2.6 GEOLOGY

The geological conditions at the Clinch River Nuclear (CRN) Site are summarized in this section. The site information is subdivided into three categories: physiography, stratigraphy, and structural geology. The information provided in these subsections is developed in accordance with the guidance provided in the U.S. Nuclear Regulatory Commission's (NRC's) Regulatory Guide (RG) 4.2, *Preparation of Environmental Reports for Nuclear Power Stations*, RG 4.7, "*General Site Suitability Criteria for Nuclear Power Stations*," and the NRC's *Standard Review Plans for Environmental Reviews for Nuclear Power Plants: Environmental Standard Review Plan*, (NUREG-1555), Section 2.6 – Geology.

The geological information in this section is based on the information contained in Site Safety Analysis Report (SSAR) Subsection 2.5.1 Geologic Characterization Information.

2.6.1 Geological Conditions

The CRN Site is located within the western portion of Oak Ridge, Tennessee, in the Valley and Ridge physiographic province (Figure 2.6-1). The Valley and Ridge province is the topographic expression of the geologic structures of the southern Appalachian foreland fold-thrust belt, which formed during the Pennsylvanian to Permian Alleghanian orogeny and the lithologies underlying those structures (see SSAR Subsections 2.5.1.1.2 and 2.5.1.1.4) (Reference 2.6-1).

2.6.1.1 Physiography

The CRN Site topography is characterized by northeast–southwest trending ridges and intervening valleys typical of the regional physiographic setting of the Valley and Ridge (SSAR Subsection 2.5.1.1.1) (Figure 2.6-2).

The Clinch River arm of the Watts Bar Reservoir follows a meandering south-westerly stream course across the CRN Site area with incised water gaps at each of the major ridges that cross the CRN Site (Figures 2.6-2 and 2.6- 4). The water level elevation of the Clinch River arm of the Watts Bar Reservoir at the CRN Site is approximately 740 feet (ft) National Geodetic Vertical Datum of 1929 (NGVD29; equivalent to 739.6 ft North American Vertical Datum of 1988 [NAVD88]). The plant grade is to be at an elevation of approximately 821 ft NAVD88, placing the power block area about 81 ft above the water level of the river. Most of the ephemeral and perennial tributaries in the major valleys follow stream courses consistent with the current topographic setting except where streams have carved incised water gaps through resistant bedrock ridges (Figure 2.6-2). The southeastern third of the CRN Site area is characterized by low hills and lacks a major northeast-southwest trending axial valley, but instead has a dendritic drainage pattern. This area is underlain by Chickamauga Group carbonate rocks with occasional karst features that have influenced the local stream network and resulted in sinking streams at several locations.

2.6.1.2 Stratigraphy

Strata sampled during the CRN Site subsurface investigation are shown in Figure 2.6-3 as they occur from the ground surface to varying depths beneath the CRN Site. A total of 82 borings (76 cored in bedrock) were drilled as part of the CRN Site subsurface investigation.

Residual soils and artificial fill are the dominant surficial sediment types, whereas the alluvial and colluvial soils are located surficially in the southern portion of the CRN Site peninsula and along the banks of the Clinch River arm of the Watts Bar Reservoir. The Quaternary surficial units in the CRN Site are described in SSAR Subsection 2.5.3.2.5.1 and are mapped on Figure 2.6-4. Colluvium (Qc) deposits consist of weathered residuum transported by hillslope processes including slopewash and creep. Colluvium is deposited at the toe of hillslopes and in hollows on the hillsides. Holocene alluvium (Qha) is deposited in hillside gullies and in the principal tributary valleys across the CRN Site (Figure 2.6-4). Unit Qha includes channel bottom alluvium and low terrace deposits that are undivided at the scale of mapping. The unit is composed largely of silt; with sand and gravel present in varying amounts dependent on the local bedrock parent material. Artificial fill is located in redress areas of the former Clinch River Breeder Reactor Project Site.

Underlying a mantle of fill/residual soil and weathered bedrock, stratigraphy at the CRN Site comprises rocks of the Lower Cambrian Rome Formation, Middle Cambrian to Lower Ordovician age rocks belonging to the Knox Group and Middle Ordovician age rocks of the Chickamauga Group (Figure 2.6-4). The Copper Creek thrust fault, located approximately 0.6 miles south of the power block area, places the Rome Formation over the Ordovician Moccasin Formation of the Chickamauga Group (Reference 2.6-2). The geologic cross section shown on Figure 2.6-3 illustrates the bedrock structure and succession of stratigraphic units encountered at the CRN Site. Orientated perpendicular to the strike of the bedding planes, rocks belonging to the Knox Group outcrop to the northwest and the progressively younger rocks belonging to the Chickamauga Group outcrop to the southeast (Figure 2.6-4). Rocks of the Rome Formation do not outcrop at the CRN Site, but they were encountered by two subsurface investigation boreholes (Figures 2.6-3 and 2.6-4). The stratigraphic units beneath the Knox Group were not encountered during the subsurface investigation boring program and include from oldest to youngest: Precambrian basement comprised of gneisses, granites, and amphibolites; the Rome Formation comprised of sandstones and shales; and the Conasauga Group comprised mostly of shales with minor amounts of limestones.

2.6.1.3 Structural Geology

Throughout the Valley and Ridge portion of the CRN Site, bedding of Paleozoic strata consistently strikes northeast (mostly between N 30 E and N 60 E) with moderate southeast dips. In general, the strike of primary bedding surfaces is roughly consistent throughout the CRN Site. Overall structural style changes significantly toward the northwestern portion of the CRN Site vicinity, which includes portions of the Cumberland Plateau physiographic province (see SSAR Subsections 2.5.1.1.1 and 2.5.1.1.4 for more detailed discussion of physiographic provinces). Alleghanian deformation was much less intense within this province; bedding is mostly subhorizontal, with maximum dips on the order of 20° to 25°. At the CRN Site location within the Valley and Ridge province, bedding strikes approximately N 52°E and dips consistently 32° to 35°SE.

Macroscale folds in the CRN Site vicinity are open, upright to overturned kilometer-scale synclines and anticlines with axes that trend parallel to major faults and the strike of lithologic units (Reference 2.6-3; Reference 2.6-2; Reference 2.6-4; Reference 2.6-5; Reference 2.6-6) (Figure 2.6-4). Fold axes can generally be traced for 0.5 to greater than 7 mi throughout the CRN Site vicinity, although macroscopic Valley and Ridge folds can locally be traced over much greater distances. Fold axes are normal to the inferred shortening direction, which supports timing of folding coincident with Alleghanian emplacement of Valley and Ridge thrust sheets (e.g., (Reference 2.6-7)).

The vast majority of faults within the CRN Site vicinity can be characterized as bedding-parallel thrusts that formed during thin-skinned deformation of the Appalachian foreland (Reference 2.6-8). The tectonic history of the region, including deformation of late Paleozoic siliciclastic strata, indicates that Valley and Ridge province faults and folds were active during the late stages of the Alleghanian orogeny (e.g., (Reference 2.6-9)). Numerous radiometric age determinations of features associated with deformation and shortening in the Valley and Ridge agree with this timing, and range from 265-290 million years ago (Ma) (Reference 2.6-10; Reference 2.6-11; Reference 2.6-12; Reference 2.6-13; Reference 2.6-14; Reference 2.6-15; Reference 2.6-16). Recent $^{39}Ar/^{40}Ar$ analyses of fault gouge illite from several Valley and Ridge faults including the Copper Creek fault in the southern portion of the CRN Site peninsula (Figure 2.6-4) suggest emplacement occurred 276-280 Ma (Reference 2.6-17).

2.6.2 References

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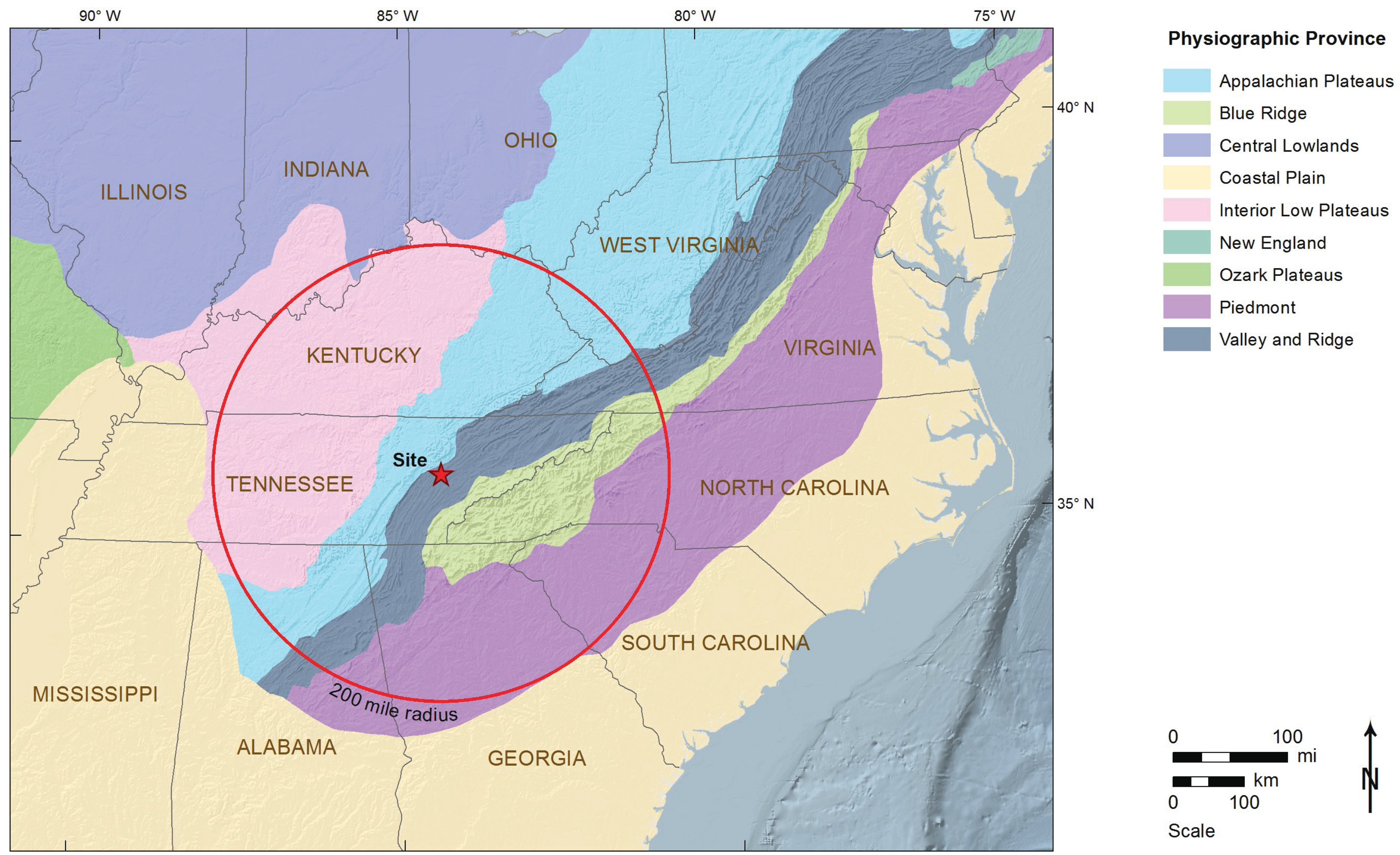
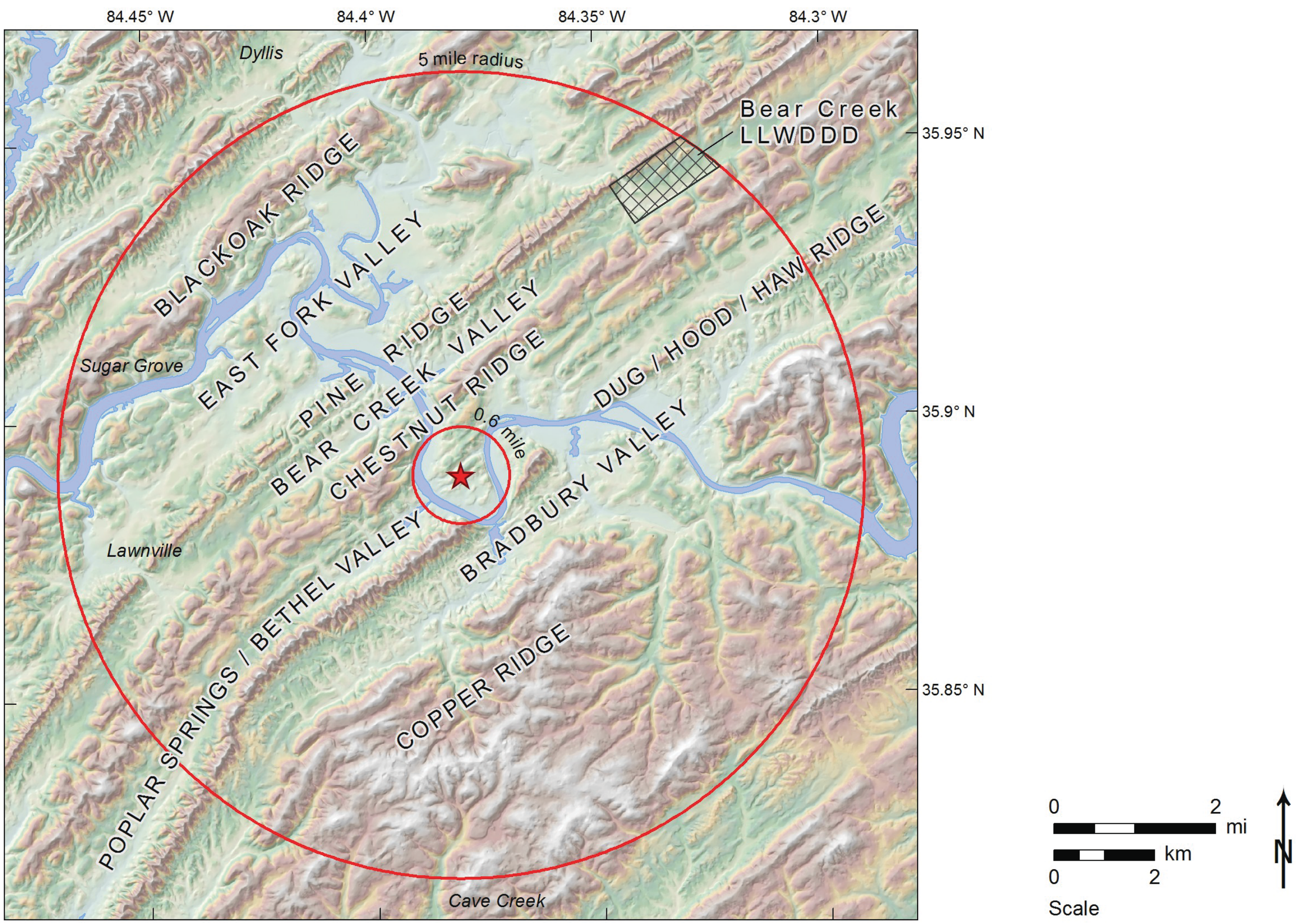
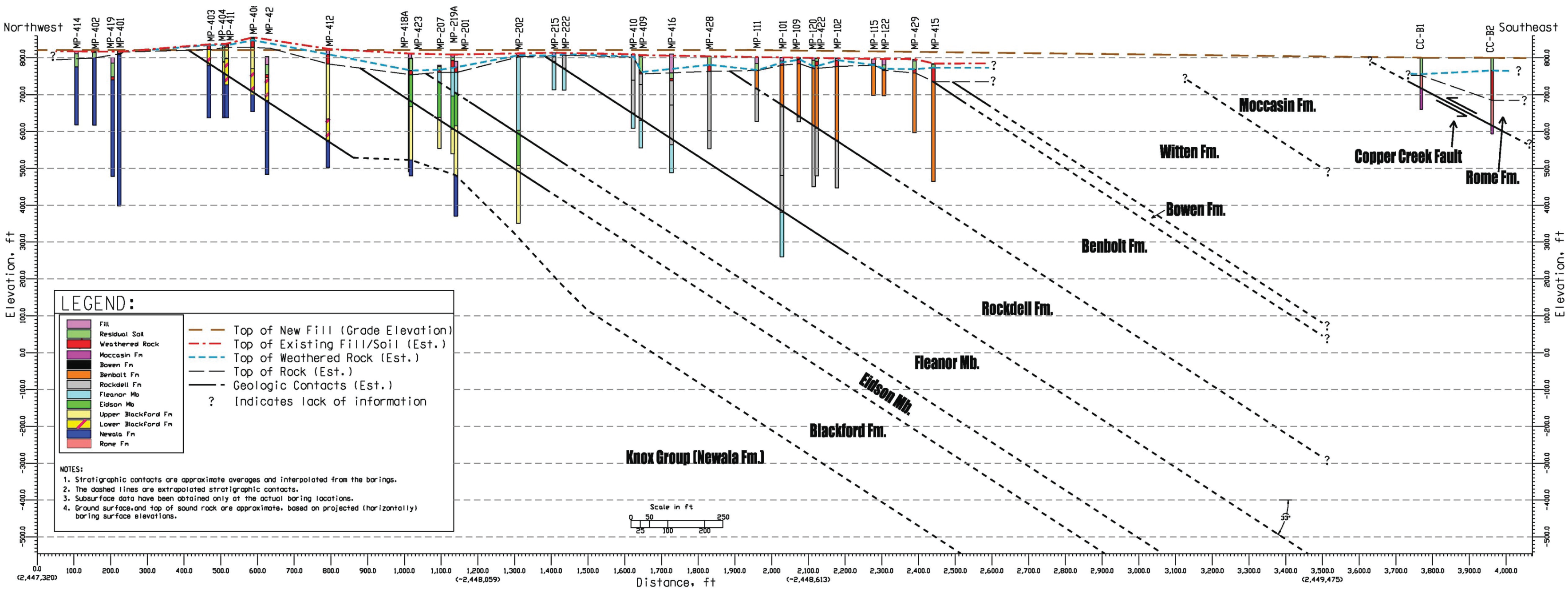


Figure 2.6-1. Map of Physiographic Provinces



Note: Local geographic nomenclature from Reference 2.6-18.

Figure 2.6-2. Local Physiography



Note: Location of cross section (K–K) is provided in Figure 2.6-3, Sheet 2 of 2

Figure 2.6-3. (Sheet 1 of 2) Geologic Cross Section of the CRN Site

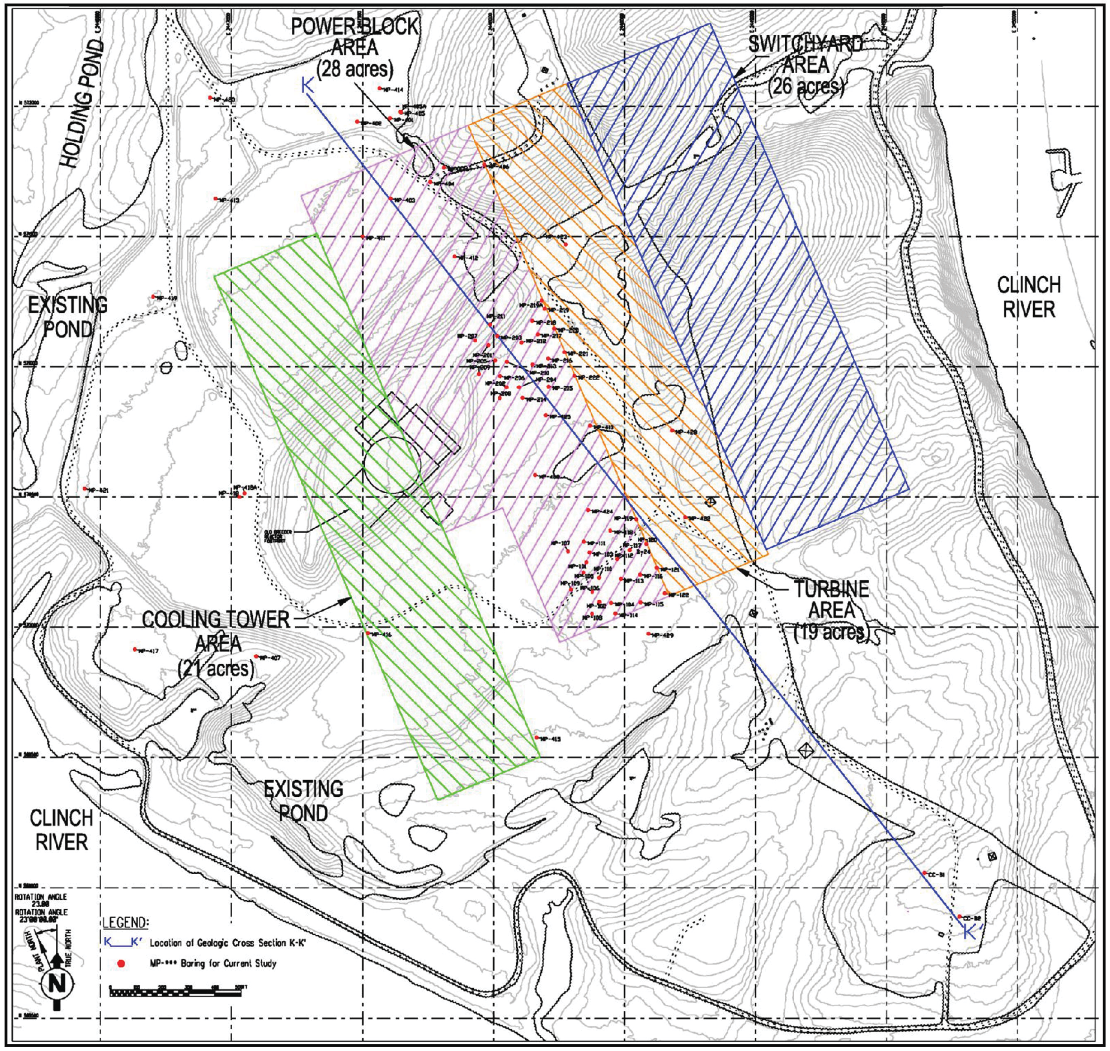


Figure 2.6-3. (Sheet 2 of 2) Geologic Cross Section of the CRN Site

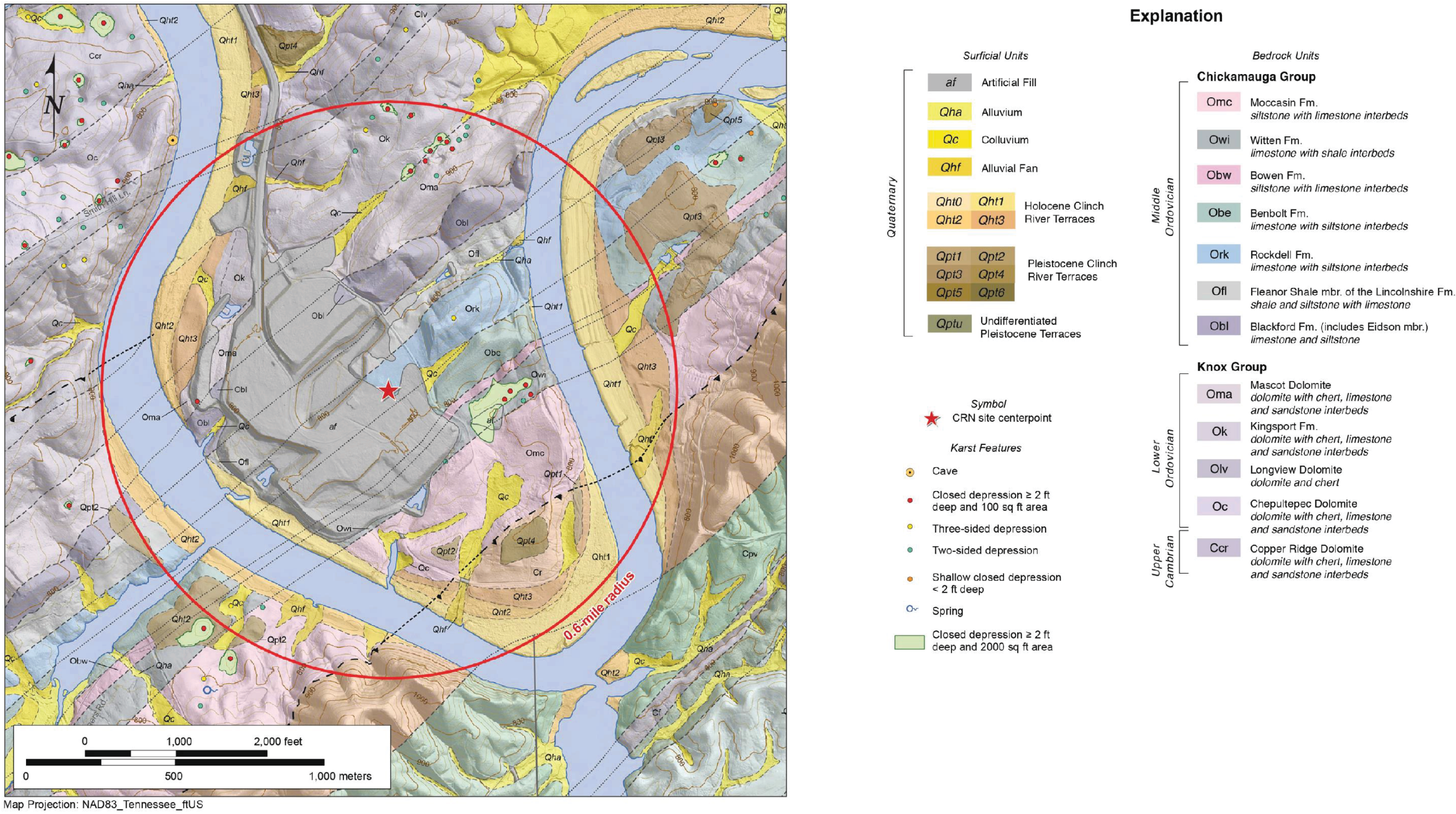


Figure 2.6-4. CRN Site Geologic Map