3.3 Soils and Geologic Hazards

3.3.1 Overview

Regulations from the CEQ direct agencies to insure the professional and scientific integrity of environmental analyses in an EIS. This direction includes using the best available science to describe existing conditions in the Project Area; in this case, the UNF. Published, peer reviewed studies are used when applicable to conditions in the UNF; however, in most cases only those studies that are relevant to identifying potential impacts from the proposed action (in Chapter 4) are considered. These studies are cited in the text. The most relevant literature for most resources in Chapter 3 comes from internal Forest Service publications and reports, because this information is based on UNF-specific investigations and assessments. Throughout Chapter 3, the UNF Land and Resource Management Plan (USFS 2003) and associated EIS (USFS 2003a) are the most frequently cited documents. These documents were not peer reviewed within the scientific community, but were written using best available science, open to public comment as dictated by the NEPA process, and revised accordingly by resource specialists.

This overview for geology and soils is intended to provide the reader with a basic understanding of the geologic formations in the UNF that have oil and gas potential, a summary of important soil information, landslide information, and an overview of other mineral resources. Following the overview is a complete description of geologic and soil resources.

Figure 3.7. **Geologic timescale.**

The Geologic Timescale		
Era	**Period**	**Epoch**
Cenozoic Era (65 mya* to today)	Quaternary (1.8 mya to today)	Holocene (10,000 years ago to present)
		Pleistocene (1.8 mya to10, 000 years ago)
	Tertiary (65 to 1.8 mya)	Pliocene (5.3 to 1.8 mya)
		Miocene (23.8 to 5.3 mya)
		Oligocene (33.7 to 23.8 mya)
		Eocene (54.8 to 33.7 mya)
		Paleocene (65 to 54.8 mya)
Mesozoic Era (248 to 65 mya)	Cretaceous (144 to 65 mya)	
	Jurassic (206 to 144 mya)	
	Triassic (248 to 206 mya)	
Paleozoic Era (543 to 248 mya)	Permian (290 to 248 mya)	
	Carboniferous (354 to 290 mya)	Pennsylvanian (323 to 290 mya)
		Mississippian (354 to 323 mya)
	Devonian (417 to 354 mya)	
	Silurian (443 to 417 mya)	
	Ordovician (490 to 443 mya)	
	Cambrian (543 to 490 mya)	
* mya= million years ago		

Geologic Formations with Oil and Gas Potential

A basic understanding of the geologic formations that have oil and gas potential and where these occur within the UNF will help the reader understand the impacts analysis in Chapter 4. Locations of areas with oil and gas potential are shown on the forest-wide resource

maps that are included in this chapter and on the UNF Base Map in Chapter 1: Purpose and Need (figure 1.2).

Undiscovered oil and gas reservoirs may be found in geologic formations of the Tertiary or Cretaceous periods (see figure 3.7) that underlie the Currant Creek, Strawberry, Spanish Fork Canyon, and Diamond Fork RFOGDs.

Additional geologic formations that may contain oil and gas reservoirs are Mesozoic or even Paleozoic rocks that may be concealed by formations associated with the Central Utah Overthrust Belt. Tertiary formations and the Central Overthrust Belt are shown in figure 3.8. Geologic formations with oil and gas potential that occur within the UNF are listed below:

- Mesaverde Group, Cretaceous Period (Currant Creek, Strawberry, Diamond Fork, and Payson RFOGDs)
- Wasatch Formation, Tertiary Period (Diamond Fork, Payson, and Deer Creek RFOGDs)
- Green River Formation, Tertiary Period (Strawberry, Diamond Fork, and Deer Creek RFOGDs)

These formations can be seen on the geology maps for each RFOGD (see figures 3.9 – 3.13).

Soils

Soil erosion is determined by a number of factors including, but not limited to, human impacts, vegetative cover, and soil erodibility. Soil erodibility is an estimate of a soil's ability to resist erosion based on physical characteristics. Generally, soils with faster infiltration rates (or permeability), higher levels of organic matter, and improved soil structure have a greater resistance to erosion.

To the extent possible and using the best information available, characteristics that influence soil erodibility and soil erosion are summarized for each MA in table 3.7. This summary also includes information about soil erosion hazard for each MA.

Table 3.7. Summary of soil characteristics by MA.

MA	Soil Texture	Soil Permeability	Disturbed Erosion Hazard
West Fork Duchesne	Medium to fine textured, soft when wet	Moderately rapid	High in the south, particularly Duchesne Ridge
Currant Creek	Medium to fine textured, high silt and sand content	Variable	Wide Range
Deer Creek Reservoir	Medium to fine textured, high cobble or gravel content	Variable	Variable
Hobble Creek	Medium to fine textured, high cobble or gravel content	Moderate	Moderate to very high
Lower Provo	High cobble or gravel content	Moderate to slow	High to very high

MA	Soil Texture	Soil Permeability	Disturbed Erosion Hazard
Diamond Fork	Medium to fine textured and shallow	Moderately slow to very slow	Locally high erosion rates; high erosion hazard because of limited vegetation and past and current grazing practices
Mona	High gravel, cobble, or stone content	Moderate	Moderate to slight
Nephi	High gravel, cobble, or stone content	Moderate	Moderate to slight
Payson	High gravel, cobble, or stone content	Moderate to moderately slow	Moderate to slight
Thistle	High or very high gravel or stone content	Highly variable	Moderate to slight
Strawberry Reservoir[1]	High gravel	Moderate to slow	Highly variable
White River	Medium to fine textured, high silt content	Not Available	High erosion rates over most of the MA because of human impacts; accelerated erosion rates has increased sediment delivery to streams
Willow Creek[2]	Substantial clay content, and/or high gravel or cobble content	Moderately slow	Very high
Upper Spanish Fork	Medium to fine textured with clay	Slow to Moderate	Moderate to high
American Fork	Medium textured loams with high gravel, cobble, or stone content	Variable	Moderate to extreme
Upper Provo	Loam, clay loam, and fine sandy loams	slow to moderate	Low
Vernon	Medium textured soils with high cobble content	Moderate to moderately slow	Slight to severe
West Sheeprock	Medium textured soils with cobbles	Moderate to moderately slow	Moderate to extreme

[1]*Please note that soil mapping is only 30 percent complete.*
[2]*Please note that only a small portion of this MA has been mapped for soils.*

Landslide

Areas with past landslide activity occur throughout the UNF. Landslides occur anywhere the cohesiveness of the soil or bedrock cannot hold the material against gravity. They can be natural or human-triggered, and can occur when the slope has been steepened or when the moisture regime has changed. Slopes can be steepened naturally, as when a stream or river changes course and erodes the toe of the slope, or through human activities such as road or infrastructure construction cutting into the slope.

According to mapping completed by the State of Utah, landslides have occurred on approximately 121,500 acres of the UNF (14 percent) (USFS 2003). Soils mapping on the UNF indicated that approximately 6,000 acres of the UNF have soils associated with landslides. Landslide information indicates the following landslide prevalence on each RFOGD (USFS 2003):

- Currant Creek - (present but mapping not completed)
- Deer Creek - (comprises less than five percent)
- Diamond Fork - (six percent)
- Payson - (seven percent in Thistle, rest not quantified)
- Spanish Fork Canyon - (comprises less than two percent)
- Strawberry - (not noted)
- American Fork - (no less than five percent)
- Upper Provo - (comprises nine percent)
- Vernon - (undetermined)

Other Mineral Resources

The complex geology of the UNF offers opportunities for other mineral resource extraction. The UNF has produced gold, silver, lead, zinc, copper, gypsum, iron, antimony, cadmium, molybdenum, gypsum, limestone, quartzite, sandstone, mangnesian dolomite, tungsten, manganese, bismuth, ozokerite (a hydrocarbon), sand, gravel, stone, and clay (FEIS pg. 3-118). There is also potential for development of oil shale and phosphate. Minerals that may be extracted from the UNF in the future are summarized for each of the RFOGDs below:

- Currant Creek - Coal
- Deer Creek - Limestone and clay
- Diamond Fork - Limestone, Phosphate
- Payson - Limestone, sand and gravel, gypsum
- Spanish Fork Canyon – Oil shale
- Strawberry - Limestone and aggregate mining, ozokerite
- American Fork – gold, silver, lead, zinc, and copper
- Upper Provo – Sands and gravels, aggregates
- Vernon - Silver, lead, gold, other minerals

3.3.2 Introduction

Geology and soils are major factors in the structure of terrestrial and aquatic ecosystems and exert considerable influence on vegetation, watershed conditions and processes, susceptibility to erosion, and land uses. General geology and soils are described in the LRMP and LRMP FEIS. These documents provide a bulk of the baseline data on geology and soils in the area and the following section is largely summarized from these reports. Additional geologic information is included in the RFDS, and is available through JBR (2006).

3.3.3 Affected Environment

Geology

The UNF is underlain predominantly by rocks of two distinct ages: Tertiary formations that, in the Uinta Basin to the east, are known to contain oil and gas reservoirs; and older Paleozoic-age rocks that are part of the exposed northern segment of the Central Utah Overthrust Belt (figure 3.8). Undiscovered oil and gas reservoirs may occur in the Tertiary formations that are known to underlie the Currant Creek, Strawberry, Spanish Fork Canyon, and Diamond Fork RFOGDs, and a relatively small area at the eastern edge of the Deer Creek RFOGD. Coal bed gas reservoirs are unlikely to be present at commercial depths in most of the UNF; however the Tabby Mountain Coal Field may offer potential for coal bed gas development, although probably not before 2017. The Tertiary formations in the Uinta Basin to the east of the UNF containing non-liquid petroleum resources, oil shale, and tar sand deposits also occur beneath the UNF; however, no known or potential commercial deposits have been identified or postulated to occur beneath the UNF (figure 3.14; Cashion 1992 and Blackett 1996).

The Paleozoic and younger rocks of the Overthrust Belt may conceal Mesozoic or even Paleozoic rocks that have the potential to contain oil and gas reservoirs. Oil and gas reservoirs have been found in both the southern part of the Central Utah Overthrust Belt in Sevier County, Utah; and the segment of the Overthrust belt north of the Uinta Uplift in northern Summit County, Utah and adjacent southwestern Uinta County, Wyoming. The reservoir rocks in both of these areas are of Jurassic age.

The eastern limit of the Overthrust Belt in the UNF has been mapped as reaching Strawberry Reservoir on the Geologic Map of Utah (Hintze 1980) and to the east of Strawberry Reservoir by Willis (1999). Recent geologic mapping of the east part of the Provo 30’ x 60’ Quadrangle, issued as a Progress Report Geologic Map (Constenius and Coogan 2004) does not show the large previously mapped thrust faults. Since this map is effectively an interim report, the absence of extensive mapped, through-going thrust faults may reflect the preliminary nature of the work. On the other hand, the lack of such major thrust faults may represent a revised interpretation of the geologic structure of this part of the Overthrust Belt.

The mountain-building process that formed what is today termed the Overthrust Belt in Utah has been named the Sevier Orogeny. This process began in late-Jurassic time, approximately 150 million years ago (mya) and was most active in the late Cretaceous Period (80 to 100 mya). This mountain-building event resulted from compressional forces driven by colliding crustal plates and continued for more than 100 million years. It is believed to have ended in the Eocene Epoch of the Tertiary Period approximately 40 to 50 mya. The plate collisions caused a shortening of the earth’s crust by approximately 100 kilometers in Central Utah. In response to this deep

crustal shortening, the overlying Paleozoic and Mesozoic rocks that now comprise the Overthrust Belt were folded and thrust over one another as the entire upper crustal section was compressed and pushed eastward. Thick shale formations within the Jurassic and Paleozoic rocks provided the zones of weakness in which the thrust faults formed and along which the individual thrust sheets moved (Willis 1999).

The Sevier Orogeny not only produced the thrust faulting and related folding that is recognized today, but also the resultant mountains that were extensively eroded as the orogenic activity progressed. Re-deposition of the eroded sediments contributed to the large accumulations of coarse-grained sediments in the immediate vicinity of the eroding thrust sheets that today have resulted in large, thick deposits of conglomerates along the Wasatch Front. To the east, these sediments contributed to the formation of late-Cretaceous fluvial sandstones and shales, coastal plain, deltaic and deeper water deposits that are widespread in eastern Utah, including at depth in the Uinta Basin (Willis 1999). The process of mountain-building and erosion progressed eastward throughout the time that the Sevier Orogeny was active. The late-Jurassic and older rocks that underlie all or parts of each of the individual RFOGDs were folded and faulted during this complex orogenic process. Late-Jurassic through early Tertiary rocks underlying the UNF were also folded and faulted by this mountain-building event. Many of these and younger sedimentary rocks formed in part from the erosion of the developing mountains and subsequent deposition of these eroded materials as sediments in fluvial and lacustrine deposits in the developing Uinta Basin.

As thrust faulting progressed eastward across Utah, the thrust sheets had less horizontal displacement and "…deformed into smaller amplitude folds between wider spaced thrust faults than the thick western plates" (Willis 1999).

Late Tertiary and Quaternary extensional tectonics began in the Miocene Period approximately 20 mya. This orogenic activity resulted in the predominantly normal faulting and resultant fault-block mountains and intervening basins that characterize the Basin and Range physiographic province whose eastern boundary overlaps the western parts of the American Fork, Deer Creek, Diamond Fork, and Payson RFOGDs; the Vernon Group is located entirely within the Basin and Range province. Prior to and during the formation of the Basin and Range, intrusive igneous activity occurred in the American Fork Group and volcanic rocks were extruded and deposited in both the American Fork and Upper Payson Groups. These geologic processes, combined with the effects of the Sevier Orogeny, have resulted in the very complex geology that characterizes the entire UNF.

Soils

Soils are independent natural bodies composed of a complex mixture of mineral matter, organic matter, and living organisms. Surface soil horizons (i.e., layers) differ from underlying geologic/rock material as the result of geologic processes and interactions of geologic materials with the climate and living organisms. Soil on the UNF can vary considerably over short distances as a result of the diverse geology, geologic processes, climate, and vegetation. Soils on many slopes can be limited, or shallow, and in general soils are deepest along low gradient slopes, valley bottoms, and in glacial basins.

Biotic (also known as cryptogamic and cryptobiotic) soil crusts formed by living organisms and their byproducts can also be found on the UNF. Biotic soil crusts are predominately found in

arid, semi-arid, and alpine areas where terrestrial vegetation is limited. On the UNF, biotic soil crusts occur mainly in sagebrush (i.e., low and black sagebrush), sagebrush/grassland, pinyon-juniper, dry native grassland, and to a more limited extent in some mountain big sagebrush, alpine, and subalpine communities. Vegetation communities potentially containing biotic crusts occupy approximately 237,700 acres (approximately 24 percent) of the UNF. Soil crusts are important to soil stability, nutrient dynamics, plant establishment, and plant growth (USFS 2003).

Soils in many areas of the UNF have been detrimentally impacted by historical land uses, including grazing, mining, water diversions, logging, roads, and dispersed recreation. Much of the UNF was overgrazed in the 1800s and early 1900s, and some areas experienced significant erosion and loss of long-term site productivity. Today, about 29 percent (261,600 acres) of the UNF is outside of active grazing allotments, with significantly lower stocking levels on areas still grazed. In addition, many of the severely eroded areas have been revegetated and measures to mitigate the impacts of grazing have been implemented. Mining occurred primarily in American Fork Canyon and the Sheeprock mountains within the American Fork and Vernon RFOGDS, respectively. Logging, roads, trails, and dispersed recreation has also resulted in compaction of soils and accelerated erosion across the UNF. While conditions in many of these areas have begun to improve due to better management, areas of limited reclamation potential occur within the UNF.

Specific soil profiles and related vegetation can be found in Natural Resource Conservation Service (NRCS) soil surveys. Order 3 soil surveys map soils to the soil association/landtype level. Over the last 30 years, Order 3 soil surveys have been completed on approximately 650,000 acres of the UNF, and additional inventories are currently underway. Table 3.8 summarizes the extent and location of various soil associations/landtypes on the UNF, which are in turn described in detail below (USFS 2003).

Table 3.8. Soil associations/landtypes on the UNF.

Soil Association/ Landtype	Tavaputs Plateau	Uinta Mountains	Strawberry Valley	Wasatch Mountains	Sheeprock Mountains	Approx. Acreage on UNF
Fault Block Mountains				X	X	5,000
Glacial Canyons, Moraines, and Scoured Uplands		X		X		66,000
Mountain Foothills	X	X	X	X	X	9,000
Stream Canyons	X	X	X	X	X	290,000
Structurally Controlled Limestone, Sand-stone, Shale, and Metamorphic Rock	Limestone, Sandstone, and Shale	Limestone	Limestone, Sandstone, and Shale	Limestone, Sandstone, Metamor-phic, and Shale	Limestone, Sandstone, and Shale	92,000
Tectonic Mountains	X	X	X	X	X	168,000
Plateaulands		X		X		6,000
Landslides	X	X	X	X	X	6,000
Lacustrine Deposits				X	X	1,000
Uninventoried or Incomplete Inventory	Some	Some	Yes	None	None	255,000

'X' indicates presence.

Fault Block Mountain Soil Associations/Landtypes

These soil associations occur primarily on the Wasatch Front and Sheeprock Mountains between 5,000 and 9,000 feet in elevation. Slopes are typically straight and steep, have little or no rounding, and have broad, shallow dissection. In the Wasatch Mountains, these soils developed mostly from the Oquirrh and Manning Canyon sedimentary rocks. Soils vary in depth and contain a high percentage of rock fragments. Many of these soils have loam topsoil. Soils are usually entisols, mollisols, or inceptisols. Present and historical activities and associated impacts to these soils have been limited. Some areas are subject to mass movement, but most are stable. Erosion can be substantial on some of these soils (USFS 2003).

Glacial Canyon, Moraine, and Scoured or Sculptured Upland Soil Associations/Landtypes

These soil associations occur where glacial action has been the dominant geologic process. Glaciations were fairly extensive in the higher elevations (above 6,000 feet) of the Wasatch and Uinta Mountains, resulting in cirques, steep-walled U-shaped valleys, and a variety of moraines. Glacial soils are elevation-controlled and not restricted by geologic formation. Many glacial soils have been transported into place by glacial action and are unrelated to the underlying bedrock. Slopes are typically steep and not rounded except at the top and bottom. Dissection is generally shallow and broad, and limited to lower elevations where the soils are deeper. Some deep soils

are found in moraines and the floors of cirques. Soils are generally well-drained and fertile. Bedrock exposures and talus rock are common, as are shallow and rocky soils. Most glacial soils are medium-textured and contain a high percentage of angular rock fragments. Most glacial soils are mollisols, though other orders of soils such as entisols also occur. Some areas are subject to mass movement, but most are stable. Erosion rates are typically low to moderate on these soils (USFS 2003).

Mountain Foothill Soil Associations/Landtypes

These soil associations occur where mountains intersect the valley floor. Numerous stream courses dissect these soils. Some soils have surfaces that are bedrock controlled as to shape and structure. These soils generally occur between 5,000 and 7,000 feet in elevation. Slopes range from 0 to 65 percent, but are typically 15 to 35 percent. Most of these soils are mollisols with loam topsoil and a high gravel or cobble content. The soils on steeper slopes are shallower, coarser-textured, and rocky; those on flatter ground are deeper and have finer textures. Some areas are subject to mass movement, but most are stable. These soils occur on relatively warm, dry sites, and revegetation following severe disturbance can be slow. Erosion can be significant in these soils (USFS 2003).

Stream Canyon Soil Associations/Landtypes

These are the most widespread soil associations on the UNF, and occur where the dominant process is fluvial erosion and deposition. These soils are intermingled with all other soil associations/landtypes. The shape of the topography is controlled by the depth and character of the bedrock. Dissection and slope shape vary. They generally occur below 9,500 feet in elevation and on all geologic formations. Soils are highly variable and include entisols, mollisols, and alfisols. They often have loamy topsoil, high water table, and a high volume of gravel or cobble. Some soils may be shallow and rock outcrops may be present. Many of these soils are highly productive and have been subject to a wide variety of uses. Some areas are subject to mass movement, but most are stable. Erosion rates in these soils vary (USFS 2003).

Structurally Controlled Limestone, Sandstone, Shale, and Metamorphic Soil Associations/Landtypes

These associations occur where the bedrock has not been strongly altered by stream or glacial action, and are generally located between 5,000 to 8,000 feet in elevation. Structurally controlled limestone soils are found in the western part of the Wasatch Mountains and in the Uinta Mountains. In general, structurally controlled slopes are steep and dissection is wide and shallow. Some slopes have a convex rounding. Soils range in depth. Soils derived from limestone and metamorphic rocks are dark, usually calcareous, and often contain many coarse fragments. Soils derived from sandstones are generally deep, red, and also contain many coarse fragments. The skeletal nature of structurally controlled soils results in a low moisture holding capacity and droughty soils. Many of these soils are moderately to highly erosive. These soil associations/landtypes include alfisols, inceptisols, and mollisols (USFS 2003).

Tectonic Mountain Soil Associations/Landtypes

Tectonic mountain soil associations occur on mountain tops, ridgelines, and side slopes. They occupy landforms that have not been altered by glaciations, stream carving, or faulting. They are generally located at the higher elevations, in all types of geologic formations, but are rarer in the soft sedimentary formations. Tectonic mountain soil associations/landtypes include alfisols, inceptisols, and mollisols, and are characterized by steep slopes, rugged terrain, and exposed

bedrock. At higher elevations, soils are generally shallow, have a high percentage of coarse fragments, and are poorly developed. At lower elevations, soils typically have a moderate depth and coarse fragment content, and are better developed. Some unstable areas occur on these soils (USFS 2003).

Plateauland Soil Associations/Landtypes

These soil associations have been mapped in the higher elevations of the Uinta Mountains northeast of Strawberry Reservoir. They are found along ridge tops and are remnants of the land surface that existed prior to glaciation. The geology is primarily sedimentary, but igneous and metamorphic bedrock also occur. Slopes are gentle. Plateauland soils are typically mollisols, fine to medium-textured, and variable in depth and development. Some have a high percentage of coarse fragments. Most of these soils are subject to moderate to high erosion rates if disturbed, are susceptible to rutting, and become slippery when wet (USFS 2003).

Landslide Soil Associations/Landtypes

These soils occur at all elevations and on all geologic formations. They occur anywhere the cohesiveness of the soil or bedrock is insufficient to hold the material against gravity. Landslides may remain at the angle of repose for centuries and develop a deep soil and vegetative cover; however, if the moisture regime is significantly changed or the slope angle steepened, landslides can be reactivated. Landslides are characterized by their flow-like configuration, interrupted drainages, hummocky surface, and slip scars. Landslides range in depth. Ancient and active landslides are found primarily on the Green River Formation and, to a lesser extent, on the Uinta Formation. The vast majority of these landslides are natural, but some have been triggered by human actions. Most soils are deep, well developed, and fine-textured mollisols. Some have a high percentage of coarse fragments. Many have high water tables and are poorly drained.

Landslides on the UNF have also been mapped by the State of Utah. This mapping was done independent of soil surveys, and done at a broader scale and using different parameters than the soils mapping. Consequently, the acreages and areas delineated differ somewhat. Based on this mapping, landslides occur on about 121,500 acres (14 percent) of the UNF. The vast majority (about 92 percent) of these are talus, colluvial slides, or rockfall. Deep-seated landslides occupy about 9,730 acres (1 percent) of the UNF.

Lacustrine Soil Associations/Landtypes

Lacustrine soil associations occupy lake deltas, beaches, and terraces created by ancient Lake Bonneville. The associations occur between 4,400 to 5,500 feet in elevation along the flanks of the Wasatch and Sheeprock Mountains. Slopes range from 8 to 80 percent. Dissection varies from non-existent to strong. These soils are characteristically not highly mixed in terms of particle size, and they usually contain layered sequences of uniform texture. Many lacustrine soils are mollisols, and many now have a veneer of oversoil created through water and wind deposition since the demise of Lake Bonneville. Much of this soil association/landtype was historically overgrazed and experienced detrimental erosion, which left some soils hummocky and armored (fine soil particles were eroded away). These soils occur on the lowest, warmest, and driest parts of the UNF (USFS 2003).

3.3.4 RFOGDs

The following is a description of geology, soils, oil and gas resources and other mineral resources by RFOGD. Accompanying the geology description is a geologic map of each RFOGD. Please refer to these maps for location of the geologic formation that are discussed; the maps are numbered as follows:

- Figure 3.9. Geology Map: Currant Creek Group
- Figure 3.10. Geology Map: Deer Creek and American Fork Groups
- Figure 3.11. Geology Map: Diamond Fork, Upper Spanish Fork Canyon, Upper Provo, and Strawberry Groups
- Figure 3.12. Geology Map: Payson Group

Currant Creek Group

Geology Description

The Currant Creek RFOGD is located in the Colorado Plateau Physiographic Province and includes the south and southwest flanks of the Uinta Uplift and an adjacent part of the Uinta Basin. The northern-most portion of this group is underlain by faulted, steeply south-dipping Mesozoic-age rocks comprised of Jurassic and Triassic sedimentary rocks and Cenozoic Tertiary volcanic and sedimentary deposits. The southern part of the group is underlain by the Tertiary Eocene and Early Oligocene Duchesne River and Uinta Formations in addition to the lower Cretaceous Mesaverde Group and various Jurassic formations that were deformed during the Sevier Orogeny when the Rocky Mountain Overthrust Belt was formed.

Soil Description

The upper elevations of the Currant Creek MA, including Red Creek Mountain, Duchesne Ridge, Currant Creek Peak, and Red Creek Mountain, contain glacially eroded and glacially deposited landforms. In addition, some active and paleolandslides exist and are generally found in areas where thin strata of conglomerate rock overlie Cretaceous shale, primarily in the Duchesne Ridge area (USFS 1999).

Landtype mapping has not been completed for the entire RFOGD. However, completed landtypes that are present include: tectonic mountain, structurally controlled shale and sandstone, stream canyon, plateauland, landslide, mountain foothill, and glacially scoured uplands, canyons, and moraine. Topsoils in the northern portion of the RFOGD are predominantly loam or fine sandy loam, but some soils have loamy sand, silt loam, or clay loam textures. Subsoils generally have loam, clay loam, or fine sandy loam textures. A lesser amount of subsoils have sand, sandy loam, or clay textures. Most topsoils and subsoils have high gravel or cobble content and are moderately deep with moderately rapid permeability and varied drainage. Soil erodibility is highest on the south, particularly Duchesne Ridge, where soils are underlain by shale substrates (USFS 1999). Most soils are moderately productive, but some have a low productivity. Many soils in the area developed from glacial deposits of quartzite, sandstone, or other rocks. In the West Fork Duchesne MA, these include: typic (31 percent) and pachic (27 percent); cryoboroll (25 percent); pachic argiboroll (4 percent); mollic (5 percent) and andeptic (4 percent) cryoboralf; and typic cryorthent (4 percent). These soils are medium- to fine-textured and can become very soft when wet (USFS 2003a).

There are no published soil surveys for the Currant Creek MA. However, soils in the MA are expected to be diverse, a reflection of the diversity of the underlying geology and geologic processes. Soils are generally medium-to fine-textured and have high silt and sand contents. Further, some soils are calcareous and have substantial clay content, as well as a high gravel or cobble content. As a result, the depth, drainage, permeability, and productivity of these soils vary. The inherent erosiveness for most of these soils is moderate with a wide range of disturbed erosion hazard.

Oil and Gas

The two wells in the Currant Creek RFOGD were drilled between 1961 and 1980. A third well was permitted; however, the location was abandoned in 1981 without the well being drilled. According to Utah Division of Oil, Gas and Mining (UDOGM) records, these wells were drilled to 2,719 and 9,290 feet and both were dry holes that were plugged and abandoned. The two wells were drilled north and west of Currant Creek Reservoir near the northwest trending axis of an unnamed anticline. This fold is located in the upper plate of what the WUB FEIS termed the Strawberry Thrust Fault. The stratigraphic targets here are not known; however, the deeper well may have been drilled through a thrust fault, as discussed in more detail in the following paragraphs.

The United States Geological Survey (USGS) has speculated that non-conventional natural gas resources in the Uinta Basin may occur in the following areas that in part underlie the UNF:

- Low-permeability sandstones in the Wasatch Formation and possibly the Mesa Verde Formation
- Shale gas in Cretaceous shales (very minor production to date); the Cretaceous Mancos Shale is a significant gas producer in the Piceance Basin of Colorado and is likely to have potential to produce gas in commercial quantities in the Uinta Basin

The Mesaverde Group, the Dakota Sandstone, and Entrada Sandstone, formations with the known or recognized potential to contain oil and gas reservoirs in the Uinta Basin to the east, are also present on the surface of the Currant Creek Group and are assumed to be present at depth.

The oil and gas reservoirs in the Southwestern Wyoming/Utah segment of the Overthrust belt occur predominantly in the Early Jurassic/latest Triassic Nugget and Twin Creeks Formations. Nothing in the available geologic information for the UNF suggests that oil fields or reservoirs similar to those found in central Utah or Southwestern Wyoming/Utah are present beneath the UNF. However, the available subsurface data certainly does not rule out the possibility that such analogs may exist. A large exposure of the Nugget Sandstone has been mapped in the northern part of the Currant Creek Group. The formation may be a potential reservoir down dip to the south and have the potential for sub-thrust occurrences as was recognized in the Currant Creek Federal 1-26. There are a number of formations, including a number of shale formations, ranging in age from upper Mississippian through Cretaceous that could, depending upon the effects of thrust faulting, act as seals to undiscovered reservoirs beneath the Currant Creek Group.

The Mesaverde Group, the Dakota Sandstone, and the Entrada Sandstone formations have the recognized potential to contain oil and gas reservoirs in the Uinta Basin. These formations are also present on the surface of the Currant Creek Group and are assumed to be present at depth.

Oil shales in the Uinta Basin occur in the Parachute Creek Member of the Tertiary Green River Formation which are certainly present beneath the Currant Creek RFOGD; however, the greatest quantities and more well-defined deposits are located in eastern Uintah County, to the east of the UNF.

Future exploration in this RFOGD is likely to begin with seismic surveys since past exploration, apparently based in large part on observed surface-exposed geologic structures, failed to result in a discovery. It is possible to assume that two exploration wells in the Currant Creek Group could be installed with a multiple-play potential. A single discovery well, a change in crude oil demand, restrictions imposed on oil and gas exploration by future statutory or regulatory actions, or any number of other factors that cannot be anticipated at this time could easily result in a greater or lesser number of new wells on the Currant Creek RFOGD.

Other Mineral Resources

The Tabby Coal Field, an east-west trending unit consisting of the Cretaceous Mesaverde Group and the Frontier Formation of the Mancos Shale, has been mapped through the middle section of the Currant Creek RFOGD. The coal in this area has been mapped as at least four feet thick and less than 3,000 feet deep. Coal as thick as 10 feet is present in the Frontier Formation (Doelling and Smith, 1982) and as many as 21 beds of coal are present in the Mesaverde Group and are up to 28 feet thick (Lupton 1912). The coal in the Frontier and Mesaverde is subbituminous C to lignite A in apparent rank.

Deer Creek Group

Geology Description

The Deer Creek RFOGD is located mainly within the Colorado Plateau Physiographic Province; however, it also lies within the southern portion of the Middle Rocky Mountain and the western edge of the Basin and Range Provinces. The RFOGD is positioned on the east side of the Wasatch Mountains and on the south side of Heber Valley.

Paleozoic Oquirrh Group siltstones, sandstones, and limestone deposits are the dominant geologic formations. Tertiary deposits of igneous lava, breccia, and tuff are the dominant rock types between the Uinta Mountains and the Wasatch Mountains on the very northeastern edge of this area. The eastern edge of the RFOGD adjoins the Charleston Thrust, one of the major thrust faults of the Sevier thrust belt.

The extreme northern portion of the Deer Creek RFOGD consists of Paleozoic Mississippian Great Blue Limestone and Manning Canyon Shale Formations; Permian-Pennsylvanian Oquirrh Group quartzite, shale and limestone; Mesozoic Tertiary Volcanics, which are faulted and dipping to steeply dipping, and Quaternary fluvial and glacial deposits.

The middle and southern sections of the RFOGD consist mainly of Mesozoic Permian-Pennsylvanian Oquirrh Group, with occurrences of Cenozoic Tertiary North Horn, Currant Creek, Green River, and Wasatch Formations, and Quaternary fluvial deposits that are intersected by north-south trending normal and reverse faults.

The southeastern portion of the RFOGD consists of Precambrian Metasedimentary deposits, Paleozoic Mississippian Great Blue and Manning Canyon Formations, Permian-Pennsylvanian Oquirrh Group, and Quaternary fluvial and glacial deposits that are intersected by north-south trending normal and reverse faults.

Soils Description

The Deer Creek RFOGD is comprised of three MAs: Deer Creek, Hobble Creek, and Lower Provo. Common landtypes in the Deer Creek MA are stream canyons (51 percent); tectonic mountains (26 percent); glacially scoured canyons, uplands, and moraines (10 percent); structurally controlled sandstones (9 percent); and landslides (4 percent). Common soil types include: cluff (3 percent), Daybell-Fitzgerald (6 percent), Daybell (9 percent), Gappmayer (6 percent), Gappmayer-Wallsburg (3 percent), Rockland (12 percent), Roundy (22 percent), Sessions (2 percent), and Wallsburg-Rock (4 percent). Most of these soils formed from glacial deposits, sandstone, other mixed sedimentary, or quartzite parent materials. Soils are generally medium- to fine-textured with high cobble or gravel contents. Most topsoil has a loam texture with high clay (clay loam) or sand (sandy loam) content. Subsoils are generally very gravelly or cobbly loam, fine sand, fine sandy loam, clay loam, or clay. Soils vary, but most are deep, moderately productive, and moderately or excessively well drained. Soil permeability and disturbed erosion hazard varies.

The Hobble Creek MA consists of stream canyons (65 percent) and tectonic mountain landtypes. Less common types include: fault block mountain; glacial moraines; scoured uplands and canyons; landslide; mountain foothill; lacustrine; and structurally controlled limestone, shale, and sandstone (each less than 5 percent). Glaciations affected the upper elevations of Provo and Spanish Fork Peaks. In addition, lacustrine deposits from Lake Bonneville extend into the westernmost edge of the MA (USFS 2003a).

The most common soils in the Hobble Creek MA are typic (6 percent), argic (14 percent), and pachic (2 percent) cryoborolls; pachic udic haploboroll (4 percent); boralfic argixerolls (13 percent); typic hapludoll (15 percent); pachic argiustoll (2 percent); lithic cryorthent (10 percent); rockland/rock (4 percent); umbric dystrochrept (8 percent); lithic ustochrept (2 percent); typic cryoboralf (5 percent); and typic eutroboralf (3 percent). These soils are generally medium- to fine-textured with high cobble or gravel contents. Topsoils are generally fine sandy loam, loam, silt loam, clay loam, or silty clay textures. Subsoils are calcareous, and have loam, fine sandy loam, silt loam, silty clay loam, sandy clay loam, clay loam, or clay textures. Most soils are moderately permeable, and well or excessively drained. Inherent erosiveness for most of these soils is moderate to low, and disturbed erosion hazard is generally moderate to very high. Soil productivity varies (USFS 2003a).

The Lower Provo MA consists of stream canyons (38 percent), glacial (23 percent), and tectonic mountains (25 percent); block mountains, lacustrine, landslide, mountain foothill, and structurally controlled shale/limestone landscapes also occur (each less than 5 percent). Past glaciations are evident on the upper elevations of Mount Timpanogos, Cascade Mountain, and Provo Peak. In addition, numerous active and ancient landslides exist within the area, and debris flows and avalanches are dominant geomorphic processes in steep, upper elevation canyons. Lacustrine deposits from ancient Lake Bonneville extend from the west onto the UNF in a few locations.

Common soil types in the Lower Provo MA include: cumulic cryoboroll (6 percent), typic cryoboroll (6 percent), calcic cryoboroll (2 percent), pachic cryoboroll (4 percent), pachic argiboroll (3 percent), typic argiboroll (4 percent), typic calciustoll (2 percent), lithic halustoll (6 percent), udic haloboroll (8 percent), typic haploboroll (8 percent), typic cryorthent (2 percent), typic cryochrept (6 percent), and rock/rockfall (10 percent). These soils generally have high

cobble or gravel content, with loam, silt loam, or fine sandy loam topsoils. Subsoils are stony loam, silt loam, fine sandy loam, clay loam, silty clay loam, or clay, and some are calcareous. Most soils are well or excessively drained, have moderate to slow permeability, and high to very high disturbed erosion hazard (USFS 2003a).

Oil and Gas

The USGS has speculated that non-conventional natural gas resources in the Uinta Basin may occur. The Wasatch and Green River Formations, located in the south central portion of the Deer Creek RFOGD, with the known or recognized potential to contain oil and gas reservoirs in the Uinta Basin to the east, are also present on the surface of the Deer Creek RFOGD and are assumed to be present at depth.

Future exploration is likely to begin with seismic surveys since past exploration, apparently based in large part on observed surface-exposed geologic structures, failed to result in a discovery. It is possible to assume that one exploration well in the Deer Creek RFOGD could be installed with a multiple play potential. A single discovery well, a change in crude oil demand, restrictions imposed on oil and gas exploration by future statutory or regulatory actions, or any number of other factors that cannot be anticipated at this time could easily result in a greater or lesser number of new wells on the Deer Creek RFOGD.

Other Mineral Resources

There is a potential for limestone mining with the occurrences of the Permian-Pennsylvanian Oquirrh Group and Mississippian Great Blue Formation within the Deer Creek RFOGD. With the presence of the Manning Canyon Shale there is also the possibility of clay resources within the RFOGD.

Diamond Fork Group

Geology Description

The Diamond Fork RFOGD is in the vicinity of where the Wasatch plateau of the Colorado Plateau Province intersects with the Wasatch Mountains of the Southern Rocky Mountain Province. The assumed eastern limit of the overthrust belt, which was formed during the Sevier Orogeny, is located through the eastern portion of this group. The southwestern region is highly faulted with most faulting trending north to south. Four major formations extend into this MA: the west side is composed largely of the Paleozoic limestone and shale of the Oquirrh formation; the northeastern and eastern portions are underlain by the Eocene siltstones, shales and conglomerates of the Green River and Uinta formations; and the Paleocene sandstones and conglomerates of the North Horn Formation extend into the south-central portion. There are also outcrops of the Mesozoic Jurassic Triassic Nugget/Navajo, Morrison, Curtis, Entrada and Carmel Formations, in addition to Mesozoic Early Tertiary volcanics and sediments and Quaternary fluvial and glacial deposits.

Soils Description

Stream cutting has been the dominant geomorphic process in the RFOGD, with past glaciations only affecting upper elevations of Spanish Fork Peak. Also, numerous active and paleolandslides exist within the area, primarily on the Uinta and Green River shale formations. Stream canyon (50 percent), tectonic mountain (30 percent), structurally controlled shale (12 percent), and landslide (6 percent) are common landtypes. Fault block mountain, glacially scoured uplands and

canyons, mountain foothill, plateaulands, and structurally controlled limestone and sandstone landtypes also occur, but none occupy more than 5 percent of the RFOGD (USFS 2003a).

Common soil types in the RFOGD include: typic (7 percent), argic (5 percent), lithic (5 percent), and pachic (8 percent) cryoboroll; pachic udic haploboroll (5 percent); boralfic and calcic argixeroll (6 percent); typic hapludoll (18 percent); pachic argiustoll (8 percent); entic halustoll (3 percent); lithic cryorthent (8 percent); umbric dystrochrept (4 percent); typic cryoboralf (6 percent); and typic and mollic eutroboralf (10 percent). These soils are generally medium- to fine-textured with loam, silt loam, silty clay loam, clay loam, fine sandy loam, or silty clay topsoils. Some topsoils have high gravel or cobble content. Most subsoils are calcareous and have high gravel, cobble, or stone contents. Subsoils have loam, fine sandy loam, silt loam, silty clay loam, sandy clay loam, clay loam, silty clay, or clay textures. These soils are generally shallow, moderately slowly permeable, and highly erodible. High alkalinity of these soils limits vegetation and further increases erosion hazard. Soil erosion in the area is high, primarily due to grazing. While current grazing practices are improving, locally high erosion rates can still be observed (USFS 2002).

Oil and Gas

Thirteen wells have been drilled in the Diamond Fork RFOGD, but completion dates are unavailable for several of them. However, the eight wells for which completion dates are available were drilled between 1945 and 1995. The 13 wells ranged in depth from 941 to 12,061 feet and all are recorded as dry holes that were plugged and abandoned. Ten of the 12 wells are located near the axis of the Diamond Fork Anticline or other unnamed structures in the area. The two wells in the southeastern part of the Diamond Fork Group are drilled in the vicinity of several inferred faults and what may be a plunging anticline.

It is probable that past exploration on UNF leases was directed at geologic structures, chiefly anticlines, identified by surficial geologic mapping. These structures occur in Cretaceous and early Tertiary sedimentary rocks deposited in the western edge of the Uinta Basin that were subsequently folded and probably thrust-faulted in the latter stages of the Sevier Orogeny. Some of the wells, based on their relatively shallow depth, may have targeted the folded early Tertiary Green River and Wasatch Formations in the upper plate. Other, deeper wells almost assuredly were drilled through the upper plate, through one or more thrust faults, and completed in lower plate rocks.

The USGS has speculated that non-conventional natural gas resources in the Uinta Basin may occur. The Wasatch and Green River Formations, located in the eastern and central portion of the Diamond Fork RFOGD, with the known or recognized potential to contain oil and gas reservoirs in the Uinta Basin to the east, are also present on the surface of the Diamond Fork RFOGD and are assumed to be present at depth.

The oil and gas reservoirs in the Southwestern Wyoming/Utah segment of the Overthrust belt occur predominantly in the Early Jurassic/latest Triassic Nugget and Twin Creeks Formations. Nothing in the available geologic information for the UNF suggests that oil fields or reservoirs similar to those found in central Utah or Southwestern Wyoming/Utah are present beneath the UNF. However, the available subsurface data certainly does not rule out the possibility that such analogs may exist. A small exposure of the Nugget Sandstone has been mapped in the central portion of the Diamond Fork RFOGD. There are a number of formations, including a number of

shale formations, ranging in age from upper Mississippian through Cretaceous that could, depending upon the effects of thrust faulting, act as seals to undiscovered reservoirs beneath the Diamond Fork RFOGD.

Oil shales in the Uinta Basin occur in the Parachute Creek Member of the Tertiary Green River Formation and are certainly present beneath the Diamond Fork RFOGD; however, the greatest quantities and more well-defined deposits are located in eastern Uintah County, to the east of the UNF.

Future exploration is likely to begin with seismic surveys since past exploration, apparently based in large part on observed surface-exposed geologic structures, failed to result in a discovery. It is possible to assume that one exploration well in the Diamond Fork Group could be installed with a multiple play potential. A single discovery well, a change in crude oil demand, restrictions imposed on oil and gas exploration by future statutory or regulatory actions, or any number of other factors that cannot be anticipated at this time could easily result in a greater or lesser number of new wells on the Diamond Fork Group.

Other Mineral Resources

There is a potential for limestone mining with the occurrences of the Permian-Pennsylvanian Oquirrh Group. There is an existing phosphate lease (lease number SL 015875) located in Township 8 South, Range 4 East, Section 23 which is associated with current and historic phosphate mining in the management area.

Payson Group

Geology Description

The Payson Group lies mainly within the Colorado Plateau Province; however the northwestern portion lies in the very southern end of the Middle Rocky Mountain Province. The Middle Rocky Mountain Province of the Payson Group consists of fault-block mountains that were formed during the compressional and extensional forces during and following the Sevier Orogenic event. The geologic formations consist of the Paleozoic Devonian-Cambrian Carbonates and the Mississippian shales and carbonates, the Permian-Pennsylvanian Oquirrh Formation limestone and shales with some occurrences of Cenozoic Quaternary fluvial, alluvial, and glacial deposits. The Colorado Province portion of the Payson Group is composed largely of thick, mainly horizontal beds, some of which have been tilted or folded due to the compressional forces of the Sevier Orogeny. The area is dominated by the Paleozoic limestone and shale of the Oquirrh Group; however, it also contains a small outcrop of Mesozoic Jurassic-Triassic Nugget/Navajo Formation in the northern central portion of the group; the Jurassic Morrison/Entrada/Carmel Formations; the Cretaceous Mancos Formation and Mesaverde Group; the Cenozoic Tertiary formations of the North Horn/Currant Creek, Wasatch and Upper Tertiary Volcanics; and Cenozoic Quaternary fluvial and alluvial deposits.

Soils Description

The Payson RFOGD is comprised of four MAs: Mona, Nephi, Payson, and Thistle. The most common soils within the Mona MA are rock/rubble (23 percent), Agassiz (9 percent), Bezant (13 percent), Flygore-Parkay/Starley-Rock (5 percent), Lizzant (4 percent), Lundy-Rock (5 percent), Pachic Cryoborolls (18 percent), and Yeates Hollow-Rock (8 percent). These soils generally have loam topsoils, most with a high gravel, cobble, or stone content. Subsoils are typically very gravelly, cobbly, or stony loam and some have high clay content and/or are calcareous. Soil

depths and disturbed erosion hazards vary, but most are deep and have moderate to slight erosion hazards. Most of these soils are moderately permeable, and are well or excessively drained. Soil productivities are generally low to moderate.

The Nephi MA's most common soils are rock/rubble (7 percent), Agassiz (4 percent), Bezzant (16 percent), Hamtah (6 percent), Pachic cryoborolls (19 percent), Saxby (8 percent), Sheep Creek (5 percent), Typic haploborolls (14 percent), and Yeates Hollow (10 percent). These soils generally have loam topsoils, many with high gravel, cobble, or stone contents. Subsoils are typically very gravelly, cobbly, or stony loam; clay loam; or sandy clay loam. Most soils are moderately permeable. These soils are well or excessively drained, and most have a moderate to slight disturbed erosion hazard. These soils have low to moderate productivity.

The most common soils in the Payson MA are Argic pachic cryoborolls (7 percent), Agassiz (4 percent), Bezzant (6 percent), Dry Creek (3 percent), Flygore-Starley-Rock (9 percent), Pachic cryoborolls (31 percent), Rockland (8 percent), Typic haploborolls (6 percent), and Yeates Hollow-Rock (5 percent). These soils generally have loam or gravelly, stony, or very stony loam topsoils. Subsoils are typically loam, sandy loam, clay loam, or clay with high stone, gravel, or cobble content. Soil depths are highly variable, have moderate to moderately slow permeability, and are well or excessively drained. Disturbed erosion hazard ranges from slight to moderate. Soil productivity varies from moderate to low.

Common soils in the Thistle MA include: Argic pachic cryoboroll (3 percent), Agassiz (4 percent), Bezzant (22 percent), Flygore-Starley-Rock (6 percent), pachic haploxeroll (5 percent), pachic cryoboroll (26 percent), typic haploboroll (12 percent), and Yeates Hollow-Rock (13 percent). These soils generally have loam topsoils, most with a high or very high gravel or stone content. Subsoils are typically loam or clay loam, but some have a clay or sandy loam subsoil, and most have a high gravel, cobble, or stone content. Soil depths and permeability are highly variable and productivity is moderate to low. Erosion hazard ranges from slight to moderate.

Oil and Gas

The Triassic-Jurassic Nugget/Navajo Formation, the Cretaceous Mesaverde Group, and the Tertiary Wasatch Formation, with the known or recognized potential to contain oil and gas reservoirs in the Uinta Basin to the east, are also present on the surface of the Payson Group and are assumed to be present at depth.

Other Mineral Resources

There is a potential for limestone mining with the occurrences of the Permian-Pennsylvanian Oquirrh Group. The occurrence of Quaternary Lacustrine Lake Bonneville Sediments and alluvial deposits could be sources for sands and gravels.

Spanish Fork Canyon Group (LRMP page 5-156)

Geology Description

The Upper Spanish Fork Canyon RFOGD lies in the area where the Wasatch Mountains to the west intersect with the Wasatch plateaus to the east and south. Eocene calcareous mudstones, siltstones, and shales of the Green River formation underlie most of the area. Tertiary conglomerate rocks from the North Horn formation surface at the Narrows on Highway 6, and extend through the west end of the management area. Eocene sandstone and siltstone rocks from the Duchesne River/Uinta formations extend into the north end.

Soil Description

Numerous active and paleolandslides exist within the area, primarily on the Uinta and Green River formations. The most common landtypes are stream canyon (47 percent), tectonic mountain (39 percent), and structurally controlled shales (12 percent). Minor areas of landslide and plateau landtypes have also been mapped, each occupying less than two percent. The most common soils are argic (10 percent), and pachic (5 percent), cryoborolls; pachic udic haploborolls (3 percent); typic hapludolls (19 percent); pachic argiustolls (12 percent); entic halustolls (11 percent); lithic cryorthents (4 percent); typic cryoboralfs (6 percent); and typic and mollic eutroboralfs (18 percent). These soils are medium-to fine-textured, often with fairly high clay content. Topsoils are typically loam, silt loam, silty clay, gravelly silt loam, gravelly loam, or cobbly loam textures. Subsoils are calcareous, and have high gravel, cobble, or stone contents, and have fine sandy loam, sandy clay loam, clay loam, silty clay loam, silt loam, or silty clay textures. Many of these soils are moderately deep. They range from poor to well drained with slow to moderate permeability. Many become very soft and slick when wet. Inherent erosiveness for most of these soils is moderate, and disturbed erosion hazard is generally high or very high. Many of these soils have moderate to high potential for mass movement. Soil productivity ranges from relatively good to low depending upon soil depth, slope, and depth to clay or calcareous layers.

Oil and Gas

Undiscovered oil and gas reservoirs may occur in the Tertiary formations that are known to underlie the Spanish Fork Canyon Group. This area was considered as having high or moderate potential for finding significant oil and gas reserves in the Western Uinta Basin Oil and Gas Leasing FEIS (USDA 1997b), and leases will continue to be offered competitively. Coal bed gas reservoirs are unlikely to be present at commercial depths in most of the UNF other than around the Tabby Mountain coal field (Currant Creek MA). The Uinta-Piceance Transitional and Migrated Gas AU is located at the southern margin of the Uinta Basin Continuous Gas AU and may extend beneath the southern part of the Strawberry Group, the Spanish Fork Group, and the southern edge of the Diamond Fork Group (figure 3.11). Reservoirs in this AU consist of many of the same formations that contain the reservoirs in the Uinta Basin Continuous Gas AU.

For both of the above-referenced AUs, the USGS estimates that most discoveries of new fields within the next 30 years will be in the vicinity of fields from which production currently takes place from the reservoirs sourced by the Mancos/Mowry Shales. These fields are located at least 100 miles east of the UNF in the eastern Uinta Basin. Accordingly, the potential for a discovery in the UNF of a reservoir of this type during the next 10 to 15 years is very unlikely. (Cashion 1992 and Blackett 1996 in RFDS Draft 8).

Other Mineral Resources

The Mahogany zone of the Parachute Creek Member of the Tertiary Green River Formation that bears oil shales in the Uinta Basin is also present below the UNF lands including the Spanish Fork Canyon RFOGD. Although of a lesser thickness than the Mahogany zone in the Uintah Basin, Spanish Fork Canyon has the potential for this type of hydrocarbon occurrence in the subsurface formations that contain reservoir rocks (RFDS V8).

Strawberry Group

Geology Description

The Strawberry Group lies at the western edge of the Uinta Basin in the vicinity where the Wasatch Mountains of the Middle Rocky Mountain Province and the Wasatch plateaus of the Colorado Plateau Province come together. In the vicinity of the Twin Peaks area and in the complex area between the Uinta and the Wasatch Mountains, the older rocks are thrust over younger rocks at the eastern limit of the Overthrust Belt. The northern portion of the Strawberry Group consists of Paleozoic Tertiary Oligocene Uinta and Colton Formations; the Mesozoic Cretaceous Mesaverde; Jurassic Morrison, Curtis, Entrada, and Carmel Formations; the Jurassic-Triassic Nugget/Navajo; the Triassic undifferentiated shales, siltstones, and carbonates; the Permian-Pennsylvanian Oquirrh Formation and Mississippian undifferentiated shales and carbonates. Rocks of the Paleozoic Tertiary Uinta, Browns Park, and Duchesne Formations dominate the central regions of the group, and then give way to the Tertiary Eocene Green River Formation that dominates the southern extent of the group.

Soils Description

An advance copy of the Order 3 NRCS Soil Survey for the Strawberry Valley Area, completed in 2005, was used to develop the following soil summary. Major soil map units within the Strawberry group include the following soil complexes:

Table 3.9. Soil complexes within the Strawberry group.

Map Unit Name	Symbol
Tabbyune-Hubin	AXD
Flygare-Sisna	ERE
Sisna-Flygare	EUE
Sisna-Baird Hollow	RXE
Sisna-Zalano	UXE
Lyard-Naphide-Sisna	WXE
Bearhole-Poisonridge-Avaya	XLD
Bearhole-Poisonridge-Jakes	XLE
Calfhollow-Gremp-Rock outcrop	YKE
Squaretop-Longridge	YND
Bigbug-Longridge	YOE
Rial-Bigbug	YPE
Allen Creek-Rock outcrop-Squaretop	YMF

The area to the north of, and the slopes to the west of Strawberry Reservoir include soils with textures ranging from fine sandy loams to very cobbly loams on hills and mountain slopes (ERE, EUE, UXE). While most soils are well drained with moderate run-off, some clay sublayers create high shrink-swell potentials (RXE, WXE) and high run-off areas. Soils on Strawberry Ridge (ERE, EUE) have an eluviated (leached) horizon. These soils are found between 7,500 to 10,000 feet elevation. Vegetation includes sagebrush and grass at lower elevations, and Engelmann spruce and aspen with shrub/forb understory at higher elevations.

East of the reservoir, along Windy Ridge and the area traversed by Highway 40, soils tend to be loams and clay loams, are well drained, have moderately slow permeability, are moderate to high in calcium carbonate and have a high to very high runoff rate due to shallow depth or swelling clays (XLD, XLE, YKE). These lands are between 6,000 and 8,000 feet elevation and support sagebrush grasslands.

Soils located along the shoreline and valley of Strawberry Reservoir have 2-25% slopes and are cobbly loams (AXD). They are well drained with medium runoff and moderately slow permeability. Vegetation is dominated by sagebrush and grass.

The YMF soil complex is found in the bottom of Willow Creek and on convex slopes including near the top of Center Canyon, Poison Ridge, and Baldy Mountain. It is only found in the southern portion of the Strawberry group. It is derived from mudstones, shales, and fine sandstones and is quite erosive. Mountain sagebrush, silver sagebrush, and mountain brome are dominant plants.

Soils on the slopes of Willow Creek drainage are also shale-derived and include an organic horizon over loams and channery clay loams. Soils are moderately deep, well drained, with moderately slow permeability and high runoff rate due to fine particle size. Some areas have high shrink-swell potential. Higher elevations have an eluviated (leached) horizon. Elevation ranges from 7,500 to 9,800 feet. Vegetation includes mountain brome, forbs, and mountain shrubs at lower elevations, and quaking aspen, forbs, and Engelmann spruce at higher elevations (YND, YOE, YPE). The YPE and YOE soils are also found on Strawberry Ridge and Willow Creek Ridge down to the south end of Strawberry Reservoir.

Livestock grazing, removal of riparian vegetation, logging, mining, and water diversions have resulted in extensive soil loss and accelerated erosion in portions of the Strawberry MA. Re-vegetation efforts, changes in water delivery mechanisms, and improved grazing practices have improved conditions in many areas. However, areas with extremely rocky soils, especially above timber line, may not recover due to wind erosion, cold temperatures, and wind induced desiccation (USFS 1996b). The most impacted areas are Trail Hollow, Devil’s Notch, Indian Creek, the Strawberry River above Mill B Corral, Bjorkman Hollow, and particularly the Little Grand Canyon area of Co-op Creek (USFS 1997).

The White River MA consists of stream canyon (35 percent), structurally controlled shale (52 percent), and tectonic mountain (13 percent) landtypes. The most common soils are argic (9 percent), lithic (27 percent) and argic pachic (27 percent) cryoborolls; typic hapludoll (18 percent); entic halustoll (4 percent); lithic cryorthent (4 percent); and typic cryoboralf (9 percent).

These soils are medium- to fine-textured and have high silt contents. Most have loam or silt loam textured topsoils. Some topsoils are calcareous, have substantial clay content, and/or have high gravel or cobble content. Subsoils typically are calcareous and have high gravel contents with fine sandy loam, silt loam, silty clay loam, or silty clay textures. Most of these soils become extremely soft and slick when wet. Soils are generally deep on northerly aspects and very shallow on south-facing slopes. In addition, south-facing slopes are generally infertile and often lack extensive plant cover, leading to naturally high erosion rates. The majority of the area has been impacted by grazing, mining, fire, and road cutting, which has accelerated erosion rates and increased sediment delivery to streams. Improved grazing practices and reclamation efforts

promise to improve conditions. However, areas with extremely rocky soils, especially above timber line, may not recover due to wind erosion, cold temperatures, and wind induced desiccation (USFS 1996b).

Soils and landtype mappings have been completed only for a very small part of the Willow Creek MA. They indicate that stream canyon and tectonic mountain landtypes are common. Given the topography and underlying geology, it is likely that structurally controlled shale landtypes also occur.

Soils in the Willow Creek MA are generally medium- to fine-textured and have high silt contents. Some topsoils are calcareous, have substantial clay content, and/or have high gravel or cobble content. Subsoils typically are calcareous, and have high gravel contents and medium or fine textures. The depth, drainage, permeability, and productivity of these soils vary. Most soils are moderately deep, moderately well drained, and have moderately slow permeability. These soils generally have low to moderate productivities due to their depth and their subsoil's high clay and lime content. Inherent erosiveness for most of these soils is moderate, and disturbed erosion hazard for most soils is very high. Many of these soils become soft and slick when wet.

Oil and Gas

Including wells drilled within the Strawberry Lands, 13 wells have been drilled in the Strawberry RFOGD between 1952 and 1982. These wells ranged in depth from 2,758 feet to 19,993 feet and all are recorded as dry holes that have been plugged and abandoned. Surficial structural geology, or perhaps remote geophysical data (e.g., gravimetric or magnetic surveys), were probably used to site the wells. The seismic lines in the southern part of the Strawberry RFOGD were shot in 1984 and 1985, apparently after the exploration wells in the area had been drilled.

One APD was filed for a location in the southeast corner of the Strawberry RFOGD near Tabbyune Creek in 2005; it has not been approved. There are no other approved or pending APDs on the UNF.

The Mesaverde Group and Green River Formation, with the known or recognized potential to contain oil and gas reservoirs in the Uinta Basin to the east, are present on the surface of the Strawberry RFOGD and are assumed to be present at depth.

Oil shales in the Uinta Basin occur in the Parachute Creek Member of the Tertiary Green River Formation which and certainly present beneath the Strawberry RFOGD; however, the greatest quantities and more well-defined deposits are located in eastern Uintah County, to the east of the UNF.

A small-known tar-sand deposit is located in the RFOGD, on the boundary of the Deer Creek group, near Daniels Summit. Additionally, tar-sand deposits have been located east southeast of the Strawberry RFOGD in Duchesne County (UGS 2004).

Future exploration is likely to begin with seismic surveys since past exploration, apparently based in large part on observed surface-exposed geologic structures, failed to result in a discovery. It is possible to assume that three exploration wells in the Strawberry RFOGD could be installed with multiple-play potential. A single discovery well, a change in crude oil demand, restrictions imposed on oil and gas exploration by future statutory or regulatory actions, or any number of other factors that cannot be anticipated at this time could easily result in a greater or lesser number of new wells on the Strawberry Group.

Other Mineral Resources

There is a potential for limestone mining with the occurrences of the Permian-Pennsylvanian Oquirrh Group. Quaternary alluvial deposits that lie north and south of Strawberry Reservoir within the Strawberry River, Co-op Creek, and Indian Creek drainages may prove to be potential areas for aggregate mining.

American Fork Group

Geology Description

The American Fork RFOGD lies on the west flank of the Wasatch Mountains, is dominated by American Fork Canyon, and is one of the most geologically diverse on the Forest. The dominant rock types found are the Paleozoic limestone, shale, sandstone, and quartzite of the Oquirrh Group, but the area also includes exposures of Tertiary volcanic and granitic rocks in the Lone Peak and Clayton Peak areas. Silver was mined from zinc and lead-sulfide ores in Mineral Basin, Mary Ellen Gulch, and Major Evans Gulch. Paleozoic carbonate rocks were eroded by percolating groundwater to form numerous caverns, including Timpanogos Cave, which was formed by solution of Mississippian limestone. Stream erosion has exposed underlying Cambrian and Pre- Cambrian sedimentary rocks in the lower part of the canyon. High elevation sites were glaciated numerous times. Deep-seated landslides often occur in the Pennsylvanian Manning Canyon shale where it is exposed, and debris flows and avalanches are dominant geomorphic processes in steep upper elevation canyons. During the last glacial period, approximately 10,000 years ago, Lake Bonneville covered the lowest reaches of the management area (USFS 2003).

Soil Description

The most common landtypes in the area are glacial (33 percent), stream canyon (29 percent), and tectonic mountain (28 percent). Fault block mountain, lacustrine, landslide, mountain foothill, and structurally controlled limestone landtypes also occur, but are less common (none occupy more than 5 percent of the area). Soils in the management area are diverse and include: cumulic cryoborolls (4 percent), typic cryoborolls (6 percent), pachic cryoborolls (9 percent), pachic argiborolls (3 percent), typic argiborolls (2 percent), lithic halustolls (4 percent), udic haloborolls (7 percent), typic haploborolls (7 percent), typic cryorthents (2 percent), lithic cryorthents (3 percent), typic cryochrepts (5 percent), and rock/rockfall (12 percent). Most soils generally have loam, silt loam, or sandy loam topsoils with a high gravel, cobble, or stone content. Most subsoils have a high gravel, cobble, or stone content. In many areas the soils are quite limited or very shallow. Permeability varies considerably. Most soils are well or excessively drained. Disturbed erosion hazard ranges from moderate to extreme. Soil productivity varies from relatively good to low. Several soils are inherently unstable. Soil stability has been heavily impacted in the past by grazing, road construction, mining, and logging. Restoration efforts, including terracing and improved grazing practices, have greatly improved soil stability (USFS 2002).

Oil and Gas

Based upon the extensive exposures of both extrusive and intrusive igneous rocks and related hydrothermal activity in the northern part of the American Fork Group, this part of the UNF is unlikely to receive consideration for oil and gas exploration during the analysis period (RFDS v8).

Other Mineral Resources

Minerals obtained in the upper reaches of the North Fork of American Fork Canyon include gold, silver, lead, zinc, and copper. Much of the land that was dedicated to mineral extraction is in private ownership, but is located within the National Forest boundary. There are currently seven active mining claims on National Forest System lands, including the Big Dane series, International, and Kearsage. Access by road is very difficult due to steep grades, narrow canyons, and the remoteness of the area. The North Fork of American Fork Canyon was withdrawn from any future mining claims for purposes of watershed protection in the 1960s. Recreational dredging is allowed but only under permit issued by the State of Utah. Owners of existing mineral claims on private property may mine in the future if the ore can be extracted and processed economically (USFS 2003).

Upper Provo Group

Geology Description

The Upper Provo RFOGD lies on the west slope of the Uinta Mountains. Sedimentary sandstone, shale, and limestone rocks dominate the northeastern portions of the area, with rocks formed from Tertiary deposits of igneous lava, breccia, and tuff in the southwestern portion. Numerous faults, including an active east-west fault, extend through the area. Solution caverning and karst formation has also been active in the Soapstone Basin area.

Soil Description

The Upper Provo RFOGD includes the upper elevations of the Uinta Mountains, most of which have been glaciated. In addition, paleolandslides have occurred within the management area, mostly on Paleozoic Manning Canyon shale. Landtypes found on the RFOGD include Tectonic mountain (32 percent), stream canyon (30 percent), glacially scoured canyon, upland, and moraine (16 percent), structurally controlled shale (12 percent), landslide (9 percent), and plateauland (less than one percent).

Soil mapping has been completed for the Soapstone area, which represents about 13 percent of the management area. This limited mapping indicates that the most common soils in the Soapstone area are typic cryocrepts (3 percent), lithic cryoborolls (1 percent), argic pachic cryoborolls (1 percent), lithic cryorthents (1 percent), typic cryoboralfs (1 percent), and rock (1 percent). These soils are medium to fine textured and are formed from glacial till, limestones, and the fine-textured Mancos shale. Due to their texture, many of these soils become soft when wet. Topsoils are loam, clay loam, or fine sandy loam. Most topsoils have a high gravel or cobble content and some are calcareous. Subsoils, where present, have sandy loam or clay textures. Soil depths, productivities, and drainage vary considerably. Most soils in the Soapstone area have moderate to high inherent erosiveness, and moderate to very high disturbed erosion potential. Permeability of most soils in the Soapstone area is slow to moderate. Potential for mass movement is generally low.

Oil and Gas

Based upon extensive surface exposures of both extrusive and intrusive igneous rocks in the Upper Provo Group, this part of the UNF is less likely to receive consideration for oil and gas exploration during the analysis period. However, the potential for sub-thrust occurrences of the hydrocarbon-bearing Nugget Formation, such as occurred in the Currant Creek Group, may exist in the Upper Provo Group particularly with deeper drilling (RFDS v8).

Other Mineral Resources

No other mineral resources of note have or are being developed on the Upper Provo RFOGD, although sand and gravel resources exist within the management area. This area is approximately 95 percent National Forest System lands, with some private land along the Provo River and the South Fork of the Provo. These private lands and the western side of Management Area 5 - 151 are being developed and have the potential for encroachment onto Forest Service lands. The Chevron Corporation pipeline bisects the management area, generally following the Wolf Creek Highway. The Forest Service's Soapstone Repeater Site is located on the southern edge of the area. Two organizational camps, the Mill Hollow Outdoor Education Center (managed by the Granite School District) and Piuta Camp, are located in this management area. These facilities provide environmental education opportunities for youth groups. Both are managed through the issuance of special use permits (USFS 2003).

Vernon Group

Geology Description

The Vernon Management Area is within the Vernon RFOGD and lies on the northeast side of the Sheeprock Mountain Range and is similar to the Sheeprock Management Area in vegetative and geologic characteristics, differing only in aspect. The Vernon Management Area faces northeast and is part of the Rush Valley watershed. The Sheeprock Mountains are formed primarily of Precambrian and Tertiary igneous and metamorphic rocks, with some sedimentary rocks present. There is evidence of possible glaciations in the North Oak Brush Canyon area and lacustrine deposits from Lake Bonneville in the lower elevations. Stream canyon, mountain foothill, fault block mountain, and lacustrine landtype associations can be found in the area.

The West Sheeprock Management Area is within the Vernon RFOGD, and like the Vernon Management Area, lies within the Sheeprock Mountains but on the southwest side. Stream canyon, mountain foothill, and fault block mountain landtype associations occur within this management area.

Soil Description

This area has been mapped for soil types. The most common soils in the Vernon MA are borvant (12 percent), Erda (10 percent), Kapod (9 percent), Lodar-Lundy (6 percent), Podmor-Onaqui (18 percent), Reywat- Broad (17 percent), and Taylorsflat (12 percent). Most soils are mollisols or aridisols. In general, these soils have loam or silt loam topsoils often with a high gravel or cobble content. Subsoils are typically loamy, although subsoils range from those with a high sand or clay content, to those that are gravelly, very gravelly, or very cobbly. Soil depths range from shallow to very deep. Permeability of these soils is moderate or moderately slow. Most of these soils are well drained. Erosion hazard ranges from slight to severe. Soil productivity varies from relatively good to low.

The most common soils in the Sheeprock MA are Kapod (25 percent), Reywat/Broad (36 percent), and Podmor/Onaqui (25 percent). Most of these soils are mollisols. In general, these soils have cobbly to very cobbly loam topsoils over gravelly or very gravelly loam, sandy loam, or clay loam subsoils. Soil depths range from shallow to deep. Permeability of these soils varies from moderate to moderately slow. These soils are typically well drained. Erosion hazard ranges from moderate to extreme. In general, these soils have relatively low productivities due to the

soil's high rock content, the moderate to steep slopes they typically occupy, and their southwest aspect.

Oil and Gas

The potential for sub-thrust occurrences of the oil and gas-bearing Nugget Formation such as was recognized in the Currant Creek Federal 1-26 well may exist in the Vernon Group, where Paleozoic rocks are part of an upper thrust plate. No drilling has been carried out to-date, but interest in Overthrust Belt-related oil and gas exploration activities in the eastern Great Basin in Utah and Nevada may lead to seismic activity in the Vernon Group. The RFDS indicates that no exploration drilling is anticipated to occur during the 10- to 15-year period on this group due to the lack of known oil or gas reservoirs in the eastern Great Basin of Utah (RFDS v8). However this EIS contemplates the possibility that prospective exploration activity could occur in any or all of the RFOGD groups.

Other Resources

Mining activities in this management area date back to the late 1800s. Ore bodies include silver, lead, gold, and perhaps other minor metals. Mining activities occurred on and off National Forest System lands, and there are many private patented lands and claimed lands within the area. There are currently 13 active mines on the Vernon and West Sheeprock Management Areas including the Desert, Dunces, Wrong Way, Contact, Blue Beauty, and Crystal. Over the last several years the Forest has worked with the State of Utah and private landowners in closing dangerous mine adits, drifts and obscure, deep vertical shafts, which create a hazard to the general public recreating in the area. Old and abandoned tailing piles from excavated mines are being evaluated for high levels of hazardous minerals and other deleterious materials that may cause environmental damage. This management area will continue to be of interest to future prospectors. Should ore become economically viable, more prospecting activity is expected to occur while abandoned and open mine shafts and tailings piles will evaluated and closed for safety reasons (USFS 2003).

Figure 3.8. Oil and gas fields and oil shale in the UNF and surrounding areas.

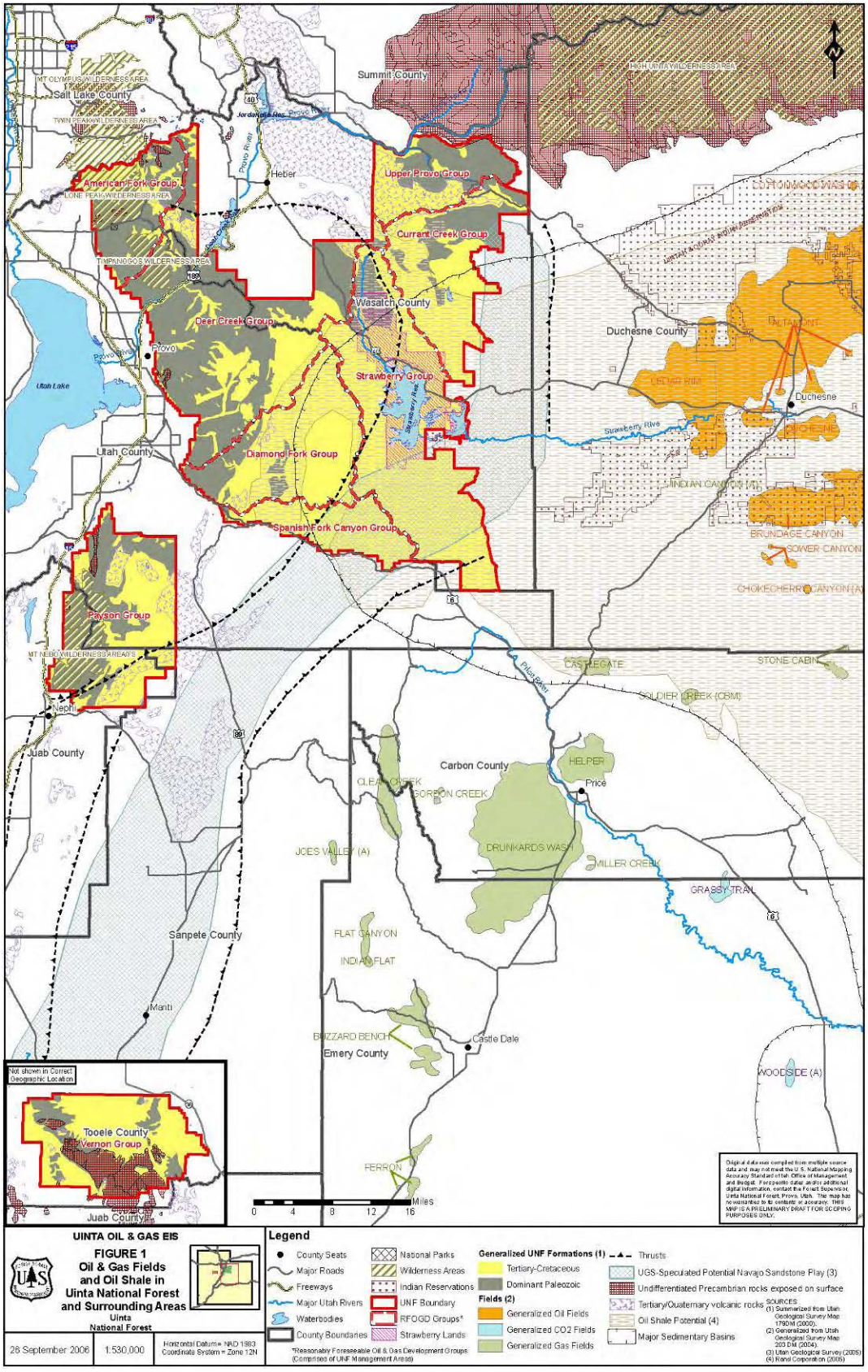

Figure 3.9. Geology map: Currant Creek group.

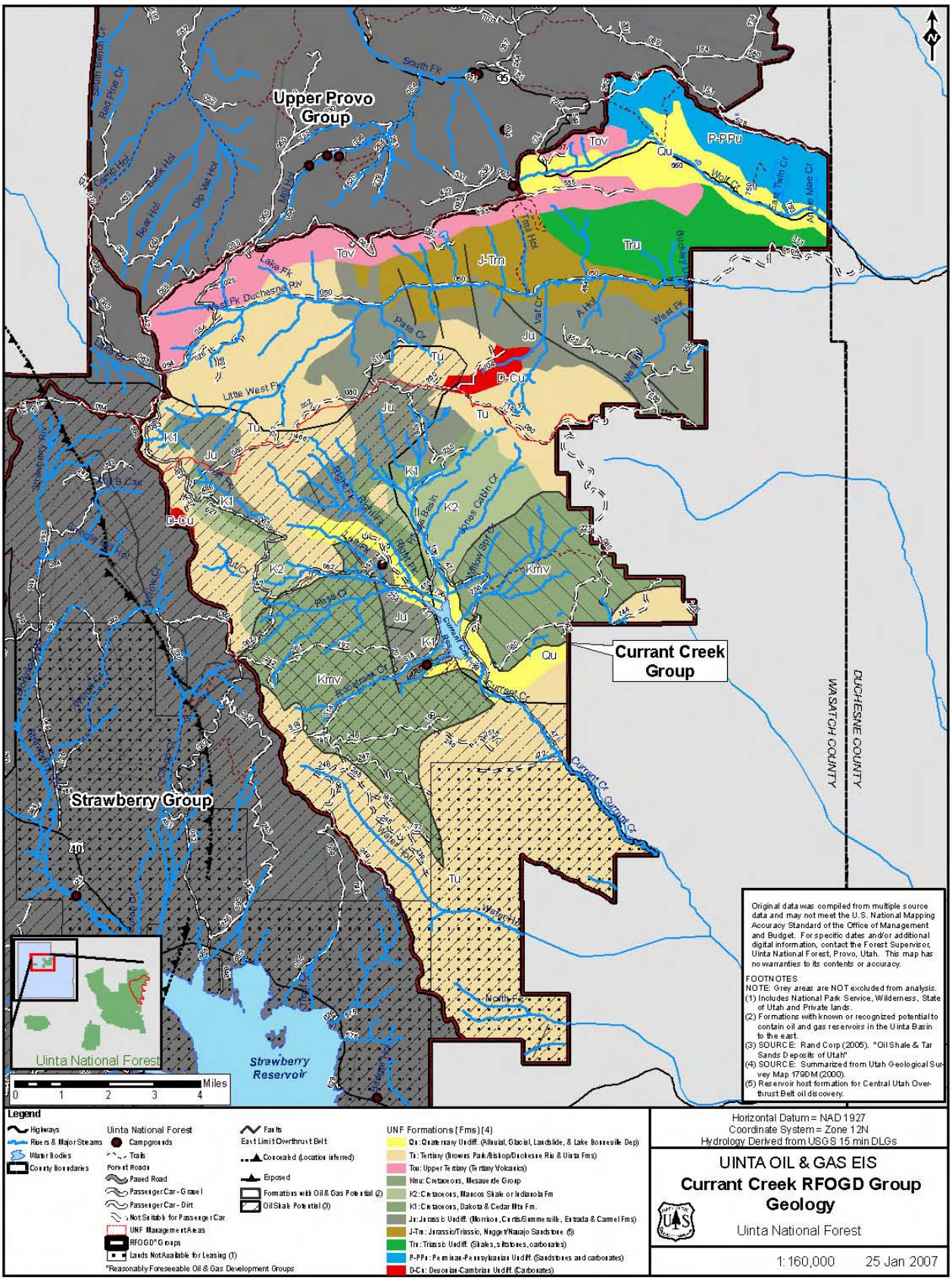

Figure 3.10. Geology map: Deer Creek Group and American Fork groups.

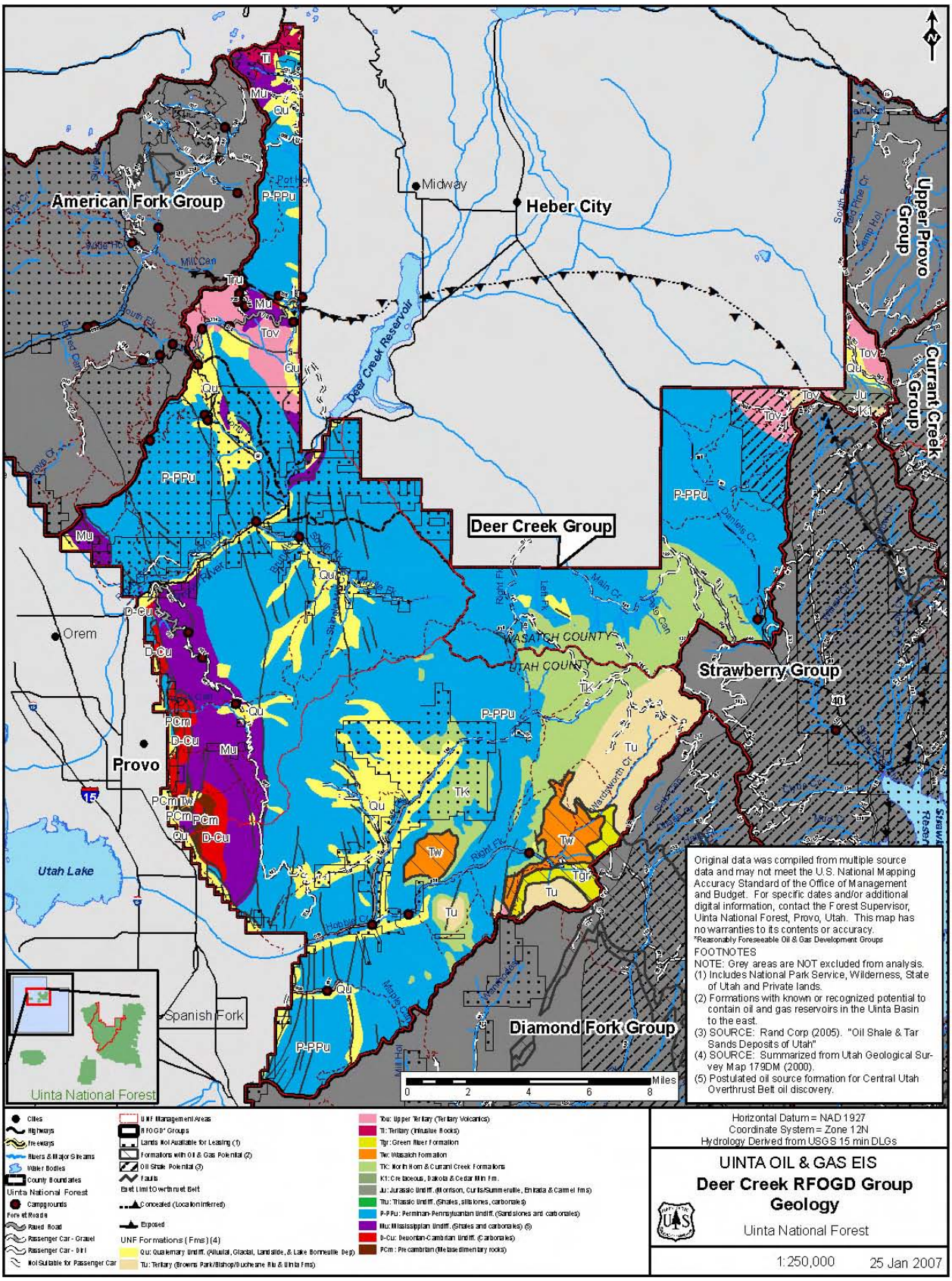

Figure 3.11. Geology map: Diamond Fork, Upper Spanish Fork Canyon, Upper Provo, and Strawberry groups.

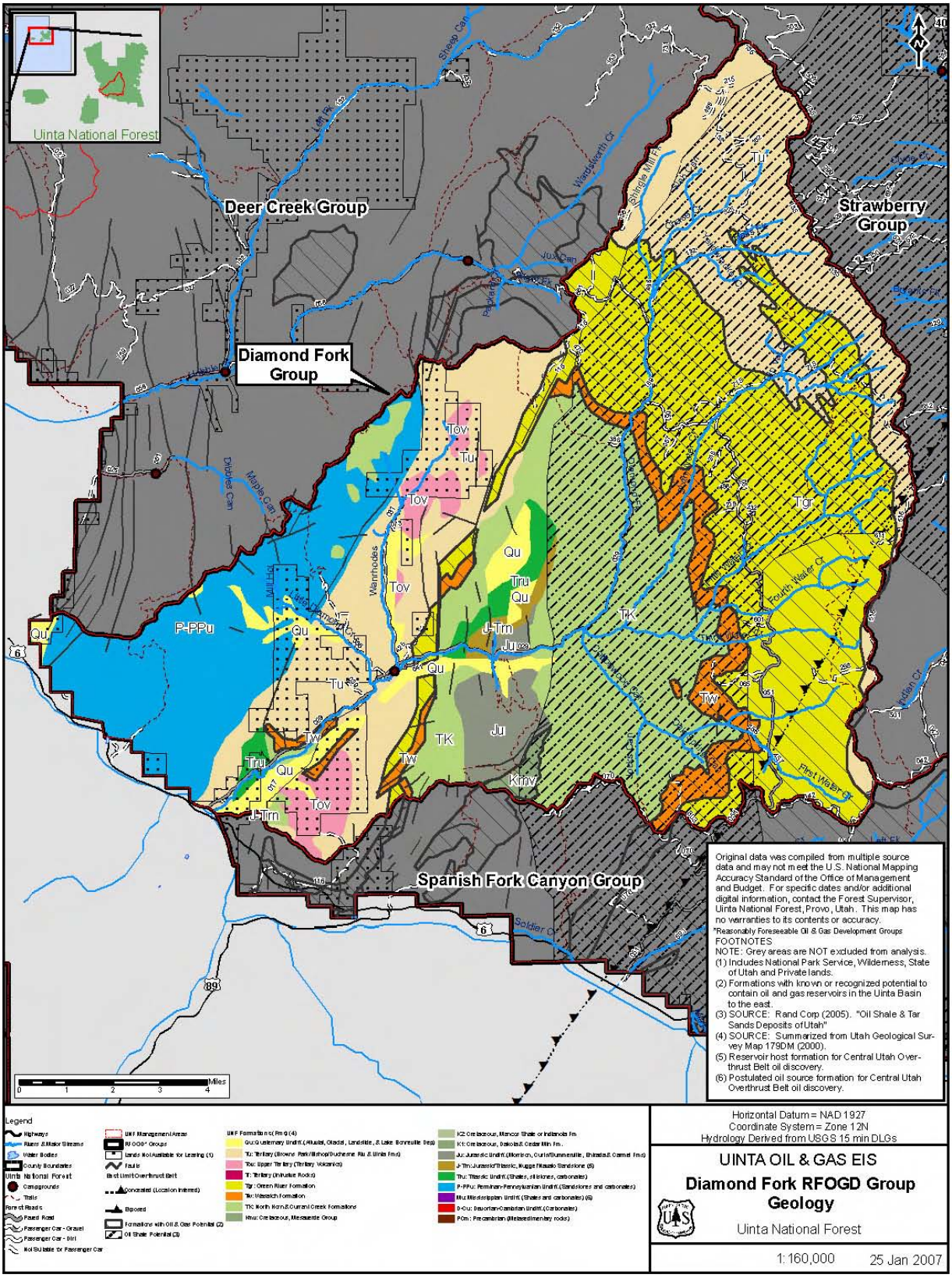

Figure 3.12. Geology map: Payson group.

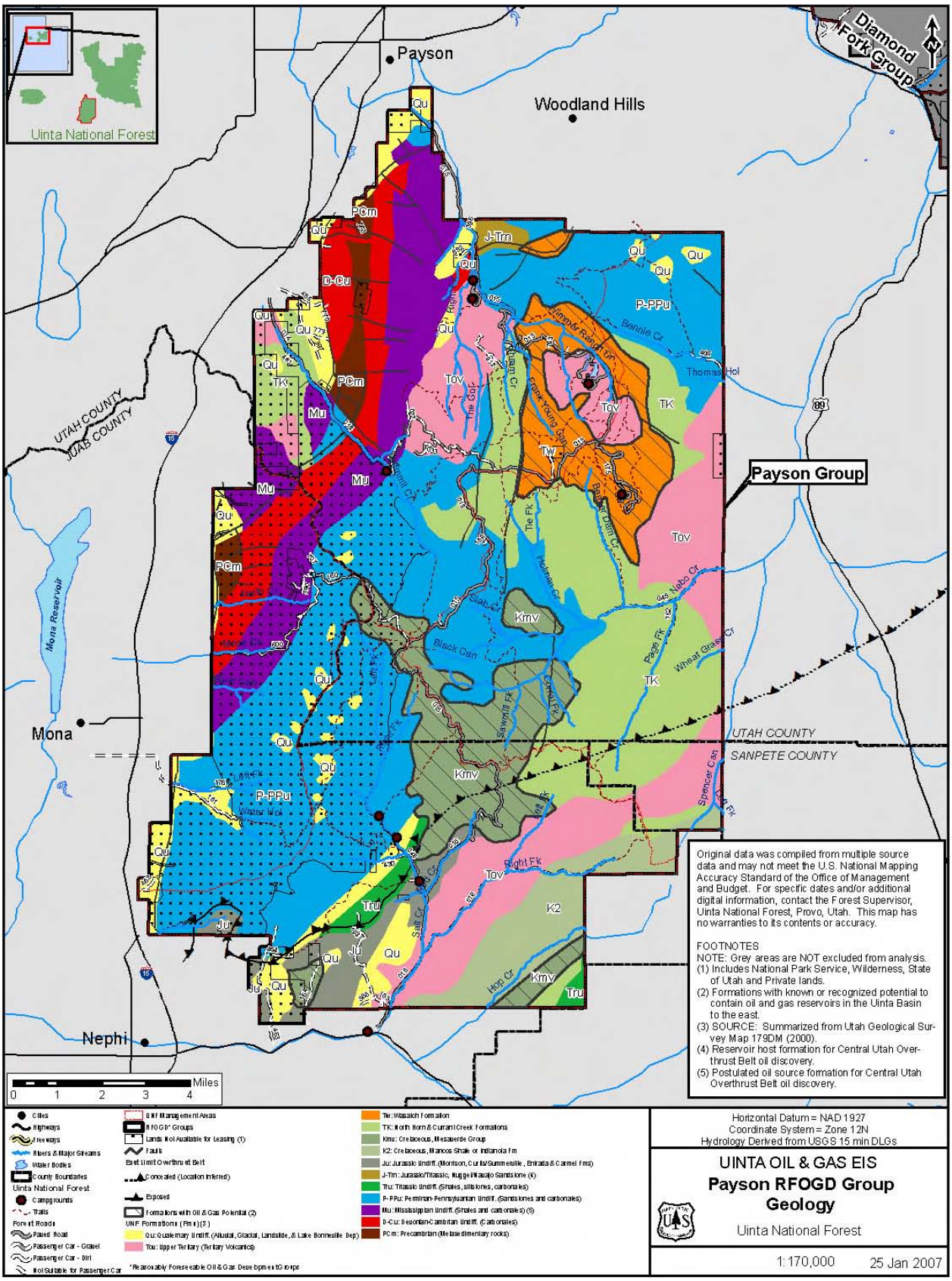
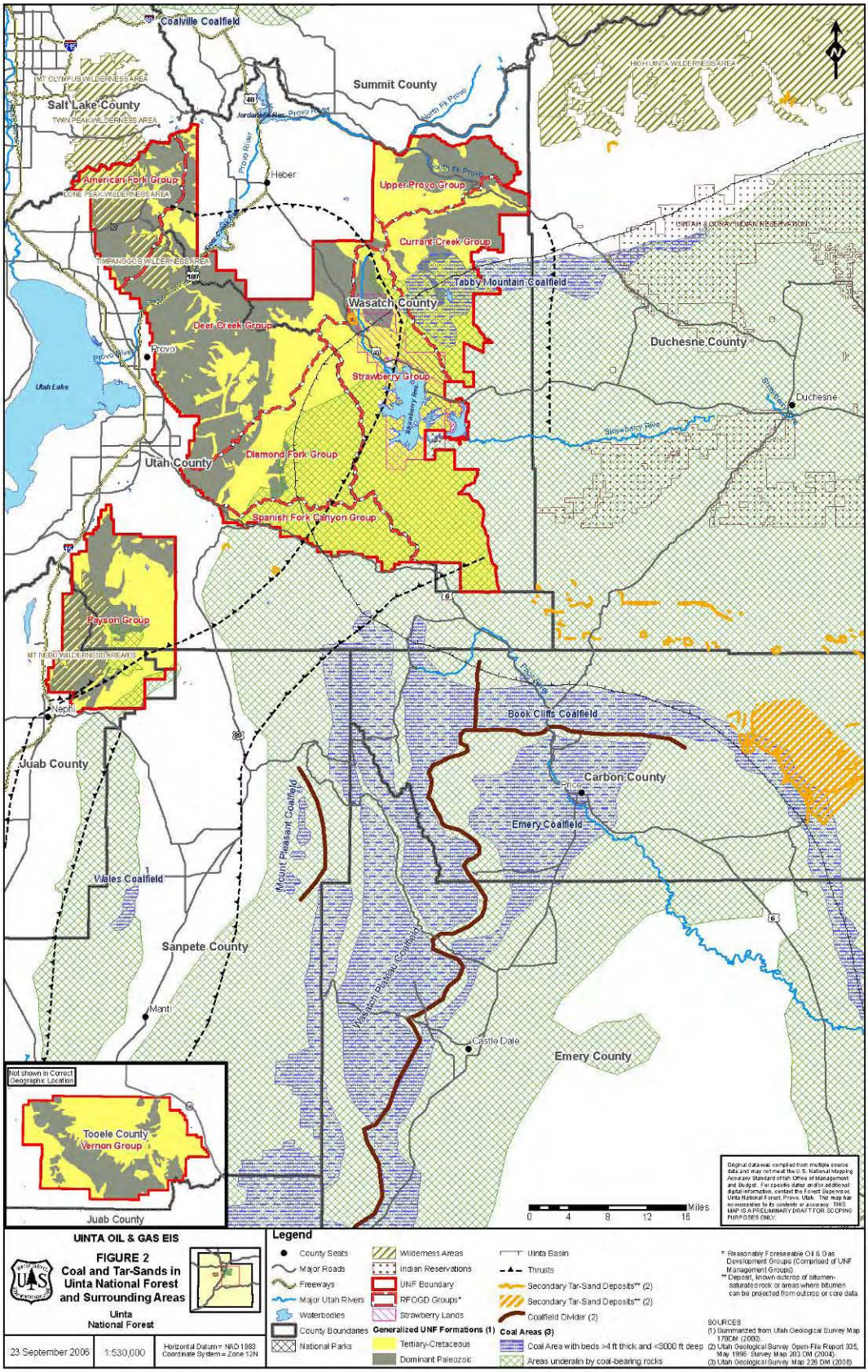
Figure 3.13. Coal and tar sands in the UNF and surrounding areas.