RESTORING OUR ENVIRONMENT ▸ DESIGNING OUR FUTURE

Missoula-Granite PMR, MAS No. 2019-02
Structure Survey Report

Montana Department of Natural Resources and Conservation (DNRC)
May 27, 2020

Pioneer Technical Services, Inc. 106 Pronghorn Trail, Bozeman Montana 59718
www.pioneer-technical.com

Missoula-Granite PMR, MAS No. 2019-02

Structure Survey Report

Prepared for:

State of Montana, Department of Natural Resources and Conservation

1424 9th Avenue

Helena, Montana 59620-1601

Prepared by:

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106 Pronghorn Trail

Suite A

Bozeman, Montana 59718

Missoula-Granite PMR, MAS No. 2019-02

Structure Survey Report

May 26, 2020

I hereby certify that all work products (maps, reports, etc.) prepared for this project were done so under my direct supervision and that I am a duly Licensed Professional Land Surveyor under the laws of the State of Montana.

David Wilson, P.L.S

Date: 05-26-20 Montana Registration No. 12212LS

Pioneer Technical Services, Inc.
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Contents

Figures

Appendices

1 INTRODUCTION

The Department of Natural Resources and Conservation (DNRC), in partnership with Federal Emergency Management Agency (FEMA) and Missoula and Granite Counties, initiated work to produce a new floodplain study along existing study reaches in Missoula County and Granite County. The Missoula-Granite Physical Map Revision (PMR) provides the process for completing floodplain mapping in Missoula and Granite Counties. The Missoula-Granite PMR, as outlined in the Mapping Activity Statement MAS No. 2019-02, is comprised of the following activities:

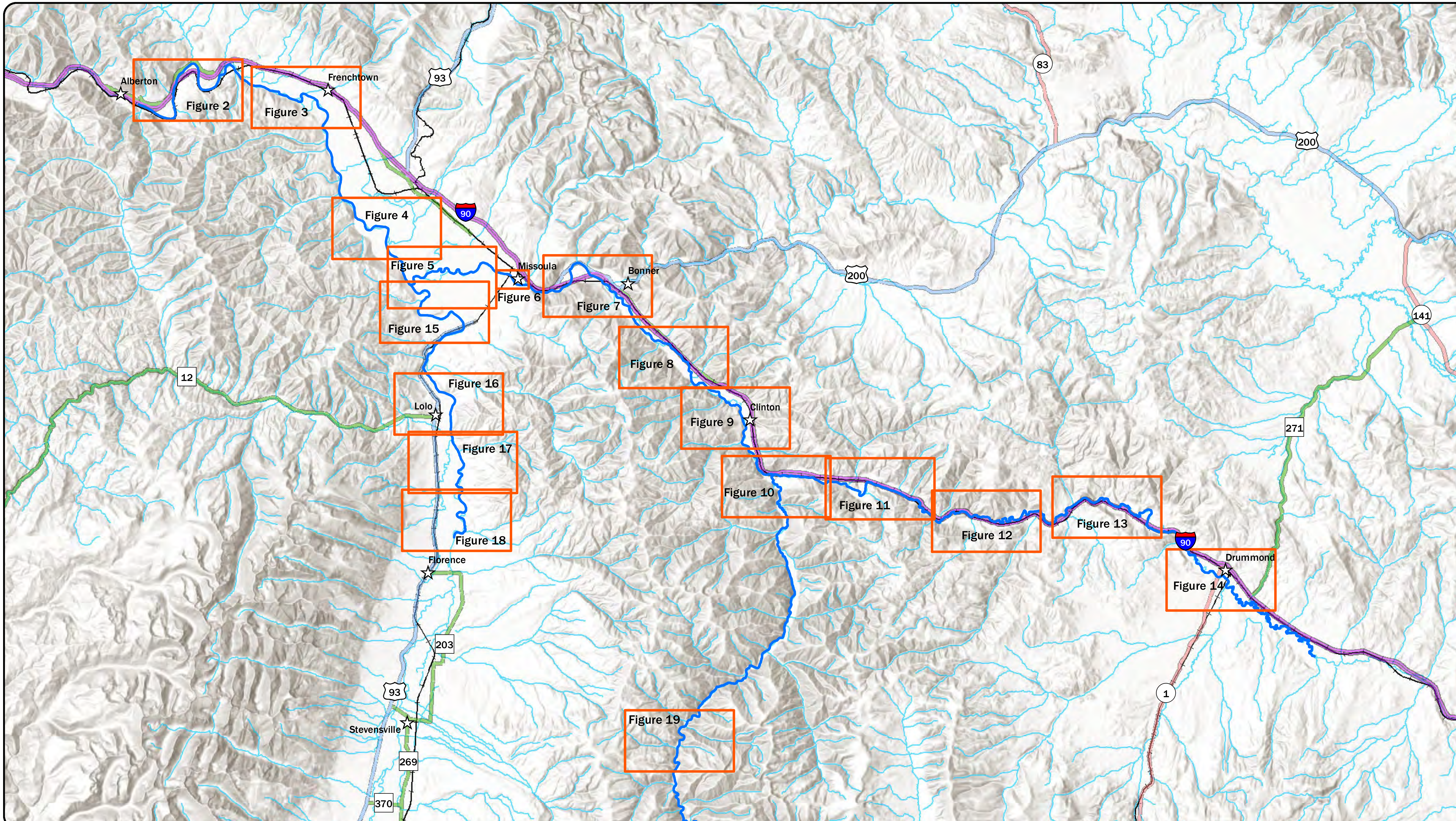
1. Perform Community Engagement and Project Outreach
2. Perform Field Survey
3. Develop Topographic Elevation Data
4. Prepare Base Map
5. Develop Hydrologic Data
6. Develop Hydraulic Data
7. Perform Floodplain Mapping
8. Develop Flood Risk Products
9. Post-Preliminary Map Production

This report documents data acquisition, processing methods, accuracy assessment, and results for the detailed hydraulic structure survey performed in October 2019 through May 2020 as part of the Perform Field Survey activity.

2 PURPOSE OF INVESTIGATION

The purpose of this investigation was to conduct a detailed hydraulic structure survey (structure survey) on the Bitterroot River, the Clark Fork River, and Rock Creek. This investigation included a hydraulic structure survey of 138 bridge structures. The study initial structure count was 144 structures. Of those 144 structures, 4 structures were not found, 1 culvert was filled with concrete and 1 structure was denied landowner access.

The DNRC has completed a Light Detection and Ranging (LiDAR) survey for all study reaches within Missoula and Granite Counties. The bathymetric survey data (conducted by others) will be combined with the LiDAR survey and structure survey information collected under this task, to support the floodplain mapping activities for the enhanced with floodway-level reaches. Figure 1 through Figure 19 show the study reach extents.



LEGEND

CITIES	NHS NON-INTERSTATE	STREAMS
FIGURE INDEX	PRIMARY	
HYDRO REACH	SECONDARY	
NHS INTERSTATE	URBAN	
	MRL RAILROAD	

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 2.5 5 10
Miles

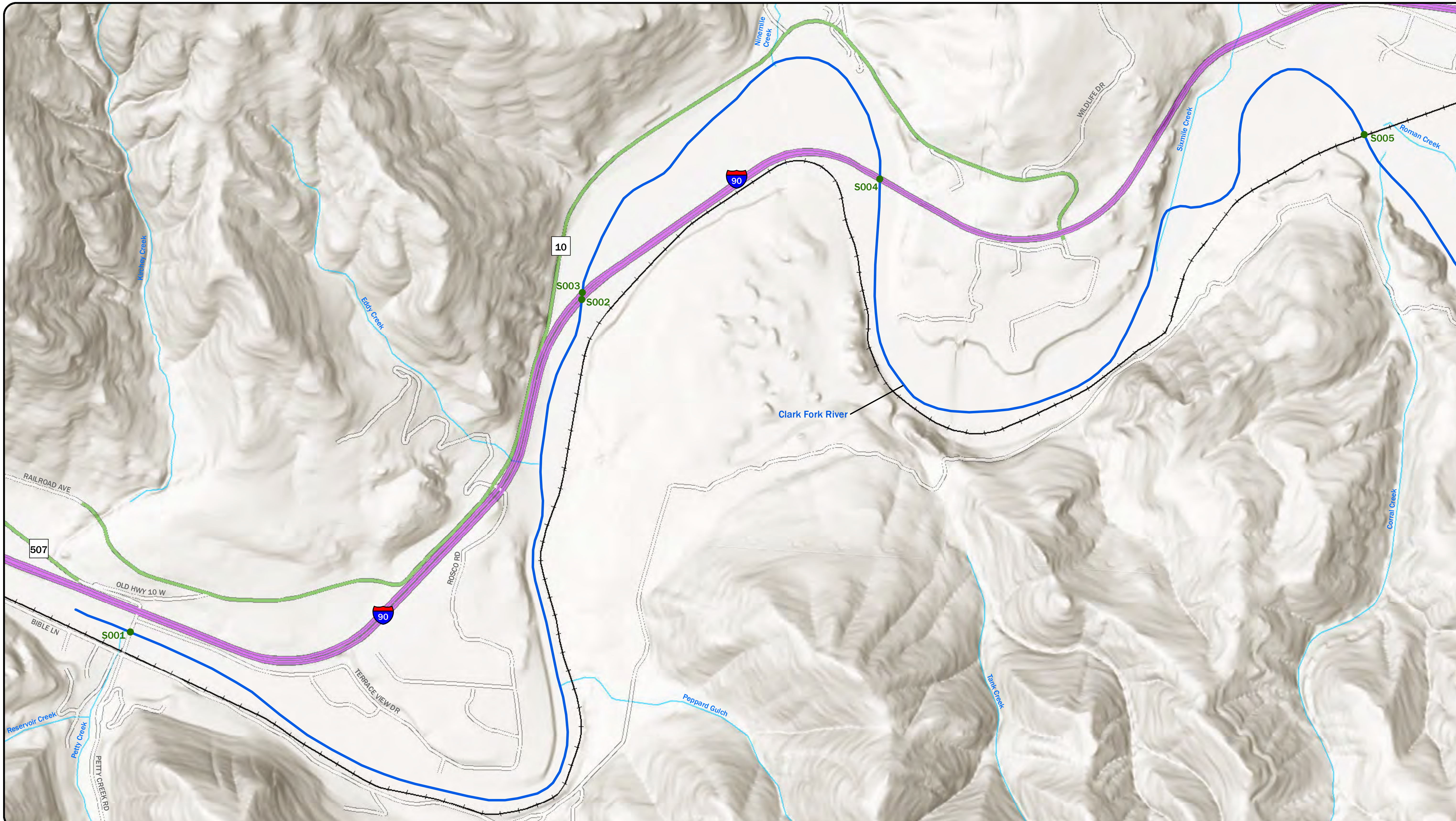
FIGURE 1

PIONEER TECHNICAL SERVICES, INC.

MISSOULA-GRANITE DETAILED STRUCTURE SURVEY FIGURE INDEX

DATE: 5/22/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-001-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (5)
- CULVERT (0)
- DIVERSION (0)
- HYDRO REACH
- NHS INTERSTATE
- SECONDARY
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

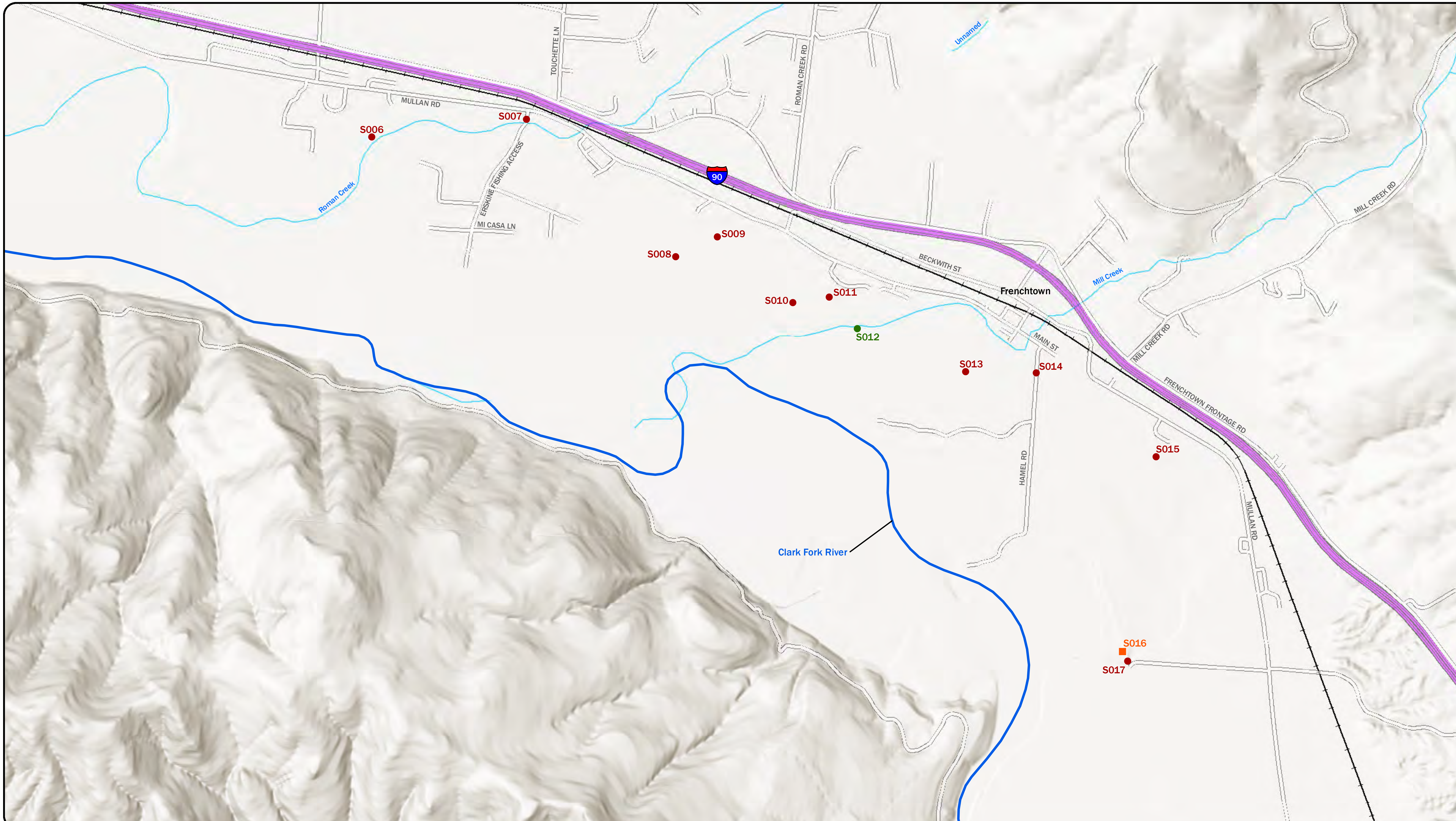
FIGURE 2

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY
STRUCTURE LOCATIONS
S001 TO S005

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (1)
- BRIDGE (1)
- CULVERT (10)
- DIVERSION (0)
- HYDRO REACH
- NHS INTERSTATE
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

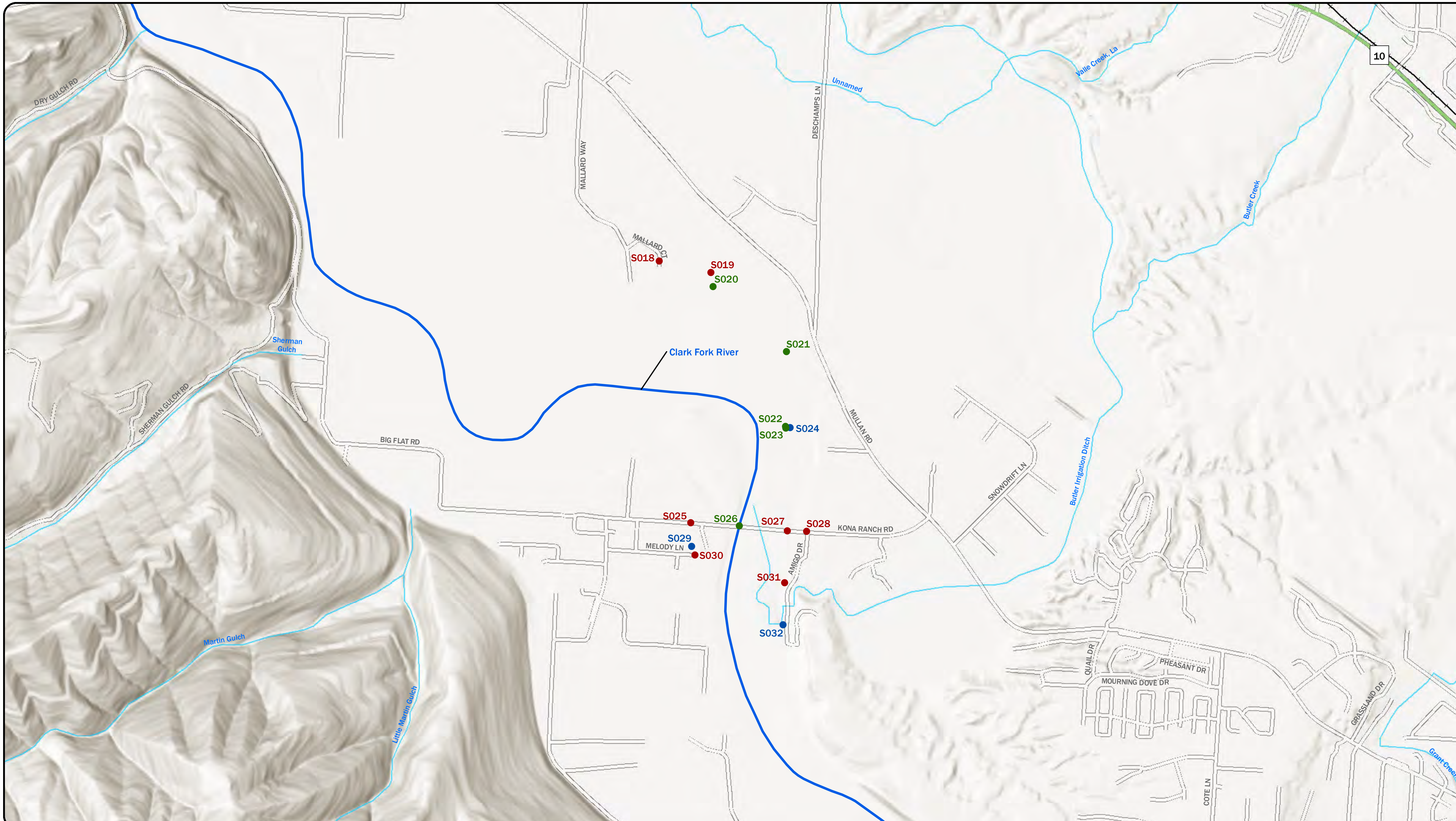
FIGURE 3

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S006 TO S017

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (5)
- CULVERT (7)
- DIVERSION (3)
- HYDRO REACH
- SECONDARY
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

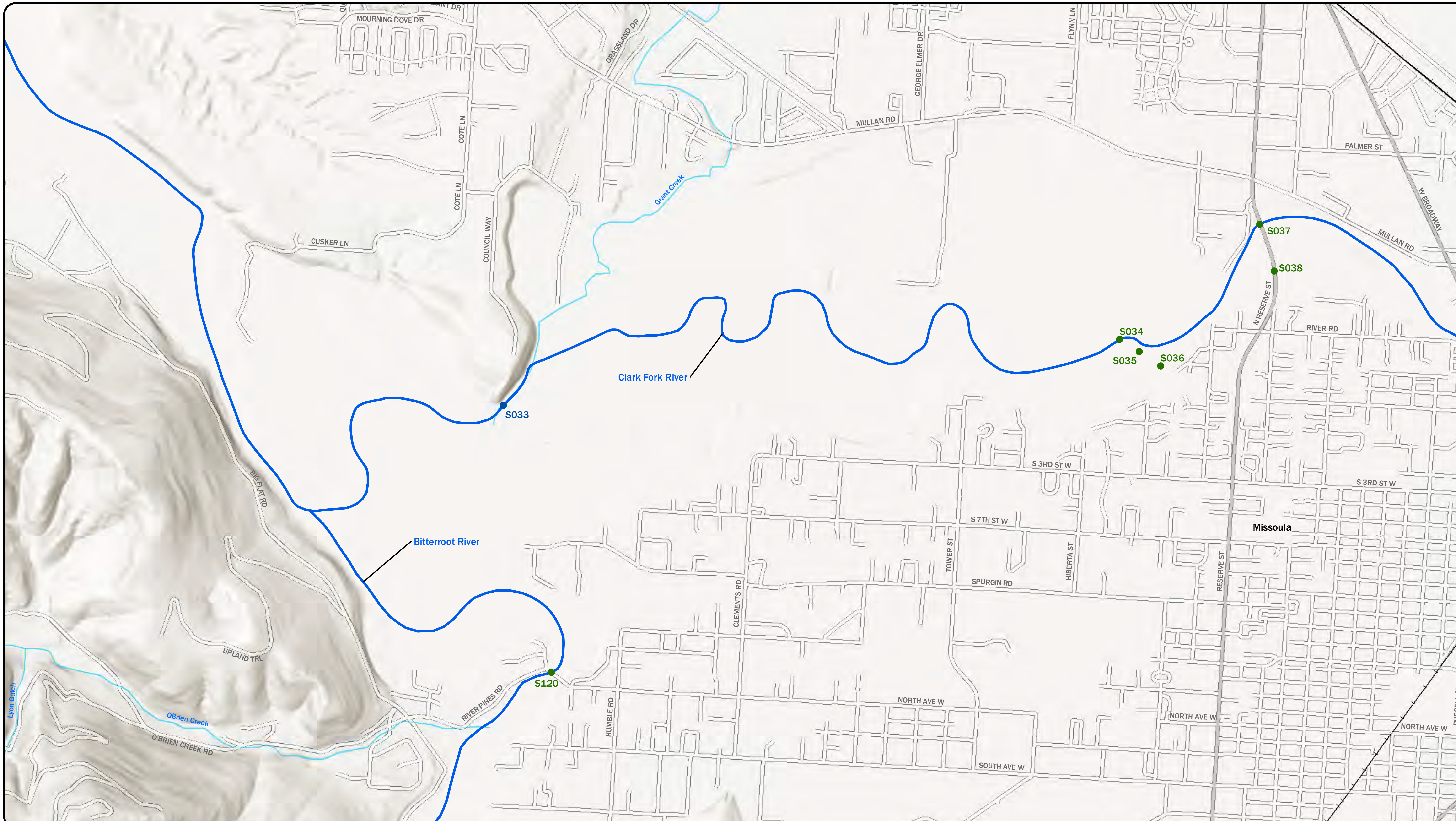
FIGURE 4

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S018 TO S032

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (6)
- CULVERT (0)
- DIVERSION (1)
- HYDRO REACH
- URBAN
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

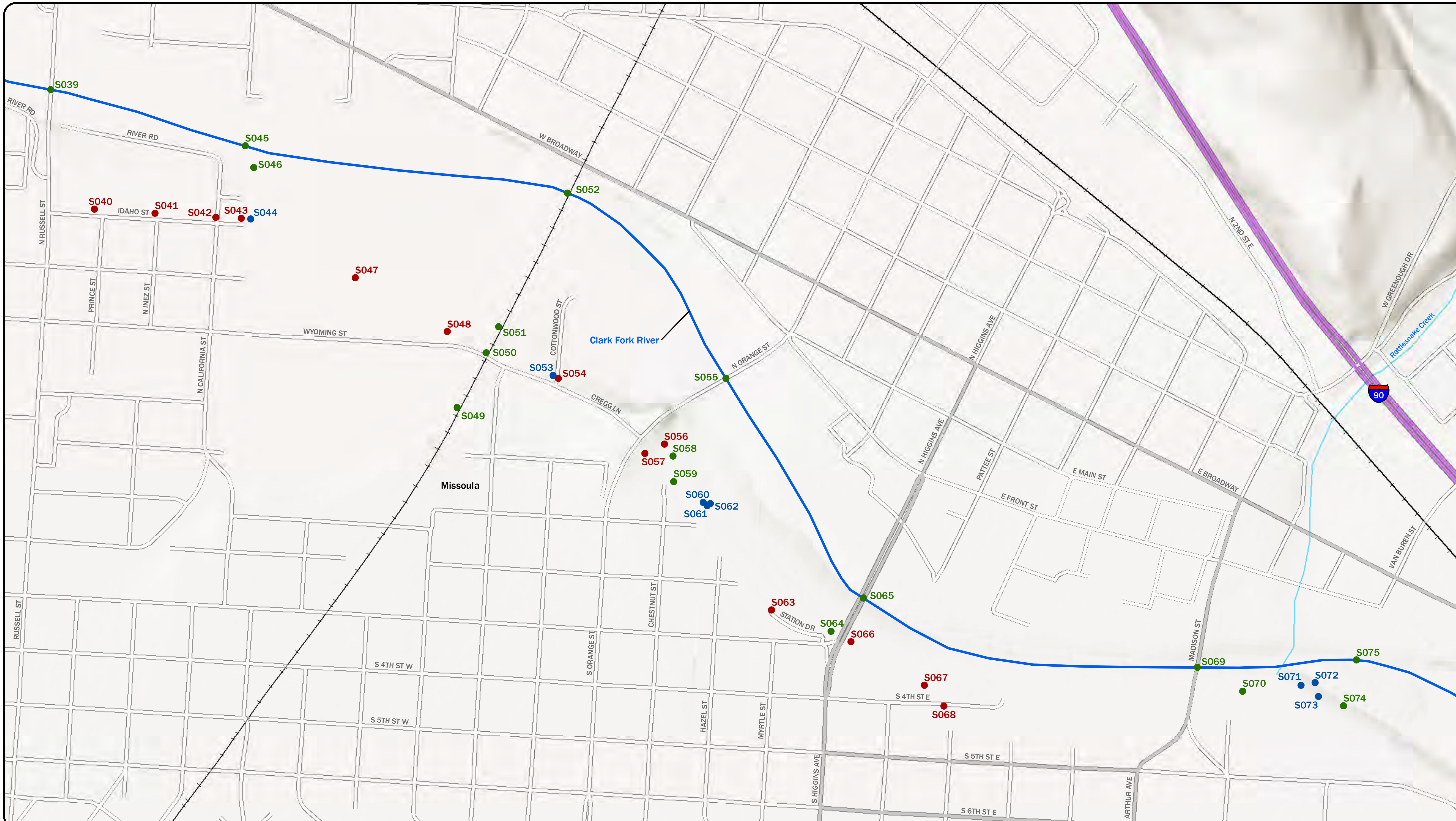
FIGURE 5

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S033 TO S038 AND S120

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (16)
- CULVERT (13)
- DIVERSION (8)
- HYDRO REACH
- NHS INTERSTATE
- URBAN
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 300 600 1,200
Feet

FIGURE 6

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S039 TO S075

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002_Fig6-20.mxd

LEGEND

NO ACCESS (0)	HYDRO REACH	CITY-COUNTY
NO STRUCTURE FOUND (1)	NHS INTERSTATE	MRL RAILROAD
BRIDGE (5)	NHS NON-INTERSTATE	STREAMS
CULVERT (0)	SECONDARY	
DIVERSION (0)	URBAN	

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

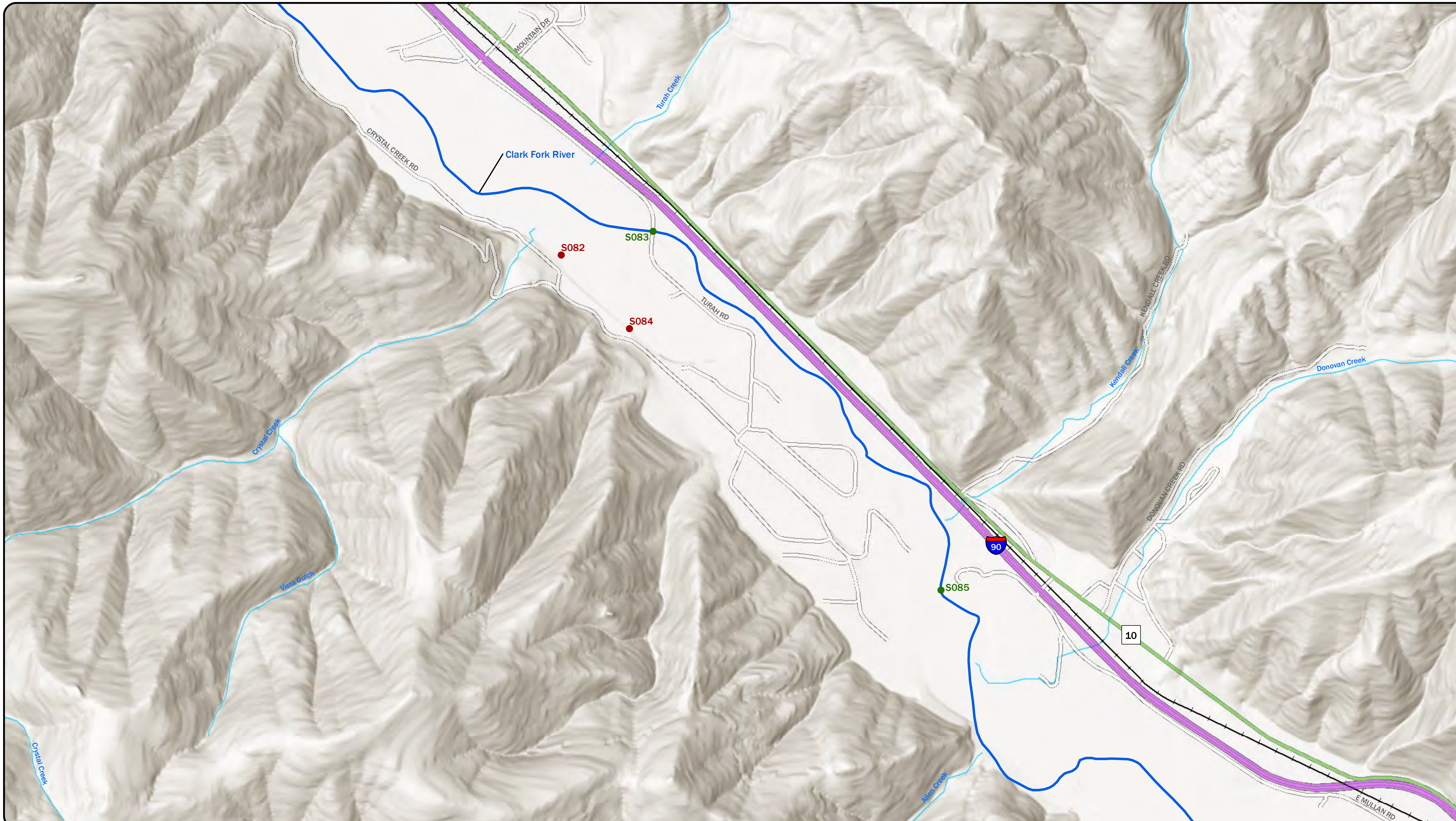
FIGURE 7

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S076 TO S081

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (2)
- CULVERT (2)
- DIVERSION (0)
- HYDRO REACH
- NHS INTERSTATE
- SECONDARY
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

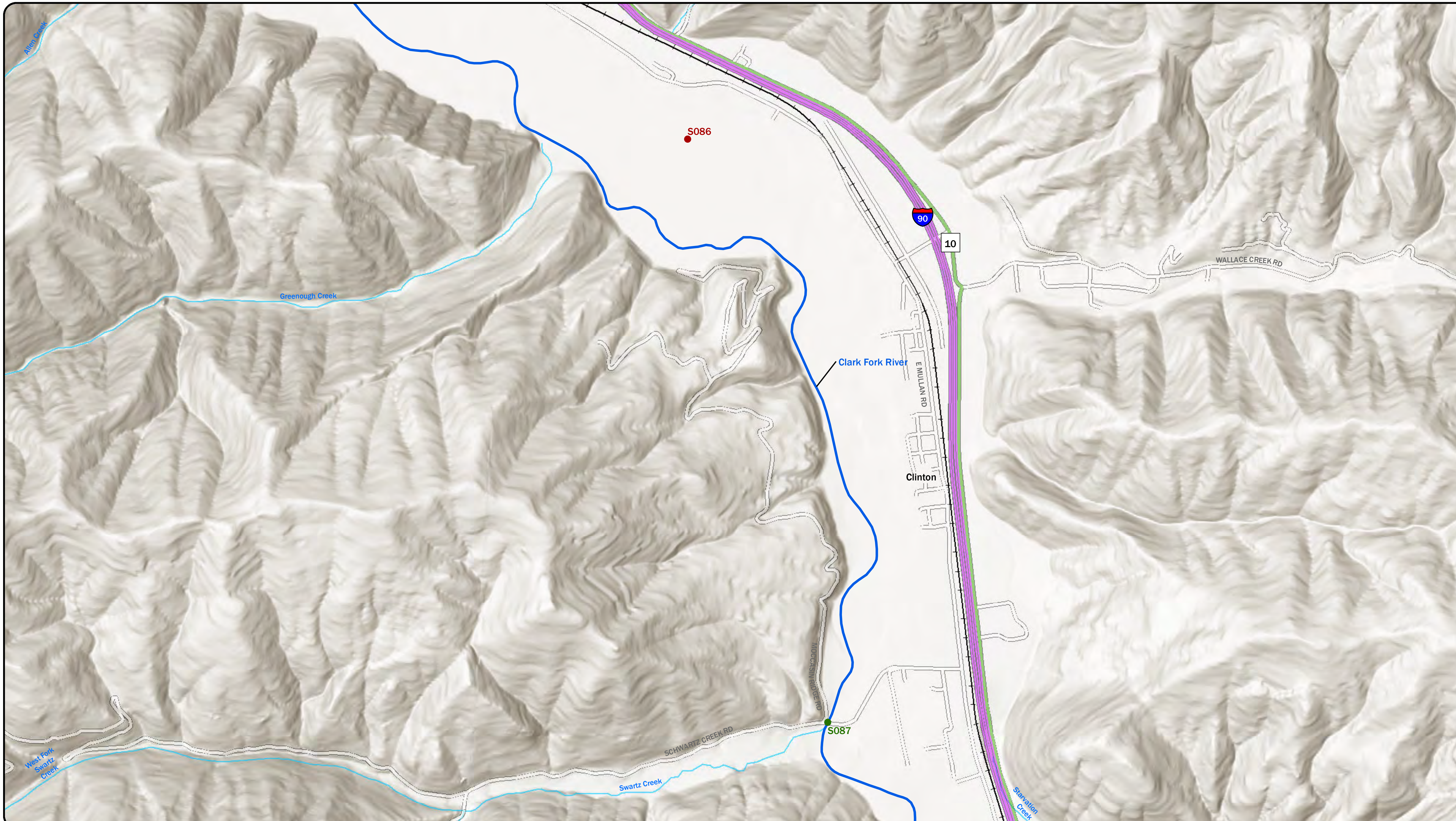
FIGURE 8

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S082 TO S085

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (1)
- CULVERT (1)
- DIVERSION (0)
- HYDRO REACH
- NHS INTERSTATE
- SECONDARY
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

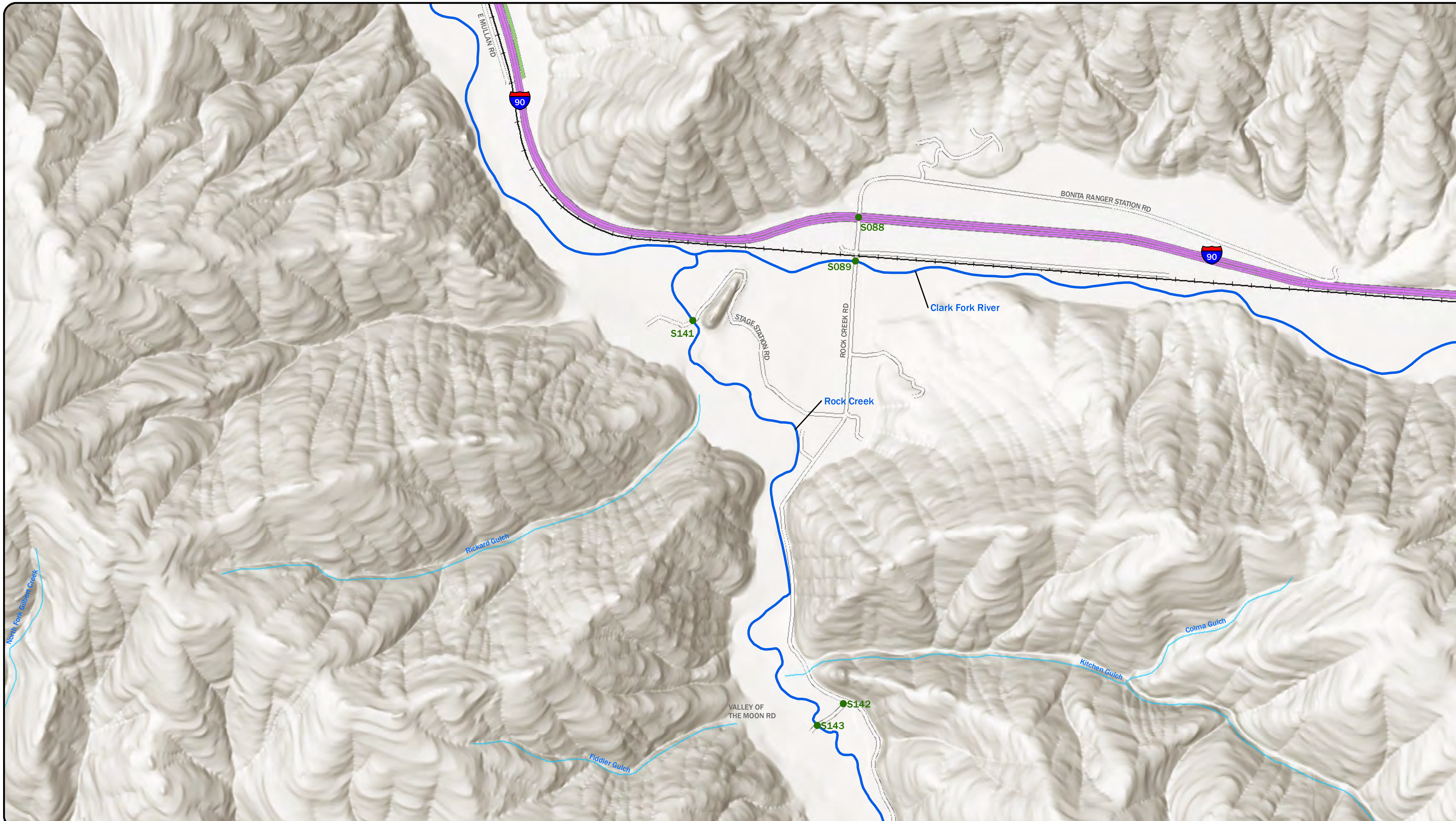
FIGURE 9

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S086 AND S087

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (5)
- CULVERT (0)
- DIVERSION (0)
- HYDRO REACH
- NHS INTERSTATE
- SECONDARY
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

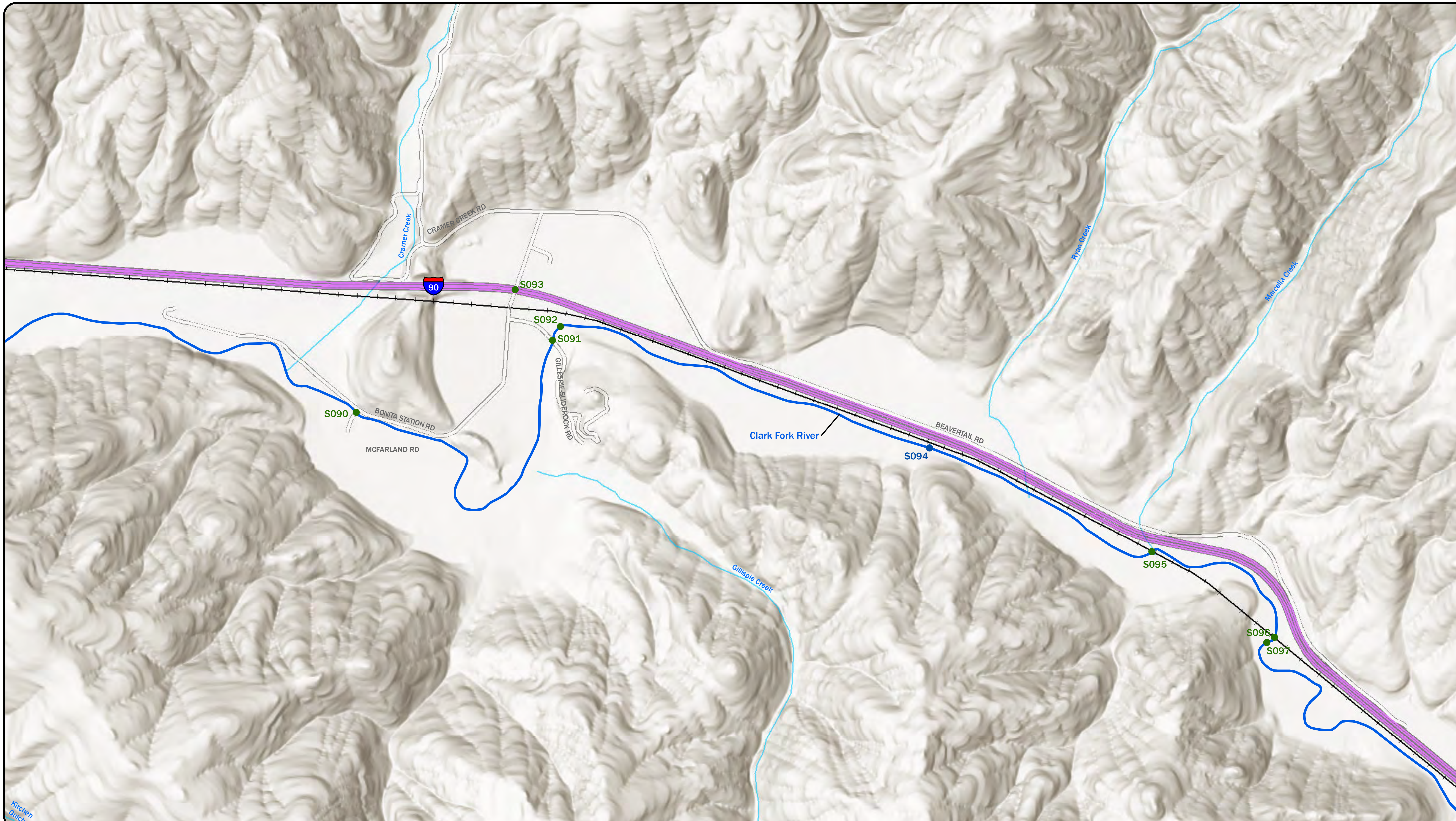
FIGURE 10

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY
STRUCTURE LOCATIONS
S088, S089, S141 TO S143

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (7)
- CULVERT (0)
- DIVERSION (1)
- HYDRO REACH
- NHS INTERSTATE
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

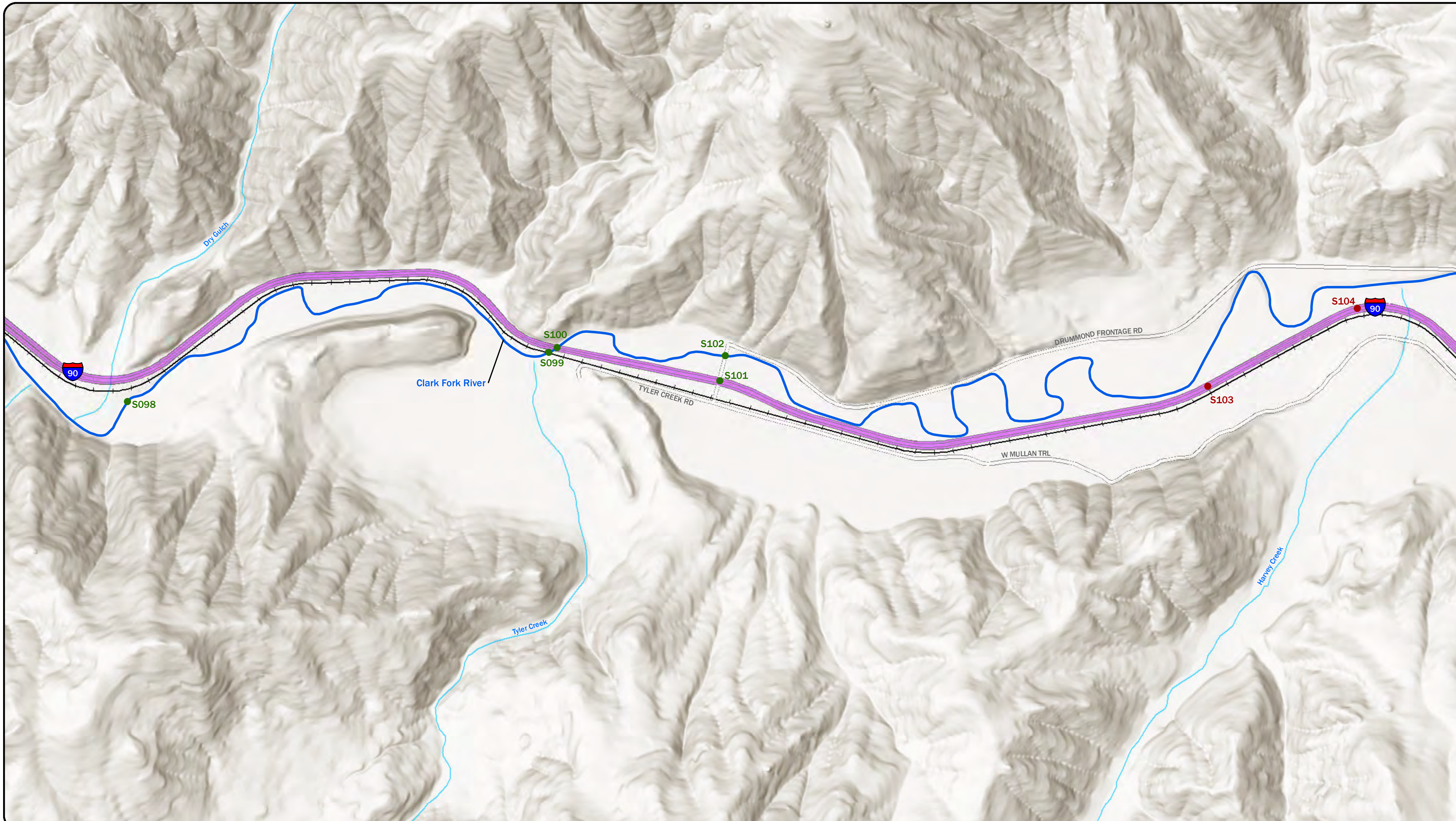
FIGURE 11

DETAILED SURVEY STRUCTURE LOCATIONS S090 TO S097

PIONEER TECHNICAL SERVICES, INC.

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (5)
- CULVERT (2)
- DIVERSION (0)
- HYDRO REACH
- NHS INTERSTATE
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

FIGURE 12

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S098 TO S104

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd

LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (4)
- CULVERT (0)
- DIVERSION (0)
- HYDRO REACH
- NHS INTERSTATE
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

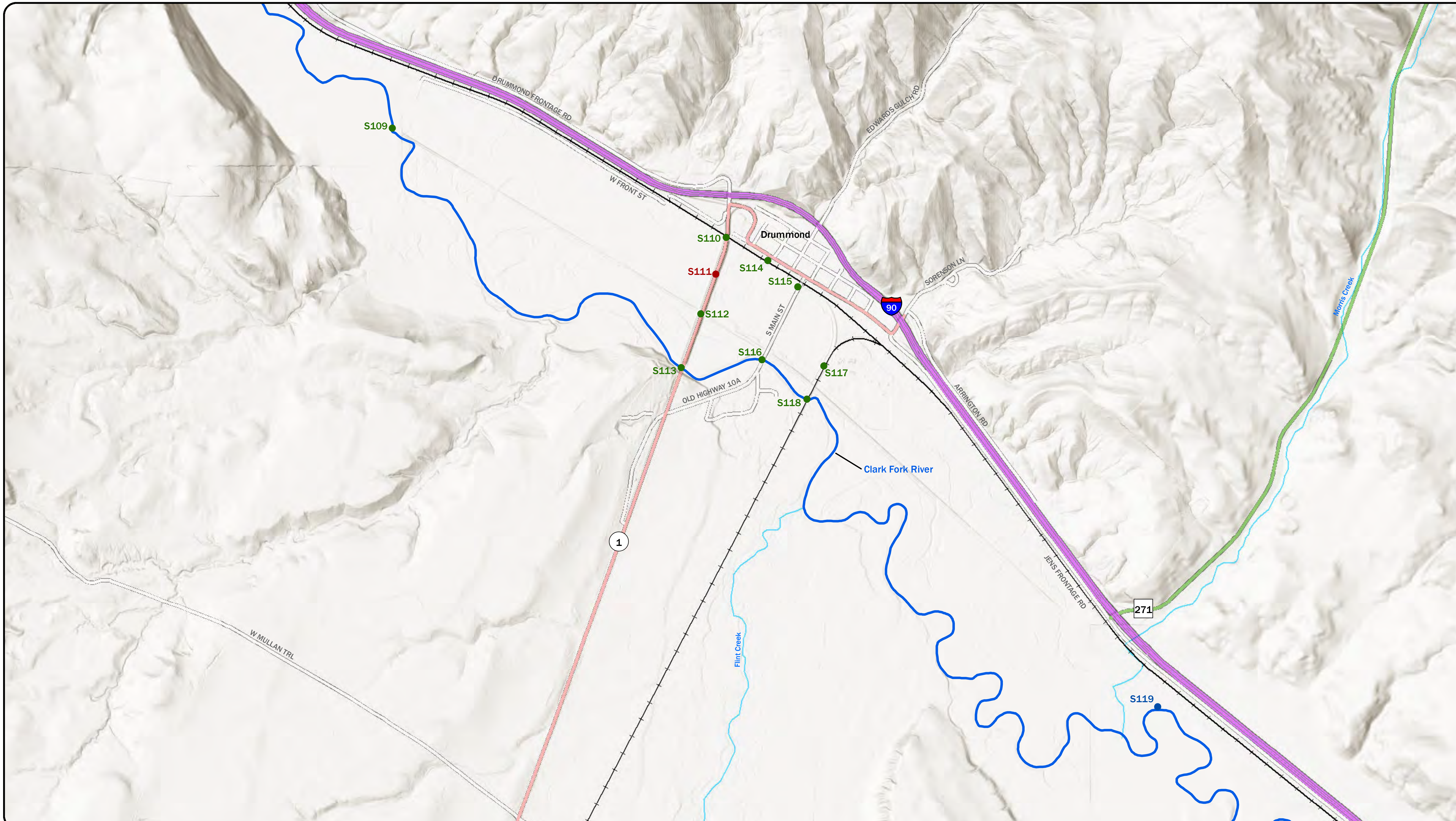
FIGURE 13

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S105 TO S108

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (9)
- CULVERT (1)
- DIVERSION (1)
- HYDRO REACH
- NHS INTERSTATE
- PRIMARY
- SECONDARY
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

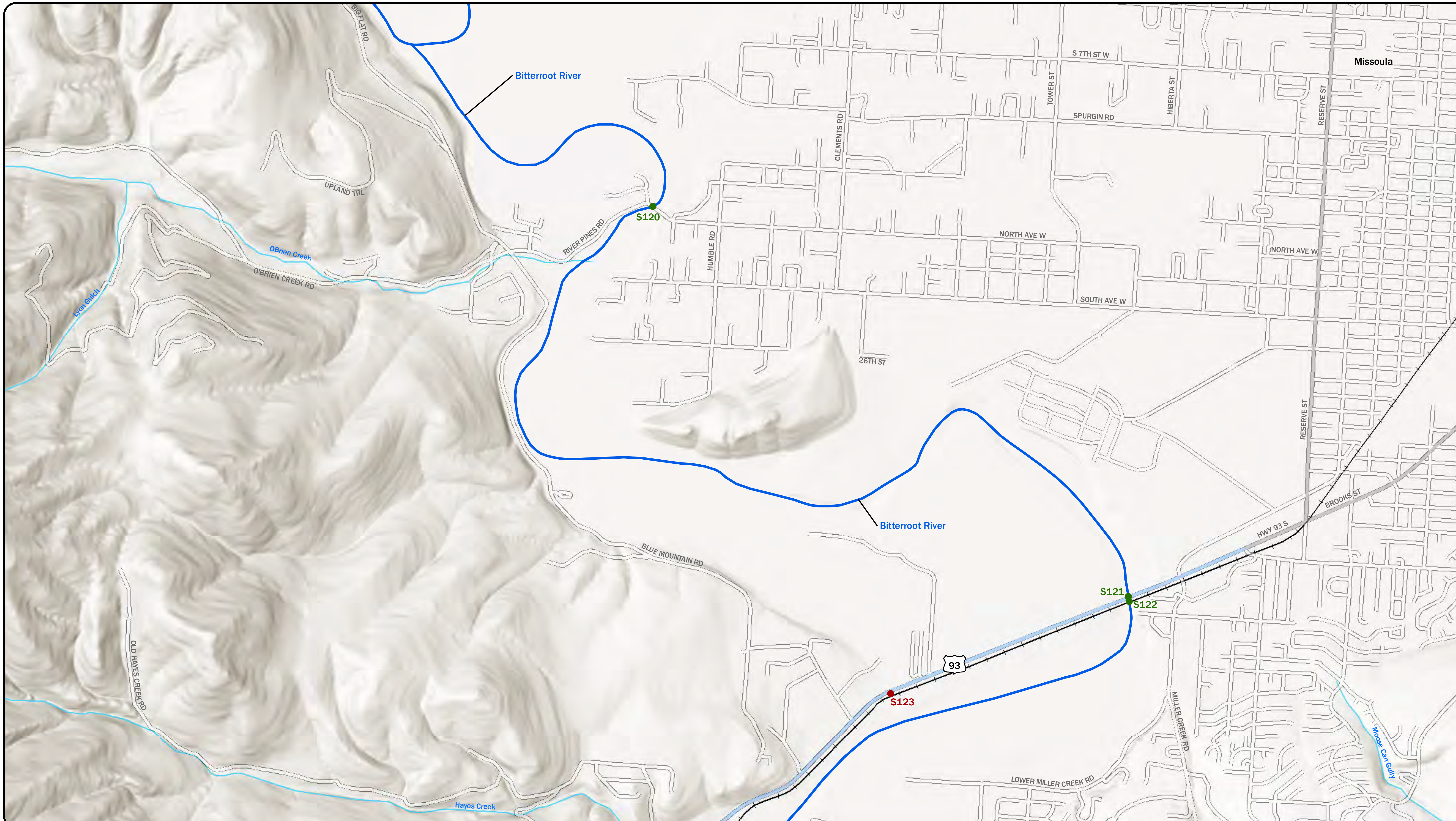
FIGURE 14

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S109 TO S119

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND
- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (3)
- CULVERT (1)
- DIVERSION (0)
- HYDRO REACH
- NHS NON-INTERSTATE
- URBAN
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

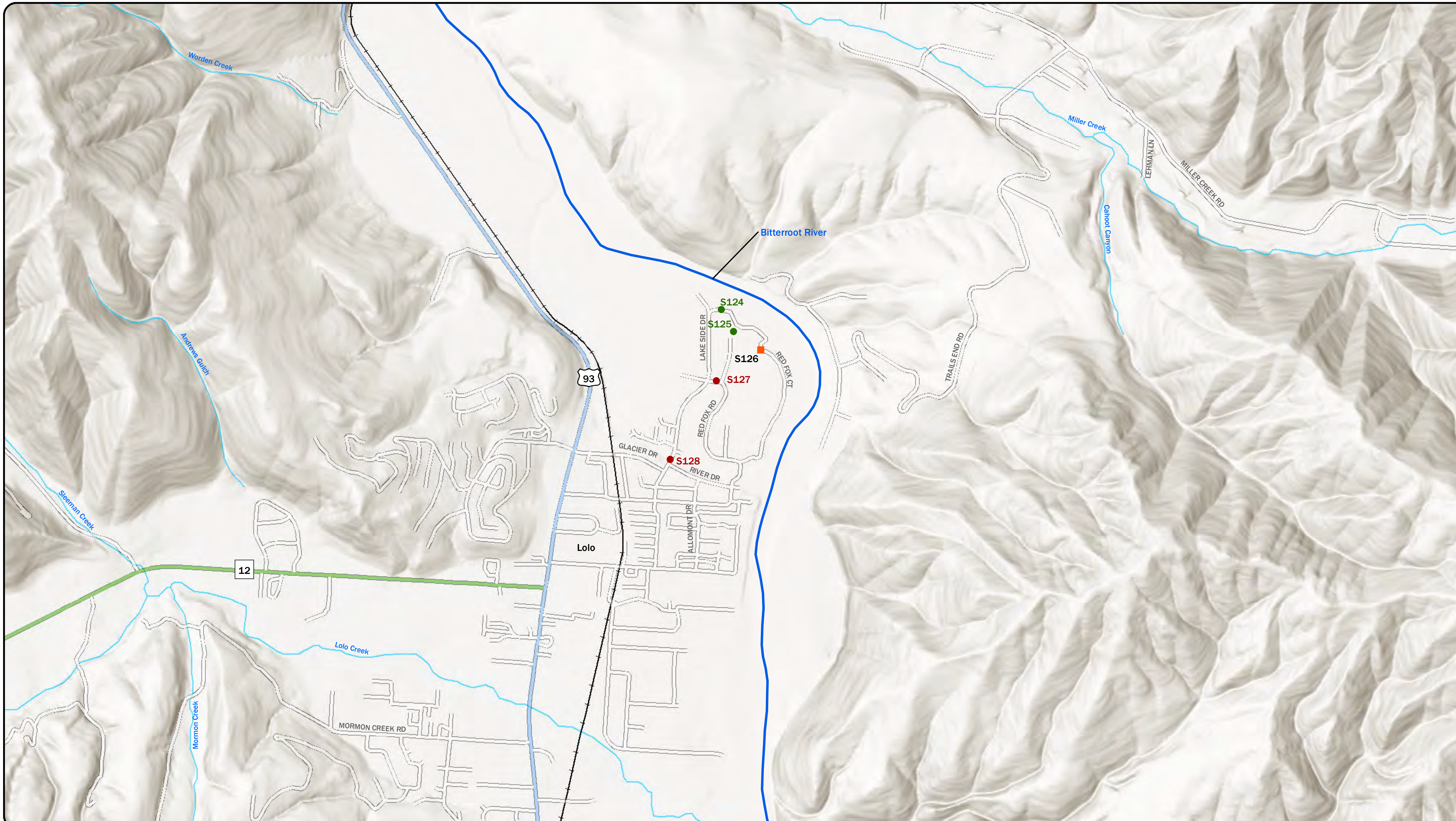
FIGURE 15

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S120 TO S123

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- ■ NO ACCESS (0)
- ■ NO STRUCTURE FOUND (1)
- ● BRIDGE (2)
- ● CULVERT (2)
- ● DIVERSION (0)
- HYDRO REACH
- NHS NON-INTERSTATE
- SECONDARY
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

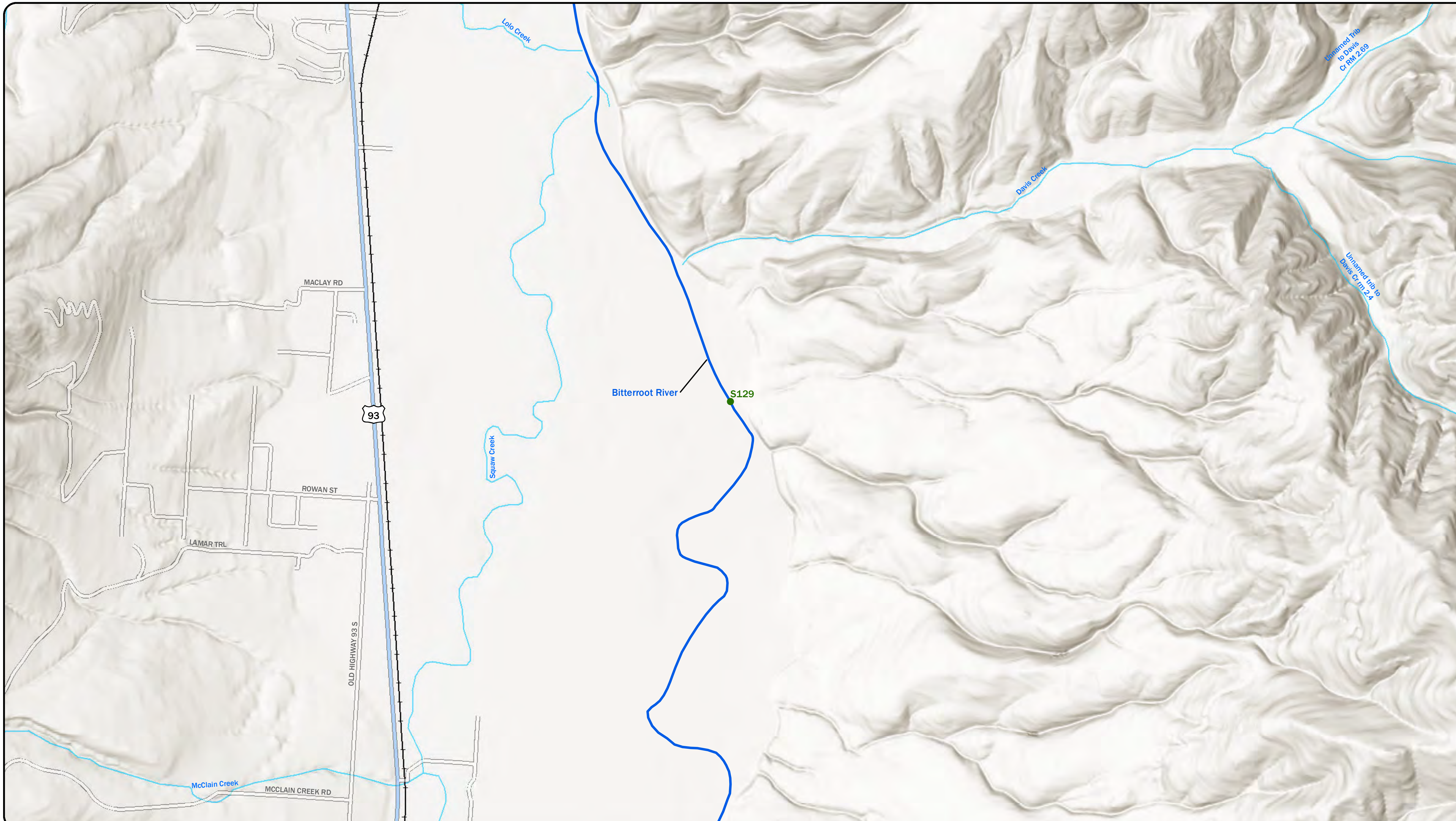
FIGURE 16

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY
STRUCTURE LOCATIONS
S124 TO S128

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (1)
- CULVERT (0)
- DIVERSION (0)
- HYDRO REACH
- NHS NON-INTERSTATE
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

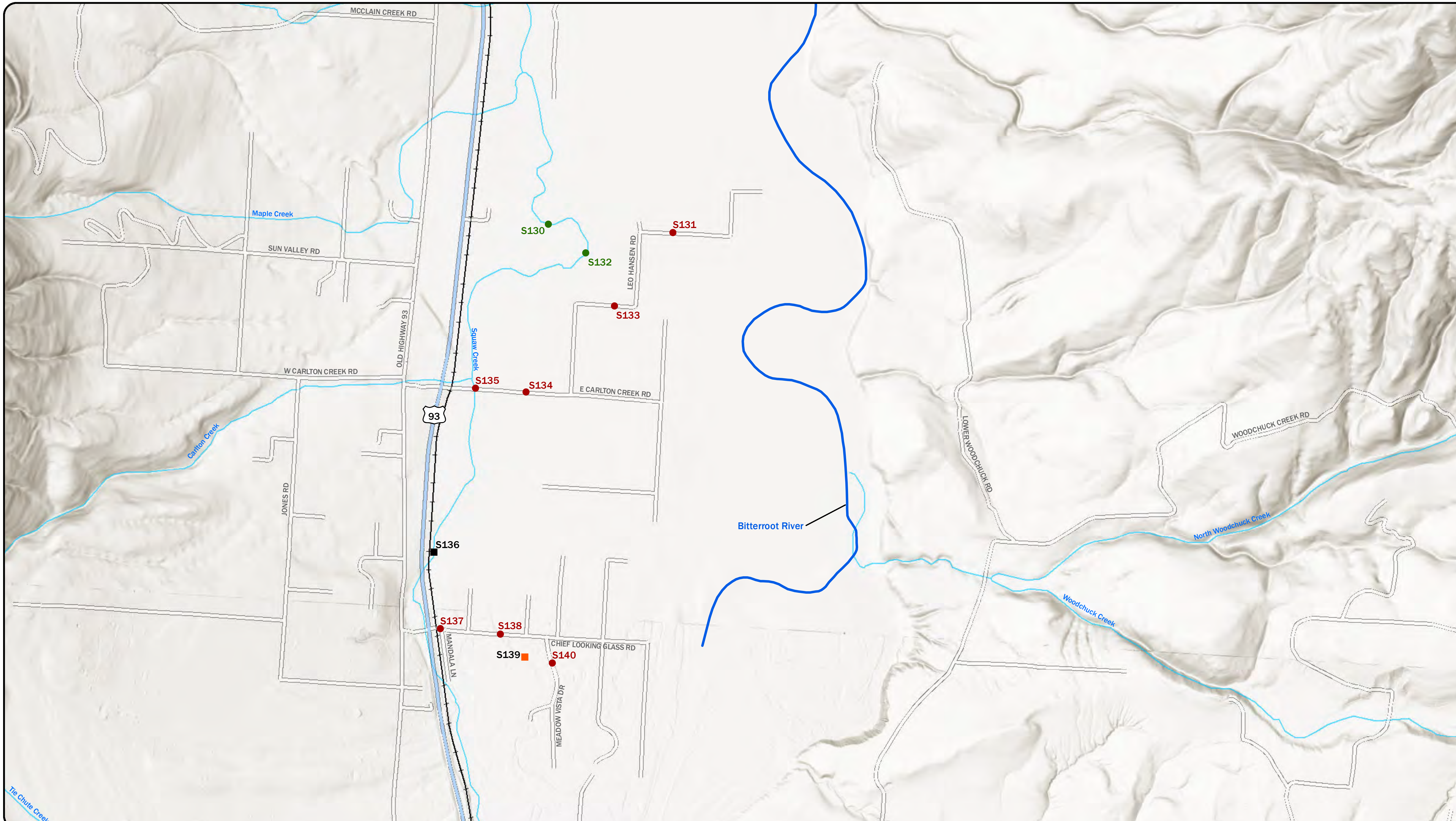
FIGURE 17

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS
S129

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd



LEGEND

- NO ACCESS (1)
- NO STRUCTURE FOUND (1)
- BRIDGE (2)
- CULVERT (7)
- DIVERSION (0)
- HYDRO REACH
- NHS NON-INTERSTATE
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

FIGURE 18

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS S130 TO S140

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd

LEGEND

- NO ACCESS (0)
- NO STRUCTURE FOUND (0)
- BRIDGE (1)
- CULVERT (0)
- DIVERSION (0)
- HYDRO REACH
- CITY-COUNTY
- MRL RAILROAD
- STREAMS

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 1,000 2,000 4,000
Feet

FIGURE 19

PIONEER TECHNICAL SERVICES, INC.

DETAILED SURVEY STRUCTURE LOCATIONS
S144

DATE: 5/27/2020

Path: Z:\Shared\Active Projects\DNRC\Missoula-Granite\GIS\StructureSurvey\MSAGNT-SU-PLN-002-20.mxd

3 METHODOLOGY

The survey work was conducted by Pioneer Technical Services, Inc. (Pioneer) between October 2, 2019, and May 21, 2020. The survey team was led by David Wilson (PLS) and included Mark Stratton (LSIT), Dan Reiss (Civil Technician), Jared Cooper (Staff Engineer), Mason Bowditch (Staff Engineer), and Talon Pallister (Staff Engineer).

3.1 Control Survey

The following instrumentation and methodologies were used to establish the survey control network used in the structure survey.

3.1.1 Control Survey Instrumentation

Trimble R8 Model 3 GNSS (R8) receivers were used during both static and Real Time Kinematic (RTK) Global Positioning System (GPS) applications. The R8 can receive satellite signals from all available satellites, and when using RTK GPS procedures it provides a 10 millimeter (mm) + 1 part per million (ppm) horizontal accuracy and a 20 mm + 1 ppm vertical accuracy. This receiver is used in tandem with the Trimble TSC3 data collector running Trimble Access Software. This software allows a seamless transition between GPS and conventional surveying.

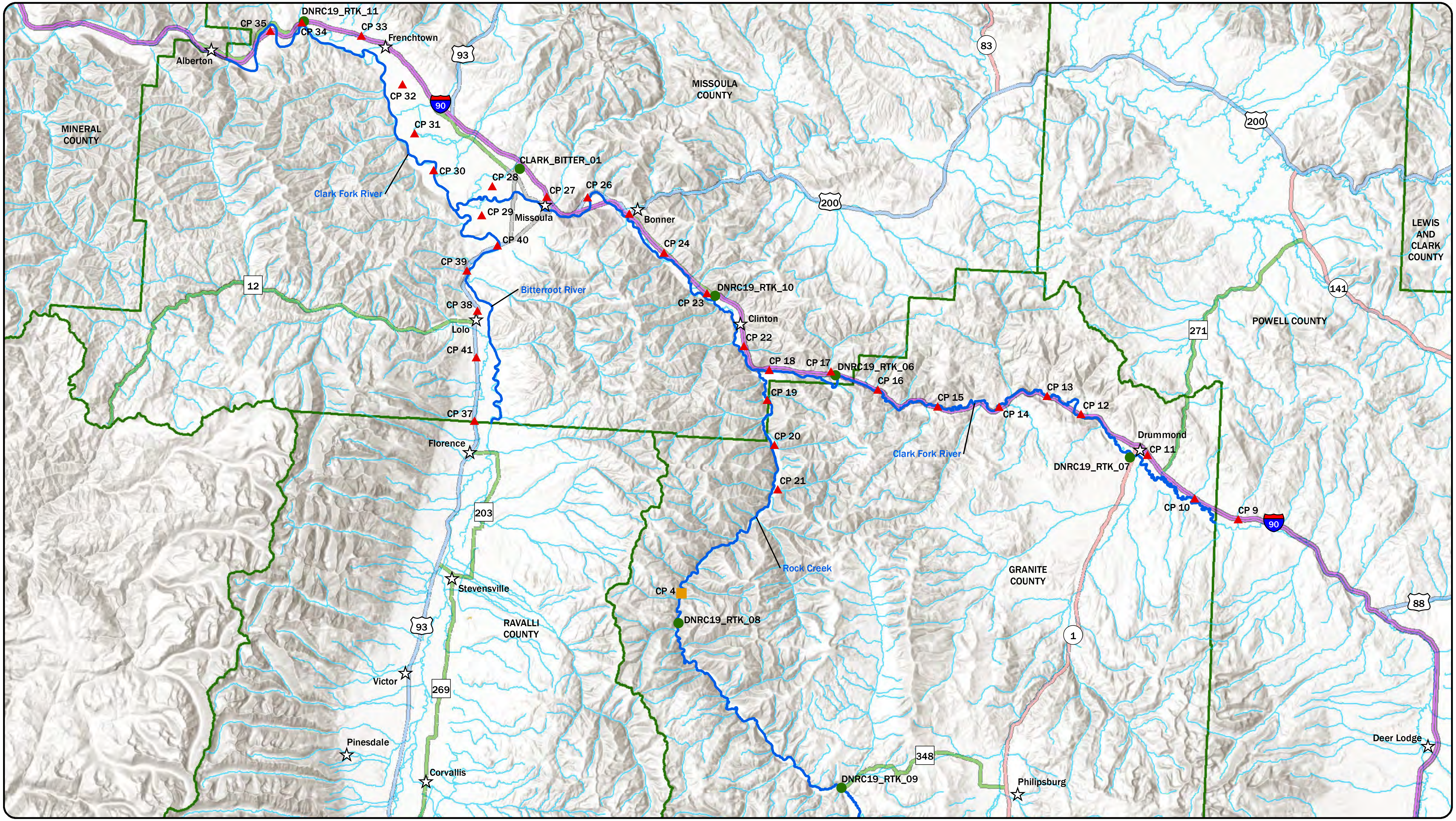
3.1.2 Control and Monumentation

The initial project control survey was conducted by Quantum Spatial (QSI) and DOWL. The QSI survey established 7 survey monuments, using Continuously Operating Reference Stations (CORS) MSOL and MTUM, to be used as ground control points during LiDAR data acquisition.

Each QSI monument consisted of a 6-inch nail driven flush with the ground. These ground control points were derived using multiple independent static sessions, National Geodetic Survey (NGS) Online Positioning User Service (OPUS) corrected surveys.

DOWL used 3 QSI control points and established 32 additional survey control points to support bathymetric survey data collection in Granite and Missoula Counties. The 32 DOWL control points were marked using a 5/8-inch by 24-inch rebar with a 2-inch aluminum cap. The DOWL control points were established using 1 or more, 2-hour or longer static observations from CORS MSOL and MTUM.

The QSI and DOWL survey reports are provided in Appendix A. Figure 20 shows the survey control point locations used in this hydraulic structure survey report.



LEGEND

- ▲ DOWL CONTROL
- ■ PIONEER CONTROL
- ● QSI CONTROL
- ☆ CITIES
- HYDRO REACH
- NHS INTERSTATE
- NHS NON-INTERSTATE
- PRIMARY
- SECONDARY
- URBAN
- COUNTY BOUNDARIES

N

DISPLAYED AS:
PROJECTION/ZONE: MONTANA STATE PLANE
DATUM: NAD1983 (2011)
UNITS: INT'L FEET
SOURCE: DNRC/MSL/PIONEER

0 3 6 12
Miles

FIGURE 20

MISSOULA-GRANITE DETAILED SURVEY CONTROL POINTS

PIONEER TECHNICAL SERVICES, INC.

DATE: 5/22/2020

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Pioneer established 1 additional survey control point using two, 4-hour or longer, static OPUS-corrected observations. The location of this additional control point provided a shorter baseline for RTK GPS procedures, which helps reduce the ppm error associated with long baselines.

Pioneer's survey control point was marked with an 18-inch spike and topped with a 2-inch aluminum cap. Figure 21 shows an example of a typical monument set by DOWL and Pioneer.

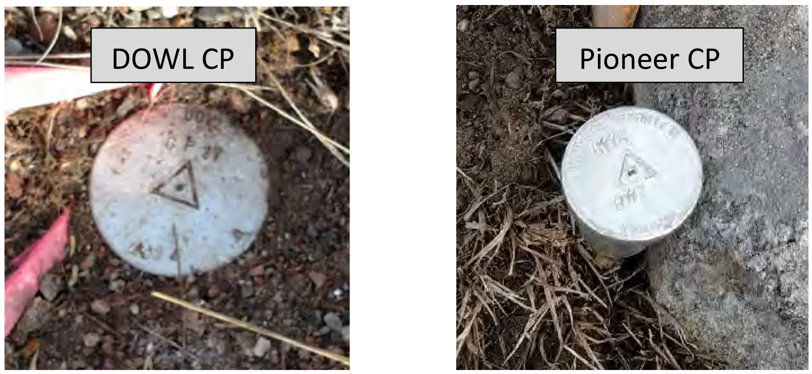

Figure 21 Typical Control Monuments Used

3.1.3 Methodology

Pioneer occupied 23 of the 32 DOWL survey control points to perform the structure survey. A Trimble R8 Model 3 GNSS receiver atop a fixed height tripod was set above a DOWL control point monument to verify the position of 9 out of the 23 total DOWL survey control points used by Pioneer. The receiver was placed in static mode and set to record measurements every 30 seconds. Each observation event was a minimum 4.0-hour session. Each session was sent to the NGS OPUS for post-processing to the existing CORS. The independent sessions were processed with a RMSE of Northing 0.04 ft (1.2 centimeters [cm]), Easting 0.02 ft (0.06 cm) and elevation 0.13 ft (4.0 cm) between the DOWL control point data and the Pioneer static observation data.

Pioneer control point CP4 was established using two, 4-hour static, OPUS-corrected positionings and averaging the results. The independent sessions were processed with a maximum horizontal difference of 0.05 feet (1.5 cm) or less and 0.00 feet (0.0 cm) vertically.

Control coordinate comparisons are provided in Appendix B.

3.2 Field Survey

The following instrumentation and methodologies were used to acquire data for the structure survey. All survey data were collected relative to the following coordinate system, data, and units: Montana State Plane, North American Datum (NAD) 83 (2011) International feet, and North American Vertical Datum (NAVD) 88 US feet.

3.2.1 Instrumentation

The Trimble R8 GNSS Model 3 receiver described in Section 3.1.1 was used for the structure survey. Additionally, a Trimble S7 Robotic Total Station was used for the structure survey where terrain and conditions required. The S7 employs robotic technology allowing for perfect alignment on the target prism, essentially eliminating pointing error. Once the S7 is set up and running, it follows the 360-degree prism automatically. Each visible point is collected using only one person. For applications where a desired shot is unreachable or unsafe to physically occupy, the S7 can be switched to direct reflector mode. The instrument is pointed directly at the target and measured remotely. This direct reflector mode produces errors of 2 mm + 2 ppm.

Both pieces of equipment were used in tandem with the Trimble TSC3 data collector running Trimble Access Software. The information was imported and reduced using Trimble Business Center Software.

3.2.2 Methodology

3.2.2.1 Structure Survey

The RTK GPS and conventional techniques were used to collect the bridge structure data. RTK surveying was used on all bridge/structure features that were accessible by foot and where satellite signals were present. All other bridge/structure features were surveyed conventionally with the total station. Typically, 2 secondary control points were established using the RTK GPS near the bridge location: 1 upstream of the bridge and the other downstream. The total station was then placed over 1 secondary control point and a back-sight check was completed on the other control point to ensure the accuracy of the secondary control. This process was repeated for points on the opposite side of the bridge.

Most points were collected using the 360-degree prism; however, when it proved more efficient, the reflector-less technology was employed. Typically, this was while collecting the Low Chord points on the underside of the bridge/structure and while collecting pier data. Pioneer crews were able to aim the instrument directly at the structure feature target and measure a position. Points were stored using codes compliant with FEMA data capture guidance workflow details (FEMA, 2019).

In some instances, the structures that were surveyed included culverts to convey flow. At these types of structures, the field crew collected data at relevant locations on the structure including the top of the culvert at the centerline. Culvert Invert elevations were also collected if possible, using RTK. The field crews recorded relevant culvert information and measured relevant dimensions (i.e., diameter, span, and distance to invert) so that culvert sizes, types, and invert elevations could be identified.

Information on both the upstream and downstream faces of the structure was collected. Bridge widths are defined as the horizontal distance of the structure perpendicular to traffic, and bridge spans are defined as the horizontal distance between abutments/piers, as shown on the bridge drawings.

3.2.3 Accuracy Verification

3.2.3.1 Field Survey

Different levels of accuracy can be achieved using RTK GNSS procedures. Pioneer exercises a rigorous standard practice to ensure that topographic data are collected at an accuracy level of ±0.16 (5 cm) feet horizontally and ±0.16 (5 cm) feet vertically. Our standard of practice is as follows:

1. Initial quality control: All Pioneer projects use a known control point or a point whose position has been established using the NGS OPUS. "*OPUS solutions using 2 hours or more of static GPS data yield a RMSE of 0.8 cm (0.03'), 2.1(0.07'), and 3.4 cm (0.11') in the north, east and up components of the derived positional coordinates, respectively. Results drastically improve for solutions containing 3 hours or more of GPS data*."[1]

   DOWL's ground control point values were used to ensure consistency with the bathymetric survey data that DOWL collected and the QSI LiDAR survey control network.

   Pioneer checked CP11, CP14, CP17, CP19, CP25, CP26, CP27, CP28, and CP35 with static, OPUS-corrected positioning.

   Each session was sent to the NGS OPUS for post-processing to the existing CORS. The independent sessions were processed with a RMSE of Northing 0.04 ft (1.2 centimeters [cm]), Easting 0.02 ft (0.06 cm) and elevation 0.13 ft (4.0 cm) between the DOWL control point data and the Pioneer static observation data.

2. Receivers are set to not record with Positional Dilution of Precision greater than 6.0 (values over 6.0 generally produce low confidence level results).

3. Receivers are set to not record measurements from satellites lower than 10 degrees below the horizon (signals received from satellites lower on the horizon introduce more error due to refraction through the earth's atmosphere).

4. Receivers are set to not collect any measurement that is not based on a fixed solution (a float solution is not a reliable solution and reduces accuracy).

[1] Accuracy of OPUS solutions for 1- to 4-h observing sessions, http://www.ngs.noaa.gov/CORS/Articles/OPUSGPSSol.pdf.

5. Receivers are set to not collect any measurement that has a higher than 5 cm (0.16 ft) root mean square (RMS) value horizontally or vertically (typical measurements are well within this range and this value represents the most inaccurate position collected).

6. Baselines are kept at less than 5.0 miles (this limits the ppm degradation to an acceptable level, typically less than 0.10 feet vertically).

7. A check tie is performed on another control point. Work does not proceed unless an acceptable value is achieved (less than 5 cm (0.16 ft).

8. A check tie was performed on Pioneer ground control point CP4 by running a fast-static observation from DOWL control point CP19 to CP4. The fast-static-measured value was equal to or less than a maximum horizontal difference of 0.09 feet (2.7 cm) or less and 0.08 feet (2.4 cm) vertically.

4 RESULTS

4.1 Structure Survey

Figure 1 through Figure 19 show the overall locations of the 138 surveyed structures. Appendix D provides plan and profile surveyed bridge structure figures. The profiles provide the upstream bridge face survey shots. LiDAR was used to show the water surface if applicable. It should be noted that the Pioneer team completed a detailed review of the study area along the Clark Fork River, the Bitterroot River, and Rock Creek prior to fieldwork to locate all structures and identify ownership in the study area. The team first identified hydraulic structure types and locations from aerial imagery and information provided by DNRC. Numbering began at the downstream extent of the study reach and progressed upstream. Structures located on "Enhanced without Floodway" study reaches have been inventoried as part of a separate hydraulic structure inventory report and are therefore not surveyed as part of this report.

Field photographs of the structures are provided in Appendix E. Digital data for the structure survey are provided as a separate work product. The structural survey data included in this report can be used to conduct detailed hydraulic modeling of the bridge, culvert, and diversion structures to support Enhanced with Floodway level floodplain studies.

5 REFERENCES

FEMA, 2019. Guidance for Flood Risk Analysis Mapping Data Capture – Workflow Details. Federal Emergency Management Agency. February 2019. Available at

https://www.fema.gov/media-library-data/1556723016888-db56f22acada9046862b968b44e86b8f/Data_Capture_Guidance_Workflow_Details_Feb_2019.pdf.

6 Quality Assurance/Quality Control

QA/QC Task Description	Reviewer\Date	Date
Conformance with FEMA guidelines and standards	Jacob Ulgenes	05-22-20
Daily survey control checks not greater than 5cm (0.16 ft).	David Wilson	05-22-20
Project control cross-ties to verify final control accuracy	David Wilson	05-22-20
Metadata xml file	Jon Jupka	05-22-20
Correspondence folder	Jon Jupka	05-22-20
Feature coding	Jacob Ulgenes	05-22-20
Photos folder	Jacob Ulgenes	05-22-20
Survey/supplemental folder	George Austiguy	05-22-20