Technical Report 9.0
Soils Resources

Oil and Gas Leasing EIS on Lands Administered by the Dixie National Forest

Prepared For:
US Forest Service
Dixie National Forest
1789 N. Wedgewood Lane
Cedar City, Utah 84720

Prepared By:

jbr environmental consultants, inc.

8160 South Highland Drive
Sandy, Utah 84093

October 2008

Table of Contents

9.1 Introduction 1
9.2 Consideration of Available Science 1
9.3 Use of GIS 1
9.4 Description of the Affected Environment 2
9.4.1 Soils Resources 2
9.4.2 Geological Resources 3
9.4.3 Soil and Geologic Conditions Identified for further evaluation 5
9.4.4 Soil Terminology Used in the Text: 6
9.4.5 Descriptions of sensitive soils and geologic hazards by Ranger District 7
9.4.5.1 Pine Valley Ranger District 7
9.4.5.2 Cedar City Ranger District 14
9.4.5.3 Powell Ranger District 15
9.4.5.4 Escalante Ranger District 16
9.5 Impact Analysis 18
9.5.1 Connected Actions 18
9.5.2 Issue Statement 19
9.5.3 Indicators 19
9.5.4 Direct and Indirect Effects 19
9.5.4.1 Impacts of connected actions by leasing option 21
9.5.4.2 Impacts of connected actions under SLT 27
9.5.4.3 Impacts by Alternative 29
9.5.4.4 Description of Cumulative Effects Area 36
9.5.4.5 Past, Present, and Reasonably Foreseeable Actions 36
9.5.4.6 Cumulative Effects by Alternative 43
9.6 Compliance with Other Laws and Regulations 49
9.7 Forest Plan Consistency Determination 49

List of Tables

Table 9.4-1 Sensitive soils and geologic hazards on the Dixie National Forest listed by Ranger District, in acres. 3
Table 9.4-2 Soil map units found in sensitive soil and geologic hazard areas and a qualitative evaluation of erosion hazard. 10
Table 9.5-1 Summary of terms used to describe effects in the technical report. 18
Table 9.5-2 Leasing options assigned to areas with sensitive soil/geologic hazards under each alternative 20
Table 9.5-3 Acreage, and percent of total acreage, of Sensitive Soils/Geologic Hazards available for leasing over a 15 year period, assuming all predicted disturbance within each Ranger District occurred on Sensitive Soils/Geologic Hazard areas*. 27
Table 9.5-4 Acreage of Resource Components under each Leasing Option, Including Overlapping Options, by Alternative. 30
Table 9.5-5 Forest Service routes impacting soil resources. 37
Table 9.5-6 Additional Reasonably Foreseeable Future Actions 39
Table 9.5-7 Summary of Cumulative Effects. 45

List of Figures

Figure 9.4-1 Sensitive Soils and Geologic Hazards 4

List of Appendices

Appendix 9A Stipulation Forms

Appendix 9B Dixie National Forest Oil and Gas Construction and Operating Standards and Well Site Design Requirements

Appendix 9C Dixie National Forest Current and Proposed Land Management Plans: Desired Conditions, Goals, Objectives, and Standards and Guidelines for Soil Resources

List of Acronyms & Abbreviations

BLM	Bureau of Land Management
BMP	Best Management Practices
CSU	Controlled Surface Use
EIS	Environmental Impact Statement
GIS	Geographic Information System
IRA	Inventoried Roadless Area
NA	Not Available for Leasing
NL	No Leasing
NSO	No Surface Occupancy
SLT	Standard Lease Terms
TL	Timing Limitation

9.0 Soils and Geologic Hazards

9.1 Introduction

This Technical Report has been prepared in support of the Oil and Gas Leasing EIS on Lands administered by the Dixie National Forest, which is an environmental analysis to identify those lands with Federal mineral rights that should or should not be made available for oil and gas leasing. This report provides background information on the soils and geologic hazards located within the Dixie National Forest. This report describes five soil and landform categories by Ranger District and assesses the potential environmental consequences of proposed leasing options on sensitive soil and geologic hazards (USFS 1995b). A more detailed description of the Purpose and Need is provided in Chapter 1 of the EIS and a description of the Proposed Action, Alternatives, and leasing options is available in Chapter 2.

9.2 Consideration of Available Science

The techniques and methodologies used in this analysis consider the best available science. The analysis includes a summary of the credible scientific evidence that is relevant to evaluating reasonably foreseeable impacts. In addition, the analysis also identifies the methods used and references the scientific sources relied on. When appropriate, the conclusions are based on a scientific analysis that shows a thorough review of relevant scientific information, a consideration of responsible opposing views, and the acknowledgment of incomplete or unavailable information, scientific uncertainty, and risk.

9.3 Use of GIS

Alternatives were developed by assigning the leasing options described in Chapter 2 of the EIS, and summarized for this Technical Report in Section 8.5.4.1, to site-specific resource components using geospatial data. Using a geographic information system (GIS), the spatial distribution of each resource component and associated leasing option were overlaid. Some lands on the Forest are not administratively available for oil and gas leasing (NA) and include wilderness areas and Brian Head Ski Resort. The most restrictive leasing option (i.e., NL or NSO) assigned to a particular resource component supersedes any less restrictive options (i.e., CSU or SLT) assigned to other resource components that occur in the same area or site-specific location. For example, where NSO was assigned to an area of high erosion potential that coincides with the habitat of a sensitive wildlife species assigned CSU, the NSO option would be applied to the area common to both of these resources. As a result, multiple lease options may apply to a resource component, depending upon its location, even if only a single option was specified for that resource component under an alternative. A full range of leasing options was incorporated into the development of alternatives so that the different alternatives would insure that differing levels of protection were addressed for each specific resource component.

Leasing options were applied to geographical areas that represent the spatial distribution of a resource component. However, it is important to note that leasing options are applied to the resource component and not simply to specific geographic areas and if unmapped resource components were identified in the future they would be protected by the same leasing option. Furthermore, the geospatial data used in this analysis is the best GIS data available; however, it comes from multiple sources and was created at varying scales. As a result, it is not assumed that these data are 100 percent complete or that they meet the US National Mapping Accuracy Standard of the Office of Management and Budget. Unless otherwise stated, GIS data was provided by the

Dixie National Forest.

9.4 Description of the Affected Environment

The data used to identify areas of soils and geologic hazards comes from completed "Order 3" soil surveys of the Dixie National Forest (unpublished) as well as the Soil Survey Geographic Database (STATSGO) data (NRCS 2005). These surveys encompass a spatial GIS coverage, which includes a National Soils Information System (NASIS) database, mapping unit and taxonomic unit descriptions. These Order 3 soil surveys have soil boundaries plotted by interpretation of aerial maps and remotely sensed data. Boundaries were verified by traversing representative areas (USDA 2004e). In addition, steep slope analysis used 30x30 meter Digital Elevation Model projections using both analog and stereo aerial imagery. These data were used to determine the acreage of four soil and geologic management concerns listed below, and explained in more detail in below:

- Areas with steep slopes (>35 percent),
- Areas of erosive soils,
- Areas with unstable slopes or soils, and
- Areas prone to rockfall.

These soil and geologic features were noted as concerns because they can be unstable and prone to erosion, landslides or mass wasting. Poorly planned oil and gas development in these areas can lead to potentially hazardous conditions for people or wildlife. Reclaiming disturbance that occurs on sensitive soils/geologic hazards can be slower than on more forgiving lands leading to long- term scars, potential invasion of noxious weeds, and degradation of forage resources.

Included in the analysis of geologic conditions are cave resources. These diverse and sensitive subterranean landforms support flora, fauna, and unique geological resources, and are significant sources of culinary water and stream flow from the forest. Potential resource concerns related to oil and gas exploration, drilling, and production include water pollution, air pollution; changes to the temperature, barometric pressure, and humidity of cave ecosystems; collapse of caverns causing surface subsidence; and explosions due to build-up of trapped natural gas (BLM 2006b).

Soils and geologic hazards and cave resources are presented and discussed in this report by Ranger District. Table 3.4-1 below lists the number of acres with sensitive soils and geologic hazards in each Ranger District and for the Forest as a whole, and includes the percentage of those lands within each Ranger District and within the Forest. Figure 3.4-1 shows these areas on a map of the forest.

9.4.1 Soils Resources

Soils are 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. Soils on the Dixie National Forest are diverse and are a reflection of soil parent material, landform processes, vegetation, and a mountainous, continental climate characterized by variable precipitation and temperature extremes (USDA 1995a). 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 (USDA 1986).

9.4.2 Geological Resources

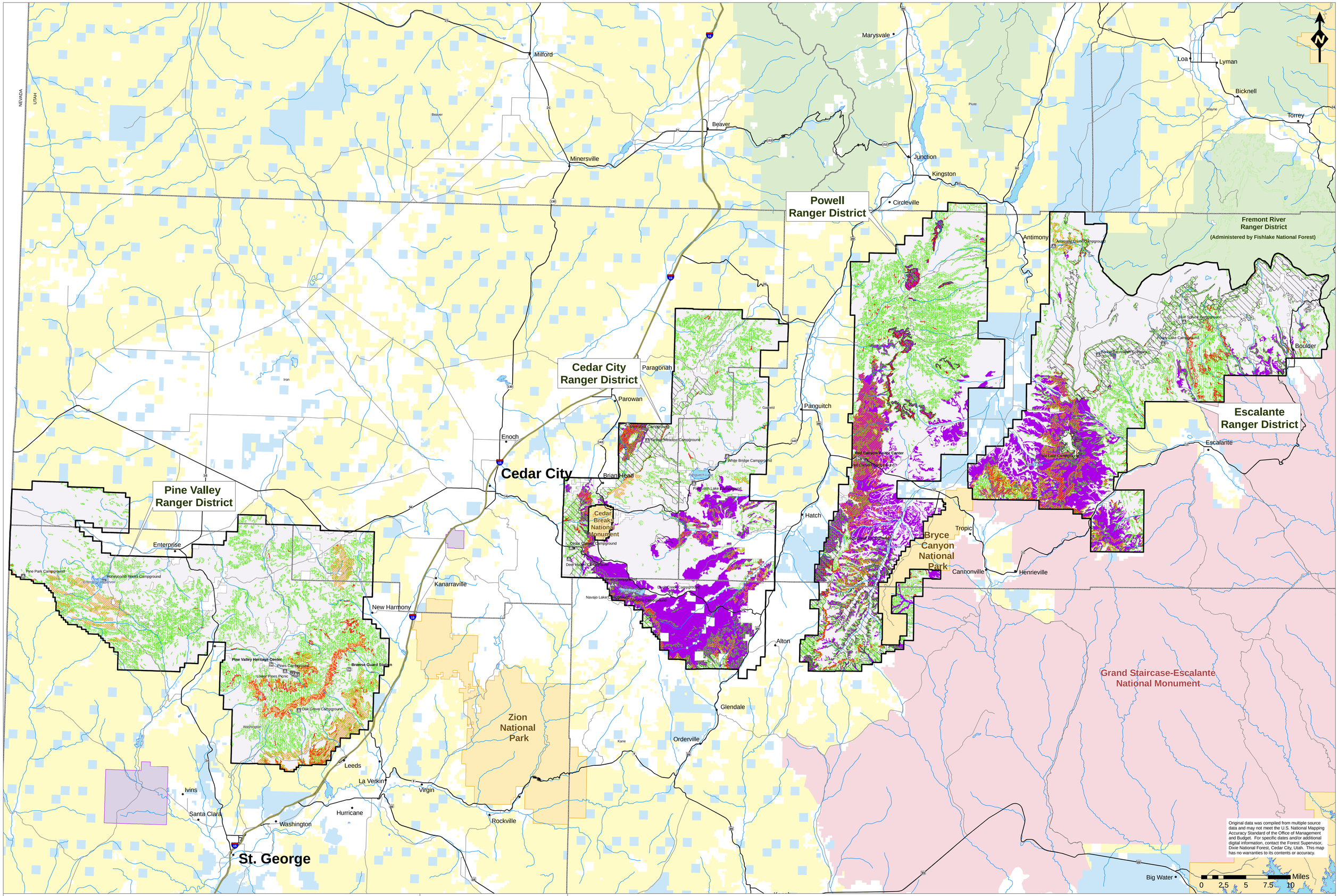
The geology of the Dixie National Forest has been discussed thoroughly in USFS (1995a). The following provides a summary of that information. The Dixie National Forest extends from southwestern Utah to south-central Utah just west of Capitol Reef National Park. It spans a zone of geologic transition from the block faulting and complex rock types of the Basin and Range physiographic province in the west to the gently warped plateau and sedimentary strata of the Colorado Plateau physiographic province in the east. The boundary between the provinces in southwest Utah generally parallels Interstate 15 between the towns of St. George and Parowan (USDA 1995a). Elevations are generally greater than 6,000 feet and include the Pine Valley Mountains and the Kolob-Markagunt, Sevier-Paunsagunt, and Aquarius-Kaiparowits Plateaus (USDA 1995c).

The Basin and Range province is characterized by steeply-faulted horsts (an upthrown area between two parallel faults) and thick, sediment-filled grabens (a downthrown block between two parallel faults). The Pine Valley Ranger District is located in the Basin and Range province (USFS 1995b). The remaining portions of the Dixie National Forest are located in the Colorado Plateau province which consists of a series of plateaus, mesas, and buttes formed from horizontal to gently dipping strata with major faults, monoclinal folds, anticlines and synclines, domes and basins. Streams have eroded deep canyons and escarpments occur in many areas. Extrusive igneous rocks occur around the province while volcanic cones and flows are common. Some alpine glaciation has occurred in a few of the highest areas such as around Boulder Mountain and Aquarius Plateau on the Escalante Ranger Districts and in the Brian Head area on the Cedar City Ranger District (USFS 1995b). Short growing seasons limit soil development in these areas.

Table 9.4-1 Sensitive soils and geologic hazards on the Dixie National Forest listed by Ranger District, in acres.

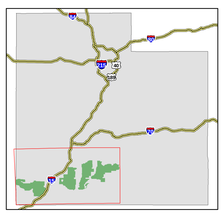
	Acres of Public Land Defined As Having Sensitive Soils, Not Taking Into Account Any Overlap:					Total Acres of Public Land	
Ranger District Name	**Steep Slopes**	**Erosive Soils**	**Unstable Soils**	**Prone to Rockfall**		**Sensitive Soils in Ranger District, with each acre counted only once**	**All Lands in Ranger District**
Pine Valley	127,273	35,646	0	7,862		**144,023**	462,921
Cedar City	61.332	12,298	15,105	1,373		**79,217**	353,530
Powell	109,070	26,373	8,041	2,900		**126,415**	383,886
Escalante	92,067	22,322	22,212	5,070		**112,190**	430,865
TOTAL Acres[1]	**389,741**	**96,639**	**45,358**	**17,206**		**461,845**	**1,631,202**

1 Note that Total Acres of Steep, erosive, unstable, and rockfall-prone soils is 513,298 acres, but there are only 461,845 acres of sensitive soils. This is because there is some overlap: some areas are both steep and erosive. The column “Sensitive Soils in Ranger District …” counts each acre of sensitive soils only once.



Oil & Gas Leasing EIS on Lands Administered by the Dixie National Forest

FIGURE 9.4-1
Sensitive Soils & Geologic Hazards



Legend

- Cities

Forest Sites
- Campgrounds
- Visitor Centers
- Interstates
- Highways
- Minor Roads*
- Major Streams & Rivers
- Water Bodies
- County Boundaries
- State Boundaries

National Forest System Lands
- Dixie National Forest
- Wilderness Areas
- Fishlake National Forest

Other Land Administration
- Bureau of Land Management
- GSENM**
- National Park Service
- Private
- State of Utah
- Tribal

- Areas of High Erosion Potential
- Rockfall Hazard
- Slopes >35%
- Unstable Areas
- Claron Formation

NOTES
*Not all roads are shown. Only some roads are depicted for orientation purposes.
**Grand Staircase-Escalanted National Monument. Managed by the Bureau of Land Management.

Horizontal Datum = NAD 83 Coordinate System = Zone 12N	1:220,000	27 February 2008

9.4.3 Soil and Geologic Conditions Identified for further evaluation

The following soil and geologic conditions were used to identify sensitive areas on the Dixie National Forest. Their definitions, to be used in the Dixie National Forest Oil and Gas Leasing Environmental Impact Statement are explained below.

Steep slopes: Steep slopes are defined as those slopes that are at 35 percent (20 degrees) or steeper, based on analysis of a 30x30 meter Digital Elevation Model. For this EIS, these projections used both analog and stereo aerial imagery to create contour lines. Approximately 389,741 acres of the Dixie National Forest are comprised of slopes at or steeper than 35 percent.

Erosive soils: These are soils that "consist of steep slopes, shallow soils, sparse vegetation, and are subject to rapid runoff." Runoff rates are determined by factors including previous human impacts, vegetative cover (less cover generally equals more runoff), water infiltration rate, soil texture, and the soil erodibility factor (K factor, as used by the Natural Resources Conservation Service). Generally, soils with faster infiltration rates (or high permeability), higher levels of organic matter, and sandy loams or loamy soil textures have lower runoff rates and a greater resistance to erosion than silts and clay textured soils, which have lower infiltration rates, lower permeability, and higher runoff rates and are therefore more erodible (USFS 2006a).

A given soil may have a high inherent erodibility, but if it occurs on flat or low gradient slopes and has a rapid permeability, it would have a low erosion hazard ranking (BLM and USFS 2001). However, wet soils can be unstable and prone to slumping even on relatively flat ground if the inherent strength of soils is low. Soils derived from swelling clays become slippery and are prone to failure along planes of weakness, such as where a slope steepens, or along the edges of gullies and washes. Volcanic ash, when loose and granular in texture, is prone to slippage when wet or dry. The same is true for shale-derived channers: flat, platy rocks from less than an inch to several inches across. Steep slopes, large particle size, very small particle size, minimal vegetation coverage, water infiltration, and road cuts all aggravate weak soil structure.

Where the underlying C horizon or bedrock forms a relatively smooth surface dipping in the same direction as the slope, water can act as a lubricant on this sliding plane, allowing overlying layers to slip. This typically happens after prolonged wet periods. Two examples of massive slides occurring in the Intermountain West due to water and sliding planes are at Thistle, Utah and Gros Ventre, Wyoming.

The Dixie National Forest estimates that 96,639 acres are covered with highly erodible soils (see Table 9.4-1, above).

Unstable Slopes: Unstable slopes are "lands which are prone to mass failure under natural conditions..., and where human activities...are likely to increase landslide distribution in time and space" (Reid et al 1994)**.** The GIS coverage depicting unstable soils used in this EIS is based on an analysis of areas that show "evidence of recent mass movement, fresh cracks are discernible, and probability of increased additional movements is high …." This GIS layer also includes "areas that show discernible evidence of past landslide activity [that are] gaining stability but [may include] areas subject to reactivation of mass movements." Landslides occur anywhere the cohesiveness of the soil or bedrock cannot hold the material against gravity, often due to high precipitation, high elevation, steep slopes, and slide-prone geologic materials (USDA 1995a). 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 or occurring on already steep slopes (USDA 2006a). These areas are

unsuited for road and well pad construction due to the high likelihood of slope failure. According to GIS mapping completed by the Dixie National Forest, unstable slopes may occur on approximately 45,358 acres of the Dixie National Forest (see Table 9.4-1).

The geologic units that commonly have slope failure in southwestern Utah include the Sevier River Formation; Tertiary volcanic rocks including the Bullion Canyon volcanics, Mt. Dutton Formation, and Mt. Belknap volcanics; Claron Formation; Tropic Shale; Carmel Formation; Chinle Formation, primarily the Petrified Forest Member; Moenkopi Formation; Wheeler Shale; and the Chisholm Formation. These formations include abundant clay weathered from parent shales and tuffs, and are affected by weathering and erosion. They are particularly prone to landslides where slope angle, precipitation, aspect, and geologic structure are favorable (USDA 1995c).

Rockfall areas: Areas mapped as having a high potential for rock fall were steep slopes of over 80 percent, or 38 degrees, covering at least five acres, according to the GIS metadata used by the Forest for mapping rockfall. Typically, rockfall occurs where there is exposed and poorly cemented rock. Rock fragments detach from parent bedrock along joints, bedding planes, or other zones of weakness. Newly detached or previously detached rock fall can roll or bounce down-slope causing damage. Rock falls are abundant in southwestern Utah, especially in the Navajo Sandstone, the sandstone members of the Kayenta and Moenave formations, and in the upper Cenozoic basalts and rhyolites (USDA 1995c). The Dixie National Forest estimates that 17,206 acres (See Table 9.4-1) have high rockfall hazard.

Caves and Cave Resources: A cave is any naturally formed void, cavity, recess, natural pit, sinkhole, or other feature that is large enough to permit a person to enter, whether or not the entrance is naturally formed or human-made. The term includes any extension or component of a cave or system of interconnected cave passages that occur beneath the surface of the earth or within a cliff or ledge, and/or natural subsurface water and drainage systems. The Federal Cave Resources Protection Act of 1988 protects cave and cave resources identified by federal agencies as significant based on the following six categories: biota; cultural; geologic/mineralogic/ paleontologic; hydrologic; recreational; educational or scientific. Cave resources include any material or substance occurring naturally in caves, such as animal life, plant life, paleontological deposits, sediments, minerals, speleogens (relief features on the walls, ceiling, and floor of any cave that are part of the surrounding bedrock), and speleothems (any natural mineral formation or deposit occurring in a cave) is considered a Cave Resource (USFS 2003a)

9.4.4 Soil Terminology Used in the Text:

Alluvium: Sediment deposited by running water on which a soil then develops. It may occur on terraces well above present streams or in the normally flooded bottom land of existing streams. Remnants of very old stream terraces may be found in dissected country far from any present stream (NRCS 2007a).

Badland: A moderately steep to very steep barren land dissected by many intermittent drainage channels. Ordinarily, the areas are not stony. Badland is most common where streams cut into soft geologic material. It is often found in steep, deep arroyos, up to 600+ feet deep. Potential runoff is very high, and erosion is active (NRCS 2007a).

Channers: Small, cobble-sized rocks that are angular instead of rounded due to being derived from shale or limestone.

Colluvium: Poorly sorted debris that has accumulated at the base of slopes, in depressions, or along small streams through gravity, soil creep, and local wash. It consists largely of material that has rolled, slid or fallen down the slope under the influence of gravity. Accumulations of rock fragments are called talus. The rock fragments in colluvium are usually angular, in contrast to the

rounded, water-worn cobbles and stones in alluvium and glacial outwash (NRCS 2007a).

Epipedon: A diagnostic soil horizon (identifiable layer) used to characterize a soil that has formed at the surface of the earth and occurs nowhere else in the soil, unless the soil is buried under water, wind, or volcanic deposits. An epipedon is defined mostly in terms of soil color, content of organic matter and base saturation (relative amounts of base ions such as calcium, magnesium, sodium and potassium as compared to the acidic ion, hydrogen). Two common epipedons found on the Forest are called “mollic” and “ochric” (NRCS 2007a).

Mollic epipedon: A dark colored, rich, loamy surface horizon with at least 2.5 percent organic matter and at least 10-25 cm depth before other soil horizons, such as a clay or calcium-rich horizon, are encountered (NRCS 1998). This is a good cropland soil.

Ochric epipedon: A soil that is lighter colored (often reddish or yellow-brown) than the mollic epipedon. It is too thin, dry, or lacks enough organic material to be classified as mollic. It is common in the Forest. The surface layer is well developed and easily identifiable because it is generally darker than deeper horizons when viewed in a soil test pit, road cut, etc., (NRCS 1998). Other common epipedons in southwest Utah are the Entic or Aridic epipedons. The layering in these soils is less obvious as the soils are less developed (NRCS 2007c).

Residuum: The term "residuum" is used when the properties of the soil indicate that it has been derived from rock which underlies it and when evidence is lacking that it has been modified by movement. The surrounding landscape and elevation are often helpful in identifying whether material has weathered in place and is thus residuum (NRCS 2007a)

Rock outcrop: Exposures of bare bedrock other than lava flows and rock-lined pits. Some areas are large, broken by small areas of soil while others are extensive (acres in size). Most rock outcrops are hard rock, but some are soft (NRCS 2007a).

Soil Complex: A group of two or more dissimilar soil types occurring in a regularly repeating pattern. Each time the soil complex is mapped, one can assume that each major component is present, though their proportions may vary (NRCS 2007a).

Soil map unit: The delineation of a soil or group of soils marked on a soils map. Different soil maps have different levels of detail, depending on map scale, but whatever the scale, the basic grouping of soils is considered the map unit (NRCS 2007a).

9.4.5 Descriptions of sensitive soils and geologic hazards by Ranger District

There are four Ranger Districts in the Dixie National Forest: the Cedar City, Escalante, Pine Valley and Powell Ranger Districts. Each district is between 380,000 and 480,000 acres in size. The following information provides detail about the sensitive soils and geologic hazards found on the four ranger districts in the Dixie National Forest.

9.4.5.1 Pine Valley Ranger District

The Pine Valley Ranger District is located on the west side of the Dixie National Forest in the Basin and Range province and covers 462,819 acres of public land. There are 125,965 acres (27 percent) on the District that are considered steep (>35% slopes), 77,631 acres (17 percent) listed as erosive, and 7,857 acres (less than 2 percent) listed as prone to rockfall. No areas of unstable soils have been identified on the Pine Valley Ranger District. There are seven main areas of steep, erosive, or rock-fall prone soils on the District. There are no areas within the District noted as having unstable soils or slopes.

Pine Valley Mountain is a very prominent landmark on the southeast side of the District, which contains the majority of steep slopes, erosive soils, and rockfall areas within the District. The steep,

southeast-facing escarpment of Pine Valley Mountain is the only part of the District identified as having rockfall hazard. This escarpment is dominated by soil map unit number s8175 (Rock Outcrop-Pinitos family-Montez-Canlon family soils association). The Pinitos soils are very deep, well-drained, moderately permeable soils that developed in eolian and alluvial material derived from sandstone and shale on hills, fan terraces, cuestas and mesas. The Montez series consists of deep, well-drained soils that formed in granite colluvium and residuum at high elevations on slopes. Canlon series consist of shallow, well-drained and somewhat excessively drained, moderately permeable soils derived from lime-cemented sandstone and caliche on ridgelines and slopes. Rock outcrops occur on slopes and ridge tops. These soils have either a clay or rock layer below the A horizon and are moderate to excessively drained with areas of rapid runoff. Warm-season grasses dominate rangeland areas, with Engelmann spruce, Douglas fir, juniper and grasses common at higher elevation. Precipitation ranges from 15-23 inches, and elevations range from 6,700 to 9,500 feet (NRCS 2007b). Table 9.4-2 summarizes characteristics for these and other soils described in this report.

The north side of the Pine Valley Mountains is labeled as s8176 (Rock outcrop-Olot family-Gralic family-Falcon family-Eyre family soil association). Most of this area is within designated wilderness. These soils are derived from volcanics and sandstone, tend to be quite steep (2-90%) and range from 4,000 to 10,000 feet in elevation. The Olot and Gralic series are moderately deep, well-drained soils that formed in volcanic ash, colluvium and residuum weathered from basalt and are somewhat acidic. The Falcon and Eyre families of soils are shallow and weathered from fractured sandstone and arkosic materials and are neutral to acidic. There is very little clay accumulation in these soils. The A horizon is typically a fine to coarse sandy loam with a weak, granular structure. Pumice and volcanic ash are common. Deeper layers are more blocky but lack stickiness or plasticity. Vegetation includes Douglas fir, white fir, ponderosa pine, snowberry, mountain mahogany, Gambel oak, sage, and cool season grasses. Precipitation ranges from 17 to 37 inches and (NRCS 2007b).

The low elevation southeast corner of the District is dominated by soil map unit numbers s8186 (Rock outcrop-Redbank family-Mespun-Caval), s362 (Rock outcrop) and s8219 (Tobish-Tacan-Nehar-Collbran family). These soils are sandstone-derived and include mostly fine sandy loams and some stony loams. These soils are associated with red soils typical of Wingate and Moenkopi formations and the blonder Navajo, Kayenta and Dakota formations. These soils are very deep to deep, moderately to rapidly permeable with slow runoff. Although they are deep, there are shallow areas (in some areas depth to rock friable sand, or unaltered gravels is only about five inches) indicating association with alluvial deposits. These soils have many steep and erosive areas due to their association with recent floodplains, dune formations, and fine, poorly cemented parent material. Elevation ranges from 3,500 to 7,000, precipitation ranges from 8 to15 inches, and vegetation is typically rangeland dominated by big sagebrush, Gambel oak, and Indian ricegrass; irrigated hayland; or non-irrigated wheat fields (NRCS 2007b).

To the west of the Pine Valley Mountains are the Bull Valley Mountains. These are on the west side of the District and are also dominated by steep slopes. West of the crest of the Bull Valley Mountains, south of Upper Enterprise Reservoir and Pine Park Campground, the land is a finely dissected upland of Tertiary volcanic flows and ash deposits. This soil map unit is numbered s5598 (Pioche-Motoqua-Gabvally map units). Soils are very shallow to shallow, well drained, with very high runoff and slow permeability. They are associated with hill and mountainsides and have slopes of 2-70 percent. They are formed from residuum and colluvium of volcanic rocks, including andesite, rhyolite, and tuff. The typical soil is a gravelly to stony loam with a mollic epipedon, a clay horizon starting between about 8 to16 inches, and welded tuff or other volcanic rock parent material at about 15 or 16 inches. Vegetation is typically pinyon-juniper parklands with sagebrush, wheatgrasses, needlegrasses, and Mormon tea. Elevation ranges from 5,500 to 8,600 feet and precipitation is

about 13 inches per year (NRCS 2007b).

Table 9.4-2 Soil map units found in sensitive soil and geologic hazard areas and a qualitative evaluation of erosion hazard.

Soil Map Unit	Found in these RDs*	Depth	Permea-bility*	Slope (%)	Surface Texture[1]	Rock Frag-ments	Precipi-tation (inches)	Vegetation Cover	Parent Material	Estimated Erosion Hazard^
Atchee	ES	Shallow	Slow	2-70	Extr. Channery sndy Lm	35-90, channers	11	PJ[2] shrub	SS, Sh	Mod-Severe
Bayfield	ES	V. deep	Slow	0-8	Lm	0-10 gravels	14	Crop, sage-grass	SS, Sh	Low-Mod
Beardall	PO	Mod. Deep	Mod. Slow	35-80	Grv-silt Lm	<35	37	Spruce- Fir	Glacial & colluvial	Mod
Behanin	PO	V. deep	Mod	25-70	Lm	Cobbly	18-30	Spruce- Fir	Volcanic & sedimentary	Low-mod
Bernal	PV	Shallow	Mod	0-8	Lm	2-15% cobble	15	PJ grass	SS	Low
Bond	ES	V. shallow	Mod	0-50	Sndy Lm	18-35	11	Grassland	SS, dunes	Mod-Severe
Bush Valley	CC	Shallow	Mod-slow	1-65	Cbly Sndy Ln	45-80	20	Mixed forest, grassland	Pyroclastic materials	Mod-Severe
Callings	PO	V. deep	Slow	1-65	Lm	35-60	18-35	Aspen grassland	Glacial till, volcanics	Low-Mod
Canlon	PV	Shallow	Mod	2-50	Lm	0-35% cobble	18-25	Grassland	Sandstone & Caliche	Mod-Severe
Cannoville	ES	V. Shallow	Slow	0-50	Clay	No Info	10	Shrub-grass	Tropic shale	Mod-Severe
Caval	PV	V. deep	Mod	2-10	Sdy Lm	No Info	?	Shrub grass	Sandstone	Low
Clapper	ES	V. deep	Mod	1-65	Gvly Lm w/ 25% surf grvl	15-30	11	Sage-grass, some SD[3] shrub	Mixed alluv-colluvium	Mod
Collbran	PV	Deep	Mod-slow	0-30	Lm	0-15	16	Sage-grass	Calcareous alluvium	Low-Mod
Dalcan	PV, CC	Mod.deep	Slow	0-60	Clay Lm	35-70% gravel	18	Shrub-grass	Basalt	Mod-Severe
Dotsero	PV	Deep	Mod-rapid	1-45	Grv-Sdy Lm	15-30% pebbles	17	Shrub grass	Basalt Tuff	Mod
Echard	PO	Deep	V. Slow	5-30	Lm	15	21	Mixed forest	Tuff, cemented	Low- Mod

Soil Map Unit	Found in these RDs*	Depth	Permea-bility*	Slope (%)	Surface Texture[1]	Rock Frag-ments	Precipi-tation (inches)	Vegetation Cover	Parent Material	Estimated Erosion Hazard^
									ash	
Eyre	PV	Shallow	Mod-rapid	5-60	Sdy Lm	35-80% flagstone	20	Shrub grass	Sandstone	Mod-Severe
Faim	CC	V. deep	Slow	2-65	Lm	0-15	30	Aspen-grass	Igneous rock	Mod
Falcon	PV	Shallow	Mod to Rapid	0-65	Sdy Lm	0-30% <3" diam	17	Pine-shrub	Arkosic SS	Mod-Severe
Fughes	PV, CC	V.deep	Slow- V. slow	0-65	Lm	No info	20	Shrub grass	Shale	Mod-Severe
Gabvally	PV	V. shallow	Mod	2-75	ExtStny Lm Crs Snd	60% on surface	10	Sage-grass	Hard rhyolitic tuff	Mod-Severe
Gralic	PV	Deep	Mod-rapid	8-75	Stny Lm	40-75% pebbles	30	Fir Pine	Metavol-canics	Mod
Harol	CC	Deep	Slow	2-60	V cblyLm	60% on surface	13-18	Shrub-grass w/ PJ	Igneous	Mod-Severe
Hesperus	ES	V. deep	Mod-slow	0-65	Lm	No Info	20	Sage-grass	Mixed	Low-Mod
Jemez	ES	Mod deep	Mod-slow	1-15	Lm	0-15	19	Mixed Forest	Tuff	Low
Lazear	ES	Shallow	Mod	0-65	Grvly Lm	0-35	12	SD shrub, shrub, grass	Shale, siltstone	Mod-Severe
Mespun	PV	V. deep	Rapid	0-30	Fn Snd	0-15% gravel	13	PJ shrub	SS dunes	Low-Mod
Mikim	ES	V. deep	Mod	0-15	Lm	0-15	10-13	Sage-grass	SS, Shale	Low
Mokiak	PV	Mod.deep	Mod	15-70	V Cbly Sdy Lm	Cobbles	14	PJ shrub	Gneiss/Schist	Mod-Severe
Montez	PV	Deep	Mod	15-50	Sdy Lm	25-60% < 3" diam	20-25	Mixed forest	Granite	Mod
Motoqua	PV	V. shallow	Mod	2-70	V Grvly Sdy Lm	numerou s	13	PJ grass shrub	Volcanics	Mod-Severe
Muzzler	PV	Shallow	Slow	15-64	Cbly Sdy Lm	40-80 cobbles	14	PJ grass	Igneous	Mod-Severe
Nehar	PV	Mod. deep	Mod slow	3-30	V Stny Sndy Lm	30-60	13-15	Chapparal	Igneous Quartzite	Mod-Severe

Soil Map Unit	Found in these RDs*	Depth	Permea-bility*	Slope (%)	Surface Texture[1]	Rock Frag-ments	Precipi-tation (inches)	Vegetation Cover	Parent Material	Estimated Erosion Hazard^
Olot	PV	Mod. deep	Mod slow	2-90	Stny Ash Slt Lm	No Info	27	Mixed forest	Volcanic ash	Mod-Severe
Pahreah	CC, PO, ES	Mod. deep	Mod	1-65	V Grvly Lm	30-90	22	Mixed forest	Limestone	Mod-Severe
Parkay	ES	Deep	Mod-slow	2-70	Cbly Lm	20-40	16-26	Aspen shrub grass	Residuum of Igneous rock	Mod-Severe
Patorius	PV	V. deep	Mod slow	1-6	Cbly Lm	Numerou s stones	18-23	Shrub grass	Cobbly alluvium	Low
Pinitos	PV	V. deep	Mod	1-15	Sdy Lm	No info	14-16	PJ grass	Eolian from SS	Low
Pioche	PV	V. shallow	Slow	8-50	Ext Stny Lm	65 pebble to stones	10-14	PJ shrub grass	Volcanic Residuum	Mod-Severe
Podmor	PV	Mod. deep	Mod	30-60	V Cbly Lm	Cobbles	16-22	Shrub grass	Quartzite	Mod-Severe
Quilt	ES	V. deep	Slow	4-60	V Cbly Lm	20-35	20-50	Sage grass PJ	Mixed residuum	Mod
Redbank	PV	Deep	Mod-rapid	0-8	Fn Sdy Lm	No Info	10-16	Grassland	Red beds	Low
Sampson	PV	V. deep	Mod	0-15	Lm	0-15 < 3” diam.	15	Grassland	Alluvium of Sed or lg rks	Low
Scout	ES	V. deep	Mod-rapid	0-70	Grvly Lm	20	34	Spruce-Fir	Mixed	Mod
Security	PV, ES	Mod. deep	Mod-rapid	5-65	V Grvly Sdy Lm	30-50 pebbles	15-20	Mixed forest & shrub	Granite	Mod
Seth	CC	V. deep	Slow	2-65	Lm	10	26	Mixed forest	Basalt	Mod-Severe
Sheege	PO	Shallow	Mod	0-70	Ext Stny Lm	50	15-27	Shrub-grass with Pinaceae	Limestone, loess	Mod-Severe
Skutum	CC, PO, ES	Deep	Slow	10-60	Fn Sdy Lm	10 gravel	25	Aspen grassland	Sedimentary Rock	Mod
Swapps	CC, PO, ES	Mod. deep	Mod	5-65	Grvly Lm	15 pebbles	22	Mixed forest	Limestone Shale	Mod-Severe
Syrett	CC, PO, ES	Mod. deep	Mod	2-40	Grvly Lm	20 gravel	19	PJ shrub	Limestn SS Shale	Mod-Severe

Soil Map Unit	Found in these RDs*	Depth	Permea-bility*	Slope (%)	Surface Texture[1]	Rock Frag-ments	Precipi-tation (inches)	Vegetation Cover	Parent Material	Estimated Erosion Hazard^
Tacan	PV	Deep	Mod	30-70	V Stny Lm	15, stone & gravel	14	Chapparal	SS Sltstn Shale	Mod-Severe
Tatiyee	ES	V. deep	Slow	0-8	Grvly Lm	>35	18-35	Sage grassland	Basalt, Ash, cinders	Low
Telephone	ES	Mod Shallow	Mod	9-60	V cbly sdy Lm	35-80	17-22	Mixed forest & shrub	SS	Mod-Severe
Tobish	PV, ES	Mod. deep	Slow	2-30	V cbly Cl Lm	75 cobble gravel	10-13	PJ shrub	SS, Shale	Mod
Tolmann	CC	Shallow	Mod-Slow	2-70	Stny Lm	15-20	16	Grassland	Sandstone	Mod-Severe
Vanet	PO	Shallow	Mod	20-40	Grvly Lm	35-50 gravel	19	Mixed forest	Shale, Limestone	Mod-Severe
Windwhistle	ES	Mod deep	Mod rapid	1-10	V Fn Sndy Lm	Sandy	9-14	Shrub grass	Sandy eolian	Low
Winnemucca	CC, PO	V. deep	Slow	1-60	Grvly Slt Lm	15-35	16-40	Grassland	Volcanic, glacial	Mod
Wye	PV	Deep	Mod-slow	15-40	Grvly Lm	35-50	15	PJ shrub	Limestone	Mod
Yenlo	ES	V. deep	Mod-slow	1-12	Sndy Lm	No Info	12-15	Shrub grassland	SS, Shale	Low
Zyme	PO, ES	Shallow	Slow	3-80	Clay Lm	No Info	13	Chapparal	Shale	Mod-Severe
Rock Outcrop[4]	All	V. Shallow	Ext Slow	0-100+	Rocky	Variable	<10 - > 50	Barren	Variable	Severe
Badland[4]	All	V. Shallow	Ext Slow	0-100+	Fines to rocks	Variable	<10 - > 50	Barren	Variable	Severe

* Ranger District Abbreviations: PV = Pine Valley, CC = Cedar City, ES = Escalante, PO = Powell, All = found in all ranger districts
* Permeability: Measured as Extremely slow, Very slow, Slow, Mod. slow, Moderate, Mod. rapid, Rapid, Very rapid.
^ Erosion Hazard on sensitive soils: Low, Moderate, Severe
1 Surface texture: Lm = loam, Sndy = Sandy, Gvly = Gravelly, Cbly = Cobbly, Stny = Stony, Sltstn = Siltstone,V = Very, Ext = Extremely, Fn = Fine
2 PJ = Pinyon-juniper forest
3 SD = Salt Desert, as in saltbush, shadscale, etc.
4 Rock outcrop and Badland are highly variable and descriptions here are generalized to represent most areas with this designation

The hills around Ox Valley, located north of the Bull Valley Mountains and east of Lower Enterprise Reservoir, also contain steep slopes. These valleys are somewhat broader, and are filled in with alluvial material from surrounding volcanic and shale rocks. Quaternary basaltic flows are also present here. This soil map unit is numbered s8178 (Security family-Podmor family-Pastorius family-Fughes family-Dalcan family soil complex). Soils are moderately-deep to deep, well drained, and moderately permeable with rapid to very rapid run-off. Most of these soils are associated with hills and mountainsides and have slopes of 0 to 65 percent. The Pastorius soils are found on flat river terraces. The other soils are formed from residuum and colluvium of basalts (Dalcan), granite and gniess (Security), shales (Fughes), and quartzite (Podmor) and are on more sloping terrain. Soils range from loams to cobbly loams and have a mollic epipedon. There is often a clay horizon below about 20 inches. The C horizon ranges from 23 inches to 60 or more inches in depth. Vegetation is typically ponderosa pine, Gambel oak, snowberry, and sagebrush with mountain muhly and wheatgrasses, depending on other associated plants. Elevation ranges from 6,500 to 10,000 feet and precipitation is 18 to 20 inches per year (NRCS 2007b).

To the east of Ox Valley and north of Pine Valley Mountain, at the north end of the District is a highland cut by Spring Creek and South Fork Pinto Creek. Harrison Peak is the most prominent peak in this area. Soil map unit is numbered s8180 (Wye family-Sampson family-Pastorius family-Nehar family-Muzzler family-Mokiak family-Bernal family soil complex) dominates this area. The Sampson, Pastorius and Bernal soils are flat-lying. The first two are found in stream channels and flat river terraces and the last is found on mesa tops. The Wye, Nehar, Muzzler, and Mokiak soils components more likely to be associated with steep areas are typically found on mountain slopes and rolling hills with between 15 to 70 percent slope. Nehar soils are on alluvial fans and are formed alluvium and residuum weathered from coarse-grained acid igneous rock, quartzite conglomerate, and with minor influence from basalt. The Muzzler soils are shallow while Mokiak soils are moderately-deep to deep. All three are well-drained soils that formed in place above igneous bedrock on mountain and hill sides. The Wye soils are deep, well-drained soils formed in material weathered from limestone. There is often a clay horizon, and run-off is slow to moderate, with moderate permeability. Elevations are between 4,300 and 7,300 feet, with precipitation between 13 to 16 inches. Vegetation is mixed shrub chapparal with grass lands interspersed. The flatter Sampson soils can be cropland or pasture, and are typically dominated by blue gramma, wheatgrass, and shrubs (NRCS 2007b).

The northeast corner of the District contains another area of steep slopes and erosive soils, dominated by soil map unit number s8179 (Rock outcrop-Motoqua family-Falcon family-Dotsero family-Bernal family soil association). The mountains in this area include Flat Top Mountain, Granite Mountain, Stoddard Mountain and Iron Mountain. These peaks and are made up of Quaternary and Tertiary intrusive and extrusive volcanics, with soils derived from basaltic tuffs and sandstone. Soils range from loams to sandy or cobbly loams that are shallow to very shallow and medium to excessively drained with moderate permeability. These soils are found on mountainside slopes, sloping mesas, and benches and have slopes ranging from 1 to 64 percent. The Falcon series is the highest elevation soil in this soil map unit and is very shallow. It is found on ridgelines and has excessive drainage and moderate permeability to the rock layer, which is about 14 inches from the surface. Vegetation at lower elevations is a mix of warm season grasses interspersed in pinyon-juniper woodlands, grading to chapparal lands of Gambel oak and mountain mahogany, and open grasslands of cool-season wheatgrasses and sagebrush as elevation increases. Precipitation ranges from 13 to –17 inches and elevation ranges from 4,000 to 9,000 feet (NRCS 2007b).

As noted above, there are no areas within the district noted as having unstable soils or slopes.

9.4.5.2 Cedar City Ranger District

The Cedar City Ranger District lies east of Interstate-15. There are a total of 353,499 acres of

public land on the District. Within this area there are 56,195 acres (16 percent) of steep slopes, 5,251 acres (1.5 percent) of erosive soils, 14,082 acres (4 percent) of unstable slopes, and 1,373 acres (less than 1 percent) prone to rockfall on this Ranger District. This Ranger District is the only one of the four known to have caves, which are discussed at the end of this section.

This district includes Cedar Breaks National Monument, which is located in the central western portion of the District. The area to the west and northwest of the Monument is designated wilderness. Both the wilderness and the Monument are not available (NA) for leasing.

The west side of the district is the same north-south trending escarpment that makes up Cedar Breaks It is called the Markagunt Plateau. The land drops off to the west from a high point of over 11,000 feet at the rim to 6,000 feet near Vermillion castle. The most widespread soils issue in this area is unstable slopes, while areas of steep slopes are confined to ridgelines and escarpments This band of steep and unstable slopes is dominated by the Winnemuca-Seth-Faim soil map unit (s8216), which is characterized by volcanically derived (basaltic) soils with moderate to rapid run-off and moderate to slow permeability. Soils on the escarpment support rangeland and wildlife habitat. All soil map units have a mollic epipedon with clay horizon below. Native vegetation on the Winnemucca and Faim soils includes needlegrasses, wheatgrasses, bromes and bluegrasses, lupine, big sagebrush, and dryland sedge, while Seth soils are found at higher elevation and include a higher component of aspen, white fir, and ponderosa pine. Annual precipitation ranges from 15 to 20 inches (NRCS 2007b).

Stout Canyon, draining out the south end of the plateau, and Little Creek Peak, Bear Creek and the Hurricane Cliffs at the north end of the district have areas of steep, rockfall-prone, unstable soils, and/or erosive soils . These soils are derived from sedimentary sandstones and shales, basaltic volcanics, and pyroclastic materials. Soils associations in these areas are s8232 (Syrett-Swapps-Skutum-Pahreah-Badland) and s8231 (Toman-Harol-Fughes-Dalcan-Bushvalley). These soils are moderately deep, well-drained, moderately permeable soils of gently to steeply sloping benches and the sideslopes of mesas. They formed in colluvium and residuum weathered from sedimentary rocks. Vegetation is mostly cool-season grasses, bitterbrush, big sagebrush, rabbitbrush, and other shrubs, with Rocky Mountain juniper, pinyon pine, and ponderosa pine at higher elevations. Elevation ranges from 6,500 to 10,000 feet Precipitation ranges from 13 to 25 inches (NRCS 2007b).

The central and eastern portions of the district are on top of the plateau, are flat-lying and dominated by stable soils.

Caves and Cave Resources: There are several lava tubes and limestone caves located on the Cedar City District. Some have been mapped. Two caves are open to the public. Ice Cave is a lava tube that is open most of the year and supports icicles year-round. Mammoth Cave is a large limestone cave that is closed during spring to protect a nursery of Townsend bats, but re-opens in June. Both caves have gates to protect cave resources.

9.4.5.3 Powell Ranger District

The Powell Ranger District is located east of Panguitch, Utah. Of the 383,881 acres of public land on this District, there are 108,482 acres (28 percent) of steep slopes, 117,224 acres (30.5 percent) of erosive soils, 8,040 acres (2 percent) of unstable slopes, and 2,865 acres (less than 1 percent) prone to rockfall on this district, mostly located on the southwest side and the central northern portion of the District. The Ranger District is dominated by the Paunsaugunt Plateau on the south and the Sevier Plateau on the north.

The rim of the Paunsaugunt Plateau is near the western and southern boundaries of the District. This rim itself is has many areas of high rockfall potential. Virtually all the slopes to the west of and below the plateau rim are listed as steep and/or unstable. The soil map unit found here is the same

as that found near Stout Canyon on the Cedar City District (s8232), and is described above.

East Fork Creek and its tributaries drain northward through the Paunsaugunt Plateau. This steep-sided drainage basin is outlined with a thin band of steep slope areas, which are surrounded by larger areas of unstable or erosive soils along the rim and in the canyon bottom. Bryce Canyon National Park is east of the East Fork and separates almost entirely a small segment of the District that's located east of the Park. This distinct area is highly dissected and riddled with steep slope areas. In short, most of the southern third of this District is dominated by unstable soils. Soil map unit s8234 (Syrett-Swapps-Skutum-Sheege-Pahreah-Badland soil map unit) is similar to that found at the south end of the Cedar City District at Stout Canyon (NRCS 2007b).

North of the Paunsaugunt Plateau is an area of lower elevation. State Route 12 crosses this area from east to west. The western half of this area, centered around Red Canyon, is dominated by, and contains the most extensive area of, erosive soils. Red Canyon is eroding back into the Paunsagunt plateau, creating a narrow, incised canyon of deep but poorly cemented red soils at its headwaters. This soil map unit, s8233 (Zyme-Vanet-Syrett-Rock outcrop-Badland map units), is made up of shallow to very shallow, well-drained soils. These soils range from 6,700 to 8,800 feet elevation. They generally have an ochric or mollic epipedon and are typically gravelly loams derived from limestone and shales. A clay horizon may occur at about 7 to 11 inches depth (Vanet). Lithic contact is between 23 to 38 inches and is typically shale or limestone (Syrett). Badlands are areas almost devoid of soils and vegetation, with bare rock and/or broken cobbles and channers exposed. These areas tend to be very erosive regardless of steepness. These soils are found on the slopes of benches and the sideslopes of mesas and range from 3 to 80 percent. Precipitation ranges from 13 to 22 inches, and vegetation includes areas of chapparal shrubs, and cool-season grasses and sagebrush (NRCS 2007b).

The Sevier Plateau, on the north end of the district, is dominated by Mount Dutton to the north, Cottonwood Peak in the middle, and Adams Head to the south. These peaks form a narrow plateau that is dissected by several ephemeral drainages on the west, north, and east. The west-facing side of the escarpment is rimmed with rockfall areas that extend from the north end to the center of the District. Both sides of the peaks are dominated by steep slope areas, although the west side is consistently steep while the east side is more of a mosaic of steeper and flatter ground. The entire plateau is grouped within soil map unit s8237 (Winnemucca-Echard-Callings-Behanin-Beardall map units) (NRCS 2007b). All these soils are deep, well-drained and slowly permeable. All are formed in alluvium and colluvium from volcanic materials except the Beardall, which is formed from limestone-derived glacial colluvium and residuum. Slopes range from 1 to 65 percent, with steep slopes being common. These higher-elevation soils receive 18 to 35 inches of precipitation and support wheatgrasses, mountain brome, juniper, aspen, Engelmann spruce, sub-alpine and white firs, and ponderosa pines (NRCS 2007b).

The largest areas of stable soils are found in the east central portions of the District.

9.4.5.4 Escalante Ranger District

The Escalante Ranger District is located east of Johns Valley and north of the Grand Staircase-Escalante National Monument. Of the 430,858 acres of public land on this District, there are 91,789 acres (21 percent) of steep slopes, 85,289 acres (20 percent) of erosive soils, 22,189 acres (5 percent) of unstable soils, and 5,057 acres (1 percent) prone to rockfall on this District, mostly located on the southern and southeastern sides of the District.

The Aquarius Plateau dominates the north central portion of the District and is made up of mostly flat, stable lands located above 10,500 feet elevation. However, the rim of the plateau is steep, and the slopes just below the rim, to the south and west of the plateau, have extensive areas of unstable soils made up of alluvium and colluvium eroded principally from the volcanic rocks and ash of the

plateau above. This is the most common soil concern on the District. These areas fall almost exclusively within one soil map unit, s8172 (Tatiyee family-Security family-Scout family-Quilt family-Parkay family-Jemez family-Hesperus family soil map units). These soils are moderately to very deep and well to excessively drained. Slopes range from 5 to 70percent. Precipitation ranges from 18 to 34 inches. Vegetation is a parkland of open and forested areas. Rangelands include a variety of grasses, bitterbrush, sagebrush and other shrubs. Forested areas include aspen, Douglas-fir, subalpine fir, and Engelmann spruce with grass understory (2007b).

At about 9,000 feet elevation at the east end of the District, and nearly 10,500 feet on the southwest end of the District the igneous lava flows and erosional alluvium, colluvium, and residuum give way to sedimentary rocks of Eocene (Wasatch Formation), Paleocene (Currant Creek Formation), and Cretaceous age (Dakota, Mancos, Mesa Verde group) that are the headwaters of the canyons of the Escalante. These lands extend across the southern third of the District. Steep slopes and rockfall areas are common, especially within and to the east of the Box-Death Hollow Wilderness (USDA 1995c)

The eastern third of these sandstone/shale bedrock areas is dominated by the s8225 (Yenlo- Mikim-Lazear-Clapper-Cannonville-Bayfield) soil map unit. These soils are derived from sandstones and shales and are typically loamy to sandy loam in texture. Soils are relatively deep. A mix of cool and warm season grasses are found here (NRCS 2007b).

The middle third of the sandstone/shale bedrock areas, located to the west of Box-Death Hollow wilderness, is dominated by soil map unit s8174 (Windwhistle family-Telephone family-Seleez family-Security family-Rock outcrop-Bond family-Atchee family). These soils are typically shallower and more sandy to cobbly in texture with more granitic parent material derived from erosional forces. There are sloping dune areas and cuestas. Vegetation is similar to the s8225 soil map unit, but also includes chapparal and timber as elevation increases (NRCS 2007b)

The western third of the sandstone/shale bedrock areas includes the Escalante Mountains, a relatively narrow ridgeline that is being eroded from both east (Escalante drainage) and west (Sevier River). The two most prominent peaks are Table Cliff Plateau (10,300 feet) and Barney Top (10,450 feet). The lowest elevation lands on the eastern flanks of the Escalante Mountains are covered by the same s8225 soil map unit noted above and have numerous isolated areas of steep slopes associated with canyon rims.

The Escalante Mountains ridge crest is dominated by the s8234 (Syrett-Swapps, Skutum, Pahreah-Badland) soil map unit. Soils are both steep and erosive. In areas other than the barren, eroding Badlands, soils are generally moderately deep, well drained, and moderately permeable sandy to gravelly loams. They are found on gently to steeply sloping benches and the sideslopes of mesas. Engelmann spruce, ponderosa pine, Rocky Mountain juniper, pinyon pine, bitterbrush, big sagebrush, rabbitbrush, manzanita, Indian ricegrass, needleandthread grass. These soils are both steep and erosive. A ring around the summit of Barney Top also has unstable soils. Precipitation ranges from 19 to 25 inches (NRCS 2007b).

The last area of steep and erosive soils is found in the southwest corner of the District at the headwaters of East Canyon, which drains to the Paria River. This soil map unit, s8233 (Zyme-Vanet-Syrett-Rock outcrop-Badland map units), is made up of shallow to very shallow, well-drained soils. These soils range from 6,700 to 8,800 feet in elevation. They generally have an ochric or mollic epipedon and are typically gravelly loams derived from limestone and shales. A clay horizon may occur at about 7 to11 inches depth (Vanet) . Lithic contact is between 23 to 38 inches and is typically shale or limestone (Syrett). Badlands are areas almost devoid of soils and vegetation, with bare rock and/or broken cobbles and channers exposed. These areas tend to be very erosive regardless of steepness. These soils are found on the slopes of benches and the sideslopes of mesas and range from 3 to 80 percent. Precipitation ranges from 13 to 22 inches, and vegetation includes areas of chapparal shrubs, and cool-season grasses and sagebrush (2007b).

9.5 Impact Analysis

This section describes the changes to soils, geologic, and cave resources that could occur as a result of implementing the Alternatives outlined in Chapter 2. Changes to these portions of the environment are described using the terms “effect” and “impact,” which are synonymous under NEPA. Effects may be direct, indirect, or cumulative in nature.

- Direct effects occur at the same time and place as the action.
- Indirect effects are reasonable foreseeable effects that occur later in time or are removed in distance from the action.
- Cumulative effects are those impacts to the environment that result from the incremental impacts of an alternative when added to other past, present, and reasonably foreseeable future actions.

In this Technical Report, the direct and indirect effects of an action are discussed in combination for the affected resource components in Section 9.5.4. Cumulative effects are described by alternative in Section 9.5.5.

NEPA requires that effects in an EIS be discussed in terms of context and intensity. In this Technical Report, context refers to the location, type, or size of the area to be affected relative to each resource component. Intensity refers to the severity or level of magnitude of impact. In this Technical Report, the intensity of effects are defined as Major, Moderate, Minor, or Negligible. In addition, the duration of effects can be temporary, short-term, or long-term. These terms are described more specifically in Table 9.5-1.

Table 9.5-1 Summary of terms used to describe effects in the technical report.

Attribute of Effect		Description
Quality	Beneficial	An improvement of current conditions.
	Adverse	A degradation of current conditions.
Magnitude (Intensity)	Negligible	No measurable change in current conditions.
	Minor	A small, but measurable change in current conditions.
	Moderate	A moderate, measurable change in current conditions.
	Major	A big, easily measurable change in current conditions.
Duration	Temporary	Short-lived (i.e., during construction).
	Short-term	10 years or less.
	Long-term	More than 10 years.

9.5.1 Connected Actions

The Alternatives described in Chapter 2 do not authorize surface disturbance. Therefore, environmental impacts in this Technical Report are analyzed as connected actions. Connected actions are defined by the Council on Environmental Quality (CEQ 1508.25) as actions that: 1) automatically trigger other actions which may require environmental impact statements; 2) cannot or will not proceed unless other actions are taken previously or simultaneously, and; 3) are interdependent parts of a larger action and depend on the larger action for their justification. Forest Service regulations (36 CFR 228.102(c)(4)) require the Forest Service to consider the subsequent actions that would be authorized by a lease as connected actions. Connected actions are the basis of the environmental analysis from which leasing decisions would be made. In this Technical Report, connected actions are the predicted disturbance from oil and gas leasing activity, which is

discussed in Chapter 2 of the EIS.

9.5.2 Issue Statement

- *Post-leasing activities could impact steep slopes and unstable and erodible soils.*

Changes in the topography, removal of vegetation, and soil disturbance from the construction and operation of oil and gas facilities such as roads, drill pads, drill rigs production facilities, and power lines can cause soil compaction, erosion, and increased land instability leading to mass movement events. Erosion and landslides result in soil loss, increased sediment production, and decreased productivity of other resources such as vegetation and wildlife. Landslides can pose safety hazards to people and structures (geologic hazard). Sensitive soil types can be difficult to reclaim.

9.5.3 Indicators

In this Technical Report, effects will be described using indicators developed for sensitive soils and geologic hazards. Using the environmental conditions described in Section 9.4 as a baseline, indicators are used to predict or measure change in a resource related to effects of the Alternatives. Some indicators are quantitative and measure effects based on numerical thresholds, while other indicators involve a narrative to qualitatively describe any changes relevant to baseline conditions.

<u>Measurement indicators</u>

1. Acres of disturbance.
2. Narrative description of potential effects to soil productivity.
3. Potential soil loss (tons/acre/year).
4. Miles of road and area of disturbance (acres) on sensitive landforms.
5. Potential for creating hazardous conditions.
6. Percentage of disturbance on sensitive soil types.

9.5.4 Direct and Indirect Effects

As defined in 9.5 above, direct effects occur at the same time and place as the action. This area would include, for example, all areas open for exploration and/or development, such as a seismic line, access road, drill pad, or production facility. Included in this area would be the entire footprint of disturbance: a proposed drill pad and its containment ditch and berms, or a proposed road surface and its borrow ditches. Indirect effects are reasonable foreseeable effects that occur later in time or are removed in distance from the action. An example would be loss of soil productivity in disturbed areas due to compaction, wind and water erosion, or the long-term storage of topsoil.

Under Alternative A there would be no leasing and thus no impacts to soils from leasing activities are anticipated.

Under Alternatives B, C, D, and E, it is assumed that activities described under the Reasonable Foreseeable Development Scenario (RFDS) (BLM 2007) would occur. Activities described under the RFDS (BLM 2007) include 60 to 120 acres (depending on Ranger District) of overland travel associated with seismic surveys, 80 to 330 acres (depending on Ranger District) of land clearing surface disturbance associated with road and pad building for exploration wells, and 254 acres of land clearing surface disturbance for a production field. The locations of these activities are not yet known.

Seismic exploration effects were noted in a BLM compliance review of a recent 2-D seismic survey conducted in northeastern Utah between 6,000 and 8,000 feet elevation. Truck-mounted drills, buggy-mounted drills ATVs, and heliportable drills were used, Effects of heliportable drills were limited to footprints by workers in the 3-foot diameter drill area with some subsurface drill cuttings left on the surface. Impacts from truck- and buggy-mounted drill rigs were more noticeable and included

up to six passes by some form of vehicle. Effects included localized compaction, decreased infiltration, corresponding increased surface run-off, and decreased ability for seedling establishment and root growth (BLM 2002).

For the Dixie National Forest, seismic work occurring on steep slopes could result in compaction of soil where wheeled vehicles pass. This could lead to the formation of rills and new flow patterns, which, over time, could develop into gullies. Where stream channels were crossed, imprints could be left on channel banks, which would be susceptible to increased erosion or head-cutting. Any vehicle path could lead to the establishment of new four-wheel drive or ATV trails. However, in the Utah study, all types of drills and transportation devices were determined to cause "little soil disturbance," which would be "normal in appearance after the next spring's rains" (BLM 2002). With this report in mind, it is likely that effects of seismic surveying on soil resources would be adverse, negligible to minor in intensity, and short term in duration.

Exploratory well development would likely cause the following impacts to soils in all locations:

- An increase in erosion of soil materials from roads and drill pads onto native lands due to run-off events, wind, and traffic. Erosion would be more likely to occur on cut slopes, fill slopes, and/or developments located on steep slopes or areas with high erosion potential. Using BMPs these impacts would most likely be adverse, negligible to minor, and short-term duration.

- An increase in sediment deposition on lands next to roads and drill pads, or in streams near these areas, due to the erosion noted above. Using BMPs these impacts would most likely be adverse, negligible to minor in intensity, and short-term duration.

- Pollution to soil resources due to hydrocarbon, drilling mud, or other chemical spills occurring on drill pads, some of which may require treatment at a land farm. Using BMPs these impacts would most likely be adverse, negligible to moderate in intensity, and would generally be short-term duration. However, if a reportable spill were to occur, effects could be adverse, major, and long-term.

- Development of any oil and gas related infrastructure on rockfall areas could result in more frequent landslides and rockfall. This would be hazardous to people, wildlife, livestock, vegetation and other resources that could be hit and injured, killed, or buried by falling rock. If proper siting of well pads and roads occurred, most incidents would be adverse, negligible in intensity, and short-term in duration.

Full-field development would likely include the same effects as described under "exploration," above.

Table 9.5-2 below lists the leasing option assigned to each sensitive soil/geologic hazard by leasing alternative. Descriptions of leasing options (and associated impacts on soils) are described in Section 9.5.4.1. Each assigned leasing option would either allow or restrict certain oil and gas activities (described under the RFDS) (BLM 2007) wherever the applicable resource component occurs on the Dixie National Forest.

Table 9.5-2 Leasing options assigned to areas with sensitive soil/geologic hazards under each alternative

Soils and Geologic Hazards	A	B	C	D	E
Rockfall areas	NL	NSO	NSO	NSO	SLT
Slopes > 35 percent	NL	NSO	NSO	CSU	SLT
Areas of High Erosion Potential	NL	NSO	NSO	CSU	SLT
Unstable slopes	NL	CSU	CSU	SLT	SLT
Cave Resources	NL	CSU	CSU	CSU	SLT

9.5.4.1 Impacts of connected actions by leasing option

Leasing options would dictate the conditions under which impacts from connected actions (described under the RFDS) (BLM 2007) may occur. Impacts from connected actions under each leasing option are discussed in this section; impacts under SLT are described more extensively in Section 9.5.4.2. Impacts to soil resources, considering leasing option overlaps (i.e., overlaps with more restrictive leasing options assigned to other resources) are discussed in Section 9.5.4.3 (Impacts by Alternative).

NOT AVAILABLE (NA)

NA applies to lands that are not administratively available for leasing, including Wilderness Areas and Brian Head Ski Resort. No oil and gas leasing would occur in these areas and no disturbance to soils in these areas would occur.

This leasing option does not apply directly to soil resource components.

NO LEASE (NL)

NL applies to lands where no new leases would be authorized, and no disturbance to soils or geologic hazards would occur under NL. Under Alternative A, NL would apply to all soils and geologic resource components listed in Chapter 2 of the EIS.

No oil and gas leasing would occur in these areas thus no disturbance to soils would occur in these areas.

NO SURFACE OCCUPANCY (NSO)

With the exception of seismic activities, NSO would prohibit occupancy or use of the land for oil and gas activities (e.g., construction of well pads, central tank batteries, access roads, pipelines, power lines, and other linear structures).

Under Alternatives B and C, NSO would apply to rockfall areas, steep slopes, and areas of high erosion potential. Under Alternative D, NSO would apply only in rockfall areas. Under Alternative C, linear features (e.g., roads, pipelines) would be allowed perpendicular to stream crossings.

Measurement Indicators

- *Measurement Indicator #1* ACRES OF DISTURBANCE

Under NSO, seismic activities could occur, and could affect 60 to 120 acres. These disturbances could be located in rockfall Areas, steep slopes, or areas with high erosion potential. Potential effects would vary depending on the soil affected and are described more fully under the measurement indicators below. Compared to the total acreage of sensitive soils, these effects would be negligible and short-term in duration.

- *Measurement Indicator #2* POTENTIAL EFFECTS TO SOIL PRODUCTIVITY

Under NSO, seismic exploration activities could occur, and could be located in rockfall areas, on steep slopes, and on areas with high erosion potential. Potential effects include a loss of soil productivity due to breaking down of the soil structure on travelways of seismic trucks and buggies, especially in areas with minimal vegetation coverage. Some downhill or downstream sedimentation would be expected if disturbed soil was eroded. If seismic work is conducted using trucks on roads, and helicopters and/or specially designed buggies, impacts to sensitive soils/geologic resources would be negligible and short-term in duration.

- *Measurement Indicator #3* POTENTIAL SOIL LOSS

Under NSO, seismic exploration activities could occur, and could be located in rockfall areas, on steep slopes, and on areas with high erosion potential. Potential effects include erosion of soil erosion due to wind and water, particularly if seismic lines went straight up and down hills.

Soil loss would be minimal on areas with high rockfall potential since these areas have little soil and are often barren of vegetation (e.g. boulder field, lava flow field). Effects of soil loss due to seismic activity in rockfall areas and cave resources would be negligible and short term.

Soil loss would tend to be more severe on steep slopes because there is often a substantial soil resource in these areas that is being pulled downward by the force of gravity and may be poorly adhered to the underlying parent material. Areas with thicker vegetation cover would be less likely to erode. Effects of soil loss due to seismic activity on steep slopes would cause adverse, minor impacts of long-term duration.

Soil loss on highly erosive soils would be most severe due to the inherent erodibility of these soils. Effects of soil loss due to seismic activity on highly erosive soils would cause adverse, minor impacts of long-term duration.

- *Measurement Indicator # 4* - MILES OF ROAD AND AREA OF DISTURBANCE ON SENSITIVE LANDFORMS

Under NSO, no roads would be constructed. However, as explained in Chapter 1.2.4.2., approximately 100 miles of seismic lines would be set on the Pine Valley Ranger District, and 200 miles would be set on each of the other Ranger Districts in the next 15 years, with 50 to 100 linear miles set per Ranger District per year. This is equivalent to 60 to120 acres of total disturbance per Ranger District over 15 years. Physical impacts of seismic surveying on sensitive soils/geologic resources are described under 9.5.4 above. The effect of running 100 to 200 miles, or 60 to120 acres, of seismic line across rockfall areas, areas with slopes over 35 percent and/or areas high erosion potential in each Ranger District would be an adverse, negligible impact of short-term duration.

- *Measurement Indicator # 5* - POTENTIAL FOR CREATING HAZARDOUS CONDITIONS

Under NSO, seismic activities taking place in rockfall areas, steep slopes, or areas with high erosion potential could create hazardous conditions if travelways were not selected to avoid potential rockfall areas, or areas or conditions prone to cause landslide. Rockfall may occur any time, but is more frequent during freeze-thaw periods. Landslides tend to occur during very wet periods, on very steep, unconsolidated slopes, or on cutbanks adjoining drainages. Because the nature of these landscapes, areas affected by rockfall or landslides would be altered permanently, effects of seismic activities conducted in hazardous areas would be adverse and minor to moderate in intensity depending on the size of any resulting landslide or rockfall area, and long term in duration.

- *Measurement Indicator # 6* - PERCENTAGE OF DISTURBANCE ON SENSITIVE SOIL/GEOLOGIC HAZARDS

The percent of disturbance that would occur on sensitive soils/geologic resources is not known at this point. Percent disturbance on sensitive soils could range from 0.0 percent if no sensitive soils/geologic resources were disturbed, to 0.8 percent if all disturbance through production wells occurred on sensitive soils/geologic resources, which is highly unlikely. Depending on the type of disturbance, duration could be short or long term. Thus, for all sensitive soils/geologic hazards, this would be a negligible, short to long-term impact.

TIMING LIMITATION (TL)

TL prohibits surface activities during specified time periods. This lease option does not apply to the operation and maintenance of production facilities unless the findings of analysis demonstrate the continued need for such mitigation, and that less stringent, project-specific mitigation measures

would be insufficient.

A TL lease option would not apply to soils directly under Alternatives A through E.

CONTROLLED SURFACE USE (CSU)

The CSU stipulation allows surface use on all or portions of a lease with special operational constraints that may otherwise exceed the mitigation provided by SLT, regulations, and operating orders.

A CSU lease option would not prevent disturbance to sensitive soil and geologic hazards. A CSU lease option would apply to unstable slopes under Alternatives B and C; and to slopes over 35 percent and areas of high erosion potential under Alternative D. Impacts to soils resources under CSU with regard to applicable measurement indicators are described below.

- *Measurement Indicator #1* - ACRES OF DISTURBANCE

Under CSU, unstable slopes and cave resources would be open to seismic exploration under Alternatives B and C. Steep slopes and areas of high erosion potential would be open to seismic exploration under Alternative D. Effects would be the same as those listed under 9.5.4, *Direct and Indirect Effects*, and above, and 9.5.4.1, *Impacts of connected actions by leasing option, NSO,* above, which were identified as negligible and short-term in duration.

Under CSU, up to 330 acres of disturbance for exploration, and 254 acres of disturbance full-field development could occur on unstable slopes and cave resource areas under Alternatives B or C, and to steep slopes and areas of high erosion potential under Alternative D. Compared to the total acreage of these sensitive soils on the DNF (see Table 9.4-1 above), impacts would be adverse, negligible to minor, and long-term in duration.

- *Measurement Indicator #2* - POTENTIAL EFFECTS TO SOIL PRODUCTIVITY

Under CSU, unstable slopes and cave resources would be open to seismic exploration under Alternatives B and C. Steep slopes and areas of high erosion potential would be open to seismic exploration under Alternative D. Between 60 and 120 acres would be disturbed by seismic exploration. Effects would be similar to those listed under 9.5.4, Direct and Indirect Effects, above. Compared to the total acreage of these sensitive soils (See Table 9.4-1), these effects would be negligible and short-term in duration.

Under CSU, exploration or full-field development on unstable slopes or cave resources areas (Alternatives B or C), or slopes over 35 % or areas with high erosion potential (Alternative D) could result in lost soil productivity if soil resources were polluted due to hydrocarbon, drilling mud, or other chemical spills on drill pads. Using BMPs, these impacts would most likely be adverse, minor in intensity, and short-term duration. However, if a spill were large enough to be reportable, effects could be adverse, major, and long-term.

Soil productivity and slope stability is generally adversely affected by oil and gas development due to compaction or disturbance by salvaging of soils on road and pad locations. Compaction inhibits water movement and root penetration within the soil matrix, and results in less water infiltration and higher overland flow. Soil physical structure is lost when soil is excavated and stockpiled for future use during reclamation of disturbed areas. Some silty or gypsum-rich soils become powdery when excavated, creating poor contact between soil and seed or soil and root, which results in poor plant growth. Powdery soil is also prone to wind and water erosion, which results in nutrient-rich topsoil loss. Effects of compaction or excavation on soil resources would be adverse, minor to moderate, and long-term in duration.

- *Measurement Indicator # 3* - POTENTIAL SOIL LOSS (tons/acre/year)

Under CSU, unstable slopes and cave resources would be open to seismic exploration under

Alternatives B and C. Steep slopes and areas of high erosion potential would be open to seismic exploration under Alternative D. Effects would be similar to those listed under 9.5.4, *Direct and Indirect Effects*, and 9.5.4.1. *Impacts of connected actions by leasing option, NSO*, above. Compared to the total acreage of these sensitive soils (see Table 9.4-1 above), these effects would be negligible and short-term in duration.

Under CSU, exploration or full-field development could result in soil loss on unstable slopes or cave resource areas (Alternatives B and C); or steep slopes or areas with high erosion potential (Alternative D) if erosion from roads and drilling pads were not controlled adequately. Erosion would be most likely to occur if the surface of roads and drill pads was not adequately watered, or was fine-textured. Erosion is also more likely to occur on cut slopes, fill slopes, and/or travelways. Erosion can increase in sediment load in streams located near existing and newly developed roads and drill pads. The erosional force of water is more pronounced on steep slopes. Soil takes many years to re-develop once it is lost. With the use of BMPs, however, impacts from soil loss on erodible soils, unstable slopes, and steep slopes should be adverse, minor, but long-term in duration.

- *Measurement Indicator # 4*- MILES OF ROAD AND AREA OF DISTURBANCE ON SENSITIVE LANDFORMS

Under CSU, seismic disturbance, no roads would be constructed. Effects would be the same as those listed under 9.5.4, *Direct and Indirect Effects*, and above, and 9.5.4.1, *Impacts of connected actions by leasing option, NSO,* above, which were identified as negligible and short-term in duration.

Under CSU for exploration and full-field development, up to 293 miles of road disturbance could occur on the Forest due to exploration activities, with a total of 996 acres (including roads and all other disturbance) disturbed for this purpose. One production field on the forest would result in approximately in a total of 15 miles of new road and 254 acres of disturbance (It is assumed the production well could occur on any district and so is included in the potential disturbance for each district). Total gross Forest-wide disturbance associated with oil and gas activity through construction of a production well would be approximately 1,673 acres. All but 220 acres of this (the production field disturbance) would be reclaimed (RFDS) (BLM 2007). There are 4,591 miles of authorized Forest roads on the DNF (USFS 2006a). Approximately 1,188 miles of these are in areas that present risks to soil resources (USFS 2003b). Exploration and production activities would increase overall Forest road mileage by 308 miles of new and reconstructed roads (7 percent). Although unlikely, if all roads were constructed in sensitive soil areas, the proportion of road mileage on sensitive soils/geologic hazard areas would increase by 26 percent.

Under Alternative C this disturbance could occur on unstable slopes or cave resource areas. Under Alternative D this could occur on steep slopes or areas with high erosion potential. Assuming that roads are constructed to standards outlined in the Gold Book (USDA and BLM 2007), and the Dixie National Forest Oil and Gas Construction and Operating Standards and Well Site Design Requirements (Appendix 9b), effects of this increased road mileage on sensitive soils/geologic resources would be an adverse, moderate impact of long-term duration.

- *Measurement Indicator # 5*-POTENTIAL FOR CREATING HAZARDOUS CONDITIONS

Under CSU, seismic exploration on unstable slopes and cave resources could occur under Alternatives B and C. Steep slopes and areas of high erosion potential would be open to seismic exploration under Alternative D. Effects would be the same as those listed under 9.5.4, *Direct and Indirect Effects*, and above, and 9.5.4.1, *Impacts of connected actions by leasing option, NSO,* above, which were identified as negligible and short-term in duration.

Under CSU, exploration drilling or full-field development could create unstable conditions on unstable slopes (Alternatives B and C), steep slopes, or highly erosive areas (Alternative D) if oil and

gas facilities are not properly planned and constructed. Hazards inherent to development on these sensitive soil types are described in 9.4.2, *Marginally Unstable Slopes*, above. Depending on the underlying geology, significant effort may be required to "anchor" facilities to the hill, or allow subsurface water to safely flow under, over, or around a road or drill pad. Under some conditions, it may be necessary to provide both surface and subsurface drainage, such as horizontal drains, drainage trenches, French drains, gabions, or drainage blankets to prevent groundwater from entering embankments, which can lead to moisture saturation and subsequent slope failure.

Effects of unstable conditions on unstable slopes (Alternatives B and C), or steep slopes and areas of high erosion potential (Alternative D) , if not properly controlled, would be adverse, minor to major, and long-term in duration.

Hazardous effects to cave resources from oil and gas activities have been given more attention recently because of increased development in karst and lava tube areas. The Environmental Assessment of oil and gas development on the New Mexico BLM-managed Southern Guadalupe Escarpment (BLM 2006b), provides information on potential and inherent impacts of oil and gas development on caves and cave resources. These include:

- Areas with sensitive bat colonies or other animals could collapse, be buried, or destroyed for the very long term if no specific lease options or limitations are in place to protect these resources. Such effects would be adverse, major, and of long-term duration.
- Most caves are not completely mapped. Exploratory drilling activities may "punch through" an unknown subterranean passage and fill or partially fill a cave cavity with drilling mud, water, hydrocarbons, and/or drill cuttings.
- Unknown voids located close to the surface can collapse when heavy trucks or drilling equipment drives or parks over the void. This occurred at the Exxon Fed. #4 location in New Mexico. The ceiling of the cavern stooped to the surface producing a 15-foot diameter hole under the drilling rig. This could result in injury or death to humans or animals, damage or destroy personal property, and/or could damage or destroy sensitive cave ecosystems (James Goodbar, BLM, personal communication). These effects would be adverse, moderate to major in intensity, and long-term in duration because of the difficulty of accessing cave reaches to mitigate effects.
- If any part of a well casing fails during drilling or testing, brine, gas, hydrogen sulfide gas, or drilling fluid could enter the cave system. Some caves are water sources for culinary water or stream water supplies. All springs on U.S. Forest Service land are considered Class 1 waters in Utah. Pollution of cave waters could pollute Class 1 and culinary water supplies for the short term or indefinitely (BLM 2006b).
- During completion of a well the casing is set to the desired depth and a mixture of cement and additives are pumped down the casing and back up outside to form a protective sheath of cement between the casing and well bore. If voids have been encountered, the cement mixture would enter the void and remain there permanently. This volume could amount to several hundred to several thousands of cubic feet of cement, the total volume of the annulus (BLM 2006b). Effects would be adverse, minor to major in intensity depending on the material and volume lost to the cave system, and long-term in duration because of the difficulty of accessing cave reaches to mitigate effects.
- The opening of new entrances to the earth's surface could influence or alter normal cave temperatures and change the flow of air, water, and humidity through the cave, thus changing the cave's microclimate. This change in the constant microclimate could affect both cave flora and fauna, and development and growth of cave formations – speleogens and speleothems – in the cave. Some cave formations would be destroyed by changes in air pressure (BLM 2006b).

- The use of lined mud pits (vs. self-contained mud pits) could cause contamination of cave environments by leaching of chemicals into the ground and groundwater systems after pits are broken and allowed to dry. Soluble chemical constituents in the mud could percolate down through natural fractures in the rock, carried by the rainwater, and enter caves and cave water systems. It is this same percolation of rainwater that provides water for the development of speleothems. Leaching of chemicals could also occur due to leaking flow lines, gas dehydrators and tanks. The chemicals and other constituents could change the chemical composition of the minerals forming speleothems and adversely alter the cave atmosphere. This chemically-altered atmosphere could cause the deterioration of existing speleothems and/or prevent their natural growth (BLM 2006b).
- In a worst case situation during the drilling, completion, or production of a well, natural gas could settle in the bottom of sinkholes and migrate into caves or fractures leading to caves and contaminate them. If natural gas were to flow through an open hole or through casing/cement that either failed or was inadvertently perforated, the gas would follow passages or other routes – some known, some unknown – such as small fractures or faults, and eventually contaminate a cave or cave system. The risk to humans and all other cave fauna from the migration of hydrogen sulfide and/or methane gas could be substantial. Explosions could result when the gas and oxygen in the cave mix and are ignited by carbide lights often used by cavers. The replacement of oxygen by the other gases endangers humans and other fauna by asphyxiation (BLM 2006b).
- The presence of hydrogen sulfide and methane gas, even in small amounts, could change the delicate balance of the cave atmosphere, causing the rapid deterioration of cave formations and the disruption or death of cave life. These gasses could also explode, causing damage to existing formations from the shockwave (BLM 2006b). Effects would be adverse, negligible to major in intensity, depending on the concentration of gasses (effects may be unknown for many years), and long-term in duration because of the difficulty of accessing cave reaches to mitigate effects.
- After a well was depleted, plugged, and abandoned, impacts to cave values could still occur. The steel casing could deteriorate over time because of interactions of the casing with hydrogen sulfide gas and weak acids in percolating water, causing leaks and the problems noted in the bullet above (BLM 2006b).

Because of the difficulty of accessing cave reaches to mitigate impacts, effects of these changes to cave resources would be adverse, negligible to major in intensity, depending on the extent of contamination (effects may be unknown for many years), and long-term in duration.

- *Measurement Indicator # 6* - PERCENTAGE OF DISTURBANCE ON SENSITIVE SOIL/GEOLOGIC HAZARDS

The percent of disturbance that would occur on sensitive soils/geologic resources is not known at this point. Percent disturbance on sensitive soils could range from 0.0 percent if no sensitive soils/geologic resources were disturbed, to 0.8 percent if all disturbances through production wells occurred on sensitive soils/geologic resources, which is highly unlikely. Depending on the type of disturbance, duration could be short or long term. Thus, for all sensitive soils/geologic hazards, this would be a negligible, short to long-term impact.

STANDARD LEASE TERMS (SLT)

Under SLT (BLM 2006), existing laws and regulations would be applied to oil and gas activities. All lands within the leasehold are available for placement of a road and drill site. At a minimum, and according to the standard surface use requirements attached to any lease, SLT would allow operations to be moved up to 200 meters and be delayed for up to 60 days if the authorizing officer deems it necessary to protect a resource. These allowances could be used to avoid certain areas of

special designation or unique vegetation features, or times of noxious weed propagation, if necessary. In general, disturbance to soils and geologic hazards, including areas with special designation, would be "minimized" under SLT, avoiding "unreasonable or unnecessary disturbances" during construction of pads, access, and other facilities, and during operations (BLM and USFS 2007). Disturbed areas would be regraded and re-vegetated after use.

In general, SLT provides an adequate level of protection to most resources due to the well-developed operating procedures set forth by the BLM and USFS. Agencies would ultimately have a central role in determining where oil and gas activities may occur under SLT, and due to the mandates inherent in their missions to protect natural resources, would not allow oil and gas activities to adversely impact resources despite the absence of more restrictive leasing options in place to protect them. Following standard operating procedures, well sites are selected in level areas, off narrow ridges, and set back from steep slopes. Well locations constructed on steep slopes cost more to construct, maintain, and reclaim, and are known to result in greater resource impacts (BLM and USFS 2007).

Under Alternative E, SLT would apply directly to all identified soil and geologic hazard areas, including within Inventoried Roadless Areas if a less conservative Roadless Area Conservation Rule were to be adopted. Impacts to soils and geologic under SLT are discussed in Section

9.5.4.2 Impacts of connected actions under SLT

The impacts of oil and gas exploration and/or development (connected actions) under the Reasonable Foreseeable Development Scenario (RFDS) (BLM 2007) are discussed in this section, assuming no restrictions or stipulations on oil and gas activities other that those listed on BLM form 3100-11 (SLT, BLM 2006;. the Gold Book (USDA and BLM 2007) and its referenced resources; the most recent Onshore Oil and Gas Approval of Operations rules set forth by the USFS; and standard constraints for all oil and gas operations dictated by the BLM, or referenced within the Dixie National Forest Oil and Gas Construction and Operating Standards and Well Site Design Requirements (Appendix 10b). Measurement indicators are discussed below for all soil resources, as SLT is the default leasing option and would cover all areas of the Dixie National Forest.

Measurement Indicators

- *Measurement Indicator #1* ACRES OF DISTURBANCE

Under SLT, all acres of sensitive soils and geologic resources would be open to seismic survey. Between 60 and 120 acres could be affected. Effects would be the same as those listed under 9.5.4, *Direct and Indirect Effects*, and above, and 9.5.4.1, *Impacts of connected actions by leasing option, NSO,* above, which were identified as negligible (with regard to the entire area of sensitive soils) and short-term in duration.

Under SLT, between 397 and 706 acres of disturbance could occur on each ranger district, or up to 1,672 acres on the forest as a whole, over the next 15 years. The locations of future oil and gas activity disturbance are unknown at this point. However, if full development were to occur based on models provided in the RFDS (BLM 2007) and presented in Chapter 2, Section 2.2.3, and in Tables 2.2-1 and 2.2-2, and if all disturbance took place on sensitive soils/geologic hazards, less than 1 percent of these sensitive areas would be disturbed in each ranger district. The Pine Valley Ranger District would have the least disturbance and the Powell and Escalante Ranger Districts would have the most (see Table 9.5-3 below). These effects would be negligible. Duration would be short-term if disturbance was related to exploratory activities, and long-term if associated with production activities.

Table 9.5-3 Acreage, and percent of total acreage, of Sensitive Soils/Geologic Hazards

available for leasing over a 15 year period, assuming all predicted disturbance within each Ranger District occurred on Sensitive Soils/Geologic Hazard areas*.

Ranger District	Seismic Disturbance (NSO)	Full field development, including seismic (CSU, SLT)	Sensitive Soils/Geologic Hazards in District^	Percent of Acres in District	
				Seismic Disturbance	Full Field Develop ment
Pine Valley	60 ac	397 ac	144,023 ac	0.04%	0.28%
Cedar City	120 ac	623 ac	79,217 ac	0.15%	0.79%
Escalante	120 ac	706 ac	112,191 ac	0.11%	0.63%
Powell	120 ac	706 ac	126,415 ac	0.09%	0.56%

*Cave resources are not quantified by acreage.
^ There are more than 706 acres of each of the sensitive soils/geologic hazards on each ranger district, except Pine Valley, which has no acres of unstable soils. The figures in this table represent potential development acreage on each type of sensitive soil. The sensitive soil acreage is not split out within a ranger district as it would be redundant.

- *Measurement Indicator #2* POTENTIAL EFFECTS TO SOIL PRODUCTIVITY

Under SLT, all acres of sensitive soils and geologic resources would be open to seismic survey. Up to about 120 acres could be affected. Effects would be the same as those listed under 9.5.4, *Direct and Indirect Effects*, and above, and 9.5.4.1, *Impacts of connected actions by leasing option, NSO,* above, which were identified as negligible and short-term in duration.

Under SLT, exploratory or full-field development of high-erosion areas, steep slopes, marginally unstable areas, and cave resources would result in effects similar to the quality, magnitude, and duration of those explained under 9.5.4.1, *Impacts of connected actions by leasing option, CSU*, Measurement Indicator 2, above. Impacts to soil productivity due to compaction and/or excavation would be minor to moderate and of long-term duration.

- *Measurement Indicator # 3* - POTENTIAL SOIL LOSS (tons/acre/year)

Under SLT, all acres of sensitive soils and geologic resources would be open to seismic survey. Up to about 120 acres could be affected. Effects would be the same as those listed under 9.5.4, *Direct and Indirect Effects*, and above, and 9.5.4.1, *Impacts of connected actions by leasing option, NSO,* above, which were identified as negligible and short-term in duration.

Under SLT, high-erosion areas, steep slopes, and marginally unstable areas could be exposed to severe soil loss if proper road and pad siting were not completed, and/or if proper design features specific to the proposed development site were not employed. Areas of high erosion potential, steep slopes, and marginally unstable areas, would not be adequately protected using standard BMPs designed to prevent erosion and sedimentation. Additional actions, such as gravel surfacing of roads and pads, may be necessary to protect “soft” road sections, steep grades, highly erosive soils, clay soils, or where all-weather access is needed. Field reconnaissance of alternative routes may be necessary to provide information on soil types, construction/reclamation limitations, type of excavation, landslide areas, subgrade conditions indicating the need for surfacing, potential cut slope problems, surface or subsurface water problem areas, suitability of fill material, and potential borrow and waste sites (BLM and USFS 2007). Appropriate technical resource staffs must be involved in an interdisciplinary approach to route location. Sufficient subsurface investigation and laboratory testing must be performed (USFS 1988) Effects of soil loss to areas of high erosion potential, steep slopes, and marginally unstable areas would be adverse, minor to major, and long-term in duration.

Under SLT, exploratory or full-field development in rockfall areas or cave resources areas would have little effect on soil loss as there is very little soil in either of these areas. Effects would be

adverse, negligible, and short-term.

- *Measurement Indicator # 4*- MILES OF ROAD AND AREA OF DISTURBANCE ON SENSITIVE LANDFORMS

Under SLT, all acres of sensitive soils/geologic resources would be open to seismic survey, exploration, and full field development. Effects would be the same as those described 9.5.4, *Direct and Indirect Effects*, and 9.5.4.1, *Impacts of connected actions by leasing option, CSU,* above, which were identified as adverse, major, and of long-term duration.

- *Measurement Indicator # 5* - POTENTIAL FOR CREATING HAZARDOUS CONDITIONS

Under SLT, all acres of sensitive soils/geologic resources would be open to seismic survey. Up to about 120 acres could be affected. Effects would be the same as those described 9.5.4, *Direct and Indirect Effects*, and 9.5.4.1, *Impacts of connected actions by leasing option, CSU,* above, which were identified as adverse, minor to major, and short-term in duration.

Under SLT, rockfall areas, high-erosion areas, steep slopes, and marginally unstable areas, would require additional study, field reconnaissance, and technical resource staff review to assure resource safety using measures as outlined in 9.5.4.2, *Impacts of connected actions under SLT, Soil Loss*, above (USFS and BLM 2007, USFS 1988). Effects to cave resources would be similar to those outlined in 9.5.4.1, *Impacts of connected actions by leasing options, CSU*, above. Effects of hazardous conditions on sensitive soils/geologic hazards, if not properly controlled, would be adverse, minor to major, and long-term in duration.

- *Measurement Indicator # 6* - PERCENTAGE OF DISTURBANCE ON SENSITIVE SOIL/GEOLOGIC HAZARDS

The percent of disturbance that would occur on sensitive soils/geologic resources is not known at this point. Percent disturbance on sensitive soils could range from 0.0 percent if no sensitive soils/geologic resources were disturbed, to 0.8 percent if all disturbance through production wells occurred on sensitive soils/geologic resources, which is highly unlikely. Depending on the type of disturbance, duration could be short or long term. Thus, for all sensitive soils/geologic hazards, this would be a negligible, short to long-term impact.

9.5.4.3 Impacts by Alternative

The degree to which the connected action impacts Sections 9.5.4.1 and 9.5.4.2 would differ by alternative are discussed in this section. Each alternative involves a unique set of leasing options for each resource component, which would restrict the locations and the nature of oil and gas activities that are allowed wherever these resources occur. Because areas for different resource components overlap, leasing options assigned to each resource component would also overlap and the most restrictive leasing option would take precedence (see Section 9.3).

Table 9.5-4 below shows the acres of each resource component for soils under each leasing option, by alternative. Table 9.5-4 incorporates the amount of overlap with more restrictive leasing options (assigned to other resources) in addition to the leasing option assigned directly to each soil resource component. The first column under each of Alternatives C, D, and E incorporates the acres within all Inventoried Roadless Areas assigned an NSO lease option as mandated by the current Roadless Area Conservation Rule (2001). The second column under Alternatives C, D, and E represents the same acres with less restrictive lease options, assuming a the 2001 RACR did not apply. There are 195,378 acres that are within Inventoried Roadless Areas (IRAs) under Alternative C and 201,761 acres within IRAs under Alternative D. The following resource components fall within Inventoried Roadless Areas: Escalante (44 percent), Cedar City (2 percent), Powell (39 percent), Pine Valley 56 percent. Cave resources have not been quantified by acreage at this time.

Table 9.5-4 Acreage of Resource Components under each Leasing Option, Including Overlapping Options, by Alternative.

Resource Component	Leasing Option^*	Alternative							
		A	B	C NSO/NSO		D NSO/CSU		E NSO/SLT*	
Rockfall	NA	0	8,793	8,793	8,793	8,793	8,793		
	NL	0							
	NSO	0	8,413	8,413	8,413	8,413	8,413	4,942	
	TL	0							
	CSU	0							
	SLT	0						12,264	17,206
	TOTAL	0	17,207	17,207	17,207	17,206	17,206	17,206	17,206
Steep Slopes	NA	0	69,836	69,836	69,836	69,836	69,836		
	NL	0	6,531	6,531	6,531	6,531	6531	6531	6531
	NSO	0	313,374	313,374	313,374	313,374	313,374	166,133	
	TL	0							
	CSU	0							
	SLT	0						217,077	382,441
	TOTAL	0	389,741	389,741	389,741	389,741	389,741	389,741	389,741
Areas of High Erosion Potential	NA	0	10,408	10,408	10,408	10,408	10,408		
	NL	0	2,020	2,020	2,020				
	NSO	0	84,210	84,210	84,210	42,180	6,202	79,435	
	TL	0							
	CSU	0				44,049	80,028		
	SLT	0						17,203	96,638
	TOTAL	0	96,638	96638	96638	96637	96638	96638	96638
Unstable Soils	NA	0	2,142	2,142	2,142	2,142	2,142		
	NL	0	<1	<1	<1	<1	<1		
	NSO	0	40,686	40,686	40,686	21,086	3,850	19,972	
	TL	0	1,063	1,063	1,063	14,957	32,193		
	CSU	0	1,468	1,468	1,468	7,128	7,128		
	SLT	0				45	45	25,386	45,358
	TOTAL	0	45,358	45,358	45,358	45,358	45,358	45,358	45,358

* The two leasing options listed under Alternatives C, D, and E represent the dual analysis for lands within Inventoried Roadless Areas if 1) the more restrictive rule (2001) remains in effect, or 2) if the 2001 RACR did not apply (see Chapter 2.0 and Technical Report 2.0).
^ Note that there is some overlap of resource components (e.g. soils can be both steep and rocky). Thus, the total acreage by resource component is more than the total acres of sensitive soils by approximately 11 percent.
^* There are no acres of Lease Notification (LN), so it is not included in this table

A more detailed table that separates the acreage by resource component and Ranger District will be available in Appendix B of the EIS. In this section, impacts are discussed mainly at the forest-wide level and not by Ranger District. This is done to avoid repetition and facilitate the comparison of impacts across alternatives. Differences among Ranger Districts were emphasized in Section 10.5.4.2 and are highlighted in this section if there are pronounced differences among Ranger

Districts.

Impacts by *Measurement Indicators* are summarized in Tables 9.5-6 below, and differences between alternatives regarding soil resources are outlined in the text below. *Measurement Indicator #1* is not discussed in this section or in Table 9.5-6 because the impacts in terms of acres disturbed would be the same under all alternatives that allow leasing (Alternatives B, C, D, and E; see Section 9.5.4.2). Measurement Indicator # 6 is not discussed because the percent of disturbance on sensitive soils is not known at this point. Percent disturbance on sensitive soils could range from 0.0 to 0.8 percent. For all sensitive soils/geologic hazards, this would be a negligible, short to long-term impact. Under Alternative A, no leasing would be allowed and impacts relative to *Measurement Indicators #1 and 6* would be negligible.

Under all Alternatives, 10 percent of the Dixie National Forest would be NA, or administratively unavailable for lease, including Wilderness Areas, Brian Head Ski Resort, private land, and $C0_2$ development areas (see Section 1.5.2 of the EIS).

Table 9.5-6 Impacts with respect to Measurement Indicators #2 through #5. LT = long term; ST = short term; neg = negligible; mod = moderate.

Resource	Measurement Indicator (*MI*)	ALT B	ALT C NSO in IRAs	ALT D NSO in IRAs	ALT D CSU in IRAs	ALT E NSO in IRAs	ALT E SLT in IRAs
Rockfall Areas	*MI #2*	Neg ST	Neg ST	Neg ST	Neg ST	Minor-Major[b] ST-LT	Minor-Major[b] ST-LT
	MI #3	Neg ST	Neg ST	Neg ST	Neg ST	Neg ST	Neg ST
	MI #4	Neg ST	Neg ST	Neg ST	Neg ST	Moderate LT	Moderate LT
	MI #5	Minor-moderate LT	Minor-moderate LT	Minor-moderate LT	Minor-moderate LT	Minor-major LT	Minor-major LT
	MI # 6	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]
Steep Slopes	*MI #2*	Neg ST	Neg ST	Minor-Major[b] ST	Minor-Major[b] ST	Minor-Major[b] ST-LT	Minor-Major[b] ST-LT
	MI #3	Neg ST	Neg ST	Minor ST	Minor ST	Minor ST	Minor ST
	MI #4	Neg ST	Neg ST	Neg ST	Neg ST	Moderate LT	Moderate LT
	MI #5	Minor-moderate LT	Minor-moderate LT	Minor-moderate LT	Minor-moderate LT	Minor-major LT	Minor-major LT
	MI # 6	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]
Areas of High Erosion Potential	*MI #2*	Neg ST	Neg ST	Minor-Major[b] ST-LT	Minor-Major[b] ST-LT	Minor-Major[b] ST-LT	Minor-Major[b] ST-LT
	MI #3	Minor LT	Minor LT	Minor ST	Minor ST	Minor ST	Minor ST
	MI #4	Neg ST	Neg ST	Moderate LT	Moderate LT	Moderate LT	Moderate LT
	MI #5	Minor-moderate LT	Minor-moderate LT	Minor-major LT	Minor-major LT	Minor-major LT	Minor-major LT
	MI # 6	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]
Unstable Areas	*MI #2*	Minor-Major[b] ST-LT**	Minor-Major[b] ST-LT**	Minor-Major[b] ST-LT**	Minor-Major[b] ST-LT**	Minor-Major[b] ST-LT**	Minor-Major[b] ST-LT

Resource	Measurement Indicator (*MI*)	ALT B	ALT C NSO in IRAs	ALT D NSO in IRAs	ALT D CSU in IRAs	ALT E NSO in IRAs	ALT E SLT in IRAs
	MI #3	Neg ST	Neg ST	Minor ST	Minor ST	Minor ST	Minor ST
	MI #4	Moderate LT	Moderate LT	Moderate LT	Moderate LT	Moderate LT	Moderate LT
	MI #5	Minor LT	Minor-mod LT	Minor- mod LT	Minor- mod LT	Minor-major LT	Minor-major LT
	MI # 6	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]
Cave Resources[a]	*MI #2*	Minor-Major [a] ST-LT*	Minor-Major [a] ST-LT*	Minor-Major [a] ST-LT*	Minor-Major [a] ST-LT*	Minor-Major [a] ST-LT*	Minor-Major [a] ST-LT*
	MI #3	Neg ST	Neg ST	Neg ST	Neg ST	Neg ST	Neg ST
	MI #4	Moderate LT	Moderate LT	Moderate LT	Moderate LT	Moderate LT	Moderate LT
	MI #5	Minor-mod LT	Minor- mod LT	Minor- mod LT	Minor- mod LT	Minor-major LT	Minor-major LT
	MI # 6	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]	Neg ST-LT[c]

a Impacts to cave resources could be major if a road, production well or field was located over a cave void or passage.
b Impacts would generally be minor and short-term. However, if a reportable hydrocarbon spill occurred, impacts could be major and long-term.
c Impacts would be negligible but could persist for a long term depending on the type of activity occurring (exploration vs. development).
.

ALTERNATIVE A

Under Alternative A, no new areas would be open to leasing. Present management activities would continue as they currently are in relation to existing oil and gas leases. The Forest Supervisor would not make any new leasing decisions and no new oil and gas leasing would be allowed on the Forest. Current operations, including the Upper Valley oil field on the Escalante Ranger District (33 wells) would continue (USDA 2006b). In total, there are 12,871 acres of existing leases on the Dixie National Forest.

Under Alternative A, impacts to sensitive soil and geologic hazards from new oil and gas leasing would be negligible because no new leases would be approved.

ALTERNATIVE B

Chapter 2 of the EIS describes how many acres of the Dixie National Forest would fall under each leasing option under Alternative B (*Measurement Indicator #1*; see Table 2.5-2). As under all alternatives, 5 percent of the Forest is administratively unavailable for leasing (NA). Approximately 69 percent of the Dixie National Forest would not be leased (NL) under Alternative B. Of the remainder, 20 percent would be NSO and 6 percent would be CSU. Alternative B is more restrictive than Alternative C and is less restrictive than Alternative A. Due to overlapping leasing options with other resource values, lease options under Alternative B include NA, NL, and NSO in rockfall areas, steep slopes, and in areas with high erosion potential. Marginally unstable slopes include NA, NL, NSO, and also CSU and TL lease options (treated as CSU in the following description). The area and locations of cave resources is unknown at this time, but would be covered by CSU if a more restrictive lease option did not overlap.

Effects under Alternative B would be the same as described under Sections 4.8.4.3 (for rockfall areas, steep slopes, and areas of high erosion potential) and 4.8.4.5 (marginally unstable slopes and cave resources). For rockfall areas, steep slopes, and areas of erosion potential, the main possibility of impacts under Alternative B (NSO for these resources) is with regard to *Measurement Indicator #5* (hazardous conditions) due to the possibility (although remote) of a catastrophic event resulting from seismic activities on these areas. Impacts to unstable slopes could be minor with an additional regard to soil productivity (*Measurement Indicator #2*) and hazardous conditions (*Measurement Indicator #5*), and moderate with regard to disturbance of sensitive landforms (*Measurement Indicator #4*), because any oil and gas activity may be allowed in these areas under Alternative B (CSU for this resource).

Impacts to cave resources would be similar under Alternatives B, C, D, and E, due to the possibility (although highly improbable) of a catastrophic event (see *Measurement Indicators #2* and *#5*), although unlikely, that could have moderate or major impacts regardless of leasing options. Impacts with regard to *Measurement Indicator #4* (acres disturbance on sensitive landforms) would be moderate under Alternatives B, C, D, and E (refer to Section 4.8.4.5).

ALTERNATIVE C WITH NSO IN INVENTORIED ROADLESS AREAS

Section 2.5.2 describes how many acres of the Dixie National Forest would fall under each leasing option under Alternative C with NSO in IRAs. All sensitive soils/geologic hazard areas outside IRAs are covered either by areas of NA, NL, or by CSU. Some areas of CSU have an additional TL for wildlife protection: this designation does not change the effects of oil and gas exploration or development.

Impacts to cave resources under Alternative C would be as described under Alternative B. Impacts

to rockfall areas, steep slopes, and areas of erosion potential would be very similar to Alternative B because leasing options are the same between alternatives. Impacts to unstable slopes would also be similar but slightly more adverse under Alternative C, relative to Alternative B, because more acres would fall under the CSU leasing option where all oil and gas activities would be allowed. For unstable slopes, moderate impacts would be possible under Alternative C with regard to soil productivity (*Measurement Indicator #2*) and hazardous conditions (*Measurement Indicator #5*), unlike Alternative B.

ALTERNATIVE D WITH NSO IN INVENTORIED ROADLESS AREAS

For sensitive soil and geologic hazards, Alternative D with NSO in IRAs is more restrictive than Alternative D with CSU in IRAs. NSO applies to all rockfall areas under this alternative and because of leasing option overlaps, steep slopes would also be under NSO (despite having a CSU leasing option applied). Leasing options under this alternative include NSO in all IRAs, rockfall areas, and steep slopes because of overlapping resource components. Areas with high erosion potential, and cave resource areas are open to leasing with the CSU option unless they are located within an IRA.

Effects of Alternative D with NSO in IRAs would be limited to seismic activities, and would be the same as described under Section 4.8.4.3 (for all sensitive soils), and Section 4.8.4.5 (for areas of high erosion potential, marginally unstable slopes, cave resources). Impacts to cave resources would be as described under Alternative B. Impacts to rockfall areas and unstable slopes would be as described under Alternative C because leasing options between alternatives are similar. Impacts to steep slopes and areas of erosion potential would be more adverse under Alternative D, relative to Alternative C, because leasing options for these resources would be CSU, thus allowing all oil and gas activities to potentially take place in these areas. Impacts to areas of high erosion potential could be major with regard to soil productivity (*Measurement Indicator #2*) and moderate with regard to sensitive landforms (*Measurement Indicator #4*), which are substantially more adverse than Alternative C. Impacts to steep slopes with regard to soil productivity (*Measurement Indicator #2*) could potentially be major in areas covered by CSU.

ALTERNATIVE D WITH CSU IN IRAS

Under Alternative D with CSU in IRAs, eight percent of the Dixie National Forest would be NSO, 34 percent would be CSU, 46 percent would be TL, and five percent would be NA. This alternative would include, in addition to a CSU leasing option in IRAs, NSO leasing options in those areas where leasing can still occur, but other, more restrictive resources values overlap. Chapter 2 of this EIS describes how many acres of the Dixie National Forest would fall under each leasing option under Alternative D with CSU in IRAs and where those acres are located. Impacts to all soil resources under this alternative would be similar to those described under Alternative D with CSU in IRAs.

ALTERNATIVE E WITH NSO IN INVENTORIED ROADLESS AREAS

Under Alternative E with NSO in IRAs, all areas of sensitive soils/geologic hazards are open to leasing under SLT except for those sensitive soils/geologic areas located within IRAs, which are covered by NSO. Relative to other alternatives, impacts under Alternative E with NSO in IRAs would be most severe with regard to rockfall areas because they are protected by NSO under other alternatives, and not protected (they would be under SLT) under Alternative E with NSO in IRAs (and E with SLT in IRAs). This would allow any oil and gas activity to take place on a rockfall area with only the minimum requirements in place for resource protection that are contained in all leases. Impacts could be major if a catastrophic event occurred on these areas, although such events are unlikely (see Section 9.5.4.2). Impacts to other soil resources could potentially be major also, but impacts are not dissimilar to those described under Alternative D, under which most resources are protected by CSU leasing options under which most oil and gas activities would still be allowed.

ALTERNATIVE E WITH SLT IN INVENTORIED ROADLESS AREAS

Alternative E with SLT in IRAs would allow leasing under the SLT leasing option on all lands, regardless of their designation as having sensitive soils, geologic hazards, or other resource values such as designated wilderness or sensitive plant populations. The potential impacts of this option are discussed for SLT in Section 9.5.4.2.

CUMULATIVE EFFECTS

Cumulative effects are the total effect, including direct and indirect effects, on a given resource resulting from the incremental impact of past, present, and reasonably foreseeable future actions. They can result from individually minor, but collectively significant actions taken over a period of time. Cumulative effects may arise from single or multiple actions and the effects may be additive or interactive. The net adverse effect of interactive actions may be less than the sum of the individual effects (countervailing) or the actions may interact to create a net adverse cumulative effect that is greater than the sum of the individual effects (synergistic). The magnitude and extent of the effect on a resource depends on whether the cumulative effects exceed the ability of a resource to function at a desired level (CEQ 1997).

9.5.4.4 Description of Cumulative Effects Area

The Cumulative Effects Area (CEA) for soils resources is the Dixie National Forest boundary.

RATIONALE

Impacts to soils and geology would not occur beyond the immediate area of disturbance (within the Dixie National Forest). Although hydrologic impacts to cave resources are possible outside the Forest boundary, impacts to water resources are covered in Technical Report 7.0, Water Resources.

9.5.4.5 Past, Present, and Reasonably Foreseeable Actions

The CEA has been used for grazing, timber harvest and small-scale mineral operations since the mid to late 1800s, while recreation is an increasingly popular forest use. Factors contributing to areas of soil resource degradation include poor grazing animal distribution; increased prevalence of noxious and undesirable plant species; fire suppression; activities related to road construction (both authorized and unauthorized); and drought.

During the late 1800s and early 1900s, overgrazing led to changes in vegetation composition and decreased soil stability on the Forest. Indiscriminant timber harvesting reduced the forest's extent considerably. Roads constructed to provide access to livestock, mineral development, and timber harvest areas were sometimes constructed in drainages or on steep side-hills, leading to localized damage to soil and water resources, and in some cases, mass wasting on hill slopes. In the last 150 years, fire suppression has created large mosaics of dense fuel loads. This has increased the frequency of large, severe fires. Vegetation changes due to grazing and fire suppression have led to the introduction of invasive, noxious, and/or problem species such as knapweeds, leafy spurge, and cheatgrass (2003b).

The past and present levels of each type of activity are listed below along with the general impacts that have resulted and the expected level of future activity.

ROADS

There are 4,591 miles of authorized Forest roads on the DNF (USFS 2006a). There are also a significant number of unauthorized routes (i.e., roads) that are not part of the Forest road or trail

system. These include old timber sale roads, old mining roads, and user-created roads (i.e., illegal OHV trails) (USFS. 2006a). The construction of roads in close proximity to streams and riparian areas leads to increased erosion on these sensitive and productive soils. Vehicles create multiple tracks and "mud bogs" as drivers go around mud and puddles to avoid getting stuck. Soil is compacted and/or washed into nearby streams. Vegetation productivity is decreased because of soil loss (USFS 2006d). Roads constructed on steep slopes adjacent to stream channels are prone to failure during flooding and also increase soil erosion rates (2003b).

The very nature of road construction involves movement of topsoil and sub-soil. Sometimes, situations are created that cause continued soil erosion for long after the initial road construction, particularly when roads are constructed on steep or long slopes. Water flowing onto roads from up-gradient areas is concentrated into the channel of the roadway. This water is released from the road at intermittent turn-outs and drains onto adjacent land, sometimes causing soil erosion. Fill areas used in road building on slopes increases the overall slope grade below the road. Water spilling off the fill edge during precipitation and snow melting events creates rills and gullies on the soil surface of the fill area and below. In addition, roads constructed on inherently unstable areas, such as on the North Horn or Claron formations, can increase the potential for mass failure. Roads also cause mass wasting by undercutting natural slopes where material is removed to build the road, or by overburdening slopes with heavy or overly steep road fills (2003b).

Table 9.5-5 shows the miles of Forest Service routes that have the potential to, or are, impacting soil resources.

Table 9.5-5 Forest Service routes impacting soil resources.

Route Impacts	Miles of Forest Service Routes			
	Pine Valley	Cedar City	Powell	Escalante
Routes have Soil compaction concerns				1
Routes are on areas of Erosive Soils		18		
Routes have Known Erosion Scars	30	195		
Routes Subject to Erosion Concerns	429	553	752	640
Route presents a moderate risk to soil and water resources	136	329	361	362
Route presents a high risk to soil and water resources	207	46	66	189

Source: Dixie National Forest Route Analysis Database

Very few new roads are expected to be constructed in the future and the overall mileage of the entire system is expected to decrease, with additional projects designed to decommission unused roads (USFS 2006a). The motorized travel management project should reduce the amount of cross-country travel by OHVs and reduce the amount of unauthorized routes.

LIVESTOCK GRAZING

Overgrazing in the late 1800s and early 1900s led to changes in vegetation composition and erosion of soil resources on the Dixie National Forest. Although impacts continue to occur, grazing practices have improved considerably in recent years. Grazing levels on the Dixie National Forest have been relatively constant. One decrease in authorized Animal Unit Months (AUMs) occurred in 2003, when average AUMs went from 87,824 to 68,684 due to drought conditions (USFS. 2006a). The drought

abated in 2004, but vegetation and soil conditions had not improved as of 2006.

At present, there is less overgrazing in south-central Utah than in the early 1900s and range conditions have generally improved over time (2006c). Range vegetation trend studies were only begun in 2004-2006, thus long term trend data on Dixie National Forest range condition is not yet available (2006e). However, short-term data collected between 2004 and 2006 indicate varying range trends depending on locale: in 2004, localized heavy grazing occurred on the Pine Valley Ranger District, with nine of 14 study sites showing downward trends in composition and vegetation cover; in 2005, a downward trend was found at 52 of 65 sites; and in 2006, among three sites sampled a downward trend was found in two, both within the Pine Valley Ranger District on a burned area that had not yet recovered. In addition to changes caused by grazing impacts, the increase of conifer, pinyon/juniper, and sagebrush-dominated plant communities on the Dixie due to fire suppression has diminished forage production and reduced carrying capacity of the range (USDA 2006c).

The number of AUMs available on the DNF has not decreased significantly over recent historical numbers, and grazing impacts are generally at the same levels as in the recent past. Current grazing practices may not provide sufficient protection for aspen, although vegetation associated with aspen communities generally has a significant understory of grasses and forbs whose roots maintain water infiltration rates and whose above-ground cover value helps prevent erosion (USFS 2006c). Grazing is expected to continue at current levels; however, correct application of revised criteria for grazing (Dixie National Forest) should result in fewer undesirable impacts to soils.

FIRE

Historical fire levels within the entire CEA likely averaged 3 percent per year, with up to 6 percent burning in active years (USFS 2006a). However, 150 years of fire suppression has created large mosaics of dense fuel loads in many watersheds within the CEA, which has increased the frequency of large, severe fires. The largest fire season since 1970 was in 2002, in which 57,745 acres burned. Large, severe fires remove vegetation, seal the soil surface in some cases, and increase overland flow and soil transport. This can remove or bury vegetation, and alter water regimes over the long term (USFS 2006a).

The 2004 Hawkins fire on the Pine Valley Ranger District resulted in increased frequency of cheatgrass, which has resulted in downward range trend (USFS. 2006a). Areas dominated by cheatgrass often lack other vegetative species, and if burned, enhance the reestablishment of cheatgrass. Total vegetative cover is lower when cheatgrass is the dominant species as compared to native, perennial grasses. This leads to increased soil temperature, lower moisture levels, erosion, and soil loss.

In 2002, the Sanford fire heavily impacted lands in the Powell Ranger District. Initial recovery efforts were hampered by the reintroduction of livestock grazing two years after the fire. However, after two year of no grazing, drainages are starting to stabilize: there appear to be lower sediment loads and aspen and cottonwoods are re-growing.

The number of uncharacteristically large and severe wildfires is expected to increase due to the limited acres than can be treated to reduce fuel loads. The use of prescribed fire and mechanical fuel treatments are anticipated to increase over the next 5 to 10 years from the current average of 4,345 acres per year (between 2004 and 2006), to over 10,000 acres per year. Most prescribed fires are small (average of 563 acres) and are low to moderate intensity. An increase in the number of prescribed fires and mechanical fuel treatments should ultimately lead to a decrease in the number of large, catastrophic fires. In general, prescribed fires have minor impacts on resources compared to large, severe fires (USFS 2006a).

TIMBER HARVESTING

Historical logging, even-aged management, and historical fire suppression have created relatively dense, late-succession, single-species forests with relatively large accumulations of woody debris and fuel (UDNR 2003). In recent years, the number of acres harvested per year has generally decreased relative to historic levels as the emphasis of timber harvests has shifted from promoting wood growth (for production) to ecosystem health. The primary strategy of the Dixie timber program is to reduce susceptibility to bark beetle attacks (USDA 2006f). Timber harvests expose forest soils to higher rain drop impact, reduce litter cover, increase soil temperature, often result in the construction of new roads, and skidding and transporting logs can create compacted paths and trails. These decrease soil productivity and can result in soil loss due to erosion.

Timber harvests (mainly commercial thinning operations) were affected 31,252 acres in 1998. Of this, 53 percent was commercial thinning. In 1999 20,280 acres (94 percent commercial thinning) were affected. Annual harvest totals between 2000 and 2007 were only 2,657 acres on average and consisted mainly of sanitation cuts (61 percent), salvage cuts (19 percent), and improvement cuts (11percent) in an attempt to create conditions favorable to tree regeneration and increased diversity in order to reduce the risk of severe outbreaks.

Table 9.5-6 below lists reasonably foreseeable future projects planned for the future, the approximate location of these projects, and the potential impacts to soil resources.

Table 9.5-6 Additional Reasonably Foreseeable Future Actions

Project	Project Description	Approximate Project Location	Potential Impacts to Soil Resources
Boulder Gravel Pit	No information available		
Bug Lake Salvage Project	Salvage dead and dying spruce on 228 acres in 2007 (in progress). Some road reconstruction may be necessary.	Escalante Ranger District; approximately 15 miles northwest of Escalante	Surface disturbance, road construction, and cutting activities can increase overland flow and erosion, leading to soil loss.
Bumblebee Fuels Treatment	Treatment of forest fuels north of New Harmony for community protection to prevent catastrophic wildfire. Includes 1004 acre harvest in 2007 and 100 acres in 2008.	Pine Valley Ranger District; 2 miles northwest of New Harmony	Surface disturbance, road construction, and timber cutting activities can increase overland flow and erosion, leading to soil loss.
Clayton Salvage	Timber salvage of 248 acres of dead and dying spruce on the Griffin Top Plateau.	Escalante Ranger District, approximately 14.5 miles northwest of Escalante.	Surface disturbance, road construction, and cutting activities can cause soil compaction, increasing overland flow and erosion, leading to soil loss.
Dipping Vat Habitat Improvement Project	Project would include the thinning of 1,132 acres of pine forests in 2008, and the mechanical treatment of sagebrush for habitat improvement and fuels reduction in Johns Valley.	Powell Ranger District; 7 miles north of Tropic	Surface disturbance, road construction, and cutting activities can cause soil compaction, increasing overland flow and erosion, leading to soil loss. Mechanical sagebrush treatment may open the vegetative canopy and

			increase erosion rates in the short-term.
Duck Creek Fuels Treatment	The Project would treat approximately 13,700 acres on the Cedar City Ranger District to reduce fuels, enhance fire-tolerant vegetation, provide fuel breaks, and reduce the risk of catastrophic wildfire. Phase 1 of the Project treated 2,800 acres in 2007. Phase II will treat 600 acres and Phase III 2,800 acres in 2008, 10,000+ acres in 2009, 5,000 acres 2010, and 1,500+ acres in 2011.	Cedar City Ranger District; four miles east of Navajo Lake along Hwy 14	Timber harvest could increase erosion rates due to road construction. Soil compaction occurs on road and staging areas, breaks down soil structure, and reduces natural infiltration. This can lead to erosion and soil loss. Constructed roads channelize overland flow and, where flow drains off of the road, leads to rilling of the soil surface or gullying if channelized flow is substantial.
Edward Spring Vegetation Treatment	Vegetation removal to increase early successional species – grass and aspen – using prescribed fire. 1,108 acres to be treated in 2008.	Cedar City Ranger District; Approximately 12 miles northeast of Parowan, near Bear Valley	Surface disturbance, road construction, and prescribed burning can cause soil compaction, increasing overland flow and erosion, leading to soil loss.
King Creek Campground Non-Commercial Thinning	Thin heavily stocked ponderosa pine to improve health and vigor in order to make these stands less susceptible to bark beetle attacks.	King Creek Campground, Powell Ranger District	Impacts should be minor due to use of developed roads, but could include localized increases in erosion on skid routes.
King Creek Campground Thinning	Thin trees in King Creek Campground to prevent insect and disease mortality and remove hazard trees.	King Creek Campground, Powell Ranger District	Impacts should be minor due to use of developed roads, but could include localized increases in erosion on skid routes.
Midway-Deer Valley Scenery Enhancement and Vegetation Treatment	Would remove dead vegetation and decadent aspen, including the salvage logging of dead spruce. The project would also include the construction of 3.8 miles of temporary roads and the prescribed burning of riparian meadows.	In the Midway-Deer Valley area along State Highway 14, sixteen miles east of Cedar City.	Surface disturbance, road construction, and prescribed burning of riparian meadows can alter natural water infiltration rates, increase overland flow and erosion rates.
Motorized Travel Planning	Would designate identified routes open to motorized use. With designation of a motorized travel system, cross-country travel would generally be prohibited.	All Ranger Districts on the Dixie National Forest	Would limit cross-country travel and lessen impacts to soil resources.
Mt. Dutton Vegetation Management Project	Remove dead spruce in Pine Creek, Mt. Dutton, and Adams Head area and establish a diverse mixture of conifer and aspen trees	Powell Ranger District; 10 miles southwest of Antimony	Timber harvest could increase erosion rates due to road construction. Soil compaction occurs on road and staging areas, breaks

	with at least 150 live trees per acre. The project would include timber harvest, prescribed burns on approximately 620 acres in 2009, 200 acres in 2010, and 50 acres in 2011. Reforestation, road reconstruction, and road decommissioning would occur on 5,490 acres in the upper drainages of Hoodle Creek, Willow Spring Creek, Forest Creek, Pine Creek, and North Fork Deep Creek.		down soil structure, and reduces natural infiltration. This can lead to erosion and soil loss. Constructed roads channelize overland flow and, where flow drains off of the road, leads to rilling of the soil surface or gullying if channelized flow is substantial. Road de-commissioning would cause temporary impacts to soil during these activities, but would decrease soil effects once work was completed and vegetation was established.
North Fork Buried Fiber optic line	Would bury fiber optic line along existing roads from Duck Creek Village to private lands along the North Fork of the Virgin River.	Cedar City Ranger District	Minimal impacts are expected to occur and would be temporary. Where soils are salvaged, some soil loss and soil compaction would occur.
Panguitch Lake Power Line Realignment	Would relocate 1.2 miles of 12.5 kV power line. Work would involve construction of a new overhead power line and removal of the old line.	Area is approximately 17 miles southwest of Panguitch on the Cedar City Ranger District	Temporary impacts to soils during construction. Where soils are salvaged, some soil loss and soil compaction would occur.
Pine Valley Fuels Treatments	Project involves the construction of fuel breaks around the communities of Pine Valley and Central. Approximately 516 acres were treated in 2003 and 2004, and another 217 planned for 2011.	Pine Valley Ranger District	Surface disturbance, road construction, and cutting activities can increase overland flow and erosion, leading to soil loss.

Pockets Vegetation Management	Would include commercial timber harvest, pre-commercial stand treatment, fencing, and travel management. The Project covers an area of 8,564 acres and would include commercial timber harvest on 4,721 acres of conifers and 2,647 acres of aspen, including 82 acres along the Antimony Creek drainage. Smaller areas would receive additional treatments. In addition, 9 miles of new roads would be required, 7.0 miles of unauthorized roads would be designated NFS roads, and 13.4 miles of existing NFS roads would be improved.	Escalante Ranger District	Timber harvest could increase erosion rates due to road construction. Soil compaction occurs on road and staging areas, breaks down soil structure, and reduces natural infiltration. This can lead to erosion and soil loss. Constructed roads channelize overland flow, and, where flow drains off of the road, leads to rilling of the soil surface or gullying if channelized flow is substantial.
Robinson/Meadow Timber Stand Improvement	Thinning for timber stand improvement. Approximately 600 acres will be treated in 2008 and 600 acres will be treated in 2009	Powell Ranger District	Timber harvest could increase erosion rates due to road construction. Soil compaction occurs on road and staging areas, breaks down soil structure, and reduces natural infiltration. This can lead to erosion and soil loss. Constructed roads channelize overland flow and, where flow drains off of the road, leads to rilling of the soil surface or gullying if channelized flow is substantial.
Upper Santa Clara River Vegetation and Fuels Project	Project includes a timber harvest, thinning, brush removal, and prescribed burning to prevent catastrophic wildfire in and around the Pine Valley Recreation Area. There are 1,662 total treatment acres planned: 714 acres treated in 2007, 352 acres to be treated in 2008, and 596 acres to be treated in 2009.	Pine Valley Ranger District; southeast of Pine Valley and west of Pine Valley Mountain Wilderness	Timber harvest could increase erosion rates due to road construction. Soil compaction occurs on road and staging areas, breaks down soil structure, and reduces natural infiltration. This can lead to erosion and soil loss. Constructed roads channelize overland flow, and, where flow drains off of the road, leads to rilling of the soil surface or gullying if channelized flow is substantial.

Webster Flat Road Reconstruction and Easement	Would involve reconstruction of 4 miles of arterial gravel road, including some new construction, relocation, widening, improved drainage, and additional surfacing.	Road is located south of Highway 14 on the Cedar City Ranger District	Surface disturbance due to soil salvage, and equipment operation, including drainage improvement work, will temporarily increase overland flow, and may increase long-term gullying. These both lead to erosion and soil loss. Increased road density exacerbates these effects.

9.5.4.6 Cumulative Effects by Alternative

ALTERNATIVE A

Under Alternative A, no new oil and gas activity would occur and there would be no cumulative effects from new oil and gas leases.

ALTERNATIVE B

Overlapping lease options and areas unavailable for leasing prevent direct disturbance on 75 percent of the Forest (65 percent NL, 10 percent NA). Another 20 percent is only eligible for seismic exploration due to NSO lease options. The potential for adverse cumulative effects to soils would be unlikely to occur in areas that are NSO. Seismic exploration generally has little impact on soil or vegetation.

Cumulative effects to soil resources would be more likely to occur on the remaining 5 percent of Forest lands that are open to full field development including road and well pad construction. Adverse effects of wells and pads located on sensitive soils or in riparian areas would be more likely to have cumulative effects if other past or planned activities were to occur in the same area. This would include past wildfires or future timber harvests or vegetation management. Areas infested with noxious weeds, or replaced by non-native vegetation, such as cheatgrass, would also be more vulnerable to cumulative effects due to poor vegetation cover, increased soil temperatures, decreased soil moisture levels, and decreased plant litter. Large fires can reduce the ability of precipitation to infiltrate, and increase the rate of surface water runoff and soil loss (2006a). Building roads, well pads, and production fields in areas recently cleared of vegetation from fire, timber harvest, or other means would also increase erosion rates, compact soils, and break down soil structure.

Specific projects of concern that could result in cumulative effects include: Cottonwood, Deep, and Deer creek watersheds (Powell Ranger District) that were impacted by the Sanford Fire in 2002; the 13,700 acre Duck creek Fuels Treatment (Cedar City District); the area to be affected by the Clayton Salvage Project (Escalante Ranger District); the Pockets Vegetation Management Project (Escalante Ranger District); the Dipping Vat Habitat Improvement Project (Powell Ranger District); and the area to be affected by the Midway-Deer Valley Scenery Enhancement and Vegetation Treatment Program (Cedar City Ranger District). Other projects are listed in Table 9.5-6 above.

Cumulative effects occurring under Alternative B would likely be long term and minor, due in part to the small area open to full-field development.

ALTERNATIVE C

Cumulative effects under Alternative C would be the same as that described under Alternative B, above. Effects would be the same as described above.

ALTERNATIVE D WITH NSO IN IRAS

Cumulative effects under Alternative D with NSO in IRAs would be similar to those described under Alternative B, except that only 33 percent of the Forest would be protected by the NSO lease option (rockfall areas, areas with steep slopes), and another 10 percent would be NA. The other 57 percent of land area would be subject to cumulative effects.

Of these lands, 46 percent of areas with high erosion potential, and 16 percent of marginally unstable soils, and all areas identified as having cave resources would be open to exploratory drilling and full-field development under the CSU lease option. Potential cumulative effects would be the same as described for Alternatives B.

These impacts could be long term and minor in rockfall areas and on steep slopes, and could be long term and moderate on areas with high erosion potential, unstable soils, or cave resources.

ALTERNATIVE D WITH CSU IN IRAS

Under this Alternative, only eight percent of the Forest would be protected under NSO. All rockfall areas and steep slopes fall under the NSO lease option. Ten percent of the Forest is not available for leasing. This leaves approximately 80 percent of the Forest open to oil and gas exploration and development; although, TL lease options would cover approximately 32,193 acres otherwise open to the CSU lease option, these short-term closures would not prevent degradation to soil resources, nor would they necessarily prevent other events, such as wildfires, from happening that could cause cumulative effects to occur. Overall, the cumulative effects that could occur under this Alternative would be similar to those described in Alternatives B and D above; however, given the decreased acreage of sensitive soils that would be covered by restrictive lease options, the potential for cumulative effects would be increased.

These impacts could be long term and minor in rockfall areas and on steep slopes, and could be long term and moderate on areas with high erosion potential, unstable soils, or cave resources.

ALTERNATIVE E WITH NSO IN IRAS

Under this Alternative, 33 percent of the Forest is protected under NSO in IRAs. However, all sensitive soils/geologic features also have some acreage open to oil and gas exploration and development. Approximately 71 percent of rockfall areas, 56 percent of steep slopes, 18 percent of areas with high erosion potential, and 16 percent of unstable soils are covered by SLT and open to full field development. Cave resources outside of IRAs are also covered by SLT. The cumulative effects that could occur under this Alternative would be similar to those described under Alternatives B and D above. Because there are fewer acres covered by restrictive lease options, the potential for cumulative effects is larger than that described in Alternative D with CSU in IRAs.

These impacts could be long term and moderate in all soil types/geologic resources.

ALTERNATIVE E WITH SLT IN IRAS.

Cumulative effects are most likely to occur under this Alternative and would be similar to those described under Alternatives B and D. No restrictive lease options would be used to protect sensitive soils or geologic resources from cumulative effects. The potential for cumulative effects to occur is greater under this option than any other option considered.

These impacts could be long term and moderate in all soil types/geologic resources.

Table 9.5-7 Summary of Cumulative Effects.

Past Actions	Present Actions	Future Actions	Alternative	Cumulative Effect
Past grazing has changed vegetation composition, compacted soils, increased overland flow, and decreased soil stability. Fire suppression has led to a buildup of fuels and the increased frequency of catastrophic fire that exposes the soil surface, allowing erosion and soil loss, and invasion of noxious weeds. Road construction in	Timber harvest, thinning, and range treatments are on-going to improve ecosystem health and reduce risks of fire and insect outbreaks. Healthy vegetation protects the soil surface from erosion. The impacts of roads and dispersed recreation continue to occur in many areas across the Forest Forests in the Escalante Ranger District are currently at risk of fire and noxious or undesirable weed	Population growth, housing and commercial development and the spread of invasive plants are expected to increase in the foreseeable future. Timber harvests, chaining of shrubs and pinyon/juniper, and prescribed fires are expected to continue at current levels in the foreseeable future. The impacts of roads and dispersed recreation (OHV use) should decrease with	**Alternative A** No new leases would be authorized and there would no direct or indirect impacts to soil resources as a result of oil and gas activity.	There would be no cumulative effects under Alternative A.
			Alternative B Overlapping NL options prevent direct disturbance on 65 percent of the forest. NSO would prevent permanent disturbance to all soil types on 20 percent of the forest. Connected actions could still occur on CSU lands (5 percent). All rockfall areas, slopes greater than 35 percent, and areas with high erosion potential are NSO. Marginally unstable areas and cave resources would be CSU.	Cumulative effects could occur as a result of oil and gas activity other than seismic work in areas degraded by past and future management activities, but would be limited to marginally unstable areas or cave resources, which are CSU. Cumulative effects could occur on unstable soils or cave resource areas in burn areas or areas with significant noxious weed issues. These impacts would be long-term and moderate. Cumulative impacts could also result from increased use of motorized travel on unauthorized roads. These impacts could be long term and minor.

riparian areas leads to erosion and/or mass wasting when roadways are flooded. Noxious weeds do not protect the soil as effectively as native plants	infestations. AUMS were decreased from an average of 87,824 to 68,684 in 2003 due to drought conditions.	implementation of the Motorized Travel Planning Project. Grazing is expected to continue at current levels for the foreseeable future.	**Alternative C** NSO would prevent permanent disturbance to all soil types in most areas (73 percent; includes areas within IRAs). Direct and indirect impacts from seismic activities could occur on NSO. All rockfall areas, slopes greater than 35 percent, and areas with high erosion potential would be NA, NL or NSO. Marginally unstable areas and cave resources would be CSU in areas outside of IRAs. Within IRAs, all sensitive soils would be NSO.	Cumulative impacts to sensitive soils/geologic impacts would be same in duration and intensity as under Alternative B. These impacts could be long term and minor.
			Alternative D with NSO in IRAs NSO would prevent disturbance from connected actions (except seismic) in 33 percent of the forest, which includes all IRAs. Exploration and development could occur on the remainder of the forest, although 10 percent would be NA. All rockfall areas and slopes greater than 35 percent would be NA, NL, or NSO. Marginally unstable areas and cave resources would be CSU in areas outside of IRAs. Within IRAs, all sensitive soils would be NSO.	Cumulative impacts to sensitive soils/geologic hazards would be the same in duration and intensity as under Alternative B and C although, in addition to unstable soils and cave resources, areas with high erosion potential would also be susceptible to cumulative effects in Alternative D. These impacts could be long term and minor in rockfall areas and on steep slopes, and could be long term and moderate on areas with high erosion potential, unstable soils, or cave resources.

			Alternative D with CSU in IRAs NSO would cover 8 percent of the Forest, including rockfall areas and steep slopes. Other areas of the forest would be largely available for lease and impacts from connected actions: 80 percent of the forest is CSU. Marginally unstable areas and cave resources would be CSU	Cumulative impacts to sensitive soils/geologic hazards would be similar to Alternative D with NSO in IRAs except that more areas of high erosion potential and unstable soils would be under CSU and thus more area would be susceptible to cumulative effects. Since the location of cave resources is unknown at this time it is not possible to determine if these areas would be more at risk than under previous Alternatives. These impacts could be long term and minor in rockfall areas and on steep slopes, and could be long term and moderate on areas with high erosion potential, unstable soils, or cave resources.
			Alternative E with NSO in IRAs NSO would prevent disturbance from connected actions (except seismic) in 33 percent of the forest in areas designated as IRAs. Connected actions could occur elsewhere, including all sensitive soils/geologic features..	Cumulative effects to sensitive soils/geologic hazards would include those that may occur under Alternatives B, C, and D (both alternatives), and in addition would include areas of rockfall and steep slopes because 71 percent and 56 percent of the acres open to SLT leasing in these soil types. These impacts could be long term and moderate in all soil types/geologic resources.

			Alternative E with SLT in IRAs Direct disturbance from connected actions could occur anywhere on the forest, including within RNAs and on all sensitive soils/geologic hazards.	Cumulative effects to sensitive soils/geologic hazards could occur on all acres of these sensitive areas. Up to 17,206 acres of rockfall areas, 382,441 acres of steep slopes, 96,,638 acres of high erosion potential, and 45,358 acres of unstable soils areas would be SLT. This increases the chance that fire, weed infestation, or poorly planned or routed roads would be located on sensitive soils where oil and gas development was proposed. These impacts could be long term and moderate in all soil types/geologic resources.

9.6 Compliance with Other Laws and Regulations

Executive Order 13112 (3 February 1999) - This Executive Order requires that the Forest Service prevent the introduction of invasive species and provide for their control in order to minimize the economic, ecological, and human health impacts of invasive species. Oil and gas leasing activities implemented with applicable BMPs would minimize the potential of introducing invasive species to the Dixie National Forest and would comply with this Order.

9.7 Forest Plan Consistency Determination

Alternative E would violate the LRMP directive for NSO lease options within Research Natural Areas. No other Standards and Guidelines within the LRMP would be violated by oil and gas leasing under any alternative.

LITERATURE CITED

Bureau of Land Management (BLM), 2002. Environmental Assessment for WesternGeco's Horse Point 3-D Seismic Exploration Project, Uintah and Grand Counties, Utah, EA No. UT-080-2002-219. November.)

Bureau of Land Management (BLM). 2006. Lease and lease offer for oil and gas. Form 3100-11.

Bureau of Land Management (BLM). 2006b. Environmental Assessment NM-520-06-418: Oil and Gas Lease Stipulations for the Southern Guadalupe Escarpment.

Bureau of Land Management (BLM). 2007. Reasonably Foreseeable Development Scenario for Oil and Natural Gas on the Dixie National Forest.

Bureau of Land Management and US Forest Service (BLM and USFS). 2001. Quitchupah Creek Road EIS tech report, soils, pg 3-19.

Bureau of Land Management and US Forest Service (BLM and USFS). 2007. Surface operating standards and guidelines for oil and gas exploration and development – the gold book. BLM/WO/ST-06/021+3071/REV 07. BLM. Denver, Colorado..

Michigan State University, 2002. RUSLE – an online soil assessment tool. Available on line at http://www.iwr.msu.edu/rusle/. Accessed various dates, September-October, 2007.

NRCS 2005. SSURGO database for select Utah soil surveys. Available at http://soildatamart.nrcs.usda.gov/County.aspx?State=UT

NRCS. 2007a. Soil Survey Manual, Chapters 2 and 3. Available URL: http://soils.usda.gov/technical/manual/contents/index.html. Accessed on October 11, 2007.

NRCS, 2007b. Official Soil Series Descriptions. Available URL: http://soils.usda.gov/technical/classification/osd/index.html. Accessed various dates, September and October, 2007.

NRCS, 2007c. Web Soil Survey. Available on line at http://websoilsurvey.nrcs.usda.gov/app/ Accessed various dates April – October, 2007.

NRCS, 1998. Soil Survey of Iron-Washington Area, Utah, Parts of Iron, Kane, and Washington Counties

Reid, L.M, R. Ziemer, M.E. Smith and C. Close. 1994. Evaluation of unstable lands for interagency watershed analysis, in Issues in watershed analysis. Discussions at interdisciplinary and interagency workshops held at the Humboldt Interagency Watershed Analysis Center in McKinleyville, CA. [Online WWW] Available URL: http://www.fs.fed.us/psw/publications/reid/3Unstable.htm.

Utah Division of Natural Resources (UDNR). 2003. Forest Health in Utah. Division of Forestry, Fire, and State Lands.

USFS. *See* US Department of Agriculture, Forest Service.

US Department of Agriculture. Forest Service. 1986. Land and Resource Management Plan for the Dixie National Forest. Ogden, Utah.

____ 1988 FSH 2509.22 – Soil and Water Conservation Practices Handbook R-1/R4. Amendment No. 1, Chapter 10– Soil and Water Conservation Practices Documentation. May

____ 1995a. Draft Environmental Impact Statement. Oil and Gas Leasing on Lands Administered by Dixie National Forest. June.

____ 1995b. Soils background report. Dixie National Forest Oil and Gas Leasing EIS. Dixie National Forest. July.

____ 1995c. Geologic Resources background report. Dixie National Forest Oil and Gas Leasing EIS. Dixie National Forest. July.

____ 2003a. Uinta National Forest Land and Resource Management Plan. Ogden, Utah.

____ 2003b. Forest-wide roads analysis. Dixie and Fishlake National Forests. Dixie and Fishlake National Forests, Roads Analysis Report, Forest-Wide Roads Analysis. January).

____ 2004e. Soils – 2004 Dixie National Forest Monitoring Report.

____ 2006a Comprehensive evaluation report summary: highlights of key conditions and trends. Dixie and Fishlake National Forests. June.

____ 2006b. Side Hollow Provenance Ponderosa Pine Genetic Study Administrative Site (Proposed), Escalante Ranger District, Dixie National Forest. History, objectives, and activities.

____ 2006c. Draft comprehensive evaluation report: Vegetation. Dixie and Fishlake National Forests.

____ 2006d. Comprehensive Evaluation Report: Watershed, Riparian, Fisheries, and Soils Dixie and Fishlake National Forests. October.

____ 2006e. Dixie National Forest monitoring report for fiscal year 2006.

____ 2006f. Proposed Land Management Plan for the Dixie and Fishlake National Forests. US Forest Service, Intermountain Region. June.

Appendix 9A – Stipulation Forms

NO SURFACE OCCUPANCY STIPULATION
Lava Fields Over Sensitive Aquifers
Alternatives B, C, and D

No surface occupancy or use is allowed on the lands described below (legal subdivision or other description).

Lava fields over sensitive aquifers shown in Figure 7.4-2 (Specialist Report 7.0).
This prohibition includes all surface disturbing activities such as roads, well pads, and other facilities.

For the purpose of:

Preventing any damage to water flow or quality of these sensitive aquifers.

A request for a waiver, exception, or modification (WEM) to the above lease stipulation may be requested along with the submission of a Surface Use Plan of Operations (36 CFR 228.104).
Any changes to this stipulation will be made in accordance with the land use plan and/or the regulatory provisions for such changes. (For guidance on the use of this stipulation, see BLM Manual 1624 and 3101 or FS Manual 1950 and 2820).
R4-FS-2820-14 (8/92)

NO SURFACE OCCUPANCY STIPULATION
Active Rockfall, Landslide, and Unstable Areas
Alternatives B, C, and D

No surface occupancy or use is allowed on the lands described below (legal subdivision or other description).

Active rockfall and landslide areas and unstable areas shown in Figure 9.4-1. This stipulation applies to all surface disturbing activities such as well pads, roads, pipelines, and powerlines. Exceptions to this stipulation can be considered if a survey is conducted by a qualified geologist/engineer and it is demonstrated to the responsible Forest Officer that operations can be located in stable areas or can be designed to prevent causing landslides and damage from natural soil creep and landslides.

For the purpose of:
Ensuring that proposed activities/facilities do not cause landslides and to prevent facilities from being damaged by landslides, rockfalls, soil creep, or avalanches which could result in hazardous conditions and spills or releases of potentially contaminating materials.

A request for a waiver, exception, or modification (WEM) to the above lease stipulation may be requested along with the submission of a Surface Use Plan of Operations (36 CFR 228.104).
Any changes to this stipulation will be made in accordance with the land use plan and/or the regulatory provisions for such changes. (For guidance on the use of this stipulation, see BLM Manual 1624 and 3101 or FS Manual 1950 and 2820).
R4-FS-2820-14 (8/92)

NO SURFACE OCCUPANCY STIPULATION
High Erosion Potential Areas and Steep Slopes (greater than 35 percent)
Alternatives B and C

No surface occupancy or use is allowed on the lands described below (legal subdivision or other description).

Areas with highly erosive soils and slopes greater than 35 percent shown in Figure 9.4-1. Not all areas are mapped and there are variable conditions within the areas shown on the map. The applicability of this stipulation to individual locations would be determined based on actual on-ground conditions. This stipulation includes all surface disturbing activities such as well pads, roads, powerlines, and pipelines.
Exceptions to this stipulation can be considered if a survey is conducted by a qualified geologist/soil scientist and it is demonstrated to the responsible Forest Officer that operations can be located in stable areas or can be designed and constructed to prevent causing excessive soil loss, landslides, or damage from natural soil creep and landslides.

For the purpose of:
Preventing excessive soil erosion and loss of productivity.
Avoiding soil damage and creating unstable/hazardous conditions.
Avoid high risk of damage to facilities from natural soil movement and landslides.

A request for a waiver, exception, or modification (WEM) to the above lease stipulation may be requested along with the submission of a Surface Use Plan of Operations (36 CFR 228.104).
Any changes to this stipulation will be made in accordance with the land use plan and/or the regulatory provisions for such changes. (For guidance on the use of this stipulation, see BLM Manual 1624 and 3101 or FS Manual 1950 and 2820).
R4-FS-2820-14 (8/92)

CONTROLLED SURFACE USE STIPULATION
High Erosion Potential Areas and Areas With Slopes Greater Than 35 Percent
Alternative D

Surface occupancy or use is subject to the following special operating constraints:

(1) Well sites will be located to avoid areas defined as having high erosion potential and slopes greater than 35 percent., Exceptions can be made if the operator can demonstrate that specific areas are stable or can be stabilized by using specific design and construction measures.

(2) Special measures may be required to stabilize slopes and soil resources to prevent slope instability, excessive soil erosion and production of sediment. Measures could include construction slope support structures, sediment collection structures, water collection systems/sediment ponds, placement of gravel to prevent rutting by vehicles, use of dust suppressants, etc.

(3) Pads may be located adjacent to existing roads, projects may be routed in corridors and cut and fill may be minimized at the discretion of the USFS or BLM authorized officer. All soil identified as the O or A horizon must be salvaged to its full extent if less than one foot deep, or at least one foot depth if these soil horizons are deeper. All salvaged soil must be stockpiled to use for reclamation.

(4) Directional drilling from approved well pads may be required at the discretion of the USF/BLM authorized officer to reduce the need for additional roads and production infrastructure.

On the lands described below:

Areas identified on Figure 9.4-1 as having high erosion potential and slopes greater than 35 percent. Actual on-ground conditions will be used to determine stipulation applicability.

For the purpose of:

Protecting soil resources from excessive impacts.

Any changes to this stipulation will be made in accordance with the land use plan and/or the regulatory provisions for such changes. (For guidance on the use of this stipulation, see BLM Manual 1624 and 3101 or FS Manual 1950 and 2820).

CONTROLLED SURFACE USE STIPULATION
Marginally Unstable Slopes
Alternatives B and C

Surface occupancy or use is subject to the following special operating constraints:

A survey must conducted by a qualified geologist/engineer to determine if the areas proposed for surface disturbing operations are stable enough to accommodate the proposed facilities. The operator must demonstrated to the responsible Forest officer that operations can be located in stable areas or can be designed to prevent causing landslides and damage from natural soil creep and landslides

On the lands described below:

Areas identified on Figure 9.4-1 as having marginally unstable slopes.

For the purpose of:

Protecting soil and water resources from excessive impacts that could result from damage to facilities from land/soil movement and failures.

Any changes to this stipulation will be made in accordance with the land use plan and/or the regulatory provisions for such changes. (For guidance on the use of this stipulation, see BLM Manual 1624 and 3101 or FS Manual 1950 and 2820).

CONTROLLED SURFACE USE STIPULATION

Lava Tubes and Limestone (karst) Cave Areas
Alternatives B, C, and D

Surface occupancy or use is subject to the following special operating constraints:

In areas with known or suspected caves, lava tubes, and karst features, surveys will be required to determine if they occur within or adjacent to the proposed project area. Surface disturbance will not be allowed within 300 meters of cave entrances, passages, or aspects of significant caves, lava tubes, or significant karst features. Waiver of this requirement will be considered when an approved plan of operations ensures the protection of lava or karst cave resources.

All casing and cementing programs must be designed to allow for a karst protection string and all strings of casing must be cemented to the surface. Upon abandonment of the well the wellbore will be cemented from the base of the cave/karst zone to the surface.

On the lands described below:
Areas identified as having potential to have lava tube or limestone cave resources below the surface. Most cave resources potential is in the Cedar City Ranger District; some areas have been mapped.

Cave resources are defined as any naturally formed void, cavity, recess, natural pit, sinkhole, or other feature that is large enough to permit a person to enter, whether or not the entrance is naturally formed or human-made. The term includes any extension or component of a cave or system of interconnected cave passages that occur beneath the surface of the earth or within a cliff or ledge, and/or natural subsurface water and drainage systems. Cave resources include any material or substance occurring naturally in caves, such as animal life, plant life, paleontological deposits, sediments, minerals, speleogens (relief features on the walls, ceiling, and floor of any cave that are part of the surrounding bedrock), and speleothems (any natural mineral formation or deposit occurring in a cave) is considered a Cave Resource (Uinta National Forest Land and Resource Management Plan. Ogden, Utah).

For the purpose of:
Protecting Lava Caves and Karst Features and associated groundwater and spring resources.

Any changes to this stipulation will be made in accordance with the land use plan and/or the regulatory provisions for such changes. (For guidance on the use of this stipulation, see BLM Manual 1624 and 3101 or FS Manual 1950 and 2820).

Appendix 9B - Dixie National Forest Oil and Gas Construction and Operating Standards and Well Site Design Requirements

Dixie National Forest Oil and Gas Construction and Operating Standards and Well Site Design Requirements

I. INTRODUCTION

The following operating standards and well site design requirements would be required by the Dixie National Forest for oil and gas facilities and operations to assure consistency with management objectives for the Forest. These operating standards should not be confused with stipulations contained in the applicable Federal oil and gas lease(s) which specify requirements regarding surface occupancy and timing within the specific areas in the lease. Operating standards must be consistent with the rights and restrictions established in the applicable lease(s) and are applicable to all drilling and production operations, unless otherwise approved by the responsible officer based on site-specific conditions.

These operating standards supplement the general requirements of the Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development (Gold Book) and Best Management Practices in place by the responsible agencies at the time of approval, and the Forest Service, Region 4 Oil and Gas Roading Guidelines. Copies will be made available to operators at first notification of proposed operations.

Authority to require such standards is provided by the Mineral Leasing Act of 1920, as amended, Federal Regulations at 36 CFR 228.106-108 (Submission, Review, and Requirements of Surface Use Plans of Operations) and 43 CFR 3162.3 (BLM procedures for approval of post-lease applications for operations).

II. PURPOSE

These operating standards have been developed to help operators meet agency and Forest requirement when planning operations and preparing their Surface Use Plan of Operations and to assure overall consistency with Forest Service management objectives/direction. They have been developed based on experience with oil and gas operations on National Forest System lands as needed to prevent or mitigate effects and conflicts with other uses.

III. PROCESS

Approvals of proposed operations on lease are subject to the application, review, and approval provisions specified in Onshore Oil and Gas Order No. 1, other Onshore Oil and Gas Orders, and all applicable laws and regulations. Surface disturbing proposals must be evaluated under the requirements of the National Environmental Policy Act of 1969 and the Energy Policy Act of 2005. Operators are encouraged to obtain these operating standards from the Forest Service early in the planning and approval process and to incorporate them into their Surface Use Plans of Operations to help streamline the NEPA analysis and approval process. If not incorporated into the initial SUPO, the Forest Service will work with the operator to revise the SUPO to include them or may otherwise require them as Conditions of Approval (COA).

Other standards or mitigations may be required based on site-specific evaluations of proposed activities. They may be modified if needed to address site-specific conditions. Operators are required to comply with all other applicable laws and regulations.

DRAFT

IV. OPERATING STANDARDS

These standards apply to the lease holder, contractors, and their sub-contractors. The term "operator" as used herein, includes the lease holder and/or company authorized to conduct operations on the lease or their contractors, subcontractors, and all employees or agents thereof.

1. The operator shall submit for review and approval, a detailed construction and maintenance plan for all exploration and production facilities and roads to be constructed or improved (reconstructed) for operations. Unless otherwise approved by the responsible Forest Service officer, pad designs must be consistent with requirements contained in the Dixie National Forest Well Site Requirements (Attachment 1). A road-use permit (or specific approval as part of the Surface Use Plan of Operations) must be obtained from the Forest Service for commercial use, improvement, and maintenance of National Forest System roads under authority of the National Forest Roads and Trails Act. Road designs must be generally consistent with the Forest Service guidelines provided in the Oil and Gas Roading Guidelines, R-4.

2. The designs for roads, pads, and other facilities are subject to approval by the Forest Service. The designs must be approved and signed by a qualified licensed engineer. Any modifications to approved plans are subject to Forest Service review and approval.

3. Existing roads will be used to the extent possible as long as the existing alignment can be used or improved to the required standard. Additional roads or rerouting of existing road segments, if needed, shall be minimized and approved by the Forest Service prior to construction. Roads or road segments replaced and/or abandoned by construction of new roads or rerouting must be reclaimed by the operator. Road locations and designs must be generally consistent with the Forest Service guidelines provided in the Oil and Gas Roading Guidelines, R-4.

4. Locate and design roads and drainage structures to prevent slope failure and minimize impacts on water quality. To the maximum extent feasible, locate facilities, including service and refueling areas, on benches upslope from streams, lakes, ponds, riparian areas, and floodplains.

5. A pre-construction meeting including the responsible company representative(s), contractors, and the Forest Service must be conducted at the project work site prior to commencement of operations. Earthwork must be construction staked prior to this meeting. Approval of the designs and earthwork staking by responsible Forest Service official is required prior to beginning earthwork.

6. A Spill Prevention Control and Countermeasures (SPCC) Plan consistent with the current EPA Region VIII Oil and Hazardous Substances Regional Contingency Plan must be filed with the Forest Service and approved by the authorized officer prior to conducting any construction and operations on National Forest System lands. The plan must address the potential for spills to occur from haulage of materials and supplies to the construction/operations site(s) as well as drilling and production facilities. Material Safety Data Sheets (MSDS) for all potentially hazardous substances used for operations used for operations must be available on-site. Operators must be trained in MSDS protocols.

DRAFT

7. All surface disturbing activities, including reclamation, must be supervised by a qualified on-site responsible designated company representative(s) familiar with the approved plans as well as terms and conditions of approval. The designated representative(s) must be available for contact within the vicinity of the project area or by telephone at all times that operations are in progress. The name and contact telephone number of the designated company representative(s) must be filed with the responsible Forest Service official. A copy of all approved permits with specifications relative to operations in the project area must be available for inspection at the project site.

8. Topsoil must be salvaged from the area to be disturbed, stored, and protected from erosion and contamination until redistributed over recontoured areas for reclamation. The depth of topsoil to be salvaged must be determined though testing and approved by the Forest Service. Methods of topsoil handling and storage must be approved in project plans and specifications and/or appropriate project permits.

9. All vegetation removed by operations must be stored, used for reclamation, or disposed of as approved in project permits or as specified by the Forest Service. The operator must reimburse the Forest Service for the fair market value of all merchantable timber removed or damaged during operations. Prior to vegetation disturbance/removal all noxious weeds must be removed from the site and handled by approved methods needed to prevent spread of seeds.

10. Where determined appropriate by the responsible Forest Service officer, the operator may be required to bury pipelines and powerlines in or adjacent to roads to reduce surface disturbance and visibility. Designs must provide sufficient depth of cover and signs to indicate the type of pipeline(s), location, and depth to prevent damage from road maintenance and other surface disturbing activities in conformance with applicable Federal and State regulations.

11. Where feasible and appropriate, the operator will be required to centralize production facilities, use telemetry to monitor wells, and delay non-essential maintenance activities in important wildlife habitat during critical seasons of use to reduce the number of vehicle trips to the sites and activity that could disturb or stress wildlife.

12. Where needed to protect wildlife, the operator will be required to construct fences and/or nets on reserve pits or use other approved methods to prevent wildlife use or entrapment.

13. Stream crossings will be planned and constructed to minimize disturbance of the riparian and aquatic habitats by locating crossings at the most advantageous location and by crossing at or near the perpendicular. Structures must be designed to allow fish passage as needed to maintain habitat. Measures must be taken to minimize disruption of stream substrate. When no longer needed for operations, crossings must be removed and the stream and banks restored to pre-disturbance conditions/stream hydraulics. Sediment control measures must be used to minimize sediment introduction during all operations. Timing restrictions (construction and reclamation) may be needed to protect fisheries as coordinated with the Utah Division of Wildlife Resources and through permitting with the Utah Division of Water Rights, Stream

DRAFT

Alteration Program.

14. Unless otherwise specified by the responsible Forest Service officer, new oil and gas access roads shall be closed to the public. Operators must construct and maintain gates to Forest Service design standards at intersections of project access roads with National Forest System roads or other highways to prevent unauthorized traffic from entering. A locking system will be required to allow a Forest Service lock in addition to the operator's lock.

15. Off-road vehicle travel is prohibited unless specifically approved in project permits.

16. Roads used for drilling and production operations which remain open to public traffic must be properly signed to warn the public of project traffic and associated hazards. Signs must be consistent with the Manual on Uniform Traffic Control Devises, Federal Highway Administration.

17. Vehicle operators must obey posted speed restrictions. If speed restrictions are not posted, the operator and contractors must observe safe speeds commensurate with weather and road conditions.

18. Watering and/or application of appropriate dust suppressants shall be used if dust becomes a concern for visibility and sediment transport. Suppressants and application procedures are subject to approval by the responsible Forest Service officer.

19. Unless otherwise approved by the responsible Forest Service officer, all production pads will be fenced to prevent entry by the public and livestock. Designs and specifications are subject to Forest Service approval.

20. Sediment control structures will be used to catch sediment at the base of fill slopes on exploration and production pads. If silt fences are used, they must be constructed with adequate support and maintained to assure that they function at all times, including the winter season and spring runoff.

21. Establishment of staging areas or camp areas outside of the area permitted for surface disturbing operations for project personnel (operator or contractors) on National Forest System lands is subject to Forest Service approval.

22. All permanent survey markers within the area to be disturbed, including section corners, benchmarks, geodetic survey monuments, etc. must be located and flagged for protection prior to any surface disturbance activities. Disturbance or relocation of monuments requires the approval of the agency responsible for their use and preservation.

23. Water needed for operations must be obtained in accordance with State water law. The location and design of diversions on National Forest System lands are subject to review and approval of the responsible Forest Service official.

24. The operator and all contractors shall take measures needed for the prevention of fires started as a result of their operations and to suppress fires that are started as a result of their operations. Fire suppression equipment must be available to all personnel in the project area consisting of shovels, axes, and other appropriate hand tools. At least

DRAFT

one properly rated fire extinguisher must be available in each vehicle and around all machinery such that they are readily assessable for suppression of fires. During times of severe fire danger when fire restrictions are implemented by order of the responsible Forest Service officer, all operations must be conducted in conformance with the order. The operator may be required to submit and implement a Fire Prevention/Suppression Plan for review/approval by the responsible Forest Service official.

25. All vehicles and other gasoline/diesel-powered equipment must be equipped with properly functioning spark arresters and mufflers. Spark arresters must meet Forest Service specifications in accordance with USDA Forest Service Spark Arrester Guide.

26. The operator will be held responsible for damage and suppression costs for fires started as a result of operations. Fires must be immediately suppressed to prevent spreading and must be reported to the responsible Forest Service officer.

27. The operator must maintain structures, facilities, improvements, and equipment in a safe and neat manner and in accordance with approved permits. The operator must take appropriate measures in accordance with applicable Federal and State laws and regulations to protect the public from hazardous or conditions resulting from the operations. Such measures must include, but are not limited to, posting signs, building fences, or otherwise identifying the potentially hazardous site or condition.

28. All accidents or mishaps resulting in resource/property damage and/or serious personal injury must be reported to the responsible Forest Service officer as soon as possible.

29. The operator may be required to locate pads and facilities in areas where they can be effectively screened from view from sensitive areas. Production facilities must be located and designed to minimize visibility from sensitive viewing areas. Painting of facilities with a non-reflective paint in the color that would best blend with the background will be required. The color will be determined by the operator with approval of the responsible Forest Service officer.

30. The operator must comply with all applicable laws and regulations pertaining to the storage, use, and disposal of hazardous substances and solid or liquid waste. All fluids, chemicals, and solid wastes must be properly contained on-site. Reserve pits, catchment ponds, and bermed areas must be constructed to prevent seepage into the ground or adjacent areas. A minimum of 2-feet of freeboard must be maintained in all reserve pits and ponds at all times to prevent overflow and spillage into adjacent areas.

31. Chemical containers should not be stored on bare ground or exposed to the sun or moisture. Containers and labels are subject to degradation and punctured drums could leak contents onto the ground. Chemical containers should be maintained in good condition and placed within secondary containment in case of a spill or puncture. Secondary containment facilities must be of sufficient size to contain all appropriate fluids, including diesel or other fuels.

DRAFT

32. Sanitary facilities must be available to operators and contractors in the project area and properly used and maintained to prevent pollution. The installation of sanitary facilities, other than self-contained chemical toilets is subject to State and Forest Service approval.

33. Unless other methods are specifically approved, all solid wastes, contaminated soil materials, drill cuttings, petroleum products, and other fluids must be properly contained on-site. Disposal of associated waste materials must be at a facility licensed by the State to accept such materials.

34. Harassment of wildlife is prohibited. Pets must be properly restrained to prevent harassment of wildlife, livestock, government officials, and the public.

35. Move-in and move-out of heavy construction and drilling equipment will not be allowed during the opening weekends of the general big-game hunts or holiday weekends (including the observed holiday) from noon the previous day until midnight on Sunday or the observed holiday. Use and maintenance of National Forest System roads is regulated under authority of the National Forest Roads and Trails Act and the National Forest Management Act.

36. Vegetation seeding methods and seed mixes (species and amounts) used for interim and final reclamation must be approved by the Forest Service. Reclamation and revegetation plans and standards for success must be approved in project plans or permits. All vegetation materials, seeds, soil amendments, and sediment control materials must be certified that no noxious weed seed or noxious weeds are present. The operator is responsible for control and eradication of noxious weeds in project area, and the control and eradication of any invasive plant species not present at the site prior to operations, until such time as reclamation standards are met and the company is relieved of further reclamation responsibilities.

37. Vehicles and equipment shall be free of mud, soil, plant materials, and other debris which could contain noxious weed seeds prior to coming onto the Forest. This is needed to avoid transporting noxious weeds, or invasive species to sites on the Forest.

38. The operator shall follow Forest guidelines designed to prevent the introduction and spread of aquatic nuisance species (Dixie and Dixie National Forest Supplement, Forest Handbook 2509.16, chapter 1.

DRAFT

Dixie National Forest Well Site Requirements

V. WELL SITE DESIGN REQUIREMENTS

A. General Requirements

The operator should propose locating the well site in cooperation with Forest Service personnel on the most nearly level location obtainable that would accommodate the intended use. However, potential well site locations should not be evaluated on the basis of site conditions alone. Access to the well site for road and possible future pipeline locations must also be considered in determining the most suitable location. What may be gained on a good location could be lost from an adverse access route. Plan the well site from the long-term standpoint, assuming a discovery could be made. Future pipeline locations are to be proposed by the operator as a part of his proposal on each well site.

Adjust the well site layout to conform to the best topographic situation. Avoid disturbance of drainages and locate reserve pits away from water courses. Deep vertical cuts and long fill slopes should be avoided. The cut and fill volumes should be balanced, excluding the topsoil and subsoil needed to backfill the reserve pit.

A contour map shall be developed for all well pad locations as an aid in the design of pad settings to the existing topography. This will allow the operator to plan the construction of facilities and the surface manager to evaluate impacts and calculate the bond more expeditiously and accurately. Maps should be prepared to a scale of 1 inch equals 20 feet horizontally and a contour interval of 2 feet vertically, or as otherwise directed by the responsible Forest Service officer.

Once this information is compiled, finished site elevations, cut and fill slopes and their respective catch points, drainage, balanced earth work, adequate storage area locations and other necessary construction features shall be determined and included with the drawings/specifications. Submittals shall include a well site plan (see Drawing No. 1), details of berms, diversion ditches, pits, catchments and other appurtenances and design features. Provide data to support drainage structure design.

B. Clearing

The site must first be cleared of all brush and trees. All merchantable timber must be purchased by the operator prior to cutting, at the appraised price determined by the Forest Service. Grasses and small shrubs need not be removed; however appropriate measure will be required to prevent the spread of noxious weeds and nuisance species prior to starting excavations if they occur on the site. Trees and brush will be disposed of by removal from the Forest, by burning, chipping, or other approved methods needed to prevent the spread of insects. Tree trunks less than 8 inches in diameter and slash can be stockpiled at an approved location to be spread over reclaimed areas. Burning permits will be required and are issued by the Forest Service. Burning would only be permitted if the fire danger is low to moderate.

C. Topsoil Removal and Storage

Surface soil material (topsoil), if present, will be stripped from all areas where surface

DRAFT

disturbance is necessary and stockpiled. All topsoil will be removed in a separate layer, avoiding mixing with other excavated materials, and stored in a stockpile to prevent loss from erosion or contamination, and from which topsoil may be easily recovered. The depth of surface soil material to be removed and stockpiled will be specified by the Forest Service but will generally include the A Horizon. The topsoil and subsoil stock piles must be located to prevent contamination from the blooie line, flare line, and other operations. Stockpiles shall be contained by silt fencing, ditches and traps or other containment measures to prevent erosion, contamination and loss. If topsoil stockpiles are to remain for more than a single season, seeding with an approved seed mix will be required to minimize loss from erosion and preserve fertility and biological activity.

D. Site Grading

Cut and fill slopes will be such that stability can be maintained for the life of operations. Cut and fill slopes will be constructed as follows (exceptions can be made depending on the type and competency of material encountered):

Height of Slope	Slope
0 – 5 feet	3:1
6 – 10 feet	2:1
over 10 feet	1.5:1

All fills will be free of vegetation and will be compacted in lifts no greater than 12 inches in thickness to a minimum of 90 percent Proctor dry density sufficient to prevent excessive settlement.

The drill site or pad surface will be surfaced with crushed gravel to a depth sufficient to support anticipated loads throughout the life of the well. Usually a depth of 12 inches of gravel is required.

E. Site Drainage

Diversion ditches having the minimum dimensions of 3 feet horizontal to 1 foot vertical (3:1 ditch) will be constructed around the site to divert existing drainages and surface runoff from flowing onto the site. Hydraulic design for ditches is required to determine capacity. The ditch(s) will be located at the top or base of the cut slope (to be determined based on site-specific conditions) and around the toe of the fill slopes (see Drawing No. 1 – Construction Requirements for Typical Well Sites). Straw dykes, catch basins, energy dissipaters or other approved structures will be constructed in the ditch outflow to trap any sediment and dissipate erosive flows. Provide data to support drainage structure designs. A culvert might be necessary where the access road enters the site.

A berm will be constructed around the perimeter of the site to contain all precipitation, spills, and other fluids from leaving the site. The berm will be a minimum of 18 inches high, 12 inches wide at the top, and have 1.5:1 side slopes. Berms will be compacted for stability and to reduce permeability as needed to contain fluids. The site surface will be graded at a minimum of 1 percent to drain to the reserve pit. Use silt fencing, ditches and traps or other containment at toe of fill slopes to prevent erosion and contamination.

The drainage pattern to be constructed will need to be designed for each site, depending on

DRAFT

site-specific conditions.

F. Construction and Maintenance of Reserve Pits

Reserve pits will be constructed of sufficient size and capacity for the necessary fluids for drilling and to contain any runoff from the drill site. The pad will be graded to empty into the reserve pit or alternative pit or buried tank. Winter operations may require larger pits/tanks due to snow accumulations and runoff. Pits will not be constructed within intermittent or perennial drainage channels. If the operator has concerns that drainage from the pad could contaminate reserve pit muds, the pad can be constructed to drain into alternative lined pits or buried containment tanks.

It is preferred that pits be constructed in undisturbed materials and below the natural ground level to minimize the risk of failure. Where conditions exist that require pits to be constructed of embankment materials, the following criteria are required:

1. The area on which the embankment is to be placed will be cleared of all materials including vegetation, topsoil, and unconsolidated soils and gravels.

2. A foundation keyway will be designed and constructed into native materials to dimensions based on site-specific conditions to provide adequate anchoring and sealing of the embankment.

3. The embankment will be constructed using impermeable materials on slopes of 3:1 into the pit and 2:1 outside the pit. The embankment will have a minimum of 10-foot top width. The materials will be compacted to 95 percent Proctor density.

The following are requirements for construction and maintenance of all reserve pits:

4. Pits must be constructed to contain fluids without leaks throughout the life of operations. If pit liners other than clay coatings are used they must be constructed of sufficiently durable and watertight materials to prevent leakage. Compacted bedding material consisting of sand, clay, or other grout may be required to prevent rocks from puncturing the liner and to seal cracks.

5. A minimum of 2-foot freeboard will be maintained in the pit at all times during the drilling operations or if the pit is left unreclaimed over the winter.

6. If wildlife concerns exist, netting or some other approved method will be used to prevent wildlife use of the pit.

G. Site Reclamation for Nonproductive Wells

Reclamation of the entire site will be required and will commence immediately after drilling, testing, and well plugging/abandonment are complete. The site will be restored to as nearly as practical to its original condition (approximate original contour). Cut and fill slopes will be reduced and graded to conform to the adjacent terrain.

Reserve pits must be allowed to dry before they are backfilled. Fluids that will not dry must be removed from the Forest. All polluting substances or contaminated materials, such as oil,

DRAFT

oil-saturated soils and gravels will be removed and disposed of at a State licensed facility licensed to receive these materials. Exceptions to allow for reserve pit solidification may be made if the operator can demonstrate to the responsible Forest Service officer that this method would be effective based on site-specific conditions.

Drainages will be reestablished and temporary measures will be required to prevent erosion on the site until all reclamation and revegetation standards established for the site are met.

In general, the well identification standpipe will be set such that it can be buried by at least two feet of soil. A final determination will be made on a case-by-case basis.

After final grading and before replacement of topsoil, the entire surface of the site shall be scarified to eliminate slippage surfaces and promote root penetration. Topsoil will be spread over the site to achieve approximate uniform stable thickness consistent with the established contours.

The site will be seeded and/or planted with a seed mix as approved in the SUPO or as otherwise approved by the responsible Forest Service officer. Nutrients and soil amendments will be applied to the disturbed surface soil needed to meet the revegetation standards.

A temporary fence will be constructed around the site until reclamation standards have been met. The fence design is subject to Forest Service approval will be designed to prevent entry by livestock or wildlife as needed for the specific area. The fence must be maintained such that it is functional at all times as intended to prevent livestock use and unauthorized access by the public. The operator is responsible for damages to the reclaimed condition of the site due to unauthorized access until final reclamation standards are met and the fence is removed. The operator will be responsible for eradicating noxious weeds and nuisance species each season until the final revegetation standards have been met. Once all reclamation standards have been met, the operator is responsible for removal of the fence, gate, and associated structures and materials.

H. Site Reclamation for Producing Wells

Interim and final reclamation for producing wells will be accomplished for portions of the site not required for the continued operation of the associated facilities. All disturbed surfaces will be treated to prevent erosion and to compliment the esthetics of the area. A new site plan will be required encompassing the facilities required for operation and interim reclamation measures. Generally, the following measures will be required:

1. The reserve pit will be reclaimed as previously discussed.
2. All polluting substances and contaminated materials, including contaminated soil and gravels will be disposed of as previously discussed.
3. All cut and fill slopes and other disturbed areas not needed for production operations will be contoured to match the surrounding area, topsoiled, and revegetated as previously discussed.
4. The berm will be reestablished on the production pad where removed to accomplish the reclamation discussed in the previous item.

DRAFT

5. The pad perimeter and reclaimed area will be fenced. Once reclamation standards have been met for the reclaimed portion of the original pad the fence will be relocated onto the perimeter of the production pad.
6. Measures such as painting facilities an appropriate color, and other practical measures will be used to decrease visibility of the site as viewed from sensitive areas such as roads, highways, and recreation areas. Noise suppression devices and submersible pumps (if feasible) may be required as needed to meet scenic, wildlife, and recreation objectives for the area.

I. Site Maintenance

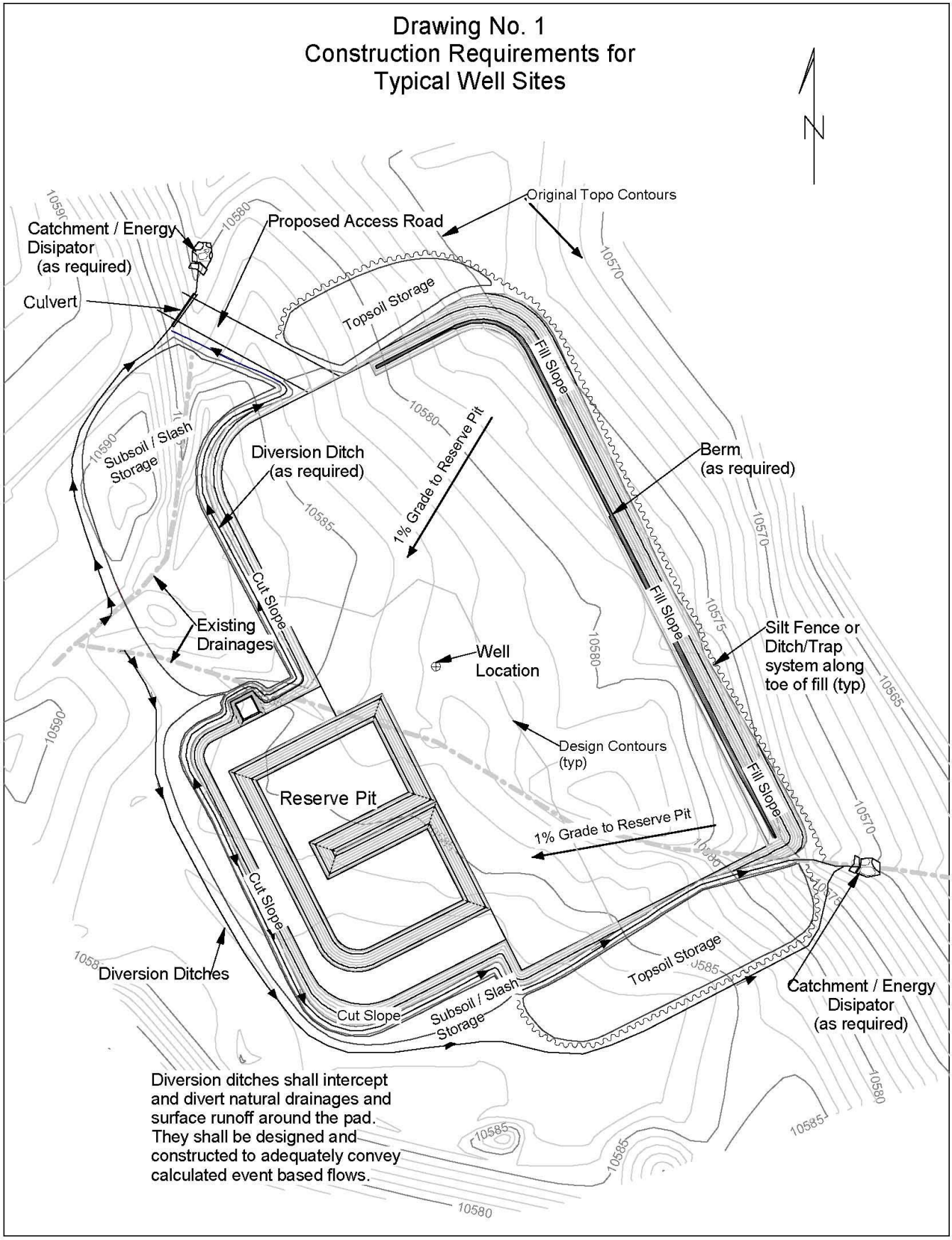
The site will require periodic maintenance to ensure that drainages remain functional and that surfaces are properly treated to reduce erosion, contamination, fugitive dust, invasion by undesirable plant species, and impacts to the adjacent areas.

All garbage, debris, and foreign materials shall be contained on site in a cage or other enclosure then will be removed to an established/licensed landfill or other recognized facility.

J. Site Reclamation for Production Wells

When production pads and production facilities are no longer needed, the facilities must be removed and final reclamation measures completed as previously prescribed for nonproductive wells. Abandoned or unneeded facilities will be removed/reclaimed within two years. In place abandonment of any facilities such as powerlines, pipelines, etc. will require approval of the Forest Service. If approved, appropriate measures to stabilize and decontaminate them will be required.

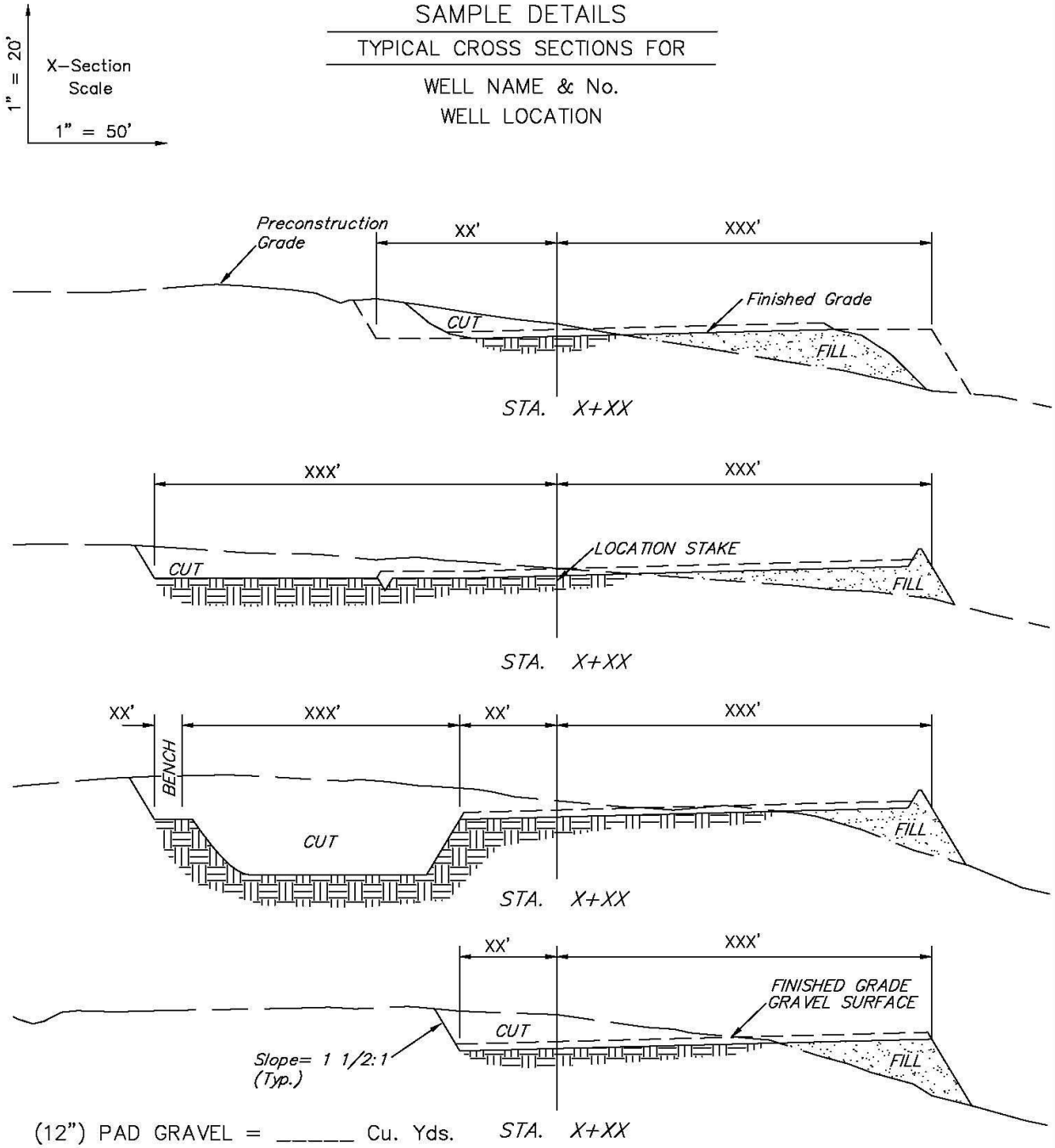
DRAFT


Drawing No. 1
Construction Requirements for
Typical Well Sites
N
Original Topo Contours
Proposed Access Road
Catchment / Energy
Disipator
(as required)
Culvert
Topsoil Storage
Fill Slope
Subsoil / Slash
Storage
Diversion Ditch
(as required)
1% Grade to Reserve Pit
Berm
(as required)
Cut Slope
Existing
Drainages
Well
Location
Silt Fence or
Ditch/Trap
system along
toe of fill (typ)
Design Contours
(typ)
Reserve Pit
1% Grade to Reserve Pit
Diversion Ditches
Cut Slope
Subsoil / Slash
Storage
Topsoil Storage
Catchment / Energy
Disipator
(as required)
Diversion ditches shall intercept
and divert natural drainages and
surface runoff around the pad.
They shall be designed and
constructed to adequately convey
calculated event based flows.
10590
10580
10570
10585
10575
10565

SAMPLE DETAILS

TYPICAL CROSS SECTIONS FOR

WELL NAME & No.
WELL LOCATION



(12") PAD GRAVEL = _____ Cu. Yds.

NOTE:
FILL QUANTITY INCLUDES
__% FOR COMPACTION

APPROXIMATE YARDAGES

CUT

Topsoil Stripping (based on xx") = _____ Cu. Yds.

Remaining (excavation) = _____ Cu. Yds.

TOTAL CUT = _____ CU.YDS.

FILL = _____ CU.YDS.

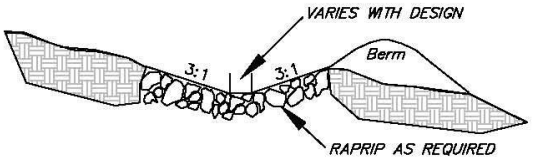
TOPSOIL STORAGE REQUIRED = _____ Cu. Yds.

SUBSOIL STORAGE REQUIRED = _____ Cu. Yds.

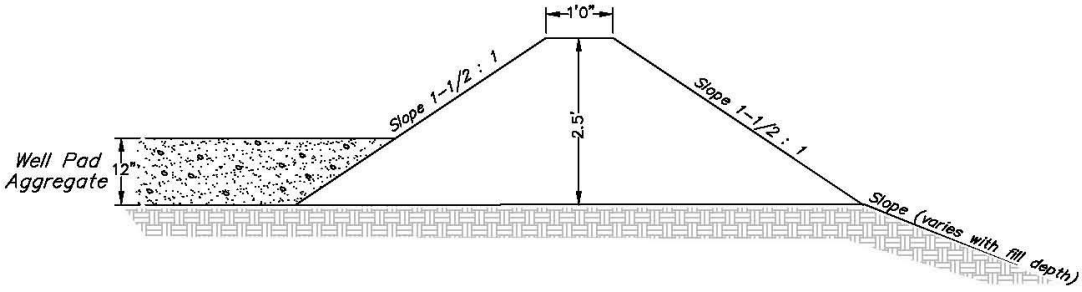
SAMPLE DETAILS

DETAIL SHEET

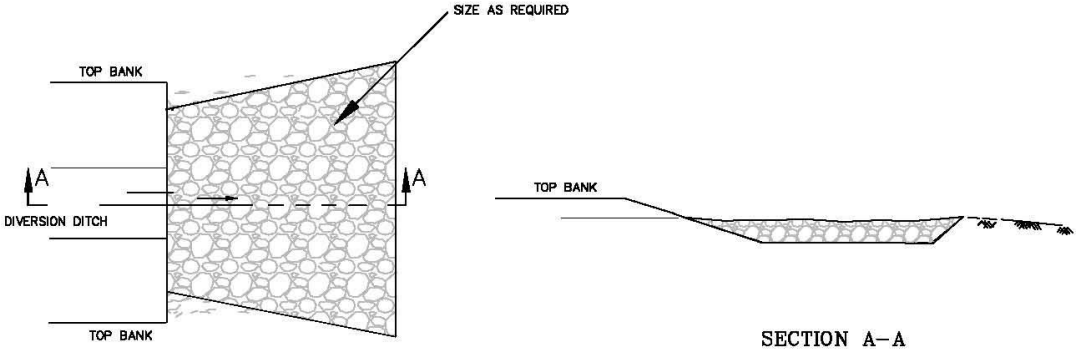
WELL NAME & No.
WELL LOCATION



DIVERSION DITCH (DETAIL)
(Only Where Specified)



BERM (EDGE OF LOCATION)
(NO SCALE)



PLAN VIEW

SECTION A–A

ENERGY DISSIPATER (DETAIL)

Appendix 9C - Dixie National Forest Current and Proposed Land Management Plan Desired Conditions, Goals, Objectives, and Standards and Guidelines For Soil Resources

DRAFT

1986 Approved Land and Resource Management Plan for the Dixie National Forest, 1986.

Aggressive action will be taken to treat the watershed restoration backlog. Unforeseen damaged watershed areas will be promptly treated. Watershed conditions will improve significantly by the end of the planning period. Livestock use on riparian areas will be moderate. Existing management related water quality problems will be mitigated before the end of the planning period occurs.

2006 Proposed Land Management Plan for the Dixie and Fishlake National Forests: Desired Conditions, Goals, Objectives, and Standards and Guidelines: Soils

The degradation of soil quality from disturbances such as displacement, puddling, compaction, and severe burning are prevented or mitigated when necessary. Soil productivity, overall site quality, and hydrologic function are restored in a timely manner when natural events or management-induced disturbances impact and contribute to an overall decline in watershed conditions. Physical, chemical, and biological processes indicate that soil properties are not detrimentally disturbed.

Where natural site conditions allow, biological soil crusts are present, protected, or encouraged to reestablish, especially within semi-arid areas. Biological soil crusts bind soil particles bound together by organic materials that limit erosion, contribute to soil fertility, and encourage the establishment of perennial grasses and forbs.

DRAFT