SOILS AND FOUNDATIONS
REPORT NO. 06-19

PROJECT WY FLAP FREMO 77(1)
WIGGINS FORK BRIDGE REPLACEMENT

FREMONT COUNTY, WYOMING

U.S. Department of Transportation
Federal Highway Administration
Eastern Federal Lands Highway Division
21400 Ridgetop Circle
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Note: Design changes subsequent to the publication of this report and prior to the project's advertisement will be documented by a memo inserted after the title page.

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Introduction

1.1 General

This report presents the results of the subsurface exploration, laboratory testing, and geotechnical analysis and provides our evaluations and recommendations for the replacement of Wiggins Fork Bridge along East Fork Road, Fremont County, Wyoming.

1.2 Project Location

The bridge replacement begins at MP 6.25 and extends to MP 6.35 for a distance of 0.1 mile on East Fork Road. The project is to replace the Wiggins Fork Bridge and the bridge approaches.

A site location and vicinity map is presented in Figure 1, Appendix A.

1.3 Background

The Wiggins Fork Bridge is a fracture critical structure that has a sufficiency rating of 52.3 and a maximum load posting limit of 20 tons, it is a very crucial element of the East Fork Road. Also, the posted legal weight limit does not currently support the loads carried by many daily users. The wooden deck is disintegrating. Numerous truss members currently need repairs. Steel elements are exhibiting corrosion and section member strength loss.[1]

Subsurface Exploration Program

1.4 Drilling and Sampling

A subsurface exploration program consisting of soil borings and rock coring was conducted to characterize subsurface conditions. Drilling was performed by the EFLHD subsurface exploration team between April 17 and April 22, 2017. The program consisted

[1] Wiggins Fork Bridge Replacement, Project Delivery Plan. Prepared for Central Federal Lands by Atkins. December 19, 2014

of drilling two (2) soil borings. Rock coring was performed in Boring BHI17-01 only. Borings BH17-01 and BH17-02 extended to depths of 24.6 ft. to 39 ft. below existing site grades, respectively. Table 1 provides a summary of the boring locations and depths.

Table 1 – Field Data

Boring No.	Location	Ground Surface EL* (feet)	Boring Depth (feet)	Depth to Auger Refusal (feet)
BH17-01	North Abutment	6727	39	14
BH17-02	South Abutment	6728	24.6	7.9

*Elevations obtained from site survey.

Borings were drilled using a CME 750 drill rig mounted on a rubber tired all-terrain vehicle (ATV). Boreholes were advanced using 3-¾-inch (inside diameter) hollow stem augers (HSA) in soil and highly weathered rock. Borings were terminated upon reaching auger refusal. Boring locations were laid out by the EFLHD Survey Team.

Soil samples were obtained using a standard split-barrel (split-spoon) sampler driven during Standard Penetration Tests (SPT) in general accordance with ASTM D 1586, *Standard Method of Penetration Test and Split Barrel Sampling of Soils*. SPT was performed by driving the split-spoon sampler 24 inches into the undisturbed soil under the impact of a 140-pound automatic hammer free falling 30 inches. SPT was generally performed at 2.5-foot intervals in the upper 20 feet and at 5-foot intervals thereafter. The number of hammer blows required to advance the split-spoon sampler the middle foot of the 24-inch sample interval is designated as the "Standard Penetration Resistance" or N value. The number of blows required to advance the sampler through each 6-inch interval was recorded on field boring logs. SPT refusal is defined by achieving 50 blows per 1-inch (or less) of penetration of the split-spoon sampler. Representative portions of the split-spoon samples were preserved in glass jars. The samples were visually classified and logged in the field by the crew team leader. Samples were then delivered to the EFLHD Materials Testing facility in Sevierville, Tennessee for testing and storage.

Core samples were retrieved using a double-walled NQ wireline core barrel. Rock samples recovered were visually examined and percent core recovery (CR) and rock quality designation (RQD) were determined for each core run to provide a quantitative basis for evaluation of the condition of the rock. Rock core samples were preserved in wooden boxes.

Details of sampling procedures and sample descriptions are provided in the boring logs included in Appendix D of this report. Boreholes were backfilled with auger cuttings upon completion.

1.5 Data Summary

Data collected from the exploratory borings were recorded on the driller's logs. These data sheets and logs indicate the boring methods employed, samples attempted and recovered, indications of the presence of various materials such as gravel, pebbles, organic matter, and observations of groundwater. The logs also contain interpretations of the subsurface conditions based on the performance of the equipment and cuttings brought to the surface by the drilling tools. Therefore, the field data represent both factual and interpretative information.

The boring logs provided in Appendix C represent a compilation of field and laboratory data and description of the soil and rock samples by a geotechnical engineer. These records occasionally do not include all data recorded on driller's logs and field data sheets, but do include all information considered relevant to the design and preparation of this report.

Groundwater levels, when encountered, were measured in the boreholes at the times and under the conditions stated in the boring logs. Fluctuations in groundwater level due to seasonal variations, rainfall, temperature, and other factors not evident at the time measurements were made should be expected.

1.6 Laboratory Testing

Laboratory testing was performed on representative soil samples recovered during the subsurface exploration to aid in classification and evaluation of engineering parameters of the subsurface materials. The following tests were performed on selected samples.

- Particle size analysis (AASHTO T-11 and T-27)
- Moisture content (AASHTO T-265)
- Liquid Limit (AASHTO T-89)
- Plastic Limit (AASHTO T-90)

A summary of the laboratory test results is presented in Table 2. Laboratory test results are provided in Appendix E.

Table 2 – Summary of Soil Laboratory Test Results

Boring No.	Sample No.	Sample Depth (feet)	Gravel (%)	Sand (%)	Fines (%)	Moisture Content (%)
BH17-01	J-5	10-12	38.1	51.8	10.1	6.8
BH17-02	J-2, J-3	3-7	51.4	37.6	11	5.2

Note: All samples tested for liquid and plastic limits were found to be non-plastic

Subsurface Conditions

1.7 Regional Geology

USGS Geologic Map of Wyoming (1985) indicated that the surface deposits at the project site are predominantly Alluvium and Colluvium (Qa), Gravel, pediment and fan deposits (Qt), Indian Meadows Formation (Twim) and Gypsum Spring Formation and Nugget Sandstone (JTgn). The Qa unit generally consists of clay, silt, sand and gravel. The Qt unit is mostly derived clasts that may include glacial deposits and gravels. Twim and JTgn units primarily consist sandstone, claystone and limestone.

A geologic map of the project area is provided as Figure 2 in Appendix A of this report.

1.8 Stratification

A brief description of the subsurface conditions encountered during our field work is presented below. Generalized subsurface profiles are presented in Appendix D of this report. Note that stratification lines designating the interfaces between layers on the boring logs and the subsurface profiles represent approximate boundaries while the transition between materials may be gradual. It should be noted that one or more of the units may be absent at specific locations.

The subsurface profile can be classified into the following strata based on descriptions on the boring logs, where classifications of the samples are recorded.

1.8.1 Fill

Fill was encountered in both borings. The fill materials consisted primarily of loose to medium dense, silty sand and poorly graded sand with various amounts of cobbles, boulders, and mica. SPT N-values recorded ranged from 6 to 24 blows per foot (bpf), with an average of approximately 16 bpf. The fill materials extended to depths of 12 ft. and 8 ft. below existing site grades in Borings BH17-01 and BH17-02, respectively.

1.8.2 Cobbles and Boulders

Underneath the fill stratum, cobbles and boulders were encountered in the borings. This stratum extended to a depth of 24 ft. below existing site grade in Boring BH17-01 and to the termination depth of Boring BH17-02.

1.8.3 Bedrock

Sandstone with was encountered at a depth of 32 ft. below existing site grades in Boring BH17-01.

1.9 Groundwater

Groundwater was encountered at a depth of 13 feet below existing site grades in Boring BH17-01 during our drilling operations. Fluctuations in groundwater levels should be anticipated due to seasonal variations, precipitation, evaporation, surface water runoff, and other reasons.

Design Analyses and Recommendations

1.10 Geotechnical Evaluation

The presence of 8 ft. to 12 ft. of man-placed fill at the site makes the use of shallow foundations an un-economical approach. Foundations should not be supported on the existing fill. Based on the anticipated structural loads and scour depths, a system of deep foundations was deemed be necessary. Drilled shafts are commonly used to support bridge foundations in similar subsurface conditions and projects and were selected to support the new bridge foundations.

1.11 Design Analyses

Design of the drilled shaft foundation was made in general accordance with the design concepts and procedures presented in FHWA Publication FHWA-GEC 010, *"Drilled Shafts: Construction Procedures and LRFD Design Methods" (2010).* After consultation with the bridge engineer, a 30-inch diameter drilled shaft, socketed 5 ft into competent bedrock was considered for analysis and evaluation. Due to the anticipated presence of cobbles and boulders a steel casing will be needed during the installation. Table 3 below presents the axial capacity of drilled shafts.

Table 3 – Drilled Shaft Axial Capacity

Shaft Diameter	Estimated Bottom Elevation	Resistance Factors φ			Axial Capacity (Compression) kips	Axial Capacity (Uplift) kips
		Side	End Bearing	Uplift		
30-inch	6688 ft.	0.55	0.50	0.40	5,000	500

The lateral capacity of the proposed deep foundations was evaluated using the software LPILE by Ensoft, Inc. (Reese and others, 2015). A summary of material properties used in our analysis in Table 4.

Table 4 – Material Properties

Soil Layer	Layer Elevation (top - bottom)	L-Pile Model	γ^1 (pcf)	ϕ^2 (deg)	k^3 (pci)	q_u** (psi)
Existing Soil Fill	Existing Grade – 6713 ft.	Sand (Reese)	120	30	90	-
Boulders*	6713 ft. – 6695 ft.	Sand (Reese)	58	36	60	-
Bedrock	6695 ft. – 6688 ft.	Vuggy Limestone***	62	-	-	4,800

Notes:
1 γ = Effective unit weight in pounds per cubic foot (pcf).
2 ϕ = Drained friction angle in degrees (deg).
3 k = Modulus of horizontal subgrade reaction.
4 S_u and ε_{50} are not presented in the table since they are properties of fine grained soil and the soil at the site is generally characterized as granular.
deg = degrees
psf = pounds per square foot
pci = pound per cubic inch
* Boulders size is expected to vary with depth.
**unconfined compressive strength was estimated from Zhang (2005)
***Vuggy Limestone is the rock model used in L-Pile to model strong rock.

Two (2) anticipated scour depths were evaluated; one where scouring does not occur and one where scour occurs to elevation 6713 feet based on "Scour Analysis Memo" from Hydraulics dated May 4th, 2018. A summary of the analysis results is presented in Table 5 below. Computer output files are included in Appendix G. The output files provide the soil input properties, drilled shaft sections geometry analyzed.

Table 5 – Summary of LPILE Analysis

Condition		Shear (kips)	Location of Max Shear (ft)	Moment (in- kips)	Location of Max Moment (ft)	Top Deflection (in)
Without scour	Service	68	0	-5400	0	0.15
	Strength	92	21	-7400	0	0.22
With scour to 6713'*	Service	68	0	-5700	0	0.17
	Strength	-100	21	-7800	0	0.25

* Scour elevation was determined from "Scour Analysis Memo" from Hydraulics dated May 4th, 2018

Construction Considerations

1.12 General

Construction shall be performed following the Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects (FP-14) and the Special Contract Requirements (SCR).

1.13 Excavations

All excavations are to be performed in accordance with applicable federal, state, local, and OSHA requirements and in accordance with Section 204 of the FP-14 Specifications. Excavation in fill and/or natural material should be achievable using conventional earthmoving equipment in proper working condition.

1.14 Drilled Shafts

Drilled shafts should be constructed in accordance with Section 565 of the FP-14 Specifications.

1.15 Backfill Material

Backfill should be placed and compacted in accordance with Section 204 of the FP-14 Specifications. Aggregates should conform to requirements in Section 703 of the FP-14 Specifications.

REFERENCES

AASHTO (2017), “LRFD Bridge Design Specifications", 8th Edition, Washington D.C. American Association of State Highway and Transportation Officials.

Brown, D.A., Turner, J.P., and Castelli, R.J. (2010). “Drilled Shafts: Construction Procedures and LRFD Design Methods”, FHWA-NHI-10-016, GEC 010. Federal Highway Administration, U.S. Department of Transportation, Washington, D.C.

Love, J.D., and Christiansen, A.C., 1985, Geologic map of Wyoming: U.S. Geological Survey, scale 1:500,000

Wyoming Department of Transportation. January 2010. Standard Specifications for Roads and Bridge Construction. Cheyenne, Wyoming

Sabatini, P. J., R. C. Bachus, P. W. Mayne, J. A. Schneider, and T. E.Zettler (2002), Geotechnical Engineering Circular No. 5 (GEC 5)- Evaluation of Soil and Rock Properties, FHWA Report No. FHWA-IF-02- 034. Federal Highway Administration, U.S. Department of Transportation, Washington, D. C..

Reese, L. C.; Wang, S. T.; Isenhower, W. M.; and Arrellaga, J. A., 2015, LPILE v. 8: Austin, Texas, Ensoft, Inc.

U.S. Department of Transportation, Federal Highway Administration, Federal Lands Highway Division (FLH), (2014), "Project Development and Design Manual (PDDM)".

Zhang, L. (2005). Engineering Properties of Rocks. 1st ed. Kidlington: Elsevier.

Disclaimer/Limitations Clause

The subsurface explorations and tests described in this report have been conducted in accordance with standard practices and procedures (except as specifically noted). The results of these explorations and tests represent conditions at the specific locations and dates indicated. Subsurface conditions between these locations may vary. The Geotechnical Design Analyses and Recommendations Sections of this report include interpretations and recommendations developed by the Government in the process of preparing the design. These interpretations are not intended as a substitute for the personal investigation, independent interpretation, and judgment of the Contractor.

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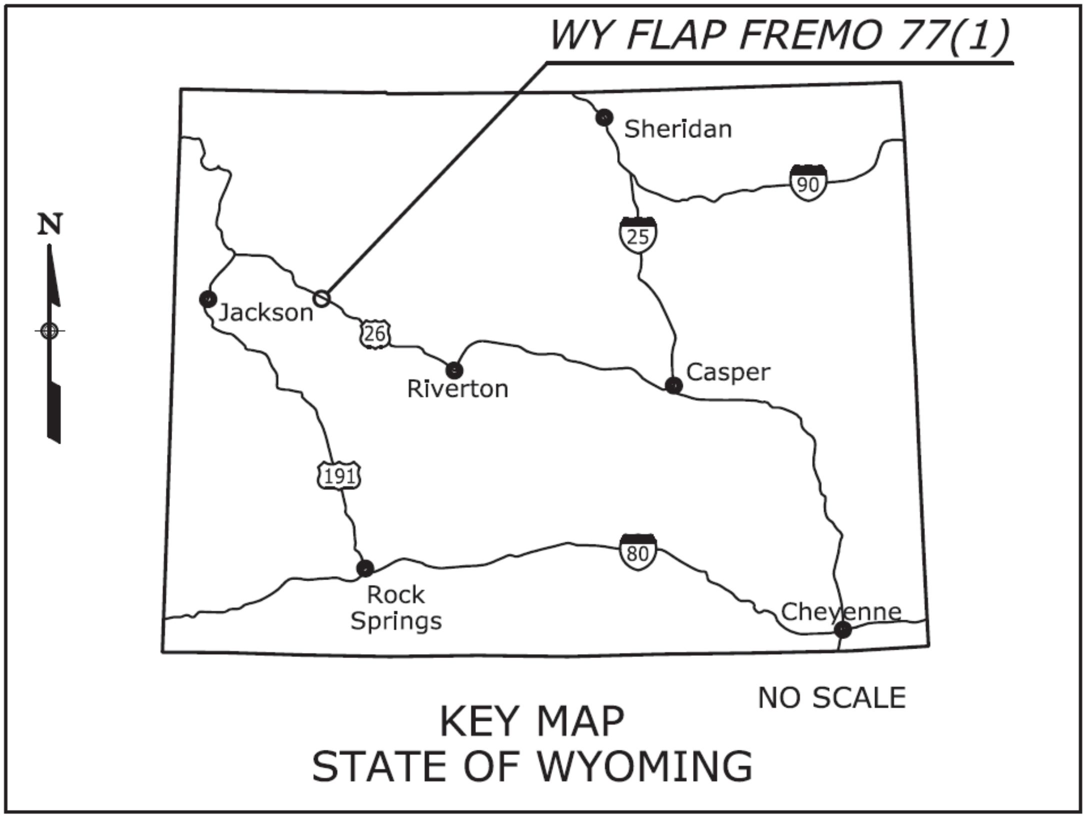
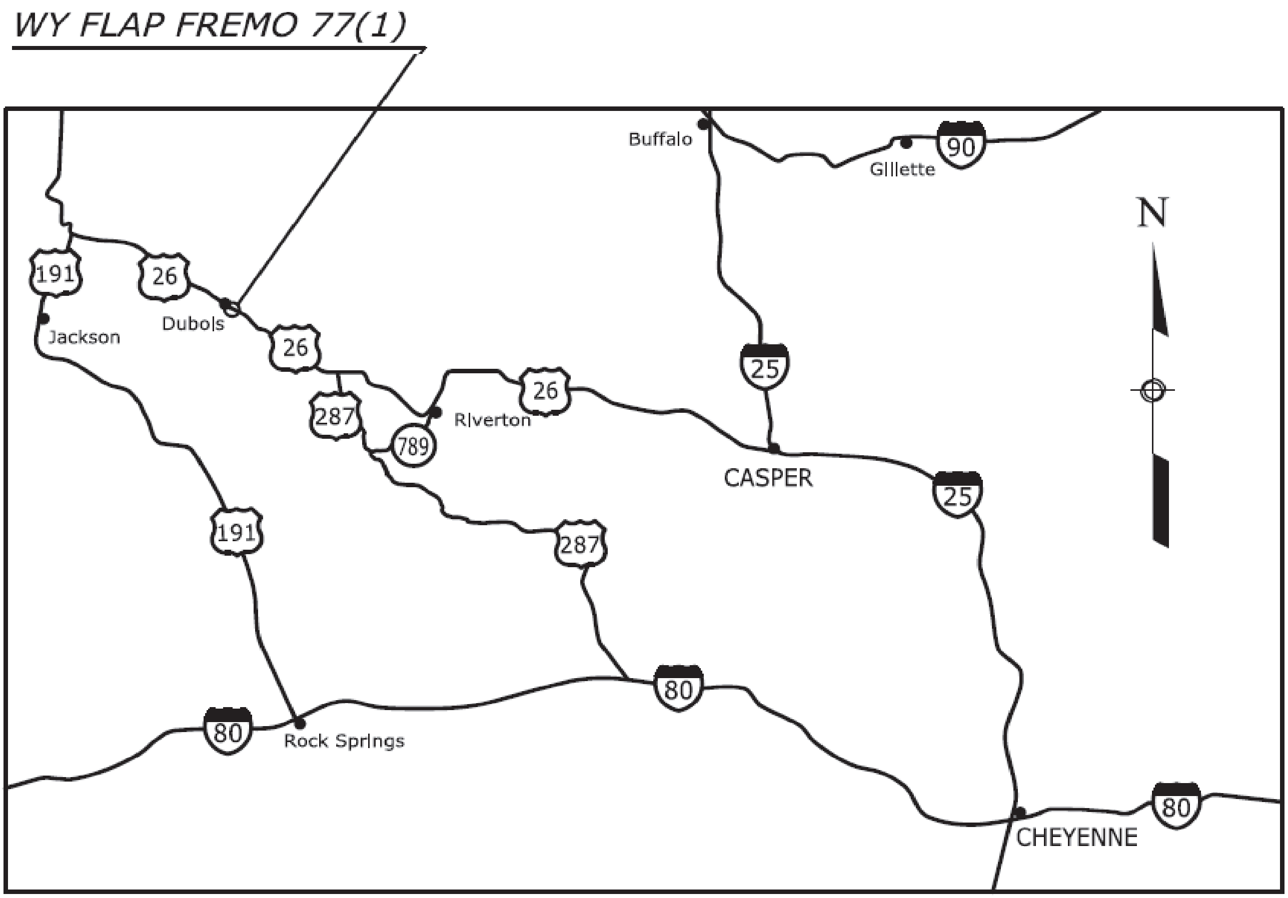
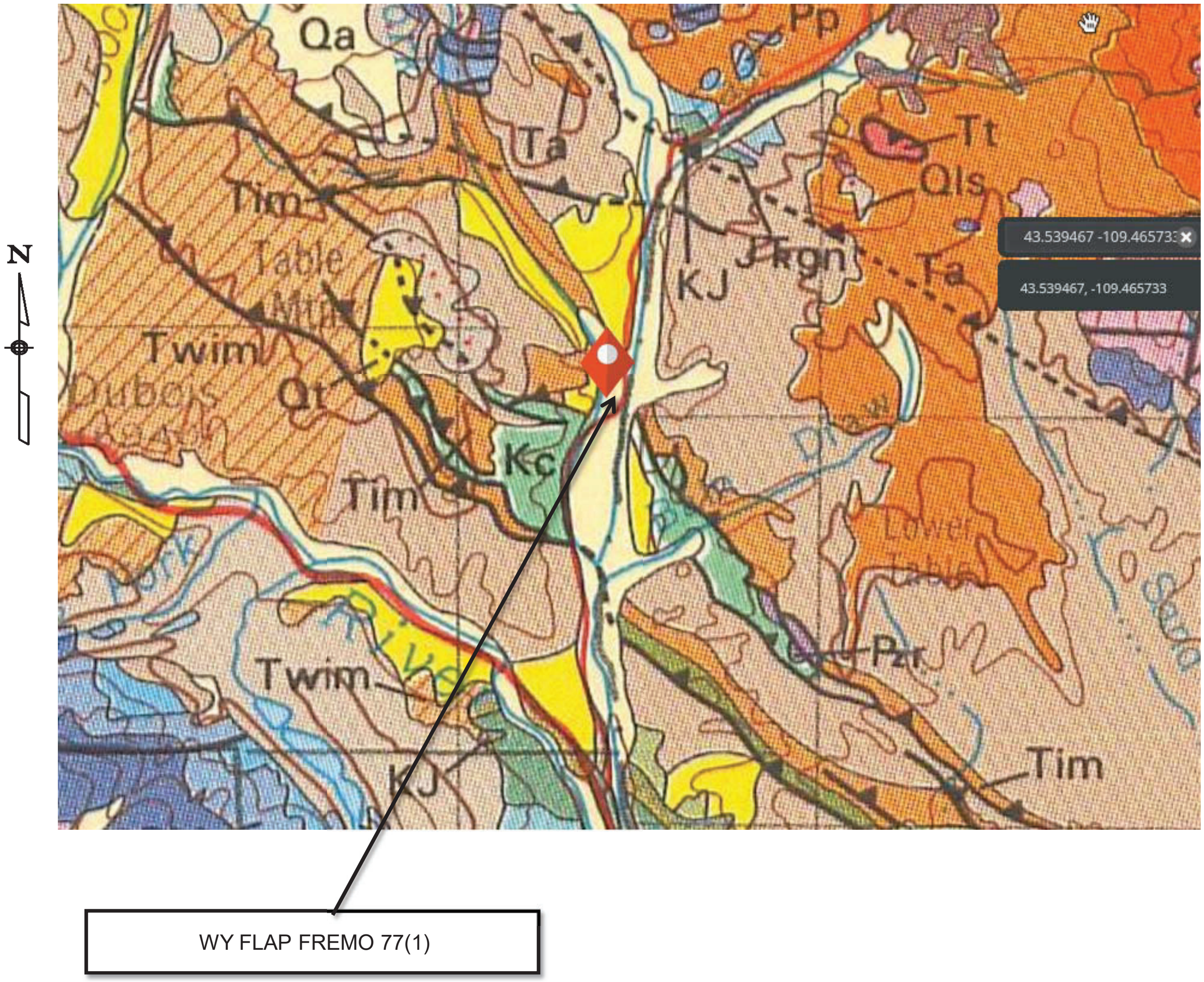
APPENDIX A
Figures





U.S. DEPARTMENT OF TRANSPORTATION FEDERAL LANDS HIGHWAY DIVISION EASTERN FEDERAL LANDS HIGHWAY DIVISION STERLING, VIRGINIA	**FIGURE 1** Site Location and Vicinity Map	REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
			WY	WY FLAP FREMO 77(1)	1	3



Qa: Alluvium and Colluvium - Clay, silt, sand, and gravel in flood plains, fan, terraces, and slopes.

Qt: Mostly locally derived clasts. Includes some glacial deposits along east flank of Wind River Range. Locally includes some tertiary gravels.

Twdr: Variegated claystone and sandstone; lenticular conglomerate.

Tim/Twim: Red to variegated claystone and sandstone, and limestone; some beds of large Paleozoic boulders and detachment masses of Paleozoic and Mesozoic rocks.

Ta: Aycross Formation - Brightly variegated bentonitic claystone and tuffaceous sandstone, grading laterally into greenish-gray sandstone and claystone.

Kc: Cody Shale - Gray to brown shale and shaly sandstone.

Source:

Love, J.D., and Christiansen, A.C., 1985, Geologic map of Wyoming: U.S. Geological Survey, , scale 1:500,000

U.S. DEPARTMENT OF TRANSPORTATION FEDERAL LANDS HIGHWAY DIVISION EASTERN FEDERAL LANDS HIGHWAY DIVISION STERLING, VIRGINIA	**FIGURE 2** GEOLOGIC MAP	REG	STATE	PROJECT	SHEET NO.	TOTAL SHEETS
			WY	WY FLAP FREMO 77(1)	2	3

APPENDIX B

Boring Location Map