Bridger Bowl Base Area

Summary Geology and Soils Report

Township 1 North, Range 7 East, P.M.M.
Gallatin County, Montana

Prepared for

Bridger Canyon Partners
P.O. Box 7078
Bozeman, MT 59771

Prepared by

HKM ENGINEERING
McChesney Professional Building
601 Nikles Drive Suite 2
Bozeman, Montana 59715
(406) 586-8834

October, 2006
Project # 04S145.101

Introduction

This report was prepared at the request of Bridger Canyon Partners, LLC to summarize existing information regarding geology, soils, and geomorphology in the vicinity of the Bridger Bowl base area in Gallatin County, MT. The sources used for this report were limited to site specific reports provided by the client and readily available published geologic and soils information. An exhaustive review of available literature and unpublished reports regarding soils and geology in the Bridger Bowl base area was out of the scope of this report.

General Geomorphology and Topography

In general, the Bridger Bowl base area is characterized by slopes dipping gently (5-10%) to the east along the eastern side of the Bridger Range. Seasonal drainages and small streams intersect this gently sloping terrain creating v-shaped valleys that run into the broader valley created by Bridger Creek to the east. On the far western side of the Bridger base area and further upslope, the topography transitions to much steeper slopes (generally around 30%) with deeper v-shaped valleys (see USGS topographic map in Appendix A).

The Bridger Bowl base area spans the transition from the base of the eastern side of the Bridger Range to the alluvial valley formed by Bridger Creek. Since this area has experienced overall uplift during the quaternary, no well developed alluvial fans or pediment surface have formed along the eastern range front as they have on the western normal fault bound side of the Bridger Range. Poorly developed triangular facets can be delineated along much of the eastern range front, though they are not nearly as well developed as the triangular facets seen on the western side of the Bridger Range.

Surface and Subsurface Geology

A large percentage of the Bridger Bowl base area is characterized by shallow bedrock (around 5-15 feet) consisting of Upper Cretaceous aged interbedded volcanoclastic sandstones and mudstones of the Billman Creek and Sedan Formations (see geologic map in Appendix B). A thin veneer of colluvial material and residual soils derived from the bedrock is present in the majority of the study area. The bedrock in this area is steeply dipping (65° to 85°) and overturned as a result of movement on Laramide thrust faults. Since the beds are overturned, older bedrock overlies younger bedrock.

Since this area has generally experienced uplift during the Quaternary period, alluvial deposits are not very deep or widespread. Small areas of young Quaternary (Holocene to upper Pleistocene) alluvial deposits (Qal) are present in the larger stream systems such as Maynard Creek and Bridger Creek. Some more widespread areas of slightly older Quaternary (Pleistocene) alluvial deposits are also present in this area, which were probably formed due to alluvial activity near the terminal point of retreating glaciers following the Pinedale glaciation (these deposits could also be described as glaciofluvial or glacial outwash).

freshwater and brackish-water mollusks. Gradational lower contact of unit is placed at base of lowest prominent sandstone ledge. Thickness is about 350–500 ft.

Ksm - Mudstone member—Greenish-gray and brownish-gray, volcaniclastic mudstone, siltstone, sandstone, and minor interbedded conglomerate and altered vitric tuff. Yellowish-gray bentonite and light-gray-weathering, altered vitric tuff are common in upper beds. Unit contains freshwater mollusks, wood, and dinosaur bones. Member forms valleys and low barren hills, and has a gradational contact with Middle sandstone member (unit Ksms) below. Thickness ranges from 900 to 1000 ft.

Ksms - Middle sandstone member—Olive-green, olive-gray, and dark-greenish-gray, volcaniclastic sandstone, conglomerate, mudflow conglomerate, and minor siltstone and mudstone. Unit forms series of ridges and disconformably overlies ash-flow tuff member (unit Ksa); contact is placed at top of highest ash-flow tuff or ash-flow tuff conglomerate. Thickness is about 1000–1430 ft.

On-Site Soils (see Appendix C for NRCS soil mapping and soil mapping unit properties)

In general, NRCS and USFS mapping shows that a large portion of the Bridger Bowl base area is underlain by a thin veneer of lean clay (CL) formed as a residual soil derived from underlying bedrock, followed by a clayey gravel (GC) colluvial layer and then weathered and unweathered bedrock at depths of 3 to 5 feet. NRCS mapping is fairly consistent with the USGS geologic map in that it shows shallow bedrock in the areas that are mapped as bedrock. The soils present over shallow bedrock generally have high clay content and high shrink-swell potential since they are derived from volcanoclastic sedimentary bedrock.

Somewhat different soils exist in areas underlain by mappable units of quaternary alluvial gravel. These deposits are common in the lower portions of the major drainages and along areas of more widespread older alluvial deposition shown on the geologic map. These soils generally consist of lean clay (CL) overlying clayey gravels and sands (SC-GC) with cobbles and boulders in some areas. The bedrock is still relatively shallow in these areas but deep enough not to be encountered within the 5 foot depth of interest to the NRCS. The geologic map of the Sedan Quadrangle suggests a depth to bedrock of around 15-25 feet underneath the Quaternary alluvial deposits. Soils present overlying Quaternary alluvial deposits are generally lower in clay content and higher in gravel and sand content than soils overlying shallow bedrock. These soils do not have as much shrink swell potential since more of the clay has been carried away by alluvial processes.

Soils formed over landslide deposits are present in some areas on the western portion of the Bridger Bowl base area and further upslope. These soils generally consist of a thin layer of lean clay (CL) overlying landslide deposits of clayey gravels with cobbles and large boulders (GC). The landslide deposits are generally very chaotic, have high clay content, and contain angular to subangular gravels, cobbles, and boulders. Large slide blocks are common in these types of deposits, which could have diameters in the tens of

Conclusions

In summary, based on review of cited information, geologic conditions within the proposed development areas are suitable for construction of the proposed housing and commercial units and associated infrastructure. Overall, the soils are stable with no indication of large scale global instability. There may be some isolated minor unstable areas located within the extreme western fringe of the Phase I area (as mapped by Whittingham, Appendix F, Figure 4). Groundwater conditions will vary but overall are not problematic provided groundwater conditions are considered for site specific building designs. Foundation water proofing perimeter drains and or sumps may be required dependent upon location and if basements are desired. Shallow groundwater is evident in low lying and drainage areas within the Phase I development area; however, It is understood that these areas are to remain as wetland areas.

Additional test pits or soils investigations will be conducted within the Phase III area to further define soil and groundwater conditions prior to final planning. More detailed surface mapping will be conducted within the western area of Phase I to further determine if isolated unstable areas are present. Site specific geotechnical investigations should be conducted at building locations during the construction stages of the project. These investigations will further define groundwater and soil conditions at specific sites to ensure compatible foundation design.

Prepared By:

Christopher Leibli
Staff Geologist

Reviewed By:

Greg Underhill P.E.
Senior Geotechnical Engineer

LIST OF APPENDICES

A. Topographic Map

B. USGS Geologic Map

C. NRCS and USFS Soil Map and Map Unit Properties

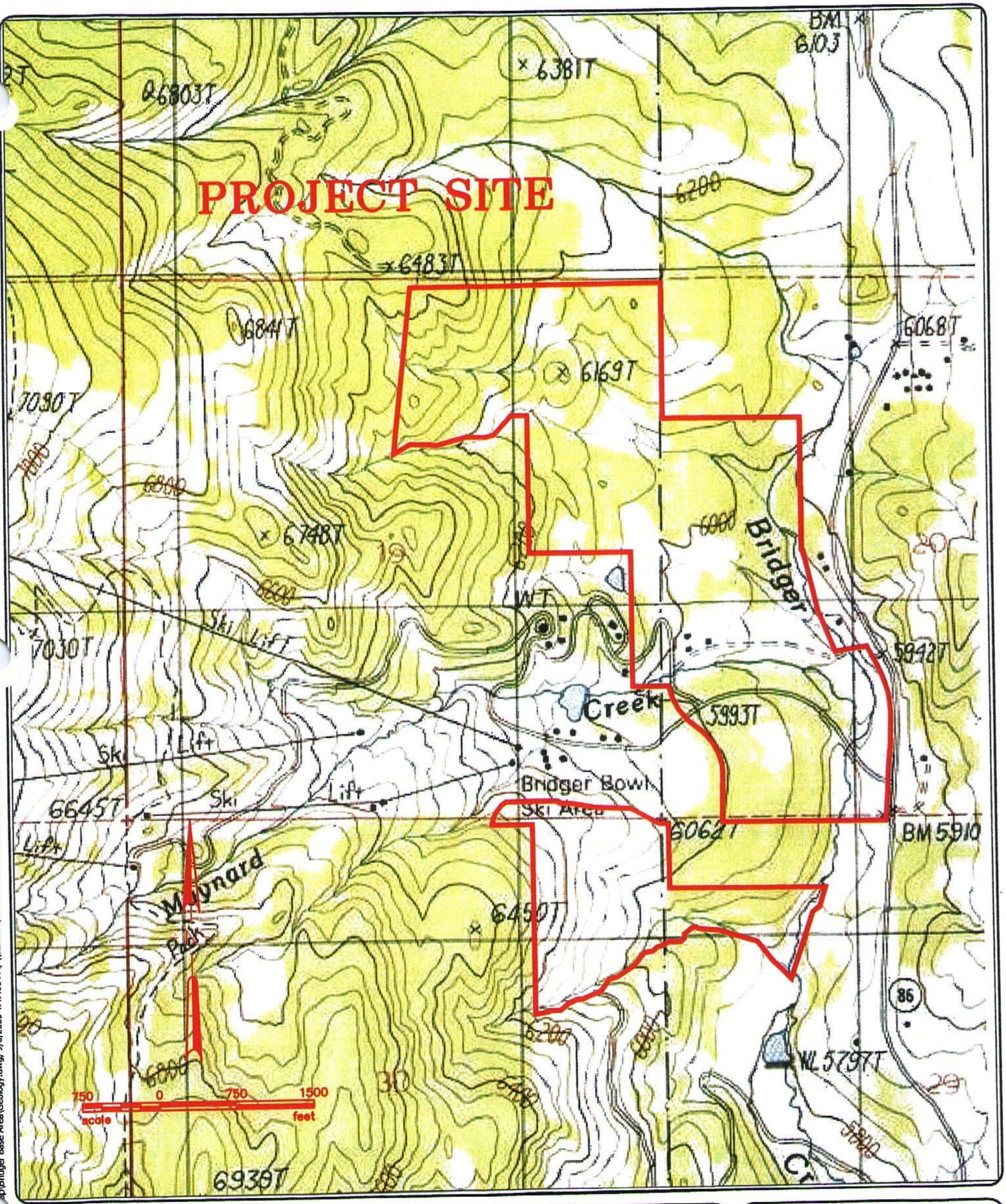
D. Braun Intertec Engineering Geotechnical Report: "A Preliminary Geotechnical Evaluation Report for Morrison Maierle/CSSA, Proposed Bridger Bowl Site Development Northeast of Bozeman, Montana". 1992

E. SCS Test Pit Location Map and Test Pit Logs

F. Chandler Geotechnical: "Geotechnical Exploration and Analysis, Deer Park Chalet Bridger Bowl, Montana". 1995

APPENDIX A

Topographic Map



Bridger Base Area
Topographic Map

FIGURE 1

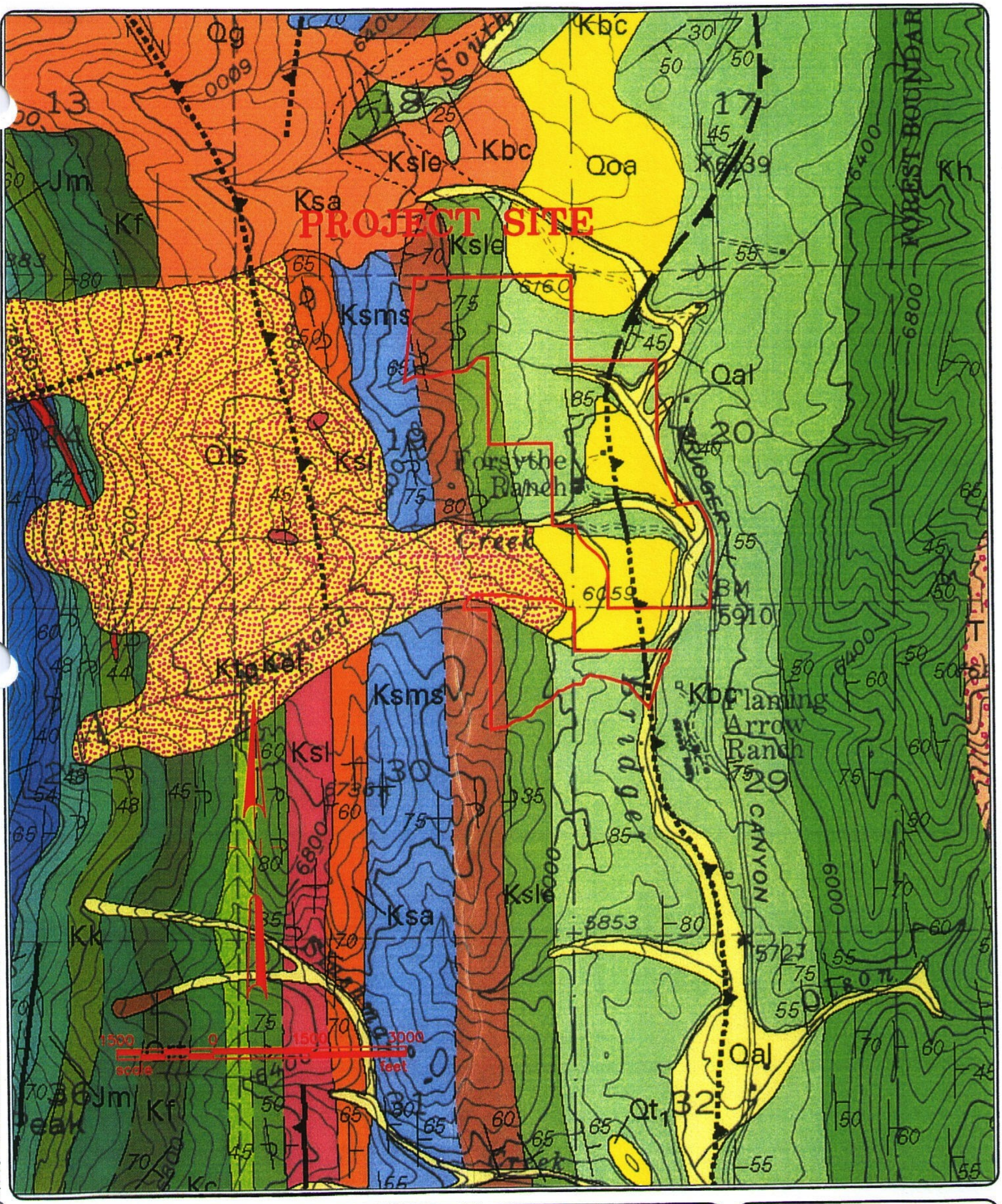
HKM ENGINEERING

9/6/06

ocuments and Settings\c...p)Bridger Base Area\Geology.dwg, 9/6/2006 4:47:01 PM, \\SERVER\HP Color LaserJet 4500 PCL 5c (Copy 2)

APPENDIX B

USGS Geologic Map



Bridger Base Area
Geologic Map

Source: Geologic Map of the Sedan Quadrangle, 1999

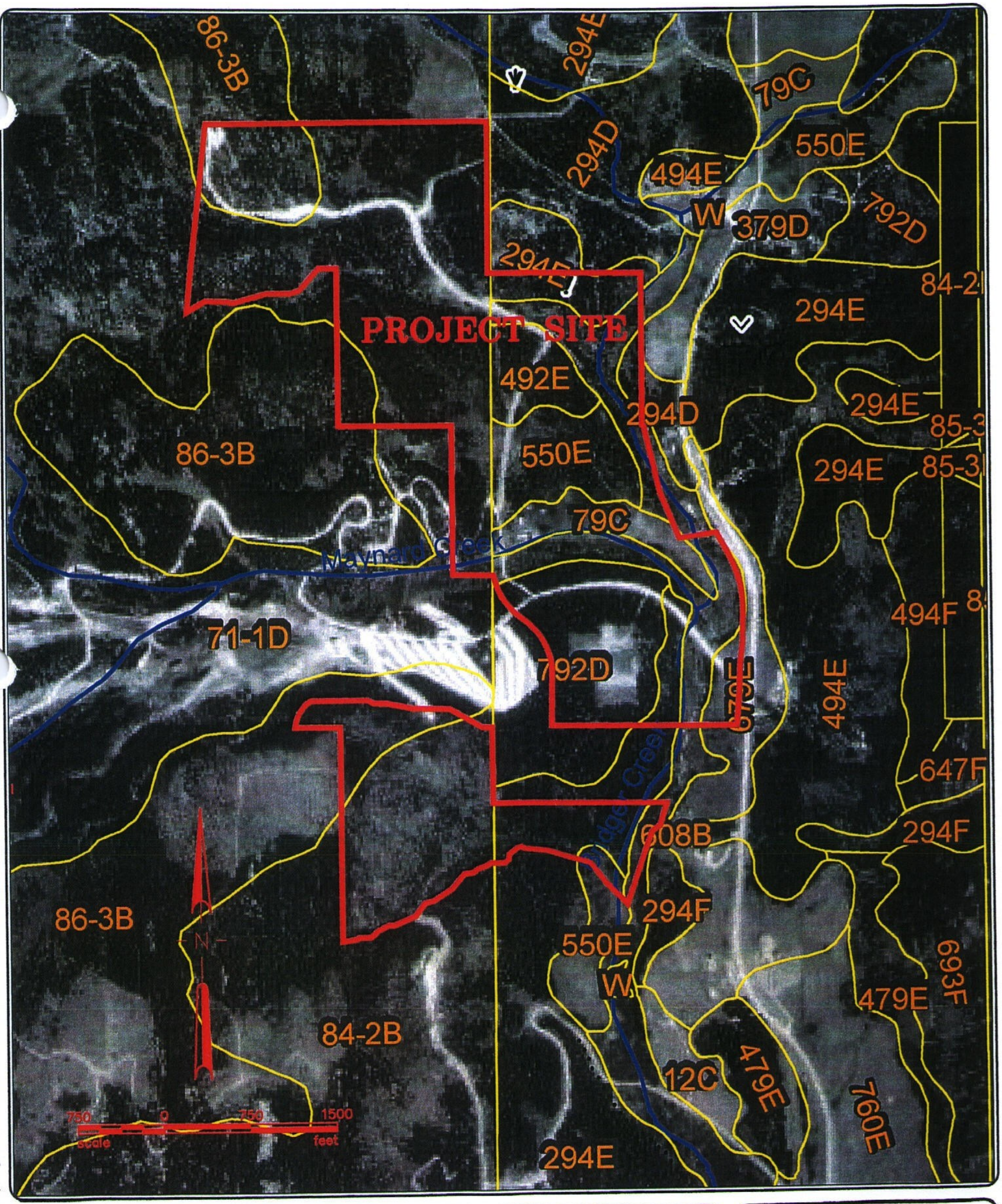
FIGURE 2

HKM ENGINEERING

9/6/06

APPENDIX C

NRCS and USFS Soil Map and Map Unit Properties



Bridger Base Area
NRCS and USFS Soils Map
Source: NRCS Web Soil Survey

FIGURE 3

HKM ENGINEERING

9/6/06