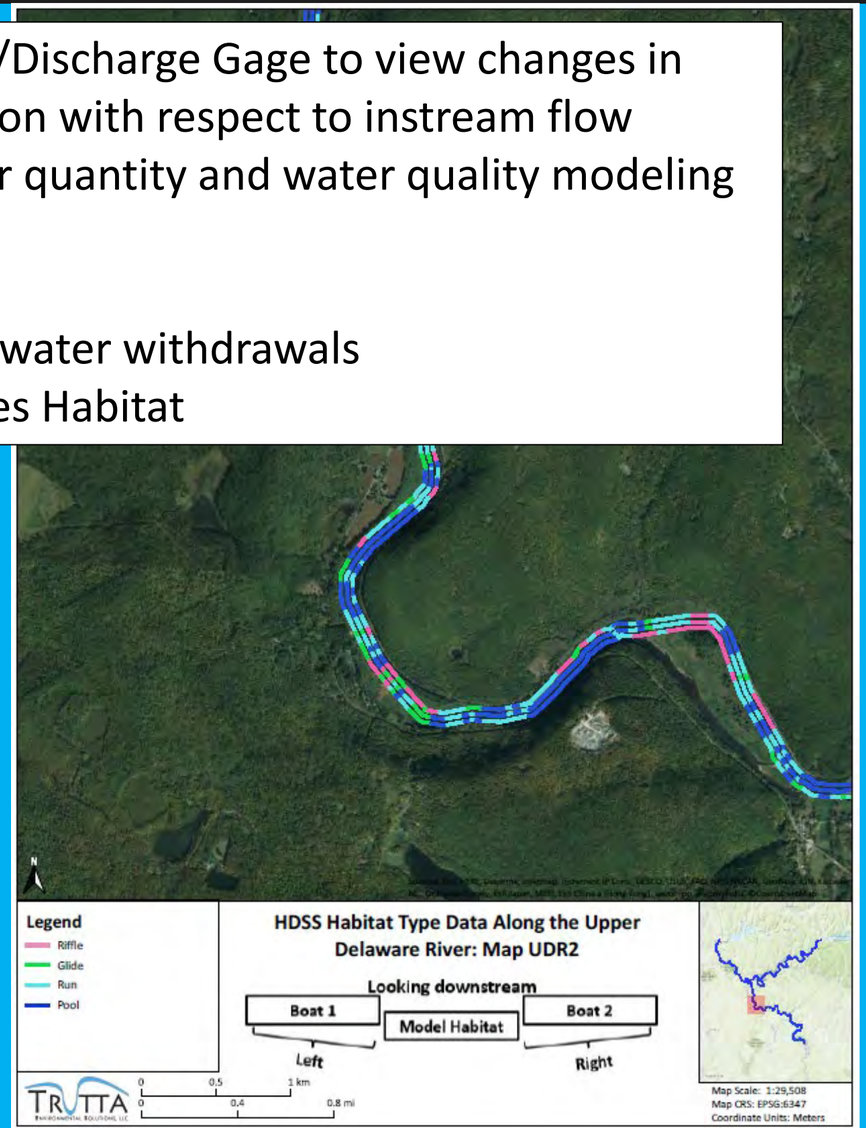
Time
Location
Elevation

DIGITALLY COLLECTED HABITAT

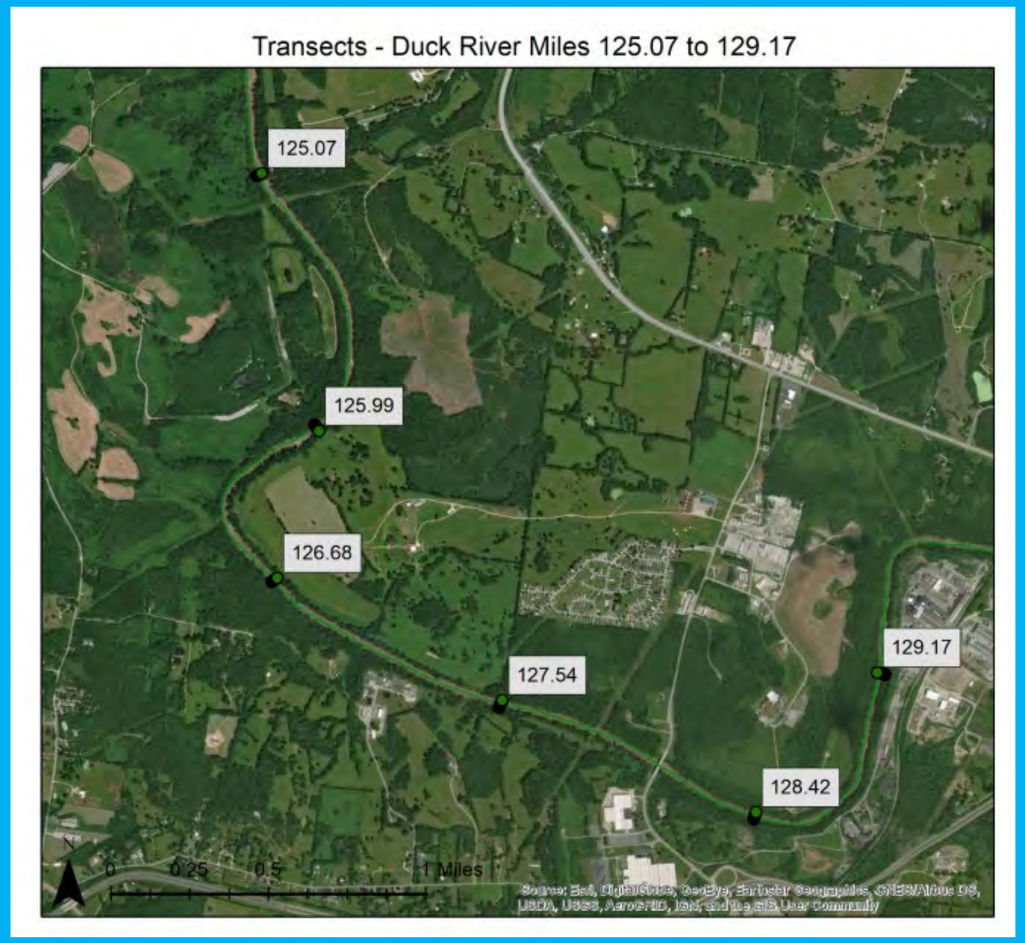
DEPTH, ELEVATION, SLOPE & HABITAT TYPE

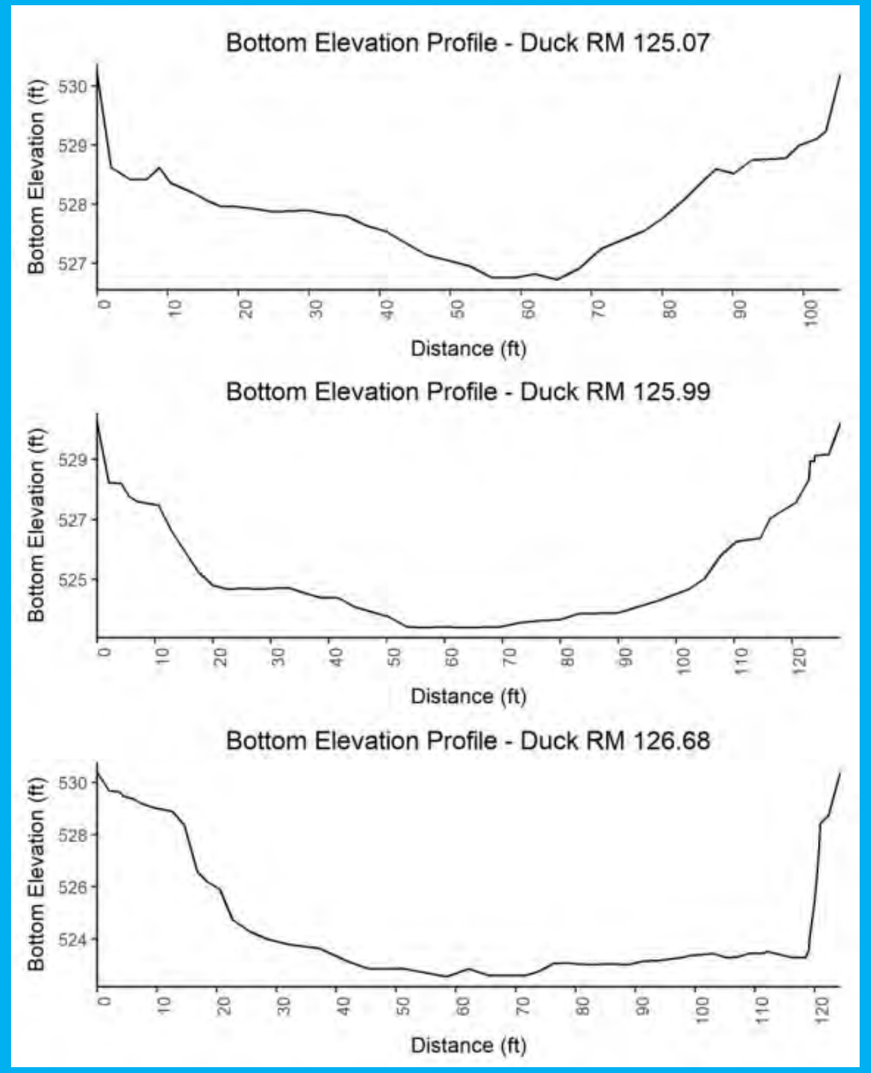


- Link with Stage/Discharge Gage to view changes in channel condition with respect to instream flow
- Useful for water quantity and water quality modeling
  - TMDL's
  - MS4
  - Municipal water withdrawals
  - T&E Species Habitat



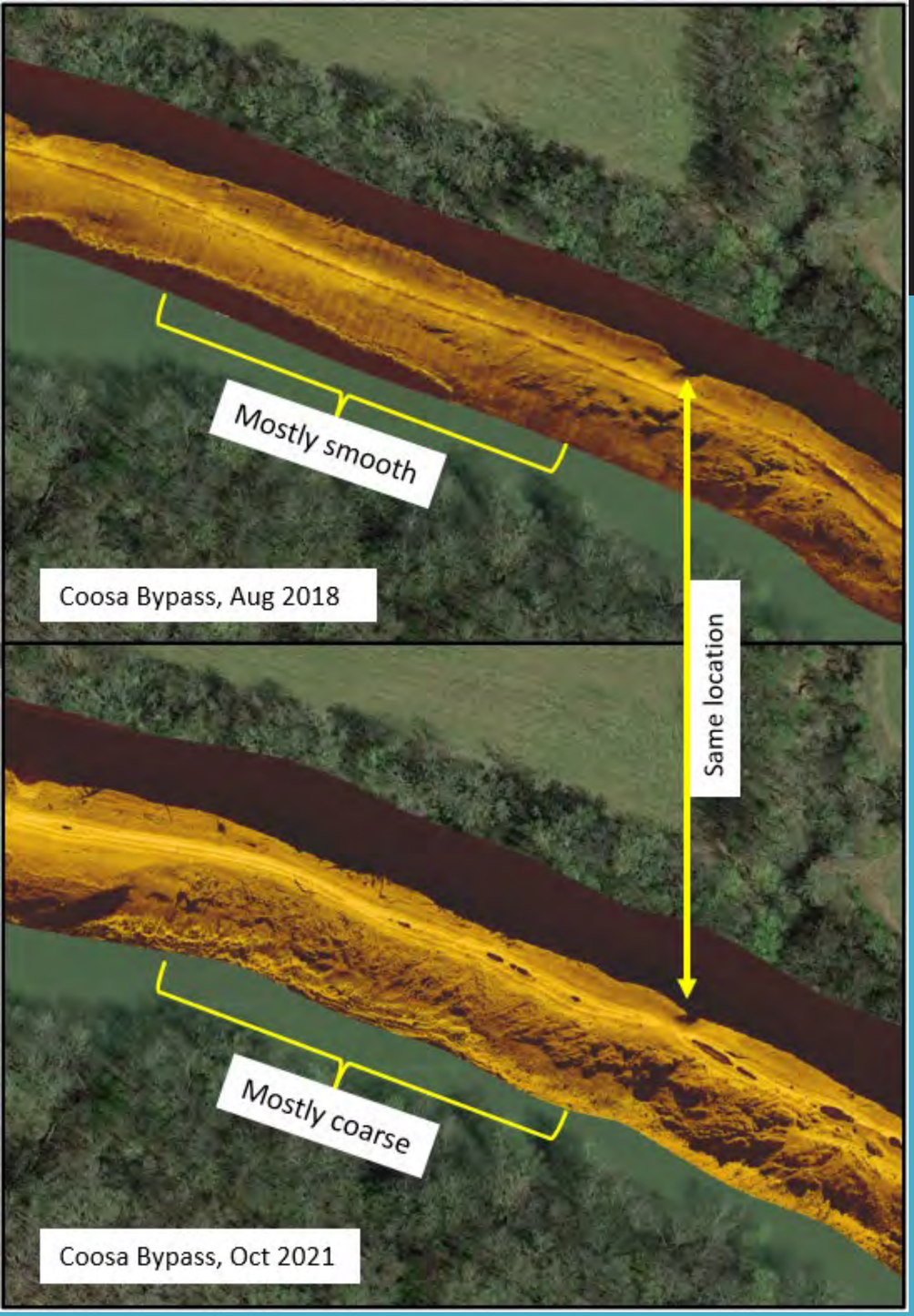
CROSS-SECTIONAL TRANSECTS

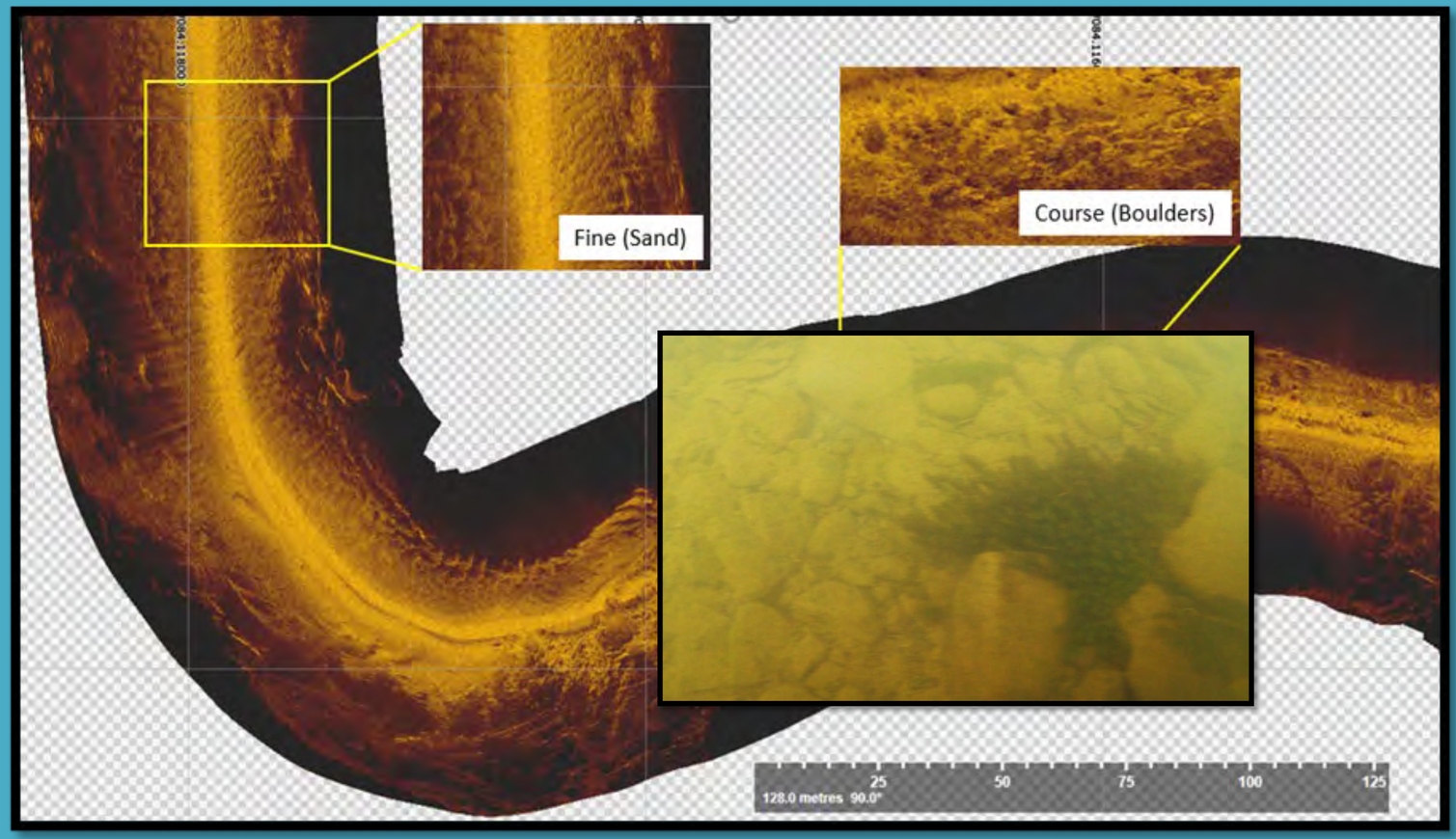




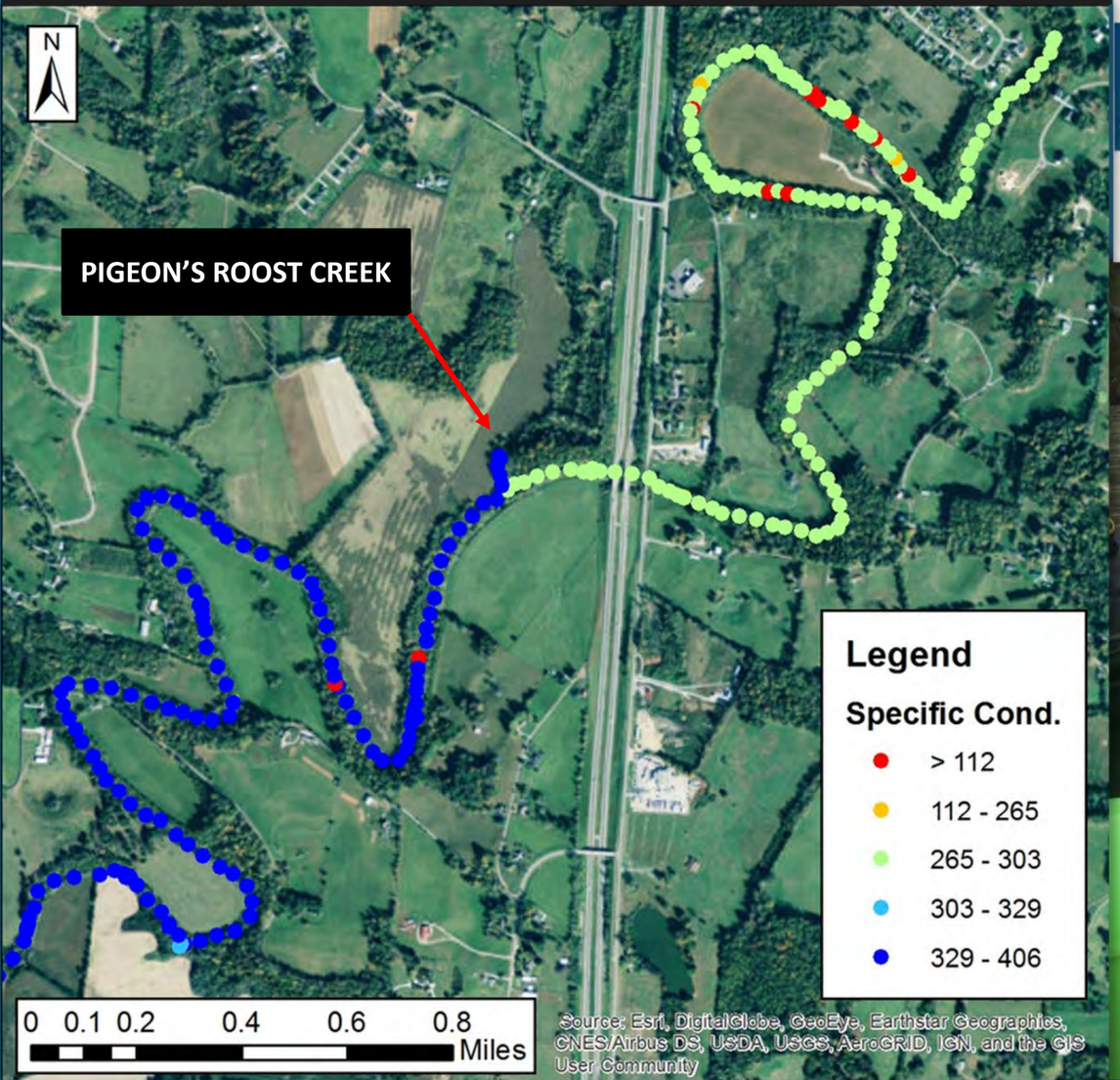
underwater habitat

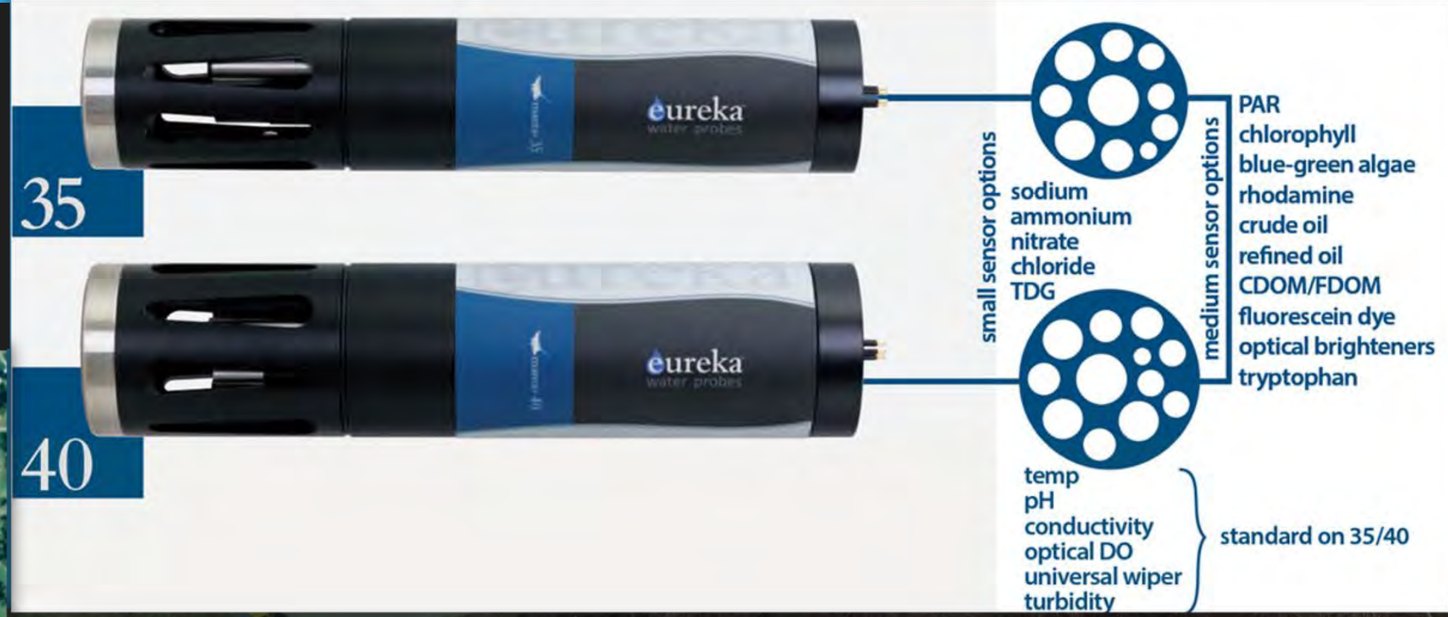
side-scan sonar &video

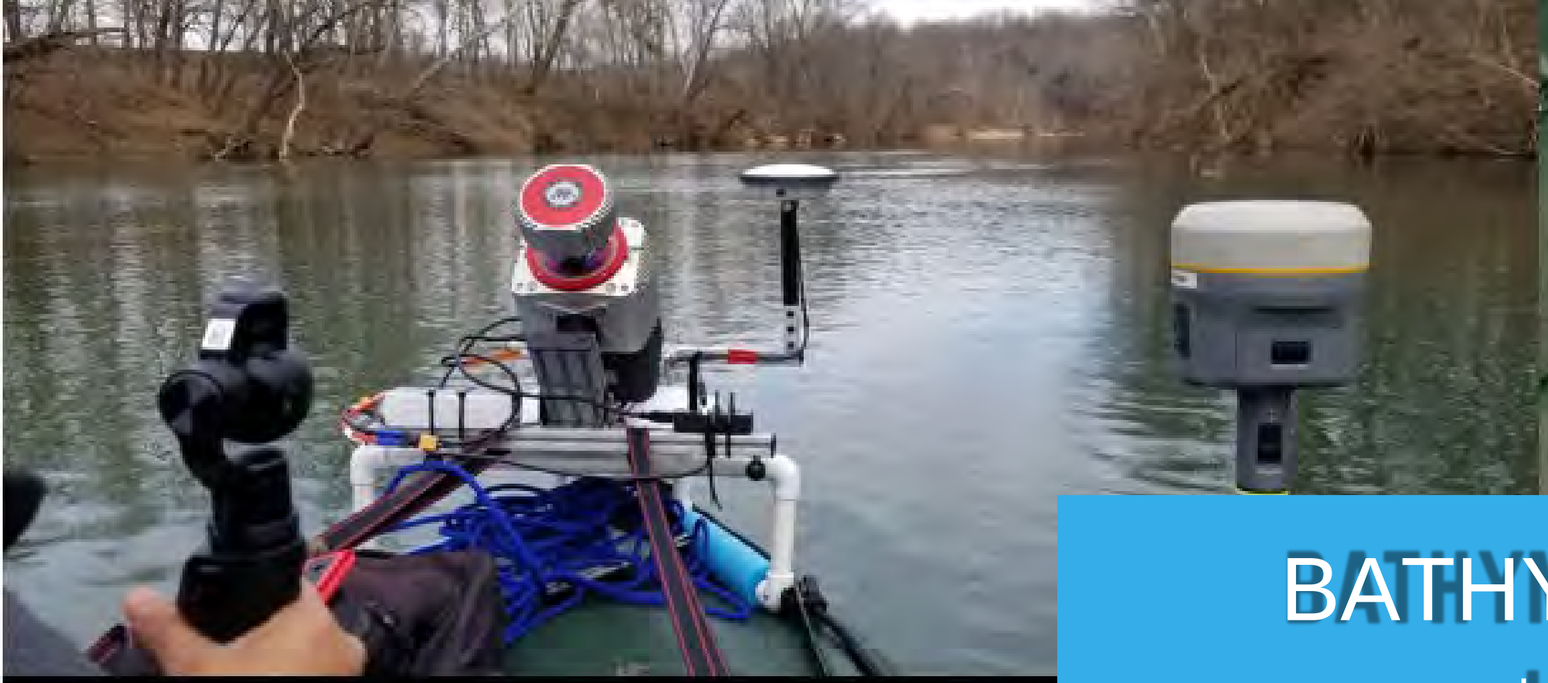


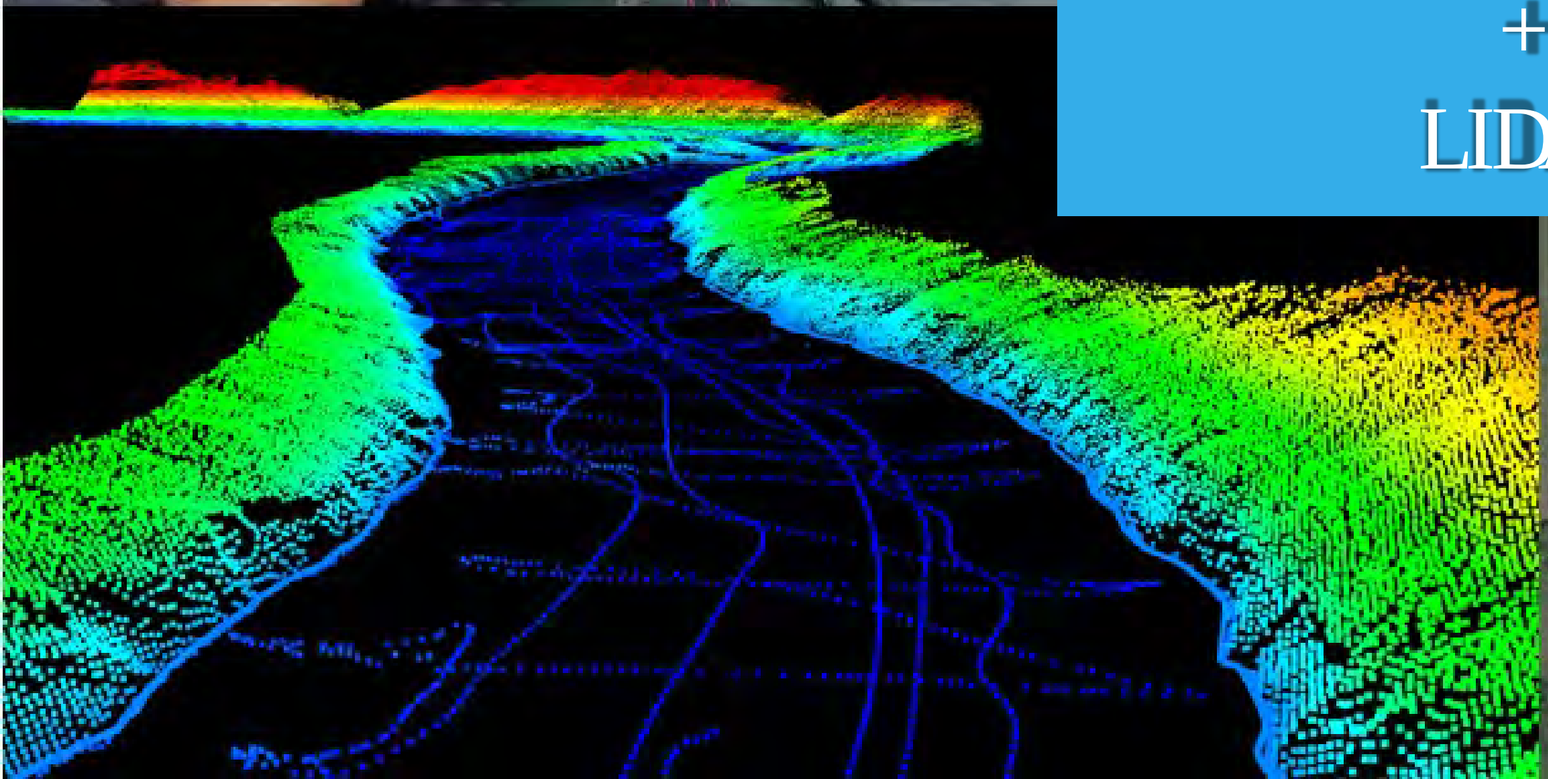


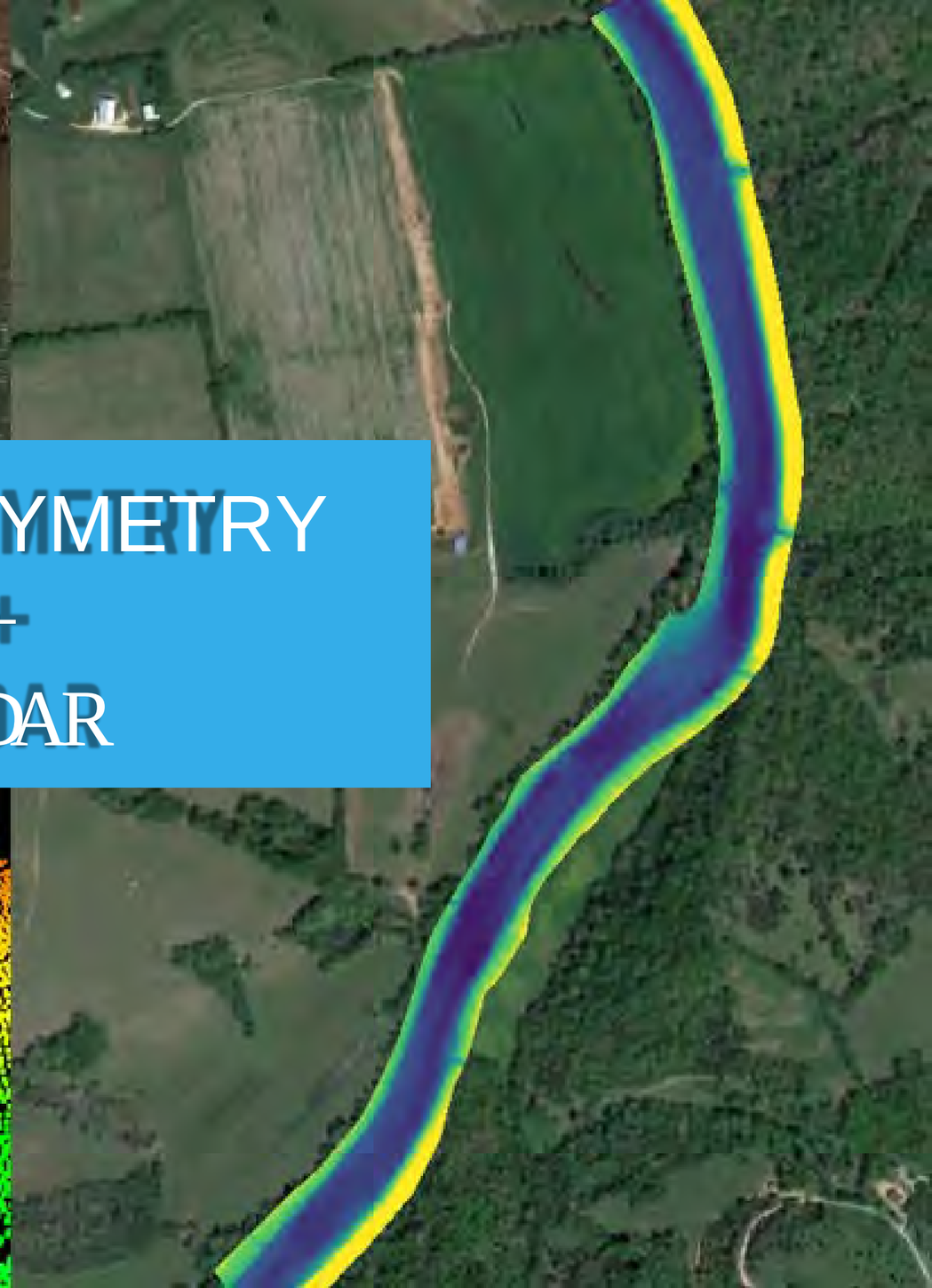
WATER QUALITY









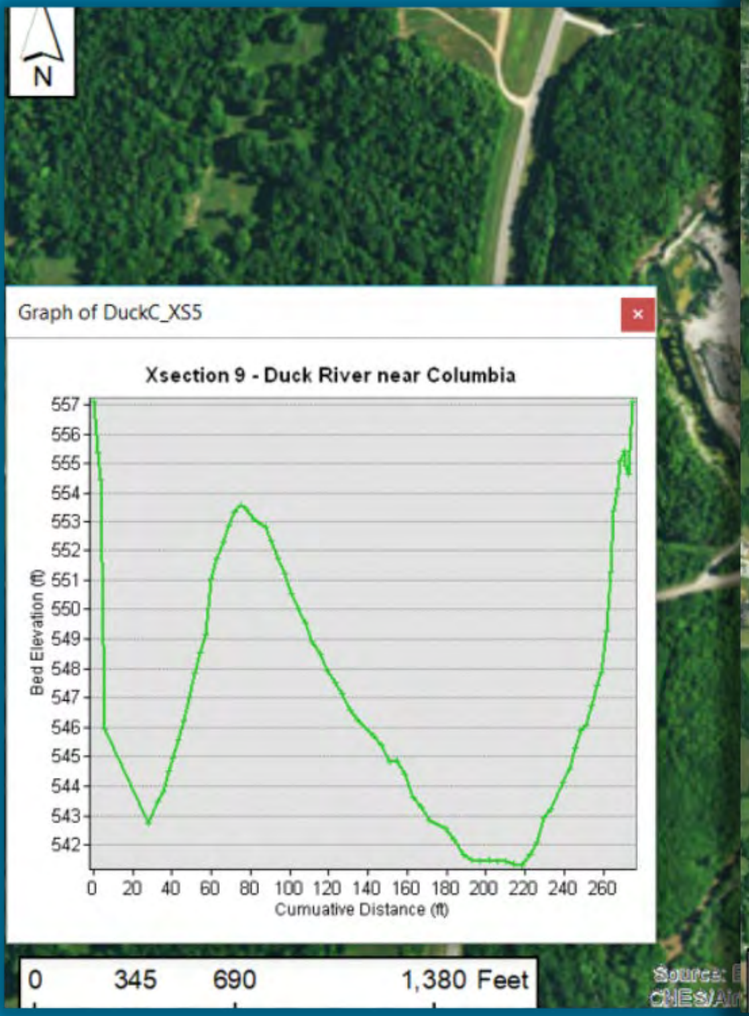


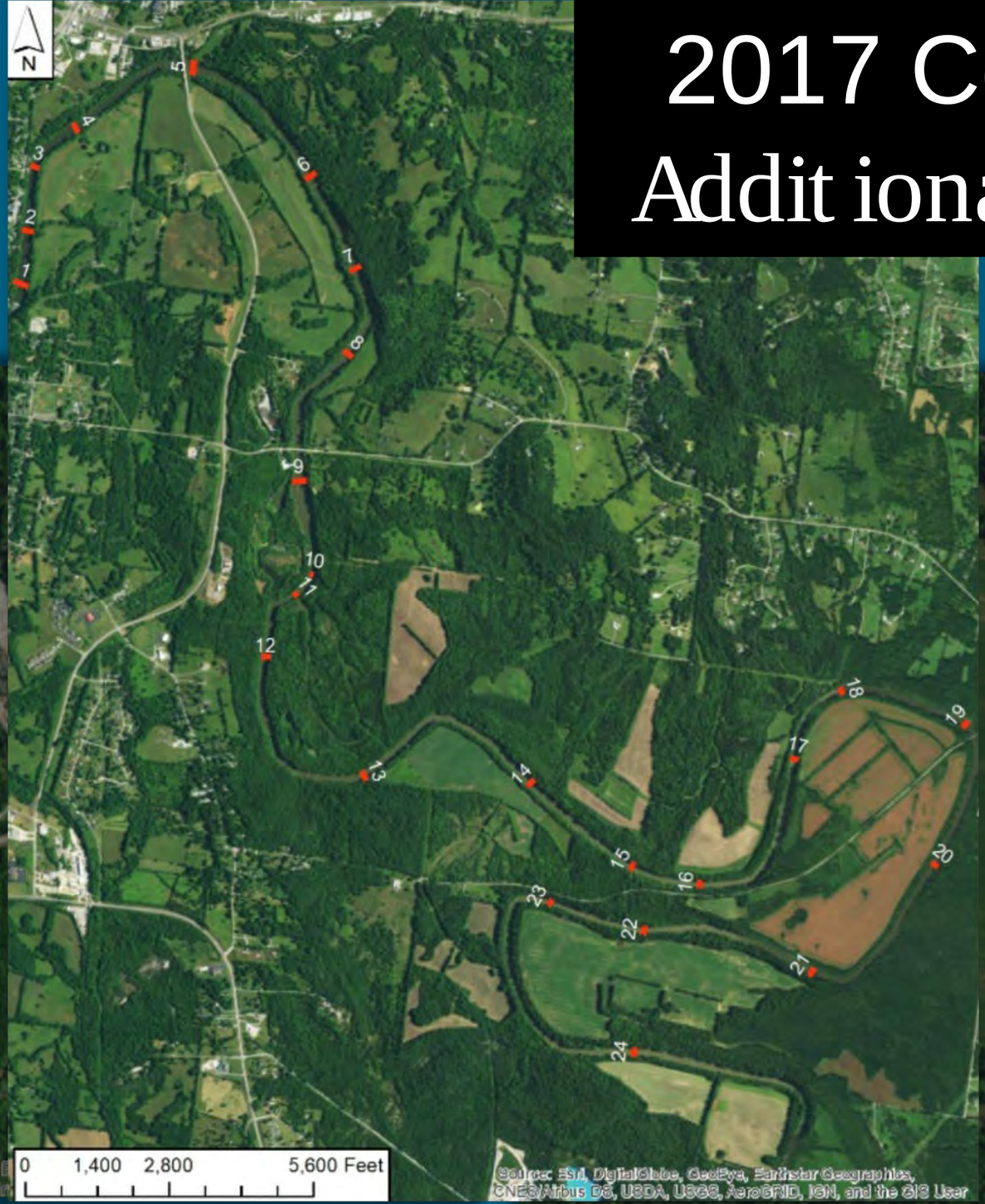
BATHYMETRY
+
LIDAR

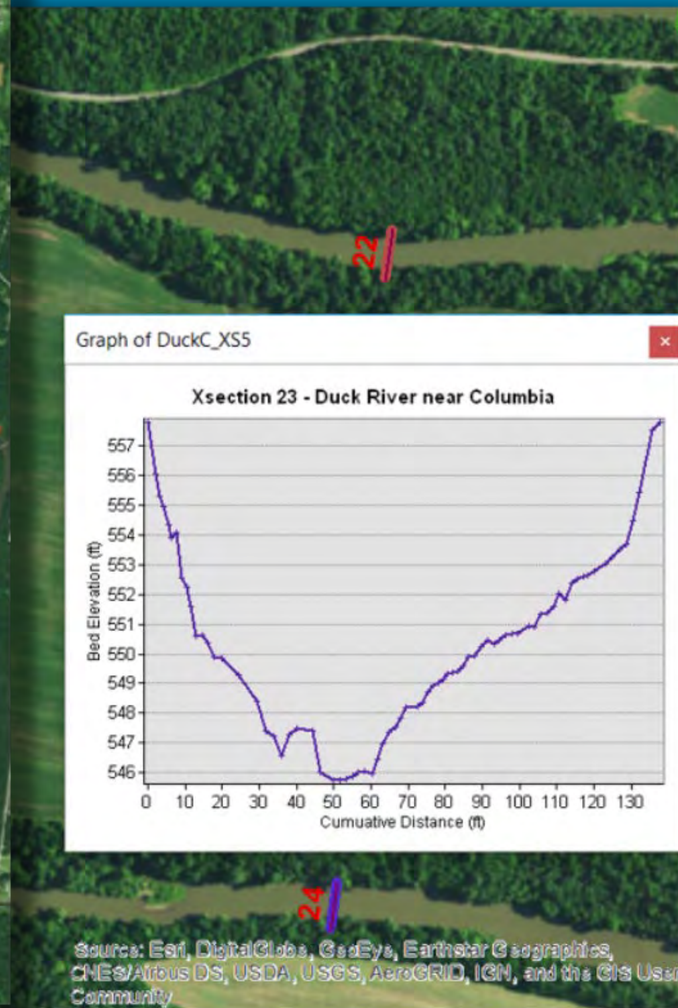
2017 Duck River HDSS RM 249 to 127

XS to support TDEC Water Quality Model

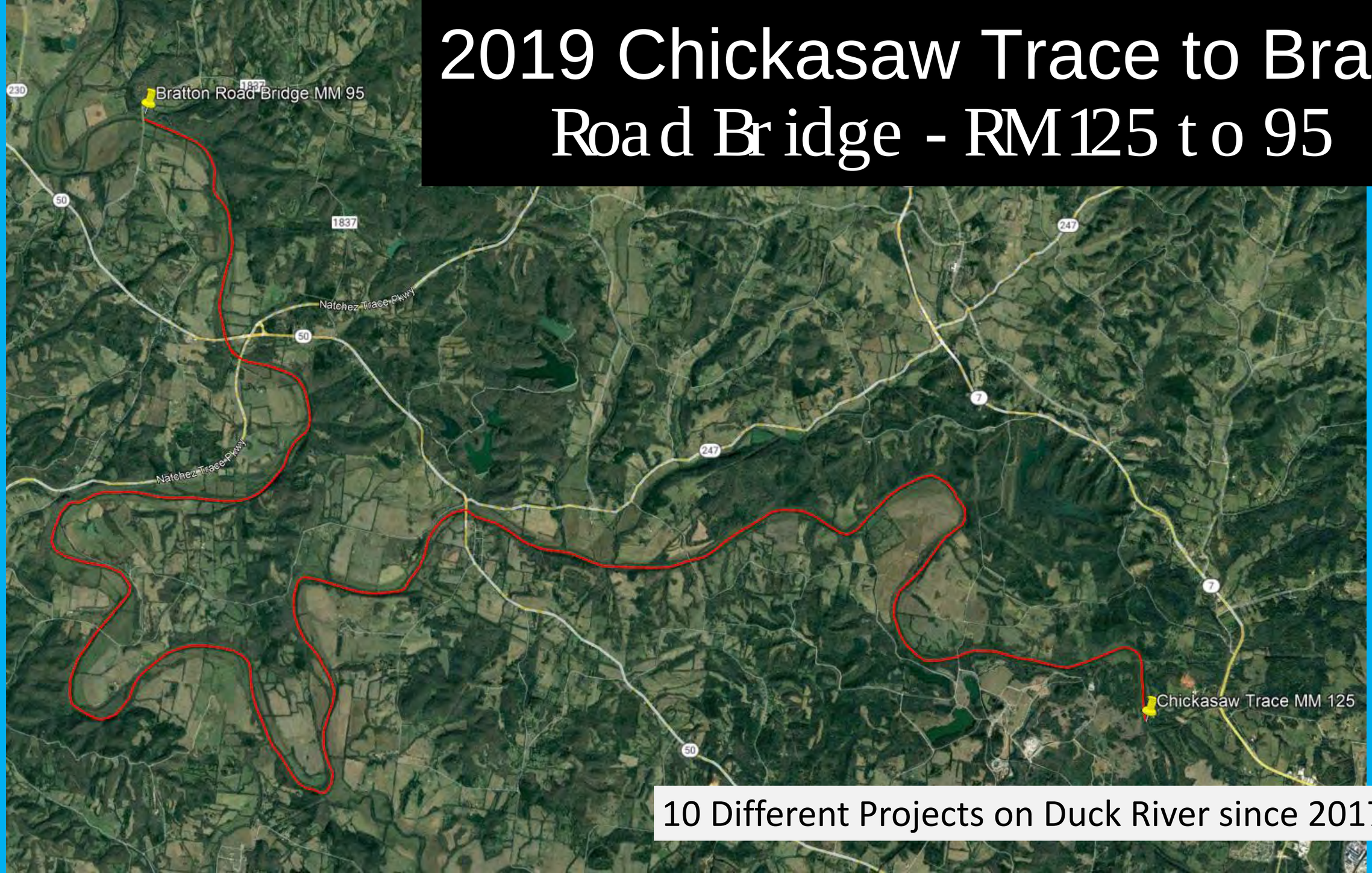
2017 Columbia Dam
Additional XS Added







2019 Chickasaw Trace to Bratton Road Bridge - RM 125 to 95



10 Different Projects on Duck River since 2017

Habitat Suitability

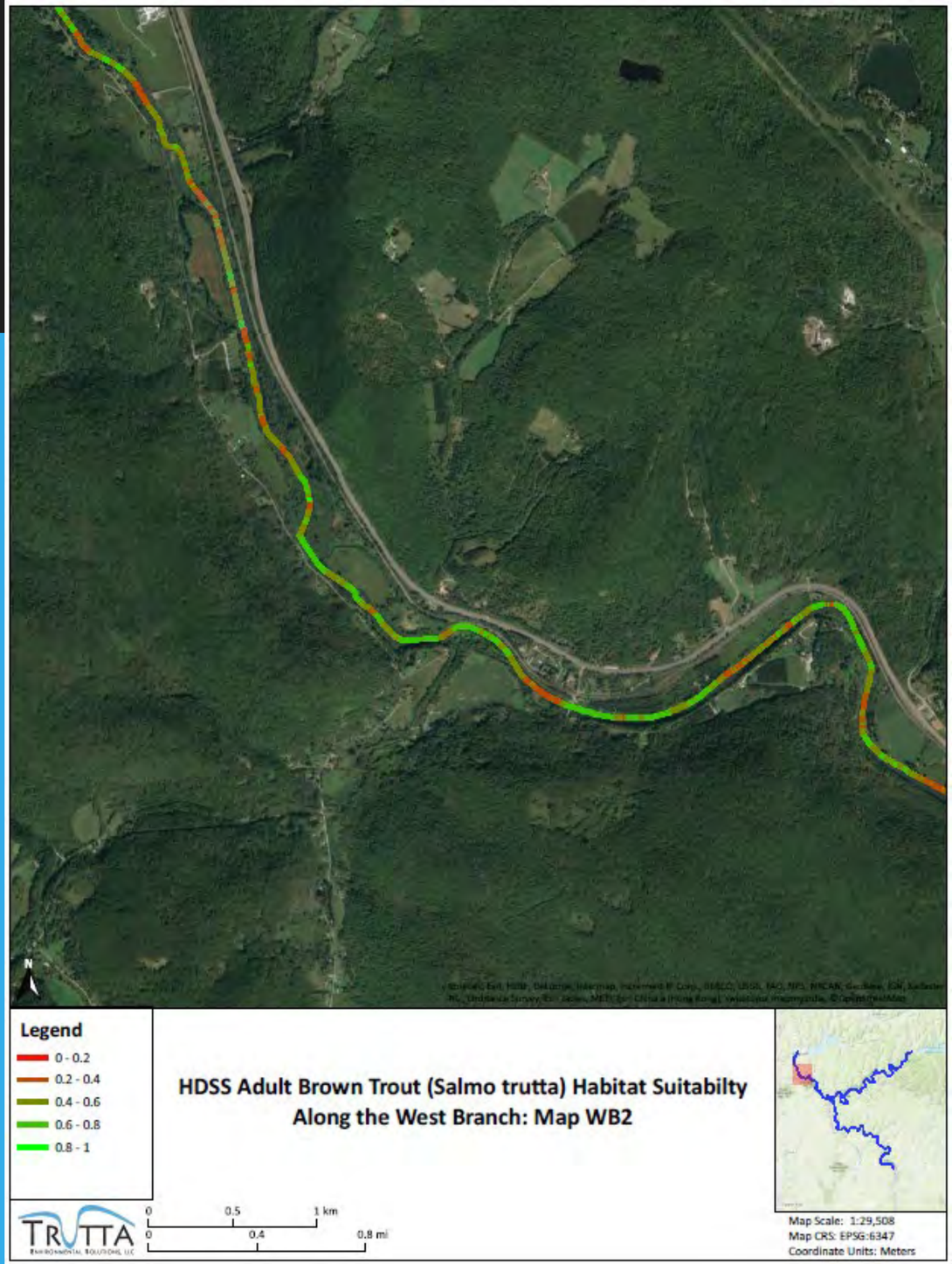
HSI Based on Depth, Velocity, Substrate & Cover

RIVER RESEARCH AND APPLICATIONS
River Res. Applic. **32**: 1765–1775 (2016)
Published online 31 March 2016 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/rra.3025

EVALUATING METHODS TO ESTABLISH HABITAT SUITABILITY CRITERIA: A CASE STUDY IN THE UPPER DELAWARE RIVER BASIN, USA

H. S. GALBRAITH[a]*, C. J. BLAKESLEE[a], J. C. COLE[a], C. A. TALBERT[b] AND K. O. MALONEY[a]
[a] *USGS Leetown Science Center, Northern Appalachian Research Laboratory, Wellsboro, Pennsylvania USA*
[b] *USGS Fort Collins Science Center, Fort Collins, Colorado USA*

Segment	Brown Trout Adult	Brown Trout Juvenile	Brown Trout Spawning	Rainbow Trout Adult	Rainbow Trout Juvenile
West Branch	0.52	0.53	0.41	0.63	0.64
Upper East Branch	0.45	0.52	0.44	0.56	0.54
Lower East Branch	0.56	0.49	0.38	0.63	0.62
Delaware River	0.63	0.45	0.32	0.67	0.65



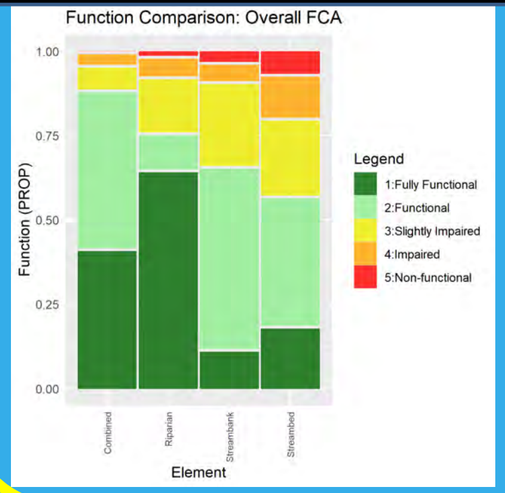
Habitat Suitability: Applications

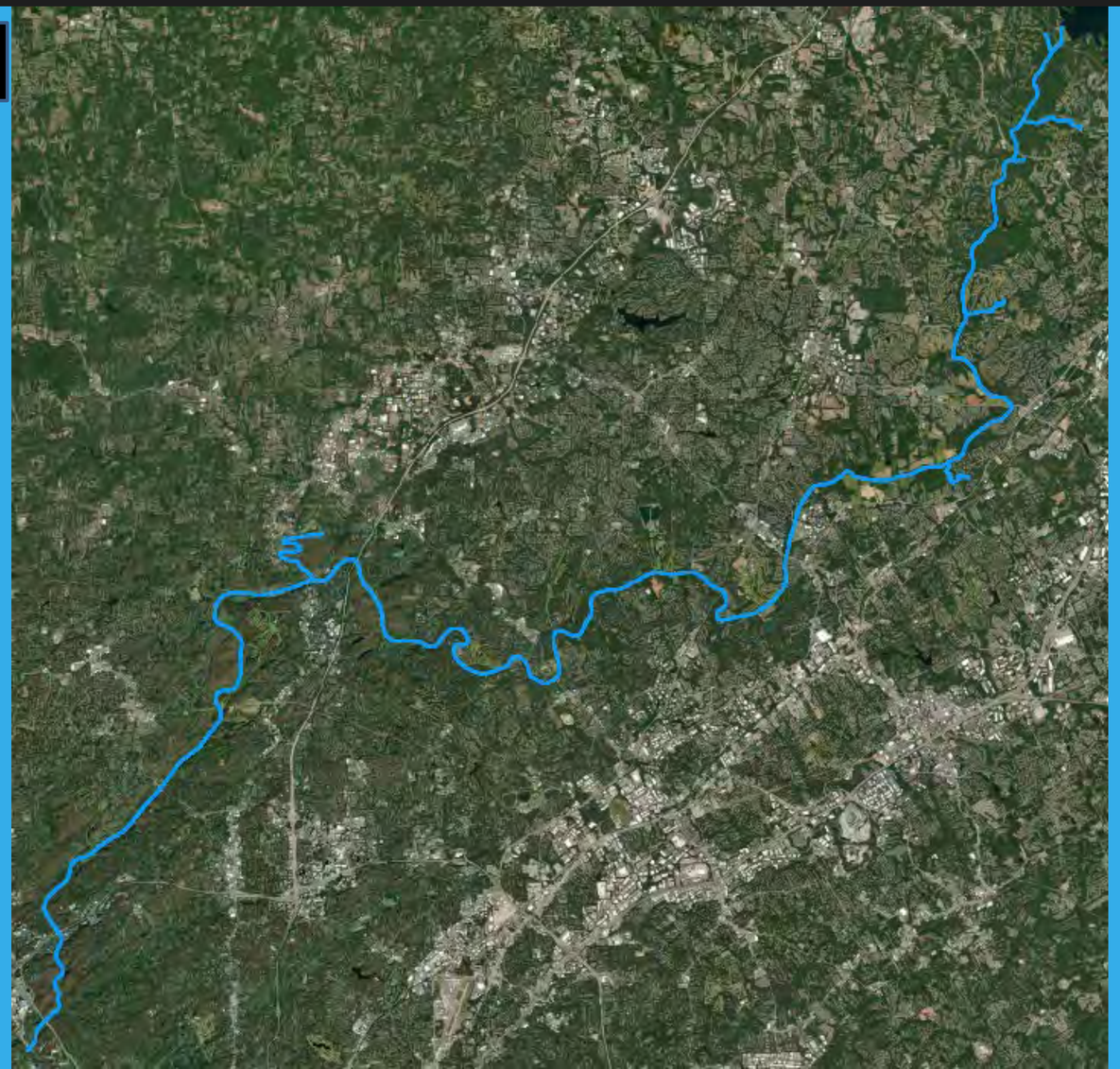
Species Suitability:
Compare sites near good adult habitat with good spawning habitat

Impact Assessment:
Effluent location impact on high quality habitat downstream

Multiscale Assessment Framework

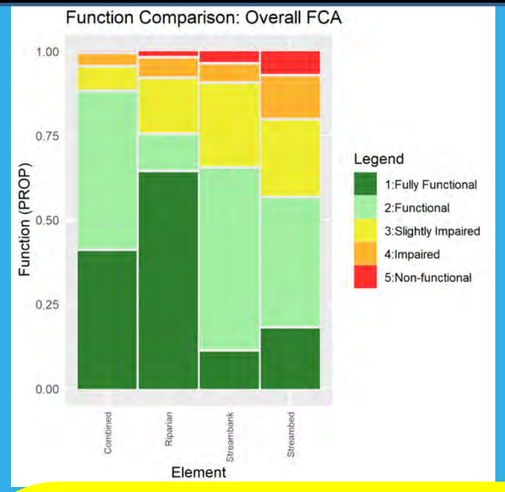
Park



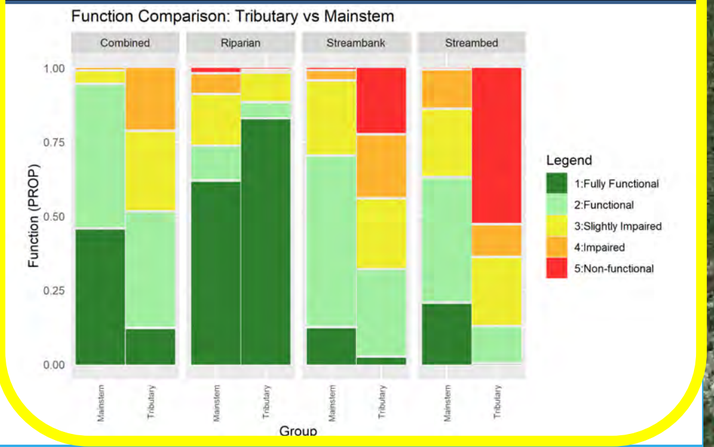


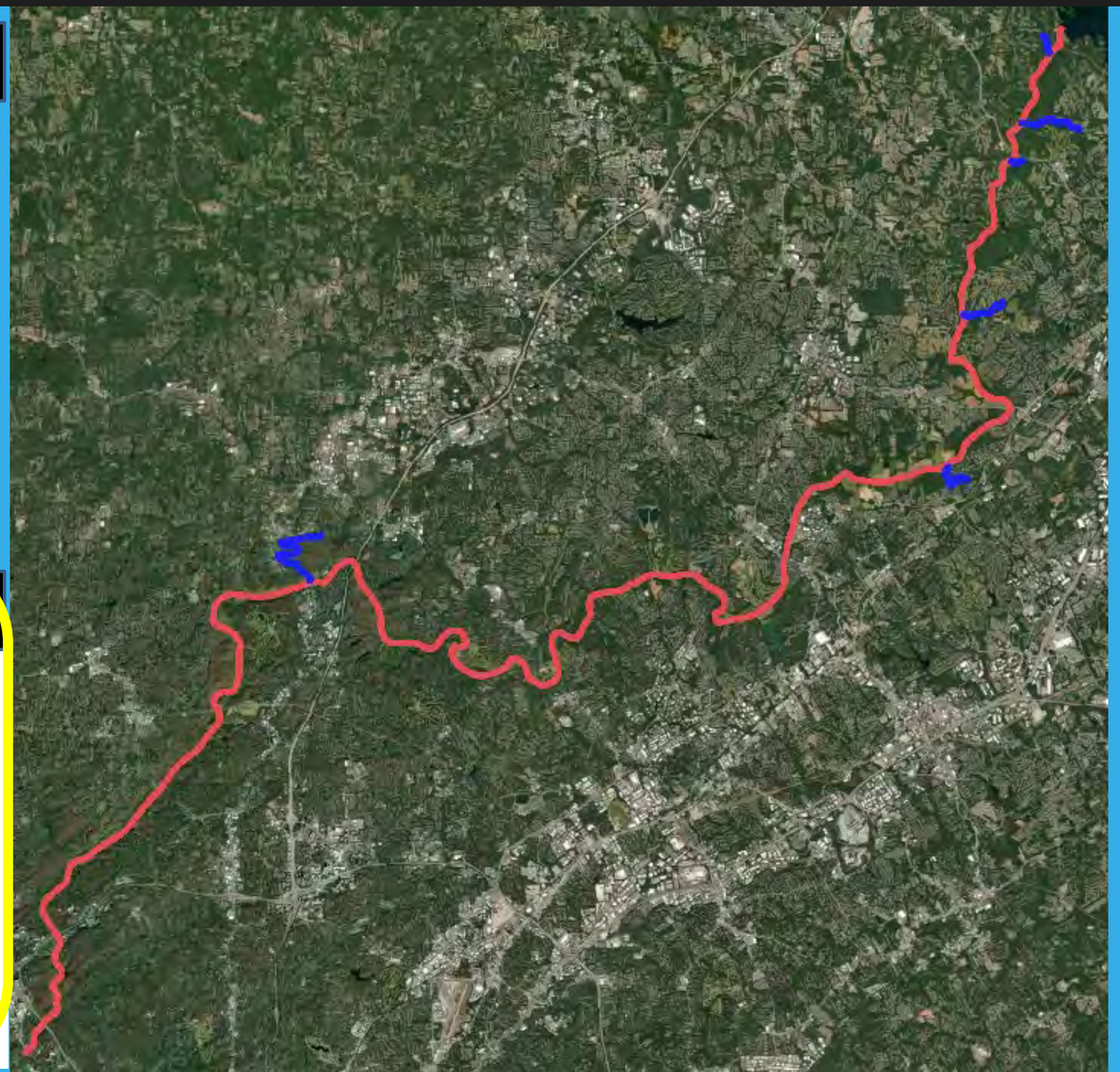
Multiscale Assessment Framework

Park



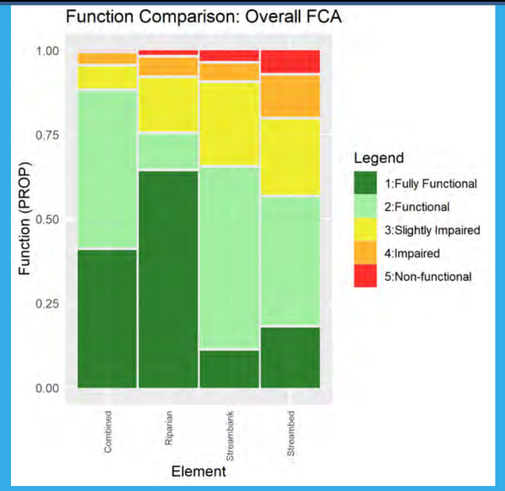
River vs. Tributaries



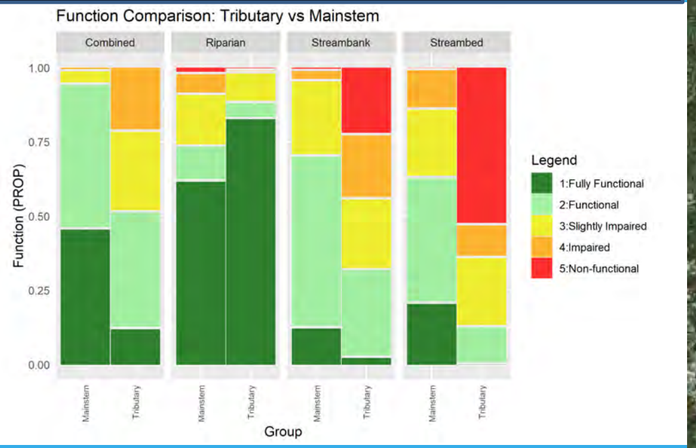


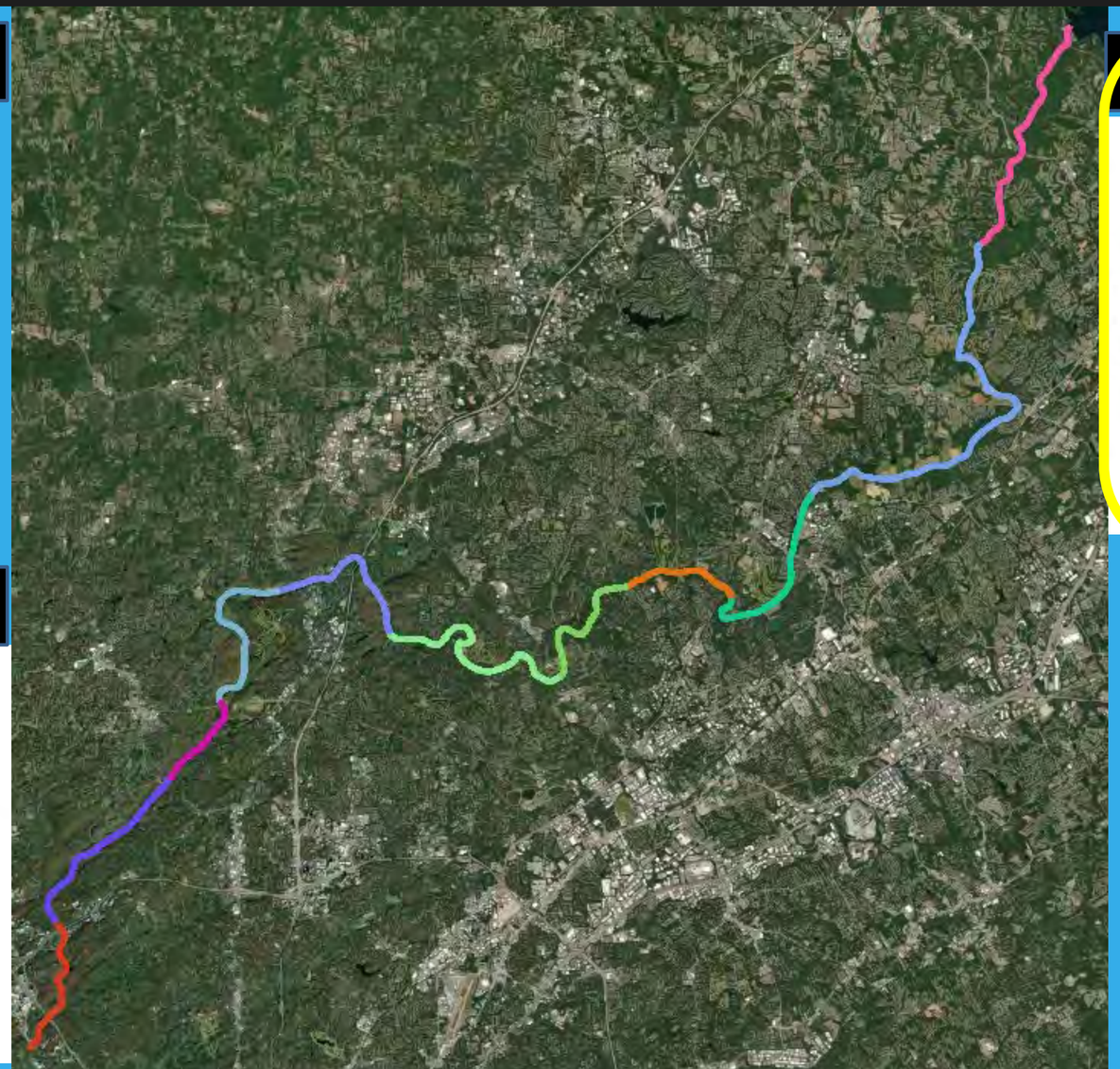
Multiscale Assessment Framework

Park

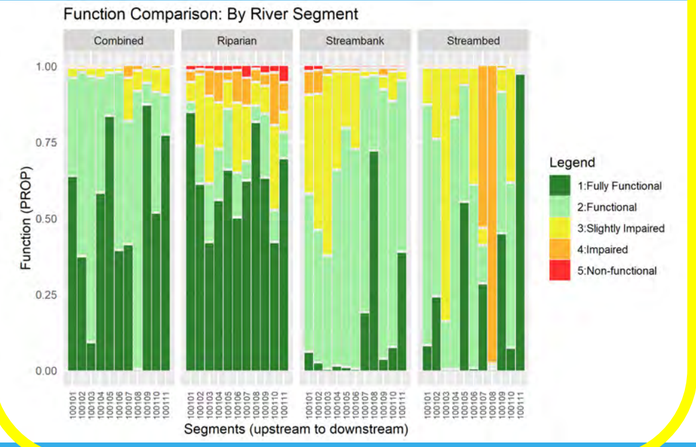


Tributaries vs. River



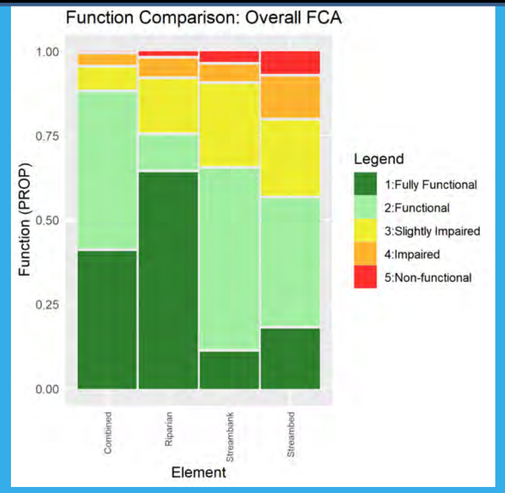


River Segments

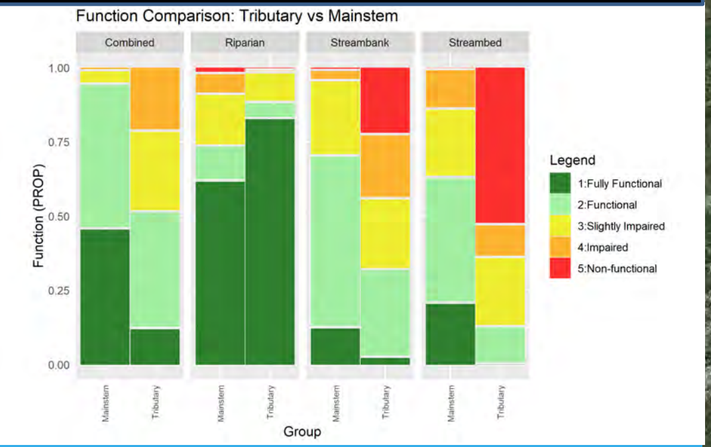


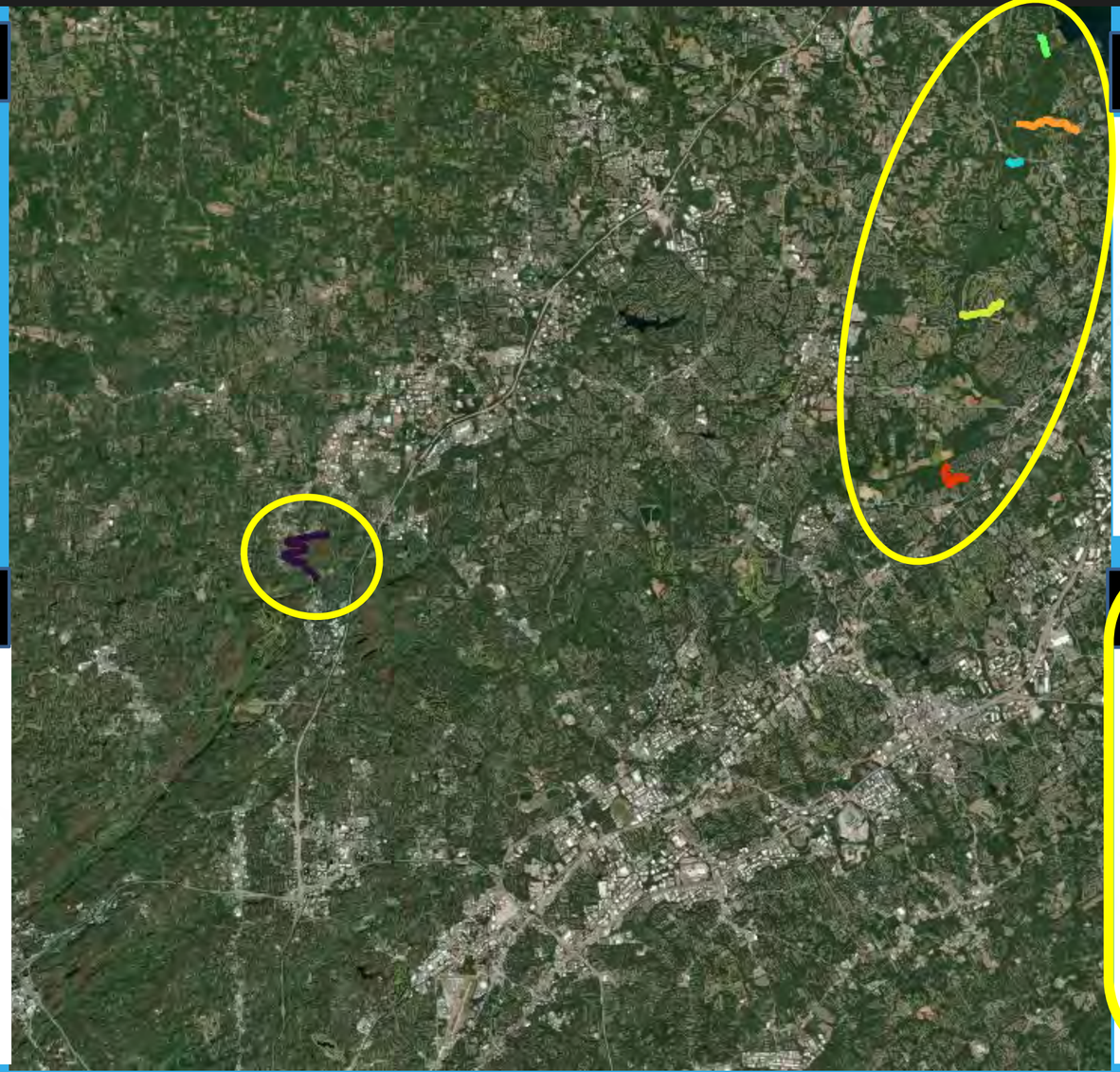
Multiscale Assessment Framework

Park

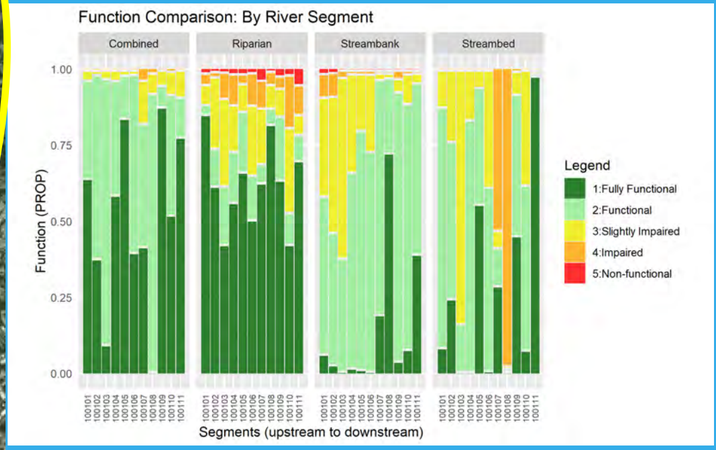


Tributaries vs. River

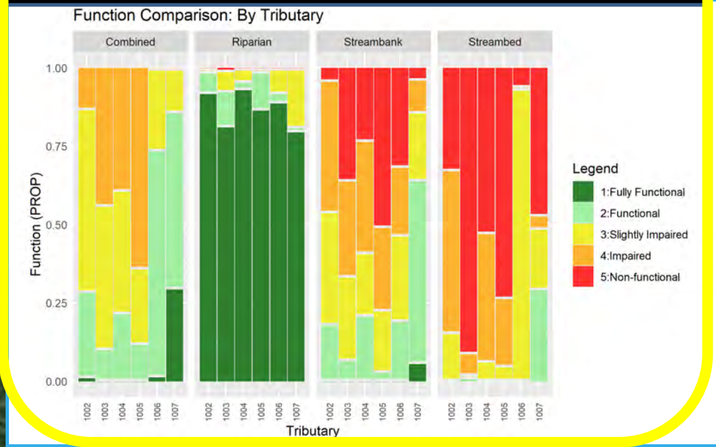




River Segments



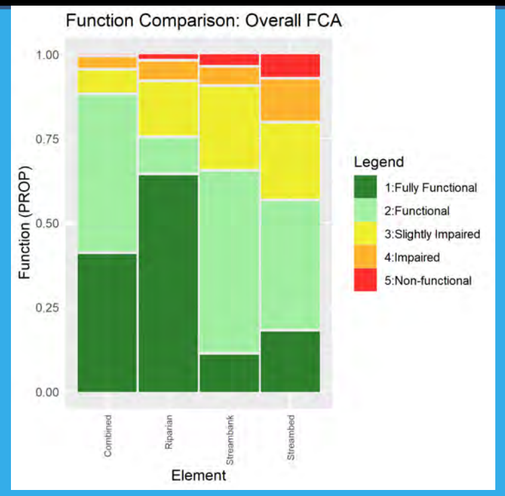
Tributaries



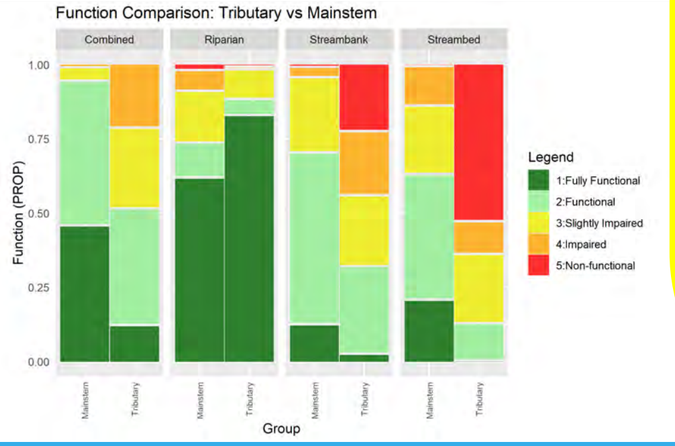
Multiscale Assessment Framework

Sites of Concern

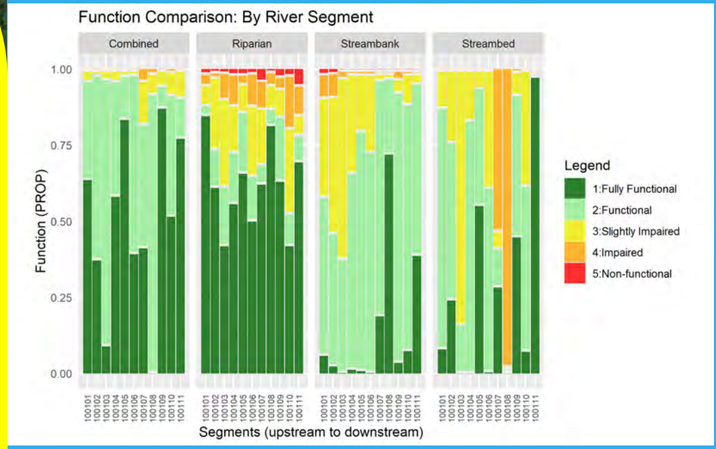
Park



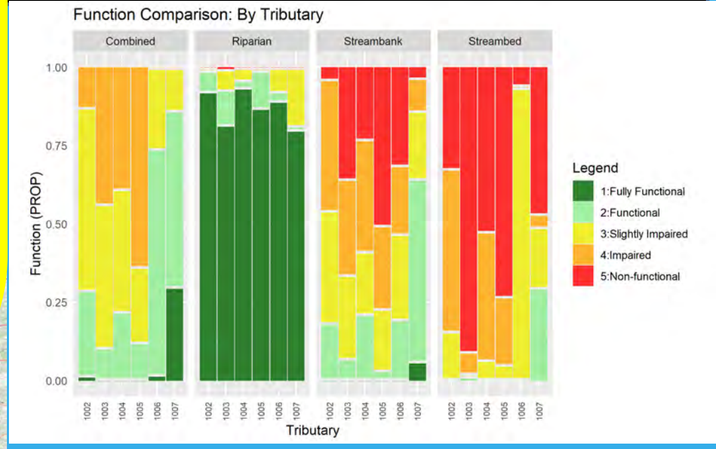
Tributaries vs. River



River Segments



Tributaries



Multiscale Assessment Framework

Sites of Concern

2.4.1 Haw Creek

Overall Function in Haw Creek was affected primarily from excessive stormwater and sediment runoff. [illegible] this was the only site where no Severe Points were documented. Overall Condition for Haw [illegible] and streambank function (Figure 42).

Site Overview

Figure 42. Image of Haw Creek identifying two sites of concern (i.e., HC1 and HC2).

Site of Concern – HC1

Site Metrics: Site of Concern HC1 (Figure 43) occurred in Haw Creek (1012), on StreamView video track 2 between the [illegible] 2:22. [illegible] had a condition score of 3.8, function score of [illegible]

Site Metrics

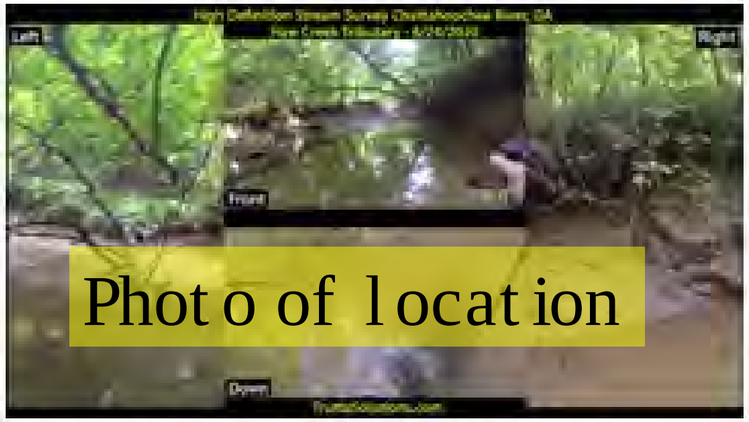


Photo of location

Figure 43. Image from the HC1 segment of Haw Creek observed on 6/26/2023 at 11:25:22.

Problem: *The HC1 segment of Haw Creek is located in the middle lower portion of the surveyed stream and is considered a SOC to due to impacts on the function of streambed and streambanks.* This segment had active channel [illegible] consisting of streambanks that were eroding and collapsing into the stream [illegible] and filled with fine sediment. In addition to the active channel [illegible] was present and classified as negligible and minor and, therefore, it was not excessive and not of concern. No streambed or streambank protective measures (i.e., modification) were documented within this *SOC*.

Problem

Problem Cause: *Haw Creek overall appeared to suffer from excessive stormwater and sediment runoff.* The excessive stormwater and sediment are likely from development and increased impervious surfaces in the upstream watershed. The increased frequency and magnitude in flow volumes during heavy rainfall events exceed the natural capacity of the stream and therefore cause excessive erosion along the stream [illegible] noted that backwater jacking and intrusion (Li et al. 2020) occurring in tributaries [illegible] data to often observed. This tributary would experience intrusion with increased discharge along the mainstem, resulting in an increased water surface elevation within the tributary. Backwater jacking would occur when the discharge along the mainstem would decrease resulting in a decrease in water surface elevation.

Cause

Restoration Approach: *A channel restoration designed to effectively transport water during high flow events and pass sediment through the system.* The specifics of this restoration action are difficult to determine from the field surveys since controls for both stormwater and sediment from the upstream [illegible] control measures near its confluence with the Chattahoochee River. These actions should also be coordinated with the other SOC along Haw Creek as all suffer from the stormwater and sediment problems.

Restoration Approach

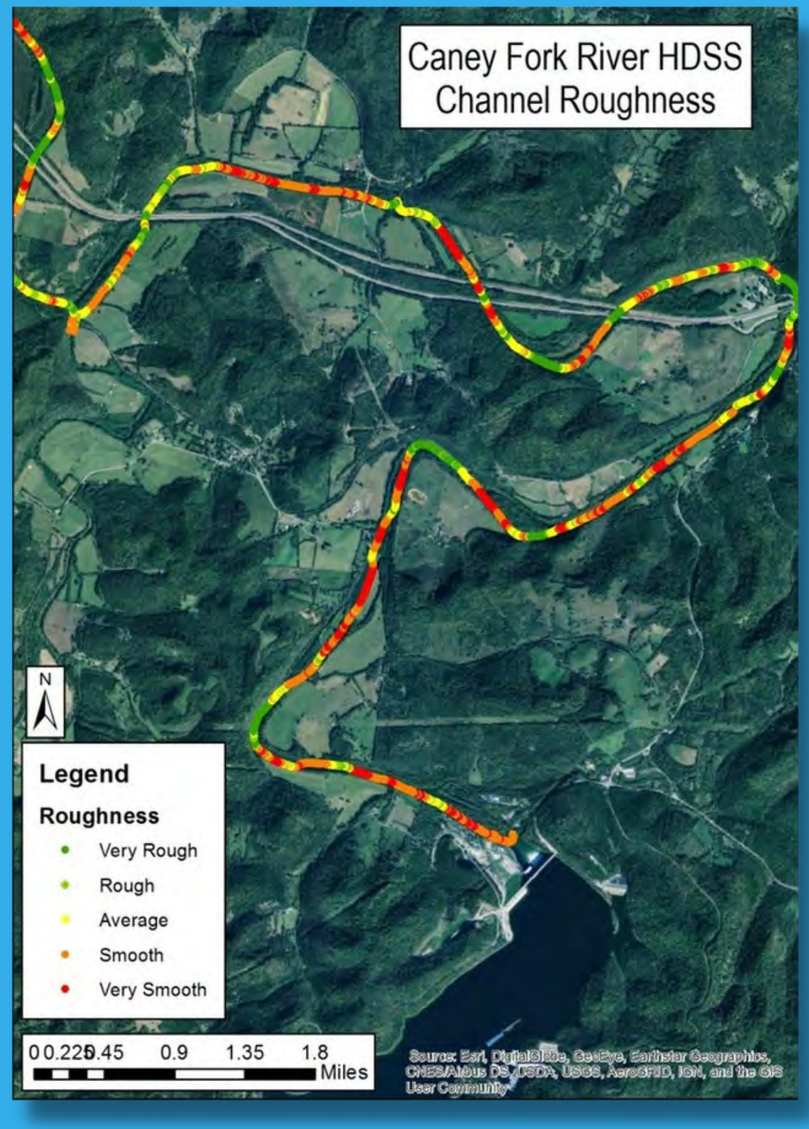
Access: *Easy*. This area would be accessed from Bowmans Island parking lot or Lower Pool Rd., allowing access for heavy equipment [illegible] restoration effort. Access on foot should be easy since the property lies within the North Unit of Bowmans Island of the CHAT.

Access

Correctability: *Difficult*. The mitigation of stormwater runoff problems requires modifications upstream of this location and/or substantial channel restoration efforts at this site. It is likely to require extensive [illegible] restoration effort.

Correctability

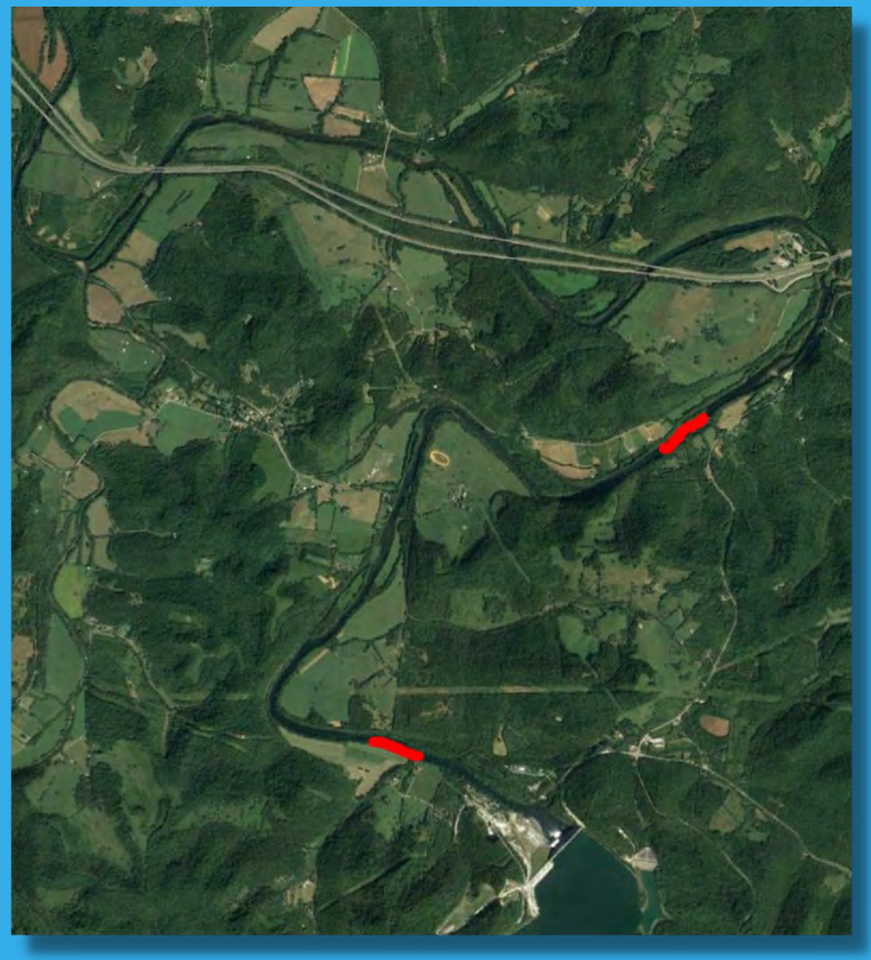
project suitability: Selecting A Site



Locations with:

- Highest Ecological Lift
- Greatest Accessibility
- Lowest Cost

Determine most suitable restoration technique



One Survey Many Uses

Hydropower

Wildlife

Stormwater
MS4

Transportation

Environmental
& Non-Profits

Water Quality
- Longitudinal Profile
- Tributary input
- Sediment TMDLs
- Point & Non-Point Source Impacts

Water Quantity
- Channel Profiles
- Channel Capacity
- Flood Risk Models
- Drought impacts
- Instream Flow

Habitat
- Riffle, Run, Pool Delineation
- Substrate Types
- Embeddedness
- Instream Cover
- Riparian Condition

HDSS
Cross-sectional Transects
and
Longitudinal Surveys

Infrastructure
Location, Extent & Condition of:
- Bridges
- Intakes & Outfalls
- Bank Stabilization
- Dams, etc.

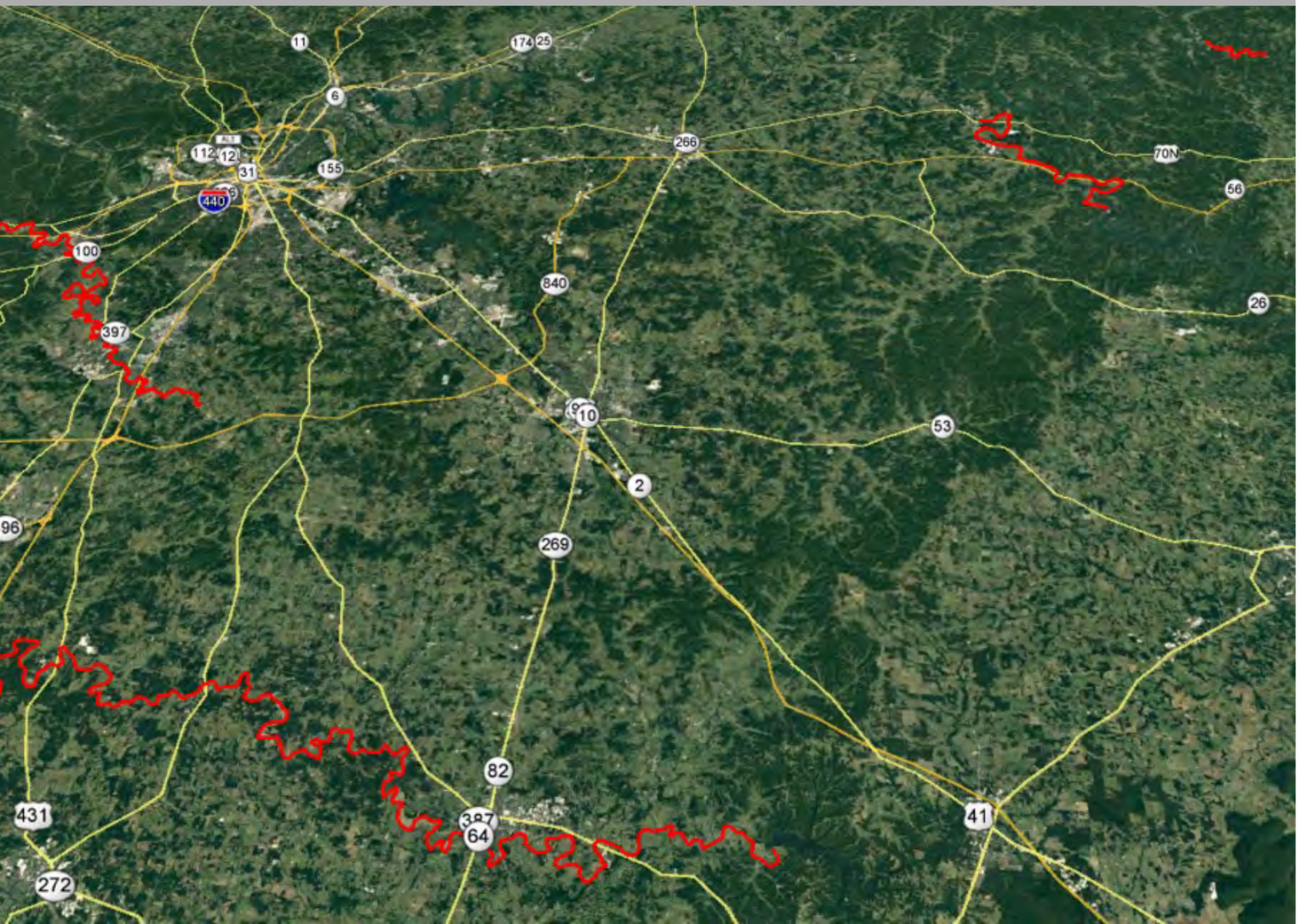
Outreach
- Virtual Stream Tours
- Integrates with Aerial Imagery
- StreamView Dashboards show data and stream conditions

Stream Corridor Assessment
- Current Conditions Archive
- Restoration Prioritization
- Mitigation Potential

Integrated Planning Framework
HDSS supports integrated planning by providing high-quality, multi-attribute, geo-referenced data of the entire stream channel

TRUTTA
ENVIRONMENTAL SOLUTIONS, LLC

federal, state &local partners



NATIONAL PARK SERVICE

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

TN Department of Environment & Conservation

DAR
Hawaii Division of Aquatic Resources

FRIENDS OF THE UPPER DELAWARE RIVER
FUDR

WILSON OKAMOTO CORPORATION

TROUT UNLIMITED

VOLKERT

SOUTHERN COMPANY

Hazen

Stantec

TENNESSEE WILDLIFE RESOURCES AGENCY

SEAL OF THE CITY
CLEVELAND
1842
TENNESSEE

SOUTH CENTRAL Tennessee DEVELOPMENT DISTRICT

RAMBOLL

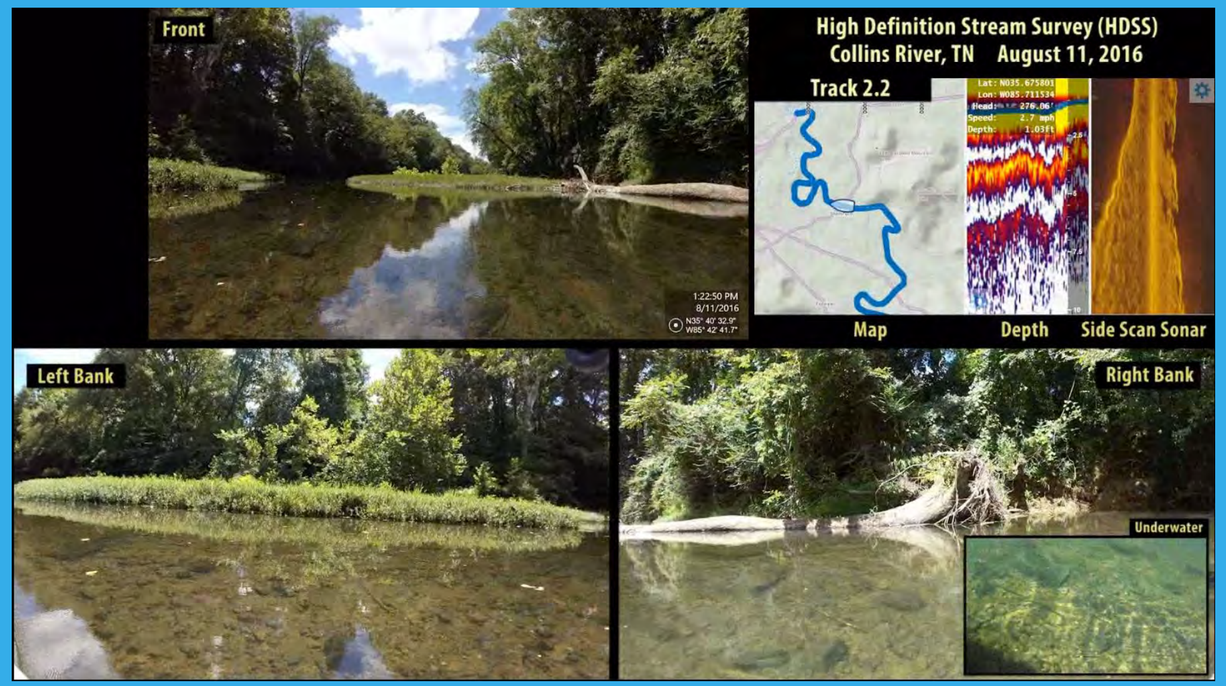
CITY OF LEWISBURG TENNESSEE

CPWS
Columbia Power & Water Systems

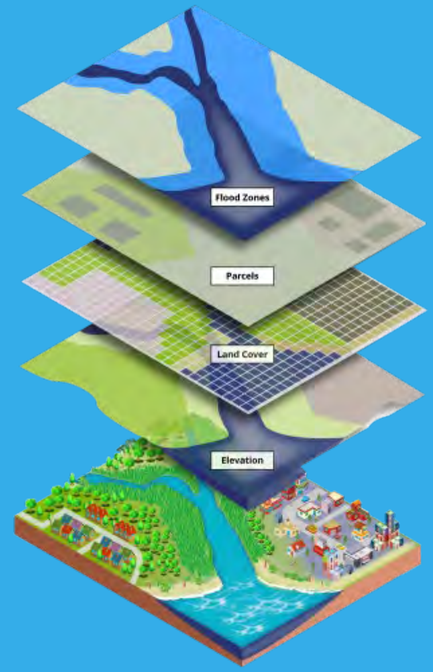
The Nature Conservancy

Data Management and Deliverables

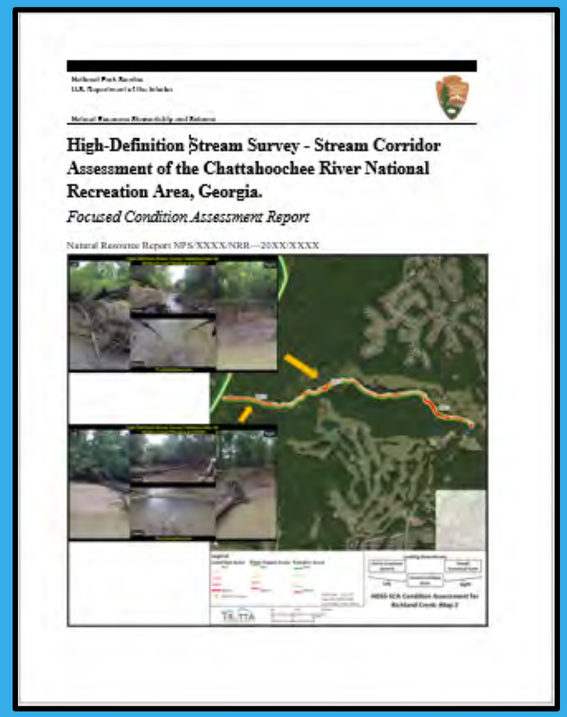
StreamView Video
(Video files - .mp4)



GIS Data
(Geopackages - .gpkg)



Report
(pdf)


High-Definition Stream Survey - Stream Corridor Assessment of the Chattahoochee River National Recreation Area, Georgia.

Focused Condition Assessment Report

≈ 500gb to 1tb per day

TRUTTA

ENVIRONMENTAL SOLUTIONS, LLC

BETTER DATA. BETTER DECISIONS.

Jim.Parham@TruttaSolutions.com
TruttaSolutions.com

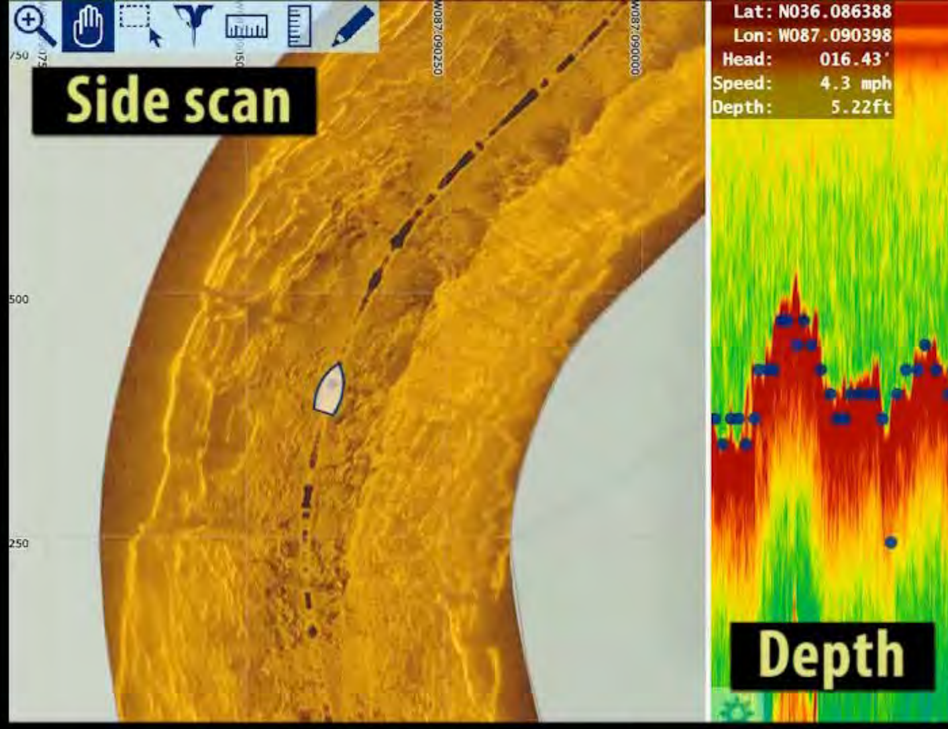
SBA U.S. Small Business Administration WOSB CERTIFIED

SBA U.S. Small Business Administration 8(a) CERTIFIED

SBA U.S. Small Business Administration EDWOSB CERTIFIED


Map
SR 249
Harpeth River

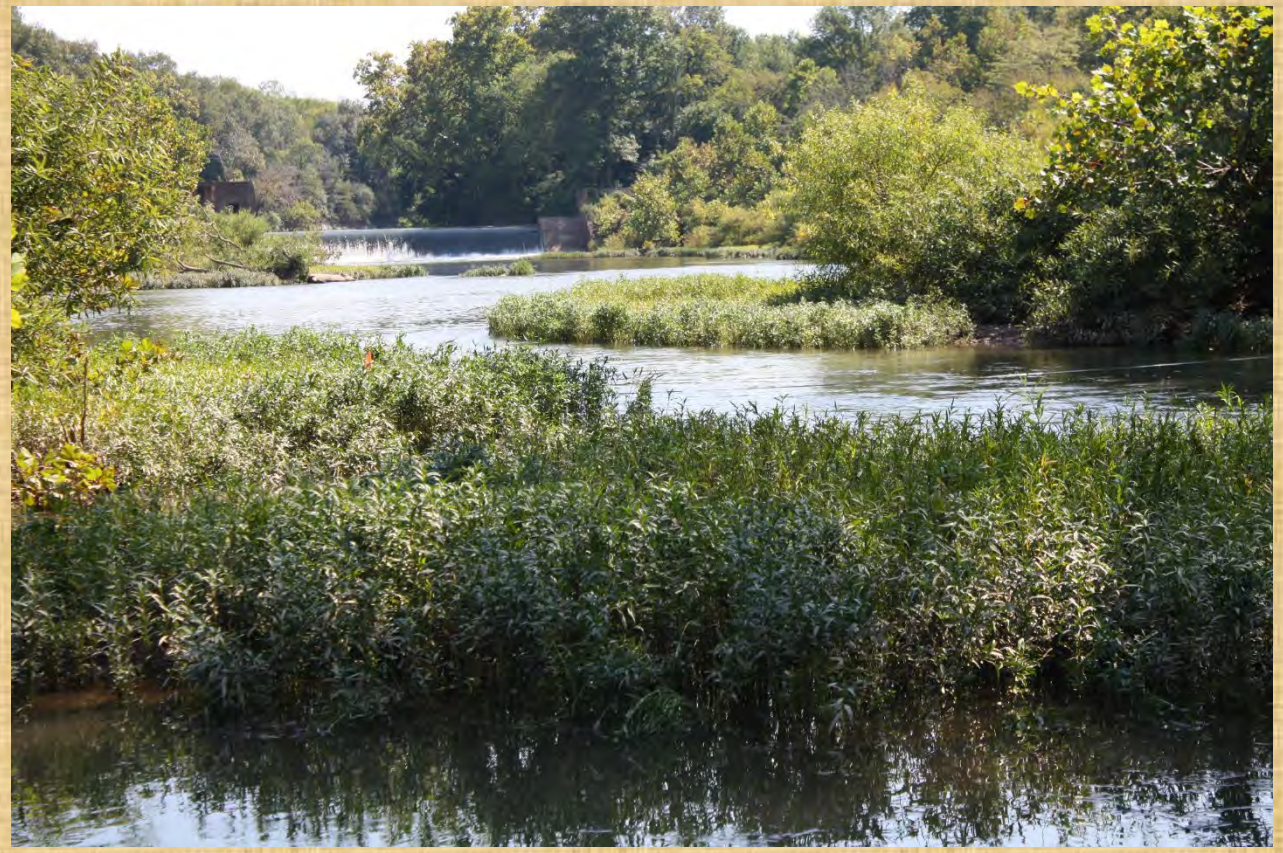

Harpeth River HDSS
March 7, 2016
Front


Side scan
Lat: N036.086388
Lon: W087.090398
Head: 016.43°
Speed: 4.3 mph
Depth: 5.22ft
Depth


Left Bank


Right Bank

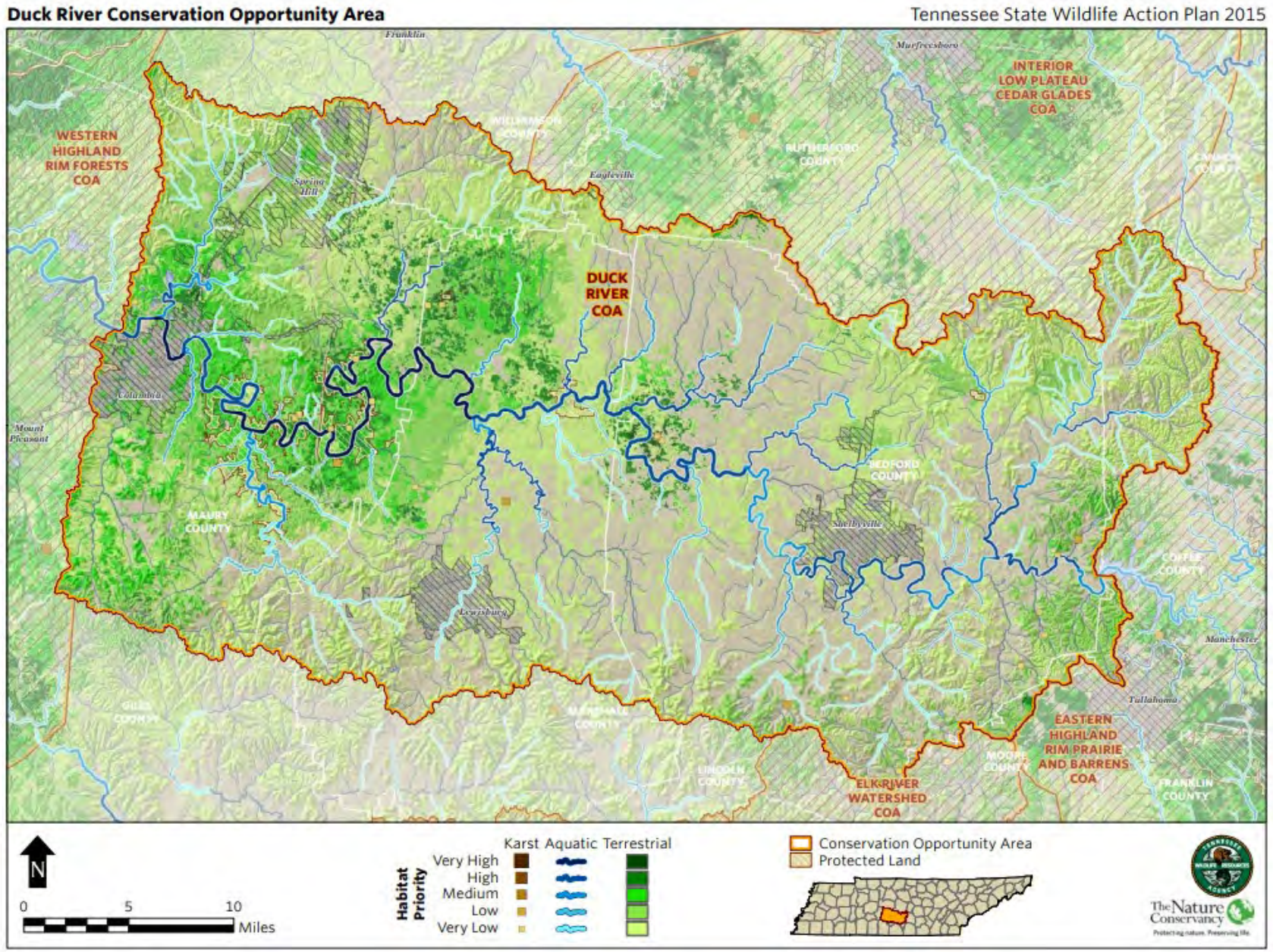
Federal T&E and At-Risk Mussels of the Duck River drainage, Tennessee



Andy Ford - U.S. Fish and Wildlife Service, Tennessee Field Office

1st Annual Duck River Symposium, Henry Horton State Park, Chapel Hill, Tennessee

December 7, 2022



Duck River, by the numbers:

- **284 miles**

Longest river entirely within the state of Tennessee.

- **650 aquatic species**

Most biologically diverse in NA
Includes:
  - 151 fishes
  - 75 mussels
  - 22 snails

- **25% of NA mussels occur within the Duck River Watershed**
  - 20 listed
  - 3 proposed for listing
  - 5 petitioned for listing

- **150 miles Federally Designated Critical Habitat**

Endangered Species Act of 1973 (as amended, 16 U.S.C. 1531 et seq.)

Endangered Species – "…any species which is in danger of extinction throughout all or a significant portion of its range."

Threatened Species – "…any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

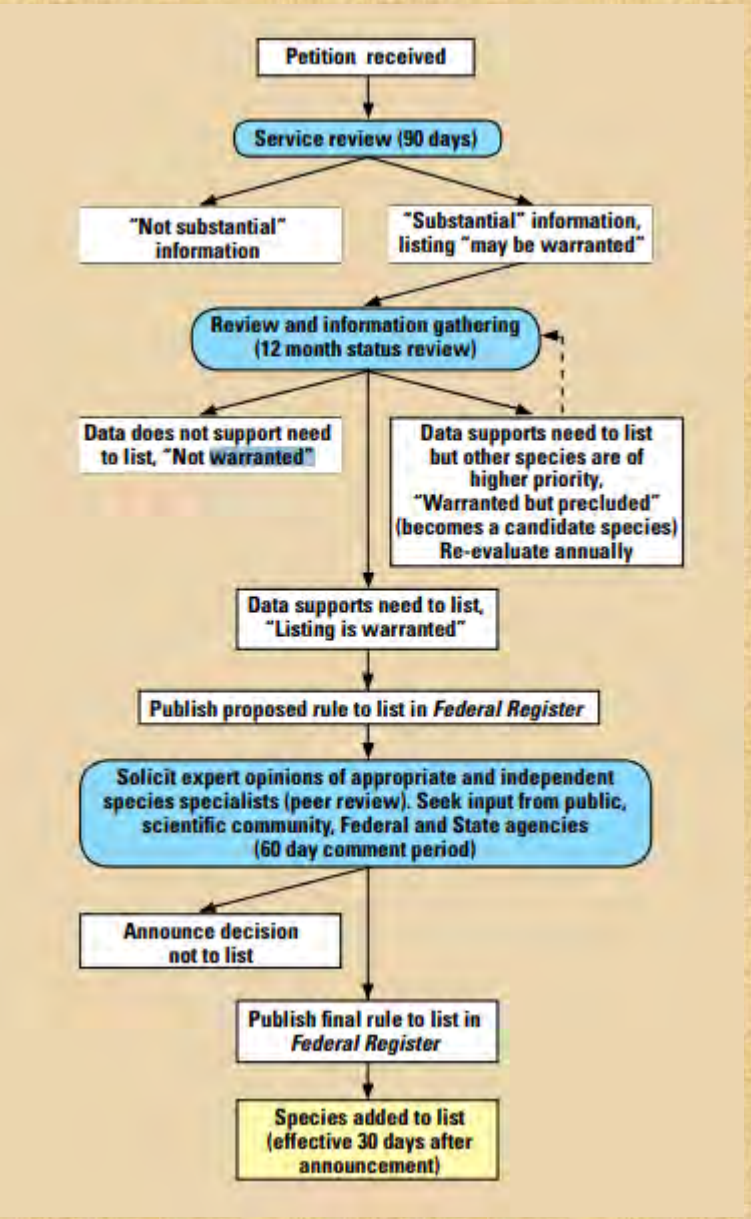
Proposed Species – "…any species of fish, wildlife or plant that is proposed in the Federal Register to be listed under section 4 of the Act."

Candidate – "means any species being considered by the Secretary for listing as an endangered or threatened species, but not yet the subject of a proposed rule."

- proposed listing regulation is precluded by other higher priority listing activities
- placed on the candidate list through the petition process.

Petitioned (Under Review) – "formal request to list a species as endangered or threatened under the ESA."

- 90 day finding – "Not substantial" or "Substantial"
- 12 month status review – "Not Warranted", "Warranted but Precluded", or "Warranted"



Mussels Currently Petitioned for Listing

(https://www.fws.gov/project/national-listing-workplan)

Cumberland Moccasinshell (*Medionidus conradicus*) – FY 2022
Tennessee Clubshell (*Pleurobema oviforme*) – FY 2022
Tennessee Pigtoe (*Pleuronaia barnesiana*) – FY 2022

Tennessee Heelsplitter (*Lasmigona holstonia*) – FY 2023
"Barrens Heelsplitter" (*Lasmigona sp. cf. holstonia*)

Salamander Mussel (*Simpsonaias ambigua*) – FY 2023

National Domestic Listing Workplan

FY22-27 Workplan (March 2022 Version)

Key to Action Types: 12M/PLPCH – 12-month finding on a petition to list a species. If listing is warranted, we generally intend to proceed with a concurrent proposed listing rule and proposed critical habitat designation, if critical habitat is prudent and determinable.

Discretionary Status Review/PLPCH – Status review undertaken by discretion of the Service. Results of the review may be to propose listing, make a species a candidate for listing, provide notice of a not warranted candidate assessment, or other action as appropriate.

PLPCH: For species that are already candidates for listing, a proposed listing determination would either propose the species for listing or provide notice of a not warranted finding. We generally intend to propose critical habitat designations concurrent with proposed listing rules, to the extent

PCH: For species that are already listed, a proposed critical habitat rule will propose to designate critical habitat for the species, if we find critical habitat is prudent.

rPCH: Revised proposed critical habitat rule.

Bolded entries have court-ordered dates associated with them.

Package Name	Common Name	Action Type	Lead FWS Legacy Region	DOI Unified Region	Priority Bin Ranking/LPN	Fiscal Year	Range	Scientific Name
	Columbia oregonian snail	12M/PLPCH	R1	9	5	FY22	OR, WA	*Cryptomastix hendersoni*
	evening fieldslug	12M/PLPCH	R1	9	5	FY22	OR, WA	*Deroceras hesperium*
	cactus ferruginous pygmy-owl	**12M/PLPCH**	**R2**	**6**	**N/A**	**FY22**	**AZ, Mexico**	***Claucidium brasilianum cactorum***
	roundtail chub	**12M/PLPCH**	**R2**	**8**	**3**	**FY22**	**AZ, NM, CO**	***Gila robusta***
	Sacramento Mountains checkerspot butterfly	Discretionary/PLPCH	R2	6	1	FY22	NM	*Euphydryas anicia cloudcrofti*
	Sonoran desert tortoise	**12M/PLPCH**	**R2**	**8**	**LPN 5**	**FY22**	**AZ**	***Gopherus morafkai***
	Mammoth Spring crayfish	12M/PLPCH	R3	3	3	FY22	AR, MO	*Orconectes marchandi*

Spectaclecase (*Cumberlandia monodonta*) Federally Endangered

Date Listed: April 12, 2012

Occurs primarily in the lower Duck

Rare in the Duck, but likely under sampled due to the specific habitat in which it occurs (deeper pools and runs, under slab rocks).

Limited numbers have been translocated to Lillards Mill in 2007 and 2008.

National Workplan – proposed CH due in FY 25

Fanshell (*Cyprogenia stegaria*) Federally Endangered

Date Listed: June 21, 1990

Species was extirpated from the Duck, but has been reintroduced using translocated individuals from the Clinch River (2013-2016).

Translocated individuals are persisting and brooding females have been documented, but not natural recruitment has been documented to date.

Reintroductions into the Duck has been identified as a priority action.

Duck River Dartersnapper (*Epioblasma ahlstedti*) Federally Endangered

Date Listed: January 10, 1997 (Oyster Mussel)
Critical Habitat Designated: August 31, 2004

Oyster mussel split into the DRDS in 2010.

Only extant in the Duck River, and is restricted to a single stretch (28 river miles) in the middle portion of the river.

Propagation and reintroduction has recently been begun for the species at CRAC in the lower Buffalo River.

Cumberlandian Combshell (*Epioblasma brevidens*) Federally Endangered

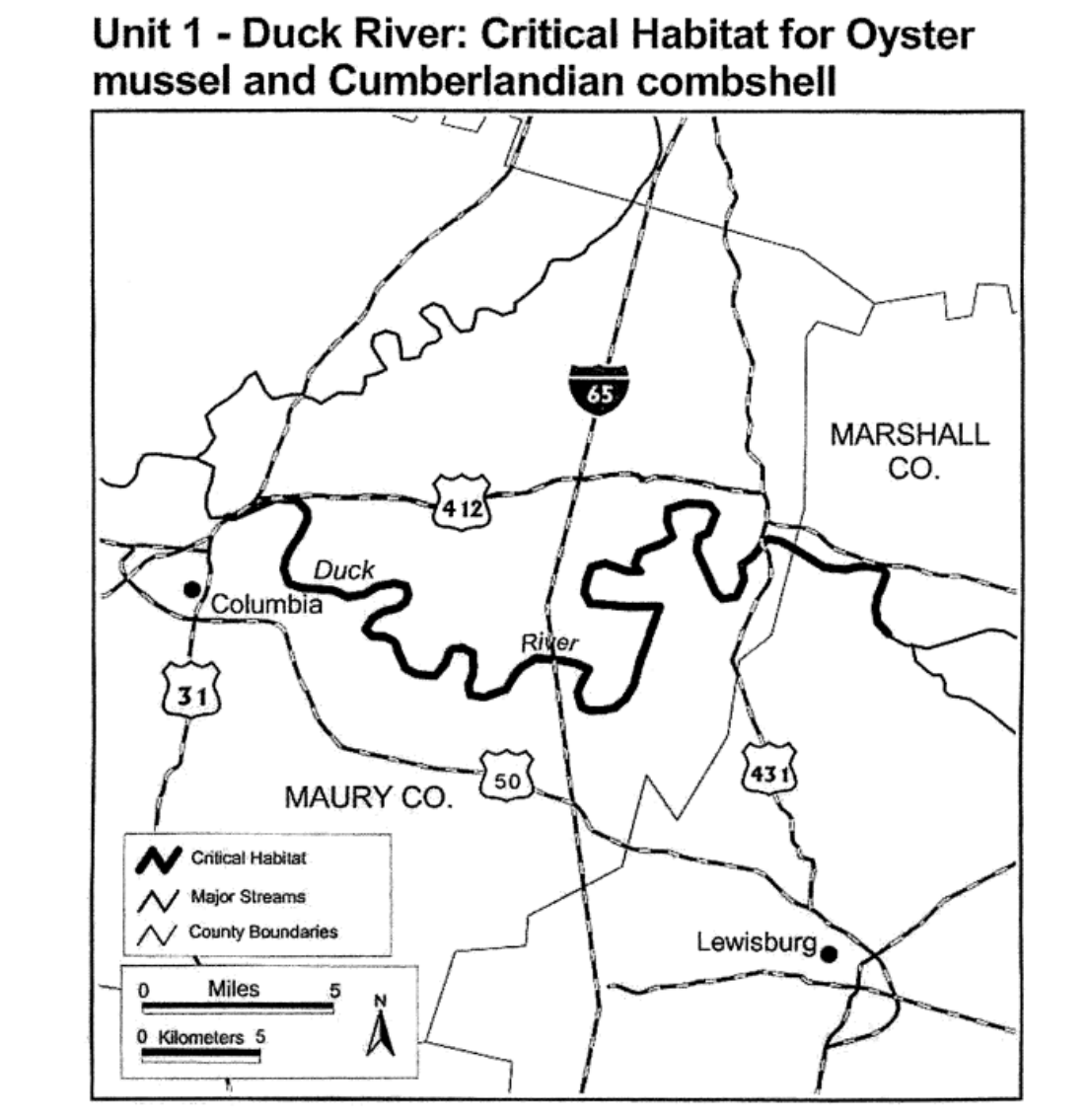
Date Listed: January 10, 1997
Critical Habitat Designated: August 31, 2004

Only extant in the Big South Fork (KY/TN) Clinch River (TN/VA), Powell River (VA), Buck Creek, (KY), and Bear Creek (AL/MS).

Has been reintroduced into the Duck River between 2007-2017 using Clinch River broodstock.

Growth and reproductive behavior have been observed in the Duck, but natural recruitment has not yet been documented.

Designated Critical Habitat for the Duck River Dartersnapper and Cumberlandian Combshell in the Duck River.



Unit 1 includes the main stem of the Duck River from rkm 214 (rmi 133) (0.3 rkm (0.2 rmi) upstream of the First Street Bridge) in the City of Columbia, Maury County, Tennessee, upstream to Lillard Mill Dam at rkm 288 (rmi 179), Marshall County, Tennessee.

Catspaw (*Epioblasma obliquata*) Federally Endangered

Date Listed: July 10, 1990

Only extant in a single stream (Killbuck Creek, OH). Has recently been reintroduced into the several historical tributaries (Licking River, KY; Green River, KY; Walhonding River, OH) in the Ohio River drainage, and the Duck River in Tennessee (2 sites).

Reintroduction effort has released 1,315 individuals to the Duck River since 2017.

Growth and reproductive behavior have been observed in the Duck, but natural recruitment has not yet been documented.

Snuffbox (*Epioblasma triquetra*) Federally Endangered

Date Listed: March 15, 2012

Historically was locally common (40-50 years ago) in the Duck River, but may have been extirpated prior to reintroduction efforts.

Reintroductions into the Duck have occurred in 2011-2013 via Clinch River translocations (n=369) and in 2019 using propagated individudals (n=214).

National Workplan – proposed CH due in FY 25.

Snuffbox (*Epioblasma triquetra*) Federally Endangered

Tan Riffleshell (*Epioblasma walkeri*) Federally Endangered

Date Listed: September 26, 1977

The species is considered extirpated from Duck River.

Live individuals were last collected from the Duck in 1964 and a single fresh dead shell was last found in 1988.

Only currently extant in the Big South Fork, TN/KY (12 river miles) and Indian Creek, VA (2 river miles).

Longsolid (*Fusconaia subrotunda*) Federally Proposed Threatened

Proposed for listing: September 29, 2020

Limited records of the Longsolid exist for the Duck River. Museum record exists from 1985.

The species is likely extirpated from Duck River.

National Workplan – final listing rule and critical habitat designation is due in FY 22, no critical habitat is proposed in the Duck River.

Cracking Pearlymussel (*Hemistena lata*) Federally Endangrered

Date Listed: September, 28, 1989

Currently extirpated from the Duck River system.

TWRA CRAC is currently propagating the Cracking Pearlymussel from the Elk River for reintroduction into the Buffalo River and Duck River.

Pink Mucket (*Lampsilis abrupta*) Federally Endangrered

Date Listed: June 14, 1976

Uncommon in the Duck and occurs primarily in the lower portions of the river as it is more common in the Tennessee River mainstem, but we do have museum records from around Columbia.

This species has been propagated and augmented (2013-2015, n=519) near Lillards Mill using Tennessee River broodstock.

Birdwing Pearlymussel (*Lemiox rimosus*) Federally Endangrered

Date Listed: June 14, 1976

Extant in the upper Clinch, VA/TN; Powell, TN; Duck, TN

The Birdwing Pearlymussel population in the Duck is robust, but is limited to the 45 river miles between the Old Columbia Dam and Lillards Mill.

This population is important for as broodstock for restoration efforts in other historical populations, especially in the lower Tennessee River system (e.g., Sequatchie, Paint Rock, Elk, Buffalo).

Round Hickorynut (*Obovaria subrotunda*) Federally Proposed Threatened

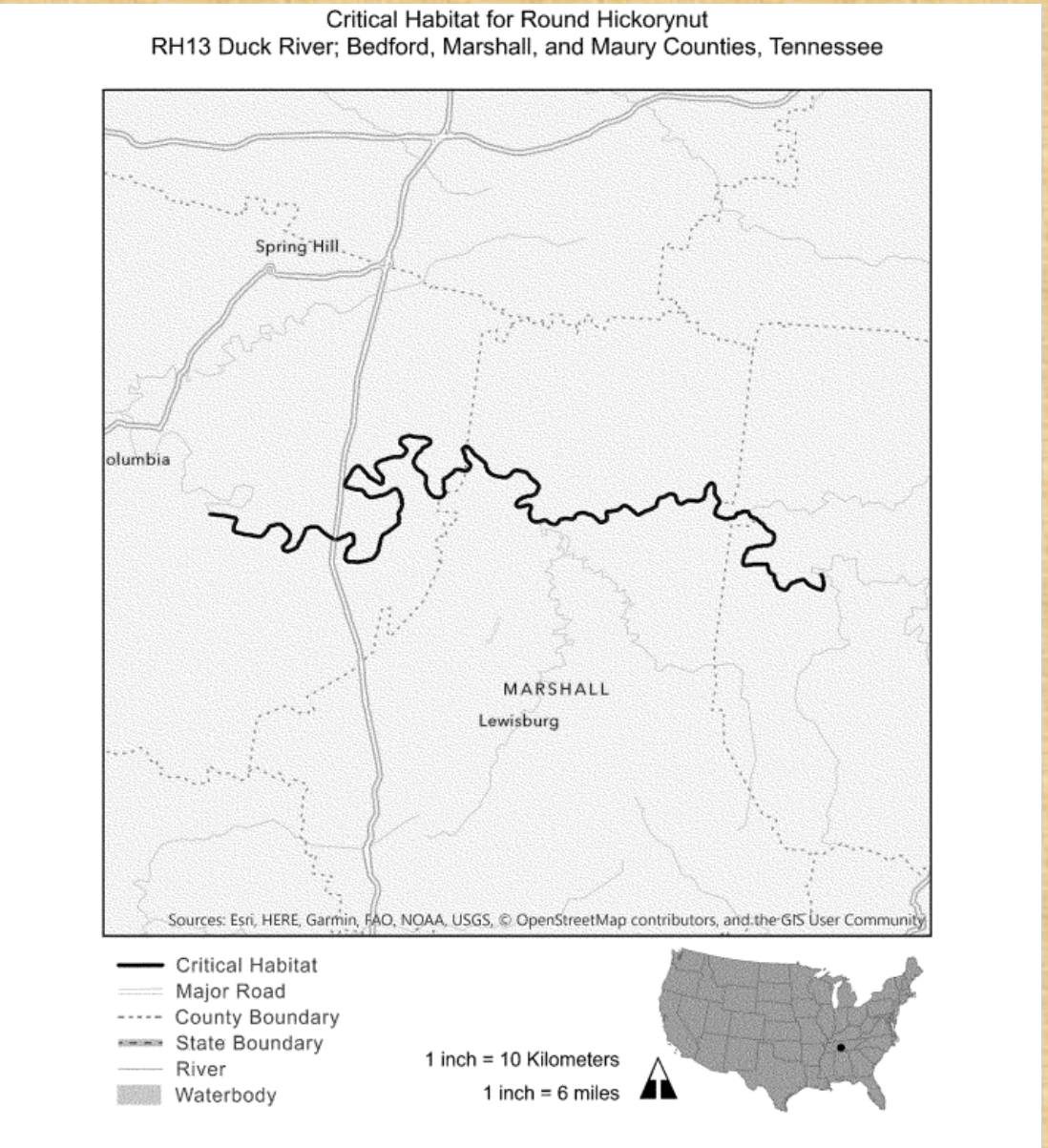
Proposed for listing: September 29, 2020

The Duck River is a stronghold population for the Round Hickorynut. Primarily occurs between between the Old Columbia Dam and Lillards Mill.

The Duck River population has increased in density over the past 30-40 years. In 1979, density was around 0.05 mussels/m^2, today some mussel beds have densities over 4 mussels/m^2.

National Workplan – final listing rule and critical habitat designation is due in FY 22, critical habitat is proposed for the Duck River.

Proposed Designated Critical Habitat for the Round Hickorynut in the Duck River.



Unit RH 13 will consist of 59 river miles of the Duck River in Bedford, Marshall, and Maury Counties, Tennessee, from its confluence with Sinking Creek in Bedford County, downstream to the mouth of Goose Creek, east of Columbia, Maury County, Tennessee.

Rayed Bean (*Paetulunio fabalis*) Federally Endangered

Date Listed: March 15, 2012

Likely extirpated from the Duck River as it as last reported live in 1982 downstream of Lillard Mill.

It was reintroduced in 2008 via translocated individuals (n=681) from the Alleghany River, PA.

No additional stockings have taken place and viability of the transplanted individuals is currently unknown.

National Workplan – proposed CH due in FY 25.

Littlewing Pearlymussel (*Pegias fabula*) Federally Endangered

Date Listed: November 14, 1988

Extirpated from the Duck River. It was last collected from the Duck in 1888, but was common in an excavation of an aboriginal deposit near Columbia in 1978.

Only currently extant in 9 river miles in Big South Fork, TN/KY and a small population in Cane Creek, TN.

Reintroductions into the Duck, Clinch, Nolichucky, and Rockcastle are recommended actions for this species.

Orangefoot Pimpleback (*Plethobasus cooperianus*) Federally Endangered

Date Listed: June 14, 1976

Likely extirpated from the Duck River. It was only recorded as a single record downstream of the old Columbia Dam in 1968.

The species is still extant in the lower Tennessee River, but has very low resiliency. It possibly historically occurred in the lower Duck near the Tennessee River confluence.

Reintroductions into the Duck, Elk, and Wilson tailwaters (TN R) are recommended actions for this species.

Sheepnose (*Plethobasus cyphyus*) Federally Endangered

Date Listed: April 12, 2012

Has never been widely distributed in the Duck, but early museum records put it primarily in the lower Duck. The last record was a live individual collected downstream of the old Columbia Dam in 2003.

Reintroductions into the Duck, upper Clinch, Nolichucky, and Rockcastle are recommended actions for this species.

National Workplan – proposed CH due in FY 25.

Pyramid Pigtoe (*Pleurobema rubrum*) Federally Proposed Threatened

Date Proposed: September 7, 2021

Generally distributed but rare in the upper and lower Duck. While the population is limited it is recruiting.

Best population in the region is likely the Duck River. Duck will likely be the brood source for population restoration actions in the lower Tennessee system.

Slabside Pearlymussel (*Pleuronaia dolabelloides*) Federally Endangered

Date Listed: October 28, 2013
Critical Habitat Designated: October 28, 2013

Duck River is one of the most rebust populations of the Slabside Pearlymussel.

Duck will likely be brood source for future restoration actions in the lower Tennessee or Cumberland River drainage where it has be extirpated.

Slabside Pearlymussel draft recovery plan is due in FY 23.

Fluted Kidneyshell (*Ptychobranchus subtentus*) Federally Endangered

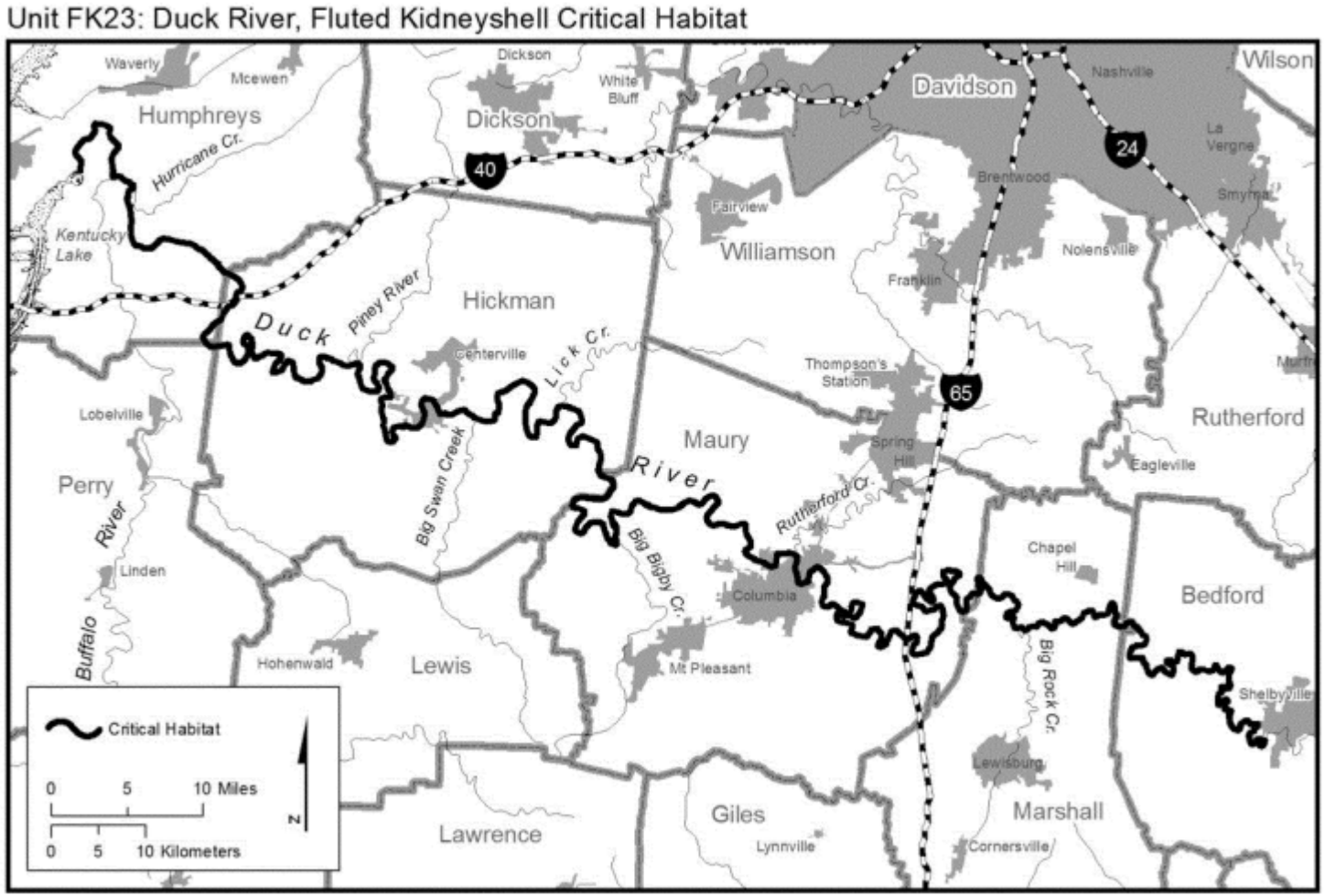
Date Listed: October 28, 2013
Critical Habitat Designated: October 28, 2013

Was extirpated from the Duck River. Last record was from 1965.

TWRA has translocated around 7,300 individual Fluted Kidneyshell from the Clinch into the Duck. This reintroduced population is persisting and has been recruiting on its own for several years.

Fluted kidneyshell recovery plan was recently finalized in FY 22.

Designated Critical Habitat for the Slabside Pearlymussel and Fluted Kidneyshell in the Duck River.



Unit FK23 and SP12 includes approximately 216 river miles of the Duck River from its inundation at Kentucky Lake in Humphreys County, TN, upstream to its confluence with Flat Creek near Shelbyville in Bedford County, TN.

Winged Mapleleaf (*Quadrula fragosa*) Federally Endangered

Date Listed: June 20, 1991

Was extirpated from the Duck River. Once widely distributed in the Duck, it was last reported from the early 1900s. It is now also extirpated from the entire Ohio River system.

TWRA reintroduced 103 propagated individuals back to the Duck River in 2013 using Saline River, Arkansas broodstock.

No recruitment has been documented at the stocking site.

Cumberland Monkeyface (*Theliderma intermedia*) Federally Endangered

Date Listed: June 14, 1976

Currently only exists in the Duck and Powell rivers. The Duck has the best remaining population range-wide for this species.

The Duck will likely provide broodstock for any population restoration in the lower Tennessee River drainage. The Elk River is a likely reintroduction possibility.

This species has only recently been successfully propagated by the Virginia Department of Wildlife Resources.

Rabbitsfoot (*Theliderma cylindrica*) Federally Threatened

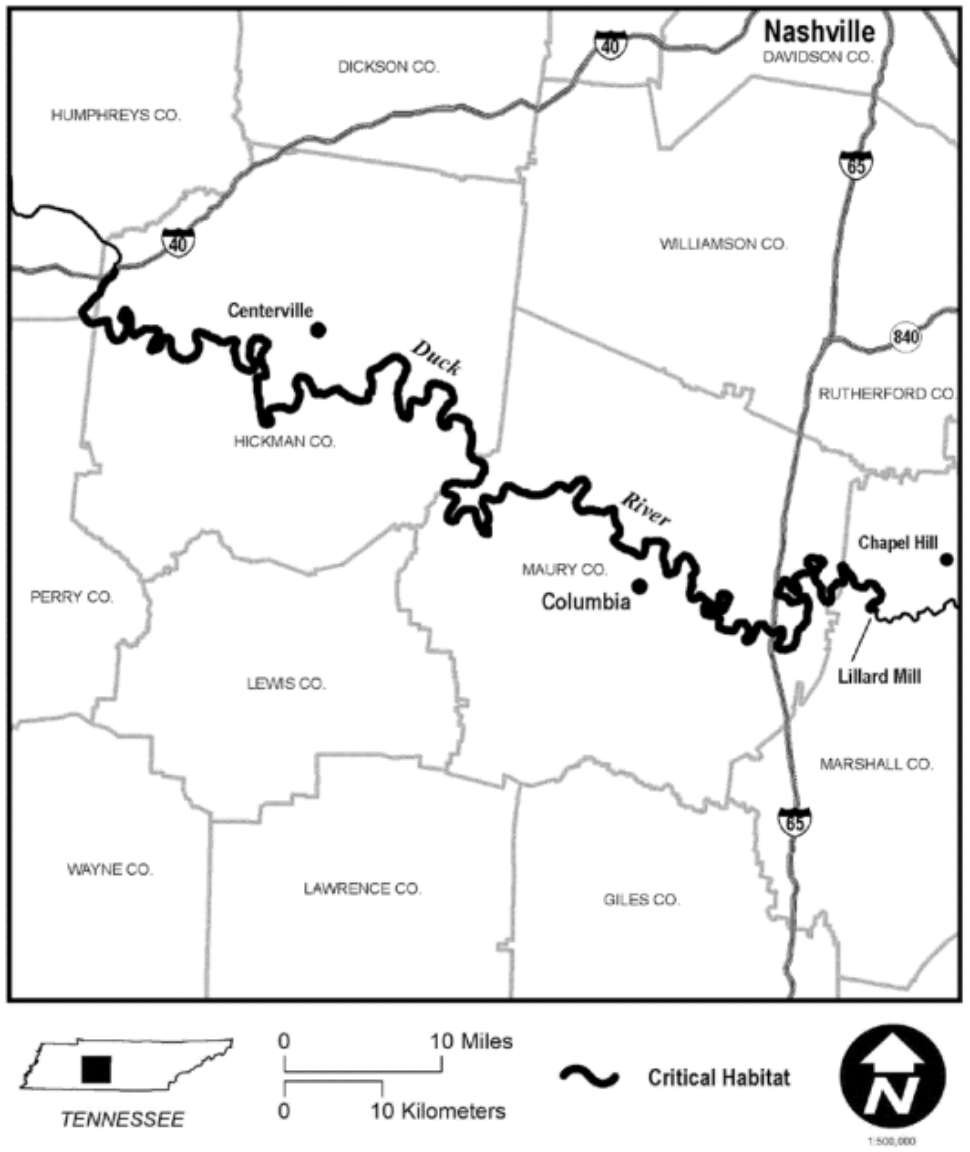
Date Listed: October 17, 2013
Critical Habitat Designated: April 30, 2015

The rabbitsfoot is common in both the upper and lower Duck River and is considered one of most robust populations range-wide.

This species is usually found in shallow, low-flow shoreline areas.

A draft recovery plan was recently released in in October 2022, final recovery plan is due in FY 23.

Designated Critical Habitat for the Rabbitsfoot in the Duck River.



Unit RF18 includes 146.2 river miles of the Duck River from Lillard Mill (rmi 179) west of Tennessee Highway 272, Marshall County, Tennessee, downstream to Interstate 40 near Bucksnort, Hickman County, Tennessee.

Pale Lilliput (*Toxolasma cylindrica*) Federally Endangered

Date Listed: June 14, 1976

The pale lilliput was once thought to be extirpated from the Duck River system, but was rediscovered in Lick Creek (Duck River tributary) in 2015.

This species has been reintroduced into the Duck River mainstem and Big Rock Creek with propagated individuals using Paint Rock River and Lick Creek broodstock since 2014.

This species is usually found in shallow, low-flow shoreline areas.

Questions?

TDEC Ammonia and Assimilative Capacity Modeling of the Duck River at Shelbyville

Rich Cochran

TDEC, Division of Water Resources

Duck River Symposium

December 7, 2022

Dennis Borders, Wayman Ho

TN Department of Environment & Conservation

TDEC Watershed Management

Background

- Early discussions on drought management plan/triggers focused on flows and withdrawals.
- Dr. Sherry Wang worked to ensure that water quality was considered as well.

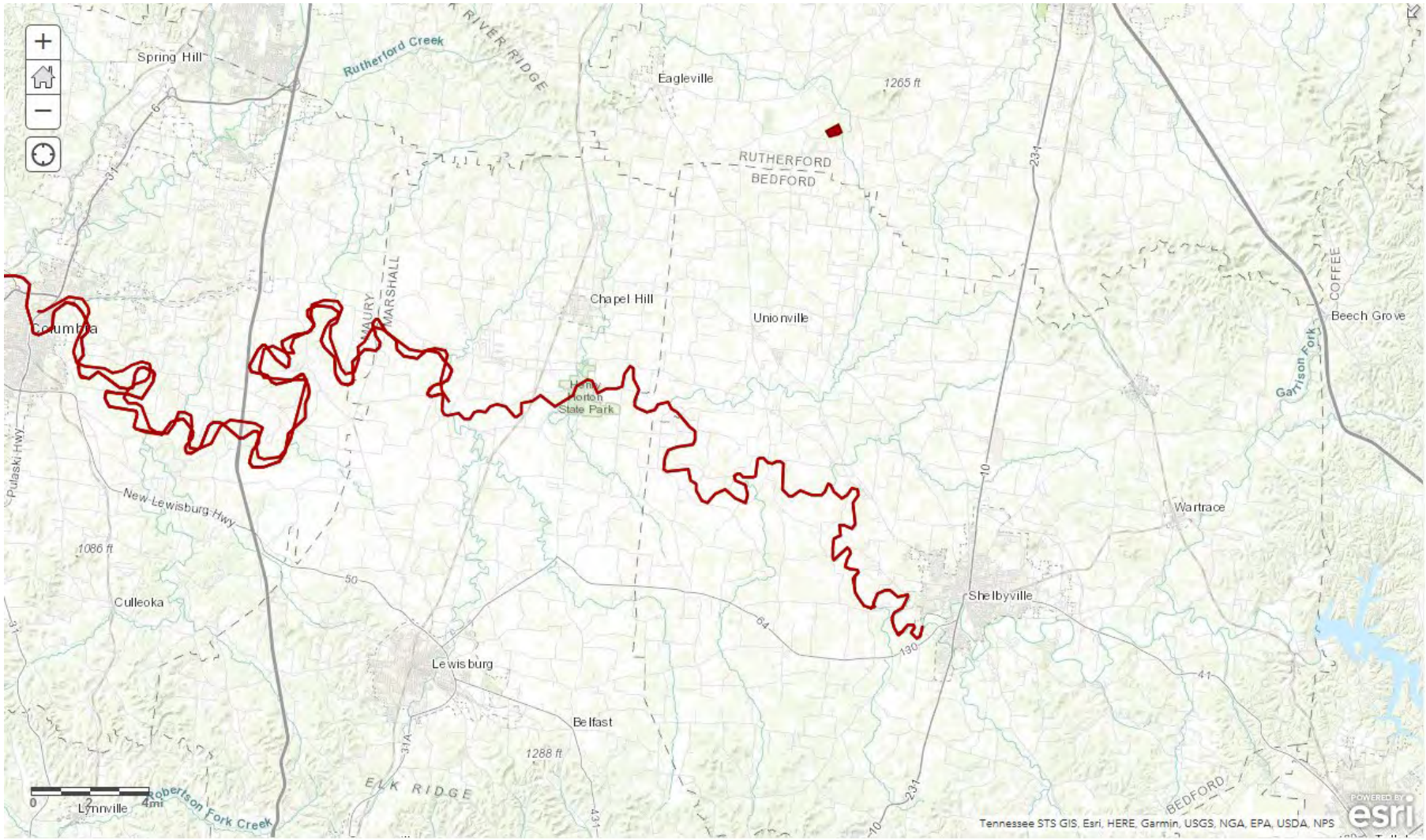
Background

- Worked on NPDES planning limits for Columbia and Shelbyville
- Permits were based on “TVA guaranteed minimum flows” rather than 7Q10 or 1Q10
- **7Q10**-lowest flow for 7 consecutive days that occurs on average once every 10 years.
- In 2018 TN adopted new EPA ammonia criteria based on a calculation using pH and temperature.

Question

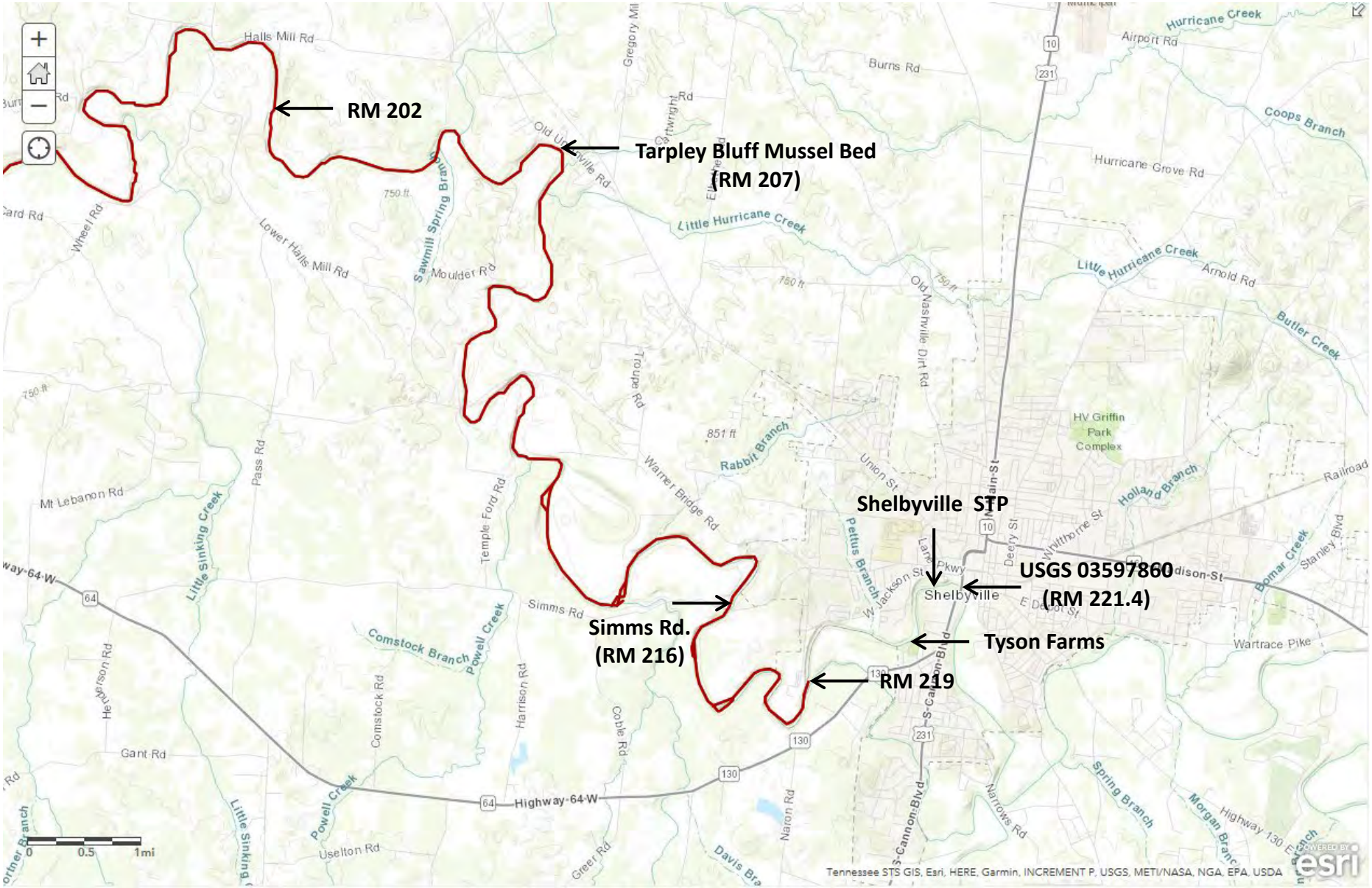
- TDEC asked to evaluate the extent of potential water quality impacts to the Duck River from changing flows.
  - Ammonia toxicity
    - Criteria varies continuously based on ammonia concentration, pH, and temperature.
  - Assimilative Capacity
    - The natural capacity of a stream to receive organic wastes without decreasing the stream dissolved oxygen concentrations below the state minimum criterion of 5.0 mg/L.

Duck River and USFWS Critical Habitat for Threatened Mussel Species*

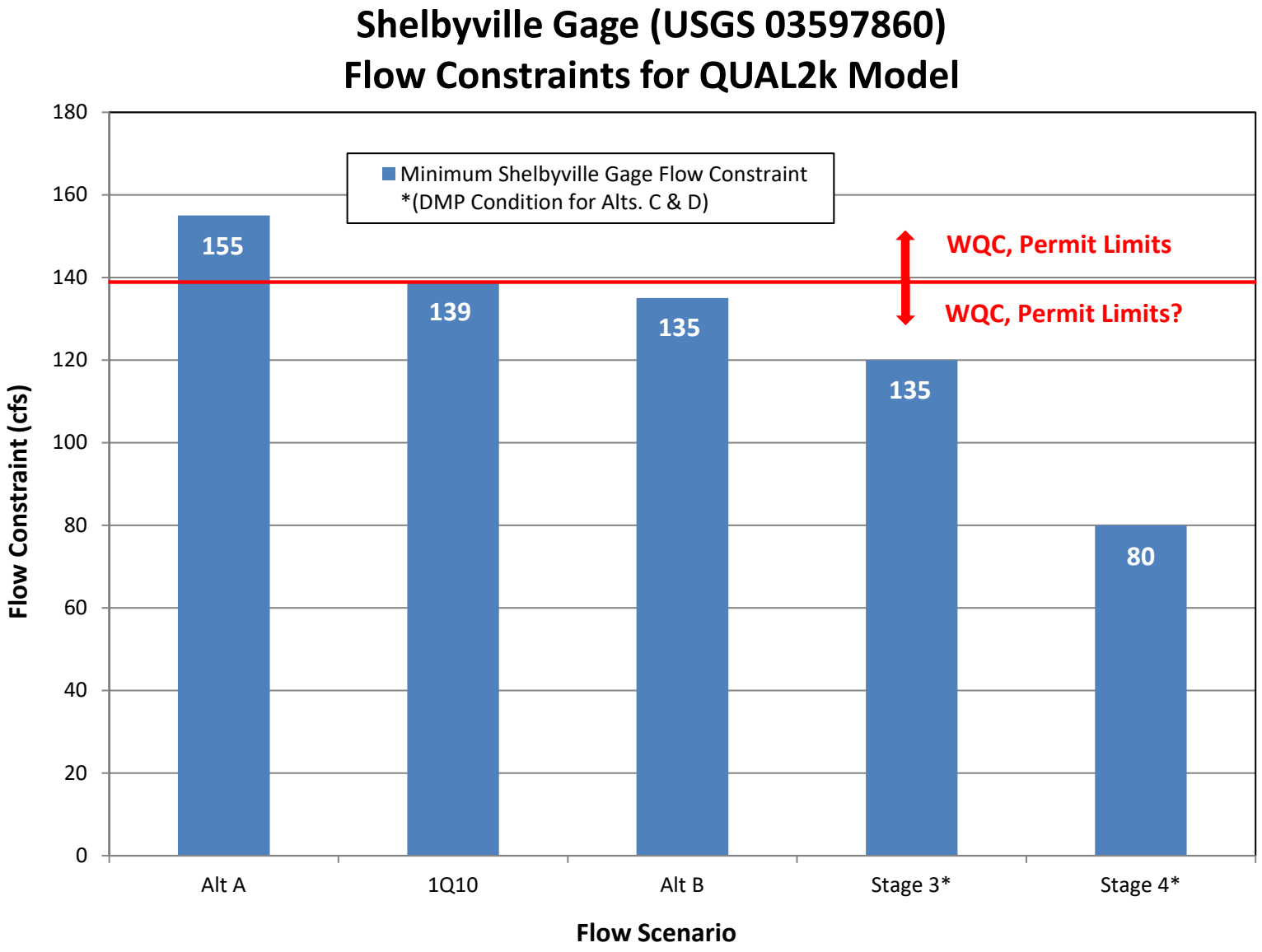


*** ECOS (Environmental Conservation Online System) / USFWS Threatened & Endangered Species Active Critical Habitat Report**

Duck River Shelbyville Segment



Duck River Flow Constraints at Shelbyville



Duck River Flow Constraints at Shelbyville

Flow Constraints at Shelbyville gage (USGS 03597860) for Duck River EA Water Quality Analyses

Flow Constraint Scenario	Minimum Flow (cfs)	Description
Alternative A	155	Existing Conditions Operational Flow Target (No Action Alternative)
$1Q_{10}$	139	Flow for application of Water Quality Criteria in Permits for Regulated Streams (critical flow occurring, on average, once in 10 years)
Alternative B	135	Revised Operational Flow Target
Stage 3	120	Stage 3 Trigger of Drought Management Plan (Applicable to Alternatives C and D)
Stage 4	80	Stage 4 Trigger of Drought Management Plan (Applicable to Alternatives C and D)

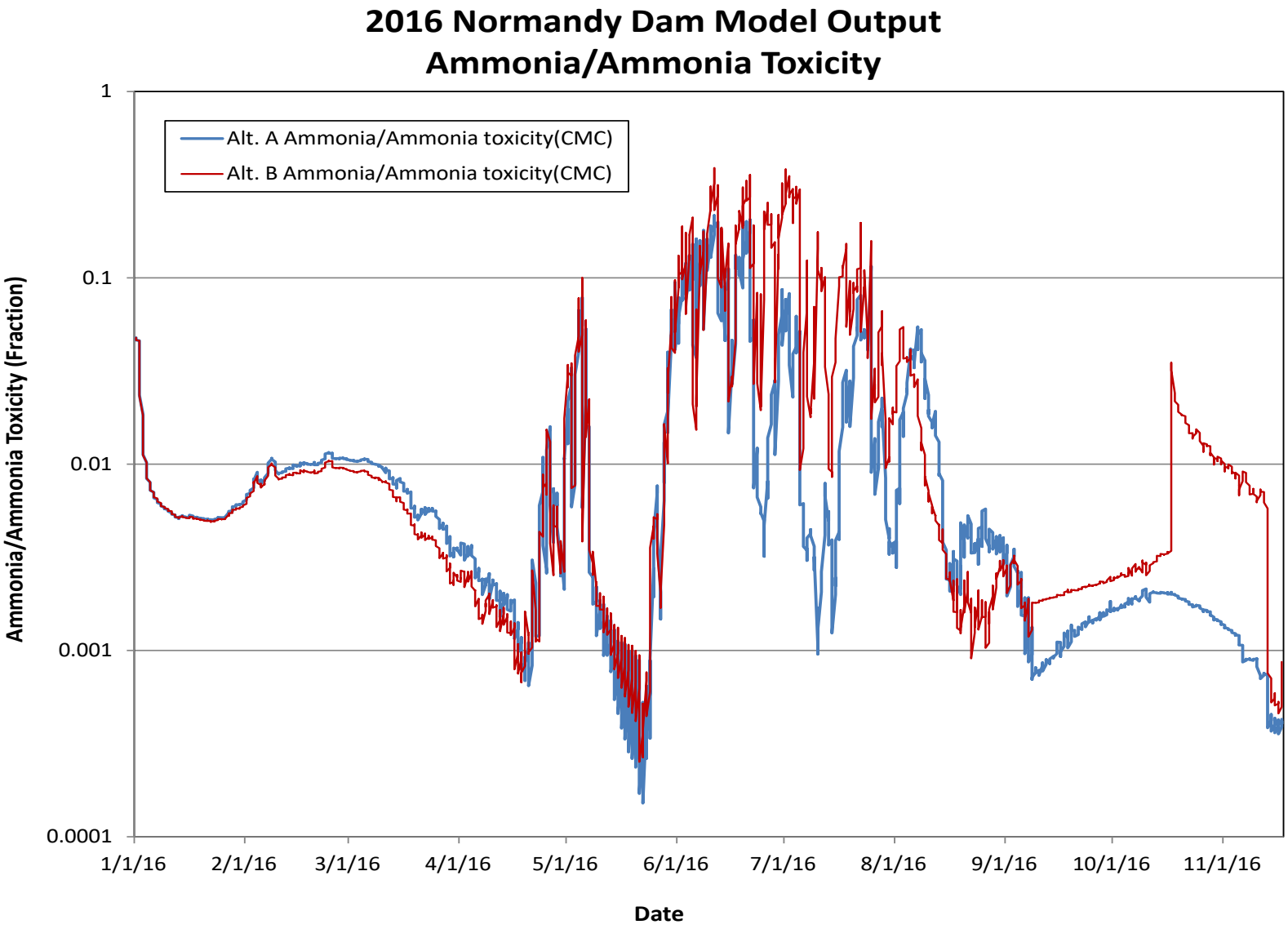
TDEC Analyses

- Ammonia (NH_3) Toxicity
  - TVA Normandy Dam (CE-QUAL-W2) Output
  - NPDES Point Source (End-of-Pipe)
  - QUAL2k Longitudinal Profile
- Assimilative Capacity for Dissolved Oxygen (DO)

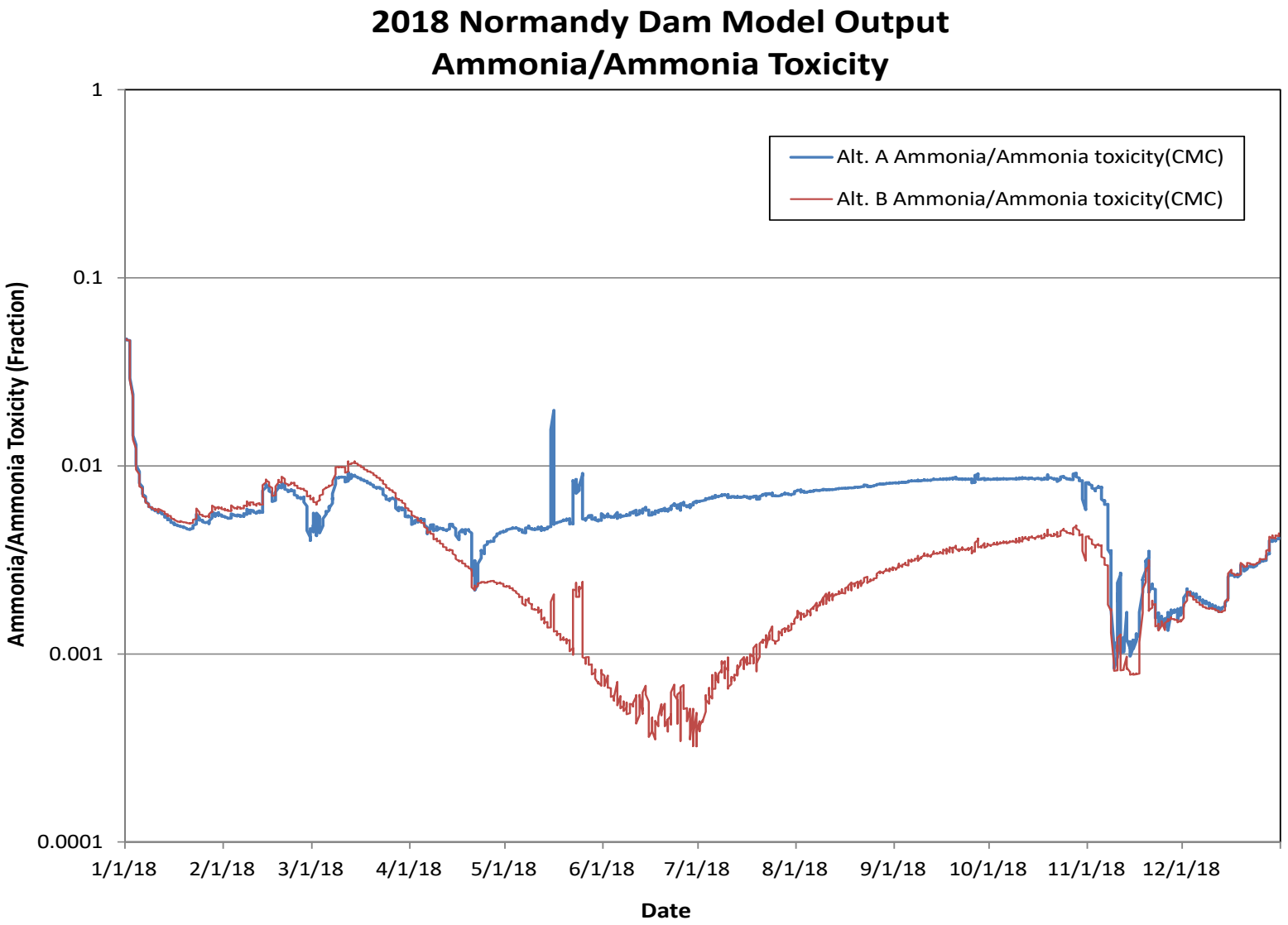
TVA CE-QUAL-W2 Normandy Dam Model

- Existing Conditions and Results for Alternative Flow Constraints
  - 2016 – Dry Year (Alts. A & B)
  - 2018 – Wet Year (Alts. A & B)
  - 2007 – Driest year on record (Alts. A and B, Stages 3 and 4)
- Output: NH_3, DO, Temperature, pH
  - Continuous Simulation
  - Timestep = 6 hr

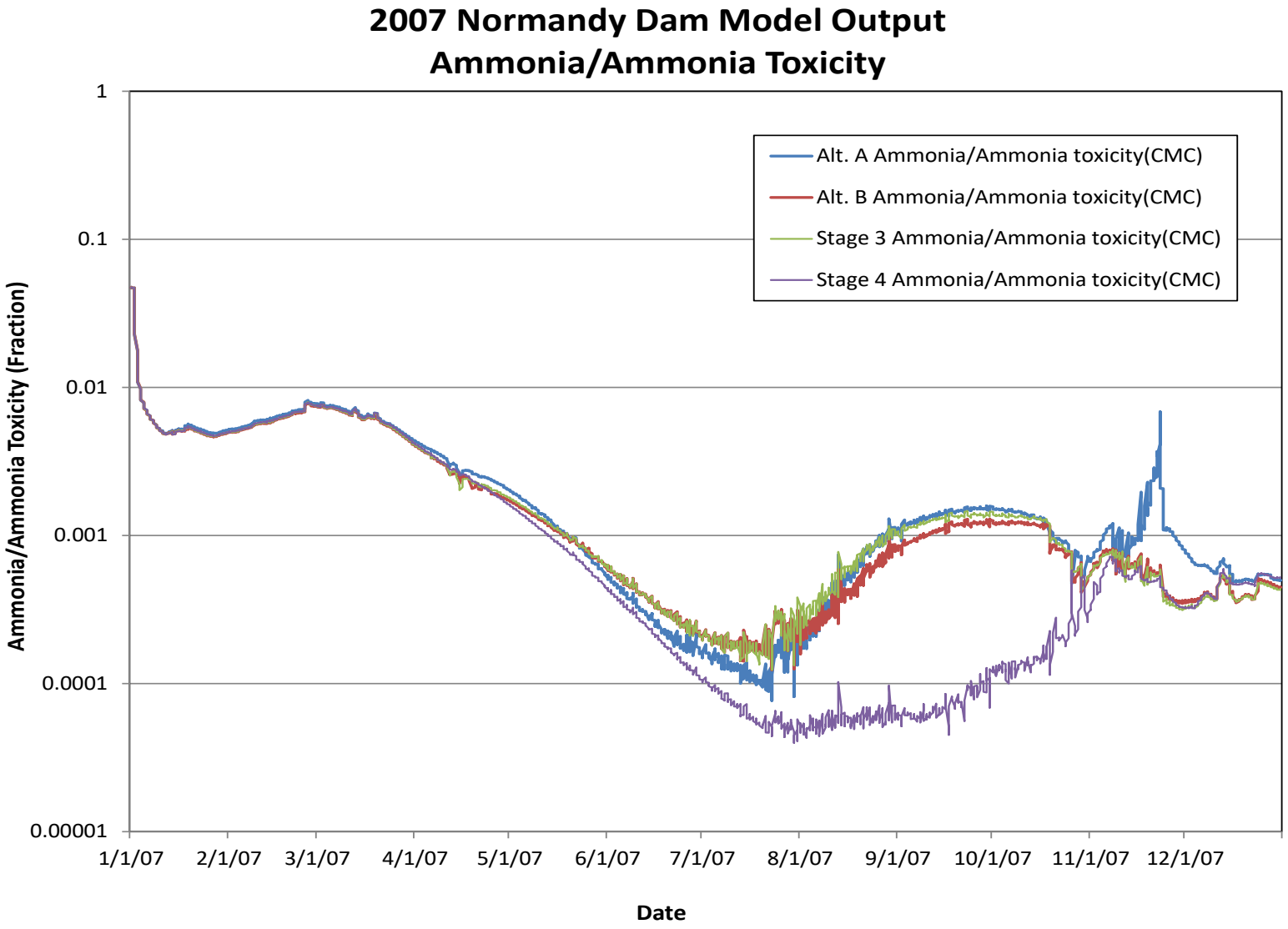
TVA Normandy Dam Model Output Acute Toxicity Analysis



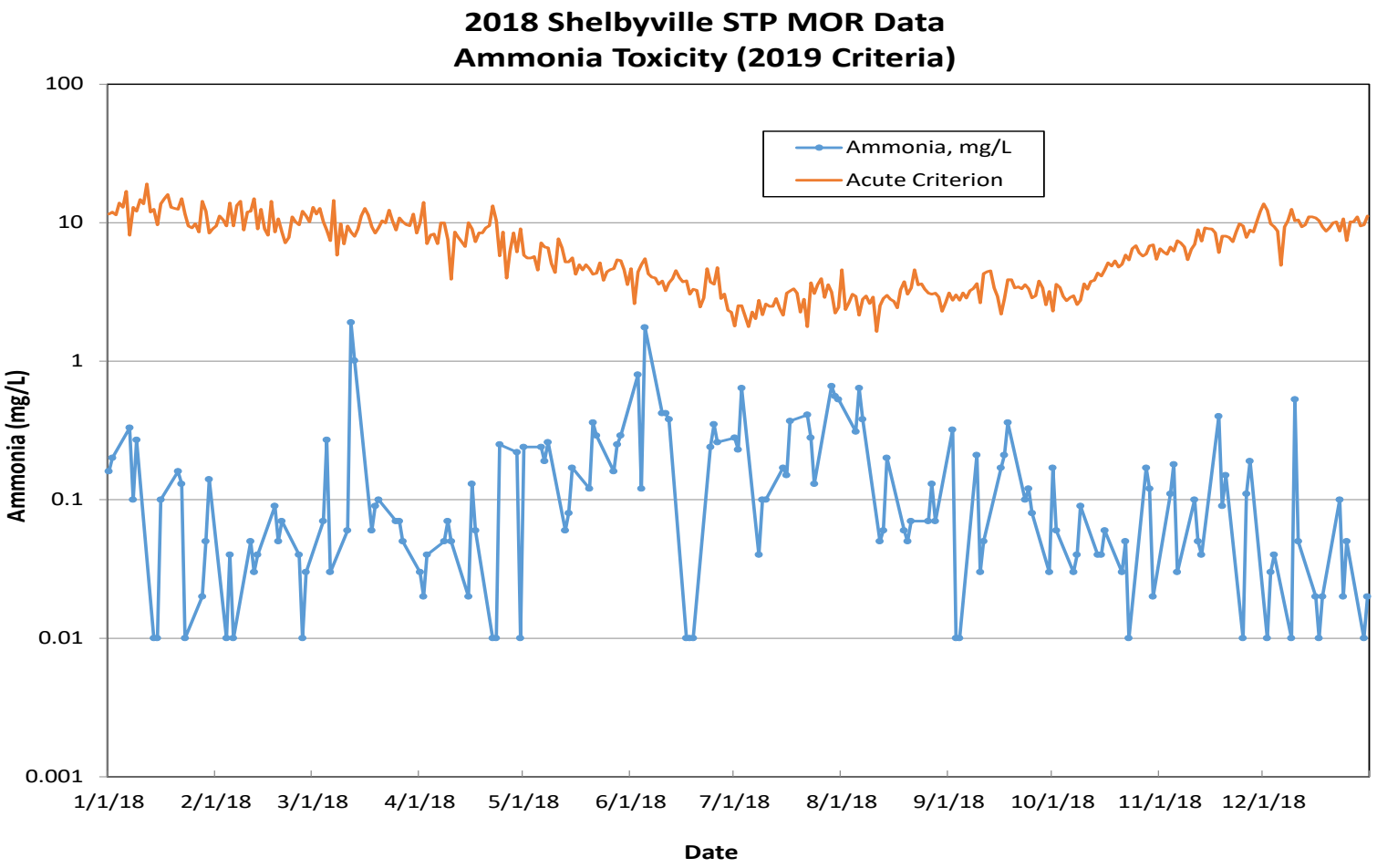
TVA Normandy Dam Model Output Acute Toxicity Analysis



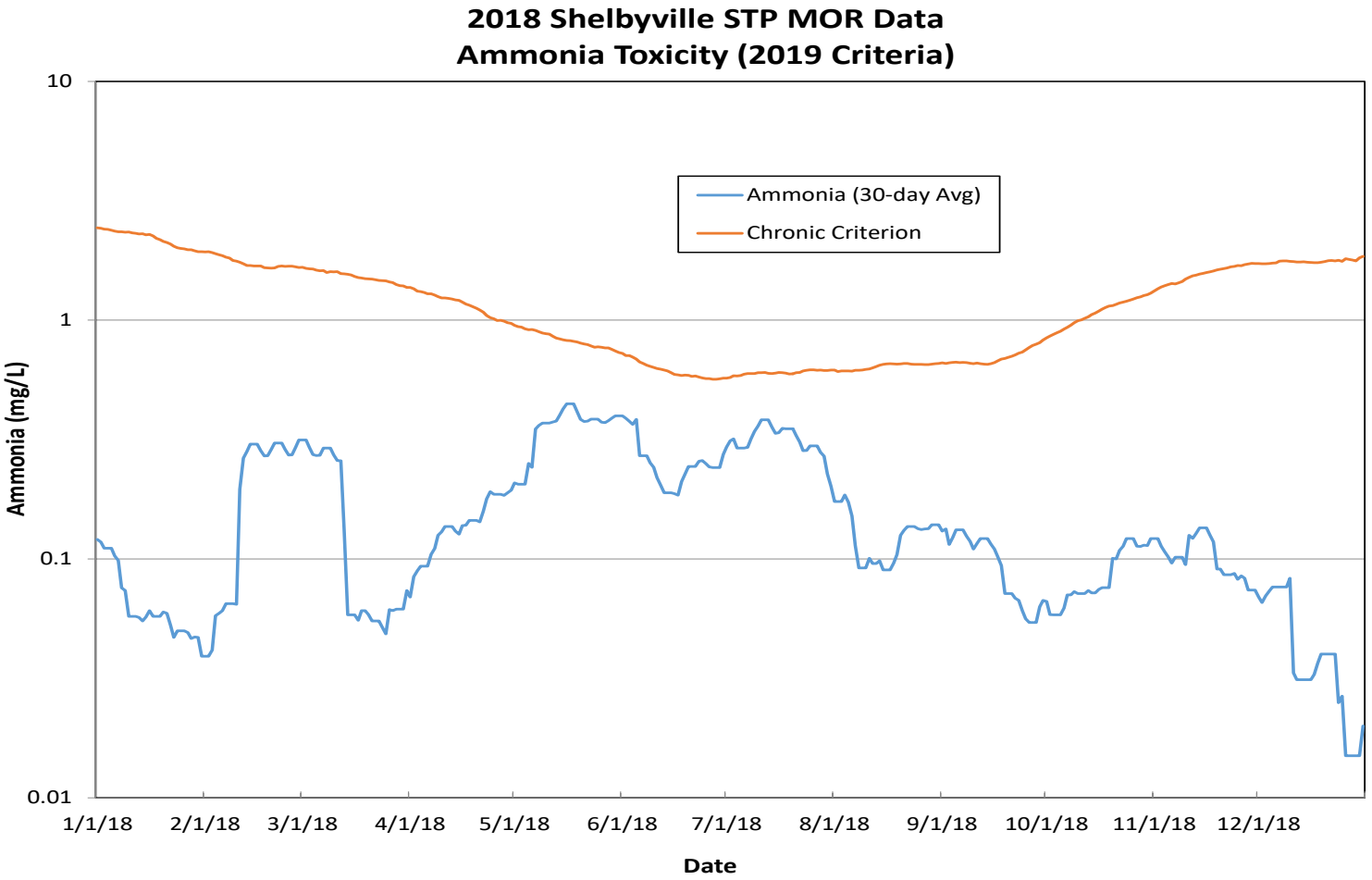
TVA Normandy Dam Model Output Acute Toxicity Analysis



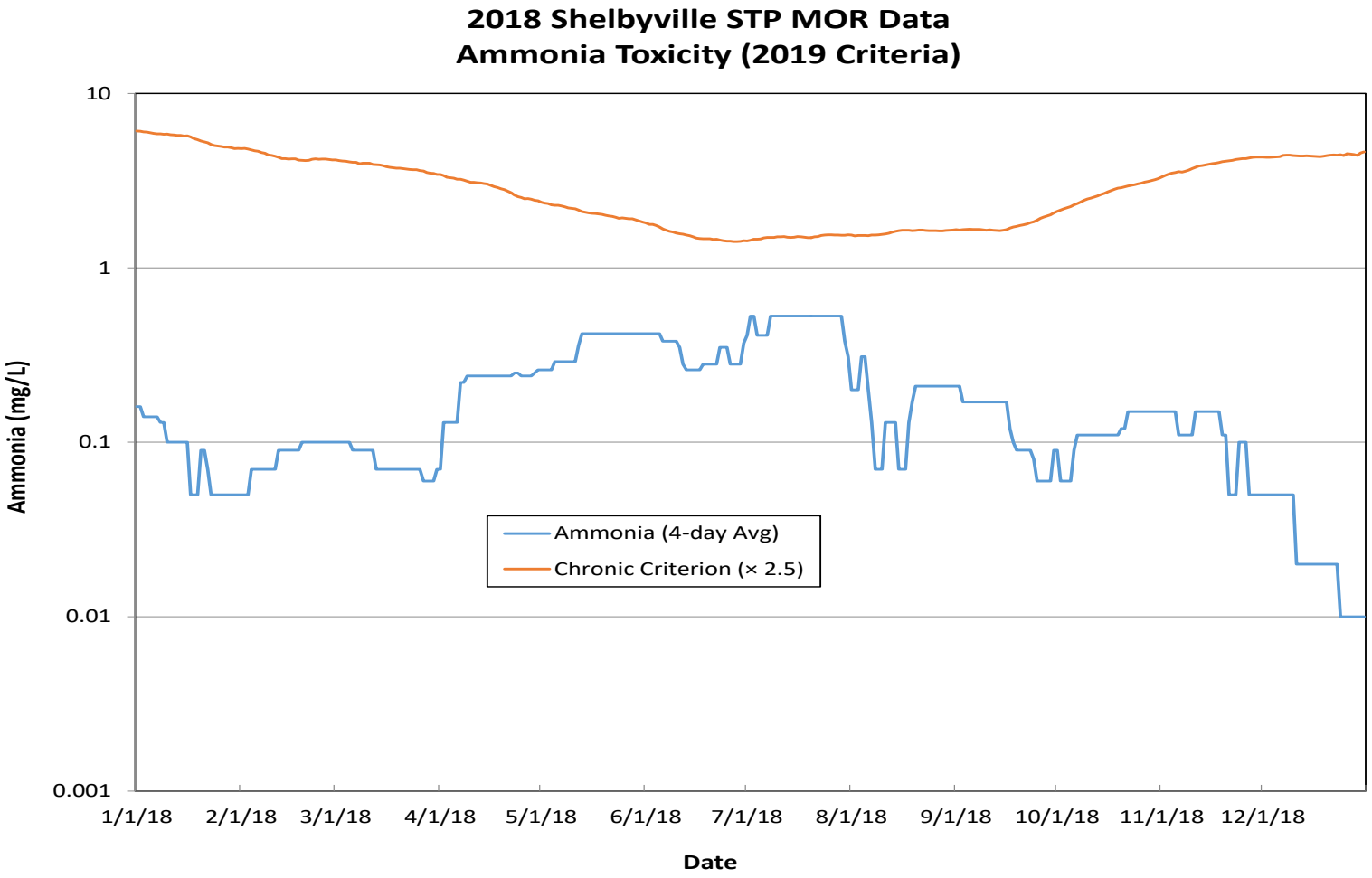
Ammonia Toxicity - Shelbyville STP



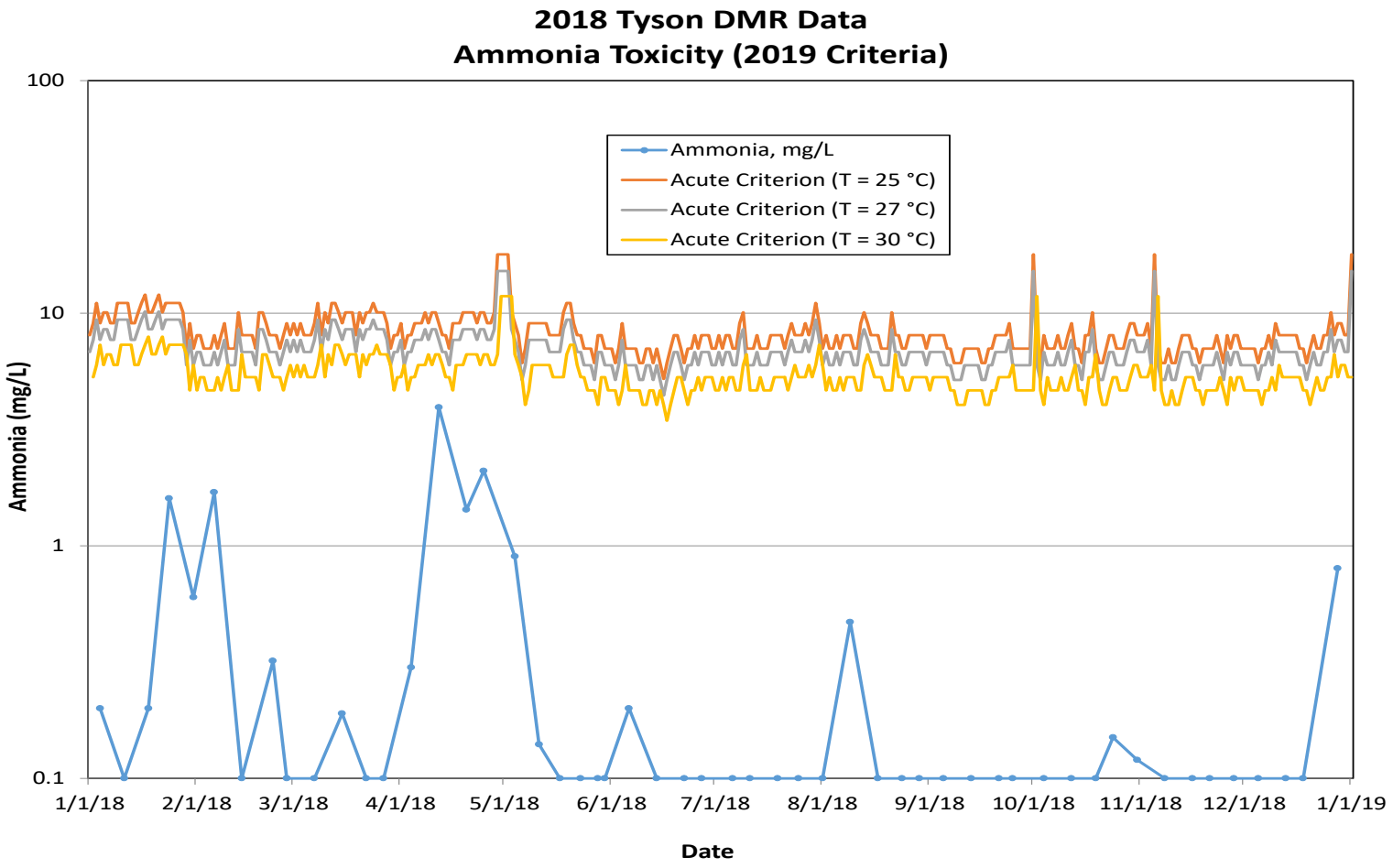
Ammonia Toxicity - Shelbyville STP



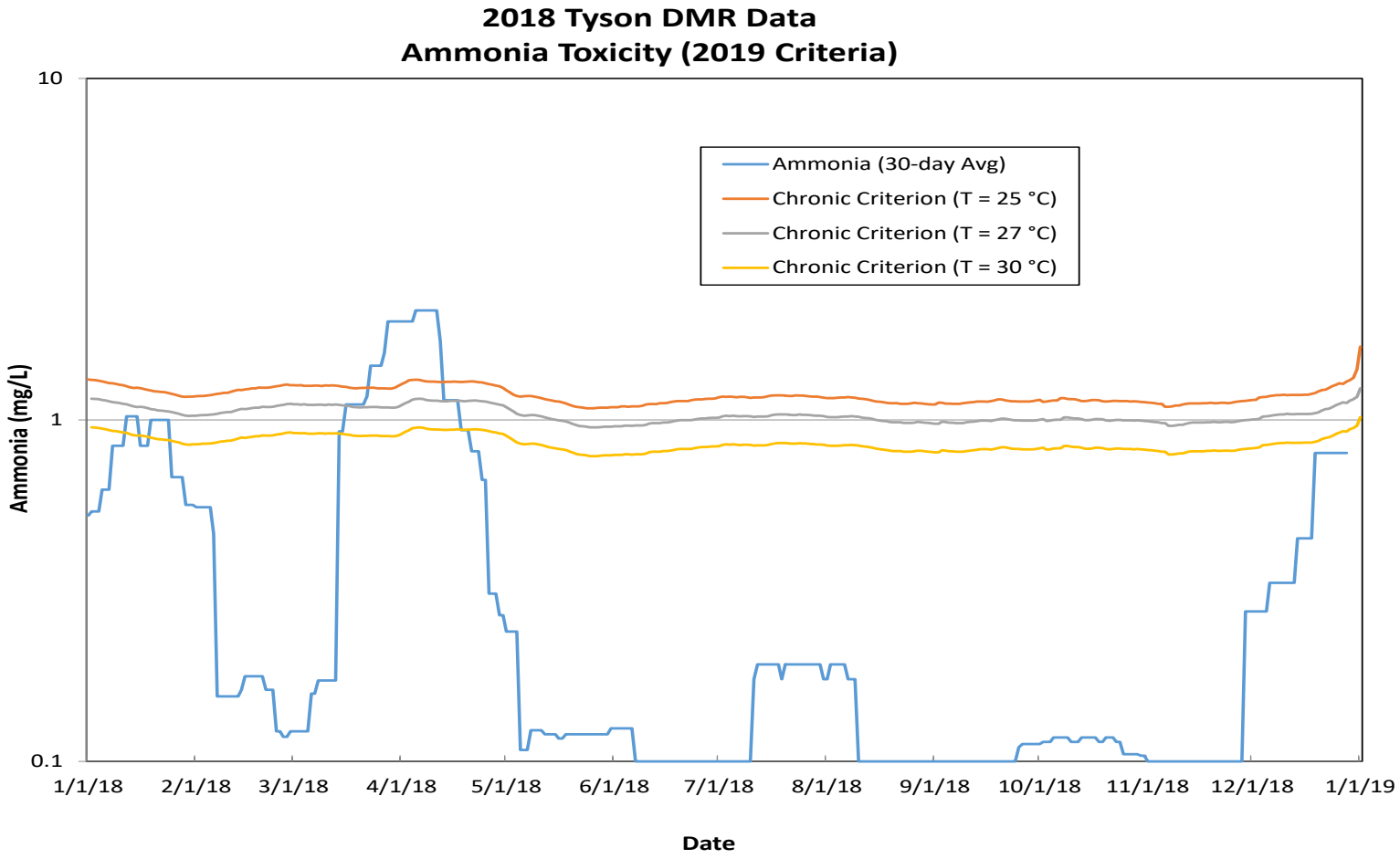
Ammonia Toxicity - Shelbyville STP



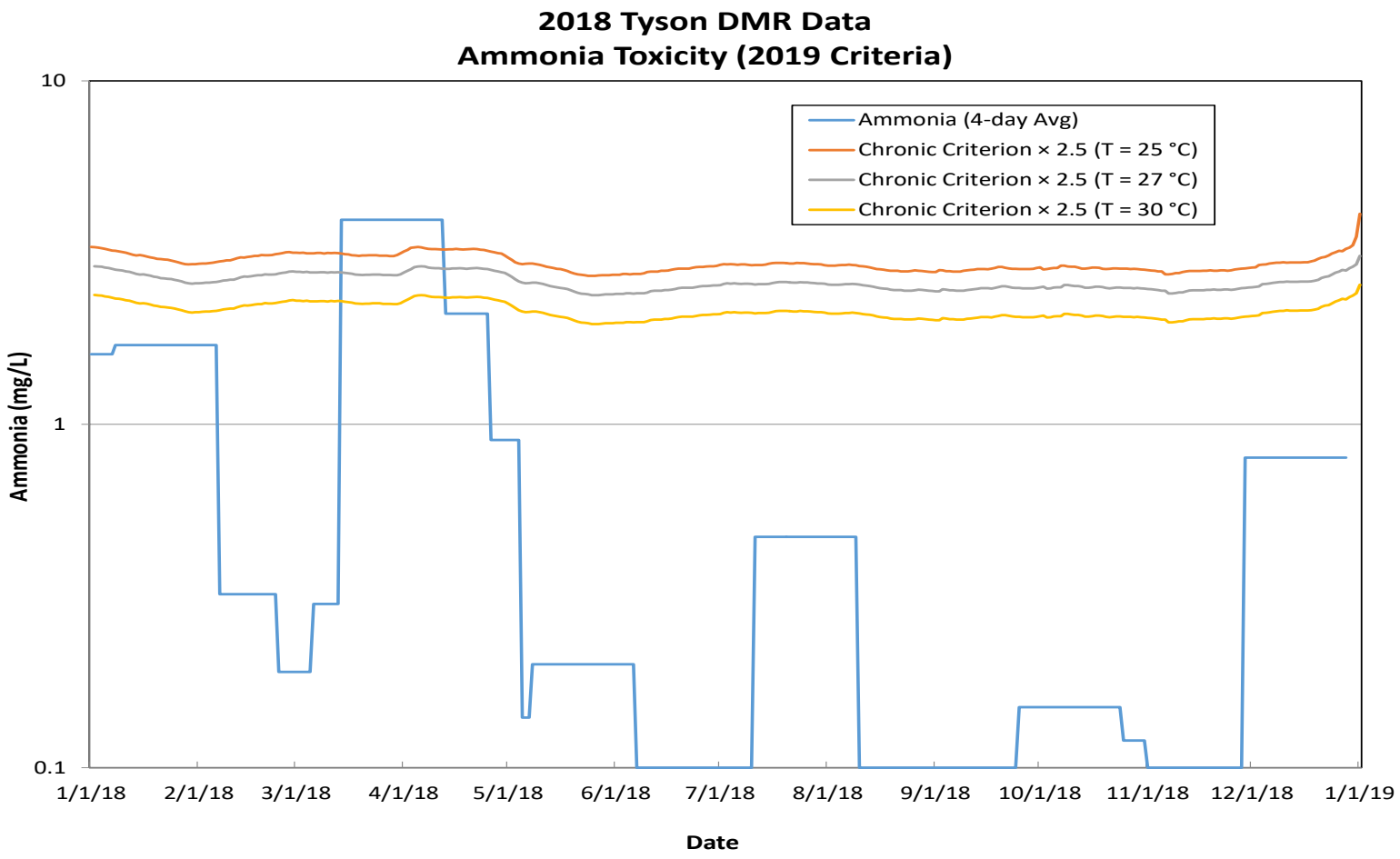
Ammonia Toxicity - Tyson Farms



Ammonia Toxicity - Tyson Farms



Ammonia Toxicity - Tyson Farms



Ammonia Toxicity - Chapel Hill WWTP

Acute Criterion (CMC)*

NH_3 Conc. (Avg) = 3.1 mg/L	CMC (New Criteria)	CMC (New Criteria)	CMC (New Criteria)
Temp. \ PH	6	8	10
25 °C	16.87	**2.58**	**0.15**
27 °C	14.29	**2.19**	**0.13**
30 °C	11.15	**1.70**	**0.10**

Chronic Criterion (CCC)*

NH_3 Conc. (Avg) = 3.1 mg/L	CCC (New Criteria)	CCC (New Criteria)	CCC (New Criteria)
Temp. \ PH	6	8	10
25 °C	**1.61**	**0.56**	**0.05**
27 °C	**1.41**	**0.49**	**0.04**
30 °C	**1.16**	**0.41**	**0.03**

*** Chapel Hill Average NH_3 Effluent Concentration (3.12 mg/L)**

Duck River EA QUAL2K Model

Critical Boundary Conditions*

- Critical Flow = Proposed Minimum Flow (e.g., $1Q_{10}$ = 139 cfs = 3.93 cms)
- Water Temperature = 27°C
- DO = 6 mg/L
- pH = Based on calibration data (or 9 for NH_3 toxicity)
- Specific Conductivity = Based on calibration data
- $CBOD_5$ = 1.5 mg/L
- NBOD = 0.1 - 1 mg/L
- NO_3 = Based on calibration data.
- NH_3 = Highest of value from state-EPA agreement or field measurement:
  - 0.231 mg/L (State EPA Agreement with NBD:NH3 ratio of 4.33), or
  - 0.196 mg/L (highest concentration of 2016 field measurements)
  - NH_3 (final) = 0.231 mg/L as N
- Org N = 1.318 mg/L as N (highest concentration of 2016 field measurements)

* From EPA Region 4 – State of Tennessee Agreement on Development of WLAs

Duck River EA QUAL2K Model

Facilities Discharge

Shelbyville STP (TN0024180 Permit Limits)

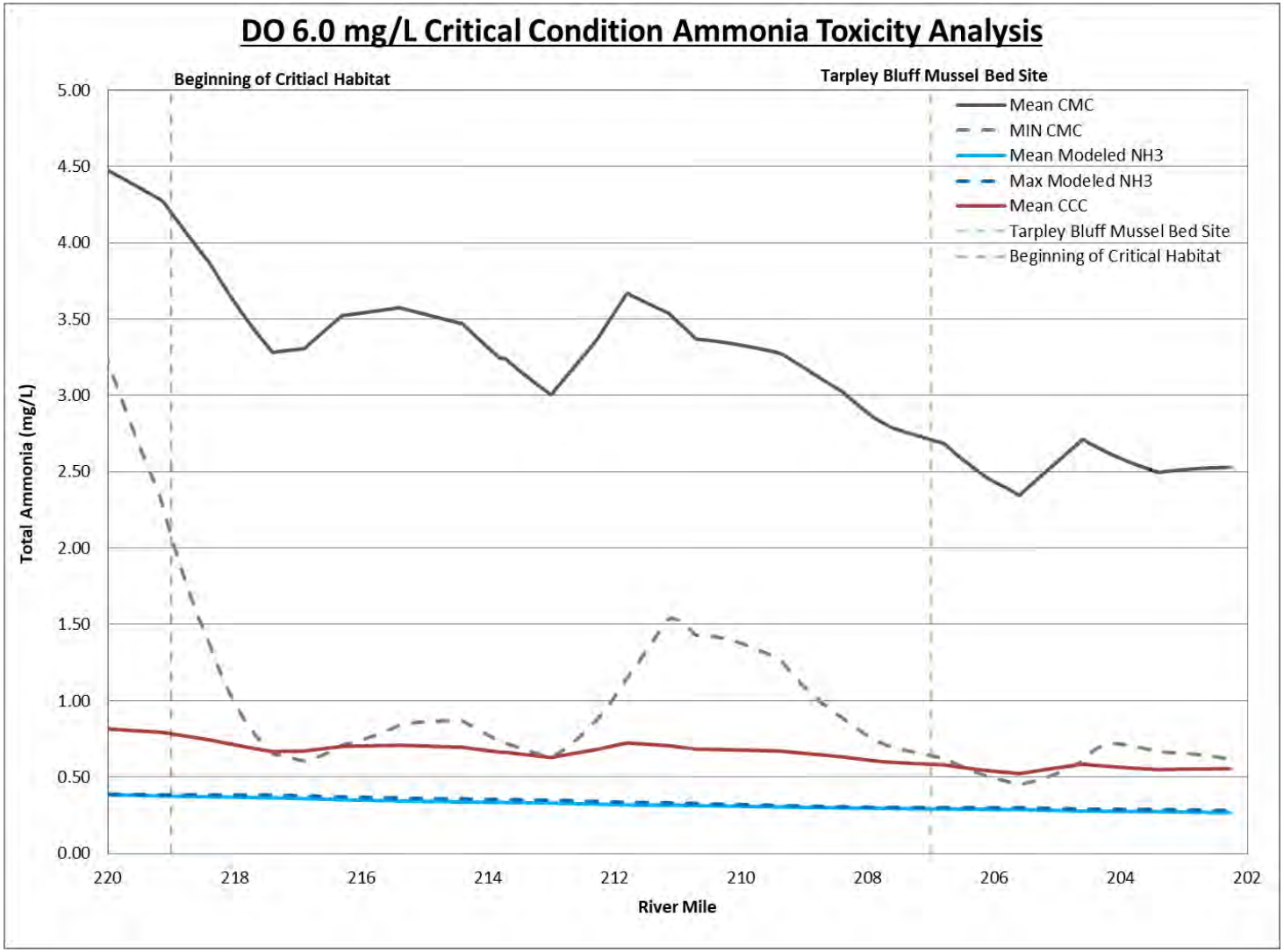
- Design Flow = 6.5 MGD = 0.285 cms
- Temperature = 29°C (High MOR effluent temperature 2016-2018)
- DO = 6.68 mg/L (minimum DO from MOR 2016-2018)
- pH = 9 (Highest pH limit)
- Specific Conductivity = Assume to be the same as Duck River concentration.
- $CBOD_5$ = 25 mg/L (Effluent Limit)
- CBOD u = 80 mg/L
- NH_3 (Monthly Average) = 2.3 mg/L (Monthly Effluent Limit, No TN limit)
- NO_3 = Based on 9/16/2016 calibration data.
- Org N = 0.190 mg/L (2016 BDY field measurement)
- Org P = 0.202 mg/L
- Ortho P = 1.82 mg/L (2016 BDY field measurement, and 90% Ortho P & 10% Organic P based on downstream measurement)

Duck River EA QUAL2K Model

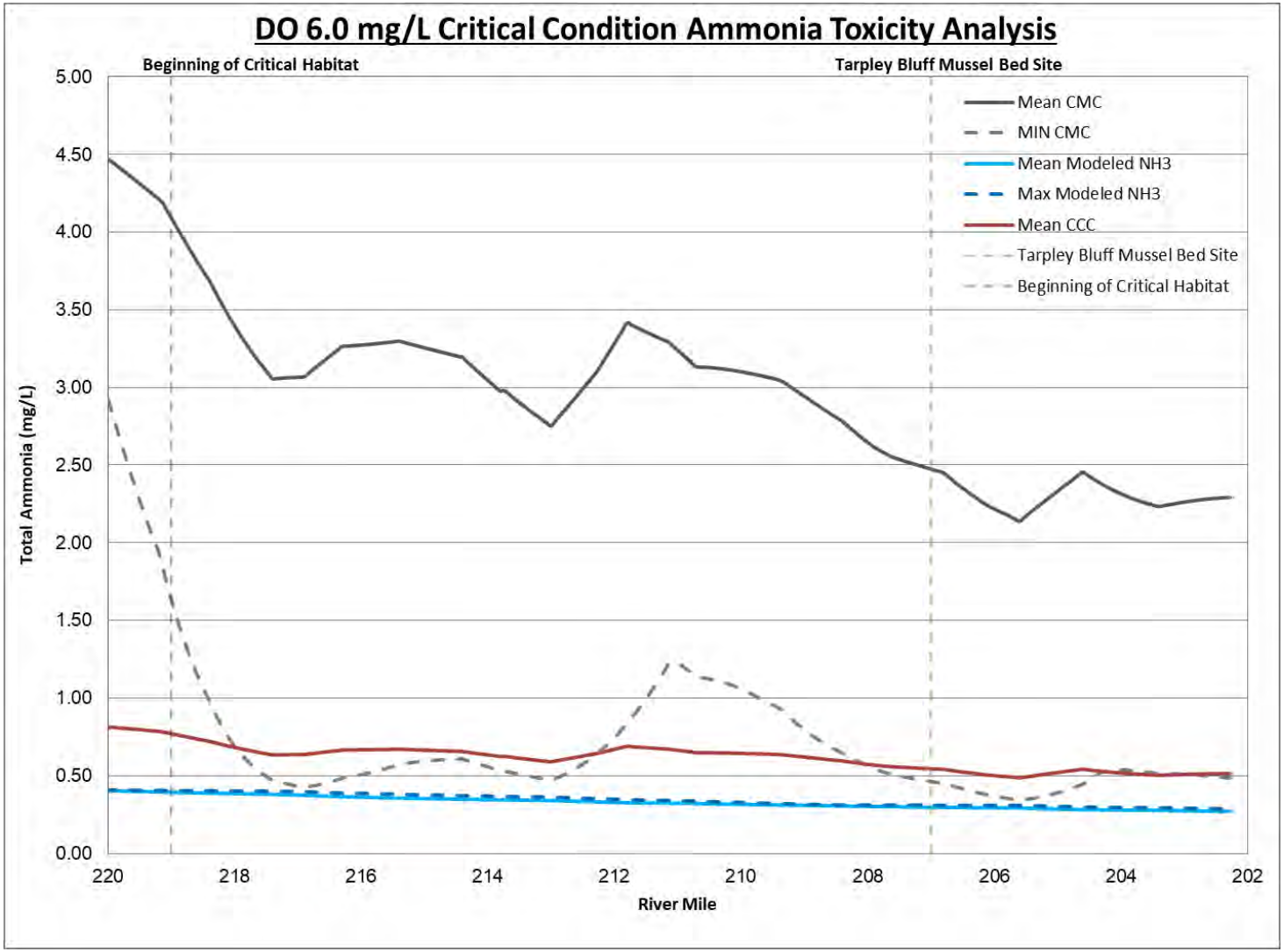
Tyson Farms Discharge

- Design Flow = 1.168 MGD = 0.0331 cms
- Temperature = 27°C (assumed due to no facility temp. data available)
- DO = 5.6 mg/L (Min DO from 2016-2018 DMR)
- pH = 9 (Max permit pH)
- Specific Conductivity = Assume same as Duck River concentration.
- $CBOD_5$ = 16 mg/L (Permit Monthly Average)
- CBODu = 16*4.47 = 71.52 mg/L
- TN = 103 mg/L (Permit Monthly Average)
- NH_3 = 4 mg/L (Permit Monthly Average)
- Org N = 1 mg/L (assumption)
- NO_3 = 98 mg/L
- TP = 20 mg/L (Max TP from 2016-18 DMR)
- Ortho P = 19.68 mg/L
- Based on information from Tyson Food Processing plant at North Fork Obion, 98.4% of the TP is Ortho-Phosphorus, and 1.6% is Organic Phosphorus.
- Org P = 0.32 mg/L

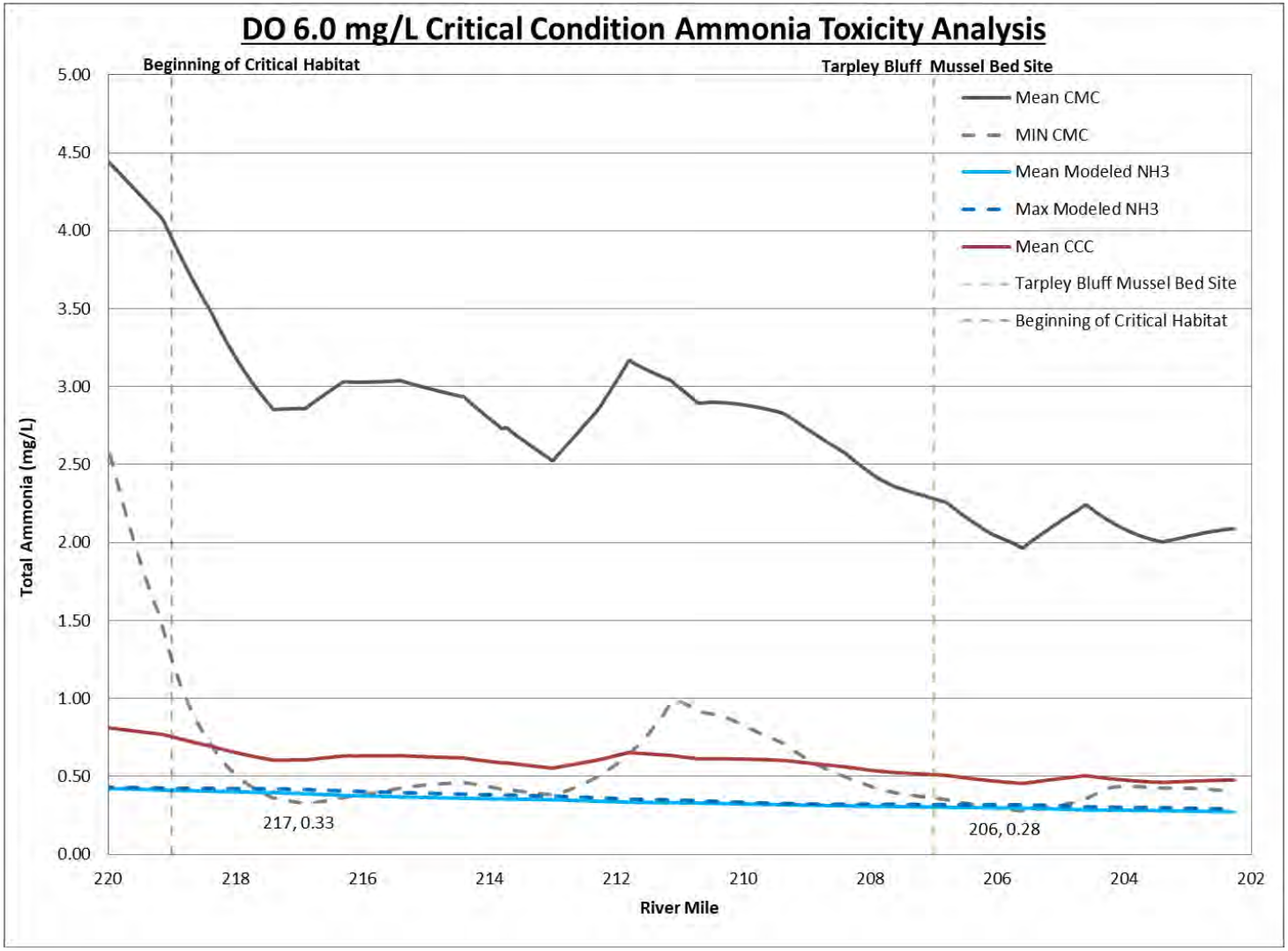
Ammonia Toxicity Analysis (Alt. A) - 155 cfs



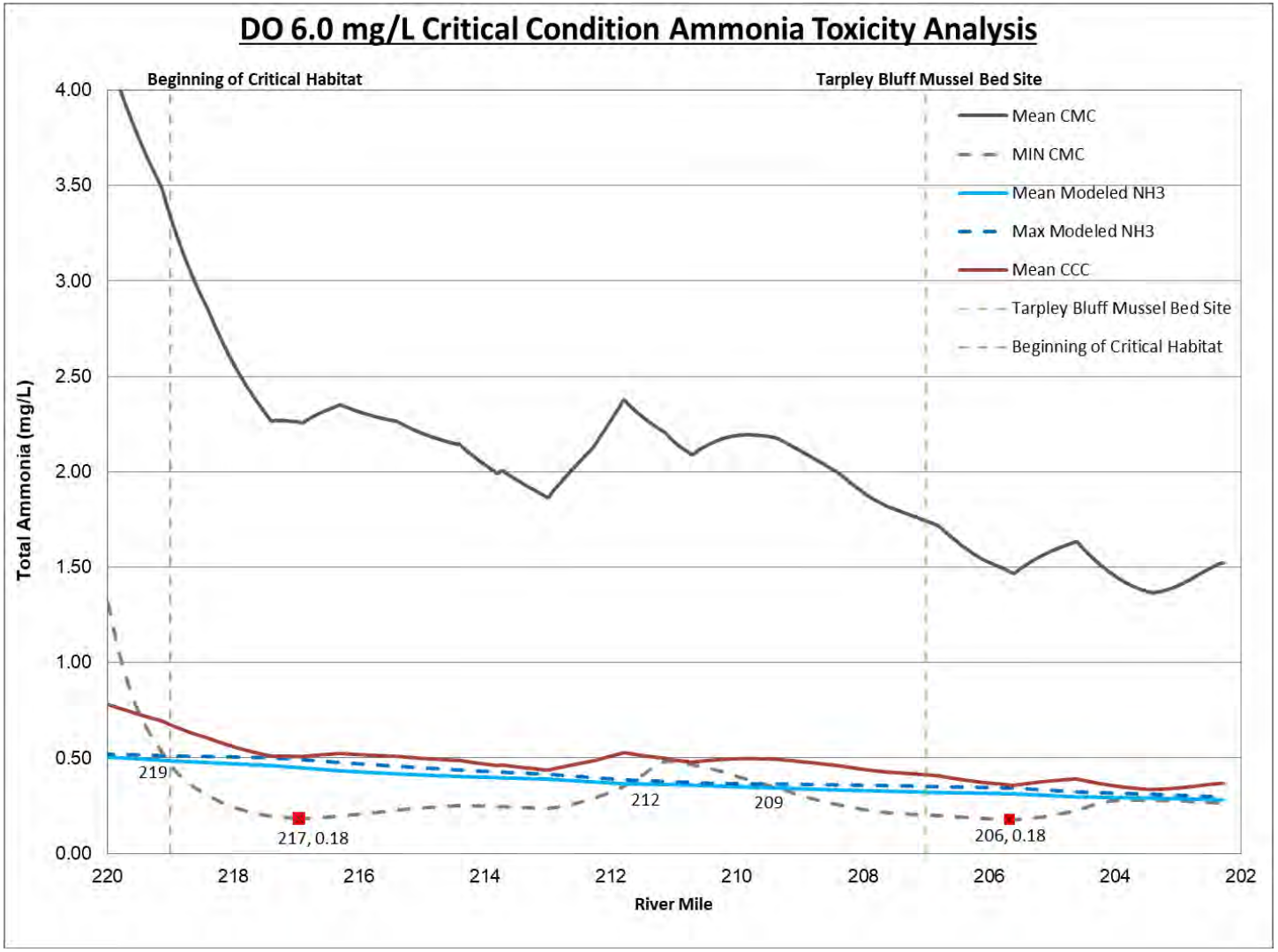
Ammonia Toxicity Analysis (Alt. B) - 135 cfs



Ammonia Toxicity Analysis (Stage 3) - 120 cfs



Ammonia Toxicity Analysis (Stage 4) - 80 cfs

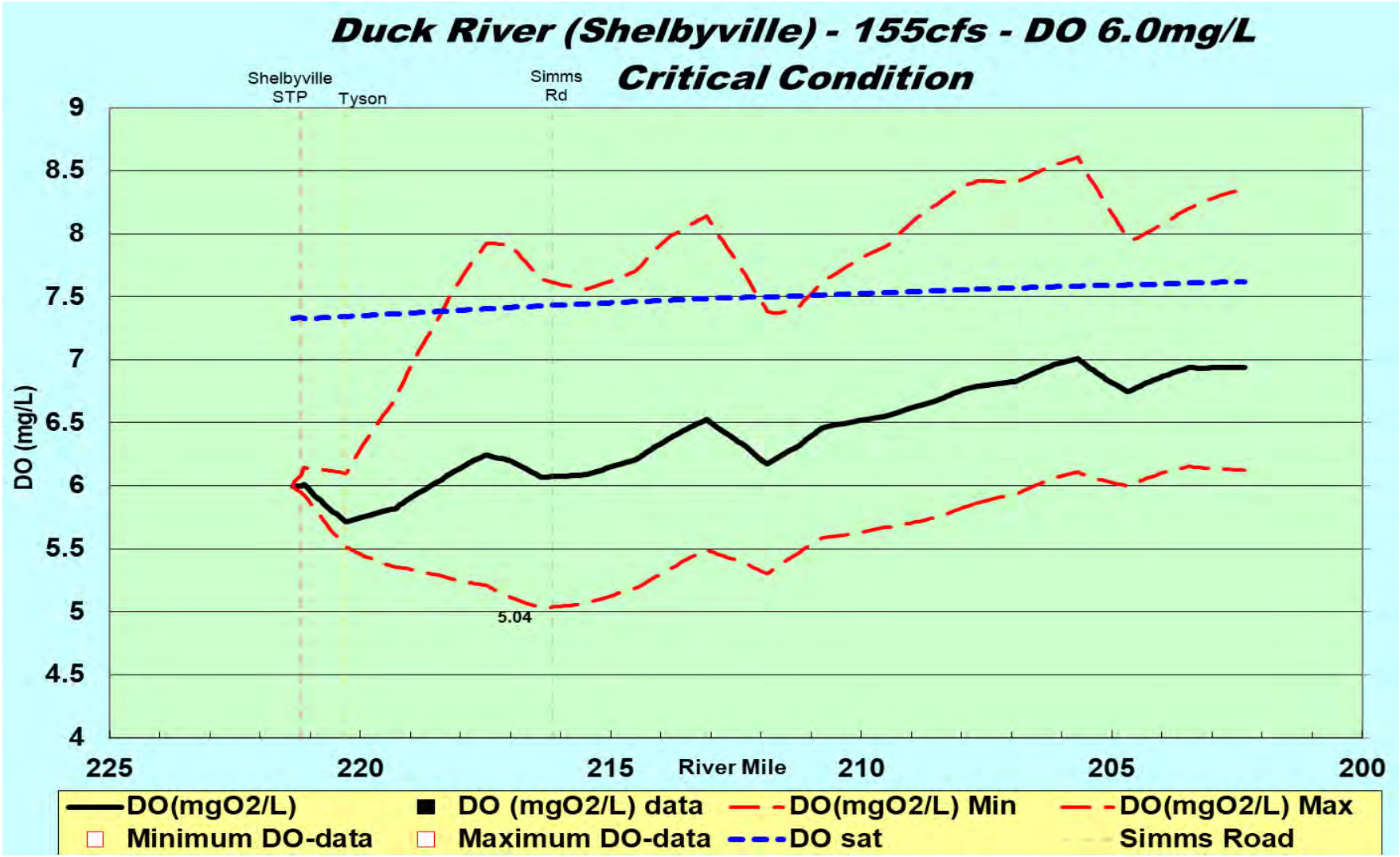


Assimilative Capacity for Dissolved Oxygen

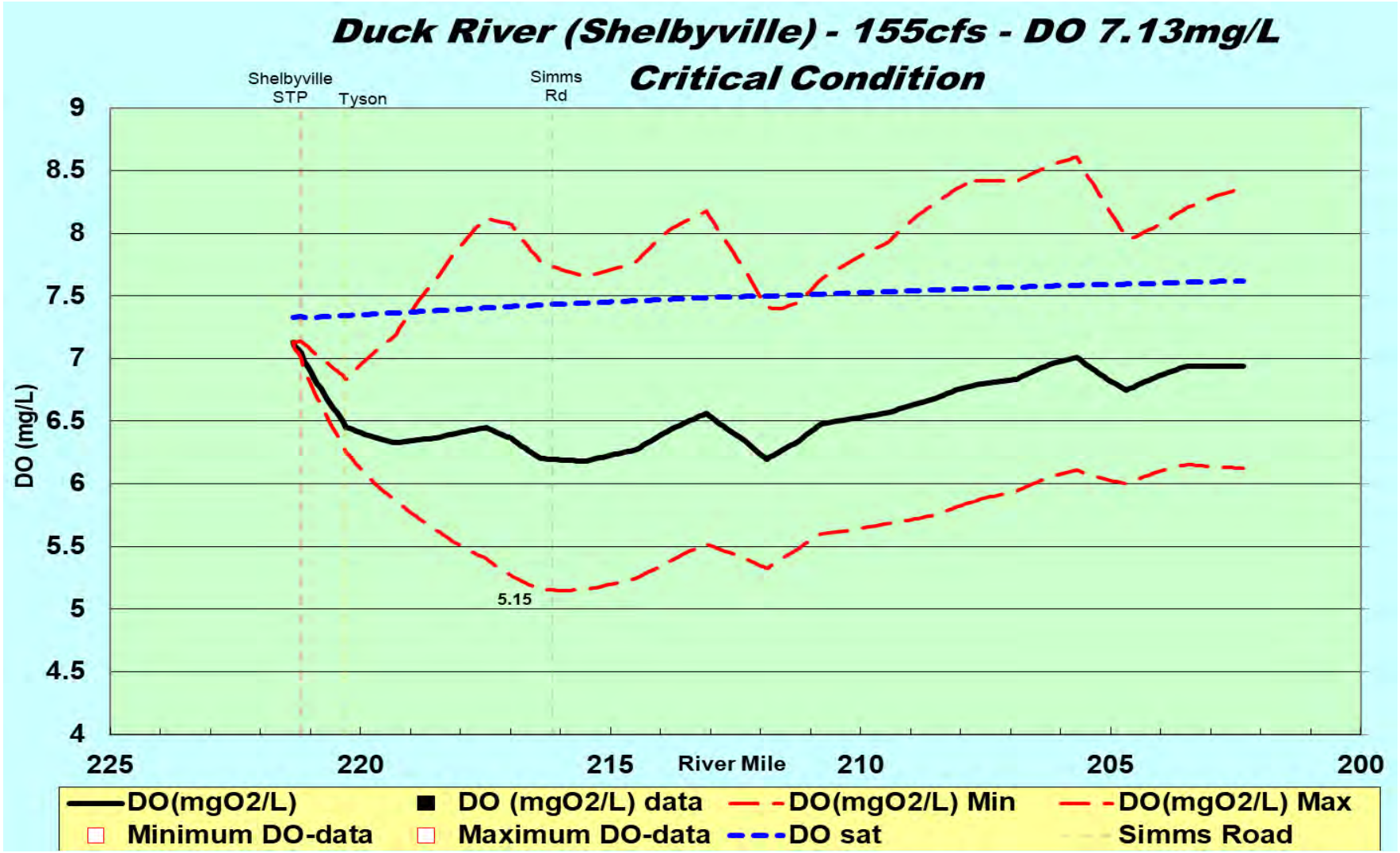
- Scenarios with proposed alternative flow constraints, plus the $1Q_{10}$ regulatory flow: (155 cfs, 139 cfs, 135 cfs, 120 cfs, and 80 cfs)
- Boundary DO concentrations
  - 6.0 mg/L (State-EPA Agreement)
  - 7.13 mg/L (minimum observed 2016 field data)*
- Results
  - Minimum DO (Sag)
  - Location of Minimum
  - Recovery Location

* Allowed by EPA-State Agreement in lieu of 6.0 mg/L

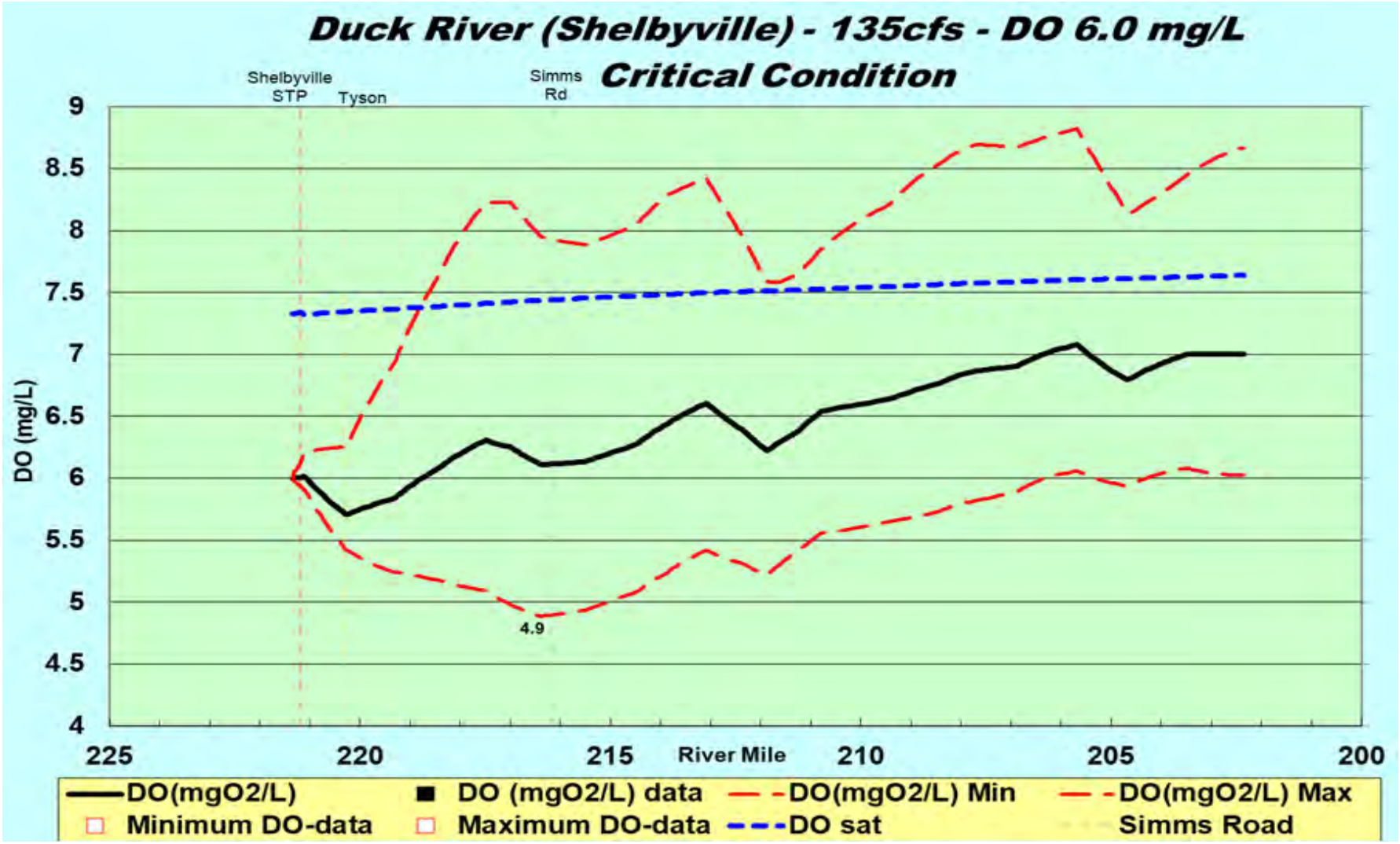
QUAL2k Assimilative Capacity Model (Alt. A)



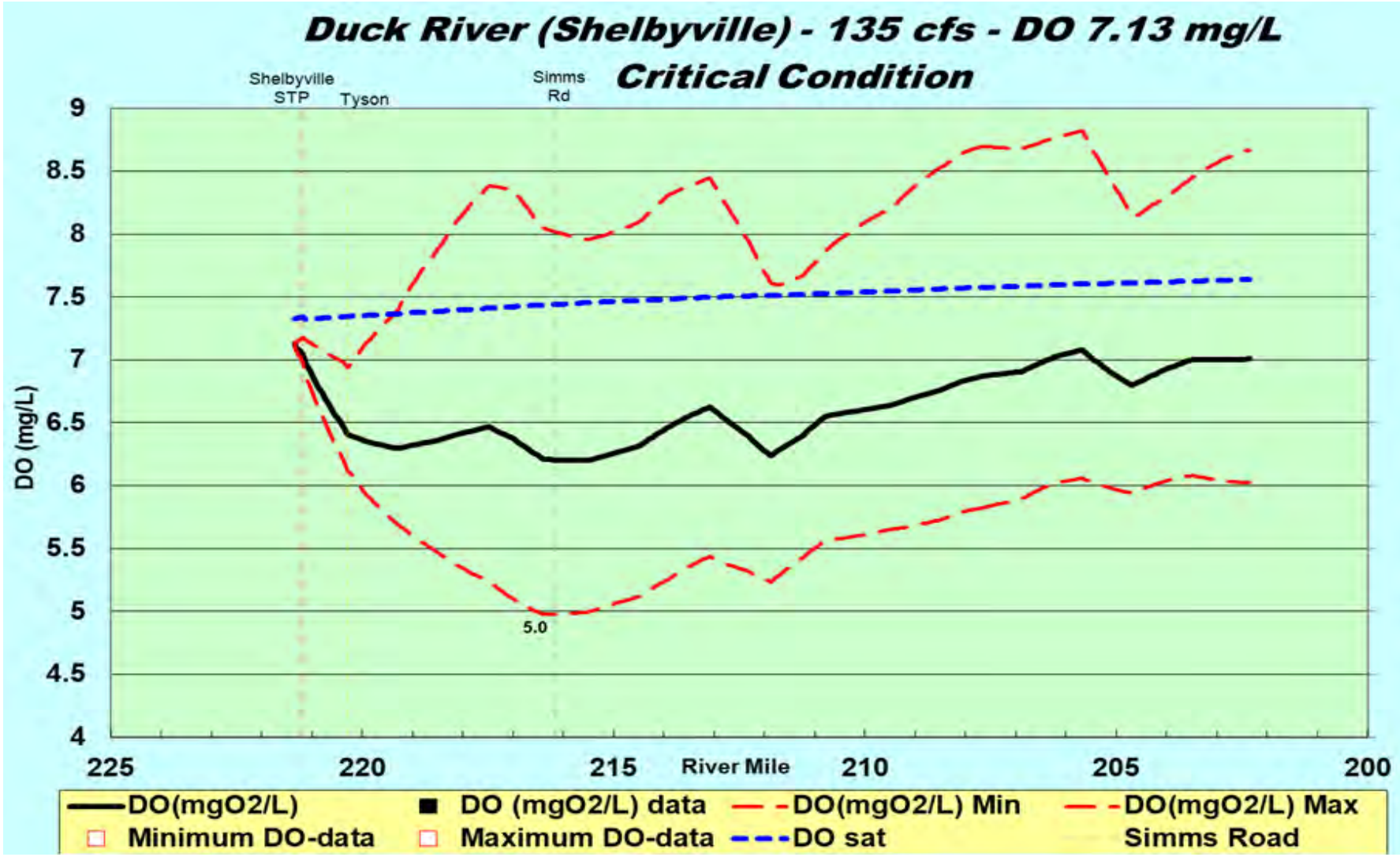
QUAL2k Assimilative Capacity Model (Alt. A)



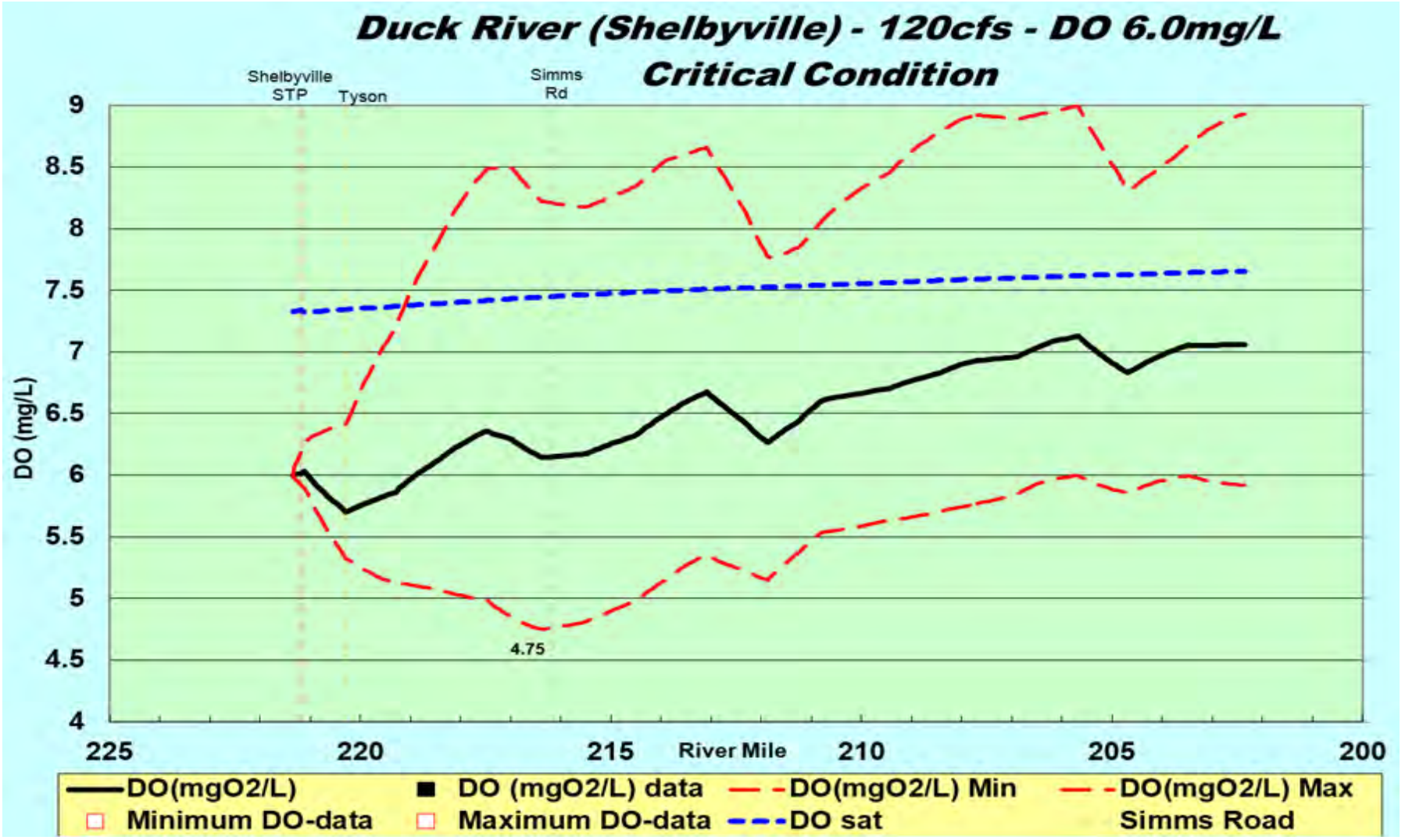
QUAL2k Assimilative Capacity Model (Alt. B)



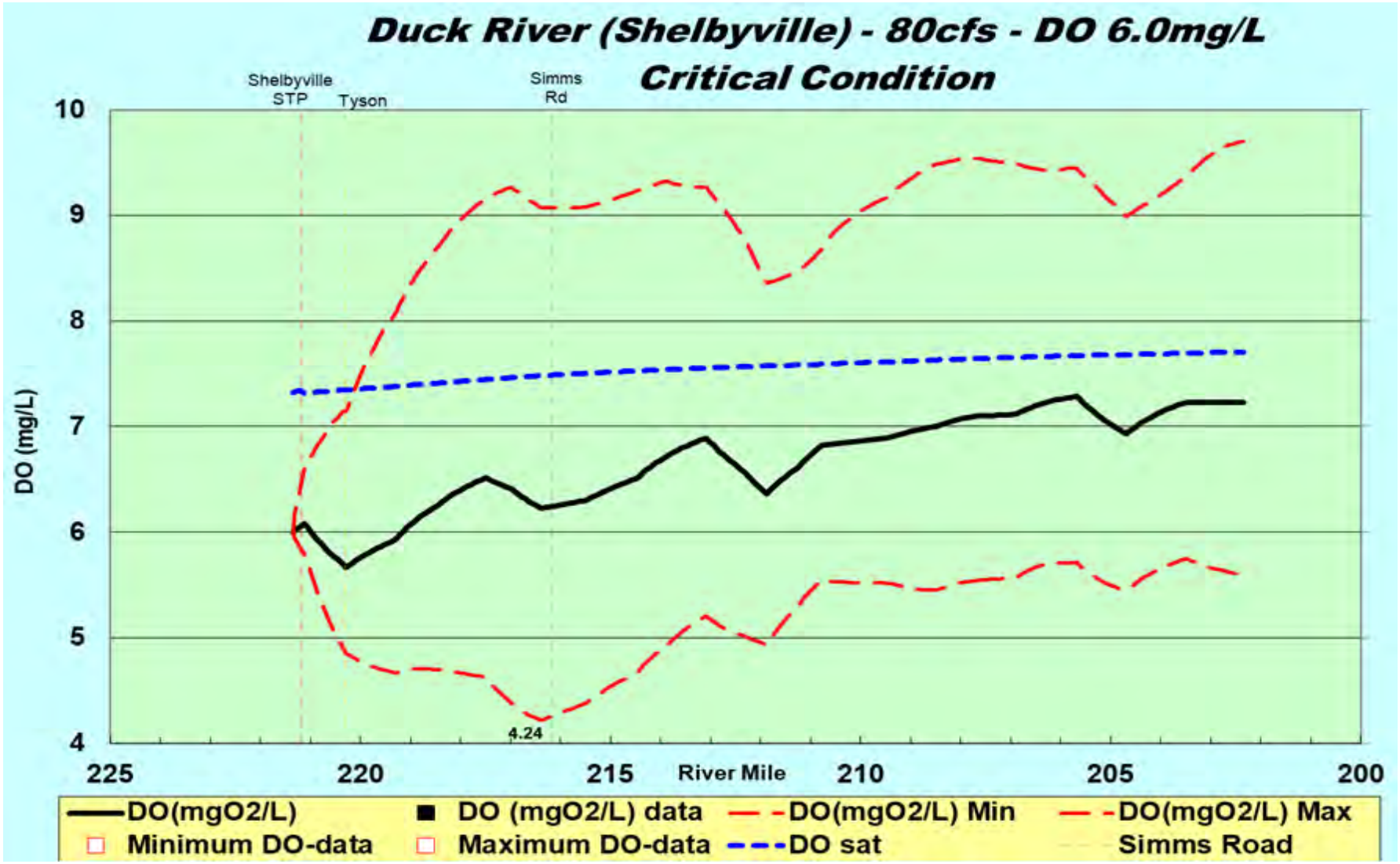
QUAL2k Assimilative Capacity Model (Alt. B)



QUAL2k Assimilative Capacity Model (Stage 3)



QUAL2k Assimilative Capacity Model (Stage 4)



Results of Ammonia Toxicity and DO Assimilative Capacity Analyses

Scenario	Flow (cfs)	Minimum DO (mg/L)[1,2]	River Mile (RM) of Minimum DO[1,2]	RM of DO Recovery (to 5 mg/L)[2]	Ammonia Toxicity (Yes/No)?[2]	RM of last Ammonia Toxicity[2]
Alt. A	155	5.04/5.15	216-217/216	NA/NA	No/No	NA/NA
$1Q_{10}$	139	4.9/5.0	216-217/216	215/NA	No/No	NA/NA
Alt. B	135	4.9/5.0	216-217/216	215/NA	No/No	NA/NA
Stage 3	120	4.75/4.82	216-217/216	214-215/214-215	Yes/Yes	205/205
Stage 4	80	4.24/4.26	216-217/216	214-215/214-215	Yes/Yes	DNR[3]

NA = Not Applicable

[1] Minimum DO (sag) occurs in the vicinity of Simms Road (RM ≈ 216)

[2] Values represented under two boundary DO concentrations (6.0/7.1 mg/L)

[3] Does Not Recover (model simulation ends at RM 202, at which point ammonia toxicity has not recovered)

Questions

Contacts:

Richard Cochran

Richard.Cochran@tn.gov

615-498-4315

Dennis Borders

Dennis.Borders@tn.gov

615-532-0706

Hazen

OASIS Model Overview

Duck River Symposium
Steve Nebiker

December 7, 2022

Systems Analysis

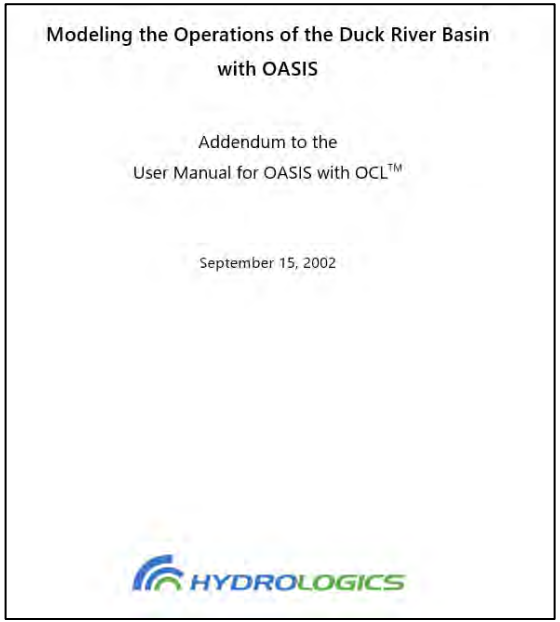
- Multiple objectives
- Striking a balance
- Engage stakeholders

- Need models that are useful, easy to use, and collaborative
- Ability to create operating rules to make efficient use of water
  - **Timing and magnitude of flows**
  - **Timing of reductions to releases and demands**
- Assist with real-time operational support, especially during drought

OASIS Applications in North America

History on the Duck

- Started back in 2002 with Duck River Agency and TNC



Modeling the Operations of the Duck River Basin with OASIS

Addendum to the
User Manual for OASIS with OCL™

September 15, 2002

HYDROLOGICS

In 2002, the DRA expanded its partnership-building efforts by inviting The Nature Conservancy, the US Geological Survey, the Tennessee Department of Environment and Conservation (TDEC), TVA, the US Fish and Wildlife Service, and other interested agencies to join a group known as the Duck River Water Resources Council (DRWRC). For the past several years, members of DRWRC and DRATAC have worked individually and collectively on a number of projects that have included water quality and hydrologic monitoring, land use planning in local communities, improvements in agricultural production practices, endangered species monitoring and recovery, stream restoration, and recreational access. One project sponsored by The Nature Conservancy—the development of a computer model for the Duck River with OASIS software from Hydrologics Inc.—helped transform initial decision-making regarding additional supply alternatives proposed by TVA. The

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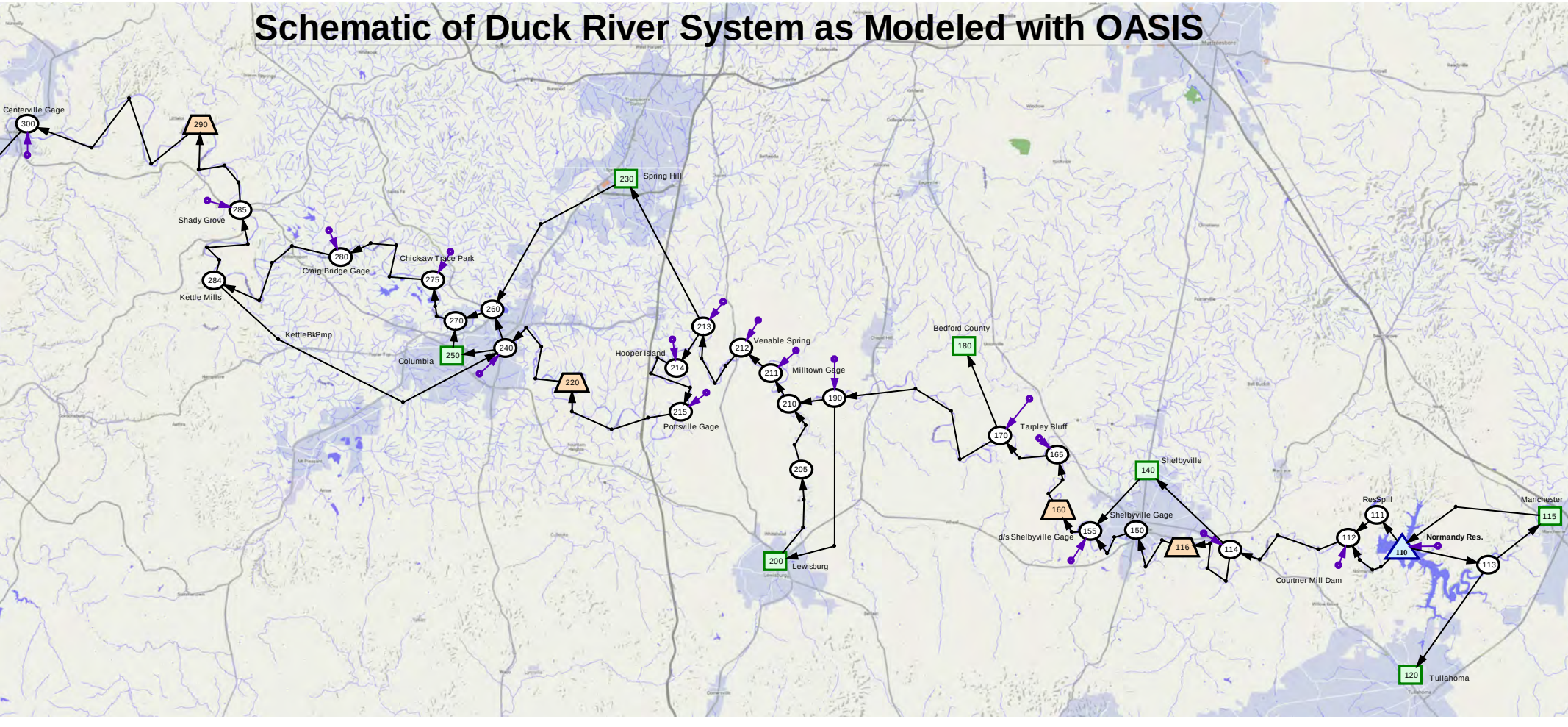
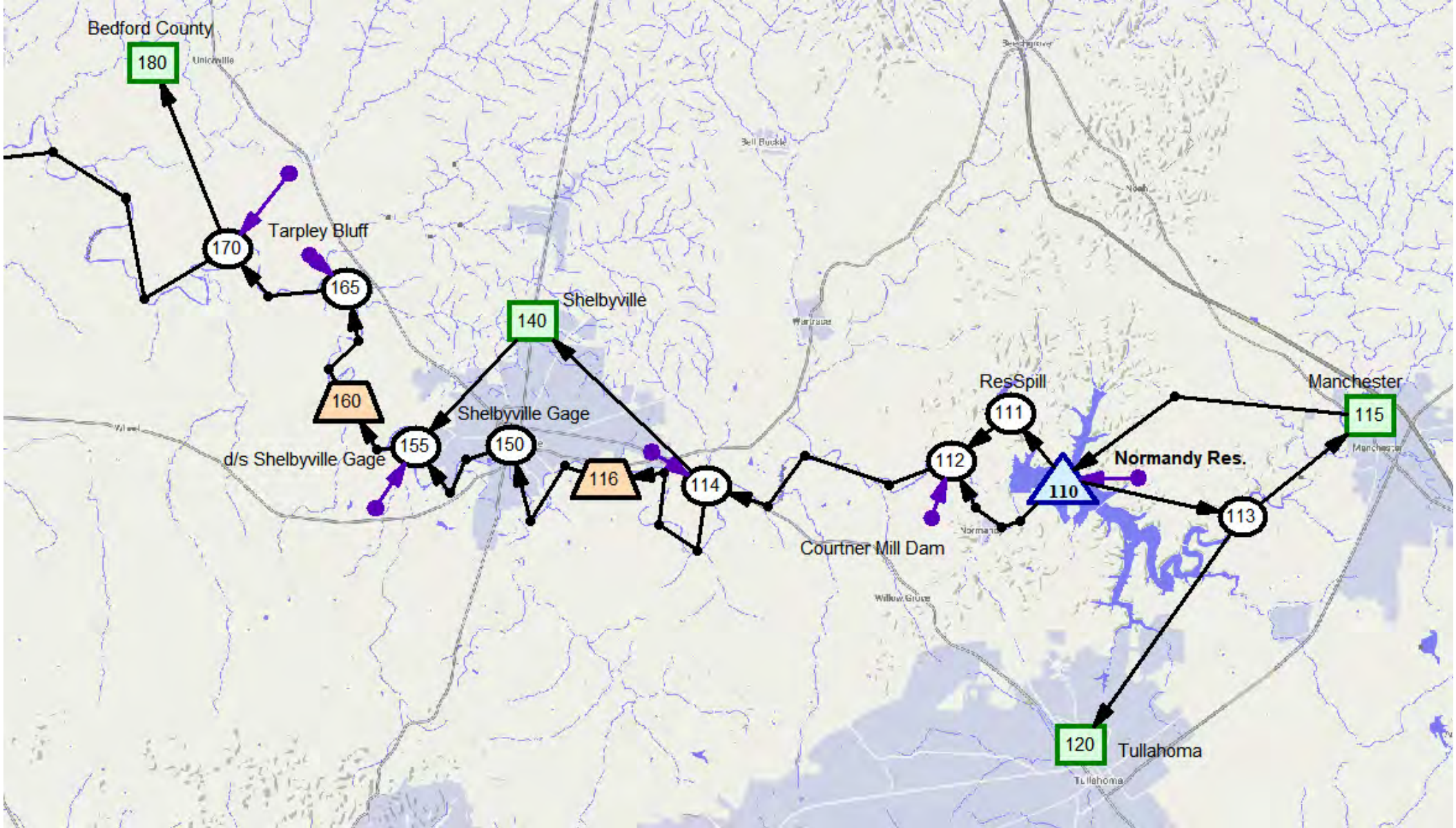
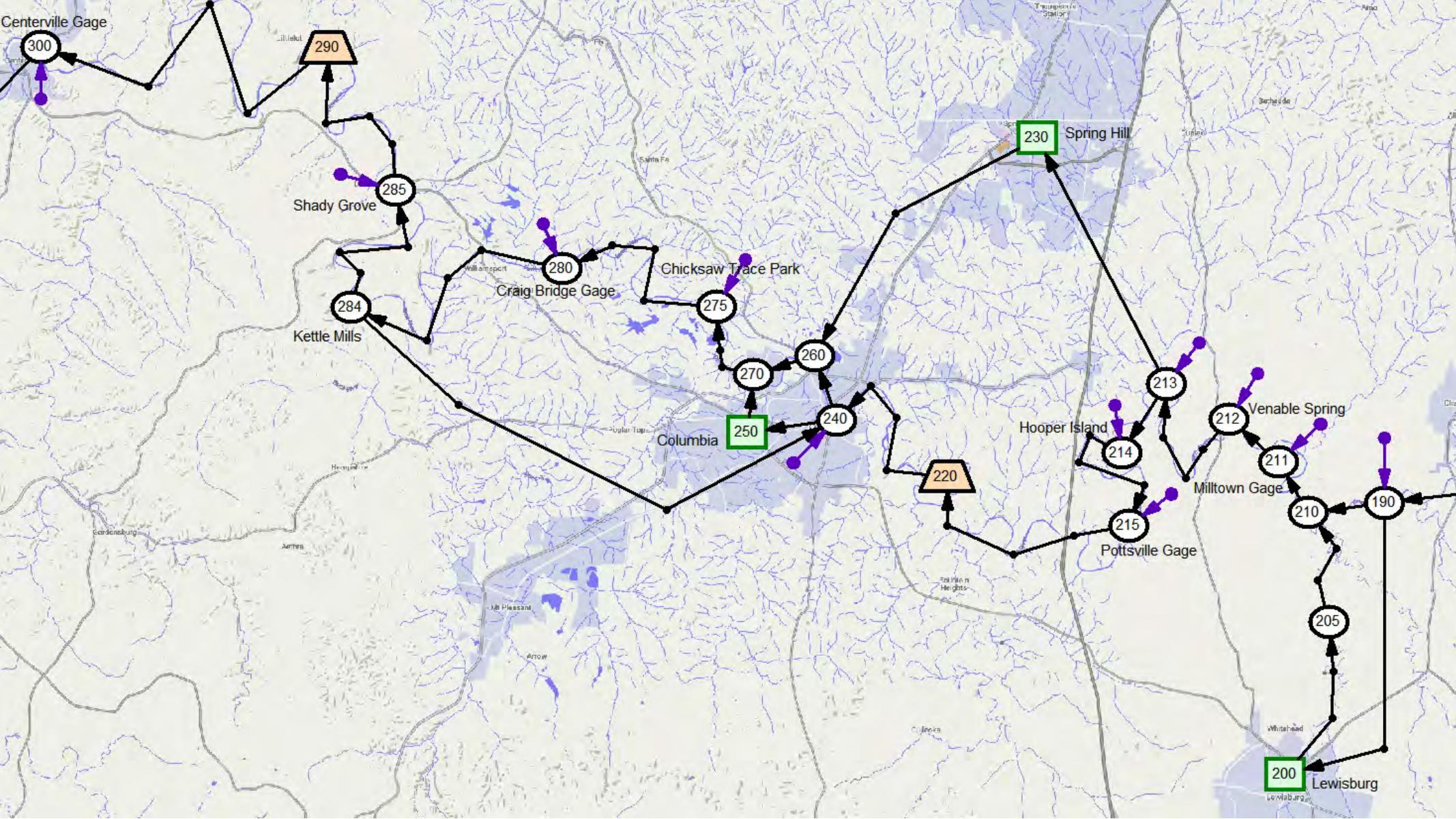
Schematic of Duck River System as Modeled with OASIS

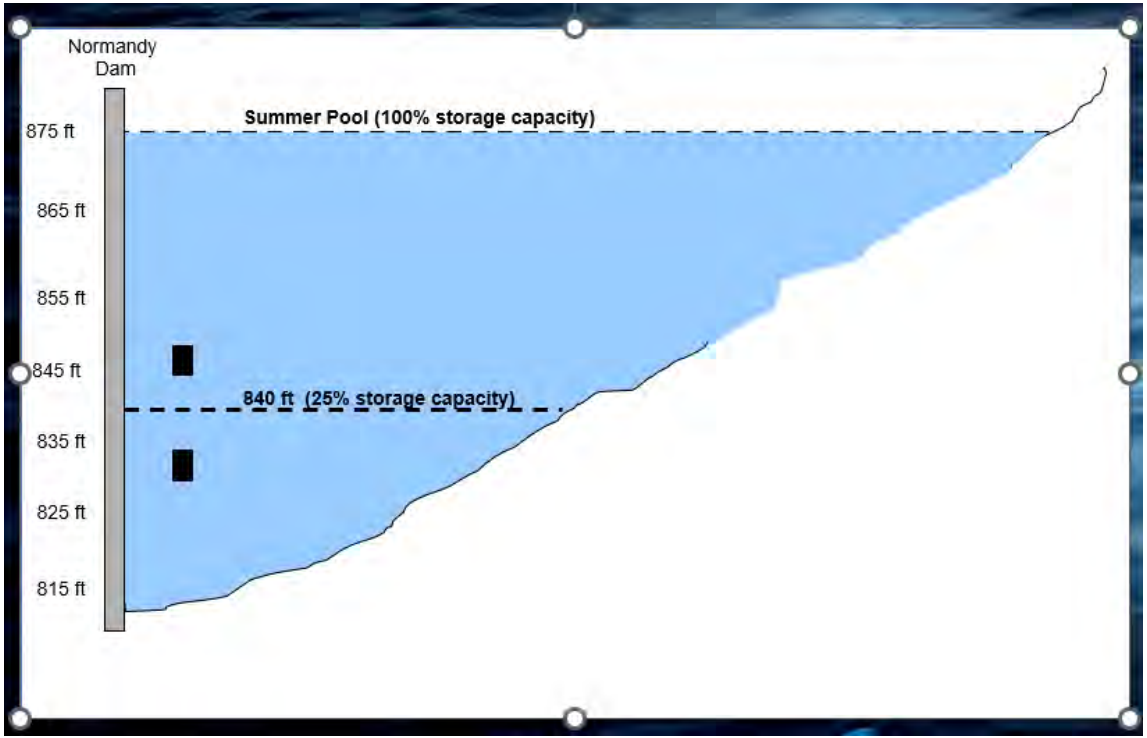



Bedford County
180
170
Tarpley Bluff
165
160
d/s Shelbyville Gage
155
Shelbyville Gage
150
140
Shelbyville
116
114
Courtner Mill Dam
112
ResSpill
111
110
Normandy Res.
113
115
Manchester
120
Tullahoma


Centerville Gage
300
290
285
Shady Grove
280
Craig Bridge Gage
Chicksaw Trace Park
275
284
Kettle Mills
270
260
250
Columbia
240
220
230
Spring Hill
213
Hooper Island
214
212
Venable Spring
211
Milltown Gage
210
190
215
Pottsville Gage
205
200
Lewisburg

Competing Needs

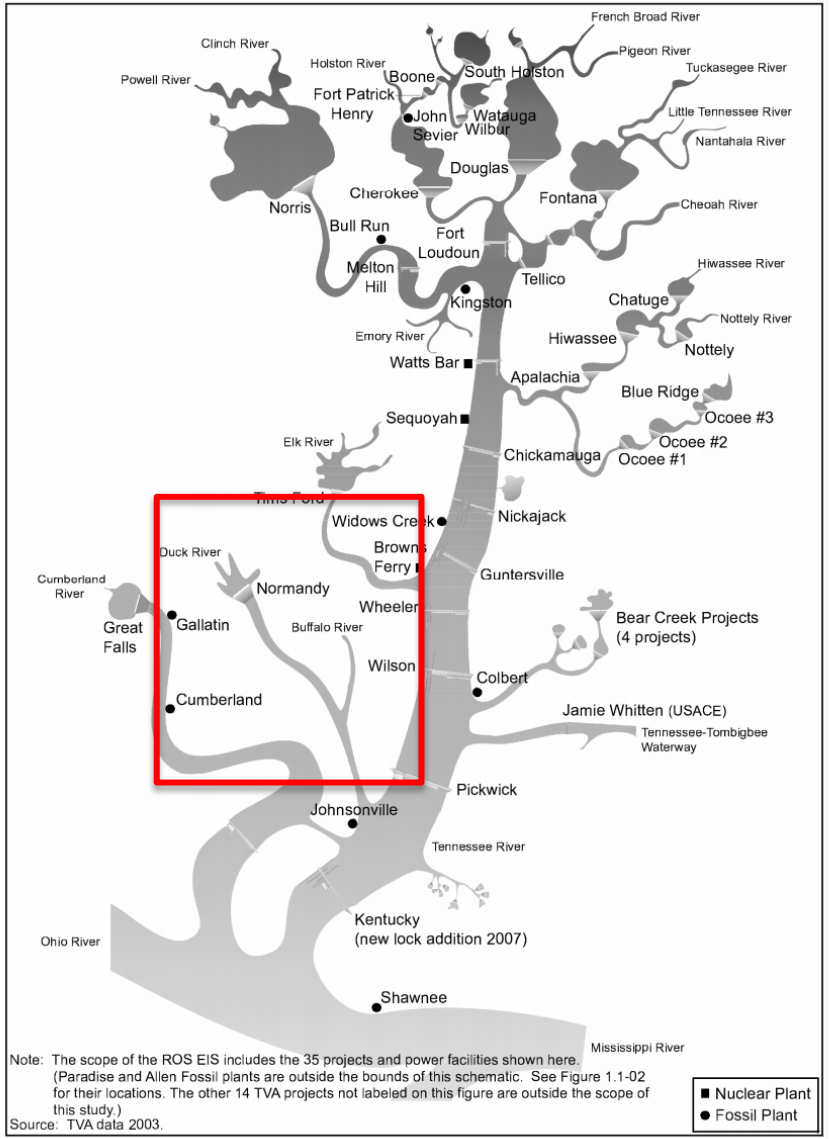
- In-lake
  - **Recreation, water supply, and water quality**



Competing Needs

- Downstream
  - **Flood control**
  - **Aquatic habitat**
  - **Wastewater assimilation**
  - **Water supply**

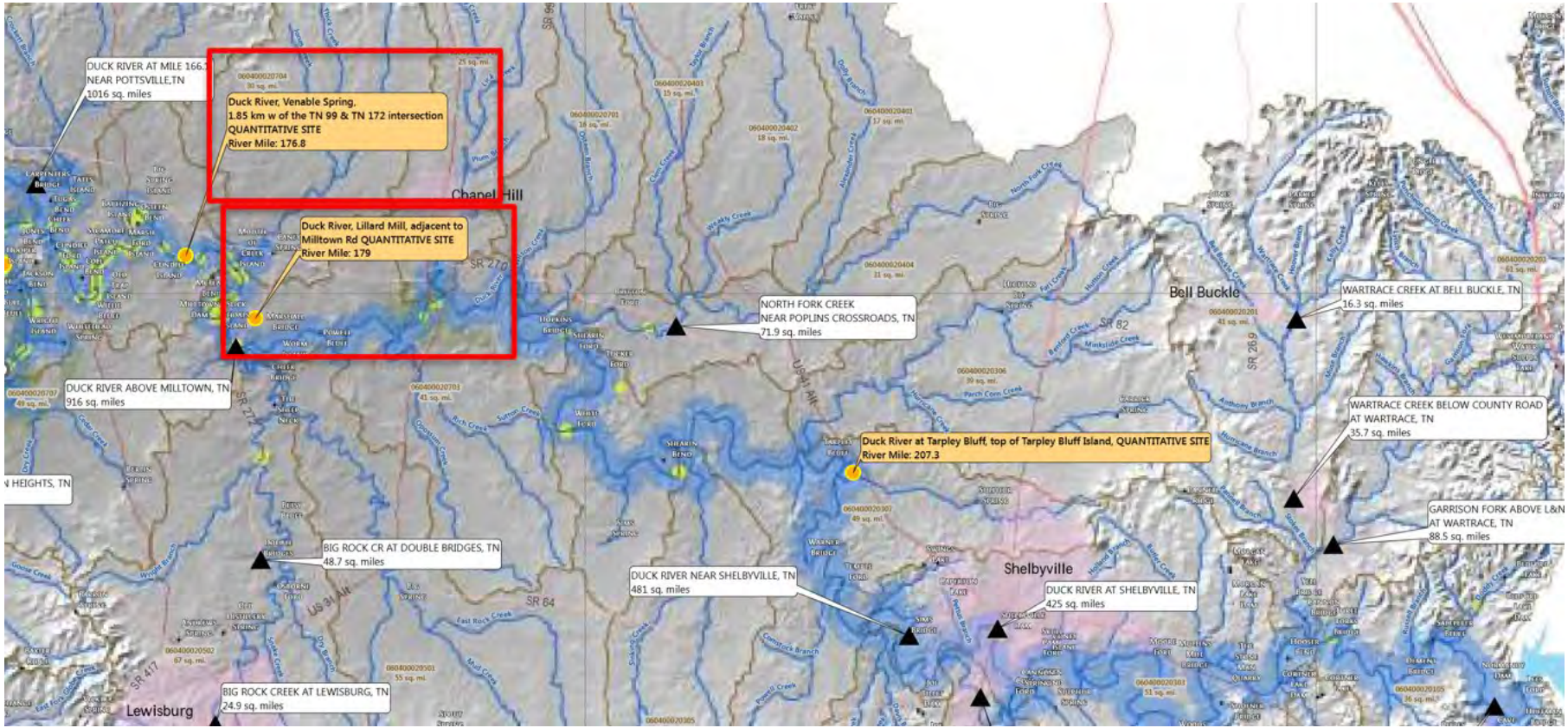
Flood Control



Note: The scope of the ROS EIS includes the 35 projects and power facilities shown here. (Paradise and Allen Fossil plants are outside the bounds of this schematic. See Figure 1.1-02 for their locations. The other 14 TVA projects not labeled on this figure are outside the scope of this study.)
Source: TVA data 2003.

Figure 2.2-01 Schematic Diagram of the TVA Water Control System

Habitat

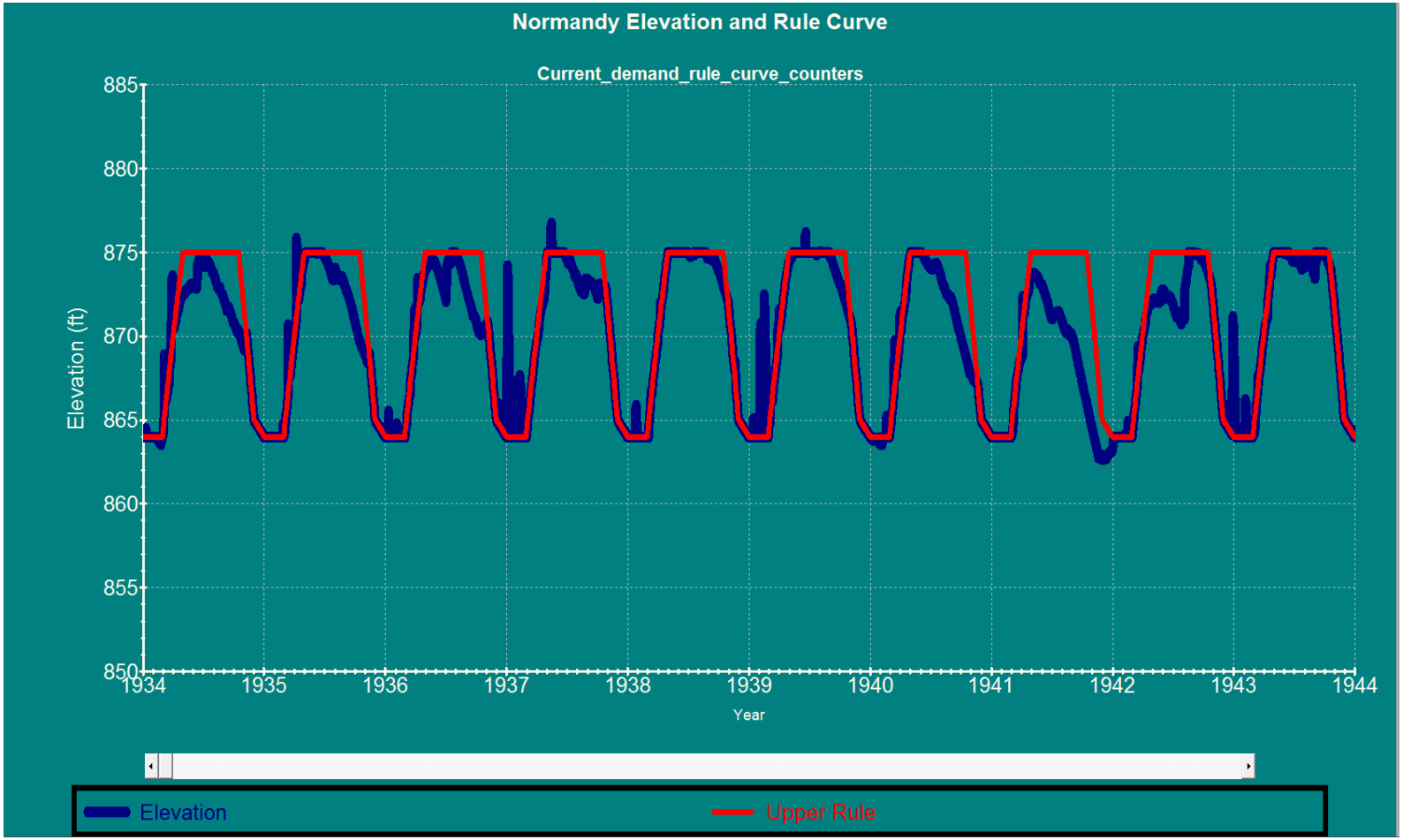

DUCK RIVER AT MILE 166.5
NEAR POTTSVILLE,TN
1016 sq. miles
Duck River, Venable Spring,
1.85 km w of the TN 99 & TN 172 intersection
QUANTITATIVE SITE
River Mile: 176.8
Duck River, Lillard Mill, adjacent to
Milltown Rd QUANTITATIVE SITE
River Mile: 179
Chapel Hill
NORTH FORK CREEK
NEAR POPLINS CROSSROADS, TN
71.9 sq. miles
Bell Buckle
WARTRACE CREEK AT BELL BUCKLE, TN
16.3 sq. miles
DUCK RIVER ABOVE MILLTOWN, TN
916 sq. miles
Duck River at Tarpley Bluff, top of Tarpley Bluff Island, QUANTITATIVE SITE
River Mile: 207.3
WARTRACE CREEK BELOW COUNTY ROAD
AT WARTRACE, TN
35.7 sq. miles
GARRISON FORK ABOVE L&N
AT WARTRACE, TN
88.5 sq. miles
BIG ROCK CR AT DOUBLE BRIDGES, TN
48.7 sq. miles
DUCK RIVER NEAR SHELBYVILLE, TN
481 sq. miles
Shelbyville
DUCK RIVER AT SHELBYVILLE, TN
425 sq. miles
BIG ROCK CREEK AT LEWISBURG, TN
24.9 sq. miles
Lewisburg
SR 270
SR 82
SR 64
SR 417
US 31 Alt
US 41 Alt

Water Supply

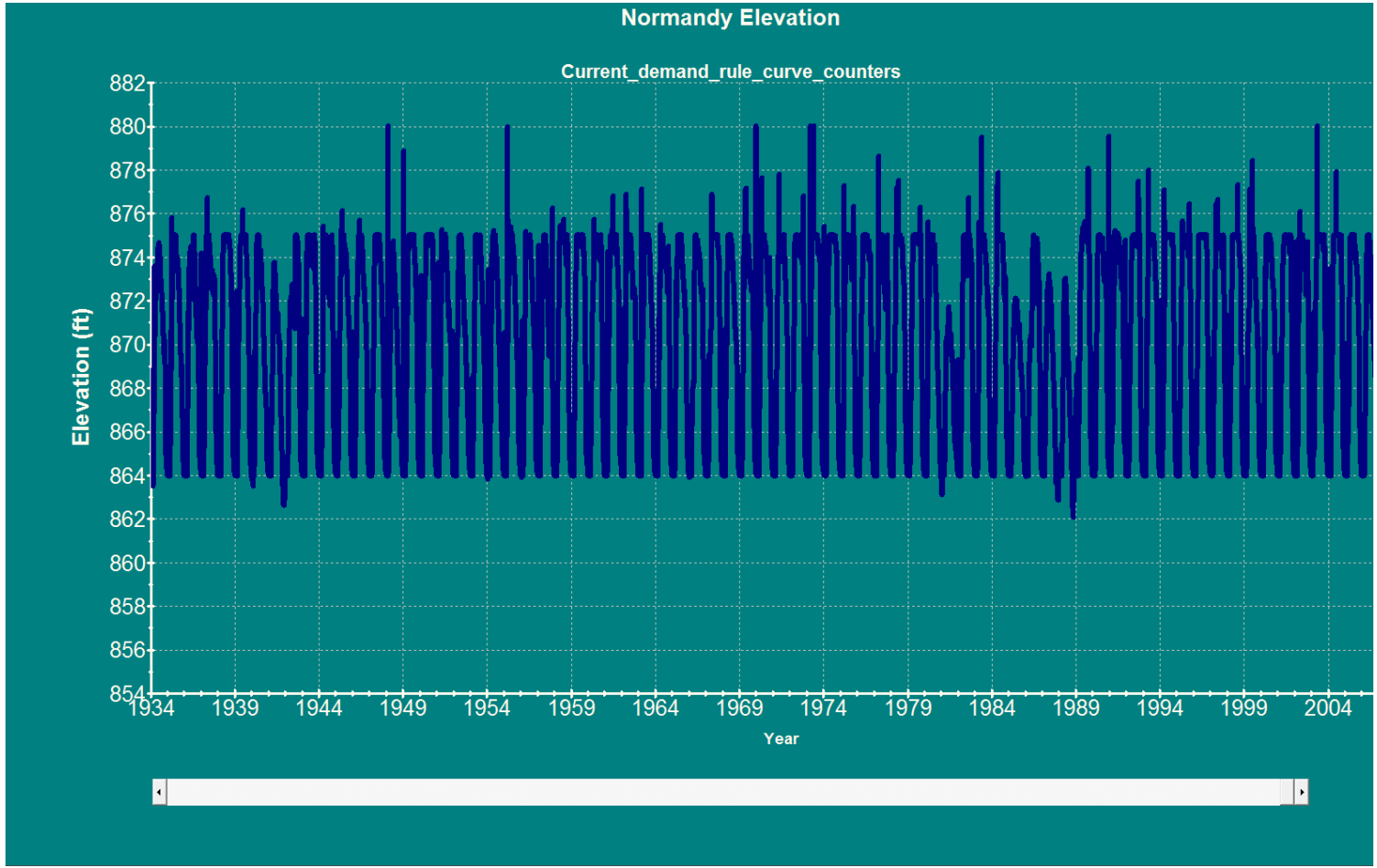
	2015	2020	2025	2030	2035	2040	2045	2050
Coffee County								
Tullahoma Utilities Board	3.08	3.39	3.73	4.12	4.55	5.03	5.57	6.18
Manchester Water and Sewer Department	2.46	2.68	2.90	3.15	3.43	3.73	4.07	4.45
Bedford County								
Shelbyville Power, Water, and Sewerage System	3.85	4.18	4.52	4.89	5.19	5.51	5.85	6.22
Bedford County Utility District	1.80	1.94	2.07	2.21	2.31	2.40	2.50	2.60
Marshall County								
Lewisburg Water and Wastewater	2.47	2.64	2.90	3.17	3.40	3.64	3.90	4.20
Maury/Southern Williamson County								
Spring Hill Water System	2.66	3.03	3.41	3.84	4.08	4.31	4.55	4.79
Columbia Power and Water Systems	7.54	8.22	8.91	9.63	10.35	11.10	11.88	12.74
Total DRA Demand WITHOUT Plumbing Code Savings	**23.86**	**26.08**	**28.44**	**31.01**	**33.31**	**35.72**	**38.32**	**41.18**

Assumed cost of demand restrictions = $2500 / MG of lost sales

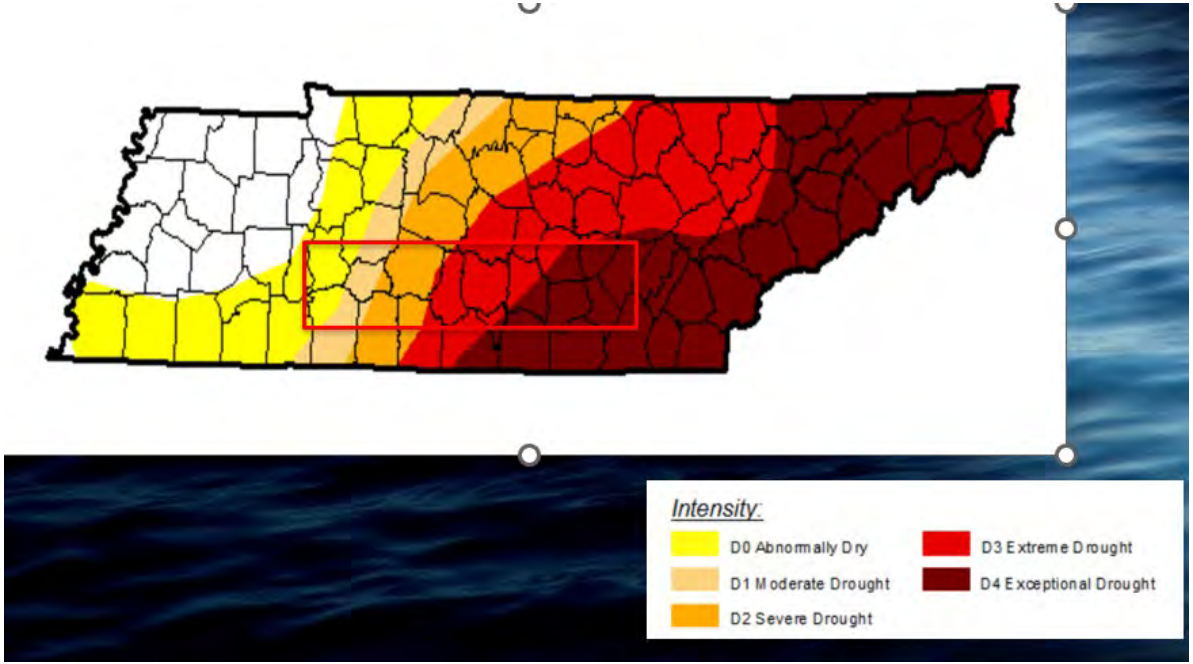
Simulated Reservoir Operations



Simulated Reservoir Operations

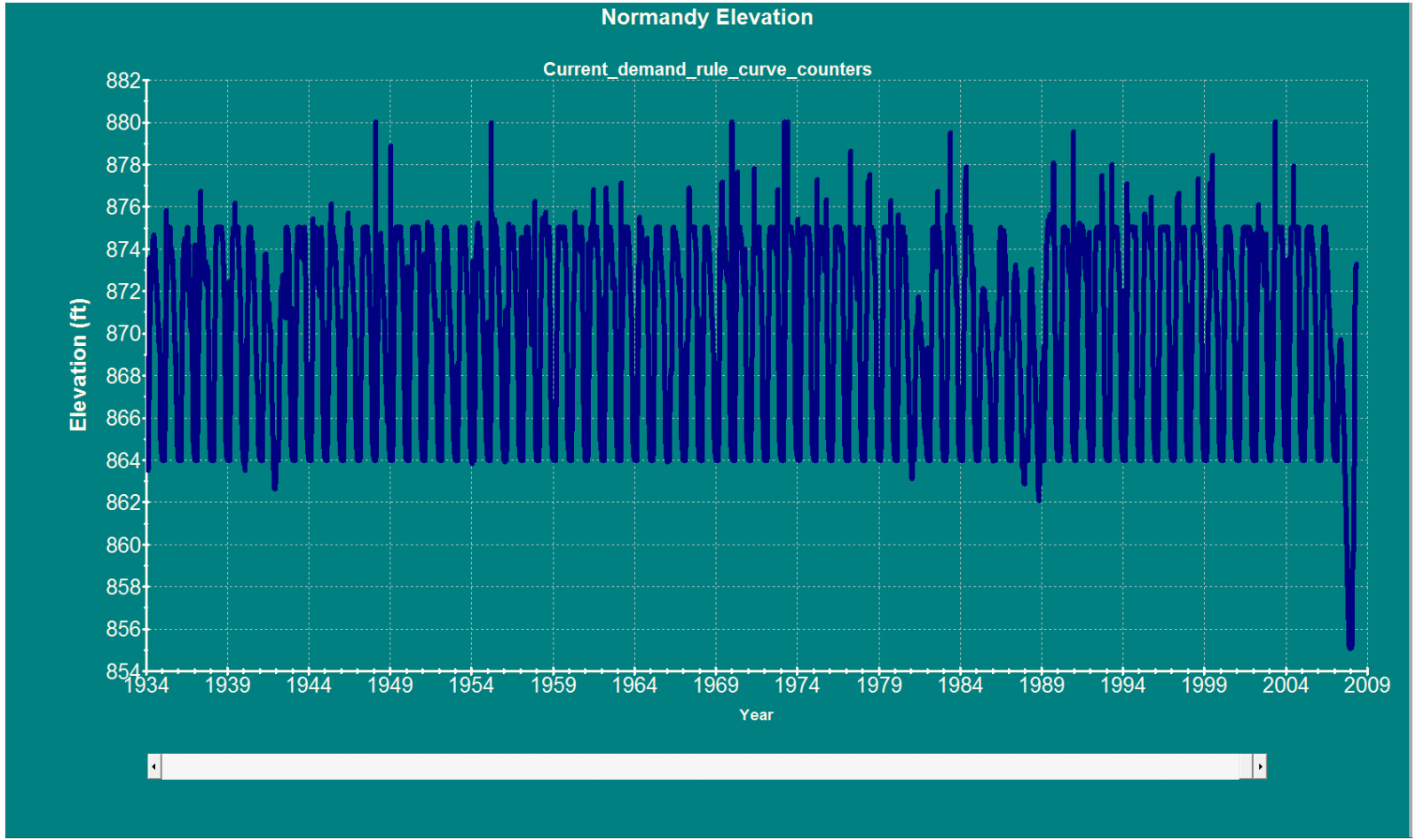


2007 Drought

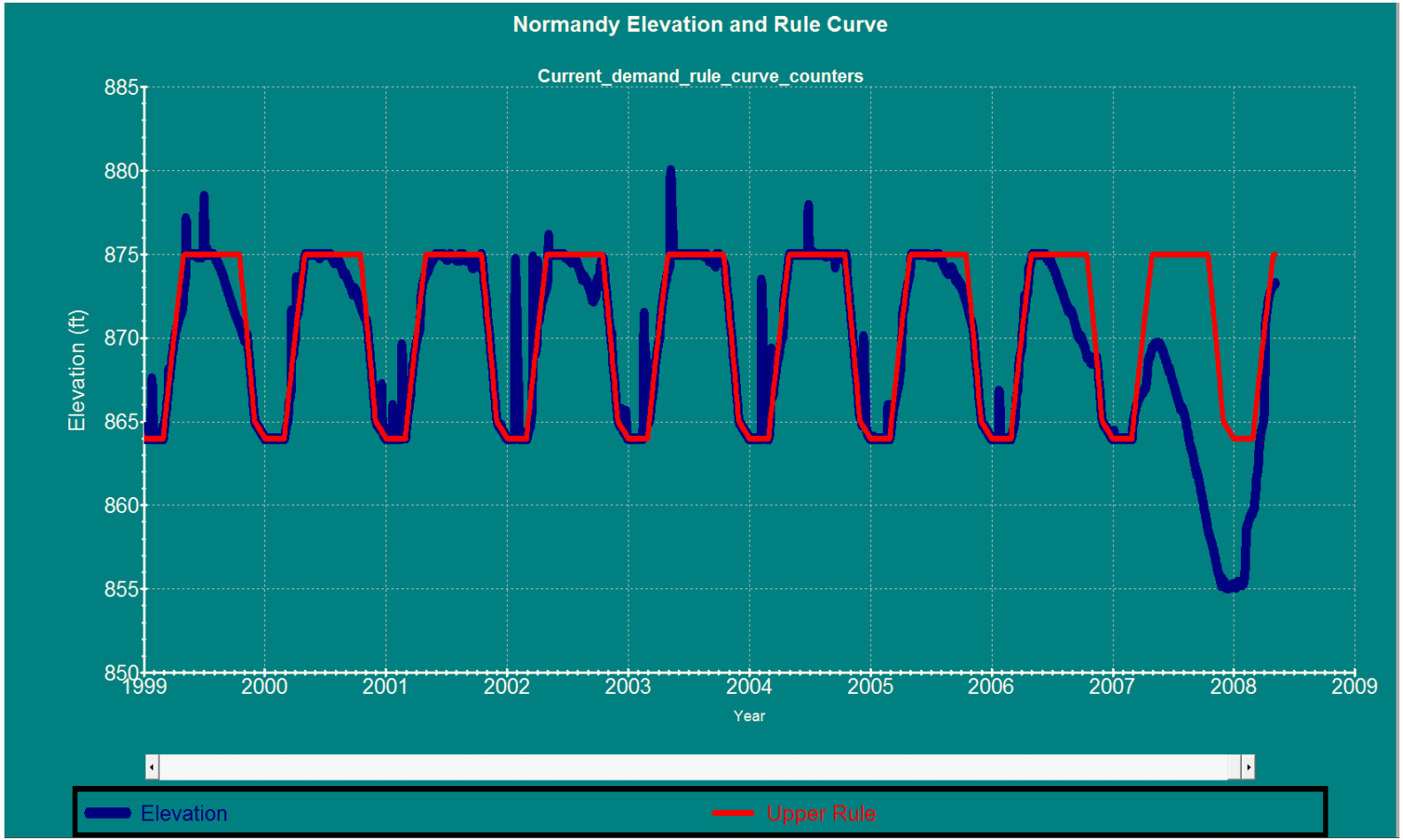


End of October drought monitor

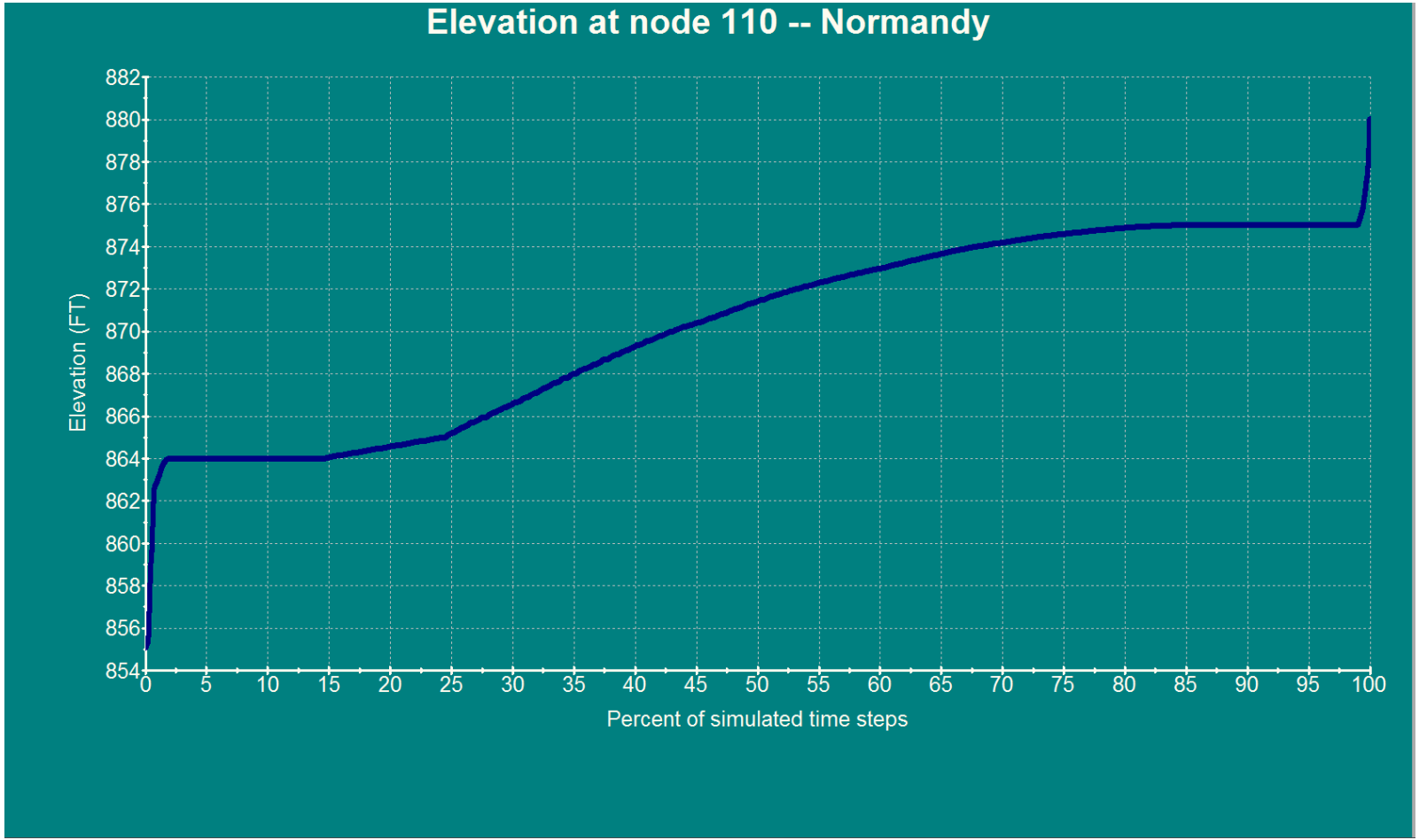
2007 Drought (Simulated)



2007 Drought (Simulated)



2007 Drought (Simulated)



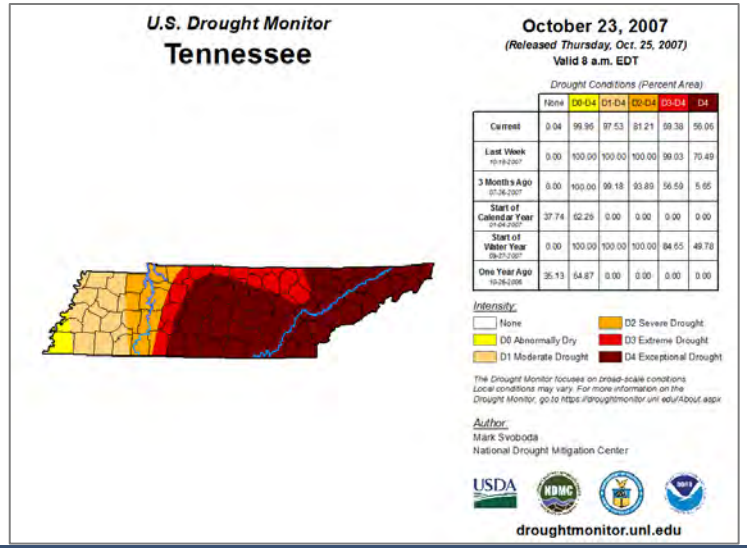
2007 Drought

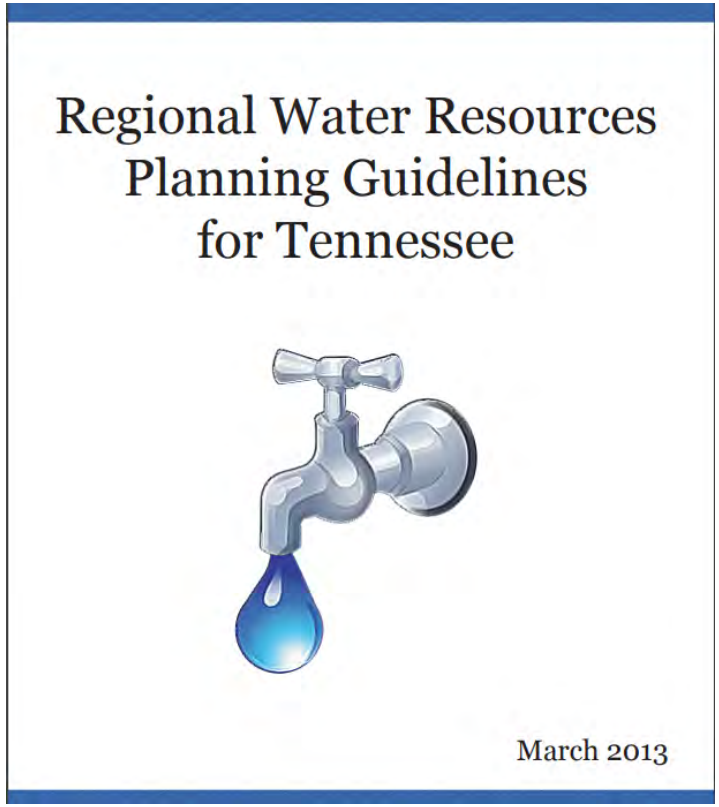
Averting a Water Supply Crisis While Protecting Endangered Species: Partnerships Pay Off for Tennessee's Duck River

In 1999, the Tennessee chapter of The Nature Conservancy launched one of its first river projects—on the Duck River in Middle Tennessee. Our Duck River program quickly became involved with many federal, state, and local partners who were beginning to tackle the water supply challenges facing several communities in the river's watershed. One of the Nature Conservancy's key partners and the local force behind water resource planning in the watershed is the Duck River Agency (DRA). From 2000 to 2002, DRA members worked to build trust between all partners within the watershed—improving tools for water management planning and coordinating research priorities and efforts. Little did we know that these first steps we made together would pay off so soon. When Tennessee's exceptional drought came along in 2007, it put our relatively new collaboration straight to the test.

2007 Drought – A Turning Point for Tennessee

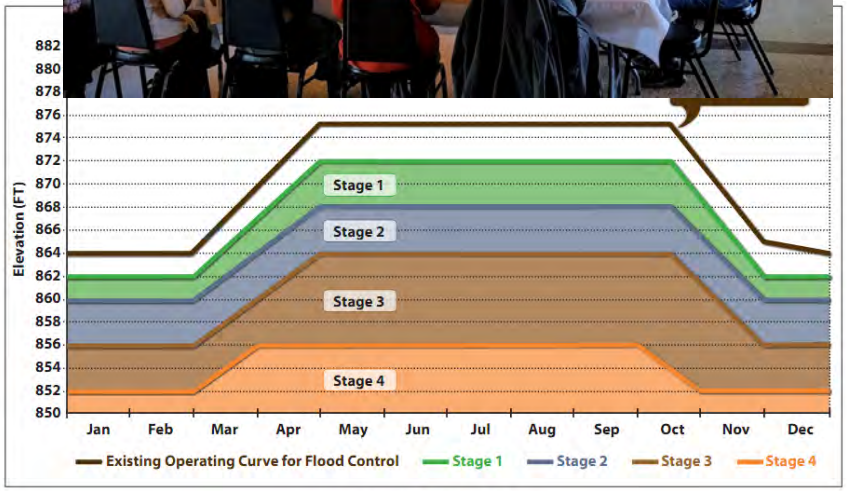
- Widespread impacts prompted state to develop drought plan guidance
- State used OASIS as part of regional pilot studies to improve system reliability





Modeling Since 2007

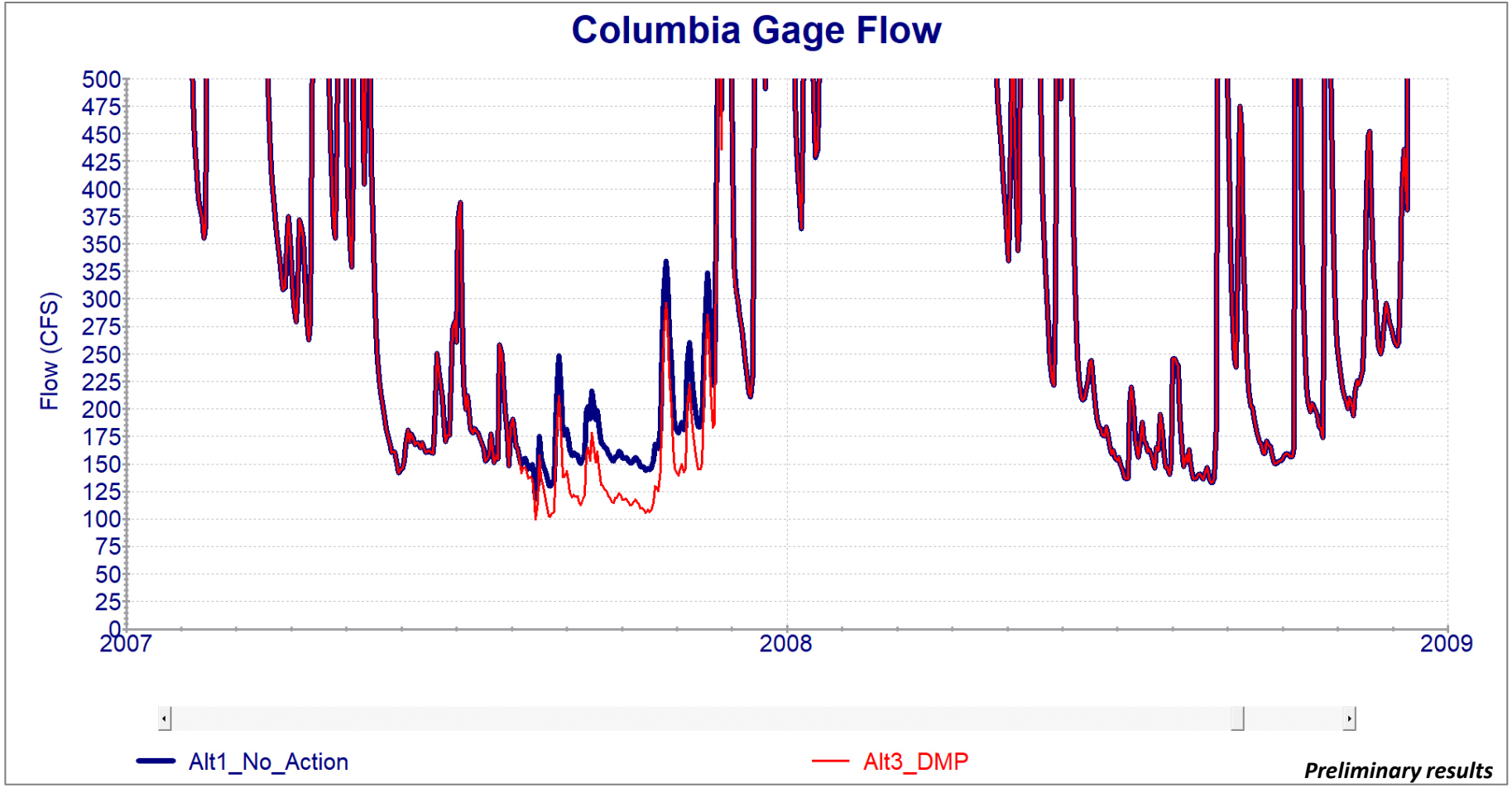
- To support DRA's Comprehensive Water Supply Plan
- To optimize Normandy releases and refine drought response
  - 100-year gaging record
  - 1000-year synthetic hydrology record
- Support water utility planning in basin
- Incorporated flow-wetted perimeter relationships from surveys at select locations
- Planning to incorporate USGS ecological flows work
- Drought exercise with stakeholders in 2017



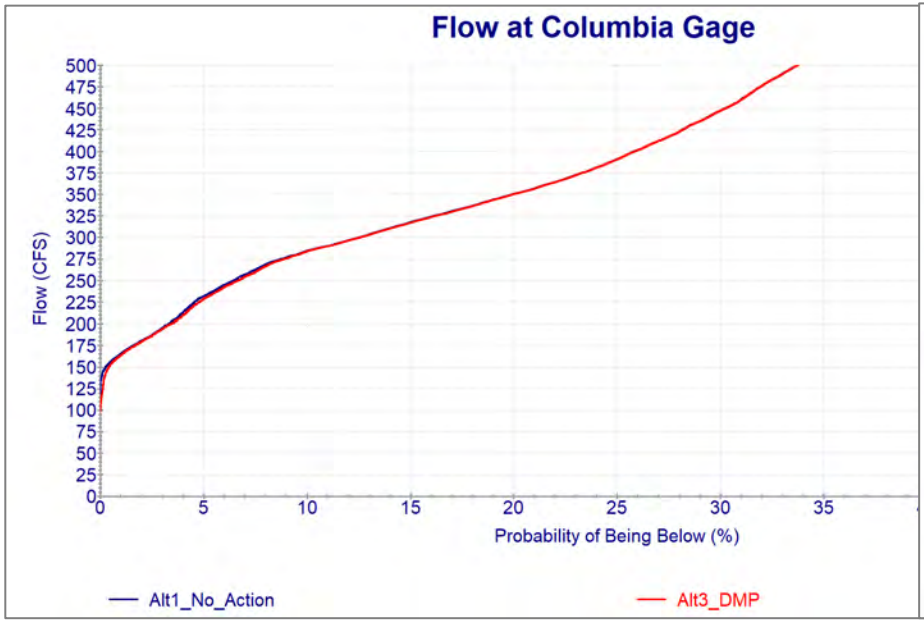
DROUGHT TRIGGERS

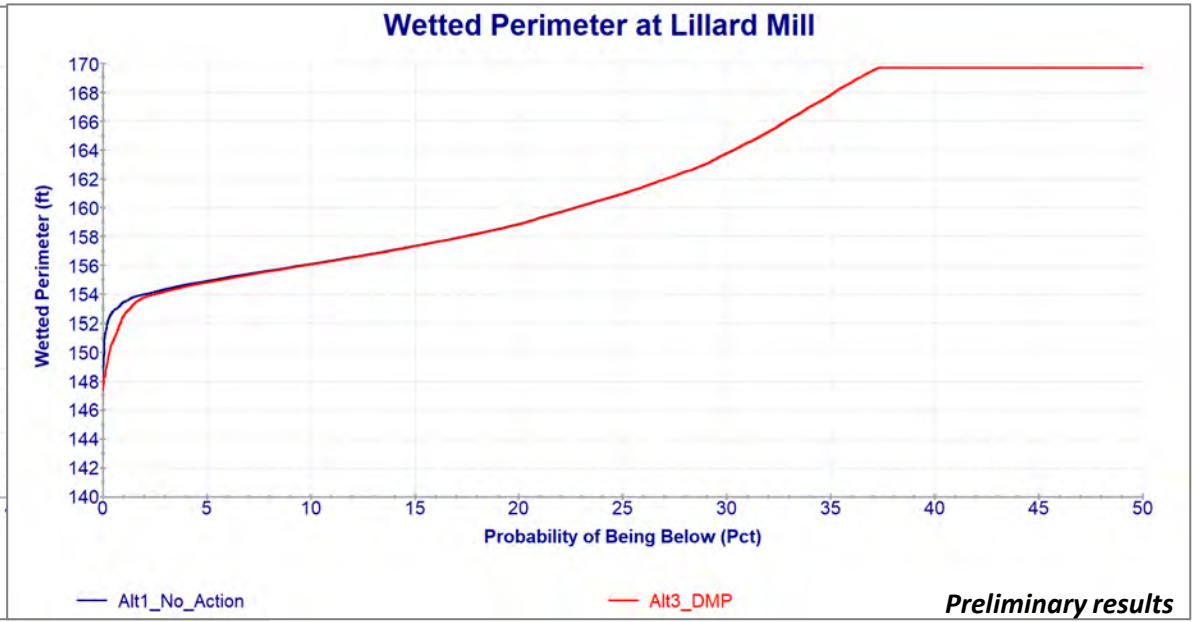
STAGE 1	STAGE 2	STAGE 3	STAGE 4
Drought Monitoring	Drought Alert	Drought Warning	Drought Emergency
▪ Initiate Drought Monitoring	▪ Alert Drought Committee ▪ Initiate Public Awareness	▪ 10 cfs / week reduction of Shelbyville target (down to 120 cfs) ▪ 10% reduction of public water use	▪ 10 cfs / week reduction of Shelbyville target (down to 80 cfs) ▪ 20% reduction of public water use

Operational Alternatives



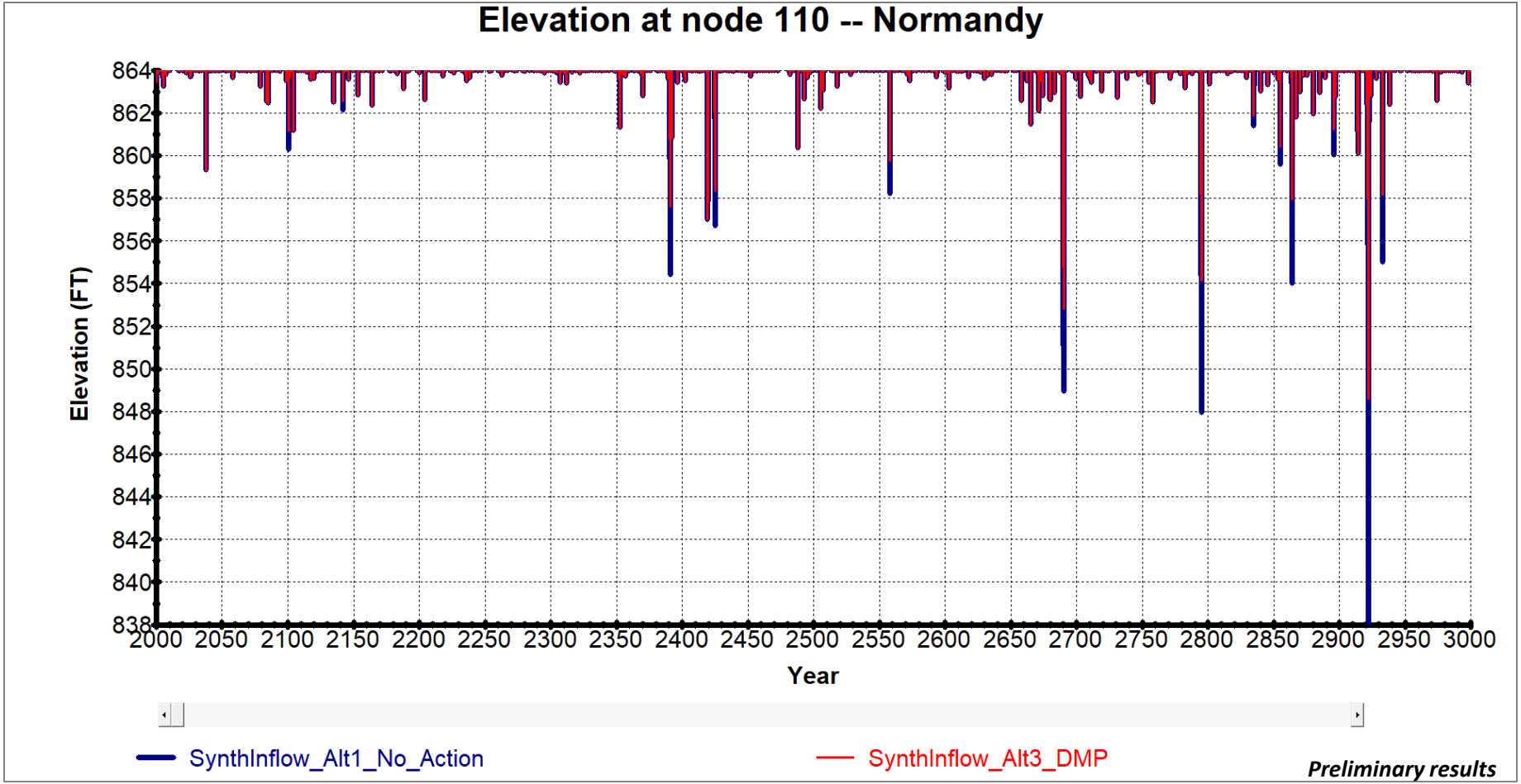
Operational Alternatives





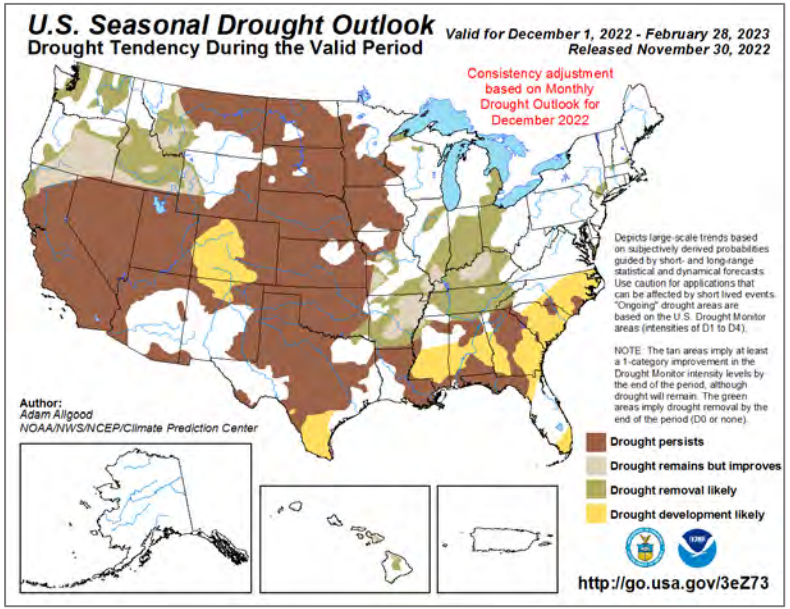
Preliminary results

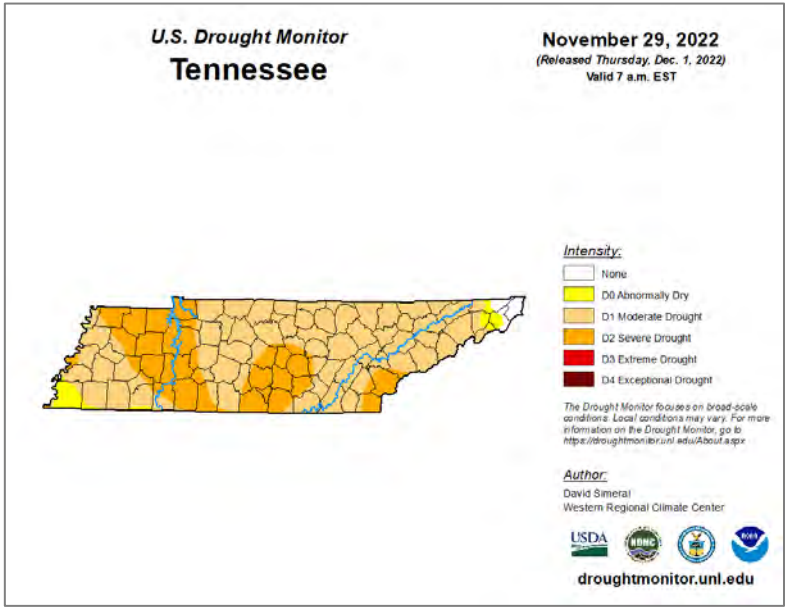
Operational Alternatives



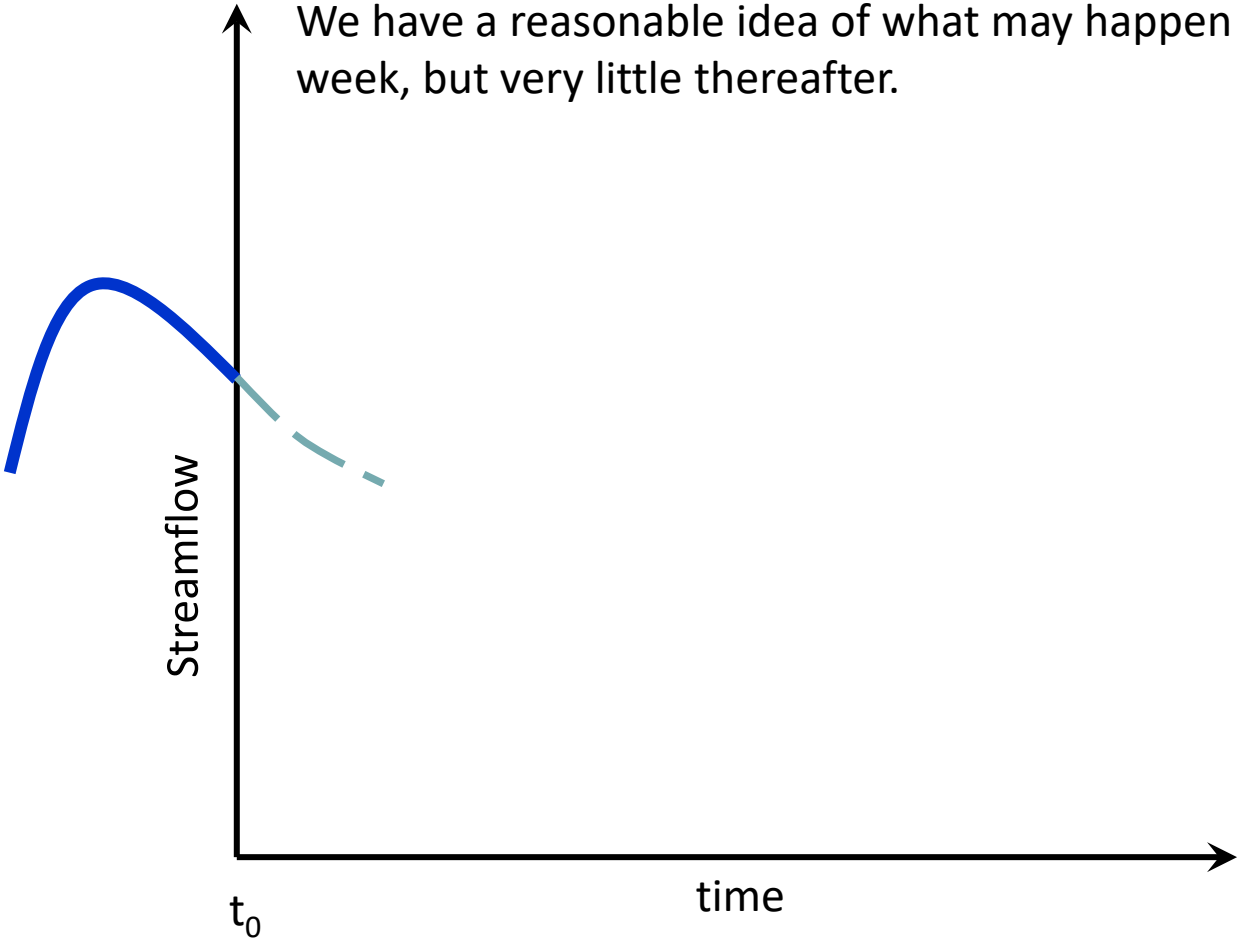
Forecasting

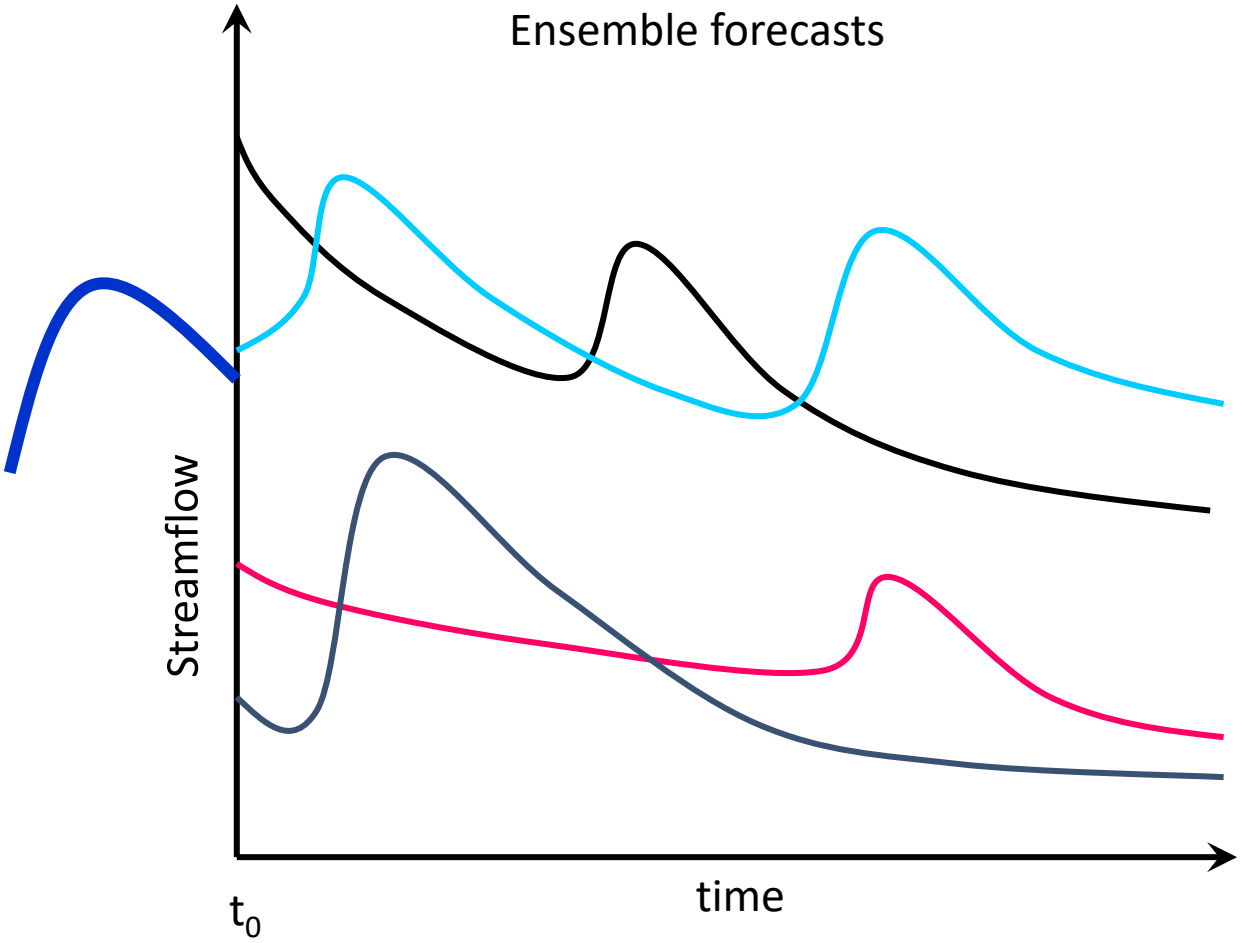
- Used to inform operations, especially during drought
- Drought monitor and NOAA long-range outlook are not river/system specific

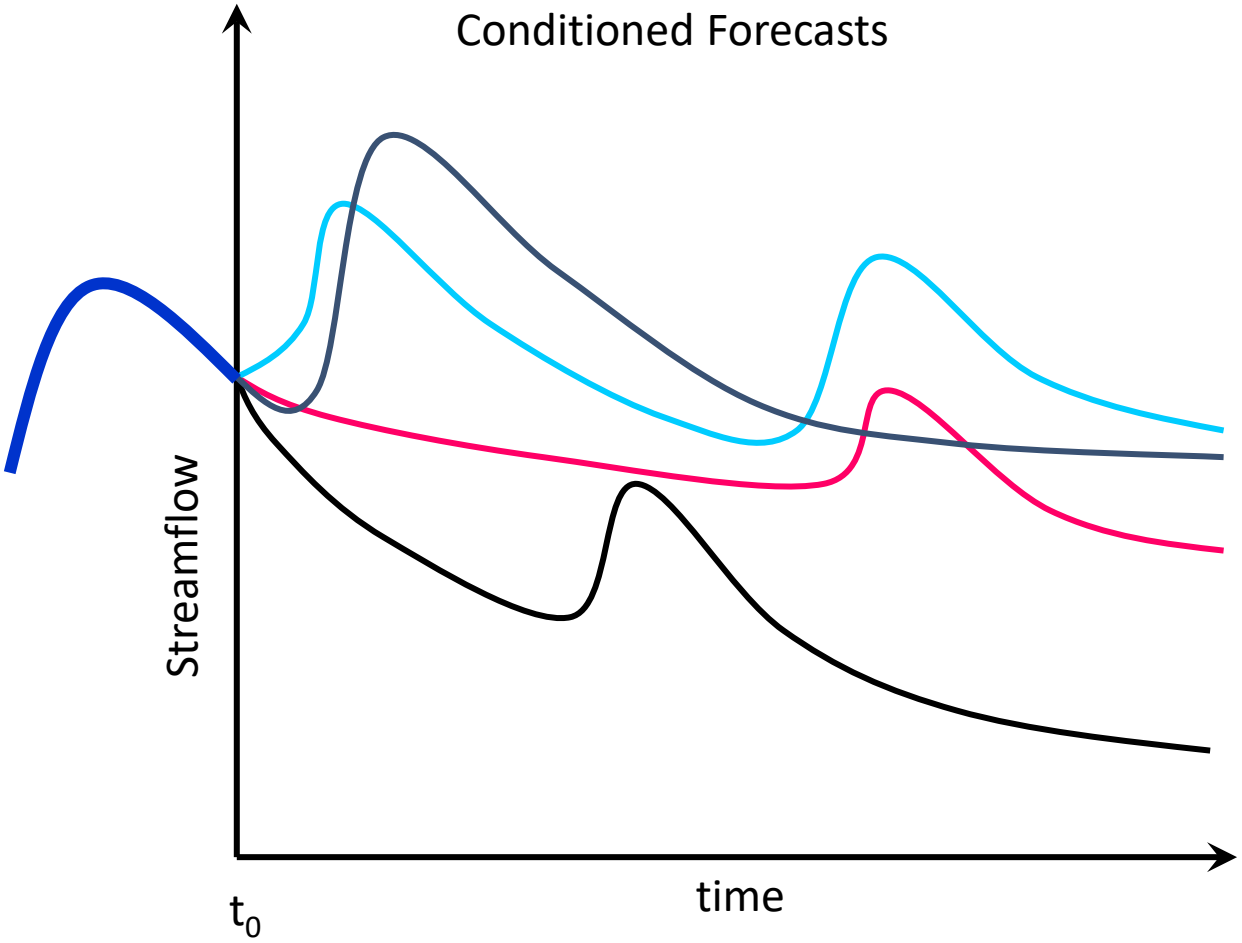




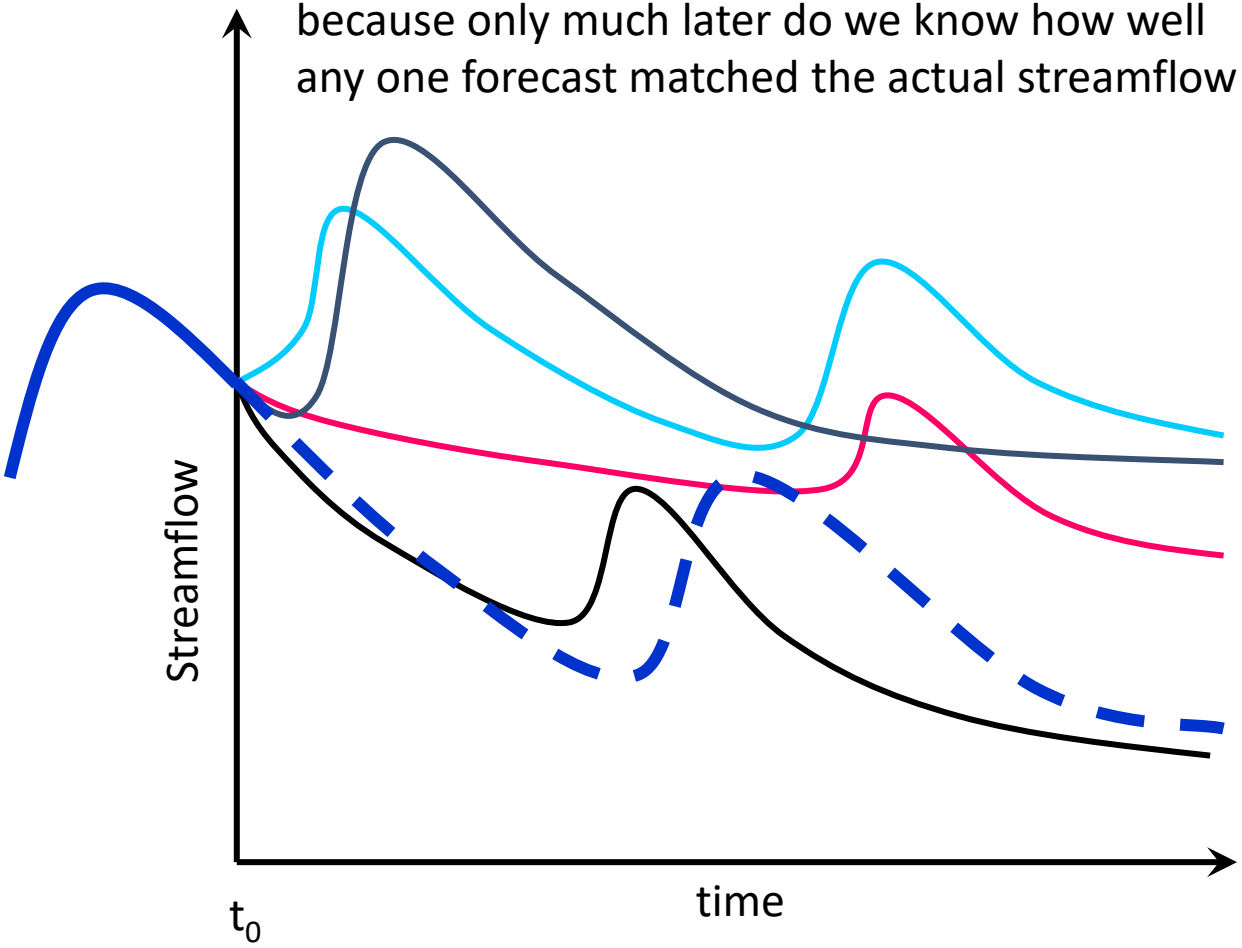
All we know today is what has happened in the past. We have a reasonable idea of what may happen next week, but very little thereafter.



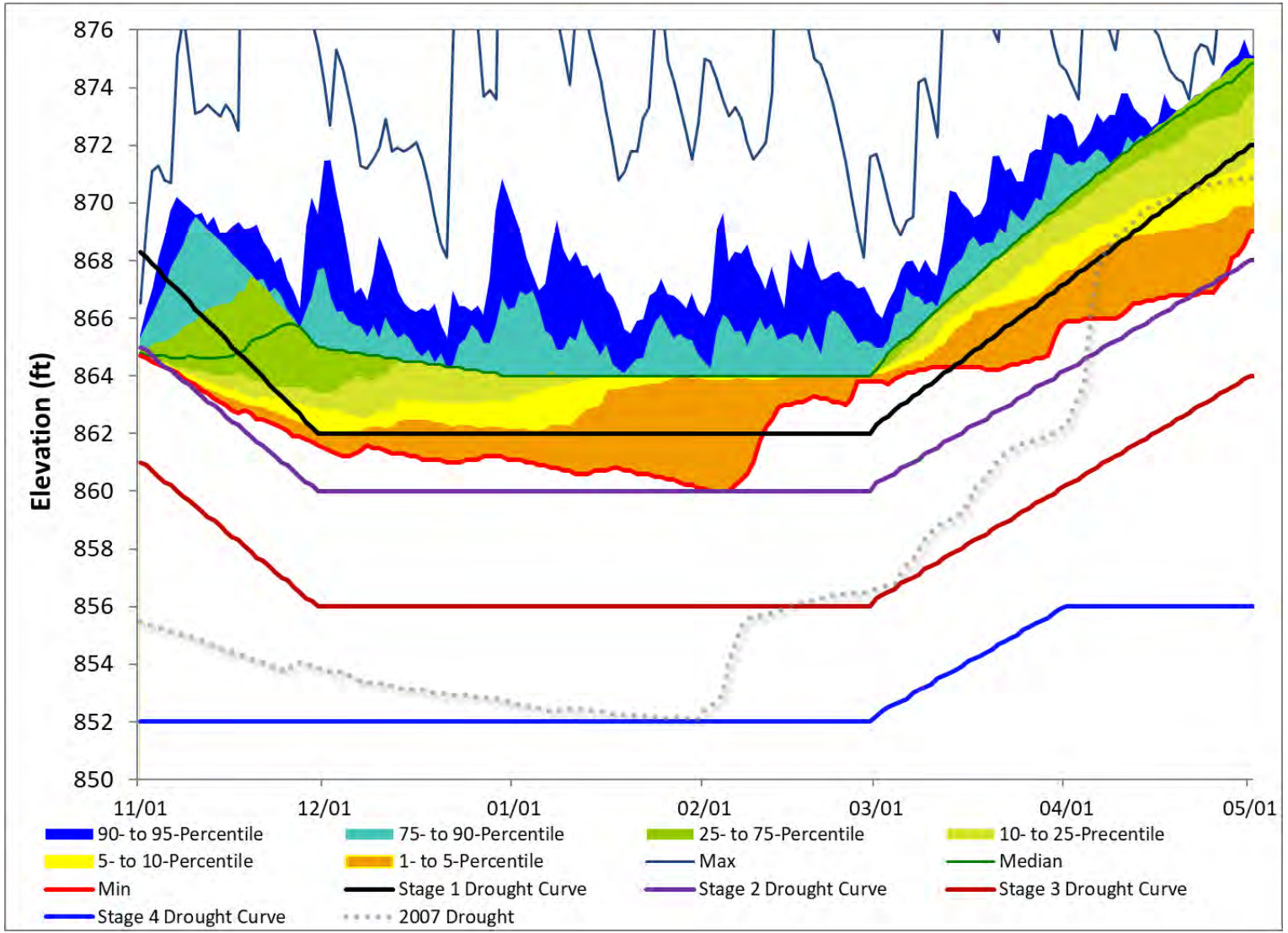

Ensemble forecasts
Streamflow
time
t_0


Conditioned Forecasts
Streamflow
time
t_0

We need to base decisions on probabilities because only much later do we know how well any one forecast matched the actual streamflow



Forecasting



Water Supply Planning

Duck River Symposium – December 7th, 2022


“Someone is sitting in the shade today because someone planted a tree a long time ago”

Excellence is NEVER an accident.


STIHL

2000 – Water Supply Needs in the Upper Duck River Basin

Future Water Supply Needs in the Upper Duck River Basin

( ) Draft (X) Final Environmental Impact Statement

Lead Agency:
Tennessee Valley Authority (TVA)

Cooperating Agencies:
TN Duck River Development Agency
TN Department of Environment and Conservation
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service

TVA has concluded that one or more action alternatives should be pursued to meet the future water needs in the Maury/southern Williamson County Water Service Area. This is the TVA preferred alternative in this programmatic EIS. TVA is not proposing to design or construct any of these facilities; however, as a regional water resource agency, TVA can assist in evaluating available alternatives and encourage cooperation among all communities that are dependent on common water resources. Local utilities, government agencies in the upper Duck River watershed, and other interested parties will be the ones to actually decide which water supply alternative(s) should be pursued. Those local agencies and the publics they serve must determine how they want to address water needs in this river basin and how those systems will be operated.

Table 5. Suggested ways of meeting the anticipated need for additional water supply in the Maury/southern Williamson County Water Service Area.

Suggestions within the Maury/southern Williamson County Water Service Area
- Finish Columbia Dam
- Build Fountain Creek Reservoir [at Elevation 630]
- Build some other full-pool reservoir in the area
- Build a run-of-the-creek reservoir on Fountain Creek [elev. 600]
- Increase capacity of the pool upstream from the existing Columbia City dam
- Construct a water intake at River Mile 163 to supply the Maury County and southern Williamson County water systems
- Construct a water intake at River Mile 108 to help supply this service area
- Ground water - intercept 5 to 10 cfs loss along Duck River
- Improve the river habitat downstream from River Mile 133 and request a wavier from the State for that reach during droughts [down to 80 cfs]
- Discharge the Columbia wastewater closer to the water intake
- Pump water downstream of the sewage outfall to the Columbia City dam pool
- Recycle waste water
- Go to a closed-loop system at Columbia

Suggestions within the Duck River watershed
- Higher discharge from Normandy Reservoir
- Re-evaluate Normandy guide curve
- Raise Normandy pool elevation
- Build off-stream storage to harvest flood water (active or passive filling)
- Raise and repair Lillard Mill dam to augment its use as a source
- Relocate the Lewisburg wastewater outfall to the Duck River
- Drill wells in the watershed
- Reduce irrigation withdrawals and develop a plan to compensate farmers
- Require industrial water conservation
- Require return of all withdrawals from the Duck River
- Impose mandatory reductions during droughts
- Water conservation through pricing and other measures; withdrawal charges
- Water rates - Jack price up past 7000 gpd use; index to rainfall records
- Promote better cooperation between water systems (consolidations?)
- Water allocation formula - consensus approach
- Manage future growth; recognize water limits
- Restrict future growth
- Educate the public about the integrated nature of water use
- Establish an [annual] intensive water use/availability assessment program

Suggestions involving a wider area
- Pipe water in from some other source (inter-basin transfer)
- Pipeline between Tims Ford and Normandy Reservoirs
- Discharge Arnold Engineering cooling water into Duck
- Buy water from nearby systems
- Search for nearby groundwater source(s)

2002 – EA FONSI for Spring Hill Raw Water Intake

area. While habitat for the leafy prairie clover was present along the easement where the access road to the intake site would be constructed, no existing populations were found in the vicinity. Therefore, there would be no effect to the leafy prairie clover from the project. The mussel survey found that while there were no mussels at the water intake site, mussels were living at a shoal downstream of the intake site. Through further discussions, FWS stated that a special condition needed to be placed in the permit to restrict the applicant from reducing the flow in the Duck River below the proposed intake structure to less than 130 cubic feet per second (cfs). By letter of August 16, 2001, FWS concurred with this flow restriction and stated that the project would not likely adversely affect the federally listed mussel species *Lemiox rimosus* and *Quadrula intermedia*, and the federal candidate species *Lexingtonia dolabelloides*. In addition, FWS agreed that the project would have no effect on the federally endangered leafy prairie clover, *Dalea foliosa*.

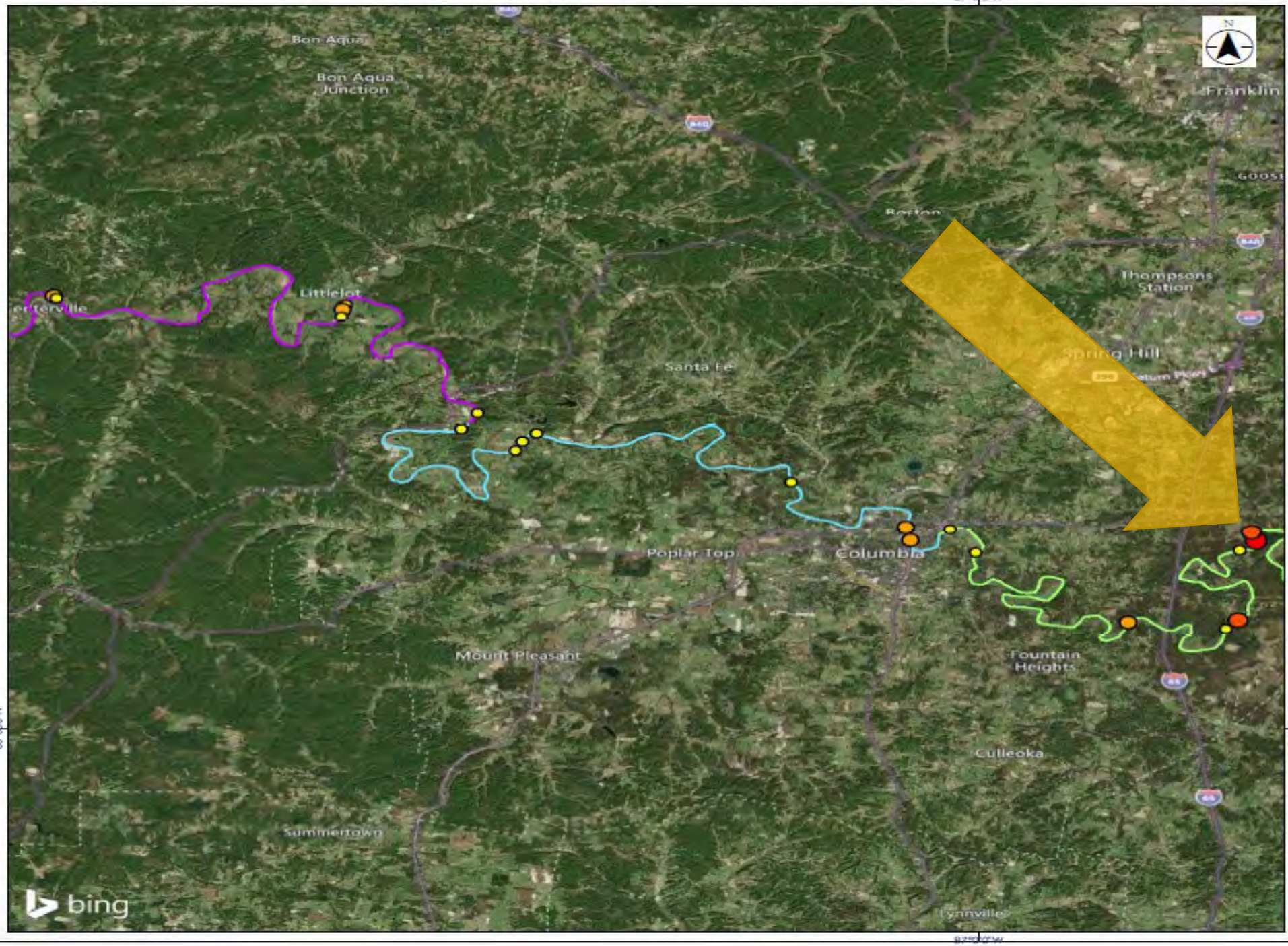
Spring Hill is not proposing a net water withdrawal increase from the river and TVA's evaluation indicates that minimum flows could still be maintained in drought years if the Spring Hill intake was granted. During the lowest flow month of an average year, there is at least 470 cfs of water available in the river to meet minimum flow needs of 100 cfs and withdrawal desires of 30 cfs at Columbia and 9 cfs at Spring Hill. Because the potential withdrawal at the proposed Spring Hill intake is less than 2 percent of the average low flow condition in the Duck River, the Spring Hill request should not adversely affect water quality nor hinder regional efforts to secure a long-term water supply. Finally, TVA would hold Columbia to the same standards for impact analysis as is now being required for Spring Hill.

By letter of March 10, 1999, a Tennessee Aquatic Resource Alteration Permit authorizing the withdrawal of up to 6 million gallons per day by Spring Hill was issued by the Tennessee Department of Environment and Conservation. This serves as the

The applicant had a mussel survey performed for the subject work. A report titled *"Aquatic Surveys, City of Spring Hill Raw Water Intake and Transmission Line (Four Stream Crossings), Maury County, Tennessee"* was prepared by Pennington & Associates, Inc., dated April 2001 (See Appendix F). The report concluded that there were no mussels found at the proposed raw water intake site. However, at approximately 300' downstream of the intake site is a riffle/shoal area that had substrate conducive to freshwater mussels. There were three federally listed species *(Lemiox rimosus, Quadrula intermedia and Lexingtonia dolbelloides)* collected from the riffle and shoal area. There were eight additional species of Mollusca observed which have no federal status but are considered very rare by the state of Tennessee. The four streams to be crossed by the transmission line are to small to support any of the endangered mussels listed for the area.

Both of the above reports were coordinated with USFWS for their review. USFWS responded to the reports by letter dated 20 July 2001 (See Appendix F). In order for USFWS to concur with a "not likely to adversely affect" finding for the federally listed mussels, a special condition was requested to be placed in the permit that restricts the applicant from reducing the flow in the Duck River below the proposed intake structure to less than 130 cubic feet per second (cfs). USFWS believes that 130 cfs is the minimal amount necessary to avoid adverse impacts to the nearby mussel bed. By letter dated 6 August 2001, the applicant accepted this condition (See Appendix F).


TWENTY
YEARS
LATER



Stantec

Legend

Live Count

- 0 - 100
- 101 - 200
- 201 - 300
- 301 - 335

Duck River Reach Name

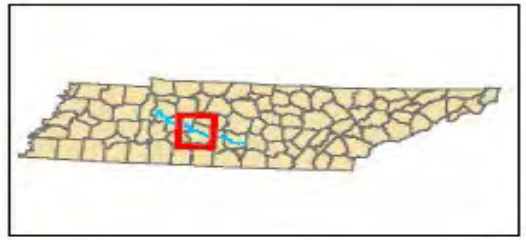
- Spring Hill Intake to CPWS Existing Intake
- CPWS Existing Intake to Proposed Intake
- Proposed Intake to Centerville

0 5.5 11 Kilometers

1:381,601 (At original document size of 8.5x11)

Notes

1. Coordinate System: GCS WGS 1984
2. Base Imagery: ESRI Map Services.



Project Location
Columbia, TN

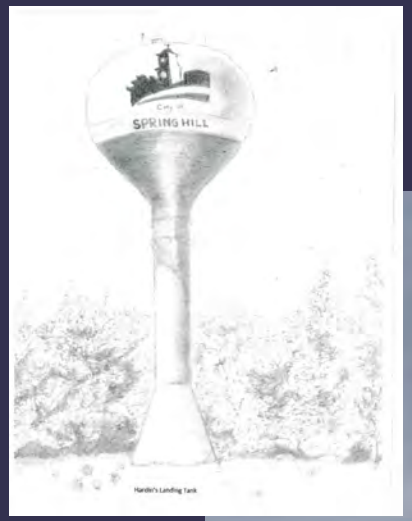
1756/09039
Prepared by BKD on 2021-11-10

Client/Project
Columbia Power & Water Systems
Long-Term Water Supply Program

Figure No.
1

Title
Mussel Abundance by Site

What has Spring Hill done over the last 20 years?



Population -> 10,530 to 56,000

Working Together Works

- Participated in Duck River Agency Drought Management Plan (2012-2013)
- Enhanced Long Term Water Supply and Wholesale Purchase Agreement with CPWS (40+ years Working Together)
- Completed Water and Sewer Capacity Study (2018)
- Completed Wastewater Treatment Plant Facilities Plan to treat 10 MGD (2019)
- Completed Water Treatment Plant Facilities Plan to Expand to 6 MGD Withdrawal and purchase 8 MGD from CPWS at New WTP and New RWI (2019)
- Completed Construction of New Booster Station to Provide 3 MGD from CPWS to Spring Hill (2022)

Millions of Dollars have been INVESTED in Infrastructure Planning based on the Regional Plans developed in Collaboration with the Duck River Agency.

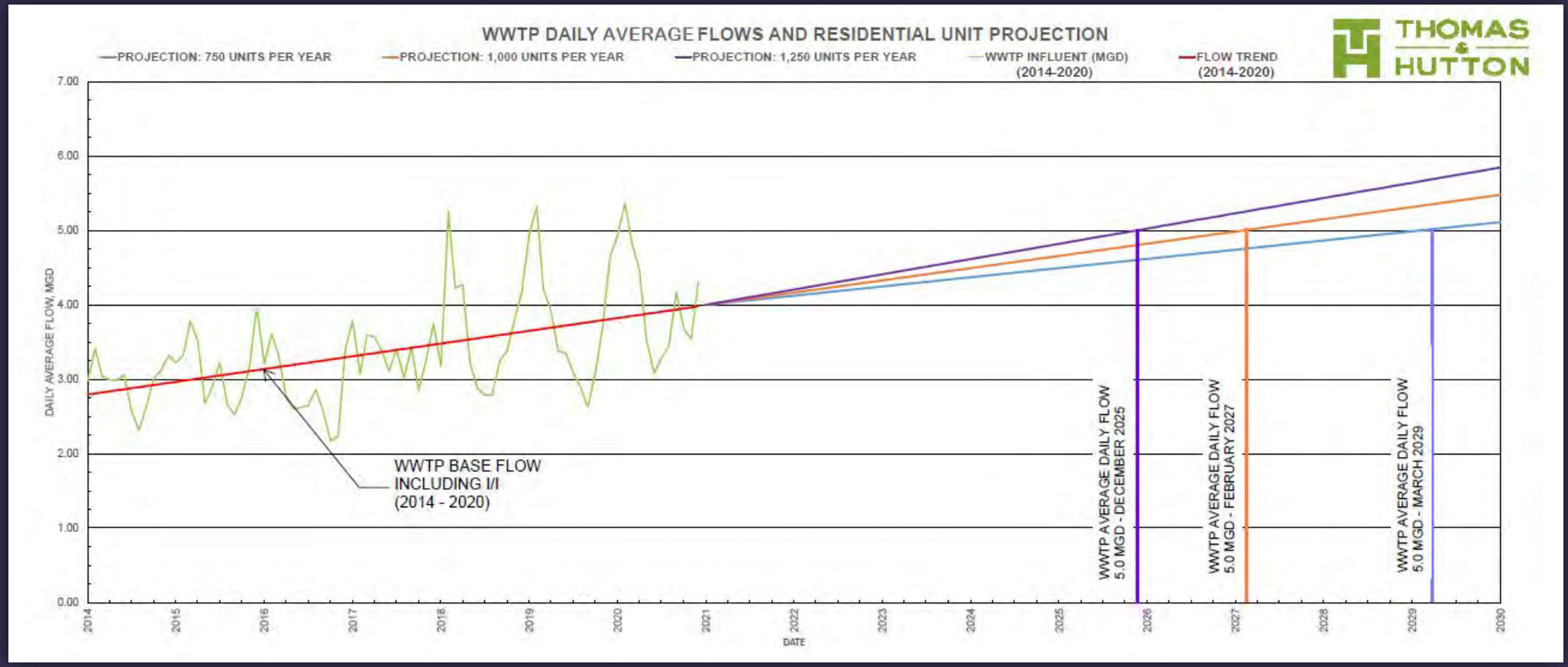
Planning the Water Supply for Build-Out in Spring Hill

- 2022 Water and Sewer Capacity Modeling Update ($300k)
  - Spring Hill Build-Out Water Demand -> 8.5 MGD average daily demand
  - Spring Hill Build-Out Water Demand -> 12.7 MGD maximum daily demand
  - Spring Hill Build-Out Sewer Demand -> 8.9 MGD average daily flow
  - Spring Hill Build-Out Sewer Demand -> 28.5 MGD peak hourly flow

- 2022 Asset Management, Condition Assessment, and Work Order System ($1M)
  - Utilizing TN SWIG Non-Collaborative Grant and SRF Loans with Forgiveness

- Water Harvesting
- Purple Pipe
- Advanced Metering Infrastructure
- Federal Agency Approval of the DRA Drought Management Plan, the Normandy Reservoir Project, and the new downstream intake for CPWS
- Indirect Reuse
- Endangered Species Habitat Protection
- Endangered Species Habitat Mitigation
- Endangered Species Habitat Creation

“To achieve great things, 2 things are needed;



A plan, and not quite enough time.”

Carollo's Potable Reuse Expertise & Experience

Carollo is the industry-recognized leader in potable reuse through planning, pilot testing, design, and implementation of advanced water purification processes.

FIRM PROFILE

WATER
OUR FOCUS
OUR BUSINESS
OUR PASSION

At Carollo, water is all we do, and we do all water like no one else. What does this focus mean for you? Uncompromising expertise across a vast range of services. A smart, experienced and innovative staff passionate about what they do. With Carollo on your team, you will be collaborating with the best in the industry—professionals who are passionate about the success of Spring Hill and bring innovative solutions to global issues with water supply.

With 1,300 staff across more than 50 offices, Carollo brings a breadth and depth of expertise across all facets of water management. For more information about the suite of water services we provide, please visit http://carollo.com/expertise.

We serve clients and communities from a few thousand to a few million from all around the country. Proposed project team members Eva Steinle-Darling and Andy Salveson have been leading applied research, planning, pilot testing, and design work for potable reuse in many different states from California to Utah, Texas, and Florida. Pranjali Kumar was responsible for managing our international award-winning demonstration project in Altamonte Springs, Florida, and is now supporting similar projects around the State of Florida and beyond.

ADAPTING PROVEN PROCESSES TO INNOVATIVE APPLICATIONS

Carollo's experience ranges from designing and operating small pilot-scale water purification facilities (20 liters per minute) to regional evaluations of water management and water supply.

We understand the technical challenges and community sensitivities of sourcing drinking water from nontraditional sources of supply. For example, our team is leading planning level work in San Francisco to find new water through direct potable reuse (DPR), facing a challenging public that has for years relied upon one of the most protected (and tasty) water supplies from the Hetch Hetchy Valley. Adding purified recycled water, no matter how high the quality, is a public outreach challenge.

Advanced Treatment

Our team is leading or assisting with the most challenging advanced treatment projects on the planet, including direct potable reuse in Big Spring, Texas, and El Paso, Texas, 100 percent water reuse in Los Angeles, California, and advanced purification for water reuse for Mekorot in Israel, along with many other potable reuse projects in between.

By the Numbers

300+
Recycled water and reclamation projects

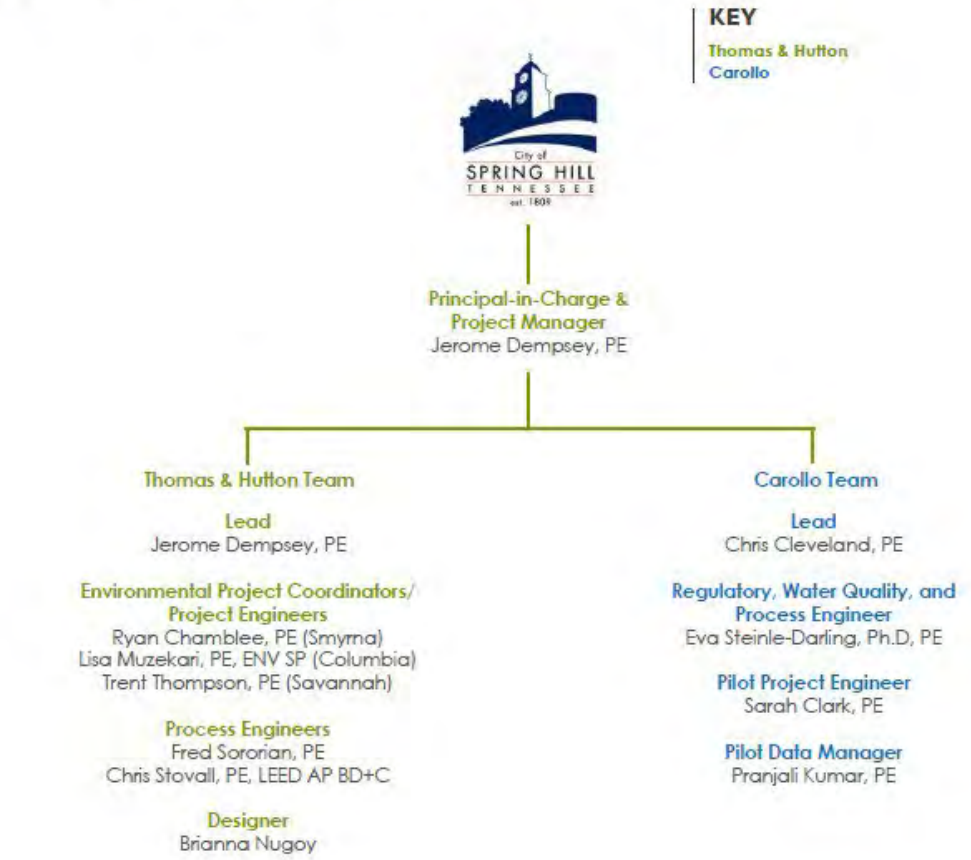
100+
Billion liters of recycled water each year

60+
Potable reuse projects over the past 10 years

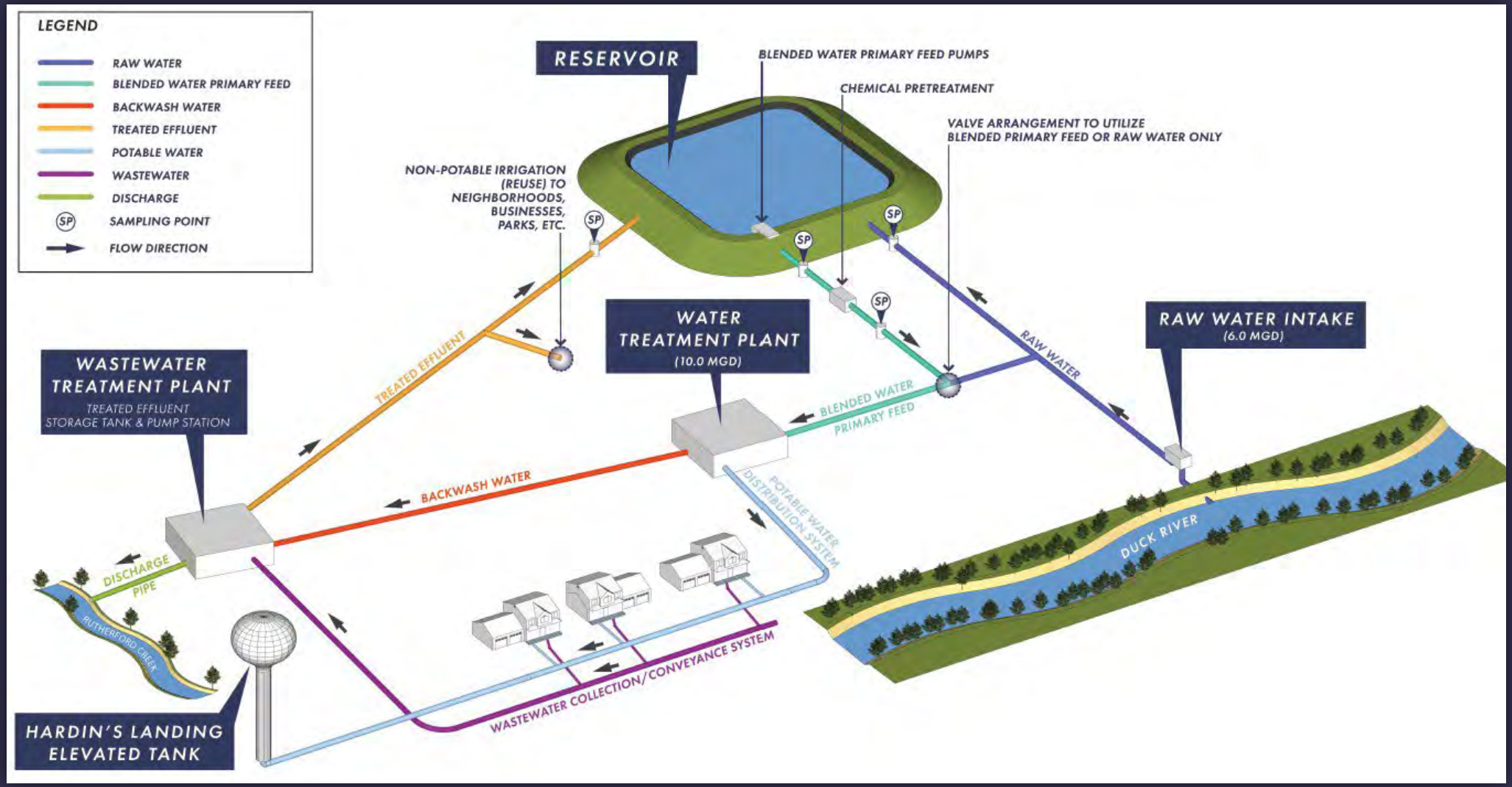
7+2
Helped develop reuse guidelines and regulations for 7 US states PLUS the National Water Research Institute PLUS the World Health Organization

THOMAS & HUTTON

PROJECT ORGANIZATIONAL CHART



Project SWIFT



// Preliminary list of parameters of interest includes regulated and unregulated groups

Parameter	Drinking Water Goal	Reference
Pathogens Enteric Virus Giardia lamblia Cryptosporidium parvum	 < 2.2×10^{-7} MPN/L < 6.8×10^{-6} cysts/L < 3.0×10^{-5} oocysts/L	 SDWA (Regli et al. (1991)) SDWA (Regli et al. (1991)) SDWA (Haas et al. (1999))
Primary MCLs		SDWA
Secondary MCLs		SDWA
Disinfection Byproduct Precursors (TOC)	Variable	Based on formation potential
Unregulated Contaminants (PPCPs, CECs, etc)	Based on health advisory levels, or risk-based health goals	Variable
PFAS	Draft MCL (expected by 2023 end)	EPA

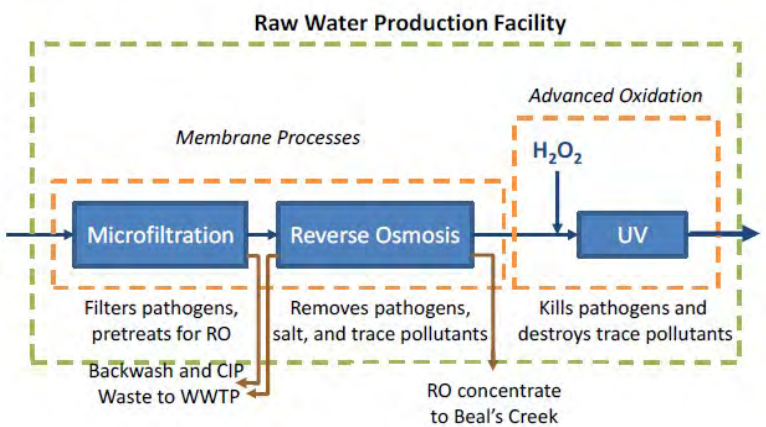
These factor into the development of treatment goals for the selected treatment train.

// "Typical" treatment options are broadly divided into two

RO-Based Advanced Treatment

1. Practiced widely in many states
2. ***Required*** in some states
3. Removes wide range of chemicals and pathogens
4. Provides desalination

BUT: Produces ~15-20% concentrate waste that needs disposal.

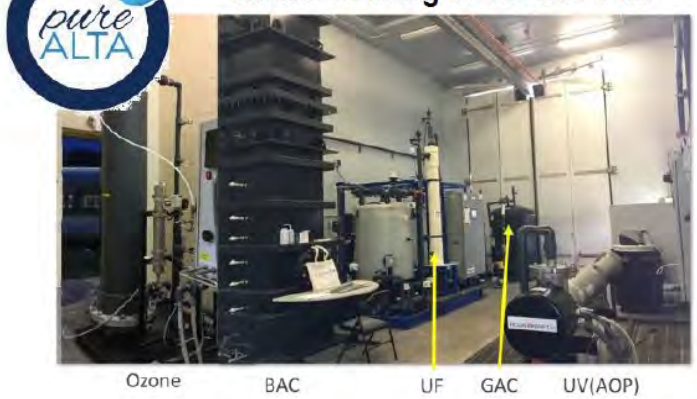


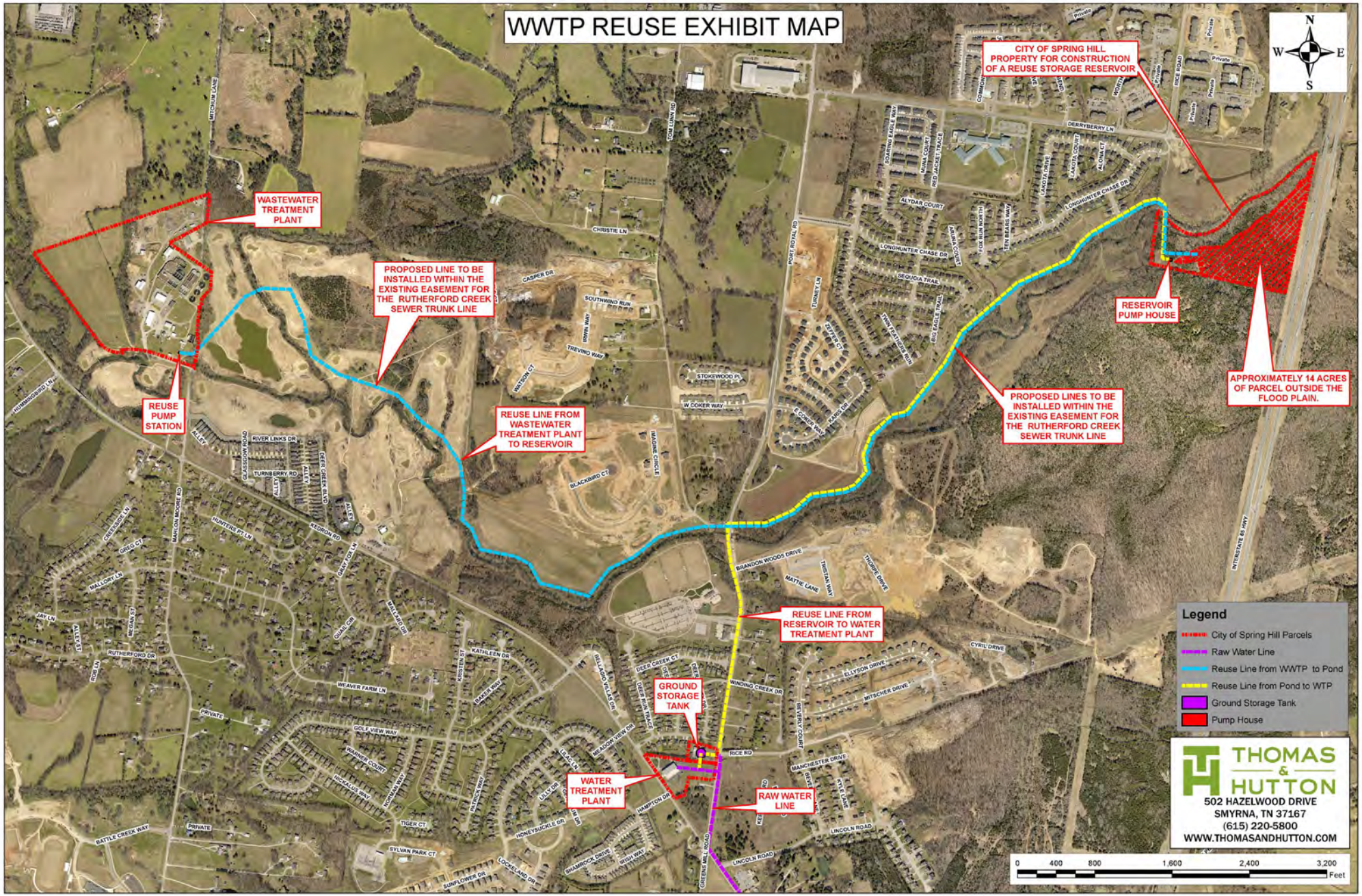
Carbon-Based Advanced Treatment (CBAT)

1. Practiced widely in many states
2. Relies on disinfection plus combination of O_3, BAC, GAC
3. Removes wide range of chemicals and pathogens.
4. Does NOT desalinate.

Process waste can be returned to head of plant.

Award-winning CBAT for DPR:




WWTP REUSE EXHIBIT MAP
CITY OF SPRING HILL PROPERTY FOR CONSTRUCTION OF A REUSE STORAGE RESERVOIR
WASTEWATER TREATMENT PLANT
PROPOSED LINE TO BE INSTALLED WITHIN THE EXISTING EASEMENT FOR THE RUTHERFORD CREEK SEWER TRUNK LINE
REUSE PUMP STATION
REUSE LINE FROM WASTEWATER TREATMENT PLANT TO RESERVOIR
RESERVOIR PUMP HOUSE
APPROXIMATELY 14 ACRES OF PARCEL OUTSIDE THE FLOOD PLAIN.
PROPOSED LINES TO BE INSTALLED WITHIN THE EXISTING EASEMENT FOR THE RUTHERFORD CREEK SEWER TRUNK LINE
REUSE LINE FROM RESERVOIR TO WATER TREATMENT PLANT
GROUND STORAGE TANK
WATER TREATMENT PLANT
RAW WATER LINE
N
W
E
S
Legend
City of Spring Hill Parcels
Raw Water Line
Reuse Line from WWTP to Pond
Reuse Line from Pond to WTP
Ground Storage Tank
Pump House
THOMAS & HUTTON
502 HAZELWOOD DRIVE
SMYRNA, TN 37167
(615) 220-5800
WWW.THOMASANDHUTTON.COM
0 400 800 1,600 2,400 3,200
Feet


Opportunity + Ability = Responsibility

Duck River Agency

"WORKING TOGETHER WORKS"

2022 Annual Duck River Symposium

December 7, 2022

Doug Murphy, DRA Executive Director

DRA Statute

- DRA was created in 1965 by the Tennessee General Assembly *"for the purpose of developing and effectuating plans and programs for comprehensive development, including the control and development of the water resources of those portions of the Upper Duck River watershed lying in Coffee, Bedford, Hickman, Marshall and Maury counties, and integrating plans, programs and development activities with the overall economic development of the area described."* TCA §64-1-601(b).

Duck River Agency
Mission Statement

"To develop, protect and sustain a clean and dependable water resource for all citizens in the Duck River Region"

Bedford, Coffee, Hickman, Marshall, and Maury Counties

Tennessee Duck River Development Agency (DRA)

- Developed in 1965 by state legislation
  - Political subdivision of the state with no funding from the state
- Govern by a 12-member board
  - 5 county citizens, 2 citizens at large, 2 county mayors, 2 city mayors, 1 governor representative
- Funding: Water systems contribute a nickel per 1,000 gallons of water sold to the Operation and Project Trust Fund
- In 1971 the DRA and water systems signed a 50-year agreement
  - Current 3-year agreement
- Water systems are members of the Duck River Agency Technical Advisory Committee (DRATAC)
- Two Trust Funds:
  - Operation and Project Trust: $2M+
  - Water Supply Project Trust: $13M+

Old History Notes

- Duck River Project
  - Columbia and Normandy Reservoir
- DRA would collect funds for the water supply portion of the two reservoirs
  - Flood Control, Water Supply, Wastewater Assimilation, Recreation
  - Normandy $5.7m; Columbia $12.6m
- Debt was canceled when Columbia was not built
- $5.7M was set aside for future regional water supply infrastructure projects

Regional Planning

Why Regional Planning

- **The Duck River is recognized as one of the most Bio-Diverse systems in the country**

- **Multiple Uses depend on the Duck River and Normandy Reservoir**
  - 250,000 resident customers
  - Industrial and commercial use
  - Agricultural
  - Waste load assimilation
  - Recreation
  - Designated Uses
- **2007 Drought of Record**
  - Normandy Reservoir reached 42% capacity
  - Flow in the upper Duck River was dependent on Normandy Reservoir
- **Legislation**
  - House Bill 3545
  - Senate Bill 2464
- **Emotions**
  - Public perception
  - Politics
- **No long term credible regional plan**
  - Good science
  - Proven decision-making model
  - Implementability

Open Process

- Tools
- 6 Workshops
- 3 Public Open Houses
- www.duckriveragency.org
- Media coverage
- Civic Group Presentations
- Garden Club Presentations
- One-on-One meetings

WSP Strategic Team

O’Brien & Gere - Principal consultant

CTI Engineers, Inc. - TN engineering firm

BDY Environmental, LLC – Environmental/Permitting

HydroLogics, Inc - Modeling

Trauger & Tuke - Legal

Participants

Water Resource Council

- **Water Systems**
  - Bedford County Utility District
  - Columbia Power and Water Systems
  - Duck River Utility Commission
  - HB&TS Utility District
  - Lewisburg Water and Waste-Water
  - Manchester Water Systems
  - Maury County Water System
  - Tullahoma Utility Board
  - Shelbyville Water and Sewer
  - Spring Hill Water Systems
- **Federal Agencies**
  - Natural Resource Conservation Service
  - Tennessee Valley Authority
  - U S Department Agricultural
  - U S Fish and Wildlife Service
  - U S Geological Survey
- **State Agencies**
  - Tennessee Advisory Commission on Intergovernmental Relations
  - Tennessee Department of Environment
  - Tennessee Water Resource Technical Advisory Committee
  - Tennessee Wildlife Resource Agency
- **Non – Government Organizations**
  - Duck River Watershed Association
  - Friends of Short Springs
  - Tennessee Environmental Council
  - Tennessee Duck River Agency Board
  - Tennessee Farm Bureau Federation
  - The Nature Conservancy
  - World Wildlife Fund
- **Municipals**
  - Columbia
  - Lewisburg
  - Manchester
  - Tullahoma
  - Shelbyville
  - Spring Hill
  - Wartrace
- **Legislators**
  - Senator Bill Ketron
  - Senator Jim Tracy

Regional Water Supply Plan Goal

"The project goal is to have a Comprehensive Plan that will provide direction to the Duck River Agency regarding the management of available water resources, including the implementation of specific water supply infrastructure projects."

50-Year Plan with a 100-Year Vision

Water Supply Plan Study Area

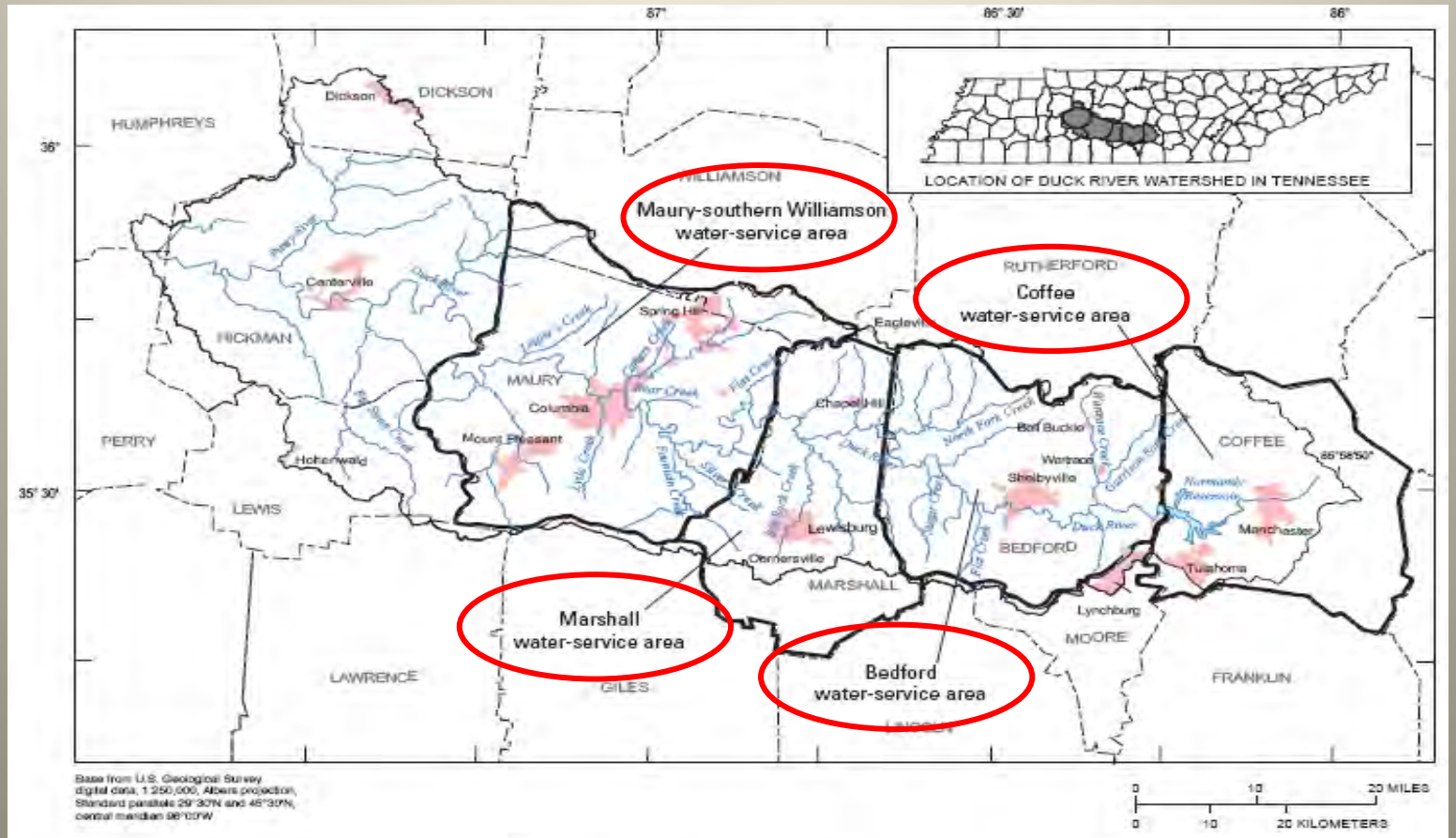
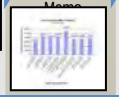
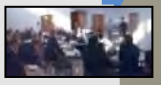


Figure 1. Upper Duck River study area and the Maury-southern Williamson, Marshall, Bedford, and Coffee water-service areas.

Comprehensive Regional Water Supply Plan

Duck River Development Agency

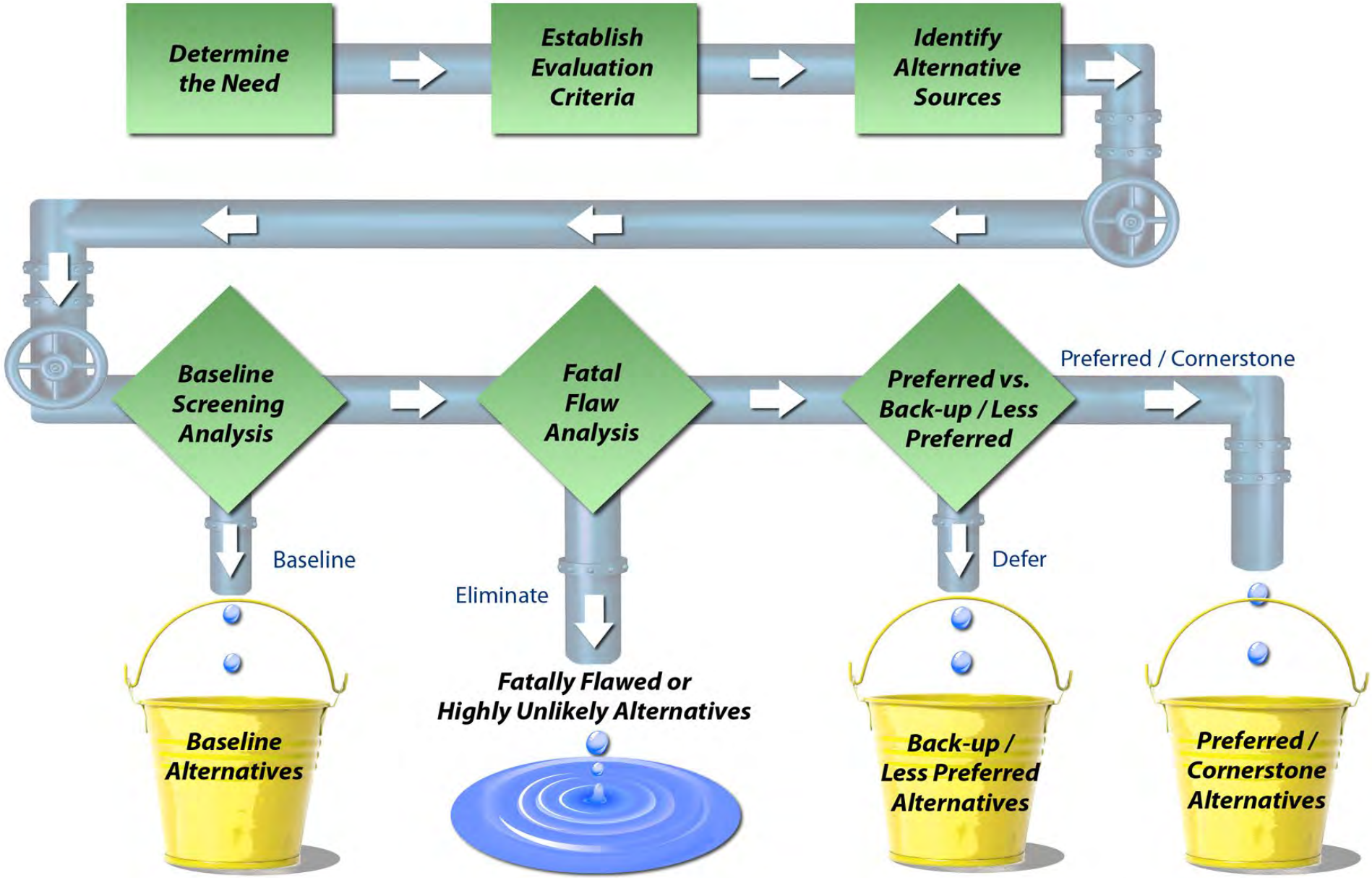
Project Approach and Decision-Making Process

	Workshop 1 Goals / Kick-off Meeting Week 2	Data Collection and Initial Investigations	Workshop 2 Preliminary Feasibility Week 12	Alternatives Development	Workshop 3 Developing Alternatives Week 23	Alternatives Evaluations	Workshop 4 Evaluating Alternatives Week 33	Report and Decision-Making	Workshop 5 Implementation Planning Week 42	Next Steps	Workshop 6 Conclusions Week 50
Water Quality and Capacity	▪ DRA goals and policies ▪ Key issues review ▪ Establish information collection program ▪ Demand projections	▪ Review stream hydrology and water quality data ▪ Review population and demands ▪ Peaking factors Draft Key Issues Memo Water Quality / Regulatory Compliance *Meetings with participants*	▪ Service areas / demands ▪ Water supply options	▪ Refine service areas and demands ▪ Identify supply alternatives Draft Key Issues Memo Water Quality / Treatment Capacity Projections	▪ Review key issues memo on water quality / capacity ▪ Select alternatives	▪ Finalize cost estimates ▪ Compare PW cost / benefits *Meetings with participants* Key Issues Memo Water Supply Alternatives	▪ Screen Alternatives ▪ Review Tech. Memo 	▪ Draft report and executive summary Draft Report	▪ Review public input ▪ Finalize alternative selection	▪ Finalize report and executive summary ▪ Draft Implementation Plan Final Report	▪ Adopt Implementation Plan ▪ Authorize design
Reliability and Permitting	▪ Reliability goals ▪ Approach to water supply permitting ▪ Environmental impacts	▪ Review reservoir release requirements and NPDES permits ▪ Revisit redundancy approaches Draft Key Issues Memo Reliability Goals and Approaches *Meetings with regulators*	▪ Review key issues memo on reliability policy ▪ Approach for supply permitting and stream quality	▪ Review demands capacity policies Draft Key Issues Memo Redundancy Approach Permitting Issues / Obstacles *Regulatory discussion*	▪ Review key issues memo – redundancy ▪ Discuss permitting obstacles ▪ Adopt reliability approach	▪ Compare PW cost / benefits of alternative approaches Update Key Issues Memo Permitting Issues and Approaches	▪ Review key issues memo ▪ Finalize reliability approach *Meetings with regulators*	▪ Pre-scoping meeting for permits and obstacles	▪ Expert panel discussion on regulatory approaches	▪ Scoping meeting for permits and environmental studies	▪ Approve scope for supplemental studies if needed
Financial	▪ Review funding options ▪ Agree on cost estimating techniques	▪ Develop basis for costing for each participant ▪ Review unit costs Draft Key Issues Memo Cost Estimating Methods	▪ Finalize costing methods	▪ Develop cost estimate, based on technical studies (above) ▪ Load cost model *Draft Cost Model*	▪ Review preliminary costs	▪ Draft report section on costs ▪ Review funding options Present Worth Cost Analysis	▪ Review draft report ▪ Sensitivity analysis of present worth	▪ Refine costs and funding options *Updated Cost Model*	▪ Select preferred funding plan *Meetings with potential funding agencies*	▪ Select preferred funding plan	▪ Endorse funding plan ▪ Retain legal and financial counsel for bonding
Community Impacts and Public Policy	▪ Stakeholders and roles ▪ Community impacts review *Community issues Water supply attitudes*	▪ Gather input on non-cost factors ▪ Website development Draft Key Issues Memo Community Impacts *Interview key stakeholders*	▪ Identify evaluation factors ▪ Develop pair-wise comparison *Open House Meetings*	▪ Define evaluation factors ▪ Website updates	▪ Review policy impacts on alternatives	▪ Update decision model with PW costs and revisit pair-wise Finalize Community Impact Assessment *Decision Model*	▪ Review draft report ▪ Select alternatives *Open House Meetings*	▪ Briefings for elected officials ▪ Public meeting 	▪ Review input from stakeholders ▪ Plan Public meeting	▪ Briefings for elected officials 	▪ Communication plan for implementation phase *Open House Meetings*

June 2009

August 2010

Evaluation Process



Alternatives

Started with over 40 non-structural and structural alternatives including:

- Implementing additional water efficiency measures
- Implementing a regional drought management plan
- Changing operation of Normandy Reservoir
- Modifying river constraints
- Constructing pipelines from reservoirs, rivers or other water systems
- Constructing tributary reservoirs (Fountain Creek Reservoir)
- Building off-stream storage reservoirs (pumped storage)
- Utilizing quarries
- Raising Normandy Dam

Alternative Analysis

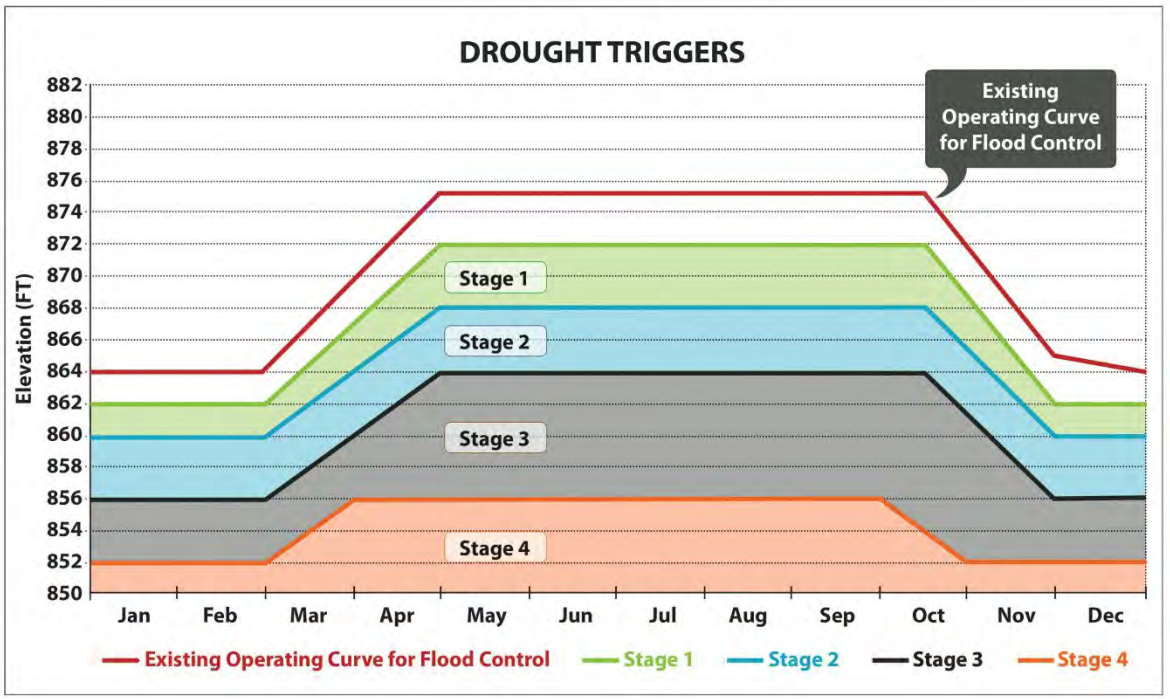
- **Each alternative was subject to 7 criteria for review:**
  1. Reliable capacity
  2. Raw water quality
  3. Cost
  4. Implementablitiy
  5. Flexibility
  6. Environmental benefits
  7. Recreation
- **The alternatives were sorted into the following groups:**
  1. Baseline
  2. Fatally flaw
  3. Backup
  4. Cornerstone

Duck River Regional Water Supply Programs and Projects

Programs/Projects	Purpose
Regional Drought Management Plan	Manage reservoir water for all uses during extended drought period
Optimizing Normandy Reservoir Releases	Provides efficient use of reservoir water
Water Management Program	A program identifying how we use water and recommending how we can be more efficient at managing our water resources
Williamsport/Natchez Trace New Downstream Intake	Additional water supply to meet growth demands in Maury County and water demands during an extended drought period
Normandy Reservoir Capacity Improvements Project	Additional water insurance for all uses during extended drought period

5 Regional Alternatives

Regional Drought Management Plan Triggers and Stages



DROUGHT STAGES

STAGE 1	STAGE 2	STAGE 3	STAGE 4
Drought Monitoring	**Drought Alert**	**Drought Warning**	**Drought Emergency**
③ Initiate Drought Monitoring	③ Alert Drought Committee ③ Initiate Public Awareness	③ 10 cfs / week reduction of Shelbyville target (down to 120 cfs) ③ 10% reduction of public water use	③ 10 cfs / week reduction of Shelbyville target (down to 80 cfs) ③ 20% reduction of public water use

③ Impose 28 day waiting period between stages

③ Move out of stage if above trigger for at least 7 days

Optimizing Normandy Reservoir Releases

Current Operating Flow Constraints

- Minimum **instantaneous** flow of 155 cfs for the period of June 1 through November 30
- Minimum **instantaneous** flow of 120 cfs for the period of December 1 through May 31

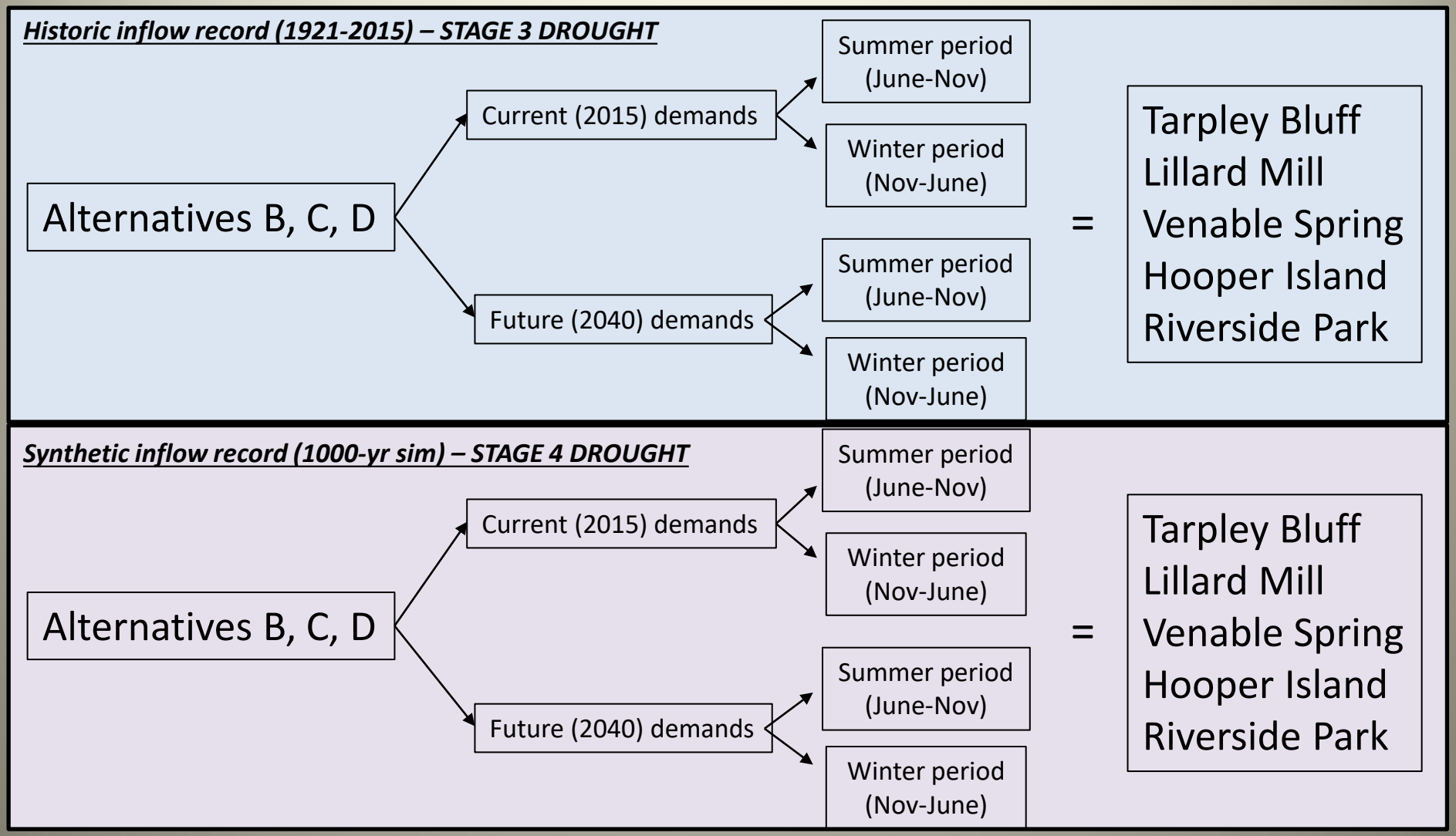
Proposed Operating Flow Constraints

- 7-day rolling **average** flow of 155 cfs for the period of June 1 through November 30 with a minimum flow of 145 cfs
- 7-day rolling **average** flow of 120 cfs for the period of December 1 through May 31 with a minimum flow of 110 cfs

NEPA Review

- Alternative A: No Action
- Alternative B: Optimizing Normandy Reservoir Releases
- Alternative C: Regional Drought Management Plan
- Alternative D: ONRR and RDMP

Wetted Perimeter


Historic inflow record (1921-2015) – STAGE 3 DROUGHT
Alternatives B, C, D
Current (2015) demands
Future (2040) demands
Summer period (June-Nov)
Winter period (Nov-June)
Summer period (June-Nov)
Winter period (Nov-June)
=
Tarpley Bluff
Lillard Mill
Venable Spring
Hooper Island
Riverside Park
Synthetic inflow record (1000-yr sim) – STAGE 4 DROUGHT
Alternatives B, C, D
Current (2015) demands
Future (2040) demands
Summer period (June-Nov)
Winter period (Nov-June)
Summer period (June-Nov)
Winter period (Nov-June)
=
Tarpley Bluff
Lillard Mill
Venable Spring
Hooper Island
Riverside Park

ALTERNATIVE D: Optimization + DMP

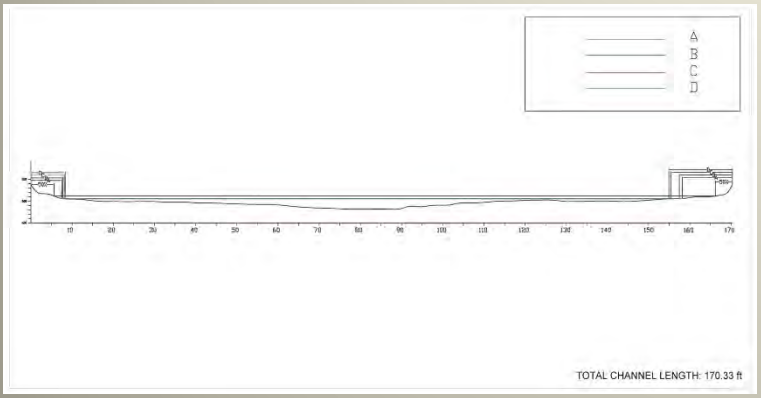
Current (2015) water demands

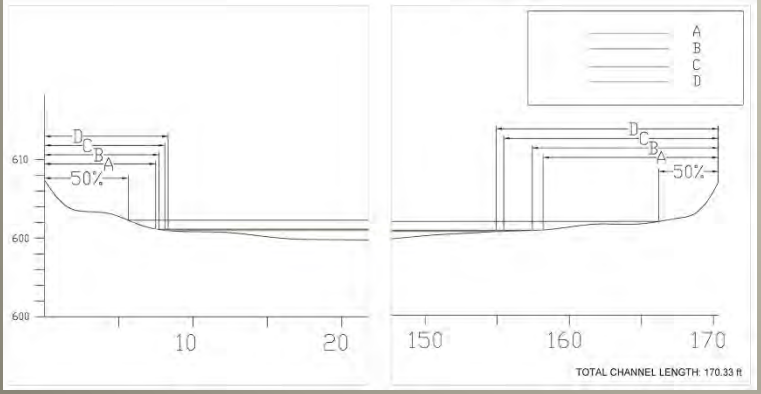
Summer period (June-November)

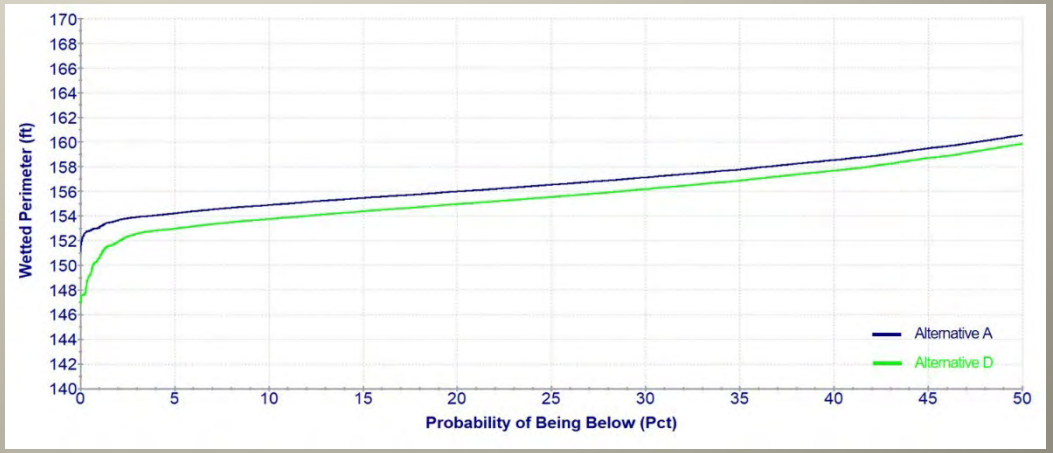
LILLARD MILL

HISTORIC RECORD

2015 Demands	Tarpley Bluff	Lillard Mill	Venable Spring	Hooper Island	Riverside Park
Summer period (Stage 3)					
***Alt A* – lowest wetted perimeter (ft)**	120	151	154	120	63
***Alt D* – lowest wetted perimeter (ft)**	-5.9 (-4.9%)	-4.2 (-2.8%)	-3.8 (-2.5%)	-13.1 (-11.0%)	-1.1 (-1.8%)







ALTERNATIVE D: Optimization + DMP

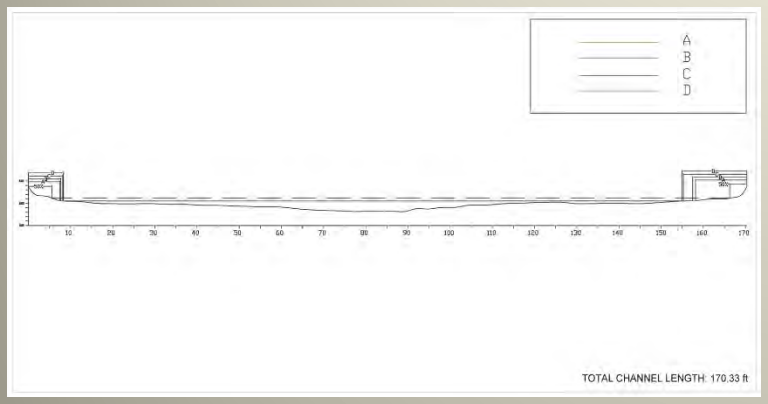
Future (2040) water demands

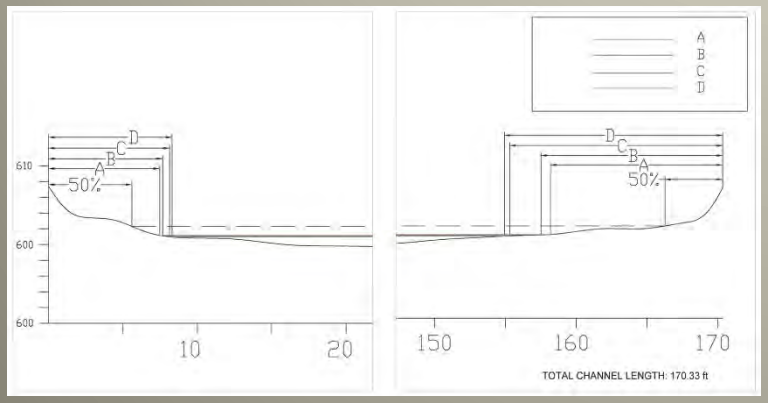
Summer period (June-November)

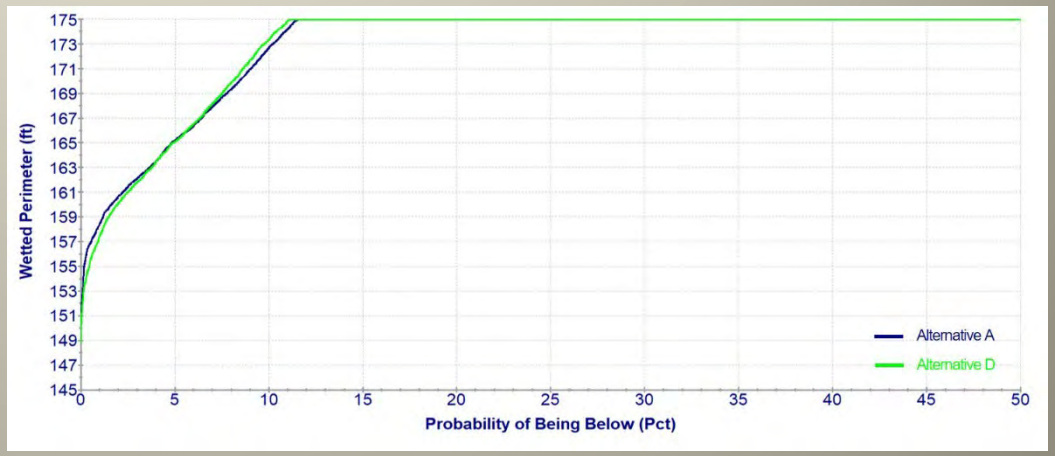
LILLARD MILL

HISTORIC RECORD

2040 Demands	Tarpley Bluff	Lillard Mill	Venable Spring	Hooper Island	Riverside Park
Summer period (Stage 3)					
***Alt A* – lowest wetted perimeter (ft)**	120	151	154	119	62
***Alt D* – lowest wetted perimeter (ft)**	-6.0 (-5.0%)	-4.1 (-2.7%)	-3.8 (-2.5%)	-13.5 (-11.3%)	-1.1 (-1.8%)







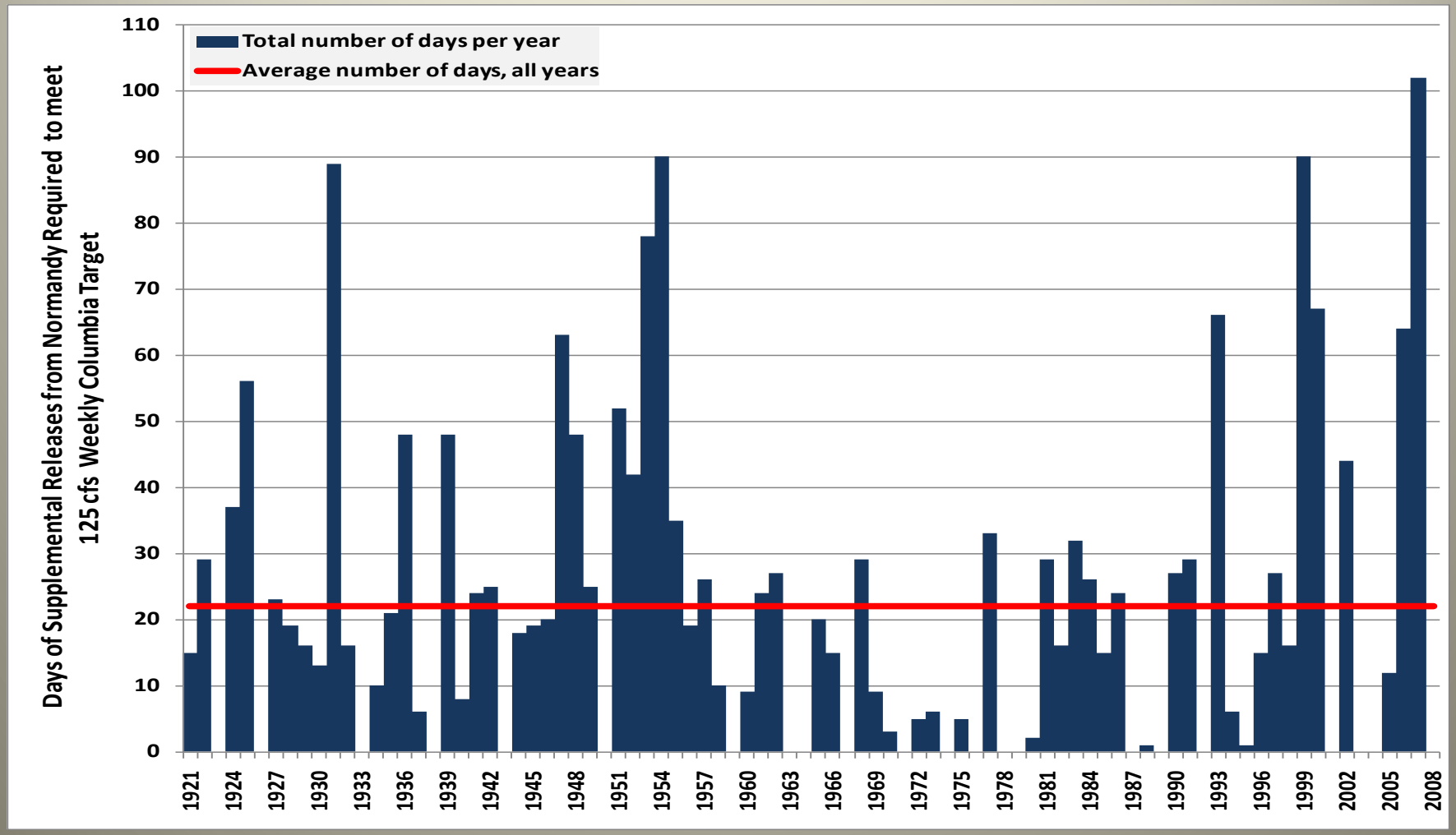
Water Management Program

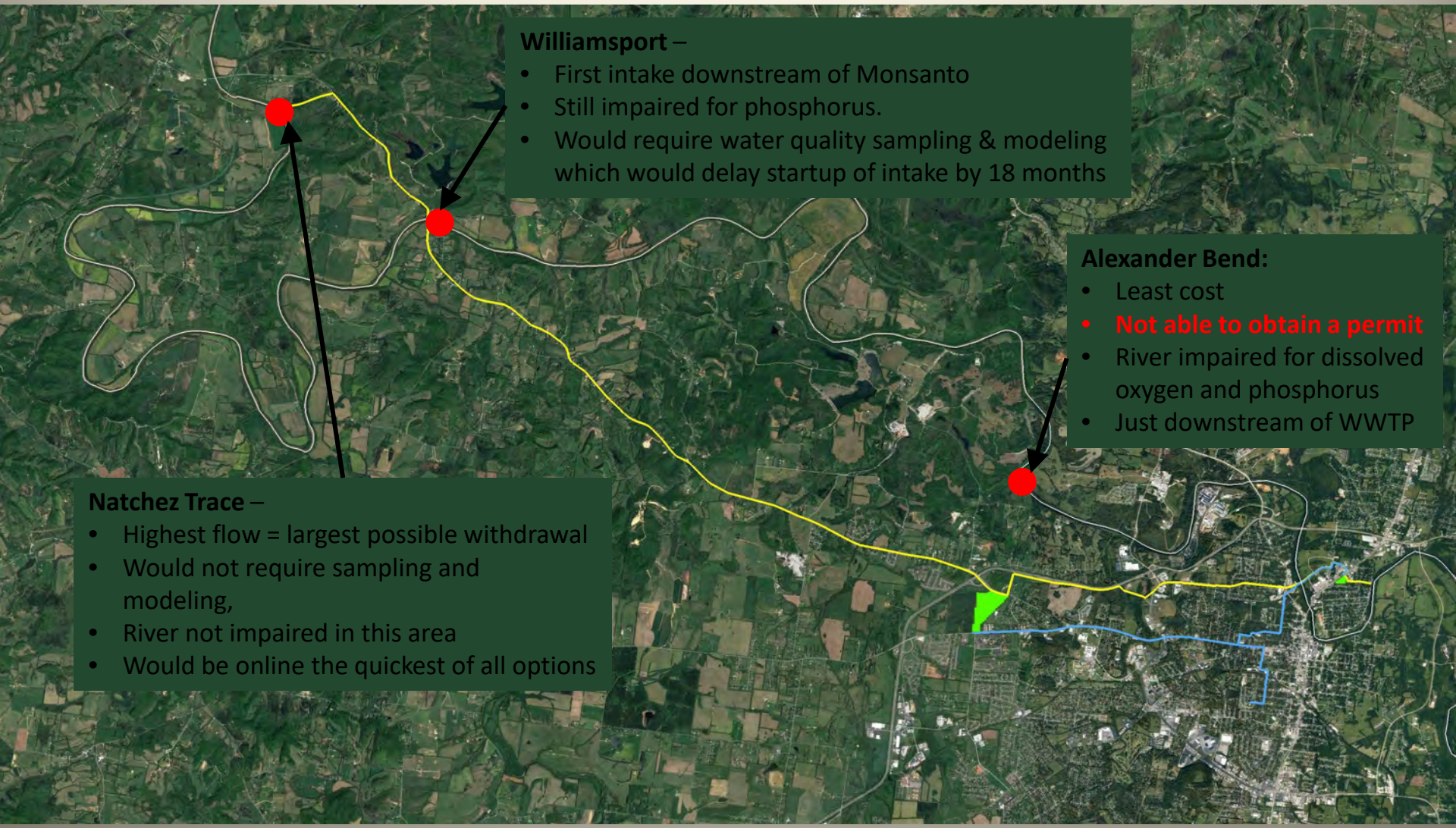
- A program designed to understand how we use our water
- Model regional water supply demands
- Perform water audits
- Water efficiency/conservation education programs
- Work to reduce unaccountable water lost
- Develop programs to address consumptive water loss
- ?

CPWS New Downstream Intake

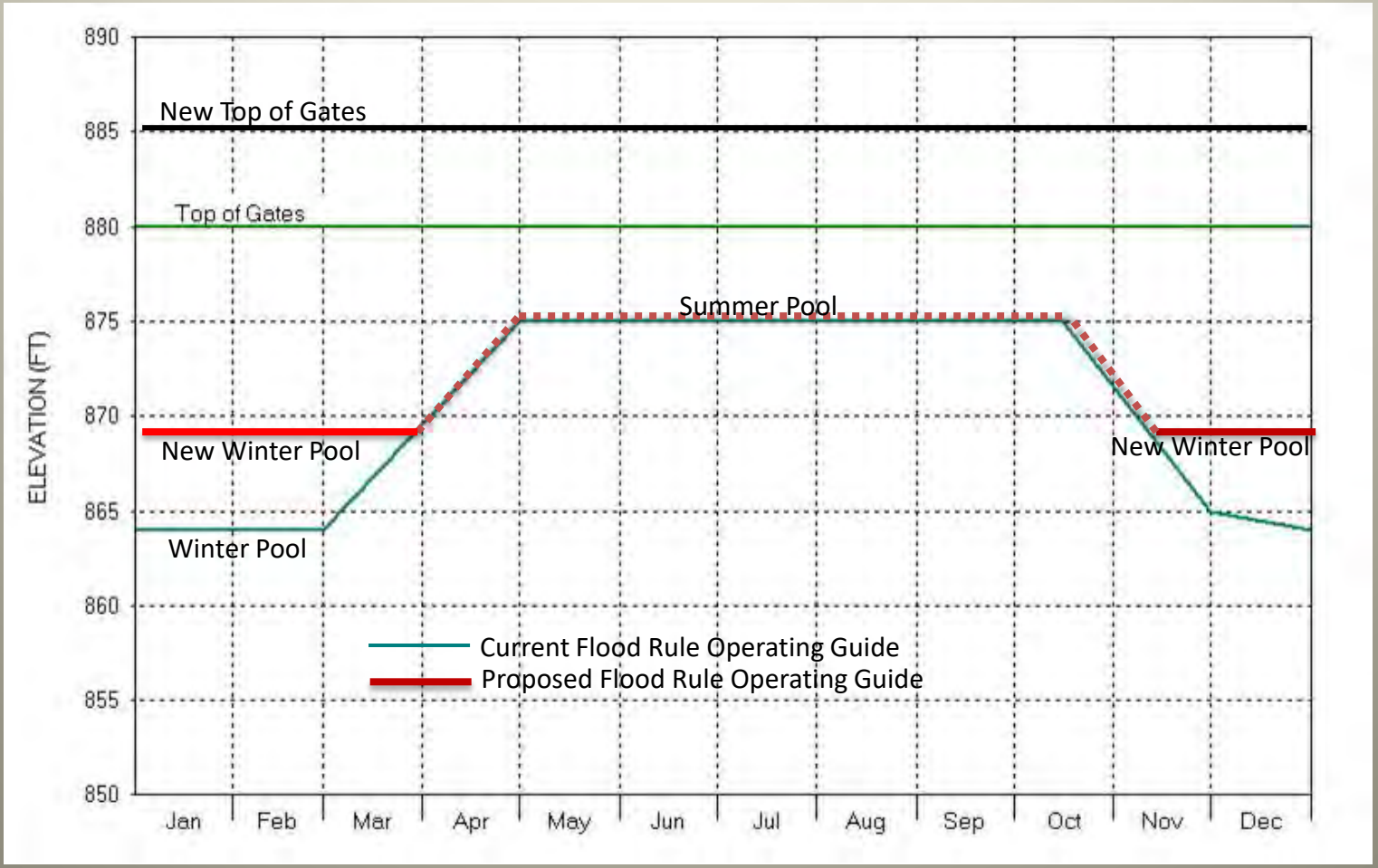
- Downstream of the 100cfs flow by constraint
- Near Maury/Hickman County Line
- Approximately 35 river miles, 20 land miles
- Removes CPWS complete reliance for water supply from Normandy Reservoir
  - Which would leave more water in the reservoir during drought periods
- Supports projected water supply needs
- CPWS is currently in the ARAP application process
- DRA is approving partial funding $10million

Number of days per year that extra water is needed to meet CPWS flow target with 2060 demands

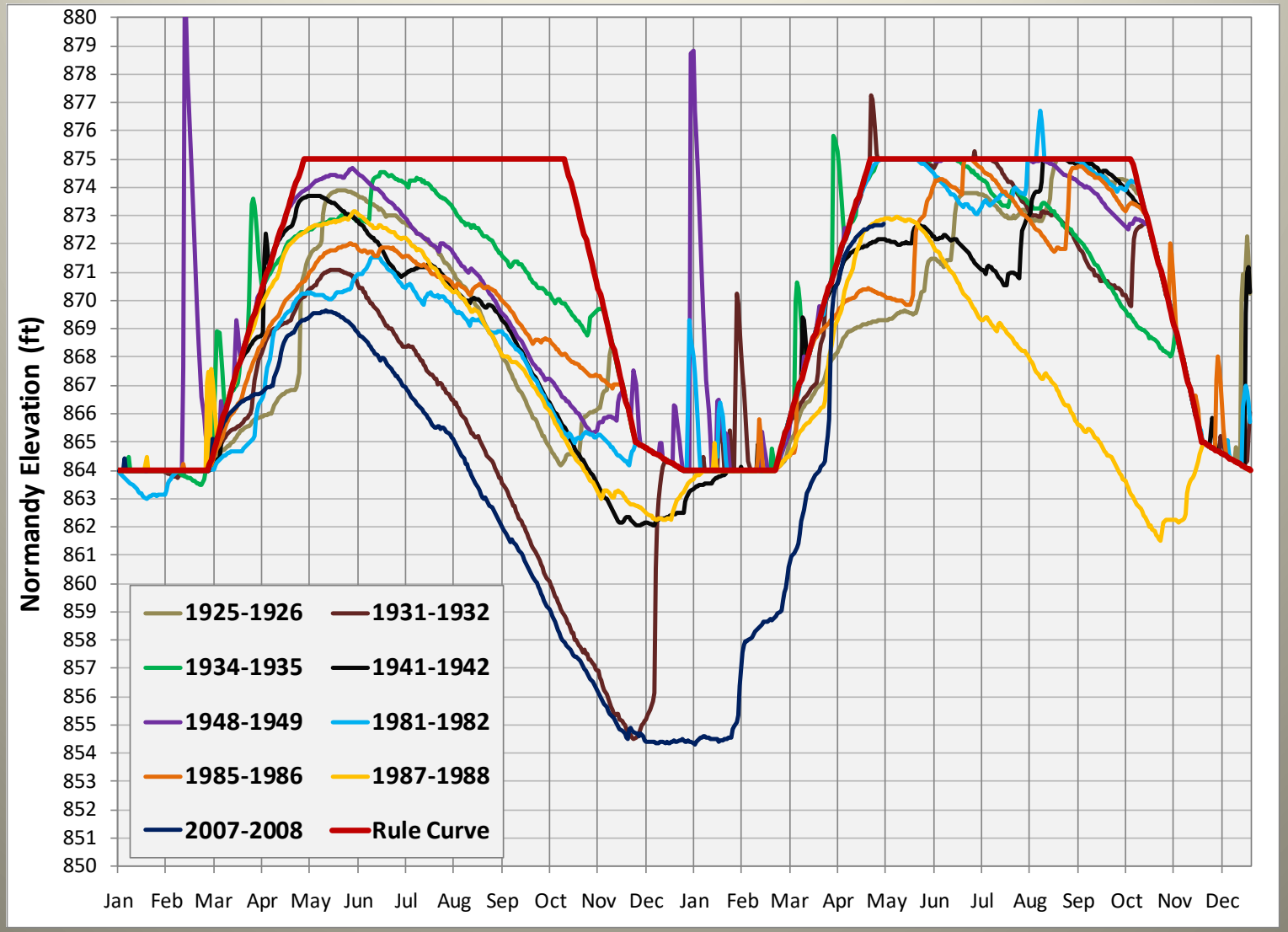



Williamsport –
• First intake downstream of Monsanto
• Still impaired for phosphorus.
• Would require water quality sampling & modeling which would delay startup of intake by 18 months
Alexander Bend:
• Least cost
• Not able to obtain a permit
• River impaired for dissolved oxygen and phosphorus
• Just downstream of WWTP
Natchez Trace –
• Highest flow = largest possible withdrawal
• Would not require sampling and modeling,
• River not impaired in this area
• Would be online the quickest of all options

Normandy Reservoir Capacity Improvements: Proposed Changes to Flood Guide



Major Normandy Droughts – Existing Rule Curve, 2020 Demands



Recent History Notes

- **Regional Water Supply Plan**
  - 2011: Duck River Comprehensive Regional Water Supply Plan
- **Regional Drought Management**
  - 2013: Regional Drought Management Plan
  - ?: NEPA Review
- **Improving Reservoir Management**
  - 2013: Optimizing Normandy Reservoir Releases Plan
  - ?: NEPA Review
- **Water Management and Stewardship**
  - 2016: Duck River Regional Demand Projection Analysis Report
- **Normandy Reservoir Capacity Improvements**
  - 2013: Normandy Dam Stability Analysis
  - 2015: Normandy Reservoir Capacity Improvements Report
- **New Downstream Intake**
  - 2014: Maury County Feasibility Report
  - 2015: Maury County Regional Water Supply Strategic Plan
  - 2017: Maury County Regional Water Supply Intake Siting Study
- **Duck River Basin Annotated Biography**

Current DRA Programs and Projects

- NEPA review for the Drought Management Plan and Optimizing Normandy Reservoir Releases
- Educational exhibits for the new Duck River Welcome Center
- Working with TDEC on the Duck River Permitting Pilot Project
- Working with TDEC as a potential grantee for the American Rescue Program Funds: CPWS new downstream intake, DRUC withdrawal backup
- Securing DRA Future: Amending DRA Statute
- Water supply demand projections
- Agreement with CPWS for partial funding of new intake
- Annual Programs: USGS stream gages, Duck River Clean-ups, Utility Board Member Training, and Duck River Watershed Education Committee

Future DRA Projects and Programs

The Landscape is Changing: Fast

- Updating the Duck River Comprehensive Regional Water Supply Plan
  - Regional Economic Impact Study on Available Water or Not
  - Water Supply Project Alternative Analysis
    - Raising Normandy Reservoir
    - TN River Pipeline
    - Cumberland River Pipeline
    - Water Reuse
- Duck River Basin Dash-Board
- Duck River Basin Water Stewardship Program

Education Outreach

NGO Groups

- Duck River Watershed Education Committee
- Friends of Henry Horton State Park
- Duck River Watershed Society

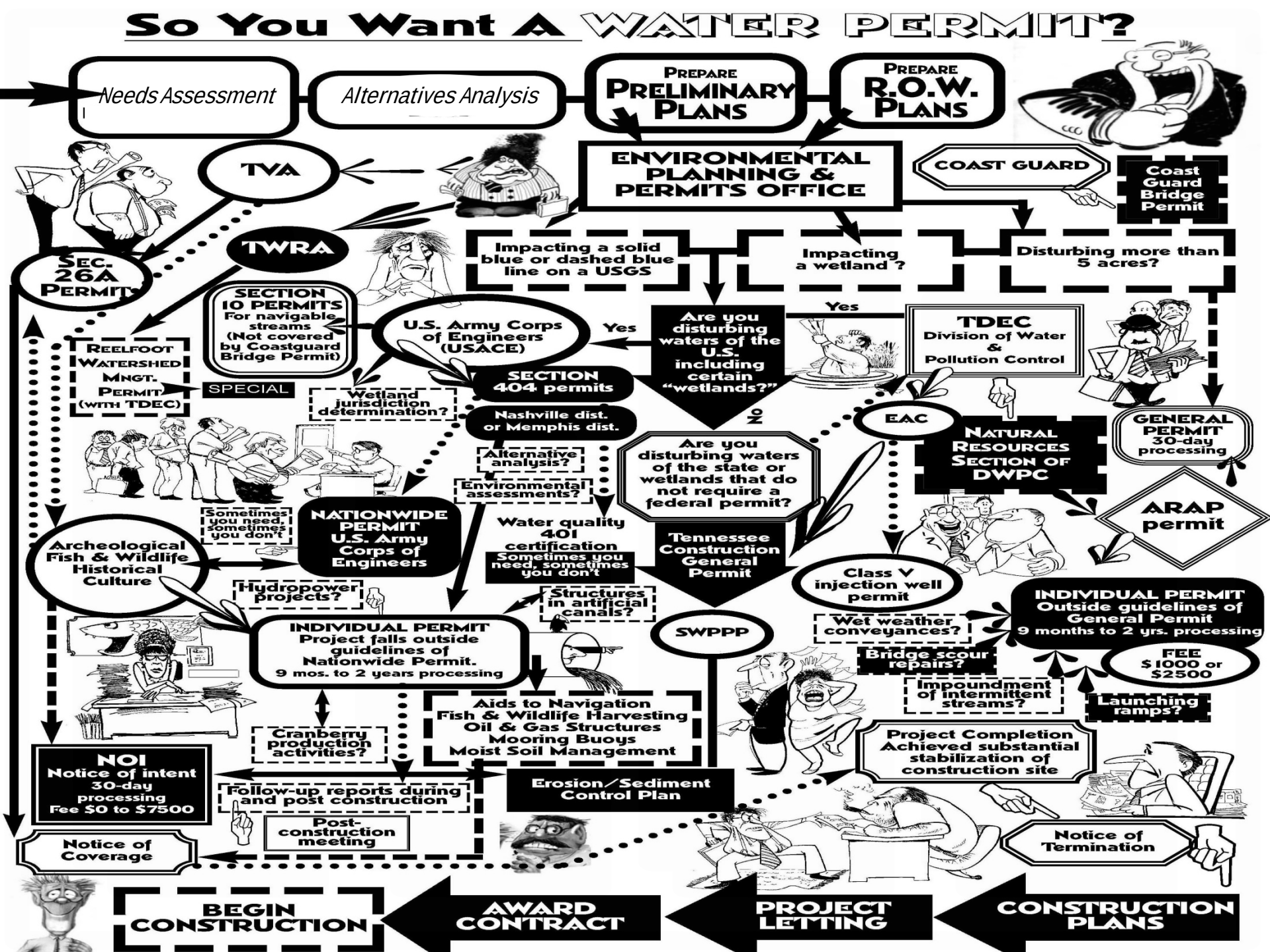
Programs

- Duck River Cleanups: public
- Duck River Education Day: 5th graders
- “Discovering the Duck River” booklet: 4th graders
- “Duck River Water Cycle” bookmarkers: 3rd graders

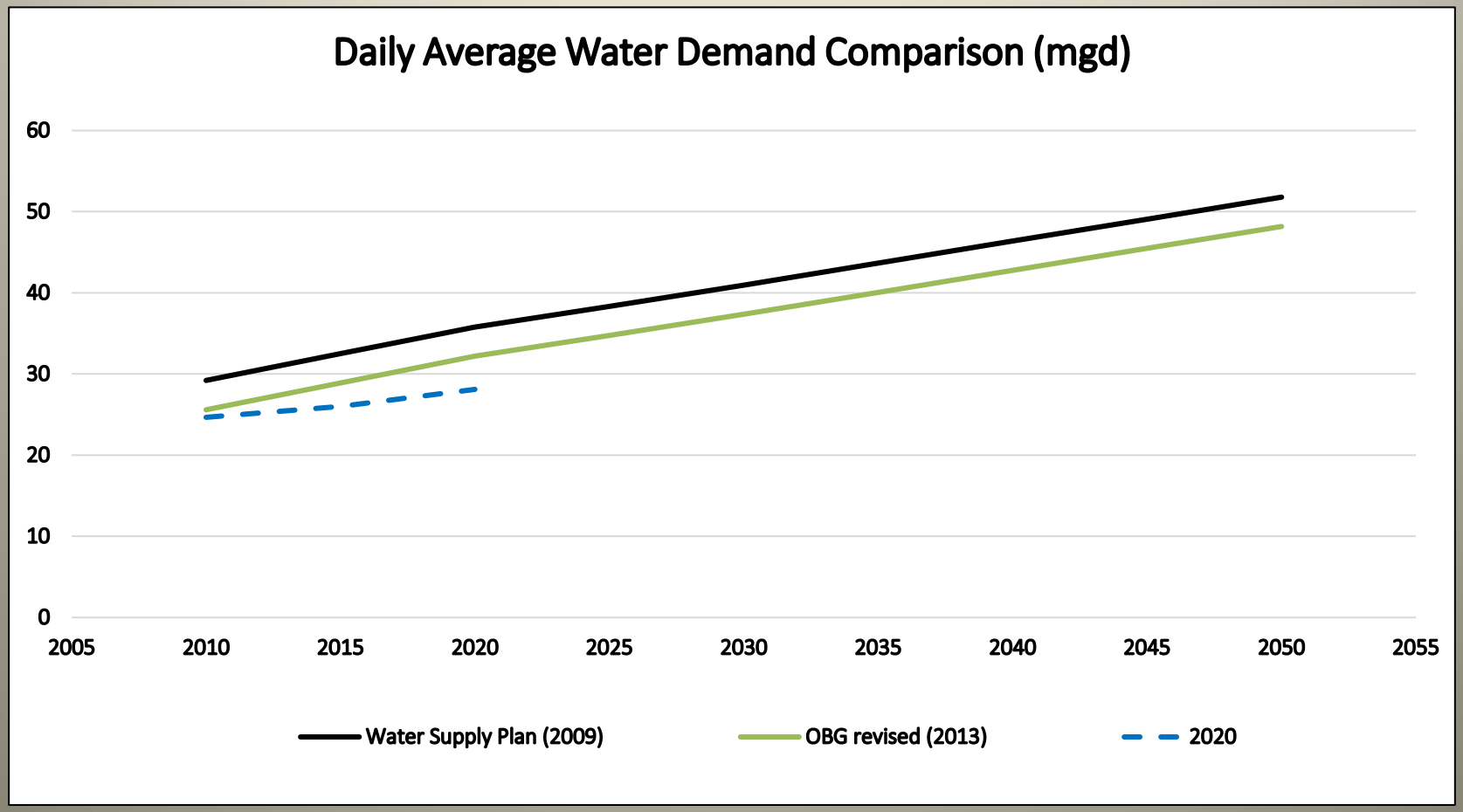
“Working Together Works”

doug @duckriveragency.org

So You Want A WATER PERMIT?



Water Demand Projections (MGD)



CPWS Request

CPWS would respectfully request $10 million dollars of DRA funds for this project under the following terms and conditions:

1) $3 million dollars now to finalize engineering and permitting.

2) $1 million dollars upon land acquisition of the downstream intake site.

3) $6 million dollars upon permitting of the downstream intake and letting of the contracts to construct both the downstream intake and the transmission line.

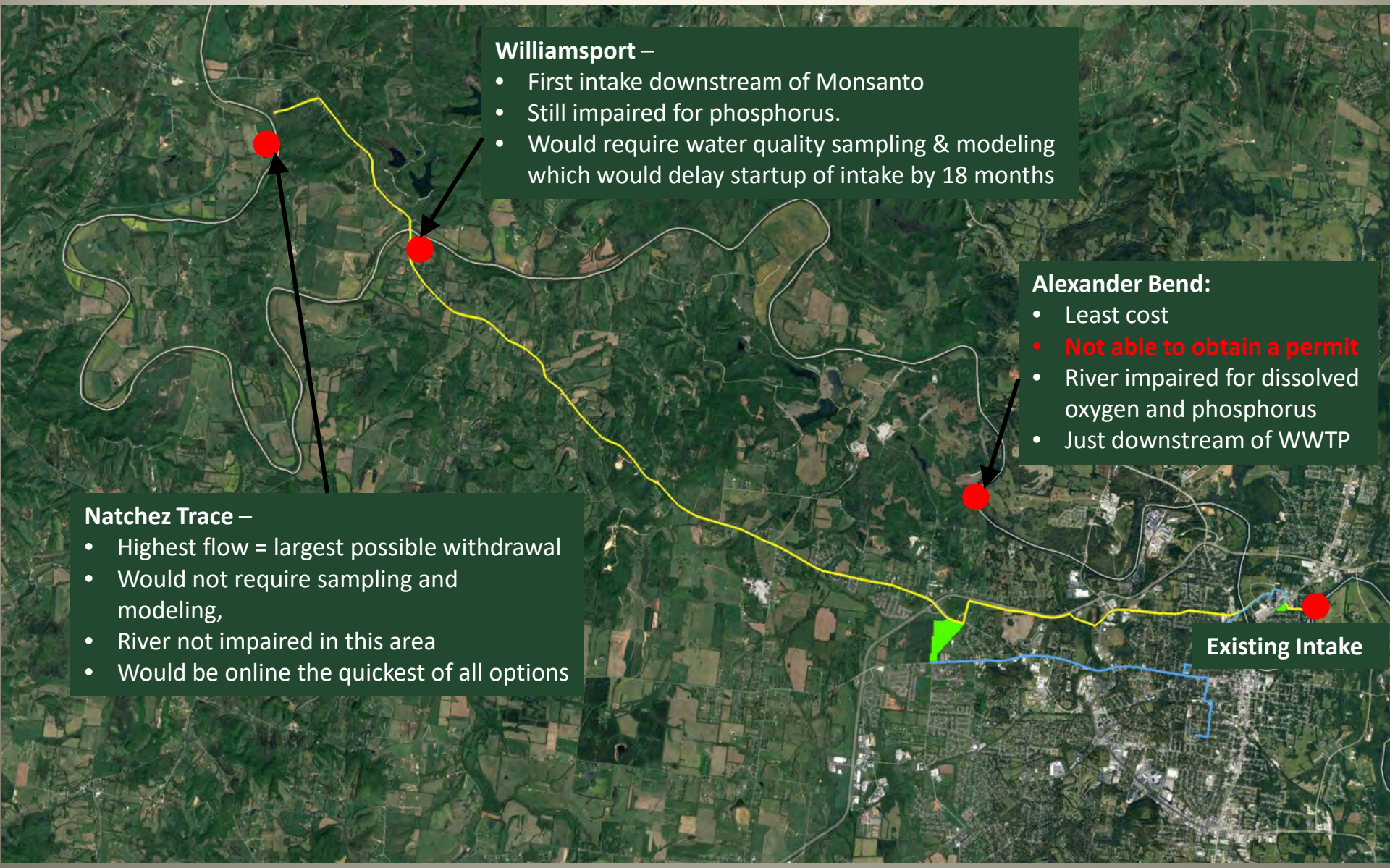
4) If not completed within ten years, CPWS would repay any sums received from DRA for this project.

What is in it for me?

- Removes CPWS, MCWS and SHWS water supply reliance from Normandy Reservoir during extended drought periods and for future growth demands
- Leaves more water in Normandy Reservoir for all upstream withdrawals during extended drought periods
- In the future this will give upstream withdrawals opportunity to increase their permitted withdrawal limits or add new water withdrawal intakes

What does it cost me?

- $5.7 million debt owed to TVA for Normandy Reservoir water supply portion was forgiven
- $5.7 million was set aside in a trust fund to be used for future new or upgraded “regional” water supply infrastructure projects
- The Water Supply Project Trust Fund is currently a little over $13 million
- No immediate cost to you, the fund is in place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