



# Consumptive Needs Technical Workgroup

February 6, 2018, 9:00 a.m. to 12:00 p.m.

Workshop

Missouri Water  
Resources Plan

# Welcome!

Jennifer Hoggatt  
Director  
Water Resources Center

# Agenda Overview

- Introduction and Meeting Format
- Missouri Department of Natural Resources Project Vision
- Demands to 2060 for all Sectors
  - Consumptive
  - Non-consumptive
  - Agricultural
- Detailed Demand Analysis Consumptive Water Use
- Preliminary Water Supply Analysis
- Next Steps
- Public Comments



# Missouri Water Resources Plan Vision

- Statutory Responsibility (640.415 RSMo):

*"The department shall develop, maintain and periodically update a state water plan for a long-range, comprehensive statewide program for the use of surface water and groundwater resources of the state, including existing and future need for drinking water supplies, agriculture, industry, recreation, environmental protection and related needs."*



The background of the slide features a dynamic water splash in shades of blue, with droplets and ripples creating a sense of movement and freshness. The splash is most prominent on the left side, with water droplets falling and splashing upwards.

The Missouri  
Water  
Resources Plan  
is a long range,  
comprehensive  
strategy to:

## Project Vision (MoDNR)

- ⑩ Provide an understanding of water resource needs
- ⑩ Ensure the quantity of water resources meets future water demands
  - ⑩ Identify future water supply shortfalls
  - ⑩ Explore options to address water needs

# Missouri Water Resources Plan Update: Goals

- 1 Gather public and stakeholder input to help identify needs and priority areas of water resource development.
- 2 Establish key stakeholder advisory and technical groups to help guide water plan development.
- 3 Develop an updated evaluation of current groundwater and surface water availability and develop projected water supply needs.
- 4 Produce an in-depth analysis of current and future consumptive, non-consumptive and agricultural water needs, and identify gaps in water availability based on water demand projections.
- 5 Identify water and wastewater infrastructure needs, and evaluate funding and financing opportunities.
- 6 Recognize water quality and assess how this affects water supply uses.
- 7 Understand areas where developing new and more sustainable water sources, better infrastructure, and more integrated water supplies can help to sustain water delivery.
- 8 To better understand regionally where future water gaps may exist, as studies have revealed in parts of southwest and northern Missouri.

# Water Demands

# ALL WATER DEMAND SECTORS

## Consumptive Demand Quantified



- Major water systems
- Self-supplied nonresidential
- Self-supplied domestic and minor systems
- Thermoelectric power generation (small portion consumed)
- Livestock
- Agriculture irrigation

## Non-Consumptive Demand Characterized



- Hydroelectric power generation
- Commercial navigation
- Aquaculture and wetlands
- Water-based outdoor recreation
- Thermoelectric power generation (small portion consumed)

*Consumptive demand* refers to water that is withdrawn from the source and consumed in a way that makes its use all or partially unavailable for other purposes or uses.

*Non-consumptive* demand refers to uses that rely on water in the streams, rivers, and lakes for everyday activities. The water is not consumed and is available for other uses.

# Agricultural Needs

# Crop Irrigation

- **Definition** – Water required to supplement natural rainfall for the commercial production of crops such as corn, soybeans, wheat, specialty vegetables, and orchards
- **Methodology**  
Irrigated Acres      X      Crop Irrigation Requirement
- Only current water demands have been estimated
- Future demands will be forecasted in the coming months

Irrigation Style	Efficiency
Sprinkler	75%
Surface (Furrow)	50%
Micro-Irrigation	90%

# Irrigation Estimation Data Sources

Data Type	Data Source
Crop acreage	2012 USDA Census of Agriculture
County rankings by crop	2012 USDA Census of Agriculture
Crop planting/harvest estimates	Missouri Crop Resource Guide
Crop evapotranspiration coefficients	FAO
Missouri crop regions	Missouri Crop Resource Guide
County-level temperature data	High Plains Regional Climate Center
County-level precipitation data	High Plains Regional Climate Center

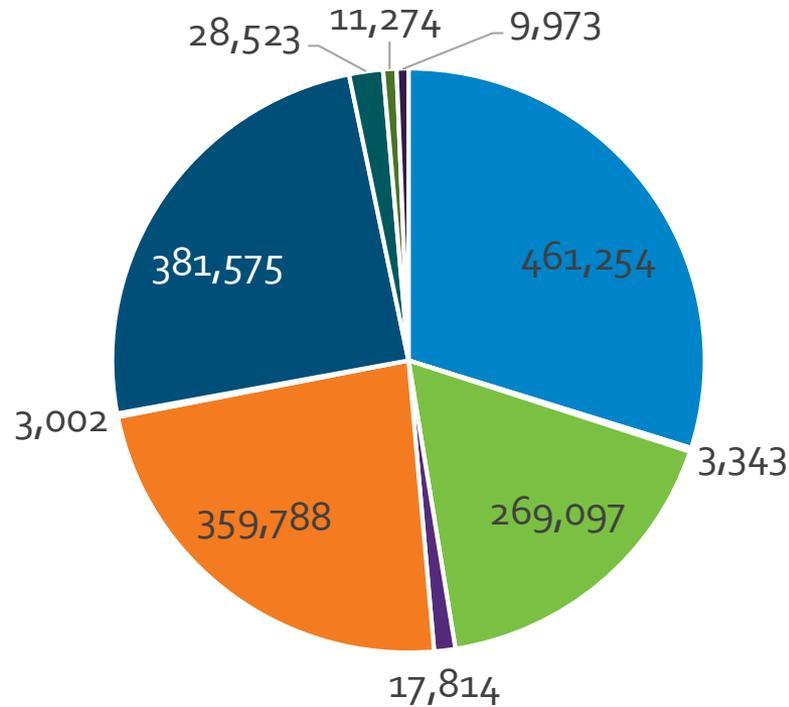


# Irrigation – Current Crop Water Demands (Billion Gallons per Year)

DRAFT RESULTS

**Total Demand**  
**503.6 BGY**  
**1,380 MGD**  
**1,545,492 AFY**

Irrigation Water Use by Crop Type



- Grain Corn
- Silage Corn
- Cotton
- Hay/Haylage
- Rice
- Sorghum
- Soybeans
- Wheat
- Vegetables
- Sod

\*Irrigation and livestock demands represent current use and are not yet forecasted

# Livestock

- **Definition** – Water required for the production of animals to meet dietary, sanitation, and overall animal health
- **Methodology**

Number of Animals    X    Animal Water Requirement

- Only current water demands have been estimated
- Future demands will be forecasted in the coming months

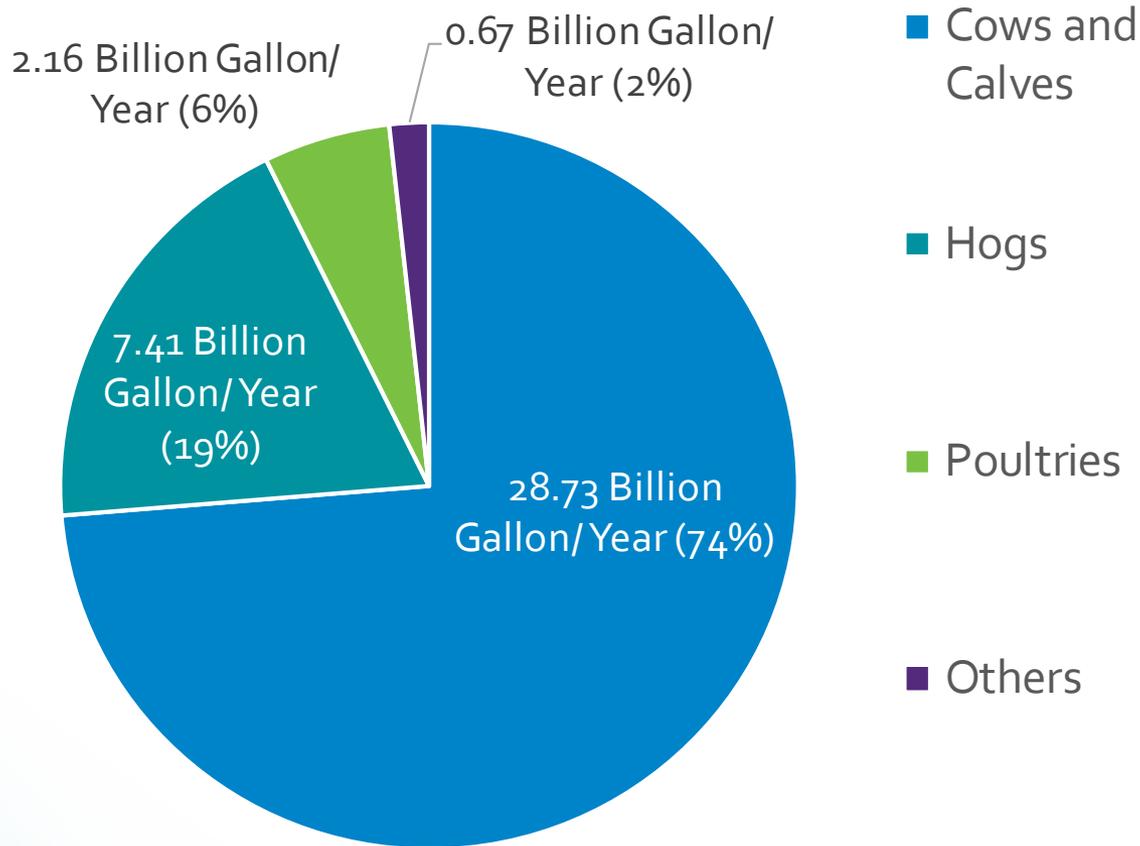


	Animal Count	Gallon per Head per day	Total Demand (MGD)
Cows and Calves	3,703,120	18	66.7
Beef Cows	1,683,731	22.75	38.3
Dairy Cattle	92,952	30	2.79
Other Cattle	1,926,437	18	34.7
Cattle/Calves Sold	2,297,985	18	52.3
Swine	2,774,597	6	16.6
Swine Sold	9,727,491	6	58.4
Sheep	91,967	2	0.18
Sheep Sold	62,049	2	0.12
Goats	103,669	1.25	0.13
Goats Sold	56,087	1.25	0.07
Broilers	46,880,714	0.06	2.81
Broilers Sold	272,389,497	0.06	16.3
Layers	8,276,409	0.045	0.37
Layers Sold	3,897,402	0.045	0.18
Turkeys	7,572,505	0.092	0.70
Turkeys Sold	18,568,732	0.092	1.71
Horses	117,295	11	1.29
Horses Sold	15,169	11	0.17
<b>TOTAL</b>	<b>380,237,808</b>		<b>294</b>

\* Irrigation and livestock demands represent current use and are not yet forecasted

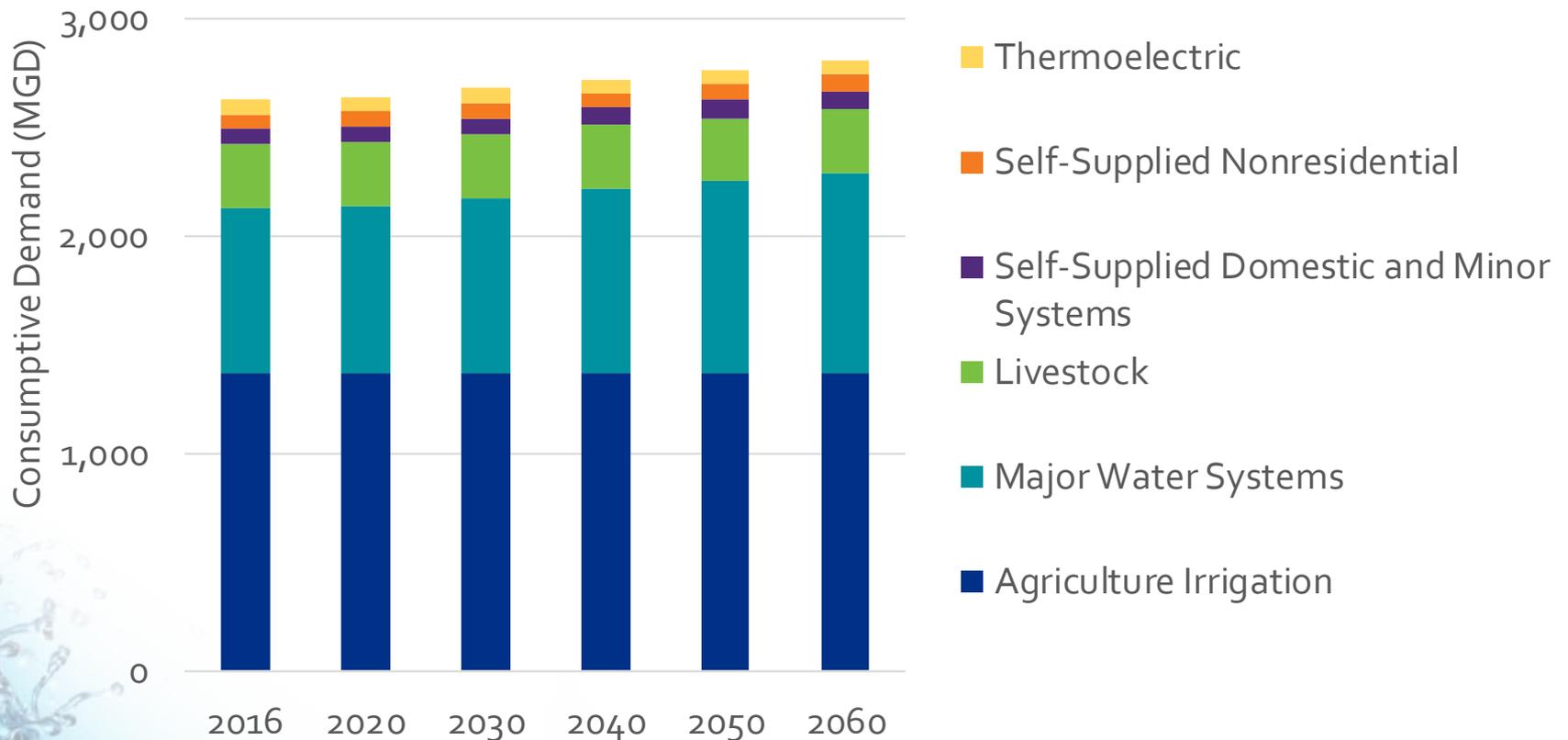
# Livestock – Current Water Demands (Billion Gallons per Year)

DRAFT RESULTS



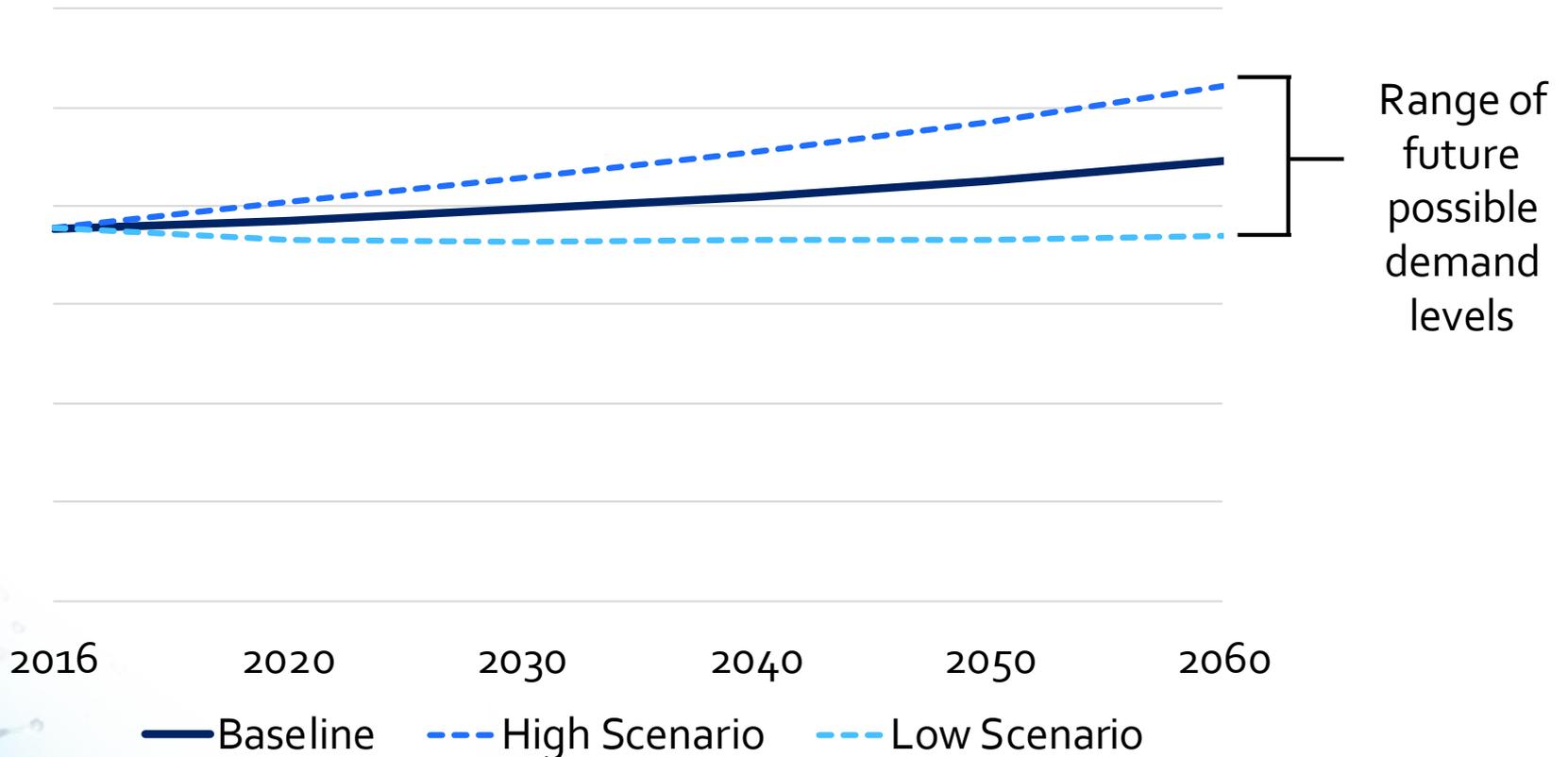
# Consumptive Demands – ALL SECTORS

## Statewide Consumptive Demand Forecast (MGD)



\* Irrigation and livestock demands represent current use and are not yet forecasted

# Consumption Demand Forecast Capturing Uncertainty



Scenarios will be developed in coming months

# Non-Consumptive Needs

# Non-Consumptive Demands

## Definition

Sectors that rely on water in the streams, rivers, and lakes for everyday activities.

The water is not consumed and is available for other uses.

## Goal

Identify and characterize the major non-consumptive sectors that rely on water.



# Non-Consumptive Demand

## *Overview of Approach*



Include in  
Missouri Water  
Resources Plan  
(where applicable)

How water is used

What activities does water support

Importance of sector to the state

Quantify water needs

Map locations of key use and  
infrastructure

Future outlook

Identify data gaps and needs

# Non-Consumptive Demand

## *Sample of Results*

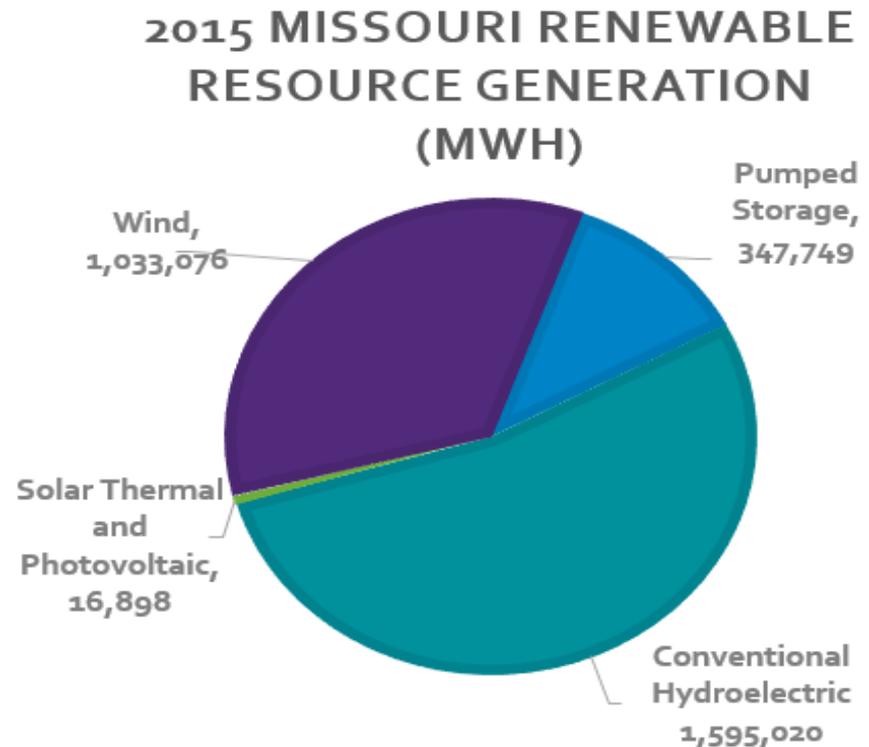




# Non-Consumptive Demand

## *Hydroelectric Power Generation*

- **Definition** – Water for generating hydroelectric power through riverine dams or other structures.
- **Features**
  - Identify and describe major facilities
  - Quantify net generation
  - Characterize reservoir water requirements
  - Economic benefits
  - Future Outlook, potential resources



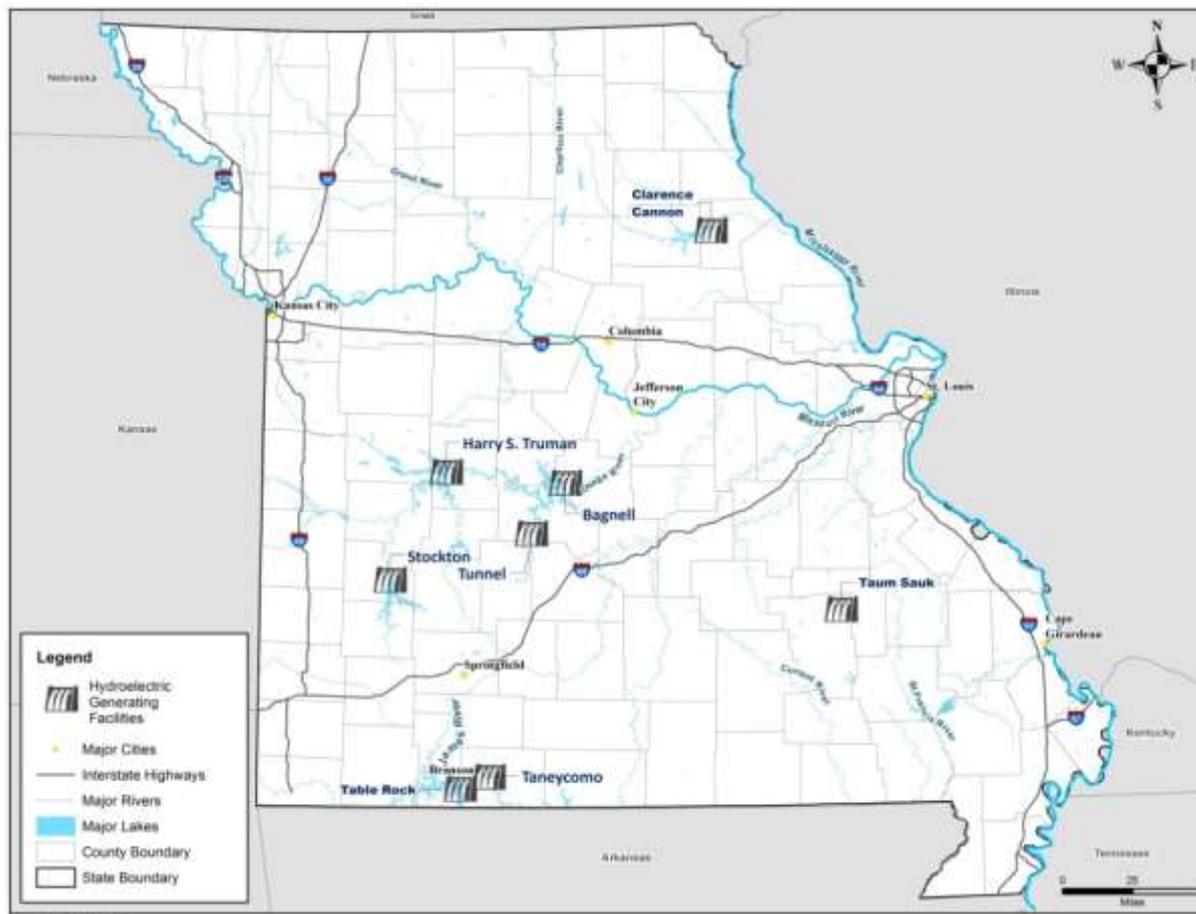
*Source: U.S. Energy Information Administration - Net Generation by State by Type of Producer by Energy Source*



# Non-Consumptive Demand

## *Hydroelectric Power Generation*

### Major Hydroelectric Facilities





# Non-Consumptive Demand

## *Hydroelectric Power Generation*

### Major Hydroelectric Plant Facility Overview

Plant Name	Facility Type	2014 Net Generation (MWh)	Owner/Operator
Clarence Cannon	Impoundment and Pumped Storage	84,772	USACE
Harry S. Truman	Pumped Storage	98,877	USACE
Niangua	Diversion	686	Sho-Me Power Electric Coop
Osage Dam (also know as Bagnell)	Impoundment	232,190	Union Electric Company
Powersite (Lake Taneycomo)	Diversion	60,693	Empire District Electric Co
Stockton Hydro	Impoundment	5,958	USACE
Table Rock	Impoundment	368,917	USACE
Taum Sauk	Pumped Storage	-135,904	Union Electric Company

Source: U.S. Department of Energy, Energy Information Administration  
Power Plant Operations Report, 2015



# Non-Consumptive Demand

## *Commercial Navigation*

- **Definition** – Water for transporting barges and boats that carry grain, raw materials, and other bulk freight.
- **Features**
  - Identify commercially navigable rivers
  - Efficiency benefits
  - Economic benefits
  - Tonnage shipped by river segment
  - Identify key infrastructure
  - Locks and dams, port authorities, and toll ferries, water control reservoirs
  - Shipping season
  - Channel water depth requirement

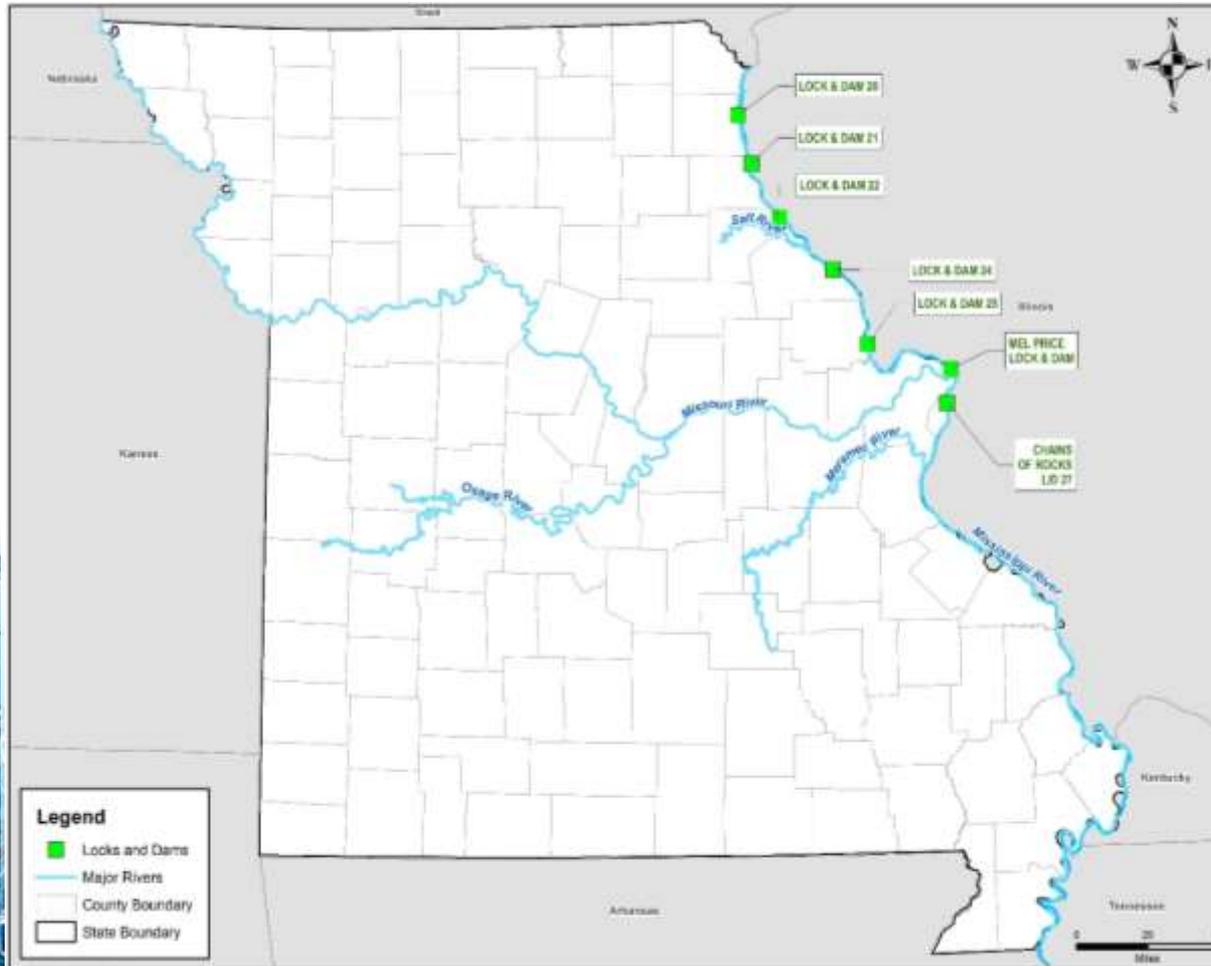




# Non-Consumptive Demand

## *Commercial Navigation*

### Mississippi River Water Requirements



- 9 ft navigation channel maintained by a series of locks and dams
- Regular dredging and river training structures such as weirs aid in maintaining navigation channel



# Non-Consumptive Demand

## *Commercial Navigation*

### Missouri River Water Requirements

- Water is released from six mainstream flood control reservoirs to maintain a channel 300 feet wide and 9 feet deep
- Flow of approximately 41,000 cfs at Kansas City provides full service navigation
- Flow of approximately 35,000 cfs at Kansas City provides minimum support to navigation



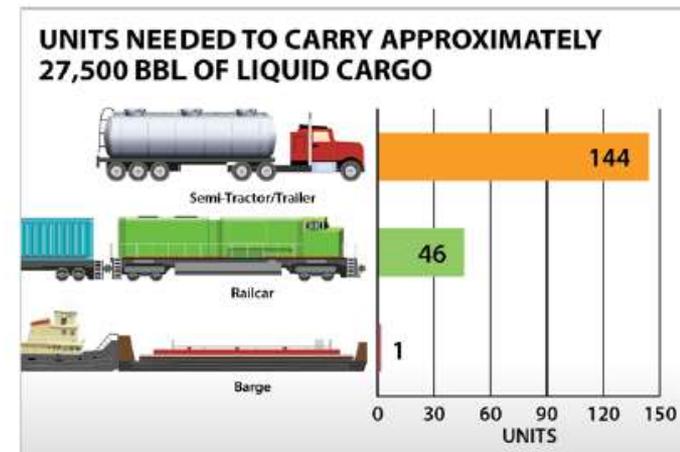
*Source: USACE (2006), Missouri River Mainstem Reservoir System Master Water Control Manual*



# Non-Consumptive Demand

## Commercial Navigation

- Efficiency benefits
  - Inland towing 36% more efficient than railroads
  - Inland towing 346% more efficient than truck freight
- Waterways are safer means of transporting goods; fatalities per million ton-miles:
  - Highway = 0.00174
  - Railroad = 0.00048
  - Water = 0.00002
- Lower greenhouse gas emissions per ton-miles



Source: Texas Transportation Institute - A Modal Comparison of Domestic Freight Transportation Effects on the General Public, 2017



# Non-Consumptive Demand

## Commercial Navigation

### Future Outlook

- 2030 Projections
  - 63.3 million tons of waterborne freight
  - ~ \$15.5 billion value of cargo



Source: Missouri Department of Transportation, Missouri State Freight Plan



# Non-Consumptive Demand

## *Aquaculture and Wetlands*

- **Definition** – Water that supports wetland restoration and preservation as well as aquaculture.
- **Features**
  - Wetland reserve easement mapping
  - Estimate withdrawals for wetland reserve easements based on proximity to irrigation well or surface water source
  - Aquaculture withdrawals
  - Economic benefits of hunting and fishing sector



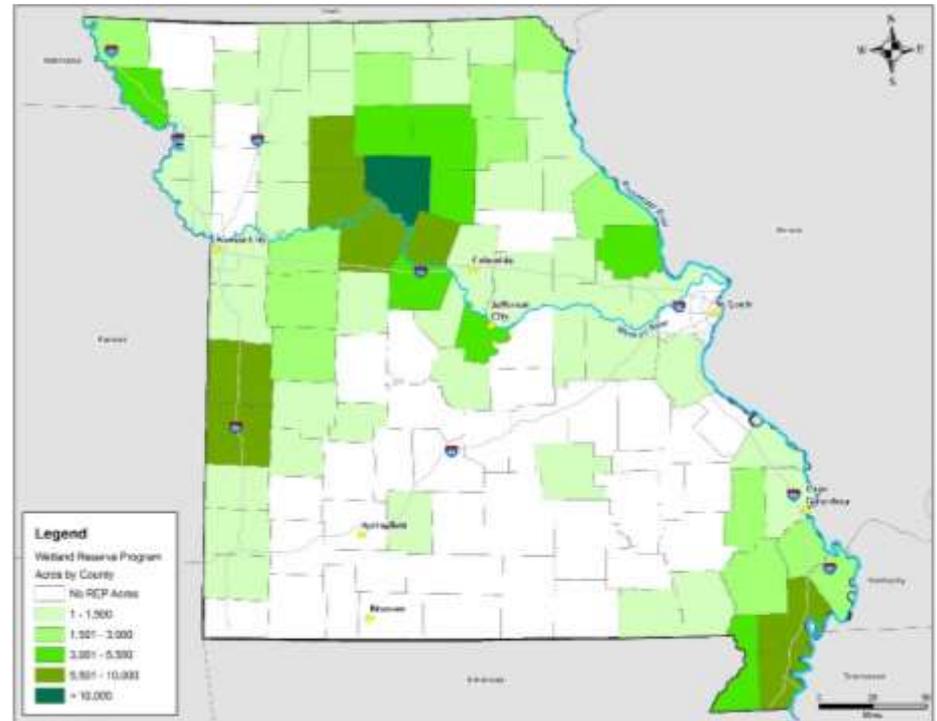


# Non-Consumptive Demand

## *Aquaculture and Wetlands*

### Wetland Reserve Easement

- Approximately 145,726 acres of wetland easements enrolled in the WREP program in Missouri; 1100 easements
- Approximately \$82 million paid in wetland easements through the WREP in Missouri
- 68% of WREP acres located in proximity to a diversion or well, assuming those are flooded in fall and drained in spring to plant food
- ~73,000 acre feet per year withdrawn (18 inches of water over one-third of acres in proximity to supply)





# Non-Consumptive Demand

## *Aquaculture and Wetlands*

### Wetland Withdrawals by Source

Source		Acres within Proximity of Source	Withdrawal (AF)
AQUIFER	Alluvium	26,647	13,190
	Ozark Aquifer (Lower)	19,813	9,807
	Ozark Aquifer (Upper)	4,852	2,402
	<b>Ground Water Total</b>	<b>51,312</b>	<b>25,399</b>
HUC 4	Chariton-Grand	14,872	7,362
	Des Moines	1,157	572
	Gasconade-Osage	2,226	1,102
	Lower Mississippi-Hatchie	5,836	2,889
	Lower Mississippi-St. Francis	2,967	1,469
	Lower Missouri	10,577	5,236
	Missouri-Nishnabotna	3,877	1,919
	Neosho-Verdigris	836	414
	Upper Mississippi-Kaskaskia-Meramec	599	296
	Upper Mississippi-Salt	4,249	2,103
	Upper White	912	451
	<b>Surface Water Total</b>	<b>48,109</b>	<b>23,814</b>
<b>Total</b>	<b>99,421</b>	<b>49,213</b>	

*Source identified from MoDNR's Major Water Users Database and Public Wells Data*



# Non-Consumptive Demand

## *Aquaculture and Wetlands*

### Aquaculture Withdrawals

- Missouri Aquaculture Directory lists 69 aquaculture related businesses
- Missouri Department of Conservation owns nine fish hatcheries
  - 4 fish hatcheries reported water use between 2013 and 2016
  - Water use averaged 14.9 to 61.9 billion gallons per year
- USGS reported aquaculture withdrawals of 180.5 MGD in 2010

Source	Aquaculture Withdrawals (MGD)	% of Source
Groundwater	10.5	6%
Surface Water	170	94%
<b>Total</b>	<b>180.5</b>	<b>100%</b>

*Source: U.S. Geological Survey - Estimated Use of Water in the United States in 2010*



# Non-Consumptive Demand

## *Water-Based Outdoor Recreation*

- **Definition** – Water that supports human recreational activities such as fishing, swimming, boating, and canoeing.
- **Features**
  - Waters suitable for recreation
  - Visitation levels
  - Water by activity – trout waters and float rivers
  - Water needs for trout production
  - Access points
  - Economic benefits

*In 2012, annual visitation for all USACE reservoirs in Missouri totaled 15.9 million and were estimated to add \$170 million to the economy surrounding the lakes.*



# Non-Consumptive Demand

## *Water-Based Outdoor Recreation*

- Waters Suitable for Recreation
  - Missouri Code of State Regulations designates suitable waters for whole body or secondary contact
  - **Whole body contact:** activities where a person is in contact with the raw surface water to the point of submergence (e.g., Swimming, Water Skiing, Diving)
  - **Secondary contact:** activities that require limited, incidental contact with the surface water (e.g., Fishing, Wading, Boating)

Source	Designated Secondary Contact Recreation – Public	Designated Whole Body Contact – Public	Designated Whole Body Contact – Open to the Public
Rivers/Streams (miles)	109,496	108,861	6,282
Lakes (acres)	318,939	318,939	260,950

Source: Missouri Spatial Data Information Service



# Non-Consumptive Demand

## *Water-Based Outdoor Recreation*

### Trout Waters

- Trout habitat is limited to 377 miles of permanent streams that are designated as suitable for “coldwater sport fishery”
- 145 miles of streams are actively managed for trout fishing by MDC
- 4 trout parks
- 7 trout management areas
- 8 wild trout management areas
- 28 urban winter trout areas in St. Louis and Kansas City Lakes
- Trout program relies on water supplies and can be impacted by low flows in the spring

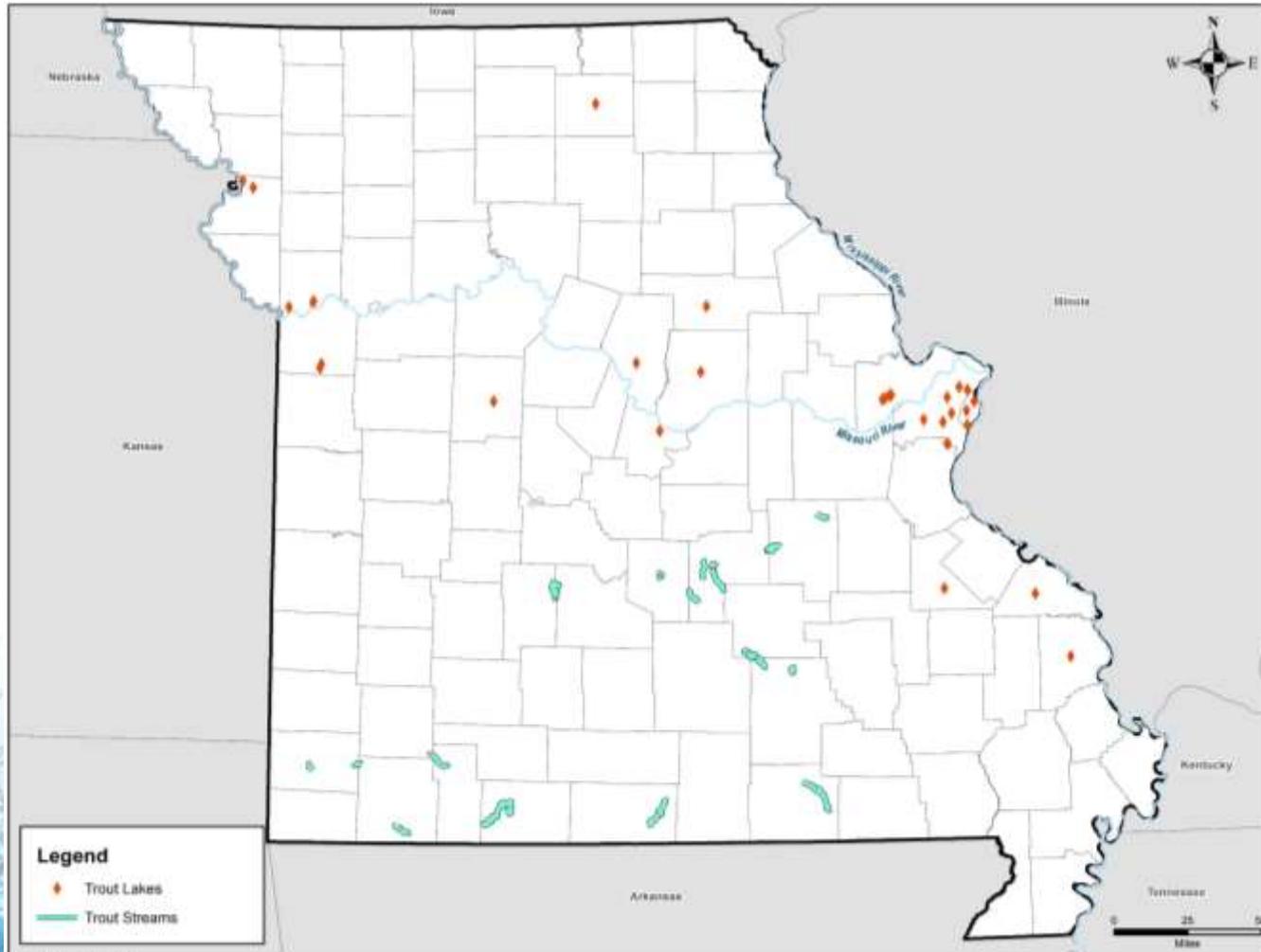
Facility	Water Supply Available (cfs)	Water Supply Needed (cfs)
Bennett Spring	150	31
Marmec Spring	144	11
Montauk	82	31
Roaring River	32	19
Shepherd of the Hills	22	22

Source: MDC 2003



# Non-Consumptive Demand

## *Water-Based Outdoor Recreation*



Trout  
Lakes and  
Streams

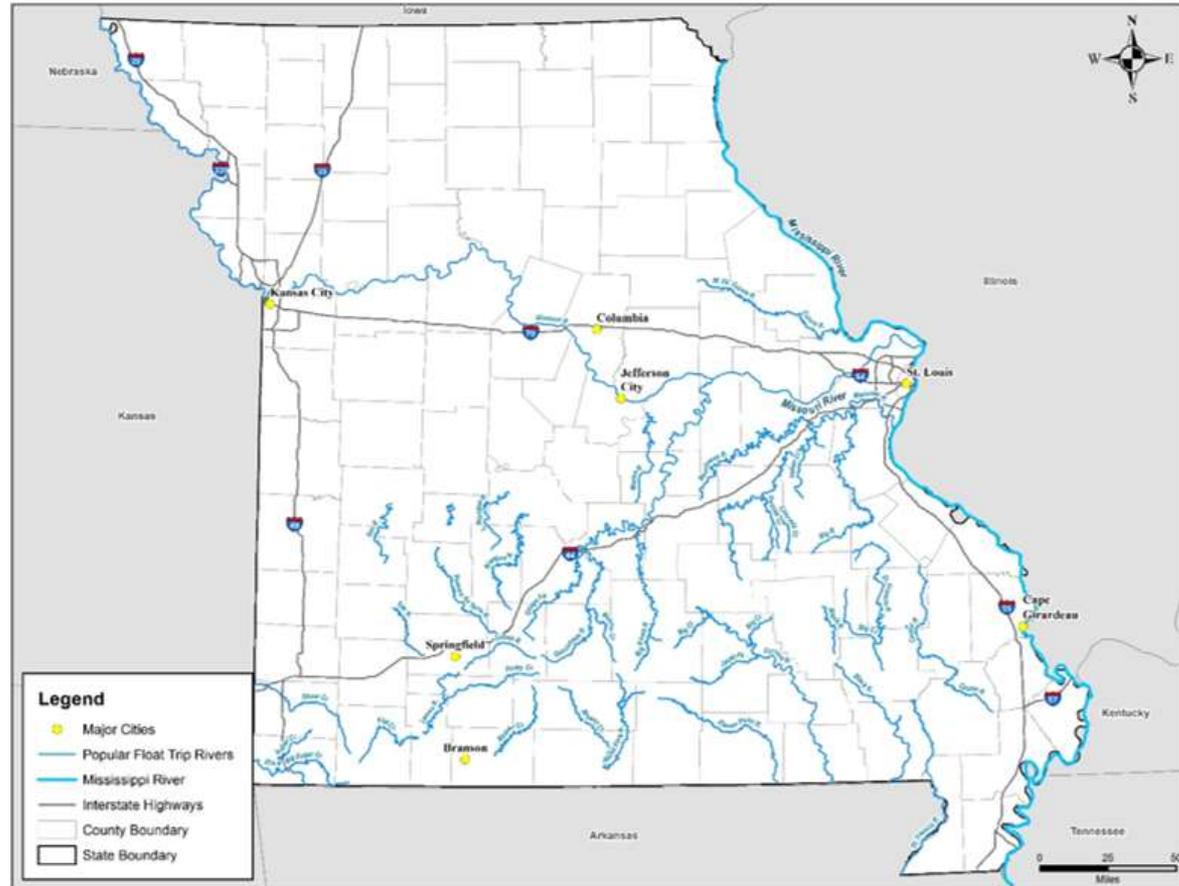


# Non-Consumptive Demand

## *Water-Based Outdoor Recreation*

### Float Rivers

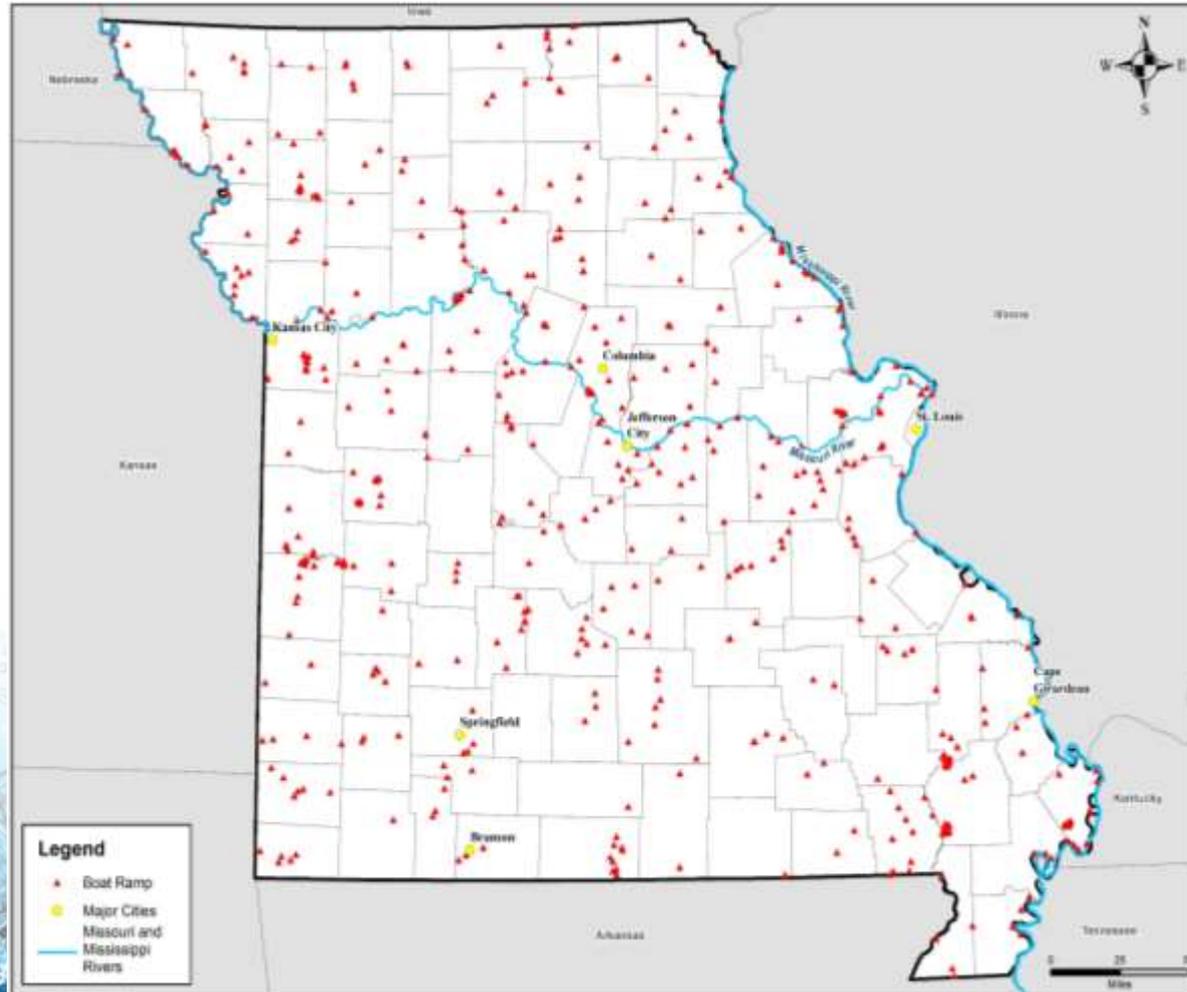
- Floating
- Canoeing
- Kayaking





# Non-Consumptive Demand

## *Water-Based Outdoor Recreation*



## Water Access Points

- Missouri Department of Conservation manages 586 water access points
- 293,660 registered boats in Missouri (2015)



# Non-Consumptive Demand

## *Water-Based Outdoor Recreation*

### Economic Impacts

- \$14.9 billion in spending annually on outdoor recreational
- \$889 million in state and local taxes
- Outdoor recreation supports ~133,000 jobs in Missouri
  - \$4.6 billion in wages and salaries per year
- \$685 million spent on fishing activities in 2011 which contributed to:
  - Nearly 11,000 jobs
  - \$211 million in federal taxes
  - \$181 million in local and state taxes
  - \$13.08 million on fishing licenses

*Source: Congressional Sportsmen's Foundation Sportsmen's Economic Impact Report*

# Consumptive Needs



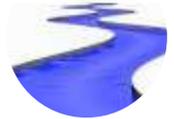
# ALL WATER DEMAND SECTORS

## Consumptive Demand Quantified



- Municipally-provided public supply
- Self-supplied nonresidential
- Self-supplied domestic
- Thermoelectric power generation (small portion consumed)
- Livestock
- Agriculture irrigation

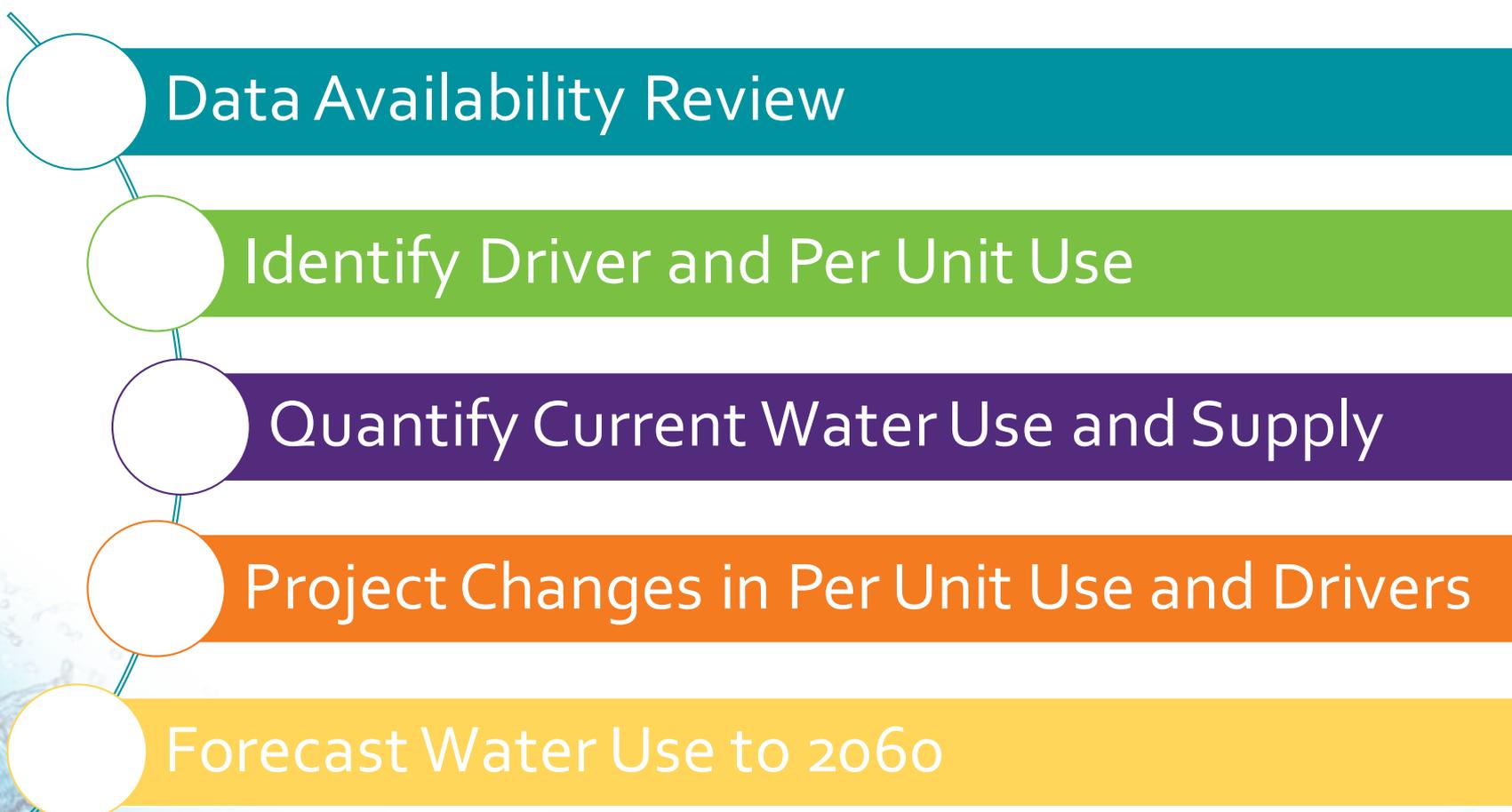
## Non-Consumptive Demand Characterized



- Hydroelectric power generation
- Commercial navigation
- Aquaculture and wetlands
- Water-based outdoor recreation
- Thermoelectric power generation (small portion consumed)

*Consumptive demand* refers to water that is withdrawn from the source and consumed in a way that makes its use all or partially unavailable for other purposes or uses.

# Consumptive Demand Approach



Data Availability Review

Identify Driver and Per Unit Use

Quantify Current Water Use and Supply

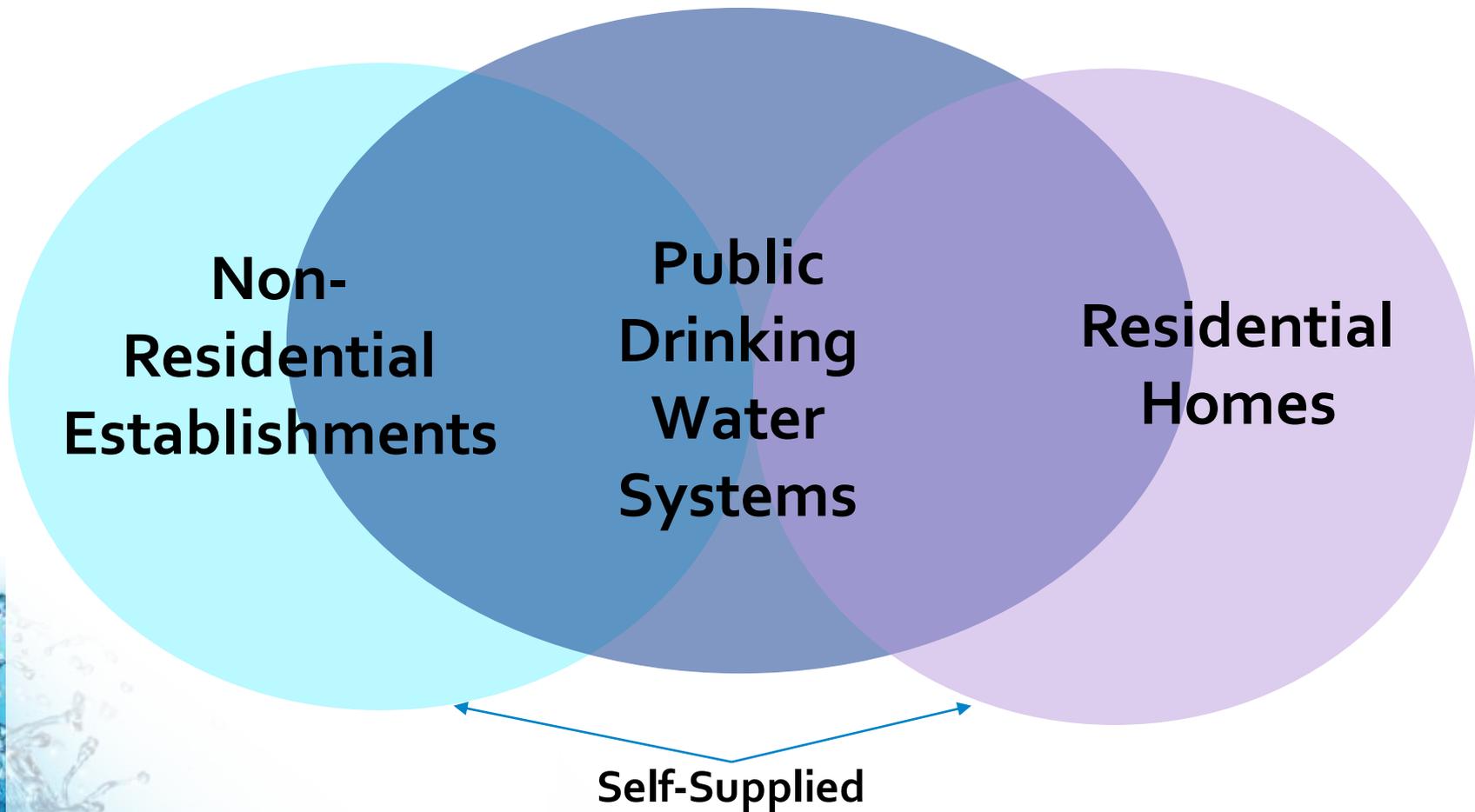
Project Changes in Per Unit Use and Drivers

Forecast Water Use to 2060

# Estimating Water Use for Homes and Businesses

- Work with available data
- Avoid double counting or “missing” major water users
- Consider future work that builds upon demands
  - Supply/demand analysis
  - Infrastructure planning
- Forecast
  - At municipal level for major water systems
  - Utilize data projections to the planning horizon
- Balance level of effort





# Estimating Water Use at Homes and Businesses

## Proposed Sector Naming

**Major Water Systems**  
**Self-Supplied Nonresidential**  
**Self-Supplied Domestic and Minor Systems**

## Primary Data Sources



**Woods &  
Poole  
Demographic  
Projections**

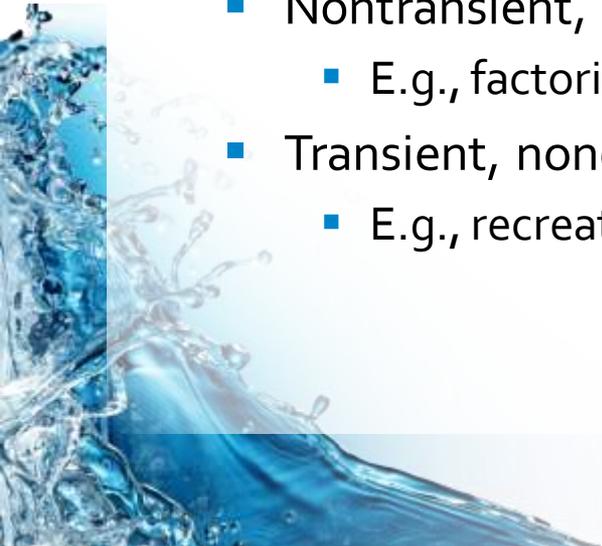
**Major Water  
Users  
Database**

**Census of  
Public Water  
Systems**

# Primary Data Source

## Census of Public Water Systems Data

- Census of Missouri Public Water Systems (2016 stats)
  - “Public Water System” = serves at least 15 connections and operated year-round or directly serves at least 25 residents
  - **Community Systems = 1,426**
    - E.g., cities, water districts, subdivisions, mobile home parks, institutions
    - Includes list of  sellers and buyers,  general source of water (surface water, groundwater, purchased),  population served,  average daily consumption,  surface water source
  - Nontransient, noncommunity systems = 216
    - E.g., factories, businesses, industries, schools
  - Transient, noncommunity systems = 1,091
    - E.g., recreation areas, restaurants, hotels, campgrounds



# Primary Data Source

## Major Water Users Database

- Water users able to pump or divert 100,000 (or more) gallons per day required to register and report
- No penalties for non-reporting
- Key data include source (groundwater or surface water), withdrawal points, use category, primary county, population served
- **Annual reporting of water use**
- Use categories: Municipal, Industrial, Commercial, Recreation, Wildlife, Electric Generation, Livestock, Irrigation, Dewatering, Other
- In 2016 – 1,182 registered users
- **Can get specific location of withdrawal and source**



# Matched Public Water Systems Between Data Sources

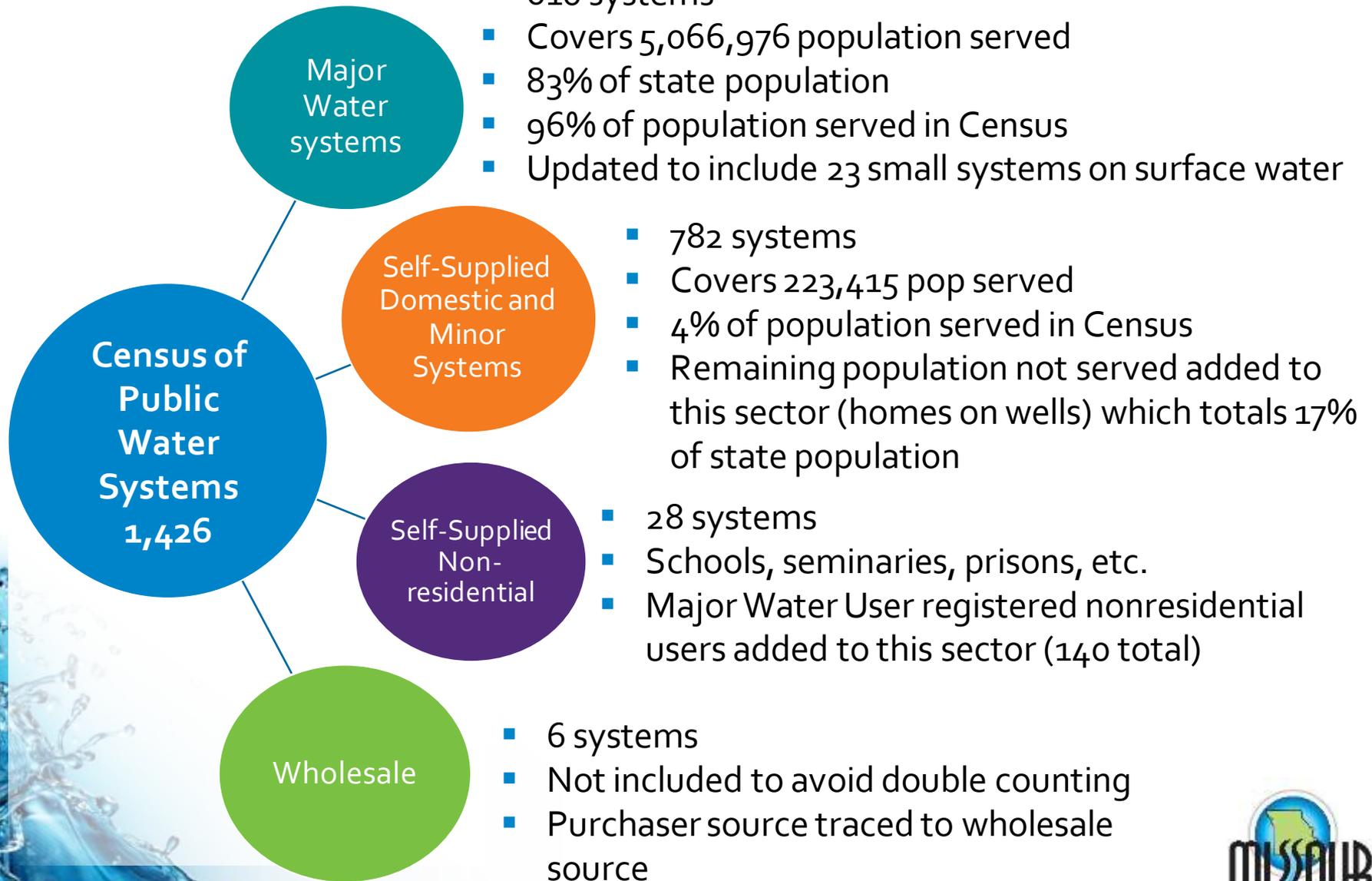


Census of  
Missouri Public  
Water Systems



Major Water  
Users  
Database

# Designate Sector



# Population at County Level Quality Control

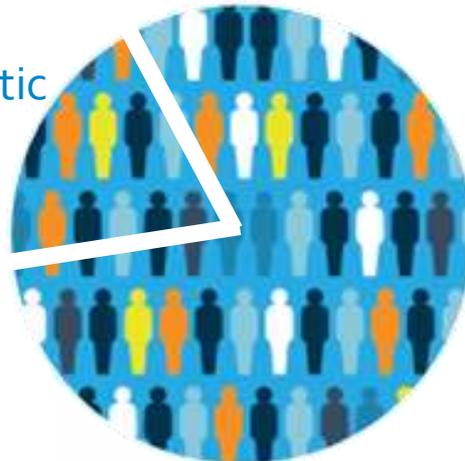
- Major Water Systems population is first calculated
- Self-Supplied Domestic and Minor Systems is the remainder
- Source: Woods & Poole

Total County Population

*minus* Major Water Systems

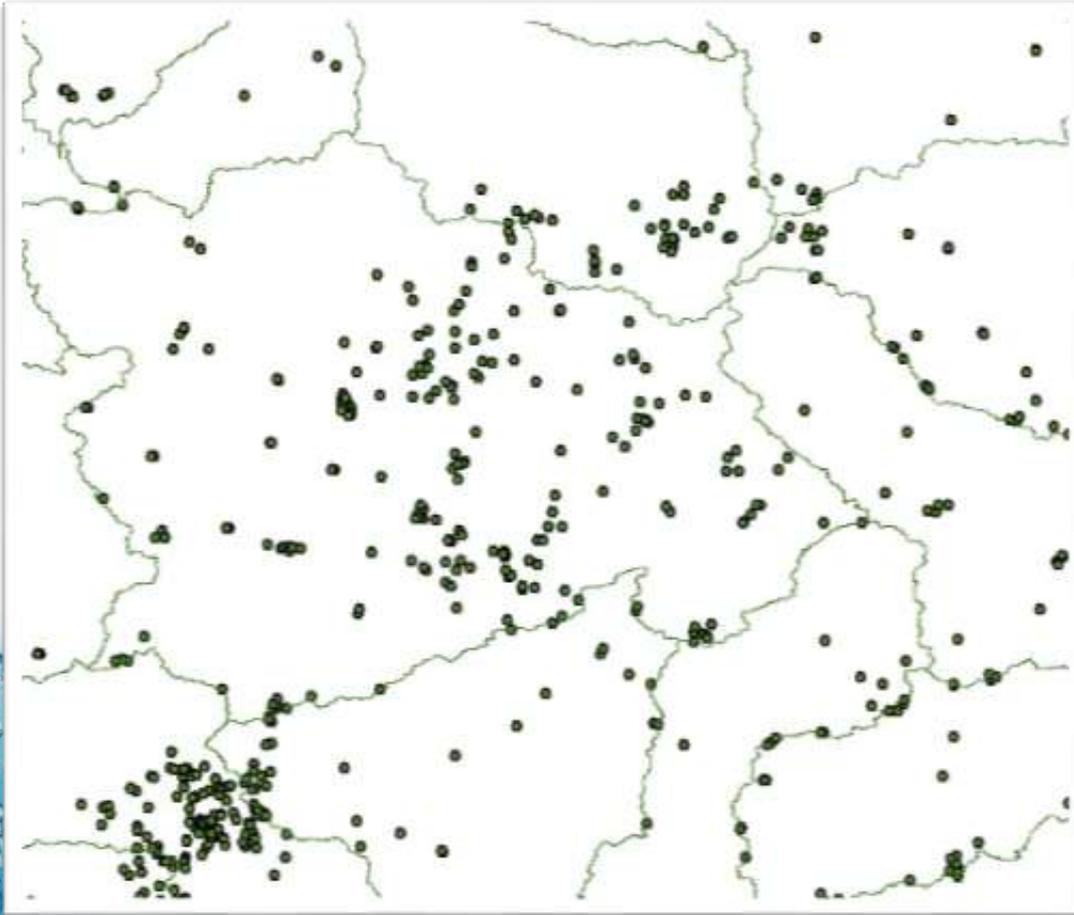
*equals* Self-Supplied Domestic and Minor Systems

Self-Supplied Domestic  
and Minor Systems  
17%



Major Water Systems  
83%

# Identifying Water Source



- Need source by **aquifer** (groundwater) and **HUC 8** (surface water)
- Surface water source identified from Public Drinking Water Census
- Groundwater aquifer identified from MoDNR Public Wells GIS layer

# Consumptive Demand Sectors Draft Preliminary Results

Major Water Systems  
Self-Supplied Domestic and  
Minor Systems  
Self-Supplied Nonresidential  
Thermoelectric Power  
Generation

# Major Water Systems

- **Definition**—Water that is provided by a municipal or public water supply entity to homes, businesses, and light industries
- Accounts for wholesale transfers and out of state supplies
- **Methodology**

Population Supplied

*times*

Per Capita Use Rate



X



Equation applied for all planning periods

2016

2020

2030

2040

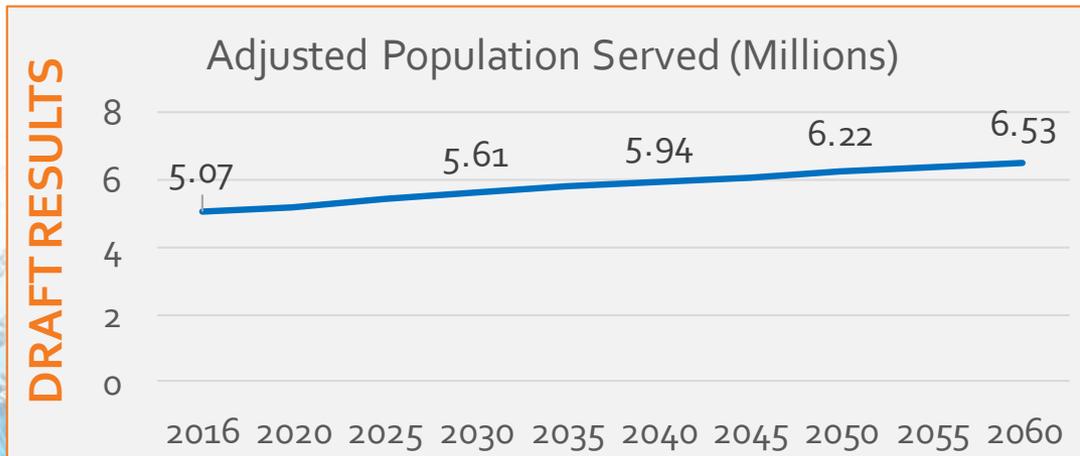
2050

2060

# Major Water Systems – Population Supplied

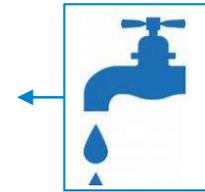
- Woods & Poole 2017 Complete Economic and Demographic Data Source
- Assumes 2016 population served from Drinking Water Census as “Base Year” (i.e., starting point)
- Growth to 2060 considers:
  - Population growth within the county or counties where the water system is located (2/3 weight)
  - Employment growth within the county or counties where the water system is located (1/3 weight)

Example: If population served by Major Water Systems in a given county is projected to grow by 2% and employment is projected to grow by 5%, then the weighted average growth of 3% is applied to municipally supplied population.



# Major Water Systems – Per Capita Use Rates

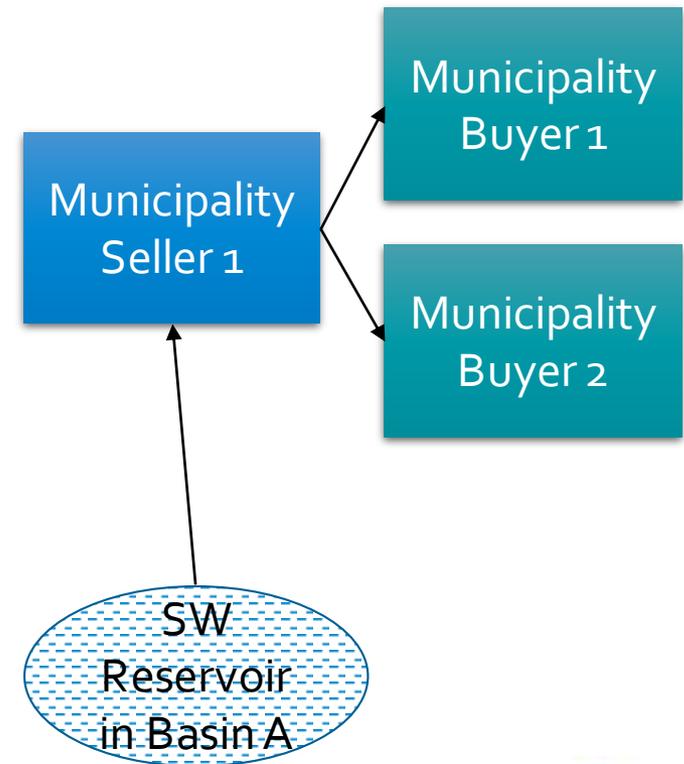
- 2016 is “Base Year” or starting point of forecast
- Per capita calculated as a **4-year average** of water use reported to Major Water Users Database or Drinking Water Census
- Per capita adjusted to remove estimated water sales
- Adjusted for **passive conservation** impacts from plumbing codes, ordinances, and standards that improve efficiency (0.25% per year to 2030)



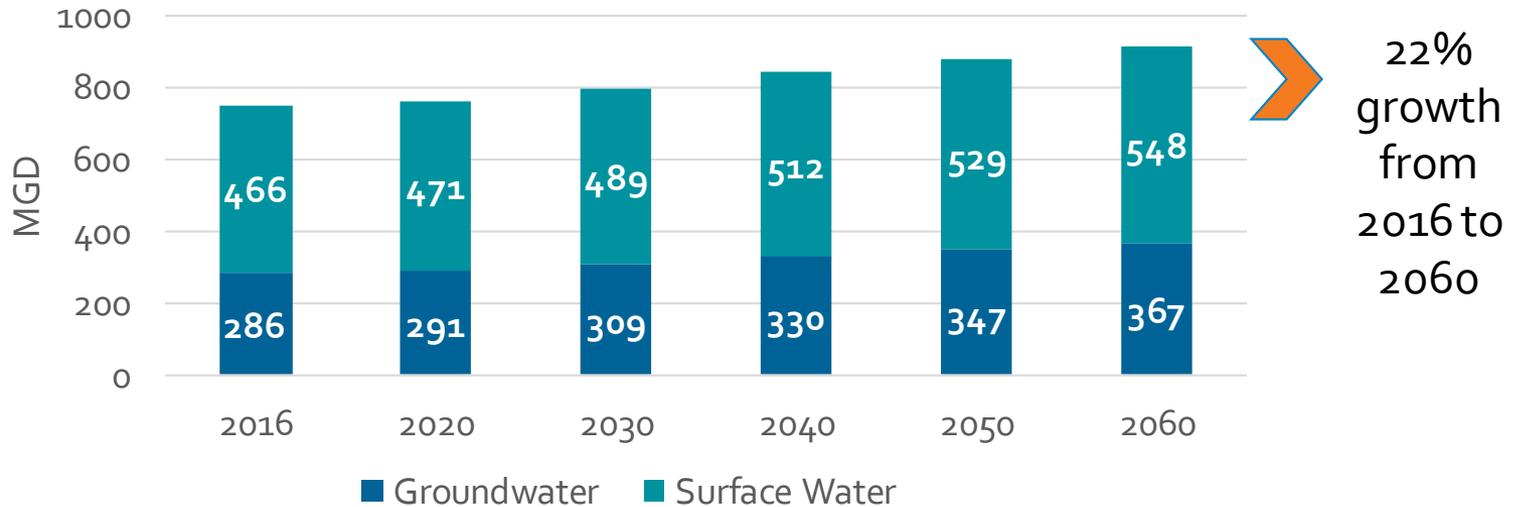
		Statewide Weighted GPCD		
DRAFT RESULTS	Year	2016	2030	2060
	GPCD	148	144	148

# Major Water Systems - Wholesale

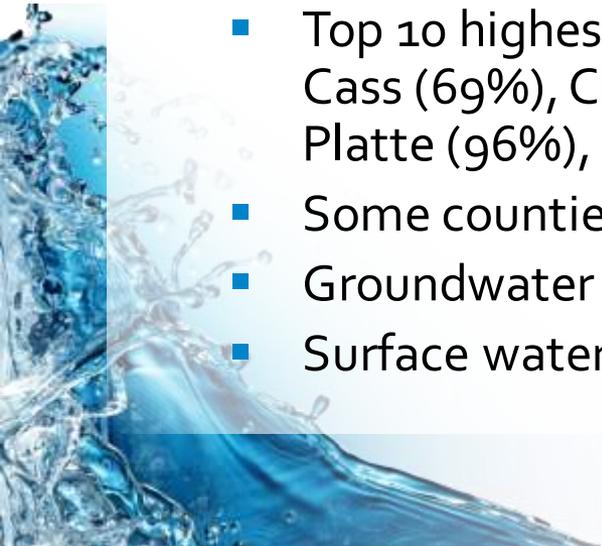
- Methodology does account for **water purchases and sales**, to the extent possible given available data
- Water sellers and buyers identified from Census of Missouri Public Water Systems
  - Supplemented with regional reports
- ~125 systems purchase majority of water from another provider
- Majority seller source of water assumed for these systems
- Captures **out-of-state supplies**
- In example, Municipality Buyer 1 and 2 source of water identified as surface water withdrawal in Basin A



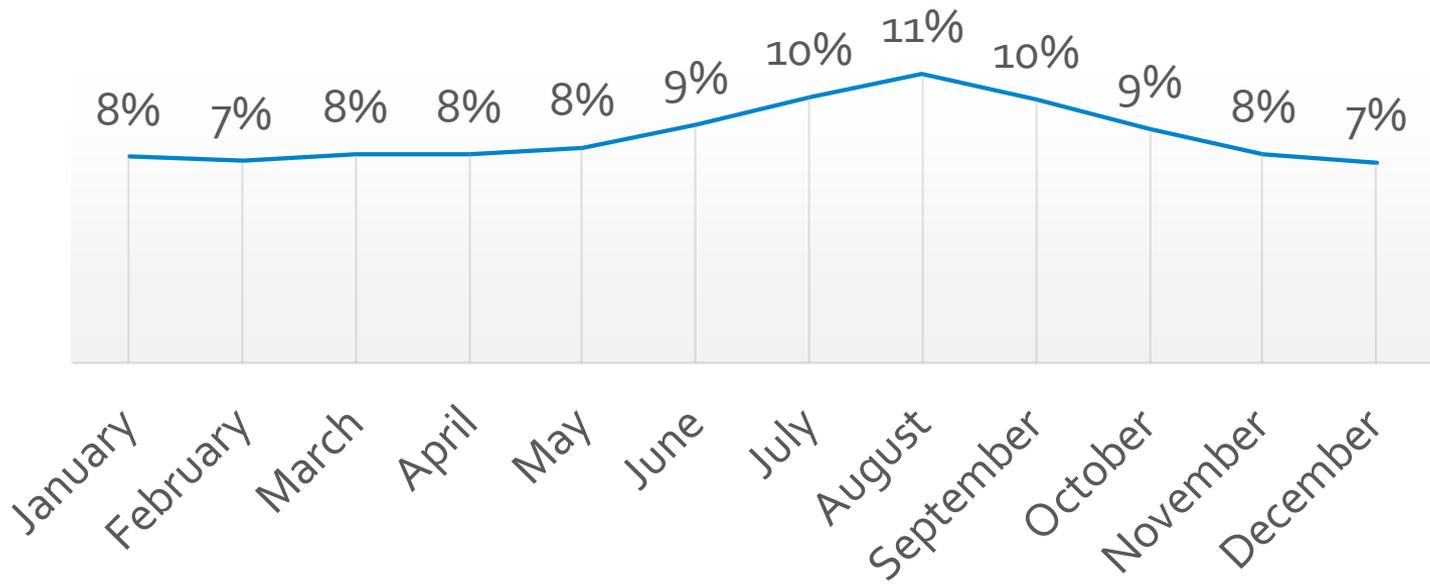
## Major Water Systems Water Demand (MGD)



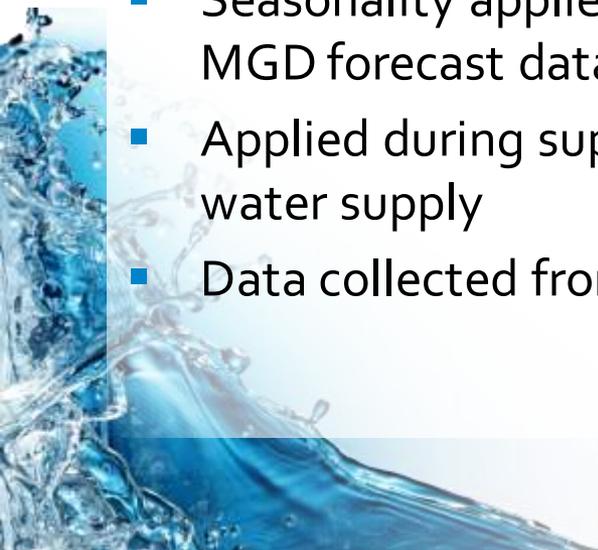
- Ozark region has highest growth
- Top 10 highest growth counties: Boone (69%), Camden (82%), Cass (69%), Christian (123%), Clay (72%), Gasconade (59%), Platte (96%), St. Charles (73%), Taney (64%), Wayne (62%)
- Some counties have little growth or negative growth
- Groundwater demand growth of 29%
- Surface water demand growth of 18%



### Major Water Systems - Seasonality



- Seasonality applied for calculating monthly withdrawals given annual MGD forecast data
- Applied during supply/demand analysis to determine seasonal gaps in water supply
- Data collected from publicly-available reports and studies



# Major Water Systems Regional Project Incorporation

- **North Central Missouri Study**
  - 2016 Reliability Study provided data on wholesale purchasing
  - East Locust Creek Reservoir
  - Little Otter Creek
- **Northwest Missouri Regional Water Supply Transmission**
- **Southwest Missouri Water Supply Study**
- At this time, all municipalities potentially impacted are in the Major Water Systems model, regardless of size
- “Baseline” forecast will assume current source of water
- Supply/demand gap assessment will take regional projects into account



# Self-Supplied Domestic and Minor Systems

- **Definition** – Water that is used by homes, sub-divisions or mobile home parks that is supplied by a privately owned and operated well or a smaller public water system assumed to be using groundwater
- **Methodology**

Population Supplied



*times*



Per Capita Use Rate



Equation applied for all planning periods

2016

2020

2030

2040

2050

2060

# Self-Supplied Domestic and Minor Systems Population Supplied



- 2016 population supplied is remainder of population after subtracting Major Water Systems population served from Total County Population
- Assessed USGS data from 1990-2010 for trends in population on private wells (Constant %, Constant #, Decreasing %, Increasing %)
- Results of trend analysis used to forecast population served to 2060

**DRAFT RESULTS**

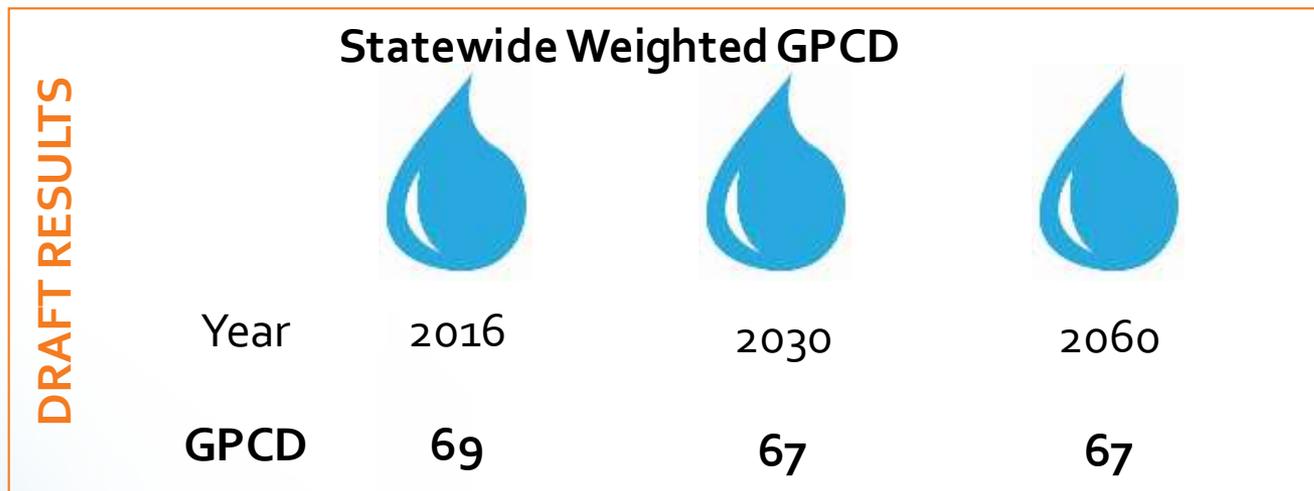
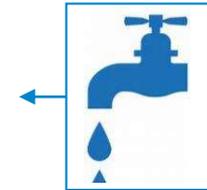
## Statewide Population Served by Self-Supplied Domestic and Minor Systems - Millions

2016	2030	2060
1.05	1.14	1.30

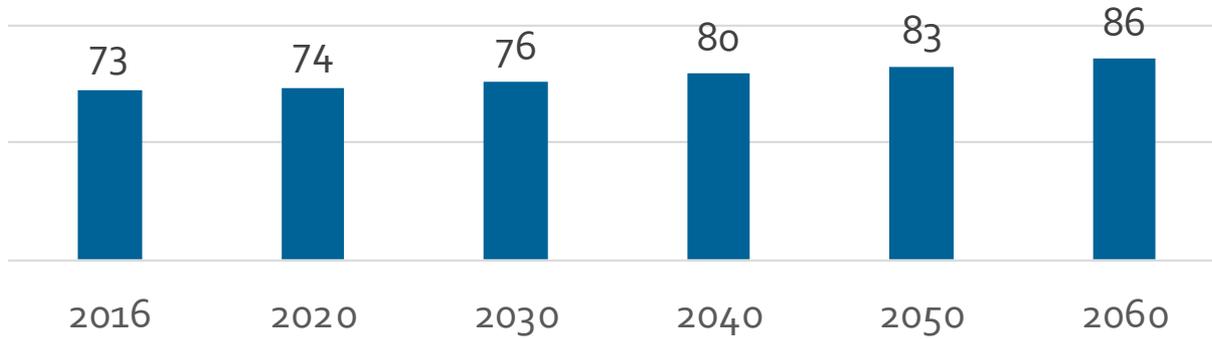


# Self-Supplied Domestic and Minor Systems – Per Capita Use Rates

- 2016 is “Base Year” or starting point of forecast
- Per capita calculated from USGS data (2010 value adjusted to represent 2016)
- Adjusted for **passive conservation** impacts from plumbing codes, ordinances, and standards that improve efficiency (0.25% per year to 2030)



## Self-Supplied Domestic and Minor Systems Water Demand Forecast (MGD)



18%  
growth  
from  
2016 to  
2060

- Ozark region has concentration and highest growth
- Central region has significant demands

	2016	2030	2060
<b>GROUNDWATER AQUIFER</b>	72.89	75.89	86.10
Alluvium	10.50	10.27	11.61
Ozark Aquifer (Lower)	40.96	43.25	49.68
Ozark Aquifer (Upper)	1.15	1.32	1.76
Precambrian	1.49	1.52	1.57
Springfield Plateau	0.05	0.00	0.00
St. Francois Aquifer	18.74	19.52	21.47



# Self-Supplied Nonresidential

- **Definition**—Water used by nonresidential establishments, such as industries, golf courses, nursing homes, hotels, mining, and prisons that is supplied by the establishments own source
- **Data Sources**
  - MoDNR Major Water Users Database
  - Census of Missouri Public Water Systems
  - Woods & Poole 2017 Complete Economic and Demographic Data
  - MoDNR Public Wells Data
- **Methodology**

Current Nonresidential Use



*times*



Employment Growth

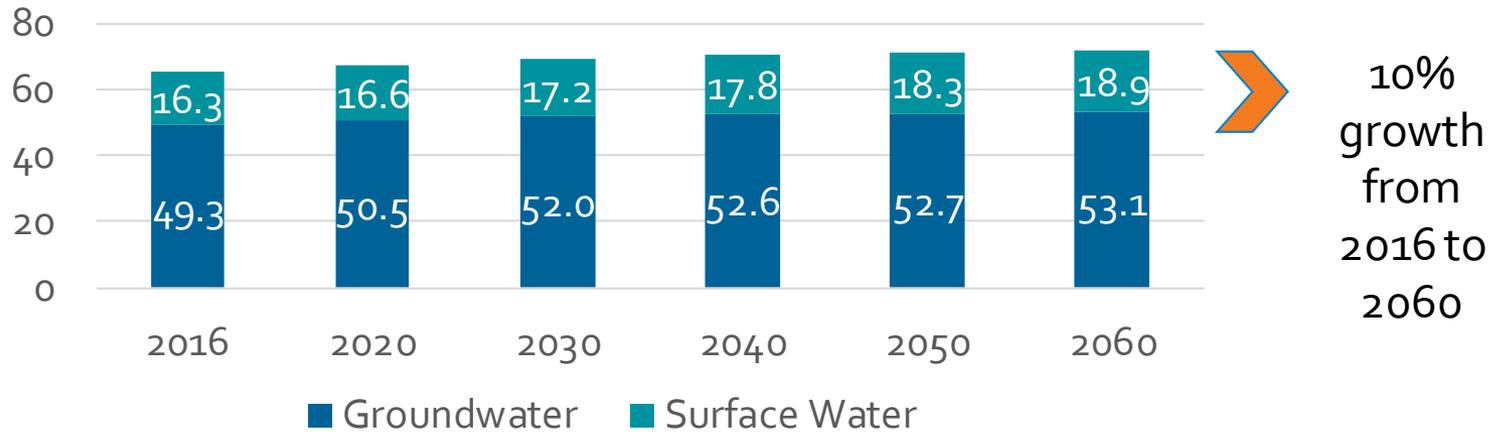


# Self-Supplied Nonresidential – Current Use

Category	# Users	Annual MGD
Food Manufacturing	15	25.6
Mining (except Oil and Gas)	16	18.3
Miscellaneous Manufacturing	6	3.72
Educational Services	8	3.63
Paper Manufacturing	1	2.87
Chemical Manufacturing	3	2.16
Federal Government, Excluding Post Office	4	1.64
State Government	17	1.51
Amusement, Gambling, and Recreation Industries	12	1.27
Petroleum and Coal Products Manufacturing	6	1.25
Accommodation, including Hotels and Motels	20	0.96
Computer and Electronic Product Manufacturing	2	0.80
Federal Government, Military	1	0.60
Beverage and Tobacco Product Manufacturing	1	0.50
Printing and Related Support Activities	1	0.31
Social Services	14	0.14
Other	13	0.36
<b>STATE TOTAL</b>	<b>140</b>	<b>65.6</b>



## Self-Supplied Nonresidential Water Demand (MGD)



- Withdrawals from Upper Ozark Aquifer is forecast to increase by 68 percent; greatest amount of withdrawals from any source in 2060
- Greatest percent of growth is projected for Boone County, followed by Jefferson County and Taney County



# Thermoelectric Power Generation

- **Definition** – Water required for the generation of electricity (excludes hydropower); only a small portion of the water withdrawn is consumed.
- Both non-consumptive and consumptive withdrawals are estimated
- **Features and Methods**
  - Identify major facilities
  - Estimate existing withdrawals for each facility and source of water
  - Future projections by facility, accounting for population growth, regional pools, and fuel type projections
  - Estimate consumptive portion
  - Seasonality description





# Thermoelectric Power Generation

## Data Sources

- U.S. Department of Energy, Energy Information Administration (923, 860, and Annual Energy Outlook)
  - EIA Plant Data
  - EIA Operating Generators
  - EIA Cooling Data
  - EIA Monthly Generation
- U.S. Geological Survey 2010
- MoDNR Major Water Users Database
- National Renewable Energy Laboratory – A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies
- Ameren Missouri 2017 Integrated Resource Plan
- MoDNR Public Wells Data

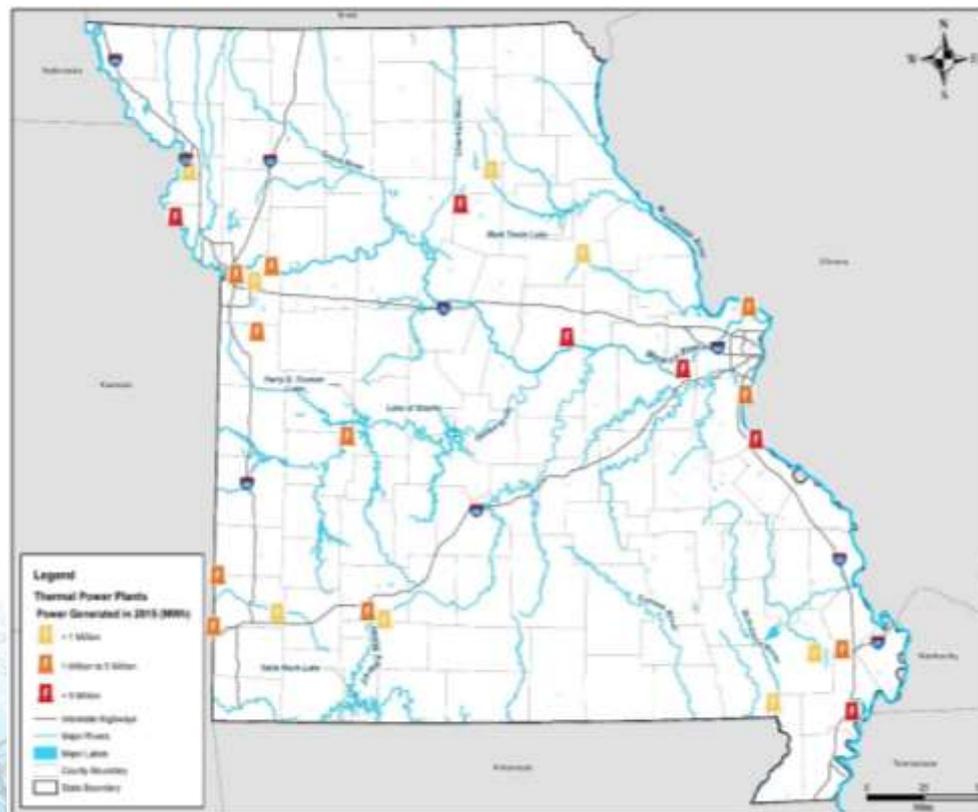




# Thermoelectric Power Generation

## Major Facilities

- 24 Facilities
- 32 Generating Units
  - 7 Coal with Cooling Tower
  - 13 Coal with Once-Through Cooling
  - 11 Natural Gas with Cooling Tower
  - 1 Nuclear with Cooling Tower



# Callaway Nuclear Power Plant Included

- Features
  - One facility – Callaway Energy Center
  - In Callaway County
  - Missouri River as source
  - NRC renewed operating license in 2015 through 2044, may be extended further
  - No new nuclear generating capacity planned in state

Source: Ameren Missouri 2017 IRP



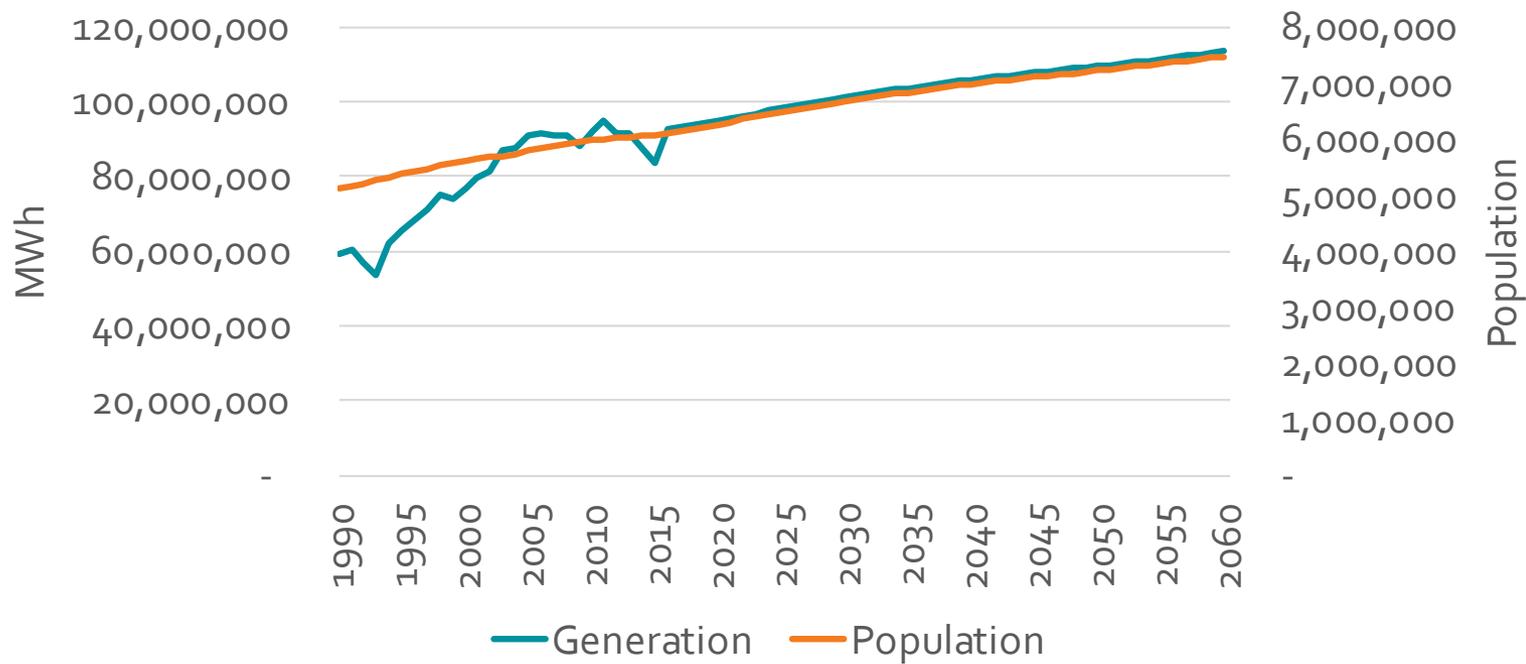
# Thermoelectric Power Generation

## Current Water Withdrawals

Year	Thermoelectric Water Withdrawals by Source (MGD)			
	Groundwater	Groundwater Alluvium	Surface Water	Total Withdrawals
2013	4.2	4.9	5,604	5,613
2014	4.0	4.1	6,035	6,043
2015	3.8	3.6	5,936	5,943
2016	3.6	4.9	4,857	4,865
Avg	3.9	4.4	5,794	5,802

Source: MoDNR's Major Water Users Database

### Missouri Projected Population & Generation



**Future generation is projected according to population growth**

**Growth assigned by fuel type - utilizes EIA Energy Outlook**



# Thermoelectric Power Generation – Consumption Rates by Configuration

Generation Configuration	Withdrawal Gallons per MWh	Consumption Gallons per MWh
Fossil/biomass, once-through cooling	36,350	250
Fossil/biomass, cooling towers	1,005	687
Nuclear, cooling towers	1,101	672
Natural gas, combined-cycle, cooling towers	253	198

Source: National Renewable Energy Laboratory – A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies

# Thermoelectric Power Generation

DRAFT RESULTS

## Withdrawal Water Demand by Source in MGD

Source	2015	2020	2030	2040	2050	2060
GW	9.42	9.35	9.50	9.51	9.38	9.71
GW Alluvium	33.13	32.37	32.80	31.00	33.66	34.85
SW	6,054	5,907	5,784	4,728	5,205	5,389
<b>Total</b>	<b>6,096</b>	<b>5,949</b>	<b>5,827</b>	<b>4,768</b>	<b>5,248</b>	<b>5,434</b>

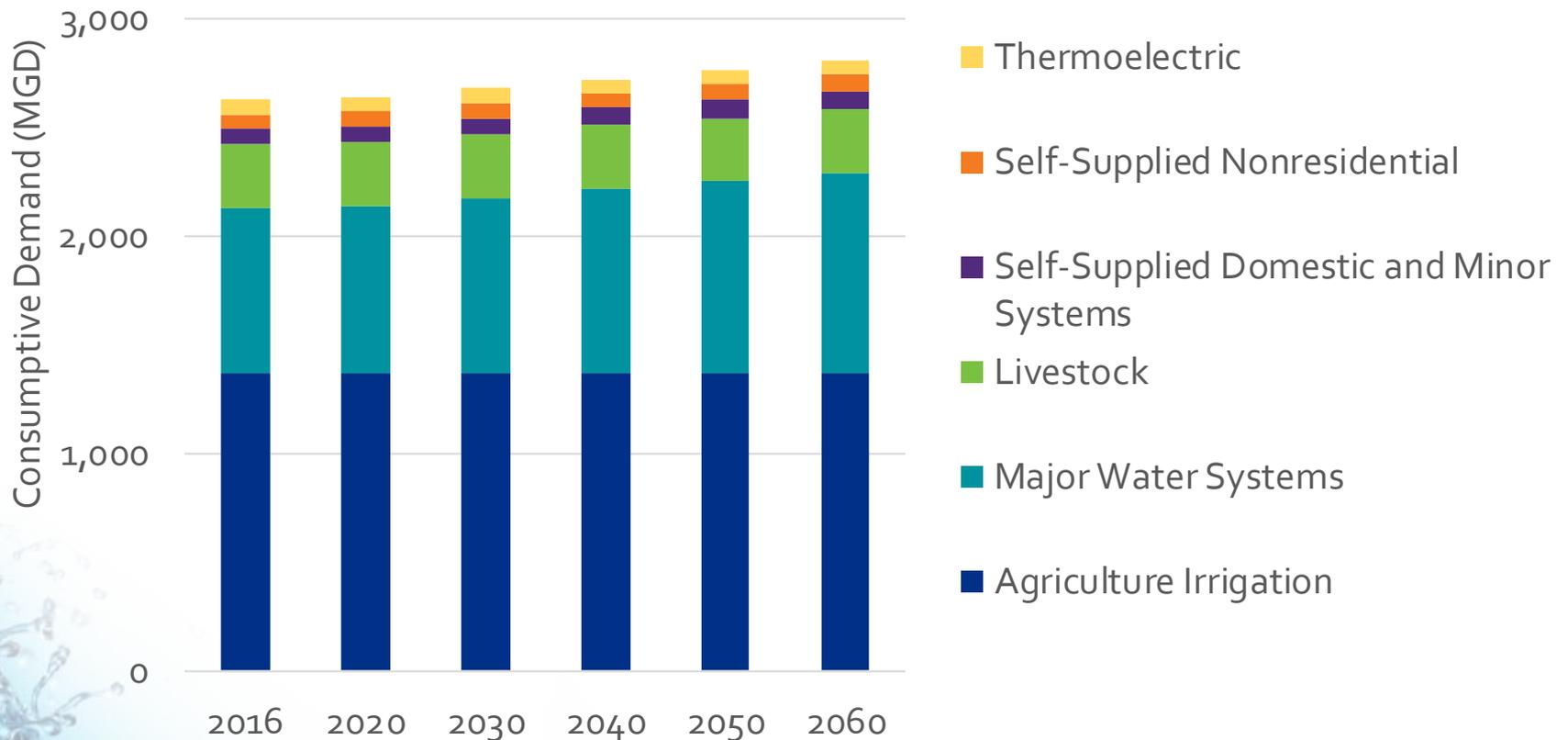
## Consumption Water Demand by Source in MGD

Source	2015	2020	2030	2040	2050	2060
GW	6.54	6.50	6.64	6.68	6.62	6.86
GW Alluvium	2.87	2.83	2.85	2.82	2.77	2.87
SW	60.9	59.4	58.3	50.4	52.7	54.6
<b>Total</b>	<b>70.3</b>	<b>68.8</b>	<b>67.8</b>	<b>59.9</b>	<b>62.1</b>	<b>64.3</b>

Decline in use attributable to retirement of coal-fired facilities with once-through cooling

# Consumptive Demands – ALL SECTORS

## Statewide Consumptive Demand Forecast (MGD)



\*Irrigation and livestock demands represent current use and are not yet forecasted

# Surface Water Supply



# Surface Water Supply Task Discussion – Discussion Objectives

- Water supply analysis goals
- Overview of water budget
- Present preliminary results for Chariton-Grand watershed
- Next steps, future outcomes and schedule



# Surface Water Supply Analysis Goals

- At a HUC 4 level, evaluate and summarize:
  - Surface water availability (streamflow)
  - Demands, both consumptive and non-consumptive
  - Gaps in available supply compared to demands
- Representative wet, dry, and average years will be evaluated on an annual and monthly basis



# Surface Water Supply Analysis Goals (continued)

- Both supply and demands will be projected to 2060
  - Supply will be projected using hydrologic variability scenarios
  - Demands have been projected based on population growth
- Results will support the infrastructure task



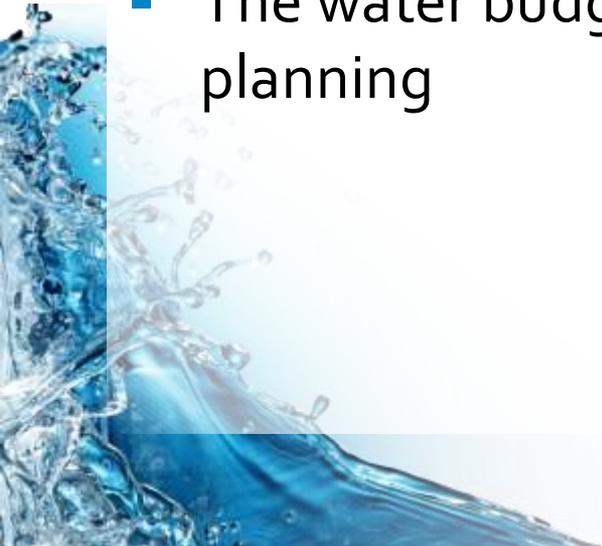
# How Water Budgets are Used to Support Statewide Planning

- Develop an understanding of the availability, movement, and use of water within each basin.
- Developing a concise means of comparing basins with each other in terms of water availability and water consumption.
- Comparing the natural versus manmade components of the hydrologic cycle.
- Identifying where water management decisions will result in the most impact by understanding which basins may have water surpluses and which may have potential shortfalls with respect to satisfying all consumptive and non-consumptive uses.
- Providing a basis to assess sustainability of water resources.

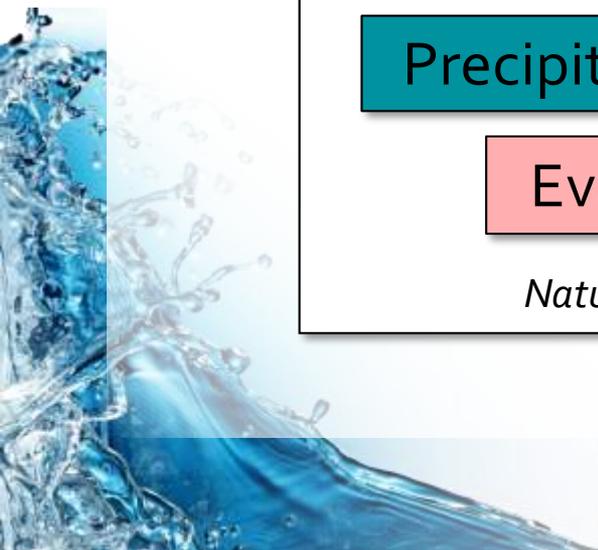
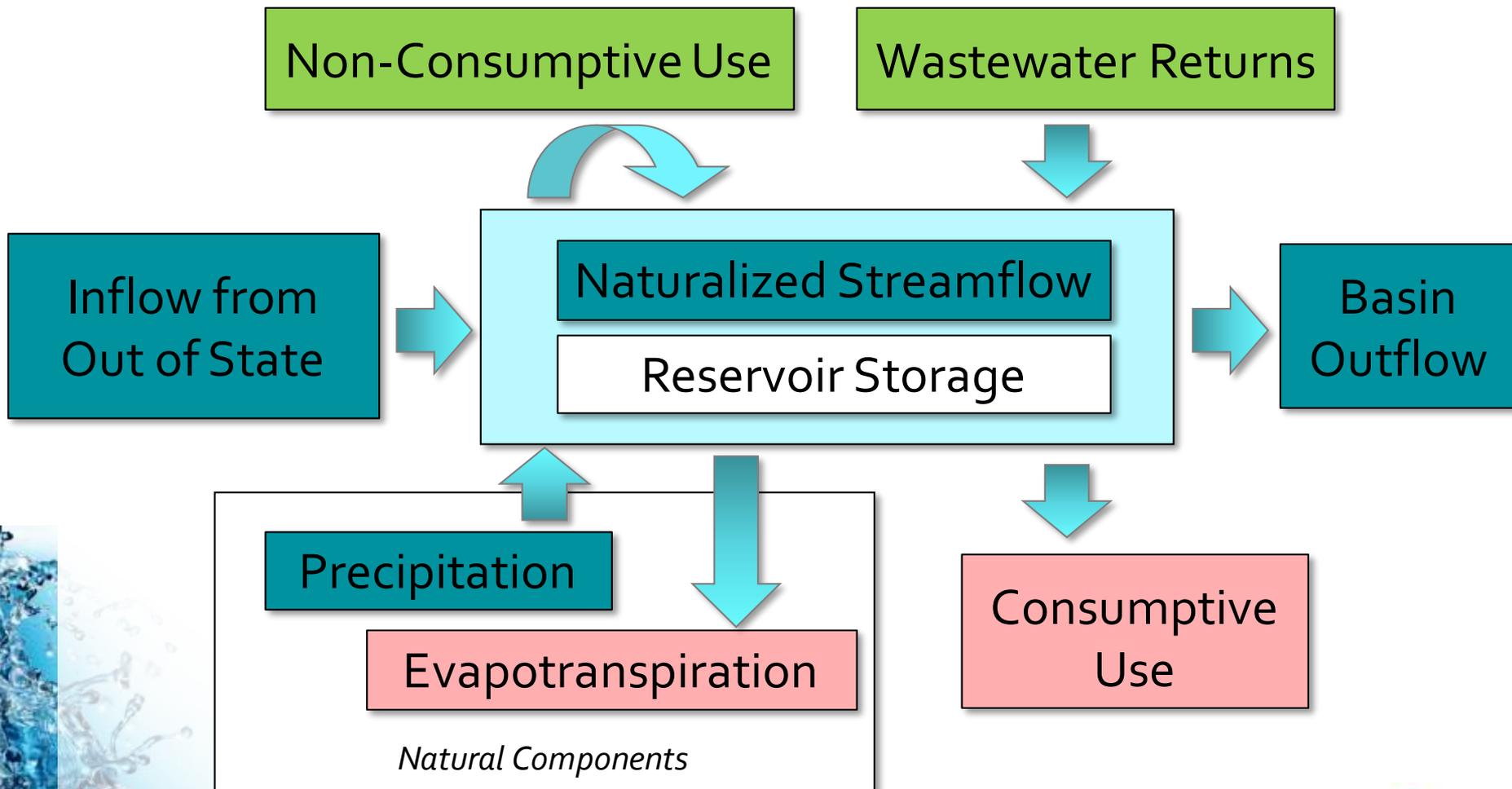


# How Water Budgets Will Support Missouri's Water Plan

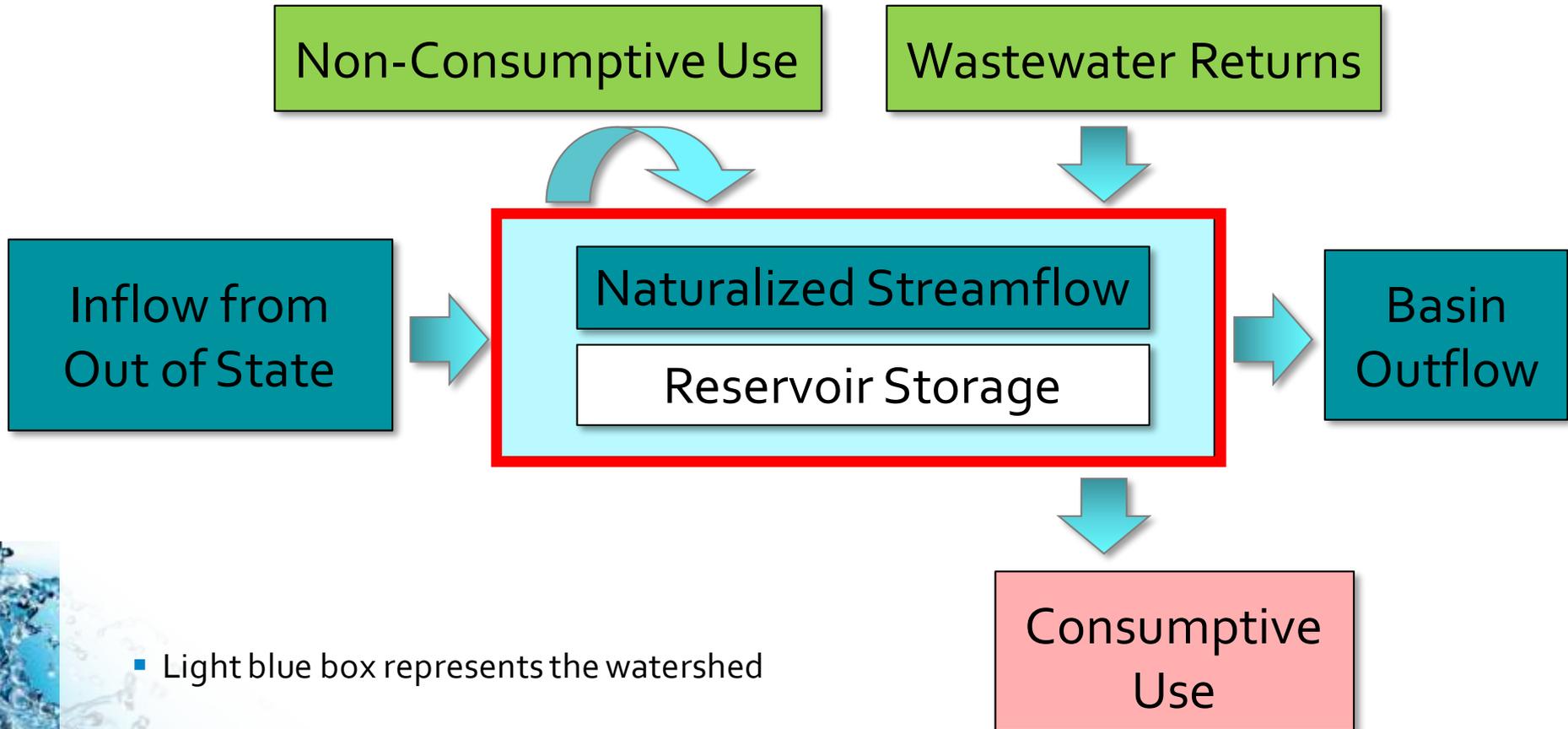
- Water budgets will be used to identify and address gaps
  - Hydrologic gaps – not anticipated at HUC 4 level for current conditions
    - Monthly analyses for drought years may yield some gaps
  - Infrastructure gaps
- The infrastructure task will use budgets to identify potential sources of water for dry areas
- The water budgets will be used as part of future scenario planning



# Water Budget



# Water Budget



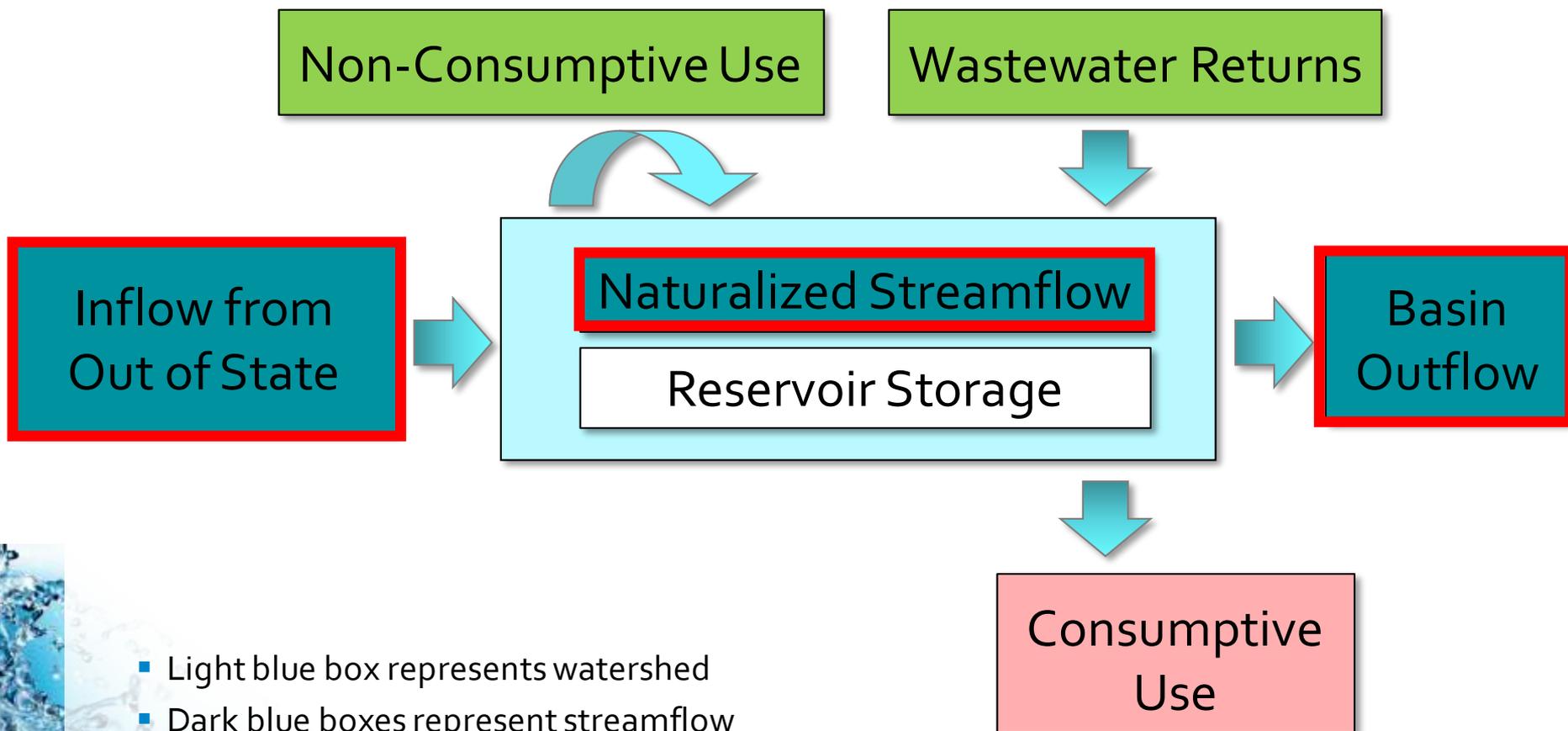
- Light blue box represents the watershed



# Watershed – Chariton-Grand HUC 4



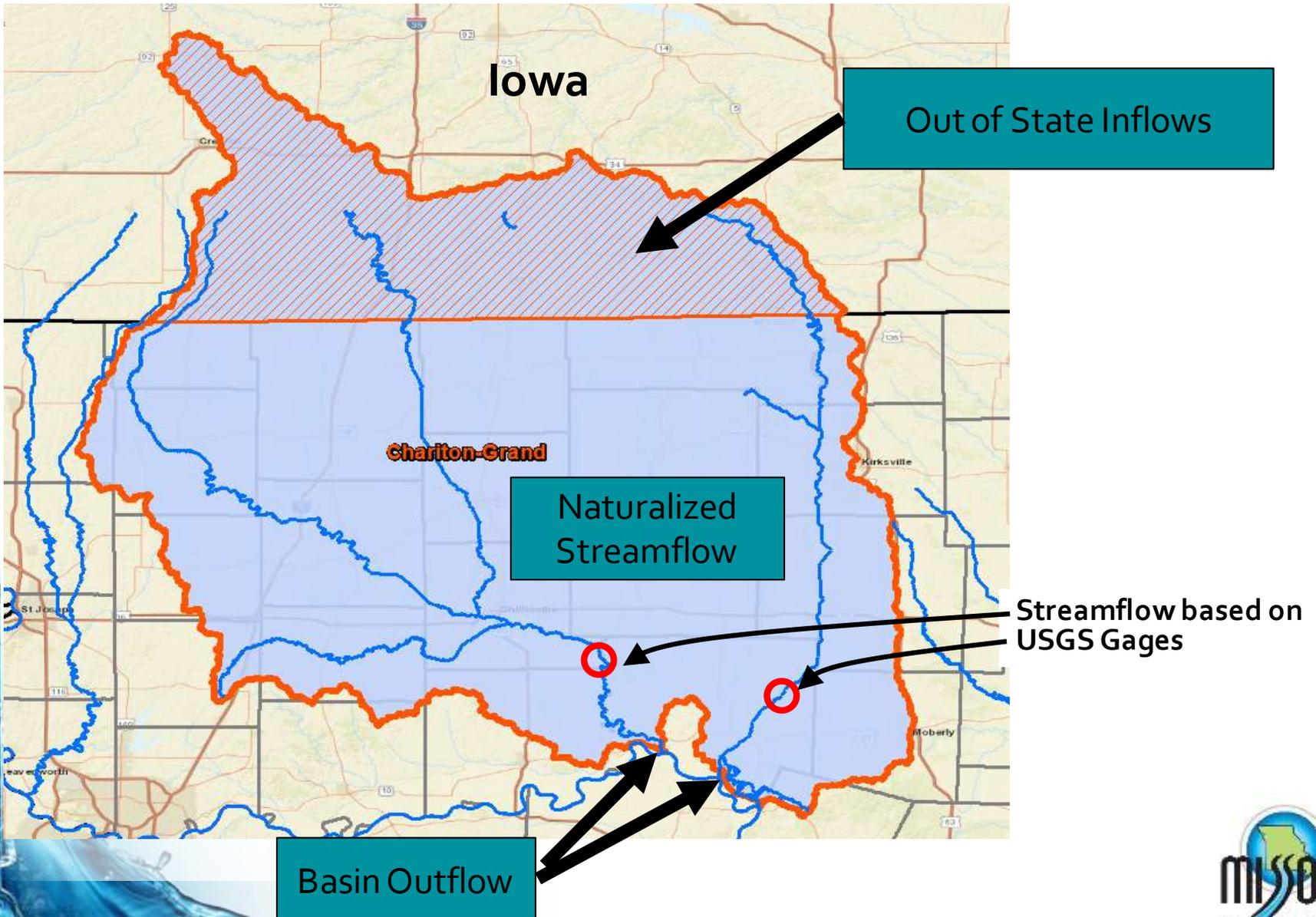
# Water Budget



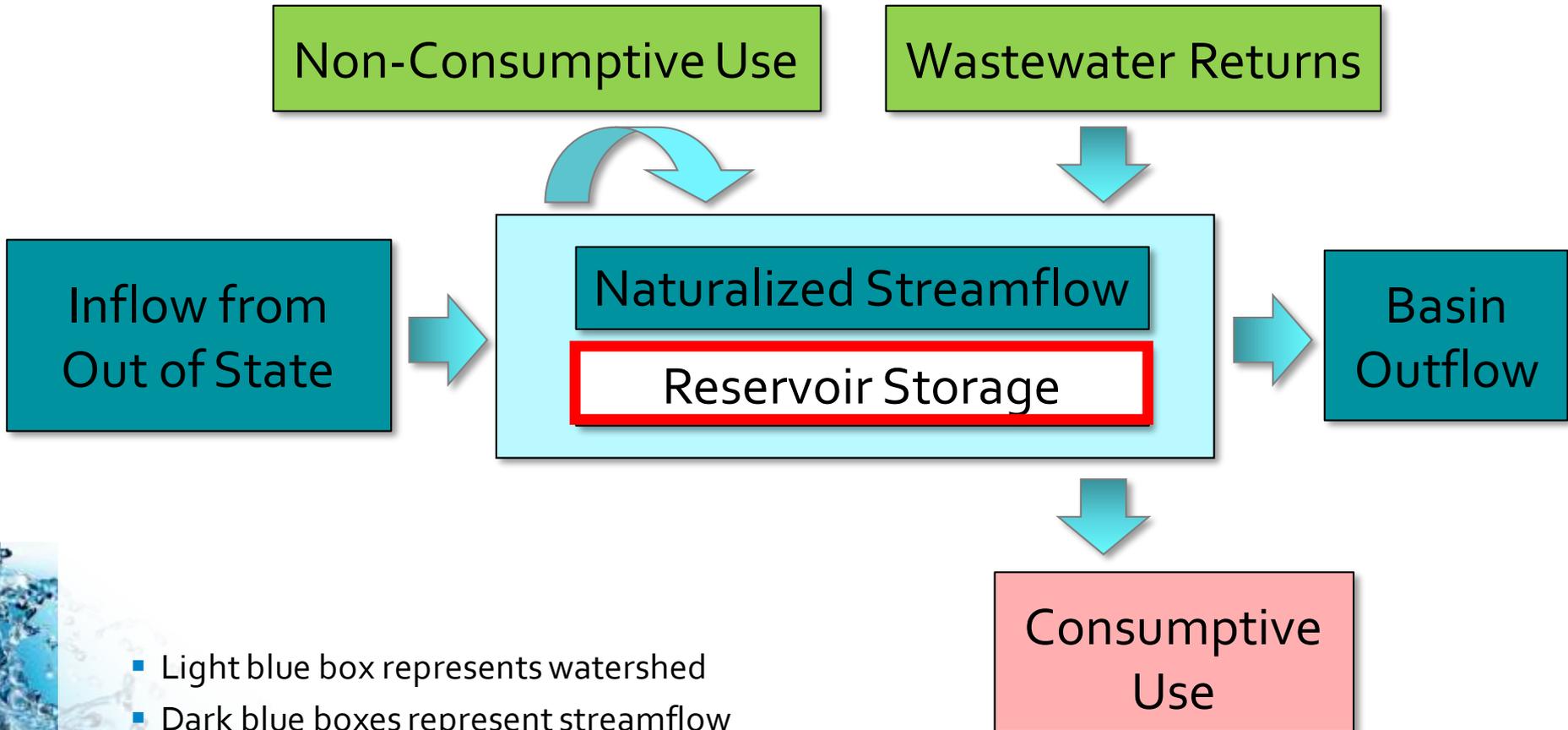
- Light blue box represents watershed
- Dark blue boxes represent streamflow



# Watershed Example – Streamflows

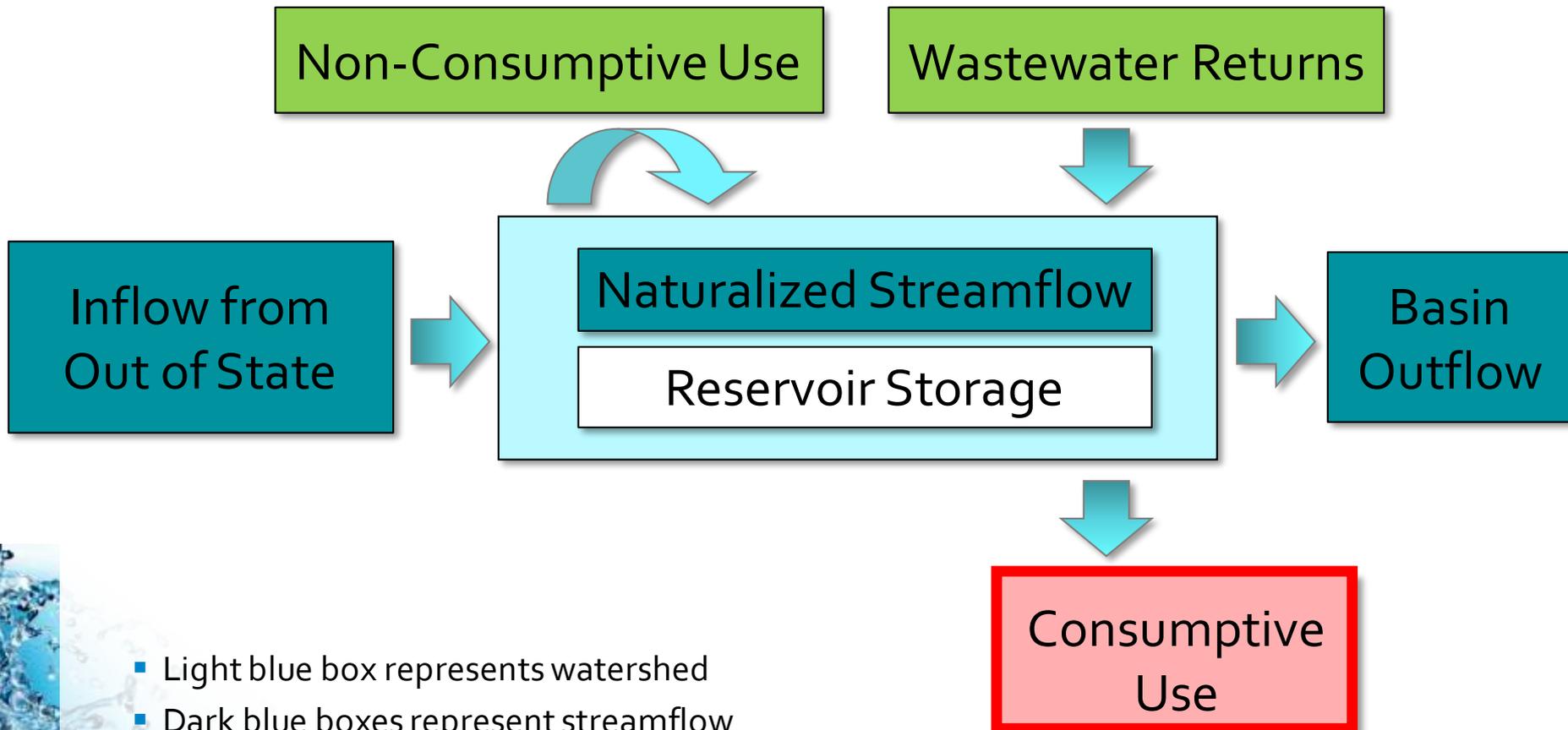


# Water Budget



- Light blue box represents watershed
- Dark blue boxes represent streamflow
- White box represents reservoir storage

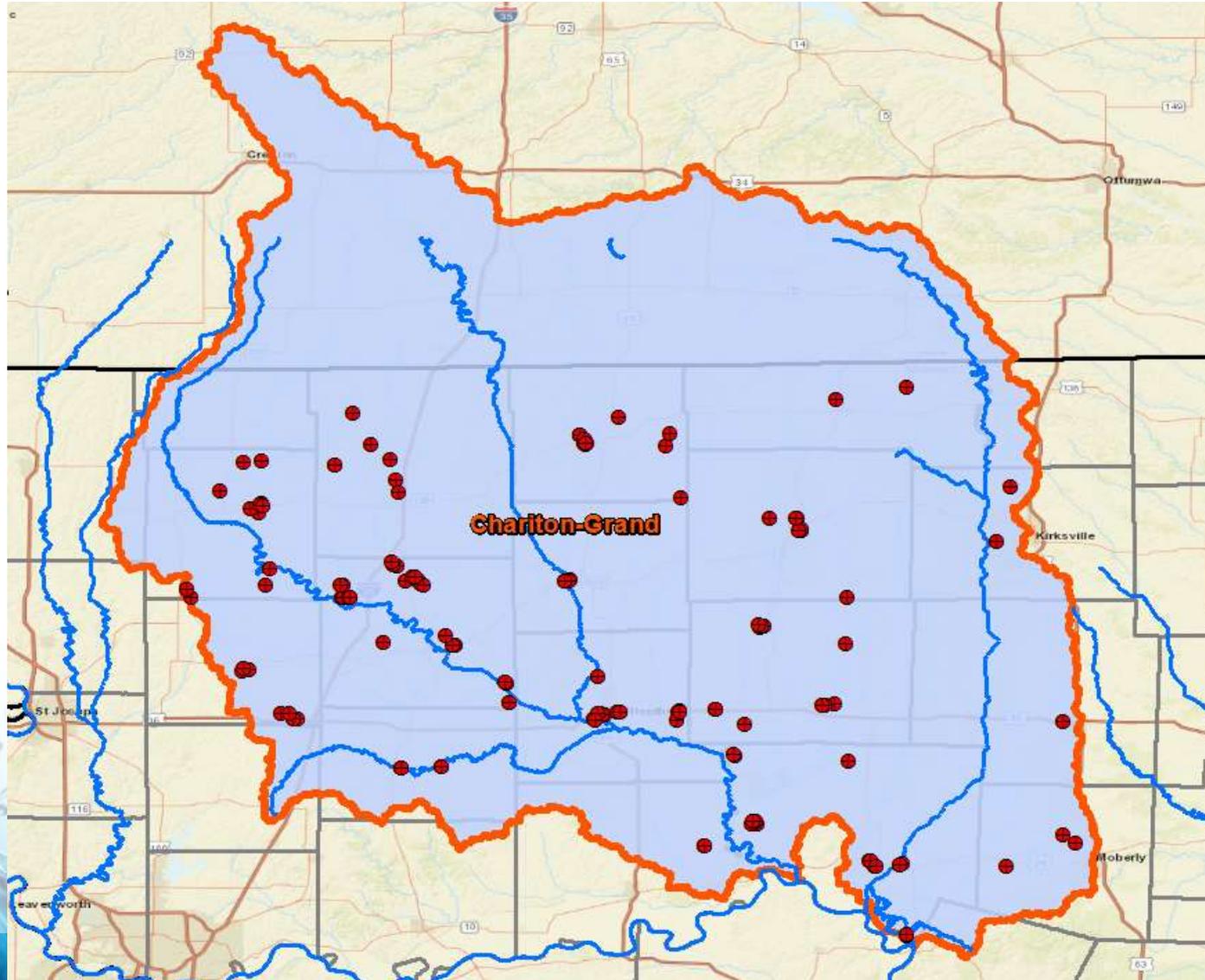
# Water Budget



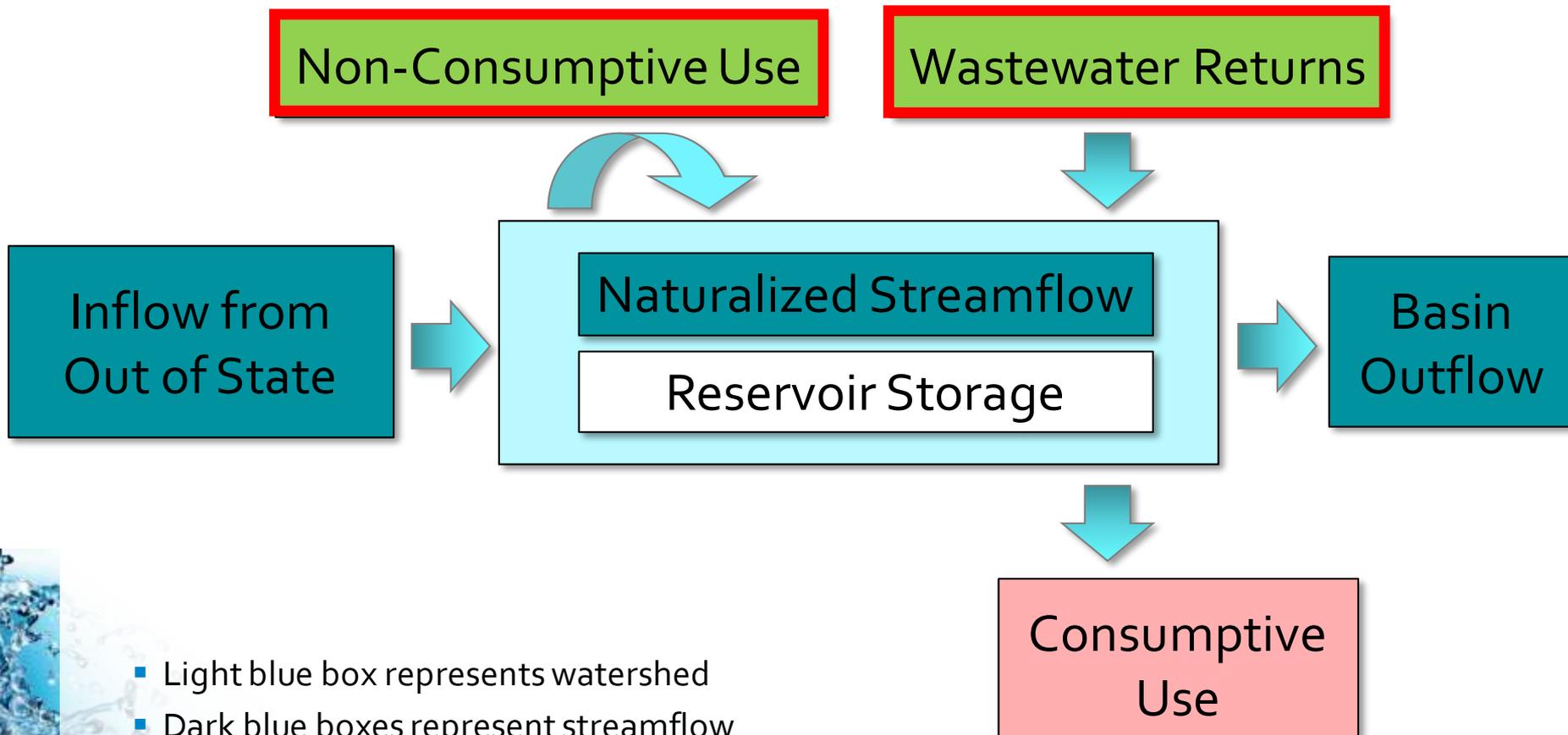
- Light blue box represents watershed
- Dark blue boxes represent streamflow
- White box represents reservoir storage
- Red box represents water losses

# Watershed Example – Consumptive Use

## Major Water Users

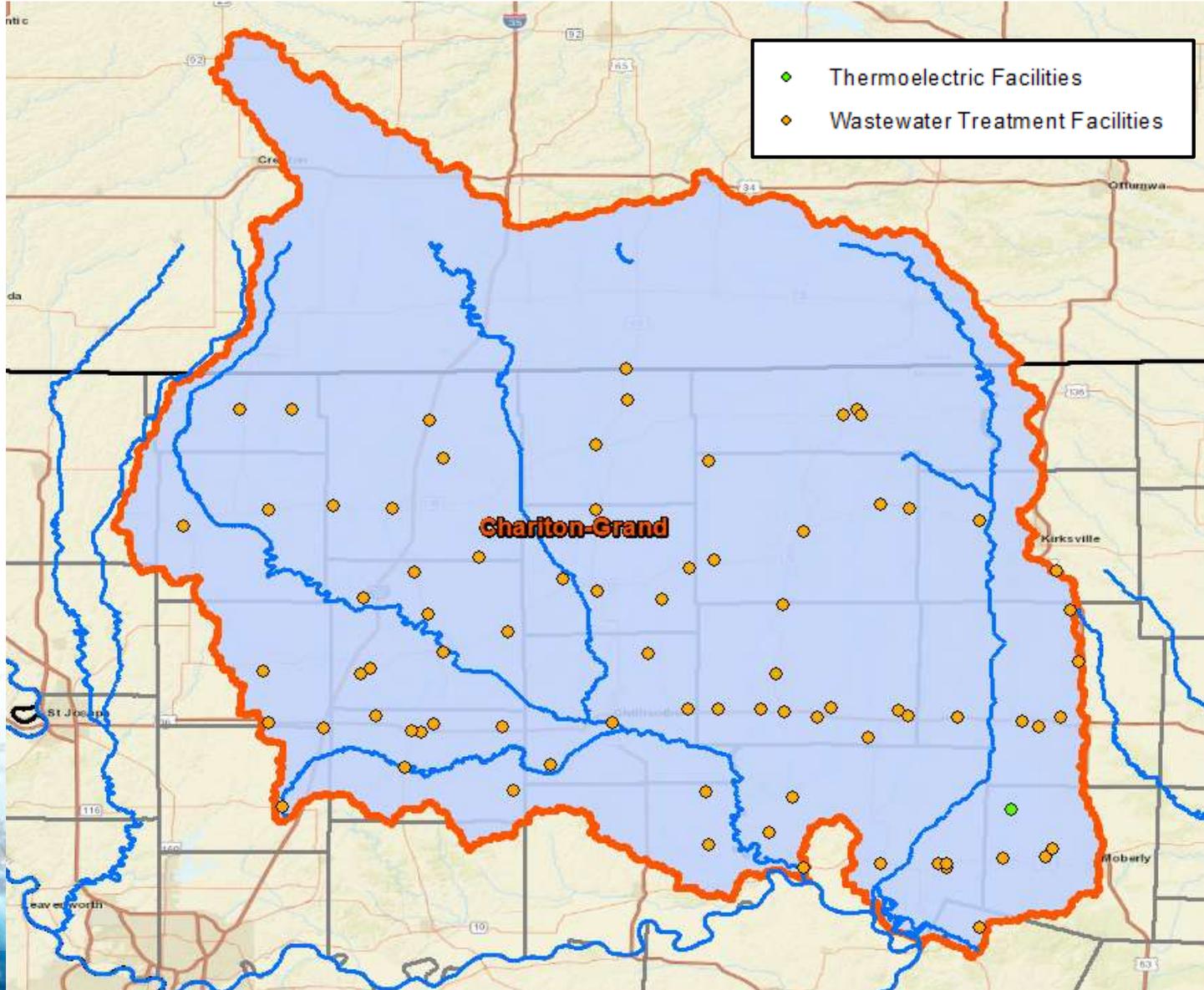


# Water Budget



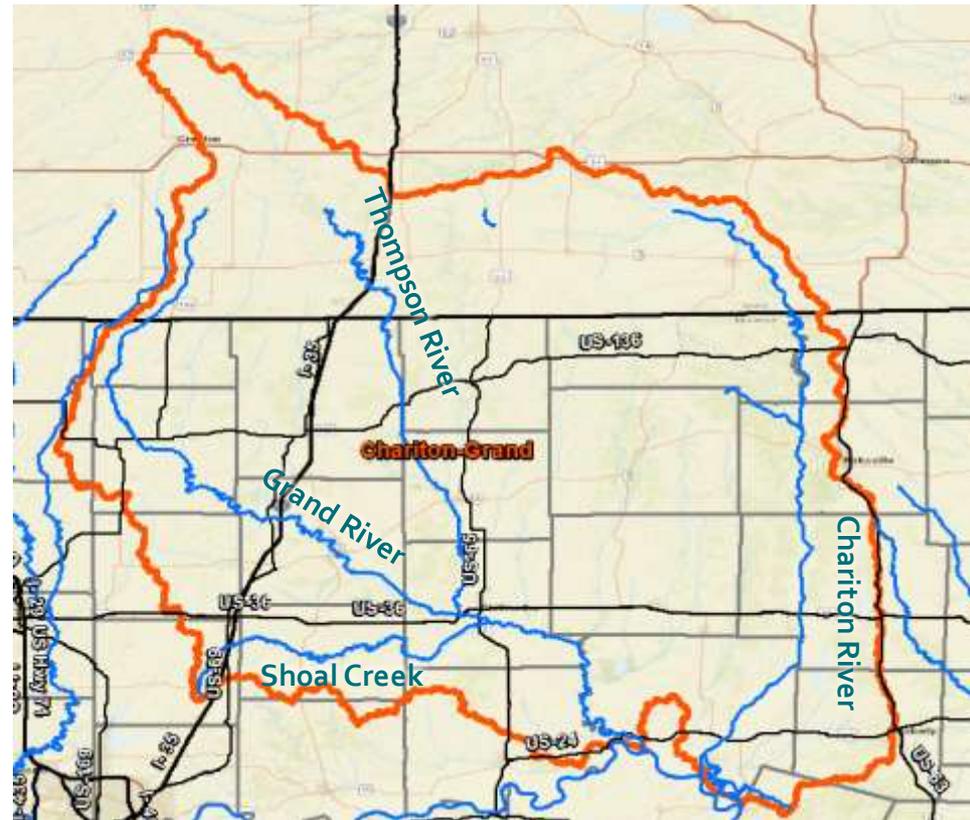
- Light blue box represents watershed
- Dark blue boxes represent streamflow
- White box represents reservoir storage
- Red box represents water losses
- Green boxes represent water returns

# Watershed Example – Non-consumptive Use



# Preliminary Results – Chariton-Grand HUC 4

- Located in central northern Missouri
- Approximately 8,306 square miles within Missouri and 2,645 square miles in Iowa
- Major waterways include:
  - The Grand River, Shoal Creek, and Thompson River in the west
  - The Chariton River in the east
- I-35 intersects the watershed in the west and Highway 63 runs along the eastern boundary
- Highly rural
  - Largest municipalities include Chillicothe, Cameron, and Trenton

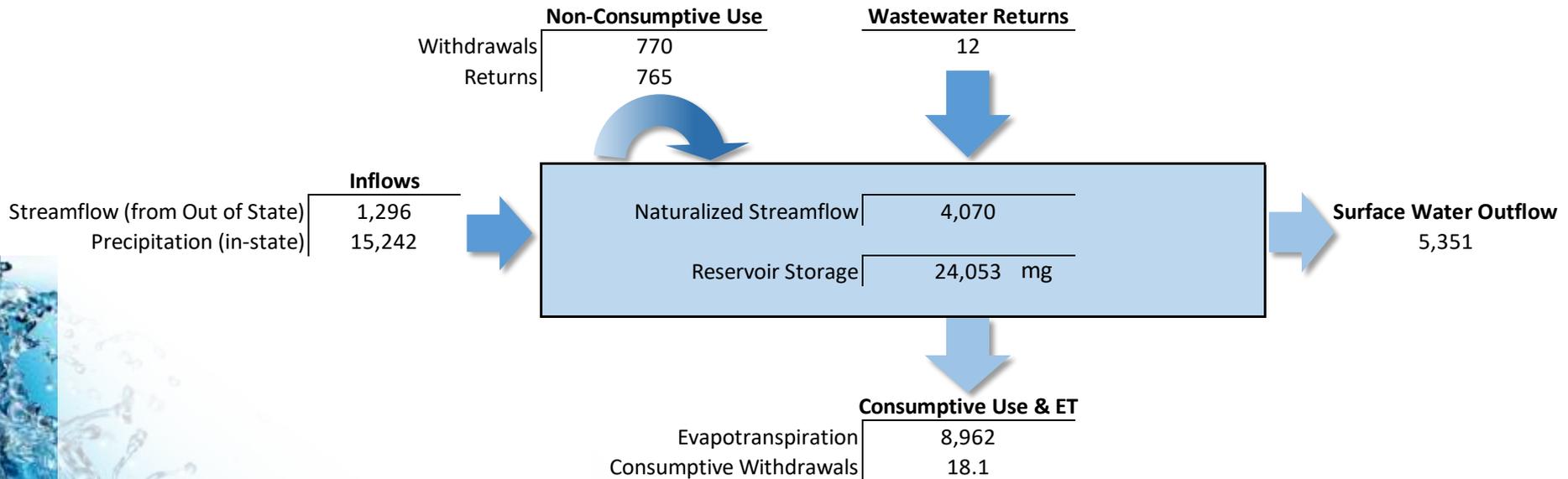


# Chariton-Grand Current Day Annual Water Budget



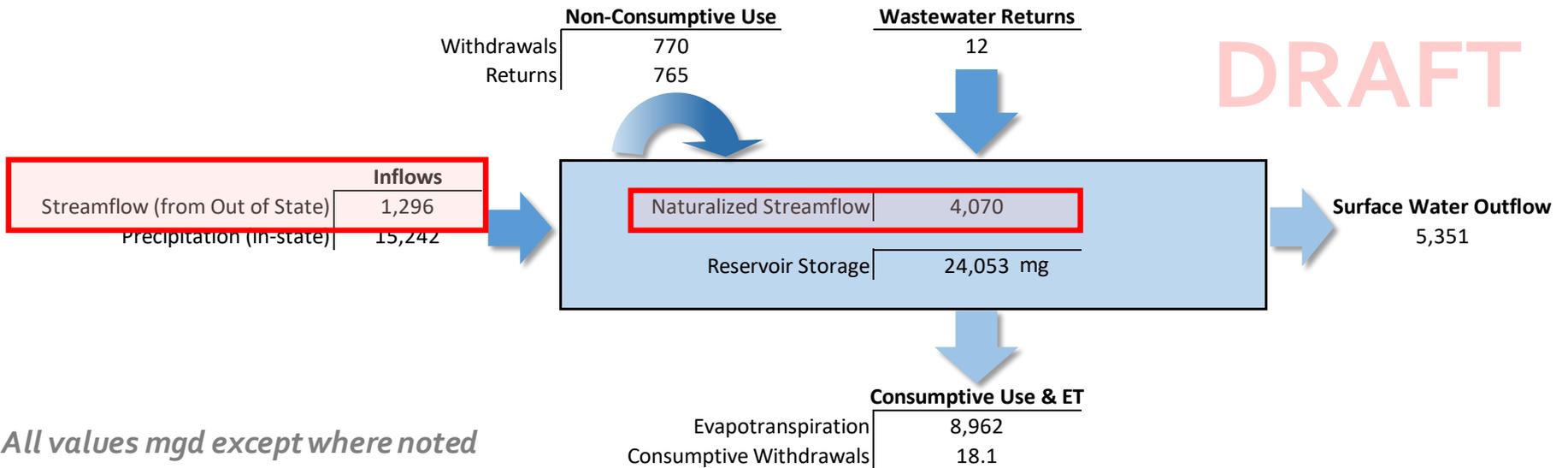
Missouri Water Budget	
<b>Basin</b>	Chariton-Grand
<b>HUC 4</b>	1028
<b>Year(s)</b>	1985 - 2016
<b>Type</b>	Long Term Average
<b>Area within Missouri (sq mi)</b>	8,306
<b>Area outside Missouri (sq mi)</b>	2,645

**DRAFT**

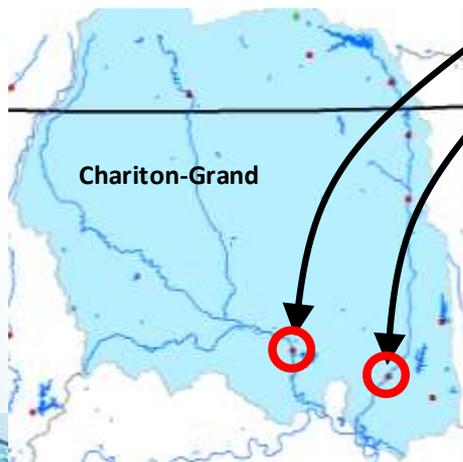


*All values in million gallons per day (mgd)  
except where noted*

# Chariton-Grand Current Annual Day Water Budget

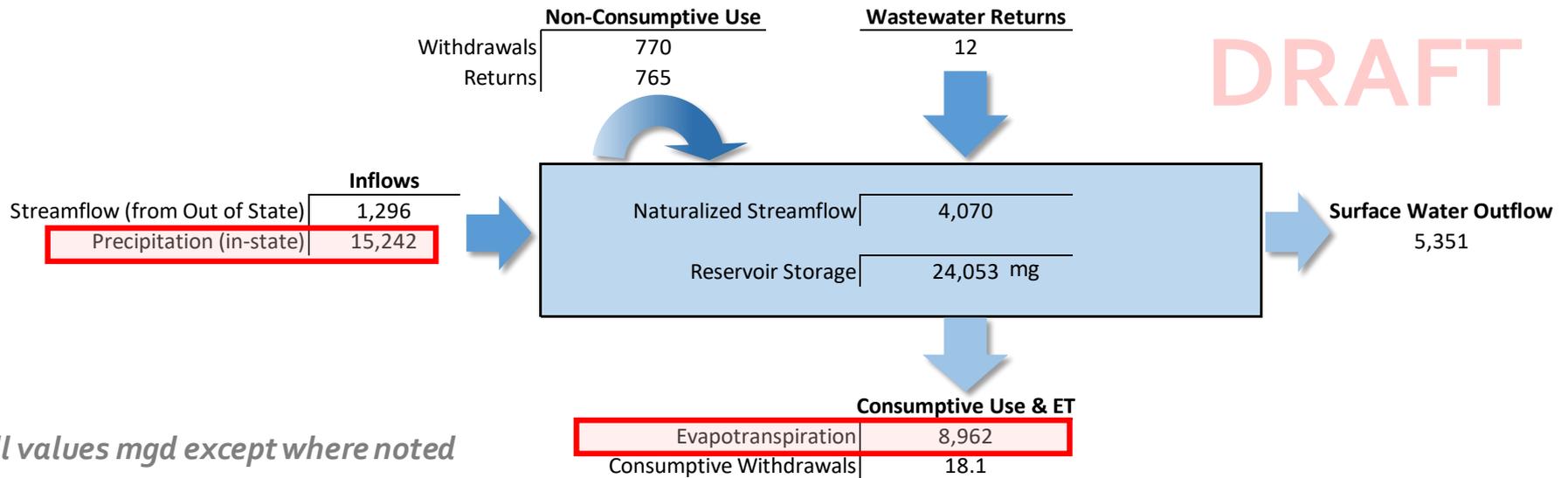


- Streamflow based on two USGS Gages (weighted avg)



- 6902000 - Grand River near Sumner (1924)
- 6905500 - Chariton River near Prairie Hill (1929)
- Flows from 1985-2015 used
- Streamflow origination in MO is presented as "Naturalized Flow". Withdrawals have been added and discharges have been subtracted out.

# Chariton-Grand Current Annual Day Water Budget



## ■ Precipitation

- Source: Daymet and SSEBop datasets via USGS Geo Data Portal
- Monthly totals by HUC-8, aggregated to HUC-4 level

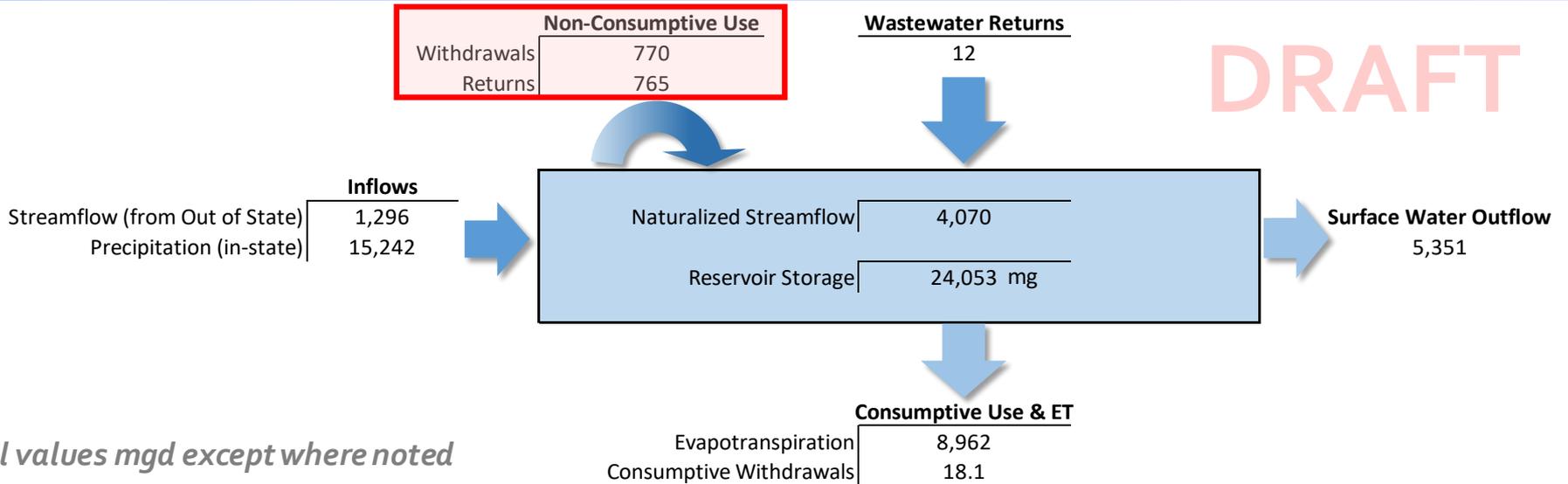
## ■ Evapotranspiration

- Source: Daymet and SSEBop datasets via USGS Geo Data Portal
- Monthly totals by HUC-8, aggregated to HUC-4 level



# Chariton-Grand Current Annual Day Water Budget

DRAFT



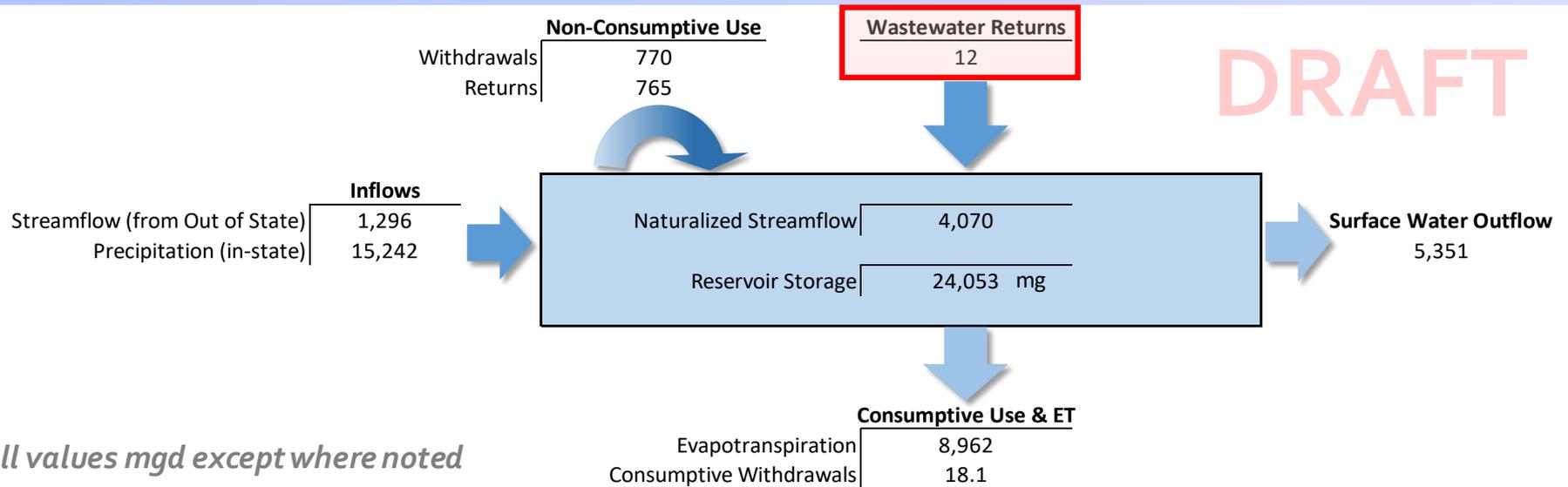
All values mgd except where noted

## Non-Consumptive Uses

- Thermoelectric Demand Model
- Aquaculture and Wetlands

Plant Id	Plant Name	County	GW/SW	%GW	Aquifer 1	HUC4	HUC8	2015	2020	2025	2030
								MGD	MGD	MGD	MGD
<b>Coal of NG, Steam Turbine, Cooling Tower</b>											
2098	Lake Road (MO)	Buchanan	SW	1.6%	Alluvium	1030	10300102	0.375	0.37	0.36	0.36
2098	Lake Road (MO)	Buchanan	SW	1.6%	Alluvium	1030	10300102	0.20	0.19	0.19	0.15
6195	John Twitty Energy Center	Greene	GW	100.0%	Ozark Aquifer	1024	10240011	4.94	4.82	4.78	4.72
2132	Blue Valley	Jackson	Municipal					0.24	0.23	0.23	0.21
2076	Asbury	Jasper	GW	100.0%	Ozark Aquifer	1030	10300101	0.20	0.19	0.19	0.15
2076	Asbury	Jasper	GW	100.0%	Ozark Aquifer	1030	10300101	2.70	2.64	2.62	2.56
6768	Sikeston Power Station	Scott	GW Alluvium	100.0%	Alluvium	1107	11070207	3.51	3.43	3.40	3.36
								0	12.16	11.87	11.76
								0	0	0	0
<b>Coal or NG, Steam Turbine, Once Through</b>											
2103	Labadie	Franklin	SW	0.4%	Alluvium	1030	10300101	1,596.84	1,558.18	1,544.42	1,525.95
2161	James River Power Station	Greene	SW	0.2%	Alluvium	1030	10300200	18.13	17.69	17.54	17.31
2080	Montrose	Henry	SW	0.0%	Alluvium	802	8020204	140.22	136.83	135.62	134.00
2079	Hawthorn	Jackson	SW	0.0%	Alluvium	1107	11070207	345.95	337.58	334.60	330.55
2094	Sibley	Jackson	SW	0.0%	Alluvium	1029	10290110	7.87	7.68	7.61	7.51
2094	Sibley	Jackson	SW	0.0%	Alluvium	1029	10290110	188.51	183.94	182.32	180.14
6155	Rush Island	Jefferson	SW	0.2%	Alluvium	802	8020203	742.80	724.82	716.42	709.81
2167	New Madrid	New Madrid	SW	0.0%	Alluvium	714	7140101	656.35	640.46	634.80	627.21
6065	Iatan	Platte	SW	2.4%	Alluvium	1024	10240011	933.73	911.12	903.07	892.22
2168	Thomas Hill	Randolph	SW	0.0%	Alluvium	1030	10300102	763.36	744.88	738.31	729.48
2107	Sioux	St Charles	SW	0.0%	Alluvium	1101	11010002	111.10	108.41	107.46	106.17
2107	Sioux	St Charles	SW	0.0%	Alluvium	1101	11010002	336.33	328.19	325.29	321.40
2104	Meramec	St Louis	SW	0.0%	Alluvium	1101	11010007	210.03	204.95	203.14	200.71
								0	6,051.24	5,904.73	5,852.60
								0	0	0	0
<b>Natural Gas, Combined Cycle, Cooling Tower</b>											
56478	MIMEUC Generating Station #1	Audrain	GW	100%	Ozark Aquifer	711	7110007	0.07	0.07	0.08	0.05
55178	Dogwood Energy Facility	Cass	Municipal					0.32	0.36	0.40	0.44
55178	Dogwood Energy Facility	Cass	Municipal					0.54	0.60	0.67	0.74
7604	St Francis Energy Facility	Dunklin	GW Alluvium	100.0%	Alluvium	801	8010100	0.28	0.31	0.35	0.38
2079	Hawthorn	Jackson	SW	0.0%	Alluvium	1107	11070207	0.03	0.04	0.04	0.04
7296	State Line Combined Cycle	Jasper	GW	100.0%	Ozark Aquifer	1028	10280203	0.40	0.44	0.49	0.54
7296	State Line Combined Cycle	Jasper	GW	100.0%	Ozark Aquifer	1028	10280203	0.70	0.77	0.86	0.95
6223	Empire Energy Center	Jasper	GW	100.0%	Ozark Aquifer	1029	10290105	0.06	0.06	0.07	0.08
56127	Macon Energy Center	Macon	Municipal					0.04	0.04	0.05	0.05
7964	Peno Creek	Pike	GW	100%	Ozark Aquifer	711	7110007	0.04	0.04	0.04	0.05
7749	Essex	Stoddard	GW	100%	Alluvium	802	8020204	0.05	0.06	0.07	0.07
								0	2.53	2.79	3.10
								0	0	0	0
								0	2.53	2.79	3.10
<b>Nuclear, Steam, Cooling Tower</b>											
6153	Callaway	Callaway	SW	1.0100%	Ozark Aquifer	711	7110009	31.49	30.80	30.60	30.31

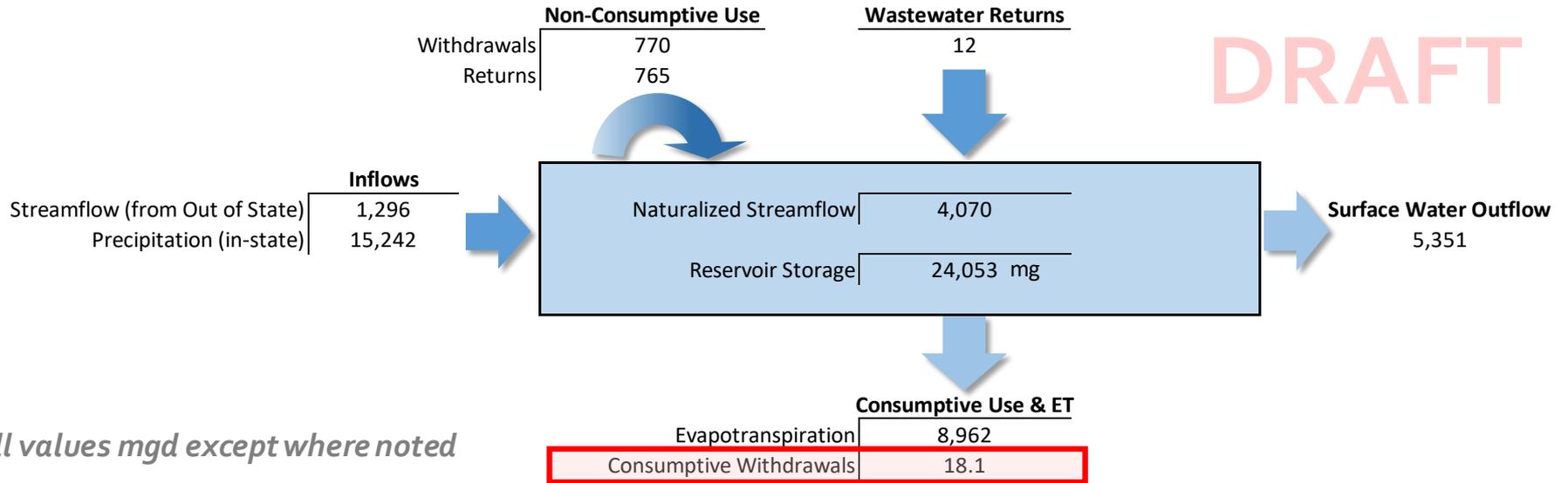
# Chariton-Grand Current Annual Day Water Budget



- Wastewater Returns**
  - MoDNR NPDES Database
  - 75% of facility design flow (temporary estimate)
  - Will incorporate facility effluent flow from permit records

Count	HUC4	PRIMARY WATERSHED HUC	FACILITY NAME	AREA (SQ MI)	DESIGN FLOW MGD	FACILITY EFFLUENT - 75% DESIGN FLOW (cubic feet per year)
1	0714	07140102	BAUMGARTNER COLLECTION SYSTEM	17,888		
2	1101	11010001	EMERALD BEACH ISDS	22,337		
3	1101	11010002	MCCORD BEND WWTP	22,337		
4	1101	11010001	KIMBERLING CITY	22,337	0.48	17,578,877
5	1030	10300102	HOLTS SUMMITT WWTP	10,340	0.5	18,311,330
6	1030	10300102	CHOCTAW RIDGE	10,340	0.032	1,171,925
7	1030	10300102	AC Collection System	10,340		0
8	1030	10300102	Lake Mykee Lagoons	10,340	0.0077	281,994
9	0714	07140104	ST. JOE STATE PARK	17,888	0.0055	201,425
10	0714	07140104	PARK HILLS MINERAL BELT WWTP	17,888	2.05	75,076,454
11	0714	07140104	LEADINGTON SEWERS	17,888		0
12	0714	07140105	CAPE GIRARDEAU WWTP	17,888	7	256,358,623
13	1107	11070207	CARTHAGE WWTP	20,804	7	256,358,623
14	1030	10300102	COLUMBIA REGIONAL WWTP	10,340	20.6	754,426,805
15	1030	10300102	FULTON WWTP	10,340	2.93	107,304,395

# Chariton-Grand Current Annual Day Water Budget



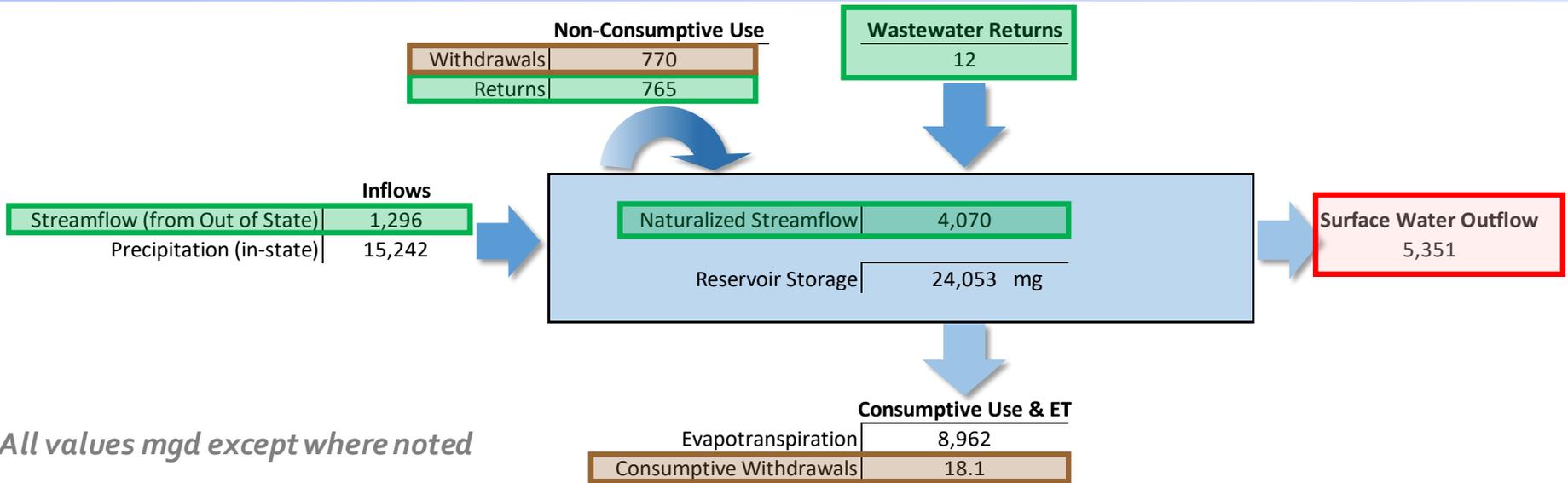
- **Consumptive Uses**
  - From MO Water User Database and Demand Model, listed by Sector

Surface Water Withdrawals By Sector	
	mgd
Major Water Systems	13
Self-Supplied Nonresidential	0.9
Agriculture Irrigation	4.60
<b>Total Consumptive</b>	<b>18.1</b>





# Chariton-Grand Current Annual Day Water Budget



- **Surface Water Outflow**

**Streamflow + WW & Non-Consumptive Returns**

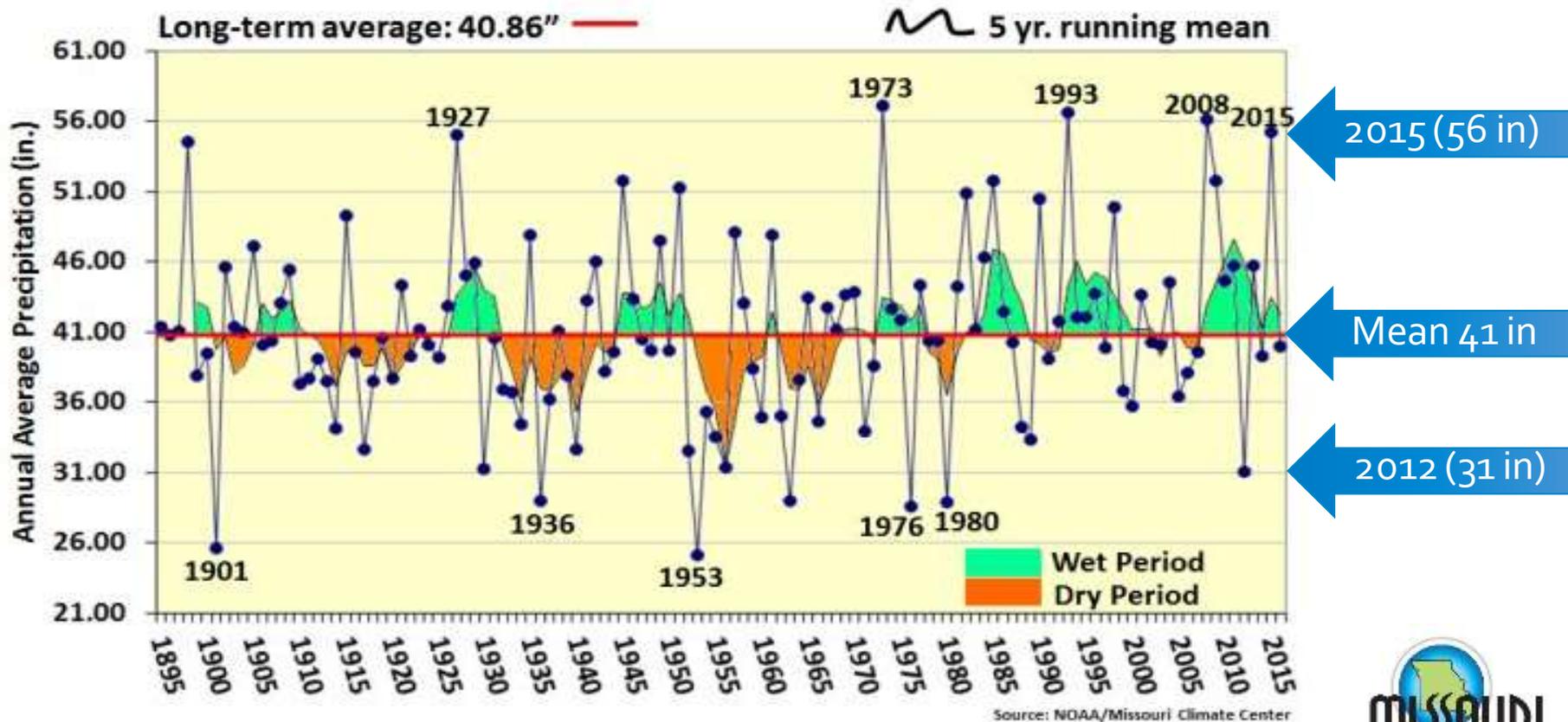
minus

**Consumptive/Non-Consumptive Withdrawals**



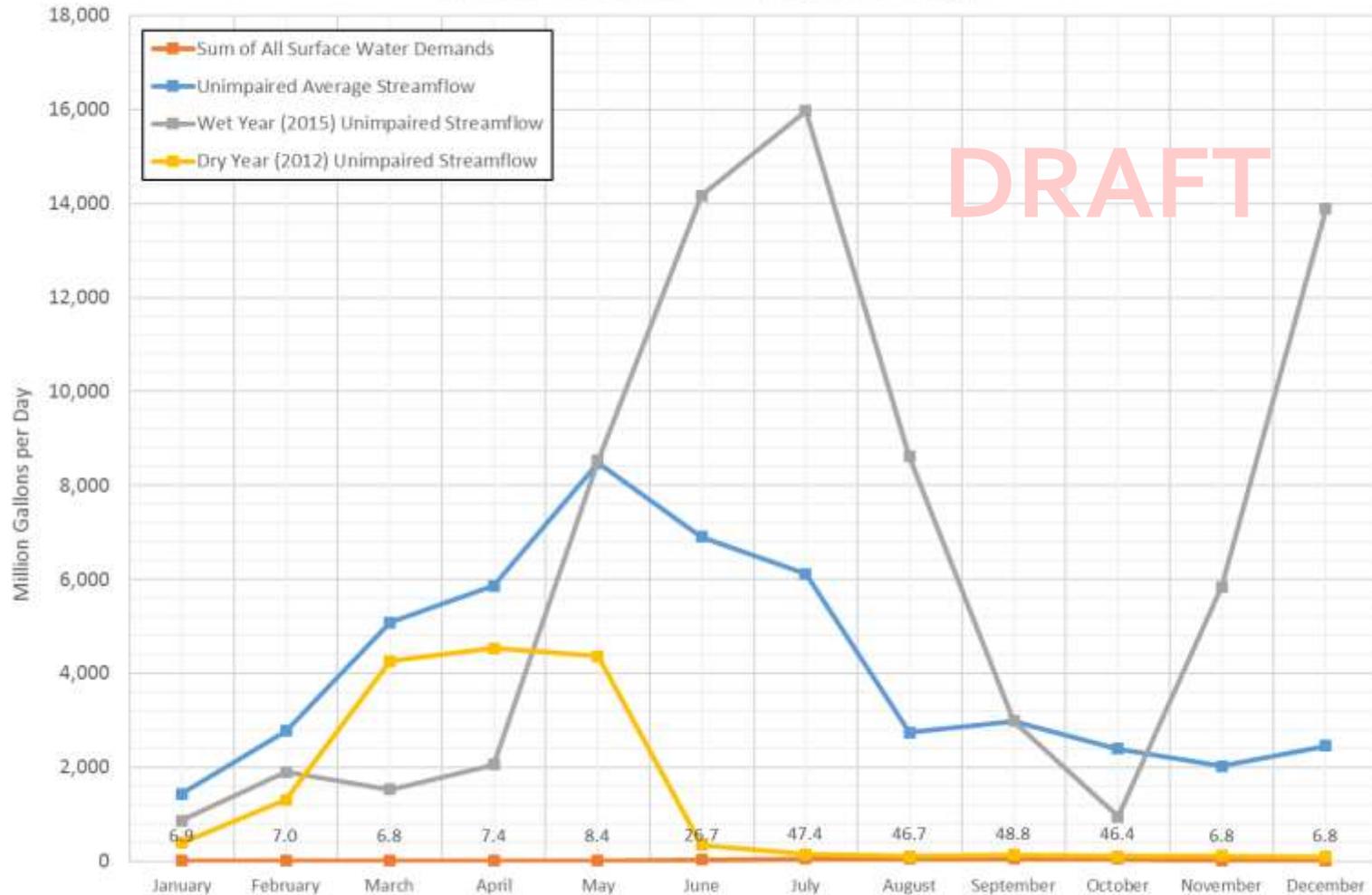
# Wet and Dry Year Water Budgets

- 2015 and 2012 provided as example recent wet and dry years
- 2012, as the dry year, had about 31 inches of precipitation and was the 6<sup>th</sup> driest year since 1895
- 2015, as the wet year, had about 56 inches of precipitation and was the 4<sup>th</sup> wettest year since 1895
- These analyses will be further refined, especially dry year analyses



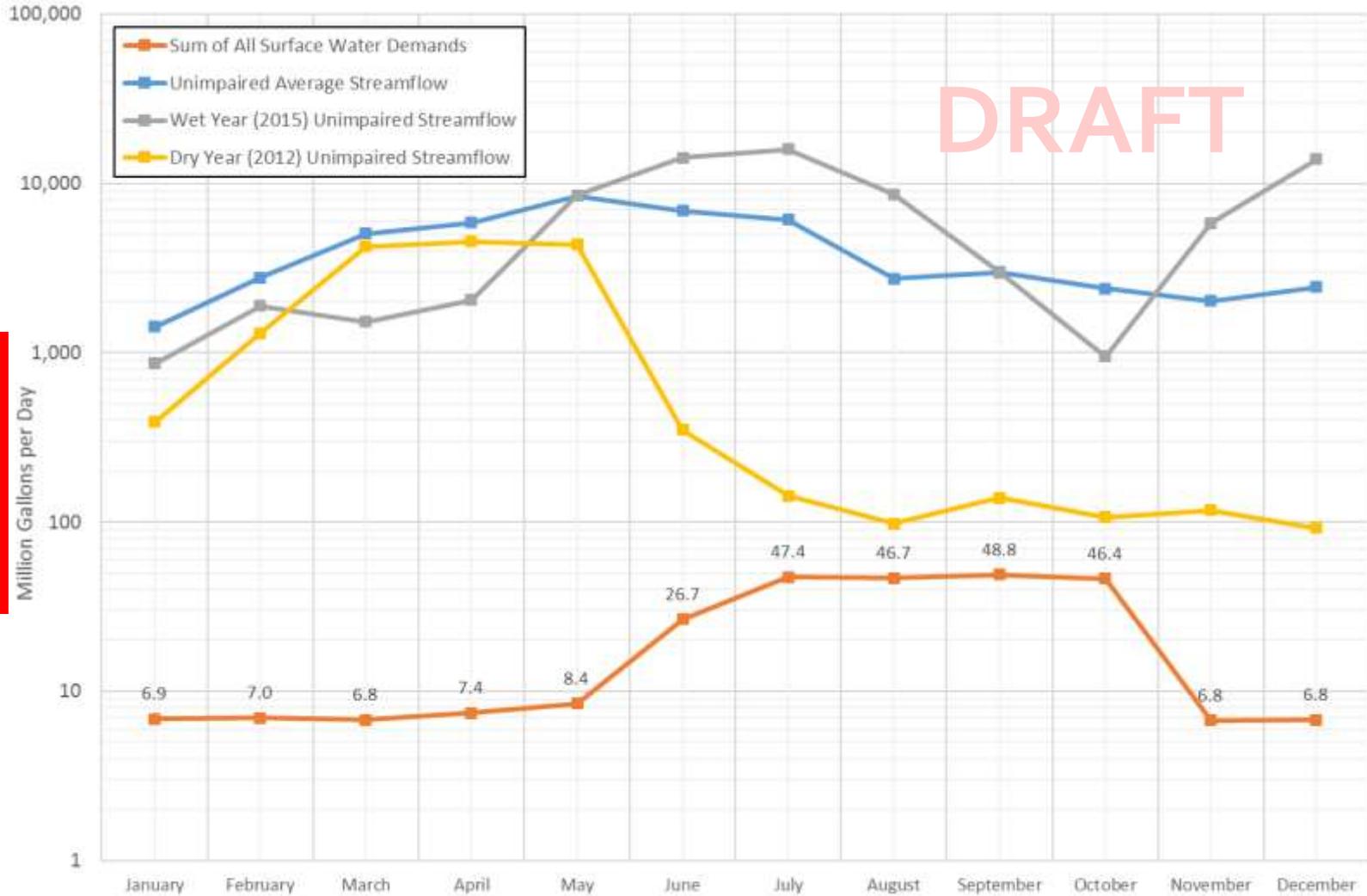
# Monthly Water Budgets

Chariton-Grand HUC 4 Monthly Water Budget



# Monthly Water Budgets

Chariton-Grand HUC 4 Monthly Water Budget

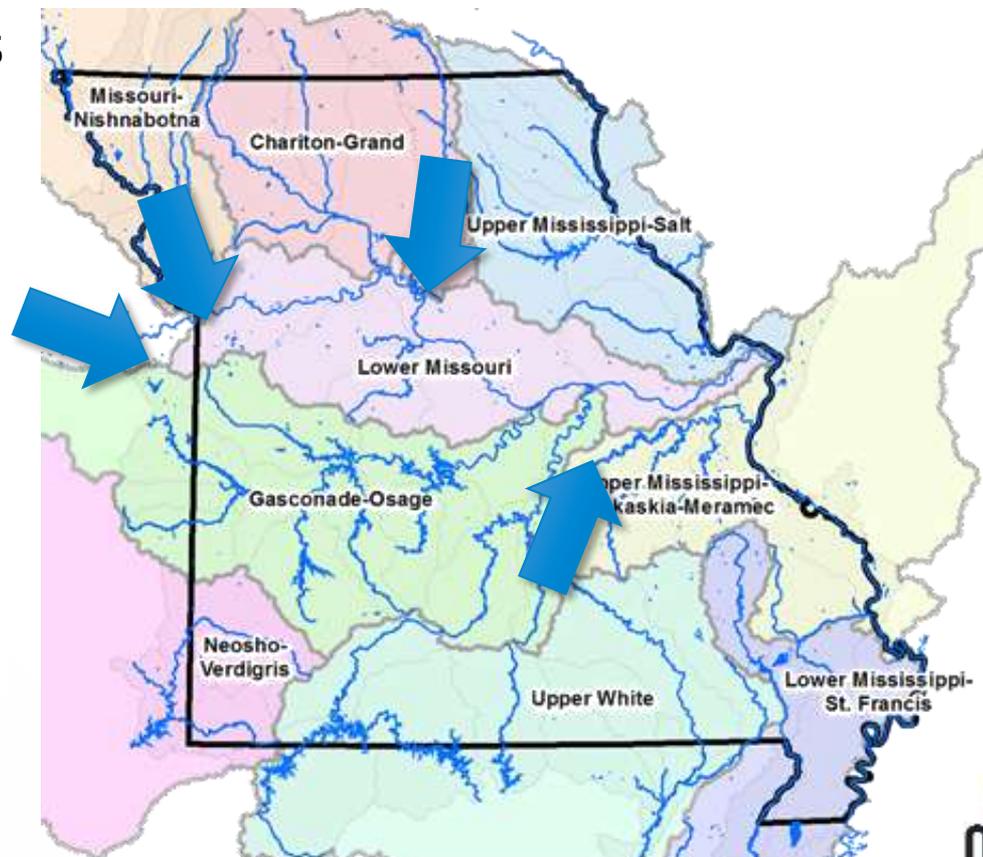


LOGSCALE

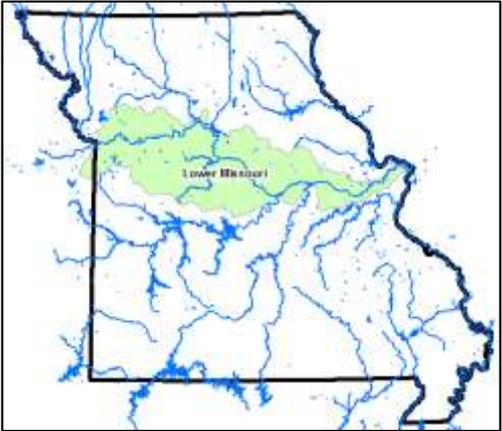
# Surface Water Supply Task: Development of Water Budgets

- **Lower Missouri Example**

Account for inflows  
From 4 different  
HUC-4s



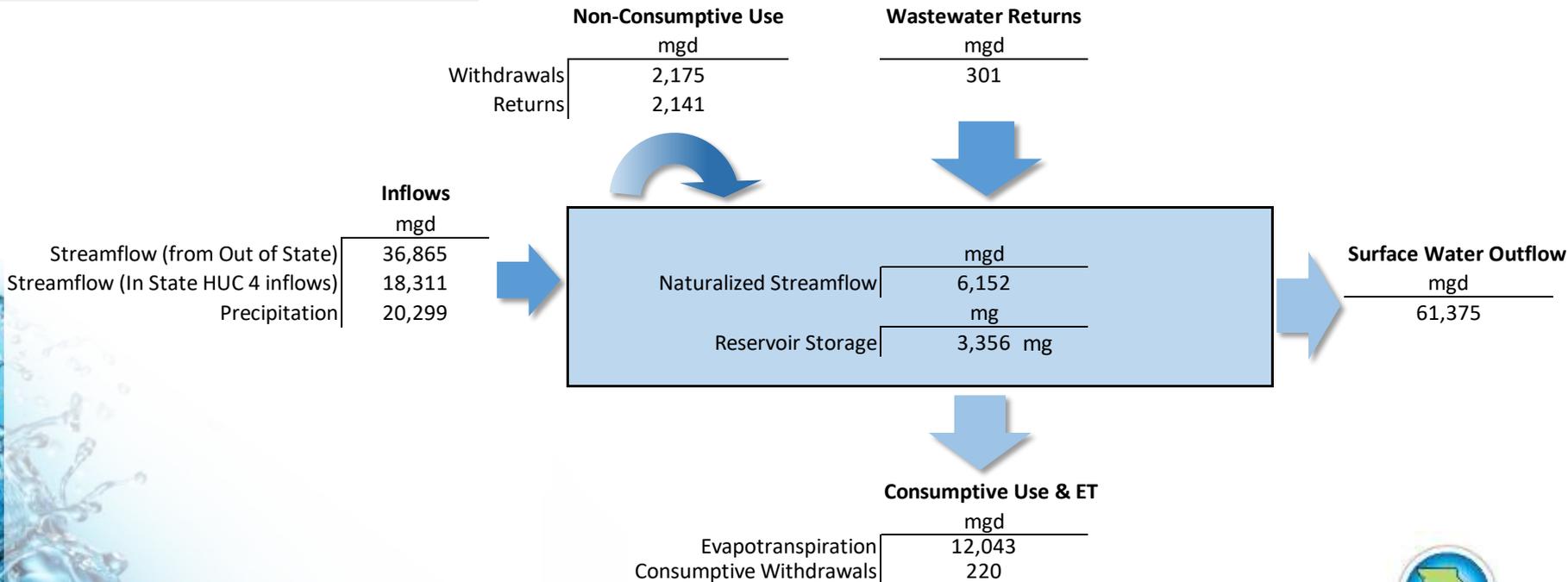
# Lower Missouri Current Day Water Budget



## Missouri Water Budget

<b>Basin</b>	Lower Missouri
<b>HUC 4</b>	1030
<b>Year(s)</b>	1985 - 2016
<b>Type</b>	Long Term Average
<b>Area within Missouri (sq mi)</b>	10,182
<b>Area outside Missouri (sq mi)</b>	158

DRAFT



All values mgd except where noted

# Surface Water Supply Task

## Next Steps

- **Complete all HUC 4 watersheds**
- **Incorporate Future Demands through 2060**
- **Develop Example Water Summary Sheet, presenting:**
  - Current (average), wet, and dry year budgets
  - Future (average), wet, and dry year budgets
  - Monthly supply vs. demand for average, wet, and dry years (current and future)
  - Hydrology Statistics (e.g., flow percentiles, flow duration curve)



# Future Outcomes and Schedule

- Results of gap analysis will feed into Infrastructure task
  - Areas lacking water will be investigated
- Areas with highest demands identified
  - Potentially investigated in more detail at HUC 8 level
- Full presentation of results of HUC 4 water budgets to all workgroups in May



# Next Steps



# Public Comments



Thank You

