Appendix A Groundwater Province Stratigraphic Sections

Table A-1. Stratigraphic Sections of the St. Francois Mountains Groundwater Province[1]

St. Francois Mountains Groundwater Province						
System	Series	Aquifer	Group or Formation	Thickness (feet)	Lithology	Hydrology
Cambrian	Croixian	Ozark Aquifer	Eminence Dolomite	Ranges from 0 to 150. Average of 75.	Deep fracturing has allowed extensive weathering of this unit.	Does not yield significant amounts of water in this province.
			Potosi Dolomite	Ranges from 260 to 470. May be absent in some areas.	Highly fractured and deeply weathered in some areas.	Small to moderate yield of 10 to 15 gallons per minute (gpm).
		St. Francois confining unit	Derby-Doerun Dolomite	Ranges from 45 to 160. Average of 120.	Chert-free dolomite with glauconite in lower part. May locally have gray-brown shale throughout.	Poor water-yielding characteristics.
			Davis Formation	Ranges from 75 to 200. Average of 125. May be absent in some areas.	Dolomitic shale, sandy dolomite, sandstone, or limestone. Unit is highly variable.	Not an aquifer.
		St. Francois Aquifer	Bonneterre Formation	Ranges from 175 to 535. Average of 400. May be absent in some areas.	Lower sandy phase may be replaced by interbedded dolomite and clastics. May rest on Precambrian where Lamotte is missing.	Yields small amounts of water to wells (3 to 20 gpm).
			Lamotte Sandstone	Ranges from 0 to 440. May be absent in some areas.	More arkosic near base with pebble conglomerates in lower third. Igneous fragments.	Yields 60 to 400 gpm with average yield of 150 gpm.
Precambrian		Basement confining unit	Igneous and Metamorphic Rocks			Not an aquifer.

[1]Miller and Vandike 1997

Table A-2. Stratigraphic Sections of the Salem Plateau Groundwater Province[1]

Salem Plateau Groundwater Province						
System	Series	Aquifer or Remarks	Group or Formation	Thickness (feet)	Lithology	Hydrology
Recent			Loess and Residuum	0 to 300	Windblown silt and weathering products of limestone, cherty dolomite, and dolomitic sandstone.	Has fair permeability.
Pennsylvanian			Undifferentiated Pennsylvanian Rocks	0 to 100	Thin limestones, shales, siltstones, sandstones, and some coal beds.	Small yields to wells. Water quality is usually poor.
Ordovician and Mississippian			Undifferentiated Formations	0 to 100	Various lithologies: limestone, shale, dolomite, thin sandstones.	Locally yields small amounts of water to wells (3 to 5 gpm).
Ordovician	Mohawkian	Upper Ozark Aquifer	St. Peter Sandstone	10 to 100	Well-sorted, frosted, rounded quartzose sand, massive-bedded.	Yields from 10 to 50 gpm.
	Whiterocklan		Everton Formation	0 to 120	Sandy, silty dolomite, clayey, dark gray shale.	Not a significant aquifer.
	Ibexian	Lower Ozark Aquifer	Cotter Dolomite	200	Fine- to medium-crystalline, cherty dolomite with numerous green shale partings; some thin sandstone beds.	5 to 15 gpm locally.
			Jefferson City Dolomite	200		
			Roubidoux Formation	170	Cherty, sandy dolomite and dolomite sandstone	15 to 35 gpm where shallow, 50 to 75 gpm where deeply buried.
			Upper Gasconade Dolomite	40	Massively bedded, coarsely crystalline, chert free dolomite.	Yields 50 to 75 gpm.
			Lower Gasconade Dolomite	250	Very cherty dolomite, algal reef zones in upper portions.	
			Gunter Sandstone Member	25 to 30	Sandstone and/or sandy dolomite.	40 to 50 gpm normal yield, 200 to 500 gpm in some localized areas.
Cambrian	Upper		Eminence Dolomite	220	Medium to coarse-grained dolomite with low chert content.	Moderate yields of 75 to 250 gpm.
			Potosi Dolomite	200	Fine- to medium-crystalline dolomite, with abundant quartz.	Yields from 200 to 1000 gpm.
		St. Francois confining unit	Derby-Doerun Dolomite	150	Fine-grained dolomite in upper part, shaley near base with glauconite.	Yields of 30 to 50 gpm available locally in upper portions, usually not a significant aquifer.
			Davis Formation	180	Shale, siltstone, fine-grained sandstone, limestone and dolomite conglomerates.	Not an aquifer.
		St. Francois Aquifer	Bonneterre Formation	350	Fine- to medium-crystalline dolomite, sandy at base.	Low yields of 10 to 15 gpm.
			Lamotte Sandstone	100 to 300	Sandstone and dolomitic sandstone, arkosic near base, absent in some localized areas.	Moderate yields of 70 to 125 gpm.

Salem Plateau Groundwater Province						
System	Series	Aquifer or Remarks	Group or Formation	Thickness (feet)	Lithology	Hydrology
Precambrian		Basement confining unit	Igneous and Metamorphic Rocks			Not an aquifer.

[1]Miller and Vandike 1997

Table A-3. Stratigraphic Sections of the Springfield Plateau Groundwater Province[1]

Springfield Plateau Groundwater Province						
System	Series	Aquifer or Remarks	Group or Formation	Thickness (feet)	Lithology	Hydrology
Pennsylvanian		Western Interior confining unit	Undifferentiated Pennsylvanian strata	Ranges from 1 to 120	Siltstone, sandstone, shale, and thin limestone.	Not a significant aquifer.
Mississippian	Meramecian	Springfield Plateau Aquifer	Warsaw Formation and younger Mississippian Strata	Average of 200	Alternating limestone and shale formations.	Not a significant aquifer.
	Osagean		Burlington-Keokuk Limestone	Ranges from 100 to 200	White to gray, medium to coarse crystalline; medium to thick-bedded limestone; relatively young karst features.	Small to moderate yields of 10 to 30 gpm in Springfield Plateau province. Localized areas in the western part of the province where more deeply buried may yield as much as 100 gpm.
			Elsey Formation	30	Similar to Reeds Spring Formation, but chert is white and is mottled with round spots.	
			Reeds Spring Formation	Ranges from 0 to 100	Alternating beds of finely crystalline limestone and sandy chert. Unit is about 50% chert.	
			Pierson Limestone	Ranges from 5 to 55	Medium to massively bedded limestone, cherty limestone.	
	Kinderhookian	Ozark confining unit	Northview Formation	Ranges from 2 to 80	Lower part is greenish gray shale; upper portion is siltstone.	Acts as aquiclude to separate Springfield Plateau aquifer from Ozark aquifer.
			Sedalia Formation	Ranges from 0 to 50	Similar to Compton Formation but more thickly bedded. Interfingers with Compton.	Not water bearing.
			Compton Formation	Ranges from 5 to 30	Finely crystalline, crinoidal limestone. Thin-bedded with greenish shale beds.	
Devonian	Upper		Chattanooga Shale	Ranges from 0 to 30	Fissile, black, carbonaceous, sandy shale. Has oily or bituminous odor.	Could cause water quality problems if left uncased in wells. Contained water is high in sulfates and may have hydrogen sulfide (H_2S) gas.
Ordovician	Ibexian	Lower Ozark Aquifer	Powell Dolomite	Ranges from 0 to 80	Fine to medium crystalline dolomite.	May yield 10 to 20 gpm locally to private domestic wells.

Springfield Plateau Groundwater Province						
System	Series	Aquifer or Remarks	Group or Formation	Thickness (feet)	Lithology	Hydrology
			Cotter Dolomite	200	Lithology similar to Salem Plateau province with silty dolomite and bedded oolitic chert.	
			Jefferson City Dolomite	210		
			Roubidoux Formation	Ranges from 140 to 210	Less sandstone than Salem Plateau province (only 10%). Primarily cherty dolomite.	Yields 60 to 200 gpm.
			Upper Gasconade Dolomite	Ranges from 40 to 70	Chert-free, medium crystalline dolomite.	Yields 30 to 100 gpm.
			Lower Gasconade Dolomite	Ranges from 240 to 335	Cherty dolomite with up to 60% chert.	
			Gunter Sandstone Member	30	Sandy dolomite with 30 to 50% sand.	Yields 25 to 150 gpm.
Cambrian	Upper	Lower Ozark Aquifer	Eminence Dolomite	0 to 340	Lithology becomes like Potosi Dolomite from east to west across province.	Yields of 50 to 150 gpm.
			Potosi Dolomite	0 to 50	Lithology unchanged from Salem Plateau province. Interfingers with Eminence Dolomite.	Yields as high as 1,200 gpm. Range in yield from 400 to 1,200 gpm, with an average of 600.
		St. Francois confining unit	Derby-Doerun Dolomite	0 to 50	Thins to the west, may be absent at the state line. Similar to Salem Plateau province.	Yields of 30 to 50 gpm locally.
			Davis Formation	0 to 100	Similar to Salem Plateau province, but less shale and more limestone to the west.	May yield 10 to 30 gpm in western portions of province. Locally a confining unit.
		St. Francois Aquifer	Bonneterre Formation	0 to 380	Thins to the west; may be absent at state line.	Yields of 10 to 20 gpm.
			Lamotte Sandstone	Ranges from 0 to 350 with average of 200	Similar to Salem Plateau province; less arkose in lower portion. Transgressive to the west.	Yields of 100 to 200 gpm.
Precambrian		Basement confining unit	Igneous and Metamorphic Rocks			Not an aquifer.

[1]Miller and Vandike 1997

Table A-4. Generalized Stratigraphic Sections of Sediments in the Southeastern Lowlands Groundwater Province[1]

Southeastern Lowlands Groundwater Province							
Era	**System**	**Group**	**Formation**	**Maximum Thickness (feet)**	**Extent**	**Lithology**	**Hydrology**
Cenozoic	Quaternary		Alluvium	250	Underlies entire lowland area except Crowley's Ridge and Benton Hills.	Gravel, sand, silt, and clay.	Primary aquifer in the area that may yield up to 3,000 gpm.
			Loess	35	Covers Crowley's Ridge, Benton Hills, and uplands.	Tan to brown silt with some intermittent clay.	Occurs above the water table so it is not water bearing.
	Tertiary		Terrace Gravel	60		Gravel, cobbles, some clay.	
		Wilcox		1,400	Crops out on Crowley's Ridge and Benton Hills. Underlies all of the area south and east of line from Campbell to Charter Oak to Sikeston to Lusk.	Sand, some clay. Contains thin beds of lignite.	Major aquifer system used primarily for municipal water supplies. Yields up to 1,500 gpm and may contain at least two aquifers with separate potentiometric surfaces.
		Midway	Porters Creek Clay	650	Crops out on Crowley's Ridge and Benton Hills. Underlies all of the area south and east of line from Neelyville to Bloomfield to Commerce.	Clay, light gray when dry, but dark gray when wet.	Does not yield significant quantities of water to wells. Acts as a barrier to groundwater movement.
			Clayton Formation	30		Calcareous, glauconitic sand and clay to fossiliferous limestone.	
Mesozoic	Cretaceous		Owl Creek Formation	100	Crops out on Crowley's Ridge and Benton Hills. Underlies entire area except within about 10 miles of the Ozarks.	Bluish-gray to brown sandy clay.	Generally impedes the flow of groundwater.
			McNairy Formation (Ripley Sand)	600 (combined)		Sand, sandy clay, and clay. Nonmarine at outcrop, but marine in deep part of the embayment.	A significant aquifer widely used for municipal supplies. High heads make this aquifer attractive, but excessive mineralization and high temperatures limit its use in localized areas.
			Pre-McNairy Cretaceous Beds		Present only in deeper parts of the embayment.	Sand, chalk, clay and limestone.	
Paleozoic				>2,680	Crops out at Crowley's Ridge, Hickory Ridge, and Benton Hills. Underlies entire area.	Limestone, sandstone, and dolomite.	Used for municipal supplies close to the Ozarks. Would probably yield large amounts of water in other areas, but this water may be highly mineralized in some areas.

[1]Miller and Vandike 1997

Table A-5. Stratigraphic Sections of Sediments in the Mississippi River Alluvium Aquifer by County[1]

Mississippi River Alluvium				
Counties	**Area (square miles)**	**Thickness (average feet)**	**Soil Characteristics**	**Hydrology**
Clark and Northeastern Lewis counties	77	100	Poor vertical permeability between deeper preglacial valley deposits and the overlying alluvium.	Potential to yield up to 775 gpm in localized areas. Water level changes primarily dependent on groundwater usage. Total estimated storage of 332,250 acre-feet of water.
Southeastern Lewis and Marion counties	54	150	Highly permeable alluvium.	Potential to yield up to 1,400 gpm. Water level changes primarily dependent on surface water fluctuations. Total estimated storage of 557,000 acre-feet of water.
Pike, Lincoln, St. Charles, and St. Louis counties	248	90 to 170	Silt, clay, fine- to coarse- grained sand, and fine to medium gravel.	Potential to yield up to 2,000 gpm in localized areas. Total estimated storage of 2.44 million acre-feet of water.
Ste. Genevieve County	8	~50	Thin alluvial deposits with fine, relatively impermeable shallow sediments and larger particle, deep sediments with higher permeability.	Relatively low water-yielding capability of up to 50 gpm. Total estimated storage of 38,400 acre-feet of water.
Perry County	43	150	Fine- to coarse-grained sand and fine to medium gravel.	Hydrologic characteristics similar to those of the Southeastern Lowlands alluvium. Total estimated storage of 536,000 acre-feet of water.

[1]Miller and Vandike 1997

Table A-6. Stratigraphic Sections of the Missouri River Alluvium Aquifer by Reach[1]

Missouri River Alluvium				
Reach	**Area (square miles)**	**Thickness (average feet)**	**Soil Characteristics**	**Hydrology**
Iowa State Line to Kansas City	446	90	Clay and silt near the surface underlain by sand and gravel. Deeper layers consist of Pennsylvanian-age shales, limestone, and sandstone.	Groundwater yields are averaged at approximately 1,000 to 2,000 gpm, depending on location. Total water storage estimated to be 3.4 million acre-feet.
Kansas City to Miami in Saline County	440	85 to 90	Upper layers of fine sand, silt, and clay while coarser sands and gravels comprise the deeper parts of the alluvium. Area underlain by Pennsylvanian-age shale, limestone, and sandstone.	Groundwater levels range from 5 to 20 below the land surface. Groundwater used for municipal, industrial, and agricultural uses. Yields of 1,000 to 1,500 gpm are common. A total of approximately 1.04 trillion gallons of water storage is available within this reach.
Miami in Saline County to Jefferson City	291	80	Alluvium surface with deeper bedrock formations that have higher permeability compared to upstream reaches.	Well yields range from 725 to 1,400 gpm. Total of approximately 546 billion gallons of water stored within this reach.
Jefferson City to St. Charles	224	100	Upper layers of fine sand, silt, and clay while coarser sands and gravels comprise the deeper parts of the alluvium. Deep Ordovician-, Mississippian-, and Pennsylvanian-age formations present below alluvium.	Well yields range from 1,000 to up to 3,000 gpm. Total of approximately 1.7 million acre-feet of water storage available within this reach.

[1]Miller and Vandike 1997

Table A-7. Stratigraphic Sections of Northwestern Missouri Groundwater Province[1]

Northwestern Missouri Groundwater Province				
System	**Series**	**Group/Formation**	**Lithology**	**Hydrology**
Quaternary	Recent	Alluvium	Sand and gravel with interbedded silt and clay.	Yields of about 30 to 500 gpm in some areas where sand and gravel are present.
	Pleistocene	Glacial Till or Drift	Mix of clay, silt, sand, gravel and some boulder-sized rocks.	Yields ranging from 3 to 50 gpm.
		Preglacial valley fill	Intermittent sand, gravel, silt, and clay.	May yield up to 500 gpm in localized areas.
Pennsylvanian	Virgilian	Wabaunsee Group	Shale, siltstone, and sandstone.	Not water bearing.
		Shawnee Group	Thick limestone formations with intermittent shale layers.	
		Douglas Group	Clastic formations with shale, sandstone, and thin limestone.	
	Missourian	Pedee Group	Thick shale with limestone on top.	Small yields of approximately 1 to 3 gpm in some areas.
		Lansing Group	Two thick limestone sequences separated by shale and sandstone.	
		Kansas City Group	Thick limestone formation with intermittent shale, sandstone, and black fissile shale in deeper portions.	Not water bearing.
		Pleasanton Group	Thick shale with sandstone in lower portion. Scattered coal beds with some thin limestone and siltstone layers.	
	Desmoinesian	Marmaton Group	Shale, limestone, clay, and coal.	
		Cherokee Group	Sandstone, siltstone, and shale.	Small yields of approximately 1 to 3 gpm at shallow depths in the outcrop area.
Deeper layers of pre-Pennsylvanian-age stratigraphy generally yield highly saline waters.				

[1]Miller and Vandike 1997

Table A-8. Stratigraphic Sections of the Northeastern Missouri Groundwater Province[1]

Northeastern Missouri Groundwater Province					
System	**Series**	**Aquifer or Remarks**	**Group or Formation**	**Lithology**	**Hydrology**
Quaternary	Recent		Alluvium	Clay, silt, sand, gravel, and stream deposits.	Yields 25 to 100 gpm where there is sufficient thickness of *clean* saturated sand and gravel.
	Pleistocene		Glacial Till or Drift	Silty, clay, sand, gravel and boulders. May be bedded or indeterminant mixture. Deposited by melting glaciers.	Yields of 5 to 275 gpm are possible where sufficient thickness of *clean* saturated sand and gravel are present.
Pennsylvanian	Missourian		Pleasanton Group	Dominant clastic sediments. Shale, siltstone, and scattered sandstone beds.	Not water bearing except where sandstone channels occur, then yields of 3 to 4 gpm are possible.
	Desmoinesian		Marmaton Group	Shale, limestone, clay, and coal beds.	Not utilized as a source of groundwater in this province.
			Cherokee Group	Sandstone, siltstone, shale, underclay, coal, and thin limestone beds. Recognizable cyclic sequences.	

Northeastern Missouri Groundwater Province					
System	**Series**	**Aquifer or Remarks**	**Group or Formation**	**Lithology**	**Hydrology**
Mississippian	Meramecian	Mississippian Aquifer	Ste. Genevieve Limestone St. Louis Limestone	Fine- to medium-crystalline limestone and shale.	May yield 5 to 10 gpm where units are not deeply buried. Water is mineralized when found below 300.
			Salem Formation	Buff-colored limestone, dolomitic limestone and shale	
			Warsaw Formation	Fine- to coarsely crystalline limestone	
	Osagean		Keokuk Limestone	Bluish gray, medium- to coarsely crystalline, medium-bedded limestone. Abundant light-gray chest.	May yield 10 to 15 gpm of potable water near the outcrop line. Water is mineralized where formation is deeply buried.
			Burlington Limestone	White to tan, coarsely-crystalline, fossiliferous limestone with layered chert nodules	
			Rock units below the base of the Burlington Limestone contain mineralized water north of freshwater-saline water transition zone.		
	Kinderhookian		Sedalia Limestone Chouteau Limestone	Limestone, dolomite, and shale.	
		Mississippian-Devonian-Silurian confining unit	Hannibal Shale	Shale.	Confining layer throughout much of northern Missouri, thinning to the south.
Devonian	Upper		Louisiana Limestone Grassy Creek Shale Snyder Creek Shale	Shale and limestone.	
	Middle		Cedar Valley Limestone	Limestone.	Unimportant as an aquifer.
Silurian			Bowling Green Dolomite	Limestone and dolomite.	
Ordovician	Cincinnatian		Maquoketa Shale	Shale.	Confining layer in extreme east along Mississippi River.
	Mohawkian	Cambrian-Ordovician Aquifer	Kimmswick Limestone	Dolomite and limestone.	Yields generally sufficient for domestic supplies; 5 to 10 gpm.
			Deccorah Group Plattin Limestone Joachim Dolomite	Dolomite, limestone, and shale.	Limited source of water. Locally may be confining layers.
	Whiterockian		St. Peter Sandstone	Sandstone and dolomite.	Good production for domestic, farm, and small industry. Excessively mineralized in the north; 25 to 75 gpm.
	Ibexian		Powell Dolomite Cotter Dolomite Jefferson City Dolomite	Dolomite.	Unimportant as an aquifer but may produce sufficient water locally for domestic and farm use; 0 to 25 gpm.
			Roubidoux Formation	Sandstone and dolomite.	Good producer. Commonly sufficient for municipal, industrial, and irrigation water supplies; 50 to 500 gpm.
			Gasconade Dolomite Gunter Sandstone Mbr.	Dolomite and sandstone.	
			Eminence Dolomite Potosi Dolomite	Dolomite.	Excellent producer. Capable of large yields for large cities,

Northeastern Missouri Groundwater Province					
System	Series	Aquifer or Remarks	Group or Formation	Lithology	Hydrology
					industry, and irrigation; 440 to 1,100 gpm.
Cambrian	Upper		Derby-Doe Run Dolomite Davis Formation	Shale and dolomite.	Limited source of water.
					Confining layer in northern Missouri.
			Bonneterre Dolomite Lamotte Sandstone	Sandstone and dolomite.	Little information available. Probably some production from the Lamotte Sandstone.
Precambrian				Igneous rocks.	Unimportant as a source of water.

[1]Miller and Vandike 1997

Table A-9. Stratigraphic Sections of the West-Central Missouri Groundwater Province[1,2]

West-Central Missouri Groundwater Province				
System	Series	Group or Formation	Lithology	Hydrology
Quaternary	Pleistocene and Recent	Undifferentiated glacial drift and alluvium	Clay, silt, sand, and gravel in northern part of the province, just south of the Missouri River, is glacially derived. Some loess near the river valley.	Missouri River alluvium yields >1,000 gpm. Drift and alluvium-filled preglacial channels may yield 50 to more than 500 gpm. Elsewhere, drift may yield 0 to 5 gpm.
Pennsylvanian	Missourian	Kansas City	Massive limestone formations with intervening shale formations. Some of the shale intervals have included sandstone beds. In the lower part of the group, these are thin, black, fissile shale members.	Small amounts of water (1 to 3 gpm) available from limestones and black shales near the outcrop line. Where more deeply buried, water is highly mineralized.
		Pleasanton Group	Thick clastic shale with a basal siltstone or very fine-grained sandstone. Locally, there are two other thick channel sandstones in the upper half of the group.	Not considered to be water bearing. Locally, may yield small amounts of water from sandstone beds. Water may be poor in quality.
	Desmoinesian	Marmaton Group	Fewer sandstone bodies than preceding group, with more thin limestones and thick shale sequences.	
		Cherokee Group	Thin sandstones and siltstones with intervening shales. The shales locally have coal seams. Thin limestone beds occur at widely scattered intervals.	May yield small amounts of water from sandstones (3 to 20 gpm). Water may be poor in quality.
Mississippian	Osagean	Burlington-Keokuk Limestone	Medium- to coarse-crystalline, medium- to thick-bedded limestone.	Yields small amounts of water to wells locally. May contain highly mineralized water.

[1]Miller and Vandike 1997

[2]The Ozark Aquifer is also present in the West-Central Province and several water systems withdraw groundwater from it at the province's southern extent. Throughout most of the province, the Ozark Aquifer is too highlighly mineralized for most uses without extensive treatment.

Appendix B
Revisions to the Missouri Water Demand Forecast Methodology

To: *Kaely Megaro, USACE*
Michael Weller, MoDNR

From: *CDM Smith Team*

Date: *January 7, 2019*

Subject: *Revisions to the Missouri Water Demand Forecast Methodology*

At the onset of the Missouri Water Plan update, Phase II Demands, a memorandum was delivered to USACE and MoDNR detailing the methodology and data sources that would be used to develop water demand forecasts. The memorandum follows with notations in ***bold italics*** where minor changes were made during the demand forecast execution. In some instances, clarification or more detail is provided.

Memorandum

To: *Kaely Megaro, USACE*

From: *CDM Smith Team*

Date: *April 7, 2017*

Subject: *Recommended Missouri Water Demand Forecast Methodology*

This document reflects a proposed revision to the methodology and data sources for estimating water use through 2060 for the publicly-supplied, residential and industrial self-supplied, and thermoelectric power generation sectors. The prominent change is that a stakeholder survey will not be part of the data collection process; existing available data sources as documented in the *Background and Methodology* (USACE, CDM Smith, January 2016) will be utilized as part of the analysis. In addition, the project team needs to identify the expectation for level of collaboration from MDNR staff as part of this analysis.

Proposed Methodology

Water demand will be estimated in ten year intervals through a planning horizon of 2060 for the following sectors. ***Naming conventions where changed for three sectors given Technical Work Group feedback.***

- Publicly-supplied (municipal) ***changed to Major Water Systems***
- Self-supplied residential ***changed to Self-Supplied Residential and Minor Systems***
- Self-supplied industrial ***changed to Self-Supplied Nonresidential***
- Thermoelectric power generation
- Livestock and crop irrigation[1]

It is recommended that the water demand forecasts by sector be estimated at the county level, and further disaggregated between surface water and groundwater sources. CDM Smith recommends disaggregation by supply source for each water use sector at the following level:

- Surface water – HUC-8 watershed
- Groundwater – Aquifer

[1] Agricultural sectors (livestock and crop irrigation) will be developed in collaboration with the University of Missouri Ag Extension, and therefore are not discussed in detail within this document.

For each sector a "*driver times rate of use*" model will be developed as illustrated in **Figure 1**. The appropriate driver and corresponding representative rate of use will be identified for each sector.

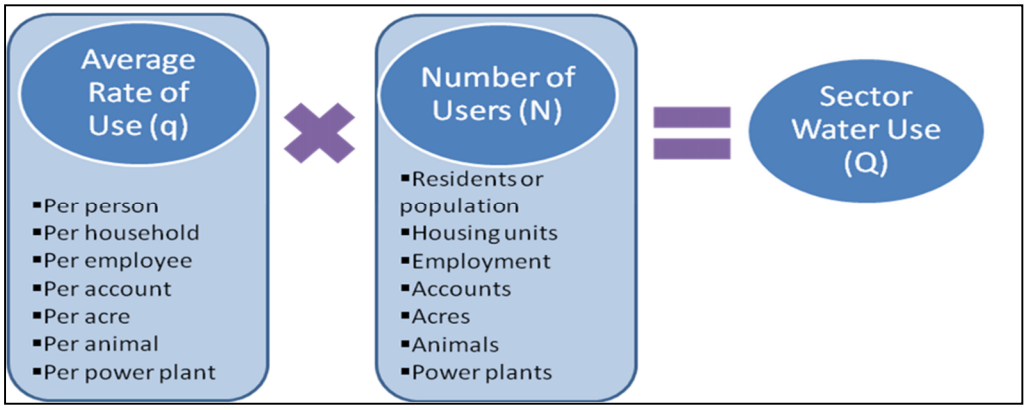

Figure 1. The Driver Times Rate of Use Approach

Historical water use data assembled to provide an estimate of base period use may vary by sector and according to data availability but generally should represent a concurrent period such as 2010 to 2015[2]. The future water use of each sector is determined by the growth of a "*driver*" (e.g., population, employment) that is appropriate for each sector and is either available from an acceptable source or projected into the future using technical expertise and standard industry practices.

During the initial phase of demand forecasting, high, medium and low alternative planning scenarios will be defined based on economic and demographic trends to provide a likely range of potential future demand. It is recommended that these scenarios and corresponding "*driver*" projections be developed in collaboration with the MDNR economist to estimate the most likely county specific future growth scenarios for the state.

For this project, several databases have been identified that provide information regarding historical water usage as well as population and employment data. The following data sources are recommended for the forecast development:

[2] Water use in some sectors was impacted by the recession from about 2008 to 2013. Water use factors developed from this time period will need to be carefully examined to determine if recessionary impacts are reflected in the data. If so, appropriate adjustments to the data will be made to assure that water use factors used to project future water use reflect non-recessionary conditions. Similarly, some sectors and areas of the state may have been affected by drought conditions, which will affect water use information. Assumptions will be based on maximum daily use for the various sectors analyzed.

- *MDNR Major Water Users Database:* According to MDNR, "Any surface or groundwater user with a water source and the equipment necessary to withdraw or divert 100,000 gallons or more per day (70 gallons per minute) from any stream, river, lake, well, spring, or other water source is considered a major water user in Missouri. Additionally, any combination of withdrawals (wells, surface water pumps or diversions) that withdraw or divert 100,000 gallons or more per day (70 gallons per minute) also qualifies as a Major Water User." The Major Water Users Database contains groundwater and surface water data meeting this definition by user and county. There are 10 categories of use, including: 1) municipal, 2) commercial, 3) fish and wildlife, 4) livestock, 5) agricultural irrigators, 6) electrical, 7) industrial, 8) drain and dewater, 9) recreational, and 10) other. Withdrawal points are provided, which allow for disaggregation of demands by HUC-8 or aquifer. All data contained within the database are self-reported annually by major water users, which can be considered a limitation based on unknown accuracy in reporting.

> **Applicability**
>
> The Major Water Users Database may be used to determine baseline water use for public-supply and self-supplied commercial and industrial water use sectors.

- *Safe Drinking Water Information System (SDWIS):* This database contains records for approximately 5,600 public drinking water systems, of which approximately 2,700 are currently active systems. SDWIS data include a complete inventory of public drinking water systems as well as sample results, compliance activities, and water quality data. Available fields for each water system which may be useful for forecasting water demands for the state include sources of water with associated percentages, wholesale water information, service connections, flow rates, population served, and average daily consumption. The database is not updated annually, which can be considered a limitation, but contains the most recently available data.

> **Applicability**
>
> The SDWIS Database may be used to determine water sources, water use rates, wholesale transfers, and number of users. This information can be used to establish baseline public-supply demands and to verify municipal data found within the Major Water Users

- *Missouri Office of Administration Population Projections:* The Office of Administration Division of Budget and Planning estimates county level population through 2030. It is recommended that these estimates serve as a baseline for high, medium, and low population projection estimates which will be extrapolated through the 2060 planning horizon. Population projections will be used as the “driver” of the public-supply and self-supplied residential water use forecast.

- *Missouri Economic Research and Information Center (MERIC) Industry Employment Projections:* MERIC has estimated regional industrial employment projections by North American Industry Classification System (NAICS) Code through the year 2024. It is recommended that these estimates serve as a baseline for deriving high, medium, and low regional employment projections which will be extrapolated through the 2060 planning horizon. Employment projections may be used as a “driver” for the self-supplied industrial and commercial demand forecast, however, collaboration with MDNR and/or MERIC economists is recommended to verify trends in self-supplied commercial and industrial water use.

- *Department of Energy's Energy Information System (EIA):* The State Energy Data System (SEDS), which operates under the U.S. Energy Information Administration (EIA), provides comprehensive state-level estimates of energy production, consumption, prices, and expenditures by source and sector from 1960 through 2013. These data can be used in developing water demands for thermoelectric power generation within the state. Collaboration with the MDNR Industrial Wastewater Unit is recommended to determine if any future generation facilities are planned, and any plans for improvements, reductions, or closures at existing facilities. This information will be used in the development of the thermoelectric water demand forecast.

- *United States Geological Society (USGS) Water Use in the United States:* Every five years, water use data at the county level are compiled into the USGS National Water Use Information Program Database. The most recent USGS available data are from 2010. All states provide estimates for public supply, domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric power. Missouri also provides estimates for water sources for each sector (groundwater and surface water). These data can be used in estimating the proportion of population in each county that is publicly-supplied and self-supplied. Data can also be used to verify calculated baseline demands[3].

- ***Missouri Office of Administration Population Projections were deemed outdated and a third-party source was identified. With approval, Woods & Pool Economics, Inc. projection series for Missouri were utilized[4]. Woods & Poole provides population and employment projections by 2-digit NAICS code for all counties in Missouri to 2050. Employment data are collected and reported by major employment categories. Employment data are typically expressed according to the 2002 North American Industry Classification System (NAICS). This system classifies employment given an industry's primary activity at an establishment (typically a single physical business location). For example, a secretary for a trucking company is considered a transportation worker while an accountant at a small plumbing company is considered a construction worker. Employees who work at an establishment's headquarters are considered management regardless of the type of services offered by the establishment. Definitions of the primary employment categories are described below.***

  > ***Farming includes establishments such as farms, orchards, nurseries, and greenhouses where the primary activity is producing crops, plants, vines, trees, etc. It also includes ranches, dairies, feedlots, egg production facilities, and poultry hatcheries primarily engaged in the keeping, grazing, or feeding of cattle, hogs, sheep, goats, poultry, or special animals.***

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[3] In Missouri, water use is provided to USGS based on data collected in the Major Water Users' Database. The Water Use in the United States Database will be used to verify demands where possible, but in some cases may be derived from the same original source of demands.

[4] Woods & Poole Economics, Inc. 2017. Complete Economic and Demographic Data Source. Washington, D.C.

***Mining** includes establishments that extract naturally occurring mineral solids, liquid minerals, and gases. It includes quarrying, well operations, beneficiating, and other preparation.*

***Construction** establishments include those primarily engaged in building new structures and roads, alterations, additions, reconstruction, installations, and repairs. It includes general contractors engaged in residential, non-residential, and heavy construction, as well as specialty trade contracting such as plumbing, electrical, masonry, and carpentry.*

***Manufacturing** includes establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. The assembling of component parts of manufactured products is considered manufacturing. Manufacturing establishments can be plants, factories, mills, as well as bakeries, candy stores, and custom tailors.*

***Retail** trade establishments are those engaged in retailing merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. These include dealers, stores, butchers, bakeries, pharmacies, and gas stations. Retail trade also includes non-store retailers such as internet and catalog sellers.*

***Wholesale trade** establishments include those wholesaling merchandise, generally without transformation, and rendering services incidental to the sale of merchandise. Wholesale establishments are primarily engaged in selling merchandise to retailers; to industrial, commercial, institutional, farm, or construction contractors; or to professional business users.*

***Professional and technical services** include establishments that specialize in performing professional, scientific, and technical activities for others.*

***Accommodation and food services** include hotels, motels, casino hotels, bed and breakfasts, campgrounds, and recreational vehicle parks, and eating and drinking establishments such as restaurants and bars. This category also includes caterers and food service contractors.*

***Education** includes private schools, junior colleges, colleges, universities, and professional schools. This category does not include public schools, colleges, and universities.*

***Health care and social services** establishments provide health care and social assistance for individuals. Health care establishments include ambulatory care, hospitals, and nursing and residential care facilities. Social services establishments include individual and family services, and community services such as food banks. Excluded from this category are public hospitals and clinics.*

State and local government ***establishments are those activities run by state and local governments. At the local level, this includes public schools and police and fire departments. This category also includes public junior colleges, colleges, and universities.***

Federal government*, both military and civilian, includes federal government works regardless of the establishment classification. This includes courts, correctional institutions, the postal service, and all federal government agencies. The military includes all branches of the U.S. military. Personnel deployed abroad are counted in their home base. This sector does not include civilians working on a military base, which are classified in the sector appropriate to their occupation.*

Finance, insurance, and real estate ***includes establishments primarily engaged in or facilitating financial transactions, renting, leasing, or otherwise allowing use of tangible assets. Examples of these establishments include banks, credit unions, credit institutions, brokers, insurance carriers, real estate leasing establishments, real estate agencies, and property management establishments.***

Administrative services ***include establishments engaged in office administration, hiring and placing of personnel, document preparation, security and surveillance services, cleaning, and waste disposal services. Excluded from this category are establishments involved in administering, overseeing, and managing other establishments of the company or enterprise.***

Transportation and utilities ***includes industries providing transportation of passengers and cargo and warehousing and storage of goods, as well as establishments engaged in the provision of electric power, natural gas, steam supply, water supply, and sewage removal. This includes private courier services. Excluded from this sector are establishments primarily engaged in waste management and federal, state, or local government-operated establishments.***

All other ***includes the remaining employment for sectors such as arts and entertainment, recreation, forestry, fishing, and information.***

The following subsections describe, in detail, assumptions for development of the water demand forecast by sector.

Public-Supply (Municipal) Water Use

Water use among publicly-supplied municipal water users by county will be projected into the future based upon the rate of growth of the county population. Estimates of publicly-supplied water use by provider will be calculated using data from the Major Water Users Database and the SDWIS database. The reported municipal water volume can be divided by the reported population served to derive the gallons per capita per day (gpcd) rate of use for each

municipality. The average per capita use for each system includes imbedded commercial and industrial water use as well as distribution system losses. Data included in baseline modeling for each municipality will include estimated gpcd baseline water use, county, source (groundwater or surface water) and withdrawal location.

Examination of the Major Water Users Database reveals that the majority of municipal providers report all municipal use under one category, combining both residential and non-residential demands. As such, it is important to evaluate the relationship between trends in population (residential driver) and employment (non-residential driver). The relationship between population and employment by county for Missouri from 1980-2010 is shown in **Figure 2**. Based on this analysis, trends align consistently, indicating validity in the use of future population estimates as the driver of the municipal forecast. Additional validation of data was completed using statistical correlation analysis. Based on this analysis, 86-percent of the variation in employment over time can be predicted from the relationship between population and employment, indicating a very strong positive correlation. Using this approach assumes that as a county population increases or decreases, county employment and thus non-residential water use on a per employee basis will follow a similar trend.

County specific population projections will be used as the driver of the forecast and will be used to estimate per capita water use through the planning horizon (2060) in ten-year intervals. Where a municipal system's service area spans multiple counties, multiple growth rates may be used to project future population served by the system. The system per capita use rate times the projected population served provides an estimate of the future water demand for each municipal system.

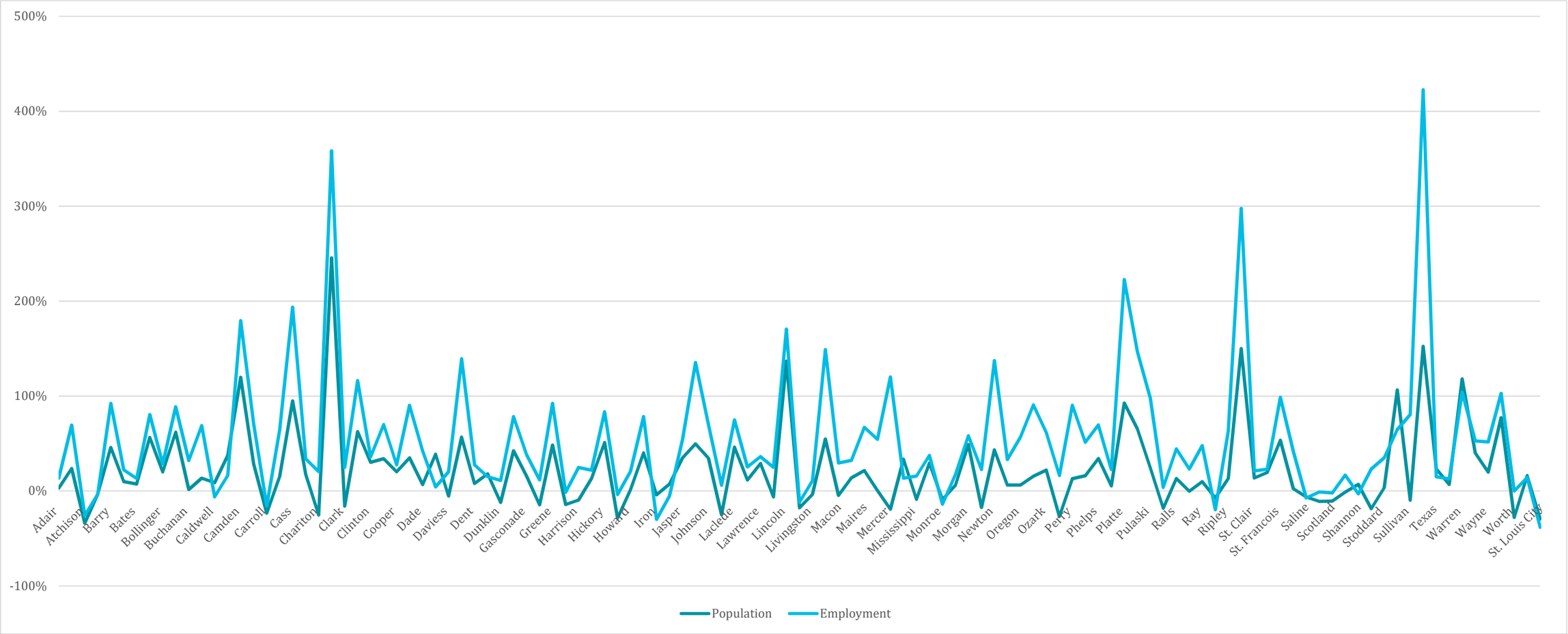
Additionally, point of withdrawal locations from the Major Water Users Database and supply source data from the SDWIS database will be utilized to assign surface water users to a HUC-8 watershed, and groundwater users to an aquifer. Thus, demands will be aggregated at the county, HUC-8 watershed, and aquifer level, individually. Different levels of aggregation will allow users to utilize the projected demands for multiple applications including surface water and groundwater modeling, and conservation and infrastructure planning.

Missouri Office of Administration Population Projections were deemed outdated and a third-party source was identified. With approval, Woods & Pool Economics, Inc. projection series for Missouri were utilized.

An adjustment was made to the forecast method to account for areas where population is not growing or is declining, but employment is growing. These areas, such as St. Louis City, are becoming economic centers and daytime population, which is linked to employment, is the primary driver of water use. The adjustement factor essentially weights the growth rate applied to the Major Water System population served to account for high employment growth. The adjustment factor was developed based on professional judement as follows:

Applied Growth Rate for Major Water System for Year = [(Future Year County Population – Base Year County Population)/Base Year County Population]*0.667 + [(Future Year County Employment – Base Year County Employment)/Base Year County Employment]*0.333

Additionally, Public Wells data were utilized to determine the specific producing aquifer for the Major Water Systems. Only active wells were considered. To determine the perctage of source by aquifer, the active Pulbic Wells were spatially linked to Major Water Users database withdrawal points using GIS and limiting links to those where the SDWIS ID matched.



Note: Not all county names are visible based on space available, however, all 114 counties and St Louis City are included in this analysis

Figure 2. Missouri Population and Employment Growth Rates 1980-2010

Domestic (Residential) Self-Supplied Water Use

USGS 2010 data on the percent of population that is publicly-supplied and self-supplied for each county will be used to estimate the percent of county population self-supplied and assumed to be on groundwater wells. Average public-supply county gpcd water use will be assumed for self-supply residential water use, or USGS data can be used to determine the self-supplied gpcd for each county. Self-supplied water use will be projected into the future based upon the rate of county population growth. That is, the population on private groundwater wells will be assumed to grow proportionally to total population. The self-supplied water demands will be assumed be withdrawn from the dominant aquifer underlying the county or proportioned among aquifers if adequate information is available to refine the assumptions. Similar to the publicly-supplied forecast, the demand forecast will be aggregated at the county level and aquifer level at ten-year intervals throughout the planning period.

The trends in Self-Supplied Nonresidential and Minor Systems population served were assessed from USGS data and found to vary by county. Thus, trend information was used to project the population in the sector. After the Self-Supplied Nonresidential population served was forecast to 2060, the Major Water Users population served was assumed to service the remaining population.

Self-Supplied Industrial Water Use

Water use among self-supplied industrial water users by county can be projected into the future based upon the rate of growth of regional employment. MERIC regional employment forecasts through 2024 will be utilized and extrapolated through 2060. It is assumed that any increase in water use in cases of increased employment will serve as proxy for growth in the number of self-supplied industrial users or expanded water use among existing self-supplied industrial users. Base period water use for each large water-using industrial facility will be obtained from the Major Water Users Database. This data will be aggregated into NAICS classifications in order to align with MERIC employment projections for estimation of future demands. In addition, the 2010 USGS data have the estimated industrial water use and number of facilities by county and may be used for verification purposes.

Future industrial water demands can be calculated by applying the employment rate of growth by NAICS code (rate of growth can be positive or negative) to the base year industrial water demand of each NAICS classification. The industrial facility water demands can be assigned to specific withdrawal nodes in the surface water and groundwater models by location. The forecast will include aggregations of demand projections at the county, HUC-8 watershed, and aquifer level at 10-year intervals throughout the planning horizon.

Minor edits to the reported data were necessary. Some projections were adjusted based on feedback received during the Technical Workgroup meetings. Woods & Poole employment projections were used as the driver of the forecast.

Thermoelectric Power Generation Water Use

Water use among self-supplied thermoelectric power (power) water users can be estimated for each major power-generating facility in the state and projected into the future based upon consideration of fuel type, prime mover, cooling method, and regional projections of future

power generation. Plant-specific withdrawal and consumption factors can be developed using data from MDNR's Major Water Users Database and the Department of Energy EIA. Base period water use factors for withdrawals and consumption (in gallons per megawatt hours [MWh]) can be multiplied by the annual power generation (in MWh) for each unit and then converted to million gallons per day (mgd). Thus, a withdrawal mgd and consumption mgd can be estimated for each generating unit. Most water use for thermoelectric power generation is from surface water sources, and the non-consumptive volume is returned to surface water. Return volume may be able to be verified using Missouri Clean Water Information System (MoCWIS) point source discharge data.

Future self-supplied thermoelectric power water demands can be based upon EIA projections of power generation by regional pool and fuel type. (Note that Missouri is supplied by both the Southeastern Electric Reliability Council Gateway region and the Southwest Power Pool North region.) The rate of growth in power generation by fuel type by region can be assigned to the facilities by fuel type and location. However, projections of future power generation for each facility may be limited by the maximum generating capacity of each unit. The projected power generation by facility can be multiplied by the withdrawal and consumptive use requirements of each generating unit to derive the estimated future water demand by facility. Estimated withdrawal and consumptive water demand can be summed statewide as illustrated in **Figure 2**. Additionally, demands can be disaggregated to the county, HUC-8, and aquifer level in ten-year intervals throughout the planning horizon.

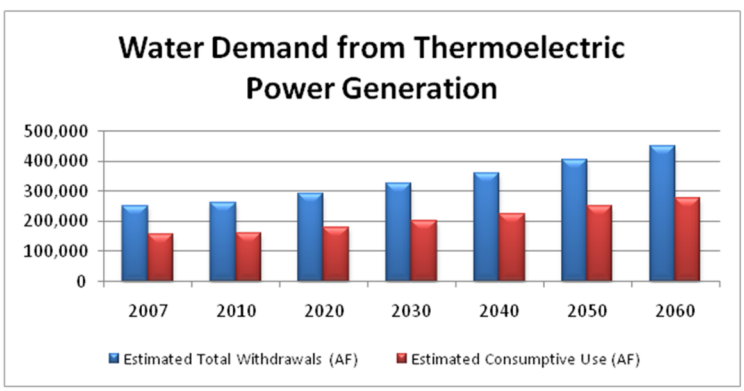


Figure 2. Example of Water Demands for the Thermoelectric Power Generation Sector

Future generation requirements are based on the population forecast trend for Missouri. Additionally, the consumptive and nonconsumptive demands were estimated using data found in MacKnick et al. (2011) that give metrics for water use based on thermoelectric power generating confirmation.

Next Steps

CDM Smith recommends completing the water demand forecast using the data and methodology as described in this memorandum. CDM Smith also recommends input and collaboration with MDNR as part of this process, including:

- Collaboration with the MDNR economist to estimate the most likely county specific future growth scenarios for the state.
- Collaboration with MDNR and/or MERIC staff to verify trends in self-supplied commercial and industrial water use.
- Collaboration with the MDNR Industrial Wastewater Unit to determine if any future power generation facilities are planned, and any future plans for improvements, reductions, or closures.

Appendix C Demographic and Water Demand Projections and Data by County

Table C-1. Projected Population to 2060 by County

County	Population Projections by County						Growth 2016–2060
	2016	2020	2030	2040	2050	2060	
Adair	25,421	25,655	26,083	26,015	25,470	24,850	-2%
Andrew	17,393	17,826	18,837	19,528	19,872	20,151	16%
Atchison	5,282	5,197	4,963	4,651	4,280	3,924	-26%
Audrain	26,123	26,298	26,620	26,504	25,972	25,378	-3%
Barry	36,037	36,976	39,270	41,043	42,234	43,341	20%
Barton	11,908	12,054	12,384	12,532	12,500	12,436	4%
Bates	16,487	16,689	17,097	17,184	16,952	16,666	1%
Benton	18,774	19,237	20,319	21,055	21,416	21,707	16%
Bollinger	12,238	12,500	13,134	13,597	13,878	14,131	15%
Boone	177,536	188,646	218,561	249,064	279,343	312,417	76%
Buchanan	89,246	90,038	91,471	91,165	89,186	86,945	-3%
Butler	43,145	44,047	46,232	47,812	48,749	49,586	15%
Caldwell	9,038	9,155	9,394	9,457	9,344	9,200	2%
Callaway	45,116	46,382	49,478	51,914	53,610	55,205	22%
Camden	44,769	47,080	53,151	59,019	64,501	70,292	57%
Cape Girardeau	79,153	81,740	88,288	93,957	98,582	103,187	30%
Carroll	8,971	8,910	8,703	8,340	7,844	7,352	-18%
Carter	6,287	6,399	6,667	6,844	6,926	6,992	11%
Cass	103,158	109,873	127,827	145,894	163,448	182,475	77%
Cedar	14,020	14,409	15,377	16,163	16,746	17,308	23%
Chariton	7,569	7,506	7,306	6,976	6,538	6,107	-19%
Christian	84,998	92,474	113,701	137,575	163,895	194,712	129%
Clark	6,780	6,713	6,527	6,251	5,900	5,556	-18%
Clay	239,149	254,313	294,698	335,019	373,843	415,708	74%
Clinton	20,733	21,286	22,591	23,521	24,038	24,480	18%
Cole	77,056	78,613	82,269	84,682	85,790	86,667	12%
Cooper	17,699	17,975	18,598	18,927	18,958	18,936	7%
Crawford	24,620	25,061	26,077	26,682	26,860	26,960	10%
Dade	7,614	7,710	7,923	8,013	7,979	7,923	4%
Dallas	16,520	17,082	18,497	19,711	20,680	21,638	31%
Daviess	8,276	8,387	8,616	8,684	8,591	8,470	2%
DeKalb	12,741	12,989	13,545	13,857	13,915	13,925	9%
Dent	15,651	15,929	16,576	16,975	17,115	17,207	10%
Douglas	13,466	13,882	14,918	15,776	16,426	17,056	27%
Dunklin	30,884	30,922	30,905	30,421	29,511	28,557	-8%
Franklin	102,707	104,100	107,166	108,485	108,047	107,297	4%
Gasconade	14,854	14,878	14,867	14,609	14,123	13,613	-8%
Gentry	6,688	6,688	6,645	6,477	6,198	5,910	-12%
Greene	290,806	302,793	333,590	361,669	386,064	410,972	41%
Grundy	10,100	10,137	10,165	10,000	9,656	9,291	-8%
Harrison	8,631	8,716	8,876	8,867	8,695	8,496	-2%
Henry	21,806	22,134	22,830	23,103	22,948	22,716	4%
Hickory	9,249	9,466	9,991	10,378	10,613	10,824	17%
Holt	4,472	4,432	4,308	4,108	3,845	3,587	-20%
Howard	10,145	10,197	10,280	10,193	9,948	9,681	-5%
Howell	40,320	41,247	43,482	45,108	46,073	46,931	16%
Iron	10,128	10,167	10,218	10,098	9,819	9,520	-6%
Jackson	689,037	696,318	710,366	710,952	698,435	683,739	-1%
Jasper	119,066	121,288	126,587	130,140	131,870	133,291	12%

Table C-1. Projected Population to 2060 by County

County	Population Projections by County						Growth 2016–2060
	2016	2020	2030	2040	2050	2060	
Jefferson	226,561	237,176	264,706	290,510	313,682	337,710	49%
Johnson	54,182	55,241	57,616	58,954	59,212	59,262	9%
Knox	3,899	3,866	3,760	3,587	3,359	3,135	-20%
Laclede	35,642	36,422	38,287	39,608	40,342	40,977	15%
Lafayette	32,821	33,381	34,605	35,193	35,132	34,949	6%
Lawrence	38,344	39,106	40,911	42,119	42,693	43,157	13%
Lewis	10,192	10,161	10,056	9,811	9,444	9,070	-11%
Lincoln	55,395	58,428	66,447	74,308	81,757	89,689	62%
Linn	12,312	12,357	12,390	12,189	11,769	11,324	-8%
Livingston	15,066	15,254	15,634	15,720	15,515	15,258	1%
Macon	15,353	15,459	15,629	15,501	15,092	14,642	-5%
Madison	12,453	12,665	13,149	13,425	13,485	13,505	8%
Maries	9,023	9,291	9,952	10,484	10,871	11,240	25%
Marion	28,901	29,063	29,390	29,303	28,824	28,290	-2%
McDonald	22,747	23,218	24,284	24,914	25,090	25,178	11%
Mercer	3,687	3,669	3,601	3,467	3,277	3,088	-16%
Miller	25,235	25,795	27,126	28,058	28,563	28,996	15%
Mississippi	14,015	13,968	13,806	13,445	12,909	12,365	-12%
Moniteau	16,061	16,503	17,580	18,420	18,996	19,535	22%
Monroe	8,575	8,565	8,501	8,299	7,974	7,641	-11%
Montgomery	11,715	11,793	11,935	11,878	11,629	11,352	-3%
Morgan	20,219	20,466	20,999	21,192	21,050	20,849	3%
New Madrid	18,162	18,027	17,636	16,999	16,155	15,317	-16%
Newton	59,229	61,915	68,934	75,600	81,720	88,117	49%
Nodaway	22,847	23,046	23,406	23,320	22,806	22,225	-3%
Oregon	10,990	11,167	11,575	11,807	11,858	11,876	8%
Osage	13,701	14,032	14,828	15,412	15,766	16,083	17%
Ozark	9,439	9,584	9,915	10,095	10,120	10,118	7%
Pemiscot	17,411	17,177	16,544	15,694	14,672	13,683	-21%
Perry	19,227	19,457	19,976	20,208	20,154	20,052	4%
Pettis	42,419	43,180	44,860	45,722	45,741	45,599	7%
Phelps	45,048	46,200	49,009	51,161	52,583	53,895	20%
Pike	18,387	18,590	19,018	19,132	18,936	18,686	2%
Platte	97,828	105,314	125,837	147,508	169,726	194,607	99%
Polk	31,598	33,203	37,428	41,519	45,346	49,390	56%
Pulaski	53,315	53,832	54,919	55,137	54,502	53,726	1%
Putnam	4,853	4,843	4,788	4,644	4,422	4,195	-14%
Ralls	10,238	10,439	10,926	11,275	11,479	11,659	14%
Randolph	25,176	25,529	26,316	26,681	26,624	26,492	5%
Ray	22,950	23,572	25,042	26,100	26,702	27,221	19%
Reynolds	6,440	6,488	6,581	6,563	6,439	6,299	-2%
Ripley	13,870	14,185	14,954	15,533	15,907	16,250	17%
Saint Charles	390,974	414,321	476,745	539,437	600,517	666,554	70%
Saint Clair	9,467	9,600	9,878	9,971	9,879	9,754	3%
Saint Francois	67,083	69,557	75,797	81,220	85,626	90,007	34%
Saint Louis	1,004,932	1,013,795	1,031,480	1,031,994	1,015,837	997,003	-1%
Saint Louis City	314,053	308,387	293,296	274,298	252,388	231,548	-26%
Ste. Genevieve	17,979	18,267	18,920	19,269	19,309	19,293	7%
Saline	23,281	23,427	23,646	23,415	22,758	22,041	-5%
Schuyler	4,449	4,512	4,643	4,688	4,646	4,589	3%
Scotland	4,849	4,841	4,804	4,695	4,523	4,346	-10%
Scott	39,051	39,331	39,906	39,893	39,319	38,659	-1%
Shannon	8,271	8,344	8,493	8,508	8,392	8,256	0%
Shelby	6,112	6,062	5,912	5,672	5,355	5,041	-18%

Table C-1. Projected Population to 2060 by County

County	Population Projections by County						Growth 2016–2060
	2016	2020	2030	2040	2050	2060	
Stoddard	29,929	30,280	31,070	31,413	31,311	31,136	4%
Stone	31,231	32,495	35,734	38,671	41,205	43,784	40%
Sullivan	6,349	6,349	6,307	6,147	5,880	5,604	-12%
Taney	55,346	58,618	67,392	76,247	84,934	94,351	70%
Texas	25,795	26,287	27,444	28,197	28,524	28,776	12%
Vernon	20,858	21,044	21,442	21,521	21,289	21,008	1%
Warren	33,836	35,246	38,854	42,117	44,918	47,765	41%
Washington	24,893	25,382	26,522	27,251	27,549	27,768	12%
Wayne	13,489	13,868	14,814	15,592	16,179	16,748	24%
Webster	37,789	39,140	42,558	45,538	47,975	50,403	33%
Worth	2,049	2,024	1,948	1,840	1,706	1,576	-23%
Wright	18,310	18,525	18,997	19,170	19,047	18,874	3%
STATE TOTAL	**6,177,768**	**6,273,843**	**6,665,432**	**6,986,254**	**7,228,615**	**7,484,904**	**22%**

Source: Woods & Poole Inc. 2017

Table C-2. Projected Employment to 2060 by County

County	Employment Projections by County						Growth 2016–2060
	2016	2020	2030	2040	2050	2060	
Adair	14,415	14,740	15,121	15,017	14,583	14,235	-1%
Andrew	5,144	5,330	5,716	5,983	6,157	6,375	24%
Atchison	2,952	3,048	3,240	3,329	3,371	3,432	16%
Audrain	13,373	13,629	14,065	14,333	14,528	14,830	11%
Barry	19,993	20,812	22,747	24,618	26,479	28,661	43%
Barton	5,852	6,065	6,425	6,510	6,477	6,462	10%
Bates	7,242	7,489	7,913	8,101	8,111	8,151	13%
Benton	7,065	7,387	8,027	8,499	8,823	9,217	30%
Bollinger	4,073	4,222	4,512	4,678	4,793	4,928	21%
Boone	127,274	136,094	158,080	178,025	197,557	220,989	74%
Buchanan	59,275	61,459	64,214	64,512	63,491	62,907	6%
Butler	25,651	27,182	31,047	34,772	38,538	42,918	67%
Caldwell	3,866	4,012	4,293	4,470	4,578	4,711	22%
Callaway	20,728	21,497	23,278	24,821	26,232	27,869	34%
Camden	25,149	26,496	29,844	33,023	36,203	39,823	58%
Cape Girardeau	55,348	58,710	66,892	74,405	81,638	89,891	62%
Carroll	4,993	5,110	5,277	5,301	5,231	5,194	4%
Carter	2,485	2,594	2,831	2,986	3,102	3,231	30%
Cass	39,637	42,547	49,644	55,971	62,224	69,405	75%
Cedar	6,039	6,325	6,932	7,376	7,738	8,171	35%
Chariton	4,075	4,184	4,350	4,393	4,338	4,297	5%
Christian	31,435	34,345	42,186	50,873	60,725	73,097	133%
Clark	2,905	2,988	3,116	3,155	3,129	3,108	7%
Clay	133,975	143,192	166,979	191,581	218,050	251,496	88%
Clinton	7,463	7,728	8,225	8,503	8,627	8,805	18%
Cole	65,712	67,881	72,845	76,933	80,339	84,291	28%
Cooper	8,456	8,703	9,221	9,571	9,832	10,138	20%
Crawford	10,156	10,568	11,397	11,982	12,462	12,991	28%
Dade	3,444	3,538	3,732	3,863	3,936	4,031	17%
Dallas	5,654	5,883	6,392	6,846	7,250	7,717	36%
Daviess	4,128	4,242	4,411	4,459	4,429	4,407	7%
DeKalb	5,454	5,691	6,123	6,342	6,446	6,561	20%
Dent	6,552	6,754	7,201	7,542	7,788	8,067	23%
Douglas	4,750	4,938	5,391	5,792	6,158	6,581	39%
Dunklin	14,646	15,141	16,354	17,489	18,546	19,786	35%
Franklin	55,606	58,343	64,733	70,185	75,376	81,227	46%

Table C-2. Projected Employment to 2060 by County

County	Employment Projections by County						Growth 2016–2060
	2016	2020	2030	2040	2050	2060	
Gasconade	8,821	9,006	9,368	9,591	9,716	9,856	12%
Gentry	4,093	4,202	4,376	4,427	4,365	4,313	5%
Greene	215,859	226,876	254,010	279,285	302,529	329,488	53%
Grundy	5,566	5,618	5,605	5,430	5,157	4,910	-12%
Harrison	4,811	4,923	5,072	5,079	4,999	4,931	2%
Henry	11,897	12,333	13,102	13,440	13,459	13,569	14%
Hickory	2,781	2,853	3,020	3,151	3,250	3,366	21%
Holt	2,537	2,607	2,711	2,742	2,722	2,710	7%
Howard	4,844	4,964	5,253	5,497	5,696	5,936	23%
Howell	22,220	23,073	25,079	26,869	28,481	30,350	37%
Iron	5,001	5,187	5,569	5,826	6,049	6,311	26%
Jackson	468,790	484,087	512,063	526,639	531,933	539,756	15%
Jasper	74,747	77,119	82,488	86,056	88,205	90,578	21%
Jefferson	70,947	74,622	83,752	92,465	101,263	111,243	57%
Johnson	27,200	28,166	30,150	31,433	32,151	33,042	21%
Knox	2,368	2,419	2,501	2,530	2,522	2,535	7%
Laclede	19,156	19,866	21,425	22,775	24,005	25,401	33%
Lafayette	14,223	14,670	15,362	15,531	15,309	15,163	7%
Lawrence	14,947	15,328	16,103	16,636	17,082	17,653	18%
Lewis	4,622	4,732	4,964	5,112	5,178	5,260	14%
Lincoln	19,224	20,404	23,363	26,260	29,188	32,558	69%
Linn	6,978	7,141	7,300	7,197	6,916	6,687	-4%
Livingston	9,305	9,566	9,953	10,032	9,925	9,853	6%
Macon	8,675	8,916	9,339	9,520	9,527	9,588	11%
Madison	5,523	5,755	6,319	6,852	7,396	8,029	45%
Maries	3,167	3,278	3,527	3,743	3,943	4,184	32%
Marion	18,552	19,621	22,070	24,146	25,947	27,953	51%
McDonald	10,279	10,714	11,628	12,358	12,888	13,522	32%
Mercer	1,783	1,839	1,926	1,947	1,931	1,920	8%
Miller	10,339	10,697	11,521	12,206	12,816	13,543	31%
Mississippi	5,535	5,655	5,931	6,046	6,048	6,082	10%
Moniteau	7,005	7,276	7,792	8,140	8,441	8,811	26%
Monroe	4,328	4,392	4,529	4,597	4,626	4,685	8%
Montgomery	5,281	5,431	5,676	5,805	5,867	5,950	13%
Morgan	8,240	8,397	8,691	8,815	8,832	8,876	8%
New Madrid	9,458	9,603	9,865	10,009	10,125	10,328	9%
Newton	28,655	30,843	36,187	41,002	45,730	51,310	79%
Nodaway	12,232	12,657	13,384	13,717	13,753	13,813	13%
Oregon	4,552	4,659	4,929	5,152	5,318	5,519	21%
Osage	6,782	7,069	7,717	8,266	8,771	9,343	38%
Ozark	3,387	3,468	3,652	3,790	3,896	4,027	19%
Pemiscot	7,819	7,986	8,292	8,467	8,573	8,799	13%
Perry	13,615	14,135	15,252	16,086	16,735	17,455	28%
Pettis	26,174	27,222	28,865	29,666	29,933	30,366	16%
Phelps	24,772	25,457	27,111	28,474	29,629	30,941	25%
Pike	8,987	9,250	9,787	10,211	10,573	10,997	22%
Platte	58,854	63,503	76,024	89,528	104,505	123,612	110%
Polk	13,799	14,522	16,293	18,032	19,822	21,976	59%
Pulaski	28,866	29,500	31,071	32,516	33,970	35,639	23%
Putnam	2,551	2,610	2,693	2,705	2,654	2,609	2%
Ralls	5,434	5,667	6,032	6,234	6,346	6,472	19%
Randolph	13,386	13,707	14,485	15,128	15,675	16,325	22%
Ray	7,767	8,079	8,698	9,104	9,378	9,725	25%
Reynolds	2,906	2,999	3,199	3,336	3,427	3,532	22%

Table C-2. Projected Employment to 2060 by County

County	Employment Projections by County						Growth 2016–2060
	2016	2020	2030	2040	2050	2060	
Ripley	4,878	5,106	5,650	6,162	6,702	7,371	51%
Saint Charles	197,295	211,222	248,800	289,066	333,099	385,382	95%
Saint Clair	3,460	3,549	3,692	3,734	3,708	3,694	7%
Saint Francois	30,934	32,413	35,977	39,196	42,202	45,551	47%
Saint Louis	795,111	836,478	933,517	1,018,101	1,089,089	1,170,064	47%
Saint Louis City	283,285	289,206	303,217	314,716	324,719	336,896	19%
Ste. Genevieve	8,383	8,657	9,372	10,019	10,630	11,355	35%
Saline	12,555	12,695	12,764	12,513	12,030	11,614	-7%
Schuyler	1,683	1,721	1,771	1,760	1,706	1,661	-1%
Scotland	2,703	2,775	2,894	2,919	2,875	2,838	5%
Scott	21,737	22,285	23,371	23,951	24,293	24,716	14%
Shannon	3,137	3,181	3,268	3,312	3,332	3,366	7%
Shelby	3,612	3,682	3,798	3,864	3,902	3,972	10%
Stoddard	15,905	16,572	18,087	19,346	20,436	21,738	37%
Stone	11,733	12,230	13,575	14,803	15,890	17,145	46%
Sullivan	4,083	4,171	4,287	4,278	4,166	4,069	0%
Taney	37,845	40,128	46,186	51,939	57,582	64,028	69%
Texas	10,200	10,566	11,326	11,889	12,334	12,844	26%
Vernon	11,220	11,636	12,429	12,860	13,118	13,407	19%
Warren	11,723	12,286	13,549	14,559	15,503	16,578	41%
Washington	7,496	7,812	8,469	8,935	9,301	9,716	30%
Wayne	4,563	4,846	5,495	6,064	6,659	7,441	63%
Webster	14,220	14,804	16,222	17,476	18,681	20,071	41%
Worth	1,124	1,159	1,196	1,188	1,137	1,096	-3%
Wright	8,182	8,354	8,743	9,025	9,199	9,420	15%
STATE TOTAL	**3,711,672**	**3,881,070**	**4,275,483**	**4,617,515**	**4,926,753**	**5,295,430**	**43%**

Source: Woods & Poole Inc. 2017

Table C-3. Major Water Systems Population Served Forecast to 2060 by County

County	Major Water Systems Population Served						Growth 2016-2060
	2016	2020	2030	2040	2050	2060	
Adair	25,642	25,655	26,083	26,015	25,470	24,580	-3%
Andrew	14,946	15,970	18,837	19,528	19,872	20,151	35%
Atchison	2,901	2,854	2,726	2,554	2,351	2,155	-26%
Audrain	18,602	18,727	18,958	18,873	18,494	18,072	-3%
Barry	17,417	17,871	18,980	19,836	20,412	20,947	20%
Barton	10,106	10,229	10,509	10,635	10,608	10,554	4%
Bates	14,519	14,697	15,056	15,133	14,928	14,676	1%
Benton	5,209	5,337	5,638	5,842	5,942	6,023	16%
Bollinger	0	0	0	0	0	0	N/A
Boone	154,547	164,218	190,260	216,813	243,171	271,963	76%
Buchanan	89,045	89,835	91,265	90,960	88,985	86,749	-3%
Butler	31,720	32,622	34,807	36,387	37,324	38,161	20%
Caldwell	4,411	4,468	4,585	4,615	4,560	4,490	2%
Callaway	35,717	36,719	39,170	41,099	42,441	43,704	22%
Camden	24,409	26,720	32,791	38,659	44,141	49,932	105%
Cape Girardeau	64,317	66,419	71,740	76,346	80,104	83,846	30%
Carroll	7,293	7,243	7,075	6,780	6,377	5,977	-18%
Carter	0	0	0	0	0	0	N/A
Cass	99,900	106,403	123,790	141,286	158,286	176,712	77%
Cedar	7,924	8,144	8,691	9,135	9,465	9,782	23%
Chariton	5,115	5,072	4,937	4,714	4,418	4,127	-19%
Christian	46,722	50,831	62,500	75,623	90,090	107,030	129%
Clark	5,131	5,628	6,527	6,251	5,900	5,556	8%

Table C-3. Major Water Systems Population Served Forecast to 2060 by County

County	Major Water Systems Population Served						Growth 2016-2060
	2016	2020	2030	2040	2050	2060	
Clay	228,755	243,260	281,890	320,458	357,595	397,641	74%
Clinton	20,212	20,751	22,023	22,930	23,434	23,865	18%
Cole	64,411	65,712	68,769	70,786	71,712	72,445	12%
Cooper	12,739	12,938	13,386	13,623	13,645	13,629	7%
Crawford	8,656	8,811	9,168	9,381	9,444	9,479	10%
Dade	2,587	2,620	2,692	2,723	2,711	2,692	4%
Dallas	3,501	3,620	3,920	4,177	4,383	4,586	31%
Daviess	7,312	7,965	8,616	8,684	8,591	8,470	16%
DeKalb	12,802	12,989	13,545	13,857	13,915	13,925	9%
Dent	6,700	6,819	7,096	7,267	7,327	7,366	10%
Douglas	2,993	3,085	3,316	3,506	3,651	3,791	27%
Dunklin	30,532	30,570	30,553	30,074	29,175	28,231	-8%
Franklin	57,286	58,063	59,773	60,509	60,264	59,846	4%
Gasconade	5,980	6,119	6,856	8,099	9,759	11,857	98%
Gentry	5,776	6,089	6,645	6,477	6,198	5,910	2%
Greene	212,128	220,872	243,337	263,819	281,614	299,783	41%
Grundy	10,279	10,137	10,165	10,000	9,656	9,291	-10%
Harrison	6,242	6,891	8,876	8,867	8,695	8,496	36%
Henry	18,664	18,945	19,540	19,774	19,641	19,443	4%
Hickory	2,553	2,613	2,758	2,865	2,930	2,988	17%
Holt	4,013	4,338	4,308	4,108	3,845	3,587	-11%
Howard	8,190	8,232	8,299	8,229	8,031	7,816	-5%
Howell	21,200	21,687	22,863	23,718	24,225	24,676	16%
Iron	2,799	2,810	2,824	2,791	2,714	2,631	-6%
Jackson	674,403	681,529	695,279	695,853	683,601	669,218	-1%
Jasper	97,310	99,126	103,457	106,360	107,774	108,936	12%
Jefferson	168,236	178,851	206,381	232,185	255,357	279,385	66%
Johnson	47,357	48,283	50,358	51,528	51,753	51,797	9%
Knox	3,759	3,727	3,625	3,458	3,238	3,022	-20%
Laclede	30,325	30,989	32,575	33,699	34,324	34,864	15%
Lafayette	32,432	32,985	34,195	34,776	34,716	34,535	6%
Lawrence	16,919	17,255	18,052	18,585	18,838	19,043	13%
Lewis	5,167	5,151	5,098	4,974	4,788	4,598	-11%
Lincoln	29,422	31,033	35,292	39,467	43,424	47,637	62%
Linn	12,603	12,357	12,390	12,189	11,769	11,324	-10%
Livingston	15,062	15,250	15,630	15,716	15,511	15,254	1%
Macon	16,875	15,459	15,629	15,501	15,092	14,642	-13%
Madison	5,959	6,060	6,292	6,424	6,453	6,462	8%
Maries	2,155	2,219	2,377	2,504	2,596	2,685	25%
Marion	25,829	25,974	26,266	26,188	25,760	25,283	-2%
McDonald	10,122	10,332	10,806	11,086	11,165	11,204	11%
Mercer	3,358	3,342	3,280	3,158	2,985	2,812	-16%
Miller	7,214	7,374	7,755	8,021	8,165	8,289	15%
Mississippi	12,734	13,135	13,806	13,445	12,909	12,365	-3%
Moniteau	9,581	9,845	10,487	10,988	11,332	11,654	22%
Monroe	8,570	8,560	8,496	8,294	7,969	7,636	-11%
Montgomery	5,450	5,486	5,552	5,526	5,410	5,281	-3%
Morgan	7,081	7,328	7,861	8,054	7,912	7,711	9%
New Madrid	12,000	11,865	11,474	10,837	9,993	9,155	-24%
Newton	24,435	25,543	28,439	31,189	33,714	36,353	49%
Nodaway	19,681	19,852	20,163	20,088	19,646	19,145	-3%
Oregon	3,600	3,658	3,792	3,868	3,884	3,890	8%
Osage	4,221	4,323	4,568	4,748	4,857	4,955	17%
Ozark	0	0	0	0	0	0	N/A

Table C-3. Major Water Systems Population Served Forecast to 2060 by County

County	Major Water Systems Population Served						Growth 2016-2060
	2016	2020	2030	2040	2050	2060	
Pemiscot	16,950	16,722	16,106	15,278	14,284	13,321	-21%
Perry	11,615	11,754	12,067	12,208	12,175	12,114	4%
Pettis	26,280	26,751	27,792	28,326	28,338	28,250	7%
Phelps	26,813	27,499	29,171	30,452	31,298	32,079	20%
Pike	15,770	15,944	16,311	16,409	16,241	16,027	2%
Platte	87,633	94,339	112,723	132,136	152,038	174,327	99%
Polk	12,729	13,376	15,078	16,726	18,267	19,896	56%
Pulaski	51,667	52,168	53,221	53,433	52,817	52,066	1%
Putnam	4,853	4,843	4,788	4,644	4,422	4,195	-14%
Ralls	10,037	10,234	10,711	11,054	11,254	11,430	14%
Randolph	24,878	25,227	26,005	26,365	26,309	26,179	5%
Ray	21,447	22,028	23,402	24,391	24,953	25,439	19%
Reynolds	1,387	1,397	1,417	1,413	1,387	1,357	-2%
Ripley	6,475	6,622	6,981	7,251	7,426	7,586	17%
Saint Charles	390,818	414,156	476,555	539,222	600,277	666,288	70%
Saint Clair	2,754	2,793	2,874	2,901	2,874	2,838	3%
Saint Francois	41,197	42,716	46,548	49,879	52,585	55,275	34%
Saint Louis	1,000,371	1,009,193	1,026,798	1,027,310	1,011,226	992,478	-1%
Saint Louis City	311,404	305,786	290,822	271,984	250,259	229,595	-26%
Ste. Genevieve	10,928	11,103	11,500	11,712	11,736	11,727	7%
Saline	19,022	19,141	19,320	19,131	18,595	18,009	-5%
Schuyler	4,740	4,512	4,643	4,688	4,646	4,589	-3%
Scotland	4,849	4,841	4,804	4,695	4,523	4,346	-10%
Scott	30,772	30,993	31,446	31,435	30,983	30,463	-1%
Shannon	2,110	2,129	2,167	2,170	2,141	2,106	0%
Shelby	4,774	4,735	4,618	4,430	4,183	3,938	-18%
Stoddard	21,329	21,579	22,142	22,387	22,314	22,189	4%
Stone	9,248	9,622	10,581	11,451	12,201	12,965	40%
Sullivan	7,514	6,349	6,307	6,147	5,880	5,604	-25%
Taney	47,102	49,887	57,354	64,890	72,283	80,297	70%
Texas	15,845	16,147	16,858	17,320	17,521	17,676	12%
Vernon	18,653	19,201	21,442	21,521	21,289	21,008	13%
Warren	20,292	21,138	23,301	25,258	26,938	28,645	41%
Washington	4,500	4,989	6,129	6,858	7,156	7,375	64%
Wayne	4,590	4,969	5,915	6,693	7,280	7,849	71%
Webster	13,025	13,491	14,669	15,696	16,536	17,373	33%
Worth	1,320	1,304	1,255	1,185	1,099	1,015	-23%
Wright	7,522	7,610	7,804	7,875	7,825	7,754	3%
STATE TOTAL	**5,066,976**	**5,195,780**	**5,527,139**	**5,789,441**	**5,984,989**	**6,192,701**	**22%**

N/A – not applicable

Table C-4. Major Water Systems GPCD Forecast to 2060 by County

County	Major Water Systems GPCD					
	2016	2020	2030	2040	2050	2060
Adair	86.0	85.5	84.6	83.5	82.6	82.6
Andrew	92.6	90.0	89.3	86.7	86.4	87.0
Atchison	174	175	173	177	181	188
Audrain	115	114	112	112	112	114
Barry	246	245	248	249	251	256
Barton	94.9	94.2	94.0	93.2	92.6	92.6
Bates	99.4	98.6	98.2	97.8	97.4	98.2
Benton	90.4	90.4	91.5	91.3	91.2	92.1
Bollinger	0.00	0.00	0.00	0.00	0.00	0.00
Boone	117	114	120	119	118	118

Table C-4. Major Water Systems GPCD Forecast to 2060 by County

County	Major Water Systems GPCD					
	2016	2020	2030	2040	2050	2060
Buchanan	195	194	193	191	190	191
Butler	91.6	91.1	94.1	95.4	97.3	100
Caldwell	74.3	74.1	74.6	74.6	74.9	76.1
Callaway	101	99	100	100	100	101
Camden	124	120	126	121	118	117
Cape Girardeau	120	119	123	124	126	128
Carroll	110	110	108	108	109	111
Carter	0.00	0.00	0.00	0.00	0.00	0.00
Cass	69.9	68.2	72.1	71.2	70.5	70.7
Cedar	122	121	123	122	122	123
Chariton	94.7	95.0	93.6	94.4	95.2	97.1
Christian	128	125	135	135	135	136
Clark	138	134	124	125	127	129
Clay	160	157	165	165	165	167
Clinton	115	114	114	113	112	112
Cole	110	109	110	110	110	111
Cooper	130	129	129	128	128	130
Crawford	151	151	153	153	153	155
Dade	127	127	127	127	127	128
Dallas	125	124	126	125	125	126
Daviess	81.0	78.5	76.9	76.2	75.7	75.9
DeKalb	144	143	144	143	142	143
Dent	121	120	120	120	120	121
Douglas	185	184	187	187	187	189
Dunklin	95.0	94.6	94.6	96.5	98.9	102
Franklin	112	112	114	116	118	122
Gasconade	124	123	125	122	116	110
Gentry	86.7	84.9	81.2	81.3	81.5	82.5
Greene	163	161	166	166	166	167
Grundy	246	245	239	235	232	231
Harrison	122	118	114	107	106	106
Henry	99.0	98.3	98.5	97.9	97.3	97.9
Hickory	69.0	68.5	69.4	68.8	68.6	69.0
Holt	74.2	72.1	70.3	70.9	71.8	73.4
Howard	120	119	119	120	121	124
Howell	142	141	142	143	144	146
Iron	89.6	90.6	90.5	91.4	92.8	95.2
Jackson	145	144	144	143	144	145
Jasper	183	181	182	182	181	182
Jefferson	97.0	94.5	98.1	96.3	95.3	95.5
Johnson	83.9	83.2	84.0	83.6	83.5	84.2
Knox	84.8	84.7	83.0	83.7	84.8	87.0
Laclede	130	128	129	129	130	132
Lafayette	277	274	273	269	266	266
Lawrence	151	150	149	148	148	149
Lewis	95.6	95.5	94.4	95.4	96.5	98.3
Lincoln	95.2	93.4	97.5	96.9	96.8	97.5
Linn	103	103	101	100	99	99
Livingston	106	105	104	103	102	103
Macon	171	175	174	173	174	176
Madison	106	106	107	109	110	114
Maries	92.6	92.0	93.0	92.4	92.3	93.1
Marion	140	140	143	147	150	155
McDonald	187	186	188	188	189	192

Table C-4. Major Water Systems GPCD Forecast to 2060 by County

County	Major Water Systems GPCD					
	2016	2020	2030	2040	2050	2060
Mercer	98.6	98.4	97.1	97.6	98.5	100
Miller	129	128	130	129	130	132
Mississippi	165	162	158	159	160	162
Moniteau	148	146	148	146	145	146
Monroe	84.1	83.5	82.1	82.4	83.1	84.7
Montgomery	81.1	81.0	80.6	80.6	80.9	82.0
Morgan	86.4	85.2	84.8	82.4	81.4	82.2
New Madrid	147	146	143	145	148	153
Newton	243	242	254	255	257	261
Nodaway	103	103	102	102	102	103
Oregon	247	246	246	245	246	249
Osage	86.9	87.0	88.2	88.2	88.8	90.1
Ozark	0.00	0.00	0.00	0.00	0.00	0.00
Pemiscot	127	127	125	127	129	134
Perry	128	128	129	129	130	133
Pettis	137	137	137	136	135	136
Phelps	114	113	113	113	112	113
Pike	96.0	95.4	95.6	95.9	96.7	98.4
Platte	159	155	166	165	165	167
Polk	96.3	94.9	98.2	97.4	97.1	97.8
Pulaski	103	102	101	102	103	105
Putnam	79.2	78.8	77.4	77.5	77.6	78.6
Ralls	79.6	78.8	79.0	78.4	78.0	78.1
Randolph	74.6	73.8	73.7	73.8	74.2	75.4
Ray	105	103	104	103	103	103
Reynolds	105	106	106	107	108	110
Ripley	107	106	108	109	110	113
Saint Charles	150	147	156	156	157	160
Saint Clair	143	143	142	140	139	140
Saint Francois	110	109	111	111	111	112
Saint Louis	160	160	163	166	170	175
Saint Louis City	435	437	429	440	455	474
Ste. Genevieve	137	135	136	137	139	142
Saline	163	161	158	155	153	153
Schuyler	52.9	53.4	53.6	52.8	52.0	51.7
Scotland	70.6	70.3	69.4	69.5	69.6	70.2
Scott	177	176	175	175	176	178
Shannon	101	100	99.1	98.5	98.5	99.4
Shelby	88.8	88.7	87.0	87.9	89.2	91.6
Stoddard	147	146	147	149	151	155
Stone	200	198	203	202	201	203
Sullivan	70.4	74.4	73.2	73.0	72.8	73.4
Taney	176	172	181	179	178	178
Texas	97.7	96.8	97.3	97.2	97.4	98.5
Vernon	103	102	104	98.9	99.3	101
Warren	84.3	82.9	85.0	84.1	83.5	83.7
Washington	131	127	131	122	119	119
Wayne	202	197	206	199	196	199
Webster	79.8	79.0	80.5	80.0	80.0	80.6
Worth	50.0	50.8	50.9	51.2	51.3	52.1
Wright	136	135	134	134	134	136
STATE WEIGHTED AVERAGE	**159**	**157**	**158**	**157**	**157**	**158**

Table C-5. Major Water Systems Demand Forecast to 2060 by County

County	Percent of Demand Source		Major Water Systems Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Adair	0%	100%	2.20	2.19	2.19	2.18	2.13	2.08
Andrew	100%	0%	1.38	1.44	1.60	1.67	1.70	1.74
Atchison	100%	0%	0.50	0.50	0.48	0.47	0.44	0.42
Audrain	92%	8%	2.13	2.13	2.12	2.12	2.10	2.09
Barry	100%	0%	4.29	4.37	4.58	4.85	5.07	5.30
Barton	60%	40%	0.96	0.96	0.98	0.99	0.98	0.98
Bates	0%	100%	1.44	1.45	1.46	1.48	1.47	1.45
Benton	100%	0%	0.47	0.48	0.50	0.53	0.54	0.55
Bollinger	0%	0%	0.00	0.00	0.00	0.00	0.00	0.00
Boone	100%	0%	18.0	18.8	21.3	24.2	27.1	30.4
Buchanan	100%	0%	17.4	17.5	17.5	17.5	17.1	16.8
Butler	43%	57%	2.91	2.97	3.17	3.41	3.59	3.79
Caldwell	36%	64%	0.33	0.33	0.34	0.34	0.34	0.34
Callaway	100%	0%	3.59	3.64	3.81	4.02	4.19	4.36
Camden	100%	0%	3.02	3.21	3.75	4.33	4.89	5.49
Cape Girardeau	100%	0%	7.72	7.92	8.51	9.21	9.83	10.48
Carroll	100%	0%	0.80	0.80	0.77	0.75	0.72	0.69
Carter	0%	0%	0.00	0.00	0.00	0.00	0.00	0.00
Cass	19%	81%	6.98	7.25	8.28	9.44	10.57	11.82
Cedar	100%	0%	0.97	0.98	1.04	1.09	1.14	1.19
Chariton	82%	18%	0.48	0.48	0.47	0.46	0.44	0.41
Christian	100%	0%	5.99	6.33	7.64	9.29	11.13	13.36
Clark	100%	0%	0.71	0.75	0.82	0.80	0.77	0.74
Clay	44%	56%	36.7	38.2	43.4	49.6	55.9	63.1
Clinton	5%	95%	2.33	2.36	2.45	2.55	2.59	2.64
Cole	53%	47%	7.07	7.16	7.38	7.67	7.85	8.03
Cooper	36%	64%	1.65	1.67	1.69	1.74	1.75	1.77
Crawford	100%	0%	1.31	1.33	1.37	1.42	1.44	1.47
Dade	100%	0%	0.33	0.33	0.34	0.34	0.34	0.35
Dallas	100%	0%	0.44	0.45	0.48	0.51	0.54	0.56
Daviess	91%	9%	0.59	0.63	0.65	0.66	0.65	0.65
DeKalb	32%	68%	1.85	1.86	1.91	1.97	1.98	1.99
Dent	100%	0%	0.81	0.82	0.84	0.86	0.88	0.89
Douglas	100%	0%	0.55	0.57	0.60	0.64	0.67	0.70
Dunklin	100%	0%	2.90	2.89	2.89	2.93	2.93	2.94
Franklin	100%	0%	6.44	6.53	6.74	6.99	7.15	7.30
Gasconade	100%	0%	0.74	0.75	0.80	0.90	1.03	1.18
Gentry	76%	24%	0.50	0.52	0.54	0.54	0.52	0.50
Greene	20%	80%	34.6	35.7	38.6	42.1	45.2	48.6
Grundy	0%	100%	2.53	2.48	2.43	2.37	2.28	2.19
Harrison	36%	64%	0.76	0.81	0.95	0.95	0.93	0.91
Henry	17%	83%	1.85	1.86	1.90	1.93	1.92	1.91
Hickory	100%	0%	0.18	0.18	0.19	0.19	0.20	0.20
Holt	100%	0%	0.30	0.31	0.31	0.30	0.29	0.27
Howard	51%	49%	0.99	0.98	0.98	0.99	0.99	0.99
Howell	100%	0%	3.00	3.05	3.18	3.33	3.45	3.57
Iron	58%	42%	0.25	0.25	0.26	0.26	0.26	0.25
Jackson	45%	55%	97.8	98.2	99.0	100	99.2	98.2
Jasper	50%	50%	17.8	18.0	18.5	19.1	19.4	19.7
Jefferson	37%	63%	16.3	16.9	18.9	21.1	23.3	25.5
Johnson	95%	5%	3.97	4.02	4.15	4.27	4.32	4.36
Knox	0%	100%	0.32	0.32	0.31	0.30	0.28	0.27
Laclede	100%	0%	3.93	3.97	4.11	4.29	4.43	4.56
Lafayette	80%	20%	8.99	9.04	9.18	9.31	9.26	9.20

Table C-5. Major Water Systems Demand Forecast to 2060 by County

County	Percent of Demand Source		Major Water Systems Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Lawrence	100%	0%	2.55	2.58	2.64	2.72	2.77	2.82
Lewis	77%	23%	0.49	0.49	0.48	0.48	0.47	0.46
Lincoln	100%	0%	2.80	2.90	3.23	3.63	4.01	4.43
Linn	8%	92%	1.30	1.27	1.25	1.23	1.19	1.15
Livingston	100%	0%	1.60	1.60	1.61	1.62	1.60	1.58
Macon	0%	100%	2.88	2.71	2.71	2.71	2.66	2.61
Madison	32%	68%	0.63	0.64	0.66	0.69	0.71	0.73
Maries	100%	0%	0.20	0.20	0.21	0.23	0.24	0.25
Marion	10%	90%	3.62	3.65	3.74	3.85	3.91	3.96
McDonald	100%	0%	1.89	1.93	1.99	2.07	2.11	2.15
Mercer	41%	59%	0.33	0.33	0.32	0.32	0.30	0.29
Miller	100%	0%	0.93	0.95	0.98	1.02	1.05	1.08
Mississippi	100%	0%	2.10	2.13	2.19	2.17	2.11	2.05
Moniteau	100%	0%	1.42	1.44	1.50	1.57	1.62	1.68
Monroe	0%	100%	0.72	0.72	0.70	0.69	0.68	0.66
Montgomery	83%	17%	0.44	0.44	0.45	0.45	0.44	0.44
Morgan	100%	0%	0.61	0.62	0.65	0.66	0.65	0.64
New Madrid	100%	0%	1.76	1.74	1.67	1.62	1.54	1.46
Newton	38%	62%	5.94	6.17	6.85	7.62	8.34	9.13
Nodaway	5%	95%	2.03	2.04	2.05	2.06	2.03	2.00
Oregon	100%	0%	0.89	0.90	0.92	0.94	0.95	0.97
Osage	100%	0%	0.37	0.38	0.39	0.41	0.43	0.44
Ozark	0%	0%	0.00	0.00	0.00	0.00	0.00	0.00
Pemiscot	100%	0%	2.16	2.13	2.05	1.99	1.91	1.84
Perry	45%	55%	1.49	1.50	1.53	1.57	1.59	1.61
Pettis	100%	0%	3.61	3.66	3.74	3.83	3.84	3.85
Phelps	100%	0%	3.06	3.10	3.21	3.36	3.47	3.58
Pike	0%	100%	1.51	1.52	1.54	1.57	1.58	1.59
Platte	48%	52%	13.9	14.6	17.1	20.2	23.4	27.2
Polk	100%	0%	1.23	1.27	1.40	1.55	1.70	1.86
Pulaski	57%	43%	5.30	5.30	5.33	5.43	5.47	5.51
Putnam	0%	100%	0.38	0.38	0.37	0.37	0.35	0.34
Ralls	0%	100%	0.80	0.81	0.83	0.86	0.87	0.89
Randolph	0%	100%	1.86	1.86	1.89	1.94	1.96	1.98
Ray	100%	0%	2.25	2.27	2.37	2.47	2.54	2.60
Reynolds	100%	0%	0.15	0.15	0.15	0.15	0.15	0.15
Ripley	100%	0%	0.69	0.70	0.73	0.78	0.81	0.85
Saint Charles	27%	73%	58.7	60.8	69.2	79.3	89.6	101.2
Saint Clair	75%	25%	0.39	0.40	0.40	0.41	0.40	0.40
Saint Francois	100%	0%	4.53	4.64	4.97	5.36	5.70	6.05
Saint Louis	1%	99%	160	161	166	171	173	175
Saint Louis City	0%	100%	135	134	128	124	119	114
Ste. Genevieve	100%	0%	1.49	1.50	1.54	1.60	1.63	1.67
Saline	100%	0%	3.10	3.09	3.03	2.99	2.90	2.81
Schuyler	0%	100%	0.25	0.24	0.25	0.25	0.24	0.24
Scotland	0%	100%	0.34	0.34	0.34	0.33	0.32	0.31
Scott	100%	0%	5.46	5.46	5.47	5.51	5.49	5.46
Shannon	100%	0%	0.21	0.21	0.21	0.21	0.21	0.21
Shelby	0%	100%	0.42	0.42	0.41	0.40	0.38	0.37
Stoddard	100%	0%	3.13	3.15	3.22	3.32	3.38	3.44
Stone	100%	0%	1.85	1.90	2.05	2.23	2.38	2.55
Sullivan	0%	100%	0.53	0.47	0.46	0.46	0.44	0.42
Taney	60%	40%	8.28	8.60	9.68	10.96	12.21	13.60
Texas	100%	0%	1.55	1.56	1.61	1.66	1.70	1.73

Table C-5. Major Water Systems Demand Forecast to 2060 by County

County	Percent of Demand Source		Major Water Systems Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Vernon	100%	0%	1.92	1.96	2.10	2.13	2.13	2.13
Warren	100%	0%	1.71	1.75	1.89	2.04	2.18	2.32
Washington	100%	0%	0.59	0.63	0.73	0.80	0.84	0.87
Wayne	41%	59%	0.93	0.98	1.12	1.26	1.38	1.50
Webster	100%	0%	1.04	1.07	1.13	1.22	1.29	1.37
Worth	100%	0%	0.07	0.07	0.07	0.06	0.06	0.06
Wright	100%	0%	1.02	1.03	1.03	1.05	1.05	1.06
STATE TOTAL	**38%**	**62%**	**807**	**817**	**850**	**893**	**926**	**963**

Table C-6. Self-Supplied Nonresidential Current Water Use by County

County	Number of Users	Annual Demand (MGD)
Audrain	1	0.42
Barry	4	1.38
Benton	3	0.03
Boone	2	1.79
Buchanan	1	0.12
Callaway	2	2.16
Camden	7	0.10
Cape Girardeau	5	11.1
Carroll	1	0.46
Cedar	1	0.01
Christian	1	0.29
Clay	2	4.12
Cole	2	0.12
Cooper	1	0.02
Dallas	1	0.00
Dent	1	0.03
Franklin	3	0.10
Gasconade	1	0.01
Greene	10	0.66
Holt	1	0.51
Iron	3	0.03
Jackson	2	1.66
Jasper	3	0.34
Jefferson	6	0.55
Johnson	2	0.61
Laclede	1	0.04
Lawrence	4	0.11
Lincoln	3	0.01
Maries	3	0.06
Marion	1	2.13
McDonald	2	2.63
Miller	3	0.01
Morgan	1	0.02
New Madrid	1	2.28
Newton	3	0.18
Pettis	3	2.19
Phelps	2	0.01
Pike	2	0.95
Platte	1	0.13
Polk	1	0.01
Ralls	1	0.15
Saint Charles	3	0.81

Table C-6. Self-Supplied Nonresidential Current Water Use by County

County	Number of Users	Annual Demand (MGD)
Saint Clair	1	0.03
Saint Francois	3	1.08
Saint Louis	5	1.63
Ste. Genevieve	2	1.93
Saline	1	0.36
Stoddard	1	0.01
Stone	4	0.91
Sullivan	1	0.86
Taney	10	2.61
Texas	1	0.55
Warren	1	0.50
Washington	3	1.44
Webster	1	0.05
STATE TOTAL	**135**	**50.2**

Note: only 55 of the 115 counties in Missouri have registered water users that make up the Self-Supplied Nonresidential sector

Table C-7. Self-Supplied Nonresidential Demand Forecast to 2060 by County

County	Percent of Demand Source		Self-Supplied Nonresidential Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Audrain	100%	0%	0.42	0.41	0.37	0.32	0.27	0.23
Barry	85%	15%	1.38	1.41	1.46	1.50	1.53	1.56
Benton	100%	0%	0.03	0.03	0.03	0.03	0.04	0.04
Boone	100%	0%	1.79	2.00	2.60	3.16	3.49	3.86
Buchanan	100%	0%	0.12	0.12	0.12	0.11	0.10	0.09
Callaway	100%	0%	2.16	2.21	2.31	2.42	2.52	2.63
Camden	100%	0%	0.10	0.11	0.12	0.14	0.15	0.17
Cape Girardeau	76%	24%	11.05	11.28	11.45	11.43	11.28	11.16
Carroll	100%	0%	0.46	0.46	0.40	0.33	0.26	0.21
Cedar	100%	0%	0.01	0.01	0.01	0.01	0.01	0.01
Christian	100%	0%	0.29	0.29	0.29	0.29	0.29	0.29
Clay	100%	0%	4.12	4.06	3.74	3.37	2.99	2.66
Cole	100%	0%	0.12	0.12	0.14	0.15	0.17	0.18
Cooper	0%	100%	0.02	0.02	0.02	0.01	0.01	0.01
Dallas	100%	0%	0.001	0.001	0.001	0.002	0.002	0.002
Dent	100%	0%	0.03	0.03	0.03	0.03	0.03	0.03
Franklin	100%	0%	0.10	0.10	0.10	0.10	0.10	0.10
Gasconade	100%	0%	0.01	0.01	0.02	0.01	0.01	0.01
Greene	100%	0%	0.66	0.66	0.65	0.62	0.59	0.56
Holt	100%	0%	0.51	0.55	0.61	0.66	0.71	0.76
Iron	100%	0%	0.03	0.03	0.03	0.03	0.03	0.03
Jackson	97%	3%	1.66	1.68	1.73	1.77	1.80	1.83
Jasper	100%	0%	0.34	0.35	0.35	0.34	0.34	0.33
Jefferson	100%	0%	0.55	0.59	0.68	0.80	0.93	1.08
Johnson	100%	0%	0.61	0.61	0.61	0.62	0.62	0.62
Laclede	100%	0%	0.04	0.04	0.04	0.05	0.05	0.05
Lawrence	100%	0%	0.11	0.11	0.11	0.11	0.11	0.11
Lincoln	100%	0%	0.01	0.01	0.01	0.01	0.02	0.02
Maries	100%	0%	0.06	0.06	0.05	0.05	0.05	0.04
Marion	0%	100%	2.13	2.17	2.07	1.89	1.70	1.53
McDonald*	100%	0%	2.63	5.07	5.14	5.14	5.13	5.11
Miller	100%	0%	0.01	0.01	0.02	0.02	0.02	0.02
Morgan	100%	0%	0.02	0.02	0.02	0.01	0.01	0.01
New Madrid	100%	0%	2.28	2.20	1.99	1.77	1.57	1.39
Newton	100%	0%	0.18	0.19	0.20	0.21	0.23	0.24
Pettis	100%	0%	2.19	2.31	2.32	2.18	1.98	1.80

Table C-7. Self-Supplied Nonresidential Demand Forecast to 2060 by County

County	Percent of Demand Source		Self-Supplied Nonresidential Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Phelps	100%	0%	0.01	0.01	0.01	0.01	0.01	0.01
Pike	0%	100%	0.95	0.89	0.71	0.55	0.42	0.32
Platte	100%	0%	0.13	0.13	0.14	0.14	0.14	0.15
Polk	100%	0%	0.01	0.01	0.01	0.01	0.01	0.01
Ralls	0%	100%	0.15	0.16	0.18	0.20	0.22	0.24
Saint Charles	100%	0%	0.81	0.83	0.86	0.87	0.89	0.9
Saint Clair	100%	0%	0.03	0.03	0.03	0.04	0.04	0.04
Saint Francois	100%	0%	1.08	1.15	1.3	1.43	1.57	1.71
Saint Louis	100%	0%	1.63	1.7	1.9	2.1	2.3	2.52
Ste. Genevieve	100%	0%	1.93	2.01	2.22	2.45	2.69	2.97
Saline	100%	0%	0.36	0.35	0.31	0.28	0.24	0.21
Stoddard	100%	0%	0.01	0.01	0.01	0.01	0.01	0.01
Stone	100%	0%	0.91	0.90	0.92	0.93	0.90	0.87
Sullivan	0%	100%	0.86	0.87	0.87	0.85	0.82	0.80
Taney	94%	6%	2.61	2.79	3.30	3.81	4.34	4.95
Texas	100%	0%	0.55	0.54	0.51	0.46	0.41	0.37
Warren	100%	0%	0.50	0.51	0.52	0.52	0.53	0.53
Washington	7%	93%	1.44	1.43	1.39	1.35	1.31	1.28
Webster	100%	0%	0.05	0.05	0.06	0.06	0.07	0.07
STATE TOTAL	**83%**	**17%**	**50.2**	**53.7**	**55.1**	**55.8**	**56.1**	**56.7**

Note: only 55 of the 115 counties in Missouri have registered water users that make up the Self-Supplied Nonresidential sector.
*McDonald County demands are increased according to plant expansion information provided through the technical work group process.

Table C-8. Self-Supplied Domestic and Minor Systems Population Served Forecast to 2060 by County

County	Self-Supplied Domestic and Minor Systems Population Served					
	2016	2020	2030	2040	2050	2060
Adair	0	0	0	0	0	0
Andrew	2,447	1,856	0	0	0	0
Atchison	2,381	2,343	2,237	2,097	1,929	1,769
Audrain	7,521	7,571	7,664	7,631	7,478	7,307
Barry	18,620	19,105	20,290	21,207	21,822	22,394
Barton	1,803	1,825	1,875	1,897	1,892	1,882
Bates	1,968	1,992	2,041	2,051	2,024	1,989
Benton	13,565	13,900	14,681	15,213	15,474	15,684
Bollinger	12,238	12,500	13,134	13,597	13,878	14,131
Boone	22,989	24,428	28,301	32,251	36,172	40,455
Buchanan	201	203	206	205	201	196
Butler	11,425	11,425	11,425	11,425	11,425	11,425
Caldwell	4,627	4,687	4,809	4,842	4,784	4,710
Callaway	9,399	9,663	10,308	10,815	11,169	11,501
Camden	20,360	20,360	20,360	20,360	20,360	20,360
Cape Girardeau	14,836	15,321	16,548	17,611	18,478	19,341
Carroll	1,678	1,667	1,628	1,560	1,467	1,375
Carter	6,287	6,399	6,667	6,844	6,926	6,992
Cass	3,258	3,470	4,037	4,608	5,162	5,763
Cedar	6,096	6,265	6,686	7,028	7,281	7,525
Chariton	2,454	2,434	2,369	2,262	2,120	1,980
Christian	38,276	41,643	51,201	61,952	73,805	87,682
Clark	1,649	1,085	0	0	0	0
Clay	10,394	11,053	12,808	14,561	16,248	18,068
Clinton	521	535	568	591	604	615
Cole	12,645	12,901	13,500	13,896	14,078	14,222
Cooper	4,960	5,037	5,212	5,304	5,313	5,307

Table C-8. Self-Supplied Domestic and Minor Systems Population Served Forecast to 2060 by County

County	Self-Supplied Domestic and Minor Systems Population Served					
	2016	2020	2030	2040	2050	2060
Crawford	15,964	16,250	16,909	17,301	17,416	17,481
Dade	5,027	5,090	5,231	5,290	5,268	5,231
Dallas	13,019	13,462	14,577	15,534	16,297	17,052
Daviess	964	422	0	0	0	0
DeKalb	0	0	0	0	0	0
Dent	8,951	9,110	9,480	9,708	9,788	9,841
Douglas	10,473	10,797	11,602	12,270	12,775	13,265
Dunklin	352	352	352	347	336	325
Franklin	45,421	46,037	47,393	47,976	47,783	47,451
Gasconade	8,874	8,759	8,011	6,510	4,364	1,756
Gentry	912	599	0	0	0	0
Greene	78,678	81,921	90,253	97,850	104,450	111,189
Grundy	0	0	0	0	0	0
Harrison	2,389	1,825	0	0	0	0
Henry	3,142	3,189	3,290	3,329	3,307	3,273
Hickory	6,696	6,853	7,233	7,513	7,683	7,836
Holt	459	94	0	0	0	0
Howard	1,955	1,965	1,981	1,964	1,917	1,866
Howell	19,120	19,560	20,619	21,391	21,848	22,255
Iron	7,329	7,357	7,394	7,307	7,105	6,889
Jackson	14,634	14,789	15,087	15,099	14,834	14,522
Jasper	21,756	22,162	23,130	23,780	24,096	24,355
Jefferson	58,325	58,325	58,325	58,325	58,325	58,325
Johnson	6,825	6,958	7,258	7,426	7,459	7,465
Knox	140	139	135	129	121	113
Laclede	5,317	5,433	5,712	5,909	6,018	6,113
Lafayette	389	396	410	417	416	414
Lawrence	21,425	21,851	22,859	23,534	23,855	24,114
Lewis	5,025	5,010	4,958	4,837	4,656	4,472
Lincoln	25,973	27,395	31,155	34,841	38,333	42,052
Linn	0	0	0	0	0	0
Livingston	4	4	4	4	4	4
Macon	0	0	0	0	0	0
Madison	6,494	6,605	6,857	7,001	7,032	7,043
Maries	6,868	7,072	7,575	7,980	8,275	8,556
Marion	3,072	3,089	3,124	3,115	3,064	3,007
McDonald	12,625	12,886	13,478	13,828	13,925	13,974
Mercer	329	327	321	309	292	276
Miller	18,021	18,421	19,371	20,037	20,398	20,707
Mississippi	1,281	833	0	0	0	0
Moniteau	6,480	6,658	7,093	7,432	7,664	7,882
Monroe	5	5	5	5	5	4
Montgomery	6,265	6,307	6,383	6,352	6,219	6,071
Morgan	13,138	13,138	13,138	13,138	13,138	13,138
New Madrid	6,162	6,162	6,162	6,162	6,162	6,162
Newton	34,794	36,372	40,495	44,411	48,006	51,763
Nodaway	3,166	3,194	3,243	3,232	3,160	3,080
Oregon	7,390	7,509	7,783	7,939	7,974	7,986
Osage	9,480	9,709	10,260	10,664	10,909	11,128
Ozark	9,439	9,584	9,915	10,095	10,120	10,118
Pemiscot	461	455	438	416	388	362
Perry	7,612	7,703	7,909	8,000	7,979	7,939
Pettis	16,139	16,429	17,068	17,396	17,403	17,349
Phelps	18,235	18,701	19,838	20,709	21,285	21,816

Table C-8. Self-Supplied Domestic and Minor Systems Population Served Forecast to 2060 by County

County	Self-Supplied Domestic and Minor Systems Population Served					
	2016	2020	2030	2040	2050	2060
Pike	2,617	2,646	2,707	2,723	2,695	2,660
Platte	10,195	10,975	13,114	15,372	17,688	20,281
Polk	18,869	19,827	22,350	24,793	27,079	29,494
Pulaski	1,648	1,664	1,698	1,704	1,685	1,661
Putnam	0	0	0	0	0	0
Ralls	201	205	215	221	225	229
Randolph	298	302	311	316	315	314
Ray	1,503	1,544	1,640	1,709	1,749	1,783
Reynolds	5,053	5,091	5,164	5,150	5,052	4,943
Ripley	7,395	7,563	7,973	8,282	8,481	8,664
Saint Charles	156	165	190	215	240	266
Saint Clair	6,713	6,807	7,004	7,070	7,005	6,917
Saint Francois	25,886	26,841	29,249	31,341	33,041	34,732
Saint Louis	4,561	4,602	4,682	4,684	4,611	4,525
Saint Louis City	2,649	2,601	2,474	2,314	2,129	1,953
Ste. Genevieve	7,051	7,164	7,420	7,557	7,573	7,566
Saline	4,259	4,286	4,326	4,284	4,163	4,032
Schuyler	0	0	0	0	0	0
Scotland	0	0	0	0	0	0
Scott	8,279	8,338	8,460	8,458	8,336	8,196
Shannon	6,161	6,215	6,326	6,338	6,251	6,150
Shelby	1,338	1,327	1,294	1,242	1,172	1,104
Stoddard	8,600	8,701	8,928	9,026	8,997	8,947
Stone	21,983	22,873	25,153	27,220	29,004	30,819
Sullivan	0	0	0	0	0	0
Taney	8,244	8,731	10,038	11,357	12,651	14,054
Texas	9,950	10,140	10,586	10,877	11,003	11,100
Vernon	2,205	1,843	0	0	0	0
Warren	13,544	14,108	15,553	16,859	17,980	19,119
Washington	20,393	20,393	20,393	20,393	20,393	20,393
Wayne	8,899	8,899	8,899	8,899	8,899	8,899
Webster	24,764	25,649	27,889	29,842	31,439	33,031
Worth	729	720	693	655	607	561
Wright	10,788	10,915	11,193	11,295	11,222	11,120
STATE TOTAL	**1,054,522**	**1,078,063**	**1,138,293**	**1,196,813**	**1,243,626**	**1,292,203**

Table C-9. Self-Supplied Domestic and Minor Systems Per Capita Use Forecast to 2060 by County

County	Self-Supplied Domestic and Minor Systems GPCD					
	2016	2020	2030	2040	2050	2060
Adair	66.8	66.1	64.5	64.5	64.5	64.5
Andrew	70.9	70.2	68.5	68.5	68.5	68.5
Atchison	64.0	63.4	61.8	61.8	61.8	61.8
Audrain	66.0	65.3	63.7	63.7	63.7	63.7
Barry	69.0	68.3	66.6	66.6	66.6	66.6
Barton	78.8	78.0	76.1	76.1	76.1	76.1
Bates	69.0	68.3	66.6	66.6	66.6	66.6
Benton	69.0	68.3	66.6	66.6	66.6	66.6
Bollinger	69.0	68.3	66.6	66.6	66.6	66.6
Boone	71.9	71.2	69.4	69.4	69.4	69.4
Buchanan	91.6	90.7	88.4	88.4	88.4	88.4
Butler	69.0	68.3	66.6	66.6	66.6	66.6
Caldwell	69.0	68.3	66.6	66.6	66.6	66.6
Callaway	69.9	69.2	67.5	67.5	67.5	67.5

Table C-9. Self-Supplied Domestic and Minor Systems Per Capita Use Forecast to 2060 by County

County	Self-Supplied Domestic and Minor Systems GPCD					
	2016	2020	2030	2040	2050	2060
Camden	69.0	68.3	66.6	66.6	66.6	66.6
Cape Girardeau	69.0	68.3	66.6	66.6	66.6	66.6
Carroll	79.8	79.0	77.0	77.0	77.0	77.0
Carter	69.0	68.3	66.6	66.6	66.6	66.6
Cass	66.0	65.3	63.7	63.7	63.7	63.7
Cedar	69.0	68.3	66.6	66.6	66.6	66.6
Chariton	73.9	73.1	71.3	71.3	71.3	71.3
Christian	69.0	68.3	66.6	66.6	66.6	66.6
Clark	69.9	69.2	67.5	67.5	67.5	67.5
Clay	55.2	54.6	53.3	53.3	53.3	53.3
Clinton	60.1	59.5	58.0	58.0	58.0	58.0
Cole	69.0	68.3	66.6	66.6	66.6	66.6
Cooper	69.0	68.3	66.6	66.6	66.6	66.6
Crawford	69.0	68.3	66.6	66.6	66.6	66.6
Dade	69.0	68.3	66.6	66.6	66.6	66.6
Dallas	69.0	68.3	66.6	66.6	66.6	66.6
Daviess	79.8	79.0	77.0	77.0	77.0	77.0
DeKalb	69.0	68.3	66.6	66.6	66.6	66.6
Dent	69.0	68.3	66.6	66.6	66.6	66.6
Douglas	69.0	68.3	66.6	66.6	66.6	66.6
Dunklin	85.7	84.8	82.7	82.7	82.7	82.7
Franklin	69.0	68.3	66.6	66.6	66.6	66.6
Gasconade	69.0	68.3	66.6	66.6	66.6	66.6
Gentry	68.0	67.3	65.6	65.6	65.6	65.6
Greene	69.0	68.3	66.6	66.6	66.6	66.6
Grundy	73.1	72.3	70.5	70.5	70.5	70.5
Harrison	89.6	88.7	86.5	86.5	86.5	86.5
Henry	69.0	68.3	66.6	66.6	66.6	66.6
Hickory	68.0	67.3	65.6	65.6	65.6	65.6
Holt	75.8	75.1	73.2	73.2	73.2	73.2
Howard	85.7	84.8	82.7	82.7	82.7	82.7
Howell	69.0	68.3	66.6	66.6	66.6	66.6
Iron	69.9	69.2	67.5	67.5	67.5	67.5
Jackson	83.7	82.9	80.8	80.8	80.8	80.8
Jasper	69.0	68.3	66.6	66.6	66.6	66.6
Jefferson	69.0	68.3	66.6	66.6	66.6	66.6
Johnson	69.0	68.3	66.6	66.6	66.6	66.6
Knox	69.9	69.2	67.5	67.5	67.5	67.5
Laclede	69.0	68.3	66.6	66.6	66.6	66.6
Lafayette	60.1	59.5	58.0	58.0	58.0	58.0
Lawrence	69.0	68.3	66.6	66.6	66.6	66.6
Lewis	75.8	75.1	73.2	73.2	73.2	73.2
Lincoln	69.0	68.3	66.6	66.6	66.6	66.6
Linn	73.1	72.3	70.5	70.5	70.5	70.5
Livingston	73.1	72.3	70.5	70.5	70.5	70.5
Macon	66.8	66.1	64.5	64.5	64.5	64.5
Madison	68.0	67.3	65.6	65.6	65.6	65.6
Maries	69.9	69.2	67.5	67.5	67.5	67.5
Marion	50.0	50.0	50.0	50.0	50.0	50.0
McDonald	69.0	68.3	66.6	66.6	66.6	66.6
Mercer	73.1	72.3	70.5	70.5	70.5	70.5
Miller	69.0	68.3	66.6	66.6	66.6	66.6
Mississippi	66.0	65.3	63.7	63.7	63.7	63.7
Moniteau	68.0	67.3	65.6	65.6	65.6	65.6

Table C-9. Self-Supplied Domestic and Minor Systems Per Capita Use Forecast to 2060 by County

County	Self-Supplied Domestic and Minor Systems GPCD					
	2016	2020	2030	2040	2050	2060
Monroe	62.1	61.4	59.9	59.9	59.9	59.9
Montgomery	68.0	67.3	65.6	65.6	65.6	65.6
Morgan	69.0	68.3	66.6	66.6	66.6	66.6
New Madrid	67.0	66.3	64.7	64.7	64.7	64.7
Newton	69.0	68.3	66.6	66.6	66.6	66.6
Nodaway	66.0	65.3	63.7	63.7	63.7	63.7
Oregon	68.0	67.3	65.6	65.6	65.6	65.6
Osage	69.0	68.3	66.6	66.6	66.6	66.6
Ozark	69.0	68.3	66.6	66.6	66.6	66.6
Pemiscot	70.0	69.3	67.6	67.6	67.6	67.6
Perry	69.0	68.3	66.6	66.6	66.6	66.6
Pettis	69.0	68.3	66.6	66.6	66.6	66.6
Phelps	69.0	68.3	66.6	66.6	66.6	66.6
Pike	70.9	70.2	68.5	68.5	68.5	68.5
Platte	71.9	71.2	69.4	69.4	69.4	69.4
Polk	69.0	68.3	66.6	66.6	66.6	66.6
Pulaski	69.9	69.2	67.5	67.5	67.5	67.5
Putnam	73.1	72.3	70.5	70.5	70.5	70.5
Ralls	81.8	80.9	78.9	78.9	78.9	78.9
Randolph	50.2	50.0	50.0	50.0	50.0	50.0
Ray	58.1	57.5	56.1	56.1	56.1	56.1
Reynolds	68.0	67.3	65.6	65.6	65.6	65.6
Ripley	69.0	68.3	66.6	66.6	66.6	66.6
Saint Charles	69.0	68.3	66.6	66.6	66.6	66.6
Saint Clair	69.0	68.3	66.6	66.6	66.6	66.6
Saint Francois	69.0	68.3	66.6	66.6	66.6	66.6
Saint Louis	69.0	68.3	66.6	66.6	66.6	66.6
Saint Louis City	69.0	68.3	66.6	66.6	66.6	66.6
Ste. Genevieve	68.0	67.3	65.6	65.6	65.6	65.6
Saline	63.0	62.4	60.9	60.9	60.9	60.9
Schuyler	66.8	66.1	64.5	64.5	64.5	64.5
Scotland	66.8	66.1	64.5	64.5	64.5	64.5
Scott	69.9	69.2	67.5	67.5	67.5	67.5
Shannon	69.0	68.3	66.6	66.6	66.6	66.6
Shelby	66.8	66.1	64.5	64.5	64.5	64.5
Stoddard	69.9	69.2	67.5	67.5	67.5	67.5
Stone	69.0	68.3	66.6	66.6	66.6	66.6
Sullivan	73.1	72.3	70.5	70.5	70.5	70.5
Taney	69.0	68.3	66.6	66.6	66.6	66.6
Texas	69.0	68.3	66.6	66.6	66.6	66.6
Vernon	65.0	64.4	62.8	62.8	62.8	62.8
Warren	69.0	68.3	66.6	66.6	66.6	66.6
Washington	69.0	68.3	66.6	66.6	66.6	66.6
Wayne	69.0	68.3	66.6	66.6	66.6	66.6
Webster	69.0	68.3	66.6	66.6	66.6	66.6
Worth	73.1	72.3	70.5	70.5	70.5	70.5
Wright	69.0	68.3	66.6	66.6	66.6	66.6
STATE WEIGHTED AVERAGE	**69.1**	**68.4**	**66.7**	**66.7**	**66.6**	**66.6**

Table C-10. Self-Supplied Domestic and Minor Systems Demand Forecast to 2060 by County

County	Percent of Demand Source	Self-Supplied Domestic and Minor Systems Demand (MGD)					
	Groundwater	2016	2020	2030	2040	2050	2060
Adair	100%	0.00	0.00	0.00	0.00	0.00	0.00
Andrew	100%	0.17	0.13	0.00	0.00	0.00	0.00
Atchison	100%	0.15	0.15	0.14	0.13	0.12	0.11
Audrain	100%	0.50	0.49	0.49	0.49	0.48	0.47
Barry	100%	1.28	1.30	1.35	1.41	1.45	1.49
Barton	100%	0.14	0.14	0.14	0.14	0.14	0.14
Bates	100%	0.14	0.14	0.14	0.14	0.13	0.13
Benton	100%	0.94	0.95	0.98	1.01	1.03	1.04
Bollinger	100%	0.84	0.85	0.87	0.91	0.92	0.94
Boone	100%	1.65	1.74	1.96	2.24	2.51	2.81
Buchanan	100%	0.02	0.02	0.02	0.02	0.02	0.02
Butler	100%	0.79	0.78	0.76	0.76	0.76	0.76
Caldwell	100%	0.32	0.32	0.32	0.32	0.32	0.31
Callaway	100%	0.66	0.67	0.70	0.73	0.75	0.78
Camden	100%	1.40	1.39	1.36	1.36	1.36	1.36
Cape Girardeau	100%	1.02	1.05	1.10	1.17	1.23	1.29
Carroll	100%	0.13	0.13	0.13	0.12	0.11	0.11
Carter	100%	0.43	0.44	0.44	0.46	0.46	0.47
Cass	100%	0.22	0.23	0.26	0.29	0.33	0.37
Cedar	100%	0.42	0.43	0.45	0.47	0.48	0.50
Chariton	100%	0.18	0.18	0.17	0.16	0.15	0.14
Christian	100%	2.64	2.84	3.41	4.12	4.91	5.84
Clark	100%	0.12	0.08	0.00	0.00	0.00	0.00
Clay	100%	0.57	0.60	0.68	0.78	0.87	0.96
Clinton	100%	0.03	0.03	0.03	0.03	0.04	0.04
Cole	100%	0.87	0.88	0.90	0.93	0.94	0.95
Cooper	100%	0.34	0.34	0.35	0.35	0.35	0.35
Crawford	100%	1.10	1.11	1.13	1.15	1.16	1.16
Dade	100%	0.35	0.35	0.35	0.35	0.35	0.35
Dallas	100%	0.90	0.92	0.97	1.03	1.08	1.14
Daviess	100%	0.08	0.03	0.00	0.00	0.00	0.00
DeKalb	100%	0.00	0.00	0.00	0.00	0.00	0.00
Dent	100%	0.62	0.62	0.63	0.65	0.65	0.66
Douglas	100%	0.72	0.74	0.77	0.82	0.85	0.88
Dunklin	100%	0.03	0.03	0.03	0.03	0.03	0.03
Franklin	100%	3.13	3.14	3.15	3.19	3.18	3.16
Gasconade	100%	0.61	0.60	0.53	0.43	0.29	0.12
Gentry	100%	0.06	0.04	0.00	0.00	0.00	0.00
Greene	100%	5.42	5.59	6.01	6.51	6.95	7.40
Grundy	100%	0.00	0.00	0.00	0.00	0.00	0.00
Harrison	100%	0.21	0.16	0.00	0.00	0.00	0.00
Henry	100%	0.22	0.22	0.22	0.22	0.22	0.22
Hickory	100%	0.46	0.46	0.47	0.49	0.50	0.51
Holt	100%	0.03	0.01	0.00	0.00	0.00	0.00
Howard	100%	0.17	0.17	0.16	0.16	0.16	0.15
Howell	100%	1.32	1.34	1.37	1.42	1.45	1.48
Iron	100%	0.51	0.51	0.50	0.49	0.48	0.47
Jackson	100%	1.23	1.23	1.22	1.22	1.20	1.17
Jasper	100%	1.50	1.51	1.54	1.58	1.60	1.62
Jefferson	100%	4.02	3.98	3.88	3.88	3.88	3.88
Johnson	100%	0.47	0.47	0.48	0.49	0.50	0.50
Knox	100%	0.01	0.01	0.01	0.01	0.01	0.01
Laclede	100%	0.37	0.37	0.38	0.39	0.40	0.41
Lafayette	100%	0.02	0.02	0.02	0.02	0.02	0.02

Table C-10. Self-Supplied Domestic and Minor Systems Demand Forecast to 2060 by County

County	Percent of Demand Source	Self-Supplied Domestic and Minor Systems Demand (MGD)					
	Groundwater	2016	2020	2030	2040	2050	2060
Lawrence	100%	1.48	1.49	1.52	1.57	1.59	1.61
Lewis	100%	0.38	0.38	0.36	0.35	0.34	0.33
Lincoln	100%	1.79	1.87	2.07	2.32	2.55	2.80
Linn	100%	0.00	0.00	0.00	0.00	0.00	0.00
Livingston	100%	0.00	0.00	0.00	0.00	0.00	0.00
Macon	100%	0.00	0.00	0.00	0.00	0.00	0.00
Madison	100%	0.44	0.44	0.45	0.46	0.46	0.46
Maries	100%	0.48	0.49	0.51	0.54	0.56	0.58
Marion	100%	0.15	0.15	0.16	0.16	0.15	0.15
McDonald	100%	0.87	0.88	0.90	0.92	0.93	0.93
Mercer	100%	0.02	0.02	0.02	0.02	0.02	0.02
Miller	100%	1.24	1.26	1.29	1.33	1.36	1.38
Mississippi	100%	0.08	0.05	0.00	0.00	0.00	0.00
Moniteau	100%	0.44	0.45	0.47	0.49	0.50	0.52
Monroe	100%	0.00	0.00	0.00	0.00	0.00	0.00
Montgomery	100%	0.43	0.42	0.42	0.42	0.41	0.40
Morgan	100%	0.91	0.90	0.87	0.87	0.87	0.87
New Madrid	100%	0.41	0.41	0.40	0.40	0.40	0.40
Newton	100%	2.40	2.48	2.70	2.96	3.20	3.45
Nodaway	100%	0.21	0.21	0.21	0.21	0.20	0.20
Oregon	100%	0.50	0.51	0.51	0.52	0.52	0.52
Osage	100%	0.65	0.66	0.68	0.71	0.73	0.74
Ozark	100%	0.65	0.65	0.66	0.67	0.67	0.67
Pemiscot	100%	0.03	0.03	0.03	0.03	0.03	0.02
Perry	100%	0.52	0.53	0.53	0.53	0.53	0.53
Pettis	100%	1.11	1.12	1.14	1.16	1.16	1.15
Phelps	100%	1.26	1.28	1.32	1.38	1.42	1.45
Pike	100%	0.19	0.19	0.19	0.19	0.18	0.18
Platte	100%	0.73	0.78	0.91	1.07	1.23	1.41
Polk	100%	1.30	1.35	1.49	1.65	1.80	1.96
Pulaski	100%	0.12	0.12	0.11	0.12	0.11	0.11
Putnam	100%	0.00	0.00	0.00	0.00	0.00	0.00
Ralls	100%	0.02	0.02	0.02	0.02	0.02	0.02
Randolph	100%	0.01	0.02	0.02	0.02	0.02	0.02
Ray	100%	0.09	0.09	0.09	0.10	0.10	0.10
Reynolds	100%	0.34	0.34	0.34	0.34	0.33	0.32
Ripley	100%	0.51	0.52	0.53	0.55	0.56	0.58
Saint Charles	100%	0.01	0.01	0.01	0.01	0.02	0.02
Saint Clair	100%	0.46	0.46	0.47	0.47	0.47	0.46
Saint Francois	100%	1.78	1.83	1.95	2.09	2.20	2.31
Saint Louis	100%	0.31	0.31	0.31	0.31	0.31	0.30
Saint Louis City	100%	0.18	0.18	0.16	0.15	0.14	0.13
Ste. Genevieve	100%	0.48	0.48	0.49	0.50	0.50	0.50
Saline	100%	0.27	0.27	0.26	0.26	0.25	0.25
Schuyler	100%	0.00	0.00	0.00	0.00	0.00	0.00
Scotland	100%	0.00	0.00	0.00	0.00	0.00	0.00
Scott	100%	0.58	0.58	0.57	0.57	0.56	0.55
Shannon	100%	0.42	0.42	0.42	0.42	0.42	0.41
Shelby	100%	0.09	0.09	0.08	0.08	0.08	0.07
Stoddard	100%	0.60	0.60	0.60	0.61	0.61	0.60
Stone	100%	1.52	1.56	1.67	1.81	1.93	2.05
Sullivan	100%	0.00	0.00	0.00	0.00	0.00	0.00
Taney	100%	0.57	0.60	0.67	0.76	0.84	0.94
Texas	100%	0.69	0.69	0.70	0.72	0.73	0.74

Table C-10. Self-Supplied Domestic and Minor Systems Demand Forecast to 2060 by County

County	Percent of Demand Source	Self-Supplied Domestic and Minor Systems Demand (MGD)					
	Groundwater	2016	2020	2030	2040	2050	2060
Vernon	100%	0.14	0.12	0.00	0.00	0.00	0.00
Warren	100%	0.93	0.96	1.04	1.12	1.20	1.27
Washington	100%	1.41	1.39	1.36	1.36	1.36	1.36
Wayne	100%	0.61	0.61	0.59	0.59	0.59	0.59
Webster	100%	1.71	1.75	1.86	1.99	2.09	2.20
Worth	100%	0.05	0.05	0.05	0.05	0.04	0.04
Wright	100%	0.74	0.75	0.75	0.75	0.75	0.74
STATE TOTAL	**100%**	**72.9**	**73.8**	**75.9**	**79.8**	**82.9**	**86.1**

Table C-11. Thermoelectric Power Generation Water Demand Withdrawal Forecast to 2060 by County

County	Percent of Demand Source		Thermoelectric Water Withdrawal Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Audrain	100%	0%	0.07	0.07	0.09	0.11	0.12	0.13
Buchanan	2%	98%	0.57	0.56	0.55	0.52	0.49	0.51
Callaway	1%	99%	31.5	30.8	30.3	29.3	27.7	28.6
Dunklin	100%	0%	0.28	0.31	0.38	0.45	0.53	0.55
Franklin	0%	100%	1,597	1,558	1,581	821	905	937
Greene	22%	78%	23.1	22.5	22.7	23.2	24.8	25.7
Henry	0%	100%	140	136	138	144	158	164
Jackson	0%	100%	542	529	536	557	614	636
Jasper	100%	0%	4.06	4.10	4.34	4.52	4.65	4.82
Jefferson	0%	100%	743	725	735	764	842	872
New Madrid	0%	100%	656	640	650	675	744	770
Pike	100%	0%	0.04	0.04	0.05	0.06	0.07	0.07
Platte	2%	98%	934	911	924	960	1,058	1,096
Randolph	0%	100%	763	745	756	785	865	896
Saint Charles*	0%	100%	447	437	443	0.00	0.00	0.00
Saint Louis*	0%	100%	210	205	0.00	0.00	0.00	0.00
Scott	100%	0%	3.51	3.43	3.36	3.22	3.02	3.13
Stoddard	100%	0%	0.05	0.06	0.07	0.09	0.10	0.10
STATE TOTAL	**1%**	**99%**	**6,096**	**5,949**	**5,827**	**4,768**	**5,248**	**5,434**

Note: only 18 counties in Missouri have thermoelectric power generation water demand.
*The retirement of large water-using facilities will reduce overall water withdrawal and consumption in these counties.

Table C-12. Thermoelectric Power Generation Water Demand Consumptive Use Forecast to 2060 by County

County	Percent of Demand Source		Thermoelectric Water Consumption Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Audrain	100%	0%	0.05	0.06	0.07	0.08	0.10	0.10
Buchanan	2%	98%	0.39	0.38	0.37	0.36	0.34	0.35
Callaway	1%	99%	19.22	18.80	18.50	17.86	16.89	17.48
Dunklin	100%	0%	0.22	0.24	0.30	0.36	0.41	0.43
Franklin	0%	100%	10.98	10.72	10.87	5.65	6.22	6.44
Greene	96%	4%	3.50	3.42	3.35	3.22	3.05	3.16
Henry	0%	100%	0.96	0.94	0.95	0.99	1.09	1.13
Jackson	0%	100%	3.76	3.67	3.73	3.88	4.27	4.43
Jasper	100%	0%	2.89	2.93	3.12	3.28	3.40	3.52
Jefferson	0%	100%	5.11	4.98	5.06	5.25	5.79	5.99
New Madrid	0%	100%	4.51	4.40	4.47	4.64	5.11	5.30
Pike	100%	0%	0.03	0.03	0.04	0.04	0.05	0.05
Platte	2%	98%	6.42	6.27	6.36	6.60	7.28	7.53
Randolph	0%	100%	5.25	5.12	5.20	5.40	5.95	6.16
Saint Charles*	0%	100%	3.08	3.00	3.05	0.00	0.00	0.00
Saint Louis*	0%	100%	1.44	1.41	0.00	0.00	0.00	0.00

Table C-12. Thermoelectric Power Generation Water Demand Consumptive Use Forecast to 2060 by County

County	Percent of Demand Source		Thermoelectric Water Consumption Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Scott	100%	0%	2.40	2.34	2.29	2.20	2.07	2.14
Stoddard	100%	0%	0.04	0.05	0.06	0.07	0.08	0.08
STATE TOTAL	**13%**	**87%**	**70.3**	**68.8**	**67.8**	**59.9**	**62.1**	**64.3**

Note: only 18 counties in Missouri have thermoelectric power generation water demand.
*The retirement of large water-using facilities will reduce overall water withdrawal and consumption for these counties.

Table C-13. Livestock-Related Water Demand Forecast to 2060 by County

County	Percent of Demand Source		Livestock Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Adair	15%	85%	0.79	0.82	0.90	0.99	1.10	1.21
Andrew	12%	88%	0.38	0.41	0.47	0.49	0.55	0.60
Atchison	10%	91%	0.16	0.16	0.19	0.19	0.22	0.25
Audrain	43%	57%	1.10	1.15	1.26	1.37	1.51	1.64
Barry	65%	35%	3.21	3.37	3.84	4.30	4.79	5.32
Barton	66%	34%	1.53	1.59	1.75	1.89	2.05	2.25
Bates	24%	76%	1.56	1.62	1.78	1.97	2.16	2.38
Benton	33%	67%	1.15	1.18	1.32	1.45	1.62	1.78
Bollinger	24%	76%	0.60	0.63	0.68	0.77	0.82	0.93
Boone	27%	73%	0.58	0.58	0.63	0.71	0.77	0.85
Buchanan	12%	88%	0.33	0.33	0.38	0.41	0.44	0.49
Butler	24%	77%	0.14	0.14	0.16	0.16	0.19	0.22
Caldwell	10%	90%	0.63	0.63	0.71	0.77	0.85	0.93
Callaway	51%	49%	1.45	1.48	1.62	1.78	1.95	2.11
Camden	20%	80%	0.68	0.68	0.77	0.85	0.93	1.01
Cape Girardeau	27%	73%	0.77	0.79	0.88	0.99	1.07	1.18
Carroll	11%	89%	0.68	0.71	0.79	0.88	0.96	1.07
Carter	27%	73%	0.16	0.16	0.19	0.22	0.25	0.27
Cass	49%	51%	1.15	1.21	1.32	1.45	1.56	1.73
Cedar	27%	74%	0.90	0.93	1.04	1.12	1.26	1.40
Chariton	18%	82%	0.96	0.99	1.10	1.21	1.34	1.48
Christian	38%	62%	0.77	0.79	0.88	0.99	1.07	1.18
Clark	24%	76%	0.55	0.58	0.63	0.68	0.77	0.85
Clay	10%	90%	0.60	0.63	0.71	0.77	0.85	0.93
Clinton	10%	91%	0.63	0.66	0.71	0.79	0.88	0.96
Cole	46%	54%	1.10	1.15	1.26	1.37	1.51	1.64
Cooper	31%	69%	0.90	0.93	1.04	1.15	1.26	1.40
Crawford	27%	73%	0.63	0.66	0.71	0.79	0.88	0.99
Dade	34%	66%	1.34	1.40	1.53	1.70	1.86	2.05
Dallas	28%	72%	1.15	1.21	1.32	1.45	1.62	1.78
Daviess	38%	63%	1.18	1.21	1.32	1.42	1.53	1.67
DeKalb	11%	89%	0.68	0.71	0.79	0.88	0.96	1.07
Dent	27%	73%	0.68	0.71	0.77	0.85	0.96	1.04
Douglas	37%	63%	1.07	1.10	1.21	1.34	1.48	1.64
Dunklin	14%	86%	0.03	0.03	0.03	0.05	0.05	0.05
Franklin	41%	59%	1.15	1.18	1.32	1.42	1.56	1.73
Gasconade	29%	71%	0.71	0.74	0.82	0.90	0.99	1.10
Gentry	4%	96%	1.78	1.84	2.00	2.16	2.33	2.52
Greene	37%	63%	1.29	1.32	1.45	1.62	1.78	1.97
Grundy	9%	91%	0.49	0.52	0.58	0.63	0.68	0.77
Harrison	12%	88%	0.77	0.82	0.90	0.99	1.10	1.21
Henry	38%	62%	1.45	1.51	1.64	1.81	2.00	2.19

Table C-13. Livestock-Related Water Demand Forecast to 2060 by County

County	Percent of Demand Source		Livestock Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Hickory	26%	74%	0.85	0.88	0.99	1.07	1.21	1.32
Holt	4%	96%	0.19	0.19	0.22	0.22	0.25	0.27
Howard	18%	82%	0.52	0.52	0.58	0.66	0.71	0.79
Howell	37%	63%	1.70	1.75	1.95	2.14	2.36	2.60
Iron	28%	72%	0.19	0.19	0.22	0.25	0.25	0.27
Jackson	30%	70%	0.27	0.27	0.30	0.36	0.38	0.41
Jasper	47%	53%	1.21	1.26	1.40	1.53	1.70	1.86
Jefferson	35%	65%	0.25	0.25	0.27	0.30	0.33	0.36
Johnson	24%	76%	1.67	1.73	1.92	2.14	2.36	2.63
Knox	22%	78%	0.77	0.79	0.88	0.99	1.07	1.18
Laclede	26%	74%	1.45	1.51	1.64	1.84	2.03	2.22
Lafayette	36%	64%	0.79	0.82	0.90	0.99	1.10	1.21
Lawrence	46%	54%	2.79	2.90	3.23	3.62	4.00	4.41
Lewis	13%	87%	0.60	0.63	0.68	0.77	0.85	0.93
Lincoln	19%	81%	0.60	0.63	0.71	0.79	0.88	0.96
Linn	15%	85%	0.96	0.99	1.10	1.21	1.34	1.48
Livingston	21%	79%	0.58	0.58	0.63	0.71	0.77	0.85
Macon	30%	70%	1.04	1.07	1.18	1.32	1.42	1.56
Madison	20%	80%	0.47	0.47	0.52	0.58	0.63	0.68
Maries	22%	78%	1.18	1.23	1.34	1.48	1.64	1.81
Marion	70%	30%	0.77	0.79	0.88	0.96	1.01	1.12
McDonald	55%	45%	1.64	1.75	1.97	2.22	2.49	2.74
Mercer	2%	98%	2.47	2.55	2.77	2.99	3.21	3.45
Miller	60%	40%	2.08	2.16	2.38	2.60	2.85	3.10
Mississippi	13%	87%	0.03	0.05	0.05	0.05	0.05	0.05
Moniteau	37%	63%	2.60	2.71	3.01	3.32	3.67	4.03
Monroe	28%	72%	0.93	0.96	1.04	1.15	1.26	1.37
Montgomery	23%	78%	0.58	0.60	0.66	0.74	0.79	0.88
Morgan	52%	48%	1.59	1.67	1.86	2.05	2.27	2.52
New Madrid	17%	83%	<0.01	<0.01	<0.01	<0.01	<0.01	0.03
Newton	52%	48%	2.82	2.96	3.34	3.75	4.19	4.63
Nodaway	13%	87%	1.07	1.10	1.21	1.34	1.48	1.64
Oregon	26%	74%	1.10	1.15	1.26	1.40	1.53	1.70
Osage	35%	65%	1.45	1.51	1.67	1.84	2.03	2.25
Ozark	36%	64%	1.29	1.32	1.45	1.62	1.78	1.97
Pemiscot	15%	85%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Perry	28%	72%	0.85	0.88	0.96	1.07	1.18	1.32
Pettis	52%	48%	1.89	1.97	2.19	2.44	2.71	2.99
Phelps	24%	76%	0.71	0.74	0.82	0.93	1.01	1.12
Pike	35%	65%	1.04	1.07	1.18	1.29	1.42	1.56
Platte	7%	94%	0.33	0.33	0.36	0.41	0.44	0.47
Polk	29%	72%	2.08	2.16	2.38	2.63	2.90	3.21
Pulaski	18%	82%	0.58	0.60	0.66	0.74	0.79	0.88
Putnam	9%	92%	1.97	2.05	2.25	2.44	2.66	2.88
Ralls	11%	90%	0.47	0.49	0.52	0.58	0.63	0.68
Randolph	10%	90%	0.85	0.88	0.96	1.04	1.12	1.23
Ray	14%	86%	0.66	0.68	0.74	0.82	0.90	1.01
Reynolds	23%	77%	0.19	0.22	0.22	0.25	0.27	0.30
Ripley	24%	76%	0.44	0.44	0.49	0.55	0.60	0.66
Saint Charles	44%	56%	0.27	0.27	0.30	0.33	0.36	0.41
Saint Clair	21%	79%	0.96	0.99	1.10	1.21	1.32	1.45

Table C-13. Livestock-Related Water Demand Forecast to 2060 by County

County	Percent of Demand Source		Livestock Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Saint Francois	28%	73%	0.38	0.38	0.44	0.49	0.55	0.60
Saint Louis	16%	84%	0.03	0.03	0.27	0.03	0.05	0.05
Saint Louis City	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ste. Genevieve	36%	64%	1.26	1.29	1.42	1.53	1.67	1.81
Saline	18%	82%	0.55	0.58	0.63	0.68	0.77	0.82
Schuyler	38%	62%	0.88	0.93	1.01	1.10	1.21	1.32
Scotland	75%	25%	0.55	0.58	0.66	0.74	0.85	0.93
Scott	28%	73%	0.38	0.41	0.47	0.49	0.55	0.60
Shannon	41%	59%	0.58	0.60	0.66	0.71	0.79	0.88
Shelby	16%	84%	0.47	0.49	0.52	0.58	0.66	0.71
Stoddard	71%	29%	0.52	0.55	0.63	0.71	0.79	0.88
Stone	46%	54%	0.66	0.68	0.74	0.82	0.93	1.01
Sullivan	39%	61%	2.96	3.07	3.32	3.59	3.89	4.19
Taney	37%	63%	0.33	0.36	0.38	0.44	0.47	0.52
Texas	36%	64%	1.56	1.64	1.81	2.00	2.19	2.44
Vernon	83%	17%	5.73	5.92	6.41	6.93	7.45	8.00
Warren	24%	76%	0.27	0.27	0.30	0.33	0.36	0.41
Washington	28%	72%	0.38	0.38	0.44	0.49	0.52	0.58
Wayne	29%	71%	0.27	0.30	0.33	0.36	0.38	0.44
Webster	39%	61%	2.03	2.11	2.33	2.58	2.82	3.12
Worth	10%	91%	0.33	0.36	0.38	0.44	0.47	0.52
Wright	36%	64%	1.53	1.59	1.75	1.95	2.14	2.36
STATE TOTAL	**36%**	**64%**	**111**	**115**	**128**	**140**	**154**	**169**

N/A – not applicable

Table C-14. Water Demand for Crop Irrigation Forecast to 2060 by County

County	Percent of Demand Source		Crop Irrigation Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Adair	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Andrew	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Atchison	70%	30%	14	14.2	15.1	15.6	16.2	16.4
Audrain	85%	15%	12.6	13.2	13.7	14.2	14.5	14.8
Barry	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Barton	80%	20%	11	11.2	11.8	12.3	12.6	12.9
Bates	65%	35%	4.4	4.4	4.7	4.9	4.9	5.2
Benton	50%	50%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Bollinger	100%	0%	21.6	22.2	23.3	24.1	24.9	25.5
Boone	50%	50%	3	3	3.3	3.3	3.3	3.6
Buchanan	0%	100%	0.5	0.5	0.5	0.5	0.5	0.5
Butler	100%	0%	325.8	335.1	350.4	363	375.3	381.4
Caldwell	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Callaway	40%	60%	0.3	0.3	0.3	0.3	0.3	0.3
Camden	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cape Girardeau	80%	20%	26.3	26.8	28.2	29.3	30.1	30.7
Carroll	100%	0%	0.3	0.3	0.3	0.3	0.3	0.3
Carter	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cass	100%	0%	1.9	1.9	1.9	2.2	2.2	2.2
Cedar	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chariton	80%	20%	0.3	0.3	0.3	0.3	0.3	0.3

Table C-14. Water Demand for Crop Irrigation Forecast to 2060 by County

County	Percent of Demand Source		Crop Irrigation Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Christian	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Clark	80%	20%	2.7	2.7	3	3	3	3.3
Clay	0%	100%	0.5	0.5	0.5	0.5	0.5	0.5
Clinton	0%	100%	0.3	0.3	0.3	0.3	0.3	0.3
Cole	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cooper	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Crawford	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dade	100%	0%	12.6	13.2	13.7	14.2	14.5	14.8
Dallas	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Daviess	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
DeKalb	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dent	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Douglas	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dunklin	100%	0%	272.3	280.3	293.2	303.6	314	319.2
Franklin	80%	20%	0.3	0.3	0.3	0.3	0.3	0.3
Gasconade	100%	0%	0.3	0.3	0.3	0.3	0.3	0.3
Gentry	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Greene	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Grundy	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Harrison	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Henry	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Hickory	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Holt	100%	0%	16.2	16.4	17.3	17.8	18.4	18.9
Howard	70%	30%	0.8	0.8	0.8	0.8	0.8	0.8
Howell	100%	0%	0.5	0.5	0.5	0.5	0.5	0.5
Iron	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Jackson	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Jasper	100%	0%	1.1	1.4	1.4	1.4	1.4	1.4
Jefferson	100%	0%	0.3	0.3	0.3	0.3	0.3	0.3
Johnson	50%	50%	0.8	0.8	0.8	0.8	0.8	0.8
Knox	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Laclede	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lafayette	70%	30%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lawrence	100%	0%	0.8	0.8	0.8	0.8	0.8	0.8
Lewis	60%	40%	0.5	0.5	0.5	0.5	0.5	0.5
Lincoln	100%	0%	2.2	2.2	2.5	2.5	2.5	2.7
Linn	0%	100%	0.3	0.3	0.3	0.3	0.3	0.3
Livingston	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Macon	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Madison	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Maries	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Marion	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
McDonald	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercer	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Miller	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mississippi	100%	0%	113.7	117	122.5	126.8	131	133.2
Moniteau	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Monroe	0%	100%	0.5	0.5	0.5	0.5	0.5	0.5

Table C-14. Water Demand for Crop Irrigation Forecast to 2060 by County

County	Percent of Demand Source		Crop Irrigation Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Montgomery	50%	50%	1.6	1.6	1.6	1.9	1.9	1.9
Morgan	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
New Madrid	100%	0%	383	394	412.3	426.8	441.4	448.8
Newton	100%	0%	0.5	0.5	0.5	0.5	0.5	0.5
Nodaway	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Oregon	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Osage	50%	50%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ozark	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pemiscot	100%	0%	203.3	209	218.9	226.6	234.2	238.4
Perry	100%	0%	0.8	0.8	1.1	1.1	1.1	1.1
Pettis	50%	50%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phelps	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pike	70%	30%	0.5	0.5	0.5	0.5	0.5	0.5
Platte	100%	0%	0.8	0.8	0.8	0.8	0.8	0.8
Polk	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pulaski	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Putnam	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ralls	60%	40%	2.2	2.2	2.2	2.2	2.5	2.5
Randolph	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ray	100%	0%	2.7	3	3	3.3	3.3	3.3
Reynolds	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ripley	90%	10%	27.7	28.5	29.9	30.7	31.8	32.3
Saint Charles	100%	0%	0.5	0.5	0.5	0.5	0.5	0.5
Saint Clair	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Saint Francois	100%	0%	0.3	0.3	0.3	0.3	0.3	0.3
Saint Louis	100%	0%	0.3	0.3	0.3	0.3	0.5	0.5
Saint Louis City	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ste. Genevieve	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Saline	76%	24%	1.4	1.4	1.4	1.4	1.4	1.4
Schuyler	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Scotland	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Scott	90%	10%	120	123.6	129.3	133.7	138.4	140.5
Shannon	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Shelby	0%	100%	0.8	0.8	0.8	0.8	0.8	1.1
Stoddard	100%	0%	470.1	483.6	505.8	523.8	541.6	550.7
Stone	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sullivan	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Taney	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Texas	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vernon	50%	50%	3.8	4.1	4.1	4.4	4.4	4.7
Warren	60%	40%	0.3	0.3	0.3	0.3	0.3	0.3
Washington	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Wayne	0%	100%	0.3	0.3	0.3	0.3	0.3	0.3
Webster	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Worth	0%	100%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Wright	100%	0%	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
STATE TOTAL	**98%**	**2%**	**2,070**	**2,129**	**2,227**	**2,306**	**2,383**	**2,424**

N/A – not applicable

Table C-15. Current Annual Water Withdrawals to Replenish Wetlands by County

County	Groundwater (AFY)	Surface Water (AFY)	Total Withdrawals (AFY)
Andrew	0.00	67.3	67.3
Atchison	855	108	963
Bates	0.00	582	582
Bollinger	1,060	108	1,167
Boone	508	4,044	4,552
Buchanan	196	157	353
Butler	327	191	518
Caldwell	0.00	505	505
Callaway	0.00	14.1	14.1
Carroll	806	618	1,424
Cass	0.00	246	246
Cedar	0.00	183	183
Chariton	3,860	1,279	5,139
Clark	83.9	264	348
Cole	0.00	75.3	75.3
Cooper	0.00	1,174	1,174
Daviess	0.00	95.9	95.9
Dunklin	2,216	15.5	2,231
Franklin	0.00	246	246
Gasconade	0.00	59.8	59.8
Gentry	0.00	119	119
Greene	0.00	50.4	50.4
Henry	0.00	828	828
Holt	18,996	244	19,240
Howard	54.4	2,278	2,333
Jackson	0.00	467	467
Knox	0.00	136	136
Lafayette	31.3	368	399
Lewis	29.4	293	323
Lincoln	5,506	916	6,422
Linn	326	334	660
Livingston	962	1,674	2,636
Macon	0.00	283	283
Miller	0.00	12.5	12.5
Mississippi	696	275	971
Moniteau	0.00	104	104
Monroe	0.00	260	260
Montgomery	109	0.00	109
New Madrid	3,138	0.00	3,138
Osage	0.00	272	272
Pemiscot	4,243	0.00	4,243
Pike	673	9,694	10,367
Platte	12.6	267	280
Putnam	0.00	170	170
Randolph	0.00	1,489	1,489
Ray	204	34.5	238
Ripley	26.6	0.00	27
Saint Charles	1,523	143	1,666
Saint Clair	0	459	459
Saint Louis	0	6,735	6,735
Saline	267	2,311	2,577
Schuyler	0	56.8	57
Scott	506	593	1,099
Shelby	0	653	653

Table C-15. Current Annual Water Withdrawals to Replenish Wetlands by County

County	Groundwater (AFY)	Surface Water (AFY)	Total Withdrawals (AFY)
Stoddard	5,582	63.1	5,645
Vernon	0.00	5,766	5,766
Warren	0.00	128	128
Wayne	4,045	0.00	4,045
STATE TOTAL	**56,841**	**47,509**	**104,350**

Note: Only 58 counties in Missouri have wetland replenishment water withdrawals identified.

Table C-16. Current Water Withdrawals to Support Aquaculture and Fish Hatcheries by County

County	Percent of Demand Source		Total Withdrawals	
	Groundwater	Surface water	AFY	MGD
Audrain	19%	81%	4,581	4.09
Barry	0%	100%	10,641	9.50
Barton	19%	81%	2,285	2.04
Benton	22%	78%	2,386	2.13
Butler	100%	0%	762	0.68
Camden	9%	91%	8,592	7.67
Christian	0%	100%	325	0.29
Cooper	19%	81%	2,285	2.04
Dent	0%	100%	34,254	30.9
Douglas	0%	100%	41,972	37.5
Dunklin	100%	0%	22.4	0.02
Howell	19%	81%	2,285	2.04
Iron	0%	100%	3,719	3.32
Jasper	0%	100%	11.2	0.01
Johnson	0%	100%	2,285	2.04
Knox	23%	77%	840	0.75
Laclede	0%	100%	13,453	12.0
Lafayette	19%	81%	2,285	2.04
Lawrence	43%	57%	3,237	2.89
Linn	19%	81%	2,285	2.04
Monroe	19%	81%	2,285	2.04
Morgan	7%	93%	3,965	3.54
Ozark	0%	100%	14,002	12.5
Pemiscot	50%	50%	1,008	0.90
Perry	19%	81%	2,285	2.04
Phelps	0%	100%	5,847	5.22
Pike	100%	0%	56.0	0.05
Polk	0%	100%	33.6	0.03
Pulaski	0%	100%	22.4	0.02
Saint Clair	50%	50%	179	0.16
Stoddard	50%	50%	941	0.84
Stone	100%	0%	1,288	1.15
Taney	2%	98%	27,343	24.4
Washington	19%	81%	4,581	4.09
STATE TOTAL	**6%**	**94%**	**202,343**	**180.6**

Note: Only 34 counties in Missouri have water withdrawals identified to support aquaculture and fish hatcheries.
Source: Maupin et al. 2014

Table C-17. Combined Consumptive Demands Forecast to 2060 by County

County	Percent of Demand Source		Total Consumptive Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Adair	4%	96%	3.00	3.02	3.09	3.17	3.23	3.28
Andrew	83%	17%	1.94	1.98	2.07	2.16	2.25	2.34
Atchison	71%	29%	14.8	15.1	15.9	16.4	16.9	17.2
Audrain	84%	16%	16.8	17.4	18.0	18.6	19.0	19.3

Table C-17. Combined Consumptive Demands Forecast to 2060 by County

County	Percent of Demand Source		Total Consumptive Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Barry	87%	13%	10.2	10.5	11.2	12.1	12.8	13.7
Barton	77%	23%	13.6	13.9	14.7	15.4	15.8	16.2
Bates	45%	55%	7.52	7.58	8.04	8.52	8.70	9.17
Benton	70%	30%	2.59	2.64	2.83	3.02	3.22	3.41
Bollinger	98%	2%	23.1	23.7	24.8	25.8	26.7	27.4
Boone	92%	8%	25.0	26.1	29.8	33.6	37.2	41.5
Buchanan	93%	7%	18.8	18.9	18.9	18.9	18.6	18.3
Butler	99%	1%	330	339	355	367	380	386
Caldwell	39%	61%	1.28	1.28	1.37	1.43	1.51	1.59
Callaway	27%	73%	27.4	27.1	27.2	27.1	26.6	27.6
Camden	89%	11%	5.21	5.39	5.99	6.68	7.33	8.03
Cape Girardeau	82%	18%	46.9	47.9	50.2	52.1	53.5	54.8
Carroll	74%	26%	2.35	2.37	2.37	2.36	2.33	2.35
Carter	80%	20%	0.60	0.60	0.64	0.67	0.71	0.74
Cass	39%	61%	10.3	10.6	11.8	13.4	14.7	16.1
Cedar	71%	29%	2.30	2.35	2.53	2.69	2.89	3.09
Chariton	51%	49%	1.90	1.92	2.01	2.10	2.20	2.31
Christian	95%	5%	9.7	10.3	12.2	14.7	17.4	20.7
Clark	77%	23%	4.11	4.14	4.47	4.50	4.55	4.88
Clay	49%	51%	42.5	44.0	49.1	55.1	61.2	68.3
Clinton	6%	94%	3.27	3.32	3.47	3.65	3.78	3.91
Cole	57%	43%	9.15	9.32	9.7	10.1	10.5	10.8
Cooper	42%	58%	2.92	2.96	3.10	3.25	3.38	3.53
Crawford	85%	15%	3.04	3.10	3.21	3.37	3.48	3.62
Dade	94%	6%	14.6	15.2	15.9	16.6	17.1	17.5
Dallas	67%	33%	2.49	2.58	2.76	3.00	3.24	3.48
Daviess	57%	43%	1.85	1.86	1.97	2.09	2.19	2.32
DeKalb	27%	73%	2.53	2.57	2.71	2.84	2.94	3.06
Dent	76%	24%	2.14	2.18	2.27	2.39	2.52	2.62
Douglas	71%	29%	2.35	2.40	2.58	2.80	3.00	3.23
Dunklin	100%	0%	276	283	296	307	317	323
Franklin	47%	53%	22.1	21.9	22.5	17.6	18.5	19.0
Gasconade	79%	21%	2.36	2.38	2.45	2.53	2.60	2.68
Gentry	22%	78%	2.34	2.39	2.54	2.70	2.85	3.02
Greene	37%	63%	45.5	46.7	50.1	54.1	57.6	61.7
Grundy	2%	98%	3.02	3.01	3.00	3.00	2.97	2.95
Harrison	33%	67%	1.74	1.79	1.85	1.93	2.03	2.12
Henry	24%	76%	4.48	4.53	4.71	4.95	5.23	5.45
Hickory	58%	42%	1.48	1.52	1.65	1.76	1.91	2.03
Holt	99%	1%	17.2	17.5	18.4	19.0	19.6	20.2
Howard	53%	47%	2.50	2.49	2.54	2.63	2.68	2.76
Howell	84%	16%	6.57	6.69	7.04	7.44	7.81	8.20
Iron	75%	25%	0.98	0.98	1.00	1.03	1.01	1.03
Jackson	45%	55%	105	105	106	107	107	106
Jasper	61%	39%	24.9	25.4	26.2	27.2	27.8	28.4
Jefferson	41%	59%	26.5	27.0	29.1	31.7	34.5	37.1
Johnson	75%	25%	7.54	7.65	7.98	8.34	8.61	8.93
Knox	16%	84%	1.10	1.12	1.19	1.29	1.36	1.46
Laclede	82%	18%	5.78	5.89	6.18	6.57	6.91	7.24
Lafayette	76%	24%	9.81	9.89	10.1	10.3	10.4	10.4
Lawrence	81%	19%	7.76	7.91	8.32	8.83	9.29	9.77
Lewis	58%	42%	2.03	2.05	2.08	2.15	2.21	2.27
Lincoln	93%	7%	7.40	7.60	8.49	9.22	9.92	11.0
Linn	10%	90%	2.53	2.53	2.62	2.71	2.81	2.90

Table C-17. Combined Consumptive Demands Forecast to 2060 by County

County	Percent of Demand Source		Total Consumptive Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Livingston	79%	21%	2.17	2.18	2.24	2.33	2.37	2.43
Macon	8%	92%	3.92	3.78	3.88	4.02	4.09	4.17
Madison	48%	52%	1.54	1.55	1.63	1.73	1.80	1.88
Maries	52%	48%	1.92	1.98	2.12	2.29	2.48	2.67
Marion	16%	84%	6.67	6.76	6.84	6.86	6.78	6.77
McDonald	90%	10%	7.04	9.63	10.0	10.4	10.7	10.9
Mercer	8%	92%	2.82	2.90	3.11	3.32	3.53	3.76
Miller	81%	19%	4.27	4.38	4.67	4.98	5.28	5.57
Mississippi	100%	0%	116	119	125	129	133	135
Moniteau	63%	37%	4.46	4.60	4.98	5.38	5.80	6.22
Monroe	12%	88%	2.20	2.22	2.29	2.39	2.49	2.58
Montgomery	57%	43%	3.09	3.12	3.17	3.52	3.56	3.63
Morgan	76%	24%	3.12	3.21	3.40	3.60	3.82	4.05
New Madrid	99%	1%	392	403	421	435	450	457
Newton	58%	42%	11.9	12.4	13.6	15.1	16.5	18.0
Nodaway	13%	87%	3.31	3.34	3.46	3.61	3.71	3.84
Oregon	68%	32%	2.49	2.56	2.69	2.86	3.01	3.19
Osage	62%	38%	2.47	2.55	2.75	2.96	3.18	3.43
Ozark	57%	43%	1.94	1.97	2.11	2.29	2.45	2.65
Pemiscot	100%	0%	205	211	221	229	236	240
Perry	61%	39%	3.68	3.73	4.11	4.27	4.40	4.55
Pettis	90%	10%	8.80	9.07	9.39	9.60	9.69	9.79
Phelps	89%	11%	5.04	5.12	5.36	5.68	5.91	6.17
Pike	22%	78%	4.26	4.24	4.20	4.19	4.21	4.26
Platte	38%	62%	22.3	22.9	25.7	29.2	33.3	37.6
Polk	68%	32%	4.61	4.79	5.27	5.84	6.41	7.04
Pulaski	54%	46%	5.99	6.02	6.11	6.29	6.38	6.50
Putnam	7%	93%	2.36	2.44	2.62	2.80	3.01	3.22
Ralls	38%	62%	3.62	3.67	3.74	3.84	4.21	4.30
Randolph	1%	99%	7.97	7.88	8.06	8.39	9.05	9.39
Ray	90%	10%	5.73	6.06	6.21	6.68	6.83	7.00
Reynolds	78%	22%	0.68	0.71	0.71	0.74	0.76	0.78
Ripley	89%	11%	29.3	30.1	31.6	32.6	33.8	34.4
Saint Charles	27%	73%	63.4	65.5	74.0	81.1	91.4	103
Saint Clair	53%	47%	1.84	1.88	2.00	2.12	2.22	2.35
Saint Francois	97%	3%	8.06	8.28	8.93	9.65	10.29	10.95
Saint Louis	2%	98%	164	165	168	174	176	179
Saint Louis City	0%	100%	136	134	128	124	119	114
Ste. Genevieve	91%	9%	4.37	4.49	4.77	5.12	5.48	5.85
Saline	82%	18%	6.35	6.36	6.41	6.44	6.44	6.44
Schuyler	12%	88%	0.80	0.82	0.88	0.93	1.01	1.06
Scotland	27%	73%	1.22	1.27	1.35	1.43	1.53	1.63
Scott	91%	9%	129	133	138	143	147	150
Shannon	73%	27%	1.02	1.05	1.10	1.13	1.18	1.22
Shelby	17%	83%	1.91	1.93	1.97	2.01	2.08	2.42
Stoddard	100%	0%	474	488	510	529	547	556
Stone	93%	7%	4.93	5.05	5.39	5.80	6.15	6.49
Sullivan	27%	73%	4.35	4.41	4.65	4.90	5.15	5.41
Taney	69%	31%	11.8	12.3	14.0	16.0	17.9	20.0
Texas	77%	23%	4.34	4.44	4.63	4.85	5.04	5.28
Vernon	75%	25%	11.6	12.1	12.6	13.4	14.0	14.8
Warren	91%	9%	3.69	3.77	4.02	4.29	4.53	4.81
Washington	58%	42%	3.82	3.83	3.91	4.00	4.03	4.07
Wayne	51%	49%	2.09	2.16	2.32	2.48	2.63	2.81

Table C-17. Combined Consumptive Demands Forecast to 2060 by County

County	Percent of Demand Source		Total Consumptive Demand Forecast (MGD)					
	Groundwater	Surface Water	2016	2020	2030	2040	2050	2060
Webster	74%	26%	4.82	4.98	5.38	5.84	6.27	6.76
Worth	34%	66%	0.45	0.47	0.50	0.55	0.57	0.62
Wright	70%	30%	3.30	3.36	3.53	3.75	3.94	4.15
STATE TOTAL	**78%**	**22%**	**3,181**	**3,257**	**3,404**	**3,535**	**3,664**	**3,764**

Appendix D
Detailed Methodology for Water Budgets

This appendix describes the calculations completed in support of **Section 4 – Missouri's Water Supply**. Four general sets of calculations were completed to create the water budgets:

- Surface water availability in which U.S. Geological Survey (USGS) streamgage data were used to estimate the availability of surface water throughout the state as described in **Section 4.2.1**
- Calculation of monthly demands such that monthly budgets could be developed to identify short-term supply gaps
- Returns to surface water in which thermoelectric plants, man-made wetlands, fish hatcheries, and wastewater treatment facilities all discharge unconsumed water back to surface waters
- Groundwater availability in which potable groundwater storage and recharge were estimated as described in **Section 4.2.2**

These calculations are described in detail in the following sections.

D.1 Surface Water Availability Calculations

The following subsections describe the calculation of surface water availability.

D.1.1 Precipitation and Evapotranspiration

Precipitation

Precipitation records from 1980 to 2014 were collected from the Daymet dataset via the USGS Geo Data Portal (EarthData 2018). Daymet is a collection of gridded estimates of daily weather parameters generated by interpolation and extrapolation from daily meteorological observations over North America. From the USGS Geo Data Portal, area-weighted mean precipitation, per month and year, was generated for each 8-digit hydrologic unit code (HUC8) and aggregated to determine the 4-digit hydrologic unit code (HUC4) area-weighted mean precipitation within Missouri. The variability in average annual precipitation across the state ranges from a low of 36.2 inches per year (in/yr) within HUC4 1024 (Missouri-Nishnabotna) to a maximum of 48.4 in/yr within HUC4 0802 (Lower Mississippi-St. Francis). Average annual precipitation per HUC4 is provided in **Table D-1**.

Evapotranspiration

Evapotranspiration (ET) records from 2000 to 2014 were collected from an operational Simplified Surface Energy Balance (SSEBop) dataset via the USGS Geo Data Portal (USGS 2018). The SSEBop model uses remotely sensed thermal data and model-assimilated weather fields to calculate ET for the contiguous United States (Senay et al. 2013). From the USGS Geo Data Portal, area-weighted mean ET, per month and year, was generated for each HUC8 and aggregated to determine the HUC4 area-weighted mean precipitation within Missouri.

Overall, ET is a dominant depletion of available surface water compared to withdrawals present per each HUC4. The variability in average annual ET across the state ranges from a low of 22.5 in/yr within HUC4 1024 (Missouri-Nishnabotna) to a maximum of 28.1 in/yr within HUC4 1107 (Neosho-Verdigris). Average annual ET calculated for each HUC4 is provided in **Table D-1**, with more detailed monthly and annual results listed in the water budgets in **Appendix E** for subregion-scale analyses and **Appendix F** for subbasin-scale analyses.

Table D-1. Average Annual Precipitation and Evapotranspiration by HUC4

Subregion HUC4 Code	Subregion Name	Precipitation (in/yr)	Evapotranspiration (in/yr)
0711	Upper Mississippi-Salt	40.1	23.7
0714	Upper Mississippi-Kaskaskia-Meramec	45.4	27.4
0802	Lower Mississippi-St. Francis	48.4	25.7
1024	Missouri-Nishnabotna	36.2	22.5
1028	Chariton-Grand	38.6	22.8
1029	Gasconade-Osage	44.5	27.2
1030	Lower Missouri	41.9	24.9
1101	Upper White	46.8	28.1
1107	Neosho-Verdigris	46.0	28.1

D.1.2 Calculation of In-State Streamflow

Streamflow available for surface water withdrawals was split into the following categories:

- Naturalized streamflow generated within the portion of each subregion within Missouri
- Major river inflows into Missouri, including the Missouri and Mississippi rivers

The calculation of streamflow generated in-state is described in this section, and the calculation of streamflow from major river inflows to Missouri is described in the following section.

USGS Streamgage Selection

Streamflow within each subregion was calculated using data from USGS streamgages for the period from 1986 through 2016 to represent the most recent 30 years of complete record. The streamflow recorded during this period was averaged on an annual and monthly basis to represent hydrologic conditions across the state for an average year.

Selecting the appropriate streamgages was the first step in developing streamflow estimates for each subregion. Streamflow within each subregion was characterized by selecting a minimum of two representative streamgages based on several factors. These factors included:

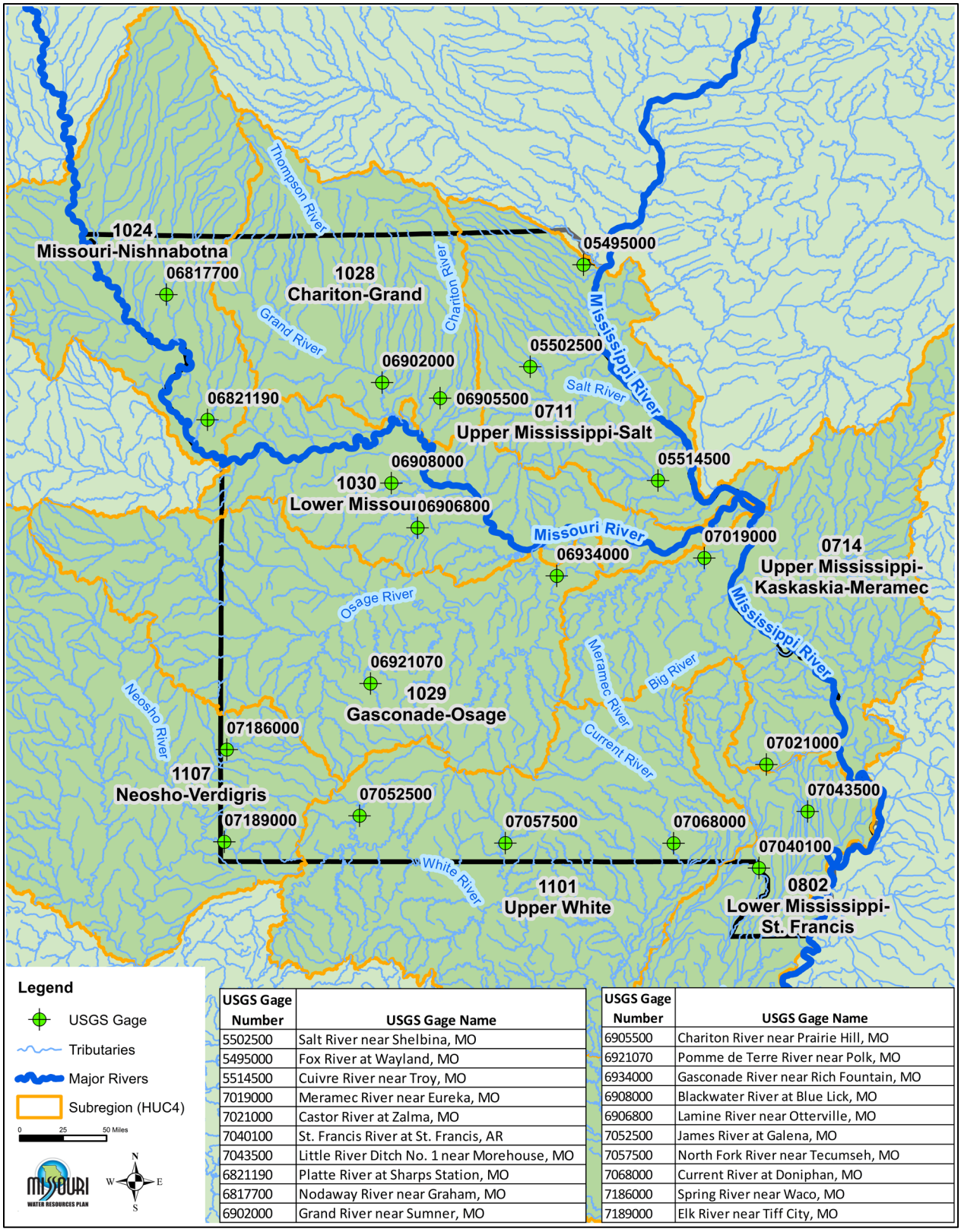
- Upstream characterization to the extent practical, preference is given to streamgages with minimal upstream alterations in which alterations were defined as urban development, withdrawals (demands) or returns to surface water, or other factors that alter the natural streamflow record
- The relative size of the streamgage(s) drainage area compared to the HUC4 subregion area for which streamgages with larger drainage areas were preferred
- The period of record of the streamgage and completeness of data within the past 30 years of record
- Characteristics of the drainage area, such as slope, land cover, and major geologic unit, which were chosen to resemble the overall HUC4 subregion

The streamgages used to determine the subregion basin streamflow were selected from the GAGES-II (USGS 2011) dataset, except for one streamgage in subregion Lower Mississippi-St. Francis (HUC4 0802), as shown in **Figure D-1** and summarized in **Table D-2**. The GAGES-II dataset is a subset of streamgages selected from USGS National Water Information System (NWIS), a collection of streamgages USGS monitors throughout the nation. The GAGES-II dataset was used because it is limited to streamgages with minimal upstream changes to the streamgage's drainage area. The GAGES-II dataset characterizes the drainage area to each streamgage as "reference" or "non-reference" based on the extent of upstream alterations, where reference streamgages typically represent those streamgages with a more natural upstream drainage area than non-reference streamgages.

For the subregion Lower Mississippi-St. Francis (HUC4 0802), the only GAGES-II streamgage with a sizeable drainage area (Streamgage 07040100) was missing data from years 1995 to 1997 and from 2010 to 2016. As a result, Streamgage 07043500 was chosen from the general USGS NWIS dataset because it had a more complete record of data and was recommended by the Missouri Department of Natural Resources (MoDNR) for use.

Table D-2. USGS Streamgages Used to Calculate Missouri Surface Water Supply – Subregional Analyses

Subregion HUC4 Code	USGS Streamgage Number	USGS Streamgage Name	Total Years of Record	Percent Record Complete 1986–2016	Source	GAGES-II Type
0711	05502500	Salt River near Shelbina, MO	66	90%	GAGES-II	Non-reference
	05495000	Fox River at Wayland, MO	94	100%	GAGES-II	Reference
	05514500	Cuivre River near Troy, MO	85	100%	GAGES-II	Reference
0714	07019000	Meramec River near Eureka, MO	97	100%	GAGES-II	Non-reference
	07021000	Castor River at Zalma, MO	86	63%	GAGES-II	Non-reference
0802	07040100	St. Francis River at St. Francis, AR	67	70%	GAGES-II	Non-reference
	07043500	Little River Ditch No. 1 near Morehouse, MO	65	80%	USGS NWIS	-
1024	06821190	Platte River at Sharps Station, MO	38	100%	GAGES-II	Non-reference
	06817700	Nodaway River near Graham, MO	34	100%	GAGES-II	Non-reference
1028	06902000	Grand River near Sumner, MO	91	100%	GAGES-II	Non-reference
	06905500	Chariton River near Prairie Hill, MO	87	100%	GAGES-II	Non-reference
1029	06921070	Pomme de Terre River near Polk, MO	47	100%	GAGES-II	Reference
	06934000	Gasconade River near Rich Fountain, MO	66	97%	GAGES-II	Reference
1030	06908000	Blackwater River at Blue Lick, MO	87	100%	GAGES-II	Non-reference
	06906800	Lamine River near Otterville, MO	29	93%	GAGES-II	Reference
1101	07052500	James River at Galena, MO	95	100%	GAGES-II	Non-reference
	07057500	North Fork River near Tecumseh, MO	67	100%	GAGES-II	Reference
	07068000	Current River at Doniphan, MO	95	100%	GAGES-II	Reference
1107	07186000	Spring River near Waco, MO	92	100%	GAGES-II	Non-reference
	07189000	Elk River near Tiff City, MO	77	100%	GAGES-II	Non-reference



USGS Gage Number	USGS Gage Name
5502500	Salt River near Shelbina, MO
5495000	Fox River at Wayland, MO
5514500	Cuivre River near Troy, MO
7019000	Meramec River near Eureka, MO
7021000	Castor River at Zalma, MO
7040100	St. Francis River at St. Francis, AR
7043500	Little River Ditch No. 1 near Morehouse, MO
6821190	Platte River at Sharps Station, MO
6817700	Nodaway River near Graham, MO
6902000	Grand River near Sumner, MO

USGS Gage Number	USGS Gage Name
6905500	Chariton River near Prairie Hill, MO
6921070	Pomme de Terre River near Polk, MO
6934000	Gasconade River near Rich Fountain, MO
6908000	Blackwater River at Blue Lick, MO
6906800	Lamine River near Otterville, MO
7052500	James River at Galena, MO
7057500	North Fork River near Tecumseh, MO
7068000	Current River at Doniphan, MO
7186000	Spring River near Waco, MO
7189000	Elk River near Tiff City, MO

Figure D-1. Selected USGS Streamgages within Missouri Subregions

Subregional Streamflow Characterization Calculation

Streamflows in each HUC4 were estimated by calculating the volume of flow recorded at each streamgage on both an annual and monthly basis and converting these values to units of inches per year for annual totals and inches per month for monthly totals. These values were then used to represent the volume of streamflow recorded across the entire subregion. Because they are reported in inches per year and inches per month, they can be directly scaled to represent the entire subregion.

These streamflow volumes were based on the streamflow recorded at each streamgage, which is influenced by alterations upstream of the streamgage, including demands and returns to surface water. Calculations to remove the effects of these activities were then completed to create a naturalized streamflow record, which is a streamflow record which has been adjusted to account for known upstream alterations.

Upstream demands reduce the streamflow recorded at each streamgage to lower than it would be in a natural state, and these were added to the streamflow records as part of the calculation to naturalize streamflow. These demands included agriculture, major water systems, self-supplied nonresidential, thermoelectric, and seasonal wetlands. For each streamgage, demands and returns to surface water were identified for individual users within each streamgage's drainage area. For agriculture demands, which were estimated on a county basis and not based on individual users, the demands of the entire subregion containing the streamgage's drainage area were scaled to the drainage area.

Similarly, returns to surface water increase the streamflow recorded at each streamgage, and these were subtracted from the streamflow records as part of the naturalization process. Returns included thermoelectric, seasonal wetland, aquaculture, and wastewater treatment facility flows.

Streamflow volumes for each subregion were then calculated as a weighted average of the volumes calculated at each streamgage, where the drainage area to each streamgage was used as the weighting factor. The resulting annual naturalized average year streamflows for each selected streamgage and for the subregions are provided in **Table D-3.**

Table D-3. Subregional Basin Average Year Streamflow

Subregion HUC4 Code	USGS Streamgage Number	USGS Streamgage Name	Tributary Drainage Area to Streamgage (sq mi)	Average Supply (in/yr)	Annual Subregional Naturalized Average Year Supply (in/yr)
0711	05502500	Salt River near Shelbina, MO	461.0	12.1	12.0
	05495000	Fox River at Wayland, MO	396.7	14.2	
	05514500	Cuivre River near Troy, MO	929.5	11.1	
0714	07019000	Meramec River near Eureka, MO	3,778.1	12.8	13.3
	07021000	Castor River at Zalma, MO	423.0	18.6	
0802	07040100	St. Francis River at St. Francis, AR	4,375.4	6.9	7.9
	07043500	Little River Ditch No. 1 near Morehouse, MO	450.0	17.6	
1024	06821190	Platte River at Sharps Station, MO	2,385.7	10.0	9.7
	06817700	Nodaway River near Graham, MO	1,516.6	9.2	
1028	06902000	Grand River near Sumner, MO	6,928.3	10.1	10.3
	06905500	Chariton River near Prairie Hill, MO	1,891.7	11.1	
1029	06921070	Pomme de Terre River near Polk, MO	275.1	13.8	13.8
	06934000	Gasconade River near Rich Fountain, MO	3,191.1	13.8	
1030	06908000	Blackwater River at Blue Lick, MO	11,1737	12.2	12.4
	06906800	Lamine River near Otterville, MO	546.2	12.6	
1101	07052500	James River at Galena, MO	991.9	14.8	18.0
	07057500	North Fork River near Tecumseh, MO	562.3	18.4	
	07068000	Current River at Doniphan, MO	2,053.5	19.5	
1107	07186000	Spring River near Waco, MO	1,157.9	13.1	13.4
	07189000	Elk River near Tiff City, MO	849.7	13.9	

sq mi – square miles

Wet and dry year streamflow volumes were also determined for each subregion using the same streamgages and approach as average year streamflow. Wet and dry year flow volumes were calculated to represent hydrologic extremes and were identified as the years between 1986 and 2016, which had the highest and lowest annual flow volumes, respectively, at each streamgage.

The results of the streamflow analysis for each streamgage and subregion representing wet and dry year conditions are provided in **Tables D-4** and **D-5**, respectively.

Table D-4. Subregional Basin Wet Year Streamflow

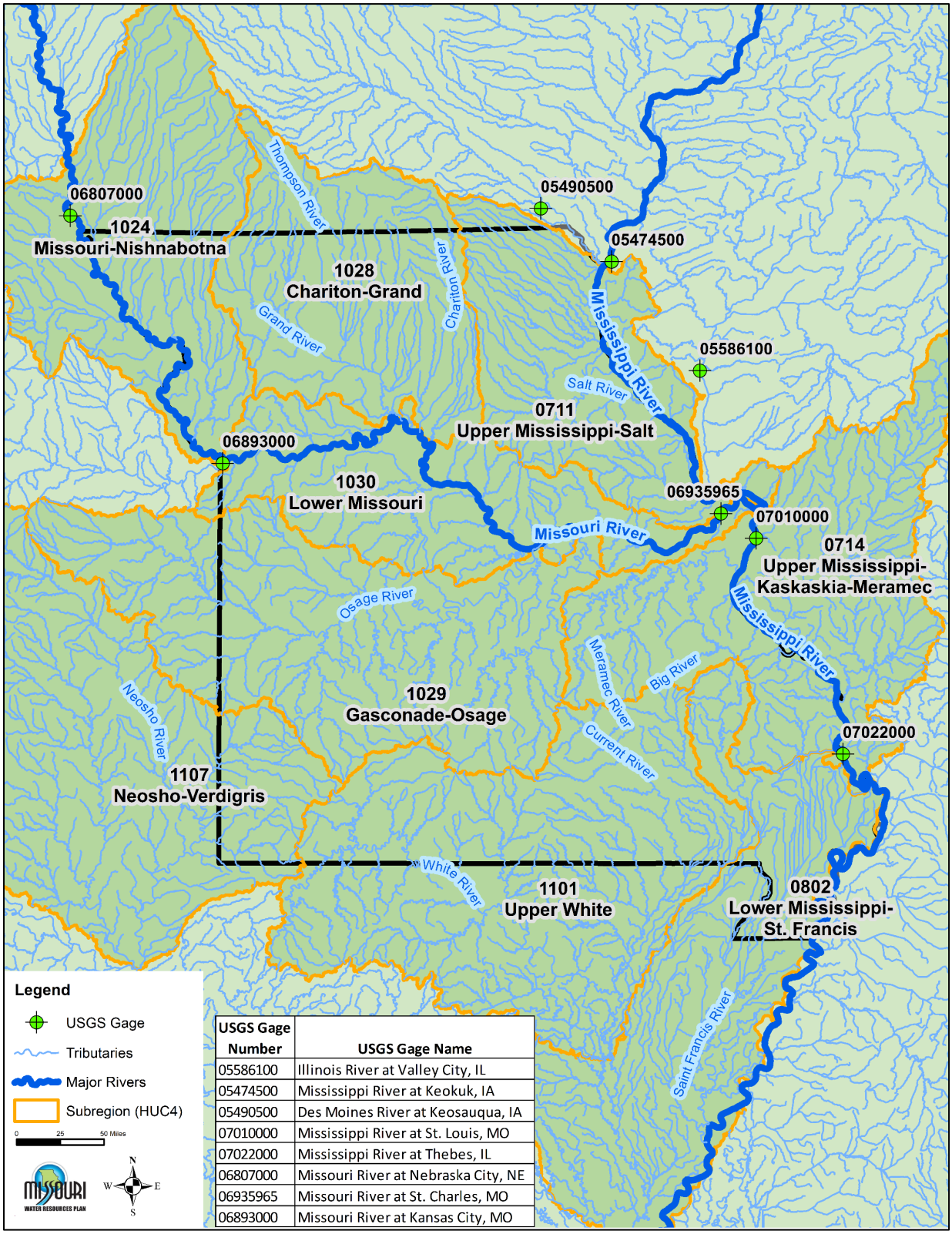
Subregion HUC4 Code	USGS Streamgage Number	USGS Streamgage Name	Drainage Area for Streamgage (sq mi)	Wet Record Year	Average Wet Year Supply (in/yr)	Subregional Naturalized Wet Year Supply (in/yr)
0711	05502500	Salt River near Shelbina, MO	461.0	2008	32.3	32.2
	05495000	Fox River at Wayland, MO	396.7	2010	33.3	
	05514500	Cuivre River near Troy, MO	929.5	1993	31.7	
0714	07019000	Meramec River near Eureka, MO	3,778.1	1993	27.2	27.7
	07021000	Castor River at Zalma, MO	423.0	2015	31.9	
0802	07040100	St. Francis River at St. Francis, AR	4,375.4	2008	11.0	12.7
	07043500	Little River Ditch No. 1 near Morehouse, MO	450.0	2002	29.5	
1024	06821190	Platte River at Sharps Station, MO	2,385.7	1993	30.6	28.1
	06817700	Nodaway River near Graham, MO	1,516.6	1993	24.2	
1028	06902000	Grand River near Sumner, MO	6,928.3	1993	30.4	30.5
	06905500	Chariton River near Prairie Hill, MO	1,891.7	2010	30.7	
1029	06921070	Pomme de Terre River near Polk, MO	275.1	2008	27.7	26.2
	06934000	Gasconade River near Rich Fountain, MO	3,191.1	1993	26.0	
1030	06908000	Blackwater River at Blue Lick, MO	11,1737	1993	26.6	27.9
	06906800	Lamine River near Otterville, MO	546.2	1993	30.5	
1101	07052500	James River at Galena, MO	991.9	2015	32.8	29.7
	07057500	North Fork River near Tecumseh, MO	562.3	1993	31.4	
	07068000	Current River at Doniphan, MO	2,053.5	2015	27.7	
1107	07186000	Spring River near Waco, MO	1,157.9	2008	30.0	28.9
	07189000	Elk River near Tiff City, MO	849.7	1993	27.4	

Table D-5. Subregional Basin Dry Year Streamflow

Subregion HUC4 Code	USGS Streamgage Number	USGS Streamgage Name	Drainage Area for Streamgage (sq mi)	Dry Record Year	Dry Year Supply (in/yr)	Subregional Naturalized Dry Year Supply (in/yr)
0711	05502500	Salt River near Shelbina, MO	461.0	1989	1.0	1.9
	05495000	Fox River at Wayland, MO	396.7	1989	0.6	
	05514500	Cuivre River near Troy, MO	929.5	2006	2.8	
0714	07019000	Meramec River near Eureka, MO	3,778.1	2000	4.6	5.0
	07021000	Castor River at Zalma, MO	423.0	2012	9.2	
0802	07040100	St. Francis River at St. Francis, AR	4,375.4	1987	3.2	3.6
	07043500	Little River Ditch No. 1 near Morehouse, MO	450.0	2012	7.4	
1024	06821190	Platte River at Sharps Station, MO	2,385.7	2003	1.2	1.4
	06817700	Nodaway River near Graham, MO	1,516.6	1988	1.6	
1028	06902000	Grand River near Sumner, MO	6,928.3	2003	1.3	1.3
	06905500	Chariton River near Prairie Hill, MO	1,891.7	2000	1.2	
1029	06921070	Pomme de Terre River near Polk, MO	275.1	2006	3.0	3.1
	06934000	Gasconade River near Rich Fountain, MO	3,191.1	2000	3.1	
1030	06908000	Blackwater River at Blue Lick, MO	11,1737	2006	2.3	1.9
	06906800	Lamine River near Otterville, MO	546.2	2006	1.1	
1101	07052500	James River at Galena, MO	991.9	2000	5.0	8.3
	07057500	North Fork River near Tecumseh, MO	562.3	2000	8.5	
	07068000	Current River at Doniphan, MO	2,053.5	2000	9.9	
1107	07186000	Spring River near Waco, MO	1,157.9	2006	1.3	2.6
	07189000	Elk River near Tiff City, MO	849.7	2006	4.2	

D.1.3 Calculation of Major River Inflows

USGS NWIS streamgages shown in **Figure D-2** and listed in **Table D-6** were used to determine streamflow along the Missouri, Mississippi, and Illinois Rivers. Specifically, streamgages were chosen to represent inflows to the state as a whole and to each subregion.



USGS Gage Number	USGS Gage Name
05586100	Illinois River at Valley City, IL
05474500	Mississippi River at Keokuk, IA
05490500	Des Moines River at Keosauqua, IA
07010000	Mississippi River at St. Louis, MO
07022000	Mississippi River at Thebes, IL
06807000	Missouri River at Nebraska City, NE
06935965	Missouri River at St. Charles, MO
06893000	Missouri River at Kansas City, MO

Figure D-2. Selected Streamgages to Represent Major River Inflows

Table D-6. HUC4 Basin Dry Year Streamflow

Subregion HUC4 Code	USGS Streamgage Number	USGS Streamgage Name	Total Years of Record	Percent Record Complete 1986–2016	Source	GAGES-II Type
Upstream of 0711	05586100	Illinois River at Valley City, IL	78	100%	USGS NWIS	-
Upstream of 0711	05474500	Mississippi River at Keokuk, IA	112	100%	USGS NWIS	-
Upstream of 0711	05490500	Des Moines River at Keosauqua, IA	47	100%	GAGES-II	Non-reference
0714	07010000	Mississippi River at St. Louis, MO	84	100%	USGS NWIS	-
0714	07022000	Mississippi River at Thebes, IL	80	100%	USGS NWIS	-
1024	06807000	Missouri River at Nebraska City, NE	64	100%	USGS NWIS	-
1030	06935965	Missouri River at St. Charles, MO	16	50%	USGS NWIS	-
1030	06893000	Missouri River at Kansas City, MO	59	100%	USGS NWIS	-

Because the streamgage on the Mississippi River that measures flow entering subregion Upper Mississippi-Salt (HUC4 0711) is located upstream of its confluence with the Des Moines River, the flows recorded on each river were combined to represent total Mississippi River inflows conveyed into Missouri. To determine the inflows of the Des Moines River and the Mississippi River as they enter Missouri, the additional drainage area was measured between the streamgages and Missouri and a ratio of the total drainage area to the streamgage's drainage area was multiplied by the streamflow to determine the inflows entering Missouri. Similarly, flows recorded on the Illinois River near St. Louis, entering the state within subregion Upper Mississippi-Salt (HUC4 0711) from USGS streamgage 05586100, were scaled based on the drainage area to represent inflows into the state.

Flows recorded at the streamgages were not naturalized due to the size of their upstream drainage areas and lack of data for demands and returns in their upstream drainage areas. Because of the large magnitude of the flows recorded in each of these major rivers, demands and returns comprise a negligible percentage of the overall flows.

The results of streamflow analysis for each streamgage selected on a major river are aggregated to represent average, dry, and wet year streamflow either entering or leaving Missouri as provided in **Tables D-7, D-8,** and **D-9**, respectively.

Table D-7. Major River Average Year Streamflow

Subregion HUC4 Code	Description	USGS Streamgage Number(s)	USGS Streamgage Name	Drainage Area for Streamgage (sq mi)	Major River Average Supply Missouri (in/yr)
Upstream of 0711	Illinois River near St. Louis entering West Missouri	05586100	Illinois River at Valley City, IL	26,743	44.7
Upstream of 0711	Confluence of Des Moines and Mississippi River entering Northeast Missouri[1]	05474500 and 05490500	Mississippi River at Keokuk, IA and Des Moines River at Keosauqua, IA	133,010	161.8
0714	Mississippi River near St. Louis	07010000	Mississippi River at St. Louis, MO	697,000	430.8
0714	Mississippi River near Cape Girardeau	07022000	Mississippi River at Thebes, IL	713,200	691.9
1024	Missouri River entering Northwest Missouri	06807000	Missouri River at Nebraska City, NE	410,000	156
1030	Mississippi River near St. Louis Leaving East Missouri	06935965	Missouri River at St. Charles, MO	524,000	120.1
1030	Missouri River near Kansas City entering West Missouri	06893000	Missouri River at Kansas City, MO	484,100	77.7

[1] Mississippi River inflows to the state represent the combined Des Moines River and the Mississippi River flows recorded by streamgages 05474500 and 05490500.

Table D-8. Major River Dry Year Streamflow

Subregion HUC4 Code	Description	USGS Streamgage Number(s)	USGS Streamgage Name	Drainage Area for Streamgage (sq mi)	Dry Year	Major River Average Dry Year Supply Missouri (in/yr)
Upstream of 0711	Illinois River near St. Louis entering West Missouri	05586100	Illinois River at Valley City, IL	26,743	2012	19.0
Upstream of 0711	Confluence of Des Moines and Mississippi River entering Northeast Missouri[1]	05474500 and 05490500	Mississippi River at Keokuk, IA and Des Moines River at Keosauqua, IA	133,010	1989	70.0
0714	Mississippi River near St. Louis	07010000	Mississippi River at St. Louis, MO	697,000	1989	205.6
0714	Mississippi River near Cape Girardeau	07022000	Mississippi River at Thebes, IL	713,200	1989	337.5
1024	Missouri River entering Northwest Missouri	06807000	Missouri River at Nebraska City, NE	410,000	1990	102.3
1030	Mississippi River near St. Louis Leaving East Missouri	06935965	Missouri River at St. Charles, MO	524,000	2006	55.0
1030	Missouri River near Kansas City entering West Missouri	06893000	Missouri River at Kansas City, MO	484,100	2006	44.2

[1] Mississippi River inflows to the state represent the combined Des Moines River and the Mississippi River flows recorded by streamgages 05474500 and 05490500.

Table D-9. Major River Wet Year Streamflow

Subregion HUC4 Code	Description	USGS Streamgage Number(s)	USGS Streamgage Name	Drainage Area for Streamgage (sq mi)	Wet Year	Major River Average Wet Year Supply Missouri (in/yr)
0711	Illinois River near St. Louis entering West Missouri	05586100	Illinois River at Valley City, IL	26,743	1993	88.8
0711	Confluence of Des Moines and Mississippi River entering Northeast Missouri[1]	05474500 and 05490500	Mississippi River at Keokuk, IA and Des Moines River at Keosauqua, IA	133,010	1993	324.7
0714	Mississippi River near St. Louis	07010000	Mississippi River at St. Louis, MO	697,000	1993	850.2
0714	Mississippi River near Cape Girardeau	07022000	Mississippi River at Thebes, IL	713,200	1993	1333.8
1024	Missouri River entering Northwest Missouri	06807000	Missouri River at Nebraska City, NE	410,000	2011	347.6
1030	Mississippi River near St. Louis Leaving East Missouri	06935965	Missouri River at St. Charles, MO	524,000	2010	197.3
1030	Missouri River near Kansas City entering West Missouri	06893000	Missouri River at Kansas City, MO	484,100	2011	142.8

[1] Mississippi River inflows to the state represent the combined Des Moines River and the Mississippi River flows recorded by streamgages 05474500 and 05490500.

D.1.4 Subbasin-Level Analyses

A subbasin-level streamflow analysis was completed that evaluated surface water supply for all subbasins within subregion Chariton-Grand (HUC4 code 1028) and one subbasin within subregion Gasconade-Osage (HUC4 code 1029). These subbasins were chosen for further analysis by recommendation from the technical workgroups and MoDNR. Available surface water within these subbasins was calculated using the same approach described in **Section D.1.2** for the subregional analyses to naturalize streamflow records and characterize annual and monthly supply for average, wet, and dry years. The HUC8 subbasin code and associated subbasin names are shown in **Table D-10**. The streamgages chosen to characterize surface water supply were taken from the GAGES-II dataset as documented in **Table D-11** and shown in **Figure D-3**.

Table D-10. Subbasin HUC8 Names

Subbasin HUC8 Code	Subbasin Name
10280101	Upper Grand
10280102	Thompson
10280103	Lower Grand
10280201	Upper Chariton
10280202	Lower Chariton
10280203	Little Chariton
10290103	Little Osage

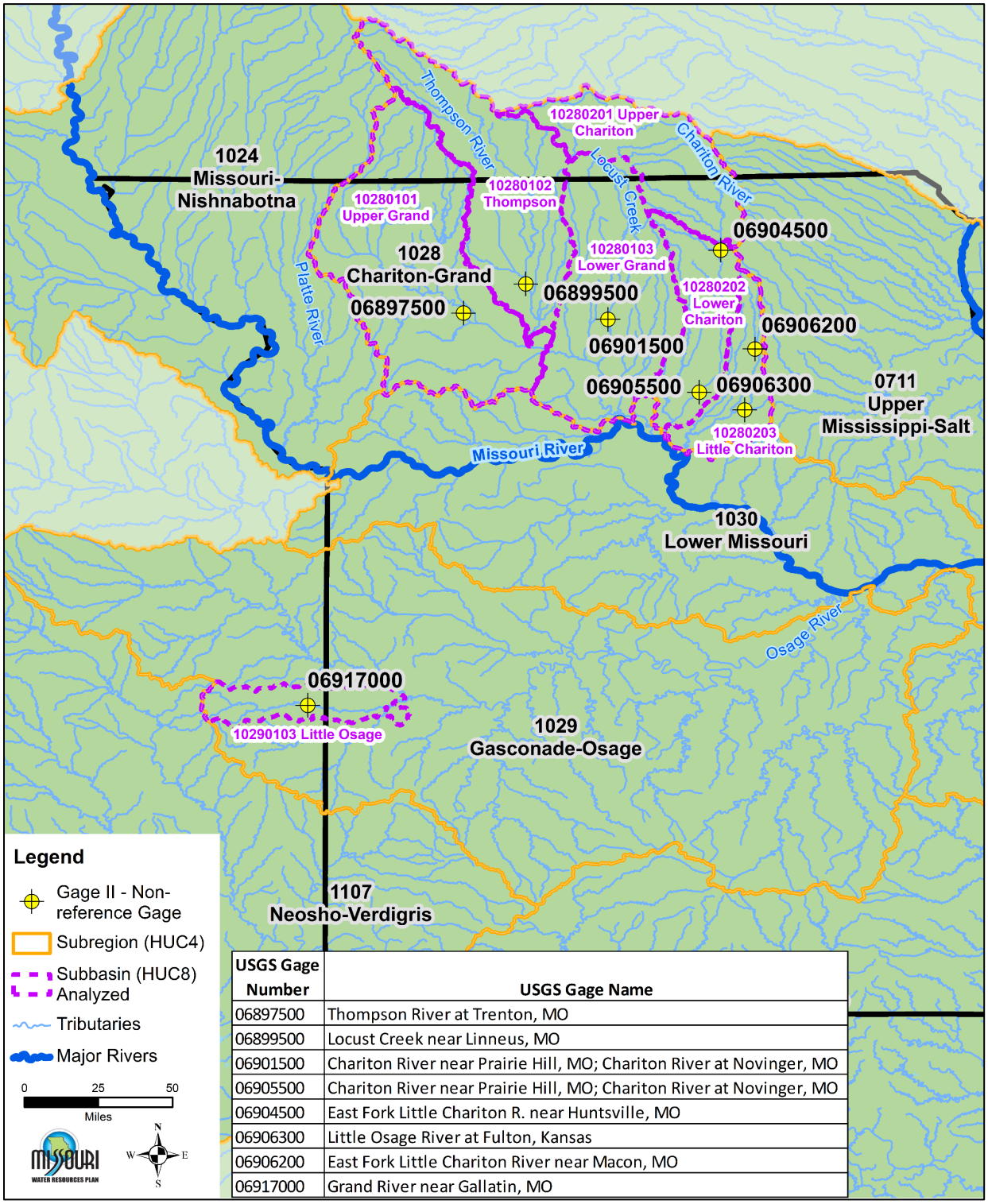
Table D-11. USGS Streamgages Used to Calculate Missouri Surface Water Supply – Subbasin-Level Analyses

Subbasin HUC8 Code	USGS Streamgage Number(s)	USGS Streamgage Name	Total Years of Record	Percent Complete 1986–2016	Source	Class
10280101	06897500	Grand River near Gallatin, MO	95	100%	GAGES-II	Non-reference
10280102	06899500	Thompson River at Trenton, MO	88	100%	GAGES-II	Non-reference
10280103	06901500	Locust Creek near Linneus, MO	58	50%	GAGES-II	Non-reference
10280201	06905500, 06904500[1]	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO	46	100%	GAGES-II	Non-reference
10280202	06905500, 06904500[2]	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO	46	100%	GAGES-II	Non-reference
10280203	06906300	East Fork Little Chariton River near Huntsville, MO	32	83%	GAGES-II	Non-reference
10280203	06906200	East Fork Little Chariton River near Macon, MO	38	100%	GAGES-II	Non-reference
10290103	06917000	Little Osage River at Fulton, KS	68	100%	GAGES-II	Non-reference

[1] The characterization of surface water supply for HUC8 10280202 was applied to HUC8 10280201 due to a lack of an appropriate streamgage to characterize the flow in HUC8 10280201.
[2] Surface water supply availability for water generated within HUC8 10280202 was characterized using a streamflow record created by subtracting flows recorded at streamgage 06905500 from those recorded at 06904500.

Calculations to estimate surface supply in these subbasins were generally straightforward, except in the Lower Chariton (HUC8 10280202) and Upper Chariton (HUC8 10280201) subbasins. To determine the available supply in the Lower Chariton subbasin, the recorded streamflow at streamgage 06904500 was subtracted from the recorded streamflow at streamgage 06905500 to isolate flows generated within the subbasin and remove contributions from the upstream subbasin. For the Upper Chariton subbasin, where a streamgage showed only local, unregulated contributions due to the presence of Rathbun Reservoir, the surface water availability was characterized using the results in the downstream Lower Chariton subbasin.

The results for the subbasin analyses are summarized in **Tables D-12, D-13, and D-14** for average, wet, and dry years, respectively.



USGS Gage Number	USGS Gage Name
06897500	Thompson River at Trenton, MO
06899500	Locust Creek near Linneus, MO
06901500	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO
06905500	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO
06904500	East Fork Little Chariton R. near Huntsville, MO
06906300	Little Osage River at Fulton, Kansas
06906200	East Fork Little Chariton River near Macon, MO
06917000	Grand River near Gallatin, MO

Figure D-3. Selected Streamgages to Calculate Subbasin-Level Surface Supply

Table D-12. Subbasin-Level Basin Average Year Streamflow

Subbasin HUC8 Code	USGS Streamgage Number(s)	USGS Streamgage Name	Tributary Drainage Area to Streamgage (sq mi)	Average Year Supply (in/yr)	Final HUC8 Naturalized Average Supply (in/yr)
10280101	06897500	Grand River near Gallatin, MO	2,250.0	9.6	9.6
10280102	06899500	Thompson River at Trenton, MO	1,720.0	12.6	12.6
10280103	06901500	Locust Creek near Linneus, MO	550.0	11.0	11.0
10280201	06905500, 06904500[1]	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO	526.0	10.1	10.1
10280202	06905500, 06904500[2]	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO	526.0	10.1	10.1
10280203	06906300	East Fork Little Chariton River near Huntsville, MO	218.1	11.7	11.6
	06906200	East Fork Little Chariton River near Macon, MO	103.8	11.2	
10290103	06917000	Little Osage River at Fulton, KS	295.7	8.5	8.5

[1] The characterization of surface water supply for HUC8 10280202 was applied to HUC8 10280201 due to a lack of an appropriate streamgage to characterize the flow in HUC8 10280201.
[2] Surface water supply availability for water generated within HUC8 10280202 was characterized using a streamflow record created by subtracting flows recorded at streamgage 06905500 from those recorded at 06904500.

Table D-13. Subbasin-Level Basin Wet Year Streamflow

Subbasin HUC8 Code	USGS Streamgage Number(s)	USGS Streamgage Name	Tributary Drainage Area to Streamgage (sq mi)	Wet Year	Naturalized Wet Year Supply (in/yr)	Subbasin Naturalized Wet Year Supply (in/yr)
10280101	06897500	Grand River near Gallatin, MO	2,250.0	1993	31.9	31.9
10280102	06899500	Thompson River at Trenton, MO	1,720.0	2008	25.4	25.4
10280103	06901500	Locust Creek near Linneus, MO	550.0	2010	32.5	32.5
10280201	06905500-06904500[1]	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO	526.0	2010	32.6	32.6
10280202	06905500-06904500[2]	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO	526.0	2010	32.6	32.6
10280203	06906300	East Fork Little Chariton River near Huntsville, MO	218.1	2008	32.4	31.8
	06906200	East Fork Little Chariton River near Macon, MO	103.8	1993	30.4	
10290103	06917000	Little Osage River at Fulton, KS	295.7	2008	23.8	23.8

[1] The characterization of surface water supply for HUC8 10280202 was applied to HUC8 10280201 due to a lack of an appropriate streamgage to characterize the flow in HUC8 10280201.
[2] Surface water supply availability for water generated within HUC8 10280202 was characterized using a streamflow record created by subtracting flows recorded at streamgage 06905500 from those recorded at 06904500.

Table D-14. Subbasin-Level Basin Dry Year Streamflow

Subbasin HUC8 Code	USGS Streamgage Number(s)	USGS Streamgage Name	Tributary Drainage Area to Streamgage (sq mi)	Dry Year	Naturalized Dry Year Supply (in/yr)	Subbasin Naturalized Dry Year Supply (in/yr)
10280101	06897500	Grand River near Gallatin, MO	2,250.0	2003	0.5	0.5
10280102	06899500	Thompson River at Trenton, MO	1,720.0	2006	1.1	1.1
10280103	06901500	Locust Creek near Linneus, MO	550.0	2006	0.8	0.8
10280201	06905500, 06904500[1]	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO	526.0	2000	1.3	1.3
10280202	06905500, 06904500[2]	Chariton River near Prairie Hill, MO; Chariton River at Novinger, MO	526.0	2000	1.3	1.3
10280203	06906300	East Fork Little Chariton River near Huntsville, MO	218.1	1989	1.4	1.3
	06906200	East Fork Little Chariton River near Macon, MO	103.8	1989	1.0	
10290103	06917000	Little Osage River at Fulton, KS	295.7	1989	0.9	0.9

[1] The characterization of surface water supply for HUC8 10280202 was applied to HUC8 10280201 due to a lack of an appropriate streamgage to characterize the flow in HUC8 10280201.
[2] Surface water supply availability for water generated within HUC8 10280202 was characterized using a streamflow record created by subtracting flows recorded at streamgage 06905500 from those recorded at 06904500.

D.1.5 Water Supply Reservoir Evaluation

A mass balance calculation was completed to evaluate reservoir storage in all subregions using average demands from 2011 (Edwards et al. 2011), average free water surface evaporation (National Oceanic and Atmospheric Administration [NOAA] 1982), and dry year inflow based on the lowest streamflow year between 1980 and 2016. No reservoir outflow was assumed. Leakage at the dam, normal spills, and required minimum releases were not accounted for. Reservoir storage was reported as total storage; therefore, the available water supply storage volume is assumed to be lower and based on the elevation of the intake. The results of this evaluation are reported on the subregion and subbasin summary sheets contained in **Appendices E** and **F**, respectively.

D.2 Monthly Demands

Monthly demands were calculated such that monthly budgets could be developed to compare supply versus demand on a seasonal basis to identify short-term hydrologic gaps. This was done by distributing annual demands as described in the following subsections.

D.2.1 Major Water Systems

The monthly demands analysis was conducted to evaluate the sensitivity of public water supply to variations in weather conditions and estimate historical weather variations by subregion throughout the state. The information obtained from these activities would be used to develop dry weather adjustment factors for major water system demands by subregion for the summer months.

Historical monthly water use and corresponding weather observations were obtained from two major water systems. Kansas City (KC) Water provided their monthly water production for the period May 1998 to April 2018, which included corresponding observations of monthly total precipitation and monthly average maximum and minimum daily temperatures for these same months. City Utilities of Springfield provided their monthly water production from October 2002 to September 2017. Weather observations for these corresponding months were obtained from NOAA for the Springfield Airport station. Monthly water production for these two public water supply systems is shown in **Figures D-4** and **D-5**. Production is reported in million gallons per day (MGD) in these figures.

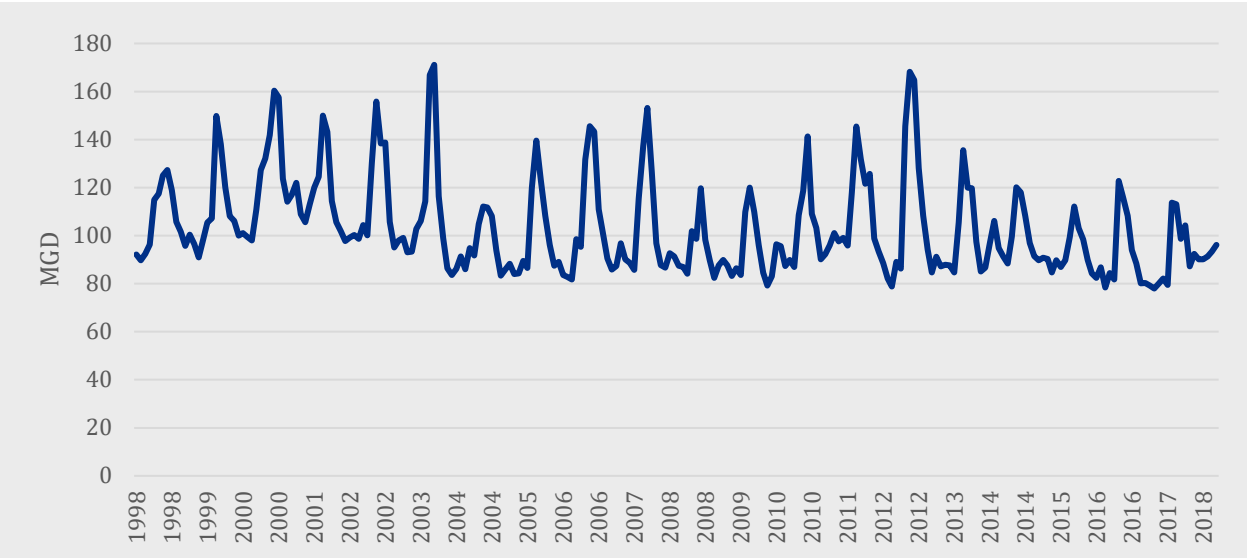


Figure D-4. Monthly Water Production for KC Water

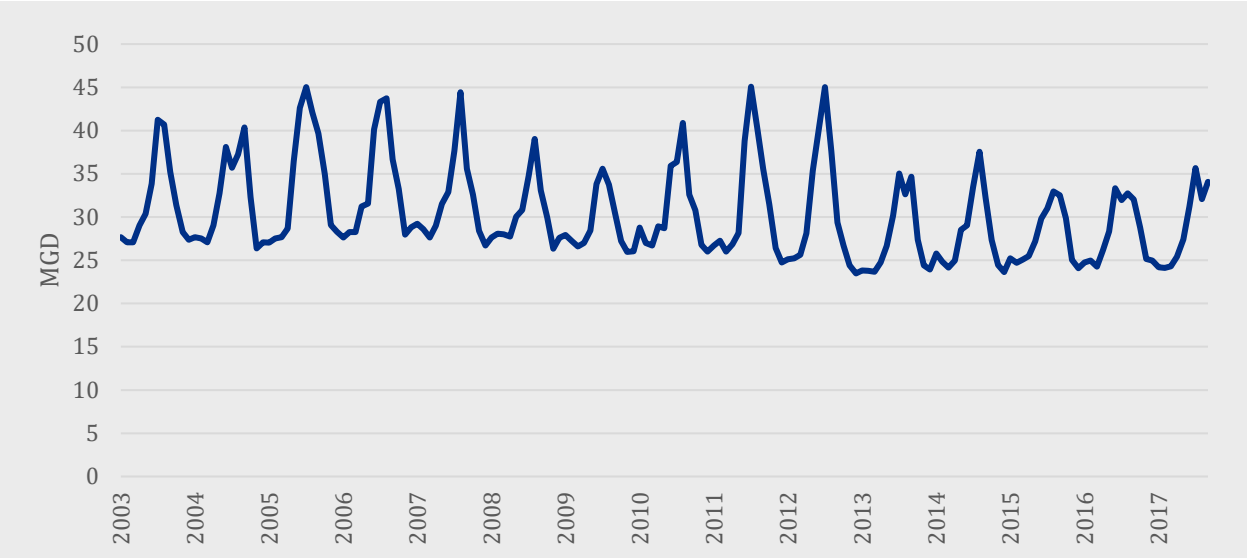


Figure D-5. Monthly Water Production for City Utilities (Springfield)

A regression analysis was completed to estimate the variation in water production with respect to variation in precipitation and average maximum daily temperature. For this analysis, only data for the six summer months of May through October were used. It was assumed that weather variation has little to no impact on water production in the winter months.

Data were converted to natural log form so that the resulting regression coefficients for precipitation and maximum temperature could be interpreted as elasticities, which reflect the percent change in water production for a given percent change in the weather parameter.

Separate regression analyses for KC Water and City Utilities data were conducted initially, and then the data from the two systems were combined, which provides a temporal, cross-sectional dataset. A binary variable (with a value of 0/1) was used to account for the influence of the KC Water data given the magnitude of the water production volume relative to the City Utilities volume. The regression analysis of the combined data

was statistically significant with an R^2 value of 0.970, where a higher R^2 value indicates less error in the predicted regression values. The elasticity for precipitation in the summer months was estimated as -0.058. The negative sign of the elasticity indicates an inverse relationship, meaning that monthly water production decreases as monthly precipitation increases. The elasticity for maximum temperature in the summer months was estimated as 1.050. Both elasticities were statistically significant at less than the 0.005 probability level.

The second step of the analysis was to evaluate historical weather variation by subregion throughout the state. Thirty years of historical monthly weather data, spanning January 1988 through November 2017, were obtained for 23 weather stations throughout the state. An analysis of weather patterns indicated that the summer of 2012 had the most months with monthly precipitation totals below 2 inches and monthly average maximum temperatures above 90°F across all stations. Therefore, the summer months of 2012 were deemed to represent a recent dry summer for all stations.

For each summer month (i.e., May through October), the 2012 precipitation and maximum temperature were compared to the 30-year average for that month at each station. Thus, a ratio of dry-to-average was computed for monthly precipitation and maximum temperature for each summer month at each station.

The 23 weather stations were then assigned to their respective subregions. Where a weather station was located near a boundary between subregions, these were assigned to both regions. Each of the nine subregions in the state had at least one weather station assigned to it. For subregions with multiple weather stations, the dry-to-average ratios were averaged among all stations within the subregion for each summer month. The monthly dry-to-average ratios by basin are shown in **Table D-15**.

Table D-15. Monthly Variations in Dry to Average Precipitation and Temperature Ratios by Subregion

Subregion HUC4 Code	Subregion Name	Dry/Average Precipitation Ratio						Dry/Average Max Temperature Ratio					
		May	June	July	Aug	Sept	Oct	May	June	July	Aug	Sept	Oct
0711	Upper Mississippi-Salt	0.432	0.375	0.439	0.357	1.466	1.218	1.085	1.043	1.107	1.046	0.981	0.969
0714	Upper Mississippi-Kaskaskia-Meramec	0.316	0.367	0.650	0.476	1.334	1.078	1.096	1.049	1.102	1.039	0.977	0.950
0802	Lower Mississippi-St. Francis	0.244	0.440	0.260	0.468	1.267	0.965	1.085	1.030	1.072	1.031	0.994	0.953
1024	Missouri-Nishnabotna	0.701	0.602	0.295	0.777	0.357	0.874	1.082	1.034	1.109	1.036	1.007	0.962
1028	Chariton-Grand	0.677	0.448	0.291	0.249	1.071	1.027	1.078	1.045	1.109	1.045	0.995	0.961
1029	Gasconade-Osage	0.398	0.482	0.236	0.588	1.098	0.851	1.086	1.041	1.108	1.031	0.979	0.947
1030	Lower Missouri	0.392	0.359	0.231	0.346	1.286	0.885	1.084	1.048	1.106	1.037	0.988	0.960
1101	Upper White	0.266	0.595	0.435	1.364	0.962	0.568	1.077	1.028	1.074	1.019	0.985	0.963
1107	Neosho-Verdigris	0.501	0.611	0.063	1.056	1.191	1.384	1.077	1.033	1.093	1.024	0.994	0.954

Previous water demand estimates of public water supply by subregion assumed average (normal) weather conditions for future years. The dry-to-average ratios for precipitation and maximum temperature in the summer months were used to calculate an adjustment factor for the prior average weather water demand estimates to provide an estimated monthly water demand under dry weather conditions. The dry weather adjustment factor for each month was calculated using the formula:

$$\textit{Adjustment Factor} = (\textit{dry/average precipitation ratio})^{\textit{precipitation elasticity}} \times (\textit{dry/average max temp ratio})^{\textit{max temp elasticity}}$$

The resulting monthly dry weather adjustment factors by subregion are shown in **Table D-16**. Any calculated adjustment factor that is less than 1.0 would reflect a condition that is wetter/cooler than normal and is therefore replaced with a value of 1.0 to reflect normal conditions. For subbasin analyses that were performed,

the adjustment factors associated with the subregion in which a subbasin was located were applied to the subbasin.

Table D-16. Monthly Adjustment Factors for Major Water Systems by Subregion

Subregion HUC4 Code	Subregion Name	Adjustment Factor for Dry Weather					
		May	June	July	Aug	Sept	Oct
0711	Upper Mississippi-Salt	1.144	1.107	1.167	1.112	1.000	1.000
0714	Upper Mississippi-Kaskaskia-Meramec	1.177	1.115	1.136	1.086	1.000	1.000
0802	Lower Mississippi-St. Francis	1.182	1.082	1.163	1.079	1.000	1.000
1024	Missouri-Nishnabotna	1.109	1.067	1.197	1.053	1.069	1.000
1028	Chariton-Grand	1.107	1.097	1.197	1.135	1.000	1.000
1029	Gasconade-Osage	1.150	1.088	1.211	1.065	1.000	1.000
1030	Lower Missouri	1.149	1.114	1.210	1.105	1.000	1.000
1101	Upper White	1.168	1.060	1.131	1.002	1.000	1.000
1107	Neosho-Verdigris	1.126	1.065	1.288	1.022	1.000	1.000

D.2.2 Self-Supplied Nonresidential

Because self-supplied nonresidential water users comprise a range of industries and variation in monthly demands are highly specific to each facility and because the magnitude of surface water withdrawals within this sector are relatively small, monthly demands were assumed to be equal. Monthly demands were subsequently developed by dividing annual demands by 12.

D.2.3 Thermoelectric Power Generation

To convert annual thermoelectric demands to monthly demands, a seasonality factor was applied. The demands analysis provided seasonality factors based on monthly energy use across 56 counties from 2004 to 2016. The seasonality estimates were obtained from the *Ameren Missouri 2017 Integrated Resource Plan* and are provided in **Table D-17** (Ameren 2017). The seasonality factor for each month was applied to the annual thermoelectric demands in the annual water budgets to determine monthly water demands.

Table D-17. Monthly Variations in Energy Usage for Missouri

Month	Percent of Annual Energy Use
January	9.1%
February	8.1%
March	7.7%
April	6.9%
May	7.6%
June	9.1%
July	10.0%
August	9.8%
September	8.0%
October	7.3%
November	7.5%
December	8.9%

D.2.4 Agriculture Irrigation and Livestock

Monthly demands for agriculture irrigation were provided by the University of Missouri (MU) on a subregional and subbasin basis, and these were directly input to the monthly budgets. The MU team also provided subregional and subbasin-level livestock demands on an annual basis. Monthly demands were assumed to be constant, such that the annual demands were divided by 12 to develop equal monthly livestock demands as more detailed data describing livestock demands were not available.

D.2.5 Seasonal Wetlands

Wetlands demands were assumed to only be applicable in the months of September and October as these represent waterfowl hunting season, which is the primary reason that seasonal wetlands are created. Therefore, to convert from annual to monthly estimates, the annual demands were divided by two and applied only to September and October.

D.2.6 Aquaculture and Fish Hatcheries

Monthly aquaculture demands were assumed to be nearly equal, and annual demands were divided by 12 to develop monthly demands.

D.3 Returns to Surface Water

This subsection documents the calculations completed to determine the volumes of returns to surface water by facilities that withdraw water and do not completely consume it. Additionally, monthly variations applied to these returns are documented in this subsection.

D.3.1 Returns from Thermoelectric Facilities

Thermoelectric power generation demand and consumption were quantified for the baseline year 2015 and for projected demands and consumption from 2020 through 2060 in 5-year increments as described in **Section 3.6**. The amount of water returned to surface was calculated on a subregion and subbasin basis by subtracting consumption from withdrawals for facilities.

For each user, the percent estimated alluvial or groundwater uses were multiplied by total demands to provide the proportion of total withdrawals, consumption, and returns from groundwater sources. The remaining portion of total demands and returns was assumed to be from a surface water source unless it was specified that the user extracted water exclusively from surface water sources.

Thermoelectric Facilities Returns Monthly Variation

Thermoelectric returns were calculated on a monthly basis by distributing annual returns using the variations in energy usage in **Table D-16**.

D.3.2 Returns from Seasonal Wetlands

Seasonal wetlands returns were assumed to be equivalent to demands such that the total water withdrawn from surface water sources was assumed to be returned.

Seasonal Wetland Facilities Returns Monthly Variation

Wetlands demands were assumed to be applicable only in the months of September and October because these months represent waterfowl hunting season when wetlands are most commonly flooded. Therefore, to convert from annual to monthly estimates, the annual returns were divided by two and applied only to September and October.

D.3.3 Returns from Aquaculture and Fish Hatchery Facilities

Aquaculture and fish hatchery facility returns were assumed to be equivalent to demands such that the total water withdrawn from surface water sources was assumed to be returned.

Aquaculture and Fish Hatchery Facilities Returns Monthly Variation

The demands analysis provided estimates on an annual basis and did not include a seasonality analysis for aquaculture. Therefore, to convert the annual aquaculture demands to monthly demands, the results of the annual water budgets were divided by 12 to evenly distribute demands by month.

D.3.4 Returns from Wastewater Treatment Facilities

A portion of consumptive water use is returned to streams and rivers after treatment in a wastewater treatment plant. Data used to estimate wastewater returns were obtained from Discharge Monitoring Reports (DMRs) provided by MoDNR and the U.S. Environmental Protection Agency (EPA) Enforcement and Compliance History Online (ECHO) database.

DMRs are collected by the state for all permitted wastewater facilities within Missouri, and the period of record analyzed spanned 2012 to 2017. As a quality check, the permit numbers within the DMRs were compared to the EPA ECHO database of permitted facilities, with a period of record from 2007 to 2017. The DMRs provide monthly average flow through a plant in MGD, whereas EPA ECHO data only provide total facility design flow and actual average facility flow, in MGD, on an annual basis. The DMRs reported 1,201

permitted plants while the EPA ECHO database recorded 1,368 permitted plants. Therefore, the EPA ECHO database was used to estimate wastewater returns.

The EPA ECHO dataset presents flow in two ways: total facility design flow and actual average facility flow, in MGD. Total facility design flow represents the facility's maximum capacity; however, facilities normally operate at flow rates lower than maximum capacity. Therefore, actual average facility flow was used for calculating annual flow, and average flow per year was compared to design flow to ensure that records with actual reported flow greater than design capacity were not used. The average facility flows were assigned to subregions and subbasins based on their location.

To calculate returns to surface water, the average actual facility flows were reduced by 25 percent such that only 75 percent of flow would be returned to surface water. This was done to underestimate returns and provide a conservative analysis of water supply. The results of this process yielded annual wastewater treatment plant returns per plant, and these were aggregated to the subregional and subbasin level.

Wastewater Treatment Facilities Returns Monthly Variation

Monthly wastewater return flows were calculated using the EPA ECHO annual flow rates with a monthly factor applied, and the monthly DMR data were used to create these monthly factors. The monthly factors, which represent percentages of annual flow returned within a given month, were calculated by comparing flow per month to total annual flow over the period of record for each permit number. These were aggregated on a subregional and subbasin level (for the subbasins analyzed in **Section D.1.4**) as shown in **Tables D-18** and **D-19**, respectively.

Table D-18. Monthly Subregional Wastewater Facility Return Factors

Subregion HUC4 Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
0711	8.0%	7.8%	13.7%	9.6%	10.6%	11.0%	7.0%	7.3%	9.0%	6.9%	6.8%	10.9%
0714	8.4%	8.7%	15.0%	9.4%	10.0%	13.5%	8.0%	7.7%	13.2%	7.6%	7.6%	11.8%
0802	11.4%	10.6%	13.2%	9.9%	10.4%	9.9%	6.6%	6.5%	6.2%	5.2%	7.5%	10.8%
1024	8.7%	7.2%	14.5%	10.2%	10.4%	16.5%	6.9%	7.2%	13.6%	7.7%	9.1%	12.7%
1028	6.2%	7.4%	15.7%	12.5%	11.4%	12.1%	7.7%	4.6%	7.7%	4.4%	7.9%	9.0%
1029	8.5%	7.5%	16.9%	10.2%	10.8%	18.7%	8.1%	7.8%	20.5%	7.8%	7.6%	15.7%
1030	8.8%	7.3%	18.1%	9.7%	10.0%	16.0%	8.1%	7.5%	12.4%	7.5%	7.7%	14.1%
1101	8.8%	7.0%	17.9%	8.2%	11.1%	16.4%	9.6%	9.3%	16.4%	6.6%	6.9%	15.4%
1107	7.9%	6.8%	10.2%	10.0%	9.5%	11.1%	7.1%	7.1%	10.5%	7.8%	5.8%	11.8%

Table D-19. Monthly Subbasin-Level Wastewater Facility Return Factors

Subbasin HUC8 Code	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
10280101	8.3%	9.1%	20.2%	11.9%	15.2%	18.0%	8.7%	6.8%	10.1%	3.6%	10.5%	10.4%
10280102	4.3%	10.8%	14.4%	9.2%	5.5%	11.7%	5.5%	2.9%	5.6%	5.9%	15.1%	7.4%
10280103	5.5%	5.8%	14.9%	14.6%	11.4%	9.2%	9.1%	3.2%	8.0%	4.7%	7.1%	8.9%
10280201	0.5%	3.2%	4.1%	5.3%	3.9%	3.5%	3.0%	3.0%	3.7%	0.8%	2.7%	3.4%
10280202	9.0%	10.3%	14.3%	14.7%	11.2%	8.1%	7.5%	5.6%	4.6%	5.8%	5.2%	5.6%
10280203	7.0%	6.0%	13.2%	16.1%	13.7%	7.5%	7.1%	4.2%	4.4%	7.8%	7.3%	14.2%
10290103	7.1%	6.1%	21.7%	13.2%	13.8%	12.4%	7.4%	6.6%	11.8%	7.3%	5.7%	19.3%

D.4 Groundwater Supply Calculations

Groundwater budgets for each subregion were developed to compare recharge and aquifer storage to withdrawals. To be consistent with the assessment of surface water availability, groundwater budgets were developed for each subregion and select subbasins; however, it is recognized that this approach has some limitations since Missouri's major aquifers do not typically follow drainage basin boundaries.

The elements of the groundwater budget and the methods used to develop estimates for each subregion are described below.

D.4.1 Recharge from Precipitation

Estimating the amount of recharge from precipitation to the water table and comparing to groundwater withdrawals provides a screening-level measure of groundwater resource sustainability. Recharge across the state was previously estimated by USGS (Wollock 2003). The estimates were derived using baseflow indexes developed from a mean annual runoff contour map for the period 1951–1980. An output to this study was the development of a nationwide 1-kilometer resolution raster (grid) dataset. The dataset is an index of mean annual natural groundwater recharge. It was created by multiplying a grid of baseflow index values by a grid of mean annual runoff values derived from a 1951–1980 mean annual runoff contour map. Mean annual runoff is the long-term average streamflow expressed on a per-unit-area basis. The concept used to construct the dataset assumes that the long-term average natural groundwater recharge is equal to the long-term average natural groundwater discharge to streams. It also assumes that the base-flow index reasonably represents, over the long term, the percentage of natural groundwater discharge in streamflow.

The raster dataset for Missouri was obtained, and geospatial tools were used to calculate averages for each subregion (HUC4) and subbasin (HUC8). The resulting average annual recharge estimates for each subbasin are shown in **Figure 4-4** of **Section 4**.

Is should be recognized wells tapping deeper confined or semi-confined aquifers may be not be withdrawing water that has recharged the aquifer (via precipitation) from the land surface surrounding the well. Recharge from precipitation to a deeper aquifer may come from adjacent subregions or subbasins, or from nearby counties. This is an important limitation that should be considered when comparing recharge from precipitation to groundwater withdrawals over the same spatial area.

D.4.2 Groundwater Withdrawals

For the purposes of this study, groundwater withdrawals included both alluvial and non-alluvial aquifer withdrawals. In the water budgets, withdrawals have been separated into consumptive and nonconsumptive categories as described in **Section 4**.

Withdrawals by aquifer were estimated based on well construction information contained in various well databases and water use databases. For most wells in the databases, the geologic formation at the casing depth and total depth were identified. **Table D-20** provides the general correlation between the geologic unit and the aquifer assignment. In some areas, exceptions to this correlation were made. While it is recognized that the production zone of some wells may span multiple aquifers, typically, only one aquifer assignment was made per well when assigning withdrawals to aquifers. This simplifying assumption was deemed appropriate because it is prohibitively difficult to estimate the amount of water each well may extract from each aquifer.

Table D-20. Aquifer Assignments for Groundwater Withdrawals, Based on Well Geologic Formation

Geologic Formation	Aquifer Assignment
Alluvium	Alluvium
Glacial Deposits	Glacial Deposits
Wilcox Group	Wilcox
Midway Group	Wilcox
Cretaceous System	McNairy Formation
Pennsylvanian System	Pennsylvanian Bedrock Aquifer
Chesterian Series	Springfield Plateau Aquifer
Meramecian Series	Springfield Plateau Aquifer
Osagean Series	Springfield Plateau Aquifer
Kinderhookian Series	Ozark Aquifer (Upper)
Devonian System/Silurian System	Ozark Aquifer (Upper)
Cincinnatian Series	Ozark Aquifer (Upper)
Kimmswick Limestone	Ozark Aquifer (Upper)
Decorah Group/Plattin Group	Ozark Aquifer (Upper)
Joachim Dolomite/Dutchtown Formation	Ozark Aquifer (Upper)
St. Peter Sandstone	Ozark Aquifer (Upper)
Everton Formation	Ozark Aquifer (Upper)
Smithville Dolomite/Powell Dolomite	Ozark Aquifer (Upper)
Cotter Dolomite	Ozark Aquifer (Lower)
Jefferson City Dolomite	Ozark Aquifer (Lower)
Roubidoux Formation	Ozark Aquifer (Lower)
Gasconade Dolomite	Ozark Aquifer (Lower)
Eminence Dolomite	Ozark Aquifer (Lower)
Potosi Dolomite	Ozark Aquifer (Lower)
Elvins Group	Ozark Aquifer (Lower)
Bonneterre Formation	St Francois Aquifer
Lamotte Sandstone	St Francois Aquifer
Precambrian Erathem	Precambrian

D.4.3 Potable Groundwater Storage

Potable groundwater storage is the amount of groundwater stored in each major aquifer that is usable or drainable. Estimates of potable groundwater storage were developed in support of the previous state water plan (Miller and Vandike 1997). Potable groundwater was defined as water containing less than 1,000 milligrams per liter (mg/l) of total dissolved solids and less than 250 mg/l each of sulfate and chloride. Estimates of potable storage were made within county, aquifer, and groundwater province boundaries. For this plan, the estimates by county were correlated to subregions and subbasins by aquifer using geographic information system (GIS) tools.

D.4.4 Returns to Groundwater

Returns to groundwater through on-site wastewater systems (e.g., septic tanks, spray fields, and other nonsurface water discharges) were not estimated. These are typically a small component of the overall groundwater budget, and developing reliable estimates of the amount of water that recharges the aquifers from these systems is prohibitively difficult.

D.5 Groundwater Modeling

D.5.1 Goals of Assessment

The USGS Ozark Plateaus aquifer system groundwater flow model was used to evaluate potential impacts at projected 2060 withdrawals within the Missouri portion of the Ozark Plateaus Aquifer System.

D.5.2 Existing Groundwater Flow Model

The Ozark Plateaus groundwater model provides suitable accuracy at a regional scale and is capable of assessing regional groundwater availability, making it appropriate for use in this broad water availability assessment (Clark et al. 2018). The model covers the area of Missouri south of the Missouri River and extends into Kansas, Oklahoma, and Arkansas. The Bootheel of Missouri in the southeastern corner of the state is not included in the model. The model is divided into nine layers encompassing the Springfield Plateau Aquifer, the Ozark Aquifer, and the St. Francois Aquifer.

The model simulates domestic, public supply, agriculture, livestock, and non-agriculture withdrawals from 1900-2015. The entire simulation is made up of back-to-back stress periods of varying length depending on availability of data; recent years have more data such that changes over shorter time periods can be simulated with greater confidence (**Table D-21**). The model simulation starts with a steady-state stress period to establish starting heads based on conditions in 1900. The model is then run for two transient simulations from 1900 to 1940 and 1940 to 1965. Annual transient stress periods are run from 1965 to 1989 and 6-month stress periods are run from 1991 -2015. The 6-month stress periods demonstrate seasonal variation between an agricultural/growing season (April-September) and a non-agricultural/winter season (October-March).

Table D-21. Available Withdrawal Data Associated with the USGS Groundwater Model

	Length of Stress Period (days)	Stress Period Type	Notes
1900	1	Steady-State	Establish starting heads in 1900
1900-1940	14,609	Transient	One 40-year stress period
1940-1965	9,132	Transient	One 25-year stress period
1965-1989	25, 365-day stress periods	Transient	Annual stress periods
1/1/1990-4/1/1991	455	Transient	Transitional stress period
1991-2015	50, 182/183-day stress periods	Transient	6-month seasonal

The USGS conducted a detailed study to develop the withdrawals for the model (Knierim et al. 2017). The withdrawal dataset was developed using site-specific data, where available, and by disaggregating county-level withdrawal rates to known well locations. County-level withdrawals were allocated to known withdrawal locations based on "the level of confidence that a well pumped groundwater for a specific use during a specific year" (Knierim et. al 2017). This level of confidence considered characteristics such as available well log data, drill date, and surrounding land use. Withdrawals were then aggregated within model cells, which are one mile by one mile in size, for use in the groundwater model.

Model withdrawal data is available in the form of a "wel" file (text file that is direct input for the MODFLOW groundwater model) and two GIS shapefiles (data with spatial information) (**Table D-22**). The wel file includes withdrawal rates in each actively pumping model cell for each stress period but does not indicate the associated withdrawal type. The first shapefile contains withdrawal rates and withdrawal types in each model cell (layer, row, column) for all withdrawal types except domestic. The second shapefile includes domestic withdrawals at the county scale (by layer but not by model row and column).

Table D-22. Available Withdrawal Data Associated with the USGS Groundwater Model

	Data Format	Discretization of data	Withdrawal Type
Wel File	Text file for direct model input	Cell (layer, row, column)	Not specified
Cell Withdrawals	GIS shapefile	Cell (layer, row, column)	Agricultural, Livestock, Public Supply, Non-Agriculture
County Domestic Withdrawals	GIS shapefile	County (layer)	Domestic

D.5.3. Model Application

Selection of Approach

The initial intent of this assessment was to apply projected demands to the model by correlating wells where demand projections were developed with withdrawal points in the model, ensuring rates are similar, and applying projected demands to those locations for future stress periods. This approach assumed that withdrawals would be included in the model as discrete points and withdrawal datasets associated with each point would be available. As described above, withdrawals associated with the model were only available at the model cell level (or county level for domestic withdrawal). Many withdrawal locations were unknown and were assigned using a multi-step procedure of assigning locations based on the likelihood of pumping. Since the datasets associated with this procedure were not readily available, a revised procedure was required.

Two procedural options were considered:

1. Create a new withdrawal file using only locations where demand projections were developed for 2016-2060 while maintaining the existing USGS withdrawal file for 1900-2015.
2. Maintain the existing USGS withdrawal file for 1900-2015 and disaggregate projected county-level demands for 2016-2060 to model cells based on the percentage of county withdrawals occurring in each model cell in past stress periods.

To pursue the feasibility of option 1, well locations where demands were projected were compared to model cells with withdrawals (pumping cells). In many cases, wells were located within pumping cells; however, some pumping cells had no well located within them and other wells were located where there was no pumping cell. If the original set of withdrawal locations was used in the model from 1900-2015 then a different set of locations was used from 2016-2060, the ability to compare results (e.g., drawdowns) between current and future periods would be difficult and results would be invalid in certain areas.

Option 2 would use the existing withdrawal locations in the model but would distribute projected demands to these cells based on their relative pumping rates. Allocating projected demands at the county level is expected to provide a reasonable degree of accuracy for use in a regional model. Option 2 was selected since it avoided the problem of potentially over or under-predicting drawdowns in the instance where withdrawal location assumptions changed between the 1900-2015 and 2016-2060 stress periods.

General Model Application

The first step in implementing this procedure was to correlate projected demand types with withdrawal types in the model. Demand projections were developed for eight withdrawal types, whereas the model distinguishes between five withdrawal types. Table 1 from Knierim et al. 2017 (copied in as **Table D-23**) indicates the water uses (site-specific water-use, SSWU) that are considered under each withdrawal type and was used for this correlation. **Table D-24** shows how the projected demand uses were categorized under one of the five model use categories. Projected agriculture and aquaculture demands were summed to correlate with USGS agricultural withdrawals, and self-supplied non-residential and thermoelectric demand projections were summed to correlate with USGS non-agricultural withdrawals. Livestock, public supply and

domestic withdrawals correlated directly with USGS withdrawals. Projected wetlands demands were not applied within the USGS model.

Table D-23. Excerpt from Knierim et al., 2017 Describing Withdrawal Divisions

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Table 1 Site-specific water-use (*SSWU*) categories, land-use/land-cover (*LULC*) classes, and USGS (*USGS*) county-aggregate categories used to derive groundwater-use divisions

SSWU categories	LULC classes[a]	LULC simple classes	USGS categories[b]	Use division
Agriculture, aquaculture, irrigation	Alfalfa, apples, barley, blueberries, cabbage, cantaloupes, christmas trees, clover/wildflowers, corn, cotton, cranberries, Dbl crop barley/corn, Dbl crop barley/sorghum, Dbl crop barley/soybeans, Dbl crop corn/soybeans, Dbl crop oats/corn, Dbl crop soybeans/cotton, Dbl crop soybeans/oats, Dbl crop winter wheat/corn, Dbl crop winter wheat/cotton, Dbl crop winter wheat/sorghum, Dbl crop winter wheat/soybeans, dry beans, fallow/idle cropland, grapes, greens, millet, misc veg and fruits, oats, other crops, other hay/non alfalfa, other tree crops, peaches, peanuts, peas, pecans, popcorn or corn, potatoes, pumpkins, rice, rye, sorghum, soybeans, speltz, spring wheat, squash, sunflower, sweet corn, sweet potatoes, tobacco, tomatoes, triticale, walnuts, watermelons, winter wheat	Crop	Irrigation, aquaculture	Agriculture
Domestic	Deciduous forest, evergreen forest, mixed forest	Forest	Domestic (self-supplied)	Domestic
-	Grassland herbaceous, herbaceous wetlands, herbs, pasture/grass, pasture/hay, shrubland, sod/grass seed, switchgrass, woody wetlands	Pasture	Livestock	Livestock
Public supply	-	-	Public supply	Public supply
Commercial, industrial, mining	Developed/high intensity, developed/low intensity, developed/medium intensity, developed/open space	Developed	Thermoelectric power generation, industrial (self-supplied), mining, commercial (self-supplied)	Non-agriculture

[a] LULC classes from US Department of Agriculture (2011)

[b] USGS categories from USGS (2015b)

Dbl double crop (as defined in the Cropland Data Layer—US Department of Agriculture 2011)

Table D-24. Correlations Between Projected Demand Types with Model Withdrawal Divisions

USGS Groundwater Model Withdrawal Division	Projected Demand Withdrawal Type
Agriculture	- Agriculture – Irrigation - Aquaculture (only have 2010 withdrawal)
Livestock	Agriculture – Livestock
Domestic	Self-Supplied Domestic
Non-Agriculture	Self-Supplied Non-Residential
	Thermoelectric
Public Supply	Major Water Systems (Public Supply)
Not included	Wetlands (non-consumptive)

A comparison of 2010 withdrawals from the USGS model (2010 withdrawals were applied for 2010-2015) with estimated 2016 county-level demands developed as part of this study demonstrated general agreement on withdrawal rates by sector (**Figure D-6**). The withdrawal rates in **Figure D-6** are for the Missouri counties in the USGS model only. Withdrawal rates from counties in other states in the USGS model were excluded and demand projections for counties in Missouri outside the USGS model extents were excluded. In general, the differences appear reasonable given the demands were from six years apart and were developed using different approaches. The withdrawal types with the largest rates, public supply and agriculture, show the highest correlation at a county level (**Figure D-7**).

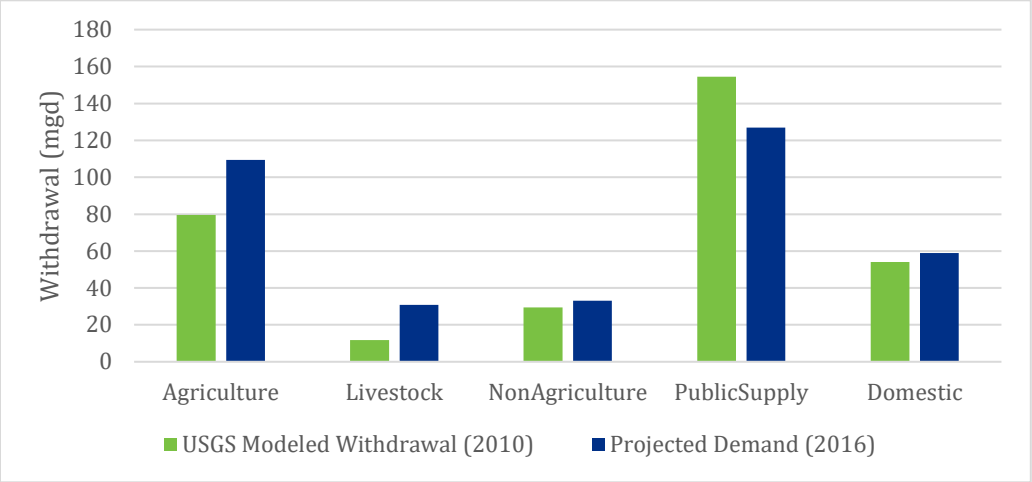

Figure D-6. Comparison of Projected Demands for 2016 with 2010 Withdrawals from the USGS Groundwater Model

Application of Non-Domestic Withdrawals

For each withdrawal type, the percentage of county-wide pumping occurring within a model cell in that county was calculated. The percentage was then multiplied by the projected demand for the county and withdrawal type, such that the total county pumping summed to the projected demand while the distribution of pumping within the county was unchanged. **Table D-25** provides an illustrative example of how this process was applied. In this example, there are three actively pumping cells in county A, such that the total county demand is 2.0 mgd. To disaggregate the projected 2.5 mgd county demand to these three cells, a percentage of total pumping occurring in each cell is calculated in the fourth column. In the sixth column, this percentage is multiplied by the projected 2.5 mgd county demand to yield a projected demand for each cell. This process was followed for 2016, 2020, 2030, 2040, 2050, and 2060 withdrawal rates for all types except domestic withdrawals (discussed in the following section).

Table D-25. Example of Disaggregation of Projected Demands within a County Based on Demands in the USGS Model

County	Cell	Withdrawal in Model (MGD)	Percentage Pumping	Projected County Pumping (MGD)	Disaggregated County Pumping (MGD)
A	1	0.4	0.4/2.0 = 20%	-	2.5 mgd x 20% = 0.50
A	2	0.6	0.6/2.0 = 30%	-	2.5 mgd x 30% = 0.75
A	3	1.0	1.0/2.0 = 50%	-	2.5 mgd x 50% = 1.25
Total		**2.0**	**-**	**2.5**	**2.5**

This approach assumes the spatial distribution of withdrawals in the model (both horizontally throughout a county and vertically among aquifer layers) is reasonably representative of future withdrawal locations and that the magnitude of withdrawals is the variable that changes with time.

There were instances where demand projections were developed for a withdrawal type in a county for which the USGS model did not have withdrawals for that use type. For these counties and demand types, specific withdrawal locations identified in the demand modeling were spatially correlated with a model cell and the withdrawal was assigned to that cell. Following this methodology, five agricultural wells in Cass County, two agricultural wells in Gasconade County and one agricultural well in Bates County were added. Additionally, one non-agricultural well for Cedar, St. Clair, Laclede, and Gasconade counties and three non-agricultural wells for St. Francois County were added to the model.

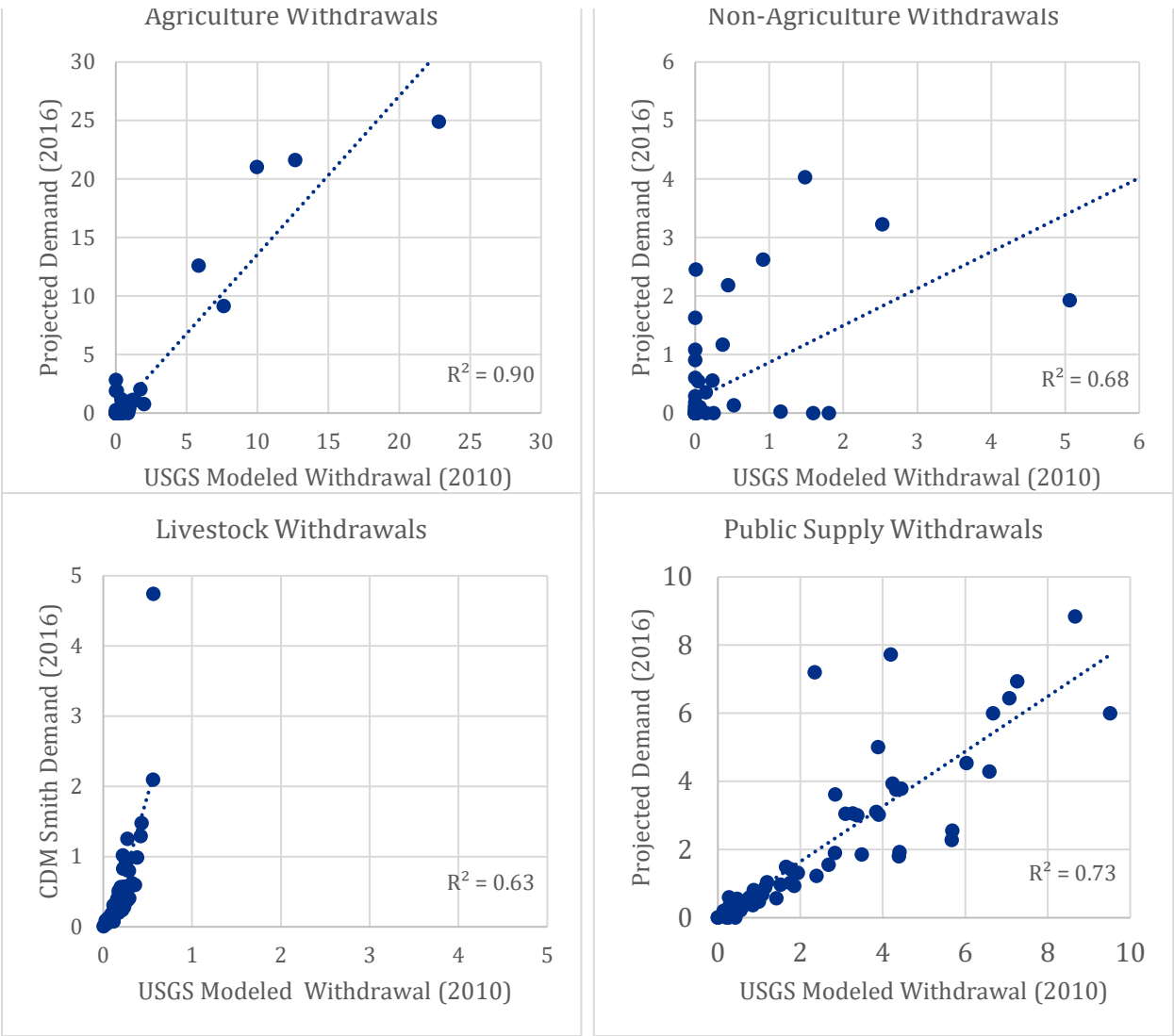

Figure D-7. Comparison of Withdrawals – Each Plotted Point Represents Rates from One County

Cass County purchases its water and the withdrawal point is located in Jackson County, north of Cass County. Jackson County borders the Missouri River, but the county was not included in the USGS model. This portion of the demand from Cass County was excluded from the model.

The USGS report indicated alluvial deposits were "not explicitly simulated in the model" (Clark et al. 2018) but it was not clear if demands from the alluvium were included. In the USGS model, withdrawals in counties adjacent to the Missouri or Mississippi River were mostly located along the river, suggesting alluvial withdrawals were included. A portion of projected demands in these counties was assigned to the alluvium. Following the disaggregation procedure, projected demands were disaggregated according to the distribution of existing withdrawals in the model. Since there is no model layer for alluvial deposits in the USGS model, these projected demands were assigned to non-alluvial layers. This assumption may result in falsely elevated withdrawals from other aquifers. Consequently, results near the rivers, where alluvial demands may be incorrectly assigned to non-alluvial aquifers, should be considered with caution.

Application of Domestic Withdrawals

Projected domestic demands were developed at the county level and were disaggregated to model cells. A comparison of projected withdrawal rates with model withdrawals by county demonstrates strong agreement with an r^2 value of 0.96 (**Figure D-8.**). Again, these discrepancies in withdrawal rates seem reasonable because the years being compared are only six years apart (2010 vs 2016).

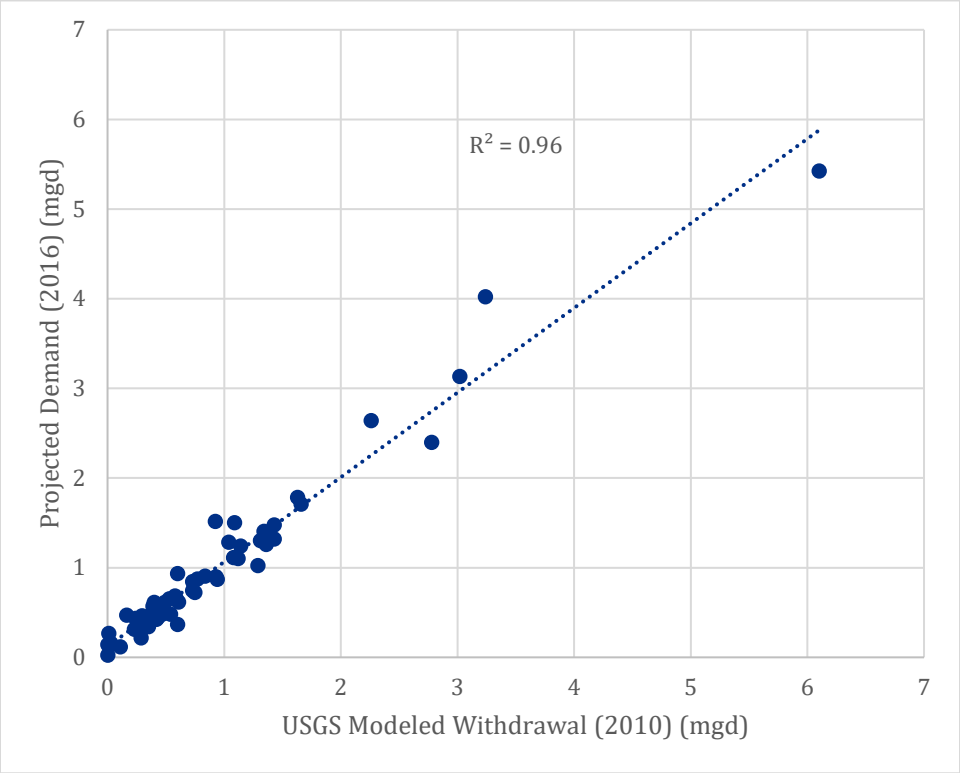

Figure D-8. Comparison of Domestic Withdrawals – Each Plotted Point Represents Rates from One County

Following a similar approach to what was done for the disaggregation of non-domestic demands, county level demand projections were disaggregated to model cells. For domestic withdrawals, county-wide withdrawal rates in each model layer were available from the USGS model, but the distribution of domestic withdrawals throughout the counties was not known. Projected county level demands were disaggregated vertically by

model layer based on the percentage pumping occurring in each layer in past stress periods. Additional information was then needed to disaggregate projected county demands spatially to model rows and columns.

The USGS identified domestic pumping as occurring at wells located within forested land, assuming wells in pasture and crop land were for agriculture/livestock and urban areas would be on city/public supply water (Clark et al. 2018). Based on the assumption that domestic pumping would occur in forested land, countywide domestic demand projections were distributed to model cells (row and column) based on the percentage of total county forested area present in each cell. The percentage of forested area was calculated using the National Landcover Database. The percentage of forested land was then multiplied by the percentage of pumping occurring in each model layer to get an overall percentage of county pumping occurring in each model cell (layer, row, column). The percentage was then multiplied by the projected county level domestic demands for 2016, 2020, 2030, 2040, 2050 and 2060.

Revisions to Model

A revised withdrawal file was created by appending 2016-2060 withdrawals by model cell to the existing USGS model withdrawals from 1900-2015. Demand projections were not developed outside of Missouri, so withdrawal rates for cells outside Missouri were maintained at 2015 rates through 2060. **Figure D-9** and **D-10** show withdrawal rates for each model cell in 2016 and 2060, respectively. Since projected domestic demands for Missouri were distributed according to landcover, small withdrawals cover nearly every model cell in Missouri (withdrawal < 10 gpm) but not areas of the model in adjacent states, where withdrawals were unchanged. The change in total withdrawal from 2016 to 2060 by cell is shown in **Figure D-11**.

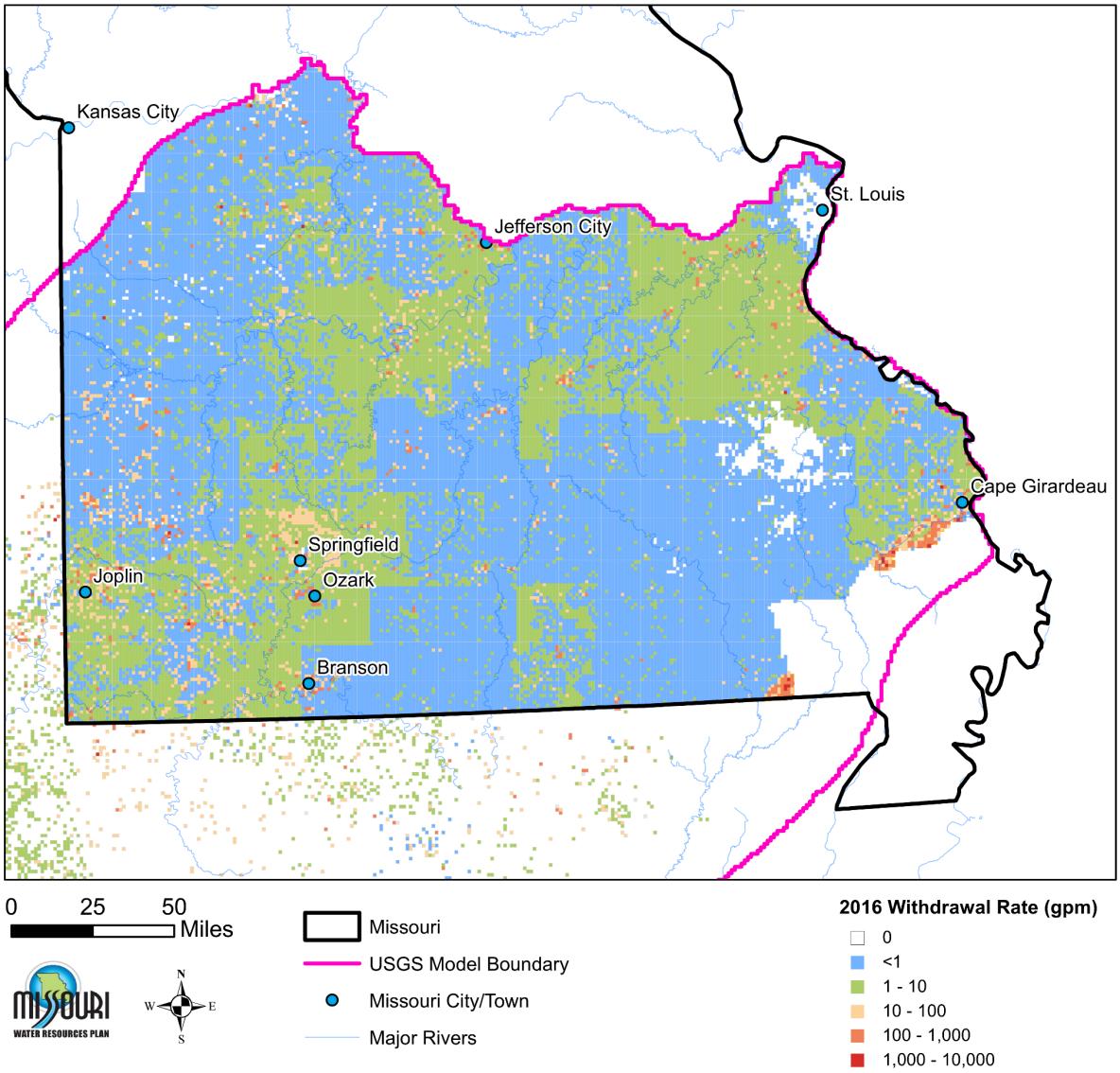

Figure D-9. Estimated Withdrawal Rates in 2016

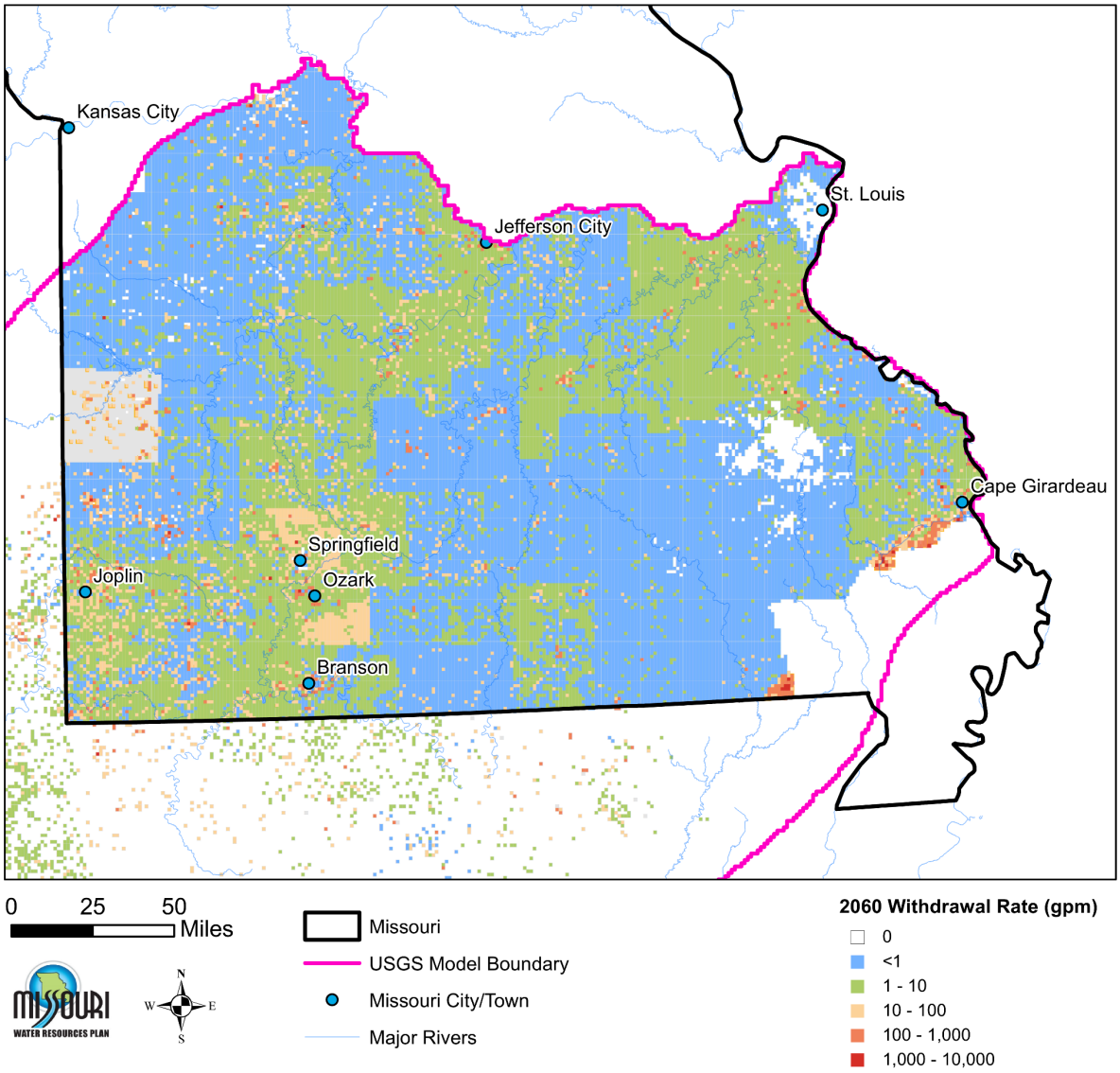

Figure D-10. Projected Withdrawal Rates in 2060

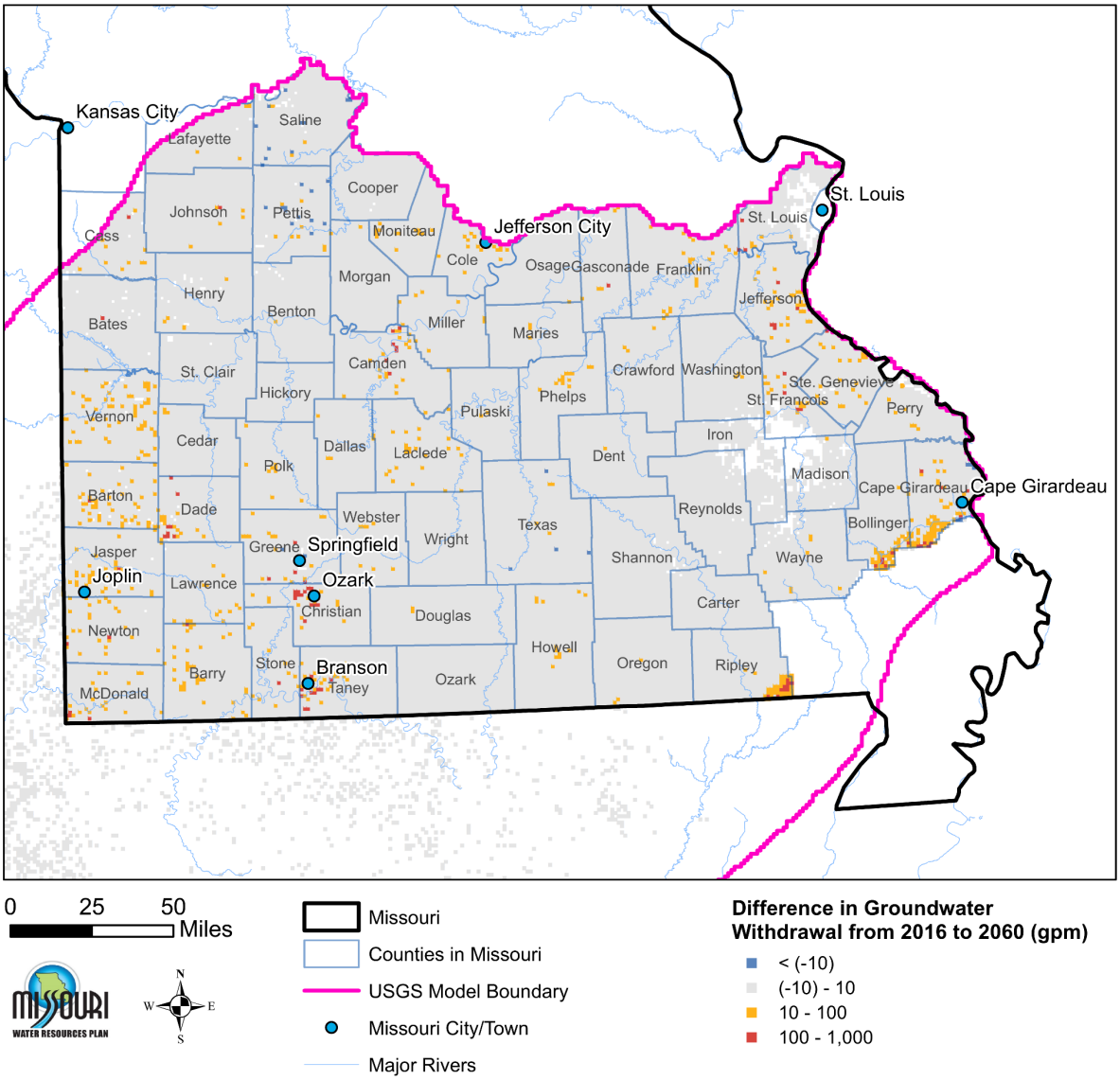

Figure D-11. Projected Changes In Demands (gpm) from 2016 to 2060

Additional transient stress periods were added to the model simulation for each projected demand time step. Average 2000-2013 recharge rates were applied for 2016-2060. Recharge rates are based on the Empirical Water Balance (EWB) regression-based methods and were spatially modified during the history-matching process (Clark et al. 2018). **Table D-26** summarizes the stress periods that were added to the model simulation.

Table D-26. Stress Periods Added To Groundwater Model to Simulate Projected Demands

Stress Period	Years	Length of Stress Period (days)	Demand Applied
80	2016-2019	1,461	2016 Demand
81	2020-2029	3,653	2020 Projected Demand
82	2030-2039	3,652	2030 Projected Demand
83	2040-2049	3,653	2040 Projected Demand
84	2050-2059	3,652	2050 Projected Demand
85	2060	366	2060 Projected Demand

D.5.4 Model Results Analysis

Analysis

Simulations were run using MODFLOW-NWT. Results were analyzed using Groundwater Vistas Version 6. Contours of simulated heads for 2016 and 2060 were interpolated and digitized using Groundwater Vistas and imported to ArcMap for further analysis. Surfaces of water levels were developed in GIS using the contours. The difference between the surfaces was calculated to represent the change in head from 2016 to 2060.

Limitations of Analysis

A number of assumptions were made for this analysis, which limit the accuracy of the results but are not expected to change the broad-scale conclusions developed as a part of this analysis.

Analysis limitation include:

- The allocation of projected demands assumes the most recent withdrawal locations and the relative withdrawal rates are representative of future withdrawal locations and relative rates.
- For some withdrawal types and counties, there are large discrepancies between the existing USGS model withdrawal rates and the projected withdrawal rates developed as part of this study. Projected demands may not be applied to the correct locations within a county if the withdrawals are based on different water users.
- Recharge applied for projections was based on average 2000-2013 levels. No annual variation in climate or projected climate changes are represented.
- Withdrawal rates outside of Missouri are unchanged so any changes near the border with Missouri would not be captured.
- Alluvium deposits were not explicitly included in the USGS model. For some counties, a portion of the projected demand comes from the alluvium. The procedure used in this assessment of assigning projected demands based on existing withdrawal locations in the USGS model will likely result in some demands being assigned to the wrong aquifer unit. Drawdowns in counties along the Missouri and Mississippi River, where a portion of demands are expected to come from the alluvium, should be considered with caution.

D.6 References

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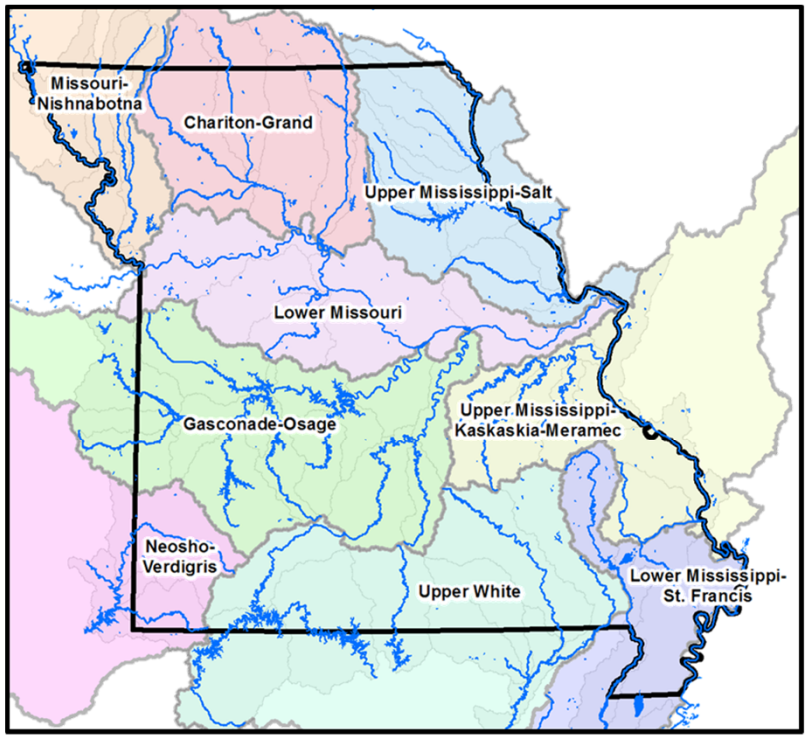
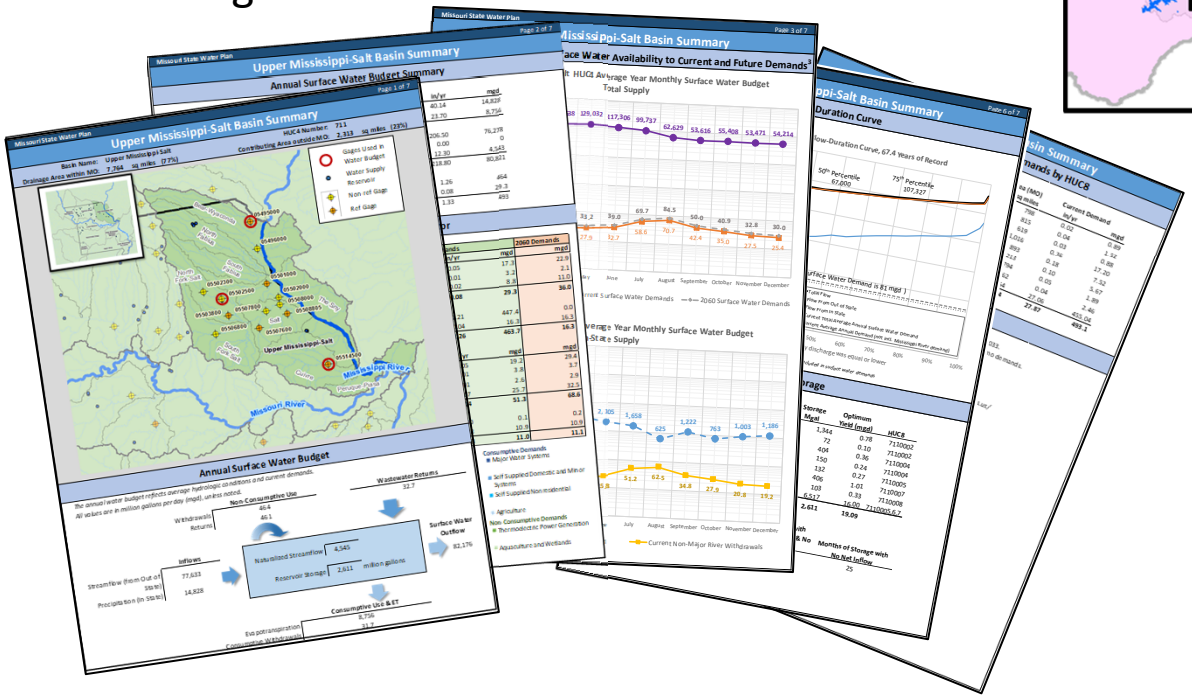
Appendix E
Subregion Summaries and User Guide

These summaries provide information about surface water availability and water use in the nine major hydrologic subregions of Missouri. The information is presented in tables and graphs to compare the amount of surface water and groundwater that is available to meet both current and future demands. This user guide is intended to help interpret and understand the information. Similar summaries are provided in Appendix F for several subbasins within two of the nine subregions.



Map of Missouri's nine subregions



The subregion name, hydrologic unit code (HUC), and drainage area – both within and outside of Missouri – are presented in this top section. The subregions are based on a HUC classification system that divides and subdivides the U.S. into successively smaller river basins. The greater the number of digits within a hydrologic unit code indicates a smaller river basin. For this analysis, the focus was primarily on the nine HUC4, or subregional drainage basins in Missouri.

The darker green area of the map represents the subregion being summarized, which in this example is Upper Mississippi-Salt. The gray lines within the dark green area further delineate the Upper Mississippi-Salt into smaller subbasins at the HUC8 scale.

The map also shows the location of the U.S. Geological Survey (USGS) streamflow gages that were considered for use when summarizing water availability. Red circles identify the gages that were ultimately used to characterize surface water availability in each subregion. Criteria considered when selecting the gages include the period of record, drainage area, data quality and the number and degree of upstream withdrawals, discharges and regulation at dams.

This section summarizes the movement of surface water into, out of, and within each subregion. All values, except reservoir storage, are shown in million gallons per day (mgd) and represent annual average conditions as determined using the most recent 30 years of data available at each USGS gage. The subregion is represented by the blue box, with flows entering and leaving the subregion represented by the arrows. The natural components of the water cycle are **evapotranspiration** (ET) and **precipitation**. ET includes evaporation from surface water into the atmosphere and uptake by plants. **Consumptive uses** account for water that is withdrawn from lakes and rivers by public water suppliers, self-supplied non-residential users such as industries, and farmers for livestock and crop irrigation. Water that is not consumed is returned as **wastewater returns**. **Nonconsumptive uses** account for water that supports aquaculture (fish hatcheries) and seasonal wetland creation. Most water withdrawn for nonconsumptive use is returned to lakes and rivers. **Reservoir storage**, which is listed in million gallons, represents the amount of storage available for public water supply.

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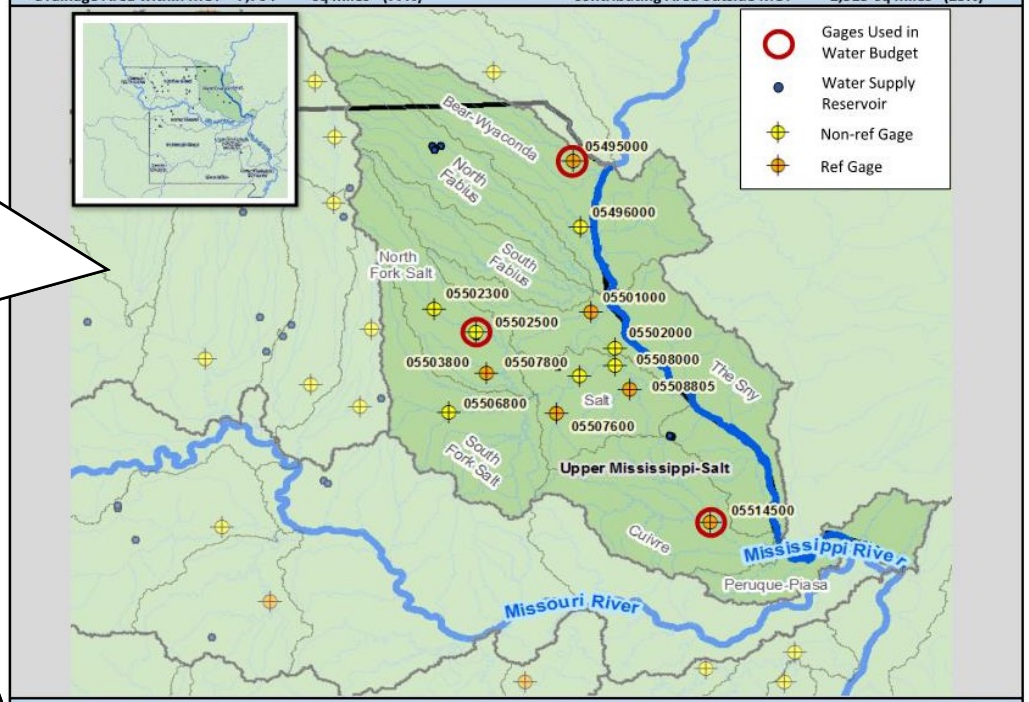
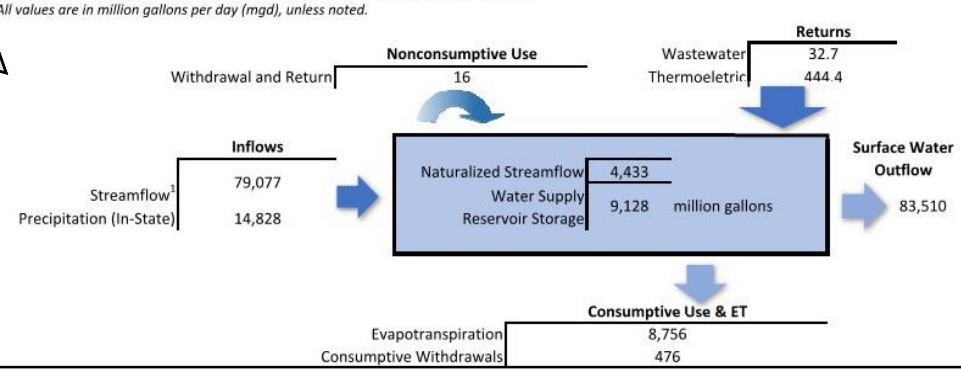
Upper Mississippi-Salt Subregion Summary

HUC4 Name: Upper Mississippi-Salt HUC4 Number: 0711
Drainage Area within MO: 7,764 sq miles (77%) Contributing Area outside MO: 2,313 sq miles (23%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.



This section provides the same information as the annual water budget summary on page 1, but the water budget components are also provided in units of acre-feet per year (ac-ft/yr) and inches per year (in/yr). The water budget components are converted to in/yr by dividing by the area of the subregion. This facilitates comparisons between subregions, and makes it easier to understand the relative importance of each component in the overall water budget.

This section summarizes surface water demands by sector. Current demands are shown in units of ac-ft/yr, in/yr, and mgd. In the far right column, projected 2060 demands for each sector are shown in mgd. **Major water systems** include municipal water utilities or water authorities that withdraw, treat, and distribute water to mostly residential and commercial users**. Self-supplied nonresidential** users of surface water are typically industries that operate their own water intake and treatment systems.

This section summarizes groundwater demands by sector. Current demands are shown in units of ac-ft/yr, in/yr and mgd. In the far right column, estimated 2060 demands for each sector are shown in mgd. **Self-supplied domestic and minor systems** include domestic wells that serve single residences or very small communities.

The pie charts provide a graphical representation of current surface water and groundwater water withdrawals by sector.

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Upper Mississippi-Salt Subregion Summary

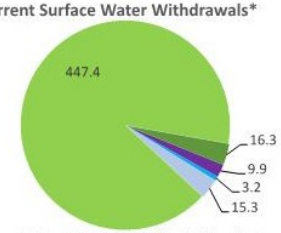
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	16,622,428	40.14	14,828
Evapotranspiration	9,815,373	23.70	8,756
Streamflow (from Out of State)	88,643,815	214.08	79,077
Streamflow (from other In-State HUC4)	0	0.00	0
Streamflow originating in HUC4	4,968,922	12.00	4,433
Total Streamflow	93,612,737	226.08	83,509
Nonconsumptive Surface Water Withdrawals	18,314	0.04	16
Consumptive Surface Water Withdrawals	533,327	1.29	476
Total Surface Water Withdrawals	551,642	1.33	492

Summary of Water Demands by Sector

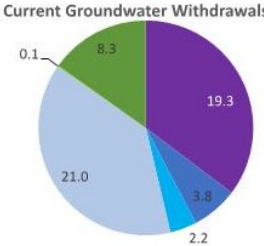
	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	ac-ft/yr	in/yr	mgd	mgd
Major Water Systems	11,052	0.03	9.9	10.0
Self-Supplied Nonresidential	3,618	0.01	3.2	2.1
Agriculture	17,120	0.04	15.3	21.1
Thermoelectric Power Generation[2]	501,537	1.21	447.4	0.0
Total Consumptive	**533,327**	**1.29**	**475.8**	**33.2**
Aquaculture and Wetlands	18,314	0.04	16.3	16.3
Total Nonconsumptive	**18,314**	**0.04**	**16.3**	**16.3**
Groundwater Withdrawals By Sector[3]	ac-ft/yr	in/yr	mgd	mgd
Major Water Systems	21,651	0.05	19.3	29.8
Self-Supplied Domestic and Minor Systems	4,294	0.01	3.8	4.8
Self-Supplied Nonresidential	2,459	0.01	2.2	2.4
Agriculture	23,524	0.06	21.0	25.4
Thermoelectric Power Generation	114	0.00	0.1	0.2
Total Consumptive	**52,042**	**0.13**	**46.4**	**62.6**
Aquaculture and Wetlands	9,297	0.02	8.3	8.3
Total Nonconsumptive	**9,297**	**0.02**	**8.3**	**8.3**

Current Surface Water Withdrawals*



*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Current Groundwater Withdrawals



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

Nonconsumptive Demands
- Aquaculture and Wetlands

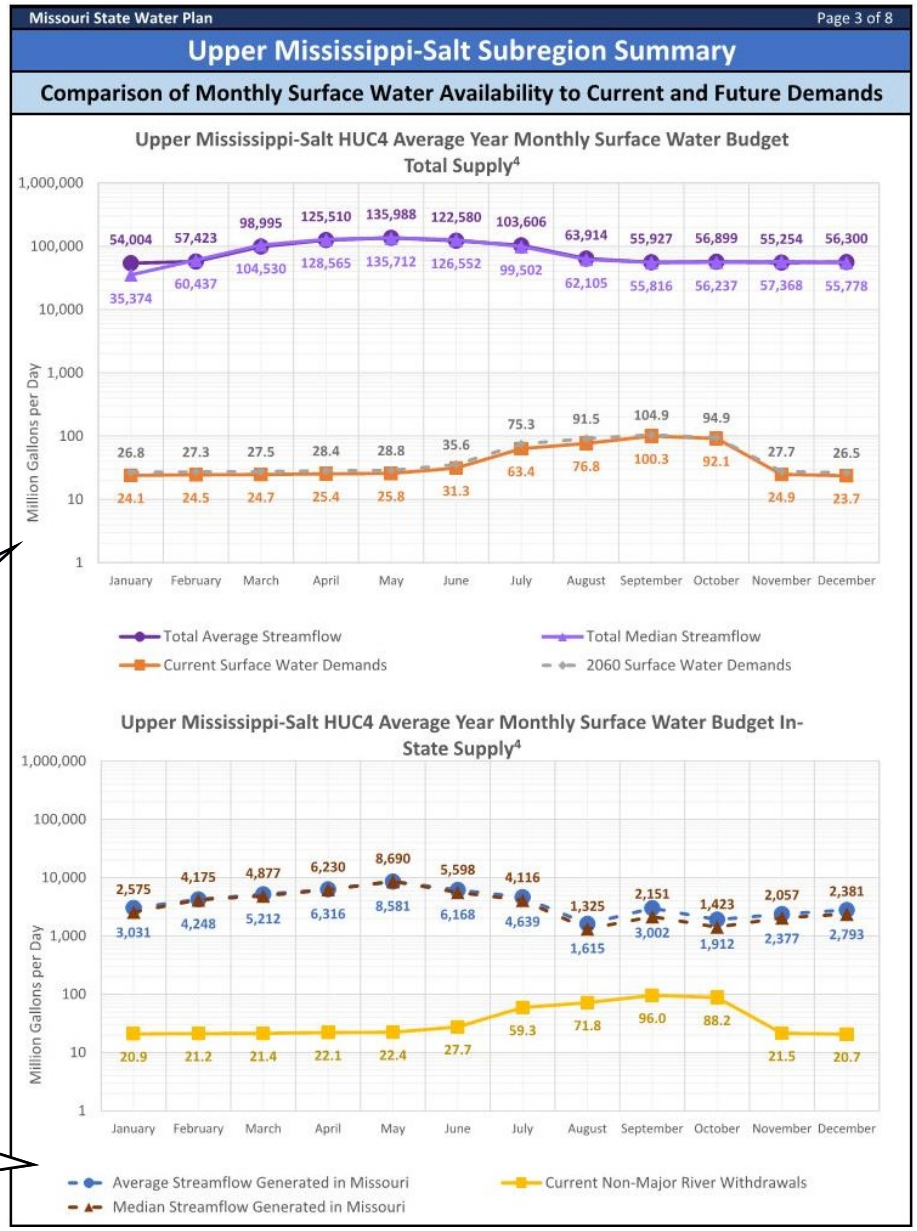
The graphs on pages 4, 5 and 6 compare average and median monthly streamflow and **dry year** streamflow to both current and projected 2060 monthly demands. Streamflow was scaled-up to represent the entire subregion, and was based on flow records from the selected USGS gages for that subregion. Average monthly streamflow was calculated using the period 1986-2016. **Dry year** monthly streamflow was selected from the year of lowest streamflow for each gage, over the period 1986-2016. Since multiple gages were used to represent the entire subregion, different dry year records were sometimes combined when the driest year for a selected gage was different than another selected gage in the same subregion. The **dry year** used at each gage is listed in the "Notes" section at the end of each HUC4 summary sheet.

Because of the large differences in streamflow and demand, the graphs are plotted on log scale (in units of mgd). For example, streamflow is more than 1,000 times greater than total subregion surface water demands in many instances. The graphs are useful in characterizing and comparing seasonal variations in supply (as represented by streamflow) and demand. They provide a better assessment than just average annual demands since the highest demands sometimes occur over a shorter (monthly) period when streamflow is at its lowest.

This graph compares total average monthly streamflow at the outlet of the subregion to current and projected 2060 surface water demands.

This graph compares average monthly streamflow originating from within the Missouri portion of the subregion to all current surface water demands, excluding those on a major river that receives flow from out-of-state. By excluding flow entering the subregion from out of state, or generated in a portion of the subregion that is out of state, we can better compare demands that rely on water generated in-state to available in-state supply.

AVERAGE YEAR

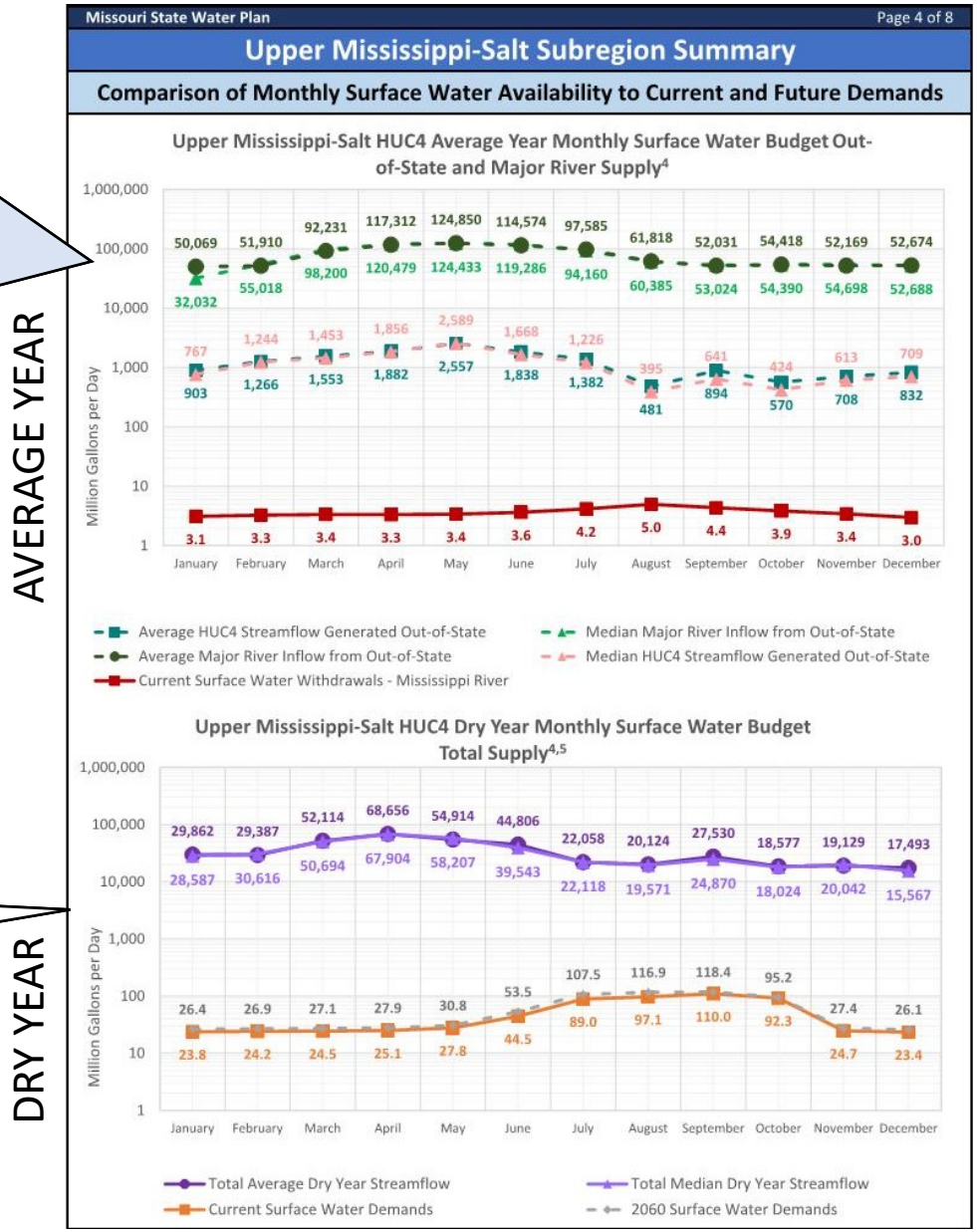


AVERAGE YEAR

This graph compares average and median monthly streamflow originating outside of Missouri to current demands within Missouri on major rivers originating outside the state. The graph includes two supply sources: one for major rivers flowing into the subregion from out of state (in dark green) and one for flow generated inside a portion of the subregion that is located out of state (in blue-green). Major river inflows in Missouri include the Missouri and Mississippi Rivers. Not every subregion has a major river inflow. Similarly, not every subregion has a portion of its drainage area flowing into Missouri from another state.

This graph provides an evaluation of the magnitude of demands that depend on water generated outside of the state compared to the monthly available water from these sources.

This graph compares total **dry year** average and median monthly streamflow at the outlet of the subregion to current and projected 2060 demands.



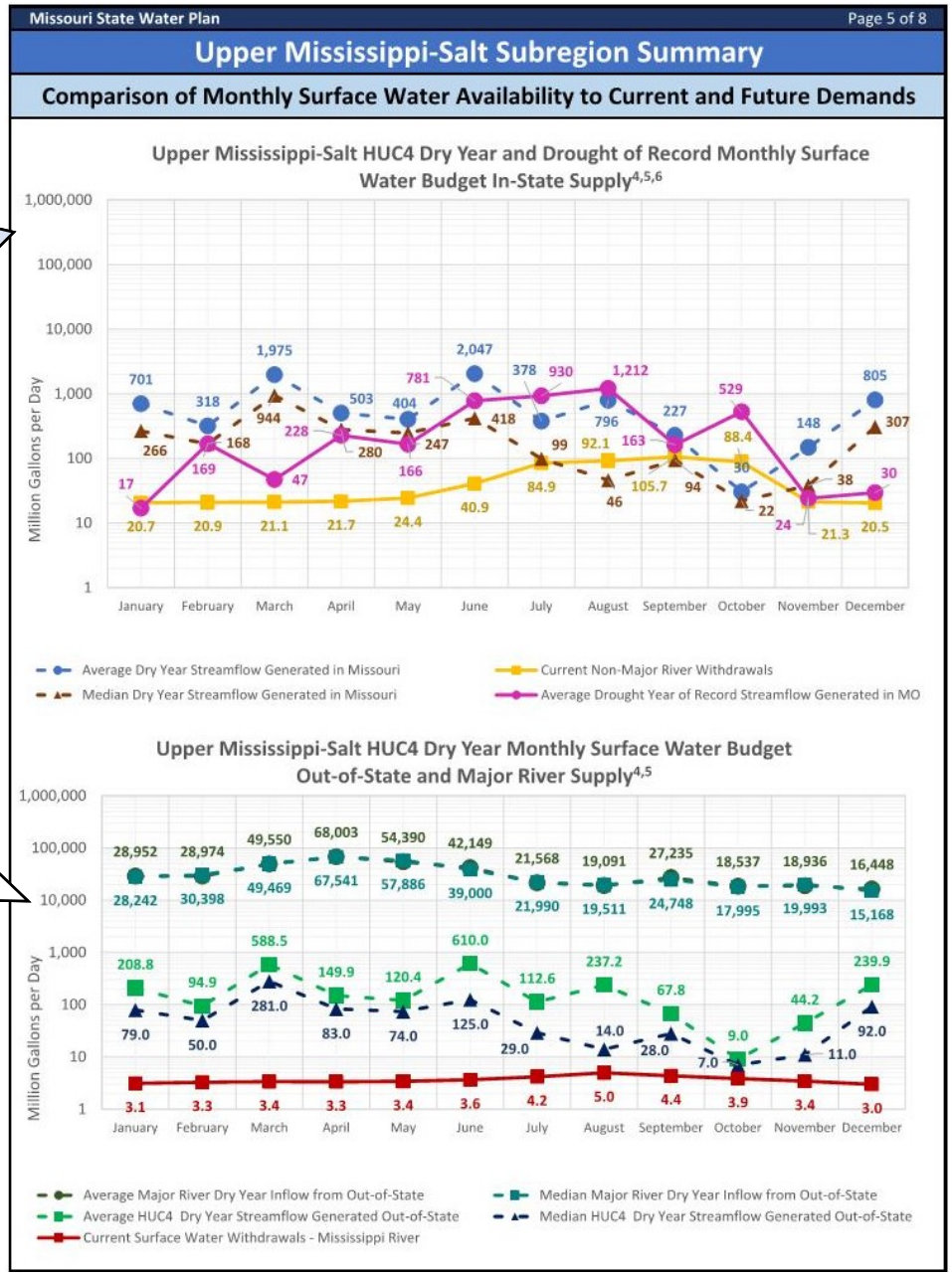
This graph compares **dry year** average and median monthly streamflow originating from within the Missouri portion of the subregion to current demands. The dry year average and median monthly streamflow are based the year with the lowest average annual streamflow between years 1986 – 2016. The **drought of record year** monthly streamflow is also plotted (in magenta). Similar to the average year graph for in-state supply, this graph excludes flow entering the subregion from out of state, or generated in a portion of the subregion that is out of state. The drought year of record monthly streamflow for each is determined based on the year with the lowest annual streamflow from either 1954 or 1956. This graph allows us to compare demands that rely on water generated in state to available in-state supply, and identify subregions that may be more vulnerable to gaps in supply during a dry year and a drought or record year.

DRY YEAR

This graph compares **dry year** average and median monthly streamflow originating outside of Missouri to current demands within Missouri on major rivers originating outside the state. Similar to the average year graph for out-of-state supply, this graph includes two supply sources: one for major rivers flowing into the subregion from out of state (in dark green) and one for flow generated inside a portion of the subregion located outside of Missouri (in blue-green).

This graph provides a comparison of the magnitude of demands which depend on water generated outside of the state.

DRY YEAR



Flow duration curves like this one show the percentage of time that flow in a stream is likely to equal or exceed a specified value. In this case, rather than plotting flow for a particular stream, total flow at the outlet of the subregion is plotted based on monthly streamflow records from the selected USGS gages (see map on page 1). In the Mississippi-Salt, 67 years of monthly records were used to create the curve. The orange line represents the range of flows entering from out of state. The blue line represents the range of flows that originate within the Missouri portion of the subregion. The black line represents the total flow at the outlet of the subregion. By plotting total surface water demands (gray lines) on the same graph, total surface water demand and the range of total flow are compared.

Reservoirs used to support public water supply use (among other uses) are listed in this table. The amount of storage in each reservoir is presented in acre feet (ac-ft) and million gallons (Mgal). The reservoirs' **optimum yields** represent the largest daily demands that could be placed on each reservoir during the 1950s drought of record (1950-1959) without the reservoir emptying. The storage volume of water supply reservoirs in the subregion (where allocated to public water supplies) was totaled to provide two different measures of storage duration during a hypothetical drought. The first measure assumes that each reservoir receives inflow equal to the average inflow calculated for the lowest year of subregion streamflow over the previous 30 years. Public water supply demands (as of 2011) and evaporation are the only two outflows considered. It was assumed that no other outflows were considered. The result is depicted in months of storage. The second measure is similar but assumes that there are no inflows and the only outflows are public water supply demands and evaporation. These two measures are meant to provide a simple and relative indication of the subregion's ability to meet surface water demands during a drought.

The information presented in this section comes primarily from the 2011 *Missouri Water Supply Study* prepared by the Missouri Department of Natural Resources (DNR), supplemented by data provided by the U.S. Army Corps of Engineers (USACE) for reservoirs managed by USACE.

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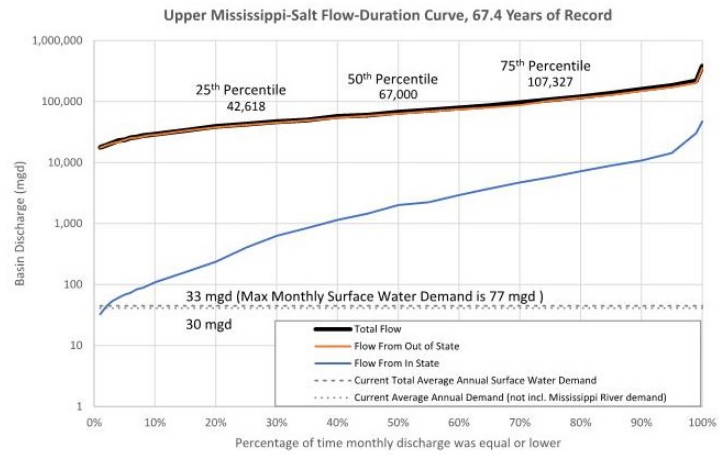
Upper Mississippi-Salt Subregion Summary

Flow-Duration Curve[7]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[8]

Reservoir (City/Town)	Water Supply Storage ac-ft	Water Supply Storage Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Lake Show Me (Memphis)	4,125	1,344	0.78	07110002	53	41
Old City Lake (Memphis)	220	72	0.10	07110002	reservoirs do not empty	21
East Lake (Bowling Green)	1,240	404	0.36	07110004	37	28
West Lake (Bowling Green)	460	150	0.24	07110004	24	16
Lake (Shelbina)	406	132	0.27	07110005	16	9
Rt. J Lake (Monroe City)	1,245	406	1.01	07110007	reservoirs do not empty	20
Vandalia Lake (Vandalia)	317	103	0.33	07110008	reservoirs do not empty	10
Mark Twain Lake	20000	6517.029024	16	07110005, 07110006, 07110007	reservoirs do not empty	4
Total	**28,013**	**9,128**	**19.09**			

In this table, total consumptive and nonconsumptive surface water demands are summarized for each watershed within the subregion. This provides an indication of which watersheds are subject to the largest withdrawals, and therefore may be candidates for further, more detailed study.

This section includes a summary of 2016 and projected 2060 groundwater demands by sector and by aquifer. Certain minor aquifers were lumped together and reclassified into a major aquifer for purposes of this table.

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Upper Mississippi-Salt Subregion Summary

Summary of Surface Water Demands by HUC8

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	Current Demand mgd
Bear-Wyaconda	07110001	798	0.04	2
North Fabius	07110002	815	0.05	2
South Fabius	07110003	619	0.04	1
The Sny	07110004	1,016	0.38	18
North Fork Salt	07110005	893	0.18	8
South Fork Salt	07110006	1,213	0.13	8
Salt	07110007	794	0.07	3
Cuivre	07110008	1,262	0.06	4
Peruque-Piasa	07110009	354	26.61	448
	Total	**7,764**	**-**	**493**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

Summary of Groundwater Demands by Aquifer

	2016 Demands (mgd)							
Groundwater Withdrawals By Sector	Alluvium	Ozark Aquifer[9]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[10]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	11.55	7.49	0.28	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.64	2.33	0.11	0.05	0.00	0.66	0.05	0.00
Self-Supplied Nonresidential	0.00	2.18	0.00	0.00	0.00	0.00	0.01	0.00
Agriculture	8.28	9.08	0.00	0.13	3.50	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**20.47**	**21.18**	**0.39**	**0.18**	**3.50**	**0.66**	**0.06**	**0.00**
Aquaculture and Wetlands	4.41	2.82	0.00	0.73	0.00	0.33	0.00	0.00
Total Nonconsumptive	**4.41**	**2.82**	**0.00**	**0.73**	**0.00**	**0.33**	**0.00**	**0.00**
Total Groundwater Withdrawals	**24.88**	**24.00**	**0.39**	**0.91**	**3.50**	**0.99**	**0.06**	**0.00**

	2060 Demands (mgd)							
Groundwater Withdrawals By Sector	Alluvium	Ozark Aquifer[9]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[10]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	19.03	10.49	0.29	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.75	3.18	0.07	0.04	0.00	0.71	0.04	0.00
Self-Supplied Nonresidential	0.00	2.35	0.00	0.00	0.00	0.00	0.01	0.00
Agriculture	10.10	10.82	0.00	0.18	4.32	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**29.88**	**27.04**	**0.36**	**0.22**	**4.32**	**0.71**	**0.05**	**0.00**
Aquaculture and Wetlands	4.41	2.82	0.00	0.73	0.00	0.33	0.00	0.00
Total Nonconsumptive	**4.41**	**2.82**	**0.00**	**0.73**	**0.00**	**0.33**	**0.00**	**0.00**
Total Groundwater Withdrawals	**34.29**	**29.86**	**0.36**	**0.95**	**4.32**	**1.04**	**0.05**	**0.00**

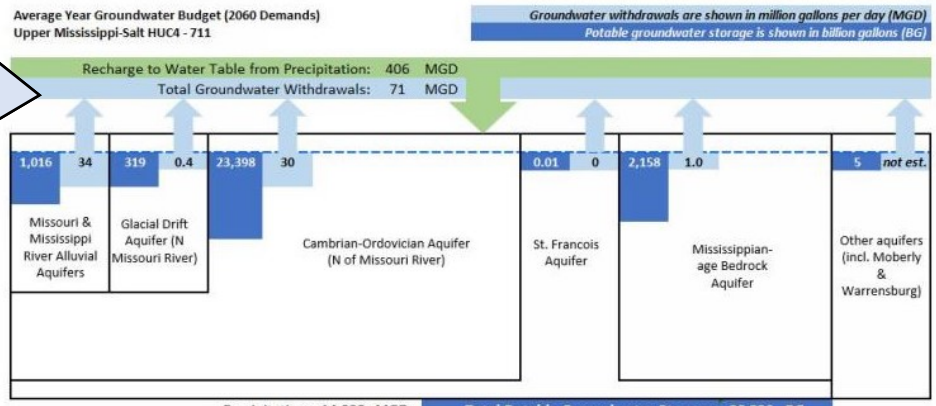
This schematic represents the groundwater budget for the subregion. Included are 2060 projected demands for each aquifer; the estimated amount of potable storage in each aquifer (within the subregion); and estimated average annual recharge to the water table from precipitation. At the bottom of the schematic total precipitation, evapotranspiration, recharge, potable groundwater storage and 2060 withdrawals are listed for the entire subregion. A number representing 2060 groundwater withdrawals as a percent of recharge from precipitation is listed. This serves as a measure of groundwater sustainability. A value exceeding 100 percent would indicate that more water is being withdrawn from the aquifers in the subregion than is being recharged from precipitation within the subregion. This would indicate that the amount of potable groundwater in storage may be declining, unless the subregion received recharge from other sources, such as recharge from rivers connected to alluvial aquifers, or recharge to deeper aquifers that occurs outside of the subregion.

This section includes various endnotes, which are referenced on the proceeding pages.

Missouri State Water Plan Page 8 of 8

Upper Mississippi-Salt Subregion Summary

Average Year Groundwater Budget (2060 Demands)[11]



Precipitation:	14,828	MGD	Total Potable Groundwater Storage:	26,896	BG
Evapotranspiration:	8,756	MGD	Total Groundwater Withdrawals:	71	MGD
Recharge to Water Table from Precipitation:	406	MGD	Increase in Withdrawals from 2016:	16	MGD
			Withdrawals as a Percent of Recharge from Precipitation:	17%	

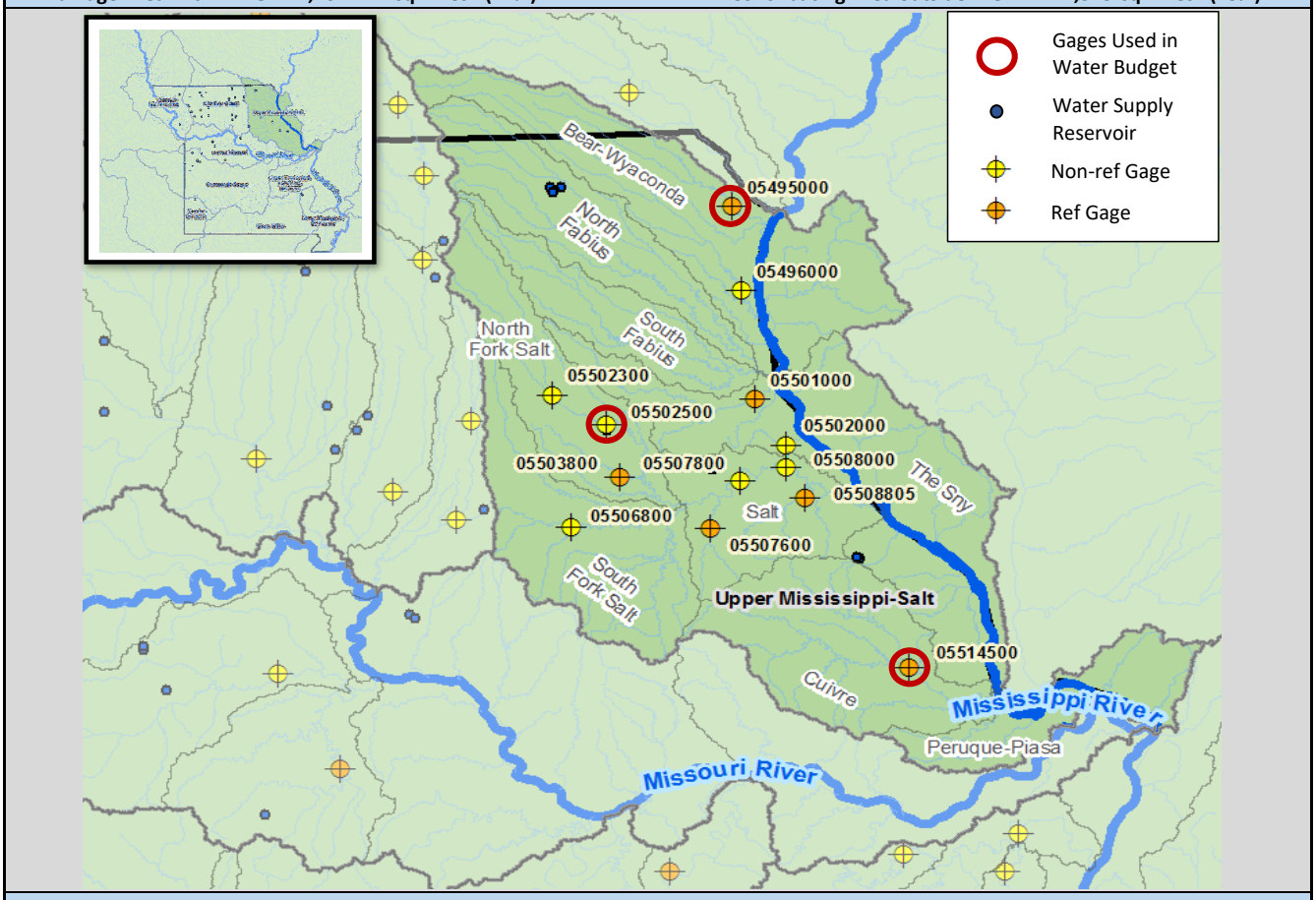
The above graphic is a generalized representation of aquifers present in each HUC4.

Notes

1. Streamflow includes out of state inflows from major rivers and HUC4 0711 inflows entering Missouri generated out of Missouri.
2. Sioux power generation facility in St. Charles County is scheduled to be retired in 2033.
3. Groundwater demands include alluvial and groundwater aquifer withdrawals.
4. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
5. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC4, the lowest annual streamflows occurred in 1989 for gage 05495000, 1956 for gage 05502500, and 2006 for gage 05514500.
6. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
7. Demands shown on flow duration curve do not include thermoelectric demands.
8. Reservoir data sources and notes:
   a. *Missouri Water Supply Study, Missouri DNR, June 2011*
   b. *US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/*
   c. In addition to Rt J. Lake, Monroe City's water supply may also be supplemented by a smaller lake, South Lake. Information on South Lake was not availalable, and thus not included in this summary.
9. The Ozark Aquifer includes the Upper, Middle, and Lower Ozark aquifer and the associated Cambrian and Ordovician systems north of the Missouri River.
10. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
11. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Upper Mississippi-Salt Subregion Summary

HUC4 Name: Upper Mississippi-Salt **HUC4 Number:** 0711
Drainage Area within MO: 7,764 sq miles (77%) **Contributing Area outside MO:** 2,313 sq miles (23%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	16

Returns	
Wastewater	32.7
Thermoeletric	444.4

Inflows	
Streamflow[1]	79,077
Precipitation (In-State)	14,828

Naturalized Streamflow	4,433	
Water Supply Reservoir Storage	9,128	million gallons

Surface Water Outflow: 83,510

Consumptive Use & ET	
Evapotranspiration	8,756
Consumptive Withdrawals	476

Upper Mississippi-Salt Subregion Summary

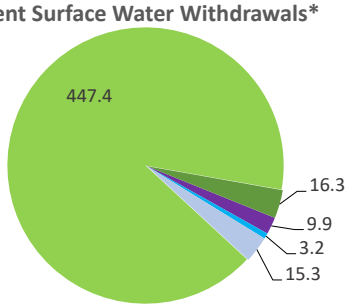
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	16,622,428	40.14	14,828
Evapotranspiration	9,815,373	23.70	8,756
Streamflow (from Out of State)	88,643,815	214.08	79,077
Streamflow (from other In-State HUC4)	0	0.00	0
Streamflow originating in HUC4	4,968,922	12.00	4,433
Total Streamflow	93,612,737	226.08	83,509
Nonconsumptive Surface Water Withdrawals	18,314	0.04	16
Consumptive Surface Water Withdrawals	533,327	1.29	476
Total Surface Water Withdrawals	551,642	1.33	492

Summary of Water Demands by Sector

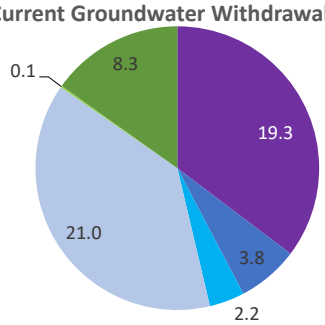
	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	11,052	0.03	9.9	10.0
Self-Supplied Nonresidential	3,618	0.01	3.2	2.1
Agriculture	17,120	0.04	15.3	21.1
Thermoelectric Power Generation[2]	501,537	1.21	447.4	0.0
Total Consumptive	**533,327**	**1.29**	**475.8**	**33.2**
Aquaculture and Wetlands	18,314	0.04	16.3	16.3
Total Nonconsumptive	**18,314**	**0.04**	**16.3**	**16.3**
Groundwater Withdrawals By Sector[3]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	21,651	0.05	19.3	29.8
Self-Supplied Domestic and Minor Systems	4,294	0.01	3.8	4.8
Self-Supplied Nonresidential	2,459	0.01	2.2	2.4
Agriculture	23,524	0.06	21.0	25.4
Thermoelectric Power Generation	114	0.00	0.1	0.2
Total Consumptive	**52,042**	**0.13**	**46.4**	**62.6**
Aquaculture and Wetlands	9,297	0.02	8.3	8.3
Total Nonconsumptive	**9,297**	**0.02**	**8.3**	**8.3**

Current Surface Water Withdrawals*



*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Current Groundwater Withdrawals

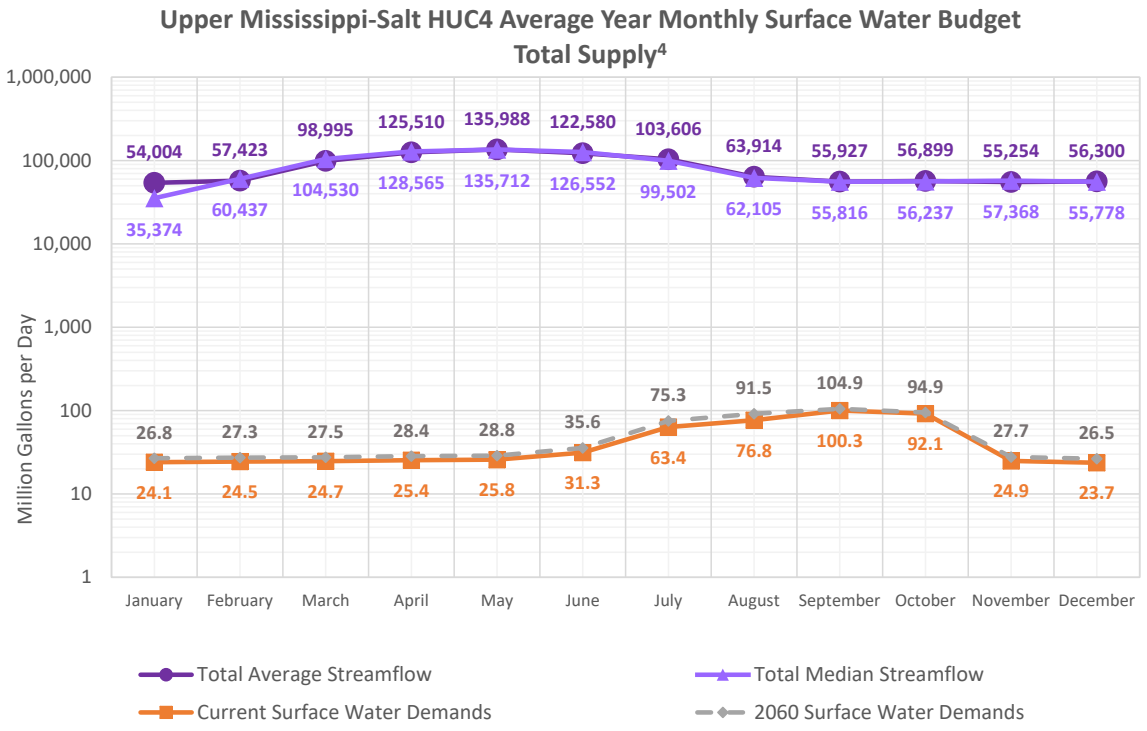


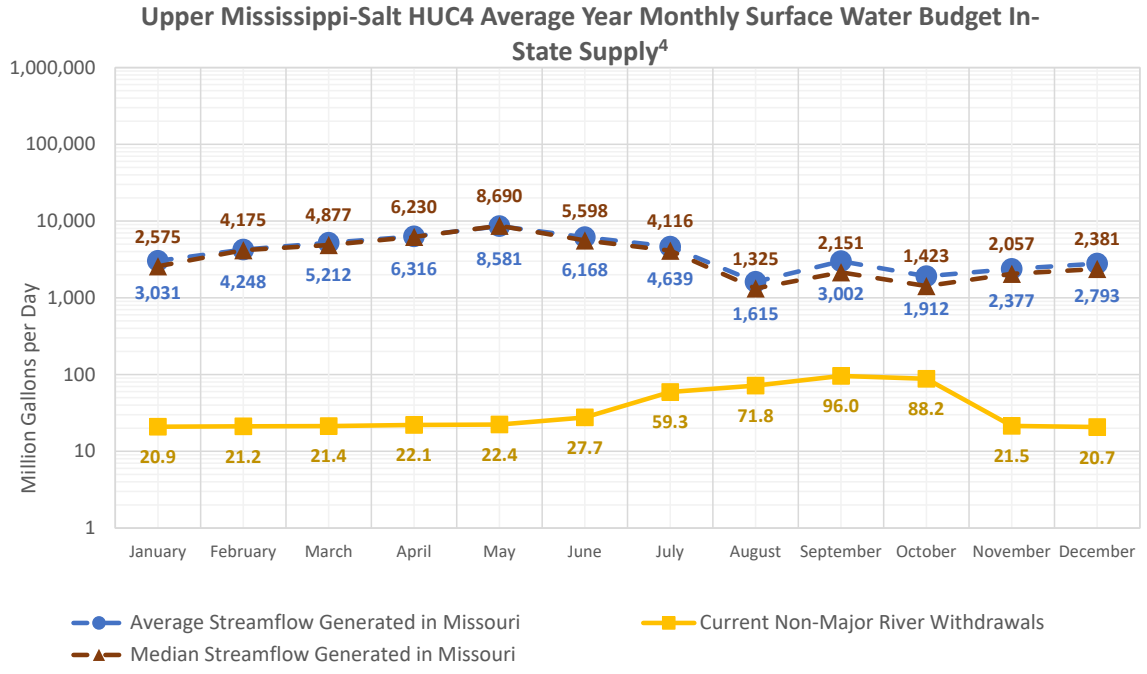
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture
- Thermoelectric Power Generation

Nonconsumptive Demands
- Aquaculture and Wetlands

Upper Mississippi-Salt Subregion Summary

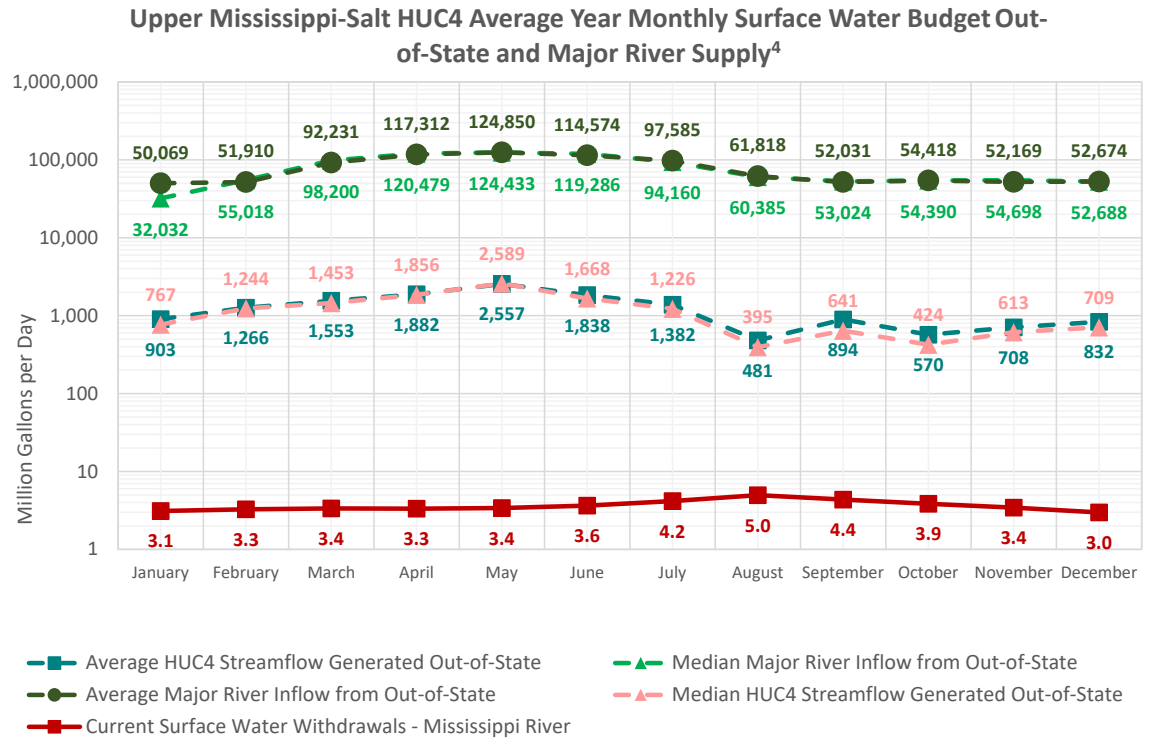
Comparison of Monthly Surface Water Availability to Current and Future Demands

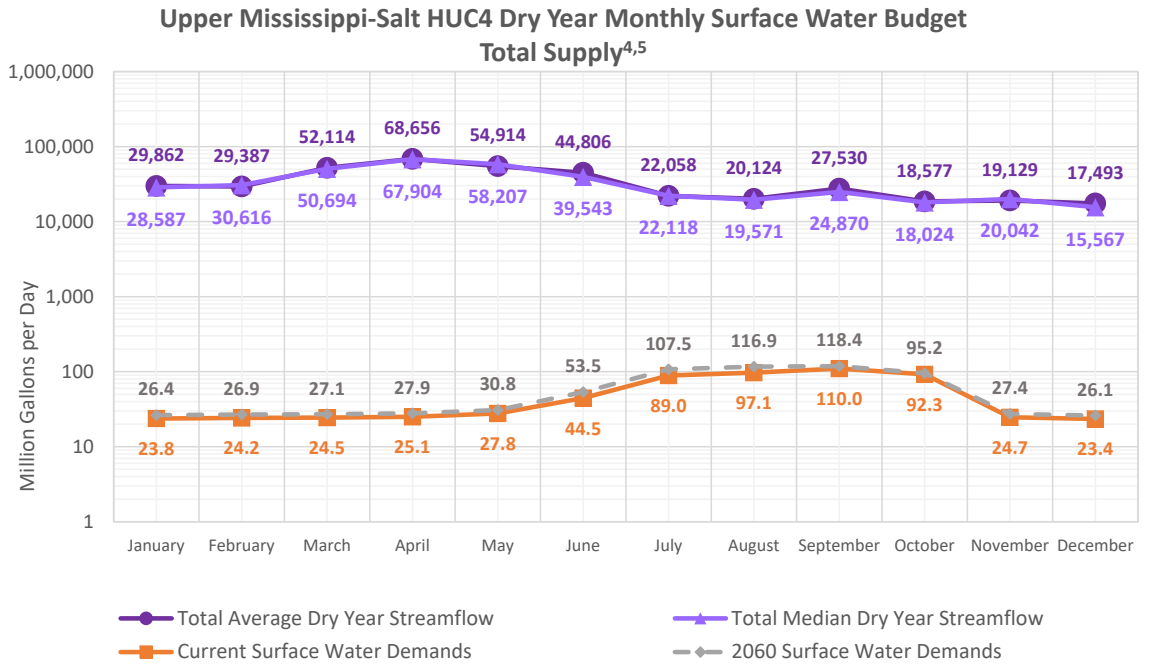




Upper Mississippi-Salt Subregion Summary

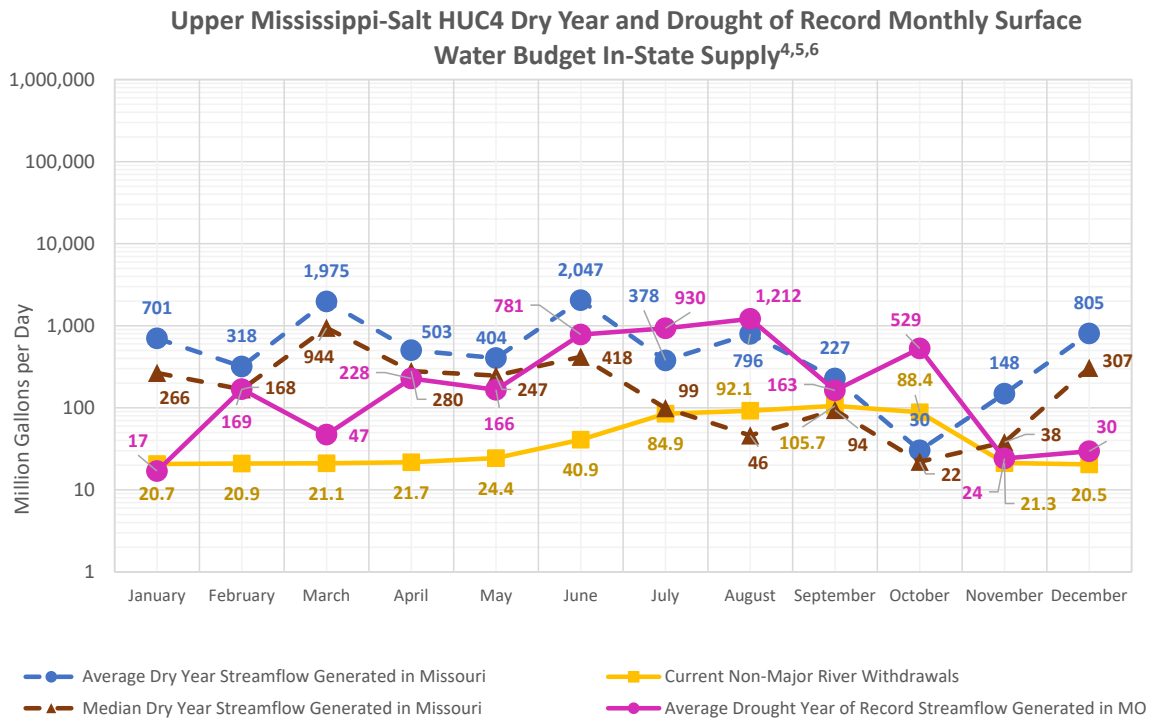
Comparison of Monthly Surface Water Availability to Current and Future Demands

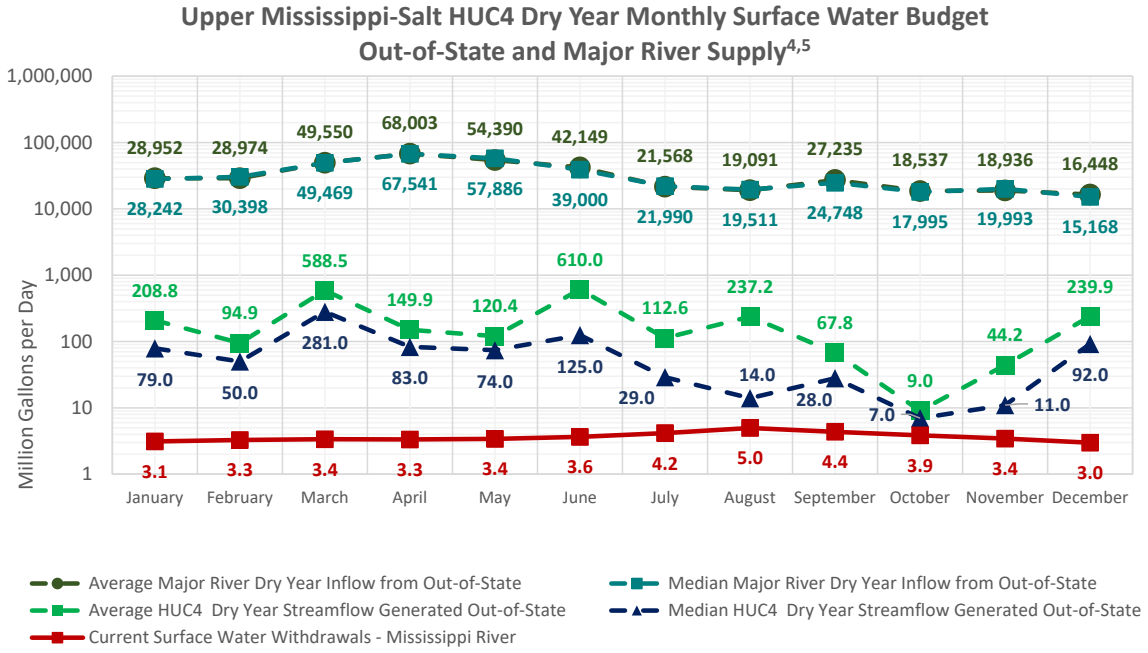




Upper Mississippi-Salt Subregion Summary

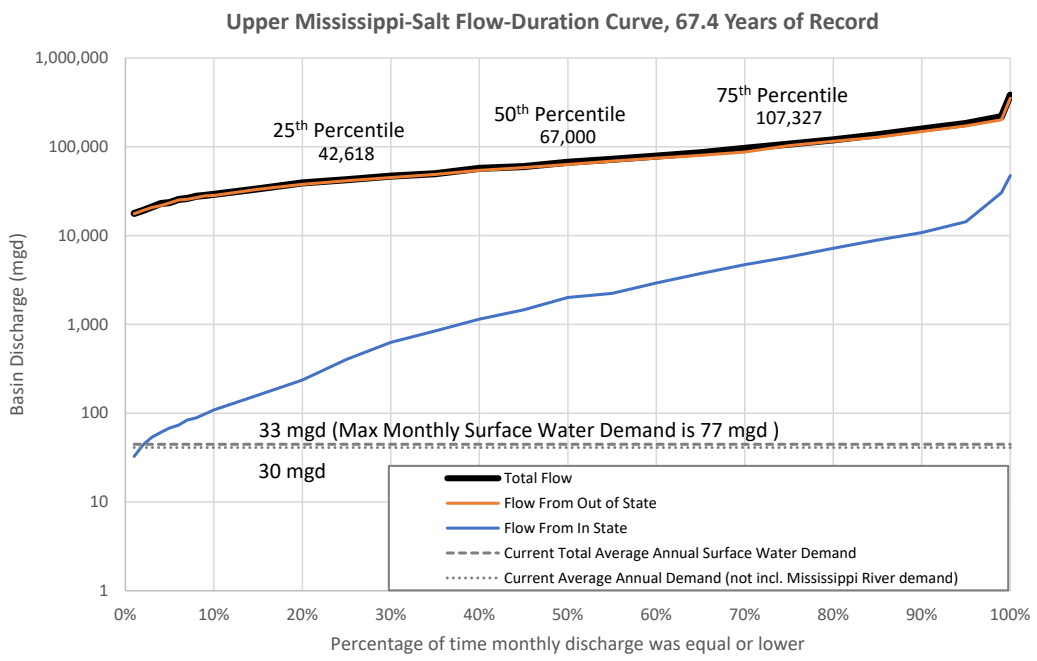
Comparison of Monthly Surface Water Availability to Current and Future Demands





Upper Mississippi-Salt Subregion Summary

Flow-Duration Curve[7]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[8]

Reservoir (City/Town)	Water Supply Storage ac-ft	Water Supply Storage Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Lake Show Me (Memphis)	4,125	1,344	0.78	07110002	53	41
Old City Lake (Memphis)	220	72	0.10	07110002	reservoirs do not empty	21
East Lake (Bowling Green)	1,240	404	0.36	07110004	37	28
West Lake (Bowling Green)	460	150	0.24	07110004	24	16
Lake (Shelbina)	406	132	0.27	07110005	16	9
Rt. J Lake (Monroe City)	1,245	406	1.01	07110007	reservoirs do not empty	20
Vandalia Lake (Vandalia)	317	103	0.33	07110008	reservoirs do not empty	10
Mark Twain Lake	20000	6517.029024	16	07110005, 07110006, 07110007	reservoirs do not empty	4
Total	**28,013**	**9,128**	**19.09**			

Upper Mississippi-Salt Subregion Summary

Summary of Surface Water Demands by HUC8

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	Current Demand mgd
Bear-Wyaconda	07110001	798	0.04	2
North Fabius	07110002	815	0.05	2
South Fabius	07110003	619	0.04	1
The Sny	07110004	1,016	0.38	18
North Fork Salt	07110005	893	0.18	8
South Fork Salt	07110006	1,213	0.13	8
Salt	07110007	794	0.07	3
Cuivre	07110008	1,262	0.06	4
Peruque-Piasa	07110009	354	26.61	448
	Total	**7,764**	**-**	**493**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

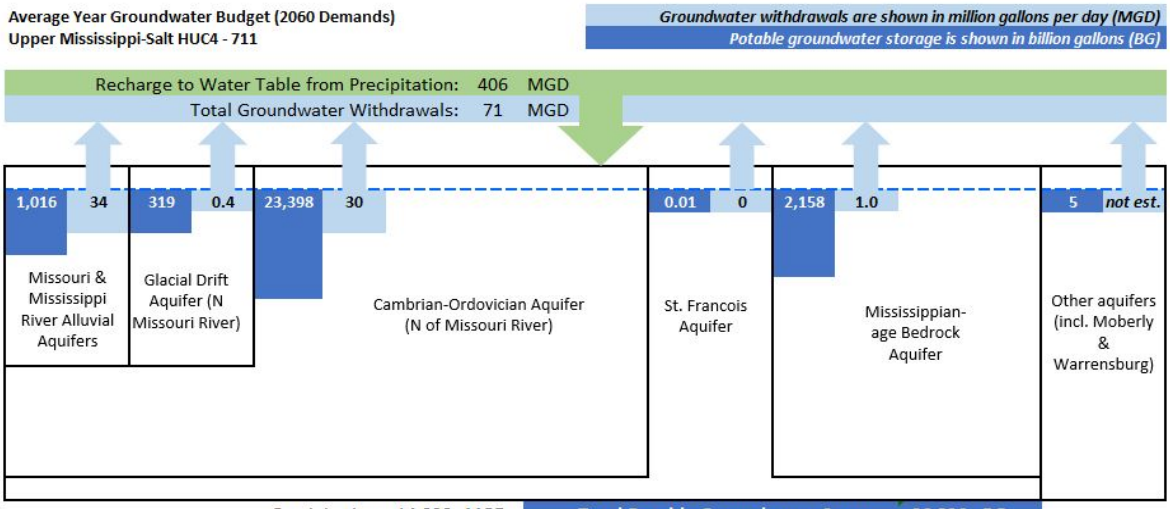
Summary of Groundwater Demands by Aquifer

	2016 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[9]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[10]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	11.55	7.49	0.28	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.64	2.33	0.11	0.05	0.00	0.66	0.05	0.00
Self-Supplied Nonresidential	0.00	2.18	0.00	0.00	0.00	0.00	0.01	0.00
Agriculture	8.28	9.08	0.00	0.13	3.50	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**20.47**	**21.18**	**0.39**	**0.18**	**3.50**	**0.66**	**0.06**	**0.00**
Aquaculture and Wetlands	4.41	2.82	0.00	0.73	0.00	0.33	0.00	0.00
Total Nonconsumptive	**4.41**	**2.82**	**0.00**	**0.73**	**0.00**	**0.33**	**0.00**	**0.00**
Total Groundwater Withdrawals	**24.88**	**24.00**	**0.39**	**0.91**	**3.50**	**0.99**	**0.06**	**0.00**

	2060 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[9]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[10]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	19.03	10.49	0.29	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.75	3.18	0.07	0.04	0.00	0.71	0.04	0.00
Self-Supplied Nonresidential	0.00	2.35	0.00	0.00	0.00	0.00	0.01	0.00
Agriculture	10.10	10.82	0.00	0.18	4.32	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**29.88**	**27.04**	**0.36**	**0.22**	**4.32**	**0.71**	**0.05**	**0.00**
Aquaculture and Wetlands	4.41	2.82	0.00	0.73	0.00	0.33	0.00	0.00
Total Nonconsumptive	**4.41**	**2.82**	**0.00**	**0.73**	**0.00**	**0.33**	**0.00**	**0.00**
Total Groundwater Withdrawals	**34.29**	**29.86**	**0.36**	**0.95**	**4.32**	**1.04**	**0.05**	**0.00**

Upper Mississippi-Salt Subregion Summary

Average Year Groundwater Budget (2060 Demands)[11]



The above graphic is a generalized representation of aquifers present in each HUC4.

Notes

1. Streamflow includes out of state inflows from major rivers and HUC4 0711 inflows entering Missouri generated out of Missouri.
2. Sioux power generation facility in St. Charles County is scheduled to be retired in 2033.
3. Groundwater demands include alluvial and groundwater aquifer withdrawals.
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6. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
7. Demands shown on flow duration curve do not include thermoelectric demands.
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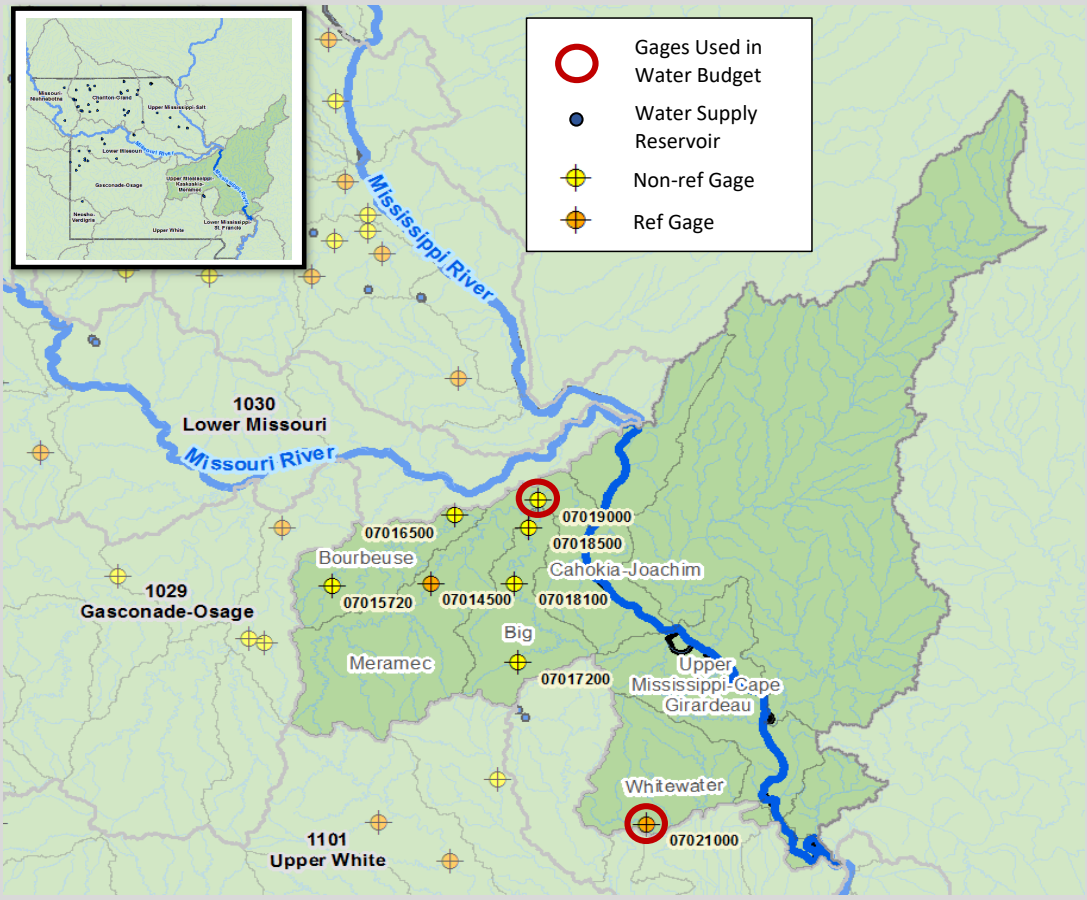
   c . In addition to Rt J. Lake, Monroe City's water supply may also be supplemented by a smaller lake, South Lake. Information on South Lake was not availalable, and thus not included in this summary.
9. The Ozark Aquifer includes the Upper, Middle, and Lower Ozark aquifer and the associated Cambrian and Ordovician systems north of the Missouri River.
10. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
11. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Upper Mississippi-Kaskaskia-Meramec Subregion Summary

HUC4 Name: Upper Mississippi-Kaskaskia-Meramec **HUC4 Number:** 0714

Drainage Area within MO: 6,986 sq miles (41%) **Contributing Area outside MO:** 10,124 sq miles (59%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	35

Returns	
Wastewater	226.5
Thermoeletric	946.2

Inflows	
Streamflow[1]	149,601
Precipitation (In-State)	15,095

Naturalized Streamflow	4,421	
Water Supply Reservoir Storage	0	million gallons

Surface Water Outflow: 154,106

Consumptive Use & ET	
Evapotranspiration	9,112
Consumptive Withdrawals	1088

Upper Mississippi-Kaskaskia-Meramec Subregion Summary

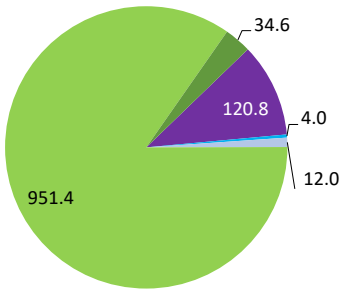
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	16,920,998	45.41	15,095
Evapotranspiration	10,214,356	27.41	9,112
Streamflow (from Out of State)	167,700,432	450.07	149,601
Streamflow (from other In-State HUC4)	0	0.00	0
Streamflow originating in HUC4	4,955,671	13.30	4,421
Total Streamflow	172,656,103	463.37	154,021
Nonconsumptive Surface Water Withdrawals	38,738	0.10	35
Consumptive Surface Water Withdrawals	1,219,879	3.27	1,088
Total Surface Water Withdrawals	1,258,618	3.38	1,123

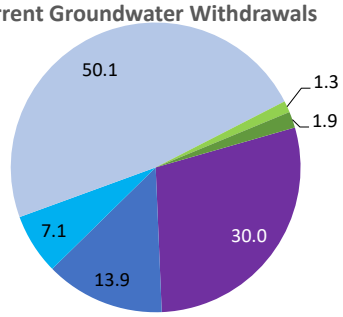
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	135,369	0.36	120.8	119.2
Self-Supplied Nonresidential	4,512	0.01	4.0	4.8
Agriculture	13,456	0.04	12.0	16.4
Thermoelectric Power Generation[2]	1,066,542	2.86	951.4	869.9
Total Consumptive	**1,219,879**	**3.27**	**1,088.2**	**1,010.3**
Aquaculture and Wetlands	38,738	0.10	34.6	34.6
Total Nonconsumptive	**38,738**	**0.10**	**34.6**	**34.6**
Groundwater Withdrawals By Sector[3]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	33,656	0.09	30.0	39.0
Self-Supplied Domestic and Minor Systems	15,586	0.04	13.9	14.3
Self-Supplied Nonresidential	7,924	0.02	7.1	9.2
Agriculture	56,197	0.15	50.1	59.4
Thermoelectric Power Generation	1,499	0.00	1.3	1.6
Total Consumptive	**114,862**	**0.30**	**102.4**	**123.5**
Aquaculture and Wetlands	2,106	0.01	1.9	1.9
Total Nonconsumptive	**2,106**	**0.01**	**1.9**	**1.9**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



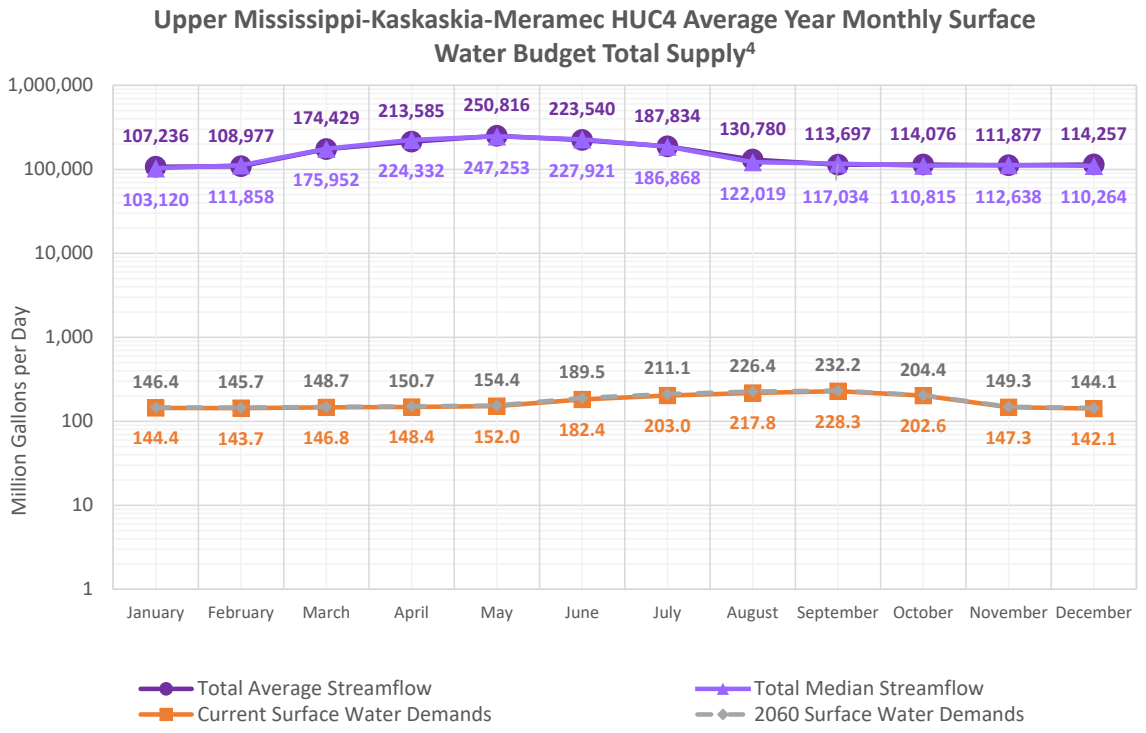
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture
- Thermoelectric Power Generation

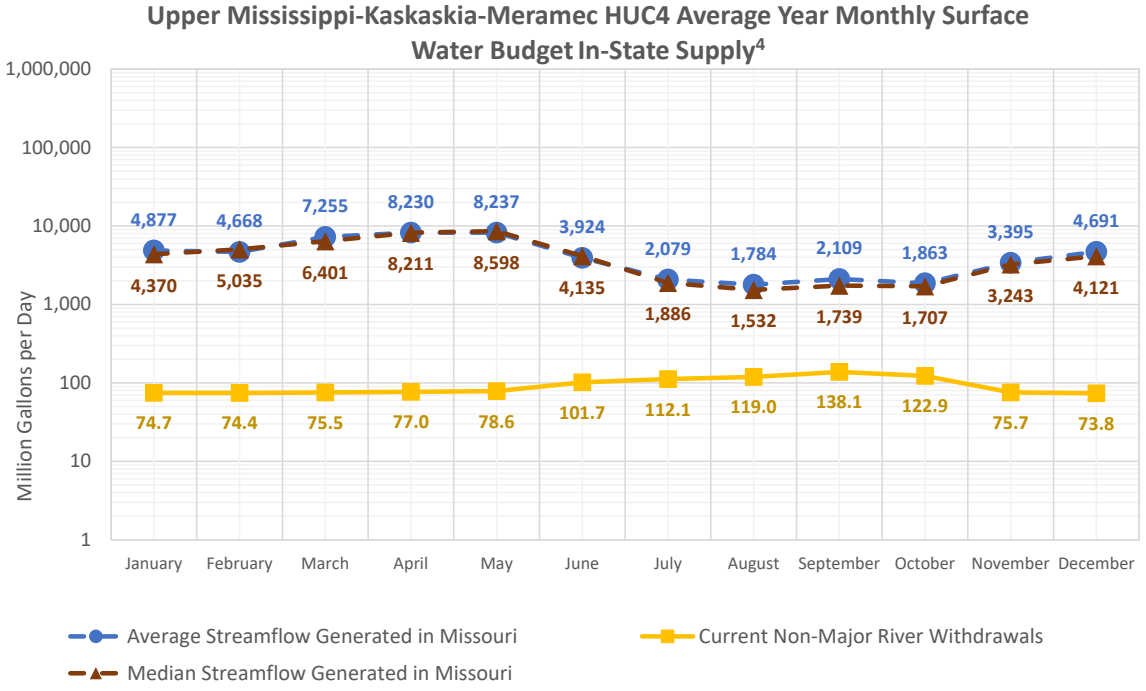
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Upper Mississippi-Kaskaskia-Meramec Subregion Summary

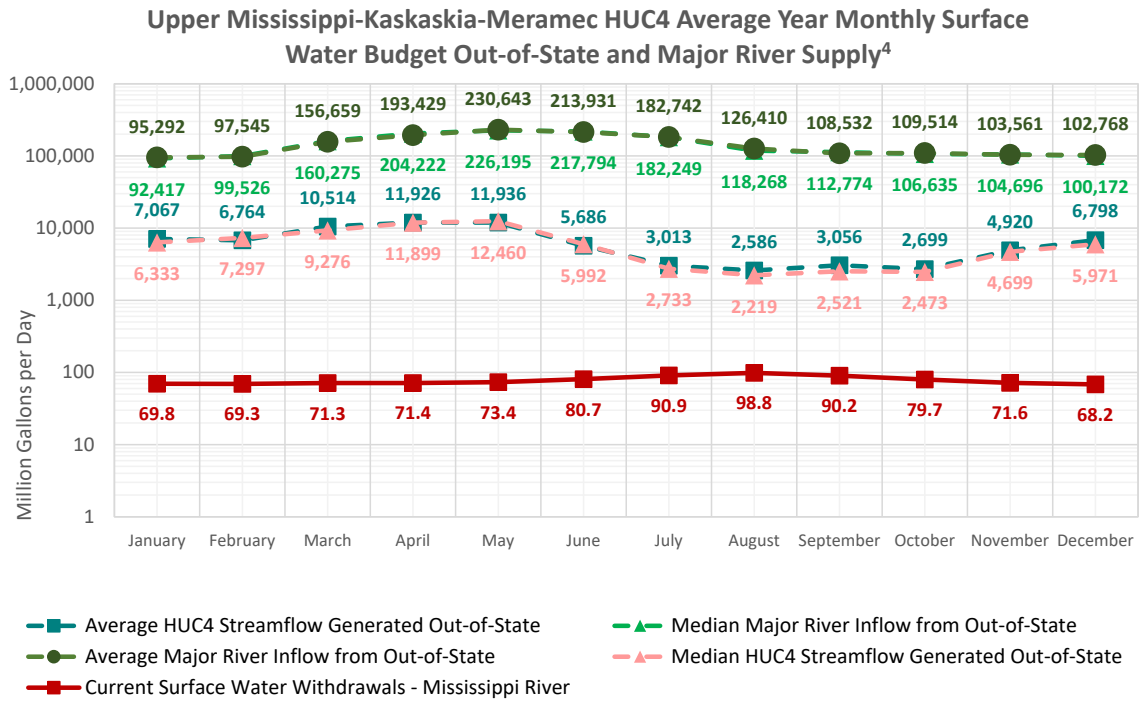
Comparison of Monthly Surface Water Availability to Current and Future Demands

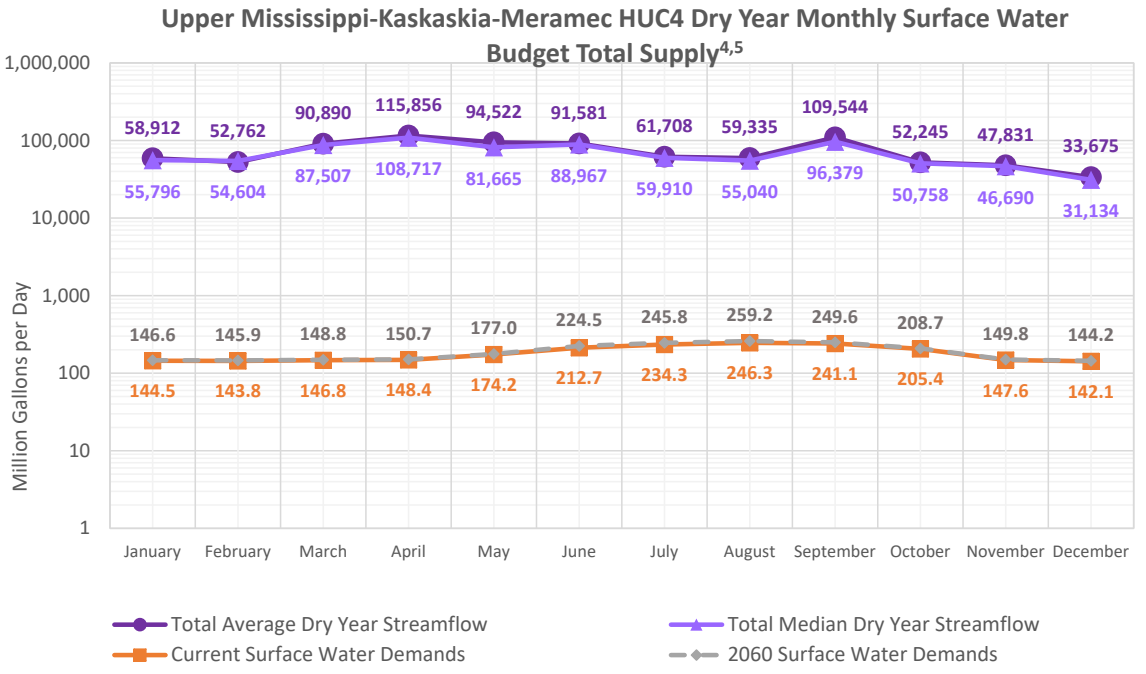




Upper Mississippi-Kaskaskia-Meramec Subregion Summary

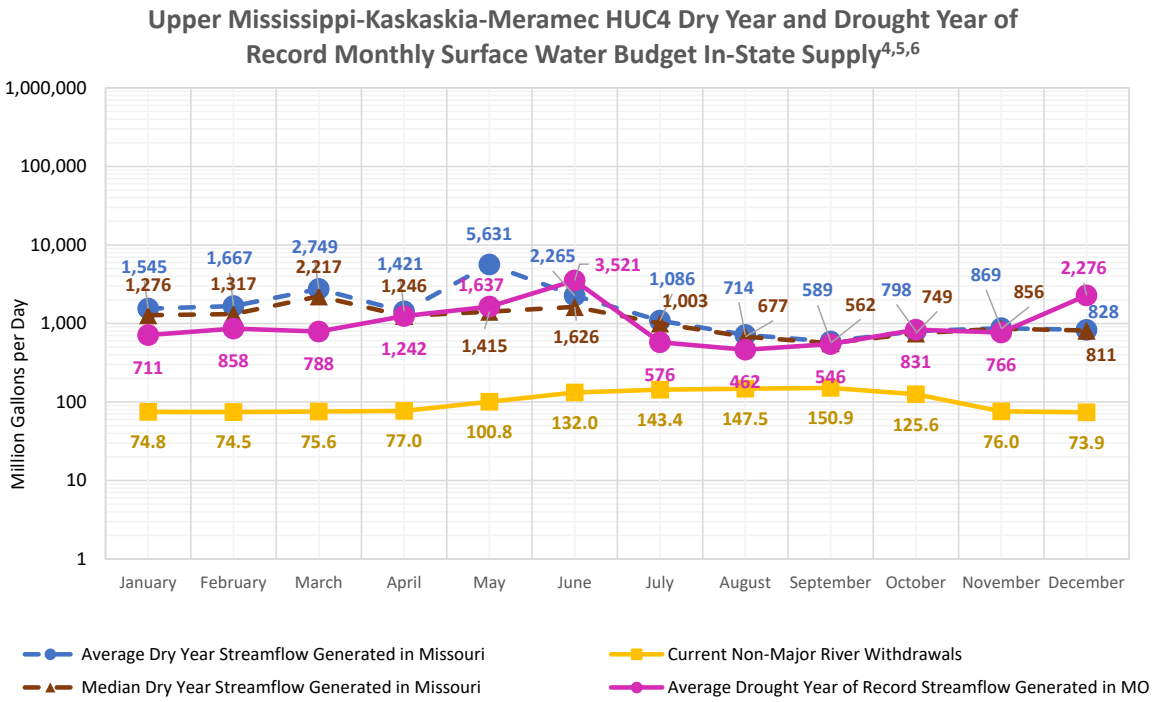
Comparison of Monthly Surface Water Availability to Current and Future Demands

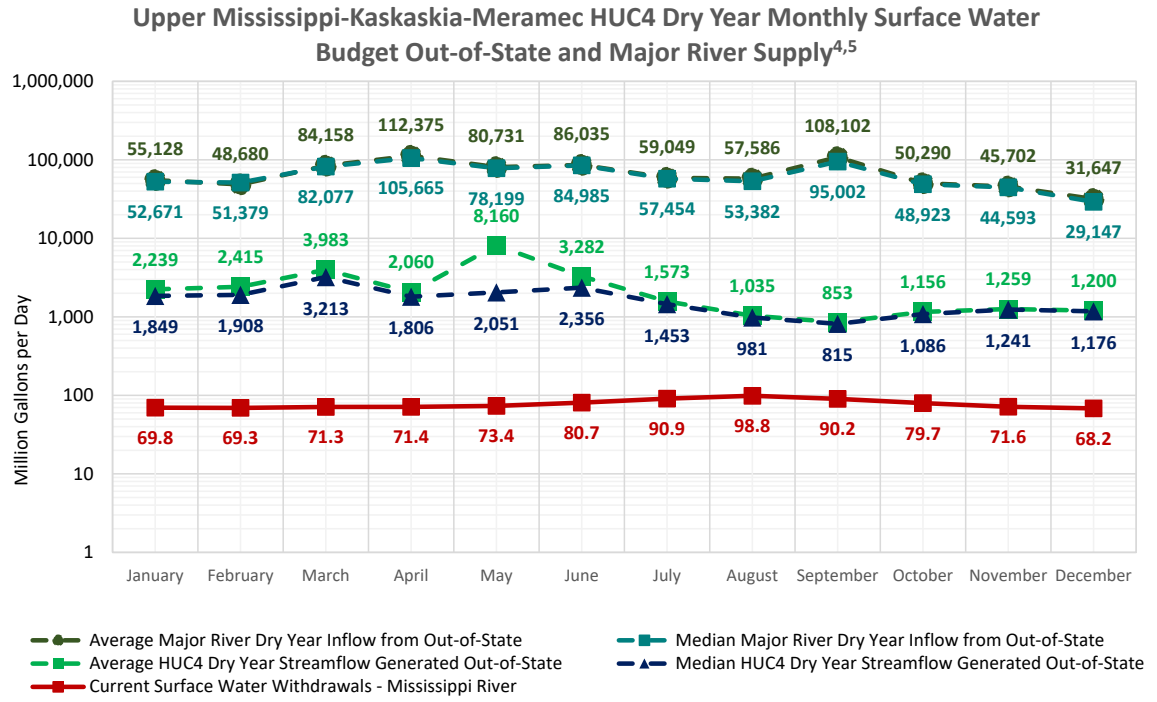




Upper Mississippi-Kaskaskia-Meramec Subregion Summary

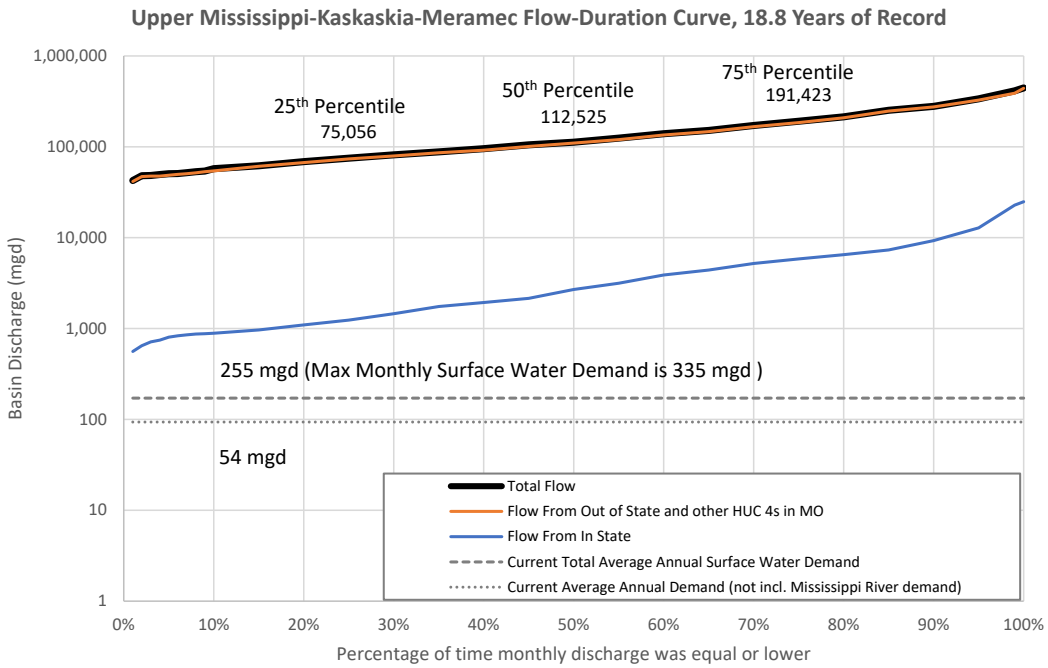
Comparison of Monthly Surface Water Availability to Current and Future Demands





Upper Mississippi-Kaskaskia-Meramec Subregion Summary

Flow-Duration Curve[7]



Note: Thermoelectric demands are not included in surface water demands

Summary of Surface Water Demands by HUC8

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	mgd
Cahokia-Joachim	07140101	781	28.12	1,045
Meramec	07140102	2,150	0.55	56
Bourbeuse	07140103	843	0.04	2
Big	07140104	970	0.11	5
Upper Mississippi-Cape Girardeau	07140105	1,049	0.20	10
Whitewater	07140107	1,193	0.09	5
	Total	**6,986**	**-**	**1,123**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

Upper Mississippi-Kaskaskia-Meramec Subregion Summary

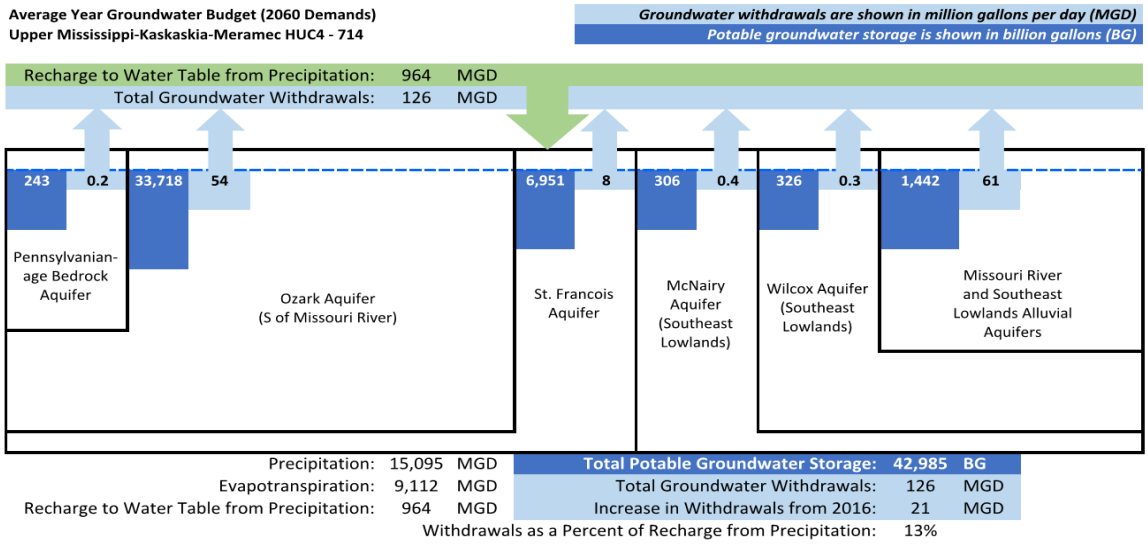
Summary of Groundwater Demands by Aquifer

	2016 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[9]**	**Glacial Deposits**	**Pennsyl-vanian**	**Other Aquifers**	**Mississippian Aquifer[10]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	6.73	19.04	1.02	0.00	0.00	0.00	3.14	0.20
Self-Supplied Domestic & Minor Systems	0.71	11.04	0.00	0.14	0.40	0.00	1.61	0.01
Self-Supplied Nonresidential	2.87	3.89	0.00	0.00	0.00	0.00	0.31	0.00
Agriculture	38.78	9.20	0.00	0.00	1.19	0.00	0.59	0.36
Thermoelectric Power Generation	1.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**50.43**	**43.17**	**1.02**	**0.14**	**1.59**	**0.00**	**5.65**	**0.57**
Aquaculture and Wetlands	0.38	1.03	0.00	0.02	0.22	0.00	0.24	0.00
Total Nonconsumptive	**0.38**	**1.03**	**0.00**	**0.02**	**0.22**	**0.00**	**0.24**	**0.00**
Total Groundwater Withdrawals	**50.81**	**44.20**	**1.02**	**0.16**	**1.81**	**0.00**	**5.89**	**0.57**

	2060 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[9]**	**Glacial Deposits**	**Pennsyl-vanian**	**Other Aquifers**	**Mississippian Aquifer[10]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	8.79	24.28	1.59	0.00	0.00	0.00	4.27	0.26
Self-Supplied Domestic & Minor Systems	0.74	11.22	0.00	0.14	0.39	0.00	1.85	0.00
Self-Supplied Nonresidential	2.57	6.17	0.00	0.00	0.00	0.00	0.49	0.00
Agriculture	45.69	11.07	0.00	0.00	1.50	0.00	0.73	0.43
Thermoelectric Power Generation	1.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**59.36**	**52.74**	**1.59**	**0.14**	**1.89**	**0.00**	**7.34**	**0.69**
Aquaculture and Wetlands	0.38	1.03	0.00	0.02	0.22	0.00	0.24	0.00
Total Nonconsumptive	**0.38**	**1.03**	**0.00**	**0.02**	**0.22**	**0.00**	**0.24**	**0.00**
Total Groundwater Withdrawals	**59.74**	**53.77**	**1.59**	**0.16**	**2.11**	**0.00**	**7.58**	**0.69**

Upper Mississippi-Kaskaskia-Meramec Subregion Summary

Average Year Groundwater Budget (2060 Demands)[11]



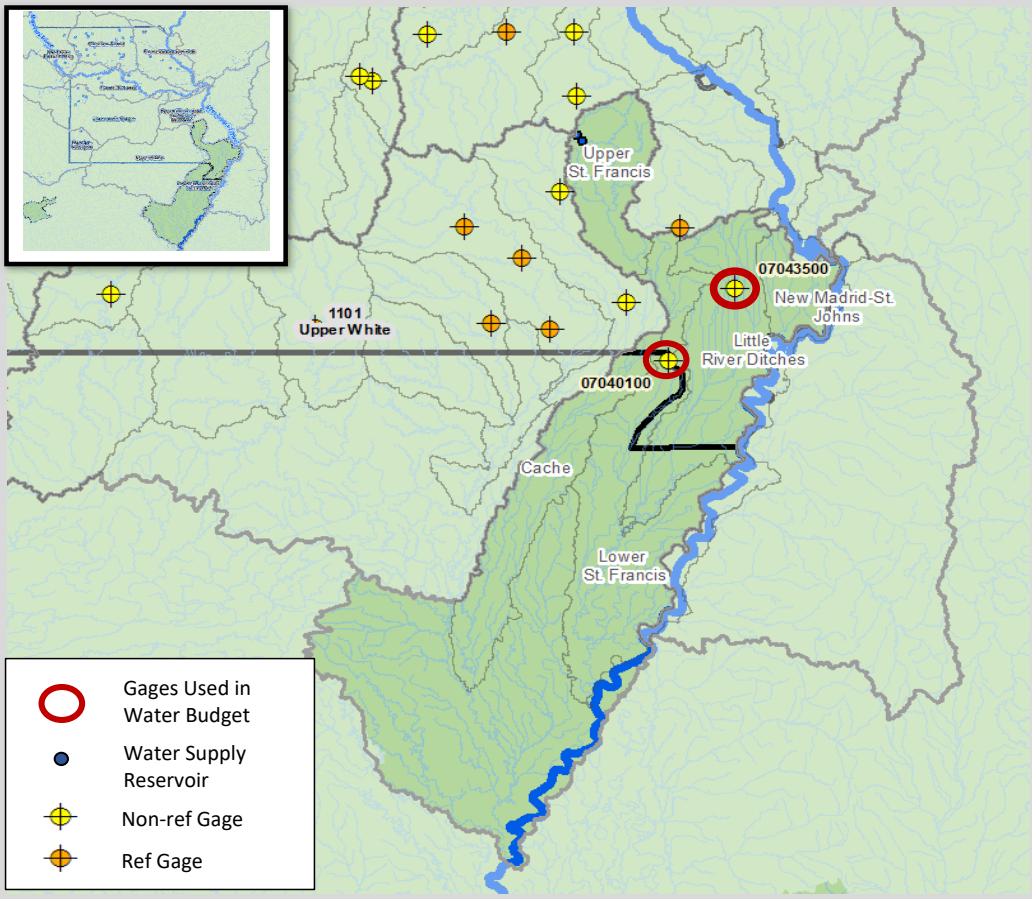
The above graphic is a generalized representation of aquifers present in each HUC4.

Notes

1. Streamflow includes all outflows from HUC4s 0711 and 1030, and HUC4 0714 inflows entering Missouri that are generated in Illinois.
2. Meramec power generation facility in St. Louis County is scheduled to be retired in 2022.
3. Groundwater demands include alluvial and groundwater aquifer withdrawals.
4. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
5. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC4, the lowest annual streamflows occurred in 2000 for gage 07019000 and 2012 for gage 07021000.
6. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
7. Demands shown on flow duration curve do not include thermoelectric demands.
8. No (major) reservoirs are used for public water supply in the subregion.
9. The Ozark Aquifer includes the Lower, Middle and Upper Ozark aquifers.
10. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
11. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Lower Mississippi-St. Francis Subregion Summary

HUC4 Name: Lower Mississippi-St. Francis **HUC4 Number:** 0802
Drainage Area within MO: 4,717 sq miles (100%) **Contributing Area outside MO:** 0 sq miles (0%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Inflows	
Streamflow[1]	155,286
Precipitation (In-State)	10,869

Nonconsumptive Use	
Withdrawal and Return	2.6

Returns	
Wastewater	12.8
Thermoeletric	1.2

Naturalized Streamflow	1,773	
Water Supply Reservoir Storage	165	million gallons

Surface Water Outflow: 157,059

Consumptive Use & ET	
Evapotranspiration	5,761
Consumptive Withdrawals	14

Lower Mississippi-St. Francis Subregion Summary

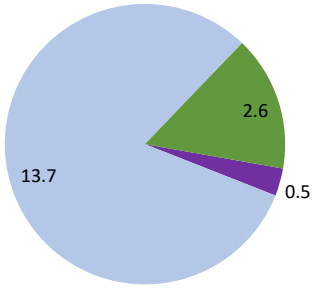
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	12,184,117	48.43	10,869
Evapotranspiration	6,457,944	25.67	5,761
Streamflow (from Out of State)	174,073,715	691.90	155,286
Streamflow (from other In-State HUC4)	0	0.00	0
Streamflow originating in HUC4	1,987,545	7.90	1,773
Total Streamflow	176,061,260	699.80	157,059
Nonconsumptive Surface Water Withdrawals	2,955	0.01	3
Consumptive Surface Water Withdrawals	15,990	0.06	14
Total Surface Water Withdrawals	18,945	0.08	17

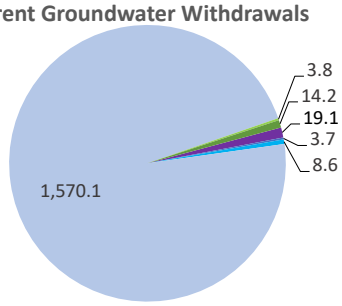
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	604	0.00	0.5	0.6
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	15,386	0.06	13.7	16.6
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**15,990**	**0.06**	**14.2**	**17.2**
Aquaculture and Wetlands	2,955	0.01	2.6	2.6
Total Nonconsumptive	**2,955**	**0.01**	**2.6**	**2.6**
Groundwater Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	21,448	0.09	19.1	19.6
Self-Supplied Domestic and Minor Systems	4,131	0.02	3.7	3.8
Self-Supplied Nonresidential	9,602	0.04	8.6	7.5
Agriculture	1,760,079	7.00	1,570.1	1,839.7
Thermoelectric Power Generation	4,312	0.02	3.8	3.8
Total Consumptive	**1,799,572**	**7.17**	**1,605.3**	**1,874.4**
Aquaculture and Wetlands	15,907	0.06	14.2	14.2
Total Nonconsumptive	**15,907**	**0.06**	**14.2**	**14.2**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



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

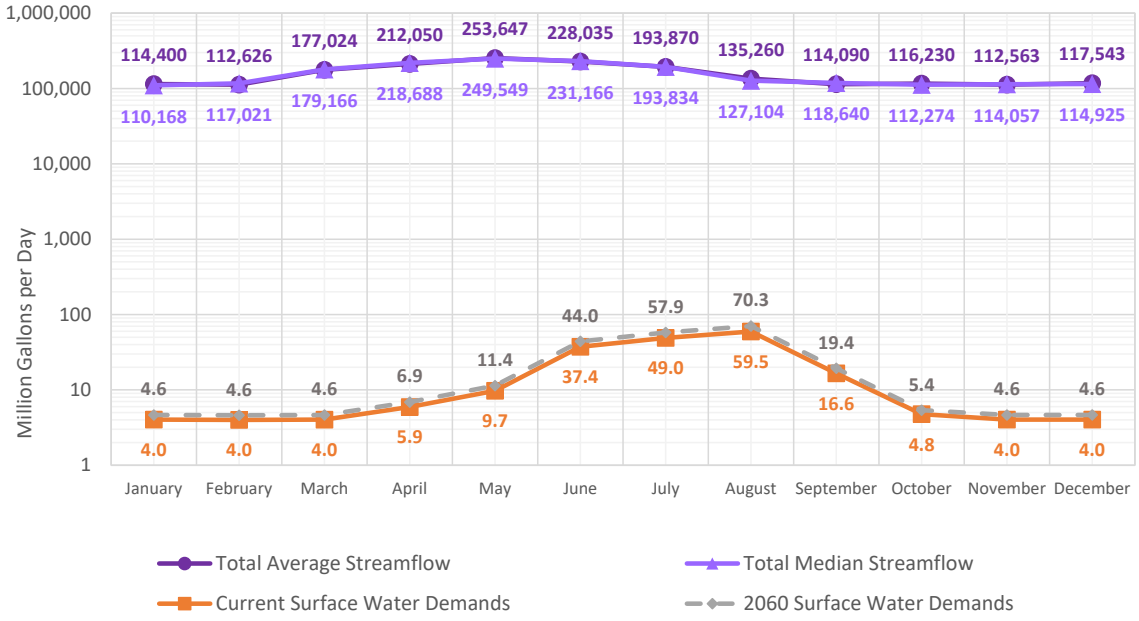
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

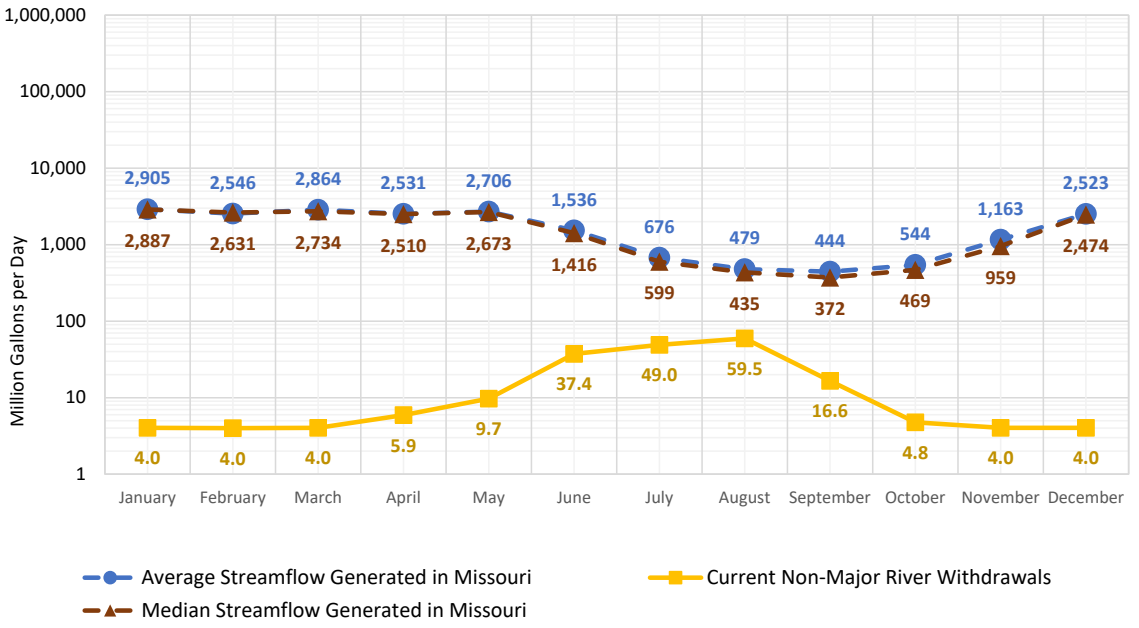
Lower Mississippi-St. Francis Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands

Lower Mississippi-St. Francis HUC4 Average Year Monthly Surface Water Budget Total Supply[3]

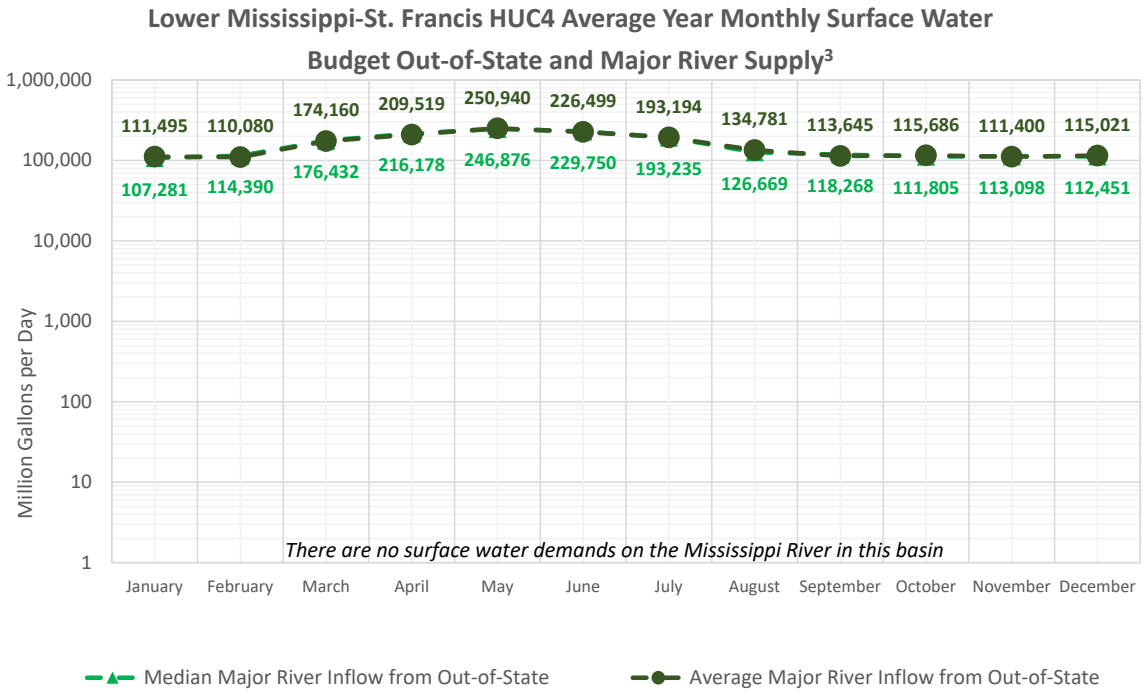


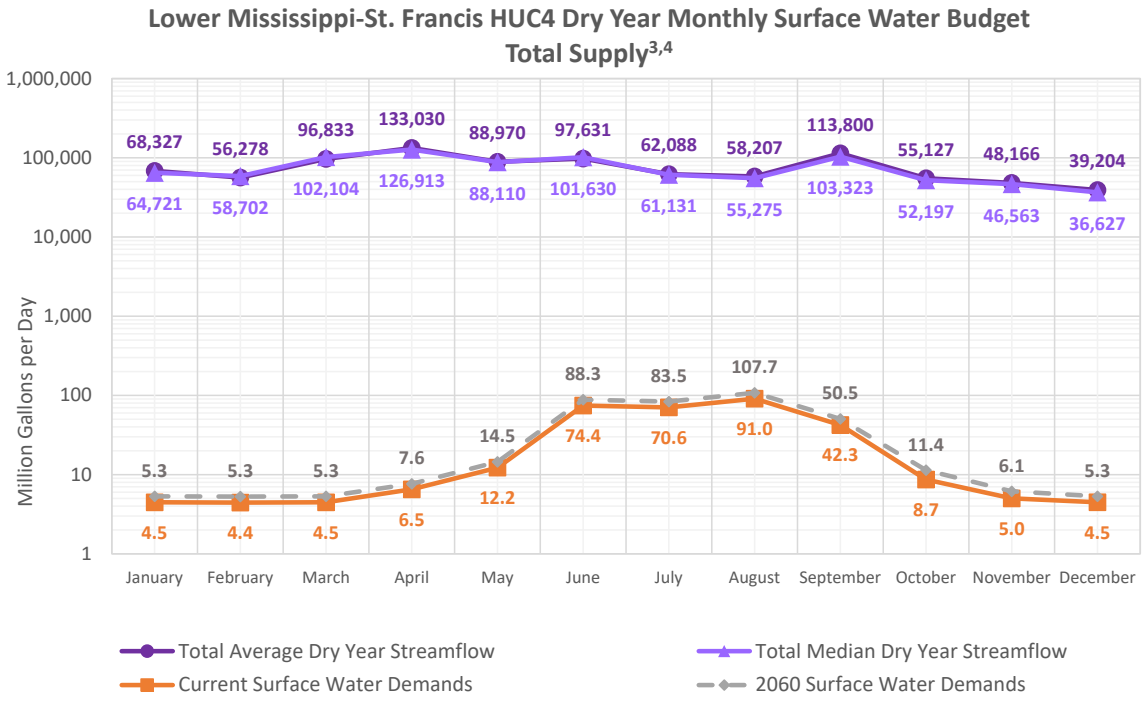
Lower Mississippi-St. Francis HUC4 Average Year Monthly Surface Water Budget In-State Supply[3]



Lower Mississippi-St. Francis Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands

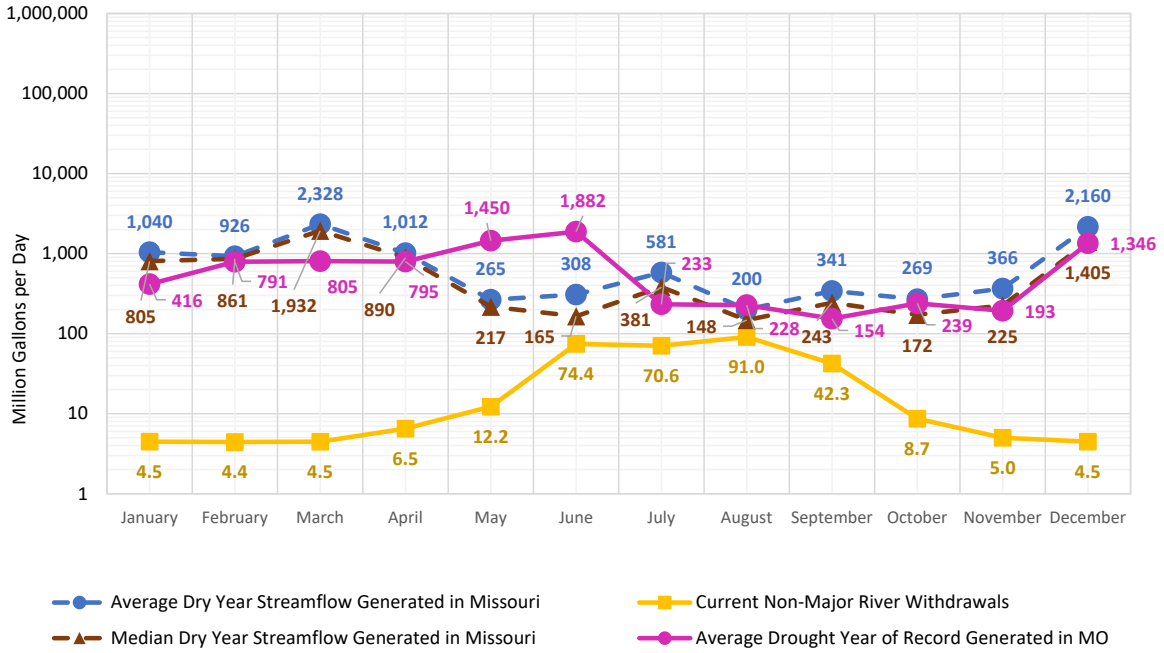




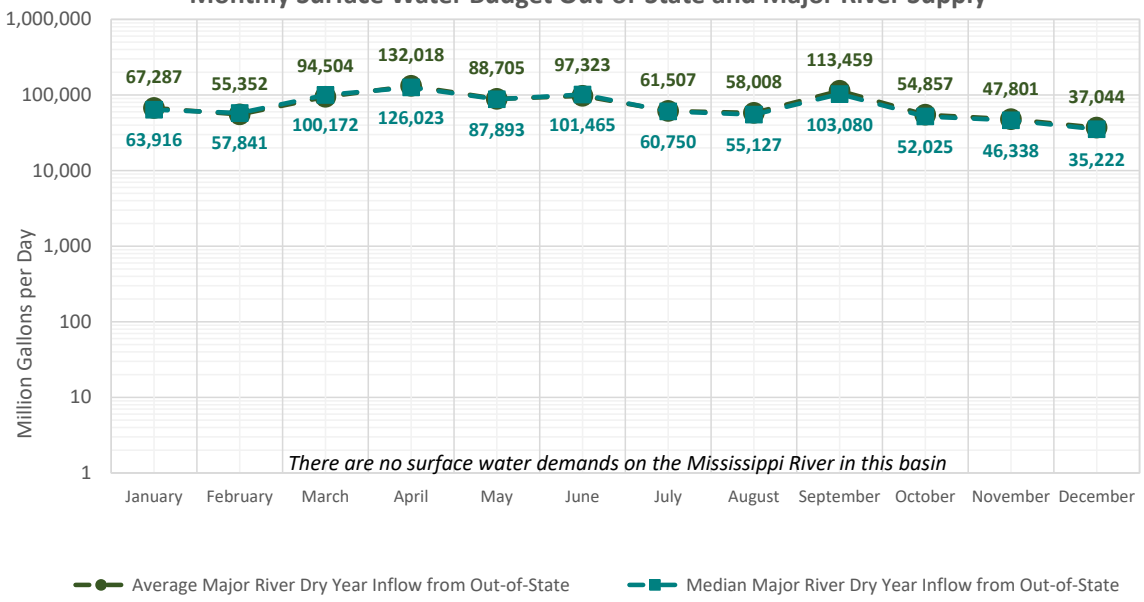
Lower Mississippi-St. Francis Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands

Lower Mississippi-St. Francis HUC4 Dry Year and Drought Year of Record Monthly Surface Water Budget In-State Supply[3,4,5]

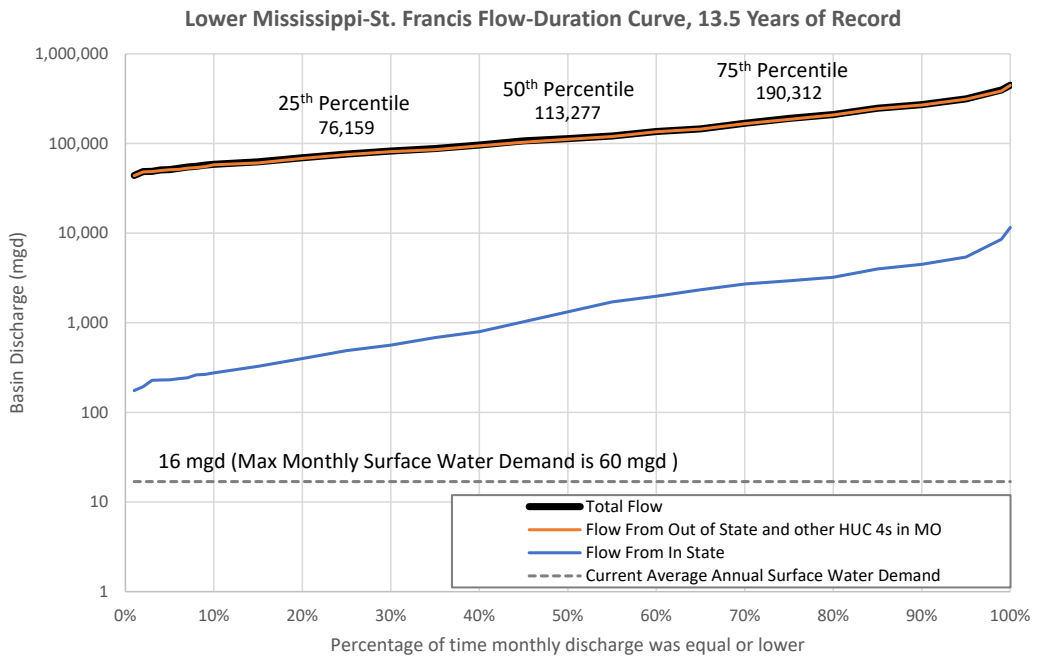


Lower Mississippi-St. Francis HUC4 Dry Year and Drought Year of Record Monthly Surface Water Budget Out-of-State and Major River Supply[3,4]



Lower Mississippi-St. Francis Subregion Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Shepherd Mountain (Ironton)	186	61	0.23	08020202	reservoirs do not empty	7
Snowhollow Lake3 (Ironton)	321	105	--	08020202	reservoirs do not empty	36
Total	**507**	**165**	**0.23**			

Summary of Surface Water Demands by HUC8[8]

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	mgd
New Madrid-St. Johns	08020201	690	0.16	5
Upper St. Francis	08020202	1,299	0.05	3
Lower St. Francis	08020203	556	0.02	1
Little River Ditches	08020204	2,122	0.08	8
	Total	**4,667**	**-**	**17**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

Lower Mississippi-St. Francis Subregion Summary

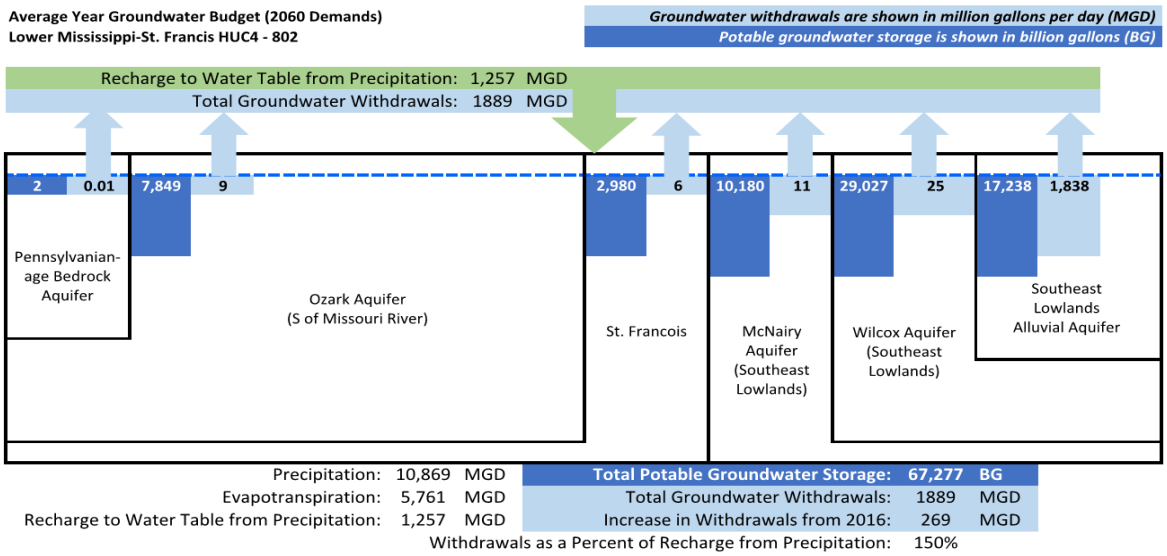
Summary of Groundwater Demands by Aquifer

	2016 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[9]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[10]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	4.47	0.42	0.00	0.00	0.00	0.00	2.31	12.05
Self-Supplied Domestic & Minor Systems	0.43	1.67	0.00	0.01	0.00	0.00	1.06	0.52
Self-Supplied Nonresidential	7.76	0.01	0.00	0.00	0.00	0.00	0.78	0.00
Agriculture	1,547.15	2.59	0.00	0.00	0.00	0.00	0.30	20.18
Thermoelectric Power Generation	3.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**1,563.66**	**4.69**	**0.00**	**0.01**	**0.00**	**0.00**	**4.45**	**32.75**
Aquaculture and Wetlands	10.23	3.95	0.00	0.00	0.00	0.00	0.01	0.00
Total Nonconsumptive	**10.23**	**3.95**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**
Total Groundwater Withdrawals	**1,573.89**	**8.64**	**0.00**	**0.01**	**0.00**	**0.00**	**4.46**	**32.75**

	2060 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[9]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[10]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	4.25	0.50	0.00	0.00	0.00	0.00	3.00	11.99
Self-Supplied Domestic & Minor Systems	0.41	1.68	0.00	0.01	0.00	0.00	1.29	0.45
Self-Supplied Nonresidential	6.29	0.01	0.00	0.00	0.00	0.00	1.24	0.00
Agriculture	1,812.77	3.06	0.00	0.00	0.00	0.00	0.40	23.64
Thermoelectric Power Generation	3.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**1,827.50**	**5.25**	**0.00**	**0.01**	**0.00**	**0.00**	**5.93**	**36.08**
Aquaculture and Wetlands	10.23	3.95	0.00	0.00	0.00	0.00	0.01	0.00
Total Nonconsumptive	**10.23**	**3.95**	**0.00**	**0.00**	**0.00**	**0.00**	**0.01**	**0.00**
Total Groundwater Withdrawals	**1,837.73**	**9.20**	**0.00**	**0.01**	**0.00**	**0.00**	**5.94**	**36.08**

Lower Mississippi-St. Francis Subregion Summary

Average Year Groundwater Budget (2060 Demands)[11]



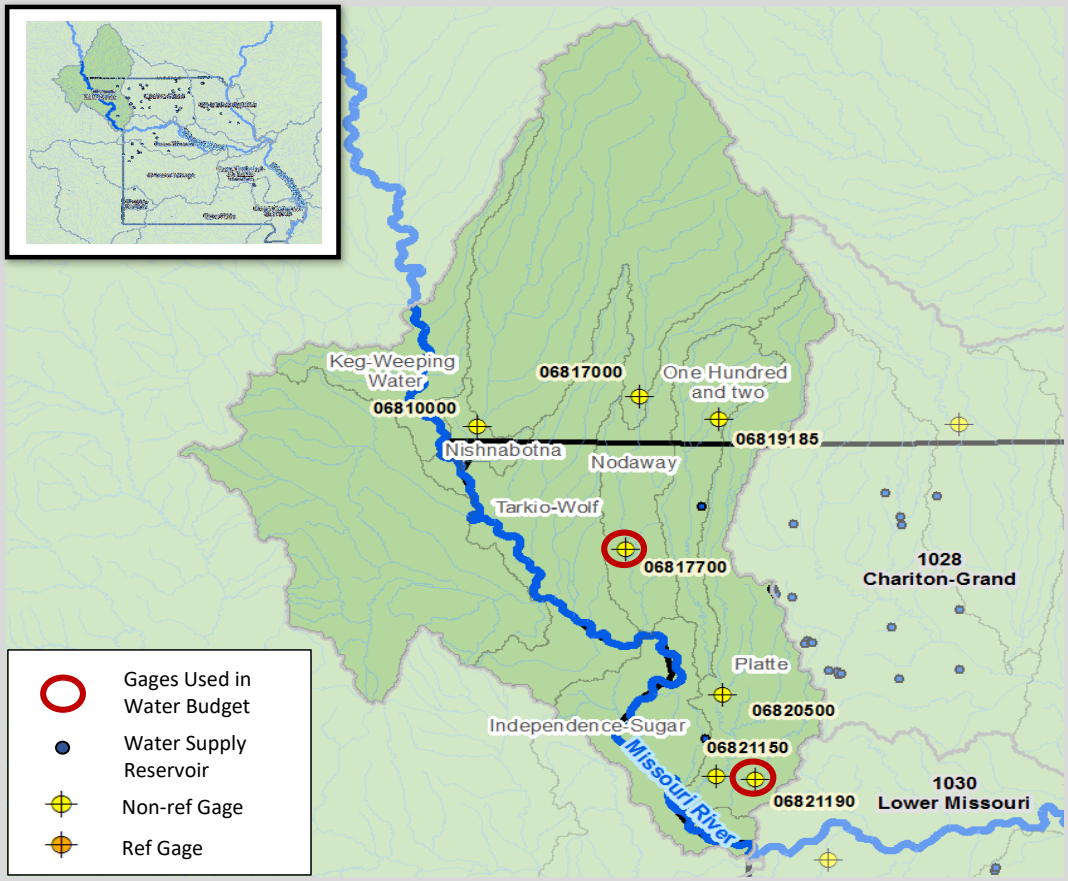
The above graphic is a generalized representation of aquifers present in each HUC4.

Notes

1. Streamflow includes outflows from HUC4 0714.
2. Groundwater demands include alluvial and groundwater aquifer withdrawals.
3. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC4, the lowest annual streamflows occurrred in 1987 for gage 07040100 and 2012 for gage 07043500.
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources and notes:
   a. Missouri Water Supply Study, Missouri DNR, June 2011
   b. US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/
   c . Three lakes that also serve as water supply reservoirs include Frontier Lake, Fredericktown City Lake, and Nims Lake (which drains to Fredericktown City Lake). Information on these small reservoirs was not available for this summary.
8. Total Area for Lower Mississippi-St. Francis HUC8 Surface Water Demands differs from total HUC4 area because HUC 8 08020302 only has 2% of its area within the state of Missouri and was not considered in HUC 8 analysis.
9. The Ozark Aquifer includes the Lower, Middle and Upper Ozark aquifers.
10. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
11. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Missouri-Nishnabotna Subregion Summary

HUC4 Name:	Missouri-Nishnabotna	HUC4 Number:	1024
Drainage Area within MO:	3,682 sq miles (27%)	Contributing Area outside MO:	9,925 sq miles (73%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.

All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	1

Returns	
Wastewater	20.8
Thermoeletric	927.4

Inflows	
Streamflow[1]	31,910
Precipitation (In-State)	6,343

Naturalized Streamflow	1,699	
Water Supply Reservoir Storage	36,747	million gallons

Surface Water Outflow: 33,548

Consumptive Use & ET	
Evapotranspiration	3,945
Consumptive Withdrawals	1009

Missouri-Nishnabotna Subregion Summary

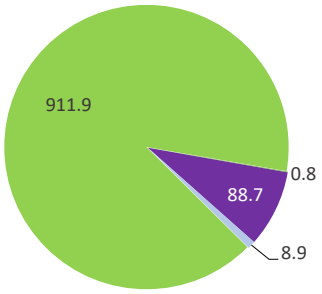
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	7,110,934	36.21	6,343
Evapotranspiration	4,422,317	22.52	3,945
Streamflow (from Out of State)	35,770,892	182.15	31,910
Streamflow (from other In-State HUC4)	0	0.00	0
Streamflow originating in HUC4	1,904,950	9.70	1,699
Total Streamflow	37,675,841	191.85	33,610
Nonconsumptive Surface Water Withdrawals	844	0.00	1
Consumptive Surface Water Withdrawals	1,131,597	5.76	1,009
Total Surface Water Withdrawals	1,132,441	5.77	1,010

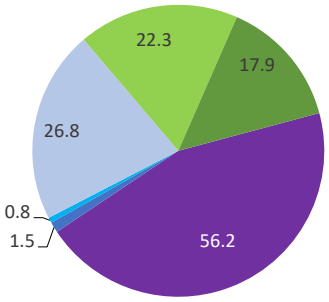
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	99,426	0.51	88.7	113.8
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	9,933	0.05	8.9	11.6
Thermoelectric Power Generation	1,022,238	5.21	911.9	1,069.7
Total Consumptive	**1,131,597**	**5.77**	**1,009.5**	**1,195.1**
Aquaculture and Wetlands	844	0.00	0.8	0.8
Total Nonconsumptive	**844**	**0.00**	**0.8**	**0.8**
Groundwater Withdrawals By Sector[2]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	63,018	0.32	56.2	67.3
Self-Supplied Domestic and Minor Systems	1,641	0.01	1.5	2.0
Self-Supplied Nonresidential	850	0.00	0.8	1.0
Agriculture	30,080	0.15	26.8	31.6
Thermoelectric Power Generation	25,024	0.13	22.3	26.2
Total Consumptive	**120,613**	**0.61**	**107.6**	**128.1**
Aquaculture and Wetlands	20,060	0.10	17.9	17.9
Total Nonconsumptive	**20,060**	**0.10**	**17.9**	**17.9**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



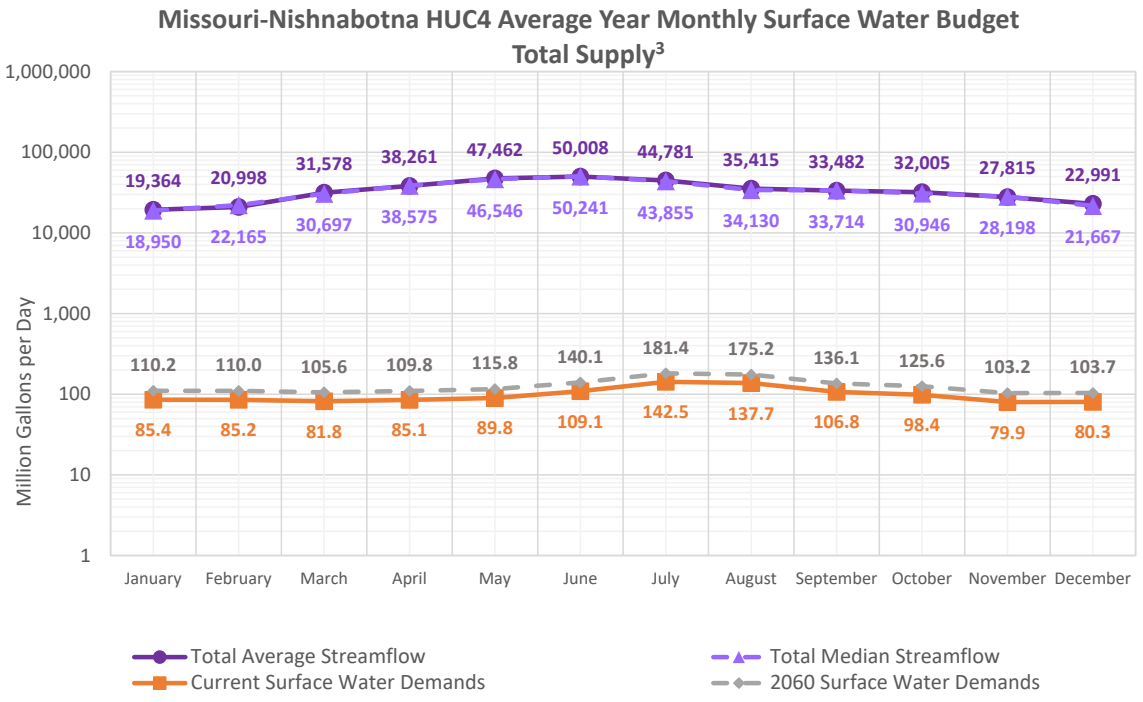
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture
- Thermoelectric Power Generation

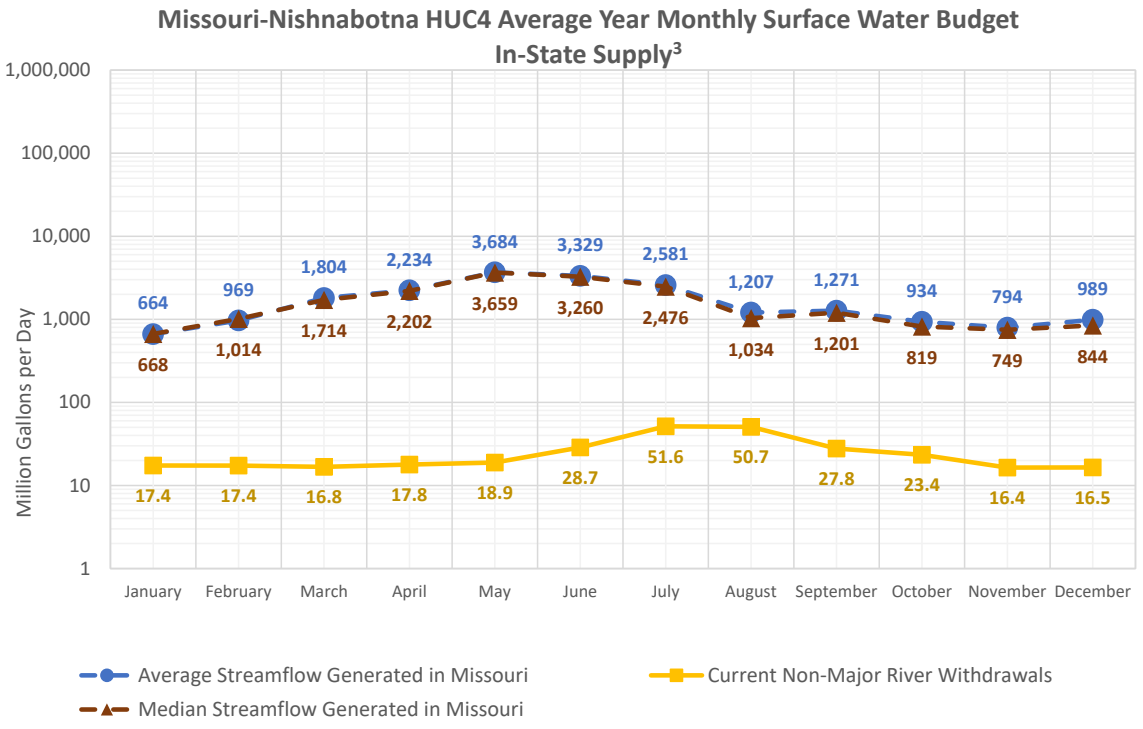
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Missouri-Nishnabotna Subregion Summary

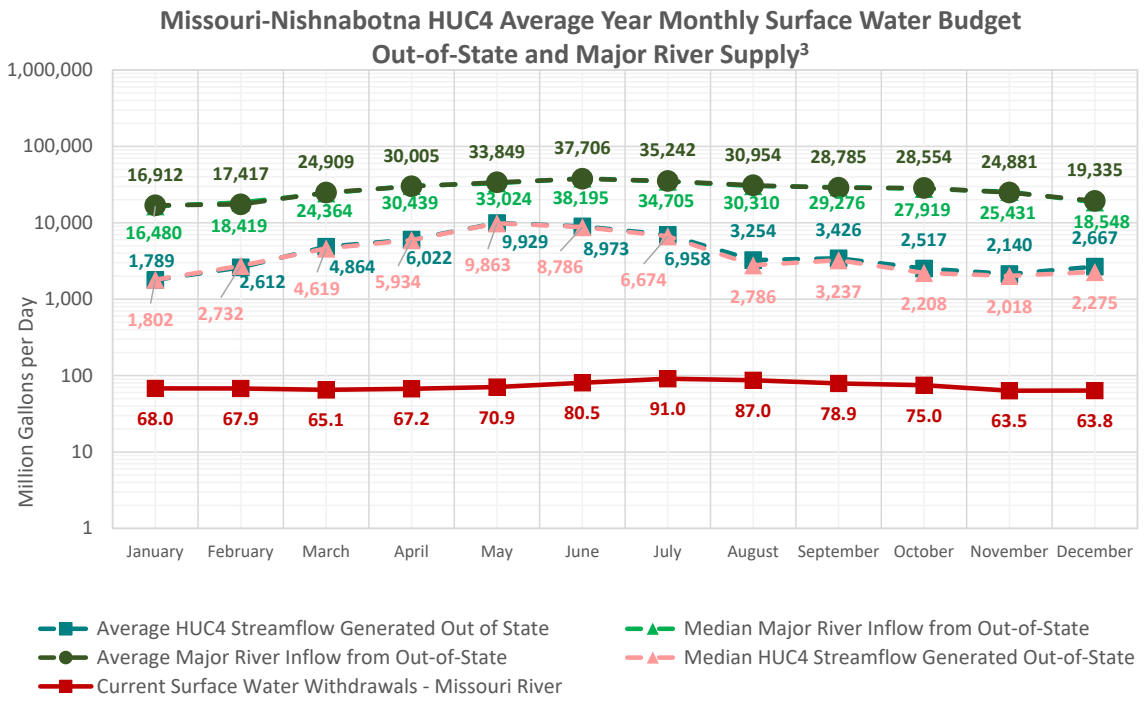
Comparison of Monthly Surface Water Availability to Current and Future Demands

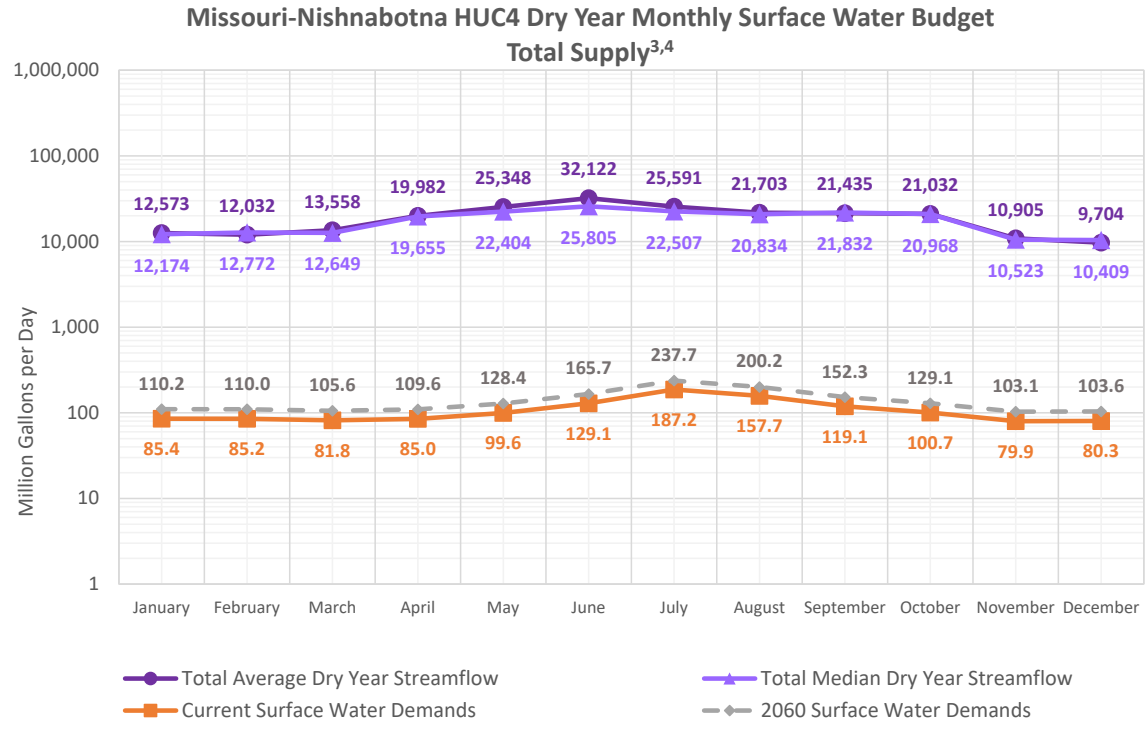




Missouri-Nishnabotna Subregion Summary

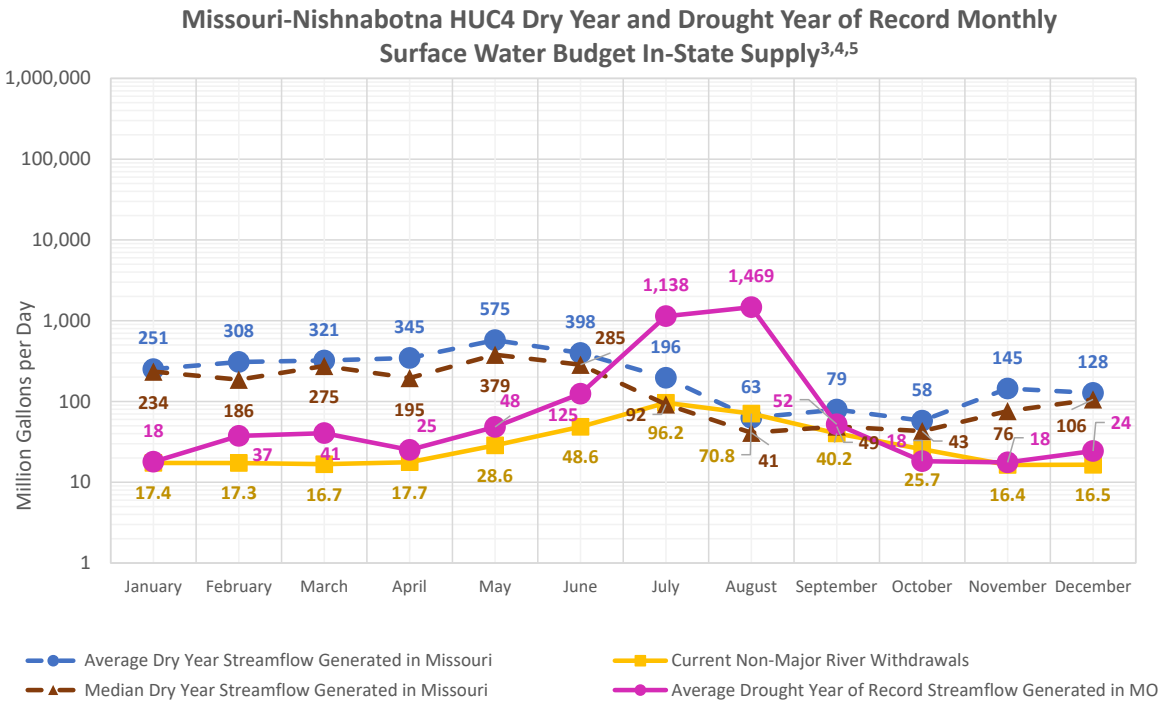
Comparison of Monthly Surface Water Availability to Current and Future Demands

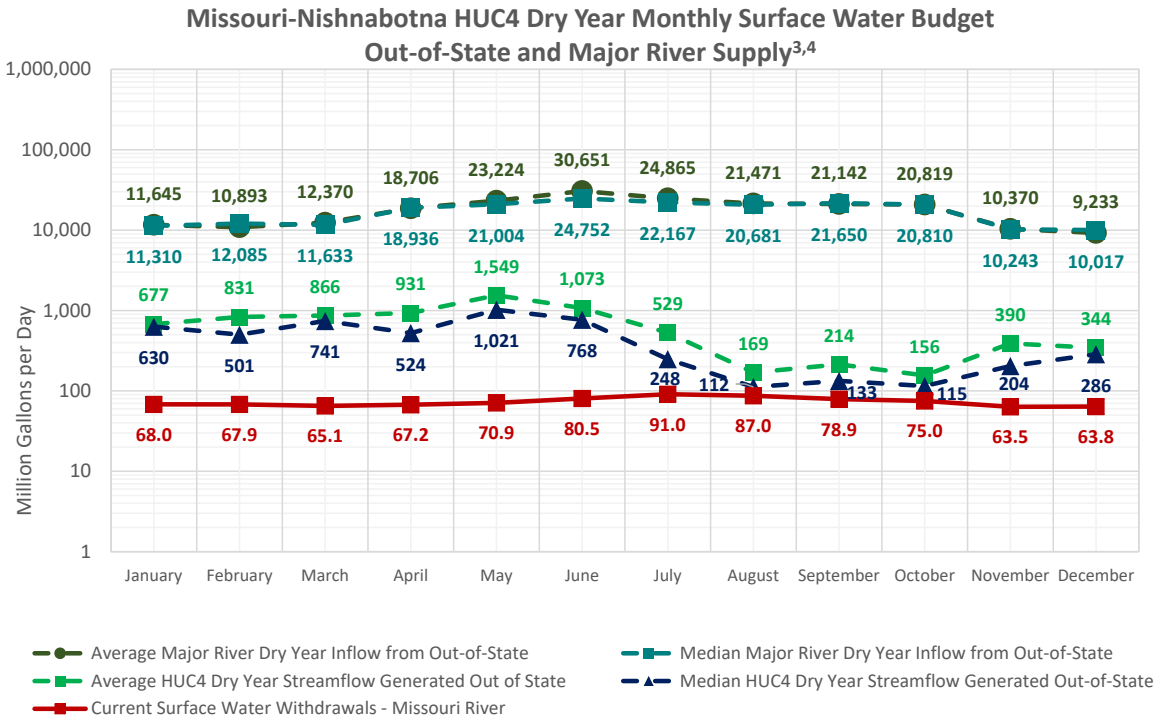




Missouri-Nishnabotna Subregion Summary

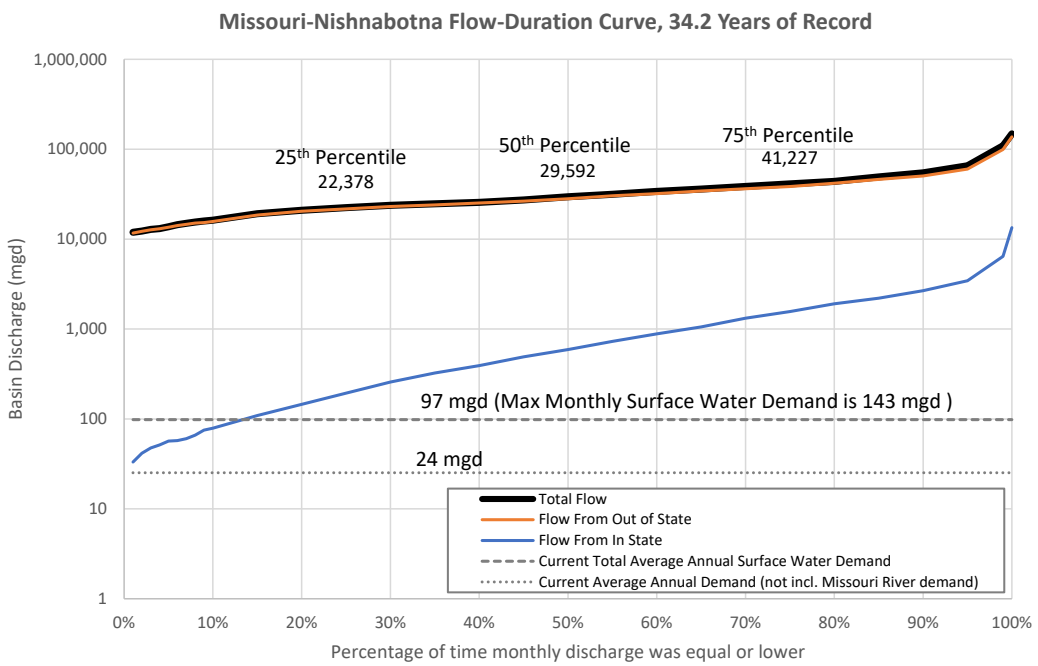
Comparison of Monthly Surface Water Availability to Current and Future Demands





Missouri-Nishnabotna Subregion Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Water Supply Storage Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
City Lake (Dearborn)	52	17	0.01	10240011	22	9
Smithville	95,200	31,021	28.8	10240012	97	41
Monzigo Lake (Maryville)	17,520	5,709	2.90	10240013	56	40
Total	**112,772**	**36,747**	**31.71**			

Summary of Surface Water Demands by HUC8[8]

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	Current Demand mgd
Nishnabotna	10240004	71	0.19	1
Tarkio-Wolf	10240005	855	0.11	4
Nodaway	10240010	567	0.03	1
Independence-Sugar	10240011	526	39.87	998
Platte	10240012	1268	0.08	5
One Hundred and two	10240013	386	0.13	2
	Total	**3,673**	**-**	**1011**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

Missouri-Nishnabotna Subregion Summary

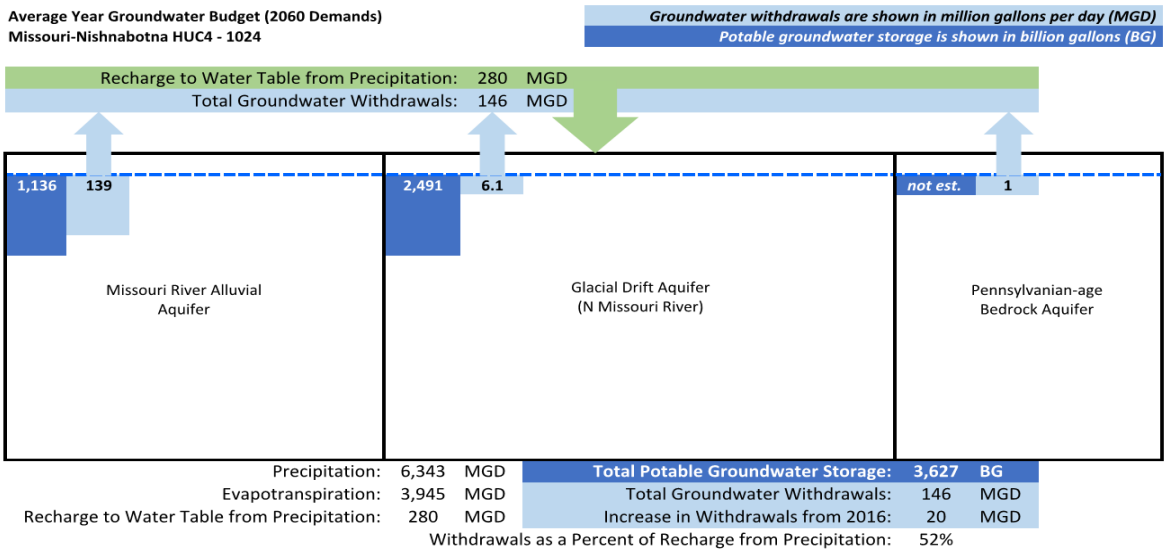
Summary of Groundwater Demands by Aquifer

Groundwater Withdrawals By Sector	2016 Demands (mgd)							
	Alluvium	Ozark Aquifer[9]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[10]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	56.03	0.00	0.19	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.86	0.00	0.55	0.05	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	21.72	0.00	4.67	0.45	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	22.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**101.69**	**0.00**	**5.41**	**0.50**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	17.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**17.90**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**119.59**	**0.00**	**5.41**	**0.50**	**0.00**	**0.00**	**0.00**	**0.00**

Groundwater Withdrawals By Sector	2060 Demands (mgd)							
	Alluvium	Ozark Aquifer[9]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[10]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	67.17	0.00	0.17	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	1.44	0.00	0.43	0.09	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	25.46	0.00	5.52	0.57	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	26.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**121.25**	**0.00**	**6.12**	**0.66**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	17.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**17.90**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**139.15**	**0.00**	**6.12**	**0.66**	**0.00**	**0.00**	**0.00**	**0.00**

Missouri-Nishnabotna Subregion Summary

Average Year Groundwater Budget (2060 Demands)[11]



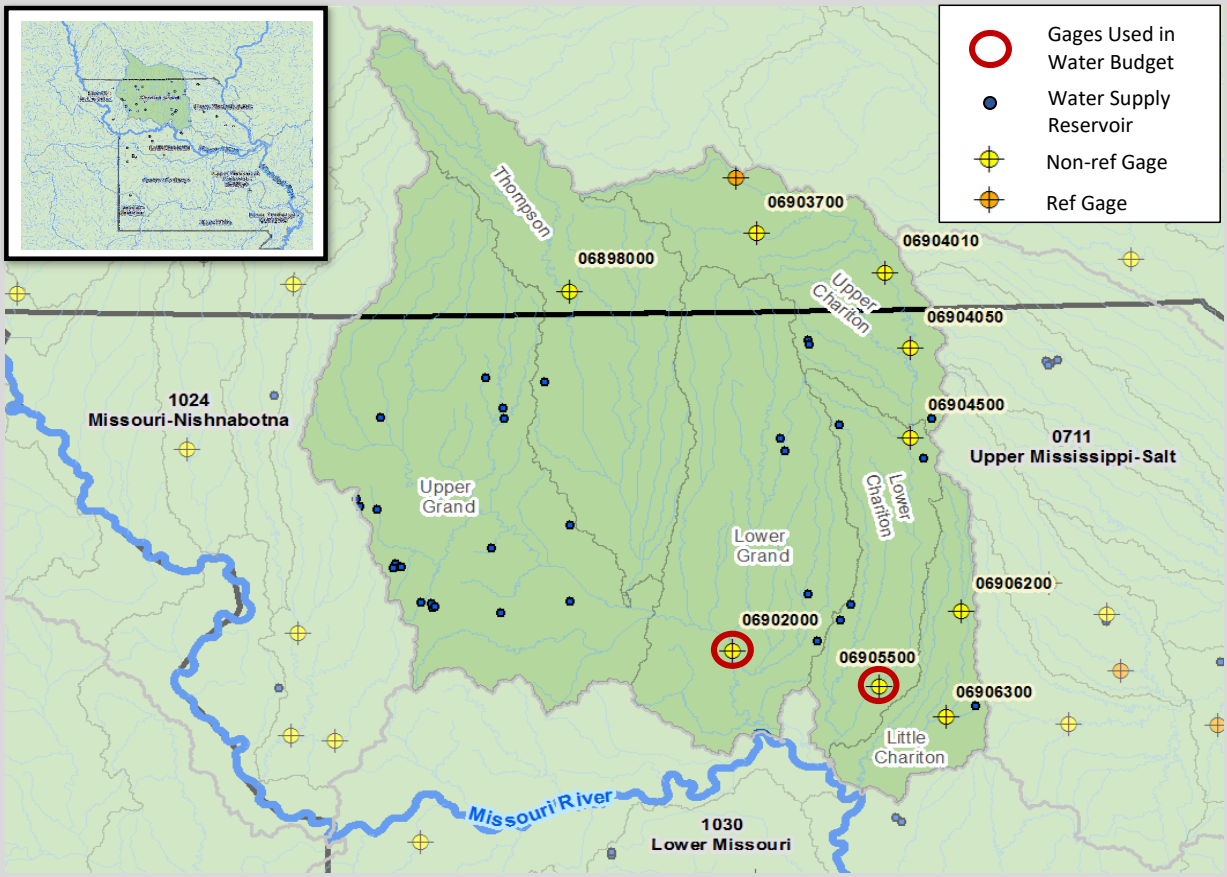
The above graphic is a generalized representation of aquifers present in each HUC4.

Notes

1. Streamflows include out of state inflows from the Missouri River and HUC4 1024 inflows entering Missouri generated in Kansas and Nebraska.
2. Groundwater demands include alluvial and groundwater aquifer withdrawals.
3. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC4, the lowest annual streamflows occurred in 2003 for gage 06821190 and 1988 for gage 06817700.
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources:
   a. *Missouri Water Supply Study, Missouri DNR, June 2011*
   b. *US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/*
8. Total Area for Missouri-Nishnabotna HUC8 Surface Water Demands differs from total HUC4 area because HUC 8 10240001 only has 1% of its area within the state of Missouri and was not considered in HUC 8 analysis.
9. The Ozark Aquifer includes the Lower, Middle and Upper Ozark aquifers.
10. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
11. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Chariton-Grand Subregion Summary

HUC4 Name:	Chariton-Grand	HUC4 Number:	1028
Drainage Area within MO:	8,306 sq miles (76%)	Contributing Area outside MO:	2,645 sq miles (24%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	7

Returns	
Wastewater	10.2
Thermoeletric	758.1

Inflows	
Streamflow[1]	1,296
Precipitation (In-State)	15,242

Naturalized Streamflow	4,070	
Water Supply Reservoir Storage	31,321	million gallons

Surface Water Outflow: 5,342

Consumptive Use & ET	
Evapotranspiration	9,020
Consumptive Withdrawals	793

Chariton-Grand Subregion Summary

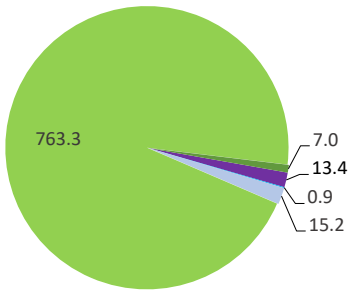
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	17,086,463	38.57	15,242
Evapotranspiration	10,111,863	22.83	9,020
Streamflow (from Out of State)	1,453,090	3.28	1,296
Streamflow (from other In-State HUC4)	0	0.00	0
Streamflow originating in HUC4	4,562,575	10.30	4,070
Total Streamflow	6,015,665	13.58	5,366
Nonconsumptive Surface Water Withdrawals	7,857	0.02	7
Consumptive Surface Water Withdrawals	888,695	2.01	793
Total Surface Water Withdrawals	896,552	2.02	800

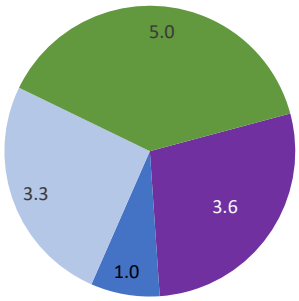
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	15,063	0.03	13.4	13.0
Self-Supplied Nonresidential	962	0.002	0.9	0.8
Agriculture	17,007	0.04	15.2	22.1
Thermoelectric Power Generation	855,663	1.93	763.3	895.6
Total Consumptive	**888,695**	**2.00**	**792.8**	**931.5**
Aquaculture and Wetlands	7,857	0.02	7.0	7.0
Total Nonconsumptive	**7,857**	**0.02**	**7.0**	**7.0**
Groundwater Withdrawals By Sector[2]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	4,063	0.01	3.6	3.6
Self-Supplied Domestic and Minor Systems	1,109	0.00	1.0	0.6
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	3,706	0.01	3.3	4.7
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**8,878**	**0.02**	**7.9**	**8.9**
Aquaculture and Wetlands	5,592	0.01	5.0	5.0
Total Nonconsumptive	**5,592**	**0.01**	**5.0**	**5.0**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



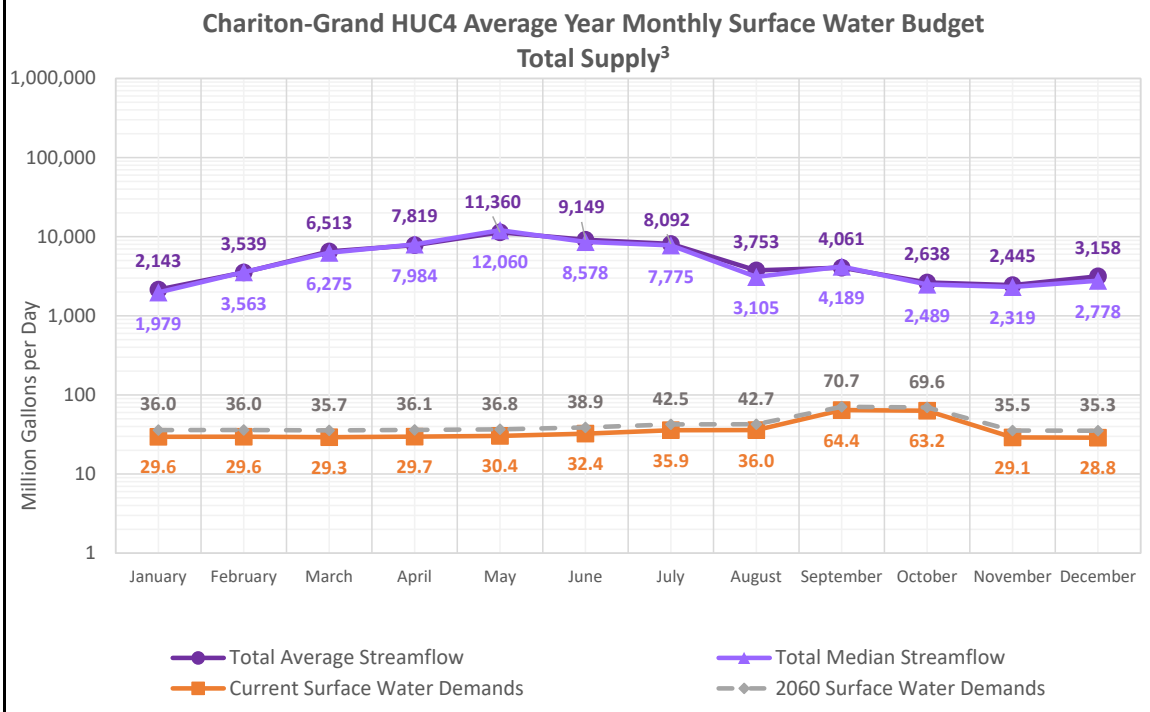
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture
- Thermoelectric Power Generation

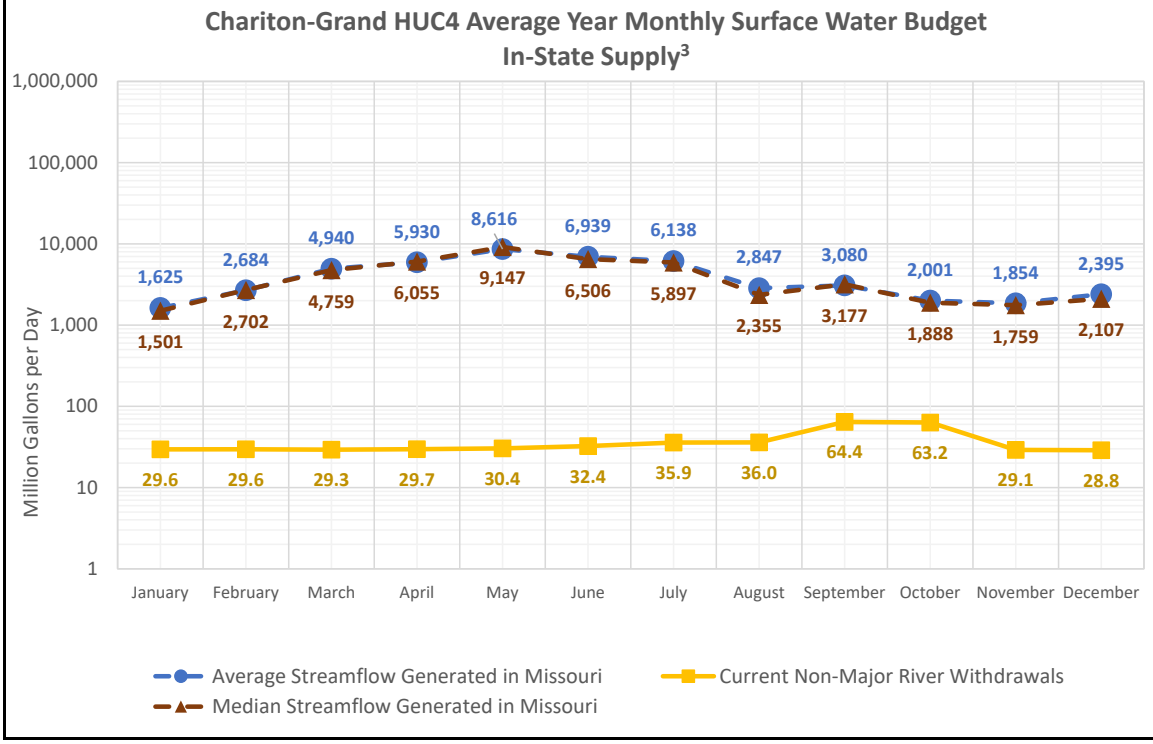
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Chariton-Grand Subregion Summary

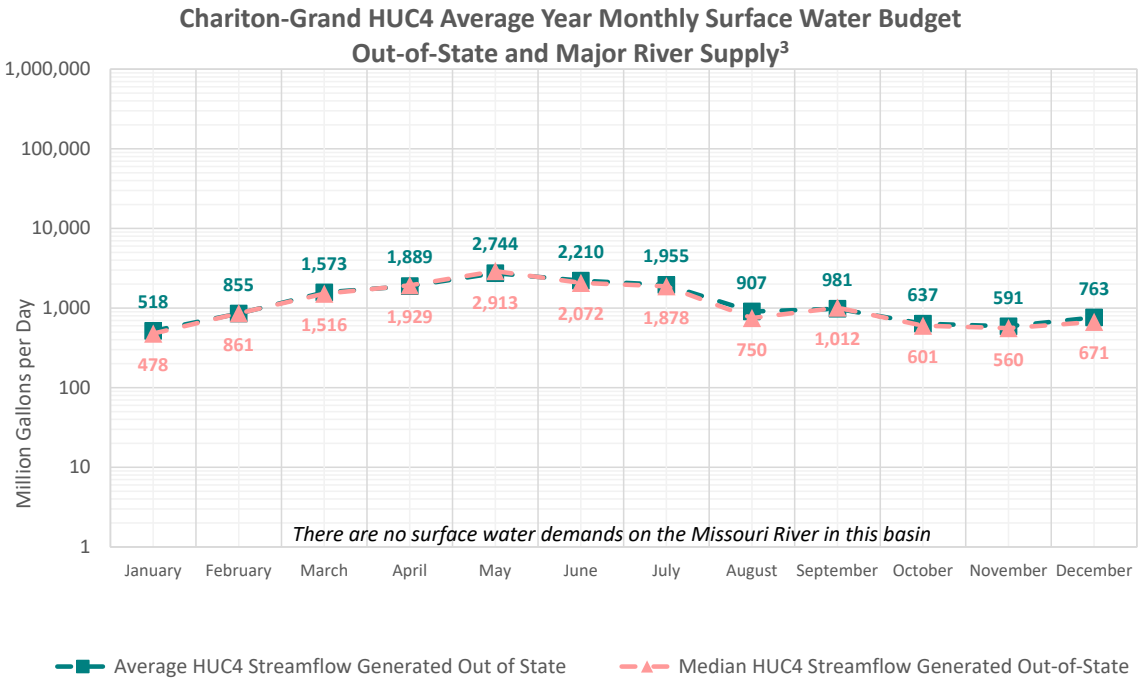
Comparison of Monthly Surface Water Availability to Current and Future Demands

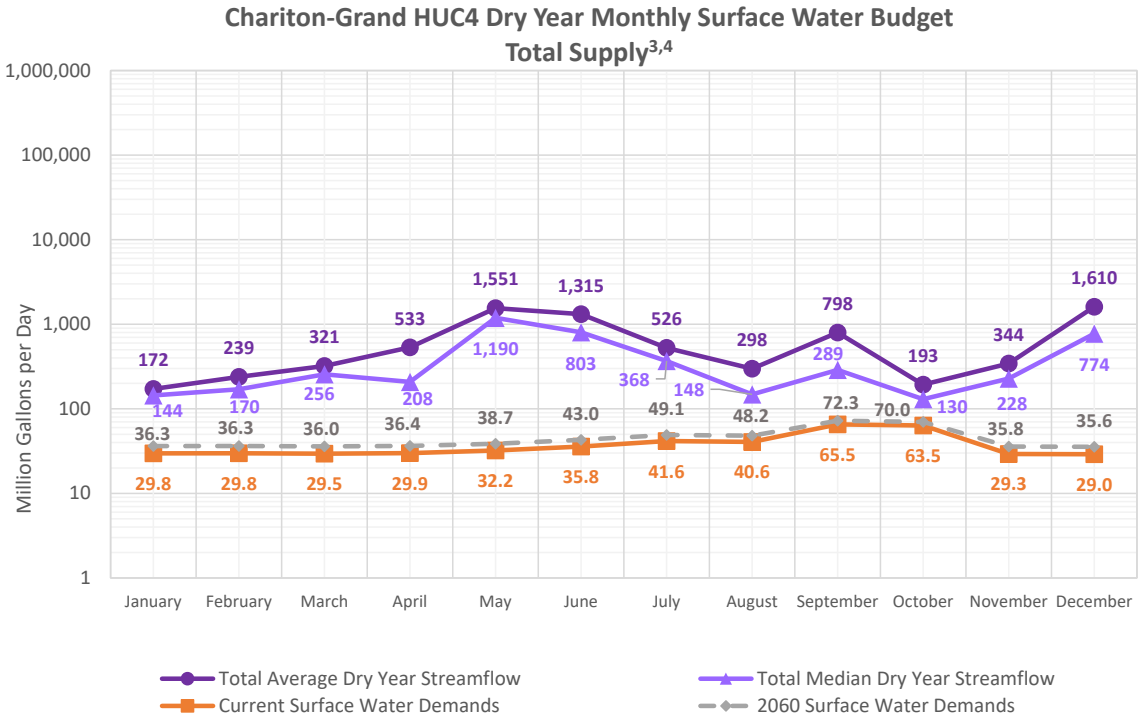




Chariton-Grand Subregion Summary

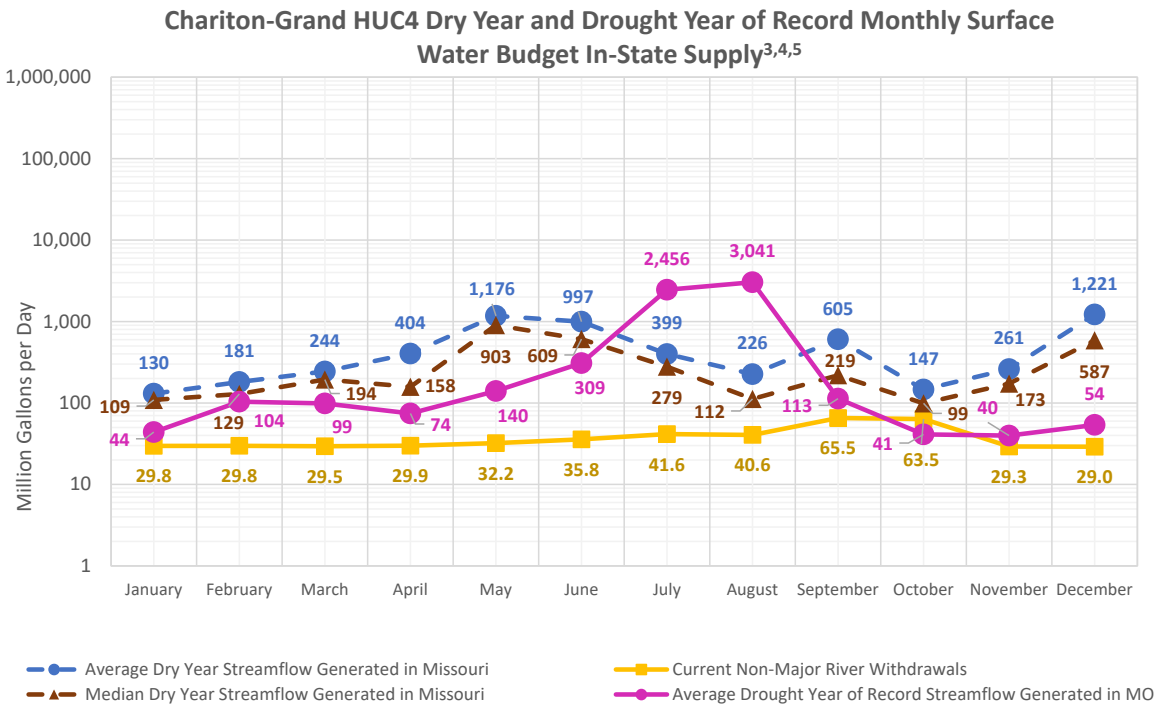
Comparison of Monthly Surface Water Availability to Current and Future Demands

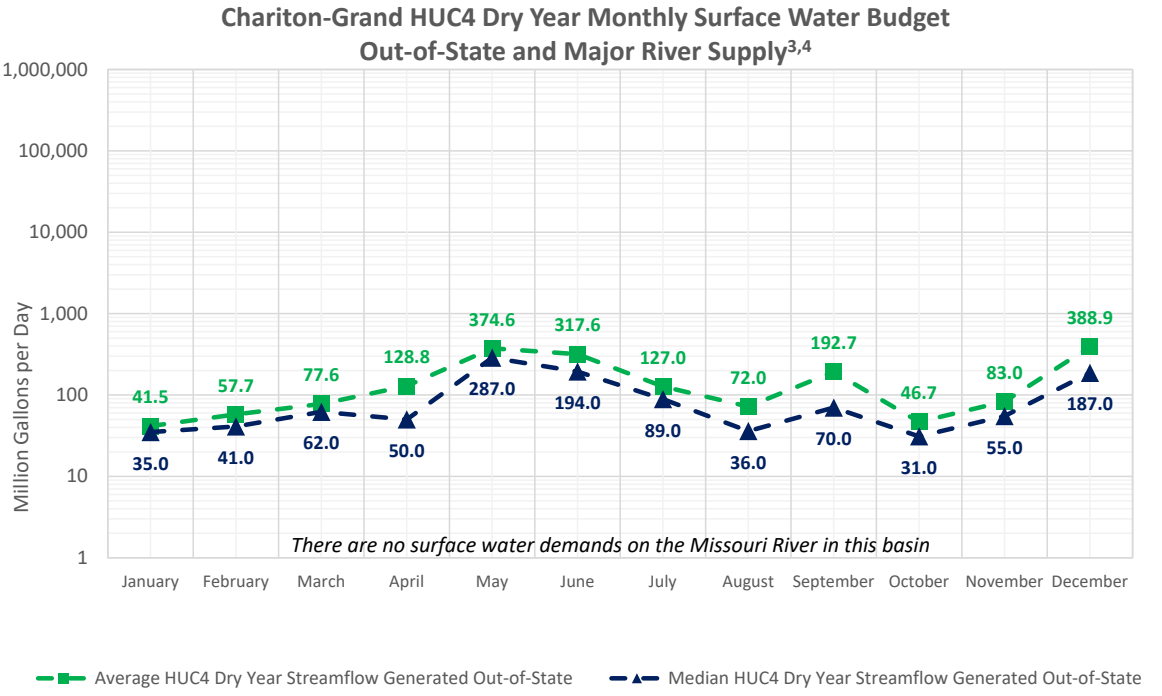




Chariton-Grand Subregion Summary

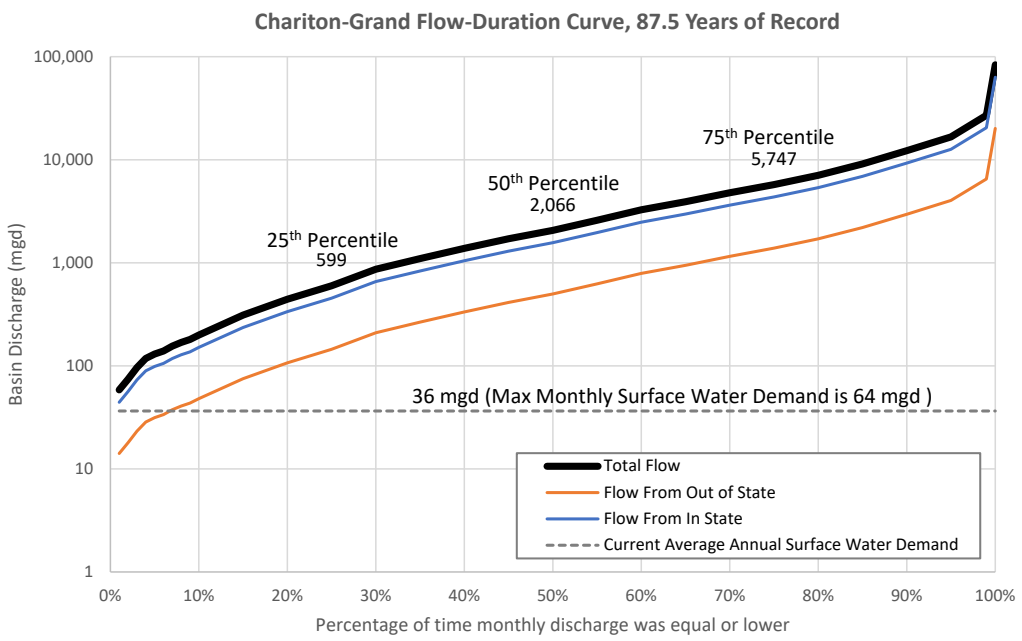
Comparison of Monthly Surface Water Availability to Current and Future Demands





Chariton-Grand Subregion Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Harrison Lake (West Fk of Big Creek)	1,095	357	0.59	10280101	6	4
Bethany New Lake (Bethany)	499	163	0.175	10280101	22	17
Bethany Old Lake (Bethany)	162	53	0.051	10280101	22	17
City Lake (Breckenridge)	140	46	0.052	10280101	26	15
GLM Lake (Cameron)	1,869	609	0.75	10280101	reservoirs do not empty	25
Lake 1 (Cameron)	115	37	0.071	10280101	5	4
Lake 2 (Cameron)	325	106	0.165	10280101	8	7
Lake 3 (Cameron)	950	310	0.4	10280101	16	13
City Lake (Hamilton)	896	292	0.19	10280101	26	20
City Lake (Jamesport)	163	53	0.069	10280101	85	16
South Lake (King City)	417	136	0.078	10280101	43	29
North upper lake (King City)	39	13	0.005	10280101	6	6
North middle Lake (King City)	65	21	0.008	10280101	109	23
North lower lake (King City)	332	108	0.042	10280101	172	87
Private Lake (Lake Viking)	12,000	3,910	2.46	10280101	165	78
Willowbrook Lake (Maysville)	784	255	0.31	10280101	46	15
South Lake (Maysville)	75	24	0.02	10280101	reservoirs do not empty	351
West Lake (Maysville)	250	81	0.12	10280101	reservoirs do not empty	23
Lake (Middle Fork)	915	298	0.381	10280101	38	15

(continued on next page)

Chariton-Grand Subregion Summary

Reservoir Storage (Continued)

Reservoir (City/Town)	Water Supply Storage ac-ft	Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Rock House Lake (Ridgeway)	461	150	0.246	10280102	reservoirs do not empty	22
City Lake (Brookfield)	2,070	675	0.207	10280103	24	22
Newer City Lake (Marceline)	1,990	648	0.412	10280103	30	23
Elmwood Lake (Milan)	2,503	816	0.737	10280103	15	12
Golf Course Lake (Milan)	555	181	0.116	10280103	133	54
Hazel Creek Lake (Kirksville)	8,680	2,828	1.954	10280201	25	22
Lake Mahoney (Unionville)	620	202	0.283	10280201	16	11
Lake Thunderhead4 (Unionville)	15,400	5,018	3.361	10280201	63	63
Forest Lake (Kirksville)	12,500	4,073	3.53	10280202	37	30
Older City Lake (Marceline)	462	151	0.06	10280202	30	26
Sugar Creek Lake (Moberly)	5,250	1,711	1.2	10280203	33	23
Long Branch Lake	24,400	7,951	1.28	10280203	112	29
Lake (Harrison Co.)	140	46	0.044	10280101	2	2
Total	**96,122**	**31,322**	**19.4**			

Summary of Surface Water Demands by HUC8

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	mgd
Upper Grand	10280101	2811	0.07	9
Thompson	10280102	1105	0.11	6
Lower Grand	10280103	2234	0.10	11
Upper Chariton	10280201	438	0.17	4
Lower Chariton	10280202	1019	0.03	1
Little Chariton	10280203	698	23.13	768
	Total	**8,305**	**-**	**799**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

Chariton-Grand Subregion Summary

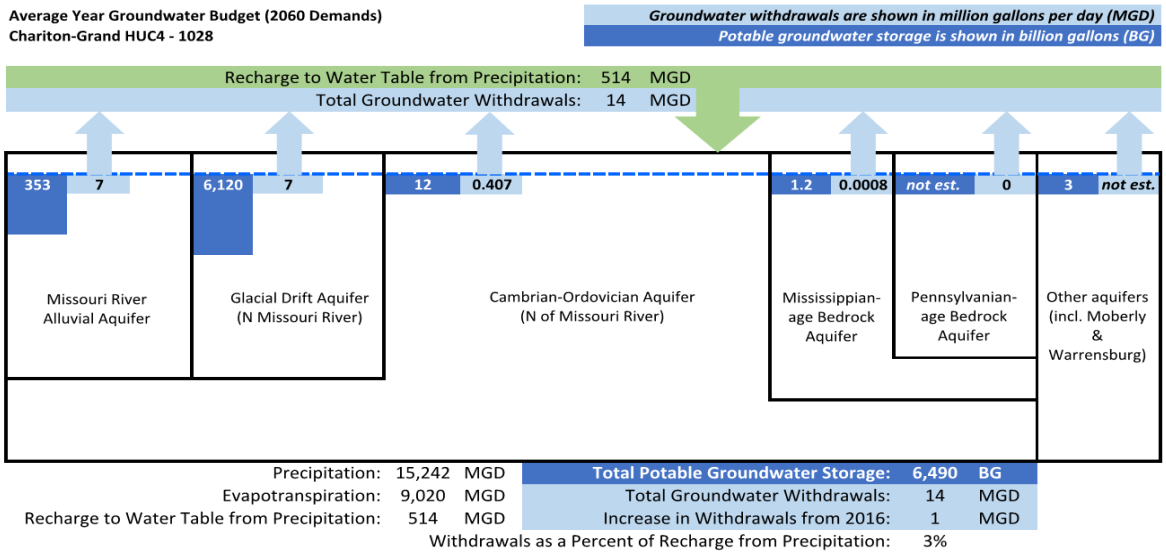
Summary of Groundwater Demands by Aquifer

Groundwater Withdrawals By Sector	2016 Demands (mgd)							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	1.34	0.00	2.29	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.10	0.00	0.88	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.40	0.29	2.62	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**1.84**	**0.29**	**5.79**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	4.63	0.00	0.00	0.36	0.00	0.00	0.00	0.00
Total Nonconsumptive	**4.63**	**0.00**	**0.00**	**0.36**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**6.47**	**0.29**	**5.79**	**0.36**	**0.00**	**0.00**	**0.00**	**0.00**

Groundwater Withdrawals By Sector	2060 Demands (mgd)							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	1.30	0.00	2.34	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.08	0.00	0.48	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.56	0.40	3.72	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**1.94**	**0.40**	**6.54**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	4.63	0.00	0.00	0.36	0.00	0.00	0.00	0.00
Total Nonconsumptive	**4.63**	**0.00**	**0.00**	**0.36**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**6.57**	**0.40**	**6.54**	**0.36**	**0.00**	**0.00**	**0.00**	**0.00**

Chariton-Grand Subregion Summary

Average Year Groundwater Budget (2060 Demands)[10]



The above graphic is a generalized representation of aquifers present in each HUC4.

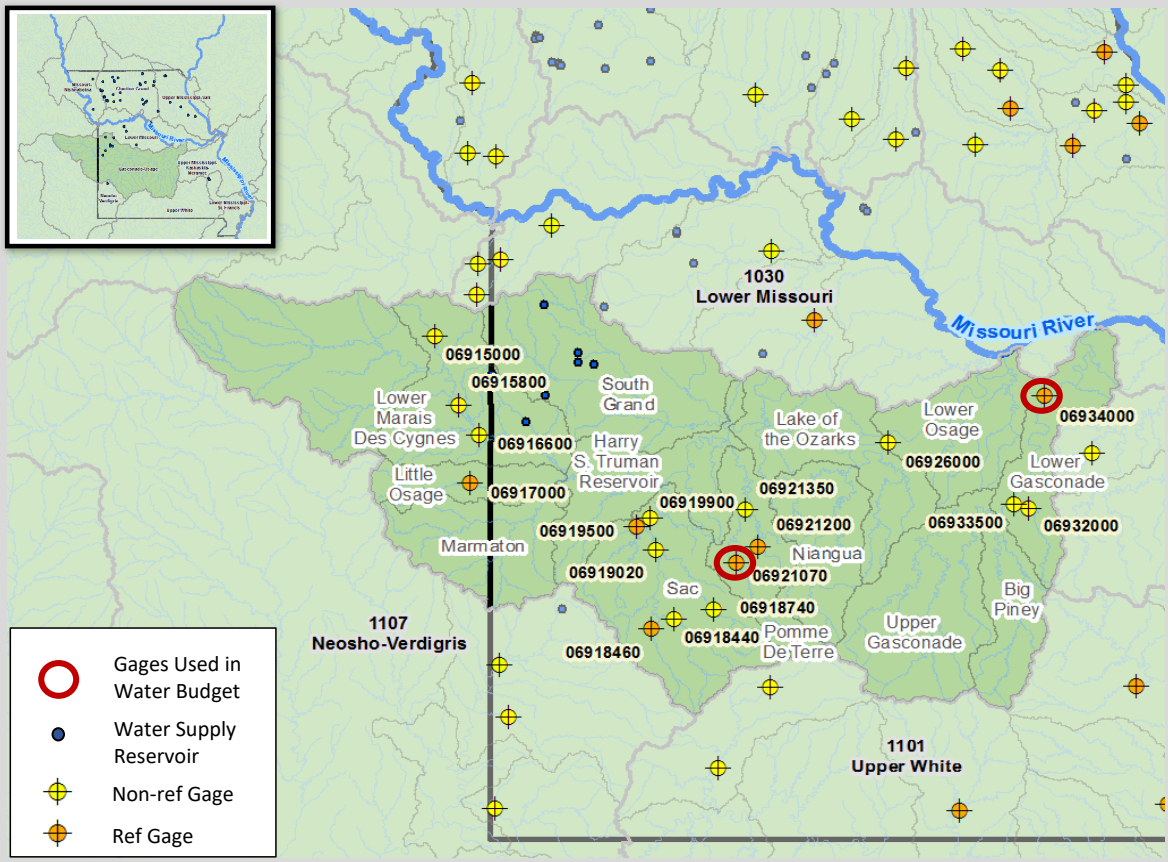
Notes

1. Streamflow includes HUC4 1028 inflows entering Missouri generated in Iowa.
2. Groundwater demands include alluvial and groundwater aquifer withdrawals.
3. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC4, the lowest annual streamflows occurred in 2003 for gage 06902000 and 2000 for gage 06905500.
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources:
   a. *Missouri Water Supply Study, Missouri DNR, June 2011*
   b. *US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/*
8. The Ozark Aquifer includes the Lower, Middle and Upper Ozark aquifers.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Gasconade-Osage Subregion Summary

HUC4 Name: Gasconade-Osage **HUC4 Number:** 1029

Drainage Area within MO: 14,301 sq miles (77%) **Contributing Area outside MO:** 4,302 sq miles (23%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	36

Returns	
Wastewater	27.0
Thermoeletric	139.2

Inflows	
Streamflow[1]	2,824
Precipitation (In-State)	30,262

Naturalized Streamflow	9,390	
Water Supply Reservoir Storage	31,085	million gallons

Surface Water Outflow: 12,200

Consumptive Use & ET	
Evapotranspiration	18,486
Consumptive Withdrawals	180

Gasconade-Osage Subregion Summary

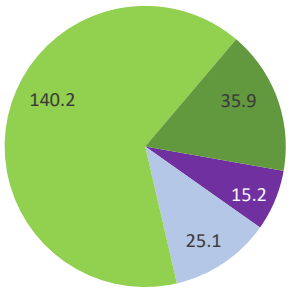
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	33,923,100	44.48	30,262
Evapotranspiration	20,723,020	27.17	18,486
Streamflow (from Out of State)	3,166,186	4.15	2,824
Streamflow (from other In-State HUC4)	0	0.00	0
Streamflow originating in HUC4	10,525,558	13.80	9,390
Total Streamflow	13,691,744	17.95	12,214
Nonconsumptive Surface Water Withdrawals	40,210	0.05	36
Consumptive Surface Water Withdrawals	202,294	0.27	180
Total Surface Water Withdrawals	242,503	0.32	216

Summary of Water Demands by Sector

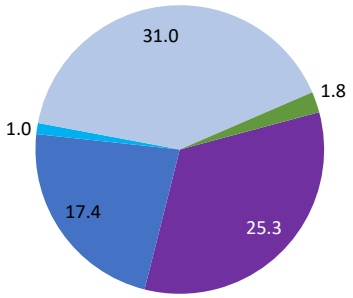
	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	16,993	0.02	15.2	19.7
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	28,123	0.04	25.1	36.8
Thermoelectric Power Generation	157,178	0.21	140.2	164.5
Total Consumptive	**202,294**	**0.27**	**180.5**	**221.0**
Aquaculture and Wetlands	40,210	0.05	35.9	35.9
Total Nonconsumptive	**40,210**	**0.05**	**35.9**	**35.9**
Groundwater Withdrawals By Sector[2]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	28,374	0.04	25.3	32.6
Self-Supplied Domestic and Minor Systems	19,526	0.03	17.4	20.5
Self-Supplied Nonresidential	1,070	0.00	1.0	0.8
Agriculture	34,781	0.05	31.0	40.3
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**83,751**	**0.12**	**74.7**	**94.2**
Aquaculture and Wetlands	1,989	0.00	1.8	1.8
Total Nonconsumptive	**1,989**	**0.00**	**1.8**	**1.8**

Current Surface Water Withdrawals*



*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Current Groundwater Withdrawals

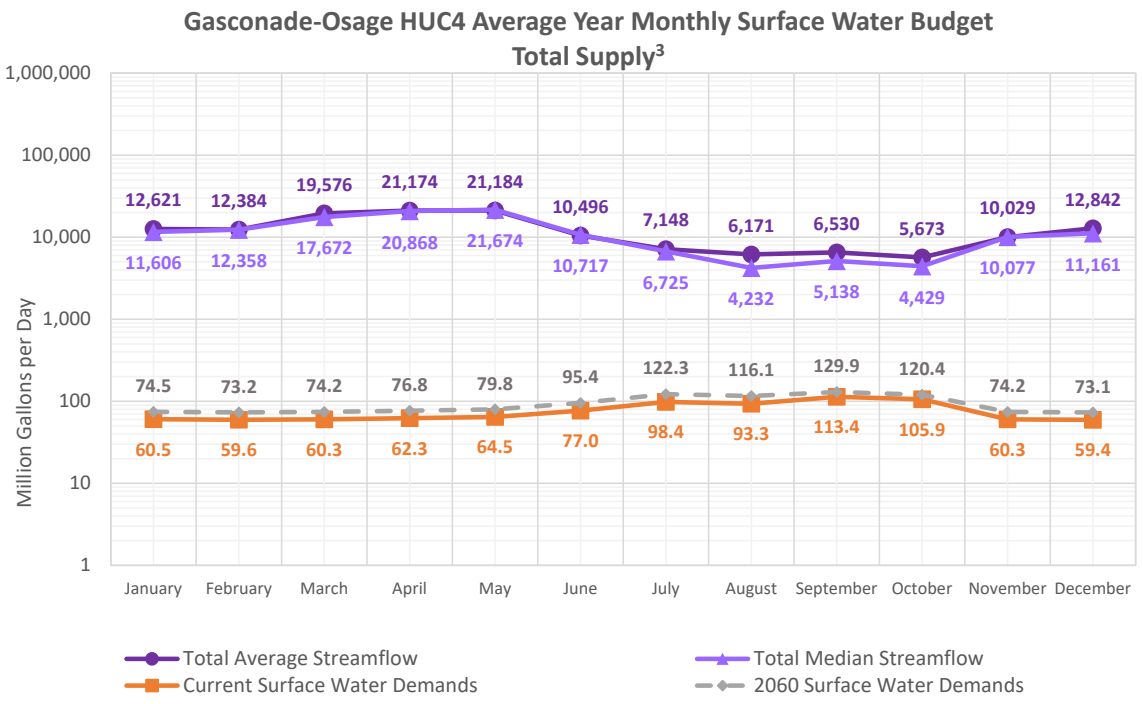


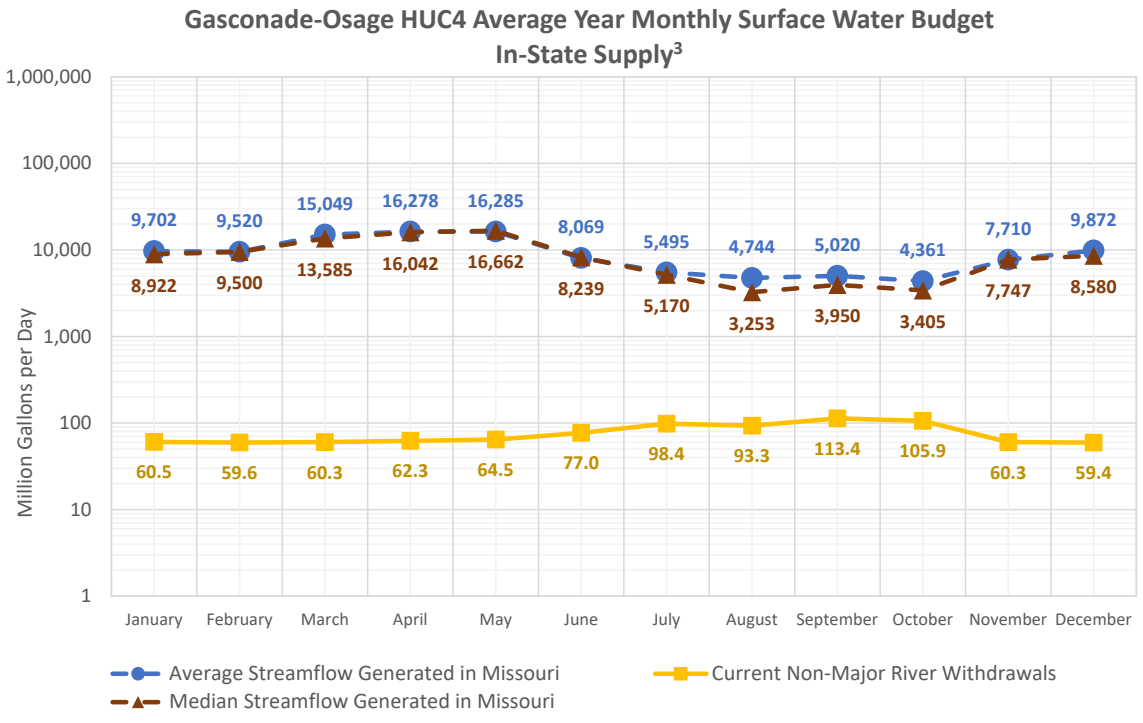
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture
- Thermoelectric Power Generation

Nonconsumptive Demands
- Aquaculture and Wetlands

Gasconade-Osage Subregion Summary

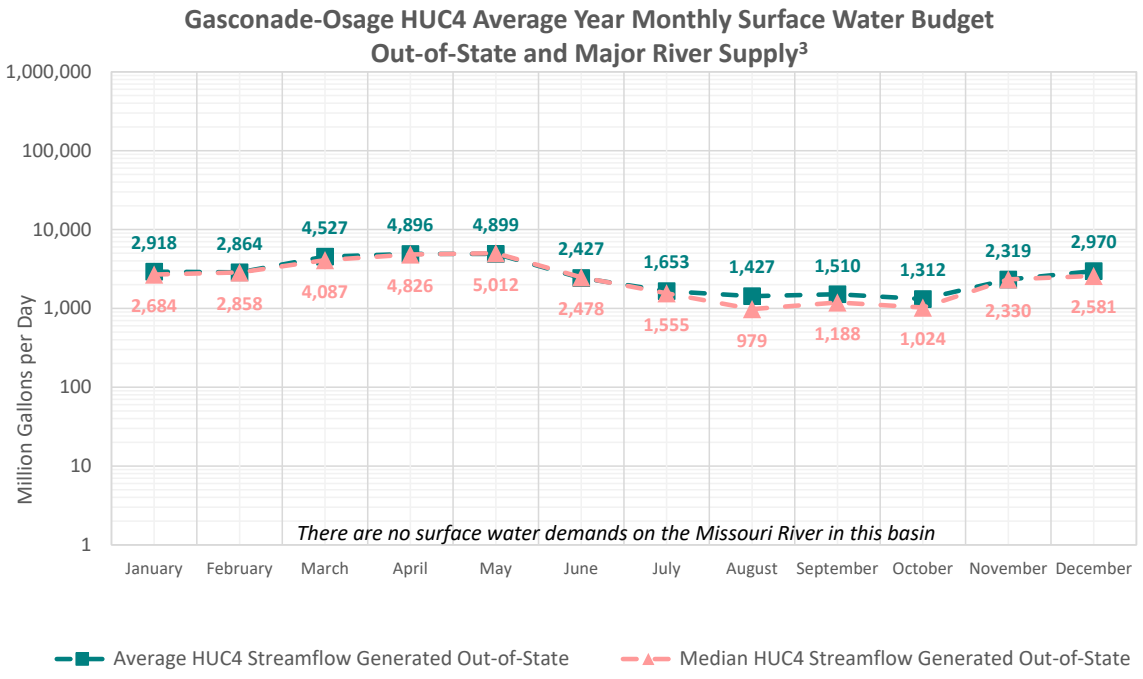
Comparison of Monthly Surface Water Availability to Current and Future Demands

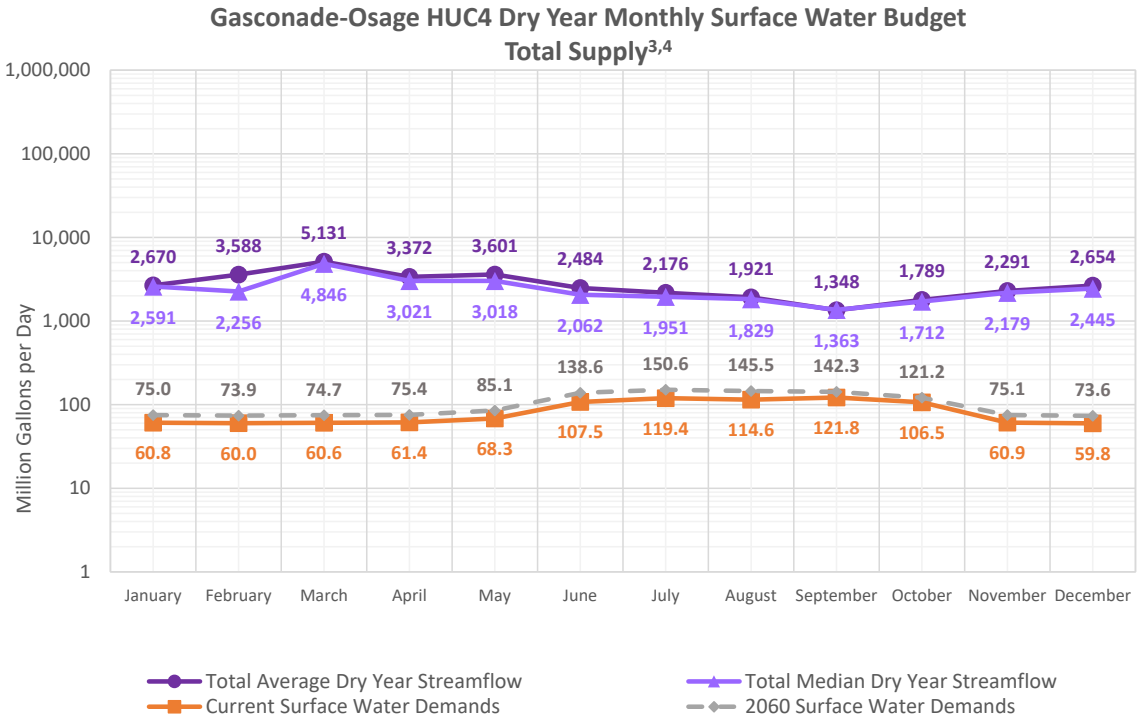




Gasconade-Osage Subregion Summary

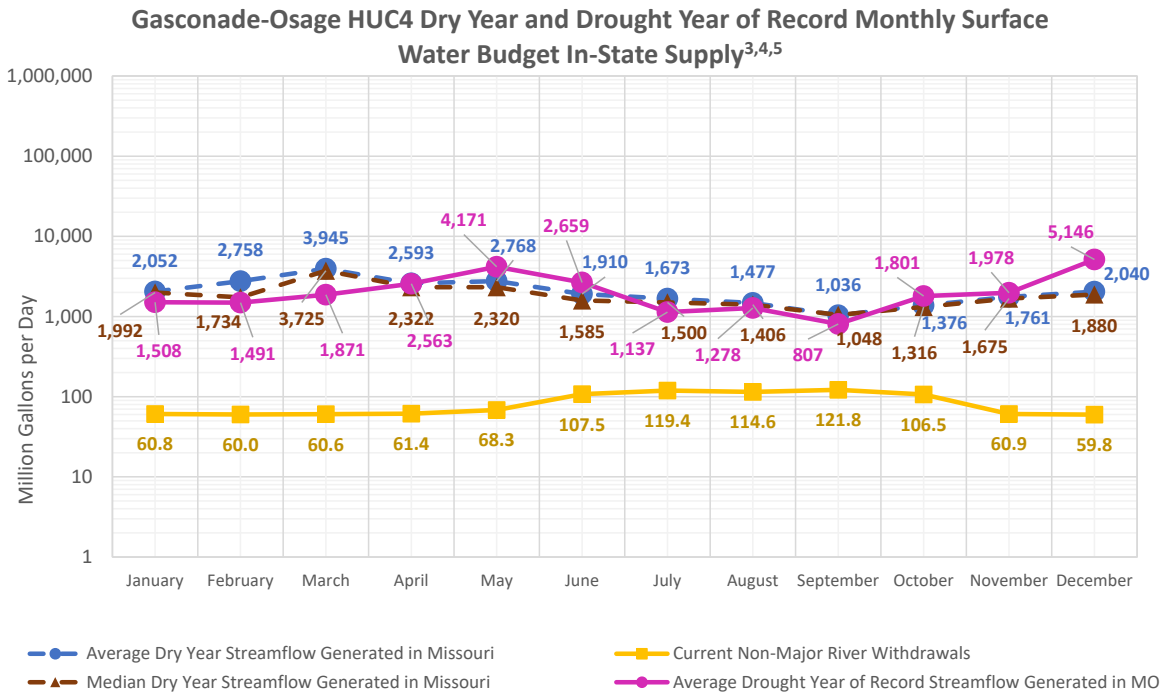
Comparison of Monthly Surface Water Availability to Current and Future Demands

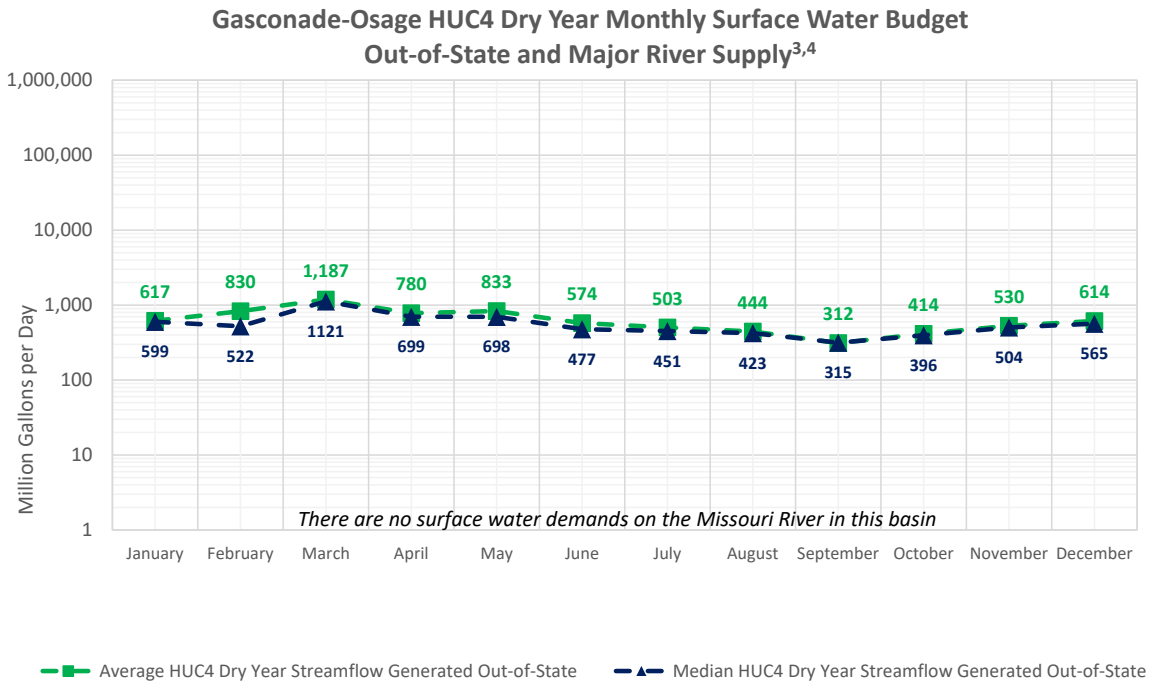




Gasconade-Osage Subregion Summary

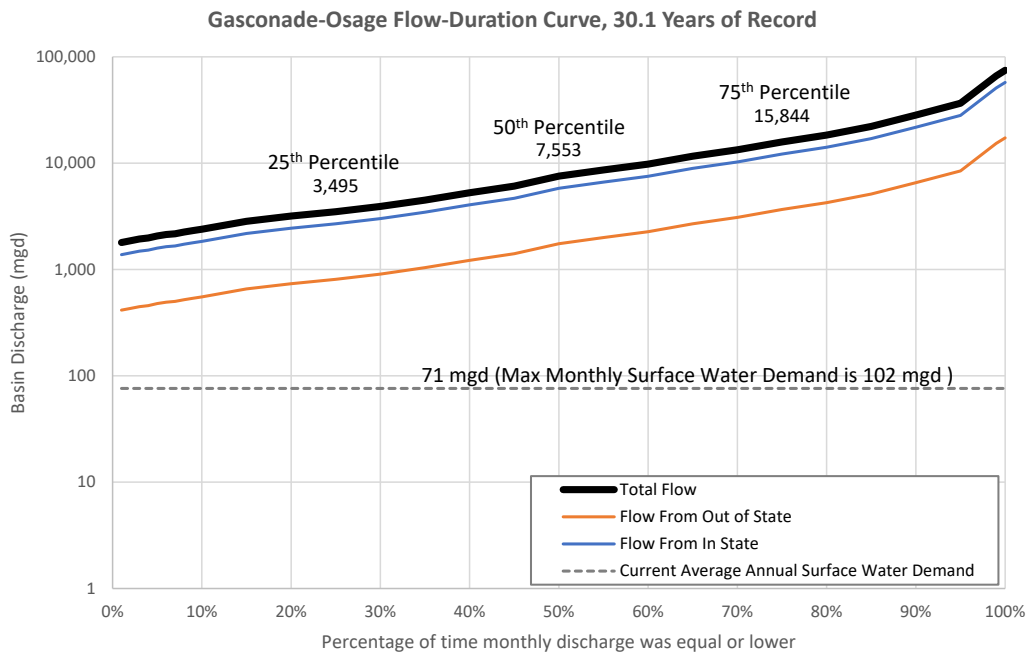
Comparison of Monthly Surface Water Availability to Current and Future Demands





Gasconade-Osage Subregion Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Water Supply Storage Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
City Lake (Butler)	749	244	0.27	10290102	11	7
City Lake #2 (Drexel)	345	112	0.119	10290102	78	22
City Lake (Adrian)	290	94	0.05	10290108	8	6
City Lake (Creighton)	113	37	0.066	10290108	reservoirs do not empty	14
Cities New Lake (Garden City)	441	144	0.182	10290108	45	23
Cities Old Lake (Garden City)	177	58	0.069	10290108	17	14
Fellows Lake (Springfield)	30,688	10,000	--	10290106	25	25
McDaniel Lake (Springfield)	4,603	1,500	--	10290106	12	12
Stockton Lake	50,000	16,293	30	10290106	reservoirs do not empty	6
Harry S. Truman Lake	1,000	326	0.7	10290105	reservoirs do not empty	1
City Lake (Harrisonville)	6,990	2,278	1.54	10290108	145	28
Total	**95,396**	**31,086**	**33.0**			

Gasconade-Osage Subregion Summary

Summary of Surface Water Demands by HUC8

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	Current Demand mgd
Lower Marais Des Cygnes	10290102	451	0.14	3
Little Osage	10290103	217	0.5	5
Marmaton	10290104	535	0.11	3
Harry S. Truman Reservoir	10290105	1203	2.5	143
Sac	10290106	1969	0.15	14
Pomme De Terre	10290107	845	0.04	2
South Grand	10290108	2017	0.09	9
Lake of the Ozarks	10290109	1386	0.16	11
Niangua	10290110	1029	0.13	6
Lower Osage	10290111	1077	0.03	2
Upper Gasconade	10290201	1786	0.14	12
Big Piney	10290202	755	0.04	1
Lower Gasconade	10290203	1033	0.11	5
	Total	**14,303**	**-**	**216**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

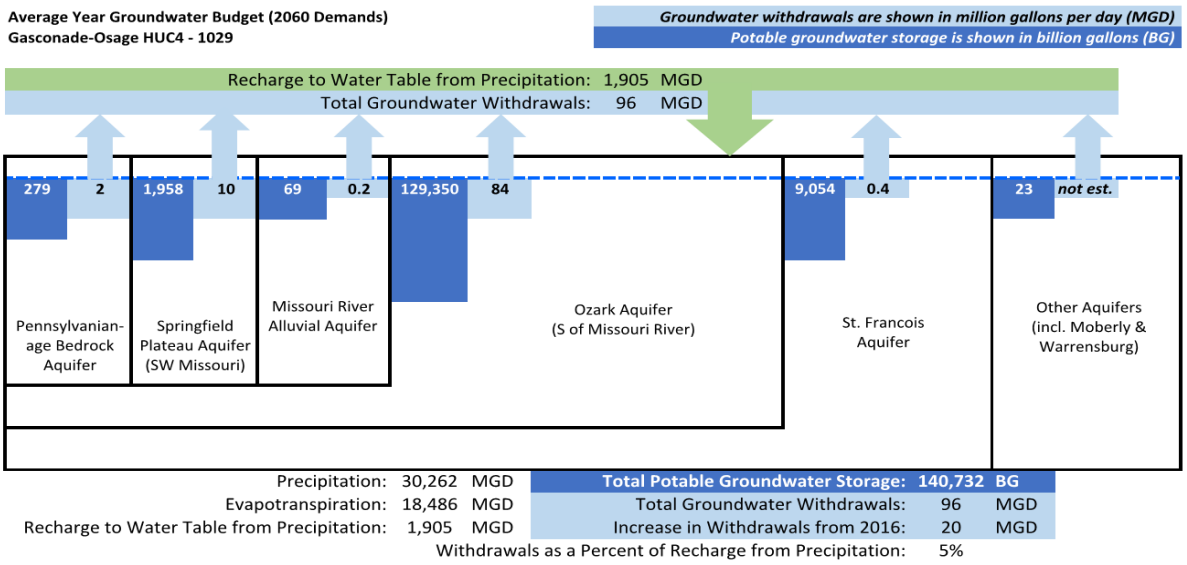
Summary of Groundwater Demands by Aquifer

	2016 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[8]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[9]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	0.00	24.99	0.00	0.00	0.33	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.14	16.17	0.00	0.25	0.47	0.00	0.39	0.00
Self-Supplied Nonresidential	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	23.38	0.00	0.80	6.84	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.14**	**65.49**	**0.00**	**1.05**	**7.64**	**0.00**	**0.39**	**0.00**
Aquaculture and Wetlands	0.00	1.09	0.00	0.40	0.29	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**1.09**	**0.00**	**0.40**	**0.29**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.14**	**66.58**	**0.00**	**1.45**	**7.93**	**0.00**	**0.39**	**0.00**

	2060 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[8]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[9]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	0.00	32.21	0.00	0.00	0.36	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.17	18.97	0.00	0.36	0.59	0.00	0.41	0.00
Self-Supplied Nonresidential	0.00	0.85	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	30.71	0.00	1.03	8.59	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.17**	**82.74**	**0.00**	**1.39**	**9.54**	**0.00**	**0.41**	**0.00**
Aquaculture and Wetlands	0.00	1.09	0.00	0.40	0.29	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**1.09**	**0.00**	**0.40**	**0.29**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.17**	**83.83**	**0.00**	**1.79**	**9.83**	**0.00**	**0.41**	**0.00**

Gasconade-Osage Subregion Summary

Average Year Groundwater Budget (2060 Demands)[10]



Precipitation:	30,262	MGD	Total Potable Groundwater Storage:	140,732	BG
Evapotranspiration:	18,486	MGD	Total Groundwater Withdrawals:	96	MGD
Recharge to Water Table from Precipitation:	1,905	MGD	Increase in Withdrawals from 2016:	20	MGD
			Withdrawals as a Percent of Recharge from Precipitation:	5%	

The above graphic is a generalized representation of aquifers present in each HUC4.

Notes

1. Streamflow includes HUC4 1029 inflows entering Missouri generated in Kansas.
2. Groundwater demands include alluvial and groundwater aquifer withdrawals.
3. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC4, the lowest annual streamflows occurred in 2006 for gage 06921070 and 2000 for gage 06934000.
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources and notes:
   a. *Missouri Water Supply Study, Missouri DNR, June 2011*
   b. *US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/*
   c. Rich Hill Reservoir, which supplies Rich Hill and North Lake, was not included.
   d. Optimum yield for Fellows and McDaniel Lakes was not available. Average daily yield in a drought condition is 3.4 mgd for McDaniel Lake (*Source Water Protection Plan,* City Utilities of Springfield Public Water System, Sept. 2014).
8. The Ozark Aquifer includes the Lower, Middle and Upper Ozark aquifers.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Lower Missouri Subregion Summary

HUC4 Name: Lower Missouri **HUC4 Number:** 1030

Drainage Area within MO: 10,182 sq miles (98%) **Contributing Area outside MO:** 158 sq miles (2%)

Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	17

Returns	
Wastewater	185.1
Thermoeletric	2136.6

Inflows	
Streamflow (from Out of State)	37,734
Streamflow (from other In-State HUC4 subregion)	20,540
Precipitation (In-State)	20,299

Naturalized Streamflow	6,007	
Water Supply Reservoir Storage	4,072	million gallons

Surface Water Outflow: 64,188

Consumptive Use & ET	
Evapotranspiration	12,055
Consumptive Withdrawals	2,415

Lower Missouri Subregion Summary

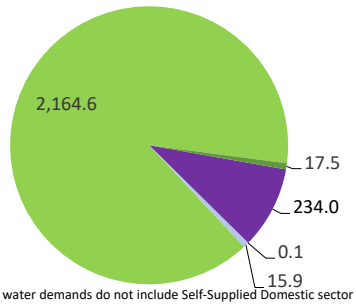
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	22,755,177	41.90	20,299
Evapotranspiration	13,513,751	24.89	12,055
Streamflow (from Out of State)	42,299,054	77.89	37,734
Streamflow (from other In-State HUC4)	23,024,911	42.40	20,540
Streamflow originating in HUC4	6,733,701	12.40	6,007
Total Streamflow	72,057,666	132.69	64,281
Nonconsumptive Surface Water Withdrawals	19,576	0.04	17
Consumptive Surface Water Withdrawals	2,706,691	4.98	2,415
Total Surface Water Withdrawals	2,726,266	5.02	2,432

Summary of Water Demands by Sector

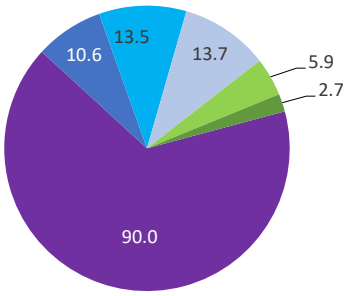
	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	262,278	0.48	234.0	266.7
Self-Supplied Nonresidential	78	0.00	0.1	0.1
Agriculture	17,798	0.03	15.9	23.1
Thermoelectric Power Generation[1]	2,426,536	4.47	2,164.6	1,598.1
Total Consumptive	**2,706,690**	**4.98**	**2,414.6**	**1,888.0**
Aquaculture and Wetlands	19,576	0.04	17.5	17.5
Total Nonconsumptive	**19,576**	**0.04**	**17.5**	**17.5**
Groundwater Withdrawals By Sector[2]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	100,863	0.19	90.0	116.2
Self-Supplied Domestic and Minor Systems	11,829	0.02	10.6	12.3
Self-Supplied Nonresidential	15,137	0.03	13.5	14.1
Agriculture	15,331	0.03	13.7	18.2
Thermoelectric Power Generation	6,621	0.01	5.9	3.6
Total Consumptive	**149,781**	**0.28**	**133.7**	**164.4**
Aquaculture and Wetlands	3,077	0.01	2.7	2.7
Total Nonconsumptive	**3,077**	**0.01**	**2.7**	**2.7**

Current Surface Water Withdrawals*



*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Current Groundwater Withdrawals

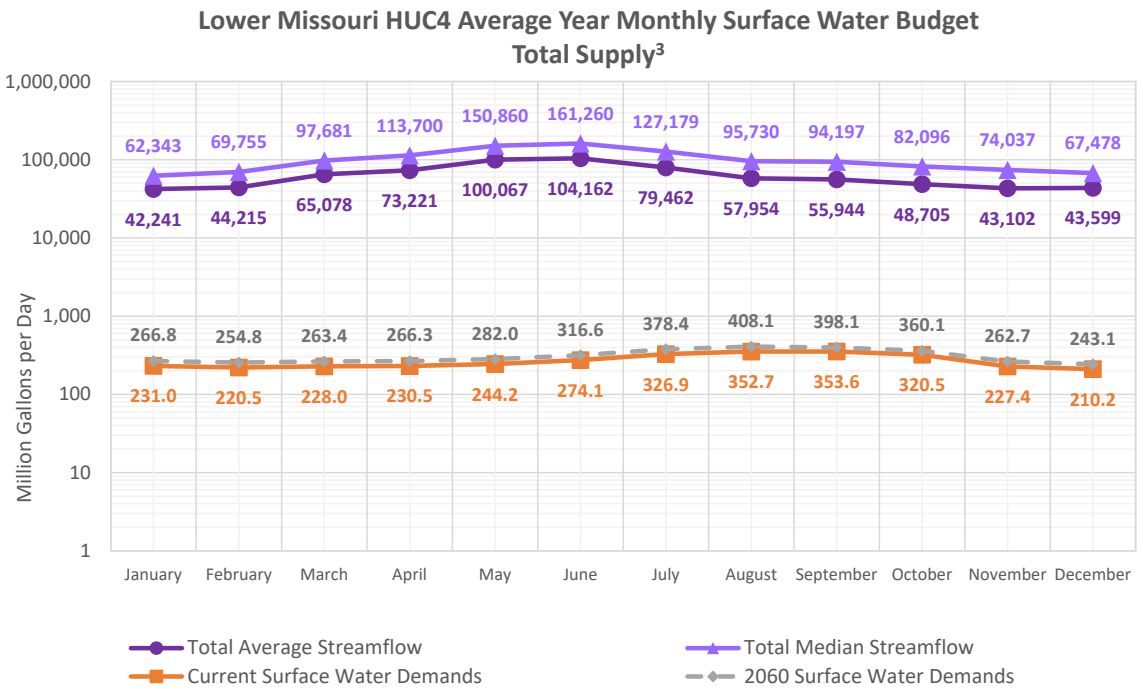


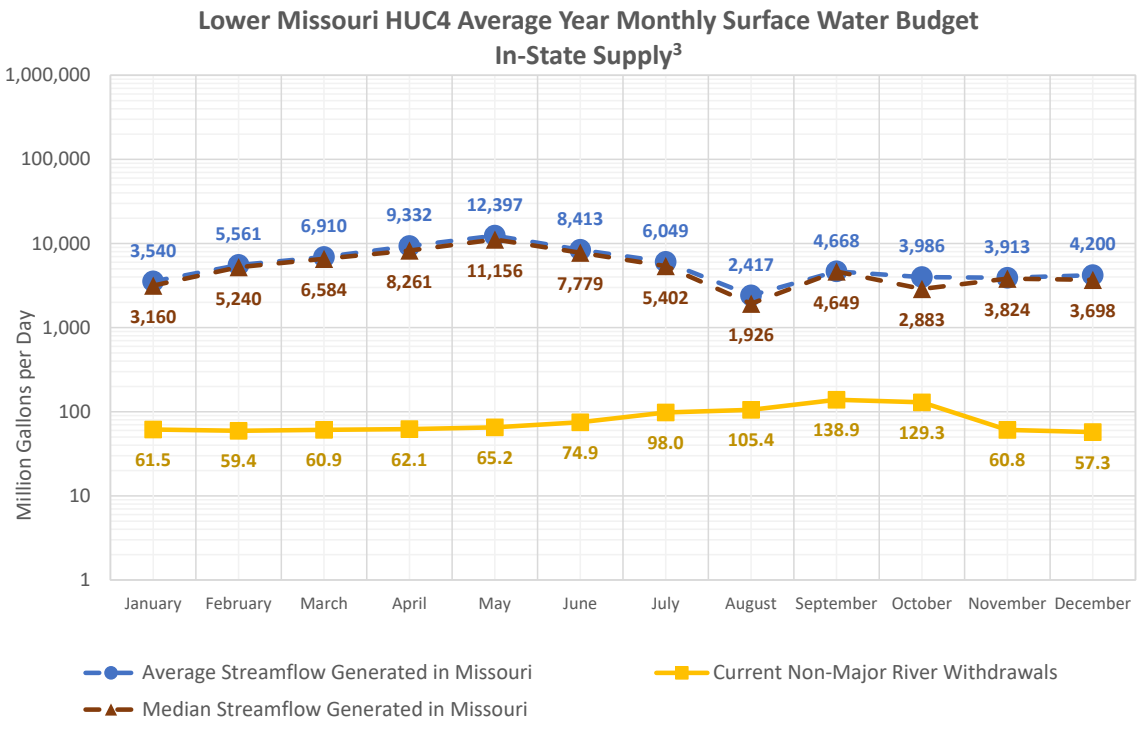
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture
- Thermoelectric Power Generation

Nonconsumptive Demands
- Aquaculture and Wetlands

Lower Missouri Subregion Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands

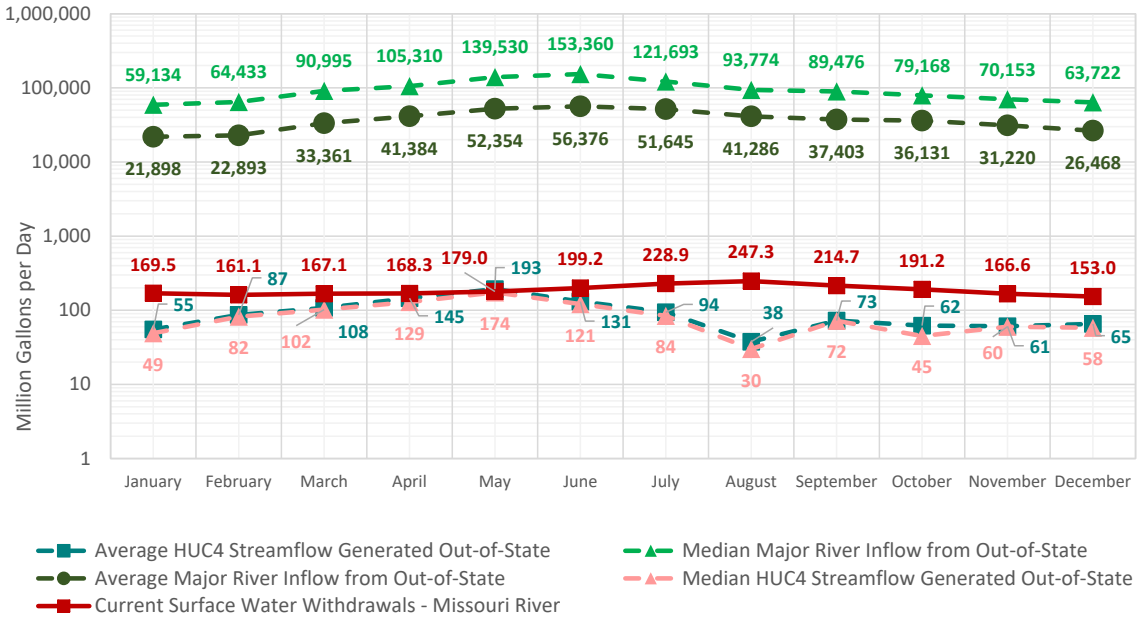




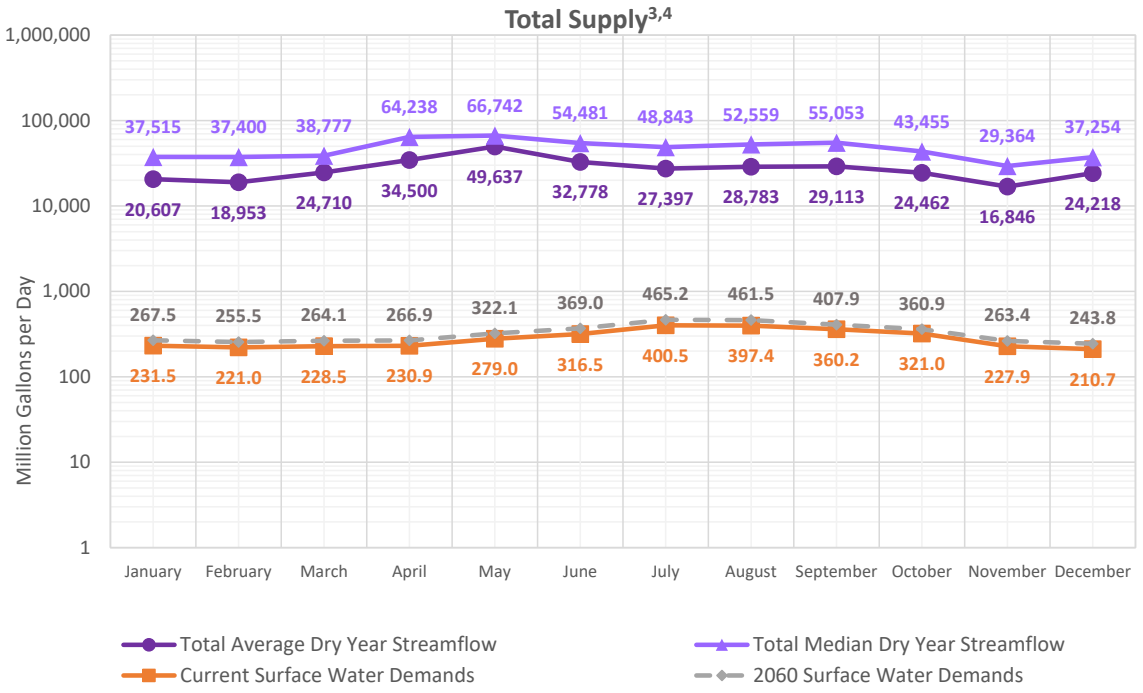
Lower Missouri Subregion Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands

Lower Missouri HUC4 Average Year Monthly Surface Water Budget Out-of-State and Major River Supply[3]

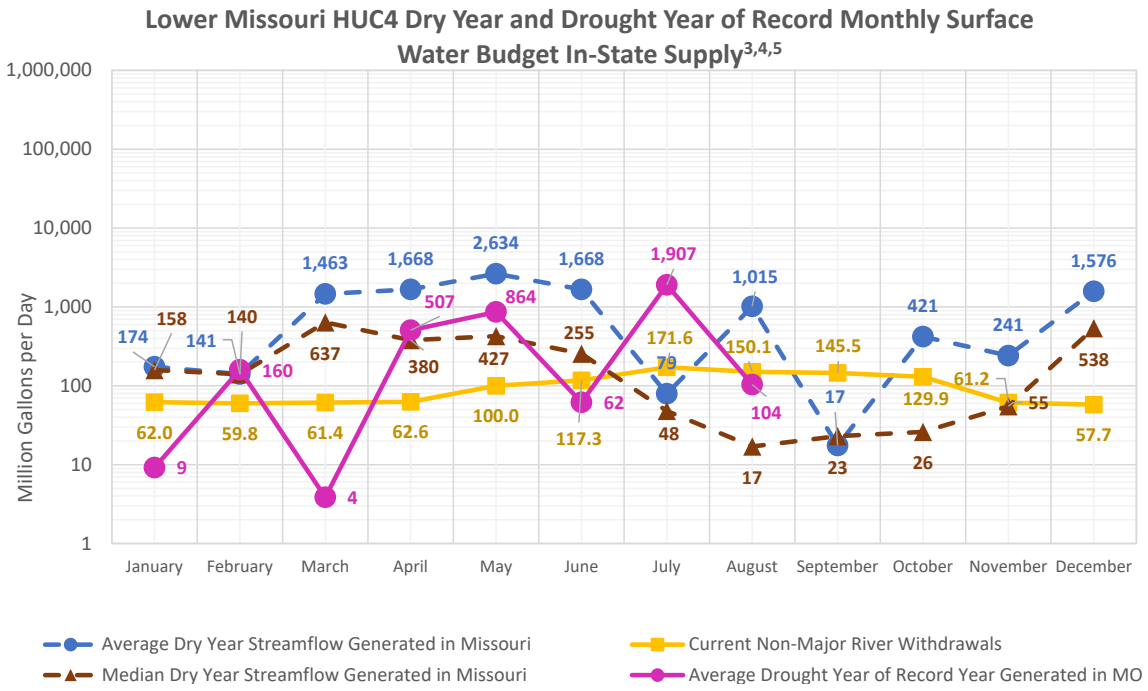


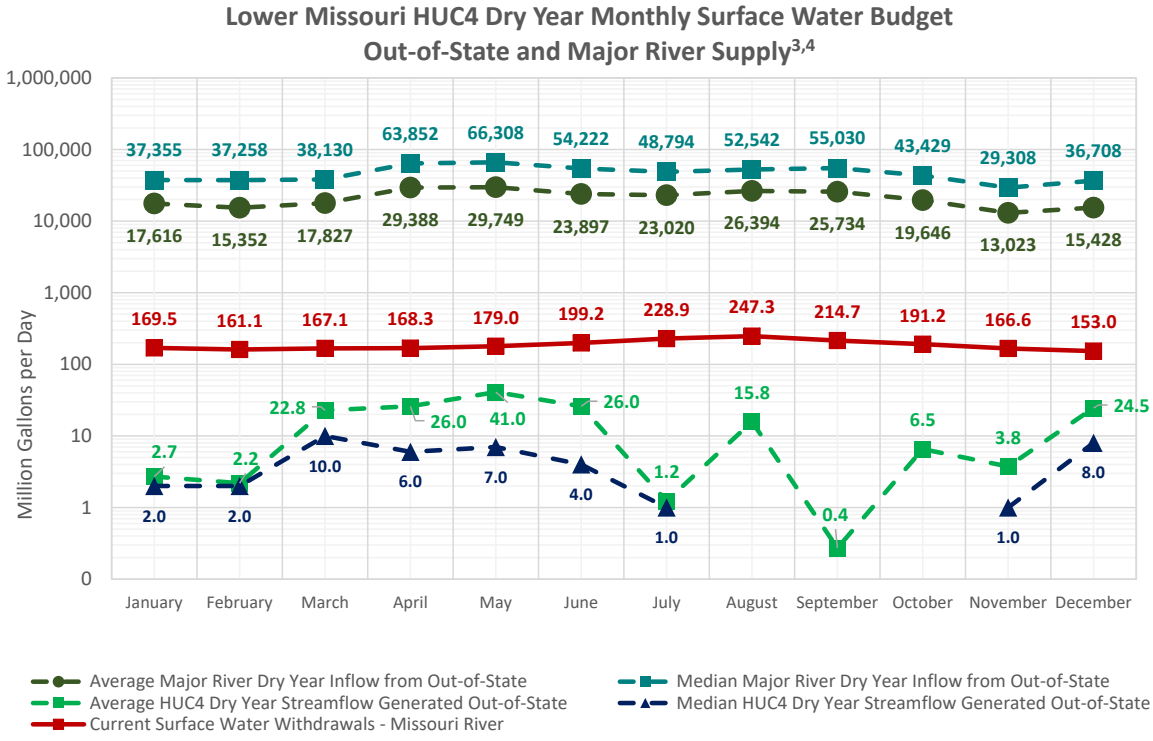
Lower Missouri HUC4 Dry Year Monthly Surface Water Budget Total Supply[3,4]



Lower Missouri Subregion Summary

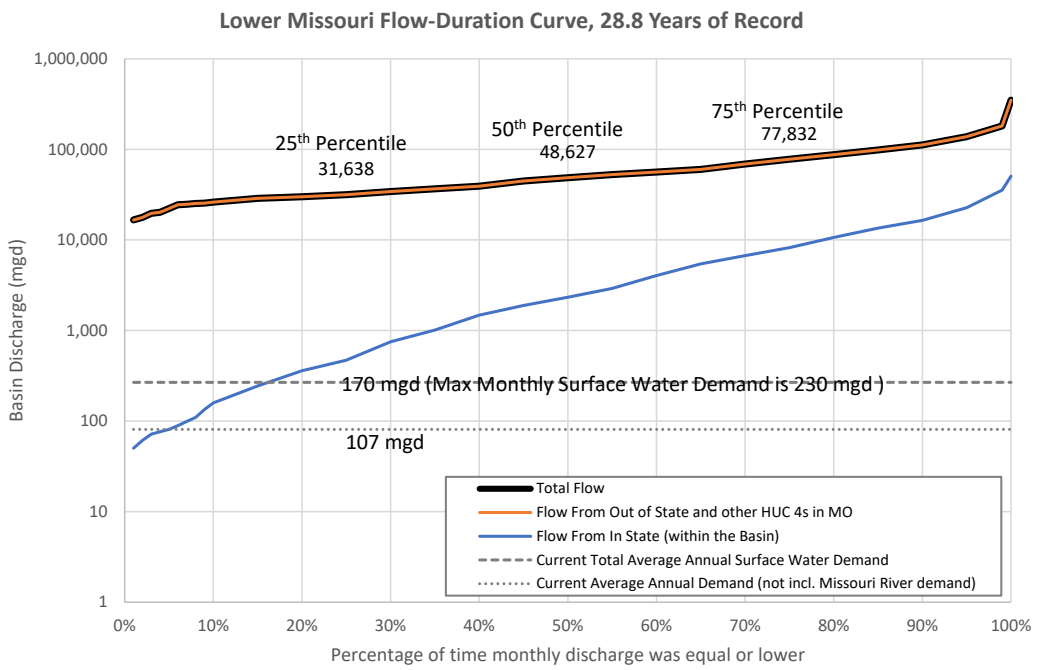
Comparison of Monthly Surface Water Availability to Current and Future Demands





Lower Missouri Subregion Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
D.C. Rogers Lake (Fayette)	2,520	821	0.19	10300102	44	28
Fayette Lake (Fayette)	717	234	--	10300102	reservoirs do not empty	44
Spring Fork Lake (Sedalia)	1,249	407	1.059	10300103	6	4
E.A. Pape Lake (Concordia)	2,740	893	0.839	10300104	51	22
City Lower Lake (Higginsville)	1,462	476	0.462	10300104	14	11
City Lake (Holden)	3,810	1,241	0.567	10300104	51	35
Total	**12,498**	**4,072**	**3.117**			

Lower Missouri Subregion Summary

Summary of Surface Water Demands by HUC8

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	Current Demand mgd
Lower Missouri-Crooked	10300101	2539	4.56	551
Lower Missouri-Moreau	10300102	3398	0.32	52
Lamine	10300103	1111	0.07	4
Blackwater	10300104	1543	0.09	7
Lower Missouri	10300200	1590	24.06	1820
	Total	**10,181**	**-**	**2433**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

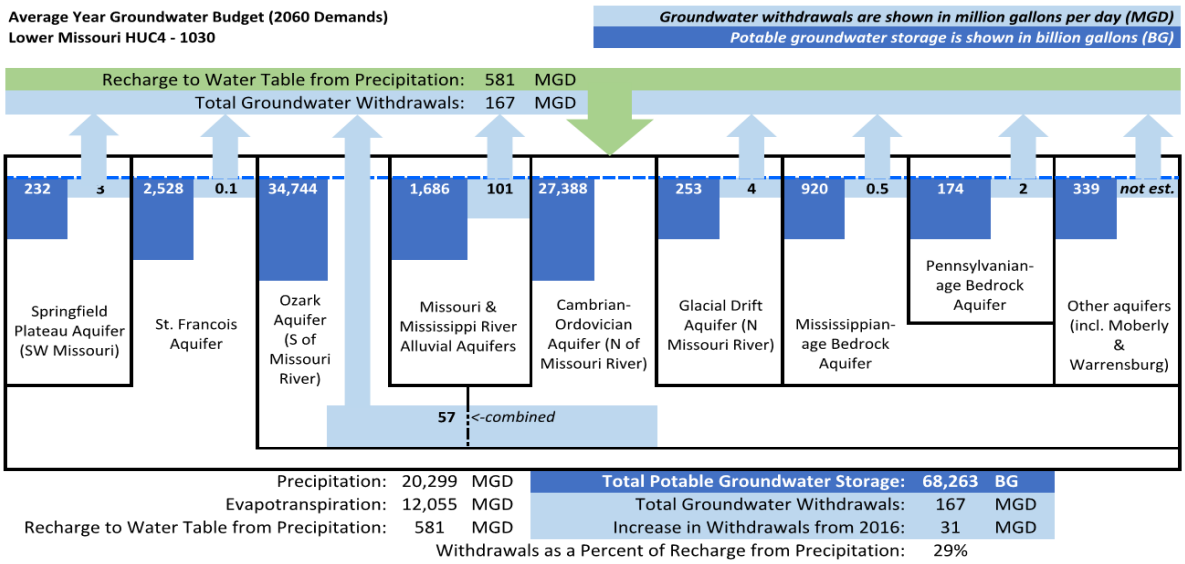
Summary of Groundwater Demands by Aquifer

	2016 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[8]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[9]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	61.37	27.27	1.35	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	1.88	7.12	0.35	0.74	0.00	0.32	0.14	0.00
Self-Supplied Nonresidential	6.68	6.82	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	6.47	3.44	1.27	0.28	2.22	0.00	0.00	0.00
Thermoelectric Power Generation	5.59	0.32	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**81.99**	**44.97**	**2.97**	**1.02**	**2.22**	**0.32**	**0.14**	**0.00**
Aquaculture and Wetlands	1.54	0.66	0.00	0.32	0.22	0.00	0.00	0.00
Total Nonconsumptive	**1.54**	**0.66**	**0.00**	**0.32**	**0.22**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**83.53**	**45.63**	**2.97**	**1.34**	**2.44**	**0.32**	**0.14**	**0.00**

	2060 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[8]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[9]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	80.26	33.94	1.98	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	2.39	8.16	0.32	0.84	0.00	0.46	0.14	0.00
Self-Supplied Nonresidential	5.03	9.03	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	8.23	4.77	1.64	0.37	3.19	0.00	0.00	0.00
Thermoelectric Power Generation	3.28	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**99.19**	**56.19**	**3.94**	**1.21**	**3.19**	**0.46**	**0.14**	**0.00**
Aquaculture and Wetlands	1.54	0.66	0.00	0.32	0.22	0.00	0.00	0.00
Total Nonconsumptive	**1.54**	**0.66**	**0.00**	**0.32**	**0.22**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**100.73**	**56.85**	**3.94**	**1.53**	**3.41**	**0.46**	**0.14**	**0.00**

Lower Missouri Subregion Summary

Average Year Groundwater Budget (2060 Demands)[10]



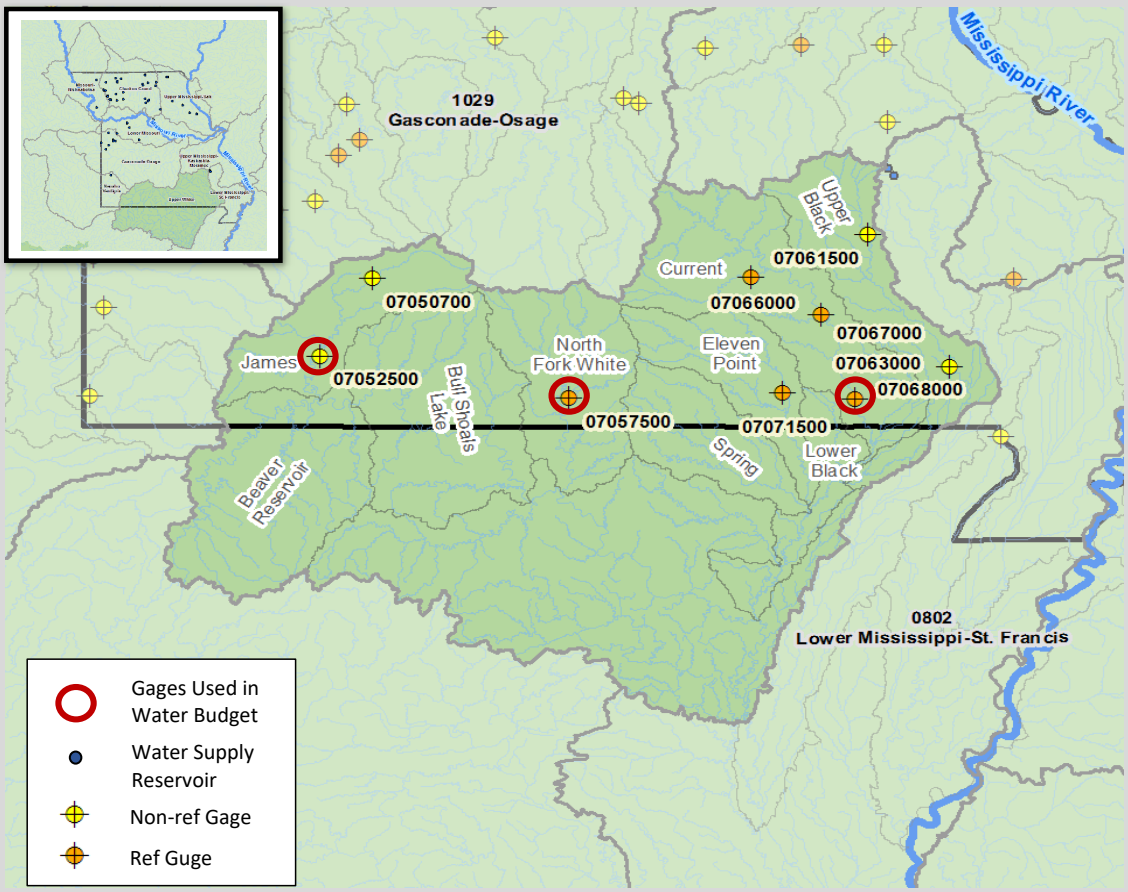
The above graphic is a generalized representation of aquifers present in each HUC4.

Notes

1. Two out of four generating units at Labadie facility in Franklin County are scheduled to be retired in 2036.
2. Groundwater demands include alluvial and groundwater aquifer withdrawals.
3. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC4, the lowest annual streamflow occurred in 2006 for gage 06908000 and 2006 for gage 06906800.
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources and notes:
   a. *Missouri Water Supply Study, Missouri DNR, June 2011*
   b. *US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/*
   c. *Two additional lakes, Unity Lake Nos. 1 and 2 also provide public water supply for Unity Village. Information on these two lakes was not available, and thus not included in this summary.*
8. The Ozark Aquifer includes the Lower, Middle and Upper Ozark aquifers.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Upper White Subregion Summary

HUC4 Name:	Upper White	HUC4 Number:	1101
Drainage Area within MO:	10,606 sq miles (83%)	Contributing Area outside MO:	2,171 sq miles (17%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	92

Returns	
Wastewater	44.5
Thermoeletric	19.6

Inflows	
Streamflow[1]	1,849
Precipitation (In-State)	23,634

Naturalized Streamflow	9,032	
Water Supply Reservoir Storage	*NA* [2]	million gallons

Surface Water Outflow: 10,890

Consumptive Use & ET	
Evapotranspiration	14,195
Consumptive Withdrawals	55

Upper White Subregion Summary

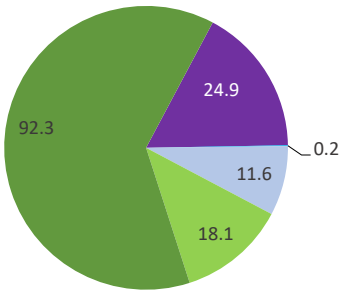
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	26,493,867	46.84	23,634
Evapotranspiration	15,912,690	28.13	14,195
Streamflow (from Out of State)	2,072,505	3.66	1,849
Streamflow (from other In-State HUC4)	0	0.00	0
Streamflow originating in HUC4	10,125,075	17.90	9,032
Total Streamflow	12,197,580	21.56	10,881
Nonconsumptive Surface Water Withdrawals	103,475	0.18	92
Consumptive Surface Water Withdrawals	61,444	0.11	55
Total Surface Water Withdrawals	164,919	0.29	147

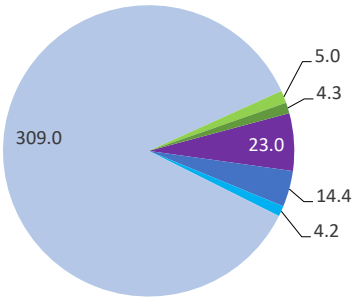
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	27,927	0.05	24.9	35.7
Self-Supplied Nonresidential	171	0.00	0.2	0.3
Agriculture	13,056	0.02	11.6	16.8
Thermoelectric Power Generation	20,290	0.04	18.1	21.2
Total Consumptive	**61,444**	**0.11**	**54.8**	**74.0**
Aquaculture and Wetlands	103,475	0.18	92.3	92.3
Total Nonconsumptive	**103,475**	**0.18**	**92.3**	**92.3**
Groundwater Withdrawals By Sector[3]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	25,733	0.05	23.0	36.7
Self-Supplied Domestic and Minor Systems	16,116	0.03	14.4	19.8
Self-Supplied Nonresidential	4,728	0.01	4.2	6.3
Agriculture	346,385	0.61	309.0	364.0
Thermoelectric Power Generation	5,575	0.01	5.0	4.4
Total Consumptive	**398,537**	**0.71**	**355.6**	**431.2**
Aquaculture and Wetlands	4,821	0.01	4.3	4.3
Total Nonconsumptive	**4,821**	**0.01**	**4.3**	**4.3**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



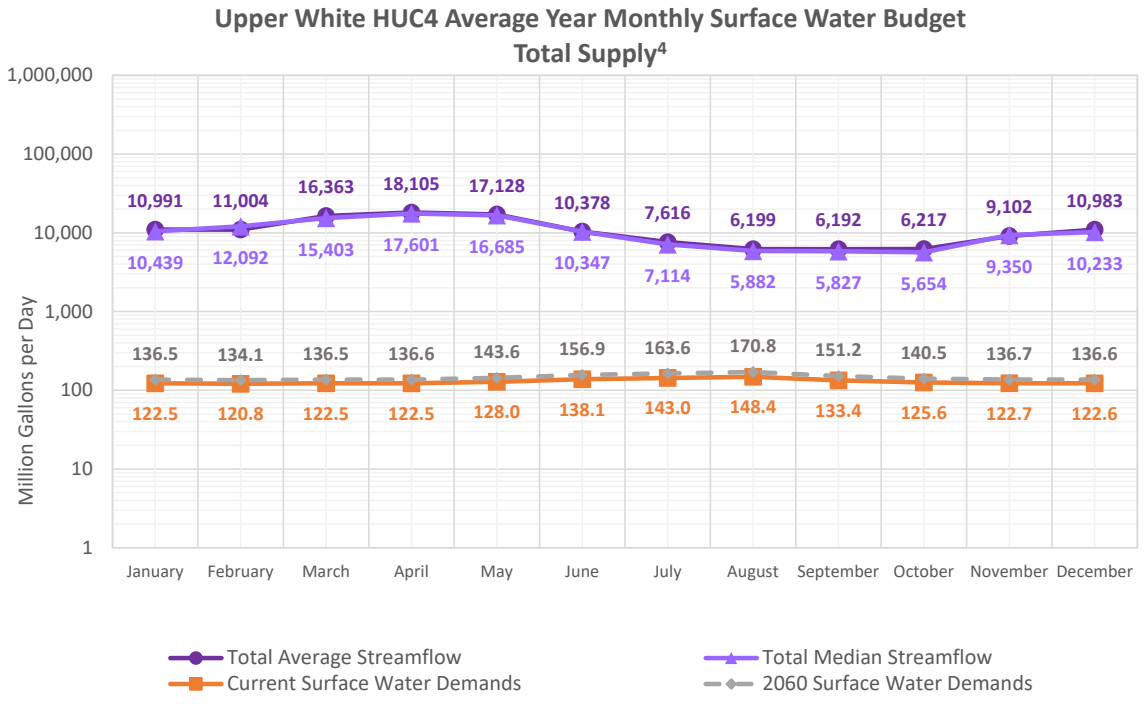
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture
- Thermoelectric Power Generation

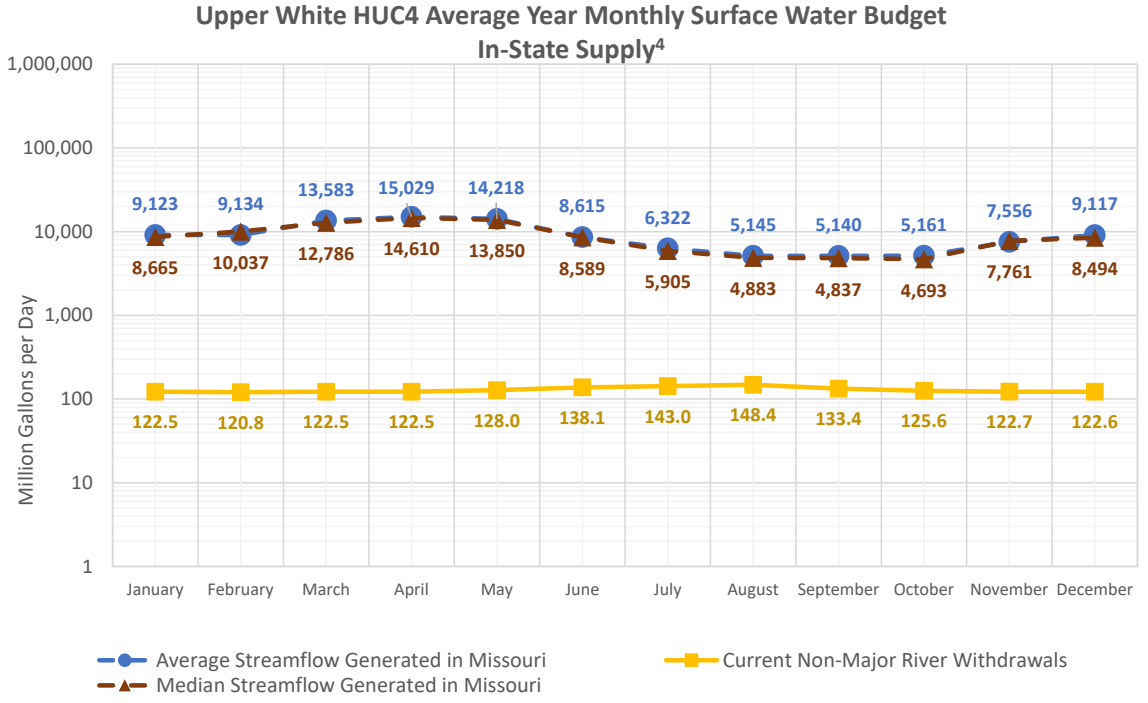
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Upper White Subregion Summary

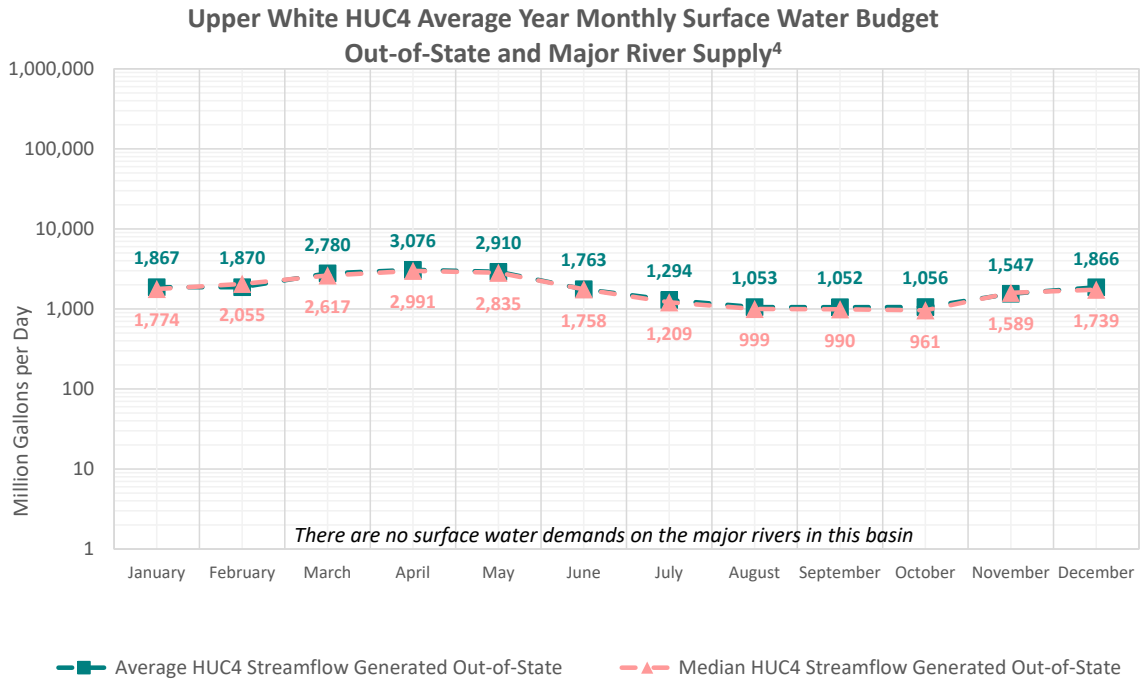
Comparison of Monthly Surface Water Availability to Current and Future Demands

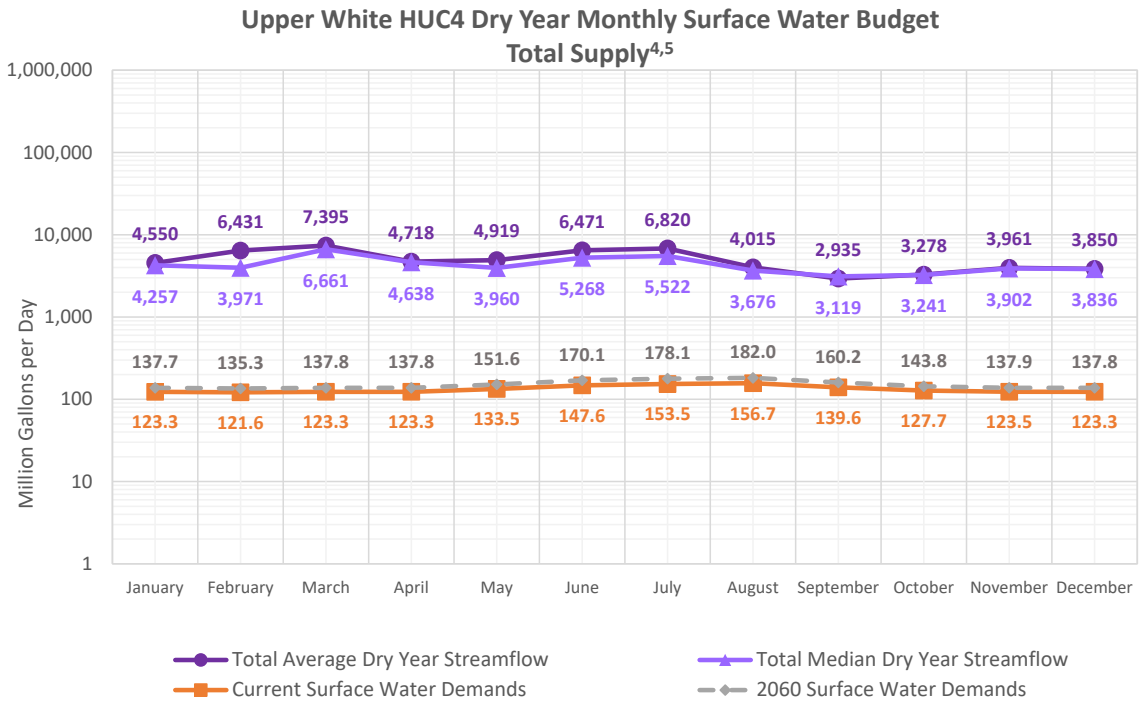




Upper White Subregion Summary

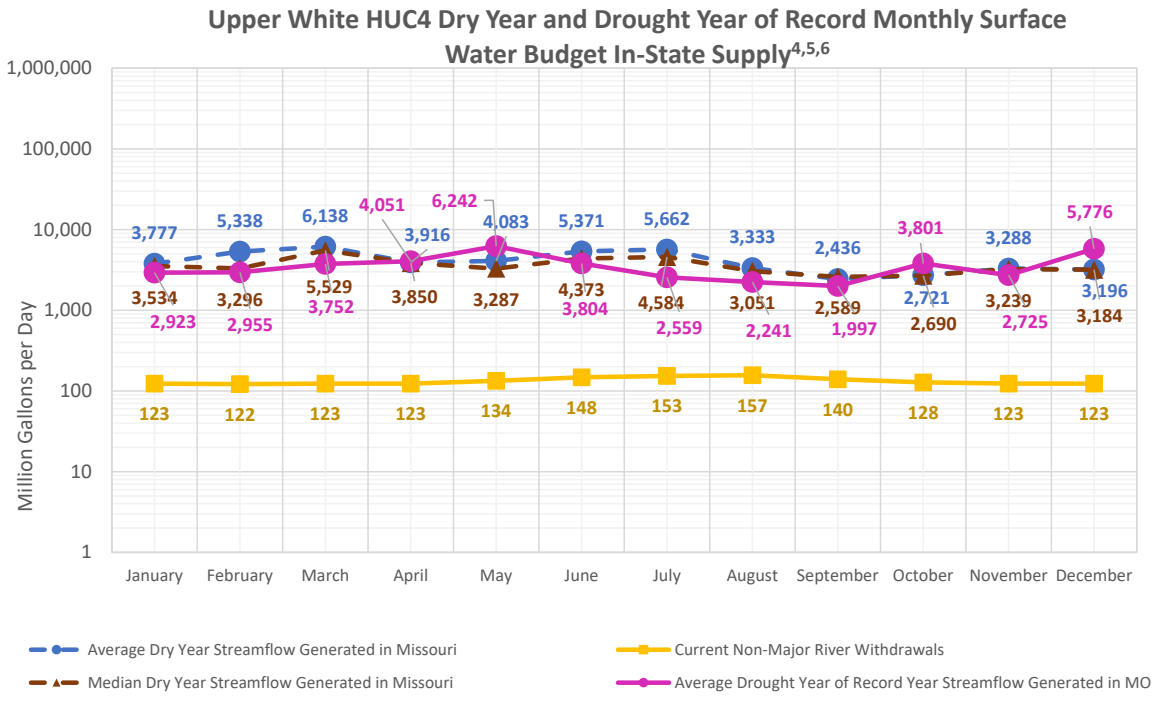
Comparison of Monthly Surface Water Availability to Current and Future Demands

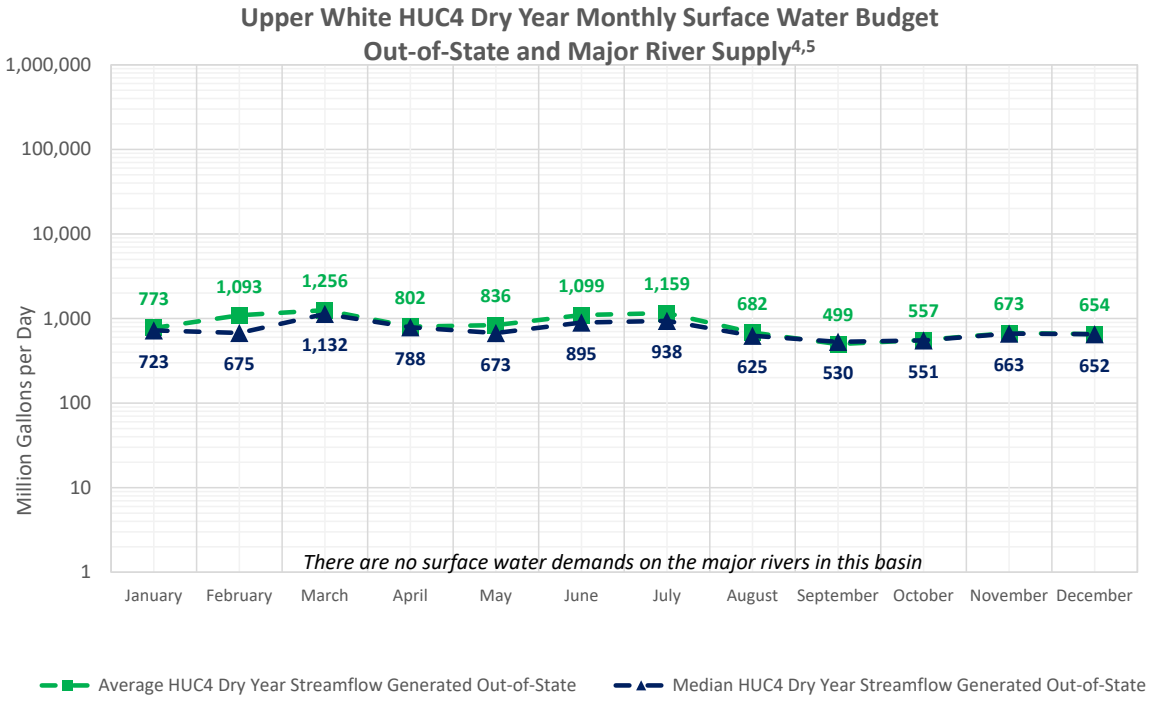




Upper White Subregion Summary

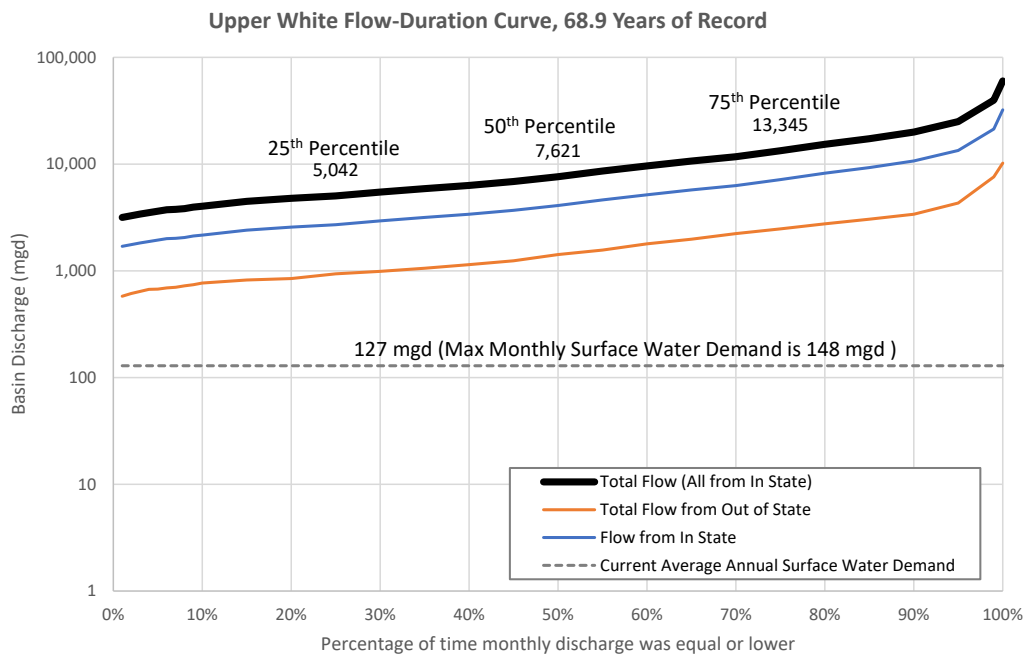
Comparison of Monthly Surface Water Availability to Current and Future Demands





Upper White Subregion Summary

Flow-Duration Curve[7]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[2]

Reservoir (City/Town)	Water Supply Storage ac-ft	Water Supply Storage Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Lake Taneycomo	*NA*	*NA*	*NA*	11010003	*NA*	*NA*

Summary of Surface Water Demands by HUC8

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	Current Demand mgd
Beaver Reservoir	11010001	382	0.19	3
James	11010002	1456	0.64	44
Bull Shoals Lake	11010003	1506	0.62	44
North Fork White	11010006	1389	0.51	34
Upper Black	11010007	1742	0.05	4
Current	11010008	2513	0.11	13
Lower Black	11010009	114	0.03	0.2
Spring	11010010	479	0.06	1
Eleven Point	11010011	1025	0.03	1
	Total	**10,606**	**-**	**146**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

Upper White Subregion Summary

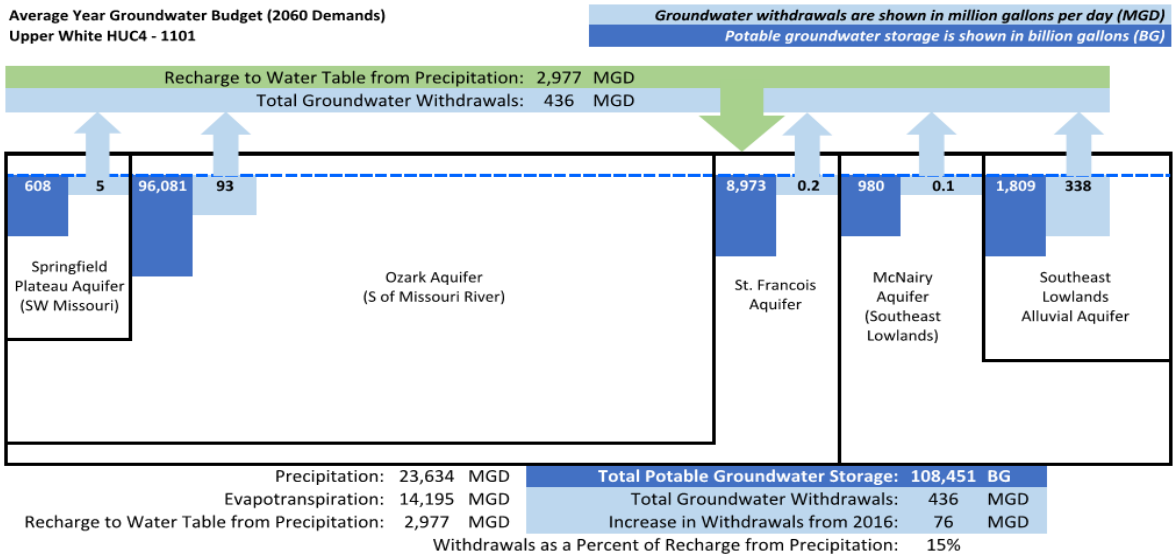
Summary of Groundwater Demands by Aquifer

Groundwater Withdrawals By Sector	2016 Demands (mgd)							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.37	22.59	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.21	13.19	0.21	0.00	0.40	0.00	0.26	0.10
Self-Supplied Nonresidential	0.00	4.22	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	285.90	21.17	0.00	0.00	1.95	0.00	0.00	0.00
Thermoelectric Power Generation	0.03	4.94	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**286.51**	**66.11**	**0.21**	**0.00**	**2.35**	**0.00**	**0.26**	**0.10**
Aquaculture and Wetlands	1.87	1.60	0.00	0.00	0.83	0.00	0.00	0.00
Total Nonconsumptive	**1.87**	**1.60**	**0.00**	**0.00**	**0.83**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**288.38**	**67.71**	**0.21**	**0.00**	**3.18**	**0.00**	**0.26**	**0.10**

Groundwater Withdrawals By Sector	2060 Demands (mgd)							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.44	36.25	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.20	18.37	0.20	0.00	0.65	0.00	0.25	0.10
Self-Supplied Nonresidential	0.00	6.35	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	335.06	25.77	0.00	0.00	3.19	0.00	0.00	0.00
Thermoelectric Power Generation	0.04	4.40	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**335.74**	**91.14**	**0.20**	**0.00**	**3.84**	**0.00**	**0.25**	**0.10**
Aquaculture and Wetlands	1.87	1.60	0.00	0.00	0.83	0.00	0.00	0.00
Total Nonconsumptive	**1.87**	**1.60**	**0.00**	**0.00**	**0.83**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**337.61**	**92.74**	**0.20**	**0.00**	**4.67**	**0.00**	**0.25**	**0.10**

Upper White Subregion Summary

Average Year Groundwater Budget (2060 Demands)[10]



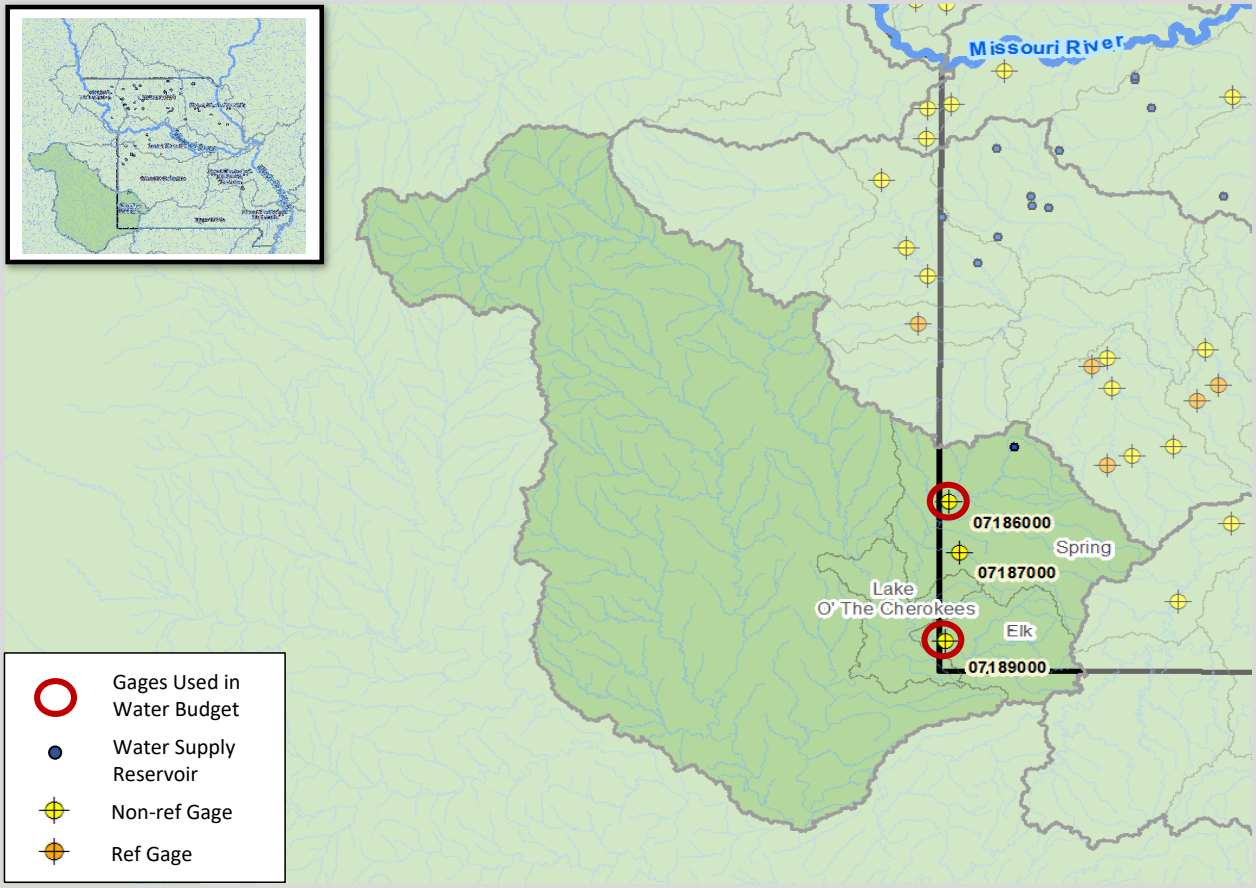
The above graphic is a generalized representation of aquifers present in each HUC4.

Notes

1. Streamflow includes HUC4 1101 inflows entering Missouri from Arkansas.
2. Reservoir storage information was not available for Lake Taneycomo. Table Rock Lake is not currently used for public water supply. Bull Shoals and Norfork Lake are not used for water supply in Missouri, but are in Arkansas.
3. Groundwater demands include alluvial and groundwater aquifer withdrawals.
4. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
5. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC4, the lowest annual streamflow occurred in 2000 for all gages (07052500, 07057500 and 07068000).
6. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
7. Demands shown on flow duration curve do not include thermoelectric demands.
8. The Ozark Aquifer includes the Lower, Middle and Upper Ozark aquifers.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Neosho-Verdigris Subregion Summary

HUC4 Name: Neosho-Verdigris **HUC4 Number:** 1107
Drainage Area within MO: 2,908 sq miles (100%) **Contributing Area outside MO:** 0 sq miles (0%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	5.2

Returns	
Wastewater	23.6
Thermoeletric	1.2

Inflows	
Streamflow[1]	0
Precipitation (In-State)	6,369

Naturalized Streamflow	1,854	
Water Supply Reservoir Storage	515	million gallons

Surface Water Outflow
1,858

Consumptive Use & ET	
Evapotranspiration	3,881
Consumptive Withdrawals	21

Neosho-Verdigris Subregion Summary

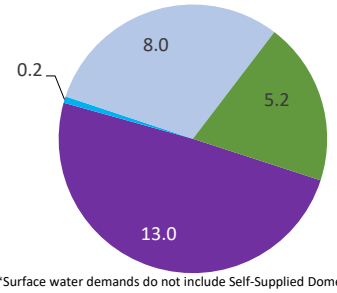
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	7,139,701	46.03	6,369
Evapotranspiration	4,351,016	28.05	3,881
Streamflow (from Out of State)	0	0.00	0
Streamflow (from other In-State HUC4)	0	0.00	0
Streamflow originating in HUC4	2,078,531	13.40	1,854
Total Streamflow	2,078,531	13.40	1,854
Nonconsumptive Surface Water Withdrawals	5,810	0.04	5
Consumptive Surface Water Withdrawals	23,787	0.15	21
Total Surface Water Withdrawals	29,597	0.19	26

Summary of Water Demands by Sector

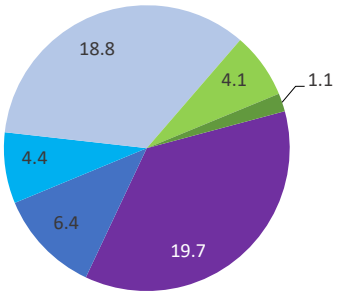
	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	14,602	0.09	13.0	16.0
Self-Supplied Nonresidential	231	0.00	0.2	0.2
Agriculture	8,953	0.06	8.0	11.5
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**23,786**	**0.15**	**21.2**	**27.7**
Aquaculture and Wetlands	5,810	0.04	5.2	5.2
Total Nonconsumptive	**5,810**	**0.04**	**5.2**	**5.2**
Groundwater Withdrawals By Sector[2]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	22,103	0.14	19.7	23.3
Self-Supplied Domestic and Minor Systems	7,168	0.05	6.4	7.8
Self-Supplied Nonresidential	4,909	0.03	4.4	7.1
Agriculture	21,117	0.14	18.8	24.7
Thermoelectric Power Generation	4,546	0.03	4.1	4.8
Total Consumptive	**59,843**	**0.39**	**53.4**	**67.7**
Aquaculture and Wetlands	1,255	0.01	1.1	1.1
Total Nonconsumptive	**1,255**	**0.01**	**1.1**	**1.1**

Current Surface Water Withdrawals*



*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Current Groundwater Withdrawals

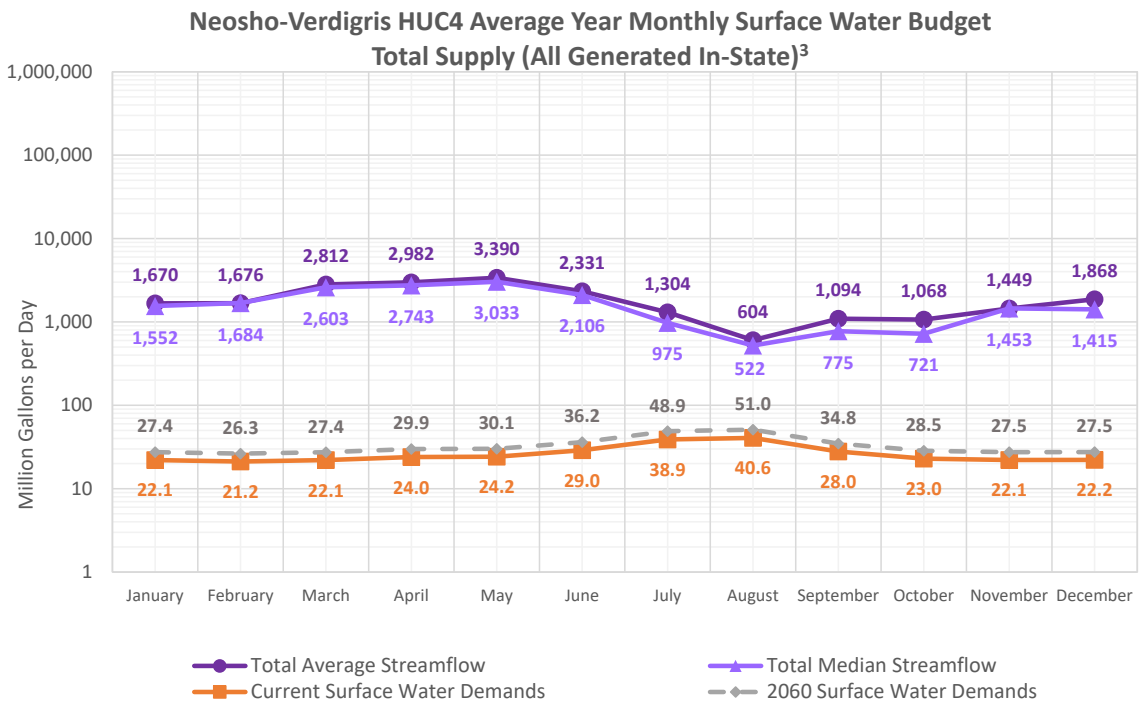


Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture
- Thermoelectric Power Generation

Nonconsumptive Demands
- Aquaculture and Wetlands

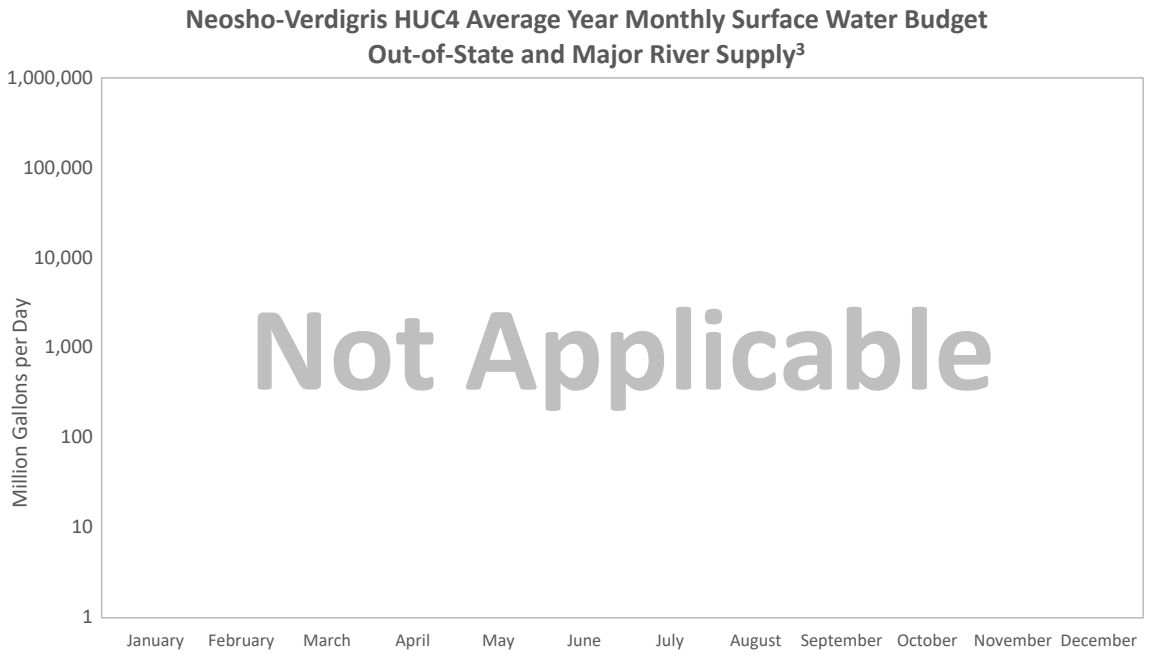
Neosho-Verdigris Subregion Summary

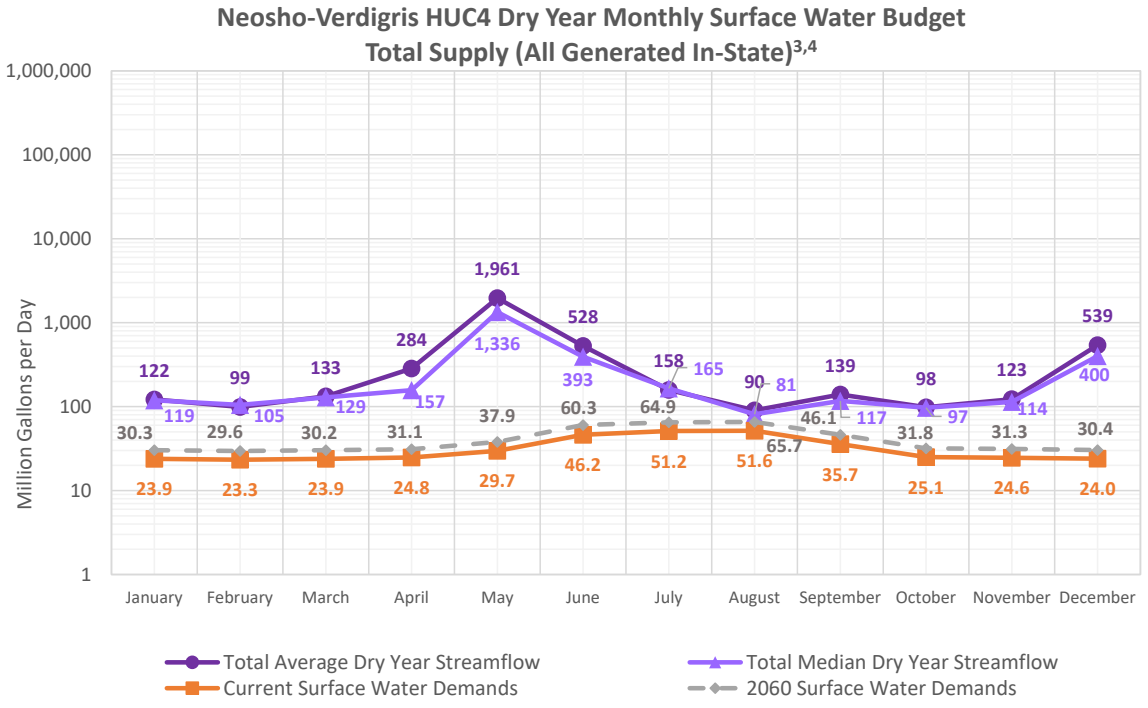
Comparison of Monthly Surface Water Availability to Current and Future Demands



Neosho-Verdigris Subregion Summary

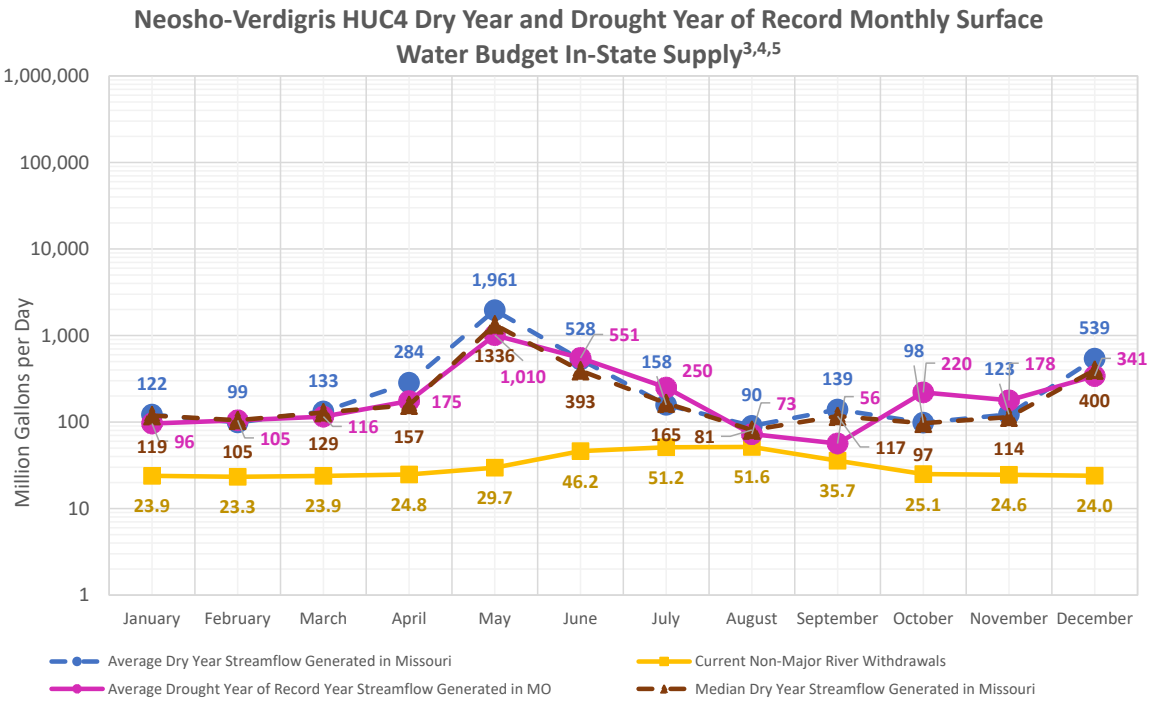
Comparison of Monthly Surface Water Availability to Current and Future Demands

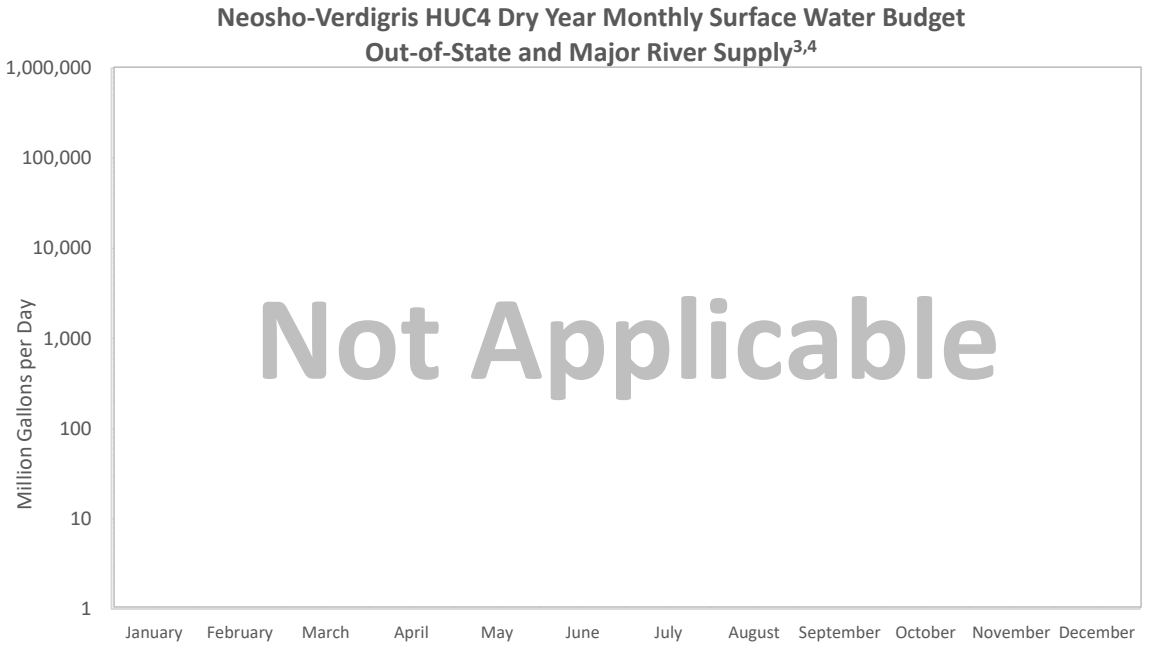




Neosho-Verdigris Subregion Summary

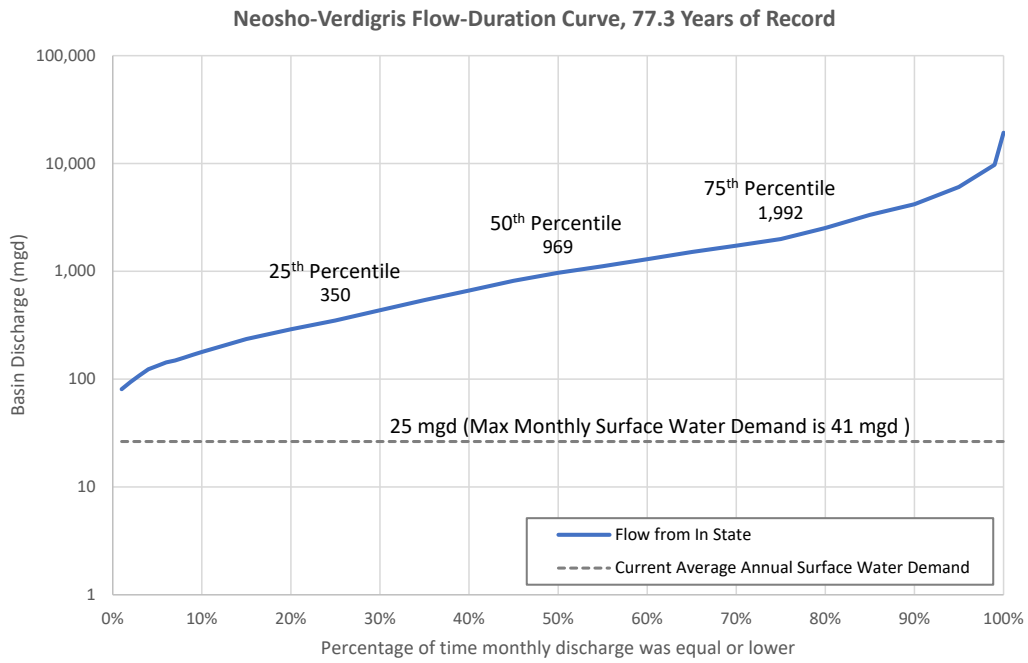
Comparison of Monthly Surface Water Availability to Current and Future Demands





Neosho-Verdigris Subregion Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
City Lake (Lamar)	1,582	515	0.427	11070207	45	18
Total	1,582	515	0.427			

Summary of Surface Water Demands by HUC8

HUC8 Subbasin Name	HUC8 Number	Area (MO) sq miles	Current Demand in/yr	mgd
Lake O' The Cherokees	11070206	113	0.05	0.3
Spring	11070207	2043	0.25	24
Elk	11070208	752	0.06	2
	Total	**2,908**	**-**	**27**

Note: HUC8 Demands in in/yr are not summed because these are calculated relative to the area of each HUC8 within Missouri.

Neosho-Verdigris Subregion Summary

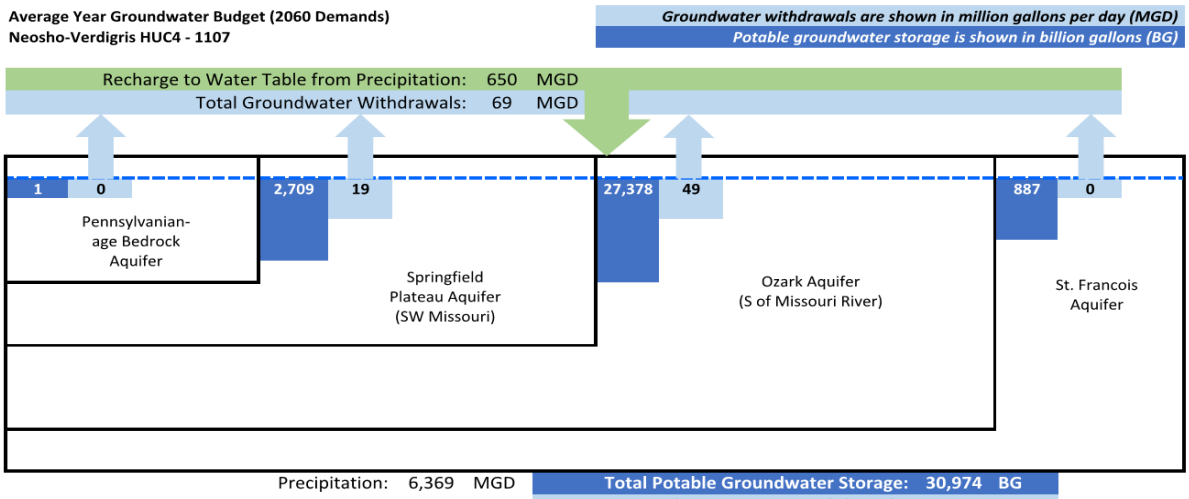
Summary of Groundwater Demands by Aquifer

	2016 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[8]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[9]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	0.00	19.67	0.00	0.00	0.05	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.00	5.78	0.00	0.00	0.61	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	4.38	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	5.71	0.00	0.00	13.13	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	4.06	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.00**	**39.60**	**0.00**	**0.00**	**13.79**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.38	0.74	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.38**	**0.74**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.00**	**39.60**	**0.00**	**0.38**	**14.53**	**0.00**	**0.00**	**0.00**

	2060 Demands (mgd)							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[8]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[9]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	0.00	23.21	0.00	0.00	0.05	0.00	0.00	0.00
Self-Supplied Domestic & Minor Systems	0.00	7.05	0.00	0.00	0.75	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	7.06	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	7.23	0.00	0.00	17.43	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	4.82	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.00**	**49.37**	**0.00**	**0.00**	**18.23**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.38	0.74	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.38**	**0.74**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.00**	**49.37**	**0.00**	**0.38**	**18.97**	**0.00**	**0.00**	**0.00**

Neosho-Verdigris Subregion Summary

Average Year Groundwater Budget (2060 Demands)[10]



Precipitation:	6,369	MGD	**Total Potable Groundwater Storage:**	**30,974**	**BG**
Evapotranspiration:	3,881	MGD	Total Groundwater Withdrawals:	69	MGD
Recharge to Water Table from Precipitation:	650	MGD	Increase in Withdrawals from 2016:	14	MGD
			Withdrawals as a Percent of Recharge from Precipitation:	11%	

The above graphic is a generalized representation of aquifers present in each HUC4.

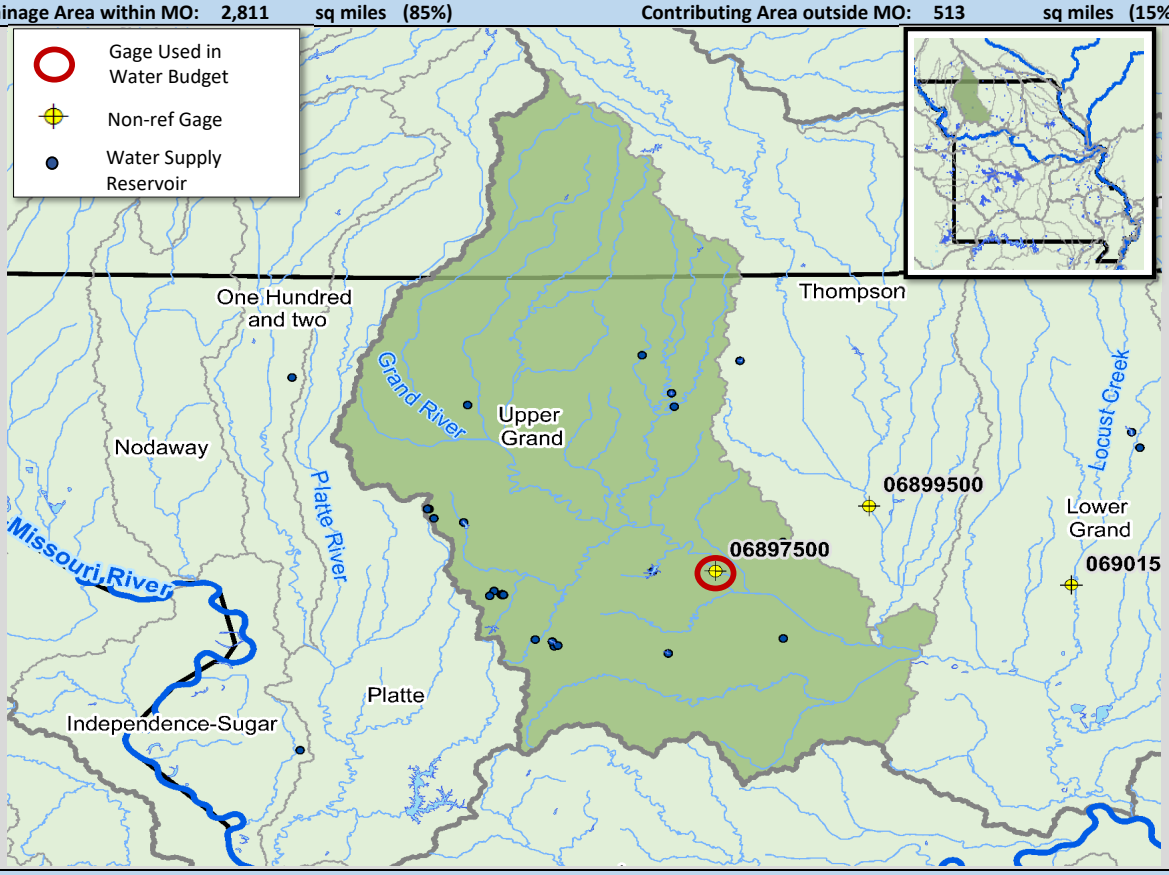
Notes

1. There is no streamflow entering Missouri within this subregion that is generated out of Missouri or from major rivers.
2. Groundwater demands include alluvial and groundwater aquifer withdrawals.
3. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC4, the lowest annual streamflow occurred in 2006 for gage 07186000 and 2006 for gage 07189000.
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources:
   a. *Missouri Water Supply Study, Missouri DNR, June 2011*
   b. *US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/*
8. The Ozark Aquifer includes the Lower, Middle and Upper Ozark aquifers.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. MoDNR, 1997. Groundwater Resources of Missouri, Water Resources Report 46, Missouri State Water Plan Series, Vol II.

Appendix F
Subbasin Summaries

Upper Grand Subbasin Summary

Subbasin Name: Upper Grand **HUC8 Number:** 10280101
Drainage Area within MO: 2,811 sq miles (85%) **Contributing Area outside MO:** 513 sq miles (15%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	1.0

Returns	
Wastewater	3.8
Thermoelectric	0.0

Inflows	
Streamflow (from Out of State and Thompson)	1,549
Precipitation (In-State)	4,985

Naturalized Streamflow	1,284	
Water Supply Reservoir Storage	7,150	million gallons

Surface Water Outflow 2,827

Consumptive Use & ET	
Evapotranspiration	1,033
Consumptive Withdrawals	8.9

Upper Grand Subbasin Summary

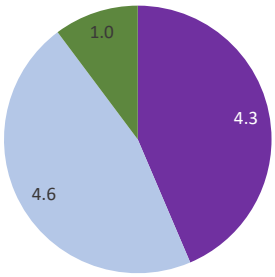
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	5,588,679	37.28	4,985
Evapotranspiration	1,158,189	7.73	1,033
Streamflow (from Out of State)	262,751	1.75	234
Streamflow (from other In-State HUC8)	0	0.00	0
Streamflow originating in HUC8	1,439,190	9.60	1,284
Total Streamflow	1,701,941	11.35	1,518
Nonconsumptive Surface Water Withdrawals	1,135	0.01	1.0
Consumptive Surface Water Withdrawals	9,972	0.07	8.9
Total Surface Water Withdrawals	11,107	0.07	10

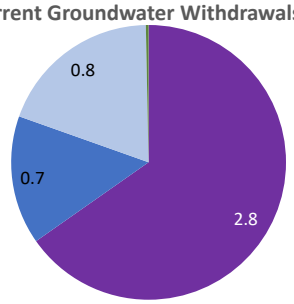
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	4,841	0.03	4.3	4.7
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	5,130	0.03	4.6	6.7
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**9,971**	**0.06**	**8.9**	**11.4**
Aquaculture and Wetlands	1,135	0.01	1.0	1.0
Total Nonconsumptive	**1,135**	**0.01**	**1.0**	**1.0**
Groundwater Withdrawals By Sector[1]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	3,141	0.02	2.8	2.9
Self-Supplied Domestic and Minor Systems	729	0.00	0.7	0.4
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	927	0.01	0.8	1.2
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**4,797**	**0.03**	**4.3**	**4.5**
Aquaculture and Wetlands	15	0.00	0.0	0.0
Total Nonconsumptive	**15**	**0.00**	**0.0**	**0.0**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



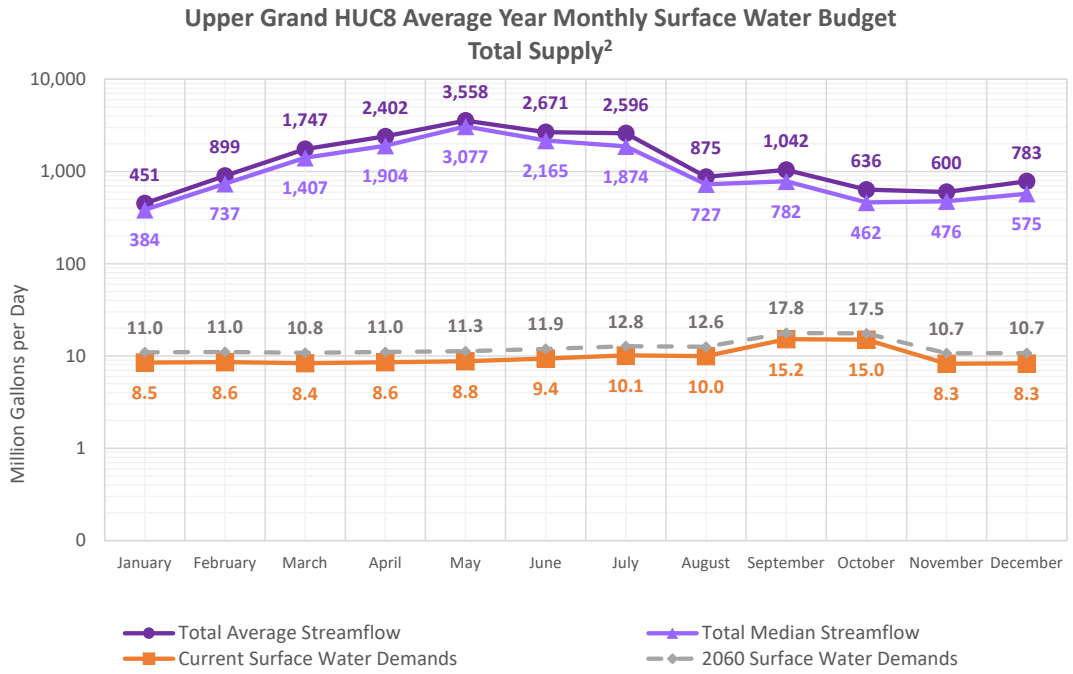
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Agriculture

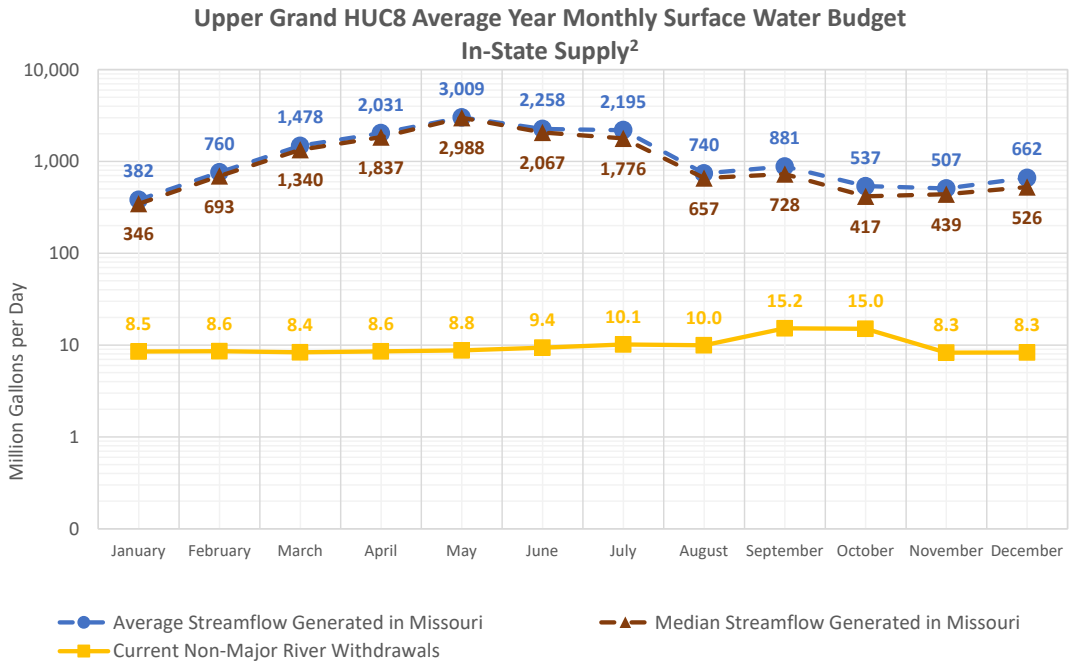
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Upper Grand Subbasin Summary

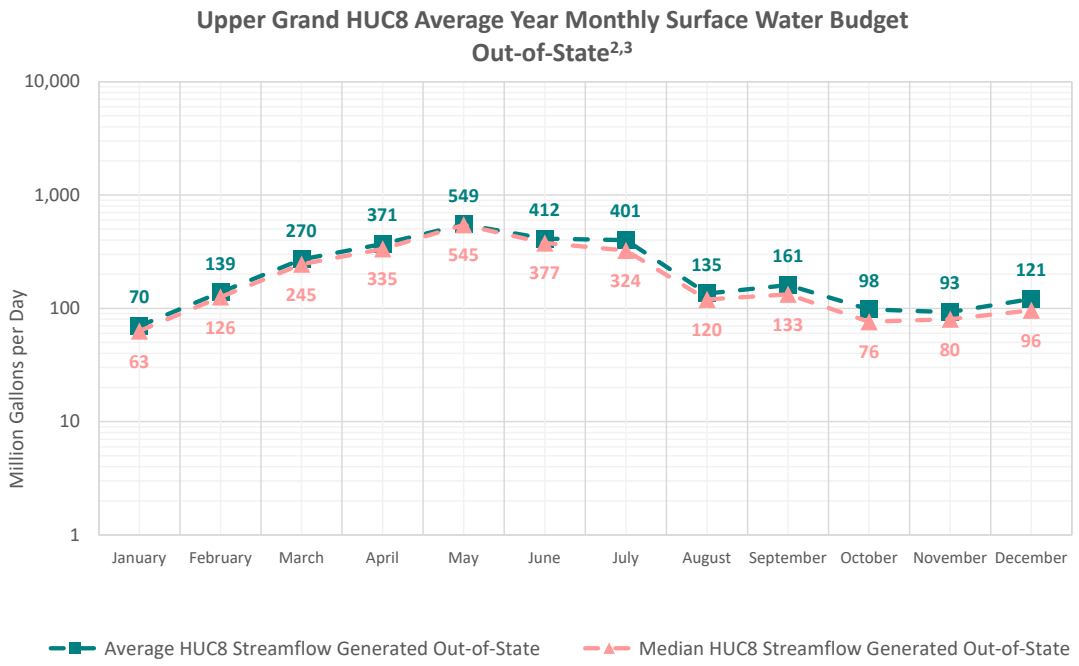
Comparison of Monthly Surface Water Availability to Current and Future Demands

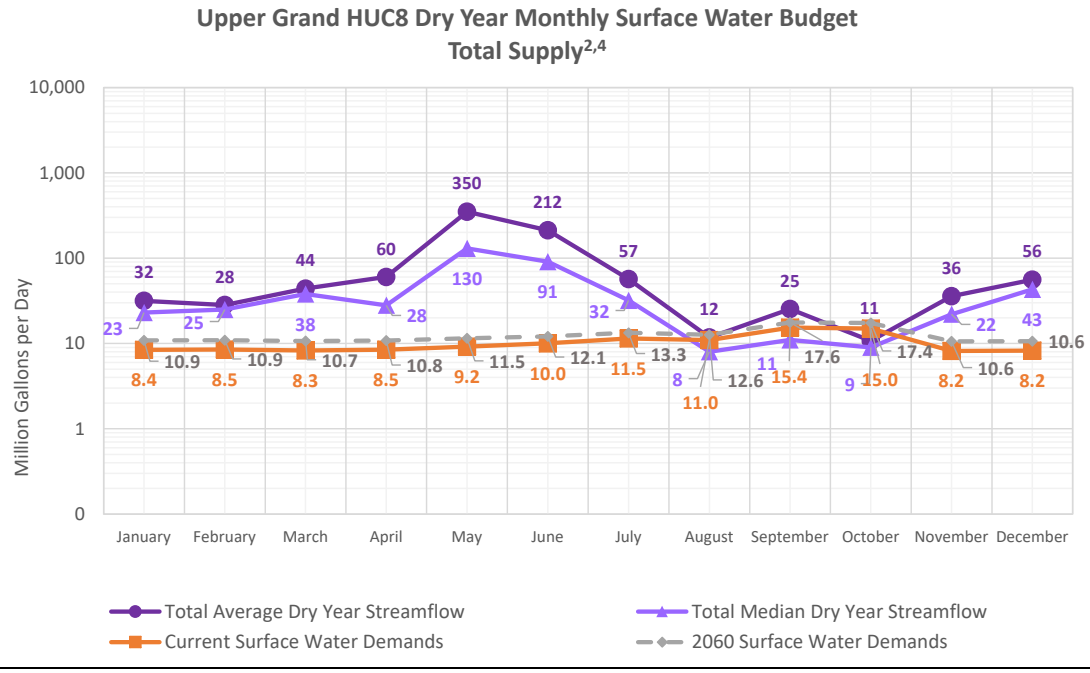




Upper Grand Subbasin Summary

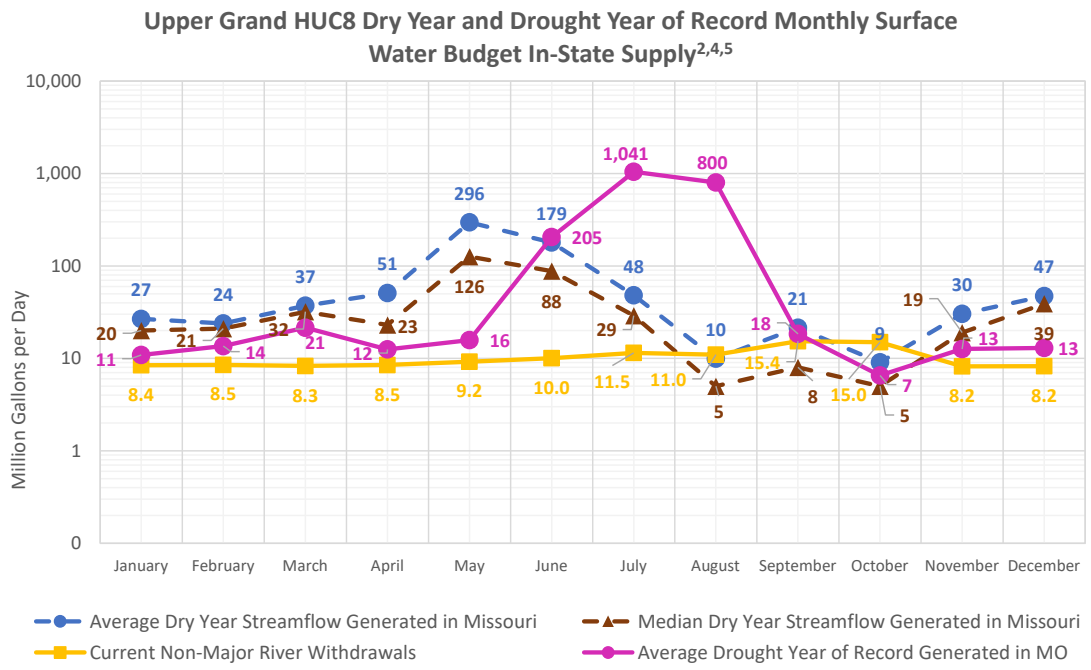
Comparison of Monthly Surface Water Availability to Current and Future Demands

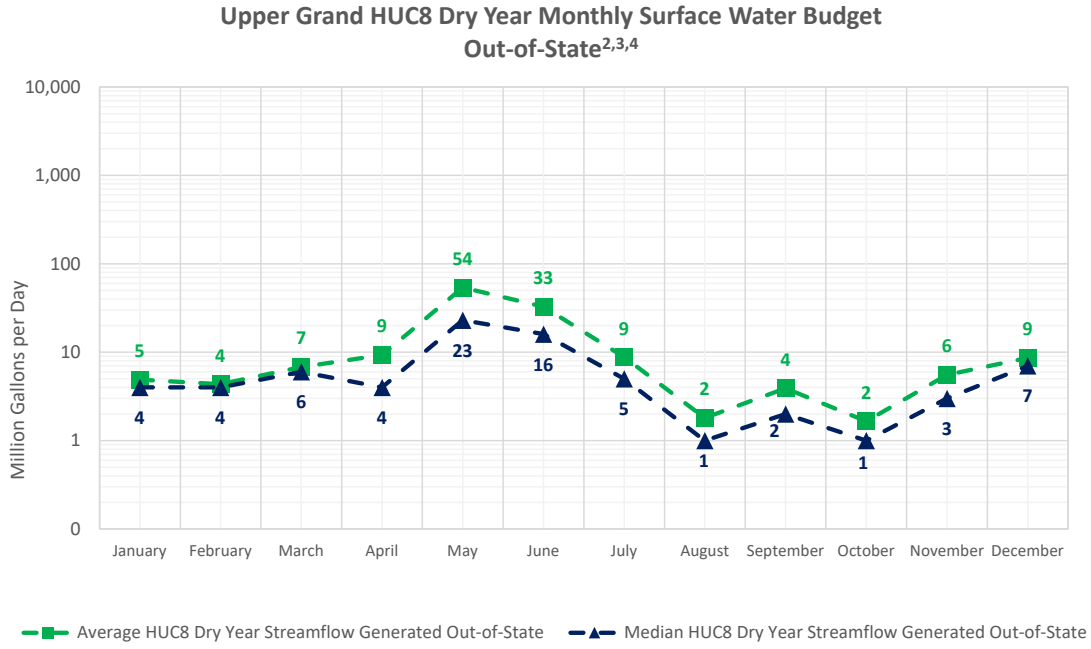




Upper Grand Subbasin Summary

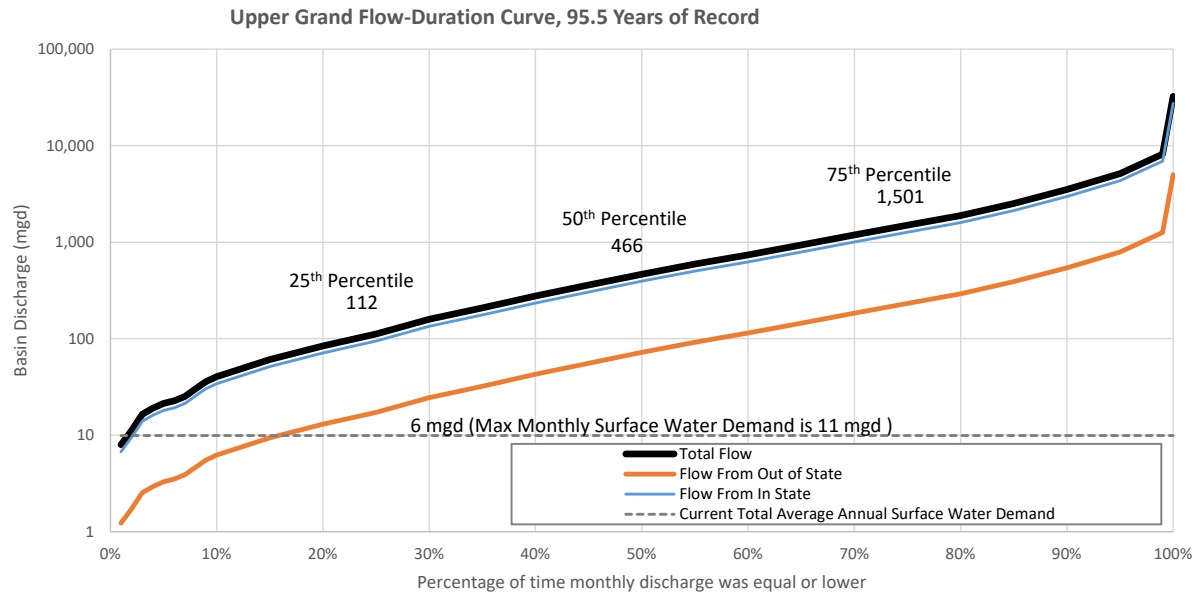
Comparison of Monthly Surface Water Availability to Current and Future Demands





Upper Grand Subbasin Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Harrison Lake (Bethany)	1,095	357	0.59	10280101	12	8
Bethany New Lake (Bethany)	499	163	0.18	10280101	18	17
Bethany Old Lake (Bethany)	162	53	0.05	10280101	19	17
City Lake (Breckenridge)	140	46	0.05	10280101	18	15
GLM Lake (Cameron)	1,869	609	0.75	10280101	64	25
Lake 1 (Cameron)	115	37	0.07	10280101	4	4
Lake 2 (Cameron)	325	106	0.17	10280101	7	7
Lake 3 (Cameron)	950	310	0.40	10280101	14	13
City Lake (Hamilton)	896	292	0.19	10280101	22	20
City Lake (Jamesport)	163	53	0.07	10280101	24	16
South Lake (King City)	417	136	0.08	10280101	33	29
North upper lake (King City)	39	13	0.01	10280101	6	6
North middle Lake (King City)	65	21	0.01	10280101	33	23
North lower lake (King City)	332	108	0.04	10280101	107	87
Private Lake (Lake Viking)	12,000	3,910	2.46	10280101	98	78
Willowbrook Lake (Maysville)	784	255	0.31	10280101	21	15
South Lake (Maysville)	75	24	0.02	10280101	reservoirs do not empty	351
West Lake (Maysville)	250	81	0.12	10280101	65	23

(continued on next page)

Upper Grand Subbasin Summary

Water Supply Reservoir Storage Continued[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Lake (Middle Fork)	915	298	0.38	10280101	20	15
Lake (Harrison Co.)	140	46	0.04	10280101	2	2
Total	**21,231**	**6,918**	**5.99**			

Summary of Groundwater Demands by Aquifer

	2016 Demands							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[8]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[9]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	0.57	0.00	2.24	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.01	0.00	0.64	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.58**	**0.00**	**3.71**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.59**	**0.00**	**3.71**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

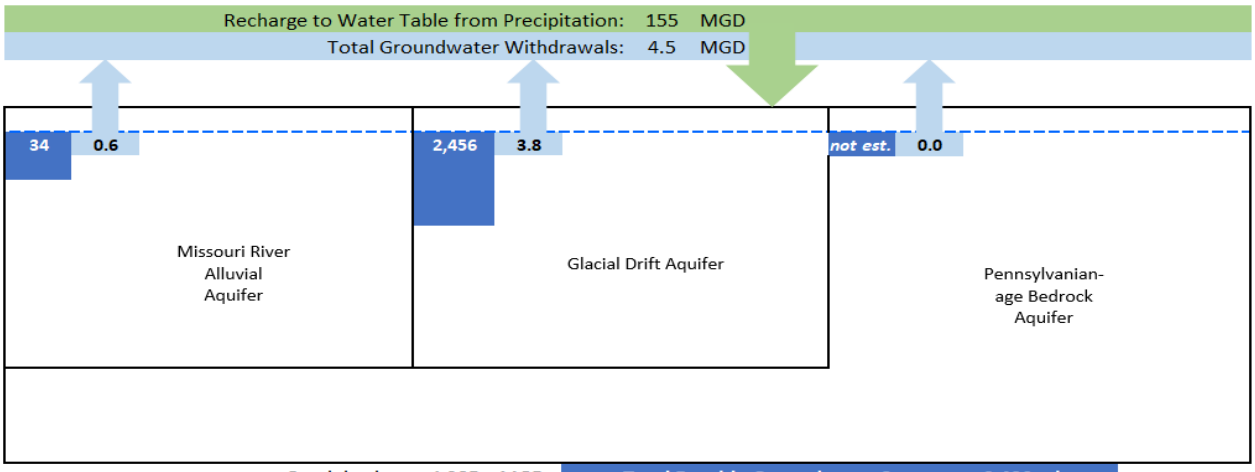
	2060 Demands							
Groundwater Withdrawals By Sector	**Alluvium**	**Ozark Aquifer[8]**	**Glacial Deposits**	**Pennsyl-vanian**	**Springfield Plateau Aquifer**	**Mississippian Aquifer[9]**	**St. Francois Aquifer**	**McNairy & Wilcox**
Major Water Systems	0.59	0.00	2.30	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.01	0.00	0.35	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	1.18	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.60**	**0.00**	**3.83**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.61**	**0.00**	**3.83**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Upper Grand Subbasin Summary

Average Year Groundwater Budget (2060 Demands)[10]

Average Year Groundwater Budget (2060 Demands)
Upper Grand HUC8 - 10280101

Groundwater withdrawals are shown in million gallons per day (MGD)
Potable groundwater storage is shown in billion gallons (BG)



Precipitation:	4,985	MGD	**Total Potable Groundwater Storage:**	**6,490**	**bg**
Evapotranspiration:	2,946	MGD	Total Groundwater Withdrawals:	4.5	MGD
Recharge to Water Table from Precipitation:	155	MGD	Increase in Withdrawals from 2016:	0.2	MGD
			Withdrawals as a Percent of Recharge from Precipitation:	3%	

The above graphic is a generalized representation of aquifers present in each HUC8.

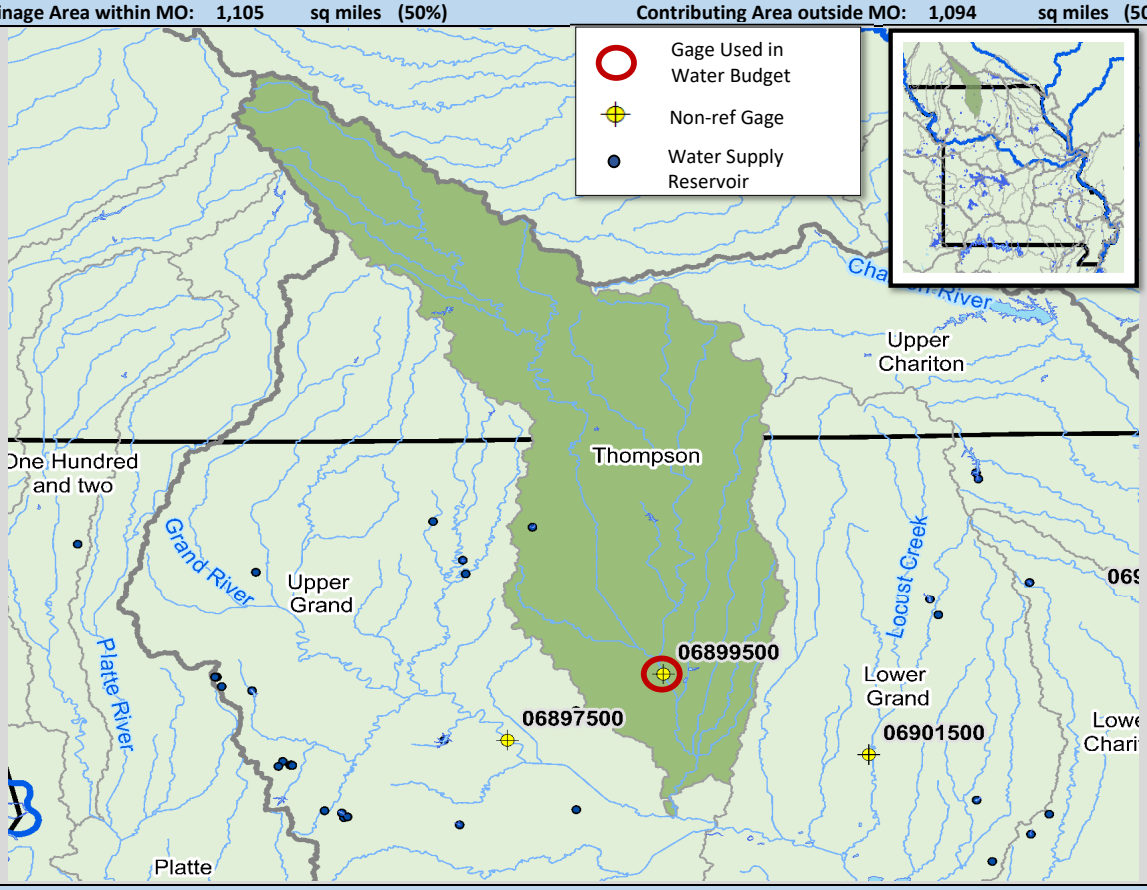
Notes

1. Groundwater demands include alluvial and groundwater aquifer withdrawals.
2. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
3. There are no major river inflows for this subbasin which is consistent with the HUC4 summary sheet.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC8, the lowest annual streamflow was 2003 (gage 06897500).
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources and notes:
   a. Missouri Water Supply Study, Missouri DNR, June 2011
   b. US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/
8. Ozark Aquifer includes both the Upper, Middle, and Lower Ozark Aquifer and the associated Cambrian and Ordavician systems north of the Missouri River.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. Aquifer storage from: MoDNR, 1997. Groundwater Resources of Missouri, WRP 46, Missouri State Water Plan Series, Vol II.

Thompson Subbasin Summary

Subbasin Name: Thompson **HUC8 Number:** 10280102

Drainage Area within MO: 1,105 sq miles (50%) **Contributing Area outside MO:** 1,094 sq miles (50%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Inflows	
Streamflow (from Out of State)	656
Precipitation (In-State)	1,956

Nonconsumptive Use	
Withdrawal and Return	0.6

Returns	
Wastewater	1.4
Thermoelectric	0.0

Naturalized Streamflow	663	
Water Supply Reservoir Storage	150	million gallons

Surface Water Outflow 1,314

Consumptive Use & ET	
Evapotranspiration	160
Consumptive Withdrawals	5.1

Thompson Subbasin Summary

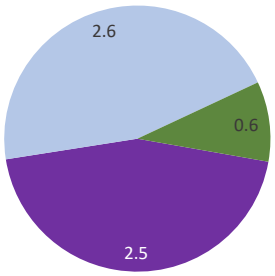
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	2,192,779	37.19	1,956
Evapotranspiration	179,111	3.04	160
Streamflow (from Out of State)	735,332	12.47	656
Streamflow (from other In-State HUC8)	0	0.00	0
Streamflow originating in HUC8	742,829	12.60	663
Total Streamflow	1,478,161	25.07	1,319
Nonconsumptive Surface Water Withdrawals	617	0.01	0.6
Consumptive Surface Water Withdrawals	5,718	0.10	5.1
Total Surface Water Withdrawals	6,335	0.11	6

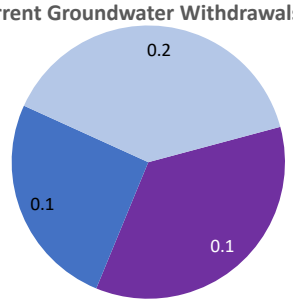
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	2,834	0.05	2.5	2.2
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	2,884	0.05	2.6	3.7
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**5,718**	**0.10**	**5.1**	**5.9**
Aquaculture and Wetlands	617	0.01	0.6	0.6
Total Nonconsumptive	**617**	**0.01**	**0.6**	**0.6**
Groundwater Withdrawals By Sector[1]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	154	0.00	0.1	0.1
Self-Supplied Domestic and Minor Systems	111	0.00	0.1	0.0
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	170	0.00	0.2	0.2
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**435**	**0.00**	**0.4**	**0.3**
Aquaculture and Wetlands	0	0.00	0.0	0.0
Total Nonconsumptive	**0**	**0.00**	**0.0**	**0.0**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



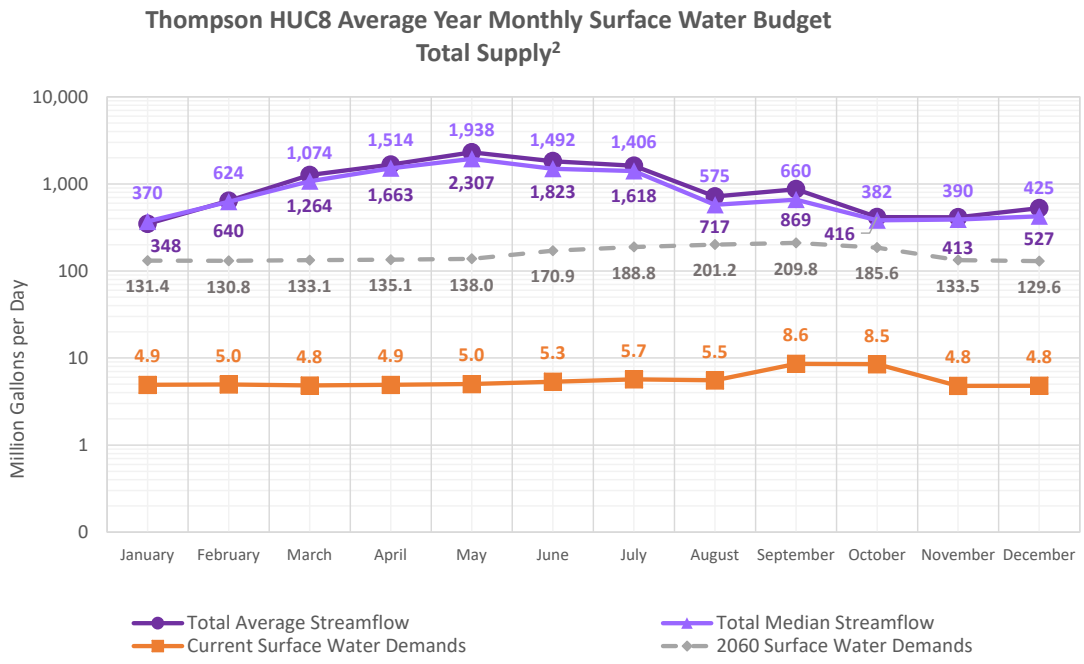
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Agriculture

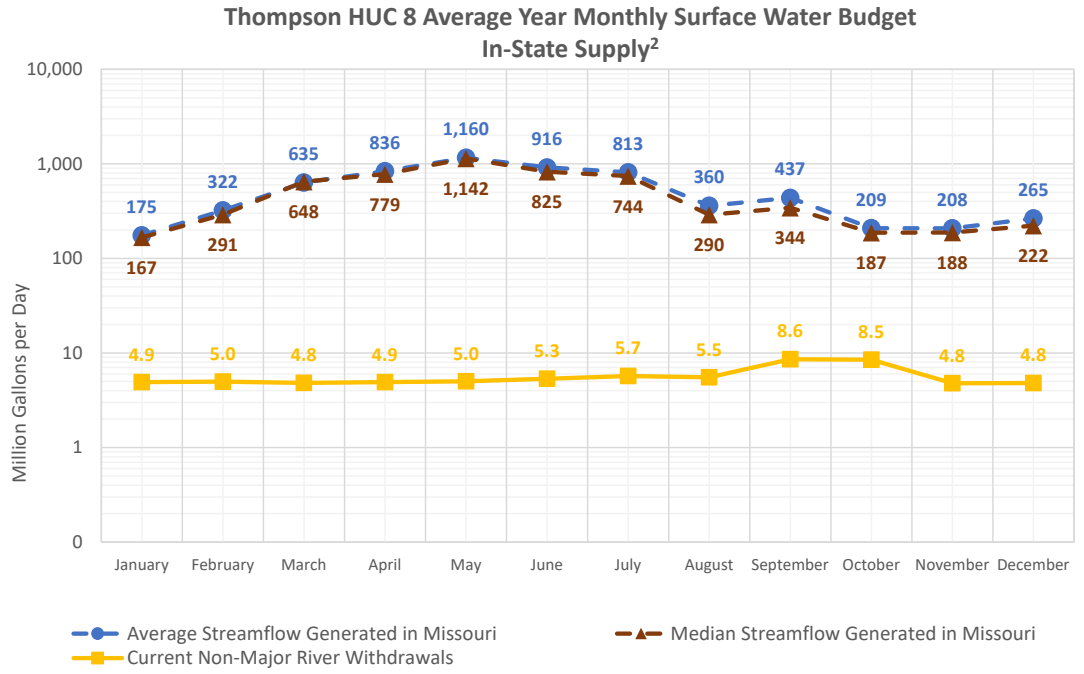
Nonconsumptive Demands
- Thermoelectric Power Generation

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Thompson Subbasin Summary

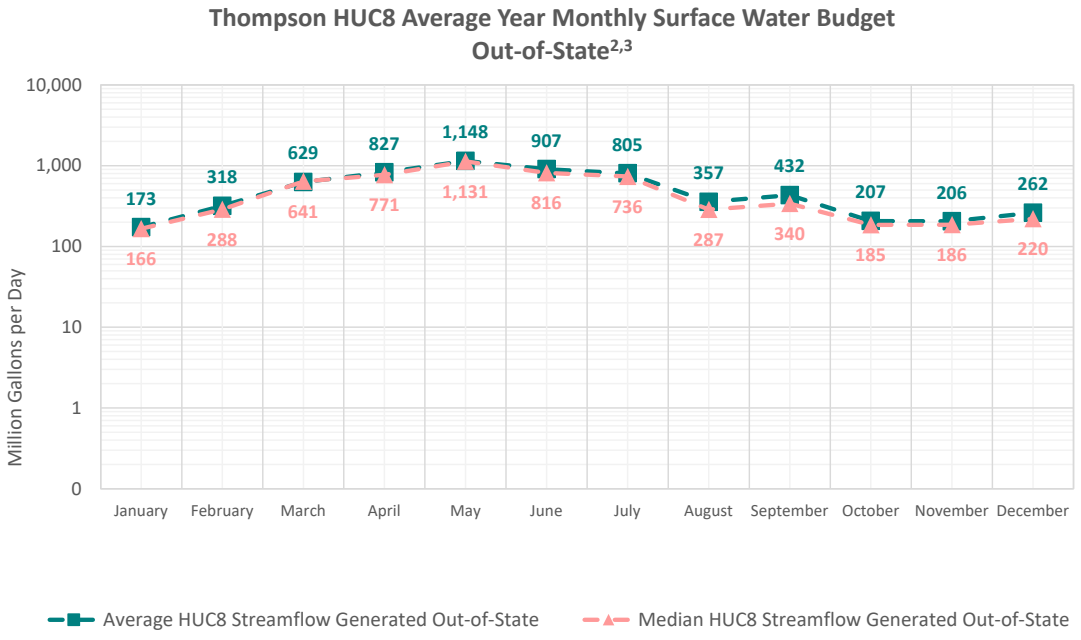
Comparison of Monthly Surface Water Availability to Current and Future Demands

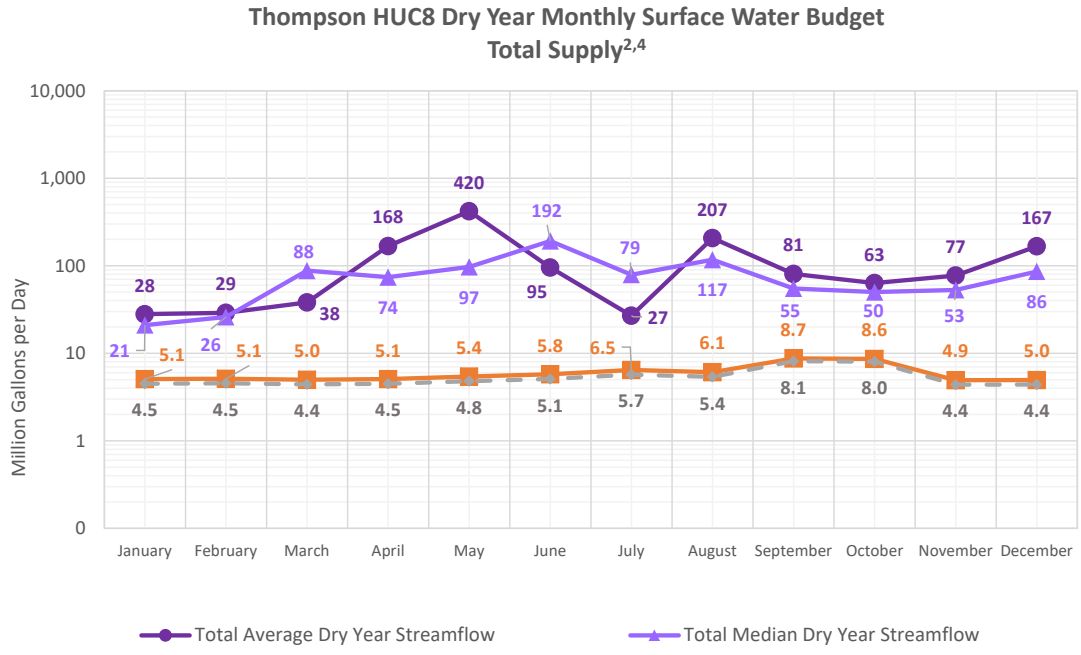




Thompson Subbasin Summary

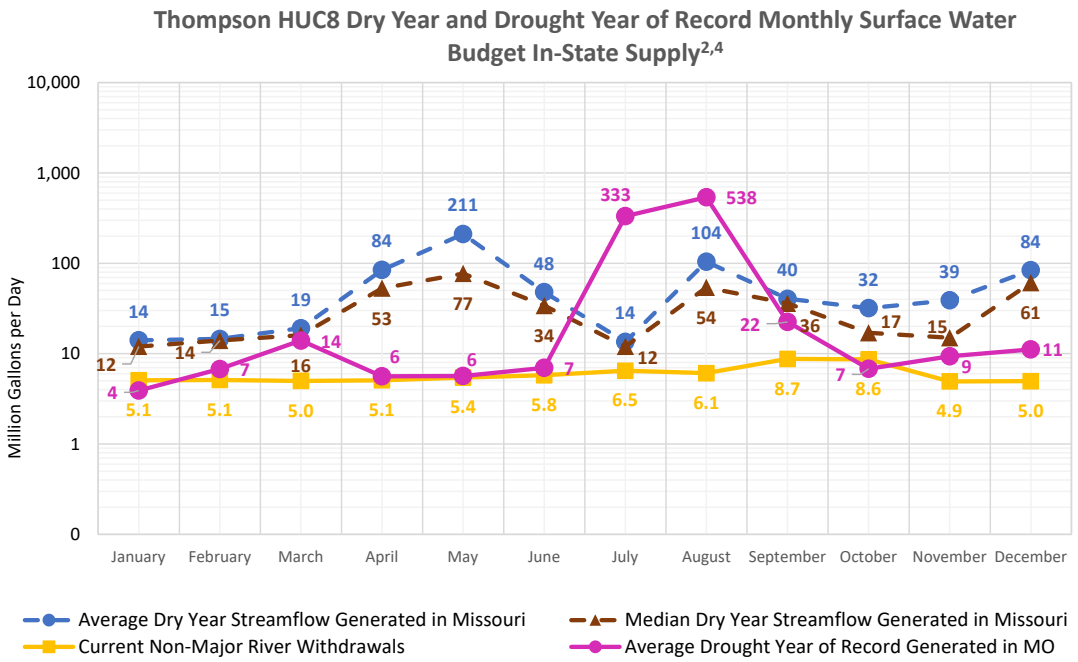
Comparison of Monthly Surface Water Availability to Current and Future Demands

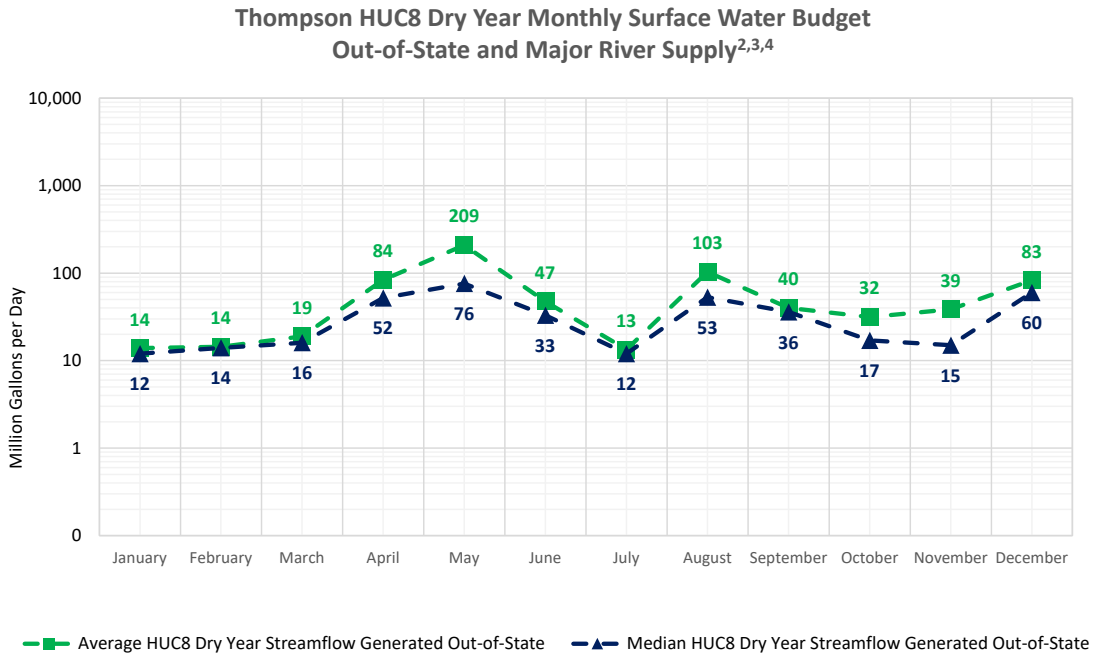




Thompson Subbasin Summary

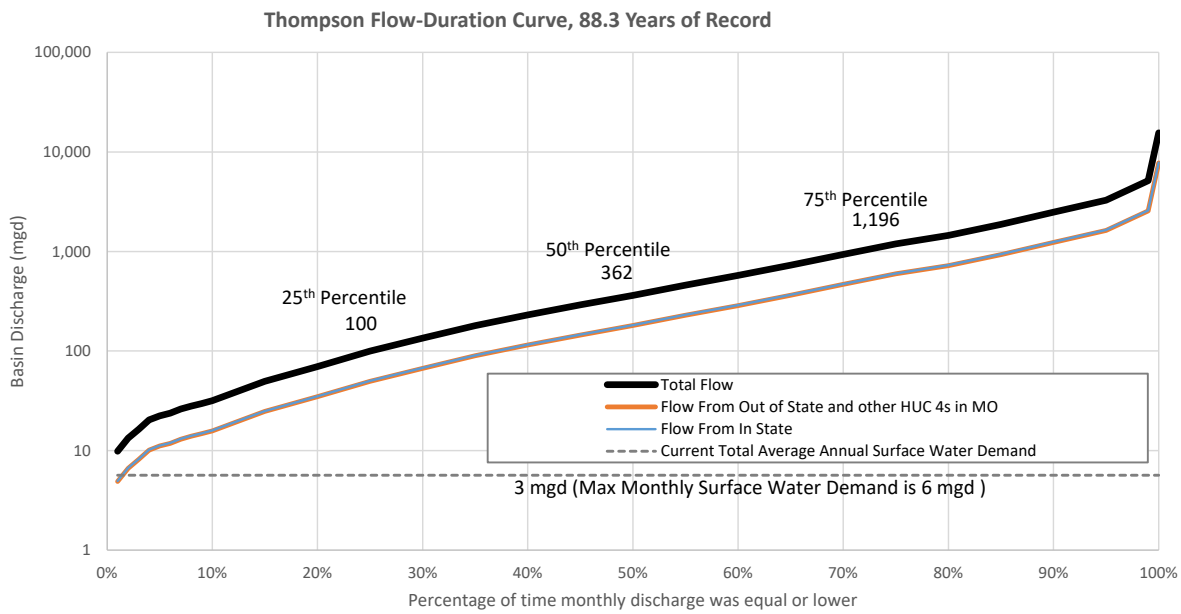
Comparison of Monthly Surface Water Availability to Current and Future Demands





Thompson Subbasin Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Rock House Lake (Ridgeway)	461	150	0.25	10280102	reservoirs do not empty	22
Total	**461**	**150**	**0.25**			

Thompson Subbasin Summary

Summary of Groundwater Demands by Aquifer

Groundwater Withdrawals By Sector	2016 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.14**	**0.00**	**0.25**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.14**	**0.00**	**0.25**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

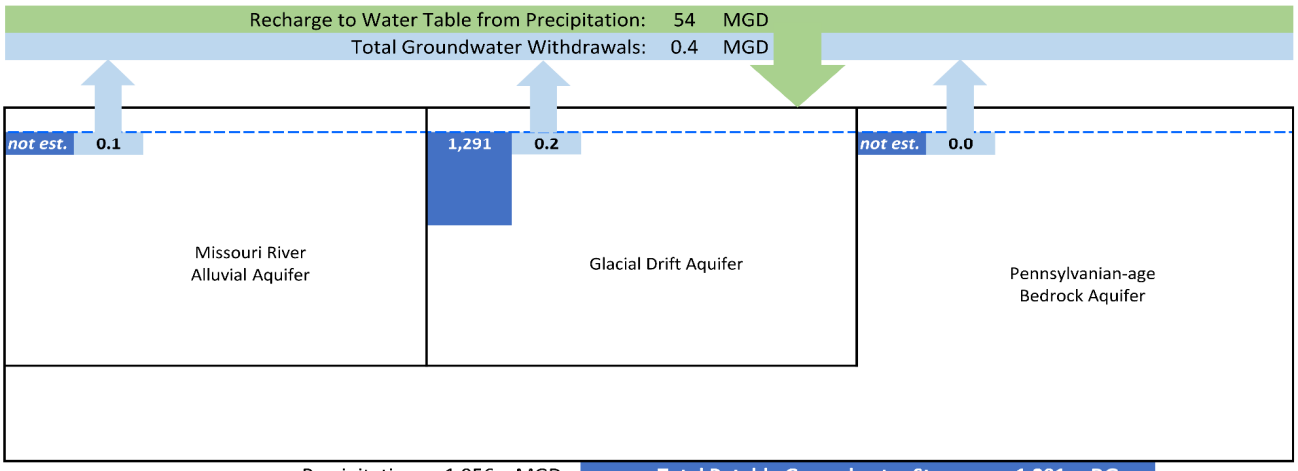
Groundwater Withdrawals By Sector	2060 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.23	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.12**	**0.00**	**0.25**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.12**	**0.00**	**0.25**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Thompson Subbasin Summary

Average Year Groundwater Budget (2060 Demands)[10]

Average Year Groundwater Budget (2060 Demands)
Thompson HUC8 - 10280102

Groundwater withdrawals are shown in million gallons per day (MGD)
Potable groundwater storage is shown in billion gallons (BG)



Precipitation:	1,956	MGD	**Total Potable Groundwater Storage:**	**1,291**	**BG**
Evapotranspiration:	1,146	MGD	Total Groundwater Withdrawals:	0.4	MGD
Recharge to Water Table from Precipitation:	54	MGD	Increase in Withdrawals from 2016:	0.0	MGD
			Withdrawals as a Percent of Recharge from Precipitation:	1%	

The above graphic is a generalized representation of aquifers present in each HUC8.

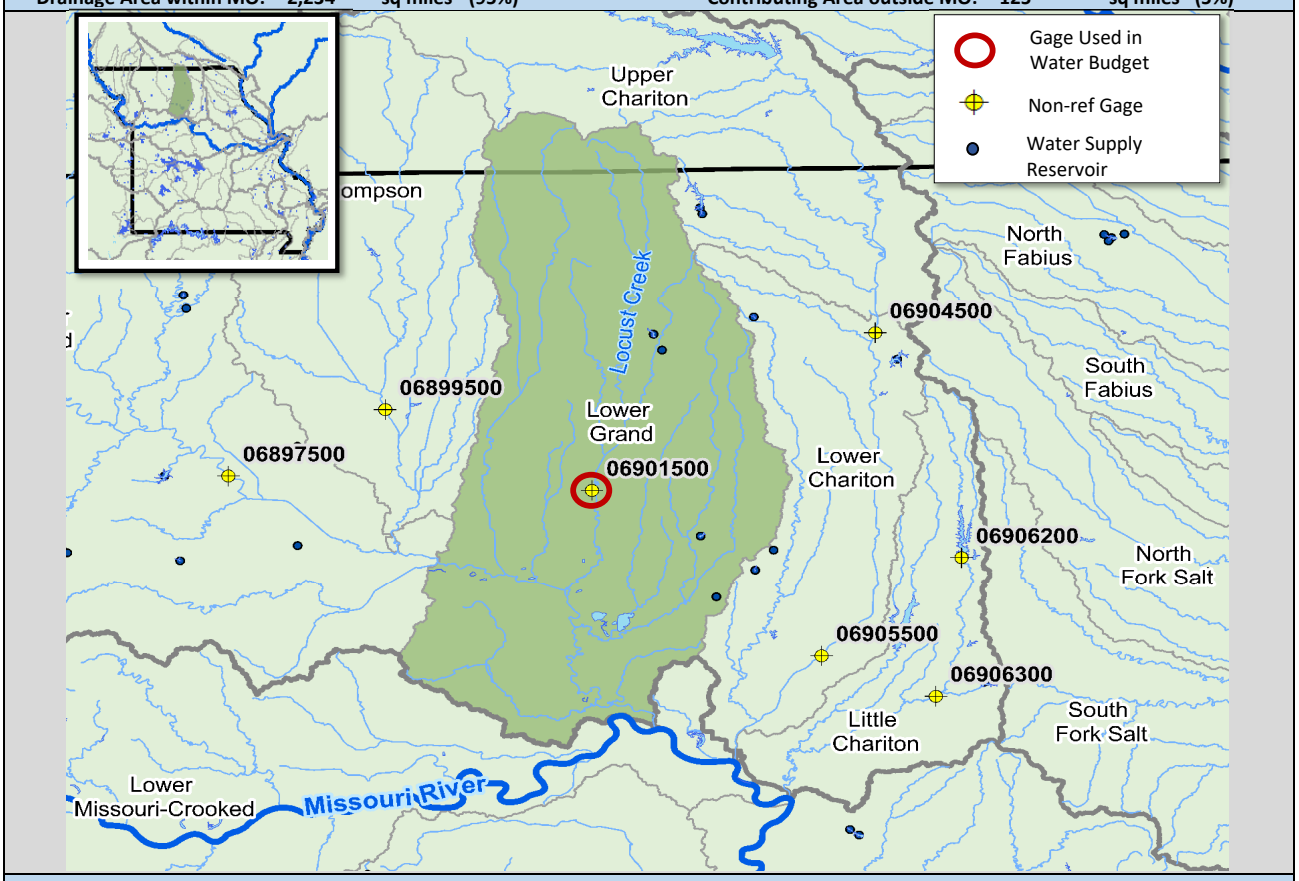
Notes

1. Groundwater demands include alluvial and groundwater aquifer withdrawals. Demands associated with Self-Supplied Domestic and Minor Systems are anticipated to decrease due to projected population decline for the Counties (Daviess, Grundy, Harrison, Livingston, and Mercer) comprising this subbasin, as documented in Table B-1 in Appendix B.
2. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
3. There are no major river inflows for this subbasin which is consistent with the HUC4 summary sheet.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC8, the lowest annual streamflow was 2006 (gage 06899500).
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources and notes:
   a. Missouri Water Supply Study, Missouri DNR, June 2011
   b. US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/
8. Ozark Aquifer includes both the upper, middle, and lower ozark aquifer and the associated Cambrian and Ordavician systems north of the Missouri River.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. Aquifer storage from: MoDNR, 1997. Groundwater Resources of Missouri, WRP 46, Missouri State Water Plan Series, Vol II.

Lower Grand Subbasin Summary

Subbasin Name: Lower Grand **HUC8 Number:** 10280103

Drainage Area within MO: 2,234 sq miles (95%) **Contributing Area outside MO:** 125 sq miles (5%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use

Withdrawal and Return	3.6

Returns

Wastewater	2.4
Thermoelectric	0.0

Inflows

Streamflow (from upstream HUC8s)	2,892
Precipitation (In-State)	4,182

Naturalized Streamflow	1,169	
Water Supply Reservoir Storage	2,459	million gallons

Surface Water Outflow

4,053

Consumptive Use & ET

Evapotranspiration	653
Consumptive Withdrawals	7.3

Lower Grand Subbasin Summary

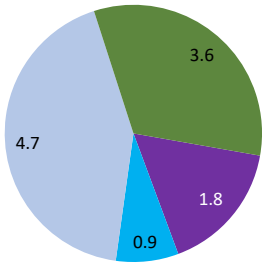
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	4,687,625	39.35	4,182
Evapotranspiration	731,468	6.14	653
Streamflow (from Out of State)	73,385	0.62	65
Streamflow (from other In-State HUC8)	0	0.00	0
Streamflow originating in HUC8	1,310,532	11.00	1,169
Total Streamflow	1,383,917	11.62	1,235
Nonconsumptive Surface Water Withdrawals	4,009	0.03	3.6
Consumptive Surface Water Withdrawals	8,233	0.07	7.3
Total Surface Water Withdrawals	12,243	0.10	10.9

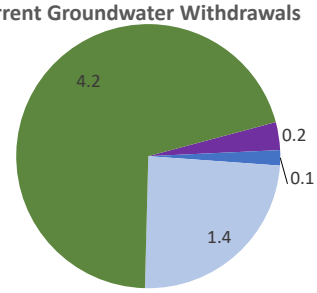
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	2,027	0.02	1.8	1.6
Self-Supplied Nonresidential	962	0.01	0.9	0.8
Agriculture	5,244	0.04	4.7	6.8
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**8,233**	**0.07**	**7.4**	**9.2**
Aquaculture and Wetlands	4,009	0.03	3.6	3.6
Total Nonconsumptive	**4,009**	**0.03**	**3.6**	**3.6**
Groundwater Withdrawals By Sector[1]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	229	0.00	0.2	0.2
Self-Supplied Domestic and Minor Systems	124	0.00	0.1	0.1
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	1,618	0.01	1.4	2.0
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**1,971**	**0.01**	**1.7**	**2.3**
Aquaculture and Wetlands	4,694	0.04	4.2	4.2
Total Nonconsumptive	**4,694**	**0.04**	**4.2**	**4.2**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



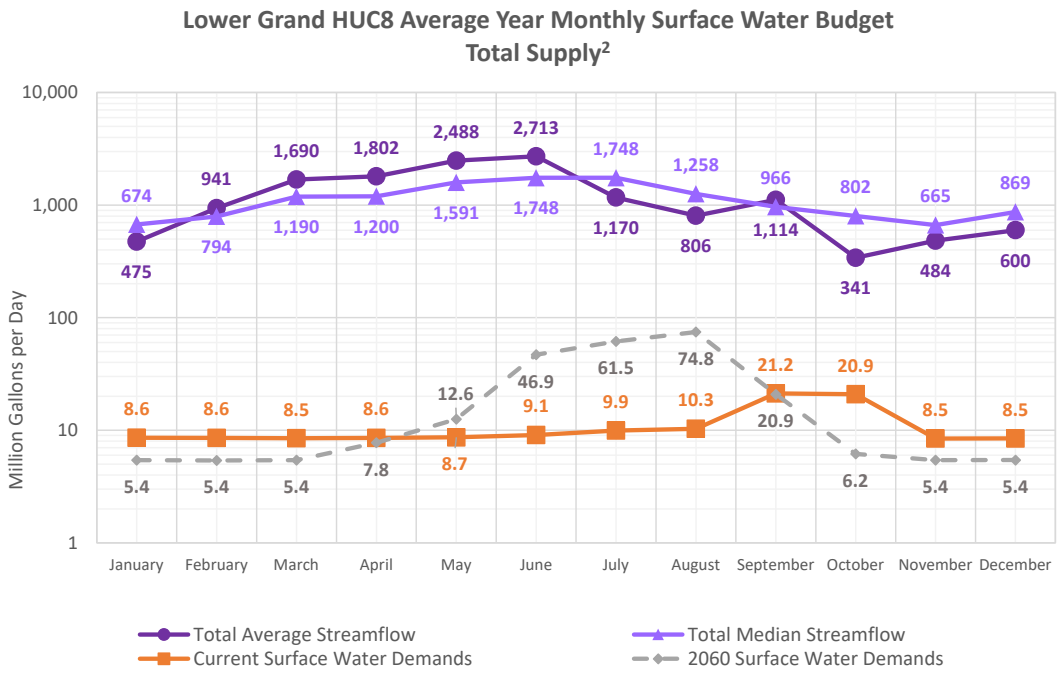
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture

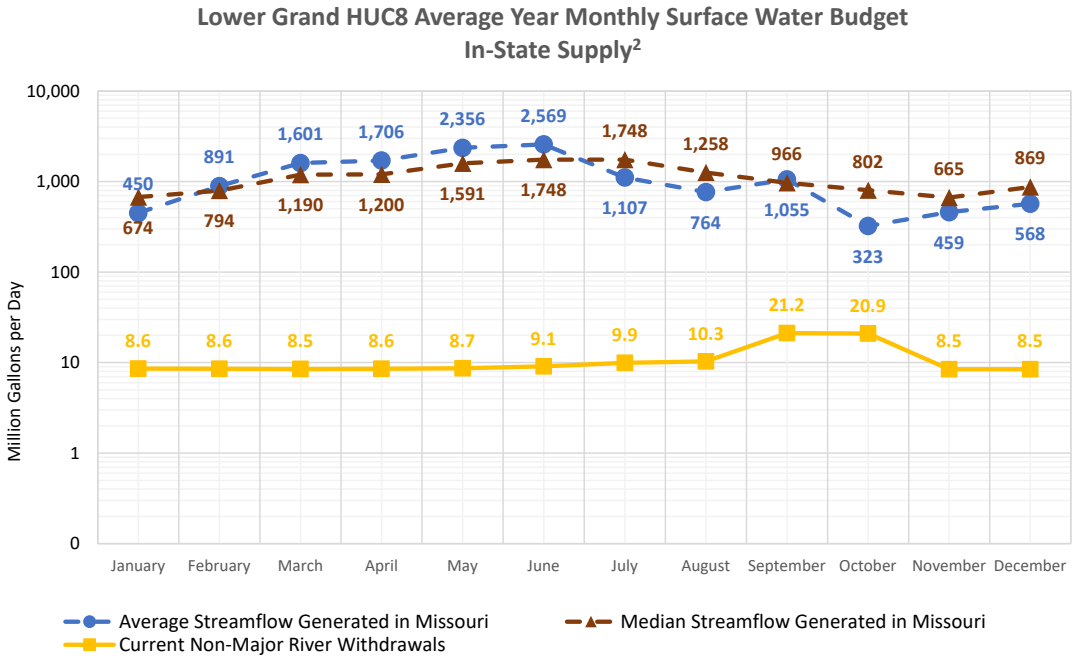
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Lower Grand Subbasin Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands

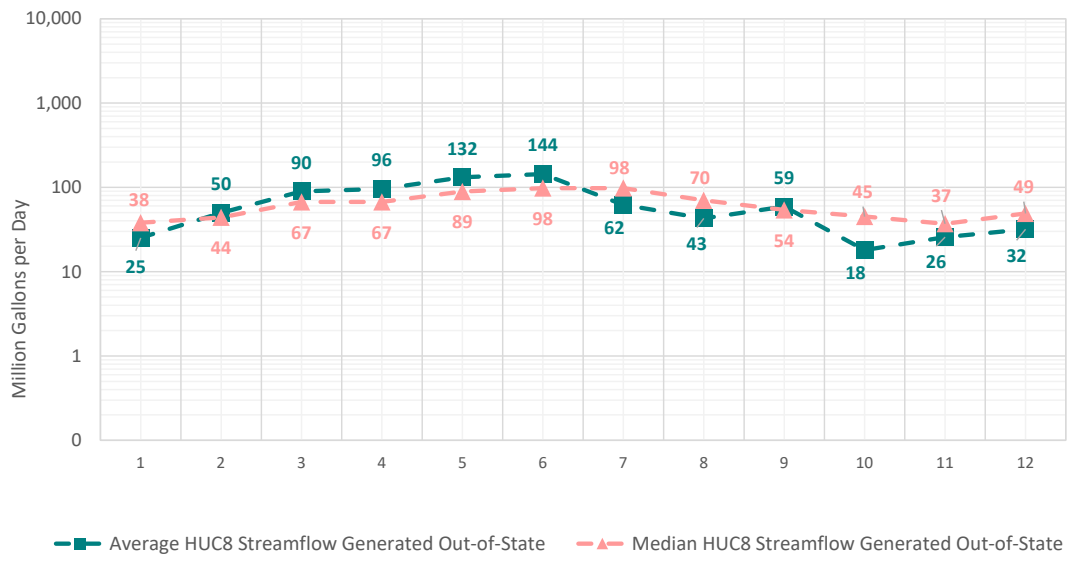




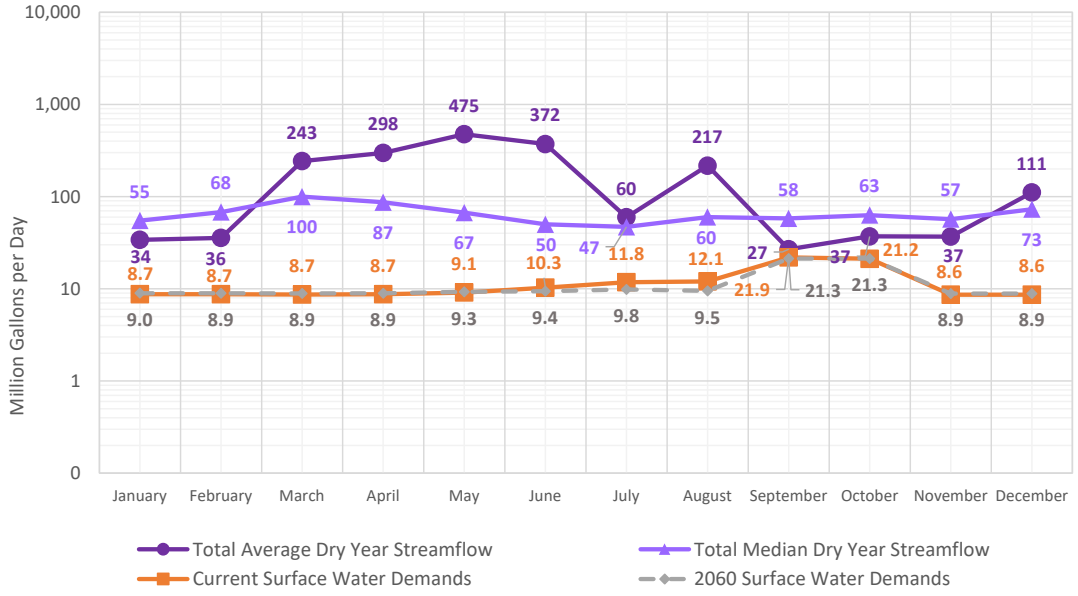
Lower Grand Subbasin Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands

Lower Grand HUC8 Average Year Monthly Surface Water Budget Out-of-State[2,3]



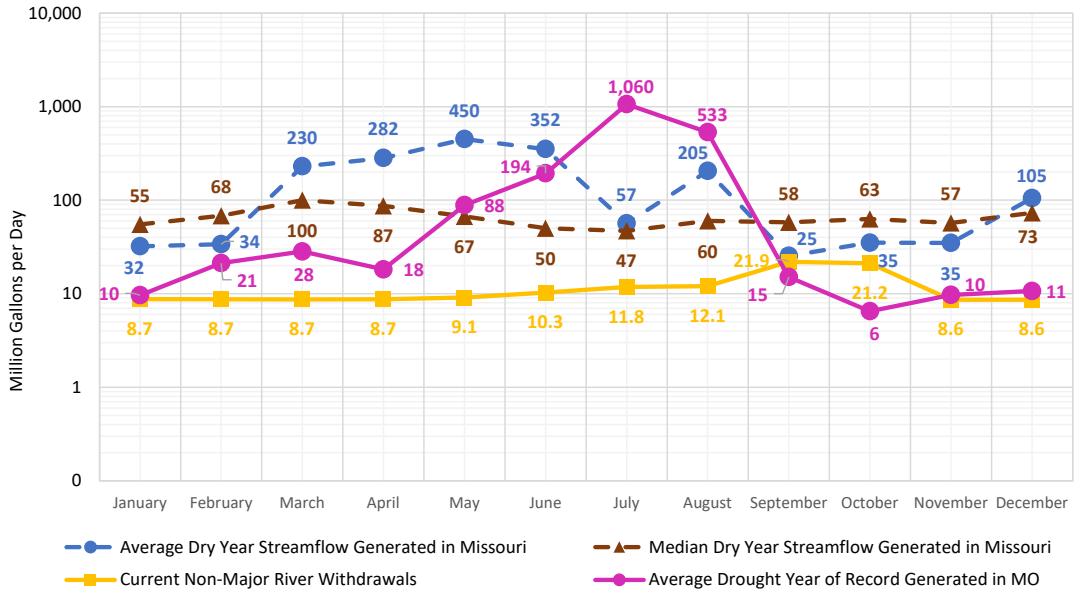
Lower Grand HUC8 Dry Year Monthly Surface Water Budget Total Supply[2,4]



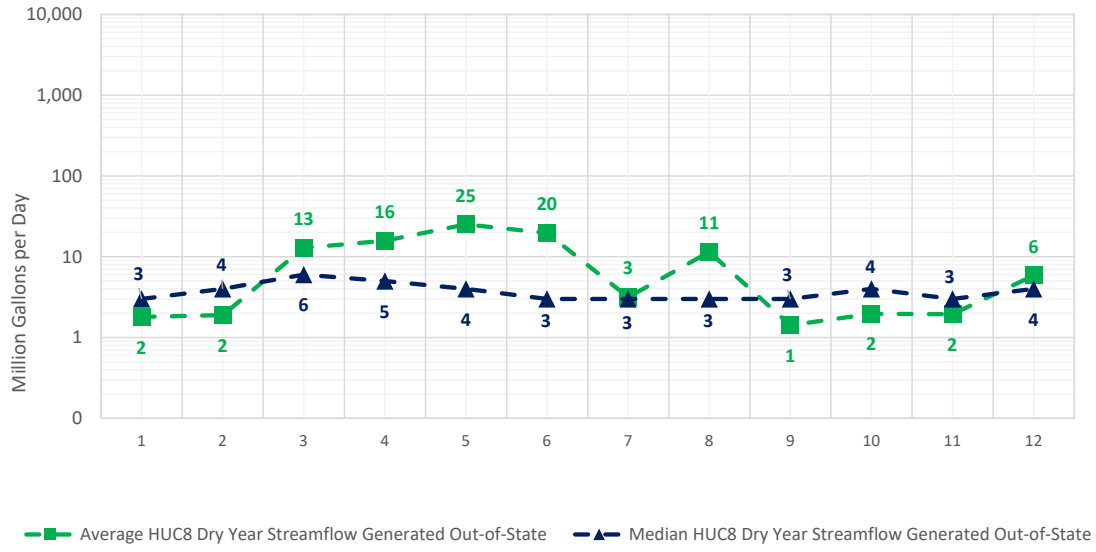
Lower Grand Subbasin Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands

Lower Grand HUC8 Dry Year and Drought Year of Record Monthly Surface Water Budget In-State Supply[2,4,5]

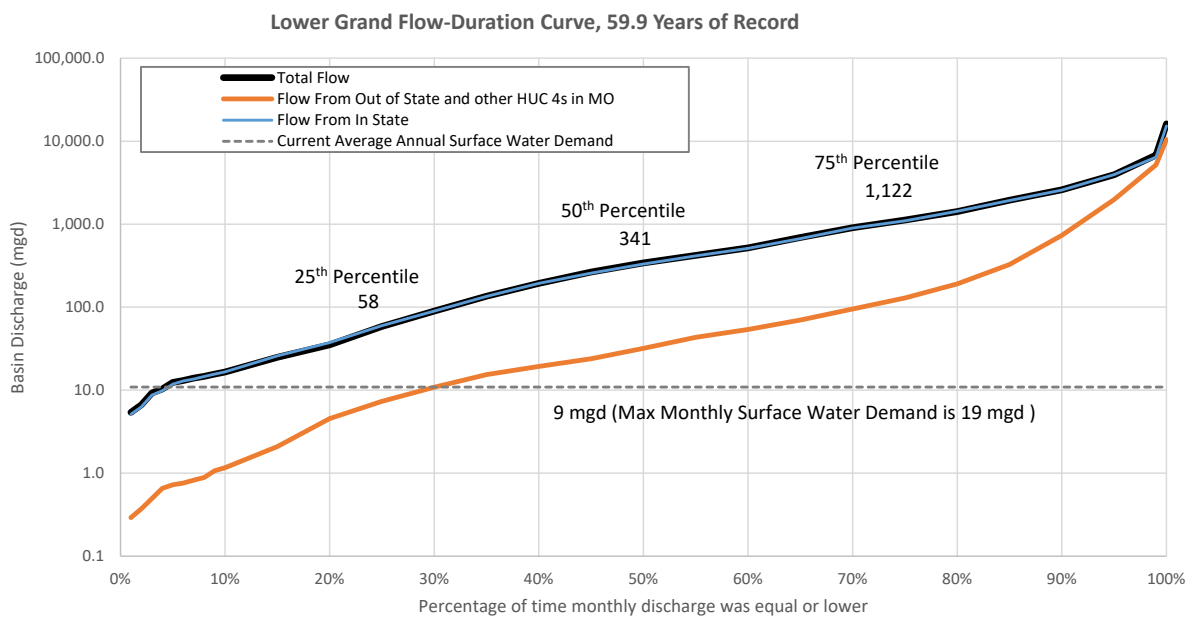


Lower Grand HUC8 Dry Year Monthly Surface Water Budget Out-of-State[2,3,4]



Lower Grand Subbasin Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Water Supply Storage Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
City Lake (Brookfield)	2,070	675	0.21	10280103	23	22
City Lake (Green City)	428	139	0.15	10280103	16	14
Newer City Lake (Marceline)	1,990	648	0.41	10280103	27	23
Elmwood Lake (Milan)	2,503	816	0.74	10280103	13	12
Golf Course Lake (Milan)	555	181	0.12	10280103	85	54
Total	**7,546**	**2,459**	**1.63**			

Lower Grand Subbasin Summary

Summary of Groundwater Demands by Aquifer

Groundwater Withdrawals By Sector	2016 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.15	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.05	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.02	0.00	1.43	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.22**	**0.00**	**1.54**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	3.84	0.00	0.00	0.35	0.00	0.00	0.00	0.00
Total Nonconsumptive	**3.84**	**0.00**	**0.00**	**0.35**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**4.06**	**0.00**	**1.54**	**0.35**	**0.00**	**0.00**	**0.00**	**0.00**

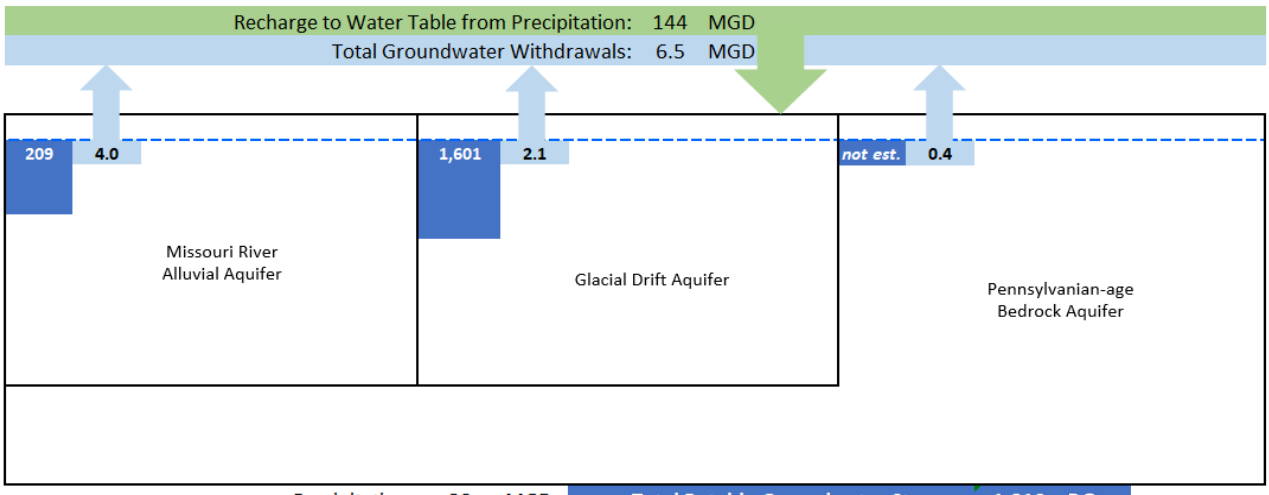
Groundwater Withdrawals By Sector	2060 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.14	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.04	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.02	0.00	2.00	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.20**	**0.00**	**2.09**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	3.84	0.00	0.00	0.35	0.00	0.00	0.00	0.00
Total Nonconsumptive	**3.84**	**0.00**	**0.00**	**0.35**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**4.04**	**0.00**	**2.09**	**0.35**	**0.00**	**0.00**	**0.00**	**0.00**

Lower Grand Subbasin Summary

Average Year Groundwater Budget (2060 Demands)[10]

Average Year Groundwater Budget (2060 Demands)
Lower Grand HUC8 - 10280103

Groundwater withdrawals are shown in million gallons per day (MGD)
Potable groundwater storage is shown in billion gallons (BG)



Precipitation:	39	MGD	**Total Potable Groundwater Storage:**	**1,810**	**BG**
Evapotranspiration:	23	MGD	Total Groundwater Withdrawals:	6.5	MGD
Recharge to Water Table from Precipitation:	144	MGD	Increase in Withdrawals from 2016:	0.5	MGD
			Withdrawals as a Percent of Recharge from Precipitation:	4%	

The above graphic is a generalized representation of aquifers present in each HUC8.

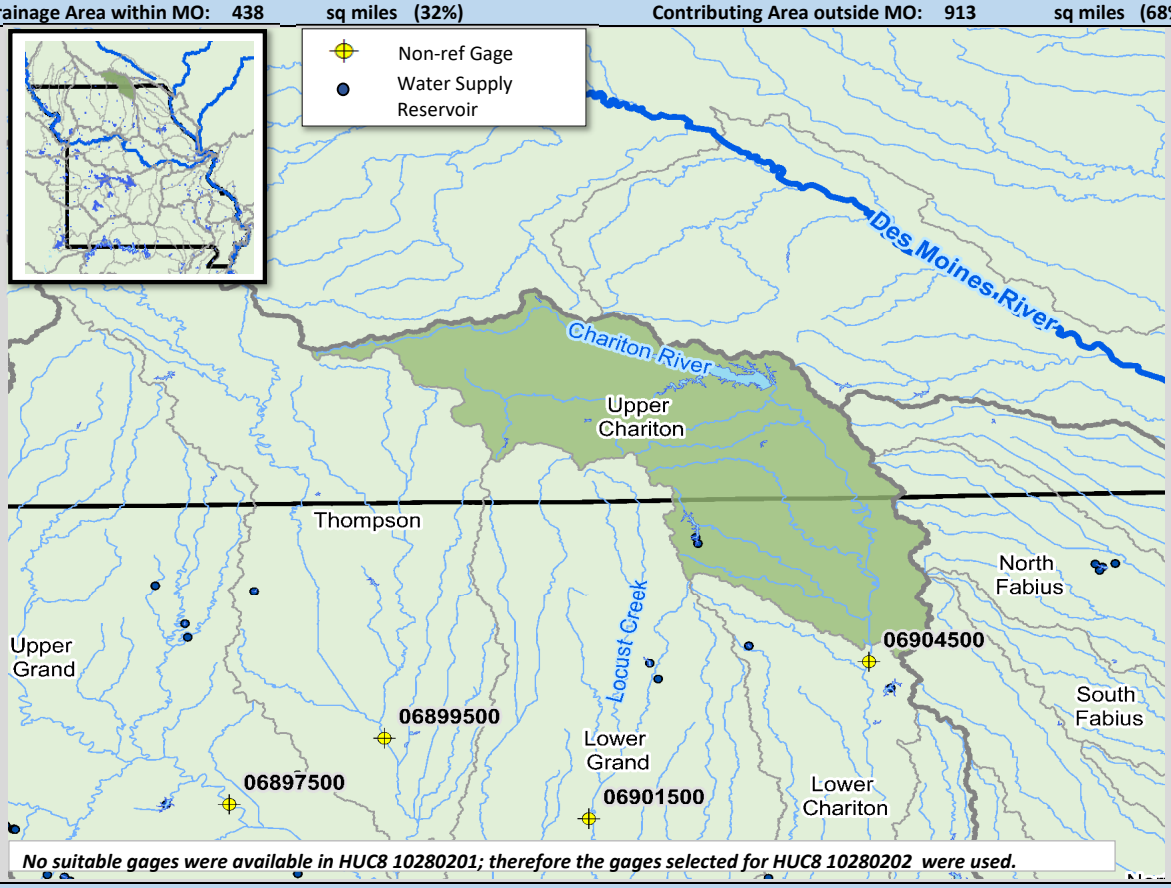
Notes

1. Groundwater demands include alluvial and groundwater aquifer withdrawals.
2. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
3. There are no major river inflows for this subbasin which is consistent with the HUC4 summary sheet.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC8, the lowest annual streamflow was 2006 (gage 06901500).
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources and notes:
   a. *Missouri Water Supply Study, Missouri DNR, June 2011*
   b. *US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/*
8. Ozark Aquifer includes both the upper, middle, and lower ozark aquifer and the associated Cambrian and Ordavician systems north of the Missouri River.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. Aquifer storage from: MoDNR, 1997. Groundwater Resources of Missouri, WRP 46, Missouri State Water Plan Series, Vol II.

Upper Chariton Subbasin Summary

Subbasin Name: Upper Chariton **HUC8 Number:** 10280201

Drainage Area within MO: 438 sq miles (32%) **Contributing Area outside MO:** 913 sq miles (68%)



No suitable gages were available in HUC8 10280201; therefore the gages selected for HUC8 10280202 were used.

Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.

All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	0.2

Returns	
Wastewater	0.6
Thermoelectric	0.0

Inflows	
Streamflow (from Out of State)	439
Precipitation (In-State)	816

Naturalized Streamflow	211	
Water Supply Reservoir Storage	8,048	million gallons

Surface Water Outflow: 646

Consumptive Use & ET	
Evapotranspiration	25
Consumptive Withdrawals	3.3

Upper Chariton Subbasin Summary

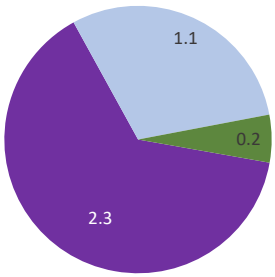
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	915,095	39.13	816
Evapotranspiration	28,185	1.21	25
Streamflow (from Out of State)	491,626	21.02	439
Streamflow (from other In-State HUC8)	0	0.00	0
Streamflow originating in HUC8	236,204	10.10	211
Total Streamflow	727,830	31.12	649
Nonconsumptive Surface Water Withdrawals	227	0.01	0.2
Consumptive Surface Water Withdrawals	3,701	0.16	3.3
Total Surface Water Withdrawals	3,929	0.17	4

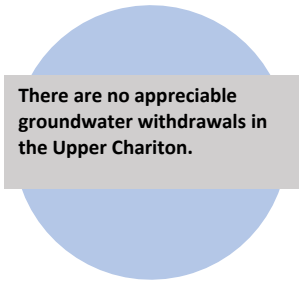
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	2,523	0.11	2.3	2.1
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	1,179	0.05	1.1	1.5
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**3,702**	**0.16**	**3.4**	**3.6**
Aquaculture and Wetlands	227	0.01	0.2	0.2
Total Nonconsumptive	**227**	**0.01**	**0.2**	**0.2**
Groundwater Withdrawals By Sector[1]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	0	0.00	0.0	0.0
Self-Supplied Domestic and Minor Systems	0	0.00	0.0	0.0
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	134	0.01	0.1	0.2
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**134**	**0.01**	**0.1**	**0.2**
Aquaculture and Wetlands	0	0.00	0.0	0.0
Total Nonconsumptive	**0**	**0.00**	**0.0**	**0.0**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



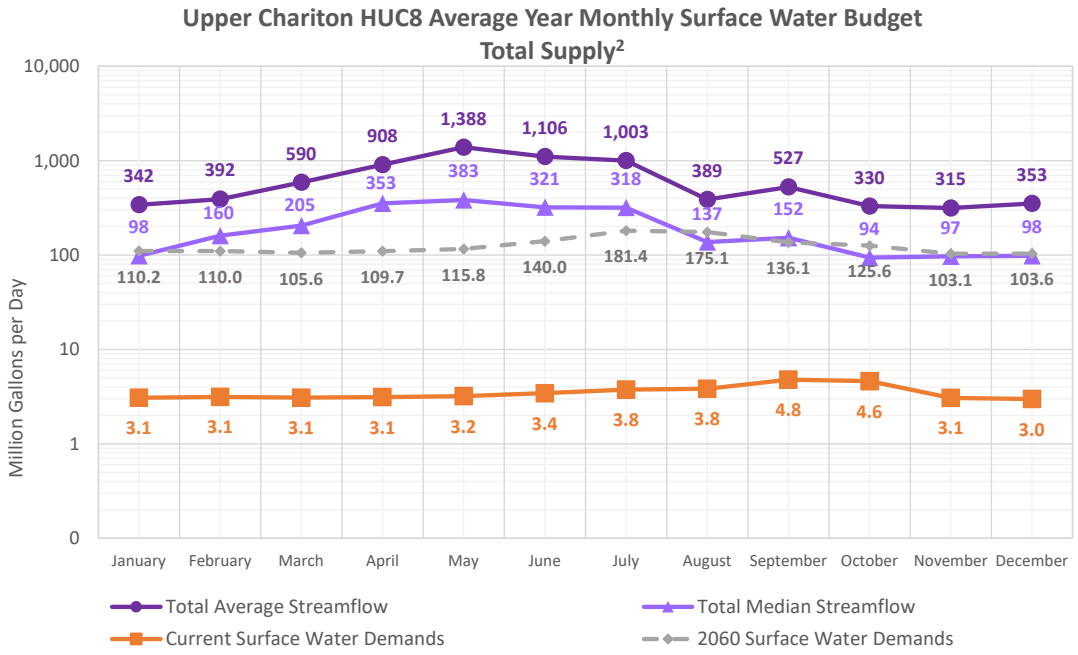
Consumptive Demands
- Major Water Systems
- Agriculture

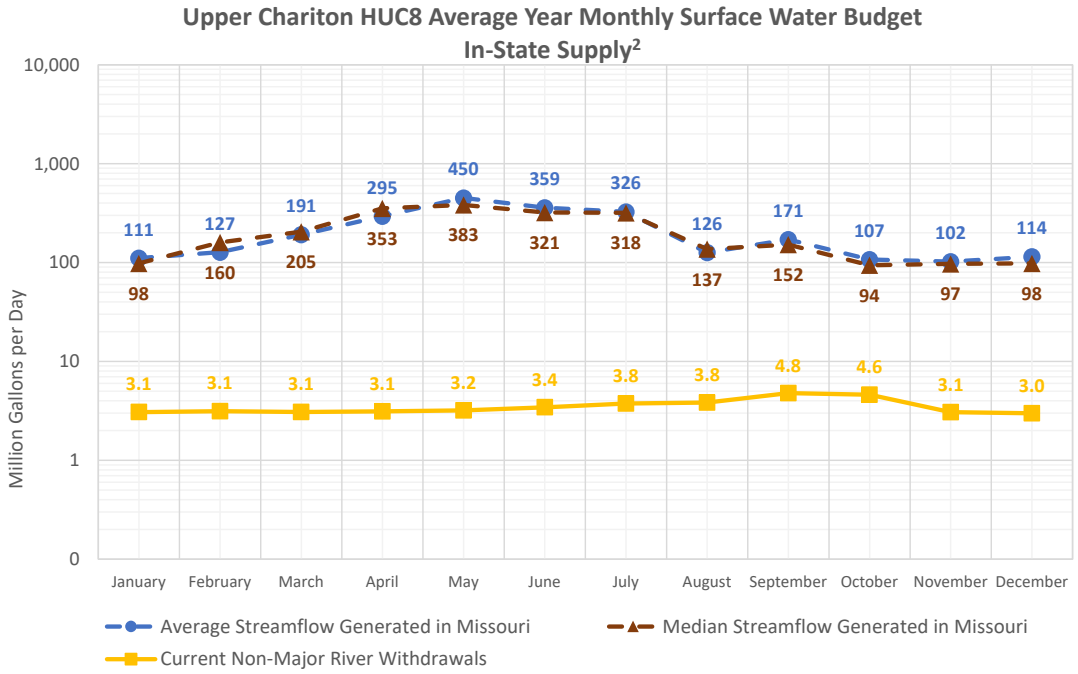
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Upper Chariton Subbasin Summary

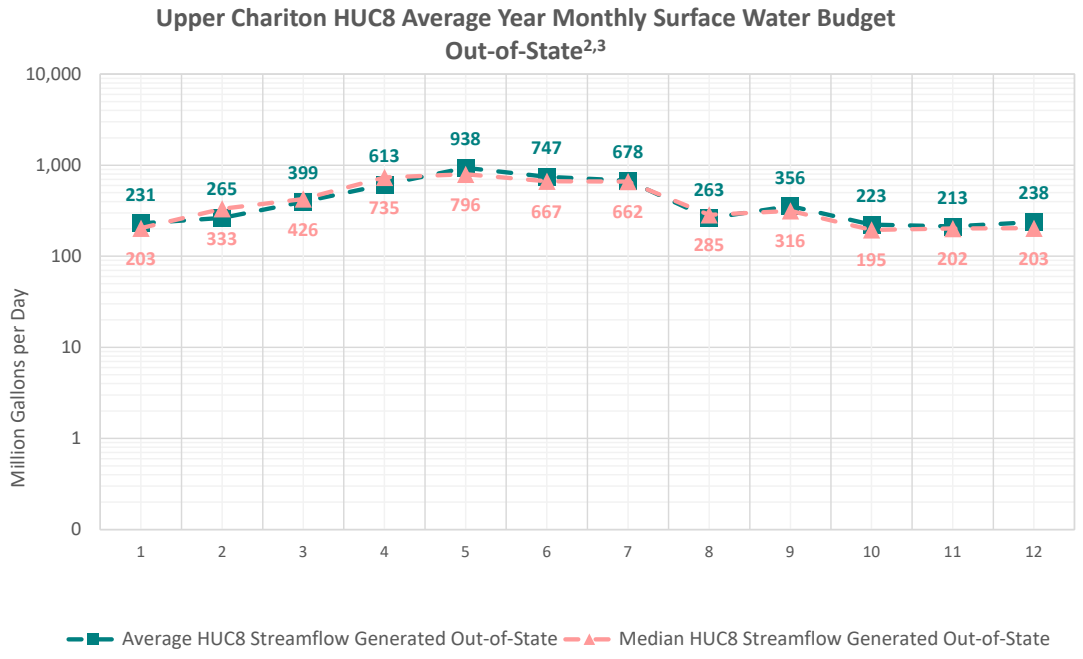
Comparison of Monthly Surface Water Availability to Current and Future Demands

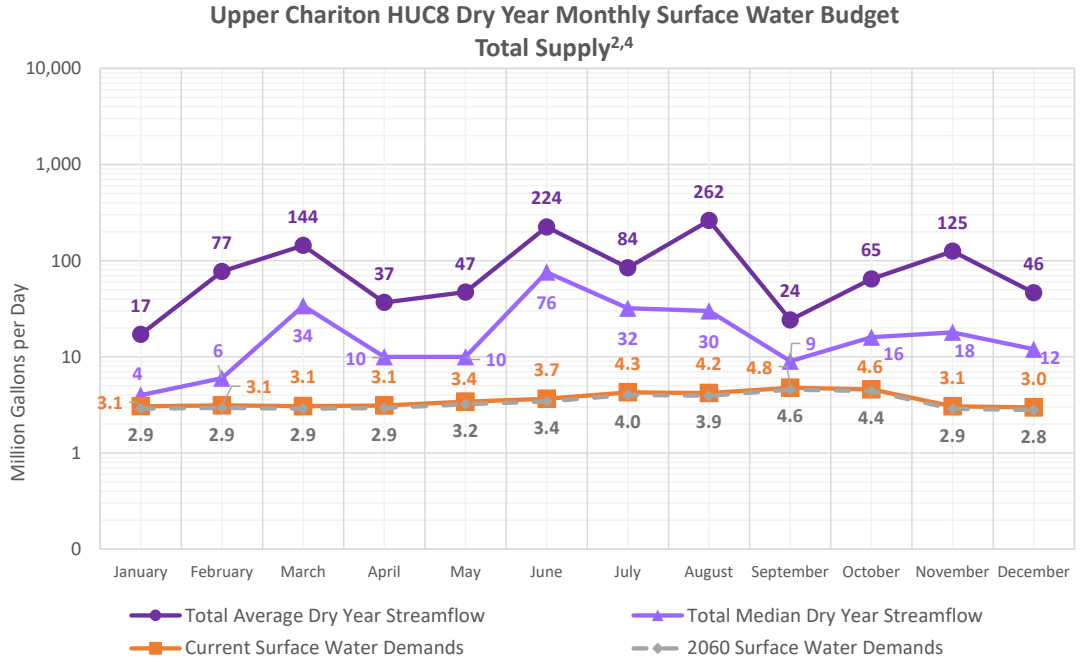




Upper Chariton Subbasin Summary

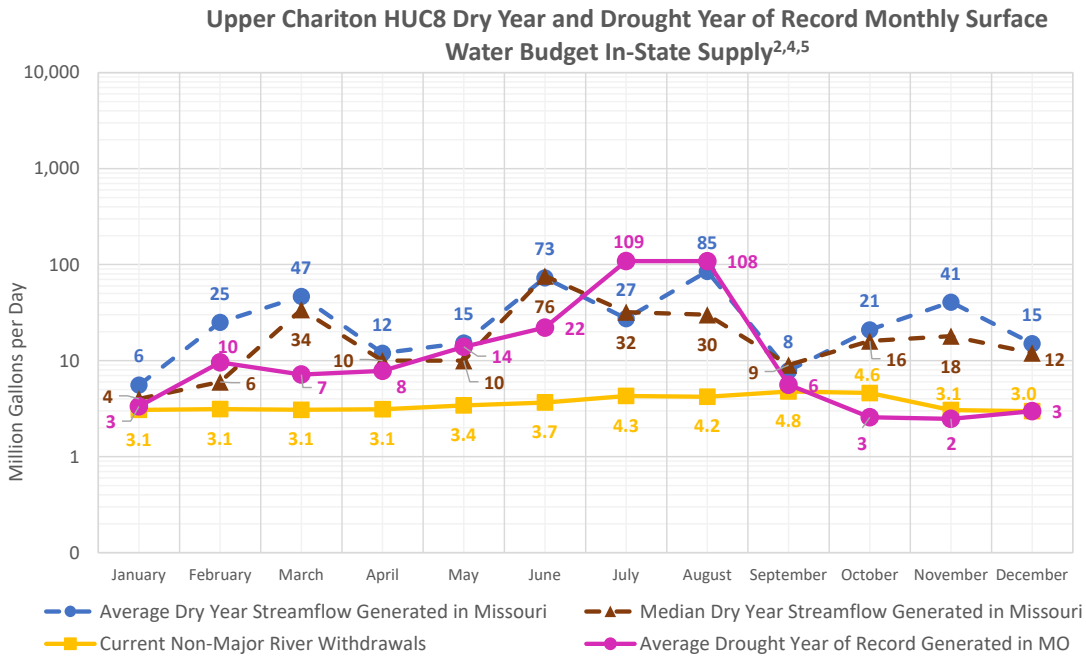
Comparison of Monthly Surface Water Availability to Current and Future Demands

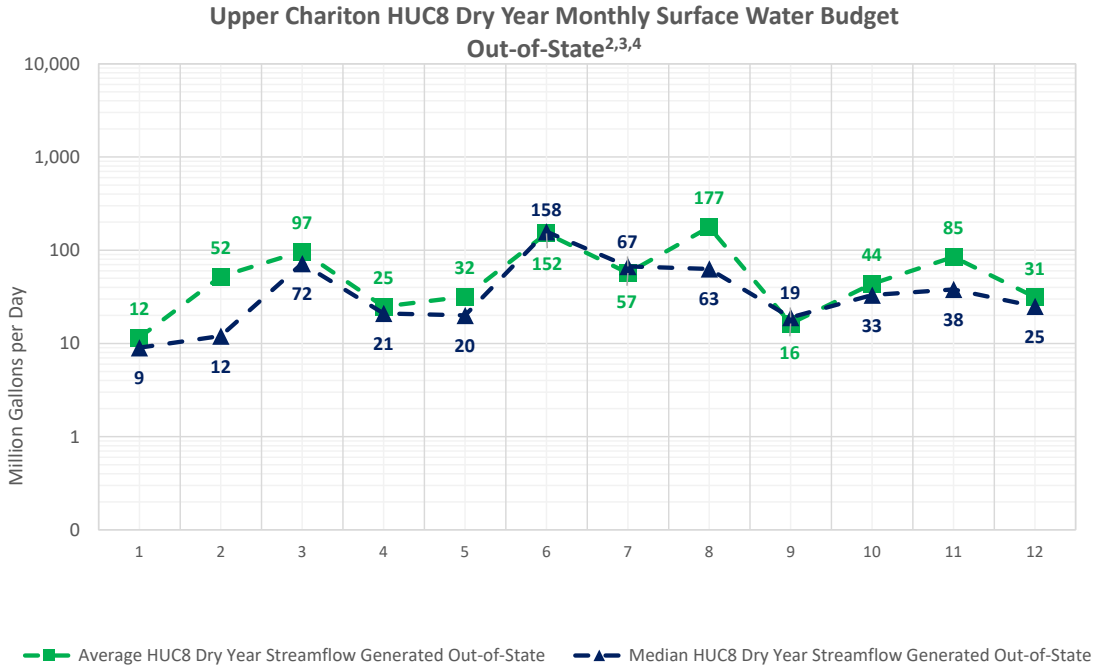




Upper Chariton Subbasin Summary

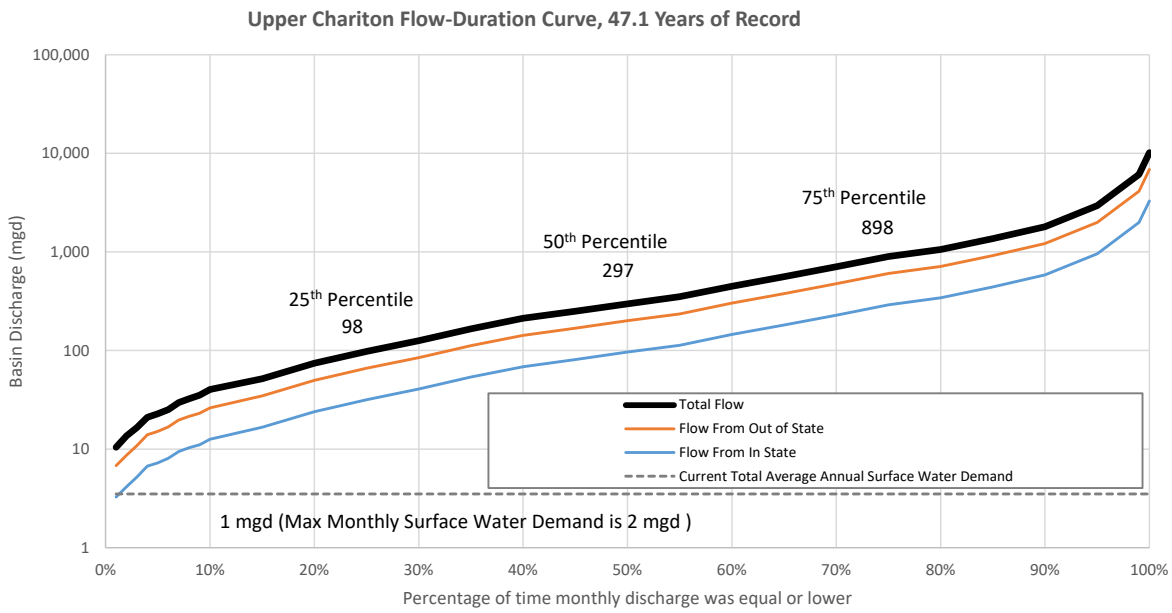
Comparison of Monthly Surface Water Availability to Current and Future Demands





Upper Chariton Subbasin Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Water Supply Storage Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Hazel Creek Lake (Kirksville)	8,680	2,828	1.95	10280201	25	22
Lake Mahoney (Unionville)	620	202	0.28	10280201	16	11
Lake Thunderhead (Unionville)	15,400	5,018	3.36	10280201	63	63
Total	**24,700**	**8,048**	**5.59**			

Upper Chariton Subbasin Summary

Summary of Groundwater Demands by Aquifer

Groundwater Withdrawals By Sector	2016 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.00**	**0.00**	**0.12**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.00**	**0.00**	**0.12**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

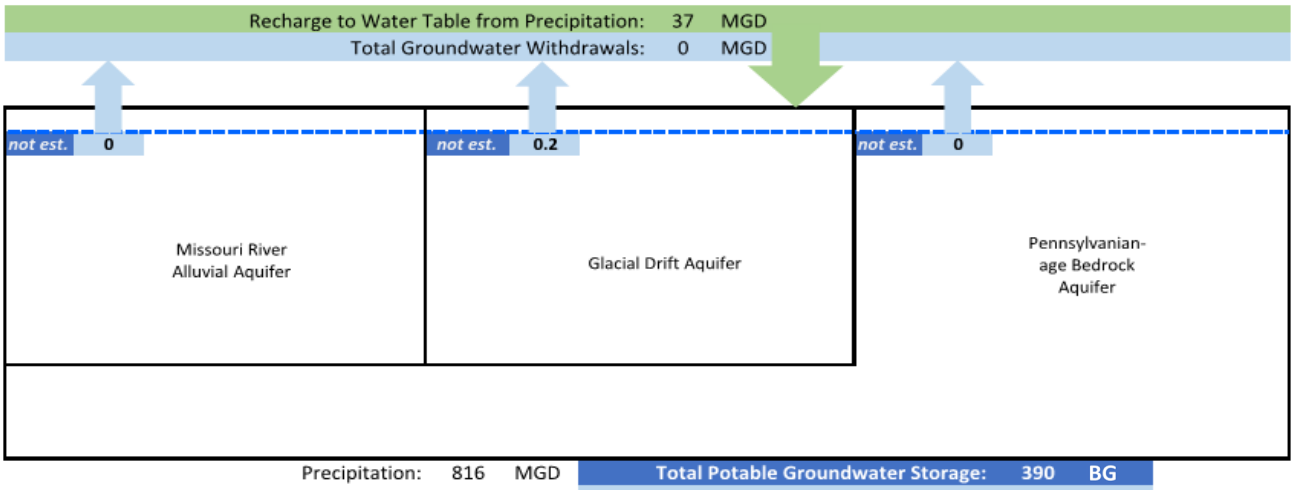
Groundwater Withdrawals By Sector	2060 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.00**	**0.00**	**0.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.00**	**0.00**	**0.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Upper Chariton Subbasin Summary

Average Year Groundwater Budget (2060 Demands)[10]

Average Year Groundwater Budget (2060 Demands)
Upper Chariton HUC8 - 10280201

Groundwater withdrawals are shown in million gallons per day (MGD)
Potable groundwater storage is shown in billion gallons (BG)



Precipitation:	816	MGD	**Total Potable Groundwater Storage:**	**390**	**BG**
Evapotranspiration:	473	MGD	Total Groundwater Withdrawals:	0.2	MGD
Recharge to Water Table from Precipitation:	37	MGD	Increase in Withdrawals from 2016:	0.1	MGD
			Withdrawals as a Percent of Recharge from Precipitation:	0%	

The above graphic is a generalized representation of aquifers present in each HUC8.

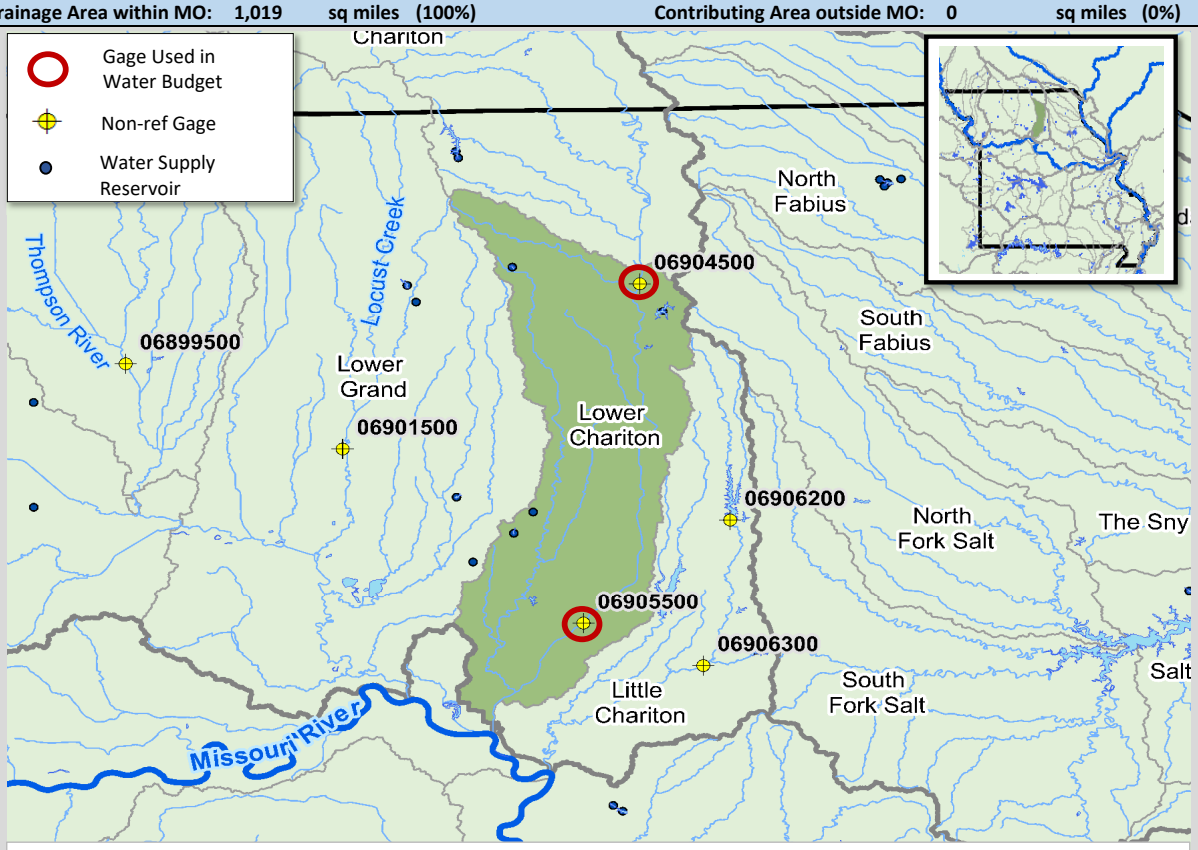
Notes

1. Groundwater demands include alluvial and groundwater aquifer withdrawals. For all subbasins, the proportion of alluvial/aquifer sources used to meet agricultural demands were assumed to remain constant through 2060. However, there are no existing groundwater withdrawals in this subbasin, therefore, projected 2060 agriculture groundwater demands were not assigned to an aquifer in the 'Summary of Groundwater Demands by Aquifer' on page 7 or the 'Average Year Groundwater Budget (2060 Demands)'
2. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
3. There are no major river inflows for this subbasin which is consistent with the HUC4 summary sheet.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC8, the lowest annual streamflow was 2000 for both gages (gages 06905500 and 06904500).
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources:
   a. *Missouri Water Supply Study, Missouri DNR, June 2011*
   b. *US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/*
8. Ozark Aquifer includes both the upper, middle, and lower ozark aquifer and the associated Cambrian and Ordavician systems north of the Missouri River.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. Aquifer storage from: MoDNR, 1997. Groundwater Resources of Missouri, WRP 46, Missouri State Water Plan Series, Vol II.

Lower Chariton Subbasin Summary

Subbasin Name: Lower Chariton **HUC8 Number:** 10280202

Drainage Area within MO: 1,019 sq miles (100%) **Contributing Area outside MO:** 0 sq miles (0%)



Streamflow data from gage 06905500 was subtracted from gage 06904500 to characterize streamflow.

Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	0.2

Returns	
Wastewater	0.1
Thermoelectric	0.0

Inflows	
Streamflow (from Upper Chariton)	646
Precipitation (In-State)	1,950

Naturalized Streamflow	490	
Water Supply Reservoir Storage	4,275	million gallons

Surface Water Outflow: 1,135

Consumptive Use & ET	
Evapotranspiration	136
Consumptive Withdrawals	1.3

Lower Chariton Subbasin Summary

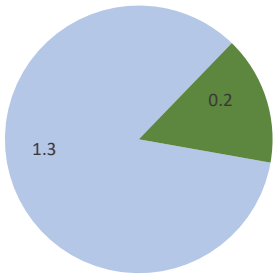
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	2,185,775	40.23	1,950
Evapotranspiration	152,155	2.80	136
Streamflow (from Out of State)	0	0.00	0
Streamflow (from other In-State HUC8)	0	0.00	0
Streamflow originating in HUC8	548,810	10.10	490
Total Streamflow	548,810	10.10	490
Nonconsumptive Surface Water Withdrawals	271	0.00	0.2
Consumptive Surface Water Withdrawals	1,475	0.03	1.3
Total Surface Water Withdrawals	1,746	0.03	2

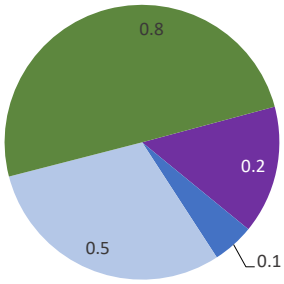
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	0	0.00	0.0	0.0
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	1,475	0.03	1.3	1.9
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**1,475**	**0.03**	**1.3**	**1.9**
Aquaculture and Wetlands	271	0.00	0.2	0.2
Total Nonconsumptive	**271**	**0.00**	**0.2**	**0.2**
Groundwater Withdrawals By Sector[1]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	267	0.00	0.2	0.2
Self-Supplied Domestic and Minor Systems	87	0.00	0.1	0.1
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	534	0.01	0.5	0.7
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**888**	**0.01**	**0.8**	**1.0**
Aquaculture and Wetlands	883	0.02	0.8	0.8
Total Nonconsumptive	**883**	**0.02**	**0.8**	**0.8**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



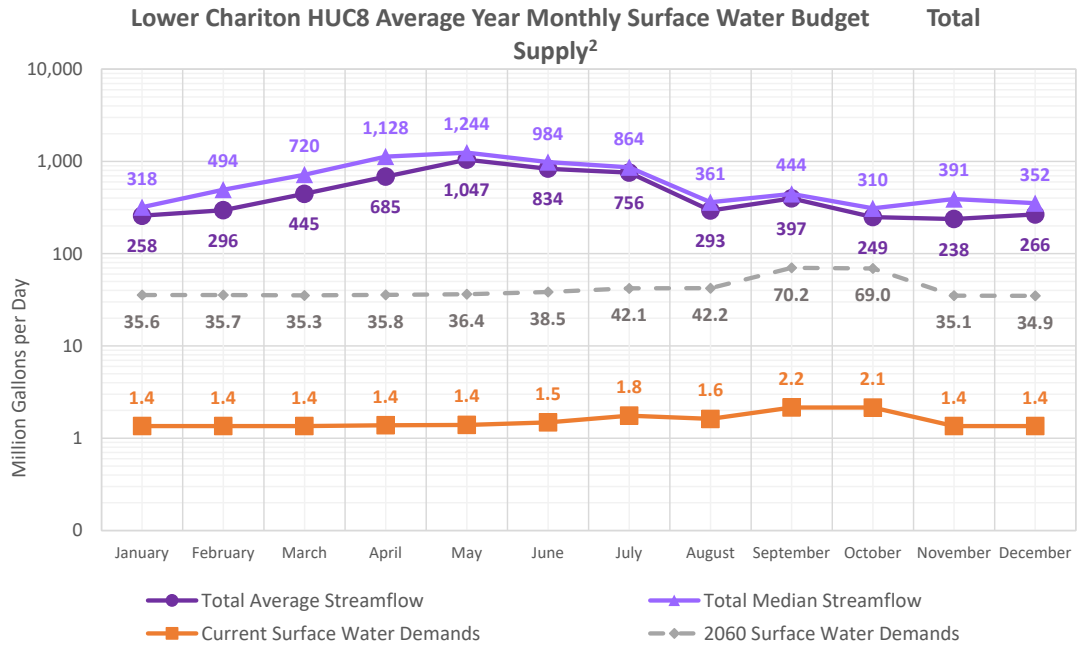
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Agriculture

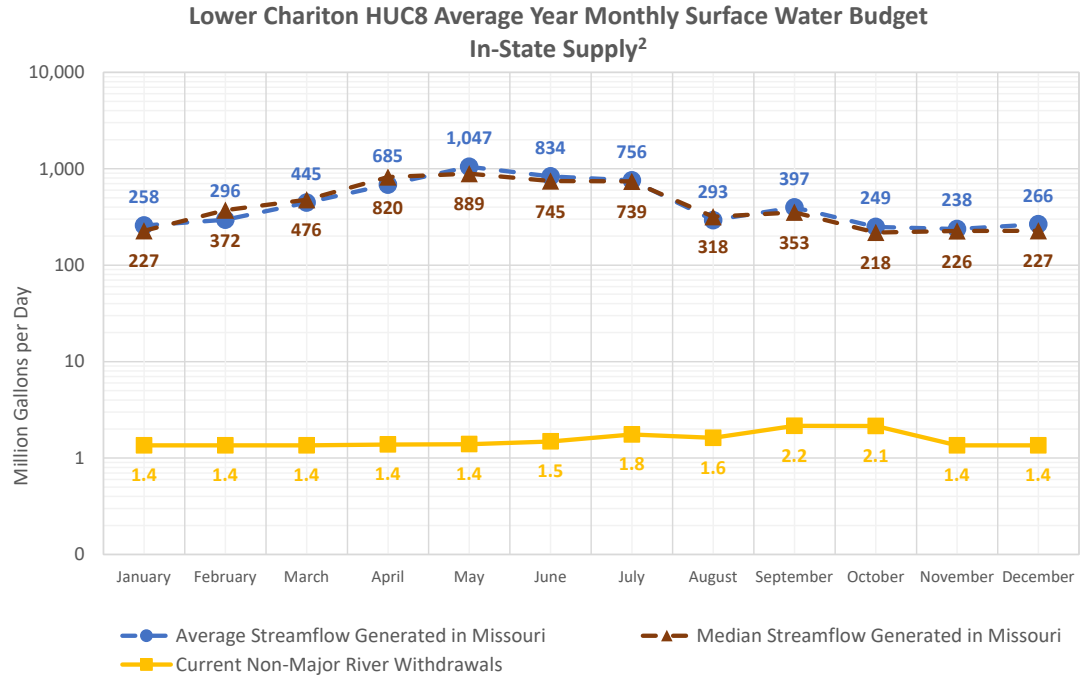
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Lower Chariton Subbasin Summary

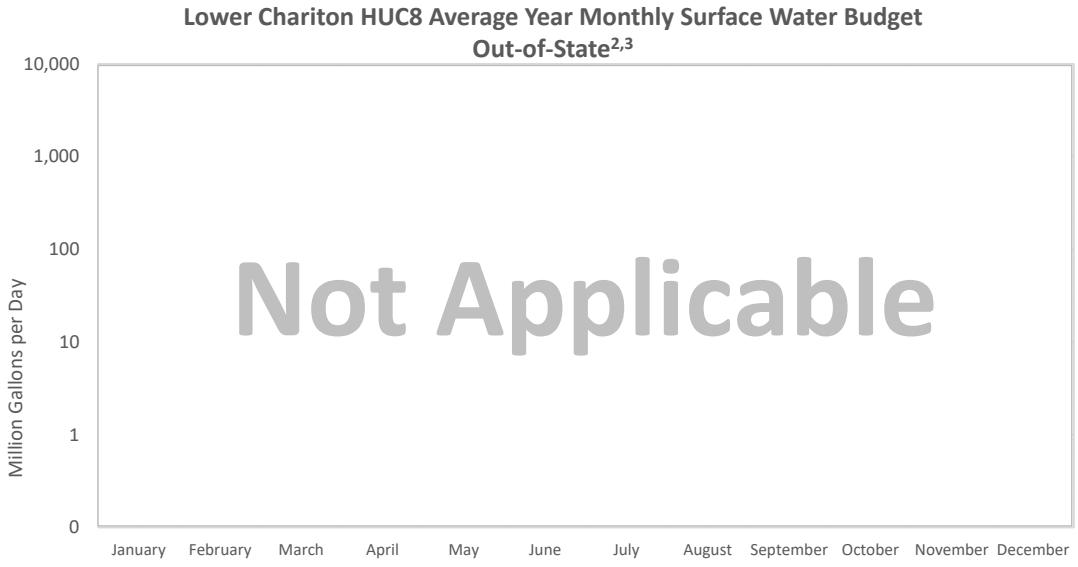
Comparison of Monthly Surface Water Availability to Current and Future Demands

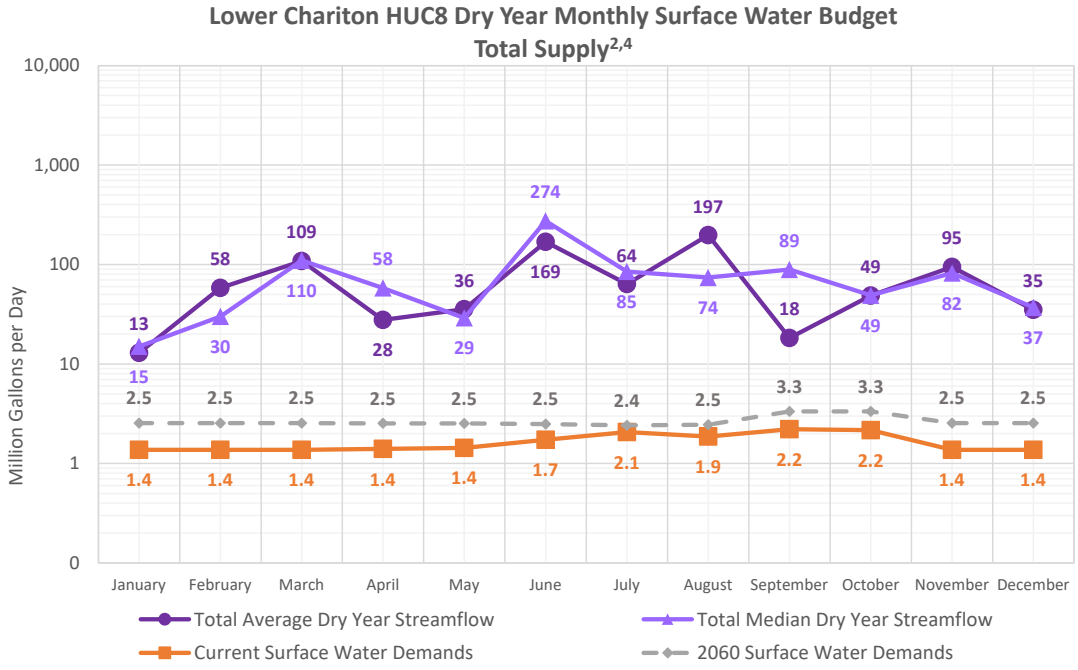




Lower Chariton Subbasin Summary

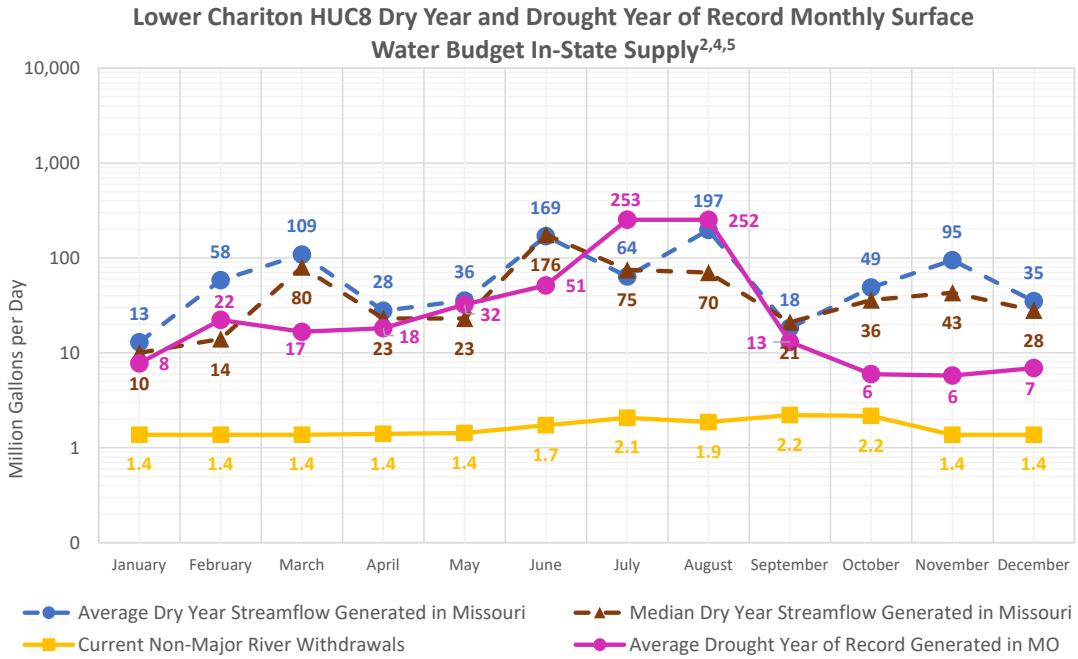
Comparison of Monthly Surface Water Availability to Current and Future Demands





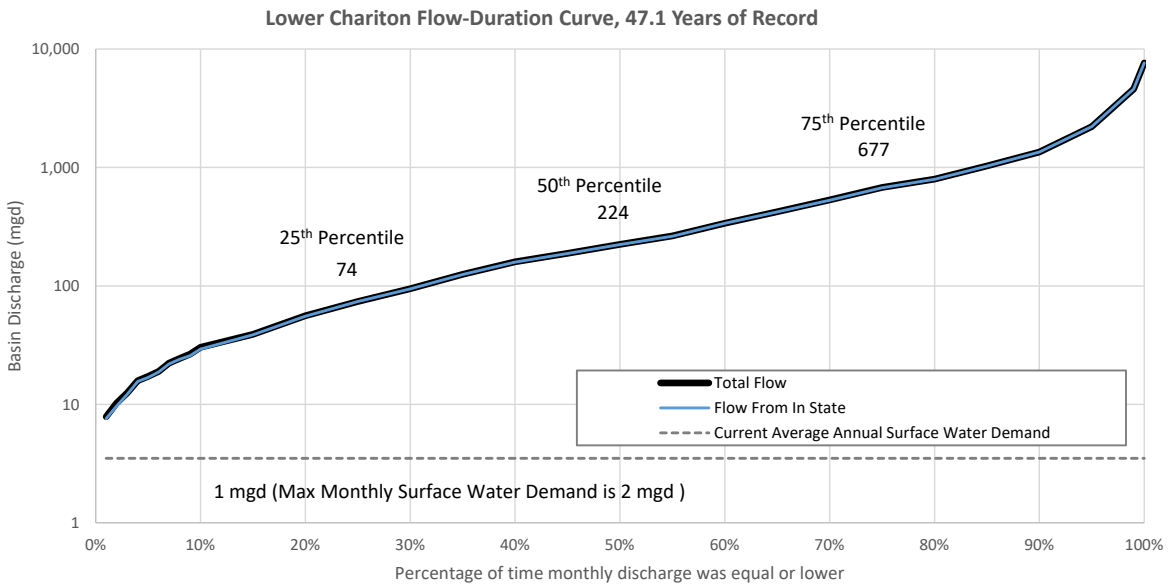
Lower Chariton Subbasin Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands



Lower Chariton Subbasin Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Water Supply Storage Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
City Lake (Bucklin)	157	51	0.05	10280202	16	12
Forest Lake (Kirksville)	12,500	4,073	3.53	10280202	36	29
Older City Lake (Marceline)	462	151	0.06	10280202	29	25
Total	**13,119**	**4,275**	**3.64**			

Lower Chariton Subbasin Summary

Summary of Groundwater Demands by Aquifer

Groundwater Withdrawals By Sector	2016 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.02	0.00	0.05	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.38	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.64**	**0.00**	**0.15**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.78	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.78**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**1.42**	**0.00**	**0.15**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**

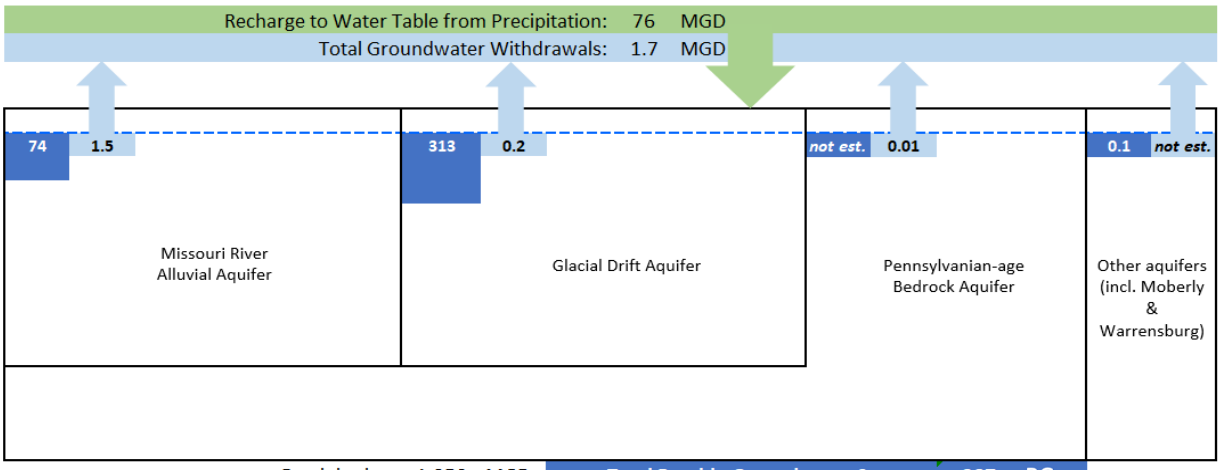
Groundwater Withdrawals By Sector	2060 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.02	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.54	0.00	0.14	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.76**	**0.00**	**0.18**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.78	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.78**	**0.00**	**0.00**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**1.54**	**0.00**	**0.18**	**0.01**	**0.00**	**0.00**	**0.00**	**0.00**

Lower Chariton Subbasin Summary

Average Year Groundwater Budget (2060 Demands)[10]

Average Year Groundwater Budget (2060 Demands)
Lower Chariton HUC8 - 10280202

Groundwater withdrawals are shown in million gallons per day (MGD)
Potable groundwater storage is shown in billion gallons (BG)



Precipitation:	1,950	MGD	**Total Potable Groundwater Storage:**	**387**	**BG**
Evapotranspiration:	1,162	MGD	Total Groundwater Withdrawals:	1.7	MGD
Recharge to Water Table from Precipitation:	76	MGD	Increase in Withdrawals from 2016:	0.1	MGD
			Withdrawals as a Percent of Recharge from Precipitation:	2%	

The above graphic is a generalized representation of aquifers present in each HUC8.

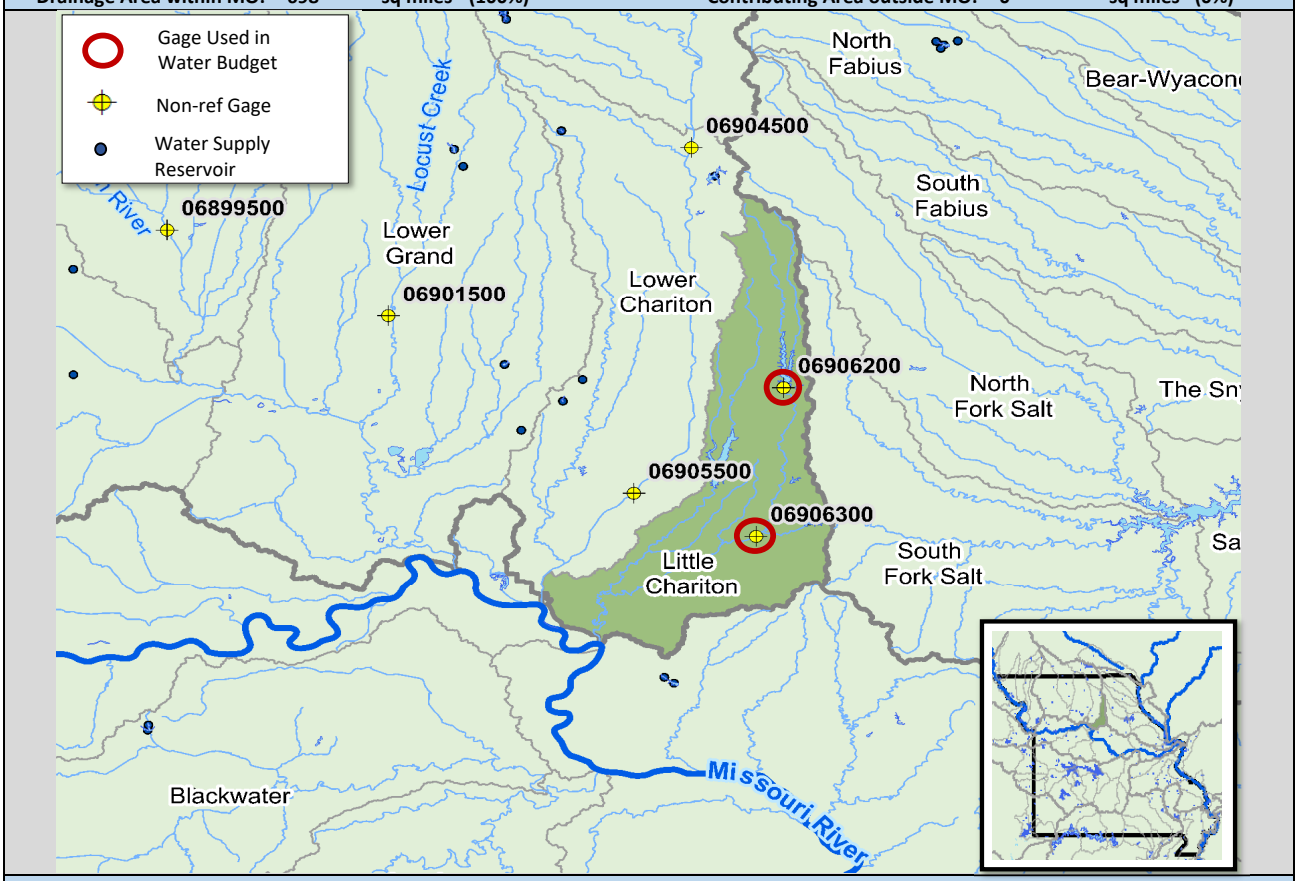
Notes

1. Groundwater demands include alluvial and groundwater aquifer withdrawals.
2. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
3. There are no major river or in-basin, out-of-state inflows for this subbasin which is consistent with the HUC4 summary sheet.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC8, the lowest annual streamflow was 2000 for both gages (gages 06905500 and 06904500).
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources:
   a. *Missouri Water Supply Study, Missouri DNR, June 2011*
   b. *US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/*
8. Ozark Aquifer includes both the upper, middle, and lower ozark aquifer and the associated Cambrian and Ordavician systems north of the Missouri River.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. Aquifer storage from: MoDNR, 1997. Groundwater Resources of Missouri, WRP 46, Missouri State Water Plan Series, Vol II.

Little Chariton Subbasin Summary

Subbasin Name: Little Chariton **HUC8 Number:** 10280203

Drainage Area within MO: 698 sq miles (100%) **Contributing Area outside MO:** 0 sq miles (0%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.
All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	1

Returns	
Wastewater	1.9
Thermoelectric	758.1

Inflows	
Streamflow (from Out of State)	0
Precipitation (In-State)	1,353

Naturalized Streamflow	379	
Water Supply Reservoir Storage	1,711	million gallons

Surface Water Outflow: 372

Consumptive Use & ET	
Evapotranspiration	64
Consumptive Withdrawals	766.8

Little Chariton Subbasin Summary

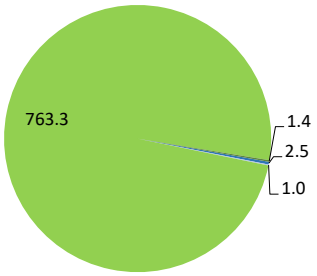
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	1,516,506	40.73	1,353
Evapotranspiration	71,446	1.92	64
Streamflow (from Out of State)	0	0.00	0
Streamflow (from other In-State HUC8)	0	0.00	0
Streamflow originating in HUC8	424,475	11.40	379
Total Streamflow	424,475	11.40	379
Nonconsumptive Surface Water Withdrawals	857,261	23.02	765
Consumptive Surface Water Withdrawals	3,933	0.11	3.5
Total Surface Water Withdrawals	861,193	23.13	768

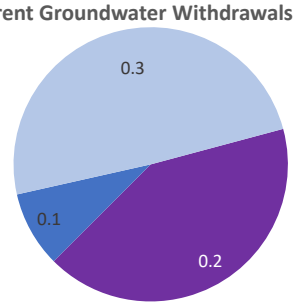
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	2,837	0.08	2.5	2.5
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	1,095	0.03	1.0	1.4
Thermoelectric Power Generation	855,663	22.98	763.3	895.6
Total Consumptive	**859,595**	**23.09**	**766.8**	**899.5**
Aquaculture and Wetlands	1,598	0.04	1.4	1.4
Total Nonconsumptive	**1,598**	**0.04**	**1.4**	**1.4**
Groundwater Withdrawals By Sector[1]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	273	0.01	0.2	0.2
Self-Supplied Domestic and Minor Systems	59	0.00	0.1	0.0
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	324	0.01	0.3	0.4
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**656**	**0.02**	**0.6**	**0.6**
Aquaculture and Wetlands	0	0.00	0.0	0.0
Total Nonconsumptive	**0**	**0.00**	**0.0**	**0.0**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



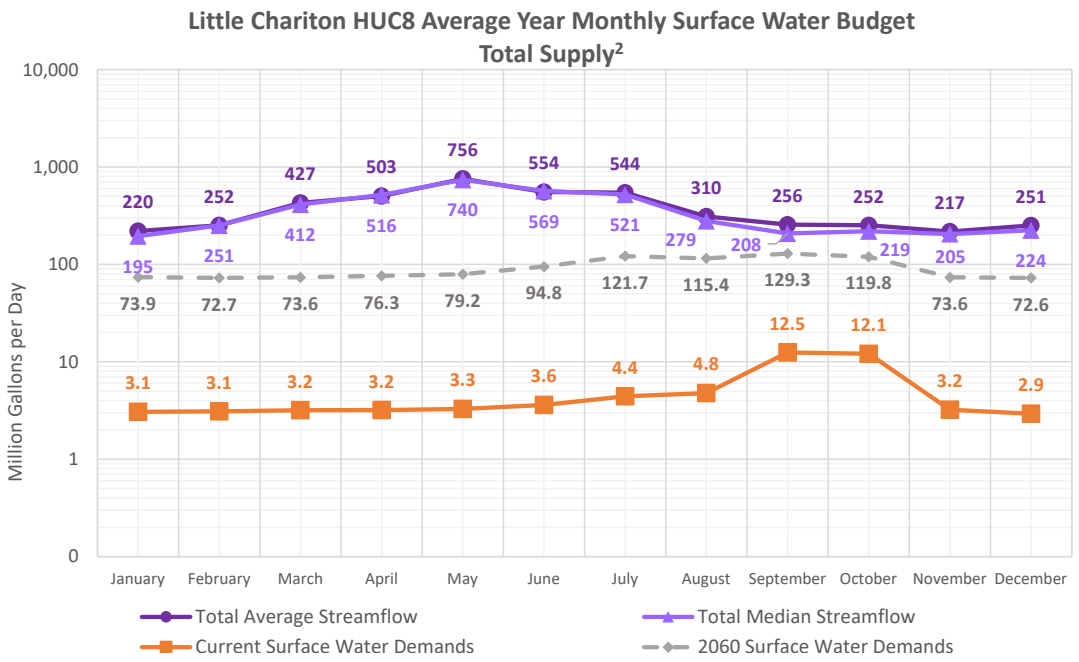
Consumptive Demands
- Major Water Systems
- Self-Supplied Domestic and Minor Systems
- Agriculture
- Thermoelectric Power Generation

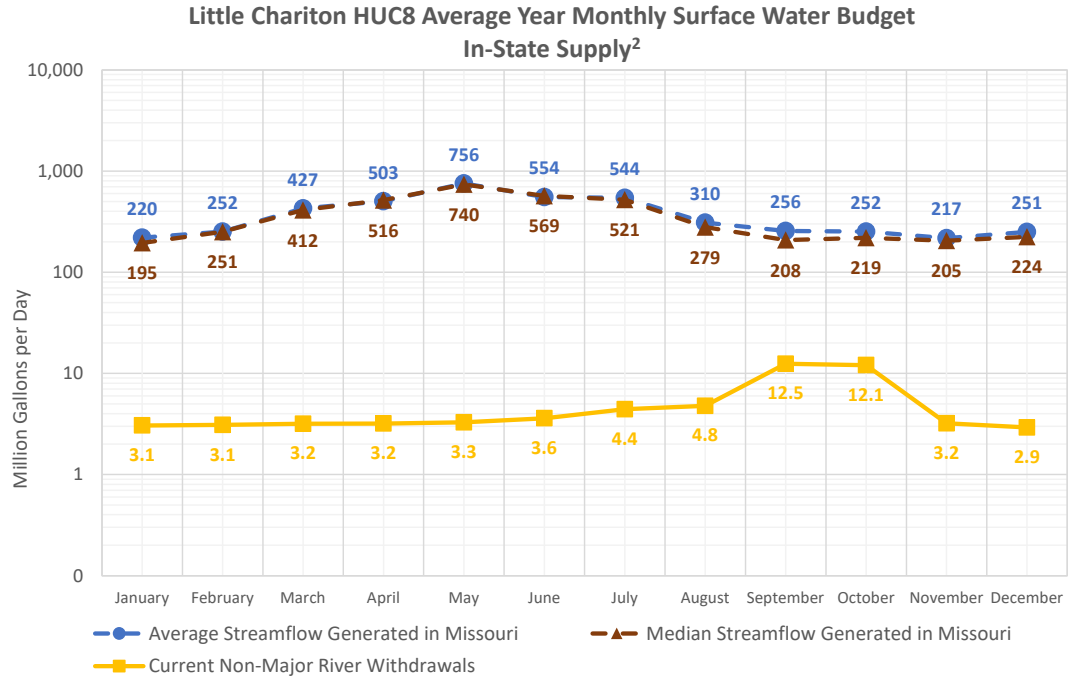
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Little Chariton Subbasin Summary

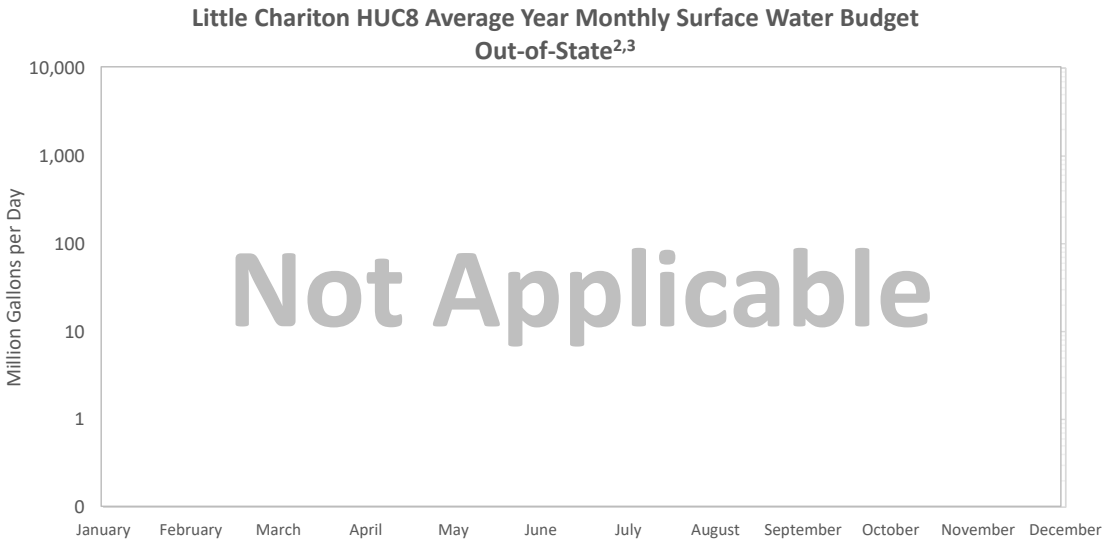
Comparison of Monthly Surface Water Availability to Current and Future Demands

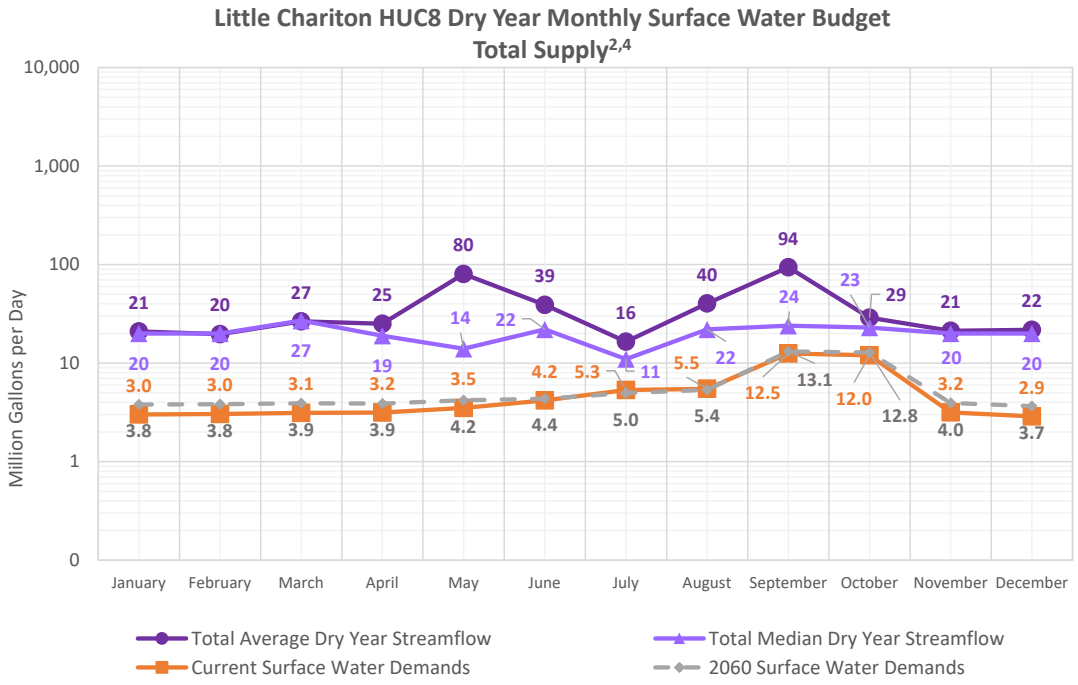




Little Chariton Subbasin Summary

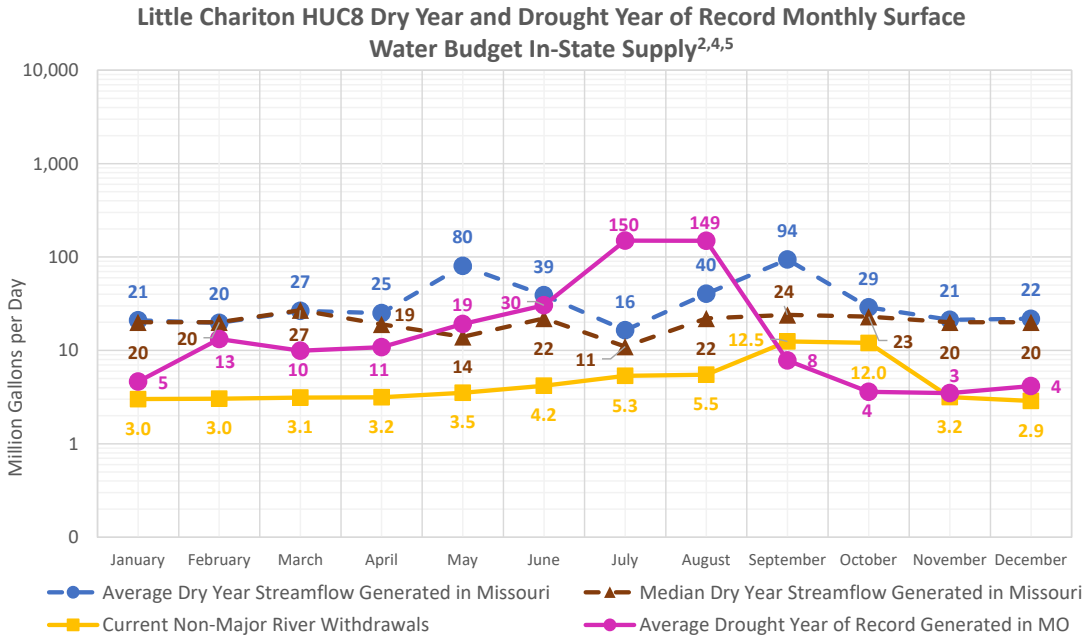
Comparison of Monthly Surface Water Availability to Current and Future Demands





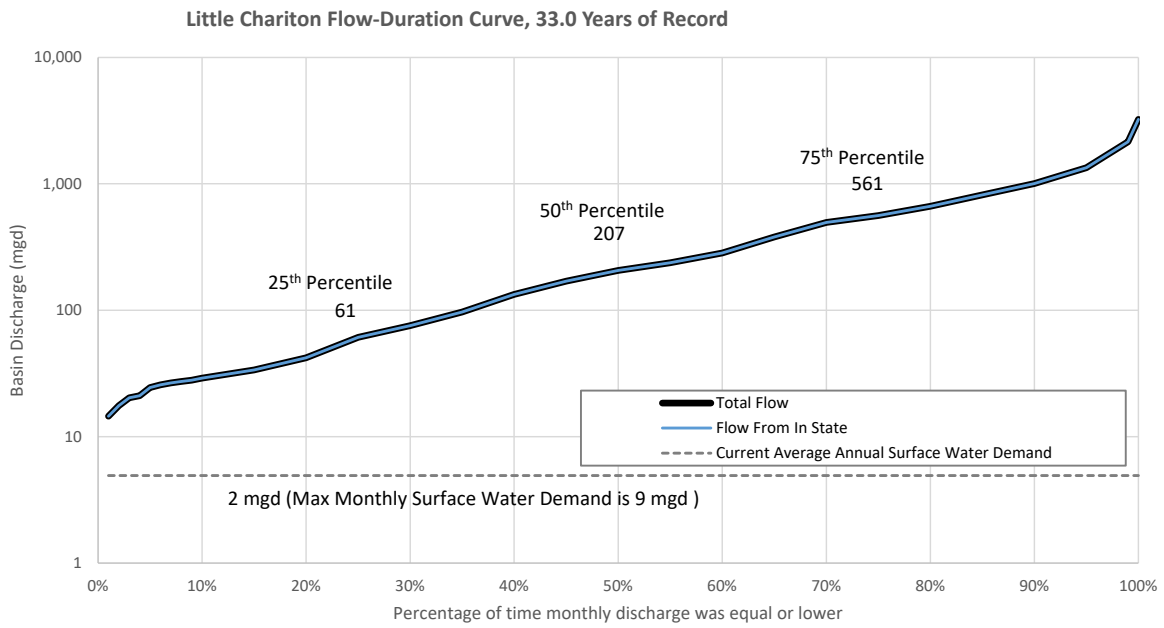
Little Chariton Subbasin Summary

Comparison of Monthly Surface Water Availability to Current and Future Demands



Little Chariton Subbasin Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Water Supply Reservoir Storage[7]

Reservoir (City/Town)	Water Supply Storage ac-ft	Mgal	Optimum Yield (mgd)	HUC8	Months of Storage with Minimum 30-Yr Inflow & No Outflow	Months of Storage with No Net Inflow
Sugar Creek Lake (Moberly)	5,250	1,711	1.20	10280203	30	23
Long Branch Lake	24,400	7,951	1.28	10280203	78	29
Total	**29,650**	**9,662**	**2.48**			

Little Chariton Subbasin Summary

Summary of Groundwater Demands by Aquifer

Groundwater Withdrawals By Sector	2016 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.02	0.00	0.03	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.26**	**0.29**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.26**	**0.29**	**0.03**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

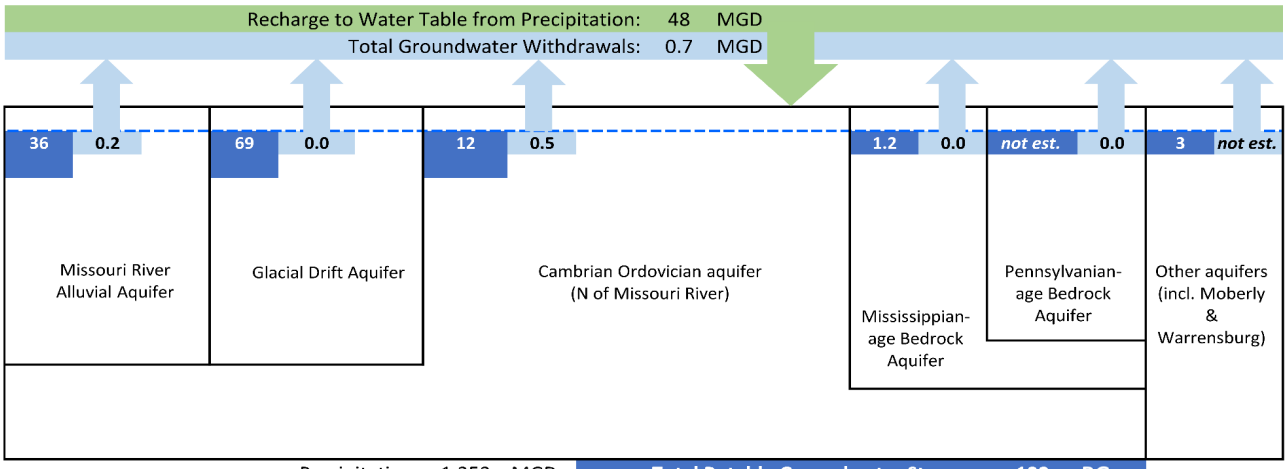
Groundwater Withdrawals By Sector	2060 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.02	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.26**	**0.40**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.26**	**0.40**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Little Chariton Subbasin Summary

Average Year Groundwater Budget (2060 Demands)[10]

Average Year Groundwater Budget (2060 Demands)
Little Chariton HUC8 - 10280203

Groundwater withdrawals are shown in million gallons per day (MGD)
Potable groundwater storage is shown in billion gallons (BG)



Precipitation:	1,353	MGD	**Total Potable Groundwater Storage:**	**122**	**BG**
Evapotranspiration:	813	MGD	Total Groundwater Withdrawals:	0.7	MGD
Recharge to Water Table from Precipitation:	48	MGD	Increase in Withdrawals from 2016:	0.1	MGD
			Withdrawals as a Percent of Recharge from Precipitation:	1%	

The above graphic is a generalized representation of aquifers present in each HUC8.

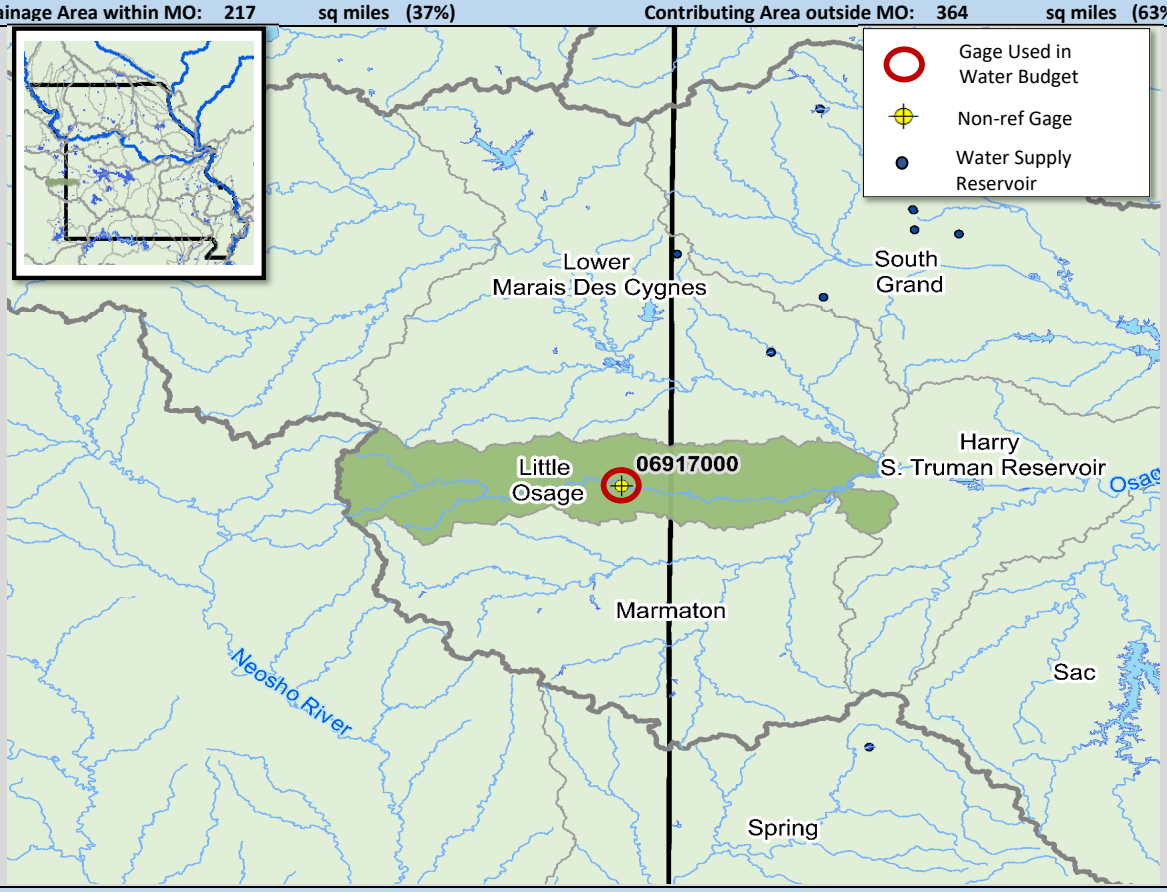
Notes

1. Groundwater demands include alluvial and groundwater aquifer withdrawals.
2. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
3. There are no major river inflows for this subbasin which is consistent with the HUC4 summary sheet.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC8, the lowest annual streamflow was 1989 (gage 06906300) and 1989 (gage 06906200).
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. Reservoir data sources and notes:
   a. Missouri Water Supply Study, Missouri DNR, June 2011
   b. US Army Corps of Engineers, Institute for Water Resources. (2014). Fiscal Year 2014 Value to the Nation Fast Facts Water Supply. Retrieved from http://www.corpsresults.us/
8. Ozark Aquifer includes both the upper, middle, and lower ozark aquifer and the associated Cambrian and Ordavician systems north of the Missouri River.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. Aquifer storage from: MoDNR, 1997. Groundwater Resources of Missouri, WRP 46, Missouri State Water Plan Series, Vol II.

Little Osage Subbasin Summary

Subbasin Name: Little Osage **HUC8 Number:** 10290103

Drainage Area within MO: 217 sq miles (37%) **Contributing Area outside MO:** 364 sq miles (63%)



Annual Surface Water Budget

The annual water budget reflects average hydrologic conditions and current demands.

All values are in million gallons per day (mgd), unless noted.

Nonconsumptive Use	
Withdrawal and Return	4.5

Returns	
Wastewater	0.0
Thermoelectric	0.0

Inflows	
Streamflow (from Out of State)	147
Precipitation (In-State)	447

Naturalized Streamflow	88	
Water Supply Reservoir Storage	0	million gallons

Surface Water Outflow 234

Consumptive Use & ET	
Evapotranspiration	4.2
Consumptive Withdrawals	0.7

Little Osage Subbasin Summary

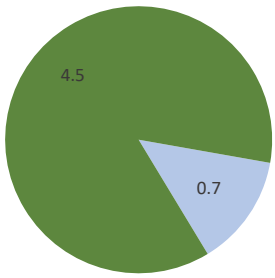
Annual Surface Water Budget Summary

	ac-ft/yr	in/yr	mgd
Precipitation (In-State)	500,774	43.36	447
Evapotranspiration	4,752	0.41	4
Streamflow (from Out of State)	165,097	14.29	147
Streamflow (from other In-State HUC8)	0	0.00	0
Streamflow originating in HUC8	98,170	8.50	88
Total Streamflow	263,268	22.79	235
Nonconsumptive Surface Water Withdrawals	5,026	0.44	4.5
Consumptive Surface Water Withdrawals	788	0.07	0.7
Total Surface Water Withdrawals	5,814	0.50	5

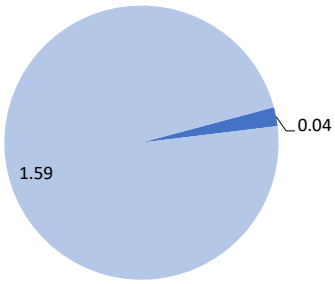
Summary of Water Demands by Sector

	Current Demands			2060 Demands
Surface Water Withdrawals By Sector	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	0	0.00	0.0	0.0
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	788	0.07	0.7	1.1
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**788**	**0.07**	**0.7**	**1.1**
Aquaculture and Wetlands	5,026	0.44	4.5	4.5
Total Nonconsumptive	**5,026**	**0.44**	**4.5**	**4.5**
Groundwater Withdrawals By Sector[1]	**ac-ft/yr**	**in/yr**	**mgd**	**mgd**
Major Water Systems	0	0.00	0.0	0.0
Self-Supplied Domestic and Minor Systems	41	0.00	0.0	0.0
Self-Supplied Nonresidential	0	0.00	0.0	0.0
Agriculture	1,782	0.15	1.6	2.0
Thermoelectric Power Generation	0	0.00	0.0	0.0
Total Consumptive	**1,823**	**0.15**	**1.6**	**2.0**
Aquaculture and Wetlands	0	0.00	0.0	0.0
Total Nonconsumptive	**0**	**0.00**	**0.0**	**0.0**

Current Surface Water Withdrawals*



Current Groundwater Withdrawals



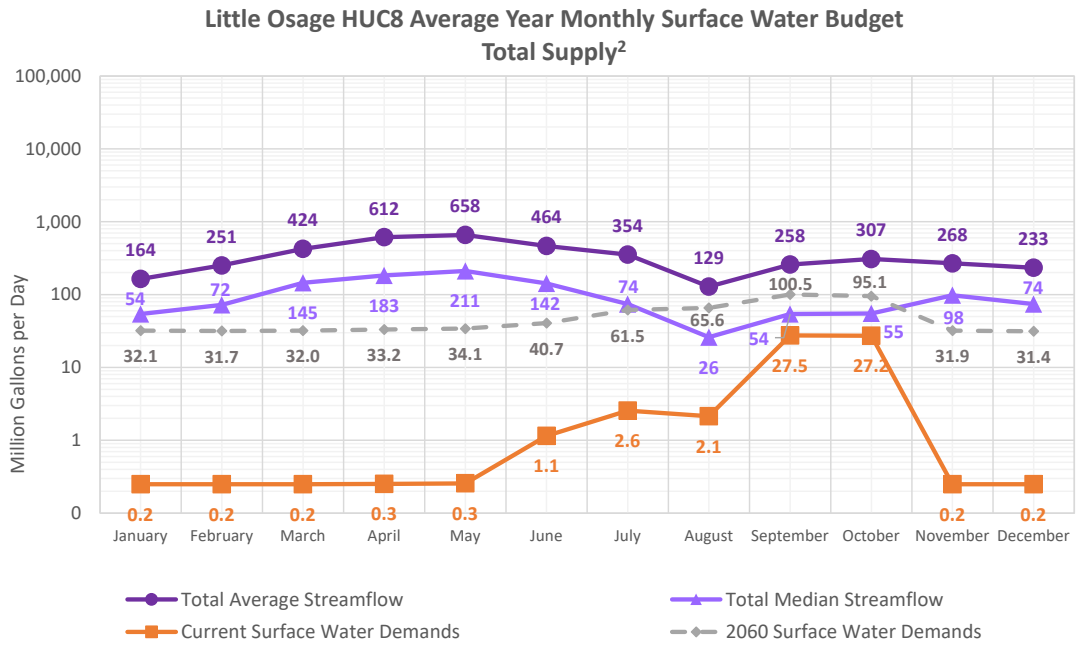
Consumptive Demands
- Self-Supplied Domestic and Minor Systems
- Self-Supplied Nonresidential
- Agriculture

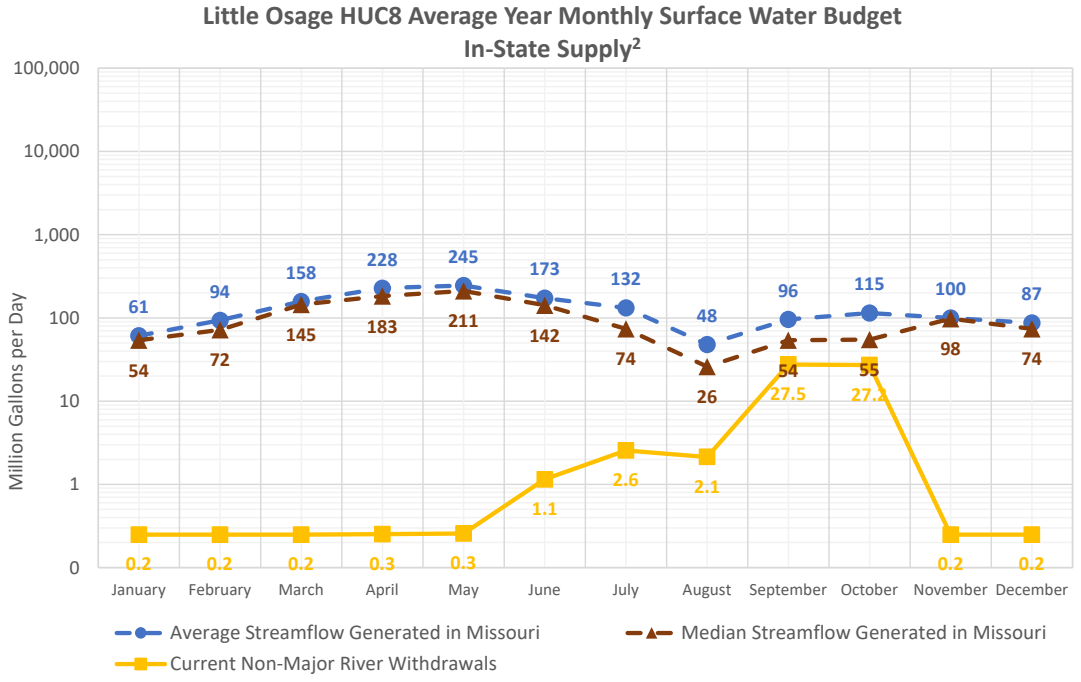
Nonconsumptive Demands
- Aquaculture and Wetlands

*Surface water demands do not include Self-Supplied Domestic sector
Note: Chart data labels represent demands in mgd.

Little Osage Subbasin Summary

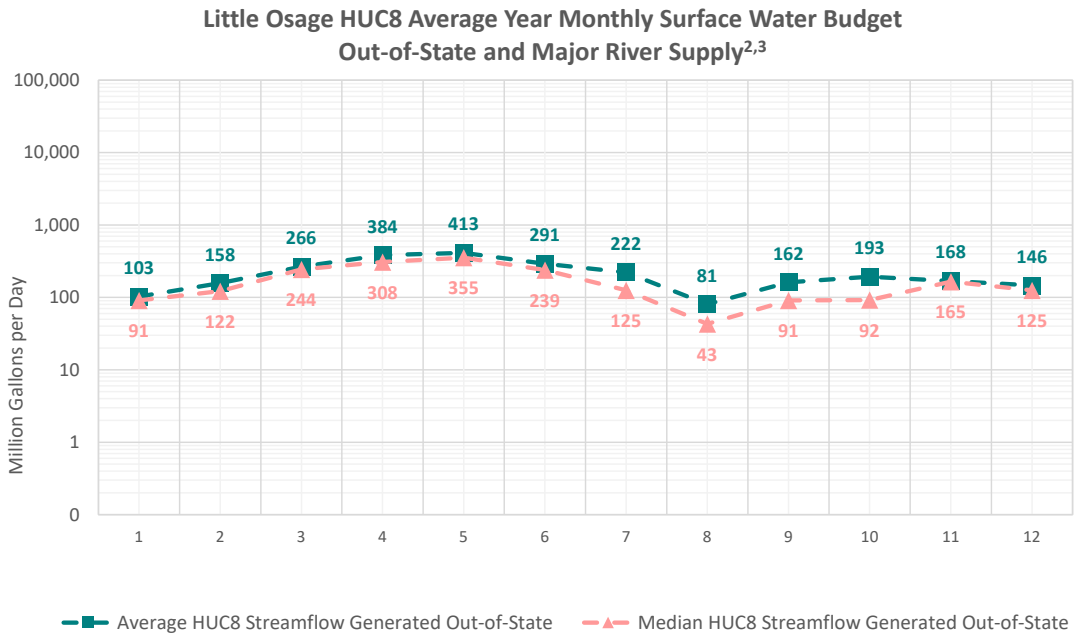
Comparison of Monthly Surface Water Availability to Current and Future Demands

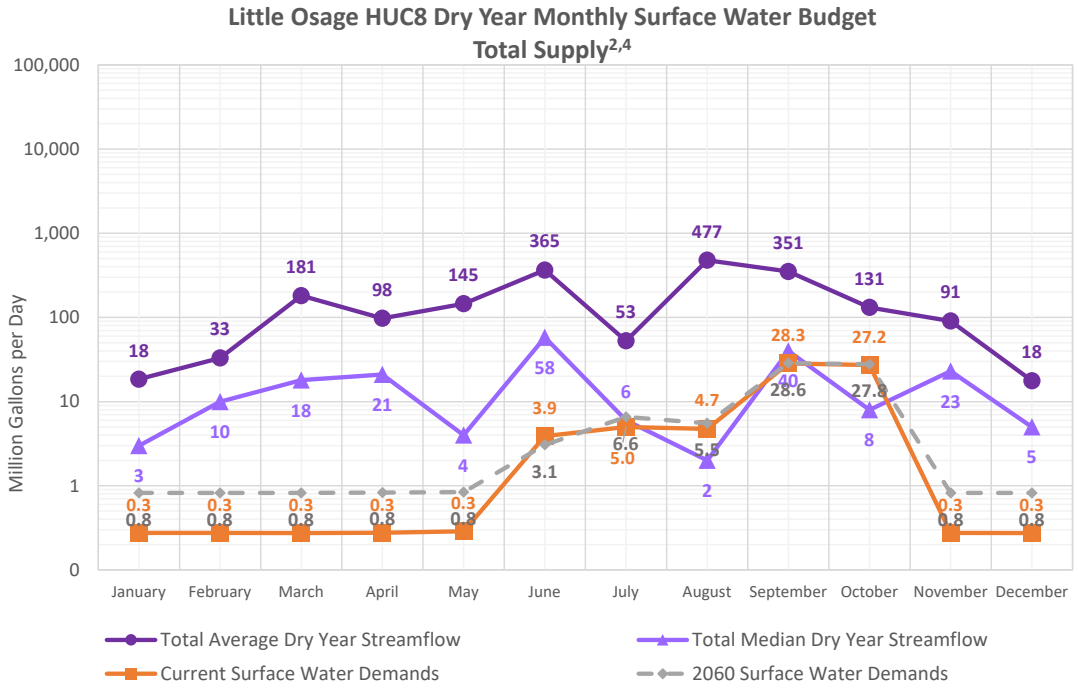




Little Osage Subbasin Summary

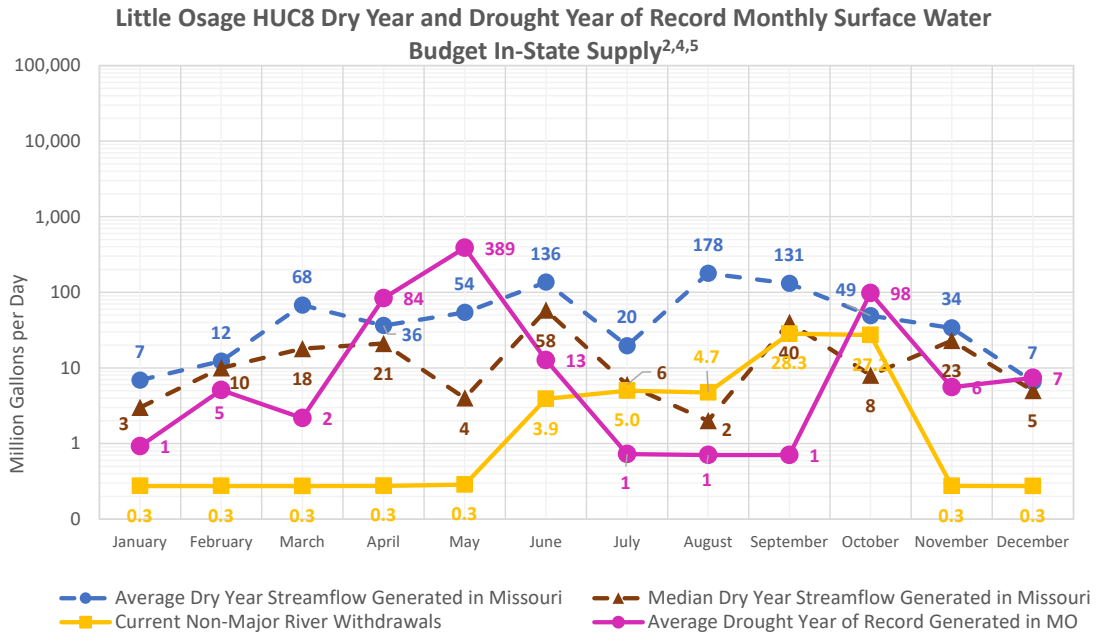
Comparison of Monthly Surface Water Availability to Current and Future Demands

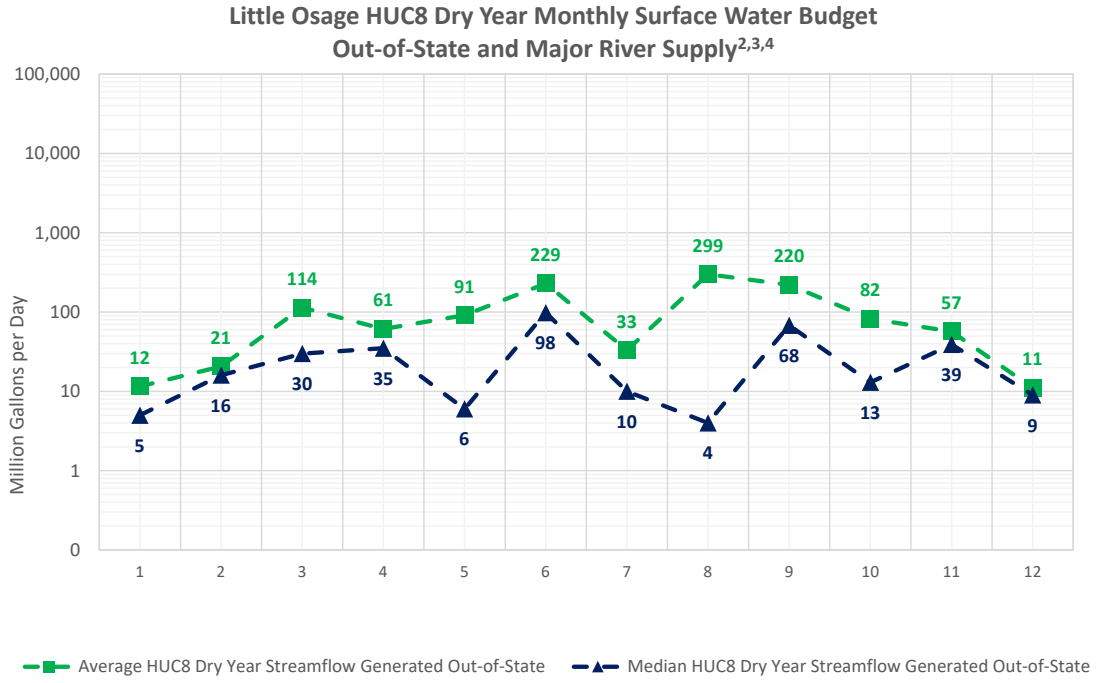




Little Osage Subbasin Summary

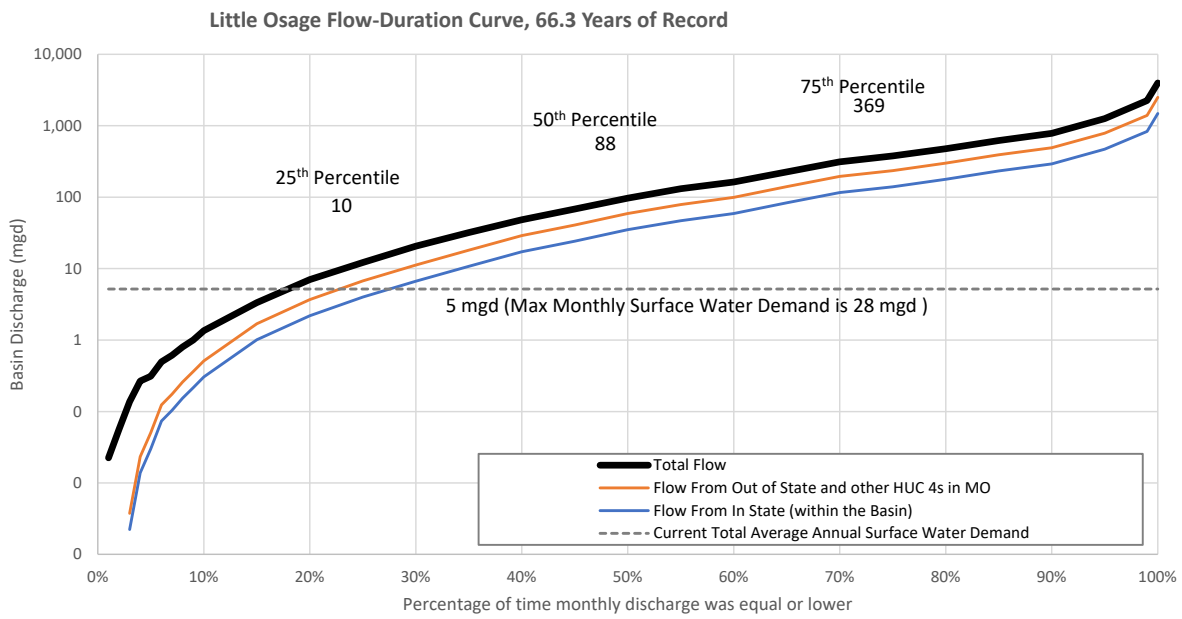
Comparison of Monthly Surface Water Availability to Current and Future Demands





Little Osage Subbasin Summary

Flow-Duration Curve[6]



Note: Thermoelectric demands are not included in surface water demands

Little Osage Subbasin Summary

Summary of Groundwater Demands by Aquifer

Groundwater Withdrawals By Sector	2016 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	1.59	0.00	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.00**	**1.62**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.00**	**1.62**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

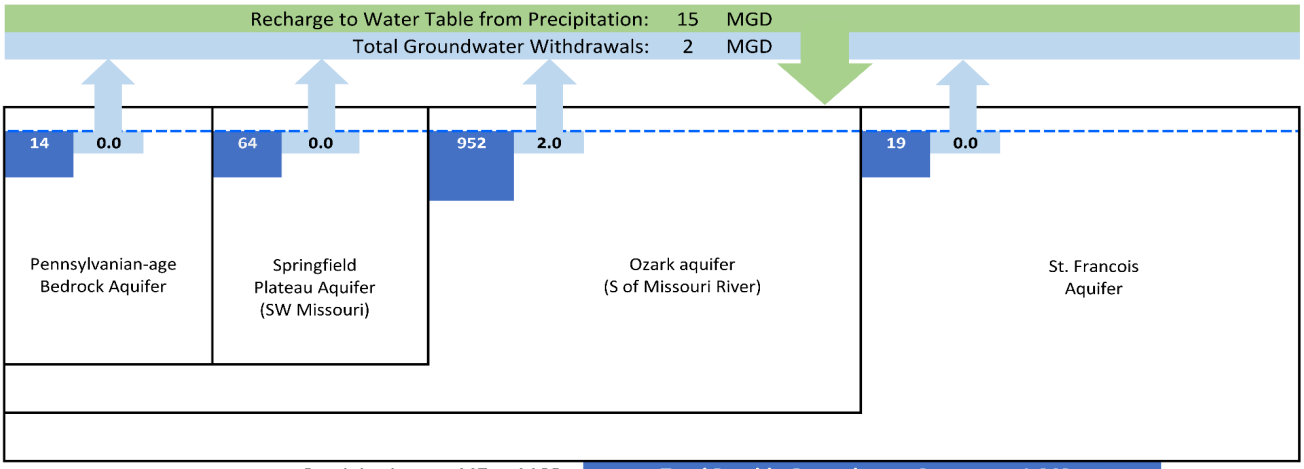
Groundwater Withdrawals By Sector	2060 Demands							
	Alluvium	Ozark Aquifer[8]	Glacial Deposits	Pennsyl-vanian	Springfield Plateau Aquifer	Mississippian Aquifer[9]	St. Francois Aquifer	McNairy & Wilcox
Major Water Systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Domestic and Minor Systems	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Self-Supplied Nonresidential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	0.00	2.04	0.00	0.00	0.00	0.00	0.00	0.00
Thermoelectric Power Generation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Consumptive	**0.00**	**2.04**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Aquaculture and Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Nonconsumptive	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Total Groundwater Withdrawals	**0.00**	**2.04**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Little Osage Subbasin Summary

Average Year Groundwater Budget (2060 Demands)[10]

Average Year Groundwater Budget (2060 Demands)
Little Osage HUC8 - 10290103

Groundwater withdrawals are shown in million gallons per day (MGD)
Potable groundwater storage is shown in billion gallons (BG)



Precipitation:	447	MGD	**Total Potable Groundwater Storage:**	**1,049**	**BG**
Evapotranspiration:	263	MGD	Total Groundwater Withdrawals:	2	MGD
Recharge to Water Table from Precipitation:	15	MGD	Increase in Withdrawals from 2016:	0	MGD

Withdrawals as a Percent of Recharge from Precipitation: 14%

The above graphic is a generalized representation of aquifers present in each HUC8.

Notes

1. Groundwater demands include alluvial and groundwater aquifer withdrawals.
2. Comparisons of monthly surface water availability to demands do not include thermoelectric demands.
3. There are no major river inflows for this subbasin which is consistent with the HUC4 summary sheet.
4. Dry year streamflow represents the lowest annual streamflow over the period from 1985-2016. For this HUC8, the lowest annual streamflow was 1989 (gage 06917000).
5. The drought year of record was calculated using streamflow recorded in either 1954 or 1956, as these are historically the lowest annual streamflow years. The year used at each gage was chosen based on which gage had the month with the lowest average streamflow.
6. Demands shown on flow duration curve do not include thermoelectric demands.
7. No (major) reservoirs are used for public water supply in the subbasin.
8. Ozark Aquifer includes both the upper, middle, and lower ozark aquifer and the associated Cambrian and Ordavician systems north of the Missouri River.
9. Includes the Mississippian system hydrogologic units outside of the Springfield Plateau.
10. Aquifer storage from: MoDNR, 1997. Groundwater Resources of Missouri, WRP 46, Missouri State Water Plan Series, Vol II.

Appendix G
Scenario Planning Methodology and Calculations

This appendix describes the methodology and calculations completed in support of **Section 9 – Future Scenarios Assessed**. For the uncertainty drivers that allowed for quantitative adjustments to the water budgets for each scenario, two general sets of calculations were completed, as described below:

- Future climate variability was quantified and applied, as factors, to the estimates of the availability of surface water described in **Section D.1** of **Appendix D.**
- Monthly demands described in **Section D.2** of **Appendix D** were then adjusted to reflect future conditions under each scenario.

Figure G-1 provides a visual representation which forecasts climate variability was assumed to affect water supply and demands. The detailed methodology and calculations are described in the following sections.

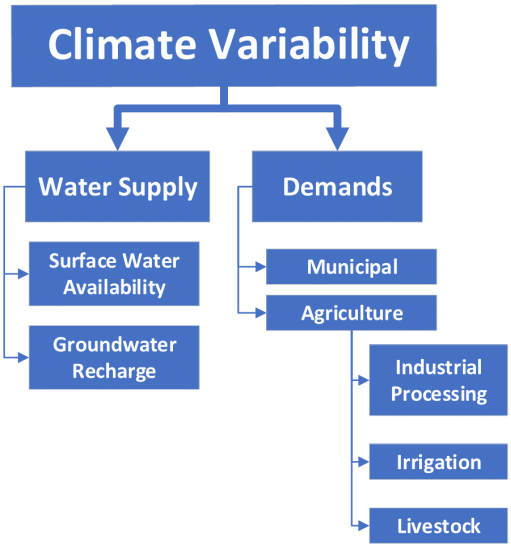


Figure G-1. Forecasts Effected by Climate Variability

G.1 Climate Variability Calculations

The objective of this task was to synthesize and summarize the suite of available climate change projections for the State of Missouri into a practical, useful, and comprehensive data set for use in calculating demands, surface water supply, and groundwater supply resulting from predicted future climate scenarios. In this specific task, climate projections were synthesized into a set of monthly mean climate deltas which numerically represented projected changes in temperature and precipitation for the planning horizon, compared to historical condition. These parameters were subsequently used for projecting future water demand in **Section 3 – Statewide Demographic and Water Use Forecast**.

G.1.1 Methods

Future climate scenarios for the state of Missouri were developed utilizing a combination of the most recent climate models and historically available climate observations using the hybrid delta ensemble (HDe) method. All scenarios are intended to represent discrete plausible climate futures centered on a 2060 planning horizon. No attempt is made to assess the likelihood that these potential climate futures will occur. The results presented as a range of projected conditions based on the best available science and engineering.

The HDe method is a numerical approach used to incorporate downscaled general circulation model (GCM) projections into a water resources planning study. The method was originally developed by the Bureau of Reclamation (2010). The method is well suited for water supply planning studies and can be used to generate inputs to hydrologic analyses, such as the surface and groundwater supply analyses described in **Section 4** and **Appendix D**. The HDe method is generally applied using monthly climate model projections and a specific future planning horizon.

The "ensemble" term in the HDe name refers to the fact that a group of projections are combined and used jointly, rather than applied discretely. "Delta" refers to the fact only modeled changes in climate (i.e., modeled future versus modeled past), rather than the modeled climate values themselves, are used to forecast future conditions. As described below, modeled delta values are used to adjust a historical observed data set to reflect future conditions. Lastly, the "hybrid" descriptor refers to the mathematical approach employed, which can be thought of as a combination of statistical methods and discrete point methods (e.g., stochastic sampling of the data). In the HDe approach, monthly ranked percentile distributions are fitted to the entire

ensemble data set, for use in subsequent analysis. This is in contrast to, for example, pure statistical methods that might only use monthly ensemble mean values to adjust a data set.

The specific calculation steps in the HDe method as they were applied for this project are described below.

Step 1. For each downscaled GCM projection, annual anomalies (departures from a reference value or long-term average) were calculated for mean annual temperature and precipitation. The annual anomalies were calculated based on the difference between modeled future climate versus modeled past climate, for a selected future planning horizon and historical hindcast (or "overlap") period. These anomalies are generally calculated as a percent change for annual precipitation and a difference term for annual temperature.

Future climate projections for the state have been summarized using the full suite of available global climate model (GCM) projection data sets. These projections include monthly mean, average daily minimum, and average daily maximum air temperature, and monthly total precipitation. All projections have been downscaled to a 1/8th degree latitude/longitude grid. These published data were obtained from the Bureau of Reclamation et.al. (2014).

A total of 106 different climate model projections were downloaded for the period 2000 to 2100. A modeling "overlap" period of hindcast projections and a historical observed dataset (gridded to same 1/8th degree grid) were also obtained for the years 1950 to 1999. All projections represent the latest in scientific research and were developed under the World Climate Research Programme Coupled Model Intercomparison Project, Phase 5 (CMIP5). The CMIP5 data set includes 35 different climate models developed at top research institutions around the world and applied across a range of model input assumptions. These model projections were strictly used to identify a range of modeled future climate scenarios for this study.

Climate model projections were obtained for three regionally representative 1/8th-degree grid cells for this analysis, the locations of which are shown below in **Figure G-2**. The selected cells are considered representative of the southeast, central, and northwest regions of the state, with respect to climate variability. An analysis of historical climate data indicates that gradients of climate variability are strongest along the southeast to northwest diagonal of the state. The selected grid cells, therefore, roughly capture the range of variability associated with climate change projections for the state.

A 2060 planning horizon was selected for this work, in line with the long-term planning horizon of the wider State Water Plan Update. A 30-year sampling band, centered on 2060, was used to capture "natural" year to year variability in the climate data, while still being representative of mid to late 21st century climate trend projections.

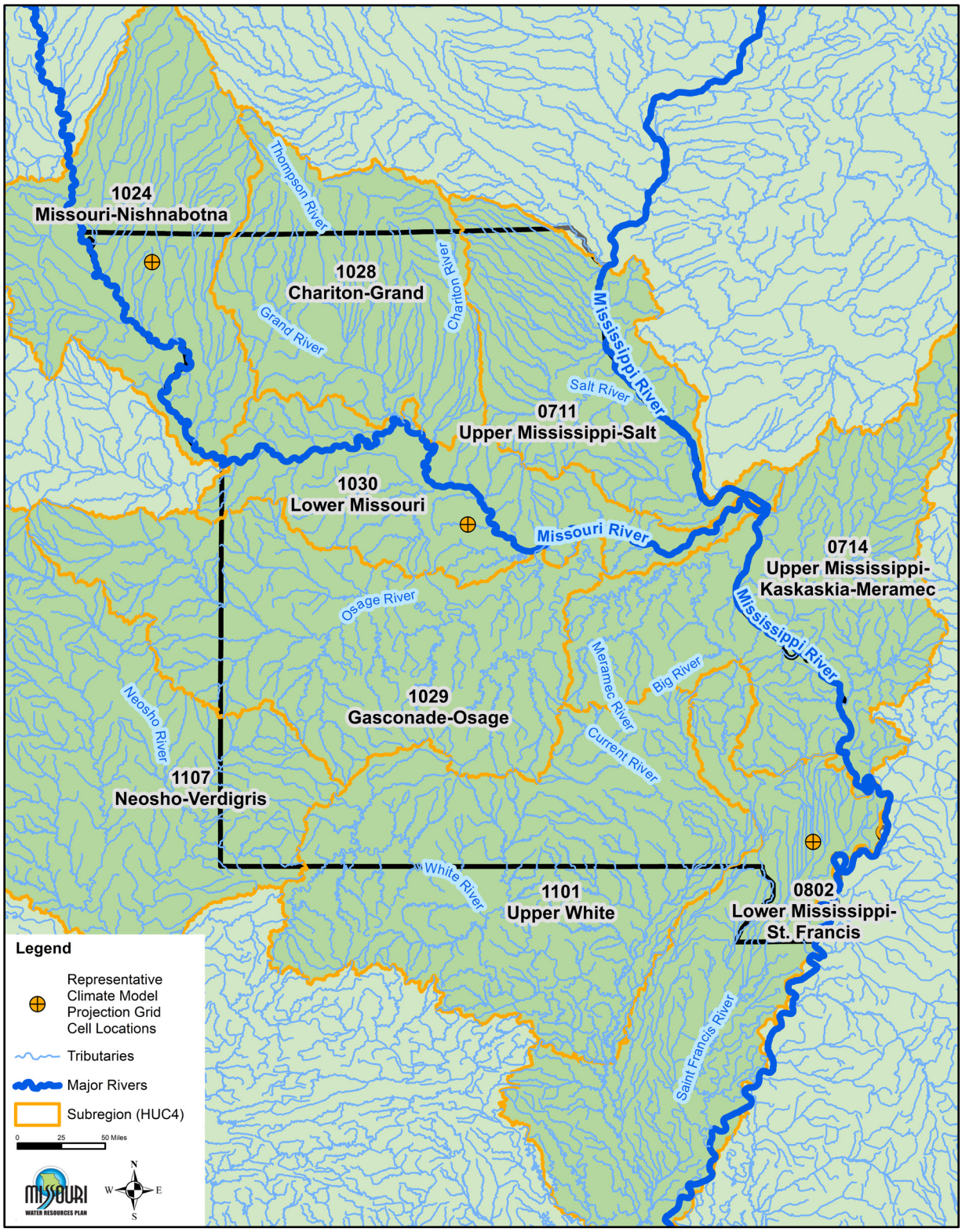


Figure G-2. Representative Climate Model Projection Grid Cells (yellow highlights)

Step 2. A scatter plot of annual anomalies for the 2060 planning horizon was constructed, with each point corresponding to a specific GCM projection. The plot was sub-divided into quantiles by 25th, 50th and 75th percentile lines. These quantiles include the four quartile regions created by the intersection of the median anomaly lines, an interquartile region bounded by the intersecting 25th and 75th percentile lines, and four outer quantile regions created by the intersection of the 25th and 75th percentile lines, respectively. See **Figure G-3** for an example. Ensembles of data were then constructed, guided by these graphed annual anomalies.

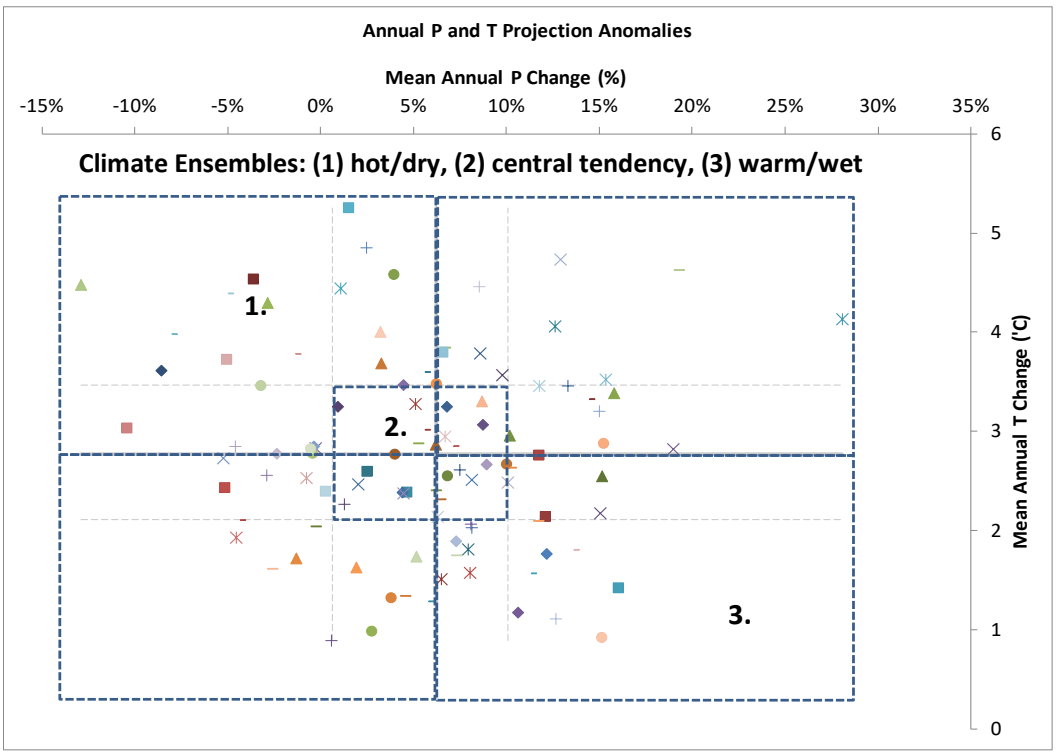


Figure G-3. Annual Anomalies (2060 versus historical) of GCM Temperature and Precipitation Projections, with Designated Scenario Ensembles (each symbol represents a different climate model projection set)

Climate model data were then pooled into three different "ensembles" based on this plot, each of which is used to develop different future climate scenarios which (1) illuminate the range of projection variability and uncertainty; (2) provide insight into the ramifications of different greenhouse gas emissions pathways; and (3) can each be easily used in subsequent water resources analyses and modeling. The scenarios are intended to be viewed as equally plausible. The ensembling process was guided by annual anomaly plots that display the changes in mean annual temperature (°C) and precipitation (as a percentage) predicted by each projection for the 2060 planning horizon, compared to the recent past (1950 to 1999) (**Figure G-3**). All 110 GCM projections, downscaled to the selected grid cell noted above, are represented on this plot as discrete points. Three different climate data ensembles were constructed using this plot representing the three numbered quantile ranges:

- Ensemble 1 - Hot/Dry: 50th to 100th percentile temperature, 0 to 50th percentile precipitation
- Ensemble 2 - Central Tendency: 25th to 75th percentiles temperature and precipitation
- Ensemble 3 - Warm/Wet: 0 to 50th percentile temperature, 50th to 100th percentile precipitation

Data from all model projections residing within a given quantile box were pooled to create the three ensembles. Advantages of this approach, as advocated by the Bureau of Reclamation (2010), are that it allows for easy visualization of the range and uncertainty in climate projections and does not require subjective selection of model projections; while at the same time still providing a practical number of pooled scenarios for use in subsequent analyses.

Step 3. The calculation then proceeded in sequential fashion, and precipitation, temperature, and evaporation records in an observed historical climate time series (usually monthly) were adjusted. For each observed climate record, a relative percentile was calculated based on the ranked position of that record in the larger observed data set for that calendar month. Corresponding percentile values of model future and modeled past from the ensemble distributions developed in Step 2 were then used to calculate climate delta values.

For precipitation, these deltas were in the form of ratios (modeled future / modeled past); while for temperature, the deltas were calculated as differences (modeled future – modeled past). For example, if July 1950 was a particularly hot July (e.g., 90th percentile of observed data), then the temperature delta term is calculated as the difference between the 90th percentile modeled future July temperature and the 90th percentile modeled past July temperature. The delta factors are then applied to the historical observed data points to generate an adjusted climate data set, reflective of projected planning horizon climate conditions.

For each projection ensemble, and each selected grid cell, monthly mean change deltas were calculated by comparing modeled future with modeled past. The averaging period for the historical projections (hindcast) was 1950 to 1999. The averaging period for the future projections was a 30-year period centered on 2060: 2045 to 2074. Monthly mean temperature, monthly mean daily maximum, monthly mean daily minimum, and monthly mean precipitation were calculated, by calendar month, for the two averaging periods. For temperature, climate change terms (°C) were then calculated as the difference between modeled future and modeled past monthly means. For precipitation, change factors (unitless) were calculated as the ratio of modeled future and past. This difference in the handling of the two climate metrics is common practice in the climate change literature and recommended by the Bureau of Reclamation (2010). The result of this analysis, for each ensemble and grid cell, is a set of monthly mean change factors and terms, reflective of projected 2060 conditions.

G.1.2 Results and Discussion

As evidenced by the annual anomaly plot presented above (**Figure G-3**), there is full consensus in the climate models for a hotter near future. Mean annual temperature changes for the 2060 planning horizon and the central grid cell, compared to historical baseline, range from approximately +1 to +5 °C. Mean annual precipitation changes for the central grid cell range from approximately -13 percent to +27 percent, with most of the projections predicting an increase in mean annual precipitation.

Calculated monthly mean climate change factors and terms are summarized in **Tables G-1** through **G-3**. In general, and as expected, the hot/dry ensemble exhibits the greatest projected temperature increases, while the warm/wet ensemble exhibits the greatest precipitation increases. Spatially, there is no clearly discernable pattern. The three grid cells exhibit the same general pattern of projected change for the three ensembles. For example, the hot/dry ensemble projects peak summer average temperature increases of approximately 4 °C and peak summer precipitation decreases of approximately 20 percent, for all three grid cells.

Table G-1. 2060 Climate Change Deltas[1], Central Grid Cell

	Hot/Dry				Central Tendency				Warm/Wet			
Month	Avg. Temp (°C)	Max. Temp (°C)	Min. Temp (°C)	Avg. Precip	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Precip	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Precip
Jan	3.6	3.7	3.9	1.08	2.8	2.8	3.0	1.02	2.2	2.1	2.3	1.07
Feb	3.2	3.6	3.4	1.13	2.8	3.0	2.9	1.15	1.9	1.9	1.9	1.18
Mar	3.1	3.4	2.9	1.12	2.4	2.6	2.3	1.15	1.8	1.8	1.7	1.18
Apr	2.9	3.1	2.8	1.16	2.3	2.4	2.2	1.20	1.8	1.8	1.8	1.16
May	3.3	3.5	3.1	1.02	2.3	2.5	2.2	1.11	1.8	1.8	1.7	1.15
Jun	3.9	4.5	3.5	0.89	2.6	2.9	2.4	1.02	1.9	2.0	1.8	1.11
Jul	4.2	4.7	3.9	0.85	3.0	3.3	2.7	0.99	2.1	2.2	2.0	1.07
Aug	4.2	4.6	4.0	0.90	3.1	3.4	2.9	0.97	2.3	2.4	2.1	1.01
Sep	4.2	4.5	4.0	0.94	3.2	3.5	2.9	0.96	2.5	2.7	2.2	1.02
Oct	3.9	4.2	3.7	0.96	2.8	3.0	2.7	1.03	2.2	2.3	2.1	1.06
Nov	3.2	3.4	3.2	1.00	2.4	2.7	2.3	1.08	1.9	2.1	1.9	1.14
Dec	3.8	4.0	3.9	1.05	2.9	2.9	3.0	1.06	2.1	2.2	2.2	1.08

[1] change terms for temperature (to be added to baseline), change factors for precipitation (to be multiplied by baseline).

Table G-2. 2060 Climate Change Deltas[1], Northwest Grid Cell

	Hot/Dry				Central Tendency				Warm/Wet			
Month	Avg. Temp (°C)	Max. Temp (°C)	Min. Temp (°C)	Avg. Precip	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Precip	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Precip
Jan	3.9	4.1	4.2	1.15	3.1	3.1	3.3	1.06	2.1	2.0	2.3	1.08
Feb	3.4	3.8	3.6	1.17	3.4	3.5	3.3	1.21	1.9	1.9	1.9	1.13
Mar	3.5	3.7	3.2	1.19	2.9	3.0	2.7	1.17	1.7	1.6	1.7	1.22
Apr	3.0	3.2	2.9	1.18	2.4	2.5	2.3	1.23	1.7	1.6	1.6	1.16
May	3.3	3.7	3.1	1.04	2.4	2.5	2.4	1.15	1.6	1.5	1.6	1.14
Jun	3.9	4.5	3.5	0.89	2.7	3.0	2.5	0.98	1.9	1.9	1.8	1.13
Jul	4.3	4.8	4.0	0.82	3.1	3.4	2.8	1.02	2.0	2.1	1.9	1.11
Aug	4.4	4.6	4.1	0.83	3.4	3.7	3.0	0.97	2.3	2.4	2.1	1.00
Sep	4.3	4.6	4.1	0.95	3.5	3.7	3.3	1.00	2.5	2.7	2.3	1.01
Oct	3.9	4.3	3.7	1.01	3.0	3.2	2.8	1.06	2.1	2.2	2.1	1.09
Nov	3.4	3.5	3.4	1.06	2.9	3.1	2.8	1.10	2.0	2.0	2.1	1.15
Dec	4.2	4.2	4.3	1.10	3.1	3.1	3.2	1.15	2.1	2.1	2.3	1.12

[1] change terms for temperature (to be added to baseline), change factors for precipitation (to be multiplied by baseline).

Table G-3. 2060 Climate Change Deltas[1], Southeast Grid Cell

	Hot/Dry				Central Tendency				Warm/Wet			
Month	Avg. Temp (°C)	Max. Temp (°C)	Min. Temp (°C)	Avg. Precip	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Precip	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Temp (°C)	Avg. Precip
Jan	3.1	3.3	3.2	1.01	2.6	2.6	2.6	1.05	2.0	1.9	2.0	1.11
Feb	3.0	3.3	3.0	1.08	2.7	2.7	2.7	1.12	1.8	1.7	1.8	1.19
Mar	2.9	2.9	2.7	1.11	2.4	2.3	2.4	1.13	1.9	1.8	1.9	1.20
Apr	3.0	3.1	2.9	1.07	2.4	2.5	2.4	1.14	1.9	1.9	1.8	1.17
May	3.3	3.6	3.1	0.98	2.6	2.8	2.5	1.09	2.1	2.3	2.0	1.05
Jun	3.9	4.6	3.5	0.91	2.8	3.2	2.5	1.01	2.0	2.1	1.9	1.12
Jul	4.2	5.0	3.8	0.90	3.1	3.5	2.8	1.01	2.1	2.1	2.1	1.12
Aug	4.3	5.0	4.1	0.92	3.4	3.8	3.1	1.01	2.2	2.4	2.1	1.11
Sep	4.3	4.7	4.0	1.00	3.5	3.8	3.2	1.01	2.5	2.7	2.3	1.14
Oct	3.8	4.0	3.6	0.99	3.0	3.2	2.9	1.08	2.4	2.6	2.4	1.05
Nov	3.0	3.2	2.9	1.01	2.6	2.8	2.5	1.05	2.0	2.1	1.9	1.13
Dec	3.5	3.5	3.5	1.07	2.5	2.5	2.4	1.09	2.1	2.2	2.1	1.09

[1] change terms for temperature (to be added to baseline), change factors for precipitation (to be multiplied by baseline).

G.2 Scenario Planning - Surface Water Supply Analyses

The objective of this task was to translate the climate change projections described above into projections of streamflow for locations across the state. These hydrologic projections are useful for providing insight on the range of potential changes in surface water availability, and in timing of delivery, across the state. The projections were specifically constructed to provide for easy input into subsequent analyses and water balance calculations.

G.2.1 Methods

For each climate model ensemble, the HDe method was again applied to adjust historical flow records to reflect the future (2060) climate projection data sets. In this method, statistical adjustments are made to the historical observed data set based on relative changes predicted by the pooled GCM projections. In this way, this method preserves the month-to-month pattern of variability and many of the core statistics of the observed historical record in its forecast of future conditions. The method has been used extensively by the Bureau of Reclamation, and others, as a means of incorporating climate model projections into water resources planning studies.

Existing recent historical flow records were modified to reflect climate change projections associated with the 2060 planning horizon. Instead of precipitation and temperature projections, which were used to calculate climate deltas in the task described above, the approach applied here used published "gridded runoff" projections from the same set of GCMs as above. The source of these runoff projections is the Bureau of Reclamation. Gridded runoff projections were developed by this consortium by routing precipitation and temperature projections through a macroscale rainfall-runoff model – the Variable Infiltration Capacity (VIC) model (Bureau of Reclamation et. al. 2020). These runoff projections can be viewed as a surrogate for projected changes in surface water availability and flow rates. The runoff projections include both a direct runoff and baseflow component.

As recommended in the above cited report, the gridded runoff projections were used within the same delta method previously described, whereby only modeled changes in surface water flow rates (as monthly depths) were used to modify streamflow records. By using runoff change factors (modeled future versus modeled past), within the HDe method, the impacts of any residual bias in the projections are minimized. Also, as

noted above, use of this approach preserved historical observed patterns of flow variability in future projections.

Additionally, within this method, the magnitudes of the applied change factors vary across a full distribution of percentiles, resulting in a more accurate reflection of the patterns of variability in the GCM projections. The selected change factor for each month in the adjusted record was based on the relative percentile value of the given month's observed streamflow record. High flow months were adjusted using change factors associated with projected high flow conditions and low flow months adjusted with change factors associated with projected low flow conditions. Note that, as in the climate analysis described above, the model hindcast period used for the calculation of change factors again corresponded to the 1950 to 1999 period per USBR guidance for downscaling and bias correction.

The same three GCM grid cells shown in **Figure G-2**, used in the climate parameter projection analysis described above, were used for this analysis. Climate model projections for these grid cells were used to modify streamflow records for 35 USGS flow gages across the state. Each flow gage was assigned one of the three representative grid cells based on proximity. Underlying this approach is the assumption that climate change projections for the three grid cells are reasonably representative of projections for regional flow gage catchments.

Deviating from the climate analysis described above, only two ensembles of GCM projections were used to develop the hydrologic scenarios: hot/dry and warm/wet. These two ensembles were considered adequate for capturing the range of available flow projections, and the central ensemble was not calculated. The ensembles were constructed based on annual climate anomalies (future versus past). These projections represent a range of GCMs and the same 30-year projection band, centered on 2060, was used.

The HDe method was used to adjust historical observed streamflow records associated with each of the 35 USGS flow gages. The final periods of record varied across sites, based on data availability. Each of the flow records were adjusted to reflect hydrologic projections for the three climate ensembles. This equates to a total of 70 new hydrologic traces (35 gages + 2 climate ensembles) that were developed for this work. These results are described below.

G.2.2 Results and Discussion

Results of this analysis, including all 70 projected monthly flow traces were tabulated. Summaries of the results, for a variety of statistical metrics and several selected example flow stations, are provided in **Tables G-4** and **G-5**.

In general, the hot/dry ensemble calculations project decreased summer streamflows and increased winter flows, with small changes in annual average flows that vary by location. These projected seasonal shifts appear to be most pronounced for the northwest portion of the state. Median flows are generally projected to decrease across the state in the hot/dry scenario.

For the warm/wet ensemble, streamflows are projected to increase across all metrics and locations. These projected flow changes are most pronounced for the high flows. In other words, high monthly flows are projected to be even higher in 2060, by as much as 50 percent. The projected changes are less pronounced for the low flows, with small decreases in extreme low flow months (10th percentile) projected at two of the stations. Seasonal shifts in stream flow are less apparent for this ensemble.

These results in general appear to have limitations with respect to the seasonal timing of flows and managing extreme high and low flow periods. High flow events would best be analyzed using daily projections, which were beyond the scope of this study.

Table G-4. Summary of Projected (2060) Flow Changes for Hot/Dry Ensemble Relative to Historical Baseline[1]

Station ID	6904500	6906200	6917000	6897500	5474500	5490500	7040100	7043500
GCM Grid Cell	NW	Central	Central	NW	Central	NW	SE	SE
10th perc.	0.79	0.79	0.82	0.77	0.79	0.85	0.91	0.90
25th perc.	0.91	0.82	0.77	0.87	0.80	0.88	0.90	0.90
median	0.94	0.76	0.84	0.98	0.82	1.00	0.89	0.88
75th perc.	1.02	0.89	0.90	1.07	0.89	1.01	0.92	0.95
90th perc.	1.20	0.85	0.94	1.15	0.92	1.12	0.97	1.02
Ann. Avg.	1.09	0.94	0.96	1.10	0.91	1.05	0.96	0.99
Jan Avg.	1.40	1.03	1.05	1.45	0.95	1.41	0.95	0.97
Feb Avg.	1.49	1.02	1.05	1.50	0.98	1.49	0.93	0.95
Mar Avg.	1.36	1.01	1.02	1.35	0.98	1.36	1.04	1.07
Apr Avg.	1.31	1.21	1.22	1.31	1.18	1.31	1.07	1.09
May Avg.	1.12	1.07	1.07	1.14	1.03	1.10	0.94	0.96
Jun Avg.	0.80	0.76	0.76	0.82	0.74	0.79	0.84	0.82
Jul Avg.	0.79	0.71	0.70	0.86	0.69	0.77	0.86	0.86
Aug Avg.	0.83	0.91	0.99	0.80	0.80	0.85	0.89	0.90
Sep Avg.	0.95	0.88	0.90	0.95	0.80	0.94	0.93	0.94
Oct Avg.	0.99	0.85	0.86	1.03	0.78	0.96	0.91	0.92
Nov Avg.	1.06	0.86	0.86	1.12	0.79	1.04	0.91	0.97
Dec Avg.	1.18	0.88	0.90	1.18	0.85	1.21	0.95	1.09

A value of 1.00 represents no change from baseline. Values lower than 1.00 represent lower flows compared to baseline flows and values greater than 1.00 represent higher flows compared to baseline flows.

Table G-5. Summary of Projected (2060) Flow Changes for Warm/Wet Ensemble Relative to Historical Baseline[1]

Station ID	6904500	6906200	6917000	6897500	5474500	5490500	7040100	7043500
GCM Grid Cell	NW	Central	Central	NW	Central	NW	SE	SE
10th perc.	1.04	1.03	0.95	0.96	1.05	1.08	1.01	1.03
25th perc.	1.20	1.14	1.03	1.19	1.09	1.18	1.07	1.06
median	1.23	1.13	1.13	1.26	1.15	1.32	1.11	1.11
75th perc.	1.39	1.22	1.29	1.34	1.21	1.31	1.17	1.20
90th perc,	1.44	1.35	1.31	1.44	1.36	1.46	1.21	1.26
Ann. Avg.	1.35	1.25	1.26	1.37	1.22	1.33	1.17	1.20
Jan Avg.	1.51	1.20	1.19	1.49	1.22	1.50	1.23	1.21
Feb Avg.	1.46	1.22	1.23	1.44	1.20	1.44	1.17	1.19
Mar Avg.	1.53	1.28	1.28	1.52	1.30	1.53	1.17	1.25
Apr Avg.	1.35	1.31	1.30	1.35	1.29	1.34	1.21	1.23
May Avg.	1.42	1.37	1.36	1.42	1.34	1.40	1.08	1.07
Jun Avg.	1.39	1.37	1.37	1.41	1.32	1.37	1.15	1.14
Jul Avg.	1.37	1.26	1.35	1.37	1.20	1.30	1.13	1.16
Aug Avg.	1.12	1.09	1.13	1.17	1.05	1.15	1.10	1.12
Sep Avg.	1.01	1.00	1.02	1.04	1.00	1.01	1.12	1.15
Oct Avg.	1.18	0.95	0.91	1.25	1.01	1.17	1.05	1.09
Nov Avg.	1.30	1.30	1.31	1.32	1.21	1.29	1.23	1.29
Dec Avg.	1.39	1.23	1.24	1.41	1.21	1.36	1.26	1.26

A value of 1.00 represents no change from baseline. Values lower than 1.00 represent lower flows compared to baseline flows and values greater than 1.00 represent higher flows compared to baseline flows.

G.3 Scenario Planning - Groundwater Supply Analyses

The objective of this task was to quantify future changes in groundwater recharge as projected by the combination of GCMs and macroscale hydrologic modeling. The focus here was on identifying general directions of change (increase or decrease) and approximate magnitudes of those projected changes on an average annual basis.

G.3.1 Methods

Groundwater recharge projections were developed by extending the analysis of macroscale hydrologic projections described above. Simple water balance calculations were performed using the available VIC output associated with the GCM projections described above. In addition to the gridded runoff projections, the Bureau of Reclamation consortium also provides monthly actual evapotranspiration (ET) projections (an output of the VIC model). These ET projections include both surface (canopy evaporation and leaf transpiration) and subsurface (soil evaporation and root transpiration) components. As noted above, the runoff projections include both direct surface runoff and shallow subsurface baseflow components. A water balance calculation of recharge can therefore be constructed as:

Equation G-1: $$Recharge(m) = Pm - ETm - Rm$$

Recharge(m) = monthly total aquifer recharge depth (in.), Pm = monthly precipitation (in.), ETm = monthly evapotranspiration (in.), and Rm = monthly total runoff depth (in.).

The three terms on the right-hand side of **Equation G-1** are all available as a monthly timeseries, for each GCM, from the same Reclamation data portal cited above. These data were therefore collated, for the 2060 planning horizon and each of the three spatial grid cells (**Figure G-2**), into the two projection ensembles described above (hot/dry and warm/wet). The ensemble membership exactly matched the ensembles used for both the climate and hydrologic projections described previously.

The HDe method was used to modify the gridded observed hindcast dataset (1950 to 1999) for each of the three known water balance terms in **Equation G-1** (right-hand side) as follows:

- Gridded observed ET and runoff were generated by the Bureau of Reclamation team by running gridded observed climate data through the macroscale VIC model. As described previously, the HDe method adjusts the historical record based on modeled delta terms. In this case, adjustments were made to the targeted gridded observed hydrologic parameters (Pm, ETm, Rm) using the ratio of modeled future parameters and modeled past parameters. In this way, coupled monthly timeseries' of precipitation, ET, and runoff were generated. These timeseries closely follow the monthly variability observed for the 50-year overlap period but are reflective of 2060 climate projections.
- **Equation G-1** was then applied for each timestep to generate a timeseries of recharge estimates, for each projection ensemble and each grid cell. These monthly recharge estimates were averaged over the full, or partial (drought), period of record to arrive at annual average recharge for both the modeled future and modeled past, for each ensemble and grid cell. Annual average change terms were calculated as the difference between average future and average past annual average recharge.

G.3.2 Results and Discussion

The results of this analysis are summarized in **Tables G-6** and **G-7**. When averaged over the full calculation period (**Table G-6**), projections indicate a net increase in groundwater recharge for both climate ensembles and all three grid cells. The net increase in recharge for both ensembles is primarily driven by the projected increase in precipitation during the winter months, when ET is low and recharge is high. Not surprisingly, projected recharge changes are generally larger for the warm/wet scenario compared to the hot/dry scenario.

For the northwest grid cell, the hot/dry scenario projection is slightly larger than the warm/wet projection, indicating a greater proportion of runoff and ET losses in the model water balance for the warm/wet scenario. When only critical drought period recharge estimates are included in the averaging (**Table G-7**), the potential for a net recharge reduction is identified (hot/dry scenario, SE and central grid cells). In other words, the hot/dry ensemble projects drier dry periods, compared to baseline, with even lower groundwater recharge during these extreme dry periods.

Table G-6. Groundwater Recharge Change Term Projections (in./yr), 2060 Relative to Historical Baseline

Grid Cell	Hot/Dry	Warm/Wet
Southeast Grid Cell	+0.1	+0.8
Central Grid Cell	+0.4	+0.7
Northwest Grid Cell	+0.6	+0.5

Table G-7. Groundwater Recharge Change Term Projections (in./yr), 2060 Relative to Historical Baseline, Critical Drought Period (1954 to 1956)

Grid Cell	Hot/Dry	Warm/Wet
Southeast Grid Cell	-1.3	+0.2
Central Grid Cell	-0.3	+0.3
Northwest Grid Cell	+1.2	+1.2

These factors were then used to adjust groundwater recharge in each subregion and the seven select subbasins for scenarios 2, 3, and 4. Groundwater withdrawals were then calculated as a percentage of total recharge from precipitation to produce the results described in **Section 9.4.3**. For scenarios 2 and 3, which included an uncertainty driver for limitations on groundwater withdrawals, a 30 percent reduction in projected 2060 groundwater withdrawal rates in the Neosho-Verdigris basin was applied. These demands were then placed on the available surface water to compensate for the loss in groundwater availability.

G.4 Water Demand Forecast Assumptions

Four scenarios were developed for the Missouri Water Resources Plan. Each scenario included a narrative of municipal and industrial (M&I), rural, agriculture processing, and agriculture irrigation water demands that are related to future possible demographic, economic, and climatic conditions. This section describes the efforts to quantify the water demand impacts for each of these demand narratives and the underlying assumptions.

G.4.1 M&I and Rural Water Demands

The definition of each demand narrative as it pertains to demographic, economic, and climatic variation followed a narrative of urban versus rural impacts to M&I demands. "M&I" generally applies to urban areas and "Rural" to rural areas. This required a designation of rural/urban for each county in Missouri, as shown in **Figure G-4**. The urban/rural designation is used for assessing population and economic growth on water use only. The related demand impacts were assessed for the water demand sectors defined and described in **Section 3**. Changes to the M&I and rural water demand apply to the Major Water Users and Self-Supplied Residential and Minor Systems sectors. The following defines the economic and demographic impacts assessed for each narrative:

- **Baseline M&I Demands** - These demands are represented by the baseline demand projections to 2060 presented in **Section 3** of the main report.
- **High M&I Demands** – For these demands, the population growth at 2060 for urban counties is assumed to be 25 percent higher than the Woods & Poole series used in the baseline projections.

- **Low M&I Demands** – For these demands associated with the Weak Economy/Low Water Stress scenario, the population growth at 2060 for urban counties is assumed to be 10 percent less than the Woods & Poole series used in the baseline projections.
- **Baseline Rural Demands** – These demands are represented by the baseline demand projections to 2060 presented in **Section 3** of the main report.
- **Higher Rural Demands** - For these demands, the population growth at 2060 for rural counties is assumed to be 10 percent higher than the Woods & Poole series used in the baseline projections.

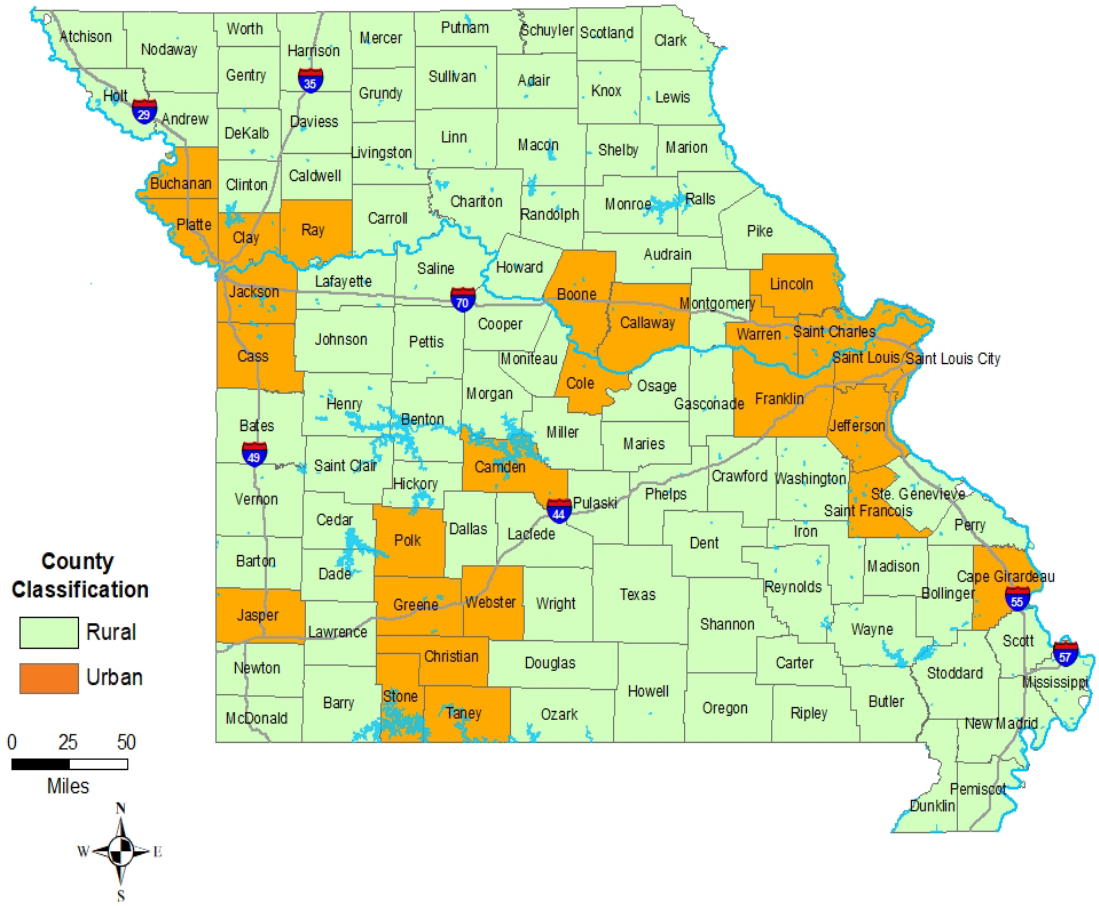


Figure G-4. County Designation as Rural/Urban Used for Scenario Planning Assessment

For each scenario, population projections were developed by county based on the above outlined changes to the baseline population projections. **Figure G-5** displays the statewide population projection totals associated with population projections, for each demand narrative summarized for the entire state. Under the high population growth scenario (for both urban and rural counties), population in 2060 is assumed to be nearly 9.1 million. For the lower growth scenario (for urban counties only), population in 2060 is assumed to be 6.9 million. Because the baseline population projections had very low growth for rural counties, there was no need to assume a lower population growth for the low growth scenario. To estimate water demands under these high and lower growth population scenarios, the gallons per capita per day (GPCD) baseline estimate was multiplied by the respective population estimate in 2060, the results of which are shown in **Figures G-6** and **G-7**.

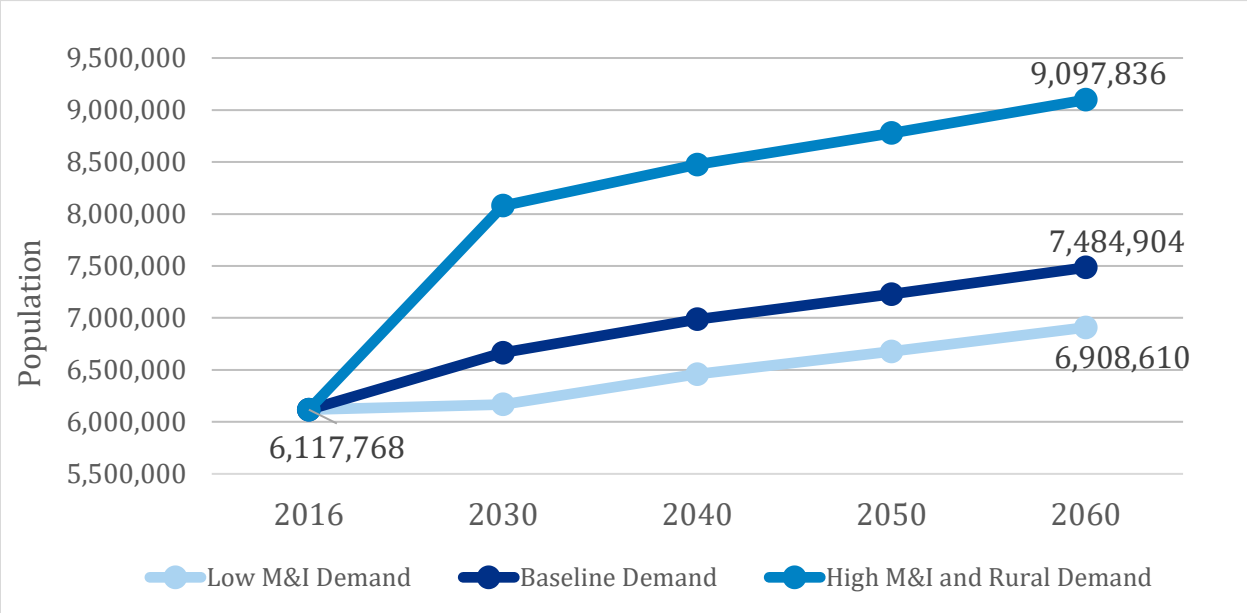


Figure G-5. Population Projection Used for Scenario Planning Assessment

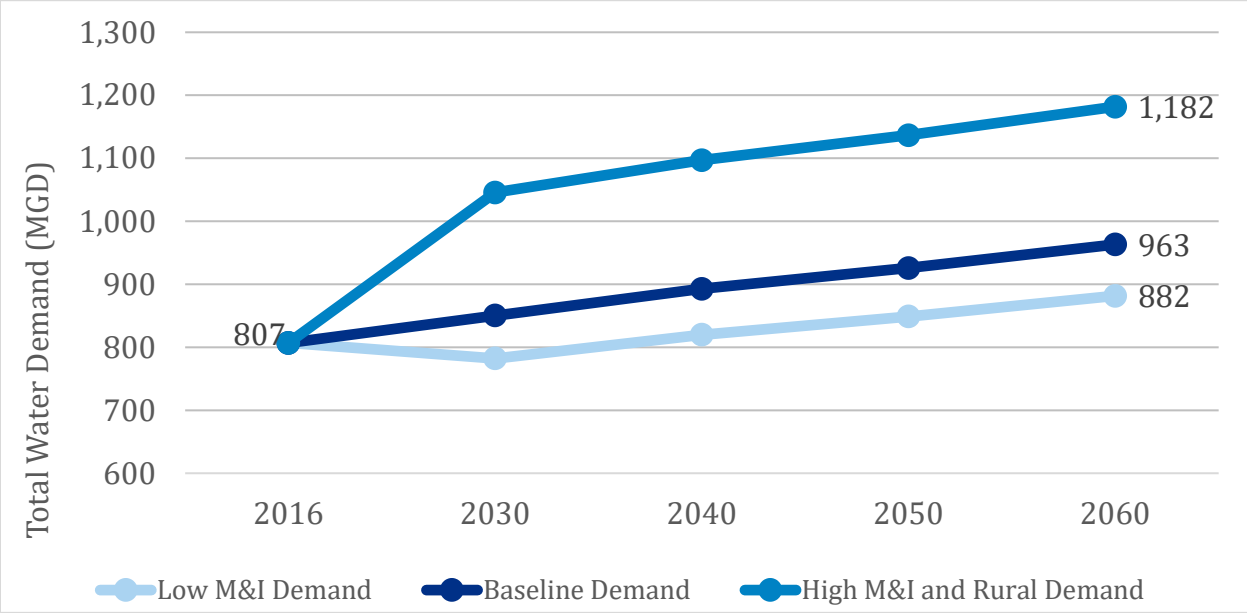


Figure G-6. Major Water Users Demand Forecast Scenarios under Average Weather

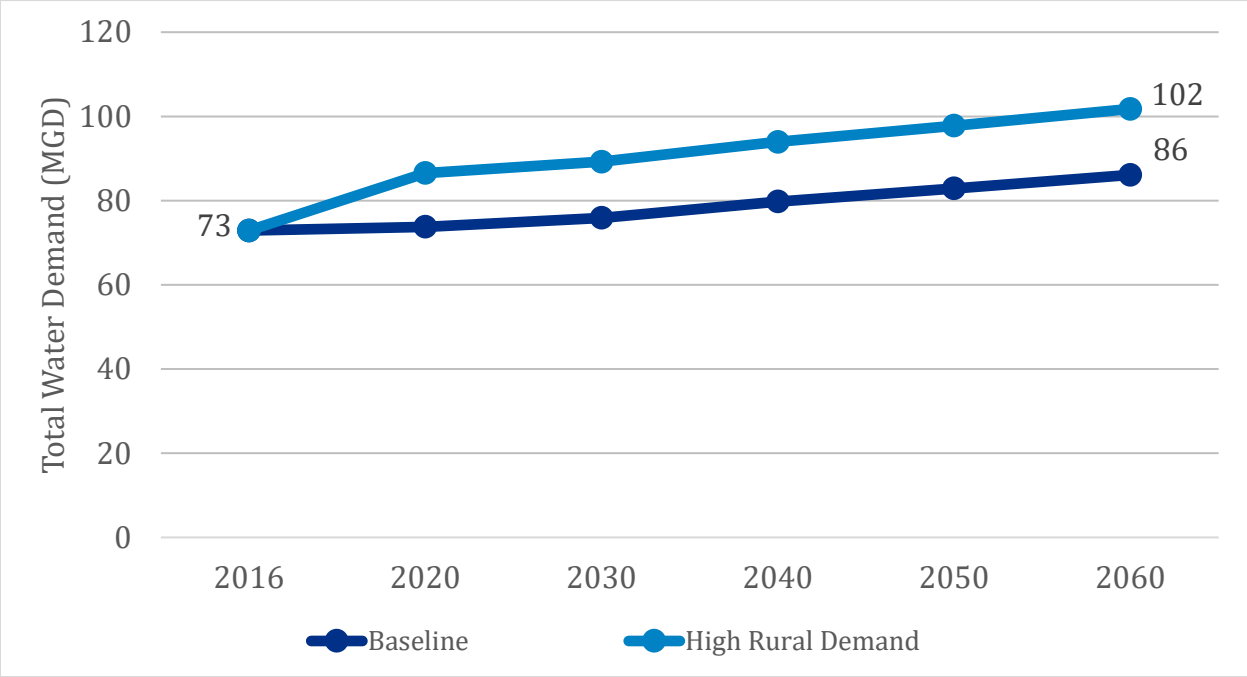


Figure G-7. Self-Supplied Residential and Minor Systems Demand Forecast Scenarios under Average Weather

Additionally, each scenario required an assessment of water demands under specific weather conditions, as water use and weather are highly correlated in summer months. The baseline demands represented average weather demands. To model impacts from deviations from average weather, an analysis was conducted to evaluate the sensitivity of public water supply to variations in weather conditions. Ultimately, the analysis resulted in weather adjustment factors for water demand by HUC for the summer months.

To determine the impacts that future weather can have on water demand, historical monthly water use and corresponding weather observations were obtained from two public water suppliers. The Kansas City Power & Light (KCPL) provided monthly water production data from May 1998 to April 2018. KCPL provided corresponding observations of monthly total precipitation, monthly average maximum daily temperature, and monthly average minimum daily temperature for these same months. The City of Springfield, MO provided monthly water production data from October 2002 to September 2017. Weather observations for these corresponding months were obtained from NOAA for the Springfield Airport station.

Regression analysis was used to estimate the variation in water production with respect to variation in precipitation and average maximum daily temperature. For this analysis, only data for the six summer months of May through October were used. It is assumed that weather variation has little to no impact on water production in the winter months in Missouri.

Data were converted to natural log form so that the resulting regression coefficients for precipitation and maximum temperature could be interpreted as elasticities, which reflect the percent change in water production for a given percent change in the weather parameter. Separate regression analysis for KCPL and Springfield were conducted initially and then the data from the two systems were combined, which provides a time-series, cross-sectional dataset. A binary variable (with a value of zero/one) was used to account for the influence of the KCPL data given the magnitude of the water production volume relative to the City of Springfield volume. The regression analysis of the combined data was statistically significant (R2 of 0.970). The elasticity for precipitation in the summer months was estimated as -0.058. The negative sign of the elasticity indicates an inverse relationship, meaning that monthly water production decreases as monthly

precipitation increases. The elasticity for maximum temperature in the summer months was estimated as 1.050. Both elasticities were statistically significant at less than the 0.005 probability level.

The second step of the analysis was to evaluate historical weather variation by HUC throughout the state. Thirty years of historical monthly weather data (January 1988 to November 2017) were obtained for 23 weather stations throughout the state. An analysis of weather patterns indicated that the summer of 2012 had the most months with monthly precipitation totals below 2 inches and monthly average maximum temperatures above 90 °F across all stations. Therefore, the summer months of 2012 were deemed to represent a recent "dry" summer for all stations.

For each summer month (May to October), the 2012 precipitation and maximum temperature were compared to the 30-year average for that month at each station. Thus, a ratio of dry-to-average was computed for monthly precipitation and maximum temperature for each summer month at each station.

The 23 weather stations were assigned to a river basin or 4-digit hydrologic unit code (HUC4). Some weather stations are on, or near, a boundary between HUC4 regions and were therefore assigned to both regions. Each of the nine HUC4 subregions in the state had at least one weather station assigned to the region. For HUC4 subregions with multiple weather stations, the dry-to-average ratios were averaged among all stations within the HUC for each summer month. The monthly dry-to-average ratios by basin are shown in **Table G-8**.

Table G-8. Monthly Dry-to-Average Ratios

Subregion HUC4 Code	Subregion Name	Dry/Average Precipitation Ratio						Dry/Average Max Temperature Ratio					
		May	June	July	Aug	Sept	Oct	May	June	July	Aug	Sept	Oct
0711	Upper Mississippi-Salt	0.432	0.375	0.439	0.357	1.466	1.218	1.085	1.043	1.107	1.046	0.981	0.969
0714	Upper Mississippi-Kaskaskia-Meramec	0.316	0.367	0.650	0.476	1.334	1.078	1.096	1.049	1.102	1.039	0.977	0.950
0802	Lower Mississippi-St. Francis	0.244	0.440	0.260	0.468	1.267	0.965	1.085	1.030	1.072	1.031	0.994	0.953
1024	Missouri-Nishnabotna	0.701	0.602	0.295	0.777	0.357	0.874	1.082	1.034	1.109	1.036	1.007	0.962
1028	Chariton-Grand	0.677	0.448	0.291	0.249	1.071	1.027	1.078	1.045	1.109	1.045	0.995	0.961
1029	Gasconade-Osage	0.398	0.482	0.236	0.588	1.098	0.851	1.086	1.041	1.108	1.031	0.979	0.947
1030	Lower Missouri	0.392	0.359	0.231	0.346	1.286	0.885	1.084	1.048	1.106	1.037	0.988	0.960
1101	Upper White	0.266	0.595	0.435	1.364	0.962	0.568	1.077	1.028	1.074	1.019	0.985	0.963
1107	Neosho-Verdigris	0.501	0.611	0.063	1.056	1.191	1.384	1.077	1.033	1.093	1.024	0.994	0.954

Previous water demand estimates of public water supply by HUC assumed average (normal) weather conditions for future years. The dry-to-average ratios for precipitation and maximum temperature in the summer months can be used to calculate an adjustment factor for the prior average weather water demand estimates that provides an estimated monthly water demand under dry weather conditions. The dry weather adjustment factor for each month is calculated using the formula:

$$\textit{Adjustment Factor} = (\textit{dry/average precip ratio})^{\textit{precip elasticity}} \times (\textit{dry/average max temp ratio})^{\textit{max temp elasticity}}$$

The resulting monthly dry weather adjustment factor by HUC is shown in **Table G-9**. Any calculated adjustment factor that is less than 1.0 would reflect a condition that is wetter/cooler than normal and is therefore replaced with a value of 1.0 to reflect normal conditions.

Table G-9. Summer Adjustment Factors for Drought Scenario

Subregion HUC4 Code	Subregion Name	Adjustment Factor for Dry Weather					
		May	June	July	Aug	Sept	Oct
0711	Upper Mississippi-Salt	1.144	1.107	1.167	1.112	1.000	1.000
0714	Upper Mississippi-Kaskaskia-Meramec	1.177	1.115	1.136	1.086	1.000	1.000
0802	Lower Mississippi-St. Francis	1.182	1.082	1.163	1.079	1.000	1.000
1024	Missouri-Nishnabotna	1.109	1.067	1.197	1.053	1.069	1.000
1028	Chariton-Grand	1.107	1.097	1.197	1.135	1.000	1.000
1029	Gasconade-Osage	1.150	1.088	1.211	1.065	1.000	1.000
1030	Lower Missouri	1.149	1.114	1.210	1.105	1.000	1.000
1101	Upper White	1.168	1.060	1.131	1.002	1.000	1.000
1107	Neosho-Verdigris	1.126	1.065	1.288	1.022	1.000	1.000

The analysis was further conducted assuming hot/dry and warm/wet deviations. Climate data were acquired from regional weather stations (see **Section G.1**) and averaged to provide climate data by HUC. **Tables G-10** and **G-11** present the calculated adjustment factors for the Hot/Dry and Warm/Wet scenarios, respectively.

Table G-10. Summer Adjustment Factors for Hot/Dry Scenario

Subregion HUC4 Code	Subregion Name	Adjustment Factor for Dry Weather					
		May	June	July	Aug	Sept	Oct
0711	Upper Mississippi-Salt	1.110	1.111	1.113	1.108	1.113	1.122
0714	Upper Mississippi-Kaskaskia-Meramec	1.089	1.108	1.113	1.111	1.111	1.111
0802	Lower Mississippi-St. Francis	1.089	1.107	1.113	1.113	1.110	1.108
1024	Missouri-Nishnabotna	1.093	1.112	1.119	1.115	1.117	1.122
1028	Chariton-Grand	1.091	1.112	1.117	1.112	1.115	1.123
1029	Gasconade-Osage	1.087	1.109	1.111	1.106	1.111	1.118
1030	Lower Missouri	1.088	1.110	1.112	1.107	1.112	1.120
1101	Upper White	1.087	1.105	1.111	1.111	1.108	1.106
1107	Neosho-Verdigris	1.086	1.107	1.110	1.104	1.108	1.114

Table G-11. Summer Adjustment Factors for Warm/Wet Scenario

Subregion HUC4 Code	Subregion Name	Adjustment Factor for Dry Weather					
		May	June	July	Aug	Sept	Oct
0711	Upper Mississippi-Salt	1.039	1.040	1.044	1.053	1.064	1.062
0714	Upper Mississippi-Kaskaskia-Meramec	1.051	1.044	1.045	1.049	1.059	1.068
0802	Lower Mississippi-St. Francis	1.057	1.052	1.052	1.056	1.064	1.070
1024	Missouri-Nishnabotna	1.037	1.051	1.058	1.064	1.068	1.062
1028	Chariton-Grand	1.043	1.052	1.056	1.062	1.067	1.065
1029	Gasconade-Osage	1.045	1.052	1.057	1.059	1.067	1.066
1030	Lower Missouri	1.046	1.053	1.058	1.060	1.068	1.067
1101	Upper White	1.056	1.052	1.051	1.055	1.063	1.068
1107	Neosho-Verdigris	1.044	1.052	1.057	1.058	1.066	1.064

G.4.2 Agricultural Processing Demands

Two scenarios were assessed representing higher water use from expanded agriculture processing, including medium-high agriculture processing demands and highest agriculture processing demands. These scenarios explore the "what-if" water use impacts associated with expanded industries that manufacture agriculture inputs (fertilizers, chemicals, machinery, etc.) and create consumable products from the outputs (meat processing plants, ethanol plants, etc.).

- **Medium Agriculture Processing Demands** – These demands are represented by the baseline water demands for the Self-Supplied Nonresidential sector.
- **Medium-High Agriculture Processing Demands** – The medium-high processing demands represent an overall increase in the baseline agriculture processing demands of 5 percent. Ethanol plant growth increases over baseline are estimated separately and assume three additional plants. This approach was suggested at a technical workgroup meeting in the agricultural breakout group. Anticipated growth in agricultural processing will most likely occur in the existing areas for which the respective processing is already occurring but on a larger scale.
- **Highest Agriculture Processing Demands** – The highest processing demands represent an overall increase in the baseline agriculture processing demands of 10 percent. Ethanol plant growth increases over baseline are estimated separately and assume six additional plants. This approach was suggested at a technical workgroup meeting in the agricultural breakout group. Anticipated growth in agricultural processing will most likely occur in the existing areas for which the respective processing is already occurring but on a larger scale.

Expansion in the ethanol industry requires new demand likely initiated by governmental adoption of a 15 percent ethanol mandate. Currently, Missouri's market share fills 2 percent of the national ethanol production. An increase from 10 to 15 percent ethanol blend suggests Missouri production expands from 300 to 450 million gallons per year. Though a sensitivity analysis needs to balance placement of new ethanol facilities between production, transportation, and end user regions, the additional ethanol production requires about 450 million gallons of water annually. The water requirement can be used as a variable in placement of new processing plants.

According to the University of Missouri Extension Report, Economic Contribution of the Missouri Corn and Ethanol Industry (2015), there are currently six ethanol plants operating within the State with a total operating capacity of 310.5 million gallons of ethanol production per year. Assuming water use of 3 gallons per gallon of ethanol produced (University of Illinois, 2018), Missouri ethanol plants would require approximately 2.5 MGD of water to produce the total Missouri ethanol plant capacity. Per discussions with MoDNR, the decision was made to add three additional plants under the Strong Economy/High Water Stress scenario, and an additional six plants under the Substantial Agriculture Expansion scenario. This equates to approximately a 50 percent increase in production under the Strong Economy/High Water Stress scenario, for a total additional water use of 1.25 MGD. Under the Substantial Agriculture Expansion scenario, the forecast assumes a 100 percent increase in ethanol production, for an additional water use of 2.5 MGD. Water use at new plants was evenly distributed, for a total water use of 0.416 MGD at each new facility.

Facilities were spatially placed in counties without existing ethanol plants, but with high corn production according to the University of Missouri Extension Report (2015). Under the strong economy scenario, plants were added to Atchison, Nodaway, and Lafayette Counties. Under the Substantial Agricultural Expansion scenario, additional plants were also added in the bootheel region of the state to Stoddard, New Madrid, and Mississippi Counties.

To estimate additional water demands for the other agriculture processing industries (non-ethanol), the self-supplied agriculture industries were identified from the Self-Supplied Nonresidential demand model. The 19 identified agriculture processing industries are estimated to require 16.5 MGD of water use annually in 2060 in the baseline forecast. To estimate water demands under the medium-high and high scenarios, these demands were increased by 5 and 10 percent, respectively. Results for the medium-high and high scenarios for all self-supplied industries, including ethanol plant expansion, are presented in **Figure G-8**.

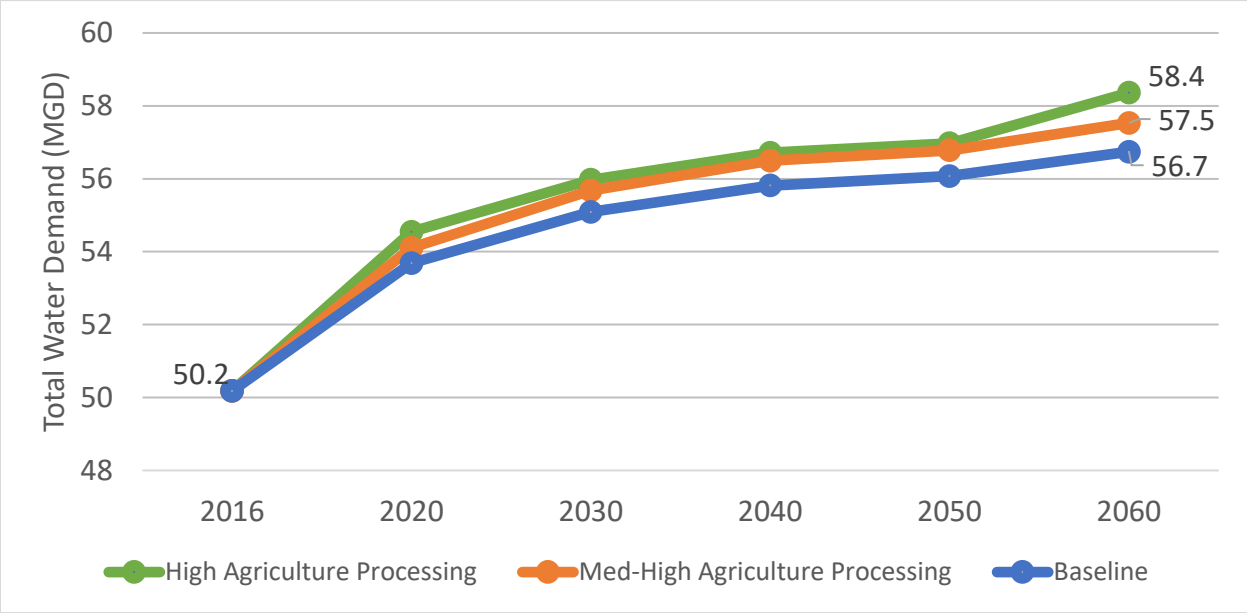


Figure G-8. Self-Supplied Nonresidential Demand Forecast Scenario Results

G.4.3 Irrigation and Livestock Agricultural Demands

Scenario planning gives stakeholders the ability to see a range of demands in water use by changing variables in different segments. For agriculture, the number of irrigated acres drives potential water use. To show how large increases in irrigated acres change the potential water demand in Missouri, the same proportion of irrigated acres seen in the alluvial plain of the Bootheel region, which is a highly-irrigated, agriculture-intensive region of the state, was applied to alluvial crop areas outside of the Bootheel region. For this analysis, the Bootheel region was assumed to be comprised of Bollinger, Butler, Cape Girardeau, Dunklin, Mississippi, New Madrid, Pemiscot, Perry, Ripley, Scott, Ste. Genevieve, Stoddard, and Wayne County; within these counties, nearly 75 percent of the alluvial farmland is currently irrigated and some opportunities for expansion exist. Outside the Bootheel, less than 20 percent of alluvial plains along the Mississippi and Missouri Rivers and their large tributaries are irrigated. For scenario planning purposes, the irrigation of alluvial farmland was assumed to increase to 85 percent for the entire state. This assumption accounts for major expansion of alluvial irrigation outside of the Bootheel region as well as some growth within the Bootheel region.

Three data sources were used to calculate these projected increases in alluvial plain irrigation:

- An estimate of currently irrigated acres in each county was obtained from the Missouri Farm Service Agency (2012).
- The National Agriculture Statistics Service (2012) land use layer for Missouri was used to determine the spatial extents of crops (both irrigated and non-irrigated)
- The spatial extents of alluvial plains within the state were obtained from a Missouri Department of Natural Resources (2018) spatial layer.

The NASS land use layer and MoDNR alluvial plains layer were merged to create a state-wide layer of crops within alluvial plains, as shown in **Figure G-9**. The following process was used convert acres from non-irrigated to irrigated such that the total proportion becomes 85 percent in the alluvial plain. These procedures utilized ESRI ArcMap for all spatial calculations and required slightly different approaches for the Bootheel region and the Non-Bootheel region.

Figure G-9. National Agriculture Statistics Service crop use layer merged with alluvial plain layer

Bootheel Region

Bootheel region counties were separated from the rest of the state spatially and for each county, the total acreage of each crop was determined and normalized to the number of irrigated acres in Bootheel counties from FSA data. Next, the total irrigated and non-irrigated acres residing in the alluvial plain were determined. A portion of these were then assumed to be converted to irrigated acres by 2060 such that the total proportion of irrigated acres in the Bootheel alluvial plain reached 85 percent.

Non-Bootheel Region

Likewise, the same methods were employed for alluvial plains in all the counties outside of the Bootheel. Review of satellite imagery indicated that in the Non-Bootheel region of the State, irrigation outside of the Bootheel is not concentrated in alluvial plains. Though the proportion of alluvial irrigation crops to non-irrigated crops varied, on average state-wide, it did not differ much from the FSA county estimates of irrigation. **Table G-12** presents the percentage of different crops grown in alluvial plains in the Bootheel and all other counties in Missouri.

Table G-12. Percentage of crops grown within the alluvial plain in Missouri

County	Corn	Cotton	Rice	Hay	Sorghum	Soybeans	Wheat	Vegetables	Sod	Pasture	Orchard
Bollinger	75	50	100	3	100	70	56	0	0	5	8
Butler	98	100	99	35	98	97	97	96	74	25	100
Cape Girardeau	46	94	99	1	93	52	38	0	3	4	0
Dunklin	99	99	100	53	100	99	96	99	96	61	7
Mississippi	100	79	94	100	100	99	99	90	100	99	0
New Madrid	100	100	98	99	100	100	100	100	97	99	0
Pemiscot	100	100	100	100	100	100	100	97	100	100	0
Perry	39	0	65	0	95	46	24	0	2	3	0
Ripley	70	0	96	6	94	91	82	0	0	3	0
Scott	93	100	100	50	97	96	90	100	100	47	33
Ste. Genevieve	32	0	50	0	0	37	14	0	0	1	0
Stoddard	94	99	100	25	99	94	78	97	97	28	11
Wayne	29	0	1	6	100	31	46	0	0	3	100
All others	16	0	0	1	4	16	4	4	1	0	4

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Appendix H
Streamflow, Precipitation, and Land-Use and Land-Cover Trends in Missouri, 1950 to 2017

Abstract

The US Army Corps of Engineers and the Missouri Department of Natural Resources (MoDNR) performed a statistical analysis of streamflow, precipitation, and land-use and land-cover within and adjacent to the State of Missouri. For streamflow and precipitation data, the period from 1950 to 2017 was analyzed for statistical trends. The Mann-Kendall (Mann 1945; Kendall 1975) test for monotonic trends was applied to all data sets for analysis of trends over time. In general, increasing trends in streamflow throughout the State of Missouri showed a stronger correlation to increasing trends in precipitation than changes in land-use and land-cover. However, principal components analyses of trends in streamflow suggest that increasing trends in streamflow in Missouri are related to increasing trends in precipitation and increasing trends in development within watersheds. Trends in precipitation and land-use and land-cover were evaluated by watershed and by 6-digit hydrologic unit code (HUC). Increasing trends in streamflow across the unregulated streams within and adjacent to the State of Missouri suggests that streamflow data summarized from the recent past should provide a reasonable accounting of water resources for planning purposes.

H.1 Introduction

Surface water is an important resource that has historically been plentiful in Missouri. However, drought, increased demand, new industries, changing demographics, and infrastructure gaps have created stresses on some surface water supplies. Consideration for the cumulative effects of these factors make it prudent to analyze trends in streamflow, as, in addition to being sources themselves, streams provide inflow to water supply reservoirs throughout the State. Trends in the occurrence and availability of streamflow, precipitation, and run-off can be used to facilitate proper water resource management in the coming years. Understanding trends in streamflow can improve the accuracy of reservoir yield studies, and combined with the statewide analysis of water supply, demand, and infrastructure performed as part of the Missouri Water Resource Plan can highlight potential supply vulnerabilities.

For this study, an evaluation of reservoir elevations was performed in order to determine whether or not reservoir elevations could be used as a surrogate for trends in reservoir capacities within and adjacent to Missouri. It was determined that without period of record operational models for all reservoirs, trends could not be evaluated for the reservoirs. Operational changes occurring in reservoirs obscure those changes which may have resulted from changing precipitation, streamflow, and water use.

H.1.1 Purpose and Scope

Trend analyses are performed for precipitation and streamflow in order to understand the constancy of surface water resources. Trend analyses are also performed on land-use and land-cover data in order to evaluate the cause of trends in streamflow. For example, if trends in run-off are increasing they may be more or less correlated to precipitation or increases in urban development within the watershed or both. In an area where no significant trends in surface water resources are observed, surface water resources may be considered to remain relatively stable. In an area where significant trends in surface water resources show significant increasing trends, surface water resources are increasing over time for the period of analysis.

H.2 Methods

Trends in precipitation, streamflow, and land-use and land-cover were evaluated for watersheds which contribute streamflow to a USGS streamflow gaging station. Trends in precipitation and land-use and land-cover were also evaluated at the larger 6-digit hydrologic unit code (HUC) level in order to get a more general sense of larger scale trends across the State of Missouri. Trends in streamflow, baseflow, and run-off were compared to trends in precipitation and land-use and land-cover on a statewide scale and some streamflow gaging stations in neighboring states which contribute streamflow to Missouri or flow from Missouri were evaluated for trends. Streams which were found to be affected by regulation, channel modifications, or waste-water discharge were excluded from this study, including USGS streamflow gaging stations on the Missouri and Mississippi Rivers.

Trend analyses for this study were performed using R Statistical Software (R Core Team 2019). The Mann-Kendall test for Kendall's tau (Kendall 1975; Mann 1945) was used to test for monotonic (unidirectional, only increasing or decreasing with time) trends in precipitation, streamflow, reservoir pool elevation, reservoir release data, and land-use and land-cover (LULC). The Mann-Kendall test is a rank-based procedure that is typically used to determine whether the central value, such as the mean or median, of a data set changes over time (Helsel and Hirsch 2002). The Mann-Kendall test does not require normally distributed data, making it an appropriate choice for trend analyses using skewed data sets such as streamflow and precipitation data.

Ordered pairs (x,y) of data are ranked by increasing values of the independent variable x in order to calculate Kendall's tau correlation coefficient (τ). As it applies to this study, x represents time and y represents the environmental variable (streamflow, elevation, precipitation, or land use/land cover) that is being evaluated over time. For τ to be positive, the y variable has to increase more often than it decreases with time;

conversely, for τ to be negative, the y variable has to decrease more often than it increases with time. For τ to be zero, the y variable has to increase and decrease the same number of times (Helsel and Hirsch 2002). The y variable for each year in the data set is compared with the y variable from every other succeeding year in the data set, for a total of n(n-1)/2 possible combinations to be made among the n (x, y) data pairs (Helsel and Hirsch 2002). Therefore, if τ is positive, the y variable is increasing through time and if τ is negative the y variable is decreasing through time.

The p-value computed for the Mann-Kendall test result indicates the significance of τ. P-values are used to assess probability of the significance of the null hypothesis. Thus, low p-values indicate the higher significance of the parameter being considered, in this case τ, and vice versa. For this analysis, P-values having a level of significance that is less than 1-percent (or $p < 0.01$) were reported as zero.

The Sen slope is a measure of the expected rate of change in the y variable for a given x variable (Sen 1968). The Sen slope is the median of the slopes computed from the data pairs used in the computation of τ. For this study, an expected annual percent rate of change was computed for each metric as the ratio of the Sen slope to the median value of the metric, expressed as a percentage.

H.2.1 Precipitation

Precipitation data used for this study was obtained from the Parameter-elevation Regressions on Independent Slopes Model, or PRISM, (PRISM Climate Group 2013). The period from 1950 to 2017 was used for analyses of precipitation data. PRISM precipitation data are derived from the National Climatic Data Center (NCDC) Global Historical Climate Network and has been corrected for the orographic effects of elevation. The precipitation data developed by PRISM are spatially gridded and available as an ACSII grid file at a 2.5-arc minute (4 kilometers) resolution. For this study, monthly precipitation data were analyzed for all watersheds contributing flow to USGS streamflow gaging stations listed in **Table H-2** and the larger 6-digit HUCs within the State of Missouri.

H.2.2 Streamflow

Streamflow data evaluated for trends in this study were collected by the USGS and obtained from the National Water Information System, or NWIS, (U.S. Geological Survey 2016). Daily mean streamflow values were retrieved for each USGS streamflow gaging station for the period of 1950 to 2017, if data were available for that period. . Of the 60 streamflow gaging stations considered for analysis, ten had gaps in the record of daily mean streamflow and two had continuous records ending in 2005. Specifics regarding the period of record analyzed are listed in **Table H-2**.

Gages for analysis were selected by the Missouri Department of Natural Resources. Of the 60 gages considered for analysis 8 were not included in the analysis. These gages were found to be under excessive non-natural influences, the effects of which would significantly alter the natural flow regime and influence computation of trends related to streamflow.

Groundwater discharge, or baseflow, is a portion of streamflow that is not run-off; it is water from the ground, flowing into the channel over a long time and with a delay. Run-off is streamflow which enters the stream from overland flow resulting from precipitation. In order to evaluate trends in baseflow and run-off, baseflow separation was performed on the daily mean time-series of streamflow data. The PART (Rutledge 1998) method for baseflow separation was used to perform baseflow separation. The PART method uses antecedent recession and linear interpolation to estimate baseflow during periods of run-off resulting from precipitation. Time-series run-off data was computed by subtracting baseflows calculated from the PART method from streamflow.

H.2.3 Land-Use and Land-Cover

Land-use and land-cover (LULC) data used for evaluation of trends were obtained from the USGS Earth Resources Observation and Science (EROS) Center. Annual raster-based maps of LULC conditions for the years 1938 to 1992 were created based on information on historical patterns and prescriptions of LULC change (Sohl et al. 2016). Subsequently, LULC data from 1992 to 2017 were interpolated from the five year National Land Cover Database (NLCD) data (Homer et al. 2015). LULC rasters for each year from 1950 to 2017 were extracted for each 6-digit HUC and for every watershed contributing flow to USGS streamflow gaging stations listed in **Table H-2**, and a mean value for percent LULC agriculture, developed, forested, and wetland was computed. Trend analysis was performed on the annual time-series of LULC data.

H.3 Results

For each streamflow gaging station evaluated for trends, Kendall's τ, p-Value, Sen's slope, median value, and expected annual rate of change are listed in **Table H-3** for seasonal and annual trends for total streamflow, baseflow, and run-off. For each streamflow gaging station and for every 6-digit HUC, annual and seasonal trends for precipitation are listed in **Table H-4**. Similarly, trends for land-use and land-cover for each streamflow gaging station and 6-digit HUC are listed in **Table H-5**.

H.3.1 Precipitation Trends

Significant, increasing trends in annual precipitation occurred in eleven of thirteen 6-digit HUC regions evaluated in this study (**Figure H-1**). Of the four seasons analyzed for precipitation trends (**Figure H-2** and **H-3**), spring and fall each had ten 6-digit HUC regions with increasing, significant trends making them the seasons with the most increased precipitation. In the two 6-digit HUC regions which did not show significant, increasing trends (p-values for these 6-digit HUC regions were 0.13), watersheds within those 6-digit HUC regions did show significant, increasing trends (**Figure H-4** through **H-6**). While this may seem counter intuitive, it is likely related to the spatial variability of long-term rainfall patterns within the two 6-digit HUC regions. Analysis of individual watersheds, or smaller sections of the 6-digit HUC regions, showed less long-term spatial variability in precipitation and showed significant, increasing trends in annual precipitation.

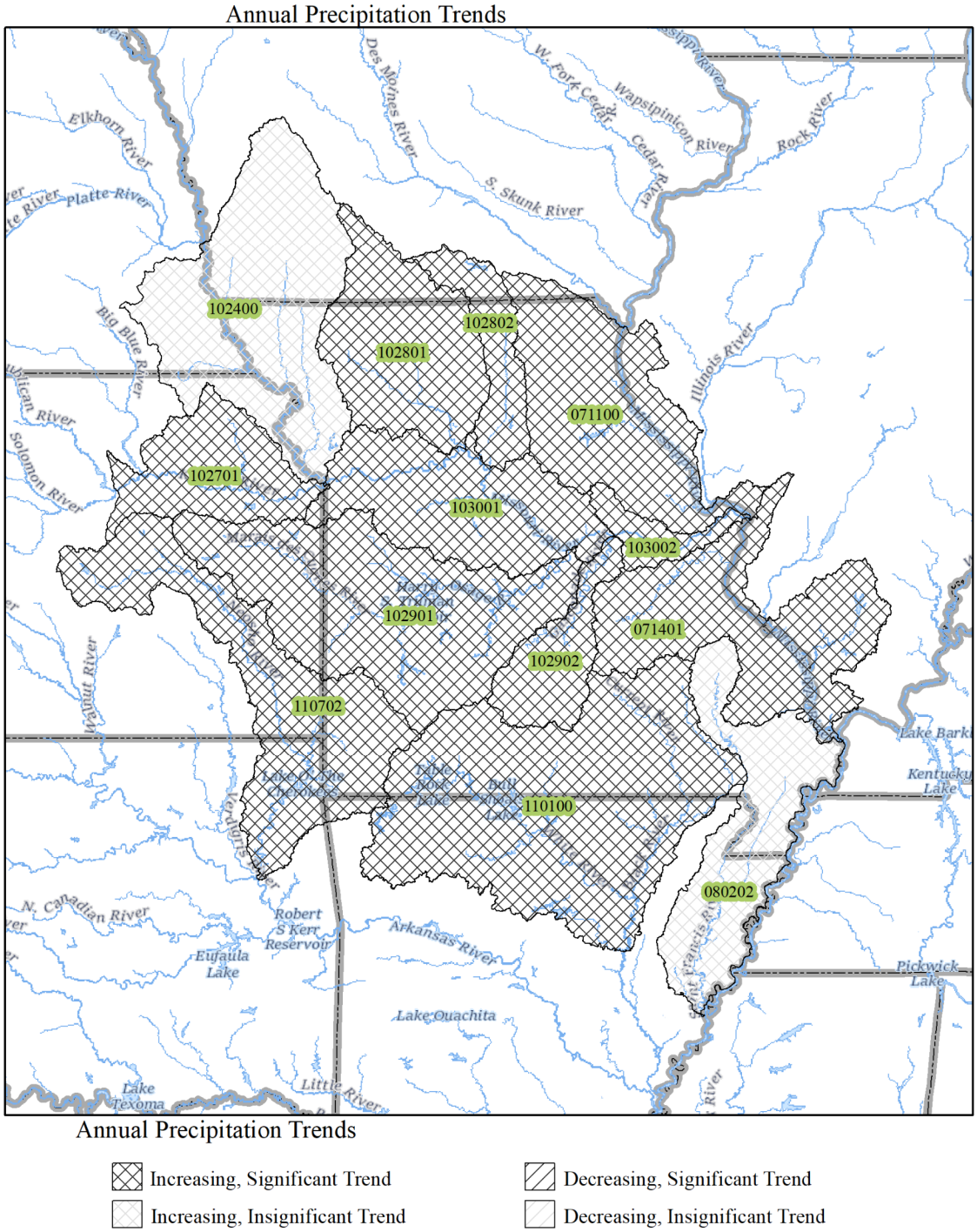

Figure H-1: Map showing annual precipitation trends for 6-digit HUCs in Missouri.

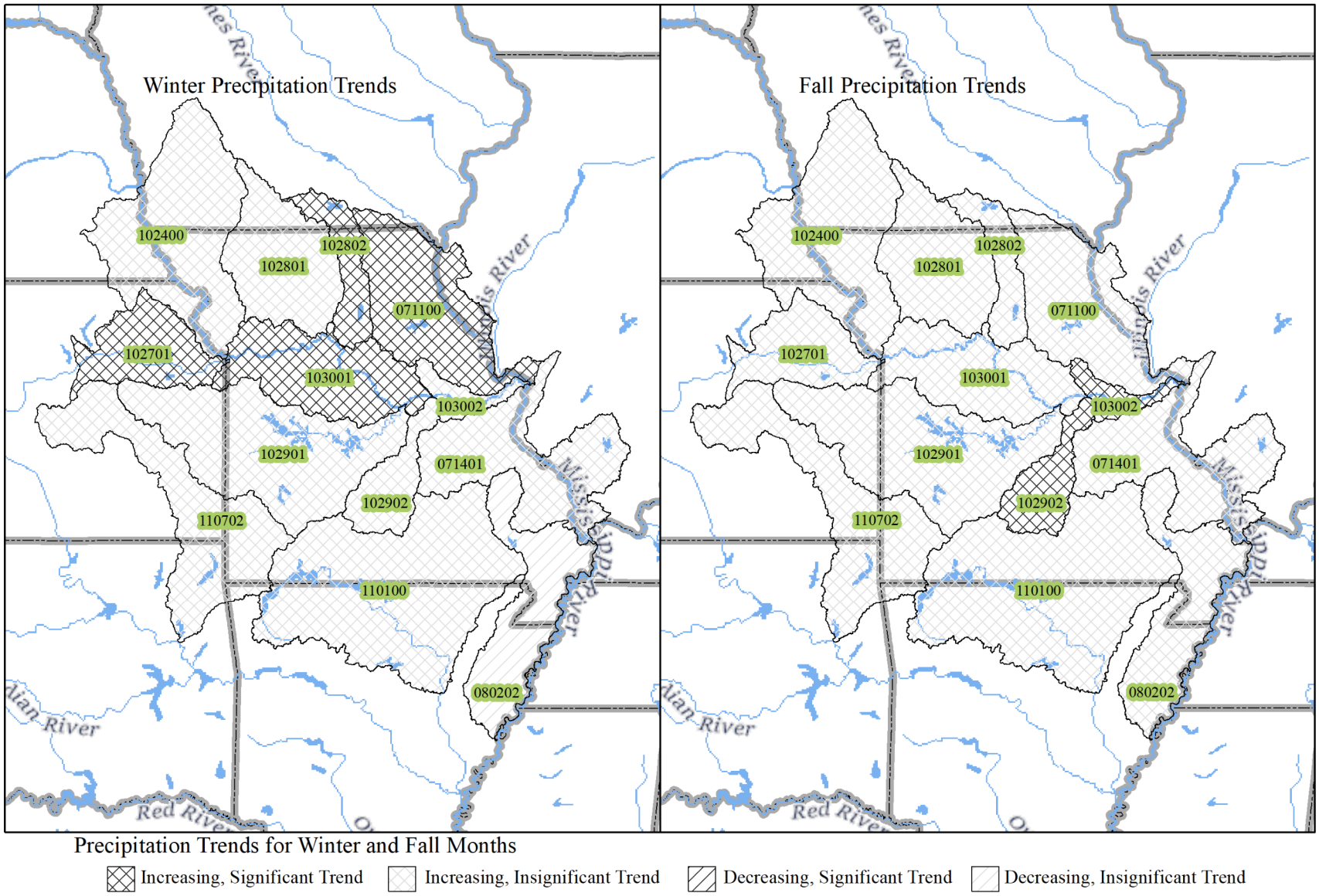

Figure H-2: Map showing winter and fall precipitation trends for 6-digit HUCs in Missouri.

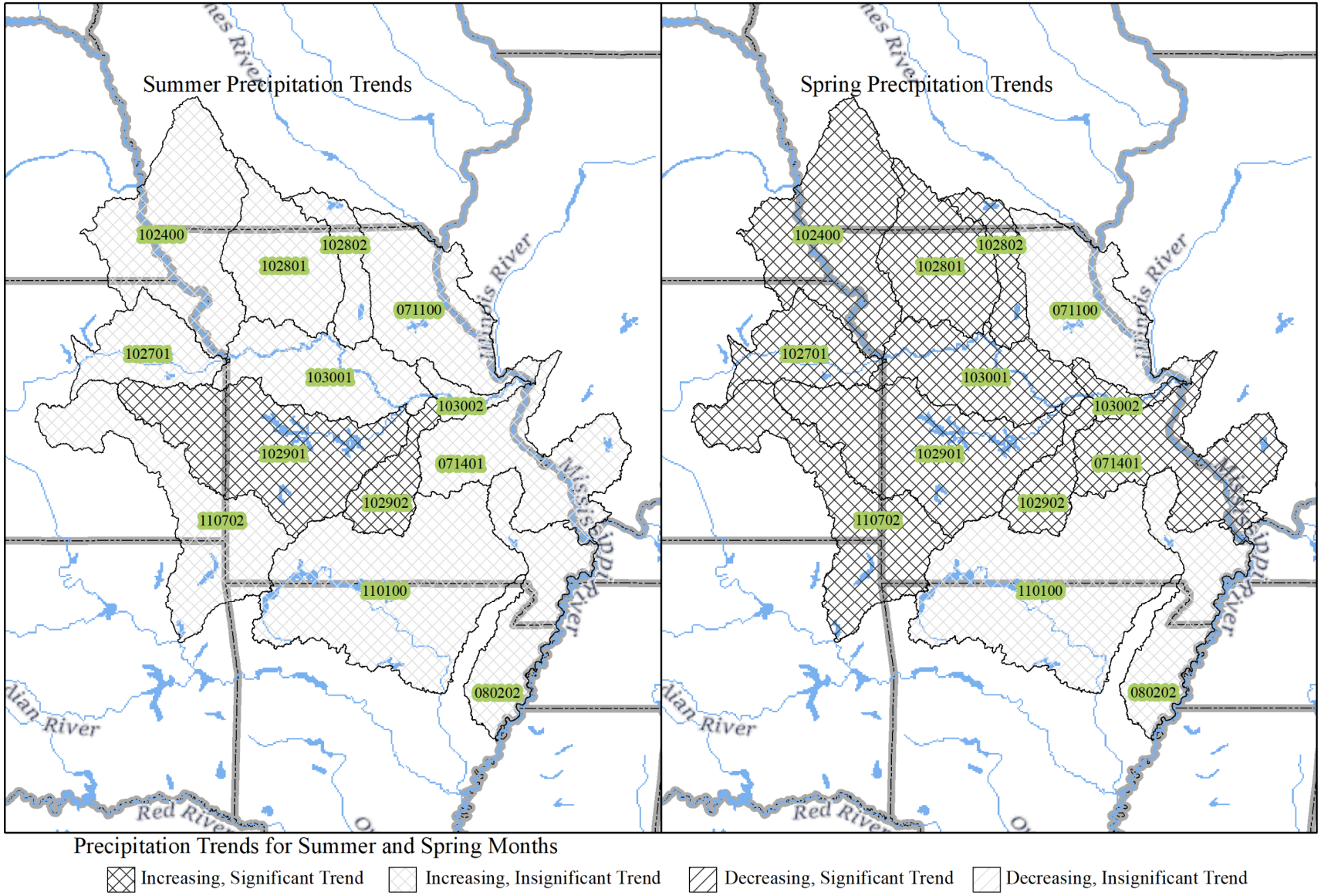

Figure H-3: Map showing summer and spring precipitation trends for 6-digit HUCs in Missouri.

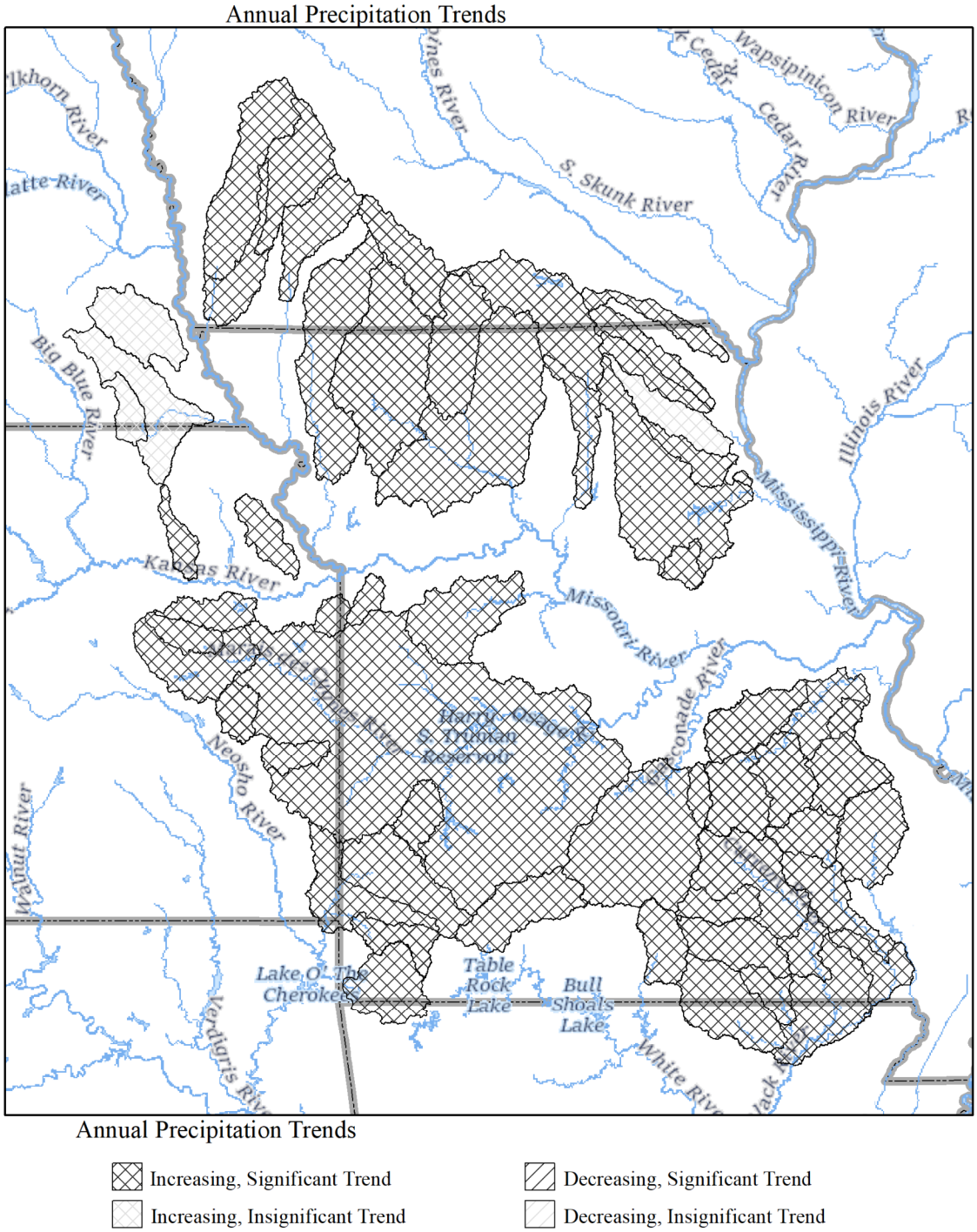

Figure H-4: Map showing annual precipitation trends for watersheds in Missouri.

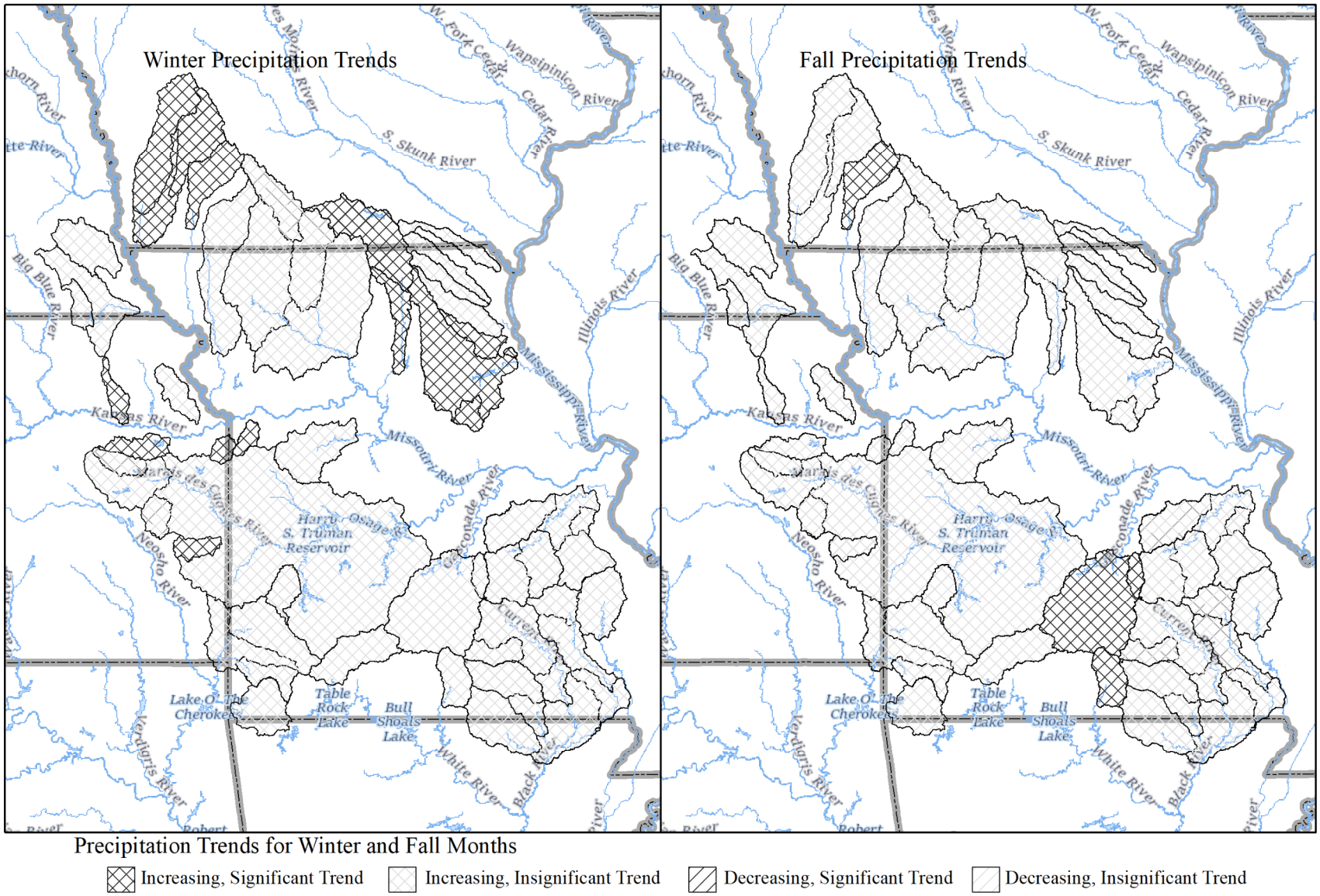

Figure H-5: Map showing winter and fall precipitation trends for watersheds in Missouri.

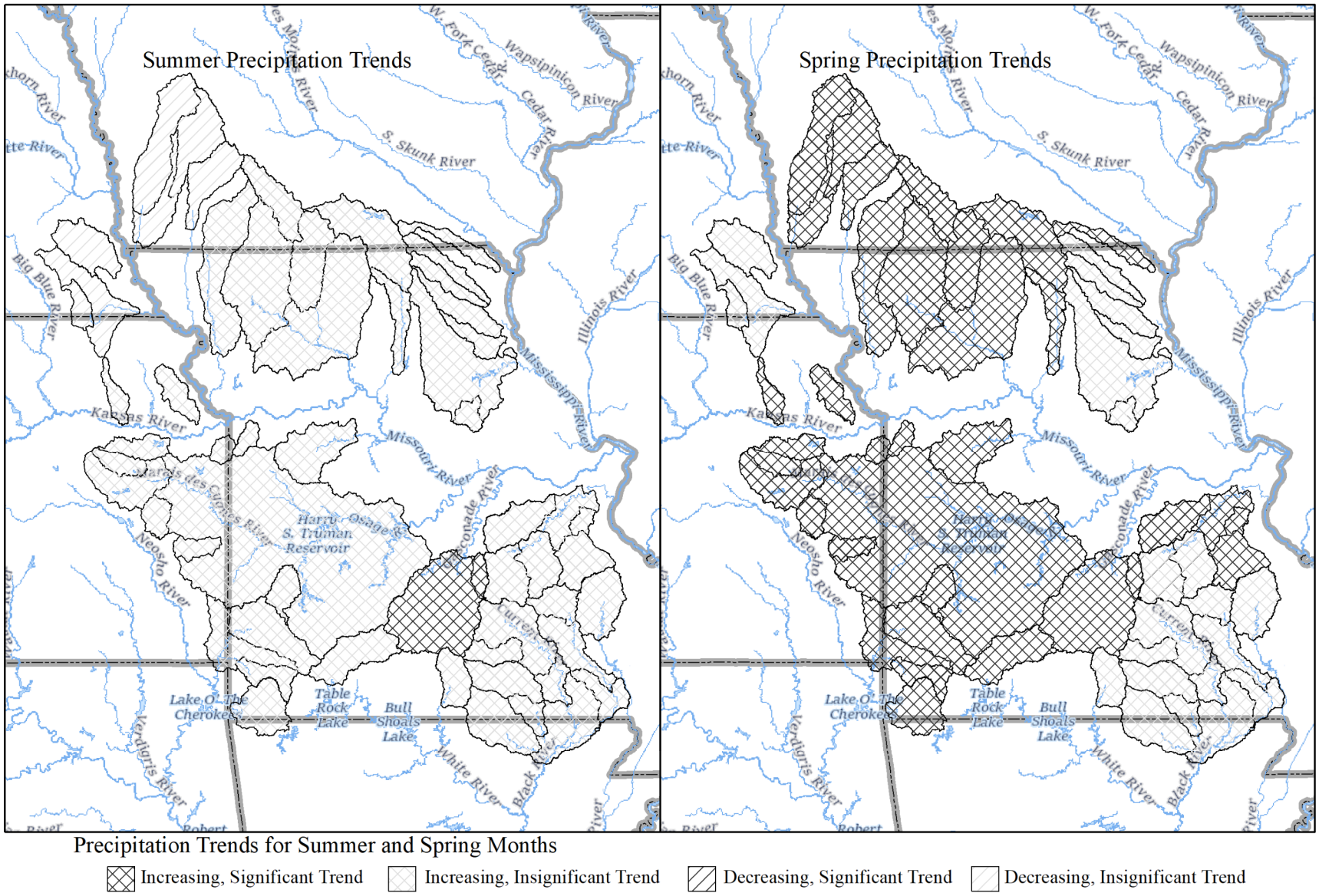

Figure H-6: Map showing summer and spring precipitation trends for watersheds in Missouri.

H.3.2 Streamflow Trends

In general, the streamflow trends that were found to be statistically significant were increasing (**Figure H-7** through **H-11**). Results for indicating the number of streamflow gaging stations that are significantly increasing or decreasing are listed in **Table H-1**. Annual mean streamflow, or 'Annual; Total' shows statistically significant increases at 41 of the 52 streamflow gaging stations analyzed. Of the 52 streamflow gaging stations analyzed, 46 show significant increasing trends in annual minimum daily flows, or 'Annual Minimum; Total'. The other six gaging stations did not show statistically significant trends.

Table H-1: Number of streamflow gaging stations showing statistically significant increasing or decreasing trends in seasonal and annual total streamflow, run-off, and baseflow.

Streamflow type	Trend direction	Number of gaging stations
Annual Maximum; Total	decreasing	4
Annual Maximum; Total	increasing	21
Annual Minimum; Total	increasing	46
Annual; Baseflow	increasing	45
Annual; Runoff	decreasing	1
Annual; Runoff	increasing	17
Annual; Total	increasing	41
Fall; Baseflow	increasing	32
Fall; Runoff	decreasing	2
Fall; Runoff	increasing	6
Fall; Total	increasing	16
Spring; Baseflow	increasing	45
Spring; Runoff	increasing	28
Spring; Total	increasing	42
Summer; Baseflow	increasing	39
Summer; Runoff	decreasing	3
Summer; Runoff	increasing	7
Summer; Total	decreasing	1
Summer; Total	increasing	21
Winter; Baseflow	decreasing	1
Winter; Baseflow	increasing	21
Winter; Runoff	decreasing	3
Winter; Runoff	increasing	1
Winter; Total	increasing	4

Trends in streamflow can be influenced by changing climate and/or changes in LULC. Correlation (Kendall 1975) and principal components analysis (Mardia, Kent, and Bibby 1979) were used in order to evaluate potential causes of trends in streamflow. In general, increasing annual streamflow trends in the state of Missouri show positive correlation to increasing trends in precipitation and percentage of developed LULC (**Figure H-12**) based on comparisons of τ. Correlations between streamflow trends and trends in LULC were generally poor. Trends in baseflow (**Figure H-13**) and run-off (**Figure H-14**) show similar correlations as for trends in streamflow, except that correlations for τ related to baseflow had very low values of Pearson's R, indicating that no real conclusions can be drawn about the origin of increasing trends in baseflow based upon

correlation alone. Principal components analyses were performed to evaluate relations between trends in streamflow, baseflow, run-off and trends in precipitation and LULC (**Figure H-15**). Based upon the principal components analyses performed, trends in streamflow, baseflow, and run-off are related to trends in precipitation and development within the watersheds of the respective streamflow gaging station.

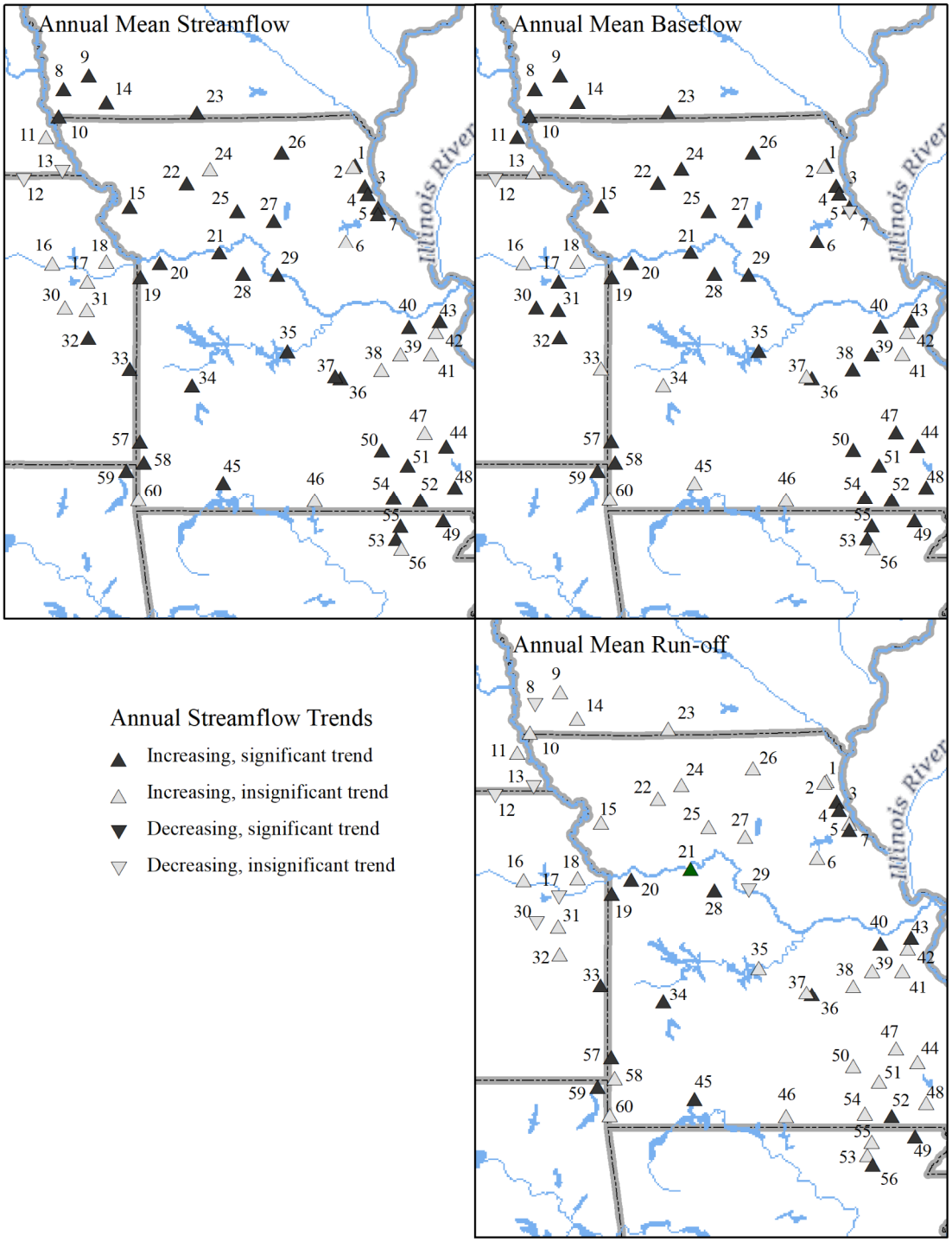

Figure H-7: Map showing annual streamflow trends in Missouri for USGS streamflow-gaging stations with map ID number referenced in Table H-2.

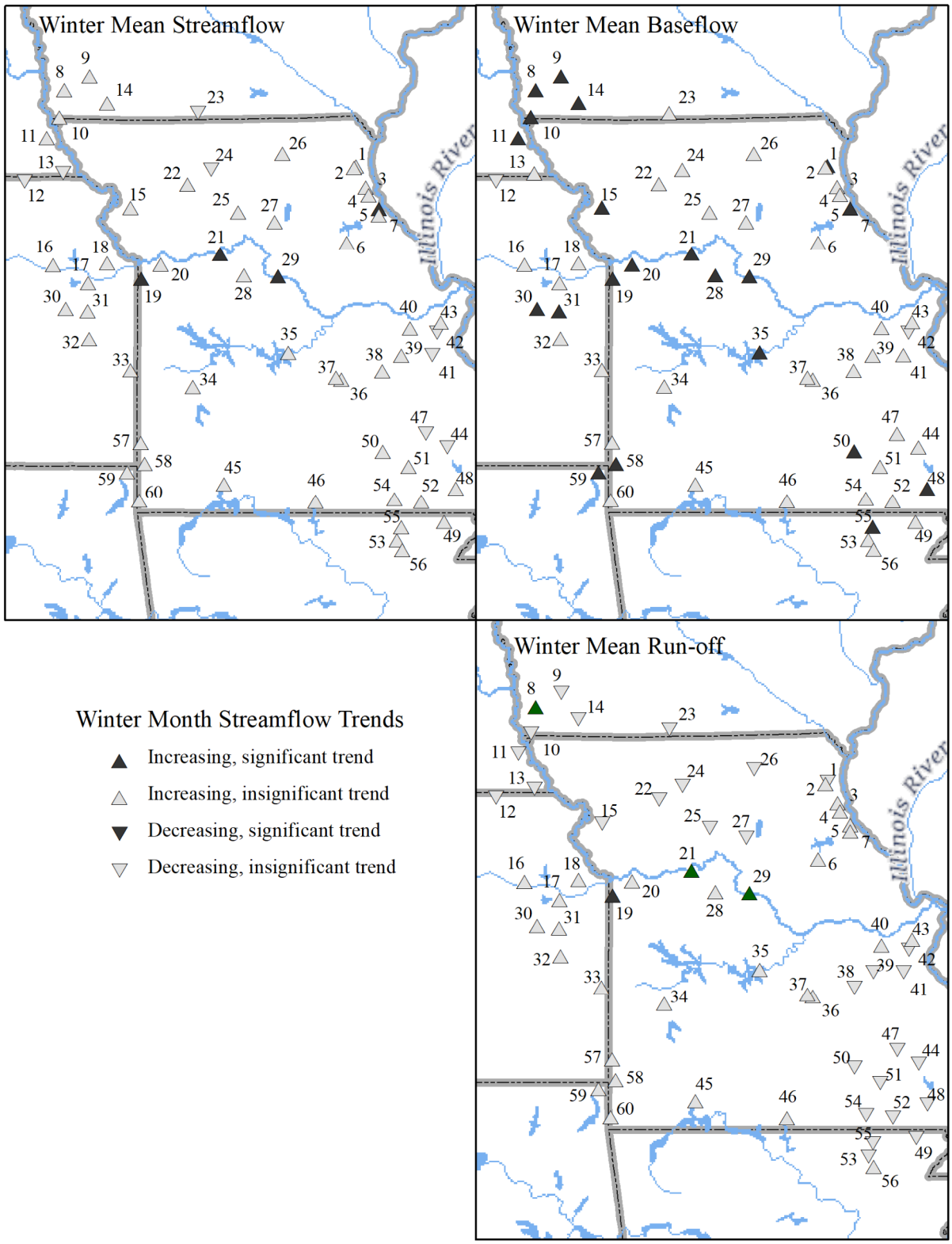

Figure H-8: Map showing winter streamflow trends in Missouri for USGS streamflow-gaging stations with map ID number referenced in Table H-2.

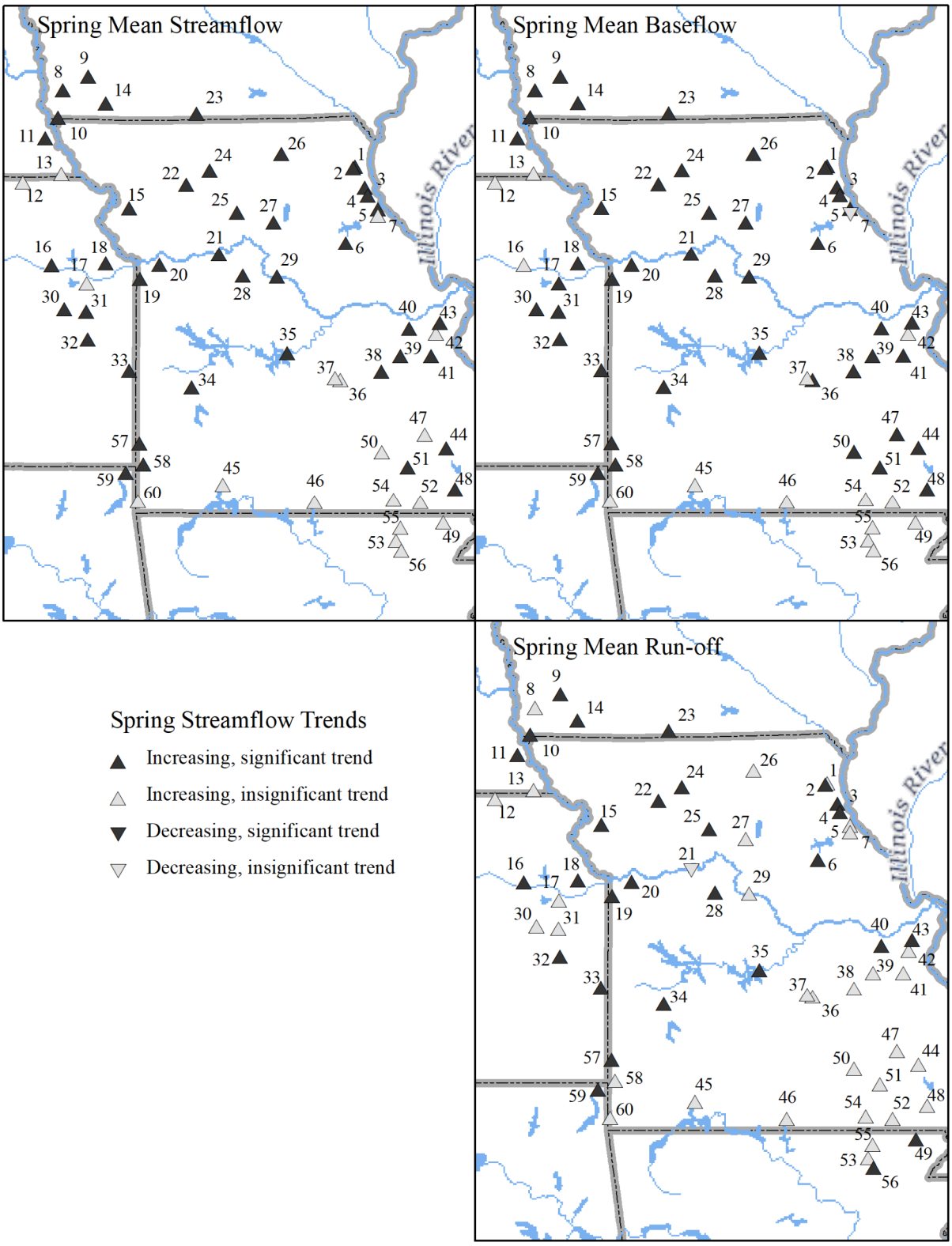

Figure H-9: Map showing spring streamflow trends in Missouri for USGS streamflow-gaging stations with map ID number referenced in Table H-2.

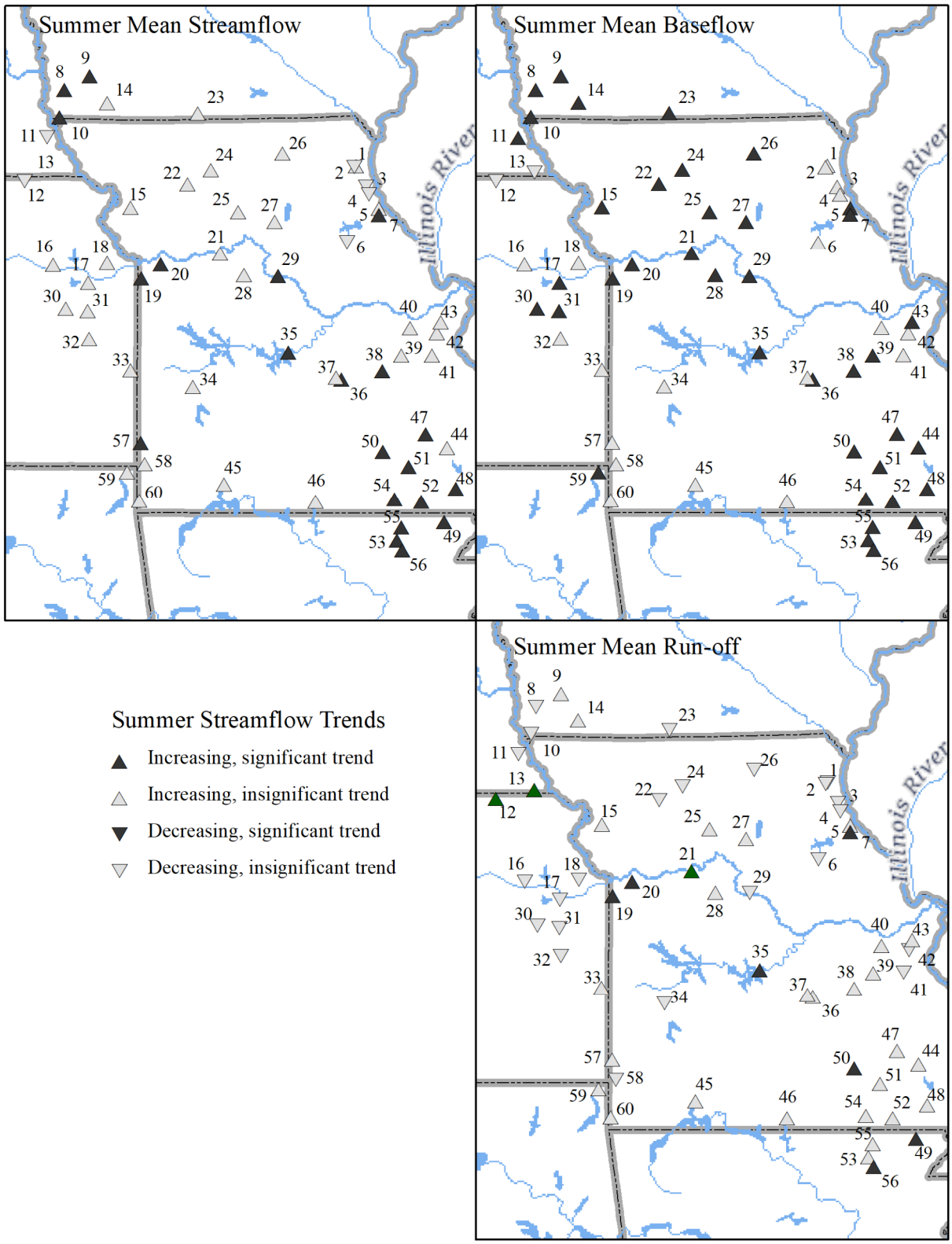

Figure H-10: Map showing summer streamflow trends in Missouri for USGS streamflow-gaging stations with map ID number referenced in Table H-2.

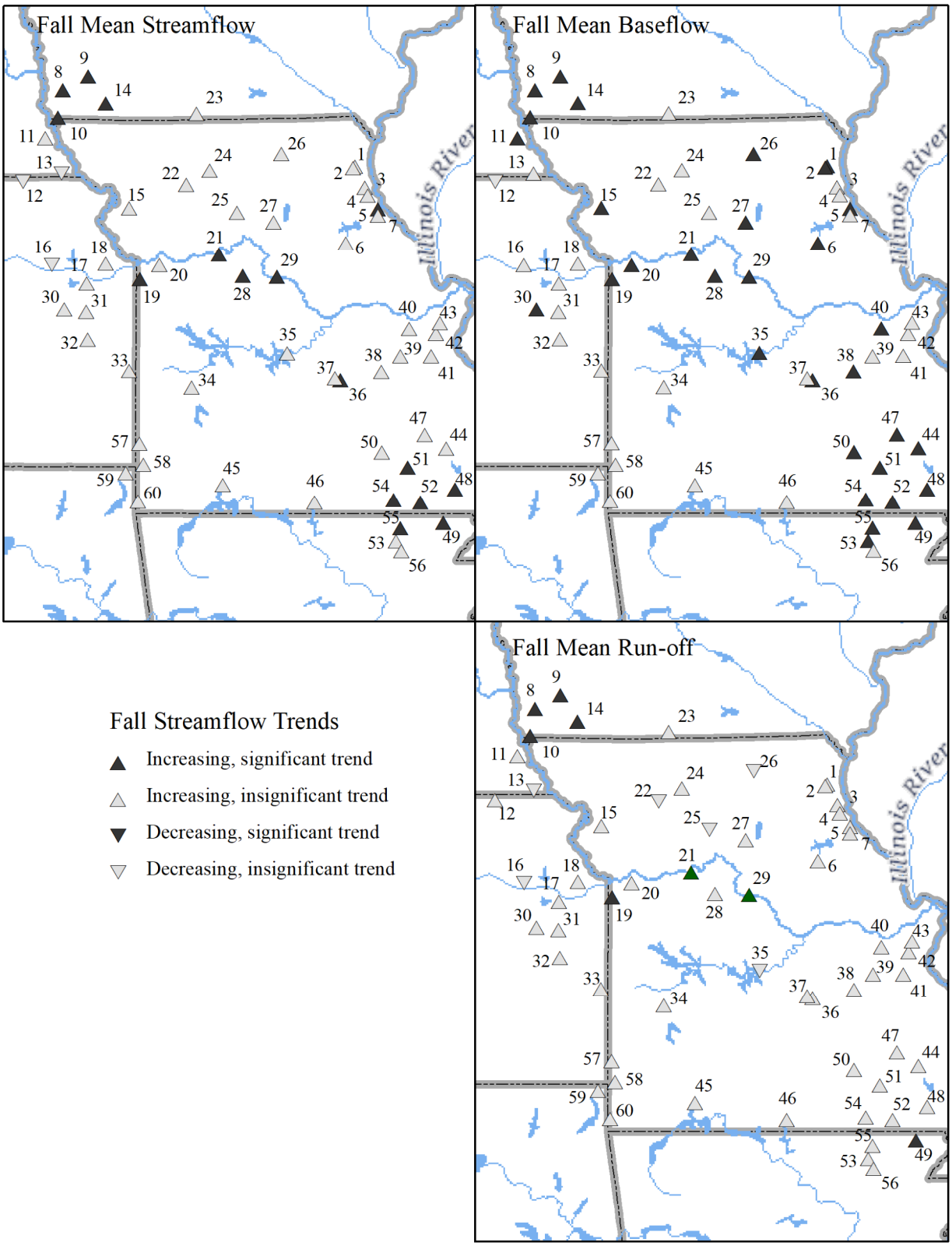

Figure H-11: Map showing fall streamflow trends in Missouri for USGS streamflow-gaging stations with map ID number referenced in Table H-2.

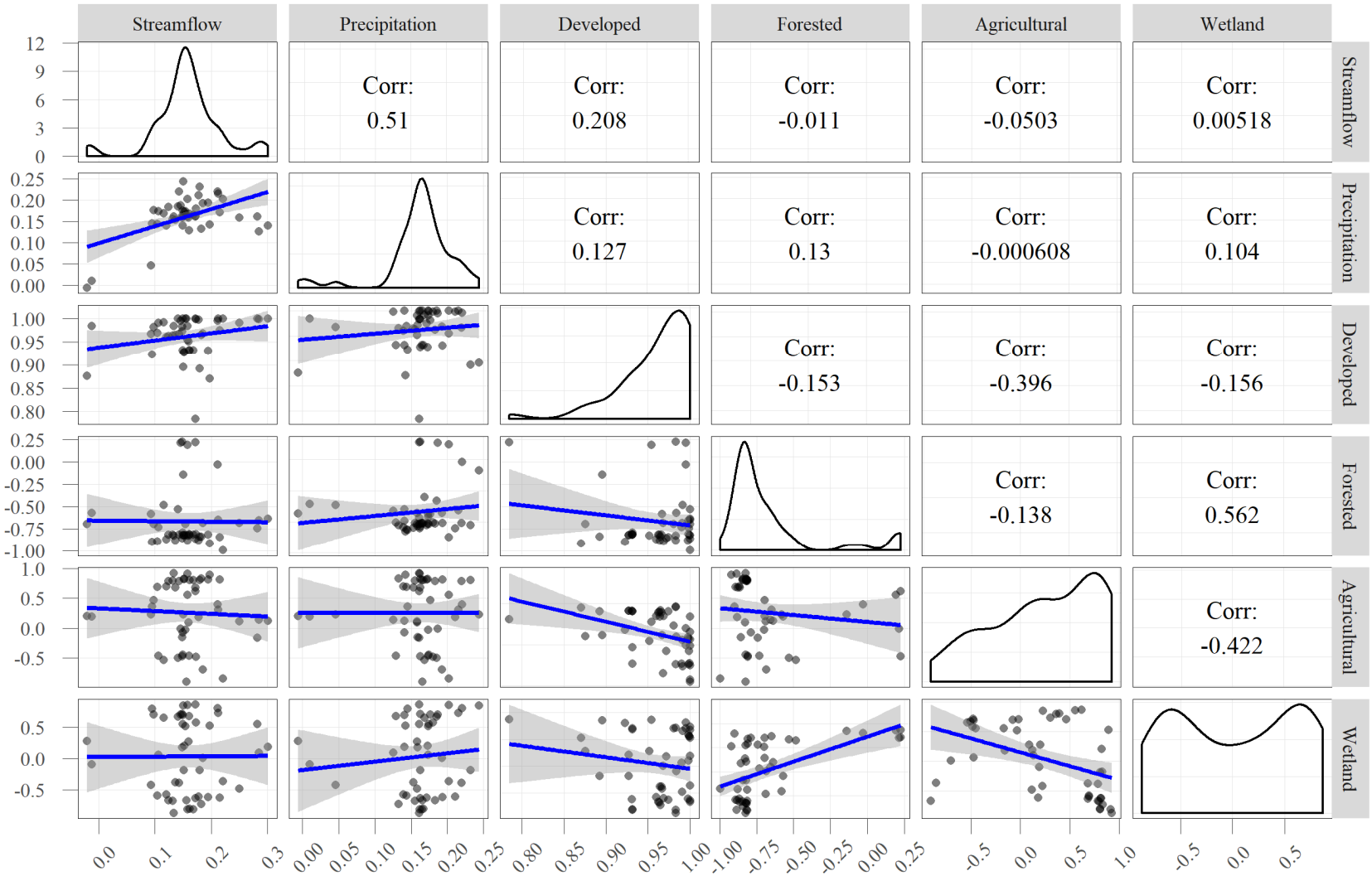

Figure H-12: Plots showing correlations among all values of Kendall's tau, Pearson's R, and the Probability Density Function for streamflow, precipitation, and LULC variables.

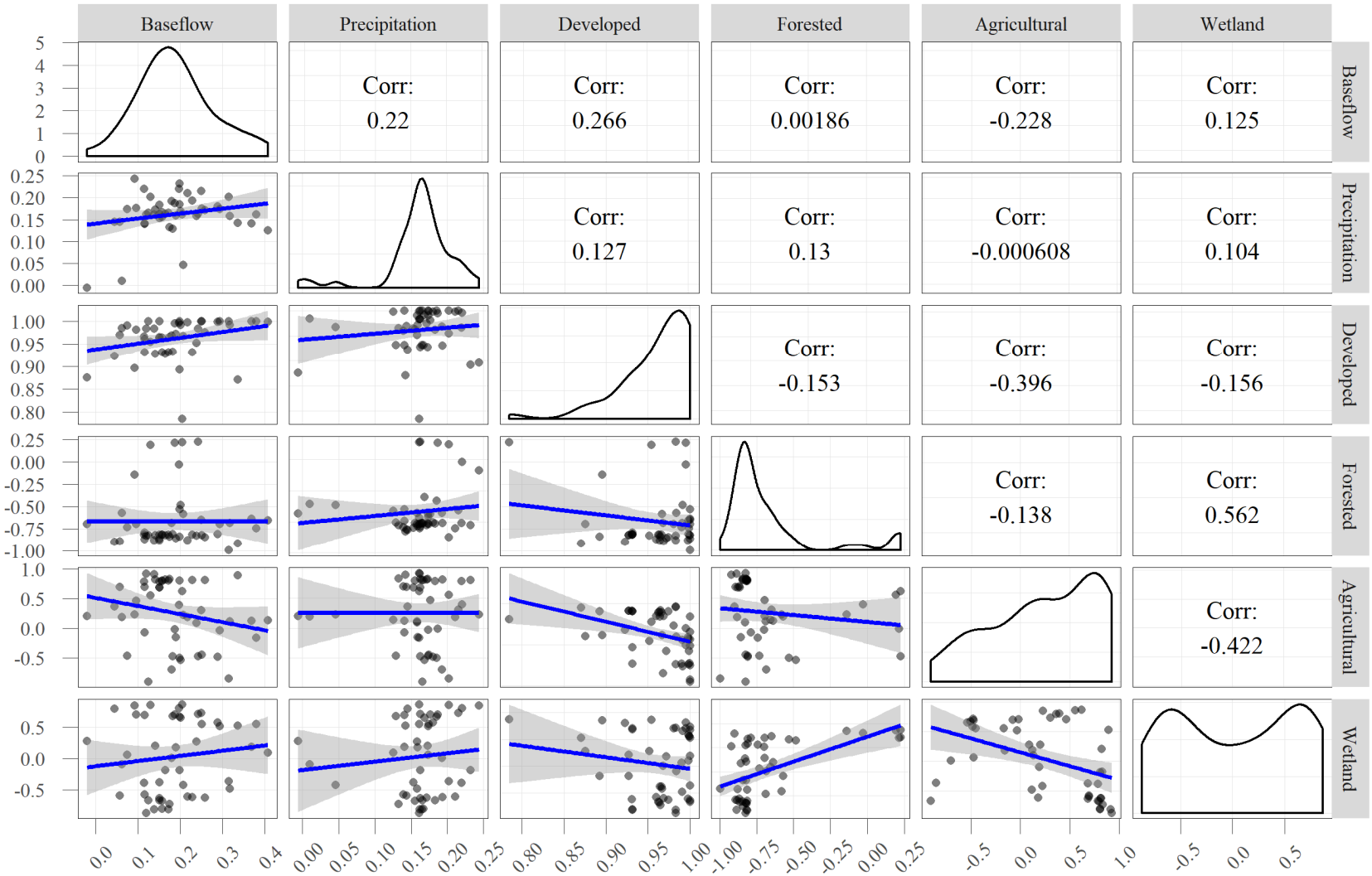

Figure H-13: Plots showing correlations among all values of Kendall's tau, Pearson's R, and the Probability Density Function for baseflow, precipitation, and LULC variables.

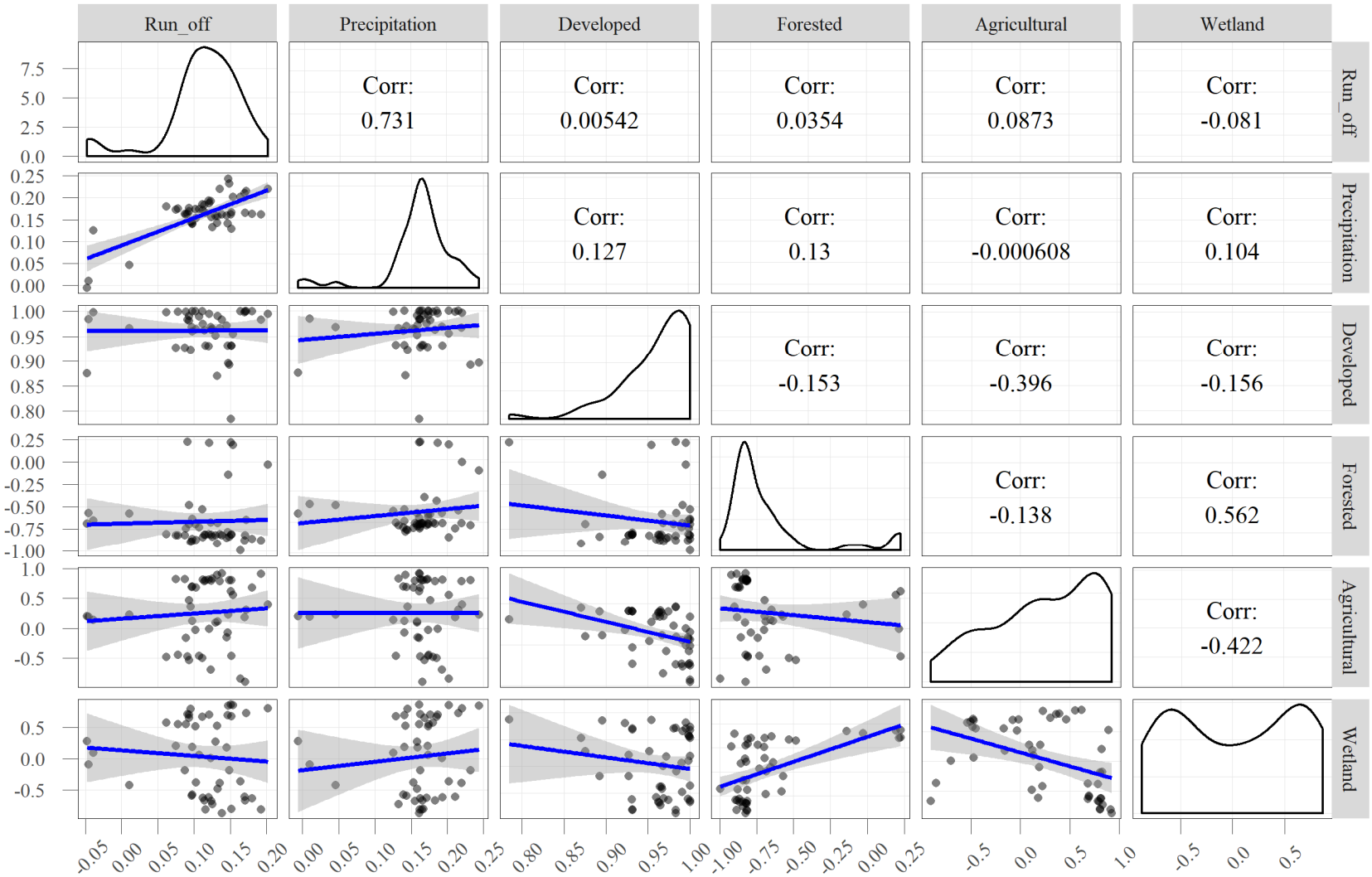

Figure H-14: Plots showing correlations among all values of Kendall's tau, Pearson's R, and the Probability Density Function for run-off, precipitation, and LULC variable.

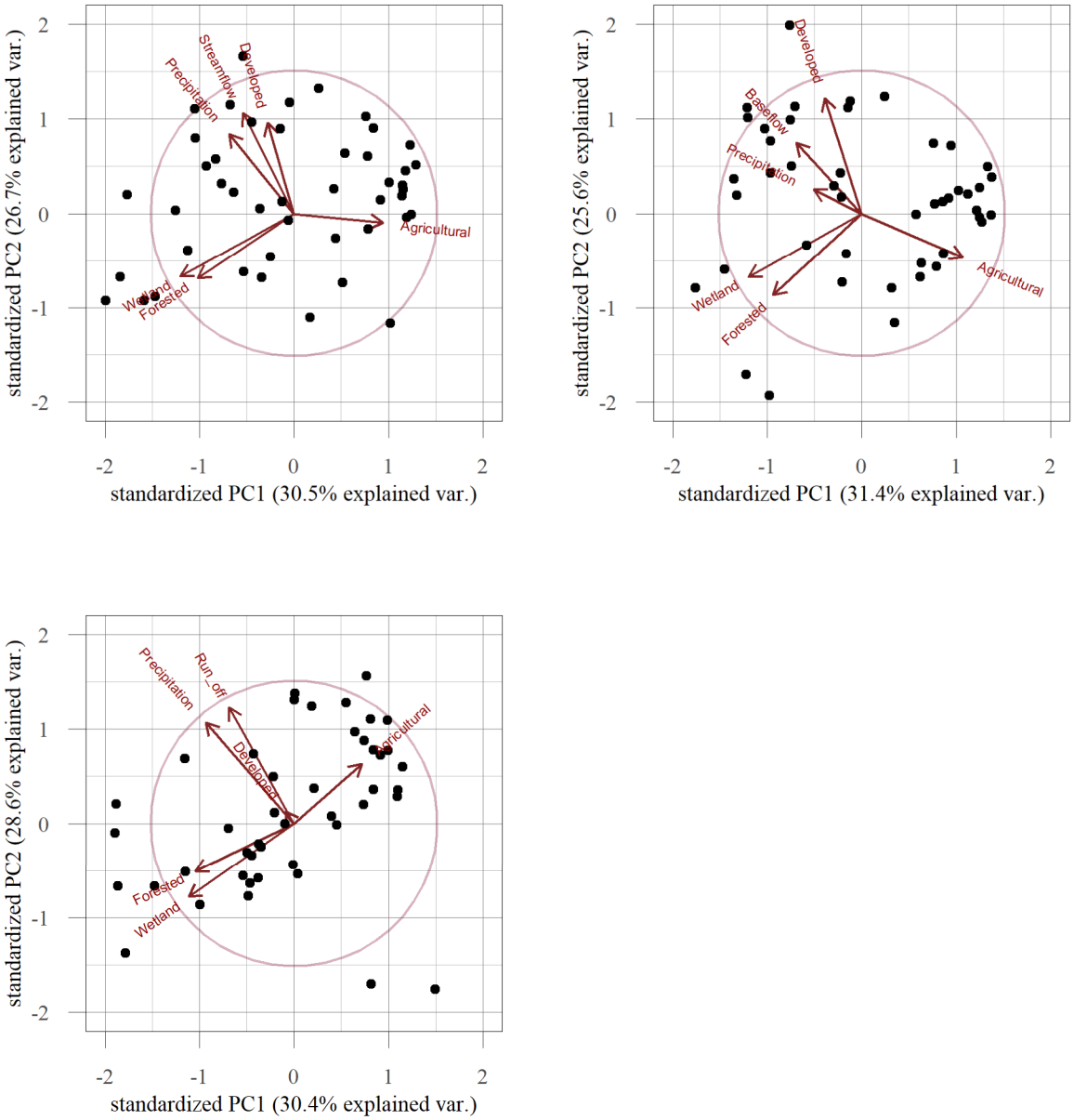

Figure H-15: Biplots from principal components analyses showing relations among all values of Kendall's tau for streamflow, baseflow, run-off, precipitation, and LULC variables.

H.3.3 Land-Use and Land-Cover Trends

All of the 6-digit HUC regions showed statistically significant, increasing trends in percent developed (**Figure H-16**). Six 6-digit HUC regions showed increasing, statistically significant trends in percent agriculture in the southern part of the study area (**Figure H-16**). Five 6-digit HUC regions showed decreasing, statistically significant trends in percent agriculture in the north, central part of the study area. All of the 6-digit HUC regions showed statistically significant, decreasing trends in percent forested (**Figure H-17**). LULC trends are displayed in **Figures H-18** and **H-19**.

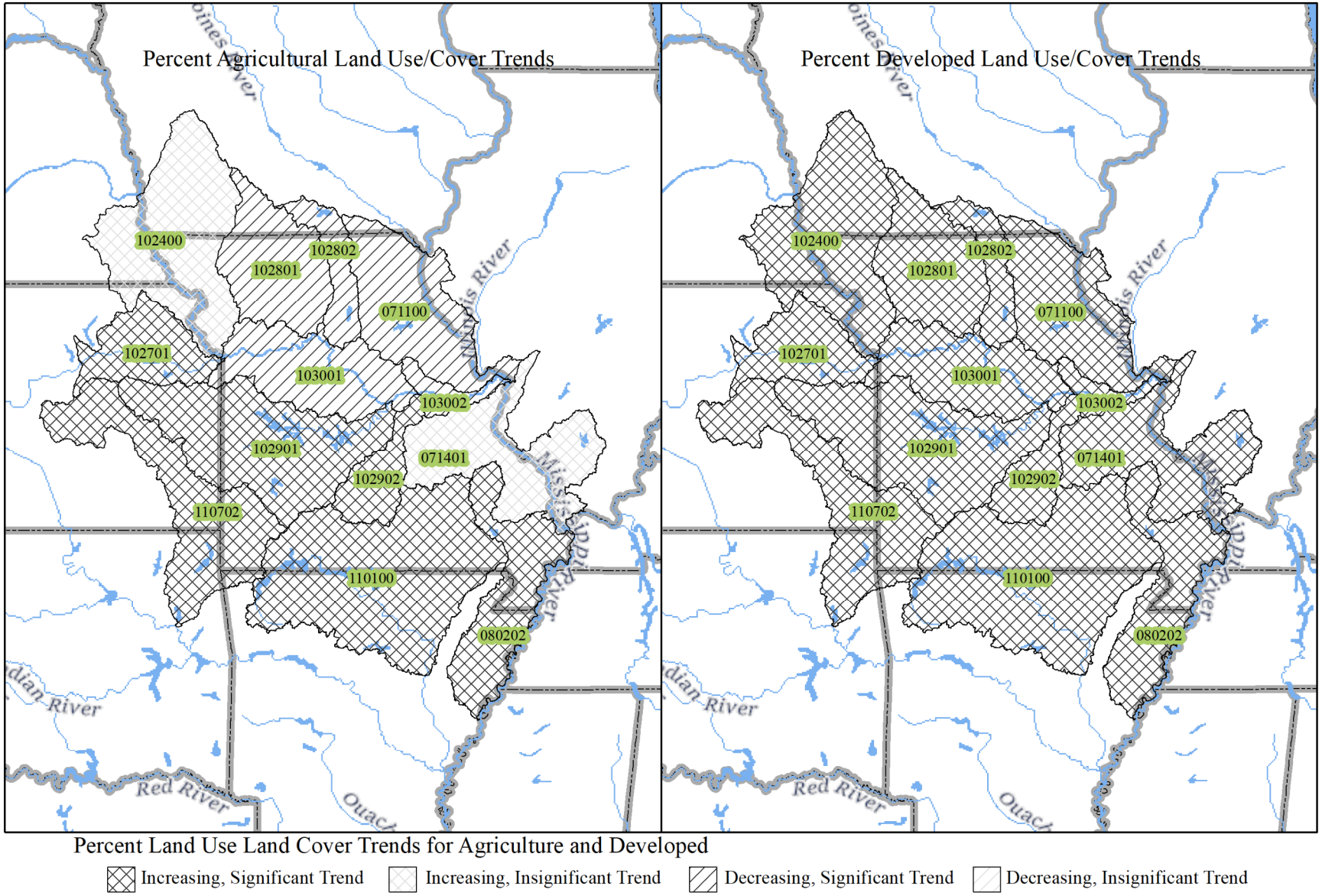

Figure H-16: Map showing land use/land cover trends for percent agriculture and percent developed for 6-digit HUCs in Missouri.

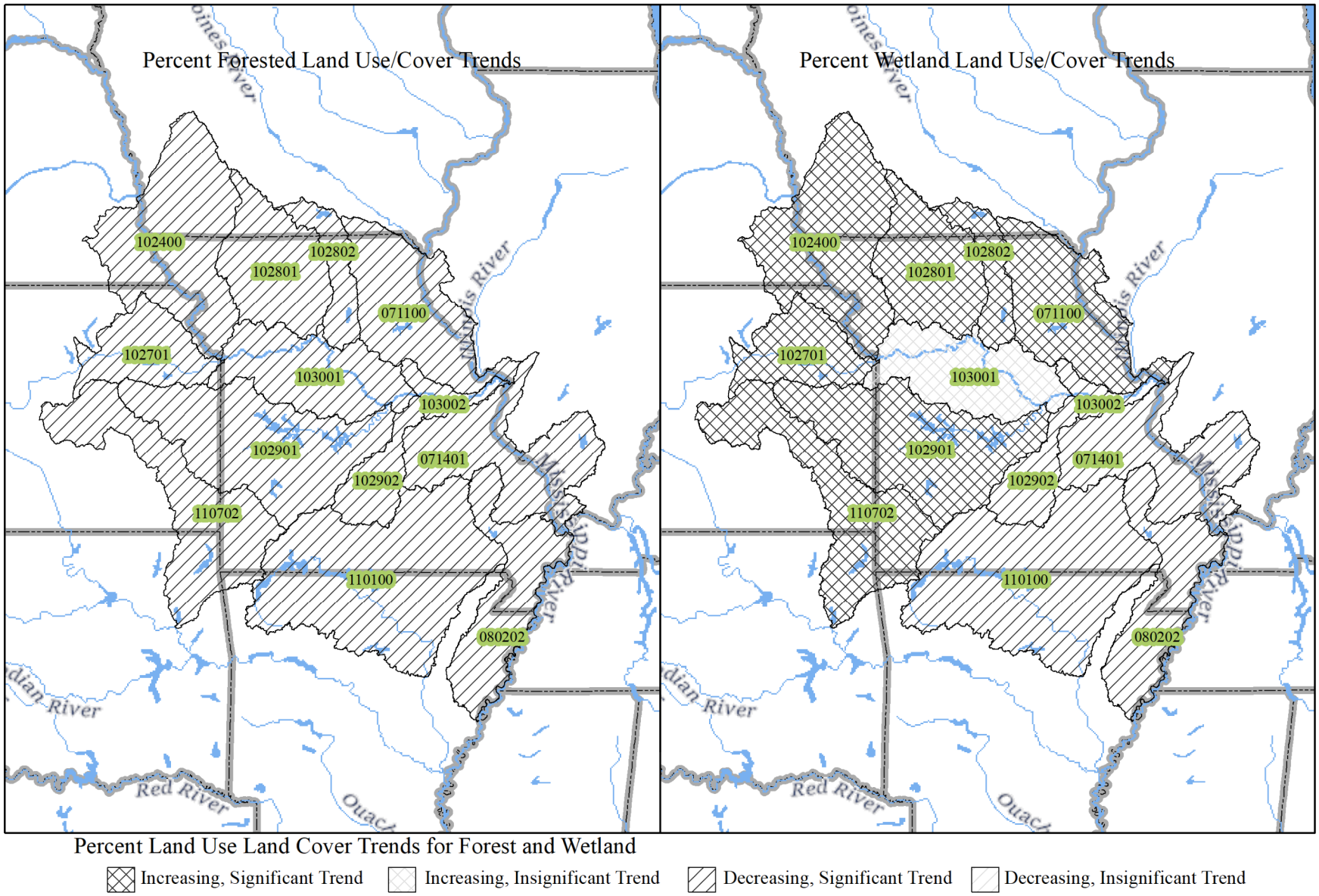

Figure H-17: Map showing land use/land cover trends for percent forest and percent wetland for 6-digit HUCs in Missouri.

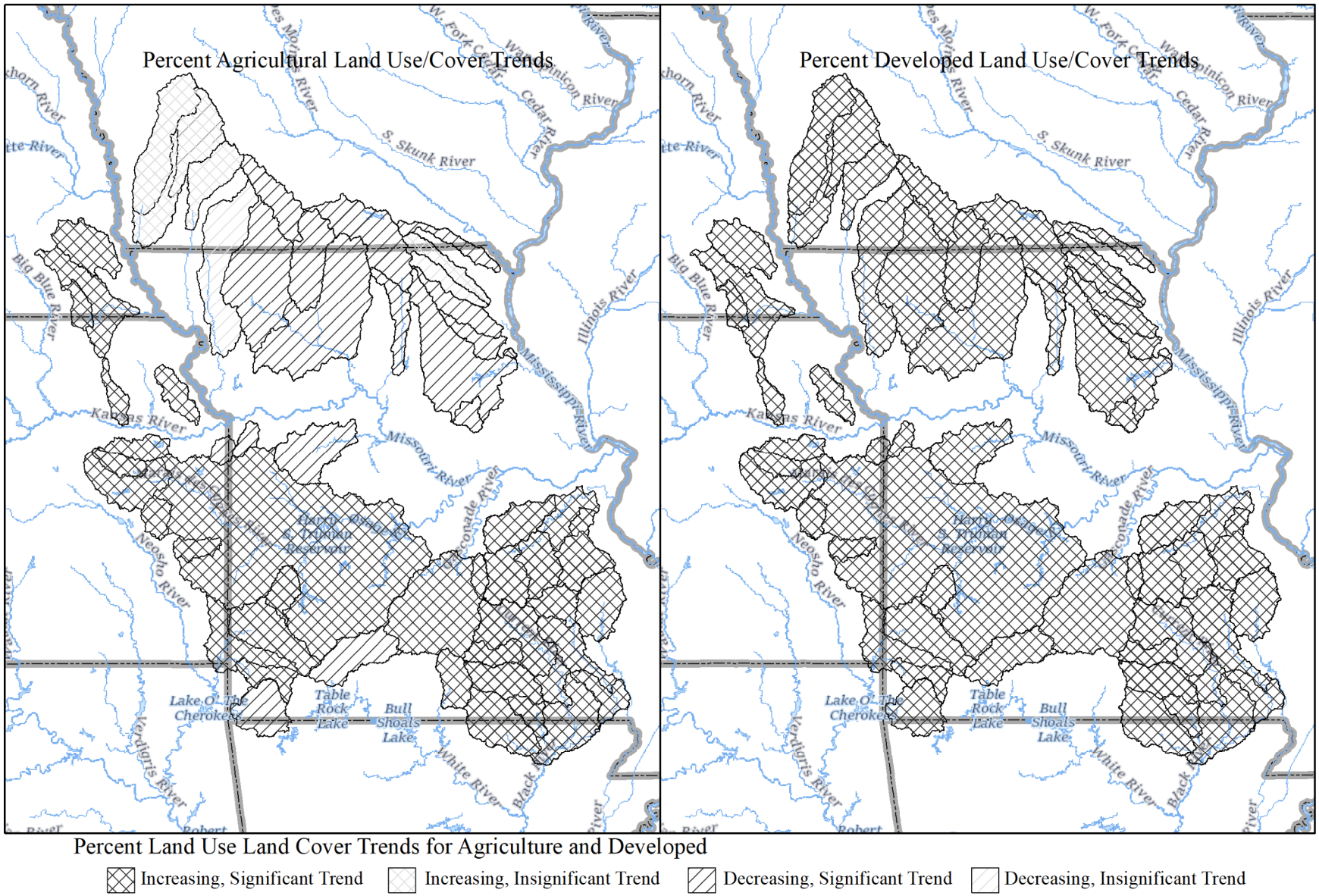

Figure H-18: Map showing land use/land cover trends for percent agriculture and percent developed for watersheds in Missouri.

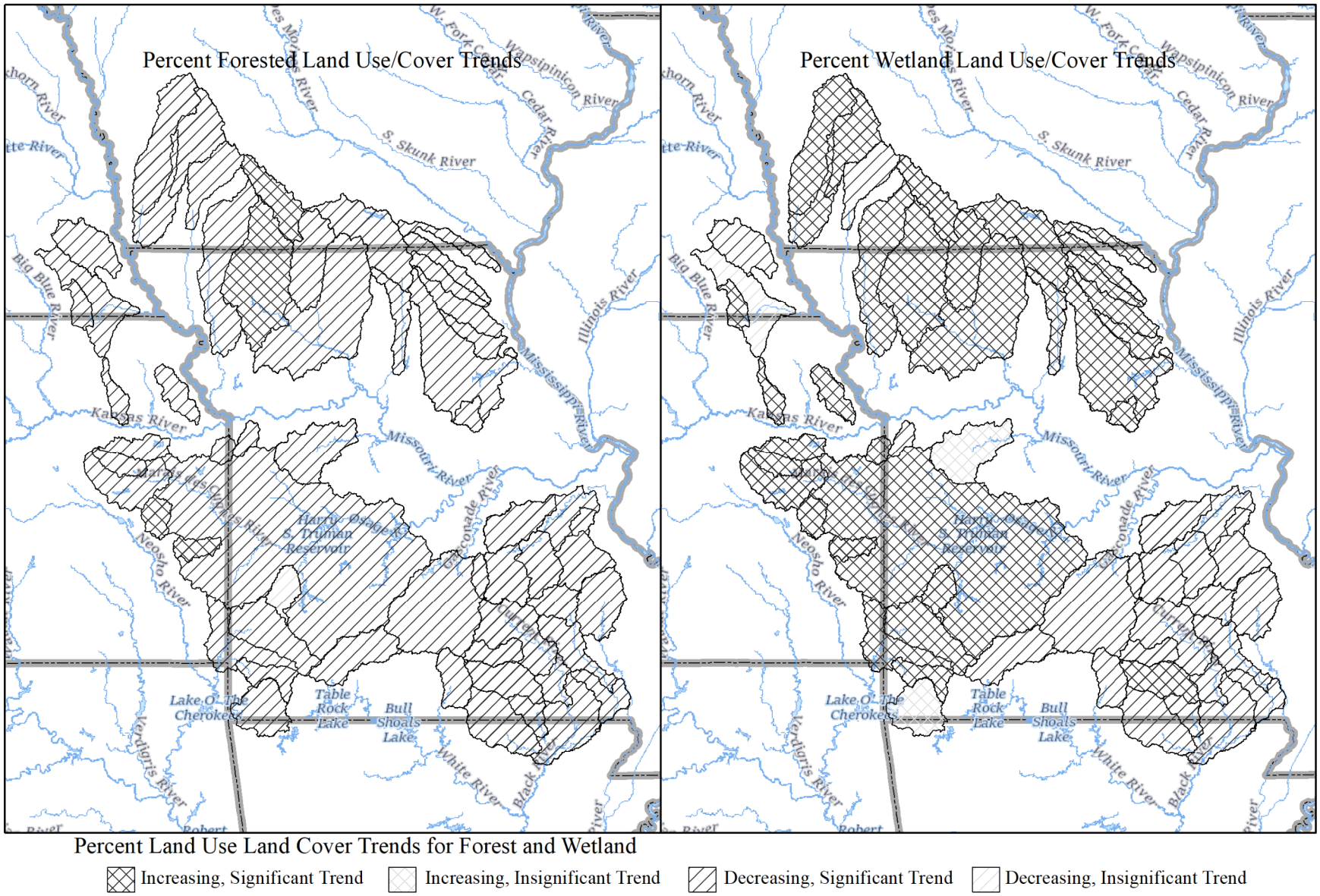

Figure H-19: Map showing land use/land cover trends for percent forest and percent wetland for watersheds in Missouri.

H.4 Conclusion

Statistical analyses of streamflow, precipitation, and land-use and land-cover within and adjacent to the State of Missouri were performed in order to determine if streamflow was increasing, decreasing, or relatively static and to potentially determine the sources of trends in streamflow. Increasing trends in streamflow across the unregulated streams within and adjacent to the State of Missouri suggests that streamflow data summarized from the recent past should provide a reasonable accounting of water resources for planning purposes. For streamflow and precipitation data, the period from 1950 to 2017 was analyzed for statistical trends. The Mann-Kendall (Mann 1945; Kendall 1975) test for monotonic trends was applied to all data sets for analysis of trends over time. In general, increasing trends in streamflow throughout the State of Missouri showed a stronger correlation to increasing trends in precipitation than trends in land-use and land-cover. However, principal components analyses of trends in streamflow suggest that increasing trends in streamflow in Missouri are related to increasing trends in precipitation and increasing trends in development within watersheds. Trends in precipitation and land-use and land-cover were evaluated for watersheds which contribute flow to USGS streamflow gaging stations and at the larger 6-digit HUC regions.

Statistically significant increasing trends occurred at 41 of the 52 streamflow gaging stations analyzed. Additional specific data related to trends in streamflow and rates of change over the periods analyzed for each streamflow gaging station are listed in **Table H-3** by annual and seasonal analyses of total streamflow, baseflow, and run-off. Significant, increasing trends in annual precipitation occurred in eleven of thirteen 6-digit HUC regions evaluated in this study. Of the four seasons analyzed for precipitation trends, spring and fall each had ten 6-digit HUC regions with increasing, significant trends making them the seasons with the largest spatial increase in precipitation for the period analyzed. All of the 6-digit HUC regions showed significant, increasing trends in percent developed.

These results indicate that for water resources planning purposes relatively recent periods of streamflow data present a reasonable basis for future planning. Water resources managers should take into account generally increasing flows when planning operations for their drinking water reservoirs and surface water intakes.

H.5 References

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Table H-2: Station information for US Geological Survey streamflow gaging stations.

Map ID number	USGS station ID	USGS station name	8-digit HUC	Drainage area (mi^2)	Period of record	Period used	Gaps in record used	Missing days in record used	Percent record missing in record used
1	05497000	North Fabius River at Monticello, MO	07110002	452	March 1922 - October 2005	January 1950 - October 2005	0	0	0
2	05498000	Middle Fabius River near Monticello, MO	07110002	393	October 1945 - September 2005	January 1950 - September 2005	0	0	0
3	05500000	South Fabius River near Taylor, MO	07110003	620	January 1935 - September 2017	January 1950 - December 2017	0	0	0
4	05501000	North River at Palmyra, MO	07110004	354	January 1935 - September 2017	January 1950 - December 2017	0	0	0
5	05502000	Bear Creek at Hannibal, MO	07110004	31	October 1938 - September 2017	January 1950 - December 2017	0	0	0
6	05504800	South Fork Salt River above Santa Fe, MO	07110006	233	October 1939 - September 2017	January 1950 - December 2017	1	202	1
7	05508000	Salt River near New London, MO	07110007	2480	October 1922 - September 2017	January 1950 - December 2017	0	0	0
8	06808500	West Nishnabotna River at Randolph, IA	10240002	1326	June 1948 - September 2017	January 1950 - December 2017	0	0	0
9	06809500	East Nishnabotna River at Red Oak, IA	10240003	894	May 1918 - September 2017	January 1950 - December 2017	0	0	0
10	06810000	Nishnabotna River above Hamburg, IA	10240004	2806	March 1922 - September 2017	January 1950 - December 2017	0	0	0
11	06811500	Little Nemaha River at Auburn, Nebr.	10240006	792	September 1949 - September 2017	January 1950 - December 2017	0	0	0
12	06814000	TURKEY C NR SENECA, KS	10240007	276	February 1949 - September 2017	January 1950 - December 2017	0	0	0
13	06815000	Big Nemaha River at Falls City, Nebr.	10240008	1339	April 1944 - September 2017	January 1950 - December 2017	1	10	0
14	06817000	Nodaway River at Clarinda, IA	10240009	762	May 1918 - September 2017	January 1950 - December 2017	0	0	0
15	06820500	Platte River near Agency, MO	10240012	1760	May 1924 - September 2017	January 1950 - December 2017	0	0	0
16	06889500	SOLDIER C NR TOPEKA, KS	10270102	290	May 1929 - September 2017	January 1950 - December 2017	0	0	0

Map ID number	USGS station ID	USGS station name	8-digit HUC	Drainage area (mi^2)	Period of record	Period used	Gaps in record used	Missing days in record used	Percent record missing in record used
17	06891500	WAKARUSA R NR LAWRENCE, KS	10270104	425	April 1929 - September 2017	January 1950 - December 2017	0	0	0
18	06892000	STRANGER C NR TONGANOXIE, KS	10270104	406	April 1929 - September 2017	January 1950 - December 2017	0	0	0
19	06893500	Blue River at Kansas City, MO	10300101	188	May 1939 - September 2017	January 1950 - December 2017	0	0	0
20	06894000	Little Blue River near Lake City, MO	10300101	184	April 1948 - September 2017	January 1950 - December 2017	0	0	0
21	06895500	Missouri River at Waverly, MO	10300101	485900	October 1928 - September 2017	January 1950 - December 2017	1	364	1
22	06897500	Grand River near Gallatin, MO	10280101	2250	June 1921 - September 2017	January 1950 - December 2017	0	0	0
23	06898000	Thompson River at Davis City, IA	10280102	701	May 1918 - September 2017	January 1950 - December 2017	0	0	0
24	06899500	Thompson River at Trenton, MO	10280102	1720	August 1928 - September 2017	January 1950 - December 2017	0	0	0
25	06902000	Grand River near Sumner, MO	10280103	6880	October 1924 - September 2017	January 1950 - December 2017	0	0	0
26	06904500	Chariton River at Novinger, MO	10280202	1370	October 1930 - September 2017	January 1950 - December 2017	1	730	3
27	06905500	Chariton River near Prairie Hill, MO	10280202	1870	April 1929 - September 2017	January 1950 - December 2017	0	0	0
28	06908000	Blackwater River at Blue Lick, MO	10300104	1120	June 1922 - September 2017	January 1950 - December 2017	0	0	0
29	06909000	Missouri River at Boonville, MO	10300102	500700	October 1925 - September 2017	January 1950 - December 2017	0	0	0
30	06912500	HUNDRED AND TEN MILE C NR QUENEMO, KS	10290101	322	October 1939 - September 2017	January 1950 - December 2017	0	0	0
31	06913500	MARAIS DES CYGNES R NR OTTAWA, KS	10290101	1250	August 1902 - September 2017	January 1950 - December 2017	0	0	0
32	06914000	POTTAWATOMIE C NR GARNETT, KS	10290101	334	October 1939 - September 2017	January 1950 - September 2001	0	0	0
33	06917000	L OSAGE R AT FULTON, KS	10290103	314	November 1948 - September 2017	January 1950 - December 2017	0	0	0

Map ID number	USGS station ID	USGS station name	8-digit HUC	Drainage area (mi^2)	Period of record	Period used	Gaps in record used	Missing days in record used	Percent record missing in record used
34	06919500	Cedar Creek near Pleasant View, MO	10290106	420	April 1923 - September 2017	January 1950 - December 2017	0	0	0
35	06926000	Osage River near Bagnell, MO	10290111	14000	June 1925 - September 2017	January 1950 - December 2017	0	0	0
36	06932000	Little Piney Creek at Newburg, MO	10290203	200	November 1928 - September 2017	January 1950 - December 2017	0	0	0
37	06933500	Gasconade River at Jerome, MO	10290203	2840	April 1903 - September 2017	January 1950 - December 2017	1	0	0
38	07013000	Meramec River near Steelville, MO	07140102	781	October 1922 - September 2017	January 1950 - December 2017	0	0	0
39	07014500	Meramec River near Sullivan, MO	07140102	1475	September 1921 - September 2017	January 1950 - December 2017	1	0	0
40	07016500	Bourbeuse River at Union, MO	07140103	808	June 1921 - September 2017	January 1950 - December 2017	0	0	0
41	07018100	Big River near Richwoods, MO	07140104	735	April 1949 - September 2017	January 1950 - December 2017	2	364	1
42	07018500	Big River at Byrnesville, MO	07140104	917	May 1922 - September 2017	January 1950 - December 2017	0	0	0
43	07019000	Meramec River near Eureka, MO	07140102	3788	October 1903 - September 2017	January 1950 - December 2017	1	0	0
44	07037500	St. Francis River near Patterson, MO	08020202	956	June 1921 - September 2017	January 1950 - December 2017	1	364	1
45	07052500	James River at Galena, MO	11010002	987	October 1921 - September 2017	January 1950 - December 2017	0	0	0
46	07057500	North Fork River near Tecumseh, MO	11010006	561	October 1944 - September 2017	January 1950 - December 2017	0	0	0
47	07061500	Black River near Annapolis, MO	11010007	484	April 1939 - September 2017	January 1950 - December 2017	0	0	0
48	07063000	Black River at Poplar Bluff, MO	11010007	1245	October 1936 - September 2017	January 1950 - December 2017	0	0	0
49	07064000	Black River near Corning, AR	11010007	1750	October 1938 - September 2017	January 1950 - December 2017	17	743	3
50	07066000	Jacks Fork at Eminence, MO	11010008	398	November 1921 - September 2017	January 1950 - December 2017	0	0	0
51	07067000	Current River at Van Buren, MO	11010008	1667	June 1921 - September 2017	January 1950 - December 2017	0	0	0

Map ID number	USGS station ID	USGS station name	8-digit HUC	Drainage area (mi^2)	Period of record	Period used	Gaps in record used	Missing days in record used	Percent record missing in record used
52	07068000	Current River at Doniphan, MO	11010008	2038	June 1921 - September 2017	January 1950 - December 2017	0	0	0
53	07069500	Spring River at Imboden, AR	11010010	1180	April 1936 - September 2017	January 1950 - December 2017	6	2334	10
54	07071500	Eleven Point River near Bardley, MO	11010011	793	October 1921 - September 2017	January 1950 - December 2017	0	0	0
55	07072000	Eleven Point River near Ravenden Springs, AR	11010011	1130	October 1929 - September 2017	January 1950 - December 2017	10	1988	9
56	07072500	Black River at Black Rock, AR	11010009	7370	October 1929 - September 2017	January 1950 - December 2017	0	0	0
57	07186000	Spring River near Waco, MO	11070207	1164	April 1924 - September 2017	January 1950 - December 2017	0	0	0
58	07187000	Shoal Creek above Joplin, MO	11070207	427	October 1941 - September 2017	January 1950 - December 2017	0	0	0
59	07188000	Spring River near Quapaw, OK	11070207	2516	July 1939 - September 2017	January 1950 - December 2017	0	0	0
60	07189000	Elk River near Tiff City, Mo	11070208	851	October 1939 - September 2017	January 1950 - December 2017	0	0	0

Table H-3: Trend analysis for US Geological Survey streamflow gaging stations.

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
05497000	**Annual**	**Total**	**0.16**	**0.08**	**2.66**	**267**	**1**
05497000	**Annual**	**Baseflow**	**0.239**	**0.01**	**0.86**	**66.4**	**1.3**
05497000	Annual	Runoff	0.13	0.16	1.56	188	0.83
05497000	**Annual Minimum**	**Total**	**0.255**	**0.01**	**0.07**	**3.6**	**1.99**
05497000	Annual Maximum	Total	0.099	0.28	34.88	7020	0.5
05497000	Winter	Total	0.008	0.94	0.24	289	0.08
05497000	**Winter**	**Baseflow**	**0.162**	**0.08**	**0.93**	**89.9**	**1.03**
05497000	Winter	Runoff	-0.032	0.73	-0.32	179	-0.18
05497000	**Spring**	**Total**	**0.158**	**0.09**	**5.13**	**399**	**1.29**
05497000	**Spring**	**Baseflow**	**0.235**	**0.01**	**1.37**	**99.9**	**1.37**
05497000	Spring	Runoff	0.135	0.14	3.75	273	1.37
05497000	Summer	Total	0.012	0.9	0.08	93.3	0.08
05497000	Summer	Baseflow	0.112	0.23	0.18	22.4	0.81
05497000	Summer	Runoff	-0.021	0.83	-0.12	66.1	-0.18
05497000	Fall	Total	0.126	0.18	0.82	86.3	0.95
05497000	**Fall**	**Baseflow**	**0.168**	**0.07**	**0.42**	**30.5**	**1.39**
05497000	Fall	Runoff	0.098	0.3	0.35	45.2	0.78
05498000	Annual	Total	0.149	0.11	2.07	241	0.86
05498000	Annual	Baseflow	0.117	0.21	0.35	54.9	0.64
05498000	Annual	Runoff	0.147	0.11	1.69	188	0.9
05498000	**Annual Minimum**	**Total**	**0.235**	**0.01**	**0.04**	**1.9**	**1.9**
05498000	Annual Maximum	Total	0.143	0.12	40.88	5340	0.77
05498000	Winter	Total	0.019	0.84	0.43	274	0.16

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
05498000	Winter	Baseflow	0.043	0.65	0.23	76.8	0.3
05498000	Winter	Runoff	0.001	0.99	0.03	193	0.02
05498000	**Spring**	**Total**	**0.166**	**0.07**	**4.68**	**355**	**1.32**
05498000	**Spring**	**Baseflow**	**0.152**	**0.1**	**0.55**	**80.3**	**0.69**
05498000	**Spring**	**Runoff**	**0.162**	**0.08**	**3.47**	**275**	**1.26**
05498000	Summer	Total	-0.038	0.69	-0.25	56.6	-0.45
05498000	Summer	Baseflow	0.04	0.67	0.03	12.1	0.27
05498000	Summer	Runoff	-0.035	0.71	-0.16	49.4	-0.33
05498000	Fall	Total	0.112	0.23	0.59	66.2	0.89
05498000	**Fall**	**Baseflow**	**0.164**	**0.08**	**0.29**	**19.2**	**1.52**
05498000	Fall	Runoff	0.1	0.28	0.32	48	0.68
05500000	**Annual**	**Total**	**0.161**	**0.05**	**3.16**	**372**	**0.85**
05500000	**Annual**	**Baseflow**	**0.183**	**0.03**	**0.74**	**86.6**	**0.86**
05500000	**Annual**	**Runoff**	**0.152**	**0.07**	**2.53**	**310**	**0.81**
05500000	**Annual Minimum**	**Total**	**0.163**	**0.05**	**0.03**	**2.2**	**1.27**
05500000	**Annual Maximum**	**Total**	**0.185**	**0.03**	**60.73**	**7660**	**0.79**
05500000	Winter	Total	0.042	0.62	0.96	450	0.21
05500000	Winter	Baseflow	0.068	0.41	0.4	125	0.32
05500000	Winter	Runoff	0.028	0.74	0.42	298	0.14
05500000	**Spring**	**Total**	**0.211**	**0.01**	**8.49**	**533**	**1.59**
05500000	**Spring**	**Baseflow**	**0.203**	**0.01**	**1.18**	**125**	**0.94**
05500000	**Spring**	**Runoff**	**0.213**	**0.01**	**6.62**	**381**	**1.74**
05500000	Summer	Total	-0.068	0.42	-0.46	132	-0.35
05500000	Summer	Baseflow	0.073	0.38	0.1	20.4	0.48
05500000	Summer	Runoff	-0.082	0.33	-0.54	110	-0.49
05500000	Fall	Total	0.061	0.47	0.24	98.3	0.24

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
05500000	Fall	Baseflow	0.094	0.26	0.14	21.4	0.67
05500000	Fall	Runoff	0.039	0.65	0.07	65.8	0.1
05501000	**Annual**	**Total**	**0.148**	**0.07**	**1.9**	**223**	**0.85**
05501000	**Annual**	**Baseflow**	**0.191**	**0.02**	**0.45**	**52.1**	**0.86**
05501000	**Annual**	**Runoff**	**0.145**	**0.08**	**1.47**	**179**	**0.82**
05501000	Annual Minimum	Total	0.115	0.17	0.01	1.4	0.81
05501000	**Annual Maximum**	**Total**	**0.155**	**0.06**	**77.91**	**8640**	**0.9**
05501000	Winter	Total	0.051	0.54	0.79	247	0.32
05501000	Winter	Baseflow	0.115	0.17	0.43	73.2	0.59
05501000	Winter	Runoff	0.026	0.75	0.31	170	0.18
05501000	**Spring**	**Total**	**0.16**	**0.05**	**3.5**	**328**	**1.07**
05501000	**Spring**	**Baseflow**	**0.182**	**0.03**	**0.73**	**78.9**	**0.93**
05501000	**Spring**	**Runoff**	**0.154**	**0.06**	**2.76**	**254**	**1.09**
05501000	Summer	Total	-0.046	0.59	-0.18	53.2	-0.35
05501000	Summer	Baseflow	0.032	0.7	0.03	14.9	0.22
05501000	Summer	Runoff	-0.056	0.5	-0.19	40.3	-0.46
05501000	Fall	Total	0.113	0.17	0.36	45.2	0.79
05501000	Fall	Baseflow	0.119	0.15	0.11	15.5	0.74
05501000	Fall	Runoff	0.098	0.24	0.18	36.2	0.5
05502000	**Annual**	**Total**	**0.198**	**0.02**	**0.19**	**19.9**	**0.98**
05502000	**Annual**	**Baseflow**	**0.336**	**0**	**0.11**	**6.3**	**1.72**
05502000	Annual	Runoff	0.132	0.11	0.09	11.9	0.72
05502000	**Annual Minimum**	**Total**	**0.243**	**0.01**	**0**	**0.19**	**2.31**
05502000	**Annual Maximum**	**Total**	**-0.154**	**0.06**	**-2.98**	**444**	**-0.67**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
05502000	**Winter**	**Total**	**0.147**	**0.08**	**0.18**	**20.9**	**0.85**
05502000	**Winter**	**Baseflow**	**0.235**	**0**	**0.12**	**8**	**1.45**
05502000	Winter	Runoff	0.047	0.57	0.04	11.6	0.39
05502000	**Spring**	**Total**	**0.141**	**0.09**	**0.22**	**27.6**	**0.79**
05502000	**Spring**	**Baseflow**	**0.202**	**0.02**	**0.09**	**7.2**	**1.31**
05502000	Spring	Runoff	0.073	0.38	0.08	17.7	0.45
05502000	Summer	Total	0.123	0.14	0.05	6.9	0.77
05502000	**Summer**	**Baseflow**	**0.263**	**0**	**0.04**	**1.8**	**1.93**
05502000	Summer	Runoff	0.059	0.48	0.02	4.9	0.34
05502000	**Fall**	**Total**	**0.189**	**0.02**	**0.05**	**6.3**	**0.78**
05502000	**Fall**	**Baseflow**	**0.262**	**0**	**0.04**	**2.3**	**1.61**
05502000	Fall	Runoff	0.1	0.23	0.01	3.9	0.35
05504800	Annual	Total	0.12	0.15	0.91	151	0.6
05504800	**Annual**	**Baseflow**	**0.157**	**0.06**	**0.18**	**23.8**	**0.75**
05504800	Annual	Runoff	0.108	0.19	0.74	125	0.59
05504800	**Annual Minimum**	**Total**	**0.222**	**0.01**	**0.01**	**0.64**	**1.52**
05504800	Annual Maximum	Total	0.115	0.17	27.07	5480	0.49
05504800	Winter	Total	0.022	0.8	0.21	153	0.14
05504800	Winter	Baseflow	0.079	0.35	0.17	34.5	0.51
05504800	Winter	Runoff	0.013	0.88	0.08	122	0.07
05504800	**Spring**	**Total**	**0.159**	**0.06**	**1.97**	**227**	**0.87**
05504800	**Spring**	**Baseflow**	**0.19**	**0.02**	**0.32**	**30.9**	**1.04**
05504800	**Spring**	**Runoff**	**0.158**	**0.06**	**1.58**	**199**	**0.79**
05504800	Summer	Total	-0.01	0.91	-0.02	36.7	-0.07
05504800	**Summer**	**Baseflow**	**0.136**	**0.1**	**0.06**	**6**	**0.98**
05504800	Summer	Runoff	-0.025	0.76	-0.06	30.6	-0.21

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
05504800	Fall	Total	0.065	0.44	0.1	43.7	0.23
05504800	**Fall**	**Baseflow**	**0.15**	**0.07**	**0.07**	**6.8**	**1.06**
05504800	Fall	Runoff	0.061	0.47	0.05	37.6	0.12
05508000	**Annual**	**Total**	**0.183**	**0.03**	**13.69**	**1610**	**0.85**
05508000	Annual	Baseflow	-0.006	0.95	-0.05	273	-0.02
05508000	**Annual**	**Runoff**	**0.189**	**0.02**	**12.07**	**1280**	**0.94**
05508000	**Annual Minimum**	**Total**	**0.5**	**0**	**0.72**	**30**	**2.4**
05508000	**Annual Maximum**	**Total**	**-0.318**	**0**	**-257.9**	**15200**	**-1.69**
05508000	Winter	Total	0.027	0.75	2.15	1740	0.12
05508000	**Winter**	**Baseflow**	**-0.17**	**0.04**	**-2.68**	**226**	**-1.19**
05508000	Winter	Runoff	0.06	0.47	5.09	1490	0.34
05508000	Spring	Total	0.099	0.23	9.93	1890	0.53
05508000	Spring	Baseflow	-0.112	0.18	-1.95	357	-0.55
05508000	Spring	Runoff	0.119	0.15	10.39	1540	0.68
05508000	**Summer**	**Total**	**0.26**	**0**	**20.47**	**1040**	**1.97**
05508000	**Summer**	**Baseflow**	**0.166**	**0.05**	**1.08**	**109**	**0.99**
05508000	**Summer**	**Runoff**	**0.249**	**0**	**18.23**	**931**	**1.96**
05508000	Fall	Total	0.1	0.23	3.2	487	0.66
05508000	Fall	Baseflow	0.068	0.41	0.29	77.3	0.38
05508000	Fall	Runoff	0.105	0.21	2.8	398	0.7
06808500	**Annual**	**Total**	**0.285**	**0**	**9.06**	**669**	**1.35**
06808500	**Annual**	**Baseflow**	**0.407**	**0**	**9.52**	**430**	**2.21**
06808500	Annual	Runoff	-0.039	0.65	-0.45	195	-0.23
06808500	**Annual Minimum**	**Total**	**0.449**	**0**	**2.49**	**96.8**	**2.57**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06808500	Annual Maximum	Total	-0.132	0.11	-50.56	8650	-0.58
06808500	Winter	Total	0.1	0.23	2.68	532	0.5
06808500	Winter	Baseflow	0.306	0	4.8	285	1.68
06808500	Winter	Runoff	-0.152	0.07	-1.99	161	-1.24
06808500	Spring	Total	0.284	0	15.28	1020	1.5
06808500	Spring	Baseflow	0.379	0	15.08	722	2.09
06808500	Spring	Runoff	0.061	0.46	1.15	273	0.42
06808500	Summer	Total	0.247	0	7.58	591	1.28
06808500	Summer	Baseflow	0.389	0	9.23	390	2.36
06808500	Summer	Runoff	-0.074	0.38	-0.63	123	-0.51
06808500	Fall	Total	0.32	0	5.49	284	1.93
06808500	Fall	Baseflow	0.342	0	5.02	253	1.99
06808500	Fall	Runoff	0.171	0.04	0.38	32.9	1.16
06809500	Annual	Total	0.283	0	6.65	468	1.42
06809500	Annual	Baseflow	0.379	0	6.05	278	2.18
06809500	Annual	Runoff	0.089	0.29	0.77	169	0.46
06809500	Annual Minimum	Total	0.389	0	1.03	51	2.01
06809500	Annual Maximum	Total	0.015	0.86	4.93	8350	0.06
06809500	Winter	Total	0.063	0.45	1.13	382	0.3
06809500	Winter	Baseflow	0.253	0	2.68	183	1.46
06809500	Winter	Runoff	-0.09	0.28	-1.07	141	-0.76
06809500	Spring	Total	0.314	0	14.72	827	1.78
06809500	Spring	Baseflow	0.355	0	10.88	492	2.21
06809500	Spring	Runoff	0.21	0.01	3.82	287	1.33
06809500	Summer	Total	0.226	0.01	4.58	340	1.35

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06809500	Summer	Baseflow	0.346	0	4.83	240	2.02
06809500	Summer	Runoff	0.003	0.98	0.03	85.2	0.03
06809500	Fall	Total	0.277	0	2.76	160	1.72
06809500	Fall	Baseflow	0.299	0	2.29	137	1.68
06809500	Fall	Runoff	0.177	0.03	0.3	25.7	1.16
06810000	Annual	Total	0.301	0	20.46	1420	1.44
06810000	Annual	Baseflow	0.369	0	18.06	900	2.01
06810000	Annual	Runoff	0.097	0.24	2.69	455	0.59
06810000	Annual Minimum	Total	0.427	0	4.68	198	2.36
06810000	Annual Maximum	Total	0.132	0.11	76.37	14600	0.52
06810000	Winter	Total	0.115	0.17	6.23	1150	0.54
06810000	Winter	Baseflow	0.237	0	8.36	616	1.36
06810000	Winter	Runoff	-0.075	0.37	-1.93	361	-0.54
06810000	Spring	Total	0.302	0	38.91	2330	1.67
06810000	Spring	Baseflow	0.349	0	29.2	1590	1.84
06810000	Spring	Runoff	0.191	0.02	8.64	743	1.16
06810000	Summer	Total	0.24	0	17.05	1170	1.46
06810000	Summer	Baseflow	0.356	0	16.89	824	2.05
06810000	Summer	Runoff	-0.006	0.95	-0.16	298	-0.05
06810000	Fall	Total	0.285	0	10.05	507	1.98
06810000	Fall	Baseflow	0.298	0	8.66	445	1.95
06810000	Fall	Runoff	0.196	0.02	0.94	79.9	1.18
06811500	Annual	Total	0.093	0.26	1.18	237	0.5
06811500	Annual	Baseflow	0.208	0.01	1.05	114	0.92
06811500	Annual	Runoff	0.011	0.9	0.15	146	0.11

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06811500	**Annual Minimum**	**Total**	**0.198**	**0.02**	**0.33**	**26**	**1.26**
06811500	Annual Maximum	Total	-0.011	0.9	-6.7	9760	-0.07
06811500	Winter	Total	0.01	0.91	0.09	179	0.05
06811500	**Winter**	**Baseflow**	**0.167**	**0.04**	**0.65**	**116**	**0.56**
06811500	Winter	Runoff	-0.126	0.13	-0.41	53.7	-0.75
06811500	**Spring**	**Total**	**0.172**	**0.04**	**4.65**	**393**	**1.18**
06811500	**Spring**	**Baseflow**	**0.247**	**0**	**2.16**	**153**	**1.42**
06811500	**Spring**	**Runoff**	**0.151**	**0.07**	**2.6**	**241**	**1.08**
06811500	Summer	Total	-0.043	0.61	-0.47	175	-0.27
06811500	**Summer**	**Baseflow**	**0.143**	**0.09**	**0.61**	**75**	**0.81**
06811500	Summer	Runoff	-0.125	0.13	-0.8	76.1	-1.05
06811500	Fall	Total	0.102	0.22	0.62	112	0.56
06811500	**Fall**	**Baseflow**	**0.155**	**0.06**	**0.6**	**79.9**	**0.76**
06811500	Fall	Runoff	0.033	0.69	0.06	26	0.22
06814000	Annual	Total	-0.02	0.81	-0.13	85.2	-0.15
06814000	Annual	Baseflow	-0.019	0.82	-0.04	28	-0.14
06814000	Annual	Runoff	-0.047	0.57	-0.16	59.1	-0.27
06814000	Annual Minimum	Total	0.042	0.61	0	1.4	0.11
06814000	Annual Maximum	Total	-0.019	0.82	-4.35	4020	-0.11
06814000	Winter	Total	-0.042	0.62	-0.17	55.9	-0.31
06814000	Winter	Baseflow	-0.048	0.56	-0.09	24.1	-0.36
06814000	Winter	Runoff	-0.039	0.65	-0.05	26.2	-0.19
06814000	Spring	Total	0.09	0.28	0.94	167	0.57
06814000	Spring	Baseflow	0.052	0.54	0.15	49.1	0.31

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06814000	Spring	Runoff	0.09	0.28	0.6	98.9	0.6
06814000	**Summer**	**Total**	**-0.135**	**0.1**	**-0.45**	**39.5**	**-1.13**
06814000	Summer	Baseflow	-0.044	0.6	-0.04	14.8	-0.24
06814000	**Summer**	**Runoff**	**-0.176**	**0.03**	**-0.35**	**24**	**-1.44**
06814000	Fall	Total	-0.003	0.98	0	22.5	-0.01
06814000	Fall	Baseflow	-0.031	0.71	-0.02	11	-0.16
06814000	Fall	Runoff	0.054	0.52	0.02	6.3	0.34
06815000	Annual	Total	-0.012	0.89	-0.42	519	-0.08
06815000	Annual	Baseflow	0.063	0.45	0.46	161	0.29
06815000	Annual	Runoff	-0.046	0.59	-0.93	318	-0.29
06815000	Annual Minimum	Total	0.014	0.87	0.02	33	0.08
06815000	Annual Maximum	Total	-0.037	0.66	-33.63	15000	-0.22
06815000	Winter	Total	-0.034	0.68	-0.63	315	-0.2
06815000	Winter	Baseflow	0.025	0.76	0.26	146	0.18
06815000	Winter	Runoff	-0.101	0.23	-0.6	115	-0.53
06815000	Spring	Total	0.124	0.14	5.32	749	0.71
06815000	Spring	Baseflow	0.134	0.11	2.08	253	0.82
06815000	Spring	Runoff	0.099	0.23	3.19	476	0.67
06815000	**Summer**	**Total**	**-0.146**	**0.08**	**-2.57**	**313**	**-0.82**
06815000	Summer	Baseflow	-0.017	0.84	-0.09	130	-0.07
06815000	**Summer**	**Runoff**	**-0.164**	**0.05**	**-2.41**	**176**	**-1.37**
06815000	Fall	Total	-0.011	0.9	-0.1	163	-0.06
06815000	Fall	Baseflow	0.004	0.97	0.01	100	0.01
06815000	Fall	Runoff	-0.019	0.82	-0.05	47.5	-0.11
06817000	**Annual**	**Total**	**0.25**	**0**	**5.07**	**409**	**1.24**
06817000	**Annual**	**Baseflow**	**0.317**	**0**	**3.39**	**187**	**1.81**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06817000	Annual	Runoff	0.133	0.11	1.64	193	0.85
06817000	Annual Minimum	Total	0.279	0	0.34	20.5	1.65
06817000	Annual Maximum	Total	0.172	0.04	81.71	8920	0.92
06817000	Winter	Total	0.025	0.76	0.5	276	0.18
06817000	Winter	Baseflow	0.192	0.02	1.52	145	1.05
06817000	Winter	Runoff	-0.061	0.47	-0.67	125	-0.54
06817000	Spring	Total	0.29	0	12.28	726	1.69
06817000	Spring	Baseflow	0.323	0	6.92	341	2.03
06817000	Spring	Runoff	0.218	0.01	5.05	334	1.51
06817000	Summer	Total	0.112	0.18	2	237	0.84
06817000	Summer	Baseflow	0.27	0	2.06	124	1.66
06817000	Summer	Runoff	0.002	0.99	0	92.8	0
06817000	Fall	Total	0.189	0.02	1.02	86.3	1.19
06817000	Fall	Baseflow	0.201	0.02	0.77	60.7	1.28
06817000	Fall	Runoff	0.213	0.01	0.3	20.5	1.44
06820500	Annual	Total	0.155	0.06	7.59	963	0.79
06820500	Annual	Baseflow	0.294	0	4	282	1.42
06820500	Annual	Runoff	0.102	0.22	3.66	603	0.61
06820500	Annual Minimum	Total	0.273	0	0.45	26.5	1.71
06820500	Annual Maximum	Total	0.179	0.03	114	17300	0.66
06820500	Winter	Total	0.026	0.75	0.79	713	0.11
06820500	Winter	Baseflow	0.144	0.08	2.58	311	0.83
06820500	Winter	Runoff	-0.029	0.73	-0.65	381	-0.17
06820500	Spring	Total	0.218	0.01	20.9	1860	1.12

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06820500	**Spring**	**Baseflow**	**0.316**	**0**	**8.48**	**490**	**1.73**
06820500	**Spring**	**Runoff**	**0.171**	**0.04**	**12.74**	**1230**	**1.03**
06820500	Summer	Total	0.099	0.23	4.25	589	0.72
06820500	**Summer**	**Baseflow**	**0.255**	**0**	**2.53**	**150**	**1.68**
06820500	Summer	Runoff	0.043	0.61	1.47	359	0.41
06820500	Fall	Total	0.118	0.16	2.3	261	0.88
06820500	**Fall**	**Baseflow**	**0.17**	**0.04**	**1.59**	**127**	**1.26**
06820500	Fall	Runoff	0.068	0.41	0.55	127	0.43
06889500	Annual	Total	0.095	0.26	0.73	144	0.51
06889500	Annual	Baseflow	0.045	0.59	0.1	45.7	0.21
06889500	Annual	Runoff	0.096	0.25	0.5	90.2	0.56
06889500	Annual Minimum	Total	0.116	0.17	0.04	5.2	0.78
06889500	**Annual Maximum**	**Total**	**0.201**	**0.02**	**72.68**	**5020**	**1.45**
06889500	Winter	Total	0.029	0.73	0.14	102	0.14
06889500	Winter	Baseflow	0.03	0.72	0.08	38.3	0.22
06889500	Winter	Runoff	0.033	0.69	0.07	40.2	0.18
06889500	**Spring**	**Total**	**0.171**	**0.04**	**2.41**	**209**	**1.16**
06889500	Spring	Baseflow	0.118	0.16	0.47	63.4	0.74
06889500	**Spring**	**Runoff**	**0.186**	**0.03**	**1.8**	**154**	**1.17**
06889500	Summer	Total	0.002	0.99	0.01	65.1	0.02
06889500	Summer	Baseflow	0.03	0.72	0.05	21.6	0.21
06889500	Summer	Runoff	-0.014	0.87	-0.04	44	-0.09
06889500	Fall	Total	-0.001	1	-0.01	45.9	-0.02
06889500	Fall	Baseflow	0.011	0.89	0.02	21.2	0.09
06889500	Fall	Runoff	-0.016	0.85	-0.01	14	-0.09
06891500	Annual	Total	0.075	0.37	0.76	226	0.34

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06891500	**Annual**	**Baseflow**	**0.242**	**0**	**1.3**	**86.1**	**1.51**
06891500	Annual	Runoff	-0.042	0.62	-0.24	109	-0.22
06891500	**Annual Minimum**	**Total**	**0.269**	**0**	**0.05**	**2.4**	**1.97**
06891500	**Annual Maximum**	**Total**	**-0.233**	**0.01**	**-43.55**	**2830**	**-1.54**
06891500	Winter	Total	0.056	0.5	0.17	108	0.15
06891500	Winter	Baseflow	0.103	0.22	0.26	59.9	0.44
06891500	Winter	Runoff	0.009	0.92	0.01	38.8	0.03
06891500	Spring	Total	0.127	0.13	2.59	295	0.88
06891500	**Spring**	**Baseflow**	**0.218**	**0.01**	**2.45**	**118**	**2.07**
06891500	Spring	Runoff	0.029	0.73	0.46	155	0.29
06891500	Summer	Total	0.009	0.92	0.09	106	0.08
06891500	**Summer**	**Baseflow**	**0.302**	**0**	**0.63**	**31.4**	**2**
06891500	Summer	Runoff	-0.081	0.33	-0.39	49.1	-0.8
06891500	Fall	Total	0.054	0.52	0.15	47.3	0.31
06891500	Fall	Baseflow	0.093	0.27	0.11	20.2	0.54
06891500	Fall	Runoff	0.025	0.77	0.02	23	0.11
06892000	Annual	Total	0.098	0.24	1.33	234	0.57
06892000	Annual	Baseflow	0.097	0.25	0.3	63.5	0.47
06892000	Annual	Runoff	0.093	0.26	0.95	162	0.59
06892000	Annual Minimum	Total	0.117	0.16	0.02	3	0.8
06892000	Annual Maximum	Total	0.086	0.3	24.33	5900	0.41
06892000	Winter	Total	0.031	0.71	0.23	168	0.14
06892000	Winter	Baseflow	0.069	0.41	0.25	67.4	0.37
06892000	Winter	Runoff	0.037	0.66	0.11	89.4	0.12

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06892000	Spring	Total	0.185	0.03	4.49	339	1.32
06892000	Spring	Baseflow	0.181	0.03	0.8	94.7	0.85
06892000	Spring	Runoff	0.191	0.02	3.42	254	1.35
06892000	Summer	Total	0.001	1	0	126	0
06892000	Summer	Baseflow	0.046	0.59	0.07	23.1	0.3
06892000	Summer	Runoff	-0.006	0.95	-0.06	91.2	-0.07
06892000	Fall	Total	0.088	0.29	0.44	75.4	0.58
06892000	Fall	Baseflow	0.093	0.26	0.14	26.7	0.52
06892000	Fall	Runoff	0.087	0.3	0.25	48.6	0.51
06893500	Annual	Total	0.324	0	2.16	172	1.25
06893500	Annual	Baseflow	0.315	0	0.66	64.1	1.04
06893500	Annual	Runoff	0.299	0	1.41	101	1.4
06893500	Annual Minimum	Total	0.553	0	0.28	12.6	2.23
06893500	Annual Maximum	Total	0.155	0.06	53.89	6220	0.87
06893500	Winter	Total	0.208	0.01	1.25	108	1.16
06893500	Winter	Baseflow	0.237	0	0.76	73	1.04
06893500	Winter	Runoff	0.181	0.03	0.45	45	1
06893500	Spring	Total	0.313	0	3.72	247	1.5
06893500	Spring	Baseflow	0.282	0	0.88	86.6	1.02
06893500	Spring	Runoff	0.301	0	2.66	154	1.73
06893500	Summer	Total	0.268	0	1.69	99.6	1.7
06893500	Summer	Baseflow	0.347	0	0.56	33.3	1.68
06893500	Summer	Runoff	0.229	0.01	1.13	68	1.66
06893500	Fall	Total	0.274	0	1.27	88.1	1.44
06893500	Fall	Baseflow	0.313	0	0.6	38.1	1.58
06893500	Fall	Runoff	0.235	0	0.62	48.2	1.29

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06894000	Annual	Total	0.221	0.01	1.5	160	0.94
06894000	Annual	Baseflow	0.314	0	0.97	71.3	1.35
06894000	Annual	Runoff	0.164	0.05	0.59	74.8	0.78
06894000	Annual Minimum	Total	0.223	0.01	0.1	8.4	1.21
06894000	Annual Maximum	Total	0.146	0.08	26.49	3910	0.68
06894000	Winter	Total	0.115	0.17	0.63	115	0.55
06894000	Winter	Baseflow	0.182	0.03	0.69	78	0.88
06894000	Winter	Runoff	0.027	0.75	0.06	39.8	0.14
06894000	Spring	Total	0.24	0	2.86	212	1.35
06894000	Spring	Baseflow	0.327	0	1.75	90.5	1.94
06894000	Spring	Runoff	0.166	0.05	1.27	118	1.08
06894000	Summer	Total	0.186	0.03	1.08	89.1	1.21
06894000	Summer	Baseflow	0.257	0	0.57	30.7	1.85
06894000	Summer	Runoff	0.147	0.08	0.47	49.5	0.95
06894000	Fall	Total	0.127	0.13	0.47	59.6	0.79
06894000	Fall	Baseflow	0.177	0.03	0.35	33.6	1.03
06894000	Fall	Runoff	0.062	0.46	0.12	30.2	0.41
06895500	Annual	Total	0.176	0.03	251	54600	0.46
06895500	Annual	Baseflow	0.366	0	391	29900	1.31
06895500	Annual	Runoff	-0.196	0.02	-146.7	23600	-0.62
06895500	Annual Minimum	Total	0.541	0	337.5	19100	1.77
06895500	Annual Maximum	Total	0.074	0.38	400	175000	0.23
06895500	Winter	Total	0.188	0.03	217	37900	0.57
06895500	Winter	Baseflow	0.474	0	389.1	23400	1.66

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06895500	Winter	Runoff	-0.32	0	-190.1	14200	-1.34
06895500	Spring	Total	0.157	0.06	344.8	69200	0.5
06895500	Spring	Baseflow	0.322	0	453.1	34300	1.32
06895500	Spring	Runoff	-0.095	0.26	-134.7	40100	-0.34
06895500	Summer	Total	0.126	0.13	157.3	54800	0.29
06895500	Summer	Baseflow	0.244	0	334.5	36100	0.93
06895500	Summer	Runoff	-0.16	0.06	-160.9	20400	-0.79
06895500	Fall	Total	0.232	0.01	294	43900	0.67
06895500	Fall	Baseflow	0.358	0	369.1	25400	1.45
06895500	Fall	Runoff	-0.161	0.05	-104.2	12600	-0.83
06897500	Annual	Total	0.146	0.08	9.06	1280	0.71
06897500	Annual	Baseflow	0.188	0.02	3.12	327	0.96
06897500	Annual	Runoff	0.121	0.15	6.23	888	0.7
06897500	Annual Minimum	Total	0.21	0.01	0.43	28.5	1.49
06897500	Annual Maximum	Total	0.199	0.02	198.6	25900	0.77
06897500	Winter	Total	0.003	0.98	0.15	904	0.02
06897500	Winter	Baseflow	0.104	0.21	1.86	322	0.58
06897500	Winter	Runoff	-0.036	0.67	-1.29	589	-0.22
06897500	Spring	Total	0.232	0.01	31.99	2090	1.53
06897500	Spring	Baseflow	0.231	0.01	6.97	526	1.32
06897500	Spring	Runoff	0.217	0.01	25.61	1570	1.63
06897500	Summer	Total	0.027	0.75	0.96	667	0.14
06897500	Summer	Baseflow	0.167	0.04	1.63	144	1.13
06897500	Summer	Runoff	-0.01	0.91	-0.17	514	-0.03
06897500	Fall	Total	0.033	0.69	0.68	325	0.21
06897500	Fall	Baseflow	0.097	0.25	0.82	123	0.67

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06897500	Fall	Runoff	-0.008	0.93	-0.06	205	-0.03
06898000	**Annual**	**Total**	**0.148**	**0.07**	**3.04**	**357**	**0.85**
06898000	**Annual**	**Baseflow**	**0.242**	**0**	**1.65**	**134**	**1.23**
06898000	Annual	Runoff	0.091	0.27	1.36	219	0.62
06898000	**Annual Minimum**	**Total**	**0.169**	**0.04**	**0.09**	**7.2**	**1.26**
06898000	Annual Maximum	Total	0.096	0.25	34.22	6630	0.52
06898000	Winter	Total	-0.026	0.75	-0.46	321	-0.14
06898000	Winter	Baseflow	0.064	0.44	0.44	120	0.37
06898000	Winter	Runoff	-0.057	0.49	-0.64	193	-0.33
06898000	**Spring**	**Total**	**0.194**	**0.02**	**7.52**	**664**	**1.13**
06898000	**Spring**	**Baseflow**	**0.279**	**0**	**3.39**	**225**	**1.51**
06898000	**Spring**	**Runoff**	**0.149**	**0.07**	**4.16**	**393**	**1.06**
06898000	Summer	Total	0.048	0.56	0.41	153	0.27
06898000	**Summer**	**Baseflow**	**0.165**	**0.05**	**0.66**	**46.8**	**1.41**
06898000	Summer	Runoff	-0.019	0.82	-0.07	97.6	-0.08
06898000	Fall	Total	0.079	0.34	0.37	84.3	0.44
06898000	Fall	Baseflow	0.125	0.13	0.31	28	1.1
06898000	Fall	Runoff	0.042	0.62	0.05	40.3	0.13
06899500	Annual	Total	0.116	0.16	6.67	973	0.69
06899500	**Annual**	**Baseflow**	**0.201**	**0.02**	**3.33**	**308**	**1.08**
06899500	Annual	Runoff	0.093	0.26	3.73	641	0.58
06899500	**Annual Minimum**	**Total**	**0.174**	**0.04**	**0.3**	**31.5**	**0.94**
06899500	Annual Maximum	Total	0.071	0.39	73.33	19600	0.37
06899500	Winter	Total	-0.023	0.79	-1.32	831	-0.16

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06899500	Winter	Baseflow	0.065	0.44	1.27	296	0.43
06899500	Winter	Runoff	-0.053	0.53	-2.17	528	-0.41
06899500	**Spring**	**Total**	**0.178**	**0.03**	**17.49**	**1610**	**1.09**
06899500	**Spring**	**Baseflow**	**0.241**	**0**	**6.65**	**570**	**1.17**
06899500	**Spring**	**Runoff**	**0.14**	**0.09**	**10.24**	**1140**	**0.9**
06899500	Summer	Total	0.041	0.62	1.07	510	0.21
06899500	**Summer**	**Baseflow**	**0.182**	**0.03**	**1.76**	**147**	**1.19**
06899500	Summer	Runoff	-0.011	0.9	-0.18	320	-0.05
06899500	Fall	Total	0.052	0.54	0.62	294	0.21
06899500	Fall	Baseflow	0.102	0.22	0.82	122	0.68
06899500	Fall	Runoff	0.016	0.85	0.04	133	0.03
06902000	**Annual**	**Total**	**0.141**	**0.09**	**31.38**	**4200**	**0.75**
06902000	**Annual**	**Baseflow**	**0.199**	**0.02**	**10.88**	**1160**	**0.94**
06902000	Annual	Runoff	0.112	0.18	20.95	2840	0.74
06902000	**Annual Minimum**	**Total**	**0.2**	**0.02**	**1.57**	**122**	**1.28**
06902000	**Annual Maximum**	**Total**	**0.176**	**0.03**	**320.3**	**62000**	**0.52**
06902000	Winter	Total	0.042	0.62	7.7	3570	0.22
06902000	Winter	Baseflow	0.119	0.15	7.48	1070	0.7
06902000	Winter	Runoff	-0.001	1	-0.04	2260	0
06902000	**Spring**	**Total**	**0.219**	**0.01**	**83.73**	**6160**	**1.36**
06902000	**Spring**	**Baseflow**	**0.257**	**0**	**20.56**	**1900**	**1.08**
06902000	**Spring**	**Runoff**	**0.203**	**0.01**	**59.39**	**4320**	**1.37**
06902000	Summer	Total	0.041	0.62	4.84	2030	0.24
06902000	**Summer**	**Baseflow**	**0.164**	**0.05**	**5.5**	**555**	**0.99**
06902000	Summer	Runoff	0.004	0.96	0.16	1450	0.01
06902000	Fall	Total	0.031	0.71	2.85	1310	0.22

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06902000	Fall	Baseflow	0.095	0.26	2.82	468	0.6
06902000	Fall	Runoff	-0.012	0.89	-0.25	745	-0.03
06904500	**Annual**	**Total**	**0.173**	**0.04**	**7.43**	**910**	**0.82**
06904500	**Annual**	**Baseflow**	**0.289**	**0**	**6.52**	**374**	**1.74**
06904500	Annual	Runoff	0.062	0.46	1.49	510	0.29
06904500	**Annual Minimum**	**Total**	**0.39**	**0**	**0.54**	**28.2**	**1.9**
06904500	**Annual Maximum**	**Total**	**0.293**	**0**	**172.9**	**11300**	**1.53**
06904500	Winter	Total	0.03	0.72	1.43	774	0.18
06904500	Winter	Baseflow	0.07	0.41	1.52	396	0.38
06904500	Winter	Runoff	-0.028	0.75	-0.77	440	-0.18
06904500	**Spring**	**Total**	**0.158**	**0.06**	**12.83**	**1470**	**0.87**
06904500	**Spring**	**Baseflow**	**0.23**	**0.01**	**7.68**	**560**	**1.37**
06904500	Spring	Runoff	0.104	0.22	5.5	812	0.68
06904500	Summer	Total	0.125	0.14	6.03	624	0.97
06904500	**Summer**	**Baseflow**	**0.29**	**0**	**8.33**	**200**	**4.17**
06904500	Summer	Runoff	-0.043	0.61	-0.61	274	-0.22
06904500	Fall	Total	0.091	0.28	1.08	307	0.35
06904500	**Fall**	**Baseflow**	**0.179**	**0.03**	**1.43**	**135**	**1.06**
06904500	Fall	Runoff	-0.01	0.91	-0.06	186	-0.03
06905500	**Annual**	**Total**	**0.149**	**0.07**	**9.2**	**1220**	**0.75**
06905500	**Annual**	**Baseflow**	**0.251**	**0**	**6.59**	**492**	**1.34**
06905500	Annual	Runoff	0.078	0.35	3.13	702	0.45
06905500	**Annual Minimum**	**Total**	**0.337**	**0**	**0.59**	**39**	**1.51**
06905500	**Annual Maximum**	**Total**	**0.244**	**0**	**185**	**15200**	**1.21**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06905500	Winter	Total	0.028	0.74	1.71	1060	0.16
06905500	Winter	Baseflow	0.063	0.45	1.95	487	0.4
06905500	Winter	Runoff	-0.01	0.91	-0.4	572	-0.07
06905500	**Spring**	**Total**	**0.161**	**0.05**	**17.81**	**2080**	**0.86**
06905500	**Spring**	**Baseflow**	**0.221**	**0.01**	**8.23**	**739**	**1.11**
06905500	Spring	Runoff	0.106	0.2	7.52	1350	0.56
06905500	Summer	Total	0.121	0.15	6.12	739	0.83
06905500	**Summer**	**Baseflow**	**0.278**	**0**	**8.57**	**236**	**3.63**
06905500	Summer	Runoff	0.005	0.95	0.1	331	0.03
06905500	Fall	Total	0.113	0.17	2.34	451	0.52
06905500	**Fall**	**Baseflow**	**0.173**	**0.04**	**1.99**	**185**	**1.07**
06905500	Fall	Runoff	0.032	0.7	0.3	221	0.14
06908000	**Annual**	**Total**	**0.23**	**0.01**	**8.38**	**745**	**1.12**
06908000	**Annual**	**Baseflow**	**0.209**	**0.01**	**1.34**	**122**	**1.09**
06908000	**Annual**	**Runoff**	**0.227**	**0.01**	**7.36**	**640**	**1.15**
06908000	**Annual Minimum**	**Total**	**0.313**	**0**	**0.1**	**3.6**	**2.72**
06908000	**Annual Maximum**	**Total**	**0.251**	**0**	**124**	**11900**	**1.04**
06908000	Winter	Total	0.123	0.14	4.54	631	0.72
06908000	**Winter**	**Baseflow**	**0.154**	**0.06**	**1.44**	**137**	**1.05**
06908000	Winter	Runoff	0.11	0.19	3.03	511	0.59
06908000	**Spring**	**Total**	**0.23**	**0.01**	**14.38**	**1040**	**1.38**
06908000	**Spring**	**Baseflow**	**0.215**	**0.01**	**1.93**	**165**	**1.17**
06908000	**Spring**	**Runoff**	**0.221**	**0.01**	**12.17**	**855**	**1.42**
06908000	Summer	Total	0.124	0.14	3.37	301	1.12
06908000	**Summer**	**Baseflow**	**0.253**	**0**	**0.52**	**26.2**	**2**
06908000	Summer	Runoff	0.119	0.15	2.97	272	1.09

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06908000	Fall	Total	0.14	0.09	2.15	253	0.85
06908000	Fall	Baseflow	0.191	0.02	0.48	36.6	1.32
06908000	Fall	Runoff	0.12	0.15	1.34	208	0.64
06909000	Annual	Total	0.197	0.02	342.1	64600	0.53
06909000	Annual	Baseflow	0.38	0	412.9	33000	1.25
06909000	Annual	Runoff	-0.096	0.25	-97.62	28000	-0.35
06909000	Annual Minimum	Total	0.577	0	380.5	21600	1.77
06909000	Annual Maximum	Total	0.146	0.08	850.9	237000	0.36
06909000	Winter	Total	0.17	0.04	233.1	44100	0.53
06909000	Winter	Baseflow	0.47	0	412.8	25900	1.6
06909000	Winter	Runoff	-0.197	0.02	-177.5	20900	-0.85
06909000	Spring	Total	0.174	0.04	489.9	82900	0.59
06909000	Spring	Baseflow	0.304	0	421.5	37100	1.14
06909000	Spring	Runoff	0.013	0.88	30.96	46200	0.07
06909000	Summer	Total	0.138	0.1	257.2	64300	0.4
06909000	Summer	Baseflow	0.311	0	340.5	38700	0.88
06909000	Summer	Runoff	-0.113	0.17	-140.2	25000	-0.56
06909000	Fall	Total	0.219	0.01	312.7	51100	0.61
06909000	Fall	Baseflow	0.38	0	371.4	29300	1.27
06909000	Fall	Runoff	-0.14	0.09	-120.9	15900	-0.76
06912500	Annual	Total	0.104	0.21	0.86	163	0.53
06912500	Annual	Baseflow	0.273	0	0.95	68.2	1.4
06912500	Annual	Runoff	-0.015	0.86	-0.05	86.7	-0.06
06912500	Annual Minimum	Total	0.382	0	0.15	5.2	2.9

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06912500	**Annual Maximum**	**Total**	**-0.217**	**0.01**	**-25.38**	**2310**	**-1.1**
06912500	Winter	Total	0.112	0.18	0.4	83.1	0.48
06912500	**Winter**	**Baseflow**	**0.192**	**0.02**	**0.51**	**44.7**	**1.14**
06912500	Winter	Runoff	0.007	0.94	0	22	0.01
06912500	**Spring**	**Total**	**0.147**	**0.08**	**2.22**	**213**	**1.05**
06912500	**Spring**	**Baseflow**	**0.291**	**0**	**1.48**	**74.5**	**1.99**
06912500	Spring	Runoff	0.068	0.41	0.7	133	0.52
06912500	Summer	Total	0.044	0.6	0.29	63.8	0.45
06912500	**Summer**	**Baseflow**	**0.266**	**0**	**0.64**	**34.5**	**1.87**
06912500	Summer	Runoff	-0.078	0.35	-0.23	29.9	-0.77
06912500	Fall	Total	0.094	0.26	0.3	54.7	0.54
06912500	**Fall**	**Baseflow**	**0.196**	**0.02**	**0.34**	**27.7**	**1.23**
06912500	Fall	Runoff	0.054	0.52	0.01	19.2	0.06
06913500	Annual	Total	0.093	0.26	3.16	703	0.45
06913500	**Annual**	**Baseflow**	**0.242**	**0**	**3.05**	**211**	**1.45**
06913500	Annual	Runoff	0.027	0.75	0.45	440	0.1
06913500	**Annual Minimum**	**Total**	**0.372**	**0**	**0.43**	**27.4**	**1.57**
06913500	Annual Maximum	Total	0.009	0.92	3.13	11600	0.03
06913500	Winter	Total	0.098	0.24	1.87	365	0.51
06913500	**Winter**	**Baseflow**	**0.177**	**0.03**	**1.71**	**168**	**1.02**
06913500	Winter	Runoff	0.052	0.54	0.26	184	0.14
06913500	**Spring**	**Total**	**0.146**	**0.08**	**9.93**	**995**	**1**
06913500	**Spring**	**Baseflow**	**0.267**	**0**	**4.93**	**273**	**1.81**
06913500	Spring	Runoff	0.112	0.18	3.93	677	0.58
06913500	Summer	Total	0.013	0.88	0.23	299	0.08

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06913500	**Summer**	**Baseflow**	**0.21**	**0.01**	**1.45**	**87.9**	**1.65**
06913500	Summer	Runoff	-0.066	0.43	-0.79	187	-0.42
06913500	Fall	Total	0.077	0.35	0.83	205	0.41
06913500	**Fall**	**Baseflow**	**0.136**	**0.1**	**0.79**	**80.1**	**0.99**
06913500	Fall	Runoff	0.022	0.8	0.06	97.7	0.06
06914000	**Annual**	**Total**	**0.172**	**0.07**	**2.15**	**207**	**1.04**
06914000	**Annual**	**Baseflow**	**0.205**	**0.03**	**0.51**	**32.2**	**1.57**
06914000	Annual	Runoff	0.151	0.12	1.54	173	0.89
06914000	Annual Minimum	Total	-0.042	0.69	0	0.09	0
06914000	Annual Maximum	Total	0.083	0.39	41.93	8150	0.51
06914000	Winter	Total	0.128	0.18	1.51	146	1.04
06914000	Winter	Baseflow	0.155	0.11	0.55	41.8	1.31
06914000	Winter	Runoff	0.113	0.24	0.93	95.2	0.98
06914000	**Spring**	**Total**	**0.161**	**0.09**	**4.02**	**307**	**1.31**
06914000	**Spring**	**Baseflow**	**0.192**	**0.05**	**0.71**	**41.2**	**1.71**
06914000	**Spring**	**Runoff**	**0.172**	**0.07**	**3.5**	**268**	**1.31**
06914000	Summer	Total	0.005	0.97	0.01	70.4	0.02
06914000	Summer	Baseflow	0.086	0.37	0.04	7.3	0.54
06914000	Summer	Runoff	-0.02	0.84	-0.04	62.1	-0.07
06914000	Fall	Total	0.128	0.19	0.76	95.1	0.8
06914000	Fall	Baseflow	0.151	0.12	0.24	15.5	1.53
06914000	Fall	Runoff	0.118	0.22	0.7	79.6	0.88
06917000	**Annual**	**Total**	**0.158**	**0.06**	**1.62**	**214**	**0.76**
06917000	Annual	Baseflow	0.13	0.12	0.34	52.7	0.65
06917000	**Annual**	**Runoff**	**0.154**	**0.06**	**1.32**	**158**	**0.83**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06917000	**Annual Minimum**	**Total**	**0.21**	**0.02**	**0**	**0.095**	**0.77**
06917000	**Annual Maximum**	**Total**	**0.139**	**0.1**	**46.16**	**6640**	**0.7**
06917000	Winter	Total	0.099	0.23	0.87	172	0.51
06917000	Winter	Baseflow	0.09	0.28	0.37	67.8	0.54
06917000	Winter	Runoff	0.097	0.24	0.32	89.9	0.36
06917000	**Spring**	**Total**	**0.183**	**0.03**	**3.46**	**324**	**1.07**
06917000	**Spring**	**Baseflow**	**0.213**	**0.01**	**0.82**	**80.5**	**1.02**
06917000	**Spring**	**Runoff**	**0.168**	**0.04**	**2.68**	**235**	**1.14**
06917000	Summer	Total	0.107	0.2	0.44	43.8	1.01
06917000	Summer	Baseflow	0.13	0.12	0.1	8.9	1.09
06917000	Summer	Runoff	0.103	0.22	0.35	32.5	1.08
06917000	Fall	Total	0.088	0.29	0.2	81.7	0.25
06917000	Fall	Baseflow	0.065	0.43	0.05	24.8	0.18
06917000	Fall	Runoff	0.094	0.26	0.12	50.8	0.23
06919500	**Annual**	**Total**	**0.151**	**0.07**	**2.15**	**318**	**0.68**
06919500	Annual	Baseflow	0.093	0.26	0.33	103	0.32
06919500	**Annual**	**Runoff**	**0.147**	**0.08**	**1.64**	**203**	**0.81**
06919500	Annual Minimum	Total	0.046	0.58	0	0.62	0.16
06919500	**Annual Maximum**	**Total**	**0.154**	**0.06**	**61.06**	**8350**	**0.73**
06919500	Winter	Total	0.026	0.75	0.49	360	0.14
06919500	Winter	Baseflow	0.018	0.83	0.15	159	0.09
06919500	Winter	Runoff	0.036	0.67	0.27	187	0.14
06919500	**Spring**	**Total**	**0.19**	**0.02**	**4.97**	**407**	**1.22**
06919500	**Spring**	**Baseflow**	**0.147**	**0.08**	**1.09**	**127**	**0.86**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06919500	**Spring**	**Runoff**	**0.187**	**0.02**	**3.82**	**272**	**1.4**
06919500	Summer	Total	0.001	1	0	60.6	0
06919500	Summer	Baseflow	0.036	0.67	0.04	15.7	0.26
06919500	Summer	Runoff	-0.02	0.81	-0.08	48.1	-0.16
06919500	Fall	Total	0.042	0.62	0.23	84.3	0.27
06919500	Fall	Baseflow	0.023	0.79	0.03	41.1	0.08
06919500	Fall	Runoff	0.046	0.59	0.1	52	0.18
06926000	**Annual**	**Total**	**0.162**	**0.05**	**74.77**	**9760**	**0.77**
06926000	**Annual**	**Baseflow**	**0.171**	**0.04**	**16.16**	**1630**	**0.99**
06926000	**Annual**	**Runoff**	**0.136**	**0.1**	**42.01**	**7840**	**0.54**
06926000	**Annual Minimum**	**Total**	**0.382**	**0**	**3.19**	**405**	**0.79**
06926000	Annual Maximum	Total	-0.062	0.46	-100	51600	-0.19
06926000	Winter	Total	0.058	0.49	29.12	9260	0.31
06926000	**Winter**	**Baseflow**	**0.166**	**0.05**	**3.64**	**502**	**0.72**
06926000	Winter	Runoff	0.035	0.68	12.85	8290	0.16
06926000	**Spring**	**Total**	**0.187**	**0.02**	**140.1**	**13200**	**1.06**
06926000	**Spring**	**Baseflow**	**0.154**	**0.06**	**8.76**	**1060**	**0.82**
06926000	**Spring**	**Runoff**	**0.194**	**0.02**	**86.08**	**11800**	**0.73**
06926000	**Summer**	**Total**	**0.176**	**0.03**	**59.33**	**5400**	**1.1**
06926000	**Summer**	**Baseflow**	**0.223**	**0.01**	**6.03**	**585**	**1.03**
06926000	**Summer**	**Runoff**	**0.162**	**0.05**	**50.37**	**4280**	**1.18**
06926000	Fall	Total	0.001	1	0.05	4500	0
06926000	**Fall**	**Baseflow**	**0.205**	**0.01**	**3.88**	**488**	**0.8**
06926000	Fall	Runoff	-0.045	0.59	-10.04	3820	-0.26
06932000	**Annual**	**Total**	**0.18**	**0.03**	**1.03**	**151**	**0.68**
06932000	**Annual**	**Baseflow**	**0.199**	**0.02**	**0.59**	**108**	**0.55**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06932000	**Annual**	**Runoff**	**0.148**	**0.07**	**0.36**	**41.8**	**0.87**
06932000	**Annual Minimum**	**Total**	**0.342**	**0**	**0.4**	**48**	**0.83**
06932000	Annual Maximum	Total	0.116	0.17	24.15	3170	0.76
06932000	Winter	Total	0.081	0.33	0.6	179	0.34
06932000	Winter	Baseflow	0.114	0.17	0.56	127	0.44
06932000	Winter	Runoff	0.012	0.89	0.04	44.5	0.08
06932000	Spring	Total	0.129	0.12	0.99	190	0.52
06932000	**Spring**	**Baseflow**	**0.173**	**0.04**	**0.86**	**144**	**0.59**
06932000	Spring	Runoff	0.073	0.38	0.27	49.3	0.55
06932000	**Summer**	**Total**	**0.204**	**0.01**	**0.55**	**77.9**	**0.71**
06932000	**Summer**	**Baseflow**	**0.247**	**0**	**0.49**	**70.1**	**0.7**
06932000	Summer	Runoff	0.047	0.57	0.03	8.1	0.34
06932000	**Fall**	**Total**	**0.141**	**0.09**	**0.47**	**97**	**0.48**
06932000	**Fall**	**Baseflow**	**0.177**	**0.03**	**0.45**	**77.1**	**0.58**
06932000	Fall	Runoff	0.071	0.39	0.06	13.4	0.48
06933500	**Annual**	**Total**	**0.143**	**0.09**	**13.36**	**2440**	**0.55**
06933500	Annual	Baseflow	0.115	0.17	5.09	1520	0.33
06933500	**Annual**	**Runoff**	**0.135**	**0.1**	**6.34**	**908**	**0.7**
06933500	**Annual Minimum**	**Total**	**0.192**	**0.02**	**2**	**483**	**0.41**
06933500	**Annual Maximum**	**Total**	**0.16**	**0.06**	**209.3**	**27400**	**0.76**
06933500	Winter	Total	0.07	0.4	9.29	3040	0.31
06933500	Winter	Baseflow	0.09	0.28	6.43	1880	0.34
06933500	Winter	Runoff	0.043	0.61	2.57	1170	0.22
06933500	Spring	Total	0.101	0.23	14.42	3010	0.48

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
06933500	Spring	Baseflow	0.097	0.25	7.19	1930	0.37
06933500	Spring	Runoff	0.086	0.3	7.78	1130	0.69
06933500	Summer	Total	0.115	0.17	4.26	847	0.5
06933500	Summer	Baseflow	0.119	0.15	2.51	708	0.35
06933500	Summer	Runoff	0.101	0.23	1.03	145	0.71
06933500	Fall	Total	0.067	0.42	3.55	1240	0.29
06933500	Fall	Baseflow	0.083	0.32	2.85	893	0.32
06933500	Fall	Runoff	0.055	0.51	0.89	323	0.28
07013000	Annual	Total	0.125	0.13	2.91	529	0.55
07013000	**Annual**	**Baseflow**	**0.152**	**0.07**	**1.52**	**337**	**0.45**
07013000	Annual	Runoff	0.114	0.17	1.14	188	0.61
07013000	**Annual Minimum**	**Total**	**0.196**	**0.02**	**0.53**	**143**	**0.37**
07013000	Annual Maximum	Total	0.048	0.57	29.37	10400	0.28
07013000	Winter	Total	0.051	0.54	1.35	625	0.22
07013000	Winter	Baseflow	0.103	0.22	1.58	399	0.4
07013000	Winter	Runoff	-0.023	0.79	-0.38	222	-0.17
07013000	**Spring**	**Total**	**0.142**	**0.09**	**4.32**	**741**	**0.58**
07013000	**Spring**	**Baseflow**	**0.173**	**0.04**	**2.53**	**439**	**0.58**
07013000	Spring	Runoff	0.098	0.24	1.83	263	0.7
07013000	**Summer**	**Total**	**0.139**	**0.1**	**1.17**	**214**	**0.54**
07013000	**Summer**	**Baseflow**	**0.18**	**0.03**	**0.97**	**187**	**0.52**
07013000	Summer	Runoff	0.115	0.17	0.24	31.1	0.77
07013000	Fall	Total	0.094	0.26	1.12	294	0.38
07013000	**Fall**	**Baseflow**	**0.144**	**0.08**	**0.87**	**220**	**0.39**
07013000	Fall	Runoff	0.056	0.5	0.21	66.6	0.32
07014500	Annual	Total	0.132	0.11	6.1	1140	0.53

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07014500	**Annual**	**Baseflow**	**0.157**	**0.06**	**3.41**	**732**	**0.47**
07014500	Annual	Runoff	0.124	0.14	2.79	439	0.63
07014500	**Annual Minimum**	**Total**	**0.21**	**0.01**	**1.41**	**262**	**0.54**
07014500	Annual Maximum	Total	0.08	0.34	77.96	17200	0.45
07014500	Winter	Total	0.049	0.56	3.17	1390	0.23
07014500	Winter	Baseflow	0.107	0.2	3.15	905	0.35
07014500	Winter	Runoff	-0.009	0.92	-0.36	486	-0.07
07014500	**Spring**	**Total**	**0.17**	**0.04**	**11.54**	**1690**	**0.68**
07014500	**Spring**	**Baseflow**	**0.183**	**0.03**	**5.99**	**991**	**0.6**
07014500	Spring	Runoff	0.12	0.15	4.14	532	0.78
07014500	Summer	Total	0.117	0.16	2.38	458	0.52
07014500	**Summer**	**Baseflow**	**0.169**	**0.04**	**2.22**	**373**	**0.59**
07014500	Summer	Runoff	0.075	0.37	0.33	78.5	0.42
07014500	Fall	Total	0.085	0.31	2.62	642	0.41
07014500	Fall	Baseflow	0.121	0.15	1.77	482	0.37
07014500	Fall	Runoff	0.047	0.57	0.41	129	0.32
07016500	**Annual**	**Total**	**0.178**	**0.03**	**4.91**	**614**	**0.8**
07016500	**Annual**	**Baseflow**	**0.218**	**0.01**	**1.36**	**221**	**0.62**
07016500	**Annual**	**Runoff**	**0.169**	**0.04**	**3.48**	**402**	**0.86**
07016500	Annual Minimum	Total	0.124	0.14	0.12	34.5	0.34
07016500	**Annual Maximum**	**Total**	**0.22**	**0.01**	**127.4**	**14400**	**0.89**
07016500	Winter	Total	0.047	0.58	1.98	834	0.24
07016500	Winter	Baseflow	0.113	0.17	1.47	297	0.5
07016500	Winter	Runoff	0.014	0.87	0.41	467	0.09

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07016500	**Spring**	**Total**	**0.217**	**0.01**	**8.82**	**827**	**1.07**
07016500	**Spring**	**Baseflow**	**0.227**	**0.01**	**2.2**	**296**	**0.74**
07016500	**Spring**	**Runoff**	**0.195**	**0.02**	**7.03**	**584**	**1.2**
07016500	Summer	Total	0.095	0.26	0.59	132	0.45
07016500	Summer	Baseflow	0.109	0.19	0.34	74.9	0.46
07016500	Summer	Runoff	0.064	0.44	0.22	47.7	0.46
07016500	Fall	Total	0.13	0.12	1.75	279	0.63
07016500	**Fall**	**Baseflow**	**0.144**	**0.08**	**0.92**	**127**	**0.73**
07016500	Fall	Runoff	0.11	0.19	0.7	119	0.59
07018100	Annual	Total	0.12	0.15	2.97	678	0.44
07018100	Annual	Baseflow	0.117	0.16	0.99	354	0.28
07018100	Annual	Runoff	0.097	0.24	1.7	336	0.51
07018100	Annual Minimum	Total	0.131	0.12	0.31	86.8	0.36
07018100	Annual Maximum	Total	0.111	0.18	93.44	14200	0.66
07018100	Winter	Total	-0.007	0.94	-0.42	918	-0.05
07018100	Winter	Baseflow	0.051	0.54	0.73	468	0.15
07018100	Winter	Runoff	-0.057	0.5	-1.31	429	-0.3
07018100	**Spring**	**Total**	**0.162**	**0.05**	**7.61**	**860**	**0.89**
07018100	**Spring**	**Baseflow**	**0.194**	**0.02**	**2.99**	**438**	**0.68**
07018100	Spring	Runoff	0.122	0.15	3.88	396	0.98
07018100	Summer	Total	0.029	0.73	0.21	215	0.1
07018100	Summer	Baseflow	0.105	0.21	0.5	143	0.35
07018100	Summer	Runoff	-0.069	0.41	-0.32	63.2	-0.5
07018100	Fall	Total	0.037	0.67	0.66	348	0.19
07018100	Fall	Baseflow	0.057	0.5	0.52	218	0.24
07018100	Fall	Runoff	0.051	0.54	0.48	128	0.37

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07018500	Annual	Total	0.104	0.21	3.47	814	0.43
07018500	Annual	Baseflow	0.058	0.49	0.64	434	0.15
07018500	Annual	Runoff	0.097	0.25	1.89	397	0.48
07018500	Annual Minimum	Total	0.1	0.23	0.29	102	0.28
07018500	Annual Maximum	Total	0.12	0.15	103.8	15200	0.69
07018500	Winter	Total	-0.039	0.65	-2.12	1100	-0.19
07018500	Winter	Baseflow	-0.021	0.8	-0.45	576	-0.08
07018500	Winter	Runoff	-0.067	0.42	-1.8	486	-0.37
07018500	Spring	Total	0.133	0.11	7.54	1080	0.7
07018500	Spring	Baseflow	0.113	0.17	2.13	585	0.36
07018500	Spring	Runoff	0.122	0.14	4.18	472	0.89
07018500	Summer	Total	0.01	0.91	0.1	242	0.04
07018500	Summer	Baseflow	0.067	0.42	0.38	166	0.23
07018500	Summer	Runoff	-0.047	0.57	-0.22	59.5	-0.36
07018500	Fall	Total	0.04	0.63	0.81	396	0.21
07018500	Fall	Baseflow	0.054	0.51	0.5	262	0.19
07018500	Fall	Runoff	0.018	0.83	0.21	125	0.17
07019000	**Annual**	**Total**	**0.172**	**0.04**	**21.69**	**3090**	**0.7**
07019000	**Annual**	**Baseflow**	**0.151**	**0.07**	**5.75**	**1690**	**0.34**
07019000	**Annual**	**Runoff**	**0.18**	**0.03**	**14.32**	**1540**	**0.93**
07019000	**Annual Minimum**	**Total**	**0.172**	**0.04**	**2.1**	**480**	**0.44**
07019000	**Annual Maximum**	**Total**	**0.236**	**0**	**406.9**	**37900**	**1.07**
07019000	Winter	Total	0.058	0.49	8.09	3820	0.21
07019000	Winter	Baseflow	0.065	0.44	5.09	2020	0.25

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07019000	Winter	Runoff	0.032	0.7	2.87	2000	0.14
07019000	**Spring**	**Total**	**0.213**	**0.01**	**39.85**	**4300**	**0.93**
07019000	**Spring**	**Baseflow**	**0.168**	**0.04**	**11.92**	**2280**	**0.52**
07019000	**Spring**	**Runoff**	**0.215**	**0.01**	**26.34**	**1960**	**1.34**
07019000	Summer	Total	0.107	0.2	4.16	1060	0.39
07019000	**Summer**	**Baseflow**	**0.159**	**0.06**	**3.73**	**778**	**0.48**
07019000	Summer	Runoff	0.064	0.44	0.89	226	0.39
07019000	Fall	Total	0.087	0.3	6.32	1420	0.45
07019000	Fall	Baseflow	0.096	0.25	3.03	1000	0.3
07019000	Fall	Runoff	0.076	0.36	1.87	426	0.44
07037500	**Annual**	**Total**	**0.137**	**0.1**	**4.81**	**1080**	**0.45**
07037500	**Annual**	**Baseflow**	**0.152**	**0.07**	**2.23**	**485**	**0.46**
07037500	Annual	Runoff	0.103	0.22	2.23	569	0.39
07037500	**Annual Minimum**	**Total**	**0.228**	**0.01**	**0.34**	**36.2**	**0.95**
07037500	Annual Maximum	Total	0.086	0.3	96.34	24700	0.39
07037500	Winter	Total	-0.04	0.63	-2	1610	-0.12
07037500	Winter	Baseflow	0.073	0.39	1.74	789	0.22
07037500	Winter	Runoff	-0.086	0.3	-3.03	847	-0.36
07037500	**Spring**	**Total**	**0.14**	**0.1**	**11.75**	**1490**	**0.79**
07037500	**Spring**	**Baseflow**	**0.151**	**0.07**	**3.86**	**694**	**0.56**
07037500	Spring	Runoff	0.124	0.14	6.77	768	0.88
07037500	Summer	Total	0.133	0.11	1.09	156	0.7
07037500	**Summer**	**Baseflow**	**0.172**	**0.04**	**0.68**	**101**	**0.68**
07037500	Summer	Runoff	0.096	0.25	0.36	50.7	0.72
07037500	**Fall**	**Total**	**0.136**	**0.1**	**4.43**	**717**	**0.62**
07037500	**Fall**	**Baseflow**	**0.17**	**0.04**	**2.57**	**314**	**0.82**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07037500	Fall	Runoff	0.105	0.21	1.9	359	0.53
07052500	**Annual**	**Total**	**0.156**	**0.06**	**5.58**	**975**	**0.57**
07052500	Annual	Baseflow	0.125	0.13	2.46	596	0.41
07052500	**Annual**	**Runoff**	**0.17**	**0.04**	**2.42**	**368**	**0.66**
07052500	**Annual Minimum**	**Total**	**0.198**	**0.02**	**0.68**	**107**	**0.63**
07052500	Annual Maximum	Total	0.116	0.17	90.45	17000	0.53
07052500	Winter	Total	0.081	0.33	4.69	1310	0.36
07052500	Winter	Baseflow	0.08	0.34	2.54	810	0.31
07052500	Winter	Runoff	0.09	0.28	1.78	431	0.41
07052500	Spring	Total	0.11	0.19	6.85	1120	0.61
07052500	Spring	Baseflow	0.125	0.13	4.63	755	0.61
07052500	Spring	Runoff	0.114	0.17	3.17	385	0.82
07052500	Summer	Total	0.126	0.13	1.89	320	0.59
07052500	Summer	Baseflow	0.093	0.26	0.95	228	0.42
07052500	Summer	Runoff	0.134	0.11	0.73	80.4	0.91
07052500	Fall	Total	0.098	0.24	2.48	508	0.49
07052500	Fall	Baseflow	0.093	0.26	1.46	318	0.46
07052500	Fall	Runoff	0.104	0.21	0.87	153	0.57
07057500	Annual	Total	0.132	0.11	2.5	725	0.35
07057500	Annual	Baseflow	0.107	0.2	1.36	586	0.23
07057500	Annual	Runoff	0.098	0.24	0.63	119	0.53
07057500	Annual Minimum	Total	0.085	0.31	0.38	292	0.13
07057500	Annual Maximum	Total	0.073	0.38	32.5	8060	0.4
07057500	Winter	Total	0.089	0.29	2.19	791	0.28

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07057500	Winter	Baseflow	0.112	0.18	1.88	663	0.28
07057500	Winter	Runoff	0.006	0.95	0.05	142	0.04
07057500	Spring	Total	0.09	0.28	2.62	938	0.28
07057500	Spring	Baseflow	0.1	0.23	2.25	779	0.29
07057500	Spring	Runoff	0.037	0.66	0.35	163	0.21
07057500	Summer	Total	0.096	0.25	0.93	409	0.23
07057500	Summer	Baseflow	0.081	0.33	0.63	388	0.16
07057500	Summer	Runoff	0.129	0.12	0.15	17.2	0.84
07057500	Fall	Total	0.084	0.31	1.37	457	0.3
07057500	Fall	Baseflow	0.082	0.33	1.06	399	0.27
07057500	Fall	Runoff	0.049	0.56	0.14	59.2	0.23
07061500	Annual	Total	0.133	0.11	2.63	559	0.47
07061500	**Annual**	**Baseflow**	**0.163**	**0.05**	**1.34**	**345**	**0.39**
07061500	Annual	Runoff	0.107	0.2	1.05	197	0.53
07061500	**Annual Minimum**	**Total**	**0.309**	**0**	**0.75**	**108**	**0.7**
07061500	Annual Maximum	Total	0.081	0.33	53.29	11000	0.48
07061500	Winter	Total	-0.005	0.95	-0.2	704	-0.03
07061500	Winter	Baseflow	0.079	0.34	0.97	431	0.22
07061500	Winter	Runoff	-0.063	0.45	-0.91	237	-0.38
07061500	Spring	Total	0.109	0.19	3.33	710	0.47
07061500	**Spring**	**Baseflow**	**0.147**	**0.08**	**1.8**	**429**	**0.42**
07061500	Spring	Runoff	0.075	0.37	1.42	261	0.54
07061500	**Summer**	**Total**	**0.163**	**0.05**	**1.12**	**201**	**0.56**
07061500	**Summer**	**Baseflow**	**0.216**	**0.01**	**0.96**	**165**	**0.58**
07061500	Summer	Runoff	0.062	0.46	0.11	31.1	0.36
07061500	Fall	Total	0.097	0.25	1.66	415	0.4

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07061500	**Fall**	**Baseflow**	**0.148**	**0.07**	**1.26**	**269**	**0.47**
07061500	Fall	Runoff	0.049	0.56	0.38	123	0.31
07063000	**Annual**	**Total**	**0.215**	**0.01**	**8.78**	**1330**	**0.66**
07063000	**Annual**	**Baseflow**	**0.258**	**0**	**7.24**	**972**	**0.75**
07063000	Annual	Runoff	0.112	0.18	1.54	364	0.42
07063000	**Annual Minimum**	**Total**	**0.225**	**0.01**	**1.65**	**359**	**0.46**
07063000	**Annual Maximum**	**Total**	**0.183**	**0.03**	**47.41**	**6920**	**0.69**
07063000	Winter	Total	0.114	0.17	6.01	1700	0.35
07063000	**Winter**	**Baseflow**	**0.21**	**0.01**	**6.64**	**1190**	**0.56**
07063000	Winter	Runoff	-0.04	0.63	-0.91	472	-0.19
07063000	**Spring**	**Total**	**0.155**	**0.06**	**11.53**	**1790**	**0.65**
07063000	**Spring**	**Baseflow**	**0.167**	**0.04**	**7.9**	**1250**	**0.63**
07063000	Spring	Runoff	0.101	0.23	2.02	524	0.38
07063000	**Summer**	**Total**	**0.249**	**0**	**4.72**	**612**	**0.77**
07063000	**Summer**	**Baseflow**	**0.273**	**0**	**3.9**	**506**	**0.77**
07063000	Summer	Runoff	0.105	0.21	0.52	97.9	0.53
07063000	**Fall**	**Total**	**0.195**	**0.02**	**7.22**	**889**	**0.81**
07063000	**Fall**	**Baseflow**	**0.265**	**0**	**5.12**	**673**	**0.76**
07063000	Fall	Runoff	0.119	0.15	1.32	232	0.57
07064000	**Annual**	**Total**	**0.158**	**0.06**	**9.42**	**1840**	**0.51**
07064000	**Annual**	**Baseflow**	**0.139**	**0.1**	**6.3**	**1440**	**0.44**
07064000	**Annual**	**Runoff**	**0.192**	**0.02**	**3.16**	**427**	**0.74**
07064000	Annual Minimum	Total	0.117	0.16	0.95	362	0.26
07064000	Annual Maximum	Total	0.082	0.33	38.67	11800	0.33

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07064000	Winter	Total	0.041	0.63	3.41	2460	0.14
07064000	Winter	Baseflow	0.063	0.46	4.42	1900	0.23
07064000	Winter	Runoff	-0.025	0.77	-0.73	539	-0.13
07064000	Spring	Total	0.11	0.2	11.67	2400	0.49
07064000	Spring	Baseflow	0.089	0.29	7.99	1890	0.42
07064000	**Spring**	**Runoff**	**0.161**	**0.06**	**4.7**	**454**	**1.04**
07064000	**Summer**	**Total**	**0.256**	**0**	**7.49**	**729**	**1.03**
07064000	**Summer**	**Baseflow**	**0.175**	**0.04**	**3.91**	**595**	**0.66**
07064000	**Summer**	**Runoff**	**0.316**	**0**	**1.96**	**110**	**1.78**
07064000	**Fall**	**Total**	**0.167**	**0.05**	**8.66**	**1040**	**0.83**
07064000	**Fall**	**Baseflow**	**0.15**	**0.08**	**4.75**	**842**	**0.56**
07064000	**Fall**	**Runoff**	**0.179**	**0.03**	**3.79**	**254**	**1.49**
07066000	**Annual**	**Total**	**0.195**	**0.02**	**2.81**	**469**	**0.6**
07066000	**Annual**	**Baseflow**	**0.229**	**0.01**	**1.89**	**325**	**0.58**
07066000	Annual	Runoff	0.12	0.15	0.76	133	0.57
07066000	**Annual Minimum**	**Total**	**0.294**	**0**	**0.74**	**128**	**0.57**
07066000	Annual Maximum	Total	0.011	0.9	4.72	8060	0.06
07066000	Winter	Total	0.076	0.36	1.41	575	0.25
07066000	**Winter**	**Baseflow**	**0.147**	**0.08**	**1.75**	**400**	**0.44**
07066000	Winter	Runoff	-0.014	0.87	-0.19	166	-0.12
07066000	**Spring**	**Total**	**0.135**	**0.1**	**3.27**	**601**	**0.54**
07066000	**Spring**	**Baseflow**	**0.191**	**0.02**	**2.69**	**419**	**0.64**
07066000	Spring	Runoff	0.044	0.6	0.59	167	0.35
07066000	**Summer**	**Total**	**0.279**	**0**	**1.72**	**202**	**0.85**
07066000	**Summer**	**Baseflow**	**0.291**	**0**	**1.37**	**175**	**0.78**
07066000	**Summer**	**Runoff**	**0.143**	**0.09**	**0.2**	**16.9**	**1.16**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07066000	Fall	Total	0.128	0.12	1.46	268	0.54
07066000	**Fall**	**Baseflow**	**0.183**	**0.03**	**1.26**	**213**	**0.59**
07066000	Fall	Runoff	0.05	0.55	0.21	69.4	0.31
07067000	**Annual**	**Total**	**0.169**	**0.04**	**10.06**	**2000**	**0.5**
07067000	**Annual**	**Baseflow**	**0.172**	**0.04**	**5.96**	**1530**	**0.39**
07067000	Annual	Runoff	0.116	0.16	2.55	428	0.6
07067000	**Annual Minimum**	**Total**	**0.206**	**0.01**	**2.66**	**733**	**0.36**
07067000	Annual Maximum	Total	0.004	0.97	6.73	22000	0.03
07067000	Winter	Total	0.076	0.37	5.57	2320	0.24
07067000	Winter	Baseflow	0.128	0.12	6.71	1680	0.4
07067000	Winter	Runoff	-0.024	0.78	-0.57	518	-0.11
07067000	**Spring**	**Total**	**0.139**	**0.1**	**14.16**	**2600**	**0.55**
07067000	**Spring**	**Baseflow**	**0.139**	**0.1**	**9.76**	**1970**	**0.5**
07067000	Spring	Runoff	0.082	0.33	3.22	567	0.57
07067000	**Summer**	**Total**	**0.186**	**0.03**	**5.79**	**1060**	**0.54**
07067000	**Summer**	**Baseflow**	**0.22**	**0.01**	**5.24**	**958**	**0.55**
07067000	Summer	Runoff	0.124	0.14	0.66	99	0.66
07067000	**Fall**	**Total**	**0.14**	**0.09**	**5.72**	**1330**	**0.43**
07067000	**Fall**	**Baseflow**	**0.188**	**0.02**	**5.2**	**1070**	**0.49**
07067000	Fall	Runoff	0.069	0.41	0.95	231	0.41
07068000	**Annual**	**Total**	**0.162**	**0.05**	**12.71**	**2680**	**0.47**
07068000	**Annual**	**Baseflow**	**0.158**	**0.06**	**7.46**	**2220**	**0.34**
07068000	**Annual**	**Runoff**	**0.152**	**0.07**	**3.74**	**518**	**0.72**
07068000	**Annual Minimum**	**Total**	**0.195**	**0.02**	**3.06**	**1220**	**0.25**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07068000	Annual Maximum	Total	0.102	0.22	115.7	24200	0.48
07068000	Winter	Total	0.085	0.31	7.06	3170	0.22
07068000	Winter	Baseflow	0.126	0.13	7.64	2520	0.3
07068000	Winter	Runoff	-0.008	0.93	-0.2	633	-0.03
07068000	Spring	Total	0.133	0.11	16.65	3520	0.47
07068000	Spring	Baseflow	0.117	0.16	9.77	2910	0.34
07068000	Spring	Runoff	0.109	0.19	4.74	652	0.73
07068000	**Summer**	**Total**	**0.197**	**0.02**	**6.65**	**1650**	**0.4**
07068000	**Summer**	**Baseflow**	**0.195**	**0.02**	**5.85**	**1580**	**0.37**
07068000	Summer	Runoff	0.118	0.16	0.76	97.9	0.77
07068000	**Fall**	**Total**	**0.137**	**0.1**	**8.04**	**1940**	**0.42**
07068000	**Fall**	**Baseflow**	**0.164**	**0.05**	**5.95**	**1700**	**0.35**
07068000	Fall	Runoff	0.074	0.38	1.19	237	0.5
07069500	**Annual**	**Total**	**0.183**	**0.03**	**8.36**	**1400**	**0.6**
07069500	**Annual**	**Baseflow**	**0.175**	**0.04**	**4.54**	**996**	**0.46**
07069500	Annual	Runoff	0.125	0.15	2.71	420	0.64
07069500	Annual Minimum	Total	0.093	0.28	0.71	375	0.19
07069500	Annual Maximum	Total	0.08	0.36	103.7	22000	0.47
07069500	Winter	Total	0.097	0.27	6.18	1750	0.35
07069500	Winter	Baseflow	0.14	0.11	6.95	1240	0.56
07069500	Winter	Runoff	-0.002	0.99	-0.11	468	-0.02
07069500	Spring	Total	0.125	0.16	9.81	1810	0.54
07069500	Spring	Baseflow	0.141	0.11	6.48	1400	0.46
07069500	Spring	Runoff	0.075	0.39	2.47	435	0.57
07069500	**Summer**	**Total**	**0.2**	**0.02**	**3.25**	**624**	**0.52**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07069500	**Summer**	**Baseflow**	**0.192**	**0.03**	**2.21**	**536**	**0.41**
07069500	Summer	Runoff	0.07	0.43	0.34	59.2	0.58
07069500	Fall	Total	0.132	0.13	5.54	987	0.56
07069500	**Fall**	**Baseflow**	**0.155**	**0.08**	**3.74**	**674**	**0.56**
07069500	Fall	Runoff	0.06	0.5	1.17	276	0.42
07071500	**Annual**	**Total**	**0.153**	**0.07**	**3.69**	**766**	**0.48**
07071500	**Annual**	**Baseflow**	**0.141**	**0.09**	**2.79**	**657**	**0.42**
07071500	Annual	Runoff	0.075	0.37	0.37	90.2	0.41
07071500	**Annual Minimum**	**Total**	**0.174**	**0.04**	**1.36**	**288**	**0.47**
07071500	Annual Maximum	Total	0.024	0.78	6.12	6040	0.1
07071500	Winter	Total	0.083	0.32	2.9	820	0.35
07071500	Winter	Baseflow	0.118	0.16	3.18	709	0.45
07071500	Winter	Runoff	-0.04	0.63	-0.19	93.7	-0.2
07071500	Spring	Total	0.075	0.37	2.95	1040	0.28
07071500	Spring	Baseflow	0.082	0.33	2.44	890	0.27
07071500	Spring	Runoff	0.028	0.74	0.22	103	0.21
07071500	**Summer**	**Total**	**0.177**	**0.03**	**2.78**	**485**	**0.57**
07071500	**Summer**	**Baseflow**	**0.183**	**0.03**	**2.62**	**461**	**0.57**
07071500	Summer	Runoff	0.032	0.7	0.03	10.9	0.24
07071500	**Fall**	**Total**	**0.145**	**0.08**	**2.71**	**504**	**0.54**
07071500	**Fall**	**Baseflow**	**0.169**	**0.04**	**2.34**	**444**	**0.53**
07071500	Fall	Runoff	0.037	0.66	0.08	43.4	0.17
07072000	**Annual**	**Total**	**0.152**	**0.08**	**6.06**	**1160**	**0.52**
07072000	**Annual**	**Baseflow**	**0.165**	**0.06**	**4.55**	**947**	**0.48**
07072000	Annual	Runoff	0.087	0.31	0.95	190	0.5

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07072000	Annual Minimum	Total	0.136	0.12	1.36	424	0.32
07072000	Annual Maximum	Total	0.104	0.23	62.52	9740	0.64
07072000	Winter	Total	0.059	0.5	3.71	1230	0.3
07072000	**Winter**	**Baseflow**	**0.152**	**0.08**	**5.35**	**1070**	**0.5**
07072000	Winter	Runoff	-0.044	0.62	-0.63	197	-0.32
07072000	Spring	Total	0.108	0.22	6.92	1550	0.45
07072000	Spring	Baseflow	0.117	0.18	5.01	1250	0.4
07072000	Spring	Runoff	0.052	0.55	1.08	206	0.52
07072000	**Summer**	**Total**	**0.216**	**0.01**	**4.47**	**689**	**0.65**
07072000	**Summer**	**Baseflow**	**0.196**	**0.02**	**3.91**	**649**	**0.6**
07072000	Summer	Runoff	0.121	0.17	0.26	30.7	0.84
07072000	**Fall**	**Total**	**0.15**	**0.08**	**4.2**	**768**	**0.55**
07072000	**Fall**	**Baseflow**	**0.158**	**0.07**	**3.4**	**687**	**0.5**
07072000	Fall	Runoff	0.092	0.29	0.76	86.4	0.88
07072500	Annual	Total	0.133	0.11	34.01	8630	0.39
07072500	Annual	Baseflow	0.12	0.15	24.12	7230	0.33
07072500	**Annual**	**Runoff**	**0.139**	**0.1**	**8.6**	**1460**	**0.59**
07072500	**Annual Minimum**	**Total**	**0.177**	**0.03**	**7.47**	**2710**	**0.28**
07072500	**Annual Maximum**	**Total**	**0.135**	**0.1**	**198.7**	**38800**	**0.51**
07072500	Winter	Total	0.065	0.44	20.21	10700	0.19
07072500	Winter	Baseflow	0.073	0.38	21.9	8530	0.26
07072500	Winter	Runoff	0.032	0.71	2.52	1830	0.14
07072500	Spring	Total	0.101	0.23	46.5	11500	0.41
07072500	Spring	Baseflow	0.076	0.37	26.63	9680	0.28

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07072500	Spring	Runoff	0.156	0.06	15.03	1860	0.81
07072500	Summer	Total	0.176	0.03	19.92	4030	0.49
07072500	Summer	Baseflow	0.176	0.03	15.82	3610	0.44
07072500	Summer	Runoff	0.156	0.06	3.73	381	0.98
07072500	Fall	Total	0.117	0.16	22.08	4860	0.45
07072500	Fall	Baseflow	0.117	0.16	15.87	4280	0.37
07072500	Fall	Runoff	0.08	0.34	3.81	916	0.42
07186000	Annual	Total	0.212	0.01	8.44	796	1.06
07186000	Annual	Baseflow	0.198	0.02	2.68	379	0.71
07186000	Annual	Runoff	0.202	0.02	5.47	457	1.2
07186000	Annual Minimum	Total	0.225	0.01	0.58	60	0.96
07186000	Annual Maximum	Total	0.194	0.02	159.7	17600	0.91
07186000	Winter	Total	0.112	0.18	4.77	783	0.61
07186000	Winter	Baseflow	0.12	0.15	2.66	453	0.59
07186000	Winter	Runoff	0.075	0.37	1.85	360	0.51
07186000	Spring	Total	0.248	0	13.97	940	1.49
07186000	Spring	Baseflow	0.24	0	5.18	449	1.15
07186000	Spring	Runoff	0.251	0	10.12	557	1.82
07186000	Summer	Total	0.147	0.08	3.76	334	1.13
07186000	Summer	Baseflow	0.131	0.12	1.28	162	0.79
07186000	Summer	Runoff	0.118	0.16	1.69	162	1.04
07186000	Fall	Total	0.076	0.36	1.84	389	0.47
07186000	Fall	Baseflow	0.072	0.39	0.87	204	0.43
07186000	Fall	Runoff	0.068	0.42	0.83	184	0.45
07187000	Annual	Total	0.185	0.03	2.73	377	0.72
07187000	Annual	Baseflow	0.18	0.03	2.05	309	0.67

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07187000	Annual	Runoff	0.123	0.14	0.51	77.3	0.65
07187000	**Annual Minimum**	**Total**	**0.16**	**0.05**	**0.44**	**80.4**	**0.54**
07187000	Annual Maximum	Total	0.109	0.19	30.72	5070	0.61
07187000	Winter	Total	0.133	0.11	2.48	384	0.65
07187000	**Winter**	**Baseflow**	**0.149**	**0.07**	**2.04**	**320**	**0.64**
07187000	Winter	Runoff	0.048	0.56	0.15	45.2	0.34
07187000	**Spring**	**Total**	**0.203**	**0.01**	**4.61**	**502**	**0.92**
07187000	**Spring**	**Baseflow**	**0.217**	**0.01**	**3.77**	**412**	**0.92**
07187000	Spring	Runoff	0.13	0.12	0.76	103	0.74
07187000	Summer	Total	0.09	0.28	0.79	214	0.37
07187000	Summer	Baseflow	0.097	0.24	0.83	186	0.45
07187000	Summer	Runoff	-0.03	0.72	-0.04	26.8	-0.15
07187000	Fall	Total	0.106	0.2	1.2	219	0.55
07187000	Fall	Baseflow	0.104	0.21	0.98	181	0.54
07187000	Fall	Runoff	0.103	0.22	0.2	30.3	0.64
07188000	**Annual**	**Total**	**0.212**	**0.01**	**18.35**	**1940**	**0.95**
07188000	**Annual**	**Baseflow**	**0.25**	**0**	**8.7**	**942**	**0.92**
07188000	**Annual**	**Runoff**	**0.172**	**0.04**	**9.2**	**1030**	**0.89**
07188000	**Annual Minimum**	**Total**	**0.254**	**0**	**1.83**	**182**	**1.01**
07188000	**Annual Maximum**	**Total**	**0.177**	**0.03**	**301.1**	**33400**	**0.9**
07188000	Winter	Total	0.126	0.13	11.76	1950	0.6
07188000	**Winter**	**Baseflow**	**0.169**	**0.04**	**8.65**	**1010**	**0.85**
07188000	Winter	Runoff	0.046	0.59	1.99	670	0.3
07188000	**Spring**	**Total**	**0.255**	**0**	**32.84**	**2380**	**1.38**

USGS station ID	Period	Type of streamflow	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median annual streamflow for type (ft^3/s)	Expected annual rate of change (%)
07188000	**Spring**	**Baseflow**	**0.272**	**0**	**16.04**	**1260**	**1.28**
07188000	**Spring**	**Runoff**	**0.229**	**0.01**	**19.19**	**1280**	**1.5**
07188000	Summer	Total	0.131	0.12	7.05	851	0.83
07188000	**Summer**	**Baseflow**	**0.177**	**0.03**	**4.19**	**471**	**0.89**
07188000	Summer	Runoff	0.077	0.35	2.79	406	0.69
07188000	Fall	Total	0.07	0.4	4.37	991	0.44
07188000	Fall	Baseflow	0.128	0.12	3.45	556	0.62
07188000	Fall	Runoff	0.034	0.68	1.11	462	0.24
07189000	Annual	Total	0.106	0.2	2.85	699	0.41
07189000	Annual	Baseflow	0.076	0.37	1.28	483	0.26
07189000	Annual	Runoff	0.107	0.2	1.2	245	0.49
07189000	**Annual Minimum**	**Total**	**0.177**	**0.03**	**0.54**	**72**	**0.74**
07189000	Annual Maximum	Total	0.095	0.26	77.27	16400	0.47
07189000	Winter	Total	0.07	0.4	3.34	801	0.42
07189000	Winter	Baseflow	0.081	0.33	1.88	552	0.34
07189000	Winter	Runoff	0.06	0.47	0.79	234	0.34
07189000	Spring	Total	0.04	0.64	1.87	941	0.2
07189000	Spring	Baseflow	0.067	0.42	1.86	692	0.27
07189000	Spring	Runoff	0.009	0.92	0.24	341	0.07
07189000	Summer	Total	0.076	0.37	1.04	269	0.39
07189000	Summer	Baseflow	0.079	0.34	0.7	199	0.35
07189000	Summer	Runoff	0.02	0.81	0.07	54.2	0.13
07189000	Fall	Total	0.101	0.23	1.87	394	0.47
07189000	Fall	Baseflow	0.104	0.21	1.37	277	0.49
07189000	Fall	Runoff	0.079	0.34	0.4	97.6	0.41

Table H-4: Trend analysis for PRISM precipitation data.

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
05497000	**Annual**	**37**	**0.158**	**0.06**	**0.1**	**36.7**	**0.27**
05497000	Winter	4.4	0.096	0.25	0.01	4.2	0.31
05497000	Spring	10.6	0.108	0.2	0.01	10.6	0.1
05497000	Summer	13.1	0.086	0.3	0.02	12.3	0.12
05497000	Fall	9	0.044	0.6	0.01	8.3	0.13
05504800	**Annual**	**39.3**	**0.2**	**0.02**	**0.13**	**38.2**	**0.35**
05504800	**Winter**	**5.9**	**0.2**	**0.02**	**0.03**	**5.2**	**0.67**
05504800	**Spring**	**11.8**	**0.171**	**0.04**	**0.01**	**11.1**	**0.1**
05504800	Summer	12.2	0.04	0.63	0.02	11.6	0.13
05504800	Fall	9.5	0.08	0.34	0.03	8.3	0.31
05508000	**Annual**	**38.4**	**0.178**	**0.03**	**0.1**	**36.7**	**0.26**
05508000	**Winter**	**5.3**	**0.147**	**0.08**	**0.02**	**4.7**	**0.48**
05508000	Spring	11.3	0.119	0.15	0.01	10.6	0.1
05508000	Summer	12.5	0.04	0.64	0.02	12.1	0.12
05508000	Fall	9.4	0.042	0.62	0.01	8.4	0.13
06808500	Annual	32.8	0.126	0.13	0.07	32.1	0.21
06808500	Winter	2.8	0.133	0.11	0.01	2.6	0.45
06808500	**Spring**	**9.8**	**0.157**	**0.06**	**0.01**	**9.5**	**0.11**
06808500	Summer	12.8	-0.04	0.63	0.02	12	0.12
06808500	Fall	7.4	0.11	0.19	0.02	6.8	0.33
06809500	**Annual**	**33.4**	**0.162**	**0.05**	**0.09**	**32.9**	**0.27**
06809500	**Winter**	**3**	**0.151**	**0.07**	**0.01**	**2.7**	**0.49**
06809500	**Spring**	**10**	**0.166**	**0.05**	**0.01**	**9.8**	**0.11**
06809500	Summer	12.9	-0.01	0.91	0.02	12.3	0.12
06809500	Fall	7.6	0.128	0.12	0.03	7.2	0.37
06810000	**Annual**	**33.3**	**0.14**	**0.09**	**0.07**	**32.4**	**0.22**

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
06810000	**Winter**	**2.9**	**0.156**	**0.06**	**0.01**	**2.7**	**0.43**
06810000	**Spring**	**10**	**0.161**	**0.05**	**0.01**	**9.7**	**0.11**
06810000	Summer	12.9	-0.027	0.75	0.02	12.2	0.12
06810000	Fall	7.5	0.118	0.16	0.02	7	0.31
06811500	Annual	32	0.046	0.59	0.03	31.9	0.09
06811500	Winter	2.8	0.083	0.32	0.01	2.6	0.27
06811500	Spring	9.7	0.11	0.19	0.01	9.1	0.12
06811500	Summer	12.4	-0.1	0.23	0.02	12.4	0.12
06811500	Fall	7.1	0.08	0.34	0.02	6.5	0.24
06815000	Annual	32.6	0.01	0.91	0	32.5	0
06815000	Winter	2.8	0.085	0.31	0.01	2.5	0.28
06815000	Spring	9.7	0.114	0.17	0.01	9.2	0.12
06815000	Summer	12.7	-0.065	0.44	0.02	12.3	0.12
06815000	Fall	7.5	0.003	0.98	0	7.6	0.01
06817000	**Annual**	**34.2**	**0.158**	**0.06**	**0.08**	**32.7**	**0.25**
06817000	**Winter**	**3**	**0.176**	**0.03**	**0.01**	**2.8**	**0.49**
06817000	**Spring**	**10.1**	**0.178**	**0.03**	**0.01**	**10.2**	**0.1**
06817000	Summer	13.1	-0.002	0.99	0.02	12.6	0.12
06817000	**Fall**	**7.9**	**0.14**	**0.09**	**0.03**	**7.5**	**0.36**
06820500	**Annual**	**35.8**	**0.174**	**0.04**	**0.09**	**35.8**	**0.25**
06820500	Winter	3.3	0.134	0.11	0.01	3	0.42
06820500	**Spring**	**10.4**	**0.194**	**0.02**	**0.01**	**10.4**	**0.1**
06820500	Summer	13.6	0.061	0.47	0.02	14	0.11
06820500	Fall	8.5	0.052	0.53	0.01	8.1	0.14
06891500	**Annual**	**36.3**	**0.145**	**0.08**	**0.09**	**35.9**	**0.25**
06891500	**Winter**	**3.5**	**0.156**	**0.06**	**0.02**	**3.1**	**0.62**
06891500	**Spring**	**10.7**	**0.19**	**0.02**	**0.01**	**10.2**	**0.1**

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
06891500	Summer	13.3	0.007	0.94	0.02	12.6	0.12
06891500	Fall	8.8	0.056	0.5	0.01	8.7	0.13
06893500	**Annual**	**39.6**	**0.217**	**0.01**	**0.14**	**39**	**0.37**
06893500	**Winter**	**4.3**	**0.162**	**0.05**	**0.02**	**3.7**	**0.56**
06893500	**Spring**	**11.4**	**0.235**	**0**	**0.01**	**11.2**	**0.09**
06893500	Summer	13.9	0.104	0.21	0.02	12.9	0.12
06893500	Fall	10	0.049	0.56	0.01	9.5	0.16
06894000	**Annual**	**40.9**	**0.202**	**0.02**	**0.14**	**40.3**	**0.34**
06894000	**Winter**	**4.5**	**0.153**	**0.07**	**0.02**	**4**	**0.5**
06894000	**Spring**	**11.7**	**0.211**	**0.01**	**0.01**	**11.2**	**0.1**
06894000	Summer	14.2	0.094	0.26	0.02	13	0.12
06894000	Fall	10.4	0.069	0.41	0.02	10.3	0.19
06897500	**Annual**	**36.3**	**0.187**	**0.02**	**0.11**	**35.6**	**0.31**
06897500	Winter	3.5	0.114	0.17	0.01	3.1	0.37
06897500	**Spring**	**10.6**	**0.2**	**0.02**	**0.01**	**10.6**	**0.1**
06897500	Summer	13.5	0.087	0.3	0.02	13.6	0.11
06897500	Fall	8.7	0.054	0.52	0.01	8.1	0.17
06898000	**Annual**	**35**	**0.162**	**0.05**	**0.09**	**33.2**	**0.26**
06898000	**Winter**	**3.3**	**0.178**	**0.03**	**0.02**	**3.1**	**0.55**
06898000	**Spring**	**10.4**	**0.193**	**0.02**	**0.01**	**10.5**	**0.1**
06898000	Summer	13	0.013	0.88	0.02	12.4	0.12
06898000	Fall	8.2	0.073	0.38	0.01	7.8	0.19
06899500	**Annual**	**36**	**0.169**	**0.04**	**0.1**	**34.9**	**0.28**
06899500	**Winter**	**3.5**	**0.152**	**0.07**	**0.02**	**3.2**	**0.47**
06899500	**Spring**	**10.6**	**0.178**	**0.03**	**0.01**	**10.7**	**0.1**
06899500	Summer	13.3	0.056	0.5	0.02	12.9	0.12
06899500	Fall	8.5	0.042	0.62	0.01	8.1	0.14

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
06902000	**Annual**	**36.8**	**0.185**	**0.03**	**0.11**	**36.7**	**0.29**
06902000	Winter	3.7	0.133	0.11	0.01	3.4	0.4
06902000	**Spring**	**10.8**	**0.193**	**0.02**	**0.01**	**10.8**	**0.1**
06902000	Summer	13.4	0.094	0.26	0.02	13.5	0.11
06902000	Fall	8.9	0.049	0.56	0.01	8.3	0.13
06904500	**Annual**	**36.9**	**0.18**	**0.03**	**0.11**	**36.4**	**0.3**
06904500	**Winter**	**3.8**	**0.144**	**0.08**	**0.02**	**3.7**	**0.47**
06904500	**Spring**	**10.7**	**0.152**	**0.07**	**0.01**	**10.2**	**0.1**
06904500	Summer	13.6	0.068	0.42	0.02	12.8	0.12
06904500	Fall	8.7	0.039	0.64	0.01	8.2	0.12
06905500	**Annual**	**37.2**	**0.175**	**0.04**	**0.1**	**36.4**	**0.29**
06905500	**Winter**	**4**	**0.139**	**0.09**	**0.02**	**3.8**	**0.41**
06905500	**Spring**	**10.8**	**0.154**	**0.06**	**0.01**	**10.3**	**0.1**
06905500	Summer	13.5	0.072	0.39	0.02	13	0.12
06905500	Fall	8.9	0.041	0.63	0.01	8.4	0.15
06908000	**Annual**	**40**	**0.204**	**0.01**	**0.14**	**39.8**	**0.35**
06908000	Winter	4.9	0.111	0.18	0.02	4.3	0.44
06908000	**Spring**	**11.9**	**0.222**	**0.01**	**0.01**	**11.5**	**0.09**
06908000	Summer	13.1	0.105	0.21	0.02	12.7	0.12
06908000	Fall	10.1	0.079	0.34	0.02	9.5	0.25
06912500	**Annual**	**36.3**	**0.135**	**0.1**	**0.09**	**36.2**	**0.24**
06912500	**Winter**	**3.5**	**0.162**	**0.05**	**0.02**	**3.1**	**0.63**
06912500	**Spring**	**10.9**	**0.189**	**0.02**	**0.01**	**10.3**	**0.1**
06912500	Summer	13.1	0.025	0.77	0.02	12.8	0.12
06912500	Fall	8.8	0.022	0.8	0.01	8.6	0.08
06913500	Annual	36.6	0.131	0.12	0.08	36.6	0.21
06913500	**Winter**	**3.6**	**0.158**	**0.06**	**0.02**	**3.2**	**0.64**

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
06913500	**Spring**	**10.9**	**0.202**	**0.01**	**0.01**	**10.2**	**0.1**
06913500	Summer	13.2	0.021	0.8	0.02	13	0.11
06913500	Fall	9	0.034	0.69	0.01	8.8	0.1
06914000	**Annual**	**38.4**	**0.162**	**0.05**	**0.1**	**38.3**	**0.26**
06914000	**Winter**	**3.9**	**0.164**	**0.05**	**0.02**	**3.4**	**0.63**
06914000	**Spring**	**11.2**	**0.236**	**0**	**0.01**	**10.7**	**0.1**
06914000	Summer	13.6	0.009	0.92	0.02	12.9	0.12
06914000	Fall	9.7	0.085	0.31	0.02	9.4	0.24
06926000	**Annual**	**41.2**	**0.209**	**0.01**	**0.13**	**41.3**	**0.32**
06926000	Winter	5.4	0.115	0.17	0.02	4.8	0.35
06926000	**Spring**	**12.3**	**0.267**	**0**	**0.01**	**11.6**	**0.09**
06926000	Summer	12.9	0.129	0.12	0.02	12.3	0.12
06926000	Fall	10.6	0.097	0.25	0.03	10	0.28
06932000	**Annual**	**43.6**	**0.232**	**0.01**	**0.17**	**42.7**	**0.4**
06932000	Winter	7.5	0.071	0.4	0.02	7.2	0.25
06932000	**Spring**	**13.2**	**0.188**	**0.02**	**0.01**	**12.1**	**0.09**
06932000	**Summer**	**12.1**	**0.183**	**0.03**	**0.02**	**11.3**	**0.13**
06932000	**Fall**	**10.8**	**0.164**	**0.05**	**0.05**	**10.2**	**0.51**
06933500	**Annual**	**43.2**	**0.219**	**0.01**	**0.14**	**42.7**	**0.34**
06933500	Winter	7.5	0.079	0.34	0.02	7	0.25
06933500	**Spring**	**13.2**	**0.137**	**0.1**	**0.01**	**11.9**	**0.09**
06933500	**Summer**	**11.6**	**0.182**	**0.03**	**0.02**	**10.9**	**0.14**
06933500	**Fall**	**10.9**	**0.139**	**0.1**	**0.04**	**10.9**	**0.4**
07013000	**Annual**	**42.8**	**0.183**	**0.03**	**0.12**	**41.9**	**0.29**
07013000	Winter	7.6	0.053	0.53	0.01	7.2	0.19
07013000	Spring	13.1	0.131	0.11	0.01	11.6	0.09
07013000	Summer	11.5	0.112	0.18	0.02	11	0.14

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
07013000	**Fall**	**10.6**	**0.137**	**0.1**	**0.04**	**10.3**	**0.4**
07016500	**Annual**	**41.5**	**0.211**	**0.01**	**0.13**	**41.1**	**0.31**
07016500	Winter	7.1	0.078	0.35	0.02	6.7	0.27
07016500	**Spring**	**12.7**	**0.178**	**0.03**	**0.01**	**12.1**	**0.09**
07016500	Summer	11.5	0.092	0.27	0.02	10.5	0.14
07016500	**Fall**	**10.1**	**0.138**	**0.1**	**0.04**	**9.7**	**0.42**
07018100	**Annual**	**41.1**	**0.14**	**0.09**	**0.08**	**39.6**	**0.21**
07018100	Winter	7.9	0.014	0.87	0.01	7.5	0.07
07018100	Spring	12.7	0.12	0.15	0.01	11.4	0.09
07018100	Summer	10.7	0.04	0.63	0.02	10.4	0.14
07018100	Fall	9.9	0.108	0.2	0.03	9.6	0.27
07018500	**Annual**	**40.9**	**0.144**	**0.08**	**0.09**	**39.6**	**0.22**
07018500	Winter	7.8	0.021	0.8	0.01	7.5	0.09
07018500	Spring	12.6	0.132	0.11	0.01	11.6	0.09
07018500	Summer	10.6	0.033	0.69	0.02	10.1	0.15
07018500	Fall	9.8	0.107	0.2	0.03	9.6	0.27
07019000	**Annual**	**41.4**	**0.162**	**0.05**	**0.1**	**40.8**	**0.24**
07019000	Winter	7.5	0.05	0.55	0.01	7.1	0.18
07019000	**Spring**	**12.7**	**0.138**	**0.1**	**0.01**	**11.8**	**0.09**
07019000	Summer	11.1	0.069	0.41	0.02	10.4	0.14
07019000	Fall	10	0.125	0.13	0.03	9.9	0.32
07037500	**Annual**	**44.3**	**0.153**	**0.07**	**0.09**	**43.2**	**0.22**
07037500	Winter	8.8	0.006	0.95	0	8.5	0.04
07037500	Spring	13.8	0.118	0.16	0.01	13.8	0.08
07037500	Summer	11.1	0.02	0.82	0.02	10.6	0.14
07037500	Fall	10.7	0.128	0.12	0.04	10.6	0.34
07052500	**Annual**	**43.6**	**0.166**	**0.05**	**0.11**	**43.6**	**0.25**

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
07052500	Winter	7.3	0.079	0.34	0.02	6.8	0.3
07052500	**Spring**	**13.1**	**0.139**	**0.09**	**0.01**	**12**	**0.09**
07052500	Summer	11.7	0.028	0.74	0.02	11.1	0.13
07052500	Fall	11.5	0.113	0.17	0.04	11.6	0.35
07061500	**Annual**	**44.4**	**0.145**	**0.08**	**0.1**	**43.4**	**0.24**
07061500	Winter	8.5	0.03	0.72	0.01	8.6	0.1
07061500	Spring	13.7	0.091	0.28	0.01	12.9	0.08
07061500	Summer	11.3	0.049	0.56	0.02	10.9	0.14
07061500	**Fall**	**10.9**	**0.138**	**0.1**	**0.04**	**10.5**	**0.38**
07063000	**Annual**	**45.3**	**0.172**	**0.04**	**0.11**	**43.8**	**0.26**
07063000	Winter	9.2	0.02	0.81	0.01	9.3	0.07
07063000	Spring	14	0.097	0.25	0.01	13.5	0.08
07063000	Summer	11.1	0.06	0.47	0.02	10.8	0.14
07063000	**Fall**	**11**	**0.147**	**0.08**	**0.04**	**11**	**0.4**
07064000	**Annual**	**45.9**	**0.162**	**0.05**	**0.11**	**44.3**	**0.26**
07064000	Winter	9.7	0.026	0.75	0.01	9.4	0.09
07064000	Spring	14.1	0.101	0.22	0.01	13.6	0.08
07064000	Summer	11	0.058	0.49	0.02	10.5	0.14
07064000	**Fall**	**11.1**	**0.137**	**0.1**	**0.04**	**10.9**	**0.36**
07069500	Annual	46.2	0.133	0.11	0.1	45.8	0.23
07069500	Winter	9.9	0.017	0.84	0.01	9.4	0.06
07069500	Spring	14.1	0.071	0.39	0.01	13.5	0.08
07069500	Summer	10.6	0.042	0.62	0.02	10.6	0.14
07069500	Fall	11.6	0.1	0.23	0.03	10.5	0.33
07072500	**Annual**	**46**	**0.162**	**0.05**	**0.11**	**44.5**	**0.25**
07072500	Winter	9.7	0.014	0.87	0	9.3	0.04
07072500	Spring	14.1	0.084	0.31	0.01	13.8	0.08

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
07072500	Summer	11	0.102	0.22	0.02	11	0.14
07072500	Fall	11.3	0.127	0.13	0.03	10.4	0.33
07186000	**Annual**	**43.9**	**0.22**	**0.01**	**0.15**	**43.2**	**0.35**
07186000	Winter	6.4	0.11	0.19	0.02	6	0.34
07186000	**Spring**	**13.2**	**0.267**	**0**	**0.01**	**12.5**	**0.09**
07186000	Summer	12.7	0.101	0.22	0.02	12	0.12
07186000	Fall	11.7	0.11	0.19	0.04	11.8	0.33
07187000	**Annual**	**44.2**	**0.192**	**0.02**	**0.13**	**43.1**	**0.3**
07187000	Winter	6.7	0.092	0.27	0.02	6.4	0.3
07187000	**Spring**	**13.5**	**0.221**	**0.01**	**0.01**	**12.6**	**0.08**
07187000	Summer	12	0.032	0.71	0.02	11.9	0.13
07187000	Fall	11.9	0.125	0.13	0.04	11.4	0.38
07188000	**Annual**	**43.8**	**0.215**	**0.01**	**0.15**	**42.9**	**0.34**
07188000	Winter	6.3	0.099	0.24	0.02	5.8	0.3
07188000	**Spring**	**13.3**	**0.28**	**0**	**0.01**	**12.5**	**0.09**
07188000	Summer	12.5	0.099	0.24	0.02	12.1	0.12
07188000	Fall	11.7	0.105	0.21	0.04	11.8	0.33
07189000	**Annual**	**44.5**	**0.174**	**0.04**	**0.11**	**42.6**	**0.25**
07189000	Winter	7.2	0.098	0.24	0.02	6.7	0.31
07189000	**Spring**	**13.8**	**0.16**	**0.05**	**0.01**	**12.5**	**0.08**
07189000	Summer	11.8	0.003	0.97	0.02	11.6	0.13
07189000	Fall	11.7	0.13	0.12	0.04	11.1	0.39
05502000	**Annual**	**38**	**0.142**	**0.09**	**0.1**	**37**	**0.27**
05502000	**Winter**	**5.6**	**0.154**	**0.06**	**0.02**	**4.8**	**0.51**
05502000	Spring	11.2	0.049	0.56	0.01	10.5	0.1
05502000	Summer	12	0.025	0.76	0.02	11.2	0.13
05502000	Fall	9.1	0.037	0.66	0.01	8	0.16

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
05498000	**Annual**	**37.3**	**0.14**	**0.09**	**0.09**	**36.9**	**0.25**
05498000	Winter	4.5	0.098	0.24	0.01	4.3	0.31
05498000	Spring	10.7	0.09	0.28	0.01	10.8	0.1
05498000	Summer	13	0.09	0.28	0.02	12.6	0.12
05498000	Fall	9.1	0.041	0.63	0.01	8.7	0.16
05500000	Annual	37.2	0.129	0.12	0.08	35.8	0.22
05500000	Winter	4.8	0.098	0.24	0.01	4.4	0.3
05500000	Spring	10.7	0.083	0.32	0.01	10.6	0.1
05500000	Summer	12.5	0.063	0.45	0.02	12.2	0.12
05500000	Fall	9.1	0.052	0.53	0.01	8.4	0.18
05501000	**Annual**	**37.9**	**0.159**	**0.06**	**0.09**	**36.3**	**0.26**
05501000	**Winter**	**5.2**	**0.14**	**0.09**	**0.02**	**4.6**	**0.39**
05501000	Spring	11.1	0.072	0.39	0.01	10.6	0.1
05501000	Summer	12.3	0.03	0.72	0.02	11.8	0.13
05501000	Fall	9.3	0.061	0.47	0.01	8.3	0.17
06814000	Annual	32.5	-0.006	0.95	0	32.9	-0.01
06814000	Winter	2.8	0.086	0.3	0.01	2.5	0.29
06814000	Spring	9.6	0.103	0.22	0.01	9.1	0.12
06814000	Summer	12.7	-0.082	0.33	0.02	12.2	0.12
06814000	Fall	7.5	0	1	0	7.8	0
06889500	**Annual**	**35.6**	**0.145**	**0.08**	**0.09**	**35.6**	**0.24**
06889500	**Winter**	**3.1**	**0.137**	**0.1**	**0.01**	**2.8**	**0.49**
06889500	**Spring**	**10.4**	**0.187**	**0.02**	**0.01**	**9.9**	**0.11**
06889500	Summer	13.5	0.027	0.75	0.02	13.7	0.11
06889500	Fall	8.6	0.036	0.67	0.01	8.4	0.09
06892000	**Annual**	**37.3**	**0.176**	**0.03**	**0.11**	**37.1**	**0.29**
06892000	Winter	3.5	0.133	0.11	0.01	3.2	0.42

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
06892000	**Spring**	**10.7**	**0.23**	**0.01**	**0.01**	**10.6**	**0.1**
06892000	Summer	13.8	0.052	0.54	0.02	14.3	0.11
06892000	Fall	9.3	0.078	0.35	0.02	9	0.24
06917000	**Annual**	**40.8**	**0.202**	**0.02**	**0.14**	**40.2**	**0.34**
06917000	**Winter**	**4.7**	**0.146**	**0.08**	**0.02**	**4.2**	**0.49**
06917000	**Spring**	**12.2**	**0.244**	**0**	**0.01**	**11.8**	**0.09**
06917000	Summer	13.4	0.115	0.17	0.02	13.5	0.11
06917000	Fall	10.4	0.078	0.35	0.03	9.9	0.26
06919500	**Annual**	**43.3**	**0.244**	**0**	**0.17**	**44.2**	**0.39**
06919500	Winter	6.2	0.109	0.19	0.02	5.9	0.31
06919500	**Spring**	**13**	**0.261**	**0**	**0.01**	**12.2**	**0.09**
06919500	Summer	12.8	0.123	0.14	0.02	12.4	0.12
06919500	Fall	11.3	0.105	0.21	0.04	11.3	0.35
07014500	**Annual**	**42.2**	**0.155**	**0.06**	**0.1**	**41.7**	**0.23**
07014500	Winter	7.7	0.042	0.62	0.01	7.3	0.16
07014500	Spring	13	0.112	0.18	0.01	11.7	0.09
07014500	Summer	11.2	0.079	0.34	0.02	10.8	0.14
07014500	Fall	10.3	0.124	0.14	0.03	10.1	0.3
07057500	**Annual**	**44.1**	**0.207**	**0.01**	**0.14**	**43.6**	**0.33**
07057500	Winter	8.4	0.078	0.35	0.02	8.3	0.26
07057500	Spring	13.9	0.108	0.19	0.01	13.3	0.08
07057500	Summer	10.7	0.04	0.63	0.02	10.4	0.14
07057500	**Fall**	**11.2**	**0.149**	**0.07**	**0.05**	**10.8**	**0.49**
07066000	**Annual**	**44.7**	**0.193**	**0.02**	**0.14**	**43.1**	**0.33**
07066000	Winter	8.4	0.047	0.57	0.01	8.6	0.14
07066000	Spring	13.9	0.077	0.36	0.01	12.6	0.08
07066000	Summer	11.4	0.121	0.15	0.02	11.1	0.14

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
07066000	**Fall**	**11.1**	**0.14**	**0.09**	**0.05**	**10.5**	**0.44**
07067000	**Annual**	**44.4**	**0.165**	**0.05**	**0.11**	**43.1**	**0.26**
07067000	Winter	8.4	0.024	0.77	0.01	8.2	0.07
07067000	Spring	13.7	0.074	0.37	0.01	12.5	0.08
07067000	Summer	11.4	0.124	0.14	0.02	11.1	0.13
07067000	Fall	10.9	0.132	0.11	0.04	10.6	0.34
07068000	**Annual**	**44.9**	**0.167**	**0.04**	**0.11**	**43.3**	**0.26**
07068000	Winter	8.7	0.018	0.83	0	8.5	0.06
07068000	Spring	13.8	0.077	0.36	0.01	12.8	0.08
07068000	Summer	11.4	0.108	0.19	0.02	11	0.14
07068000	Fall	11	0.132	0.11	0.04	10.6	0.37
07071500	**Annual**	**45.6**	**0.173**	**0.04**	**0.13**	**45.1**	**0.28**
07071500	Winter	9.1	0.04	0.63	0.01	8.6	0.13
07071500	Spring	14.2	0.031	0.71	0.01	13.4	0.08
07071500	Summer	11.1	0.13	0.12	0.02	10.9	0.14
07071500	**Fall**	**11.3**	**0.136**	**0.1**	**0.04**	**10.2**	**0.42**
07072000	**Annual**	**45.8**	**0.163**	**0.05**	**0.12**	**44.6**	**0.28**
07072000	Winter	9.4	0.02	0.82	0.01	9.2	0.06
07072000	Spring	14.1	0.045	0.59	0.01	13.6	0.08
07072000	Summer	11	0.123	0.14	0.02	10.9	0.14
07072000	Fall	11.3	0.126	0.13	0.04	10.2	0.39
080202	Annual	48.3	0.134	0.11	0.08	48.5	0.17
080202	Winter	11.8	-0.032	0.7	-0.01	11.4	-0.1
080202	Spring	15	0.104	0.21	0.01	14.1	0.08
080202	Summer	10.4	0.03	0.72	0.02	10.8	0.14
080202	Fall	11.1	0.102	0.22	0.03	10.5	0.3
110100	**Annual**	**46.3**	**0.139**	**0.1**	**0.09**	**45.5**	**0.2**

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
110100	Winter	9.4	0.03	0.72	0.01	9.3	0.09
110100	Spring	14.3	0.098	0.24	0.01	13.9	0.08
110100	Summer	11	0.002	0.98	0.02	11.1	0.14
110100	Fall	11.5	0.117	0.16	0.04	10.8	0.34
071100	**Annual**	**37.8**	**0.174**	**0.04**	**0.09**	**36.7**	**0.26**
071100	**Winter**	**5.4**	**0.14**	**0.09**	**0.02**	**5.1**	**0.38**
071100	Spring	11.1	0.123	0.14	0.01	10.6	0.1
071100	Summer	12.1	0.047	0.57	0.02	11.7	0.13
071100	Fall	9.2	0.066	0.43	0.02	8.2	0.19
071401	**Annual**	**42.8**	**0.187**	**0.02**	**0.1**	**41.8**	**0.24**
071401	Winter	8.4	0.022	0.79	0	8.3	0.05
071401	**Spring**	**13.2**	**0.148**	**0.08**	**0.01**	**12.7**	**0.08**
071401	Summer	11.1	0.067	0.42	0.02	10.8	0.14
071401	Fall	10.1	0.133	0.11	0.03	9.8	0.3
102701	**Annual**	**35.7**	**0.143**	**0.09**	**0.08**	**35.2**	**0.23**
102701	**Winter**	**3.3**	**0.137**	**0.1**	**0.01**	**2.9**	**0.5**
102701	**Spring**	**10.4**	**0.17**	**0.04**	**0.01**	**10.2**	**0.1**
102701	Summer	13.4	0.043	0.6	0.02	13.3	0.11
102701	Fall	8.6	0.027	0.75	0.01	8.5	0.07
102802	**Annual**	**37.9**	**0.186**	**0.03**	**0.11**	**37**	**0.29**
102802	**Winter**	**4.4**	**0.137**	**0.1**	**0.02**	**4**	**0.41**
102802	**Spring**	**11**	**0.178**	**0.03**	**0.01**	**10.9**	**0.1**
102802	Summer	13.4	0.102	0.22	0.02	12.8	0.12
102802	Fall	9.2	0.061	0.47	0.01	8.5	0.18
102902	**Annual**	**42.9**	**0.236**	**0**	**0.15**	**42.9**	**0.34**
102902	Winter	7.3	0.094	0.26	0.02	7	0.28
102902	**Spring**	**13**	**0.159**	**0.06**	**0.01**	**11.9**	**0.09**

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
102902	**Summer**	**11.7**	**0.182**	**0.03**	**0.02**	**10.9**	**0.14**
102902	**Fall**	**10.8**	**0.153**	**0.07**	**0.05**	**10.7**	**0.43**
103002	**Annual**	**40.1**	**0.264**	**0**	**0.15**	**39.7**	**0.39**
103002	Winter	6.8	0.128	0.12	0.03	6.5	0.42
103002	**Spring**	**12.1**	**0.229**	**0.01**	**0.01**	**11.7**	**0.09**
103002	Summer	11.4	0.076	0.37	0.02	10.5	0.14
103002	**Fall**	**9.8**	**0.181**	**0.03**	**0.05**	**9.4**	**0.51**
102801	**Annual**	**37**	**0.186**	**0.03**	**0.11**	**36.8**	**0.29**
102801	Winter	3.8	0.132	0.11	0.01	3.4	0.38
102801	**Spring**	**10.8**	**0.204**	**0.01**	**0.01**	**10.9**	**0.1**
102801	Summer	13.4	0.102	0.22	0.02	13.6	0.11
102801	Fall	9	0.055	0.51	0.01	8.4	0.12
102901	**Annual**	**41.2**	**0.202**	**0.02**	**0.13**	**41.1**	**0.33**
102901	Winter	5.5	0.126	0.13	0.02	4.9	0.34
102901	**Spring**	**12.3**	**0.267**	**0**	**0.01**	**11.5**	**0.09**
102901	**Summer**	**12.8**	**0.139**	**0.1**	**0.02**	**12.3**	**0.12**
102901	Fall	10.6	0.093	0.27	0.03	10.1	0.29
103001	**Annual**	**39.9**	**0.247**	**0**	**0.15**	**40.2**	**0.37**
103001	**Winter**	**5.2**	**0.14**	**0.09**	**0.02**	**4.7**	**0.45**
103001	**Spring**	**11.8**	**0.249**	**0**	**0.01**	**11.5**	**0.09**
103001	Summer	12.9	0.112	0.18	0.02	11.9	0.13
103001	Fall	10	0.096	0.25	0.03	9.2	0.28
102400	Annual	34.3	0.133	0.11	0.07	33.5	0.21
102400	Winter	3.1	0.133	0.11	0.01	2.8	0.37
102400	**Spring**	**10.1**	**0.192**	**0.02**	**0.01**	**9.9**	**0.11**
102400	Summer	13.2	0.018	0.84	0.02	13	0.12
102400	Fall	8	0.089	0.29	0.02	7.9	0.2

USGS station ID or 6-digit HUC	Period	Mean precipitation (in)	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median precipitation (in)	Expected annual rate of change (%)
110702	**Annual**	**40.5**	**0.164**	**0.05**	**0.11**	**39.9**	**0.27**
110702	Winter	5.2	0.122	0.14	0.02	4.6	0.34
110702	**Spring**	**12.3**	**0.263**	**0**	**0.01**	**11.9**	**0.09**
110702	Summer	12.5	0.079	0.34	0.02	12.3	0.12
110702	Fall	10.5	0.073	0.38	0.02	10.2	0.23

Table H-5: Trend analysis for land use/land cover data.

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
05497000	Developed	0.951	0	0	1.5	0.1
05497000	Forest	-0.826	0	-0.08	22.6	-0.35
05497000	Agriculture	0.093	0.32	0.01	67.4	0.01
05497000	Wetland	0.276	0	0	5.6	0.06
05504800	Developed	0.979	0	0.01	1.6	0.8
05504800	Forest	-0.878	0	-0.03	17.6	-0.17
05504800	Agriculture	-0.476	0	-0.06	74.2	-0.08
05504800	Wetland	0.424	0	0	2.7	0.08
05508000	Developed	0.999	0	0.01	1.4	0.56
05508000	Forest	-0.917	0	-0.05	20.2	-0.27
05508000	Agriculture	-0.546	0	-0.04	71.5	-0.06
05508000	Wetland	0.506	0	0	3.6	0.11
06808500	Developed	0.998	0	0.01	1.2	0.72
06808500	Forest	-0.655	0	-0.02	1.4	-1.64
06808500	Agriculture	0.134	0.15	0.02	94.2	0.02
06808500	Wetland	0.1	0.3	0	0.43	0.01
06809500	Developed	0.999	0	0.01	1.6	0.86
06809500	Forest	-0.742	0	-0.01	1.8	-0.64
06809500	Agriculture	-0.164	0.07	-0.01	92.4	-0.02
06809500	Wetland	0.557	0	0	0.67	0.06
06810000	Developed	1	0	0.01	1.4	0.8
06810000	Forest	-0.637	0	-0.02	1.8	-1.28
06810000	Agriculture	0.123	0.18	0.02	92.3	0.02
06810000	Wetland	0.191	0.04	0	0.72	0.02
06811500	Developed	0.967	0	0	0.64	0.23
06811500	Forest	-0.581	0	-0.02	2.8	-0.71

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
06811500	Agriculture	0.224	0.02	0.1	81.4	0.12
06811500	Wetland	-0.418	0	0	0.3	-0.11
06815000	Developed	0.984	0	0	0.65	0.43
06815000	Forest	-0.57	0	-0.02	3.7	-0.44
06815000	Agriculture	0.19	0.04	0.07	72.7	0.1
06815000	Wetland	-0.095	0.33	0	0.71	0
06817000	Developed	0.991	0	0.01	1.1	0.47
06817000	Forest	-0.686	0	-0.01	3.2	-0.34
06817000	Agriculture	0.115	0.21	0.03	88.9	0.03
06817000	Wetland	-0.477	0	0	1.2	-0.04
06820500	Developed	1	0	0.01	1.9	0.74
06820500	Forest	-0.697	0	-0.01	6.2	-0.18
06820500	Agriculture	-0.032	0.73	-0.01	83.4	-0.01
06820500	Wetland	0.522	0	0	2.7	0.12
06891500	Developed	0.995	0	0.03	1.4	2.11
06891500	Forest	-0.617	0	-0.02	14.2	-0.11
06891500	Agriculture	0.613	0	0.48	40.7	1.17
06891500	Wetland	0.432	0	0.01	1.2	0.53
06893500	Developed	1	0	0.72	15.6	4.59
06893500	Forest	-0.919	0	-0.04	12.7	-0.36
06893500	Agriculture	-0.469	0	-0.47	53.5	-0.88
06893500	Wetland	0.821	0	0.02	1.5	1
06894000	Developed	1	0	0.49	27.3	1.78
06894000	Forest	-0.996	0	-0.08	20.3	-0.4
06894000	Agriculture	-0.85	0	-0.25	40.3	-0.62
06894000	Wetland	-0.362	0	0	0.83	-0.08
06897500	Developed	0.995	0	0	1.5	0.32

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
06897500	Forest	0.213	0.02	0	10.7	0.04
06897500	Agriculture	-0.018	0.85	-0.01	76.7	-0.01
06897500	Wetland	0.707	0	0.02	3.7	0.56
06898000	Developed	0.983	0	0	1.4	0.25
06898000	Forest	0.226	0.01	0	11.5	0.03
06898000	Agriculture	-0.474	0	-0.06	77.2	-0.08
06898000	Wetland	0.717	0	0.01	3	0.28
06899500	Developed	0.991	0	0	1.3	0.25
06899500	Forest	-0.482	0	-0.01	13.5	-0.04
06899500	Agriculture	-0.536	0	-0.09	76.1	-0.12
06899500	Wetland	0.652	0	0.01	3.8	0.18
06902000	Developed	1	0	0	1.4	0.33
06902000	Forest	-0.531	0	-0.01	13.1	-0.05
06902000	Agriculture	-0.501	0	-0.05	75.6	-0.07
06902000	Wetland	0.672	0	0.01	4.5	0.27
06904500	Developed	0.998	0	0.01	1.7	0.41
06904500	Forest	-0.81	0	-0.03	16.8	-0.21
06904500	Agriculture	-0.483	0	-0.11	70.4	-0.16
06904500	Wetland	0.582	0	0.01	4.7	0.21
06905500	Developed	0.999	0	0.01	1.5	0.38
06905500	Forest	-0.824	0	-0.05	19.4	-0.25
06905500	Agriculture	-0.449	0	-0.06	69.2	-0.09
06905500	Wetland	0.554	0	0.01	4.5	0.13
06908000	Developed	0.993	0	0.01	0.99	0.85
06908000	Forest	-0.676	0	-0.01	15.6	-0.06
06908000	Agriculture	-0.511	0	-0.06	77.9	-0.08
06908000	Wetland	0.144	0.12	0	2.1	0.03

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
06912500	Developed	0.963	0	0.01	1.2	0.52
06912500	Forest	-0.746	0	-0.01	5.6	-0.13
06912500	Agriculture	0.751	0	0.6	39.9	1.51
06912500	Wetland	0.797	0	0	0.84	0.54
06913500	Developed	0.994	0	0.01	0.83	1.01
06913500	Forest	-0.88	0	-0.01	6.6	-0.14
06913500	Agriculture	0.731	0	0.52	35.9	1.44
06913500	Wetland	0.65	0	0	0.85	0.49
06914000	Developed	0.785	0	0	0.14	0.17
06914000	Forest	0.224	0.02	0	5.9	0.02
06914000	Agriculture	0.622	0	0.76	57.6	1.31
06914000	Wetland	0.867	0	0.01	1.2	1.26
06926000	Developed	1	0	0.01	0.86	1.33
06926000	Forest	-0.784	0	-0.02	28.6	-0.07
06926000	Agriculture	0.526	0	0.13	54.9	0.24
06926000	Wetland	0.722	0	0.01	2.8	0.25
06932000	Developed	0.892	0	0	0.57	0.35
06932000	Forest	-0.841	0	-0.19	74.9	-0.26
06932000	Agriculture	0.808	0	0.16	23	0.71
06932000	Wetland	-0.187	0.08	0	0.18	0
06933500	Developed	0.966	0	0.01	0.69	0.99
06933500	Forest	-0.813	0	-0.18	64.1	-0.29
06933500	Agriculture	0.786	0	0.15	33.2	0.46
06933500	Wetland	-0.384	0	0	0.46	-0.28
07013000	Developed	0.962	0	0.01	0.8	1.49
07013000	Forest	-0.818	0	-0.16	70.6	-0.22
07013000	Agriculture	0.785	0	0.13	26.9	0.47

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
07013000	Wetland	-0.665	0	0	0.56	-0.17
07016500	Developed	0.998	0	0.02	1.5	1.6
07016500	Forest	-0.881	0	-0.06	57.9	-0.1
07016500	Agriculture	0.183	0.05	0.01	36.5	0.03
07016500	Wetland	-0.609	0	0	0.36	-0.35
07018100	Developed	0.96	0	0.02	1.4	1.16
07018100	Forest	-0.866	0	-0.14	75.9	-0.18
07018100	Agriculture	0.697	0	0.1	19.4	0.51
07018100	Wetland	-0.574	0	0	0.51	-0.18
07018500	Developed	0.969	0	0.02	1.5	1.23
07018500	Forest	-0.892	0	-0.13	75.4	-0.17
07018500	Agriculture	0.695	0	0.09	19.5	0.47
07018500	Wetland	-0.594	0	0	0.59	-0.15
07019000	Developed	1	0	0.02	1.3	1.58
07019000	Forest	-0.864	0	-0.1	72.4	-0.14
07019000	Agriculture	0.686	0	0.06	23.4	0.27
07019000	Wetland	-0.632	0	0	0.57	-0.2
07037500	Developed	0.964	0	0.02	1.3	1.34
07037500	Forest	-0.878	0	-0.14	78.1	-0.18
07037500	Agriculture	0.686	0	0.09	16.8	0.55
07037500	Wetland	-0.376	0	0	0.46	-0.13
07052500	Developed	1	0	0.11	6	1.86
07052500	Forest	-0.823	0	-0.05	28.6	-0.19
07052500	Agriculture	-0.903	0	-0.09	62.7	-0.15
07052500	Wetland	-0.663	0	0	0.68	-0.12
07061500	Developed	NA	NA	0	0.044	0
07061500	Forest	-0.799	0	-0.03	94.1	-0.03

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
07061500	Agriculture	0.806	0	0.03	4.5	0.56
07061500	Wetland	-0.344	0	0	0.28	-0.05
07063000	Developed	0.975	0	0	0.3	0.76
07063000	Forest	-0.844	0	-0.05	90	-0.05
07063000	Agriculture	0.815	0	0.03	7.2	0.44
07063000	Wetland	-0.625	0	0	0.81	-0.13
07064000	Developed	0.983	0	0.01	0.63	1.25
07064000	Forest	-0.884	0	-0.08	74.5	-0.11
07064000	Agriculture	0.917	0	0.11	20.5	0.53
07064000	Wetland	-0.809	0	-0.05	2.9	-1.68
07069500	Developed	0.965	0	0.01	0.63	1.39
07069500	Forest	-0.841	0	-0.14	74.6	-0.18
07069500	Agriculture	0.832	0	0.12	24.4	0.48
07069500	Wetland	-0.728	0	0	0.0062	-9.66
07072500	Developed	0.983	0	0	0.4	1.16
07072500	Forest	-0.825	0	-0.17	74.1	-0.22
07072500	Agriculture	0.926	0	0.17	22.6	0.77
07072500	Wetland	-0.871	0	-0.03	2.1	-1.27
07186000	Developed	0.995	0	0.01	1.6	0.63
07186000	Forest	-0.028	0.77	0	11.5	0
07186000	Agriculture	0.396	0	0.06	80.6	0.07
07186000	Wetland	0.806	0	0.01	2	0.55
07187000	Developed	0.968	0	0.03	3	0.98
07187000	Forest	-0.682	0	-0.01	25	-0.06
07187000	Agriculture	-0.699	0	-0.09	69.1	-0.13
07187000	Wetland	0.007	0.95	0	0.81	0
07188000	Developed	1	0	0.02	3.4	0.7

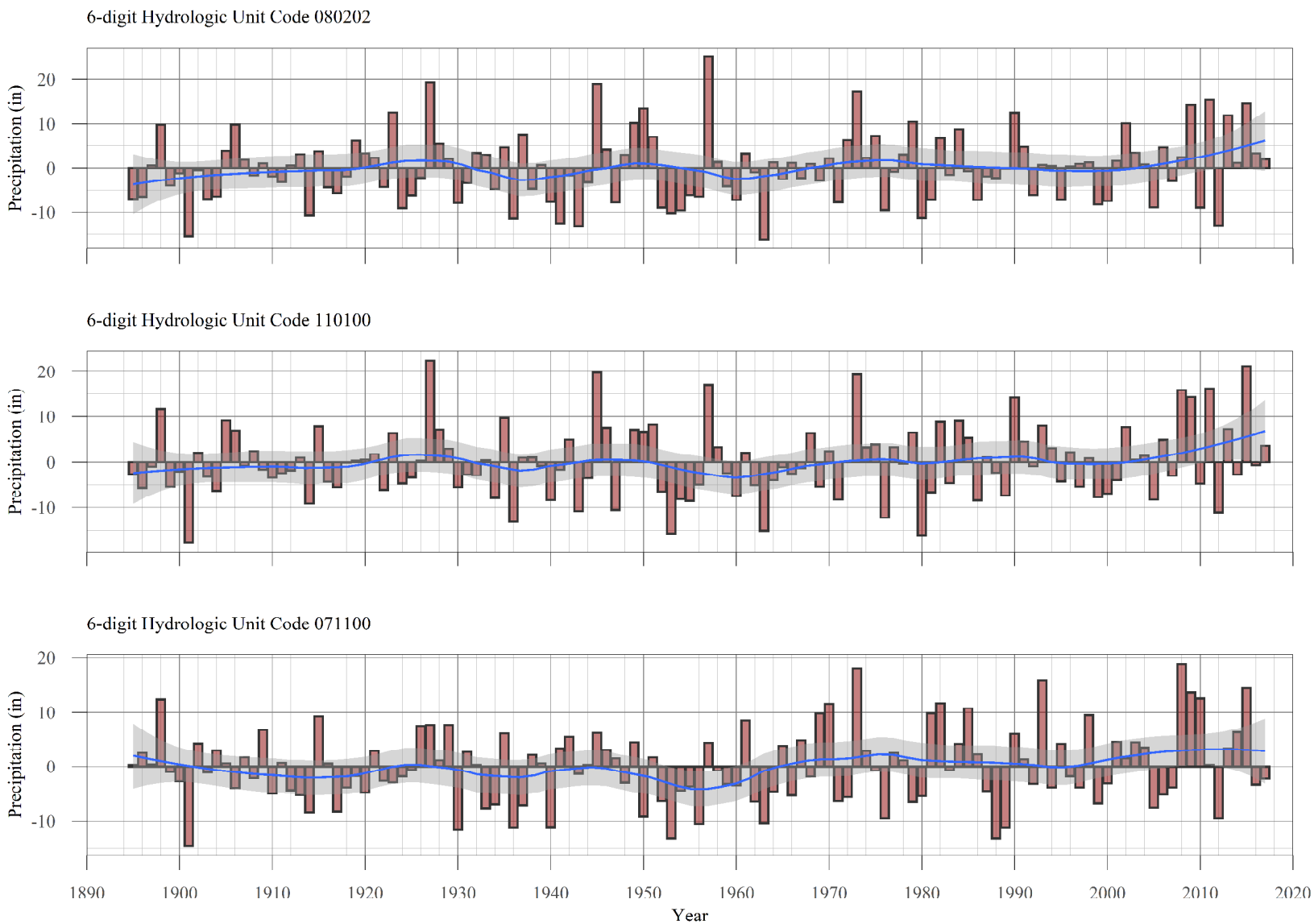
USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
07188000	Forest	-0.649	0	-0.01	16.3	-0.05
07188000	Agriculture	0.305	0	0.04	73.4	0.06
07188000	Wetland	0.734	0	0.01	2.2	0.54
07189000	Developed	0.99	0	0.02	1.6	1.36
07189000	Forest	-0.732	0	-0.02	51.4	-0.04
07189000	Agriculture	-0.47	0	-0.03	44.6	-0.07
07189000	Wetland	0.065	0.52	0	0.44	0
05502000	Developed	0.871	0	0.02	1.7	1.15
05502000	Forest	-0.92	0	-0.15	19.9	-0.74
05502000	Agriculture	0.895	0	0.12	77.6	0.15
05502000	Wetland	0.525	0	0	0.16	0
05498000	Developed	0.931	0	0	1.3	0.25
05498000	Forest	-0.789	0	-0.08	23.7	-0.34
05498000	Agriculture	-0.073	0.43	0	66.2	-0.01
05498000	Wetland	0.701	0	0.01	6.3	0.17
05500000	Developed	0.932	0	0	1.5	0.19
05500000	Forest	-0.809	0	-0.06	21.4	-0.3
05500000	Agriculture	-0.472	0	-0.03	68.2	-0.04
05500000	Wetland	0.683	0	0.01	5.7	0.13
05501000	Developed	0.972	0	0.01	1.5	0.36
05501000	Forest	-0.855	0	-0.06	27.9	-0.23
05501000	Agriculture	-0.156	0.09	-0.01	63.2	-0.01
05501000	Wetland	0.177	0.06	0	4.5	0.03
06814000	Developed	0.876	0	0	0.46	0.13
06814000	Forest	-0.694	0	-0.01	4.5	-0.13
06814000	Agriculture	0.202	0.03	0.05	64.9	0.08
06814000	Wetland	0.281	0.01	0	0.49	0

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
06889500	Developed	0.923	0	0	0.25	1.19
06889500	Forest	-0.9	0	-0.03	7.1	-0.35
06889500	Agriculture	0.364	0	0.16	59.1	0.27
06889500	Wetland	0.797	0	0	1.4	0.31
06892000	Developed	0.981	0	0.01	0.46	1.28
06892000	Forest	-0.696	0	-0.01	16	-0.08
06892000	Agriculture	0.466	0	0.25	69.2	0.36
06892000	Wetland	0.704	0	0.01	0.89	0.64
06917000	Developed	0.954	0	0	0.23	1.43
06917000	Forest	0.192	0.04	0	20.4	0.01
06917000	Agriculture	0.554	0	0.47	58.5	0.8
06917000	Wetland	0.855	0	0.03	2.8	1.03
06919500	Developed	0.896	0	0	0.25	0.51
06919500	Forest	-0.14	0.13	0	25.6	-0.01
06919500	Agriculture	0.231	0.01	0.02	69.2	0.04
06919500	Wetland	0.847	0	0.01	2.3	0.28
07014500	Developed	0.964	0	0.01	0.51	1.47
07014500	Forest	-0.815	0	-0.12	78.8	-0.15
07014500	Agriculture	0.797	0	0.1	19.1	0.51
07014500	Wetland	-0.675	0	0	0.5	-0.23
07057500	Developed	NA	NA	0	0.047	0
07057500	Forest	-0.814	0	-0.18	70.7	-0.25
07057500	Agriculture	0.816	0	0.15	28.1	0.54
07057500	Wetland	-0.524	0	0	0.28	0
07066000	Developed	0.931	0	0.01	0.18	3.57
07066000	Forest	-0.813	0	-0.21	82.3	-0.26
07066000	Agriculture	0.816	0	0.18	16.8	1.07

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
07066000	Wetland	-0.618	0	0	0.083	0
07067000	Developed	0.931	0	0	0.12	1.68
07067000	Forest	-0.814	0	-0.16	85.8	-0.19
07067000	Agriculture	0.806	0	0.14	13.2	1.06
07067000	Wetland	-0.811	0	0	0.17	-0.13
07068000	Developed	0.931	0	0	0.11	1.65
07068000	Forest	-0.816	0	-0.14	87.3	-0.16
07068000	Agriculture	0.809	0	0.12	11.5	1.04
07068000	Wetland	-0.799	0	0	0.41	-0.08
07071500	Developed	0.927	0	0	0.24	0.92
07071500	Forest	-0.821	0	-0.22	75	-0.29
07071500	Agriculture	0.823	0	0.2	24.2	0.82
07071500	Wetland	0.21	0.04	0	0.13	0
07072000	Developed	0.927	0	0	0.22	0.81
07072000	Forest	-0.821	0	-0.26	73.9	-0.35
07072000	Agriculture	0.827	0	0.24	25.3	0.94
07072000	Wetland	-0.181	0.08	0	0.097	0
080202	Developed	1	0	0.02	1.6	1
080202	Forest	-0.844	0	-0.15	18.9	-0.81
080202	Agriculture	0.842	0	0.24	73.2	0.33
080202	Wetland	-0.848	0	-0.1	5	-2.08
110100	Developed	1	0	0.01	0.82	1.64
110100	Forest	-0.803	0	-0.14	67.7	-0.21
110100	Agriculture	0.801	0	0.12	27.6	0.42
110100	Wetland	-0.904	0	-0.02	1.6	-1.38
071100	Developed	1	0	0.03	2.5	1.15
071100	Forest	-0.921	0	-0.07	24.4	-0.3

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
071100	Agriculture	-0.286	0	-0.01	65.6	-0.01
071100	Wetland	0.192	0.04	0	4.1	0.02
071401	Developed	1	0	0.06	5.1	1.17
071401	Forest	-0.962	0	-0.08	47.9	-0.16
071401	Agriculture	0.031	0.74	0	40.2	0
071401	Wetland	-0.835	0	-0.01	3	-0.34
102701	Developed	1	0	0.05	3	1.72
102701	Forest	-0.943	0	-0.02	10.5	-0.21
102701	Agriculture	0.429	0	0.13	51.9	0.26
102701	Wetland	0.683	0	0	1.2	0.31
102802	Developed	1	0	0.01	1.4	0.45
102802	Forest	-0.829	0	-0.06	20.1	-0.32
102802	Agriculture	-0.361	0	-0.03	68.2	-0.04
102802	Wetland	0.36	0	0	5	0.07
102902	Developed	0.966	0	0.01	0.61	1
102902	Forest	-0.814	0	-0.17	64.3	-0.26
102902	Agriculture	0.787	0	0.14	32.4	0.42
102902	Wetland	-0.436	0	0	0.52	-0.34
103002	Developed	1	0	0.11	8.8	1.2
103002	Forest	-1	0	-0.08	45.7	-0.17
103002	Agriculture	-0.731	0	-0.05	39.1	-0.12
103002	Wetland	-0.978	0	0	2.2	-0.1
102801	Developed	1	0	0	1.4	0.34
102801	Forest	-0.613	0	-0.01	12.9	-0.07
102801	Agriculture	-0.533	0	-0.05	75.5	-0.07
102801	Wetland	0.705	0	0.01	4.9	0.22
102901	Developed	1	0	0.01	0.83	1.35

USGS station ID or 6-digit HUC	Land use/land cover type	Kendall's tau (τ)	p-Value	Sen slope ((ft^3/s)/yr)	Median value (%)	Expected annual rate of change (%)
102901	Forest	-0.803	0	-0.02	30.8	-0.08
102901	Agriculture	0.523	0	0.12	53.6	0.23
102901	Wetland	0.728	0	0.01	2.7	0.24
103001	Developed	1	0	0.06	3.7	1.53
103001	Forest	-0.931	0	-0.03	22.9	-0.13
103001	Agriculture	-0.697	0	-0.06	64.4	-0.09
103001	Wetland	0.053	0.57	0	2.2	0.01
102400	Developed	1	0	0.02	1.7	1
102400	Forest	-0.787	0	-0.04	5.8	-0.68
102400	Agriculture	0.14	0.13	0.05	82.2	0.06
102400	Wetland	0.252	0.01	0	1.7	0.04
110702	Developed	1	0	0.01	1.6	0.77
110702	Forest	-0.768	0	-0.01	16.7	-0.05
110702	Agriculture	0.566	0	0.17	54.7	0.32
110702	Wetland	0.674	0	0.01	1.6	0.44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10
0
-10
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Precipitation (in)
20
10
0
-10
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1920
1930
1940
1950
1960
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1990
2000
2010
2020
Year

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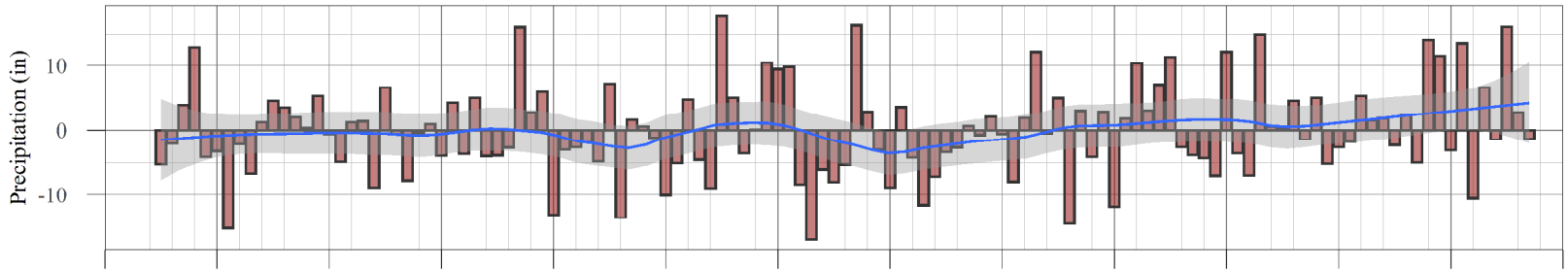

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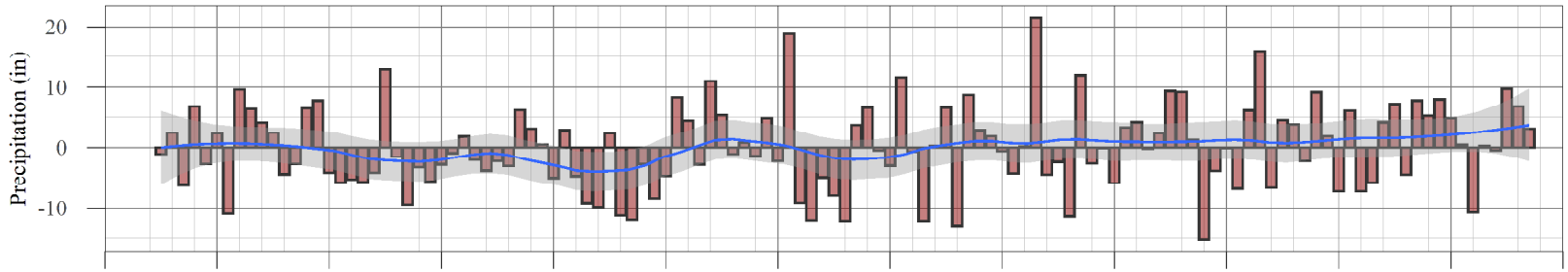

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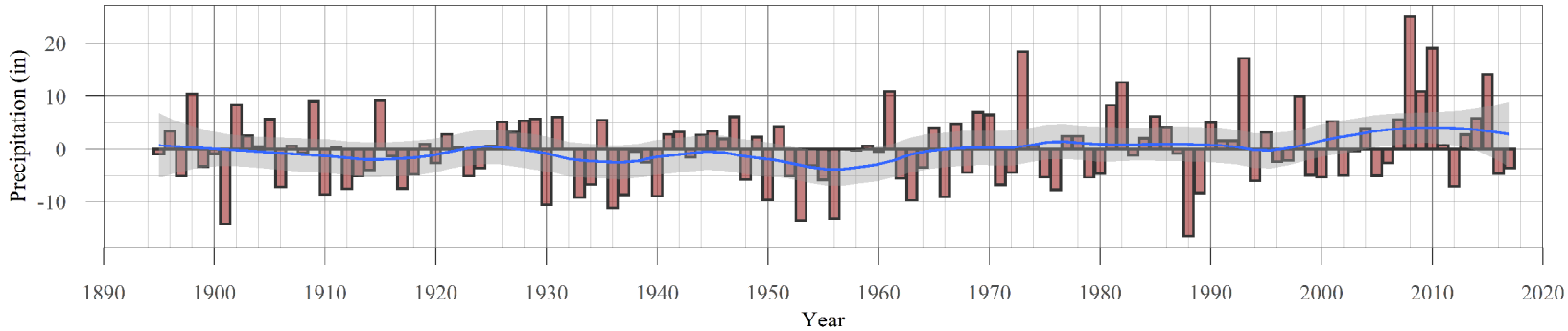

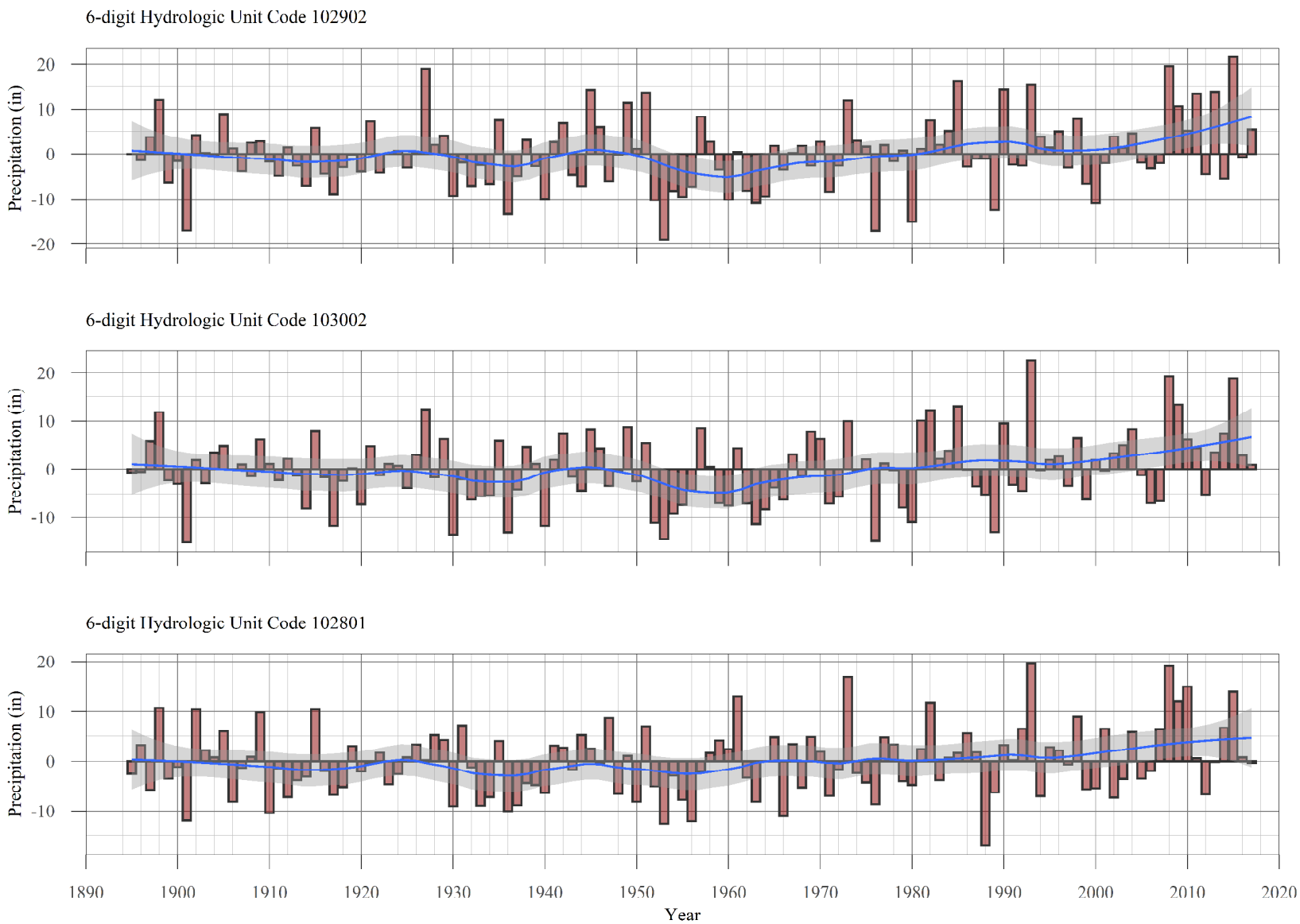
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Precipitation (in)
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10
0
-10
6-digit Hydrologic Unit Code 102801
Precipitation (in)
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1920
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1950
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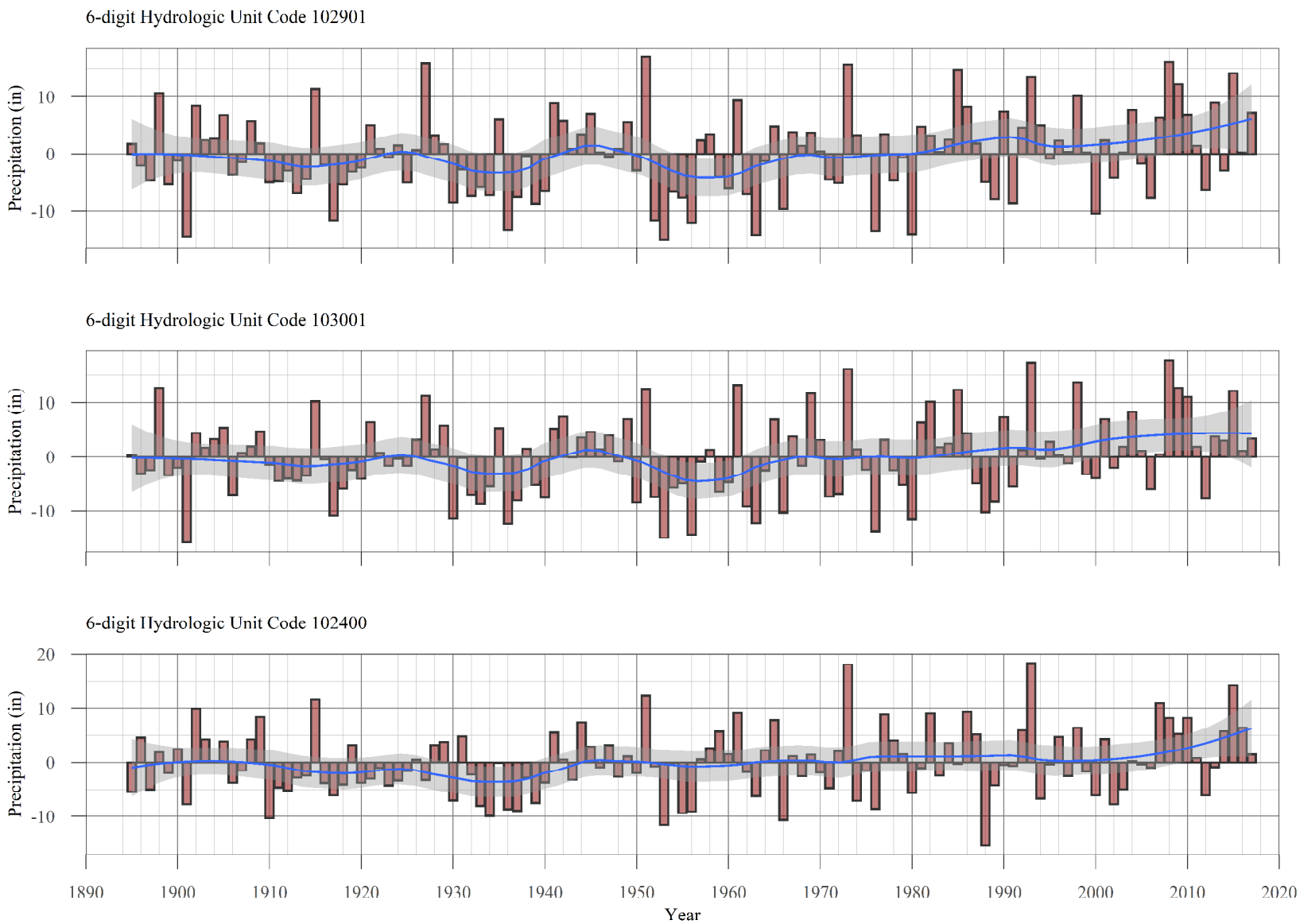
2020
Year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Precipitation (in)
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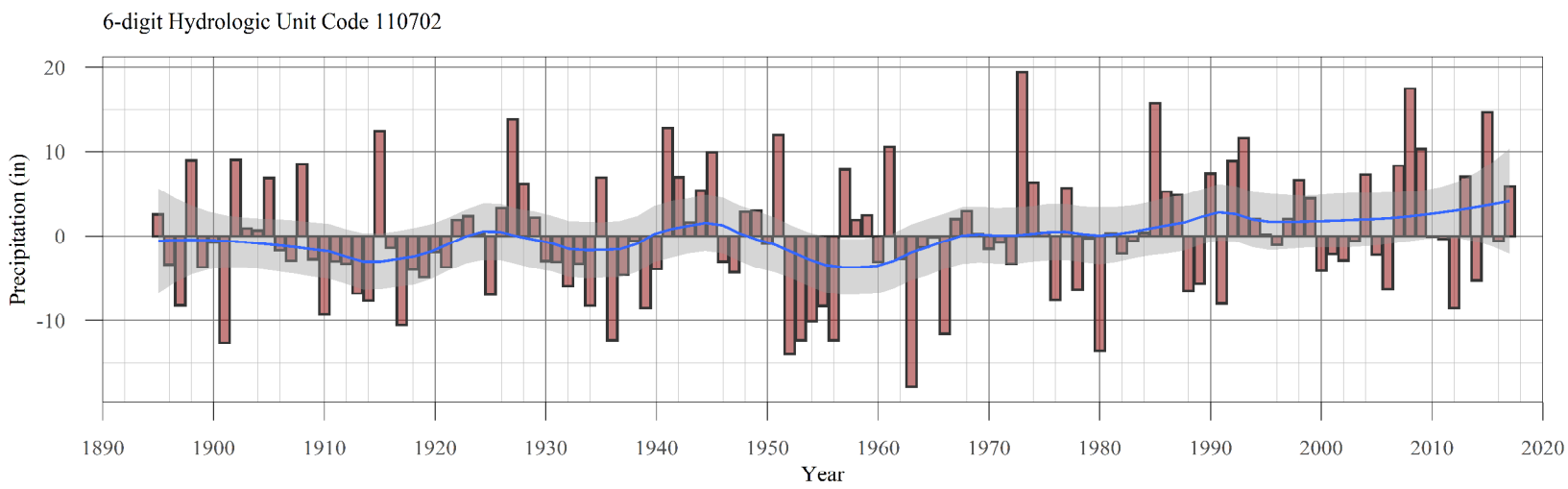

Figure H-20: Annual departures from long-term median annual precipitation for 6-digit HUCs and LOESS curve (span = 0.5) for the State of Missouri, 1895 - 2017.