

SAMPLING AND ANALYSIS PLAN

POPO AGIE CONSERVATION DISTRICT

Middle Fork of the Popo Agie River Bacterial Monitoring Project

2012-2014

Revised, September 2014

Popo Agie Conservation District
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*Middle Fork of the Popo Agie River Bacterial Monitoring Project
Sampling and Analysis Plan: 2012-2014*

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ABSTRACT

This Sampling and Analysis Plan (SAP) is written to meet the Quality Assurance/Quality Control (QA/QC) requirements of the Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program (WDEQ), and the United States Environmental Protection Agency (EPA) for collection, analysis, and reporting of water quality data as required by the Clean Water Act. All water quality monitoring will meet the requirements of the State of Wyoming Statutes 35-11-103, and 35-11-302 (b) (i) and (ii) (also known as the Credible Data Legislation).

The SAP is intended as a field guide for personnel who will be conducting the water quality monitoring activities, data analysis, and reporting efforts within the Popo Agie Watershed, as a QA/QC plan, and as a data management plan.

Samples are collected using the methods, procedures and protocols in the Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program Manual of Standard Operating Procedures for Sample Collection and Analysis, September 2011, which are incorporated by reference in this Sampling and Analysis Plan in the table on page 11, and the Natural Resource Conservation Service National Handbook of Water Quality Monitoring, May 1998.

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INTRODUCTION

Purpose

Coliform bacteria are used as an indicator to determine the suitability of a water body for recreational and other uses. Coliform bacteria are comprised of non-fecal and fecal subgroups. *Escherichia coli* (*E. coli*) bacteria are one subset of the fecal coliform group used to detect the presence of fecal material originating from warm-blooded animals and is more strongly correlated with incidents of gastrointestinal illnesses than fecal coliform. Since February 2007, *E. coli* has been the new standard to evaluate surface water quality impairments for contact recreation in Wyoming. Because *E. coli* does not reproduce in surface water, a test for both their presence and concentration can be used to define localized point source or nonpoint source pollution (WDEQ, 2004).

In 2002, a segment of the Middle Fork of the Popo Agie River near the City of Lander was listed as impaired by the Wyoming Department of Environmental Quality (WDEQ). Water quality data demonstrated that the stream segment was not meeting acceptable surface water quality standards for fecal coliform levels, which was the surface water quality standard for contact recreation at the time (Clark, 2000). As a result, the segment of the Middle Fork of the Popo Agie River (WYPR 10080003) was included on the Wyoming 2002 Section 303(d) list, Table A, List of Waters requiring Total Maximum Daily Load (TMDL) studies (a requirement of the Clean Water Act) (WDEQ, 2002). This stream is currently listed as a low priority for TMDL development for contact recreation beneficial use. Originally Table A classified the extent of the Middle Fork's concern as "undetermined distances upstream and downstream of the City of Lander." The 2012 Integrated 305(b) and 303(d) Report currently lists the location of the impairment from the confluence with Baldwin Creek to a point 4.0 miles upstream (WDEQ, 2012).

The primary goal for the 2012-2014 Bacterial Monitoring Study for the Middle Fork of the Popo Agie River is to assess if installed Best Management Practices (BMPs) and changes to livestock management within the vicinity of the 303(d)-listed segment are sufficient to reduce bacterial numbers. The objective is to monitor *E. coli* geometric means at seven monitoring sites on the Middle Fork of the Popo Agie and two monitoring sites on its tributary Hornecker Creek for three years to assess BMP effectiveness.

History of Water Quality Monitoring on the Middle Fork since the Impairment Listing

PACD has been monitoring bacteria levels on the Middle Fork in the vicinity of the City of Lander since 1999, when it began a four year Beneficial Use Reconnaissance Protocol (BURP) study. The result of this monitoring supports the designation that the Middle Fork is impaired by biological contaminants, namely fecal coliform bacteria, and by extension to the new standard, *E. coli* bacteria. Beginning in 2002, more intense monitoring data was collected through the 2005 recreation season (Ready, 2005a). Conclusions from this data indicated that warm temperatures and low flows encountered during the late summer period (late July through early September) may exacerbate bacteria levels in the Middle Fork of the Popo Agie River. No particular site indicated a consistent contribution of high bacteria levels. Because high levels of

bacteria coincide with periods of low flow and warm temperatures during the late summer recreation period, this relationship suggests that the sources are not related to overland flow/runoff, but would rather indicate continuous contributions from nonpoint sources such as septic systems. This conclusion led to the pursuit of the Middle Fork of the Popo Agie Septic Rehabilitation Section 319 Project that would focus on reducing potential bacterial contributions from failing septic systems.

The Middle Fork of the Popo Agie Septic Rehabilitation Section 319 Project spanned the years of 2006-2011 (PACD, 2011; Ready, 2005b). The project focused on reducing potential bacterial contributions from failing septic systems. It was estimated that 40 new or rehabilitated septic systems would be implemented. Due to the voluntary nature of the program only five new septic systems were completed. Although it's likely that the replaced septic systems contributed towards the overall improved quality of the river, it is difficult to tell the effectiveness of the septic rehabilitation with varying environmental factors (discharge & temperature) from year to year and the ability of other potential sources of bacteria to mask downstream sources. While the primary goal of the monitoring was to monitor the effectiveness of the septic rehabilitation cost-share program, PACD continued to identify spatial boundaries of the impairment, identify potential contributions, and implement voluntary mitigation of potential bacterial contributions with best management practices (Morneau, 2011).

Following the 2006 season, data suggested that the segment that limits the Middle Fork from achieving water quality criteria is between the Public Fishing Access and Mortimore Lane Bridge (Ready, 2006; Smith, 2006). Because a significant tributary, Hornecker Creek is located between these two monitoring sites, it was recommended that the monitoring staff sample Hornecker Creek near its confluence with the Middle Fork. This monitoring could help partition subsurface septic loading contributions from surface water loading sources in the Hornecker/Sheep Creek watershed. In 2007, four monitoring sites were added providing enough data to show that Hornecker Creek was contributing *E. coli* bacteria to the Middle Fork (Morneau, 2007). Potential contributions identified were septic and agriculture. Mitigation included the replacement of a failed septic system, a BMP installed at a small livestock operation and a gradual change in pasture management at a larger cattle operation. Though other potential projects were identified, landowners were either not interested or did not meet eligibility requirements for funding.

Since 2007, there has been mostly a downward trend of bacterial levels along the Middle Fork of the Popo Agie River and Hornecker Creek. Annual discharge on the Middle Fork began to rise in 2008 and peaked in 2010 with the occurrence of a categorized fifty year flood (Morneau, 2008 & 2010). Five years (2007-2011) of data verified that *E. coli* levels on the Middle Fork above the confluence of Hornecker Creek did not exceed the primary recreation water quality standard. Consequently the location of the impairment was changed from undetermined distances to, "From the confluence with Baldwin Creek to a point 4.0 miles upstream" in the Wyoming Water Quality Assessment and Impaired Waters List (WDEQ, 2012).

During the 2011 monitoring season, running geometric mean data collected within the impaired stretch of the Middle Fork was the lowest ever recorded with only one running geometric mean

at one site (Second Street Bridge) exceeding the *E. coli* standard for primary contact recreation. At the end of 2011, Section 319 nonpoint source pollution control program grant funding came to an end. Popo Agie Conservation District (PACD) decided with the positive direction that monitoring data was heading, and time still available before the 2014 TMDL deadline that the continuation of bacterial monitoring was warranted. PACD was approved for funding by the Wyoming Nonpoint Task Force for the Section 205(j) grant, Middle Fork of the Popo Agie River Planning and Assessment Project” in November of 2011. The 205(j) grant includes bacterial monitoring from 2012 through 2014 as one of the main tasks for the grant.

Credible Data Legislation

It is set forth in Wyoming state statute that Conservation Districts “provide for the conservation of the soil, and the soil and water resources...and the conservation, development, utilization, and disposal of water...” (Wyoming Conservation District Law, § 11-16-103). In support of this legislative declaration and charge, the PACD continues to implement water quality monitoring projects to assure that beneficial uses are maintained in the Popo Agie Watershed.

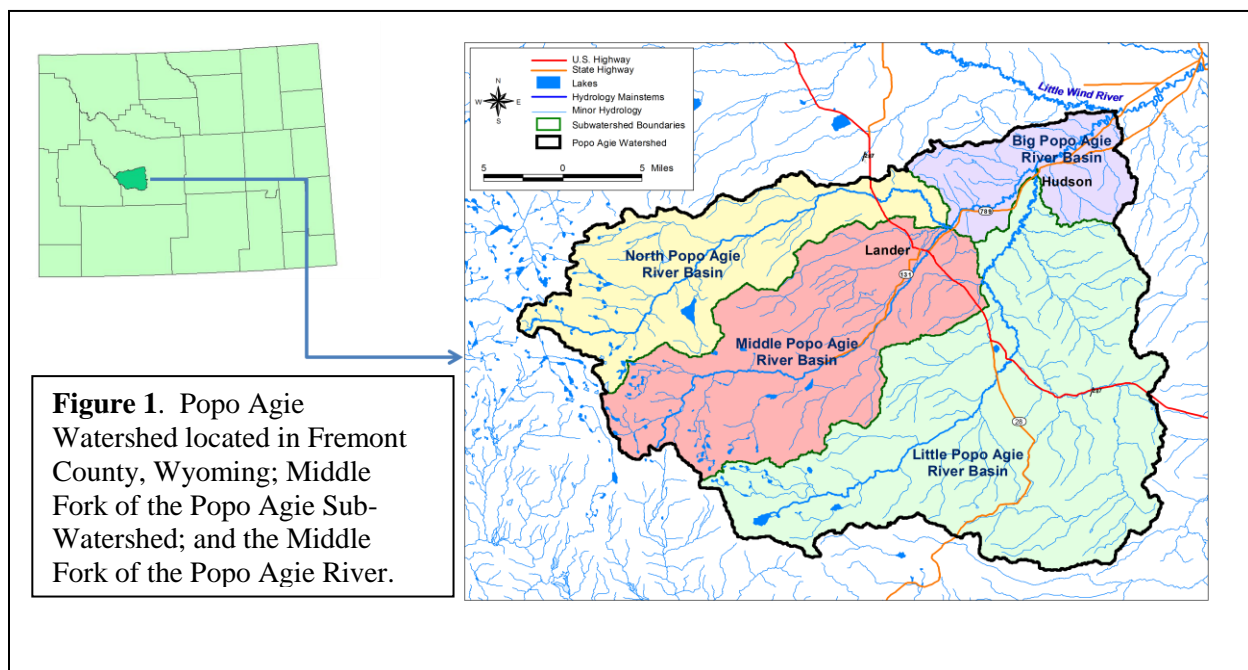
In addition to Wyoming Conservation District Law, this SAP also fulfills requirements set forth by Wyoming State Statutes 35-11-103, and 35-11-302 (b) (i) and (ii), commonly known as the Credible Data Legislation. This Legislation requires examination of the biological, chemical, and physical attributes of a watershed within the context of related historical records, as well as its intended beneficial use such as drinking, recreation, irrigation, and fisheries. This Sampling and Analysis Plan was written with guidance from the Popo Agie Conservation District Board of Supervisors and the Water Quality Technical Advisory Group (TAG) and submitted to WDEQ for approval. This Sampling and Analysis Plan will replace the 2006-2011 plan.

Corrective Actions

Project evaluation will regularly occur during the 2012-2014 Middle Fork of the Popo Agie River Planning and Assessment Project. Any need for modification in this Sampling and Analysis Plan, including site locations and schedule, number of samples per site, number of sites, sampling forms, calibration logs, laboratory choice, number or type of quality control samples, sampling methods or standard operating procedures, methods for determining surface water quality condition or database application will be decided concurrently by the PACD employees/field personnel, the PACD Board of Supervisors, and WDEQ personnel. Records, such as field personnel/training, which may be subject to change during the course of the project, will be updated as necessary. If any change in the structure of the monitoring plan is needed, the Project Manager will insert the dated amendment in the SAP. The Project Manager will also notify all field and WDEQ personnel of amendments to the SAP. Following any changes made, the Project Manager will assess the effects of the changes. If quality control samples are not meeting project criteria or if any other event requires corrective action, PACD employees/field personnel will follow the procedures in the PACD QAPP (Wolstenholme, 2000b) for assessment and response actions.

PHYSICAL DESCRIPTION OF THE STUDY AREA

The primary study area focuses on the Middle Fork of the Popo Agie River and one of its tributaries, Hornecker Creek, near the City of Lander, Fremont County, Wyoming (**Figure 1**). The study segment will focus on an approximate length of stream channel of six miles beginning at the mouth of Sinks Canyon and ending at the confluence of the Middle Fork of the Popo Agie River with the North Fork of the Popo Agie River below the City of Lander. The City of Lander, the Town of Hudson, and rural residents rely on the Popo Agie River system as their source for drinking water, agricultural irrigation, recreation, wildlife, and other beneficial uses. The entire Popo Agie Watershed, including the North, Middle, and Little Popo Agie Rivers, is approximately 522,300 acres in size. The Middle Fork of the Popo Agie sub-watershed encompasses roughly 166,120 acres, or 32 percent, of the total land area.



The length of the Middle Fork of the Popo Agie River is 54 miles from its headwaters near Bill's Park at an elevation of 12,000 feet above sea level, to its confluence with the Little Wind River at approximately 5,000 feet above sea level. Sinuosity, measured from the headwaters to the confluence with the Little Wind River is 1.33. Gradient for the length of the Middle Fork channel is 0.019 ft/ft. Irrigated acres on Middle Popo Agie tributaries amount to 11,503 acres. The tributaries included in this count are: Baldwin Creek (1,078 ac), Squaw Creek (578 ac), Squaw Creek and Middle Popo Agie (597 ac), and Middle Popo Agie (9,250 ac).

The Middle Fork is fed from spring sources, seasonal precipitation and annual snow melt, irrigation return flows, several tributaries including the Sawmill, Hornecker, and Baldwin Creeks, and the North Fork of the Popo Agie River which joins the Middle Fork of the Popo

Agie River at 5,200 feet (near WYPO Bridge, 1.5 miles north of Lander). The stream is then called the Popo Agie, or Big Popo Agie, below the confluence of the North and Middle Forks. The Popo Agie River terminates at its confluence with the Little Wind River near Arapahoe, Wyoming.

Hornecker Creek measures 2.8 miles long from its headwaters at an elevation of 5,800 feet down to the Middle Fork of the Popo Agie River at approximately 5,400 feet. Hornecker Creek is fed from spring sources and irrigation return flow. Contributing tributaries to Hornecker Creek include Sheep Creek and Thompson Creek. Hornecker Creek terminates at its confluence with the Middle Fork just above Mortimore Lane Bridge south of Lander.

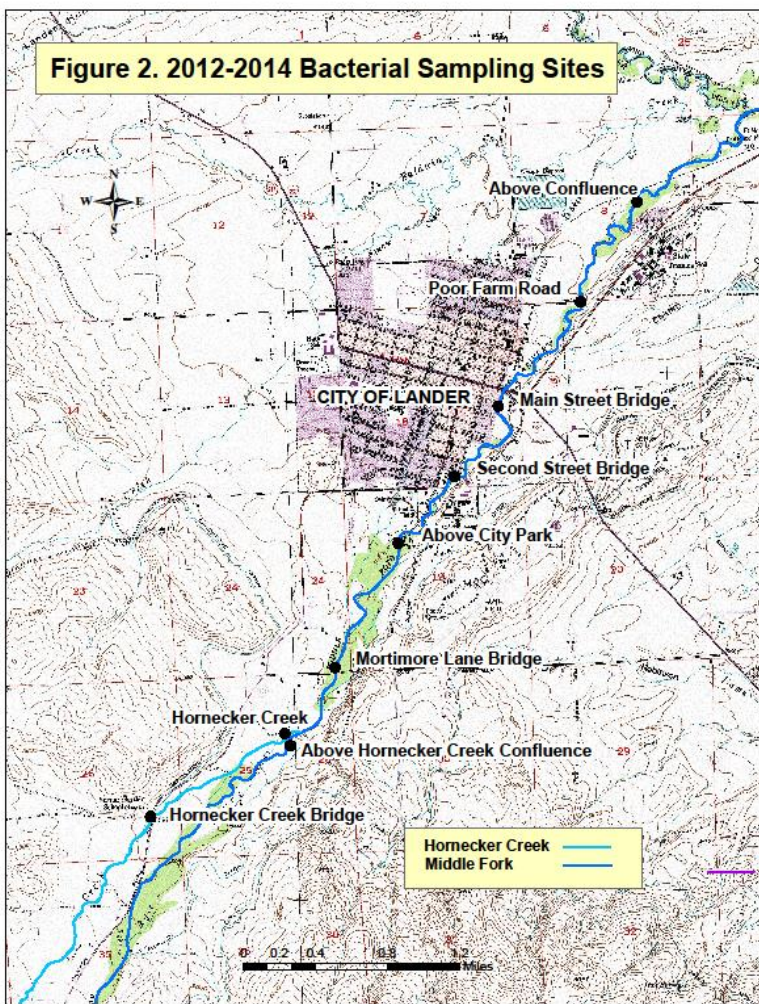
BACTERIAL MONITORING

Sampling Personnel, Training, & Experience

Nine sites will be monitored from May to September 2012-2014. There are two certified members in the PACD field crew. The monitoring personnel (**Table 1**) will be familiar with the PACD SOP manual and will ensure those protocols are followed in the field and the laboratory. Samplers and oversight personnel will have access to this SAP, SOPs, and the Quality Assurance Project Plan (QAPP), and will be required to review these documents before the beginning of each monitoring season.

Sampling Sites

The 2012-2014 bacterial sampling site design was created based on sites where elevated bacteria levels were initially encountered by USGS as part of the NAWQA study (1999-2001) and at sites selected by PACD from 2002-2011 during their bacterial monitoring studies to segment the river into smaller portions and to be in proximity to possible suspected bacterial influences (**Table 2**). There is a blend of two types of study design being implemented in 2012-2014; above-and-below and trend. Sites are located in easily accessible public areas or select participating private lands



(**Figure 2**). Landowner permission is obtained before accessing private and public property. Permission is obtained for monitoring at the sample site and access to that site. Agreement forms for water quality monitoring activities between landowners and PACD are on file at the PACD Office.

A total of nine sampling sites will be utilized to measure *E. coli* bacteria. The first five sites fall within the impaired reach of the segment identified as WYBH100800030207_01 and extends from the confluence with Baldwin Creek to a point 4.0 miles upstream. Sites six and seven are located on the Middle Fork upstream of the impairment. The final two sites are situated on the tributary, Hornecker Creek. Reference photos will be taken at each site annually. Each site will have a

snapshot taken upstream, downstream, and across the channel. Reference photos are on file at the PACD Office.

Sites will include:

1. Above Confluence
2. Poor Farm Road
3. Main Street Bridge
4. Second Street Bridge
5. Above City Park
6. Mortimore Lane Bridge
7. Above Hornecker Creek Confluence
8. Hornecker Creek
9. Hornecker Creek Bridge

Justification for Site Selection

Above Confluence (ACF)

This site is located on private property directly upstream from the confluence of the Middle and North Forks of the Popo Agie Rivers. This site will provide useful data for measuring the effectiveness of all upstream BMP's because the site will represent upstream contributions before dilution of the North Fork.

Poor Farm Road (PFR)

This site is located at the end of a public city street and will provide additional data at an equal interval between the Confluence and Main Street Bridge sites.

Main Street Bridge (MSB)

This site is located on City of Lander property approximately 500 feet upstream of Main Street Bridge. The site is accessible on the northwest bank of the river channel, across from the Lander Greenway. This site was originally sampled at part of the USGS NAWQA study in 1997 (Clark, 2000). PACD and WDEQ have utilized this location in several other monitoring efforts due to history of bacterial presence as well as high contact recreation potential.

Second Street Bridge (SSB)

This site is located on private property approximately 250 feet upstream from Second Street Bridge. The site is accessible from the Lander Greenway on the north bank of the river channel. This site has also been included in historical supplemental bacterial monitoring efforts and will be renewed for the 2012-2014 monitoring schedule due to the presence of coliform bacteria detected at the site during 2002-2004 Supplemental Bacterial Monitoring. This site also has potential for contact recreation.

Above City Park (ACP)

This site is located on City of Lander property upstream from City Park/McManus Park and can be accessed from the northwest bank of the river channel. This site also has potential for contact recreation.

Mortimore Lane Bridge (MLB)

This site is located on private property 250 feet below Mortimore Lane Bridge on the east bank of the river channel. Although the site is surrounded by rural subdivision development, contact recreation by the public (i.e. swimming, boating) is limited at this site. Mortimore Lane Bridge also has agricultural lands present upstream and adjacent to the site and agriculture has appeared to be a factor in the 2006-2011 study.

Above Hornecker Creek Confluence (AHCC)

This site is located on the northwest bank of the river channel, and is located on private property. This site was first sampled in 2007 in an effort to more accurately define the extent of the impairment. Five years (2007-2011) of data from the AHCC site verified that *E. coli* levels there did not exceed the primary recreation water quality standard. This site will act as an upstream control.

Hornecker Creek (HC)

This site is located on private property approximately 60 feet upstream from where a braid of Hornecker Creek confluences with the Middle Fork. This tributary can contribute the majority of water into the Middle Fork channel in the late summer when snow pack finishes and irrigation diversions lower flows.

Hornecker Creek Bridge (HCB)

Located where Sinks Canyon Road and Hornecker Creek intersect, this private site was first monitored in 2007 when it was suspected to contain high levels of *E. coli*. This site is downstream of livestock ranches and single homes with septic systems.

Sampling Schedule, Frequency, and Activity Plan

The sampling schedule will occur during the summer recreation period (May 1 through September 30). Previous PACD data has shown that early (May) recreation period samples have demonstrated slight bacterial concern. WDEQ are convinced that there is sufficient data demonstrating that bacterial numbers do not exceed the water quality standard in the month of May and propose that PACD begin sampling in June to conserve monitoring resources (Zygmunt, Jennifer & Thorp, Richard. personal communication. February 2, 2012). Weekly sampling at all nine sites will begin on the first Tuesday in June and continue every Tuesday until the end of September. Samples will be scheduled weekly throughout the monitoring season to collect running geometric mean data which is required for listing and de-listing 303(d) impaired segments.

Valuable trend data has been collected for years in May and the Water Quality TAG team suggested in April, 2011 that it would still be valuable to collect some data at key locations during the entire recreational season in order to have full-season trend data. Four sites were selected. These sites are the most downstream site, *Above Confluence*; two upstream sites above the confluence on the Middle Fork, *Above Hornecker Creek Confluence* and on Hornecker Creek, *Hornecker Creek*, and finally, *Main Street Bridge* which was the original monitoring location used by USGS (**Table 3**).

In addition to sample collection and analysis, PACD will also submit an annual report following data review by the PACD Executive Director and the WDEQ project sponsor. **Table 4** details the 2012-2014 bacterial assessment activities.

Rational for Parameters Sampled

Specific parameters to be sampled include pH, turbidity, temperature, flow, and *E. coli* (**Table 5**).

Field Chemistry Parameters

Turbidity, water temperature, and pH will all be recorded using properly calibrated meters. Results will be recorded in the field data sheet, and will be added to the bacterial assessment Excel© spreadsheets upon return to the PACD office. These chemical parameters will provide a useful comparison for determining potential causes or areas of concern when compared to bacterial results.

Physical Parameters

Flow will be included in the 2012-2014 bacterial assessment design in order to more accurately evaluate surface water quality conditions during each sample period and provide information for developing load allocation curves that would be useful if a TMDL study is required. Rating tables were developed by the State Engineer's Office in 2011 in order to record high flows that were unattainable in the past because of safety concerns. Flow will be collected by stretching a tape from a mounted measuring point to the water surface on Main Street Bridge and a private foot bridge at Hornecker Creek.

Additionally, flow will be collected according to WDEQ-SOP protocol with a Marsh-McBirney Flo-Mate 2000 when flows are lower than levels calculated on the rating tables. Data will be

recorded in the field log book and calculations will be performed in the field to assure that results accurately reflect water levels and conditions. Data will be entered into a Microsoft Excel™ spreadsheet. Calculations will be reviewed for errors during data entry at the PACD office. PACD recognizes that flow conditions may vary slightly between sites due to irrigation withdrawal/return and other factors affecting flow rates. However, the Main Street Bridge site will provide a useful representation of the general flow conditions on the Middle Fork below the confluence with Hornecker Creek.

Biological Parameters

The major component in the evaluation of water quality status is the determination of presence and concentration of *E. coli* bacteria. Although total coliform is not used as a water quality standard, it has a role in the interpretation of *E. coli* data. Because *E. coli* and total coliform do not normally reproduce in water, they can be used as indicators of localized point source or non-point source pollution from both human and animal wastes.

CORRECTIVE ACTION (effective 4/29/14): Data collected in 2014 is subject to the revised methodology to recreational use support determinations. *E. coli* criteria found in section 27 of chapter 1 are based on a 60 day geometric mean of *E. coli* samples. WDEQ requires that a minimum of five samples are collected and they are separated by a minimum of 10 days. (Wyoming's Methods for Determining Surface Water Quality Condition and TMDL Prioritization; Document #14-0367, pages 13-14)

Health and Safety

The health and safety of all members of the PACD field crew will remain the highest priority during the Middle Fork of the Popo Agie River Planning and Assessment Project. Protocols for sampling and safety will be strictly followed (Safety SOP) and emergency and evacuation plans will be discussed prior to each season. PACD staff will wear protective latex gloves during sample collection and processing to reduce risk of exposure to certain pathogens. In addition, postponing sampling may be necessary during extreme conditions and/or high water. The crew will carry a cellular phone to remote sites as an added precaution.

Nearest Hospital: Sage West Medical Center
1320 Bishop Randall Dr.
Lander, WY
(307) 332-4420

Standard Operating Procedures (SOPs)

PACD will utilize the SOPs in the following table. All SOPs originate from and are page referenced to the Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program Manual of Standard Operating Procedures for Sample Collection and Analysis, September 2011.

Standard Operating Procedures References		
Middle Fork of the Popo Agie Bacterial Monitoring Project		
Topic	Title	SOP Pages
Aseptic Technique	Aseptic Technique	189
Blanks	Blanks	191-193
Discharge	Discharge, Stream Wadeable Streams and Rivers	136-139
Duplicates	Duplicates	222-223
<i>E. coli</i>	Escherichia coli & Total Coliform Bacteria Colilert®- Defined Enzyme Substrate	63-68
Field Log Books	Field Log Books	227-228
Geometric Mean	Geometric Mean, Calculating and Using	75-76
GPS Data	Global Positioning System (GPS) Data	114-115
Instrument Calibrations	Instrument Calibrations and Calibration Logs	230-231
pH	pH	170-171
Photographic Documentation	Photographic Documentation	235-236
Quality Control	Quality Control Measures, Summary of	239-242
Safety and Safety Equipment	Safety and Safety Equipment	244
Sample Collection	Sample Collection	245-246
Sample Labeling	Sample Labeling	247
Temperature	Temperature, Water	176
Turbidity	Turbidity	178
Waste Disposal	Waste Disposal	278
Whirl-Pak™ Bacteria Sampling	Coliform Bacteria Sampling Procedure	59-62

Sample Labeling

PACD field personnel will follow the WDEQ-SOP for sample labeling. Since samples are not shipped to an off-site contract laboratory or exchange hands from the field to the PACD lab, the sample ID Code written in permanent waterproof marking ink is the only labeling requirement for all sample labeling.

Waste Disposal

This monitoring program will follow the WDEQ-SOP for waste disposal during field sampling and lab analysis.

References

Please refer to **Appendix 3** for a list of references and other information used in compiling this document.

Photo Documentation

Photographs taken at sampling sites using a digital camera will be identified with the sample ID code and date and stored on the office computer hard drive. A narrative will be included when an explanation of the subject is needed. All the above information must be recorded on the field data sheet at the time photographs are taken. Photographs may be taken to assist future samplers return to the exact site location, or to document relevant conditions (flow, potential NPS, etc.) at each sample site.

QUALITY ASSURANCE AND QUALITY CONTROL

Field Data Sheets and Log Books

Several data forms will be used in the field and in the laboratory (**Appendix 2**). Staff will record field parameters, time, date, site name/code, weather and stream conditions, and the sampler's name on one field data sheet for each site. A separate data sheet or the rite-in-rain books will be utilized for flow data. Equipment calibration log forms are archived in the PACD office and updated after each calibration. Any calibration, maintenance conducted in the field, or changes to the SAP or SOP will be recorded on field data sheets or log books and transcribed on the calibration logs upon return to the PACD office.

Chain of Custody

Chain of custody procedure is not required for this SAP since PACD has established their own laboratory at 221 South 2nd Street, in Lander for processing all of their *E. coli* lab samples.

Calibration Standards

Fresh calibration standards will be kept in stock throughout the sampling/monitoring portion of the study for the following meters/equipment: Hach Sension 1 (pH, Temperature); HACH 2100P Turbidimeter. PACD purchases the calibration standards for the pH and Turbidimeter meter from Hach Company (www.hach.com), P.O. Box 389, Loveland, CO 80539,-1-800-227-4224. The standards will be marked with expiration dates and stored according to manufacturer specifications.

Equipment Calibration and Maintenance

Following the sampling procedures in the appropriate SOP's, the equipment listed in **Table 6** will be utilized to measure stated parameters for the bacterial assessment study. Detailed calibration and maintenance methods from the manual of each piece of equipment are archived at the PACD office and are reviewed by staff prior to the monitoring season. Copies of meter manuals are carried in the field and are available to personnel for reference at all time. Crewmembers will follow manufacturer calibration, maintenance, and storage recommendations. Calibration logs are permanently archived at the PACD office in their original (paper) format.

Water chemistry probes are calibrated to known standards prior to each use. All standards and solutions are supplied by the PACD. Solutions are replaced before the manufacturer's expiration date printed on each bottle, and used standards are disposed as per manufacturer's instructions. Equipment will be double-checked, organized, and packed at least one week prior to the sampling season. Back up batteries, and spare parts (i.e. vials) will be carried to all sampling sites by field personnel.

Sampling Methods

Samples are collected using the methods, procedures and protocols in the Natural Resource Conservation Service National Handbook of Water Quality Monitoring, May 1998, and the Wyoming Department of Environmental Quality, Water Quality Division, Watershed Program

Manual of Standard Operating Procedures for Sample Collection and Analysis, 2011, which are incorporated by reference in this Sampling and Analysis Plan.

The IDEXX Colilert ® Defined Enzyme Substrate Method will be utilized to test for *Escherichia coli*.

Data Verification and Validation

The PACD-QAPP lists the requirements and methods of data review, validation, and verification. It is the intention of PACD that this SAP will meet those QAPP requirements by following the listed methods, review processes, and documentation procedures.

Review and validation of data will be coordinated by the PACD Project Manager, Executive Director, data QC officer, reporting QC officer and the water quality Technical Advisory Group (TAG). Data review and validation will follow the preliminary quality control and correction methods taken (**Table 7**). There are several review and validation steps:

Step 1) A duplicate bacterial sample will be sampled at 10% of total sites visited per season, or a minimum of one duplicate per sample run. Duplicate samples will be used to examine whether variation in field observations, sample collection, and laboratory analysis is present. More duplicate samples may be analyzed depending on water sample characteristics, sampling conditions, data requirements and assessment objectives. The parameters that will be duplicated at 10% of the sites are identical to regularly scheduled samples (**Table 5**). The PACD Executive Director and Project Manager will review the results. If relative percent differences occur greater than 40%, they will determine why they occurred, whether it was based on inconsistency in the laboratory or the field, and what actions need to be taken to reduce any future variation. According to the PACD-QAPP, a 40% relative percent difference applies to values above 100 cfu/100ml. Statistical calculations break down when values are near the low end of a reporting limit. Potential actions could include: collection of additional duplicate samples, or stricter quality control in the field.

Step 2) Certain water quality parameters (pH, temperature, and turbidity) will be duplicated by field personnel where duplicate bacterial samples are also collected. The results will be reviewed, and if differences greater than 10% for temperature and turbidity occur or 5% for pH in duplicate samples, the data and results will be re-examined to determine why differences occurred, and how future variation can be minimized. (Turbidity has been handled differently during previous monitoring. Water quality auditors and WDEQ water quality personnel have suggested to PACD that three readings should be collected for each sample and then averaged. The 10% difference applies to values above 10 NTU since statistical calculations break down when values are near the low end of a reporting limit. No additional readings are necessary for duplicates.)

Step 3) Prior to leaving each field sampling site, the field personnel will proof read and initial the field data sheets. In this way, recording errors or any missing information can be corrected before leaving the site. Data will be entered into a Microsoft Excel™ spreadsheet. 100% of the data will be proof read by the Data Processing Leader and then proof read a second time by the

Data QC Officer. The original paper data sheets and forms will be archived permanently at the PACD office in Lander with all other raw data (see the Data Archiving Section in this SAP).

Step 4) Duplicate and Split samples will be collected as necessary, by the PACD and WDEQ monitoring personnel when schedules allow, for comparison purposes of *E. coli* samples. Preferably, samples can be collected twice a year during different flow regimes. These samples will be processed by each team separately using the IDEXX Colilert™ method. If differences greater than 40% occur, the data and results will be re-examined to determine why differences occurred, and how future variation can be minimized.

Step 5) A Field Blank/Sterile Control will be included with each trip using distilled water. The Field Blank will be filled in the field prior to any other sampling activity and stored in the same cooler with other samples during collection. Each sampling day is considered, for the purposes of this SAP, as a group of samples prepared and incubated as one lot during an uninterrupted time period. A Lab Blank will be processed in the lab using distilled water prior to processing the other samples in the lot. PACD will utilize the PACD-SOP as reference for quality control for the *E. coli* sampling.

Quality Control (QC) Samples

Many precautionary measures will be taken to discover and eliminate sampling and analysis method errors (See WDEQ QAPP). Table 8 describes each parameter, possible causes of error, and planned quality control and correction methods to address any error.

Data Quality Objectives

Data quality objectives in terms of accuracy, precision, and completeness for water quality metrics are described in **Table 9**. The bacterial sampling precision and accuracy objectives and determinations are detailed in the *Escherichia coli* & Total Coliform Bacteria SOP (WDEQ 2004). Definitions for data accuracy, precision, and completeness are in the Summary of Quality Control Measures SOP.

Reconciliation with Data Objectives and Project Objectives

After data analysis, the PACD Executive Director and Project Manager will determine whether or not the data quality objectives of this project were met. The project data gathered will be compared to the list of data quality objectives. If the data quality objectives were not met, the possible reasons will be listed and the reviewers will decide whether the data should be qualified or rejected, and if future objectives should be altered.

The PACD Executive Director and Project Manager along with the PACD Board of Supervisors, and the water quality TAG will examine the initial list of project objectives. If any of the project objectives were not met, the reviewers will decide whether the objectives should be altered for future monitoring, or if other changes can be made to ensure all objectives are reached in the future. The PACD Project Manager will document the data quality objectives and project objectives review, conclusions, and any changes in objectives that may be made.

Assessment and Response Actions

Any modification of this SAP, including site locations, schedule, sampling forms, laboratory choice, number of samples per site, number or type of quality control samples, sampling methods or standard operation procedures, number of sites, or database application will be decided by the PACD Executive Director, the Project Manager, the water quality TAG, and the PACD Board of Supervisors. Records, such as field personnel and training will be updated when necessary during the project. If any change in the monitoring plan is needed, the Project Manager will submit any amendment to the SAP to the Quality Assurance Officer at WDEQ for review and approval. All amendments will be dated and inserted into the SAP. The Project Manager will also notify all field samplers of amendments to the SAP. Following any changes made, the Project Manager will assess the effects of the changes. If quality control samples are not meeting project criteria or if any other event requires corrective action, PACD employees and field personnel will follow the procedures in the QAPP for assessment and response actions.

Audit

PACD has made arrangements with WDEQ monitoring personnel to perform an annual audit with PACD certified monitoring personnel.

LABORATORIES

Laboratory QA/QC Plan

Bacterial samples will be hand delivered to a laboratory at:

Popo Agie Conservation District
221 S. 2nd Street
Lander, WY 82520
(307) 332-3114

QA/QC: PACD laboratory personnel will follow current WDEQ QA/QC protocol.

Test: See Colilert™ Defined Enzyme Substrate Method SOP (WDEQ 2011).

DATA

Data Entry

Data will be entered into a Microsoft Excel™ spreadsheet following each sample run. The Data Processing Leader will proof all data (100%) entered into a computer using the original hard copies of the data forms. Following that initial proofing, the Data QC Officer will proof 100% of all entered data for errors. All data analysis will be reviewed by WDEQ after initial review by the PACD personnel and Water Quality TAG. Numerical outliers and totals and unusual numbers will be examined closely for errors.

If outliers appear during data analysis, concerning any project parameter, raw data used in the interpretation will be proofed again against the hard copies of data forms. If no discrepancy is discovered, calibration logs and field notebooks will also be reviewed to discover whether or not equipment calibration was successful, or if there was any other reason that might explain the outlier. If equipment calibration was conducted properly and this SAP, the SOPs, and the QAPP were followed, the data will be accepted as valid. Statistical tests assist with the interpretation of outliers, and may aid in perceiving patterns in the data that are not immediately obvious. Data will be reviewed outside of PACD staff by the WDEQ Auditor and the water quality TAG.

If errors are found during data entry proofing, the incorrect entry will be corrected, and all the entered data will be subject to additional spot checks for accuracy against the original data sheets. If errors are discovered in calibration methods, the data will be considered invalid. All calibration logs will then be checked to ensure other data are correct. If field personnel did not follow this SAP, the SOPs, or the QAPP for the given parameter, the Executive Director and Project Manager will decide whether or not the data should be rejected as invalid or qualified. This decision is dependent on how and why the field personnel deviated from the SAP, SOPs, or QAPP. Qualified data may be used in the interpretation of results, but all result reports and summaries must note the reason it had been subject to question, and why and how it had been qualified and considered usable.

Whether the data is accepted, rejected or qualified, the Project Manager is responsible for documenting in project reports which outliers were checked, as well as how, what (if any) errors were discovered, whether or not those errors made the data invalid, and how the data was qualified. All summary reports and presentations will be scrutinized by the PACD personnel and the water quality TAG prior to review by WDEQ. If a summary report does not accurately present project findings, the report will be rejected and rewritten. By agreeing upon and following a standard format for data reporting, errors will be minimized and completeness ensured.

Format of Results and Data Archiving

The PACD will follow the PACD SOP for data archiving. The original paper format of all field data sheets will include sampled parameters with the appropriate units and the numerical result for each parameter (pH, temperature, turbidity, flow, and *E. coli*) will be archived in their

original paper format at the PACD office in Lander. The validity of sterile controls will also be reported.

All project results will be entered into a Dell computer with Microsoft Office programs (i.e. Excel, Access, Word) or equivalent computer and/or software. All files will be saved on the hard drive of the computer, and a backup copy will be made of every data file, graphic interpretation, and related project report each day data is entered or edited. Computer files and backup copies will be kept at PACD permanently, along with the original paper copies of all monitoring results. The PACD Document Production Coordinator/Project Manager will be responsible for all original paper and electronic copies of project data forms, chain of custody forms, calibration logs, field log books, project data and reports, maps and photographs of sampling sites, and other related files archived at the PACD office. The PACD Document Production Coordinator/Project Manager will use project results to generate reports, including annual and Final Reports, to submit to the WDEQ-Water Quality Division (WQD).

Statistical Analysis

The PACD will use Microsoft Excel™ to calculate the geometric mean for the *E. coli* samples and will be verifying those calculations with a calculator. Statistical analysis will be reviewed by the Data QC Officer.

REPORTS

Data Verification Report

PACD will follow the WDEQ SOP for data verification. This report will be prepared annually as part of the annual report following the monitoring season (June-September), by the Project Manager and provided to the PACD Executive Director and WDEQ-WQD. This report addresses Results and Quality Control, as well as deviations from the QAPP, analytical methods, or SOPs.

Data Validation Report

The PACD will follow the WDEQ SOP for data validation. A report will be prepared annually as part of the annual report by the Project Manager after the monitoring/sampling season is complete, and provided to the PACD Executive Director and WDEQ-WQD. This report addresses analytical deficiencies and field QC non-compliance.

Corrective Actions and Assessment Reports

Should corrective actions be necessary, they will be summarized and provided with the Data Validation and Verification reports sent to WDEQ-WQD. The water quality monitoring/sampling portion of this study will be assessed by the PACD field personnel and a WDEQ-WQD Auditor. The WDEQ-WQD Auditor will determine appropriate responses needed to be sure that PACD are following the safety SOPs, sampling SOPs, QC checks, paperwork requirements, and proper data analysis. Project assessment results will be included in the Section 205j Surface Water Quality Monitoring Audit included in the appendix of the annual report.

Laboratory Report

Included in the annual report will be information detailing laboratory procedures, any issues regarding lab equipment and results of lab blanks.

Section 205 (j) Surface Water Quality Monitoring Audit Report

Included in the annual report will be the results of an annual audit performed by WDEQ. The audit includes an assessment of sampling techniques, QA/QC, and data management and reporting.

Annual Reports

The Project Manager will compile an annual report each year for submittal to the PACD Executive Director and WDEQ on December 15 following each sample season. A final report will be compiled and submitted at the conclusion of the 205j grant period. Reports will be written using Microsoft Office programs or equivalent. Backup copies (on disks) of every file, graphic interpretation, and related project reports and maps will be made daily as the annual reports are being written and/or edited. Final copies of reports will remain on the hard drive of the computer, be stored on office server and CD ROM, and printed as hard copies to be permanently archived as reference material at the PACD office in Lander, Wyoming. Paper copies of quarterly reports will be delivered to the PACD Board of Supervisors, the Water

Quality TAG, participating landowners, and the WDEQ upon request. The purpose of reports is to:

- Keep the WDEQ/WQD informed as to project progress;
- Establish whether or not project objectives are being met as planned;
- Present project results in a way they can be reviewed by board members and other technical advisors;
- Determine whether or not changes in the SAP or SOPs are needed to meet project objectives or data quality objectives;
- Present project results and interpretation;
- Present both field and laboratory Quality Assurance and Quality Control information;
- Describe any deviations from the SAP, QAPP, or SOPs that took place during sampling or analysis.