

Middle Fork Popo Agie River Delisting Decision 2024

Wyoming Department of Environmental Quality – Water Quality Division

January 30, 2024

Table of Contents

Middle Fork Popo Agie River Delisting Decision 2024.....	1
Introduction and Background.....	1
Use Support Determinations.....	4
References.....	10
Appendix A. <i>E. coli</i> Sampling Data.....	11
Appendix B. 2022 Climate and Streamflow Data.....	13
Appendix C. Table of BMPs and Watershed Changes from 2005 to 2022.....	17
Appendix D. Map of BMPs and Watershed Changes from 2005 to 2022.....	29

Introduction and Background

This memo provides the rationale for removing a segment of the Middle Fork Popo Agie River (AUID WYBH100800030207_01) from the 303(d) list of impaired waters and for retaining Hornecker Creek (AUID WYBH100800030207_03) on the 303(d) list (**Figure 1**). The Recreation designated use of this segment of the Middle Fork Popo Agie River, hereafter referred to as the “lower 4-mile Middle Fork segment”, was originally listed as impaired in 2002 due to exceedances of fecal coliform. The Recreation designated use of Hornecker Creek, a tributary of the Middle Fork Popo Agie River, was first listed as impaired in 2018 due to exceedances of *E. coli*.

The use support determinations presented herein are based primarily on *E. coli*¹ data collected in 2022 by the Popo Agie Conservation District (PACD), and analyzed in accordance with Wyoming’s Methods for Determining Surface Water Quality Condition (hereafter as “Wyoming’s Assessment Methods”; WDEQ, 2020) and the assessment method for Evaluating Attainment of Wyoming’s *E. Coli* Criteria (hereafter as “Wyoming’s *E. coli* Method”; WDEQ 2021).

¹ *The Wyoming Surface Water Quality Standards were revised in 2007 and included a change in the parameter used to assess pathogens from fecal coliform to E. coli. The new standard for E. coli (Chapter 1, Section 27; WDEQ 2018) states, “In all waters designated for primary contact recreation, during the summer recreation season (May 1 through September 30), concentrations of E. coli bacteria shall not exceed a geometric mean of 126 organisms per 100 milliliters during any consecutive 60-day period.”*

History of 303(d) listings in the Middle Fork Popo Agie watershed

In August 2000, WDEQ collected fecal coliform bacteria data at three locations along the Middle Fork Popo Agie River (WDEQ 2001). These data were used to calculate a 5-sample geometric mean at the Town sampling station (i.e., Main Street Bridge (MSB); **Figure 1**), which exceeded the existing standard for Total Fecal Coliforms (200 colony forming units per 100 mL during the summer contact recreation season of May 1 – September 20). This resulted in the designated use of Recreation in the segment (WYBH100800030207_01; “lower 4-mile Middle Fork segment”; **Figure 1**) being listed as impaired in the 2002 Integrated Report (WDEQ 2002).

In 2018, an additional 0.7 miles of the Middle Fork Popo Agie (WYBH100800030207_05) upstream of the lower 4-mile Middle Fork segment and 1.3 miles of the tributary Hornecker Creek (WYBH100800030207_03) were listed as impaired due to multiple exceedances of Wyoming’s primary contact recreation criteria for *E. coli* (**Figure 1**). The 0.7-mile segment of the Middle Fork Popo Agie River (WYBH100800030207_05) was delisted in 2020, due to *E. coli* samples collected by PACD in 2017 and 2018 demonstrating the geometric means of *E. coli* samples from two consecutive years were below the threshold of 126 organisms/100 mL. However, continued exceedances of the *E. coli* criteria were observed in samples from the lower 4-mile Middle Fork segment in 2017 and the Hornecker Creek segment in 2017 and 2018.

E. coli samples in the Middle Fork Popo Agie River from just upstream of Hornecker Creek at the site Above Hornecker Creek Confluence (AHCC; **Figure 1**) did not exceed the 60-day primary contact recreation criterion based on data collected in 2014. Thus, a very short 0.02-mile assessment unit (WYBH100800030207_04) was delineated between the Hornecker Creek confluence and the AHCC monitoring site and determined to be fully supporting its primary contact recreation designated use (WDEQ 2018b).

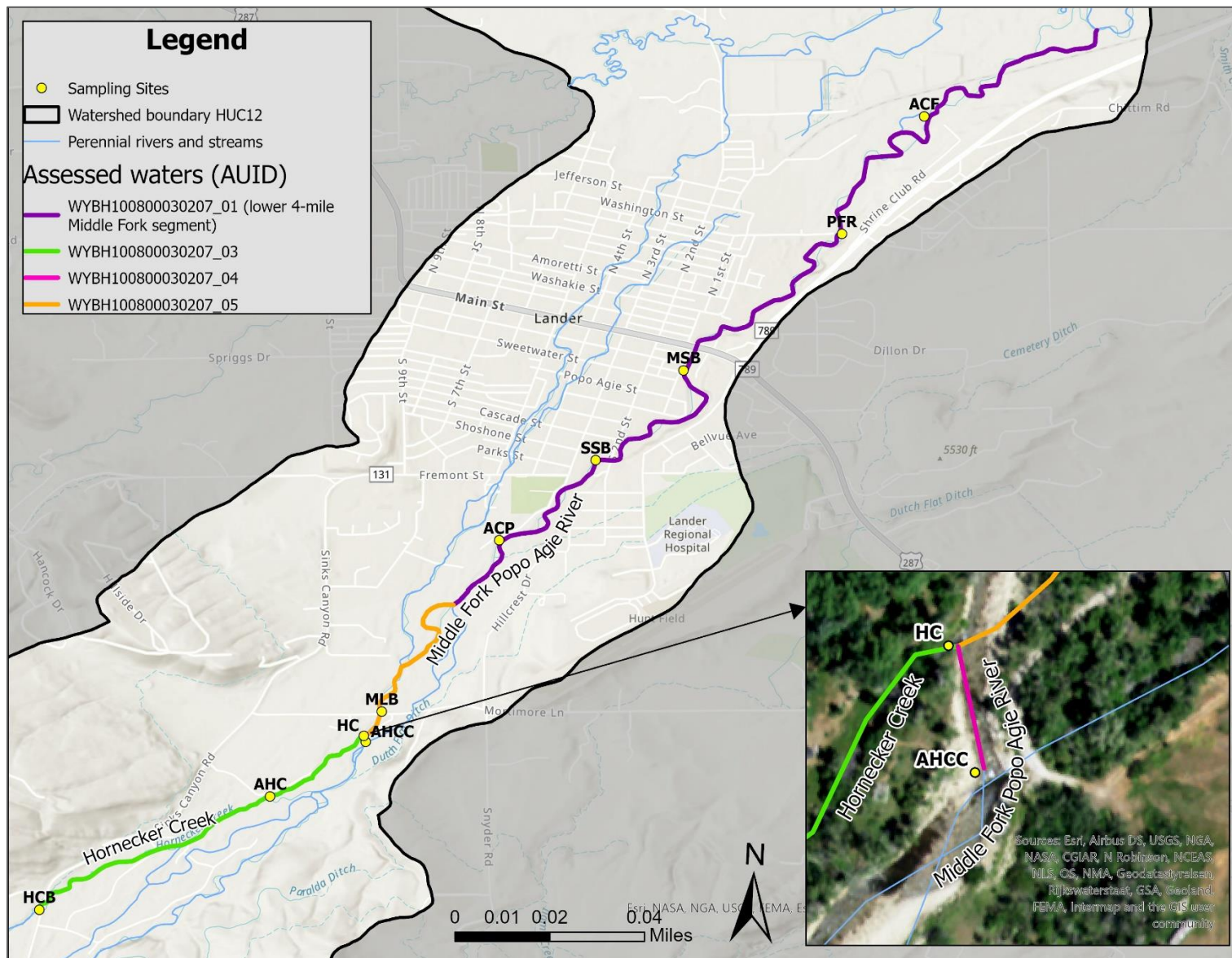


Figure 1. Water quality monitoring sites and the four assessment units in the Lower Middle Fork Popo Agie watershed.

Use Support Determinations

Summary of *E. coli* sample data

In 2022, PACD collected *E. coli* data at four sites on the Middle Fork Popo Agie and two sites on Hornecker Creek (**Error! Reference source not found.; Appendix A. *E. coli* Sampling Data**). The samples were all collected during the summer recreation season and each sample was collected in a separate 12-day block following WDEQ’s assessment methods (WDEQ 2021). Samples were collected during typical watershed conditions, evaluated by comparing air temperature, precipitation, streamflow and the U.S. Drought Monitor to the conditions of previous years (**Appendix B. 2022 Climate and Streamflow Data**).

Four monitoring sites were located within the lower 4-mile Middle Fork impaired segment, and enough samples (10) were collected between 6/7/2022 and 9/2/2022 to enable calculation of two independent geometric means at each site. All geometric means at these four sites were below the 126 organisms/100 mL threshold, thereby meeting the criteria for primary contact recreation (**Error! Reference source not found.**).

Enough samples (10) were also collected at the three Hornecker Creek sites to enable calculation of two independent geometric means at each site. At least one geometric mean at each site exceeded the threshold of 126 organisms/100 mL, indicating the Hornecker Creek segment is still not supporting its Recreation use (**Error! Reference source not found.**).

Table 1. 60-day geometric means of *E. coli* concentrations (organisms/100mL)¹.

Sampling period	Middle Fork Popo Agie River (Downstream → Upstream)				Hornecker Creek (Downstream → Upstream)		
	Above Confluence (ACF)	Main Street Bridge (MSB)	Second Street Bridge (SSB)	Above City Park (ACP)	Hornecker Creek (HC)	Above Hornecker Creek (AHC)	Hornecker Creek Bridge (HCB)
6/7/2022 – 8/2/2022	101.7	94.5	85.7	54.9	276.2	125.2	341.8
8/9/2022 – 9/27/2022	76.3	53.6	118.7	33.7	140.9	insufficient samples	102.2
<i>The below data from 2023 are provisional data, having not yet undergone QAQC to be considered for use support determinations in the 2022/2024 IR.</i>							
5/9/2023 – 7/25/2023	44.8	31.8	28.7	19.8	77.8	28.0	124.2
8/1/2023 – 9/26/2023	18.4	39.0	46.6	46.5	89.6	98.0	223.5

¹Geometric means were calculated from five *E. coli* samples at each sampling site. The sampling sites are listed in order (left to right) from downstream to upstream for each waterbody. Values in red text exceeded the geometric mean threshold of 126 organisms/100 mL.

In 2023, PACD collected *E. coli* samples at the same four sites on the Middle Fork Popo Agie River and three sites on Hornecker Creek. All resulting geometric means in 2023 at the Middle Fork Popo Agie River sites were also below the 126 organisms/100 mL threshold (Error! Reference source not found.). However, these data were submitted after the April 15, 2023 WDEQ deadline for receipt of data for the 2022/2024 IR and have not yet undergone QA/QC review. The 2023 sampling data are provisional, but offer supporting evidence that attainment of Wyoming's *E. coli* criteria likely extends across two consecutive years.

Advanced Restoration Plan / Watershed Based Plan

In 2020, PACD, in collaboration with WDEQ, wrote a Watershed Based Plan (WBP) to address *E. coli* impairments in the Middle Fork Popo Agie watershed (PACD 2020). This WBP also functions as an Advanced Restoration Plan (previously known as TMDL Alternative), and includes an implementation plan focused on reducing bacteria loads and attaining water quality standards in the impaired segments of the Middle Fork Popo Agie River and Hornecker Creek. Geometric means calculated from *E. coli* samples from 2014-2017 and 2022 at the sampling site upstream of the Hornecker Creek confluence have resulted in 0 exceedances of the *E. coli* standard, suggesting the significant sources of bacteria are downstream of and include Hornecker Creek (PACD 2020). PACD has been active for many years providing outreach, financial, and technical support to landowners to address sources of *E. coli* identified in the WBP.

Documentation of changes in the watershed

Section 4.4. of the WDEQ method "Evaluating Attainment of Wyoming's *E. coli* Criteria" states that proposals to remove a waterbody from the 303(d) list should include documentation describing the conditions in the watershed that have changed to support the hypothesis that water quality has improved (WDEQ 2021). PACD provided this documentation by summarizing in a table (Appendix C) and map (Appendix D) best management practices (BMPs) that may have reasonably influenced *E. coli* concentrations observed in samples from 2022. The table described the project purpose, whether it addressed a known or suspected source of *E. coli*, practice completion date, and the general location of the practice. The table includes projects that PACD was involved with and changes that occurred for other reasons from 2005 to 2022, after the listing of the lower 4-mile Middle Fork segment.

The BMPs and other changes that have occurred in the watershed are summarized below in context with the potentially significant sources of fecal bacteria described in Appendix C of the Watershed Based Plan (PACD 2020). All sources of bacteria were determined to be nonpoint sources and included septic systems, potential leakage from sewer systems, recreation and camping, livestock, pets, and wildlife (PACD 2020).

Human sources. Potential human sources include septic systems, sewer systems, and recreation (PACD 2020). Residences not connected to the Lander city sewer that likely include a septic system occur throughout the length, and several miles upstream, of the lower 4-mile Middle Fork segment. The areas of highest density of these residences are on Hornecker Creek near the confluence with the Middle Fork Popo Agie River and throughout the lower 4-mile Middle Fork segment (**Figure 2**). A total of 17 septic systems located between 10 and 500 feet from the Middle Fork Popo Agie River were rehabilitated or replaced between 2005 and 2020 (**Appendix C**. Table of BMPs and Watershed Changes from 2005 to

2022.). These septic projects occurred upstream of and throughout the lower 4-mile Middle Fork segment. On Hornecker Creek, near the confluence, an additional three septic systems were rehabilitated or replaced during that same time frame. The City of Lander also replaced and conducted maintenance on several sewer pipelines that crossed or were adjacent to the Middle Fork Popo Agie River in the lower 4-mile segment, which potentially also reduced risk of fecal bacteria transfer to the river (see **Table C. 1** for details on sewer project; project # 40-43). Thus, substantial improvements have been made to address the potential human sources of *E. coli*. However, Optical Brightener testing in 2012 and Microbial Source Tracking from 2015-2017 failed to identify any positive human sources of wastewater or bacteria, suggesting that human sources of *E. coli* may not have been the chronic, large sources of *E. coli* to the Middle Fork Popo Agie River and Hornecker Creek.

Pets. Dog waste along pathways, trails, and parks in the lower 4-mile Middle Fork segment, especially in the City of Lander, was identified as a potentially significant source of *E. coli* (PACD 2020). PACD led education events in the Lander community to address proper dog waste removal and partnered with the City of Lander to provide a network of dog waste bag stations, trash cans, and pet waste decals along trails and in parks (**Figure 2; Table C. 1**). Based on anecdotal observation, people are using these resources to remove dog waste. However, the lower 4-mile Middle Fork segment begins upstream of the City of Lander, where dog waste is not likely a significant source of *E. coli*. Thus, the projects addressing dog waste were likely effective at reducing the dog waste sources of *E. coli* in the Middle Fork Popo Agie River in and near the City of Lander but dog waste may not be a significant source of *E. coli* upstream of Lander.

Wildlife. Wildlife are a natural background source of bacteria. Several types of wildlife use the riparian and aquatic habitats of the Middle Fork Popo Agie River and Hornecker Creek including waterfowl, big game, and small mammals. However, there is not information to suggest that their concentrations are greater along the lower 4-mile Middle Fork segment and Hornecker Creek compared to their concentrations further upstream where there have not been exceedances of the *E. coli* criteria. Thus, while wildlife may contribute a constant background amount of *E. coli* and potentially occasional larger amounts during sporadic wildlife congregations, existing information does not suggest that wildlife are a significant contributor to the chronic *E. coli* exceedances. Accordingly, no projects specifically addressing wildlife sources of *E. coli* have been completed.

Livestock. Many livestock operations exist along the Middle Fork Popo Agie River and Hornecker Creek. In Appendix C of the Watershed Based Plan (PACD 2020), high priority areas were identified for BMPs to address *E. coli* sources from livestock manure. High priority areas were those where: 1) livestock had direct access to surface water or were close to surface water, 2) livestock were present for longer periods of time during the summer recreation season, 3) stocking density was relatively high and flood irrigation could potentially result in overland flow across a pasture containing manure.

Along the Middle Fork Popo Agie River, BMPs implemented to address livestock sources of *E. coli* included irrigation improvements (convert ditch to pipe, replace flood irrigation with sprinkler), changes in number, type, and management of livestock grazing in riparian areas, and development of off-site water combined with riparian fencing (**Table C. 1, Figure D. 1**). Along Hornecker Creek, BMPs included riparian fencing, changes from ditch to pipe to support transition from cattle pasture to hay production, and changes in number, type, and management of livestock grazing in riparian areas (**Table C. 1, Figure D. 1**). Most livestock BMPs were implemented in medium priority areas and few were implemented in the highest priority areas identified in the WBP. Additionally, some high priority areas had no BMPs implemented or known changes that addressed *E. coli* from livestock. Thus, it is likely that the livestock

BMPs implemented have reduced *E. coli* from livestock sources, but there remain some known sources of *E. coli* from livestock in the immediate vicinity of the lower 4-mile Middle Fork segment and Hornecker Creek.

Remaining Sources of *E. coli*

While many known and suspected sources of *E. coli* have been minimized or eliminated by projects and watershed changes, there remain some known sources of *E. coli* in the immediate vicinity of the lower 4-mile Middle Fork segment. One remaining source is Hornecker Creek, a tributary that confluences with the Middle Fork Popo Agie River 0.7 miles upstream of the lower 4-mile Middle Fork segment, which remains impaired due to *E. coli* exceedances. Some known *E. coli* sources along Hornecker Creek have previously been addressed by BMPs (e.g., riparian fencing), but changes in land ownership have led to the practices no longer being effective. Some of the known sources in Hornecker Creek and further downstream along the Middle Fork Popo Agie River are being actively investigated and may be addressed in the near future (e.g., failing septic systems). The high priority livestock BMP areas where limited BMPs have occurred also likely remain sources of *E. coli* in the lower 4-mile Middle Fork segment. PACD plans to continue providing support to landowners to address remaining *E. coli* sources.

Four of the samples collected in 2022 on the Middle Fork Popo Agie River exceeded the single-sample maximum concentration of *E. coli* threshold for high use swimming area threshold (235 organisms/100 mL) and the threshold for lightly used full body contact (410 organisms/100 mL). Single-sample maximum values are not cause for listing a waterbody as impaired but may be used to post Recreation use advisories (Section 27 of WDEQ 2018). PACD plans to continue sampling post-2023 at some of the sampling sites within the segment WYBH100800030207_01 and use the data to continue identifying sources of *E. coli* and post Recreation use advisories, as warranted. The sample collected on 8/25/2022 had a very high *E. coli* concentration of 2419.6 organisms/100 mL. This concentration may have been influenced by the preceding day's precipitation event (**Figure B.2**). In the future, when feasible, samplers may want to target some samples immediately following precipitation events or other events likely to increase fecal contamination of the river to capture likely times when *E. coli* and other fecal contaminants may be elevated and pose a human health risk.

Conclusions and Assessment Decision

Two *E. coli* geometric means below the threshold of 126 organisms/100 mL collected from two independent 60-day periods (five *E. coli* samples for each 60-day period) are required to conclude that the *E. coli* criteria are met. The sampling data submitted from the 2022 summer recreation season met these criteria. Additionally, the submission of the spreadsheet and map documenting implemented BMPs and watershed changes provide evidence that conditions in the watershed have improved in ways that reduce *E. coli* input to the stream from certain identified sources. The data submitted also meet all other requirements detailed in the assessment method "Evaluating Attainment of Wyoming's *E. coli* Criteria" (WDEQ 2021). Therefore, the lower 4-mile Middle Fork segment will be removed from the 303(d) list of impaired waters (Category 5) and into Category 2 (**Figure 2**). The Recreation use is considered fully supported and no other uses have been assessed (**Table 2**).

No new data were available for the Mortimore Lane Bridge site during this IR cycle, so the 0.7-mile segment of the Middle Fork Popo Agie River (WYBH100800030207_05) remains in Category 2, with only the Recreation use assessed (**Figure 2, Table 2**).

Because at least one geometric mean from *E. coli* samples in 2022 at each of the two sampling sites on Hornecker Creek exceeded the threshold of 126 organisms/100 mL, the Hornecker Creek assessment unit is considered not fully supporting its Recreation use and will remain in Category 5R, on the 303(d) list of impaired waters (**Figure 2, Table 2**).

All assessment units in **Table 2** have only been assessed to determine whether the Recreation use is supported; no assessments of other designated uses have been completed.

Table 2. Assessment¹ history of waterbodies in the Lower Middle Fork Popo Agie River watershed.

	Assessment unit	Length (mi)	Location	Year Listed on 303(d) List	Year Delisted
Middle Fork Popo Agie River	WYBH100800030207_01 <i>("lower 4-mile Middle Fork segment" in this document)</i>	4	From the confluence with Baldwin Creek to a point 4.0 miles upstream	2002	2024
	WYBH100800030207_05	0.7	From the confluence with Hornecker Creek to a point 0.7 miles downstream	2018	2020
	WYBH100800030207_04	0.03	From the confluence with Hornecker Creek to a point 0.03 miles upstream	This AU was assessed in 2018 and the Recreation use was determined to be supported.	
Hornecker Creek	WYBH100800030207_03	1.3	From the confluence with Middle Fork Popo Agie River upstream 1.3 miles to Sinks Canyon Road	2018	--

¹ The designated use Recreation is the only use that has been assessed in these four assessment units.

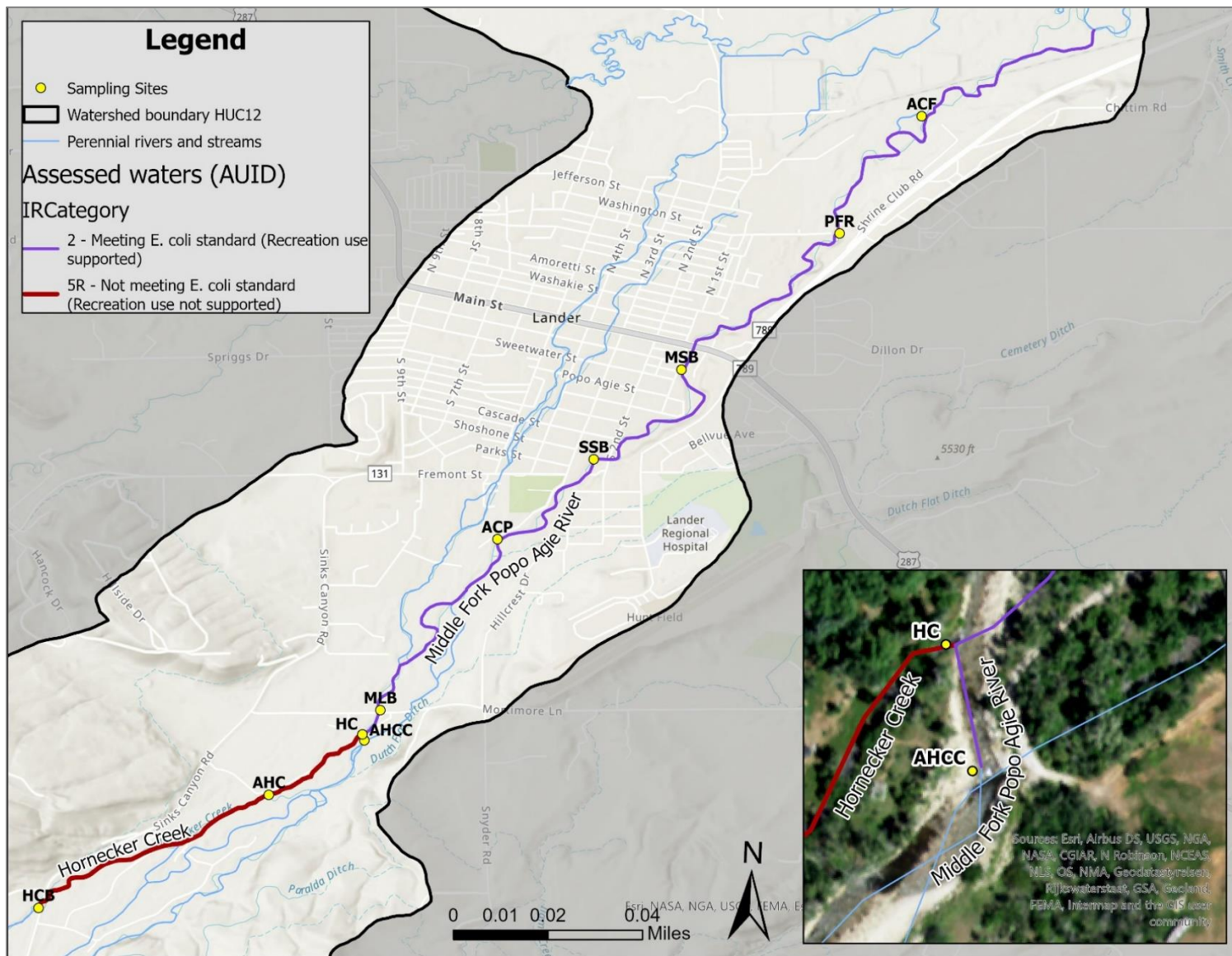


Figure 2. Assessment status in 2024 of waterbodies in the Lower Middle Fork Popo Agie River watershed.

References

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Appendix A. E. coli Sampling Data

Table A. 1. E. coli sample concentrations¹ (organisms/100 mL) from samples collected by PACD in 2022 and the resulting 5-sample geometric means in early to mid-summer. Sites are listed in the table in order from downstream (top) to upstream (bottom) on each waterbody. Cells highlighted in pink indicate the geometric mean exceeded the standard for primary contact recreation.

Waterbody	6/7/2022	6/21/2022	7/6/2022	7/19/2022	8/2/2022	Geometric mean
Middle Fork Popo Agie River	Above Confluence (ACF)					
	105.0	47.4	121.1	131.4	137.6	101.7
	Main Street Bridge (MSB)					
	86.7	35.9	75.4	325.5	98.8	94.5
	Second Street Bridge (SSB)					
	54.8	33.6	95.9	410.6	63.8	85.7
	Above City Park (ACP)					
78.9	15.6	60.2	108.6	62.0	54.9	
Hornecker Creek	Hornecker Creek (HC)					
	146.7	166.4	185.0	410.6	866.4	276.2
	Above Hornecker Creek (AHC)					
	137.6	63.7	88.4	108.6	365.4	125.2
	Hornecker Creek Bridge (HCB)					
224.7	727.0	435.2	238.2	275.5	341.8	

¹Values in red text indicate concentrations that are above the single-sample maximum concentration for high use swimming areas (235 organisms/100 mL). While Hornecker Creek is protected for primary contact recreation, there are no known high use swimming areas in this segment. See Chapter 1: Wyoming Surface Water Quality Standards (WDEQ 2018) for E. coli thresholds pertaining to other types of body contact with water.

Table A. 2. E. coli sample concentrations¹ (organisms/100 mL) from samples² collected by PACD in 2022 and the resulting 5-sample geometric means in mid- to late-summer. Sites are listed in the table in order from downstream (top) to upstream (bottom) on each waterbody. Cells highlighted in pink indicate the geometric mean exceeded the standard for primary contact recreation.

Waterbody	Site and Date of Sampling					Geometric mean
Middle Fork Popo Agie River	Above Confluence (ACF)					
	8/9/2022	8/25/2022	8/30/2022	9/13/2022	9/27/2022	
	16.1	2419.6	55.6	27.5	43.5	76.3
	Main Street Bridge (MSB)					
	8/9/2022	8/23/2022	8/30/2022	9/13/2022	9/27/2022	
	36.4	77.1	68.9	42.8	53.6	53.6
	Second Street Bridge (SSB)					
	8/9/2022	8/23/2022	8/30/2022	9/13/2022	9/27/2022	
	2419.6	78.9	71.2	24.7	70.3	118.7
	Above City Park (ACP)					
8/9/2022	8/23/2022	8/30/2022	9/13/2022	9/27/2022		
33.6	29.9	22.8	55.4	34.5	33.7	

Hornecker Creek	Hornecker Creek (HC)					276.2
	6/7/2022	6/21/2022	7/6/2022	7/19/2022	8/2/2022	
	146.7	166.4	185.0	410.6	866.4	
	Above Hornecker Creek (AHC)²					195.6
	8/9/2022	8/23/2022	8/30/2022	9/13/2022	9/27/2022	
	104.6	435.2	104.6	no sample	307.6	
	Hornecker Creek Bridge (HCB)					102.2
	8/9/2022	8/23/2022	8/30/2022	9/13/2022	9/27/2022	
	214.3	172.5	129.6	69.1	33.6	

¹Values in red text indicate concentrations that are above the single-sample maximum concentration for high use swimming areas (235 organisms/100 mL). While Hornecker Creek is protected for primary contact recreation, there are no known high use swimming areas in this segment. See Chapter 1: Wyoming Surface Water Quality Standards (WDEQ 2018) for E. coli thresholds pertaining to other types of body contact with water.

²The geometric mean for the Above Hornecker Creek site was calculated from only 4 samples.

Appendix B. 2022 Climate and Streamflow Data

Air Temperature. The daily temperature in May-October, 2022 was compared with the preceding 29 years of temperature (**Figure B. 1**). In July and late August 2022, daily temperatures (average, minimum, and maximum) were consistently above average (**Figure B. 1**). At least some of the samples collected in 2022 to calculate the geometric means were collected under warmer than average temperatures and did not exceed the *E. coli* criteria.

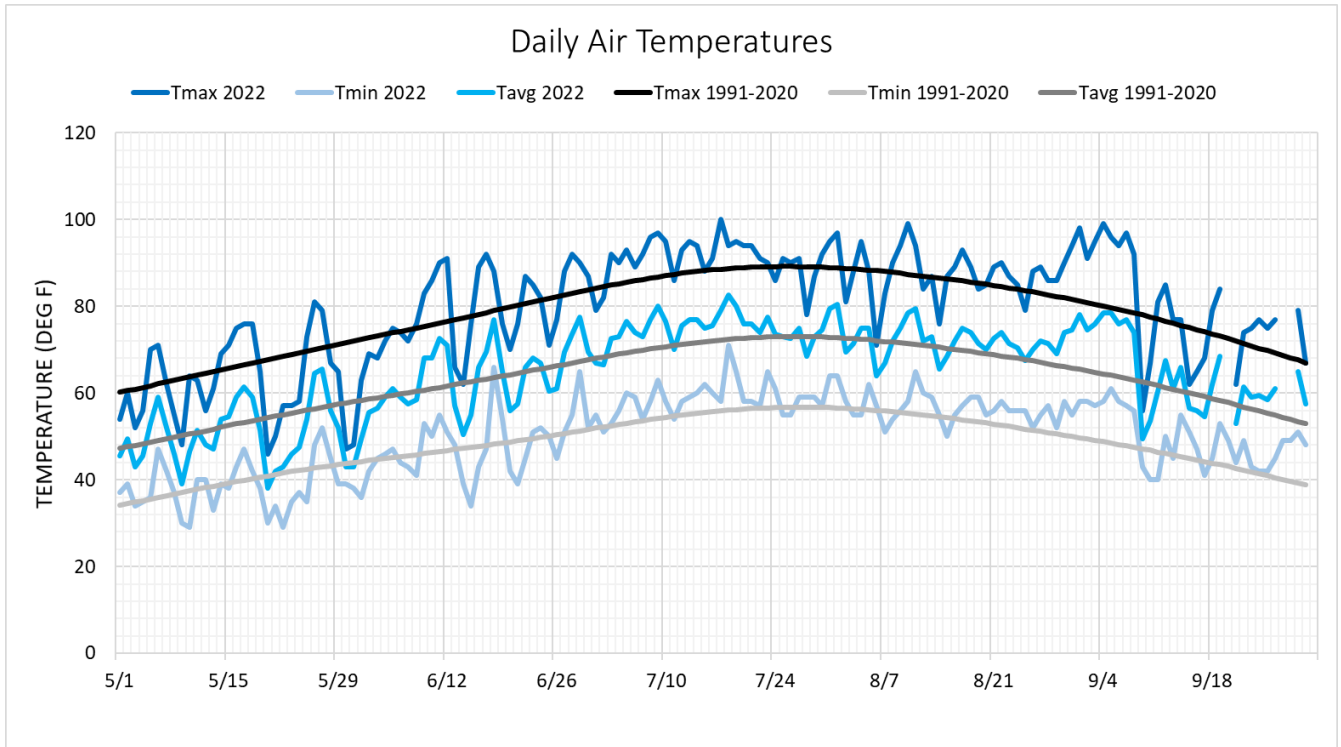


Figure B. 1. Daily air temperature (maximum daily, average daily, minimum daily) in 2022 and the period 1991 to 2020. Data were obtained by Popo Agie Conservation District from the Water Resources Data System – Wyoming State Climate Office.

Precipitation. Precipitation can result in overland flow that may increase inputs of *E. coli* into surface water. It is challenging to sample immediately after precipitation events due to logistical constraints and the need to represent typical conditions across the 60-day period when calculating geometric means. During the first sampling period in 2022 (6/7-8/2) there were only three precipitation events (**Figure B. 2**), indicating that precipitation was rare during this period so targeting samples following precipitation is not needed to be representative of climate conditions during the date range. During the second sampling period (8/9-9/27) there were 11 precipitation events, although only 7 of the 11 precipitation events during the second sampling period were >0.07 inches, indicating that substantial precipitation events were rare (i.e., more substantial precipitation events with >0.07 inches of rain only occurred during 15% of the sampling period days). The sample on 8/25/2022 at the Above Confluence sampling site occurred one day after a precipitation event and the *E. coli* concentration was very high (2419.6 organisms/100 ml). This may suggest that if samples were collected more immediately after precipitation events, *E. coli* concentrations in more samples may be higher. However, the intent is to represent the sampling period. Capturing at least one of the precipitation events is considered representative of precipitation conditions during the sampling period since there were 11 total events out of a 48-day period (23% of the days) and a total of 5 samples is required to calculate a geometric mean (i.e., 20% of the samples were taken following a precipitation events). Even with the high *E. coli* concentration on 8/25/2022 following precipitation, the geometric mean for the Above Confluence site (76.3 organisms/100mL) was still well below the *E. coli* standard of 126 organisms/100mL. If samples had also been taken on 8/25/2022 at the other three sampling sites on the Middle Fork Popo Agie River and resulted in the same very high concentration, the geometric means at three of the four sampling sites would still have been well below the *E. coli* standard of 126 organisms/100mL. Additionally, some late August and September sample collections occurred 2-3 days following a precipitation event, representing any lag effects of precipitation events. Overall, it does not appear that precipitation conditions were underrepresented during either sampling period, given that substantial precipitation events were rare.

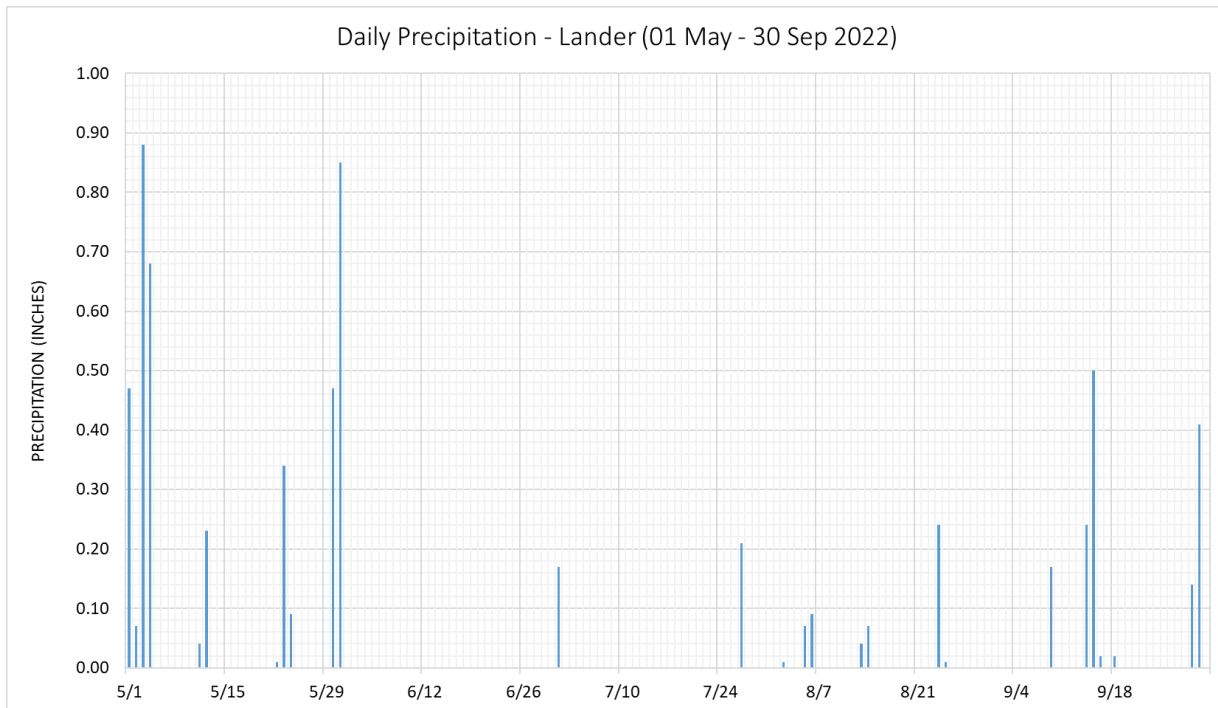


Figure B. 2. Daily precipitation in 2022. Data were obtained by Popo Agie Conservation District from the Water Resources Data System – Wyoming State Climate Office.

Streamflow. In 2022, streamflow in the Middle Fork Popo Agie River, measured by PACD at Mortimore Lane Bridge, dropped more quickly in early July than the average daily discharge of the preceding 6 years, but the magnitude of peak flows and base flows, and the timing and duration were largely similar (**Figure B. 3**).

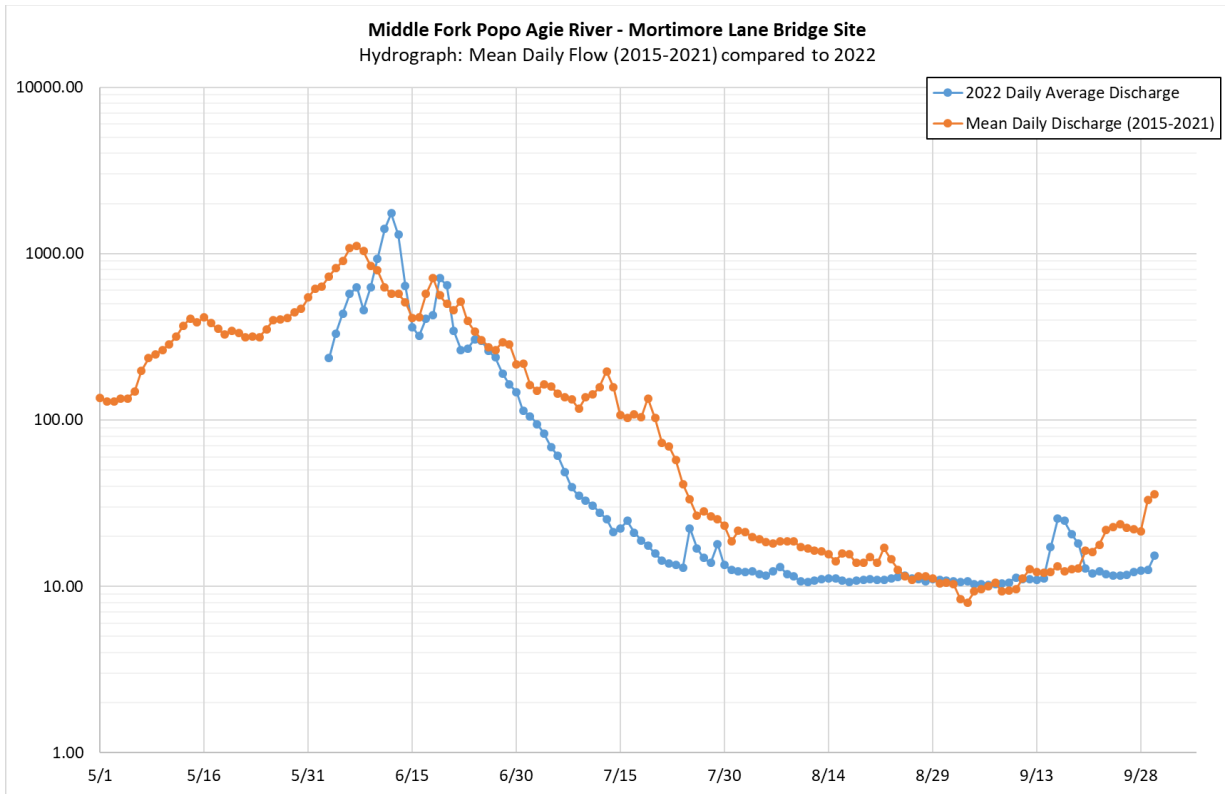


Figure B. 3. Mean daily stream flow, measured by Popo Agie Conservation District at Mortimore Lane Bridge on the Middle Fork Popo Agie River in 2022.

Drought. The U.S. Drought Monitor shows that conditions during summer 2022 in Fremont County (contains the entirety of the Popo Agie watershed) were Abnormally Dry to Moderate Drought, but not Severe or Extreme drought (NOAA, 2023). This was similar, but slightly less severe drought compared to conditions in the previous two years. Based on U.S. Drought Monitor from 2001 to 2023, conditions in Fremont County in 2022 were not severe drought or unusually wet, but are likely representative of conditions in many years during those 22 years (**Figure B. 4**).

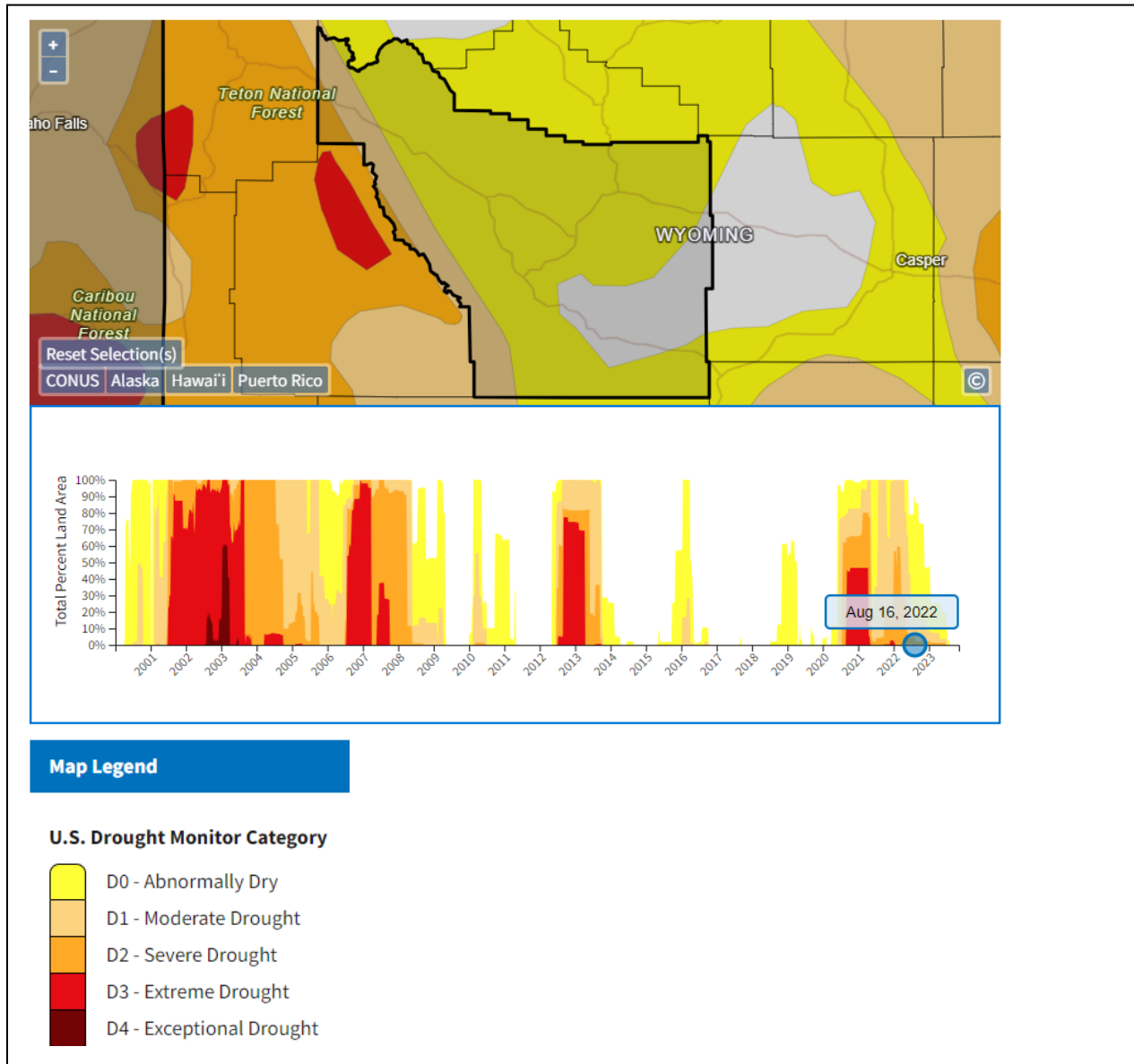


Figure B. 4. U.S. Drought Monitor for Fremont County, Wyoming from 2001 to 2023 (NOAA, 2023).

Appendix C. Table of BMPs and Watershed Changes from 2005 to 2022.

Table C. 1. Summary of the known BMPs implemented and watershed changes in the Lower Popo Agie River watershed following the initial 303(d) listing of the Middle Fork Popo Agie River. The projects and changes in this table occurred between 2005 and 2022. Projects are grouped by land ownership and geographical area (e.g., seven projects were associated with “Hornecker Creek Ranch #1”). Projects were also assigned a rank (1 = impactful (bright green), 2=likely impactful (pastel green), 3=marginally impactful (light yellow) according to how much a project was likely to have reduced *E. coli* concentrations in the impaired stream segments. This table was developed by the Popo Agie Conservation District as part of the data submission package in 2023. Note that the term “MLB reach” under Segment Location refers to the assessment unit “WYBH100800030207_05”, located just downstream of Hornecker Creek.

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
1	Hornecker Creek Ranch #1	Hornecker Creek	Hornecker Creek Fencing Phase I - Riparian	Known ; summer cattle grazing	Exclude livestock; prevent direct deposition and protect riparian area. Fencing was installed in conjunction with water gap project (#3).	2,544 LF 2-wire poly electric fence.	Effective; Data shows downward trend during base flows from 2007-2018 at Mortimore Lane Bridge sampling site.	2013	1
2		Hornecker Creek	Land-use/Livestock Management	Known ; summer cattle grazing	Land-use change.	Previous owner ran ~ 600 yearling cattle. New landowner ran about 120 pair of cattle in less paddocks on the ranch.	Effective; Data shows downward trend during base flows from 2007-2018 at Mortimore Lane Bridge sampling site.	2013	1
3		Hornecker Creek	Stock water - Hornecker Creek Water Gap	Known ; summer livestock grazing	Limit Direct deposition. Water gap was installed in conjunction with riparian fencing project (#1). Cattle had continuous access to Hornecker Creek before implementation. Provides stock water to	Installed posts, continuous fence panel and gravel.	Effective; Data shows downward trend during base flows from 2007-2018 at Mortimore Lane Bridge sampling site.	2014	1

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
					pastures on both sides of the creek.				
4		Hornecker Creek	Hornecker Creek Fencing Phase II - Riparian	Known ; summer cattle grazing	Exclude livestock; prevent direct deposition and protect riparian area.	1,665 LF electric fence.	Effective; Data shows downward trend during base flows from 2007-2018 at Mortimore Lane Bridge sampling site.	2014	1
5		Hornecker Creek	Sheep Creek Fencing - Riparian	Known ; summer cattle grazing	Exclude livestock; prevent direct deposition and protect riparian area.	6,360 LF 3-wire permanent power fence installed in 2014. All of the fence was removed in 2021 and since then several hundred head of bison have full access to Sheep Creek when grazing that part of the ranch.	Effective from 2014-2021; Data shows downward trend during base flows from 2007-2018 at Mortimore Lane Bridge sampling site. New landowner removed all fencing in 2021 along Sheep Creek because it was not effective with bison herd.	2014	3

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
6		Hornecker Creek	Land-use/Irrigation Improvement - Piped ditch & ditch maintenance	Known ; summer cattle grazing	Improve ditch conveyance to improve field irrigation for increased production. Goal is to defer livestock grazing by transitioning from heavily-used cattle pasture use susceptible to surface run-off adjacent to Hornecker Creek to hay production.	500 LF of 15" underground pipe installed to replace two leaking ditch reaches. Cleaned over a mile of earthen ditch. Both practices resulted in improving conveyance to a large hillside pasture resulting in increased production that allowed the manager to transition to a hay pasture.	Effective; Data shows downward trend during base flows from 2007-2018 at Mortimore Lane Bridge sampling site.	2014	1
7		Hornecker Creek	Hornecker Creek Fencing Phase III - Riparian & Cross	Known ; summer cattle grazing	Exclude livestock; prevent direct deposition, protect riparian area. Promote rotational grazing of marginal pasture space unable to hay and elk proof.	5,987 LF 3-wire permanent power fence installed in 2016. Some riparian fence replaced existing rail or temporary fencing. The South Fence section (2,662') was removed in 2021.	Effective; Data shows downward trend during base flows from 2007-2018 at Mortimore Lane Bridge sampling site. New landowner removed some cross fencing in 2021 because it was not effective with bison herd. The North Fence section (3,325') remains.	2016	2

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
8	Middle Fork Ranch #1	Middle Fork - MLB Reach	Irrigation Improvement - Pipe Ditch	Known ; confined animal feeding operation (sheep & goats)	Prevent the transport of animal manure into the irrigation ditch which outlets in 1000' to the Middle Fork by piping the ditch water through confined pens. Pipe replaced ditch in conjunction with stock water project (#9).	425 LF of 12" underground pipe.	To be determined; need to review Mortimore Lane Bridge sampling site data from 2007-2017.	2009, 2015	1
9		Middle Fork - MLB Reach	Stock water	Known ; confined animal feeding operation (sheep & goats)	Limit Direct deposition. Stock water project was installed in conjunction with ditch piping project (#8).	Well drilled, three heated livestock tanks were installed in livestock paddocks to replace irrigation ditch as watering source and allowed ditch to be piped.	To be determined; need to review Mortimore Lane Bridge sampling site data from 2007-2017.	2009	1
10		Middle Fork - MLB Reach	Livestock Management	Known ; summer sheep grazing	Land-use change.	Stopped running sheep (~ 20 head) on small acreage property with surface water	To be determined; need to review Mortimore Lane Bridge sampling site data from 2007-2017.	2016	2
11	Middle Fork Ranch #2	Middle Fork - 4.0 Mile Reach	Middle Fork Braid Fencing - Riparian	Known ; summer cattle grazing	Exclude livestock; prevent direct deposition into braid of Middle Fork/irrigation ditch with return flows back to main channel of Middle Fork. Fencing was installed in conjunction with stock water project (#14).	1,630 LF Buck & Pole	Effective: 60-day Geomean data before (2014-2017: 20% exceedance - 9/46 geomeans exceeded). 60-day Geomean data after (2018 & 2022: 0% exceedance - 0/14 geomeans exceeded)	2018	2

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
12		Middle Fork - 4.0 Mile Reach	Irrigation Improvement Phase I - Sprinkler Conversion; head gate installation	Known ; summer livestock grazing	Prevent overland flow from flood irrigation to wash animal waste into braid of Middle Fork (MF) that confluences with impaired reach of MF.	4' x 4' headwall with 8" screw gate	First phase of project only.	2018	1
13		Middle Fork - 4.0 Mile Reach	Irrigation Improvement Phase II - Sprinkler Conversion; Pumping Plant, Irrigation pipeline, risers, & pod system	Known ; summer livestock grazing	Prevent overland flow from flood irrigation to wash animal waste into braid of Middle Fork (MF) that confluences with impaired reach of MF.	Pumping Plant (24" wet well, 5 HP Berkeley pump, air & pressure valves), Pipeline (932 LF of 4" PIP pipe), Sprinkler System (23 sprinkler pods in four lines, four 3" risers w/ valve openers).	Effective: 60-day Geomean data before (2014-2017: 20% exceedance - 9/46 geomeans exceeded). 60-day Geomean data after (2018 & 2022: 0% exceedance - 0/14 geomeans exceeded)	2018	1
14		Middle Fork - 4.0 Mile Reach	Stock water	Known ; summer livestock grazing	Provide stock water after fencing off braid of the Middle Fork. Stock water was installed in conjunction with riparian fencing project (#11).	Stock tank and frost-free hydrant installed split on a cross-fence.	To be determined; need to review Above City Park sampling site data from 2007-2017.	2018	2
15		Commercial Septic System #1	Middle Fork - 4.0 Mile Reach	Septic Replacement	Suspected ; 100 feet from septic components to the Middle Fork, existing system was 45 years old.	Old shrine club system began increased use when Oncology Center & Doctor's Office moved into building. There are at least 14 bathrooms in facility.	Commercial Septic System replacement	Effective; need to review Above Confluence sampling site data from 2007-2017.	2015

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
16	Residential Septic System #1	Middle Fork - Upstream Hornecker Creek Confluence	Septic Replacement	Known ; tank top was rusted open so that effluent could escape and run to a braid of the Middle Fork. Also, pipe from tank was discovered by contractor to be directed towards braid.	Qualified for 2019-2023 Middle Fork Popo Agie Implementation & Monitoring Phase II Project.	Residential Septic System replacement	Before and after data at AHCC shows <i>E. coli</i> data generally lower after project than before.	2020	1
17	Residential Septic System #2	Middle Fork - 4.0 Mile Reach, near City Park	Septic Replacement	Known ; livestock were likely penned up with irrigation ditch running through the pen.	Monitoring data pointed to high <i>E. coli</i> concentrations around City Park. PACD staff met with homeowner to share data and encourage to rectify problem which homeowner did voluntarily.	Residential Septic System replacement	At the time the monitoring data pointed to this residence as a likely source.	2006	1
18	Middle Fork Ranch #3	Middle Fork - 4.0 Mile Reach	Livestock Management	Known ; summer cattle grazing	Land-use change.	Stopped grazing riparian area with ~ 20 yearling cattle.	To be determined; need to review Above Confluence sampling site data from 2007-2017.	2014	2

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
19	City of Lander Pet Waste decals & campaign	Middle Fork - 4.0 Mile Reach	Outreach - Pet Waste	Known ; dogs walked often along greenway path. Waste visible.	Encourage picking up pet waste along river corridor/greenway path.	15-20 decals.	Unknown	2010-2018	2
20	Residential Septic System #3	Middle Fork - MLB Reach	Septic Rehabilitation	Known ; effluent had backed up from belly in pipe and discharged to surface.	Grey waterline was accidentally sending out waste near pond which has direct connection to the river.	Plumber replaced pipe from house to tank and installed a check valve.	Unknown	2020	2
21		Middle Fork - MLB Reach	Septic Replacement	Suspected ; 10 feet from septic components to the Middle Fork, 4' to groundwater, existing system was 40+ years old.	Qualified for 2006-2011 PACD Septic Rehabilitation Program based on Homeowner Self-Assessment Form & Priority Ranking Worksheet scores	Residential Septic System replacement	Unknown	2007	2
22	Residential Septic System #4	Hornecker Creek	Septic Replacement	Known ; effluent/wastewater surfaced less than 100 feet upslope from Hornecker Creek.	Qualified for 2006-2011 PACD Septic Rehabilitation Program based on Homeowner Self-Assessment Form & Priority Ranking Worksheet (1200 points) scores.	Residential Septic System replacement	Unknown	2006	2

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
23	Residential Septic System #5	Middle Fork - 4.0 Mile Reach	Septic Replacement	Known; effluent/wastewater surfaced between 100-500 feet upslope from Middle Fork.	Qualified for 2006-2011 PACD Septic Rehabilitation Program based on Homeowner Self-Assessment Form & Priority Ranking Worksheet (1,100 points) scores.	Residential Septic System replacement	Unknown	2006	2
24	Storm drain decals	Middle Fork - 4.0 Mile Reach	Outreach - Storm Drain	Suspected; animal waste, sediment.	Educate public that storm drains are connected to the river and to avoid letting pollutants flow into storm drains.	15-20 decals	Unknown	2008-2022	3
25	Residential Septic System #6	Middle Fork - MLB Reach	Septic Rehabilitation - lined ditch near leach field	Suspected;	Prevent irrigation ditch from interfering with septic system function.	Ditch was piped.	Unknown	2019?	3
26	Residential Septic System #7	Middle Fork - Upstream Hornecker Creek Confluence	Septic Replacement	Suspected; leach field too close to irrigation ditch that drains to the Middle Fork	Qualified for 2019-2023 Middle Fork Popo Agie Implementation & Monitoring Phase II Project.	Residential Septic System replacement	Before and after data at AHCC shows <i>E. coli</i> data generally lower after project than before.	2020	3

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
27	Residential Septic System #8	Middle Fork - 4.0 Mile Reach	Septic Replacement	Suspected ; 100 feet from septic components to the Middle Fork, existing system was 45 years old.	Qualified for 2006-2011 PACD Septic Rehabilitation Program based on Homeowner Self-Assessment Form & Priority Ranking Worksheet scores	Residential Septic System replacement	Probably lower, but within impaired reach. Just downstream of MLB site. It is possible that the failing septic system was contaminating groundwater because of moderately suitable soils for absorption; greenline above leach field, large vegetation within 10 feet of leach field.	2008	3
28	Residential Septic System #9	Middle Fork - 4.0 Mile Reach	Septic Replacement	Suspected ; house wastewater was connected to old wooden crib cesspool within 45' of focus water to the Middle Fork.	Qualified for 2015-2017 Middle Fork Popo Agie Monitoring & Implementation Project.	Residential Septic System replacement	<i>E. coli</i> concentrations are still high at downstream site the following year. There must have been other sources upstream.	2014	3
29	Residential Septic System #10	Middle Fork - MLB Reach	Septic Replacement	Suspected ; a few hundred feet from the Middle Fork.	Failed; lid was compromised so effluent could escape potentially (Did not qualify for CWA 319 Grant Funding).	Residential Septic System replacement	Unknown	2009	3

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
30	Commercial Septic System #2	Middle Fork - Upstream Hornecker Creek Confluence	Septic Replacement	Known ; effluent was visible on surface less than a 100' from the Middle Fork.	USFS inspection documented effluent overflowing from cesspool that services Caretakers Cabin & Sacajawea Cabin Bathroom.	Commercial Septic System replacement	While the likelihood of contamination in Sinks Canyon was probably moderately high, the source is several miles upstream of the impaired reach of the Middle Fork and above the Sinks & Rise so may have had a low impact on impaired reaches downstream.	2017	3
31	Residential Septic System #11	Middle Fork - Upstream Hornecker Creek Confluence	Septic Replacement	Suspected ; within a hundred and fifty feet from the Middle Fork and river braid.	Unknown	Residential Septic System - tank replacement only	Unknown	2012	3
32	Residential Septic System #12	Middle Fork - 4.0 Mile Reach	Septic Replacement	Suspected ; about 400' hundred feet and upgradient from the Middle Fork.	Unknown	Residential Septic System replacement - chambers bed	Unknown	Unknown	3
33	Residential Septic System #13	Hornecker Creek	Septic Replacement	Suspected ; within a couple hundred feet from Hornecker Creek.	Unknown	Residential Septic System - field replacement only (chambers trench)	Unknown	Unknown	3

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
34	Residential Septic System #14	Hornecker Creek	Septic Replacement	Suspected ; within a couple hundred feet from Hornecker Creek and Sandstone Ditch.	Unknown	Residential Septic System replacement - chambers trench	Unknown	Unknown	3
35	Residential Septic System #15	Middle Fork - Upstream Hornecker Creek Confluence	Septic Replacement	Suspected ; within a couple hundred feet from the Middle Fork.	System failed in summer of 2004.	Residential Septic System replacement - pipe & stone	Unknown	2005	3
36	Residential Septic System #16	Middle Fork - Upstream Hornecker Creek Confluence	Septic Replacement	Suspected ; within a couple hundred feet from braid of the Middle Fork.	Unknown	Residential Septic System replacement - chambers	Unknown	2019	3
37	Residential Septic System #17	Middle Fork - Upstream Hornecker Creek Confluence	Septic Replacement	Suspected ; within a couple hundred feet from the Middle Fork.	Unknown	Residential Septic System replacement	Unknown	2013	3
38	Residential Septic System #18	Middle Fork - 4.0 Mile Reach	Septic Replacement	Suspected ; within a hundred feet from braid of the Middle Fork.	Unknown	Residential Septic System replacement - chambers trench	Unknown	Unknown	3

#	Project	Segment Location	Practice	Does the Practice Address a <u>known</u> or <u>suspected</u> source?	Project Purpose	Description	Project Effectiveness	Practice Completion Date	Rank
39	Residential Septic System #19	Middle Fork - Upstream Hornecker Creek Confluence	Septic Replacement	Suspected ; within a couple hundred feet from braid of the Middle Fork.	Unknown	Residential Septic System - field replacement only (chambers trench)	Unknown	2013	3
40	Sewer river crossing - Wyoming St to City Park Drive	Middle Fork - 4.0 Mile Reach	Sewer Improvement	Suspected ; crossed Middle Fork	Bore under river to replace sewer line exposed by 2017 flood.	Replaced pipeline	Unknown	~2022	3
41	Sewer pipe replacement - 2nd Street	Middle Fork - 4.0 Mile Reach	Sewer Improvement	Suspected ; within a hundred feet from the Middle Fork.	Remove belly in line and replace un-gasketed pipeline.	Replaced pipeline	Unknown	~2021	3
42	Sewer pipe replacement - Wyoming Street	Middle Fork - 4.0 Mile Reach	Sewer Improvement	Suspected ; within a hundred feet from the Middle Fork.	Replace sewer line that was un-gasketed and penetrated by tree roots.	Replaced pipeline	Unknown	~2020	3
43	Sewer Pipe sealing - 1st & Canyon St.	Middle Fork - 4.0 Mile Reach	Sewer Improvement	Suspected ; crossed Middle Fork	Prevent remote chance of sewage back-up; sewer line was open upgradient to the Middle Fork.	Pipeline to river capped with concrete	Unknown	~2022	3

Appendix D. Map of BMPs and Watershed Changes from 2005 to 2022

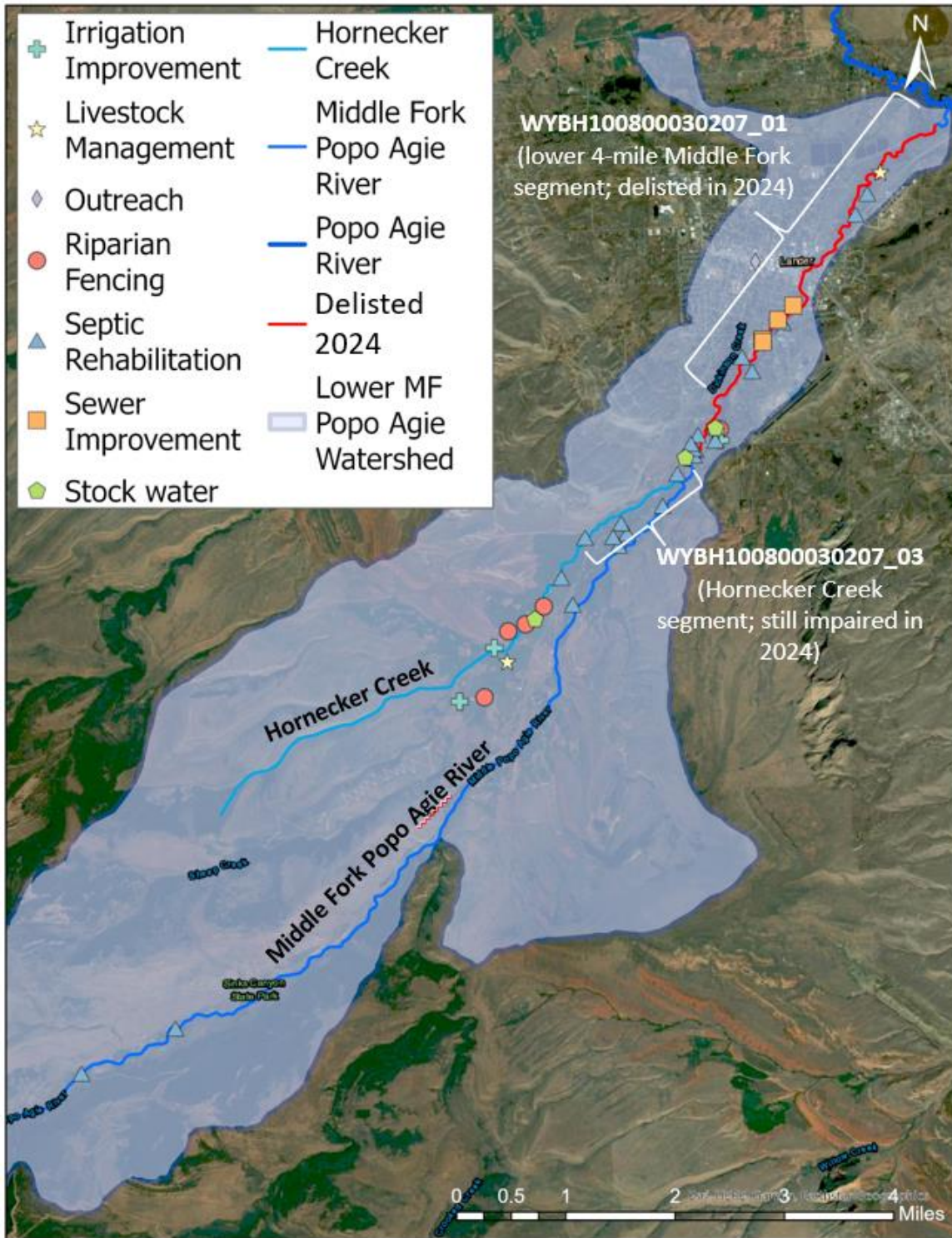


Figure D. 1. Map of BMPs and watershed changes that occurred between 2005-2022 that may have contributed to lower *E. coli* concentrations in the Middle Fork Popo Agie River. These projects are described in Appendix C. This map was created by Popo Agie Conservation as part of the data submission package in 2023.