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**FSM 2800 - MINERALS AND GEOLOGY**

**CHAPTER 2880 - GEOLOGIC RESOURCES, HAZARDS, AND SERVICES**

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<b>Superseded Document(s) by Issuance Number and Effective Date</b>	2880 (Amendment 2800-2006-1, 02/10/2006)	78 Pages

**Digest:**

2880.3 – Clarifies policy on who may address geologic resources and hazards.

2880.65 – Adds a reference to Forest Service Technical Guide to Managing Ground Water Resources.

2881.2 – Clarifies what information should be provided during planning.

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An understanding of the geologic factors and principles which affect the safety, economy, and efficiency of Forest Service programs is a fundamental requisite for good land and resource management. The term “geologic” applies to geology and all its subdisciplines, including geomorphology, paleontology, hydrogeology, mineralogy, seismology, structural geology, and so forth. This chapter contains instructions for the acquisition, storage, and use of geologic information.

## **2880.1 - Authority**

### **2880.11 - Statutory Authority**

The following statutory authorities govern geologic resources and services activities essential to Forest Service programs:

1. Organic Administrative Act of June 4, 1897, as Amended (30 Stat. 34, as Supplemented and Amended; 16 U.S.C. 473-478, 482-482(a), 551. (FSM 2501.1.) This act authorizes the Secretary of Agriculture to issue rules and regulations for the occupancy and use of the National forests. This is the basic authority for issuing special use permits for the collection of vertebrate paleontological resources for scientific and educational purposes on National Forest System lands.
2. Preservation of American Antiquities Act of June 8, 1906 (34 Stat. 225; 16 U.S.C. 431 et seq.). (FSM 2361.01.) This act authorizes permits for archeological and paleontological exploration involving excavation, removal, and storage of objects of antiquity or permits necessary for investigative work requiring site disturbance or sampling which results in the collection of such objects.
3. Federal Aid Highway Act (72 Stat. 913; 23 U.S.C. 305). This section of the United States Code allows federal funding for mitigation of archeological and paleontological resources recovered pursuant to Federal aid highway projects.
4. Multiple Use -- Sustained Yield Act of June 12, 1960 (MUSY) (74 Stat. 215; 16 U.S.C. 528-531). (FSM 2501.1.) This act requires due consideration for the relative values of all resources and implies that the administration of nonrenewable resources must be considered.
5. Watershed Protection and Flood Prevention Act of August 4, 1954, as Amended (68 Stat. 666; 16 U.S.C. 1001). (FSM 2501.1.) This act authorizes the Secretary of Agriculture to share costs with other agencies in recreational development, ground-water recharge, and water-quality management, as well as the conservation and proper use of land.

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6. Federal Water Pollution Control Act of July 9, 1956, as Amended (33 U.S.C. 1151) (FSM 2501.1); Federal Water Pollution Control Act Amendments of 1972 (86 Stat. 816) (FSM 2501.1), and Clean Water Act of 1977 (91 Stat. 1566; 33 U.S.C. 1251). (FSM 2501.1, 7440.1.) These acts are intended to enhance the quality and value of the water resource and to establish a national policy for the prevention, control, and abatement of water pollution. Ground water information, including that concerning recharge and discharge areas, and information on geologic conditions that affect ground water quality are needed to carry out purposes of these acts.
7. Wilderness Act of September 3, 1964 (78 Stat. 890; 16 U.S.C. 1131-1136). (FSM 2501.1.) This act describes a wilderness as an area which may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value. These geological features are generally identified for wilderness classification purposes.
8. National Forest Roads and Trails Systems Act of October 13, 1964 (78 Stat. 1089; 16 U.S.C. 532-538). (FSM 7701.1.) This act provides for the construction and maintenance of an adequate system of roads and trails to meet the demands for timber, recreation, and other uses. It further provides that protection, development, and management of lands will be under the principles of multiple use and sustained yield of product and services (16 U.S.C. 532). Geologic conditions influence the final selection of route locations.
9. Wild and Scenic Rivers Act of October 2, 1968 (82 Stat. 906 as Amended; 16 U.S.C. 1271-1287). This act states that it is the policy of the United States that certain selected rivers of the Nation which, with their immediate environments, possess outstanding scenic, recreation, geologic, fish and wildlife, cultural, or other similar values shall be preserved in free-flowing condition.
10. National Environmental Policy Act of January 1, 1970 (NEPA) (83 Stat. 852 as Amended; 42 U.S.C. 4321, 4331-4335, 4341-4347). (FSM 1950.2.) This act directs all agencies of the Federal Government to utilize a systematic interdisciplinary approach which will ensure the integrated use of the natural and social sciences in planning and in decision making which may have an impact on man's environment. Geology is one of the applicable sciences.
11. Mining and Minerals Policy Act of December 31, 1970 (84 Stat. 1876; 30 U.S.C. 21a). This act provides for the study and development of methods for the disposal, control, and reclamation of mineral waste products and the reclamation of mined lands. This requires an evaluation of geology as it relates to ground water protection and geologic stability.

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12. Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531-1536, 1538-1540). This act provides for the conservation of endangered and threatened species and their habitats.
13. Archeological and Historical Conservation Act of 1974 (AHCA) (88 Stat. 174; 16 U.S.C. 469). (FSM 2361.01.) This act requires all Federal agencies to notify the Secretary of the Interior when a construction project threatens to irreparably harm or destroy significant scientific, prehistoric, historic, or archeological data. The paleontological resource may have significant scientific and historic value.
14. Disaster Relief Act of 1974 (88 Stat. 143; 42 U.S.C. 5121, 5132). Section 202(b) states that the President shall direct appropriate Federal agencies to ensure timely and effective disaster warnings for such hazards as earthquakes, volcanic eruptions, landslides, and mudslides. The Federal Register, Vol. 42, No. 70 of April 12, 1977, "Warnings and Preparedness for Geologic Related Hazards," implies coordination with the U.S. Geological Survey in such warnings.
15. Forest and Rangeland Renewable Resources Planning Act of August 17, 1974 (RPA) (88 Stat. 476; 16 U.S.C. 1600-1614) as Amended by National Forest Management Act of October 22, 1976 (90 Stat. 2949; 16 U.S.C. 1609). (FSM 1920 and FSM 2550.) This act requires consideration of the geologic environment through the identification of hazardous conditions and the prevention of irreversible damages. The Secretary of Agriculture is required, in the development and maintenance of land management plans, to use a systematic interdisciplinary approach to achieve integrated consideration of physical, biological, economic, and other sciences.
16. Resource Conservation and Recovery Act of 1976 (RCRA) (90 Stat. 2795; 42 U.S.C. 6901) as Amended by 92 Stat. 3081. This act, commonly referred to as the Solid Waste Disposal Act, requires protection of ground water quality and is integrated with the Safe Drinking Water Act of December 16, 1974, and Amendments of 1977 (42 U.S.C. 300(f)). (FSM 7420.1.)
17. Surface Mining Control and Reclamation Act of August 3, 1977 (SMCRA) (30 U.S.C. 1201, 1202, 1211, 1221-43, 1251-79, 1281, 1291, 1309, 1311-16, 1321-28). This act enables agencies to take action to prevent water pollution from current mining activities, and also promote reclamation of mined areas left without adequate reclamation prior to this act.
18. Archaeological Resource Protection Act (ARPA) October 31, 1979 (93 Stat. 721; 16 U.S.C. 470 aa). This act protects archeological resources, and prohibits the removal, sale, receipt, and interstate transport of archeological resources obtained illegally from public lands. Archeological resources include paleontological resources in context with archeological resources. Also, this act authorizes the Secretary of Agriculture to issue permits for archeological research, investigations, studies, and excavations.

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19. Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended (CERCLA) (94 Stat. 2767; 42 U.S.C. 9601, et seq). This act provides authority to the Environmental Protection Agency and to other Federal agencies, including the U.S. Department of Agriculture, to respond to release of hazardous substances, pollutants, and constituents. It also provides for joint and several liability to potentially responsible parties (PRPs) for cleanup costs of existing water contamination. See also FSM 2160.

20. Federal Cave Resources Protection Act of 1988 (102 Stat. 4546; 16 U.S.C. 4301 et seq). This act provides that Federal lands be managed to protect and maintain, to the extent practical, significant caves.

### **2880.12 - Executive Orders**

The following Executive orders provide direction for geologic resources and services activities on National Forest System lands:

1. Executive Order 11593, Protection and Enhancement of Cultural Environment, May 13, 1971 (3 CFR 559, 1971-75 Compilation). This Executive order directs agencies to preserve, restore, and maintain the historic and cultural environment of the Nation.
2. Executive Order 12113, Independent Water Project Review, January 5, 1979. This Executive order requires an independent water project review by the Water Resources Council on preauthorization reports and preconstruction plans for Federal and federally assisted water and related land resource plans. The technical review will evaluate each plan for compliance with the Council's principles and standards, agency procedures, other Federal laws, and goals for public involvement.

### **2880.2 - Objectives**

The objectives of geologic resources, hazards, and services programs are to provide geologic information needed for:

1. Preparing land management plans.
2. Interpreting surface and subsurface geologic conditions and processes as they relate to or affect the capability of National Forest System lands to produce renewable and non-renewable resources.
3. Sustaining ecosystems.
4. Protecting life and property from the occurrence of geologic hazards.
5. Managing geologic resources to meet the needs of Forest Service programs.



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### **2880.3 - Policy**

1. Identify the geologic components of ecosystems (including geologic processes, materials, landforms, fossils, caves, and significant outcrops), and monitor and manage them in a manner appropriate to meet Forest Service responsibilities for National Forest System (NFS) lands and resources.
2. Locate, design, and maintain facilities (such as roads, trails, bridges) and other management activities to avoid, minimize, or mitigate their susceptibility to, or causal effects on, geologic hazards.
3. Integrate geologic resources and hazards into Forest Service land management activities, including associated NEPA processes.
4. Manage geologic hazards on NFS lands to ensure the protection of public safety, health, property, and the environment by using qualified geologists for the recognition, inventory, analysis, and interpretation of those hazards, and the integration of that information into forest and project planning, design, construction, maintenance, and monitoring activities, reviews of proposals, permits, approvals, concurrences, and recommendations for uses of NFS lands.
5. Manage geologic resources on NFS lands by using qualified geologists to recognize, inventory, analyze, and interpret those resources; protect public health and the environment; and integrate that information into Forest and project planning, design, construction, maintenance, and monitoring activities, reviews of proposals, permits, approvals, concurrences, and recommendations for uses of NFS lands.
6. Establish guidelines and standards for acquiring, analyzing, and reporting geologic information to meet the specific needs of Forest Service programs.
7. Encourage cooperation, partnerships, and information exchange with scientific and geological communities for optimal management of geologic resources and hazards.
8. Provide geologic resources for appropriate educational, scientific, recreational, and other public purposes to the extent consistent with Forest Service management objectives.

### **2880.4 - Responsibilities**

#### **2880.41 - Washington Office Director, Minerals and Geology Management,**

The responsibilities of the Washington Office Director, Minerals and Geology Management, are to:

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1. Provide program and technical direction in all aspects of the management of National Forest geologic resources, hazards, and services, including establishing national and technical standards and procedures for geologic:
  - a. Inventories.
  - b. Investigations.
  - c. Plans.
  - d. Data storage and retrieval.
  - e. Monitoring.
2. Conduct regional program management and activity reviews.
3. Coordinate with other Federal and State agencies and private organizations on issues of mutual geologic concern.
4. Develop an inventory and monitoring program and implementing the program as part of the agency's Inventory and Monitoring Framework.
5. Recommend legislation needed to improve management of geologic resources and resolving problems created by legislation proposed by other entities.
6. Provide national policy, objectives, guidelines, and minimum standards for protection and improvement of ground water and ground-water-dependent ecosystems and preservation of paleontologic resources on National Forest System (NFS) lands.
7. Provide national policy, objectives, guidelines, and minimum standards for the protection, preservation, and curation of paleontological resources on NFS lands.
8. Provide Forest Service research programs, including Research Natural Areas, with geologic resource management needs.
9. Coordinate ground-water policy and management on National Forest System lands with the Washington Office Director, Watershed, Fish, Wildlife, Air, and Rare Plants.
10. Coordinate lead responsibility for cave and cave ecosystem management on National Forest System lands with the Washington Office Director, Recreation, Heritage, and Wilderness Resources. Forest Service Manual 2356 provides the direction for significant caves and karst features developed for recreational use; FSM 2880 provides direction for protection and management of non-recreational significant caves and their associated ecosystems.

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11. Developing minimum standards for curation of paleontological resources in non-federal repositories.
12. Developing standard terms and conditions for paleontological resources special use authorizations to minimize resource conflicts.

### **2880.42 - Regional Foresters**

The responsibilities of the regional foresters are to:

1. Establish and maintaining a regional inventory and monitoring program that ensures the acquisition of quality geologic data in support of land management planning, land use, and resource management and development.
2. Conduct management and activity reviews of forest geologic resources, hazards, and services programs.
3. Establish regional guidelines for monitoring and evaluation of ground-water resources and conditions.
4. Develop standards for data collection, data storage and retrieval, analysis, and geologic resource inventories used at the regional and forest levels.
5. Provide appropriate technical standards, guidance, training, and quality control for staff with expertise in or responsibility for geologic resources to assist them in data collection, analysis, and storage, and preparing protection and improvement prescriptions and action plans.
6. Coordinate and complete agreements with Federal and State agencies, universities, institutions, and appropriate private groups for participation and cooperation in the collection of geologic, geomorphic, hydrogeologic, and paleontologic information on National Forest System lands in their region.
7. Ensure that all geologic resources are included in the land management planning process.
8. Provide criteria for monitoring the effectiveness of measures implemented for the protection, investigation, and improvement of all geologic resources in their region.
9. Develop criteria to define ground-water dependent ecosystems in terms of source water, fauna, vegetation, and geologic and hydrogeologic setting in their region.
10. Develop criteria to define cave ecosystems in terms of geologic and hydrogeologic setting, development processes, airflow, and vegetal-, faunal-, and aquatic-associated resources in their region.

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11. Develop criteria for monitoring, preventing, and prosecuting theft of paleontological resources in their region.

### **2880.43 - Forest Supervisors**

The responsibilities of the forest supervisors are to:

1. Ensure that geologic resource inventories, investigations, and monitoring activities are conducted in the National Forest System (NFS) lands under their jurisdiction.
2. Ensure that geologic, hydrogeologic, and paleontologic support service and expertise is applied and scheduled in a timely manner to the planning, implementation, quality control, and monitoring of all management activities.
3. Cooperate with Federal and State agencies, universities, institutions, and private organizations in collecting geologic information, including geomorphic, hydrogeologic, and paleontologic data, on NFS lands in accordance with regional cooperative agreements and approve memoranda of understanding for cooperative management of geologic and paleontological resources, when needed.
4. Ensure that geologic data and other geologic information are used in forest planning, assessments, and project implementation.
5. Ensure that measures to manage and protect ground-water quality and quantity and ground-water dependent ecosystems are developed and implemented according to national and regional standards.
6. Implement criteria and guidelines for monitoring, preventing, and referring to law enforcement and investigation prosecution for theft of paleontological resources from NFS lands under their jurisdiction.
7. Ensure that appropriate terms and conditions are included in special use authorizations for paleontological resources on their forest to minimize resource conflicts.
8. Ensure that all caves within their jurisdictions are evaluated in accordance with the Federal Cave Resources Protection Act of 1988 and Title 36, Code of Federal Regulations, part 290 (36 CFR 290).
9. Serve as the authorized officer for purposes of information disclosure of a significant cave or a cave nominated for designation (36 CFR 290.4).
10. Ensure that qualified geologists conduct these activities.

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### **2880.5 - Definitions**

Aquifer. Rock or soil bodies that store and transmit ground water in economic quantities.

Bedrock Geology. Bedrock geology consists of “primary” lithology, which is the class to which a rock belongs (such as, igneous extrusive, igneous intrusive, sedimentary, or metamorphic), and “secondary” lithology, which is the specific rock type (such as, basalt, granite, sandstone, gneiss), each implying one and only one primary lithology; texture; weathering; chemistry; fracture interval; competence; and structure type, strike and dip.

Cave. Any naturally occurring void, cavity, recess, or system of interconnected passages which occurs beneath the surface of the Earth or within a cliff or ledge, including any cave resource therein, but which is large enough to permit an individual to enter, whether or not the entrance is naturally formed or manmade. Such a term must include any natural pit, sinkhole, or other feature which is an extension of the entrance.

Cave Ecosystems. All ground-water recharge and discharge areas connected to a cave, both discrete and diffuse, and the intermediary aquifers or flow paths; air flow into and out of the cave; vegetation, fauna, and aquatic communities in or linked to the cave; and all other cave resources. Cave ecosystems can be sensitive to changes in the temperature or chemical composition of the water or air. Some examples of the types of cave ecosystems include: karst, pseudokarst, lava tubes, ice caves, river undercuts, and erosional features.

Cave Resource. Any material or substance occurring in caves, including but not limited to, those which are biotic, cultural, mineralogic, paleontologic, geologic, and hydrologic.

Confined Aquifer. An aquifer that is bounded above and below by impermeable layers.

Diffuse Recharge and Atmospheric Connection. Recharge of water and exchange of atmospheric gases into caves through dispersed fractures and other small openings.

Discrete Recharge and Atmospheric Connection. Recharge of water and exchange of atmospheric gases into caves through large primary cave openings and passages, including sinkholes.

Ecological units. Areas of similar physical characteristics and processes which often affect or define specific plant and animal habitat conditions.

Engineering Geology. A specialty of geology relevant to:

- a. The planning, design, operation, and maintenance of civil and mining engineering works.

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- b. The development, protection, and remediation of ground- and surface-water resources.
- c. Other human activities where geologic factors and conditions impact the public welfare and safeguarding of life, health, property, and the environment.

Epikarst. A relatively thick portion of bedrock that extends downward from the base of the soil zone and is characterized by extreme fracturing and enhanced dissolution. The thickness may vary significantly, but 15 to 30 meters may be a good generalization. It is separated from the phreatic zone by an inactive, relatively waterless interval of bedrock that is locally breached by vadose percolation. Significant water storage and transport are known to occur in this zone.

Fossil Yield Potential Classification (FYPC) Values. These values rank the degree to which a bedrock unit, usually at the formation or member level, is likely to yield scientifically significant fossil resources. The values only apply to areas where bedrock is exposed or in the shallow subsurface (covered by less than 1 meter of surficial material). Fossil yield potential classification values are assigned to geologic units on the basis of empirical data gathered through literature or database research and field research by zone paleontologists and other local Forest Service staff.

Geologic Hazards. Geologic conditions that create a threat to life or property, such as mass wasting, seismicity, volcanism, flooding, subsidence, snow avalanche, seiches, reactive soils, toxicity associated with mineralization, acid mine drainage, and naturally occurring hazardous minerals and gases, such as asbestos and radon.

Geologic Information. Information relevant to the geology and all its subdisciplines, including inventories and maps of bedrock, geomorphology, hydrogeology, paleontology, structure, and derivative resource and hazard maps.

Geologic Inventory. The collection, analysis, and interpretation of geologic data necessary for identification and solution of management problems, and for the assessment and development of the geologic resources. The creation of geologic inventories is basic to carrying out geologic resources and services programs (FSM 2881). Geologic inventory includes bedrock geology, surficial geology, stratigraphy, hydrogeology, geomorphic features, geological hazards, karst features, caves, and paleontology, including potential for geologic formations to yield fossil resource of scientific and other values.

Geologic Investigation. Investigations conducted by a qualified geologist for a specific purpose or project, usually to determine a combination of the (1) geologic history; (2) location and extent of locatable, leasable, and salable minerals; (3) location and extent of

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aquifers; (4) ground-water quality and quantity; (5) structural features; (6) geologic and geomorphic processes affecting the area; (7) cave and karst; and (8) paleontological resources.

Geologic Report. A compilation of geologic information for a specific purpose or project containing the data from geologic inventories or investigations, and also containing one or more of the following: evaluations, predictions, conclusions, or recommendations obtained by using scientific principles and methods of geology (FSM 2885.3).

Geologic Resources. Any geologic feature or area that has important scientific value or that is significant to natural resource management or human health and safety concerns. Geologic resources include landforms, bedrock exposures, aquifers, recharge areas, ground-water dependent ecosystems, caves, cave resources and associated cave ecosystems, karst features, paleontology, geologic and paleontological special interest areas, interpretive sites, and recreational collecting sites for fossils, rocks, and minerals.

Geologic Resource Activities. Activities involving the gathering, evaluating, and reporting of geologic information for the development of geologic resources (such as, ground water, aquifers, ground-water dependent ecosystems, caves, cave ecosystems, karst features, paleontology, mineral materials, and underground spaces) (FSM 2882).

Geologic Service Activities. Activities involving the gathering, evaluating, and reporting of geologic information in support of planning, development, design, construction, maintenance, or other management functions on NFS lands. These services also include the identification and interpretation of special interest areas for land management planning and recreation (FSM 2883). Geologic service activities include describing geomorphology (process, landform, morphometry) and performing hydrogeologic analyses and investigations.

Geologic Special Interest Areas. Areas designated for their outstanding geologic value. The management objective for these areas is to protect their outstanding values and to encourage public use and enjoyment, as long as such use is not detrimental to the values being protected.

Geology/Geologic. The study of the Earth, including all its subdisciplines, such as historical geology, mineralogy, paleontology, seismology, geomorphology, speleology, structural geology, hydrogeology, and so forth.

Geomorphic Generation. A component of geomorphic classification that allows for the recognition and documents the status of more than one geomorphic type at any given location on the ground (overprinting).

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Geomorphic Process. The dominant internal or external geologic force that has interacted with the existing geologic structural framework to shape the Earth's surface at a given location or area.

Geomorphology. The study of the classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes as recorded by these surface features. Geomorphology has three primary components:

- a. Geomorphic process.
- b. Landform.
- c. Morphometry.

The Forest Service data standards for geomorphology are described in Haskins (FSM 2880.63).

Ground-Water-Dependent Ecosystems. Wetlands fed by ground water, terrestrial vegetation and fauna sustained by shallow ground water, ecosystems in streams and lakes fed by ground water, caves and karst aquifers, aquifer systems, hyporheic and hypolentic zones, and springs.

Ground-Water Resource. That part of the subsurface water that is in the zone of saturation, including underground streams in karst environments.

Hydrogeology. The science that deals with subsurface waters and with related geologic aspects of surface waters.

Karst. Terrain created by the chemical solution of the bedrock, including carbonate rocks, gypsum, and to a minor extent on other rocks, and characterized by disrupted surface drainage, abundant enclosed depressions, and a well-developed system of underground drainage systems, which may include caves. The term "pseudokarst" is sometimes used to distinguish karst terrain formed on non-carbonate bedrock.

Karst Resources. The elements of a karst landscape, commonly characterized by losing streams, sinkholes, collapse features, caves, or springs. These may not only be physical features, but may also relate to karst ground-water systems, system(s) function, and biological significance to the vegetative, wildlife, and aquatic communities.

Landform. Any physical feature of the Earth's surface having a characteristic, recognizable shape and produced by natural causes directly linked to geomorphic process.



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Map Unit. A classification or name and a description applied to many polygons, and usually representing a summary of information about a number of similar polygons, rather than describing a particular polygon. The map unit name is derived by applying rules and conventions to the descriptive information.

Mineral Materials. Earth construction materials that are not considered locatable under Federal mining laws or leasable under the Federal mineral leasing laws. They include common varieties of rock or stone, sand and gravel, pumice aggregate, pumicite, cinders, and soil materials suitable for compacted earth structures, landscaping, and other uses.

Morphometry. The measurement and mathematical analysis of the configuration of the Earth's surface and of the shape and dimensions of landforms. Morphometry is used to quantify the land surface and further describe the variability in landforms. Morphometric parameters such as relief, elevation, aspect, slope gradient, slope position, slope shape, slope complexity, landform width, dissection frequency, dissection depth, drainage pattern, and drainage density can be used to predict changes in slope hydrology, soils, and plant communities.

Paleontological Resources. Any remains, traces, or imprints of organisms preserved in or on the Earth's crust which have paleontological value.

Polygon. A unique spatial instance of a geologic feature on a map.

Qualified Geologist. A specialist who, by reason of education and experience, meets the qualifications determined by the Office of Personnel Management for the GS-1350 professional series or has received licensure or registration as a professional geologist within the state or states where the work is being conducted. Given the range of subdisciplines within the geological sciences, for example, hydrogeology, engineering geology, and so forth, consideration should be given to the disciplinary expertise needed for a particular project.

Significant Cave. A cave located on NFS lands that meets the criteria in Title 36, Code of Federal Regulations, sections 290(c) or 290(d) (36 CFR 290 (c) or (d)), and has been designated in accordance with section 290.3(e).

Stratigraphy. Stratigraphy is the description of all rock bodies forming the Earth's crust, and their organization into distinctive, useful, mappable units based on their inherent properties or attributes. It includes the classification, naming and correlation of these units to establish their relationship in space and succession in time.

Surficial Materials. Surficial materials are in the "unconsolidated" primary lithology class. They are defined as non-lithified deposits lying on bedrock or occurring on or near the Earth's surface. Surficial materials are characterized by their depositional

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environment (“kind”) and the rock type (secondary lithology) from which they came (“origin”). Examples include glacial till from granite, alluvium from sedimentary rocks, landslide deposit from limestone, volcanic ash of basaltic composition.

Unconfined aquifer. An aquifer that is bounded below by an impermeable layer, but is open to the atmosphere above.

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## **2880.7 - Coordination**

### **2880.71 - In-Service**

The coordination of geologic resources and services program activities with other Forest Service programs must be on a timely and continuing basis along horizontal and vertical lines of organization. Coordination is necessary in preparing land management plans, in environmental assessments, and during the development of lands and facilities. The geologist should initiate and maintain such coordination.

### **2880.72 - Out-Service**

Geologic investigations frequently involve cooperation and/or joint studies with Federal or State agencies, universities, and colleges, Tribes, and private organizations. Professional integrity must be exercised in using technical information provided by the sources. The information must be used with discretion and be properly cited. Contributors should be given the opportunity to review reports citing their work.

## **2881 - GEOLOGIC RESOURCES AND HAZARDS INVENTORIES**

### **2881.02 - Objective**

The objectives of geologic resources and hazards inventories are:

1. To provide information about National Forest Systems lands for the periodic assessment required by the Forest and Rangeland Renewable Resources Planning Act (RPA), as amended.
2. To develop a basic knowledge of geologic resources and hazards and their associated landscapes at a level appropriate for management needs.

### **2881.03 - Policy**

The policy of geologic resources and hazards inventories is:

1. To collect and evaluate interpretive information to:
  - a. Rate the potential for the presence of caves and cave ecosystems.
  - b. Assess the quantity, quality, and vulnerability of ground-water resources and ground water-dependent ecosystems.
  - c. Rate the potential for the presence of fossil resources and a prediction of their yield.

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- d. Identify the presence of hazardous geologic conditions and to predict their potential to threaten life or property.
2. To display interpretive information in the most useful form and manner for multiple-use and project planning.
3. To use the four orders of geologic inventory to assist in selecting the intensity level commensurate with management needs (FSM 2881.1). The order of geologic inventory will be selected to meet the needs of each Forest Service project (FSM 2884.1).

### **2881.1 - Orders of Geologic Resources and Hazards Inventories**

#### **2881.11 - Inventory Order 4**

1. Data Sources. Data sources for order 4 inventories include:
  - a. Immediately available published literature and “in house” information.
  - b. Aerial photography.
  - c. Remote sensing imagery.
  - d. Immediately accessible computerized information.
  - e. Description of materials based on common knowledge and literature.
  - f. Information on the existence of caves from the caving community and Tribes.
2. Sample Intensity. The minimum sample intensity for order 4 inventories includes:
  - a. No traversing or sampling are required; target the entire geologic unit of interest.
  - b. For ground-water inventories, use existing wells. Sample wells and other ground-water features once, or select one well as part of a long-term network to be sampled on a fixed-time interval. Conduct a broad array of analyses to encompass all monitoring program objectives.
3. Polygon Size and Map Scale.
  - a. Minimum polygon size is 640 acres
  - b. Map scale is 1:250,000; however, for ground water, use the ground-water region scale. Spatial well coverage is based on project objectives. Spatial data is used for known cave locations.

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4. Purpose or Use. Following are examples of purpose or use of order 4 inventories:
  - a. To describe regional geologic factors affecting project planning.
  - b. To describe areas requiring further work.
  - c. To set priorities for workload.
  - d. To describe broad areas of geologic or paleontologic resource potential.
  - e. To depict a regional distribution of known caves or paleontological resources; location data kept confidential.

**2881.12 - Inventory Order 3**

1. Data Sources. Data sources for order 3 inventories include all data for order 4 plus:
  - a. Published literature and theses.
  - b. Unpublished and “in-house” reports.
  - c. Various scales of aerial photography.
  - d. Reconnaissance mapping of bedrock and surficial geology.
  - e. Computerized information systems, including those from agencies, institutions, and companies.
  - f. Information on caves from caving communities and Tribes.
2. Sample Intensity. The minimum sample intensity for order 3 inventories includes:
  - a. 5.0 to 10.0 square miles/day.
  - b. 0.25 to 0.50 miles of traverse/square miles of area considered.
  - c. Collect data and document 25 percent of polygons for each geologic map unit.
3. Polygon Size and Map Scale.
  - a. Minimum polygon size is 100 acres.
  - b. Map Scale is 1:100,000, but may require actual site data for some purposes, such as well locations and cave locations.



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4. Purpose or Use. Following are examples of purpose or use of order 3 inventories:
  - a. To designate geologic factors, such as soils, surficial deposits, bedrock, landslides, structures, and processes, and resources, such as ground water, minerals, and underground spaces, affecting resource allocations.
  - b. General facility locations and management alternatives.
  - c. Likely presence or absence of caves.

**2881.13 - Inventory Order 2**

1. Data Sources. Data sources for order 2 inventories include all data for order 3 plus:
  - a. More detailed mapping of bedrock and surficial geology.
  - b. Applicable geophysical testing and hand sampling.
  - c. Development of field cross sections of selected sites or slopes.
2. Sample Intensity. The minimum sample intensity for order 2 inventories includes:
  - a. 1.0 to 4.0 square miles/day.
  - b. 1.0 to 1.5 miles of traverse per square mile of area considered.
  - c. Collect data and document 75 percent of polygons for each geologic map unit.
3. Polygon Size and Map Scale.
  - a. Polygon size is 2.5 acres; active landslide polygons are smaller.
  - b. Actual site data is used for some resources, such as well locations and cave locations.
  - c. Map Scale is 1:24,000.
4. Purpose or Use. Following are examples of purpose or use of order 2 inventories:
  - a. To classify geologic and paleontologic factors and resources (see order 3) because they affect specific facility locations and land-use management decisions.
  - b. Estimating quality and quantities within established ranges.
  - c. Documenting the location and known extent of caves.

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**2881.14 - Inventory Order 1**

1. Data Sources. Data sources for order 1 inventories include all data for order 2 plus:
  - a. On-site surveying and mapping of bedrock and surficial geology.
  - b. Drilling, in-place sampling, and test-pit excavation.
  - c. Laboratory testing.
  - d. Identifying engineering properties of soil and rock materials.
  - e. Field measurement of quality and quantity.
  - f. Field surveying caves; mapping karst, hydrologic features, and cave resources; dye tracing to determine ground-water flow patterns; determining air flow patterns.
  - g. Field surveying paleontological resources.
2. Sample Intensity. The minimum sample intensity for order 1 inventories is that which is required to resolve problems or meet project needs.
3. Polygon Size and Map Scale.
  - a. Polygon size is the project feature.
  - b. Map Scale is generally on the order of 1:240 to 1:1,200, but can be larger, as in cases of mapping caves or active landslides.
4. Purpose or Use. Following are examples of purpose or use of order 1 inventories:
  - a. Identifying geologic and paleontologic resources and hazards affecting site-specific projects.
  - b. Evaluating ground-water source locations.
  - c. Providing design data for earthworks, stabilizing structures, roads, and small dams. Normally, this is the order used in geotechnical investigations.
  - d. Mapping caves and cave ecosystems to identify cave resources, hazards, and sensitivity to human disturbance.
  - e. Mapping field occurrences of paleontological resources to verify fossil yield potential.

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f. Mineral investigations (for example, validity exams, mineral land determinations, valuation of mineral properties, and so forth).

### **2881.2 - Inventory and Analysis of Ground-Water Dependent Ecosystems**

During the land management planning process, all available information on the following should be provided to the authorized officer for consideration of ground-water resources:

1. Location, function, and value of ground-water dependent resources.
2. The value of ground water-dependent vegetation to:
  - a. Provide fish and wildlife habitat.
  - b. Control sediment originating in upland areas.
  - c. The maintenance of stream temperatures.
  - d. The stability of stream banks and channels (FSM 2526, FSM 2527).
3. Ground-water recharge and discharge areas and effluent and influent stream channel conditions.
4. Water quality and the deposition or buffering of potential water pollutants (FSM 2526, FSM 2532).
5. Fluctuations in ground-water levels, discharge quantities, and timing of flow in relation to aquatic and terrestrial species habitats, and to maintenance of phreatophytes and other ground water-dependent vegetation.
6. Cumulative effects of management activities on ground-water resources.

### **2881.3 - Inventory and Analysis of Paleontological Resources**

A paleontological resource inventory identifies and evaluates the existence of and distribution of fossil resources in a particular area. Literature searches (FSM 2881.11a, FSM 2881.12a) identify geologic units most likely to host fossil resources. Subsequent field reconnaissance of most likely areas (FSM 2881.12a, FSM 2881.13a) verifies whether fossil resources occur in them. Based on these findings, fossil yield potential classification (FYPC) values must be assigned to geologic units in the area, and a map of suitable format and scale depicting the surface expression of fossiliferous units shall be prepared.

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## **2881.4 - Cave and Karst Resources and Ecosystems Inventory**

### **2881.41 - Inventory and Analysis of Cave and Karst Resources**

Forest supervisors are responsible (FSM 2880.43) for ensuring that the location, geologic setting, resource value, and role in the local ecosystem of all caves in the area of their jurisdictions are assessed and inventoried. They should also coordinate cave and karst inventory and analysis efforts with Tribes and local caving groups.

### **2881.42 - Significant Caves**

Forest supervisors are responsible for nominating all known caves for determination of significance, in accordance with the Federal Cave Resource Protection Act of 1988 (16 U.S.C. 4301 et seq) and Title 36, Code of Federal Regulations, part 290. Regional foresters are responsible for approving special area designations, such as significant caves. Also, see FSM 2356.

All significant caves (FSM 2880.5) and associated ecosystems must be inventoried and classified based on resource value and sensitivity to disturbance. Cave inventories should include information about the geology, hydrology, biology, paleontology, archaeology, cave climate, abundance and quality of cave formations, recreation potential, educational and scientific values, and be considered in the preparation of land management plans. Inventory and management guidelines for associated resources, such as ground water, must be followed where appropriate.

## **2882 - GEOLOGIC RESOURCES PROGRAM MANAGEMENT**

Forest management activities, including development of geologic resources, can result in ecosystem damage when the activity's location, design, construction, or implementation is not based on an understanding of geologic conditions and geomorphic processes.

### **2882.02 - Objective**

The objectives of geologic resources activities are to:

1. Protect, conserve, and develop geologic resources in a sustainable, ecologically sound, and efficient manner.
2. Conserve and protect paleontological resources in perpetuity.
3. Protect, manage, and improve ground water and ground-water dependent ecosystems, recognizing their unique values, while implementing land management activities.
4. Secure, protect, and preserve significant caves for the perpetual use, enjoyment, and benefit of all people, and to foster increased cooperation and exchange of information with those who utilize caves for scientific, educational, or recreational purposes.

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### **2882.03 - Policy**

The geologic resources activities are guided by the following policies:

1. Identify significant geologic resource capabilities, land base limitations, and affected management activities in all land management plans.
2. Work plans for each Forest Service project, requiring geologic information must identify the appropriate geologic resource activity, establish the order of inventory that meets projects needs (FSM 2881), and provide an estimate of the time required for accomplishment.
3. Manage ground-water dependent ecosystems in relation to legal mandates, including, but not limited to, those associated with floodplains, wetlands, water quality, dredge and fill material, endangered species, and cultural resources.
4. Protect paleontological resources from loss due to threat, vandalism, or the natural elements through responsible planning, management, partnerships with qualified museums and other institutions, and collaboration with Forest Service law enforcement.
5. Protect and maintain caves and cave ecosystems in accordance with Federal law and develop volunteer management agreements with the scientific community or recreational caving groups to assist with cave protection. Do not make available to the public the locations of significant caves except in response to a qualified written request or when it is determined that the disclosure would not create a risk of harm, theft, or destruction of cave resources (see also FSM 2356).

### **2882.1 - Earth Construction and Mineral Materials**

1. Activity Description. The earth construction and mineral materials program activity evaluates the:
  - a. Quality, quantity, site suitability, development logistics and rehabilitation for pits and quarries on NFS lands. Emphasis is on management of road-surfacing, concrete aggregate, highway sand, riprap and structural fill material for in-service use.
  - b. Potential for erosion or landslides and the presence of deleterious materials from both engineering and geochemical perspectives on NFS lands.
2. Order of Inventory (FSM 2881). Order 3 or Order 2 inventories should be conducted based on the size of the area of interest (region, forest, or district). Order 1 inventories should be conducted for site-specific purposes.

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3. RPA Element and FSM Reference. The following table displays the RPA elements that relate to this activity and the appropriate FSM references:

RPA Element	FSM Reference
Range	2240
Water	2510
	2520
Recreation	2310
	2320
	2330
	2340
Minerals	2840
	2850
Facilities	7110
	7170

4. Purpose of Activity. The purpose of the earth construction and mineral materials activity is to:

- a. Assess distribution, quality and quantity of material for in-service use.
- b. Evaluate deposits for disposal (sale or free-use).
- c. Provide riprap for stream stabilization.
- d. Provide material for roads, small dams, and all types of constructed recreation facilities.
- e. Prevent or suppress airborne pollution by asbestiform minerals or particulates at material sites.

## **2882.2 - Mineral Resources**

1. Activity Description. The mineral resources activity evaluates and classifies the potential for occurrence of recoverable mineral resources in accordance with Bureau of Land Management (BLM) Manual 3031, Energy and Mineral Resource Assessment.

2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the size of the area of interest (region, forest, or district).

3. RPA Element and FSM Reference. The following table displays the RPA elements that relate to this activity and the appropriate FSM references:

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RPA Element	FSM Reference
Minerals	2810
	2820
	2830
	2850
	2860

4. Purpose of Activity. The purpose of the mineral resources activity is to provide land managers an assessment of mineral resources potential for consideration when making land use, allocation, or disposition decisions.

### 2882.3 - Ground Water and Dependent Ecosystems

1. Activity Description. The ground water and dependent ecosystems activity:
  - a. Evaluates the availability, quantity, quality, depth to, and extent of the ground-water resources. These factors are related to the development, use, and conservation of ground water and its dependent ecosystems. Design parameters and recommendations may be given for well development and other potentially ground-water depleting or contaminating activities.
  - b. Evaluates effects of surface-use development and/or disturbance on ground-water quality, quantity, recharge, and dependent ecosystems.
  - c. Identifies recharge systems.
  - d. Inventories karst and volcanic ecosystems and adjacent lands that drain to them to determine the level of karst/cave development and the hydrology of volcanic terrains.
2. Order of Inventory (FSM 2881). Order 3 or Order 2 inventories should be conducted for Forest planning. Order 1 inventories should be conducted for site development and ground-water protection.
3. RPA Element and FSM Reference. The following table displays the RPA elements for ground water and dependent ecosystems and the appropriate FSM references:

RPA Element	FSM Reference
Water	2240
	2520
	2530
	2540
	2543

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RPA Element	FSM Reference
Recreation	2310
	2320
	2330
	2380
Minerals	2810
	2820
	2840
	2850
Facilities	7110
	7170

4. Purpose of Activity. The purpose of the ground water and dependent ecosystems activity is to provide recommendations for best locations and development of potable water for recreation, administration, municipalities, and stock watering sites.

#### **2882.4 - Underground Spaces**

1. Activity Description. The underground spaces activity:

- a. Interprets and evaluates geologic reports and maps to locate areas favorable for potential future development of underground spaces, such as for storage, research, and so forth.
- b. Examines favorable areas to the extent necessary for the intended use. Site-specific studies may be required.

2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the size of the area of interest (region, forest, or district). Order 1 inventories may be required for site-specific purposes.

3. RPA Element and FSM Reference. The following table displays the RPA elements for underground spaces and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
	2520
Water	2530
	2540
	2543



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RPA Element	FSM Reference
Recreation	2310
	2320
	2330
	2380
Minerals	2810
	2820
	2840
	2850
Engineering	7130
	7140
	7150
	7500

4. Purpose of Activity. The purpose of the underground spaces activity is to:
- Identify existing underground spaces.
  - Determine the feasibility for storage in underground spaces.
  - Determine hazards posed by underground spaces to surface uses.
  - Determine ground-water conditions in underground spaces and needs for protection.

### **2882.5 - Cave Resources and Ecosystems**

- Activity Description. The cave resources and ecosystems activity:
  - Inventories and classifies all caves and related ecosystems.
  - Evaluates cave resources for significance.
- Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted for determination of the geologic units where caves are likely to occur based on the size of the area of interest (region, forest, or district). Order 1 inventories are required for cave inventories and other site-specific purposes.
- RPA Element and FSM Reference. The following table displays the RPA elements for caves and cave ecosystems and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920

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RPA Element	FSM Reference
Recreation	2310
	2320
	2330
	2380
Timber	2410
Water	2520
	2530
	2540
Minerals	2810
	2820
	2850
	2860
Wildlife/Fisheries	2630

4. Purpose of Activity. The purpose of the cave and cave resources activity is to:
- a. Protect and preserve significant caves by regulating or restricting use, as appropriate, and monitoring the condition of cave resources.
  - b. Promote volunteer management agreements and the exchange of information with the scientific and recreational caving communities.
  - c. Secure all cave-related documents to protect cave locations.
  - d. Determine the effects of proposed activities on the hydrologic function and biological significance, safety, recreational opportunities, and cultural and paleontological resources of cave resources and ecosystems.
  - e. Determine the need for protection of cave resources and ecosystems as critical wildlife or aquatic habitat.
  - f. Determine the actions necessary for protection, mitigation, and recovery of cave resources and ecosystems.

### **2882.6 - Paleontological Resources**

1. Activity Description. The paleontological resources activity:
- a. Identifies, classifies, and evaluates geologic formations for existing or potential paleontological resources using fossil yield potential classification (FYPC) methodology.
  - b. Evaluates protection, mitigation, resource conflicts, and recovery needs of fossils.

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2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the size of the area of interest (region, forest, or district). Order 1 inventories may be required for site-specific purposes.
3. RPA Element and FSM Reference. The following table displays the RPA elements for paleontological resources and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
Wildlife	2230
Recreation	2310
	2320
	2360
	2370
Water	2520
	2530
	2540
Wildlife/Fisheries	2630
Lands	2709
	2710
	2720
Minerals/Geology	2860
	2880
Law Enforcement	5320

4. Purpose of Activity. The purpose of the paleontological resources activity is to:
- a. Inventory paleontological resources.
  - b. Protect and preserve known significant paleontological resources.
  - c. Preserve legacy values.
  - d. Protect government property by curtailing fossil theft and vandalism in cooperation with Forest Service law enforcement.
  - e. Protect and preserve collections curated in non-federal repositories.
  - f. Actively promote partnerships with museums and other institutions having professional paleontologists and appropriate facilities.

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**2882.7 - Landforms (Geomorphology)**

1. Activity Description. The landforms (geomorphology) activity:
  - a. Identifies and evaluates natural and anthropogenic landforms, landforming processes, and the sequence of landform development.
  - b. Determines the shapes and dimensions of landforms to support detailed analyses, ensuring consistent mapping, correlation, and interpretation.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the size of the area of interest (region, forest, or district). Order 1 inventories may be required for site-specific purposes.
3. RPA Element and FSM Reference. The following table displays the RPA elements for landforms (geomorphology) and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
Wildlife	2230
Recreation	2320
	2350
	2360
	2370
	2390
Timber	2400
Water	2520
	2530
	2550
Minerals/Geology	2880
Engineering	7110
	7170

4. Purpose of Activity. The purpose of the landforms (geomorphology) activity is to inventory and classify landforms based on:
  - a. Geomorphic generation (overprinting).
  - b. Origin and development (process).
  - c. Structure and shape (landform).
  - d. Dimensions and characteristics (morphometry).

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**2882.8 - Geologic Special Interest Areas and Research Natural Areas**

1. Activity Description. The Geologic Special Interest Areas and Research Natural Areas activity:
  - a. Inventories and evaluates geologic areas of public, scientific, or academic interest.
  - b. Evaluates safety where conditions may endanger life or property.
  - c. Develops management prescriptions for designated areas.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (for example, region, forest, or district). Order 1 inventories may be required where safety is a concern.
3. RPA Element and FSM Reference. The following table displays the RPA elements for Geologic Special Interest Areas and Research Natural Areas and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
Wildlife	2230
Recreation	2320
	2350
	2360
	2370
Timber	2390
	2400
	2520
Water	2530
	2550
	2860
Minerals/Geology	2880
	5430
Lands	5530
	7110
Engineering	7170

4. Purpose of Activity. The purpose of the Geologic Special Interest Areas and Research Natural Areas activity is to:
  - a. Identify and describe areas and features of public or scientific interest.

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- b. Identify risk factors relevant to public safety.
- c. Inventory areas for possible inclusion into the Research Natural Area system.
- d. Determine the effect of geologic special-interest features on land values and management alternatives.
- e. Nominate areas of regional or national significance for protection as Research Natural Areas or natural history resources. Others may warrant descriptions for public information (for example, paleontological sites, collecting areas for gems or minerals, formation type sections, caverns, arches, craters, gorges, and so forth).

### **2882.9 - Interpretations Derived from Geologic Resources**

The geologic databases supporting map units can be used to make interpretive or derivative maps. These maps may depict, for example, one or more of the following:

- 1. Thickness of surficial deposits.
- 2. Bedrock characteristics or topography.
- 3. Aquifer locations and their susceptibility to contamination.
- 4. Landslide or erosion susceptibility.
- 5. Likelihood for a geological unit to host paleontological resources, caves, or mineral deposits.

Interpretations are based on existing geologic maps and reports, aerial photographs, drilling records, rock outcrops, drill holes, and geophysical measurements.

Geologic interpretations should be incorporated in land management planning to protect water supplies (surface water and ground water), reduce runoff, increase recharge rates for shallow ground-water aquifers, and increase understanding of caves, cave ecosystems, wetlands, and other natural areas. Geologic interpretations also serve to protect geologic resources, restore environmentally degraded areas, avoid and recover from geologic hazards, identify and preserve access to mineral resources, and prevent paleontological resource damage and conflicts.

### **2883 - GEOLOGIC HAZARDS PROGRAM MANAGEMENT**

The geologic hazards activities involve the management of the assessment and mitigation of existing and potential geologic hazards (FSM 2880.5). They require a sound understanding of the geologic processes that contribute to the occurrence of geologic hazards.

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## **2883.02 - Objective**

The objective of geologic hazards program activities is to protect human life and property from the effects of geologic hazards.

## **2883.03 - Policy**

1. Identify existing and potential geologic hazards, land base limitations, and affected management activities in all land management plans.
2. Work plans for each Forest Service project, requiring geologic information must identify the appropriate geologic hazard activity, establish the order of inventory that meets projects needs (FSM 2881), and provide an estimate of the time required for accomplishment.

## **2883.1 - Landslides**

1. Activity Description. The landslides hazard activity:
  - a. Inventories active landslides and areas of high landslide susceptibility under natural and managed conditions.
  - b. Considers the factors that produced past landslides, such as geology, slope, morphology, and soils, and assesses the susceptibility for future landslides.
  - c. Considers the potential for earthquake-induced landslides in addition to slides occurring in response to precipitation and fire events.
  - d. Identifies people, infrastructure, and resources at risk of landslide movement and related effects.
  - e. Assists project planners in avoiding activities on highly unstable terrain, or minimizing the destabilizing effects of activities on landslides and/or potentially unstable lands.
  - f. Assists with design and implementation of landslide stabilization and/or mitigation measures.
  - g. Develops management prescriptions for areas so identified.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district). Order 1 inventories may be required for individual landslides.

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3. RPA Element and FSM Reference. The following table displays the RPA elements for landslides and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
	2330
Recreation	2350
	2360
	2370
	2390
Timber	2410
Water	2520
	2530
	2540
	2550
Minerals/Geology	2860
	2880
Lands	2710
	5430
Engineering	7170
	7310
	7520
	7710

4. Purpose of Activity. The purpose of the landslides activity is to:

- a. Increase awareness of landslides and their potential effects on people, infrastructure, and resources.
- b. Prevent, minimize, or mitigate the effects of naturally-occurring and management-related landslides.
- c. Assess risk factors relevant to public safety.

### **2883.2 - Volcanic Activity**

1. Activity Description. The volcanic hazard activity:

- a. Inventories areas of high susceptibility to volcanic hazards.
- b. Considers the potential for volcanic activity.



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- c. Coordinates with U.S. and State Geological Survey in inventory and monitoring activities of volcanic terrains, and assists with these efforts, as appropriate.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district).
3. RPA Element and FSM Reference. The following table displays the RPA elements for volcanic activity and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
	2330
Recreation	2360
	2370
	2390
	2520
Water	2530
	2580
	2880
Minerals/Geology	7170
	7310
	7520
	7710

4. Purpose of Activity. The purpose of the volcanic activity is to:
- a. Assess volcanic hazards and risks to minimize or eliminate their effects on people and infrastructure.
  - b. Increase awareness of volcanic activity and its potential effects on people, infrastructure, and resources.
  - c. Develop hazard zonation maps for volcanic activities, particularly ballistic projectiles, pyroclastic flows and debris avalanches, lahars, and lava flows.

### **2883.3 - Earthquakes**

1. Activity Description. The earthquakes hazard activity:
- a. Inventories areas of high susceptibility to earthquake hazards.
  - b. Considers the potential for earthquake hazards.

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- c. Assesses earthquake hazards and risks to help minimize or avoid the effects on people using National Forest lands, facilities, and infrastructure.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district).
3. RPA Element and FSM Reference. The following table displays the RPA elements for earthquakes and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
Recreation	2310
	2330
	2350
	2360
	2370
	2390
Timber	2410
	2520
Water	2530
	2540
	2550
Minerals/Geology	2860
	2880
Lands	2710
	5430
Engineering	7170
	7310
	7520
	7710

4. Purpose of Activity. The purpose of the earthquakes activity is to:
- a. Develop local seismic hazard and risk maps using Federal and State information on earthquake location, magnitude, and frequency.
- b. Provide current information and site assessments for new infrastructure designs and seismic retrofits of existing structures.

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### 2883.4 - Flooding

1. Activity Description. The flooding hazard activity:
  - a. Determines the influences of bedrock and surficial materials on storm water runoff rates and volumes.
  - b. Identifies flood hazards and risks.
  - c. Identifies channel and flood plain substrate materials, channel stability, and sediment budgets.
  - d. Assesses the influences of roads, stream crossings, and facilities on storm water runoff rates and volumes.
  - e. Develops plans to minimize or eliminate flood damage or effects on people, infrastructure, and resources.
  - f. Assists with the design and implementation of landslide stabilization and/or mitigation measures.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district).
3. RPA Element and FSM Reference. The following table displays the RPA elements for flooding and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
	2330
Recreation	2350
	2370
	2510
Water	2520
	2530
	2540
	2550
Minerals/Geology	2880
Wildlife/Fisheries	2620
	2630

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RPA Element	FSM Reference
Engineering	7310
	7520
	7710

4. Purpose of Activity. The purpose of the flooding activity is to:
- a. Assess the role of geology and geomorphology plays in basin and watershed hydrology, particularly storm response.
  - b. Assist with local flood hazard mapping and risk assessment.
  - c. Assess risk factors relevant to public safety.

**2883.5 - Karst - Potential Collapse and Rapid Contaminant Transport**

1. Activity Description. The karst hazard activity:
- a. Identifies potentially hazardous karst conditions.
  - b. Inventories karst terrain for potential collapse features like sinkholes, disappearing streams, springs, caves, and areas vulnerable to contamination from anthropogenic or natural events.
  - c. Identifies resources and infrastructure at risk from collapse or contamination.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district). Order 1 inventories may be required for site-specific purposes.
3. RPA Element and FSM Reference. The following table displays the RPA elements for karst and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
	2330
Recreation	2350
	2360
	2370
Timber	2410
Water	2520
	2530

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RPA Element	FSM Reference
Minerals/Geology	2860
	2880
Engineering	7310
	7710

4. Purpose of Activity. The purpose of karst hazard activity is to:
- a. Mitigate potentially hazardous karst conditions.
  - b. Develop protection and mitigation plans.
  - c. Develops karst management prescriptions.

### 2883.6 - Other Geologic Hazards

1. Activity Description. The other geologic hazards activity:
- a. Identifies and inventories other geologic processes that can create potentially hazardous conditions and put people, infrastructure, and other resources at risk.
  - b. Identifies and inventories infrastructure and management activities that can cause or contribute to other geologic hazards.
  - c. Evaluates and classifies other geologic hazards by nature, timing, distribution, and magnitude.
  - d. Determines the occurrence probability of other potential geologic hazards, such as the potential for collapse of lava tube ceilings and natural occurrence of radioactive or asbestiform minerals.
  - e. Considers safety where conditions may endanger life or property.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district). Order 1 inventories may be required for site-specific purposes.
3. RPA Element and FSM Reference. The following table displays the RPA elements for other geologic hazards and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920

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RPA Element	FSM Reference
Recreation	2330
	2350
	2360
Timber	2410
Water	2520
	2530
	2540
	2550
Minerals/Geology	2880
Engineering	7170
	7310
	7530
	7710

4. Purpose of Activity. The purpose of the other geologic hazards activity is to:
- a. Determine the associated risks and occurrence probability of other geologic processes that can create hazardous conditions.
  - b. Mitigate the effects of management activities that can cause or contribute to other geologic hazards.

## **2884 - GEOLOGIC SERVICES PROGRAM MANAGEMENT**

Geologic service activities are conducted in support of various functional units or elements in developing, implementing, and carrying out their management objectives and tasks. Among the most common management activities requiring geologic evaluation are road construction and reconstruction, vegetation management (timber harvest, fuels reduction, grazing), minerals and mineral materials extraction, oil and gas development, geothermal power production, water resource development, and development of recreational sites.

### **2884.02 - Objective**

The objectives of geologic service activities are:

1. To provide geologic support to other resource activities to help them achieve their resource management objectives.
2. To better integrate the consideration of the influence of geology in the management of other resources.
3. To use a consistent and scientific approach in the interpretation of geologic factors that may affect the management of other resources.

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### **2884.03 - Policy**

The geologic support activities are guided by the following policies:

1. Provide geologic support to other forest activities in a timely manner.
2. Work plans for each Forest Service project requiring geologic support must identify the appropriate geologic support activity needed, establish the order of inventory that meets projects needs (FSM 2881), relate the activity to the National Activity Structure Handbook, and provide an estimate of the time required for accomplishment.

### **2884.1 - Planning and Analyses**

#### **2884.11 - Land Management Planning**

1. Activity Description. The land management planning services activity identifies geology-related issues and concerns and compiles the data necessary to properly address them. Consideration may be given to any or all of the geologic resources, hazards, and services activities.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district). Order 1 inventories may be required for intensive planning of small areas.
3. RPA Element and FSM Reference. The following table displays the RPA elements for land management planning services and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920

4. Purpose of Activity. The purpose of the land management planning services activity is to:
  - a. Conduct inventories and assessments of geologic resources and hazards, paleontologic resources, and mineral resources for use in land management planning.
  - b. Identify and evaluate issues and concerns related to geologic resources and hazards, paleontologic resources, and mineral resources, as they may affect, or are affected by proposed actions and alternatives.

#### **2884.12 - Mineral Activities Planning**

1. Activity Description. The mineral activities planning services activity:

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- a. Identifies areas for probable mineral development, areas for potential mineral development, and areas of existing mineral activity.
  - b. Compiles and interprets geologic and hydrogeologic maps for use in minerals activity planning.
  - c. Identifies caves, sensitive aquifers, and ground-water dependent ecosystems. Cave locations are identified, but kept confidential.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district).
3. RPA Element and FSM Reference. The following table displays the RPA elements for mineral activities planning services and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
Watershed	2530
Lands	5430 5460
Recreation	5530
Minerals/Geology	2810
	2820
	2850 2860

4. Purpose of Activity. The purpose of the mineral activities planning activity is to:
- a. Inventory and evaluate mineral potential or development activities.
  - b. Determine the effects of mineral potential and development on land values and allocations, cave and ground-water resources, and cave and ground-water dependent ecosystems.
  - c. Evaluate lands proposed for withdrawal or exchange.

### **2884.13 - Ecological Unit Inventory**

1. Activity Description. The ecological unit inventory services activity utilizes geology and geomorphology to help define both terrestrial ecological units and aquatic ecological units.



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2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district).
3. RPA Element and FSM Reference. The following table displays the RPA elements for ecological unit inventory services and the appropriate FSM references:

RPA Element	FSM Reference	
Land Management Planning	1920	
	2410 2470	
Timber	2510 2520 2530 2550	
	2620 2670	
	Wildlife/Fisheries	2810 2820 2840 2850

4. Purpose of Activity. The purpose of the ecological unit inventory services activity, that is terrestrial ecological unit inventory and aquatic ecological unit inventory, is to perform forest, watershed, and landscape analysis; forest and grassland project planning; and ground-water and cave ecosystems management.

## **2884.2 - Watershed Support**

### **2884.21 - Watershed Improvement/Restoration**

1. Activity Description. The watershed improvement/restoration services activity identifies the geologic and geomorphic factors that influence watershed function when designing for watershed improvement and restoration.
2. Order of Inventory (FSM 2881). Order 2 inventories are normally required. Order 1 inventories may be required for site-specific purposes.
3. RPA Element and FSM Reference. The following table displays the RPA elements for ecological unit inventory services and the appropriate FSM references:

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RPA Element	FSM Reference
Watershed	2510
	2520
	2543
Wildlife/Fisheries	2620
	2630
Engineering	7170
	7310
	7720

4. Purpose of Activity. The purpose of the watershed improvement/restoration services activity is to:
- a. Ensure that geology and geomorphology are considered in watershed improvement or restoration efforts.
  - b. Analyze sediment sources and depositional environments.
  - c. Assess hydrologic budget to evaluate ground-water contribution to watershed resources.
  - d. Help determine the effects of hydrogeology and sedimentation on fisheries, water quality, soil nutrient loss, and reservoirs.

#### **2884.22 - Erosion and Sedimentation**

1. Activity Description. The erosion and sedimentation services activity considers geologic, geomorphic, and hydrogeologic factors relating to production, transportation, and deposition of sediments. Origins, sources, rates, quantities, and particle size distributions of erosion and sedimentation are usually emphasized.
2. Order of Inventory (FSM 2881). Order 3 or Order 2 inventories are normally required. Order 1 inventories may be required for site-specific purposes.
3. RPA Element and FSM Reference. The following table displays the RPA elements for erosion and sedimentation services and the appropriate FSM references:

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RPA Element	FSM Reference
Timber	2400
	2510
Watershed	2520
	2543
	2550
	2560
Wildlife/Fisheries	2630
Engineering	7170
	7310
	7330
	7520
	7720

4. Purpose of Activity. The purpose of the erosion and sedimentation services activity is to:
- a. Analyze sediment sources and depositional environment.
  - b. Determine the effects of sedimentation on fisheries, water quality, soil nutrient loss, and reservoirs.

**2884.23 - Burned Area Emergency Response**

1. Activity Description. The burned area emergency response services activity:
- a. Identifies post-wildfire geologic hazards.
  - b. Evaluates the risks to resources, public safety, and infrastructure.
2. Order of Inventory (FSM 2881). Order 2 inventories are normally required. Order 1 inventories may be required for site-specific purposes.
3. RPA Element and FSM Reference. The following table displays the RPA elements for burned area emergency response services and the appropriate FSM references:

RPA Element	FSM Reference
Watershed	2520
	2530
	2550
Engineering	7300
	7500
	7700

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4. Purpose of Activity. The purpose of the burned area emergency response services activity is to:
  - a. Assess post-wildfire landslide and erosion potential and identify off-site resources, public safety, and infrastructure at risk.
  - b. Prescribe mitigation and monitor the effectiveness of mitigation.

### **2884.3 - Soil Parent Material**

1. Activity Description. The soil parent material services activity determines the effect of soil parent material on the physical and chemical properties of soil, its rate of formation, and areal extent.
2. Order of Inventory (FSM 2881). Order 1 inventories are normally required because the activity involves detailed laboratory analyses.
3. RPA Element and FSM Reference. The following table displays the RPA elements for soil parent material services and the appropriate FSM references:

RPA Element	FSM Reference
Timber	2470
Watershed	2550

4. Purpose of Activity. The purpose of this activity is to provide geologic and geomorphic information to identify soil parent material properties that may affect fertility, erodability, and potential natural vegetation.

### **2884.4 - Geologic Hazard Evaluation**

1. Activity Description. The geologic hazard evaluation services activity:
  - a. Assesses the risk of loss of life and property resulting from geologic hazards, such as mass wasting, flooding, avalanche, seismic activity, faulting, seiches, subsidence, reactive soils, toxicity associated with mineralization, and certain naturally occurring hazardous minerals and gases like asbestos and radon to affect the safety of life and property associated with proposed projects and resource development.
  - b. Assesses type, location, and probability of occurrence, frequency, and magnitude.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted based on the objectives and the size of the area of interest (region, forest, or district). Order 1 inventories may be required for project work.

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3. RPA Element/FSM Reference. The following table displays the RPA elements for geologic hazard evaluation services and the appropriate FSM references:

RPA Element	FSM Reference
Services	1620
	1630
Land Management Planning	1920
Range	2240
Recreation	2320
	2330
	2340
	2350
	2360
Timber	2410
Watershed	2510
	2520
	2530
	2550
Wildlife/Fisheries	2620
Lands	2710
	5420
	5430
	5460
Minerals/Geology	2820
	2840
	2850
	2860
Engineering	7170
	7310
	7400
	7500
	7710
	7720

4. Purpose of Activity. The purpose of the geologic hazard evaluation services activity is to:

- a. Determine the effect of geologic hazards on land allocations and values or the effect of land allocations on geologic hazards.
- b. Assess the safety of roads, infrastructure, recreation sites, and facilities.

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- c. Recommend avoidance, control, or mitigation measures.

### **2884.41 - Mass Wasting**

1. Activity Description. The mass wasting services activity:
  - a. Maps geomorphic features to assess mass wasting potential.
  - b. Inventories kinds, locations, frequencies, and magnitudes of mass wasting processes over broad areas. This provides the basis for further analysis and recommendations for mitigating or preventing adverse effects as in FSM 2883.42.
  - c. Considers natural and management-related cause-effect relationships for creep, solifluction, earthquakes, and rockslides, avalanches and falls.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted, depending on the objectives and the size of the area of interest (region, forest, or district). Order 1 inventories may be required for mitigating measures.
3. RPA element/FSM Reference. The following table displays the RPA elements for mass wasting services and the appropriate FSM references:

RPA Element	FSM Reference
Services	1620
	1630
Land Management Planning	1920
Range	2240
Recreation	2320
	2330
	2340
	2350
	2360
Timber	2410
Watershed	2510
	2520
	2530
	2550
Wildlife/Fisheries	2620
Lands	2710
	5420
	5430
	5460

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RPA Element	FSM Reference
Minerals/Geology	2820
	2840
	2850
	2860
Engineering	7170
	7310
	7400
	7500
	7710
	7720

4. Purpose of Activity. The purpose of the mass wasting services activity is to:
- Determine site suitability and risk to public safety.
  - Assess the effect of mass wasting on water quality.
  - Evaluate the potential for soil loss.
  - Determine suitable access corridors or locations for facilities.

**2884.42 - Landslide Assessment and Stabilization**

- Activity Description. The landslide assessment and stabilization services activity evaluates geologic, geomorphic, and hydrogeologic factors influencing selection and design of stabilization systems, possible route or site relocation, and other project design factors.
- Order of Inventory (FSM 2881). Order 1 inventories are usually required.
- RPA element/FSM Reference. The following table displays the RPA elements for landslide assessment and stabilization services and the appropriate FSM references:

RPA Element	FSM Reference
Services	1620
	1630
Land Management Planning	1920
Range	2240
Recreation	2330
	2340

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RPA Element	FSM Reference
Timber	2430
	2450
	2470
Watershed	2510
	2520
	2550
	2560
Wildlife/Fisheries	2630
Lands	2710
	5420
	5430
	5460
Minerals/Geology	2820
	2840
	2850
	2860
Engineering	7170
	7310
	7330
	7520
	7720

4. Purpose of Activity. The purpose of the landslide assessment and stabilization services activity is to:
- Assure that geologic, hydrogeologic, and geomorphic factors are considered where landslide stabilization is required to protect property, life, and resources.
  - Provide geologic parameters for design of stabilizing structures.

### **2884.5 - Engineering Support**

#### **2884.51 - Route Feasibility**

1. Activity Description. The route feasibility services activity:
- Evaluates the geologic and geomorphic factors affecting route locations when identifying potential suitable routes or route feasibility.
  - Assesses the effects of geologic, geomorphic, and hydrogeologic influences on proposed routes for roads, trails, railroads, tunnels, and utility corridors.



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2. Order of Inventory (FSM 2881). Order 2 inventories are usually required. Order 1 inventories are necessary to meet development requirements.
3. RPA Element/FSM Reference. The following table displays the RPA elements for route feasibility services and the appropriate FSM references:

RPA Element	FSM Reference
Land Management Planning	1920
	2330
Recreation	2340
	2350
Lands	2710
Engineering	7110
	7170
	7710
	7720
	7730

4. Purpose of Activity. The purpose of the route feasibility services activity is to determine geologic and geomorphic effects on proposed access routes for roads, trails, railroads, and pipelines.

**2884.52 - Foundation and Earth Support Structures**

1. Activity Description. The foundation and earth support structures services activity evaluates geologic factors affecting the suitability of earth materials as structural foundations for constructed improvements, such as bridges, small dams, roads, retaining walls, and buildings.
2. Order of Inventory (FSM 2881). Order 1 inventories are usually required.
3. RPA Element/FSM Reference. The following table displays the RPA elements for foundation and earth support structures services and the appropriate FSM references:

RPA Element	FSM Reference
Timber	2430
	7170
Engineering	7310
	7530
	7550
	7720
	7730

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4. Purpose of Activity. The purpose of the foundation and earth support structures services activity is to:
- a. Ensure that geologic factors affecting the stability of structures are considered.
  - b. Provide engineering geologic parameters necessary to design stabilization measures.

**2884.53 - Site Assessment and Cleanup**

1. Activity Description. The site assessment and cleanup services activity characterizes conditions of geologic and ground-water resources at Comprehensive Environmental Response and Compensation Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), and abandoned mine land (AML) candidate sites.
2. Order of Inventory (FSM 2881). Order 1 inventories are usually required.
3. RPA Element/FSM Reference. The following table displays the RPA elements for site assessment and cleanup services and the appropriate FSM references:

RPA Element	FSM Reference
Environmental	2160
Watershed	2520 2550
Wildlife/Fisheries	2650
Minerals/Geology	2810 2840
Engineering	7410

4. Purpose of Activity. The purpose of the site assessment and cleanup services activity is to provide the geologic information necessary to design effective remediation of candidate sites.

**2884.54 - Facilities Development, Operations, and Maintenance**

1. Activity Description. The facilities development, operations, and maintenance services activity identifies the geologic, geomorphic, hydrogeologic, and paleontological influences relative to sitting, operating, or maintaining agency-owned and agency-authorized facilities.
2. Order of Inventory (FSM 2881). Order 1 inventories are usually required.

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3. RPA Element/FSM Reference. The following table displays the RPA elements for facilities development, operations, and maintenance services and the appropriate FSM references:

RPA Element	FSM Reference
Watershed	2543
	7300
Engineering	7400

4. Purpose of Activity. The purpose of this activity is to protect geologic, paleontological, and ground-water resources when developing, operating, or maintaining agency-owned and agency-authorized facilities and their associated water supplies.

### 2884.6 - Waste Disposal

1. Activity Description. The waste disposal services activity inventories and evaluates the geologic, hydrogeologic, and geomorphic factors and conditions relative to solid and liquid waste disposal. Emphasis is on protecting surface- and ground-water resources.

2. Order of Inventory (FSM 2881). Order 3 or Order 2 inventories are usually required for preliminary planning. Order 1 inventories are required for site-specific purposes.

3. RPA Element/FSM Reference. The following table displays the RPA elements for waste disposal services and the appropriate FSM references:

RPA Element	FSM Reference
Recreation	2330
	2340
Watershed	2520
	2540
	2543
Engineering	7420
	7440
	7460

4. Purpose of Activity. The purpose of this activity is to:

- a. Assure adequate, safe disposal of wastes in compliance with applicable Resource Conservation and Recovery Act and State/Tribal standards and with emphasis on preventing hazardous materials liability.
- b. Protect surface- and ground-water resources.

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### 2884.7 - Interpretive Services and Education

1. Activity Description. The interpretive services and education services activity identifies and interprets geologic features of public interest.
2. Order of Inventory (FSM 2881). Order 1 inventories are usually required.
3. RPA Element/FSM Reference. The following table displays the RPA elements for interpretive services and education services and the appropriate FSM references:

RPA Element	FSM Reference
Recreation	2330
	2350
	2360
	2390
Minerals/Geology	2880

4. Purpose of Activity. The purpose of the interpretive services and education services activity is to:
  - a. Prepare maps, brochures, reports, or pamphlets in support of this service.
  - b. Educate the public.

### 2884.8 - Paleoecology/Climate Change

1. Activity Description. Paleoecology/climate change service activity interprets the geologic and geomorphic record for information about the paleoecology of National Forest System lands.
2. Order of Inventory (FSM 2881). Order 4, Order 3, or Order 2 inventories should be conducted, depending on the objectives and the size of the area of interest (region, forest, or district). Order 1 inventories may be required for site-specific purposes.
3. RPA Element/FSM Reference. The following table displays the RPA elements for paleoecology/climate change services and the appropriate FSM references:

RPA Element	FSM Reference
Watershed	2550
Wildlife/Fisheries	2630

4. Purpose of Activity. The purpose of the paleoecology/climate change service activity is to help establish the range of natural variability in local ecosystems.

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## **2885 - STANDARDS**

### **2885.02 - Objectives**

The objectives of geologic resources, hazards, and services standards are to ensure:

1. Optimum level of work quality.
2. Uniform geologic data-gathering procedures.
3. Proper communication of study or investigation results.

### **2885.03 - Policy**

1. Geologic data collection, interpretation, and transmittal must be designed to answer the specific user needs.
2. Geologic resources, hazards, and services activities must be conducted in accordance with established guidelines and standards (FSM 2885.1).
3. Reports on geologic studies or investigations, and transmittal of geologic data must be prepared and reviewed by a geologist with qualifications in the subject area (FSM 2885.3).

### **2885.1 - Guidelines and Performance Standards**

Broad guidelines and performance standards provided by the Chief for each activity (FSM 2882, 2883, 2884) must be used as a basis for program planning, budgeting, accountability, and quality control.

1. Appropriate Orders of Study and Investigation. Sample intensity, as described in FSM 2881.1, is intended to distribute traverses and data points within delineated polygons, commensurate with the map order chosen, and includes:
  - a. Area covered in square miles/day.
  - b. Traverse density in miles/square mile.
  - c. Number of polygons sampled, or number of wells or other ground-water features sampled.

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These are used in Order 2 and Order 3 levels of geologic inventory. Area covered defines the minimum area to be assessed per day in the field. "Traverse density" includes a minimum number of data points commensurate with the geologic complexity of the area mapped. Data should be collected from enough outcrops so that at least 25 percent of the map unit polygons are sampled, depending on the map order chosen.

2. Technical Procedure to be Followed. Bedrock and surficial materials data collection must conform to the standards described in FSM 2880.61, paragraphs 3 and 6. Landslide inventories, investigations, and analyses must conform to the standards established in FSM 2880.64, paragraph 1. Ground-water data collection and analysis must conform to standards described in FSM 2880.65, paragraph 2. Paleontological resource handling, collection, and curation must conform to the standards described in FSM 2880.66, paragraphs 1 through 4.
3. Skill and Knowledge Levels Required. For each geologic resource, hazard, or service, data shall be collected, described, and analyzed by persons who meet the minimum requirements for the GS-1350 job series and have experience in the particular activity involved. State registration or certification of geologists is encouraged.
4. Coordination and Support Services Required.
5. Units of Measure and Output.
6. Appropriate Work Activity Code.

Regional offices may augment or further refine the broad guidelines and performance standards to accommodate their specific needs within this framework.

### **2885.2 - Data Storage and Retrieval**

Geologic data storage must conform to Forest Service Natural Resource Applications (FSNRA) standards, such as the National Resource Information System (NRIS) and service-wide GIS data standards (FSH 6609.15), and stored in FSNRA databases. Each of the FSNRAs that minerals and geology specialists and managers will use, for example, NRIS, Infra, Automated Lands Program (ALP), and Forest Service Activity Tracking System (FACTS), has a unique data standard. The standards are managed within each application through Graphical User Interface architecture and software structure that prevents users from entering non-standard data that may corrupt the databases.

Each FSNRA has documentation designed to inform users about data standards. This documentation is found on each FSNRA website and in the FSNRA electronic HELP system.

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### **2885.3 - Reports**

Geologic reports must be written by a qualified geologist or mining engineer and include the following, appropriate to the purpose of the report:

1. Title Page. Identifies the subject of the report, signature(s) of the preparer(s), reviewing geologist, if necessary, and date(s) the report was signed.
2. Executive Summary. Includes the results of the field examination, if conducted, conclusions drawn from the analysis, and recommended actions. The summary should be written in clear, concise language that generally avoids the use of technical terms or jargon, or explains them when needed.
3. Introduction. Describe the problem, purpose, and location of the study and states that the conclusion(s) of the report is limited to the action that prompted the report. The introduction also identifies the dates of any field work and the personnel involved.
4. Lands Involved. Describes by legal subdivision, protracted survey, or metes and bounds the area investigated and the acreage involved. It describes the general use of the land and any ongoing activities and discusses access to the property, transportation network, and availability of power and water, if applicable.
5. Geomorphic Setting. Describes the processes, landforms, and topography of the area, including significant and unusual origins of particular topographic features, such as karst and lava flows.
6. Geologic Setting. Describes the regional geology of the area, including the area's geology, stratigraphy, and tectonics. If regional geophysical or geochemical data are available, include a summary here. A geologic map at a scale not less than 1:250,000, if available, should be attached, or at least referenced in the report. Larger scales (1:100,000 or 1:125,000) should be used if available.
7. Site Geology. Describes the site-specific geology within the project boundary, including data relevant to the report's purpose, such as local structure and stratigraphy, alteration, subsurface data, favorable reservoir rocks, ore controls, rock and/or soil engineering properties, overburden, stratigraphic and structural traps, and so forth. If local geophysical or geochemical data are available, summarize the findings. Cite all geologic references used in the report. A geologic map at a scale not less than 1:63,500, if available, should be attached to the report. Larger scales (1:24,000 or 1:50,000) should be used if available. Cross-sections should be included also.

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a. Mineral Report. For mineral reports, include the following:

(1) Production History. Summarize the production from the mining district, leasing area, or basin. If the district or basin is inactive or non-producing, give reasons, if known.

(2) Mineral Deposits. Discuss the form and type of mineral deposit(s) present and describe the minerals and their relationship to the local geology, using cross sections when necessary. A statement as to the presence or absence of critical and strategic minerals, as contained in the Stockpile Report to Congress, is necessary. Discuss in detail deposits of critical or strategic minerals where at least 30 percent of the grade and the tonnage of the deposit is commercially produced.

(3) Mineral Exploration and Development Work. Discuss exploration and development that has occurred on the property and include a map of the pertinent mine workings, well locations, and other related facilities. Summarize any exploration or production data, if available.

(4) Mineral Potential. Discusses the potential of the area for the occurrence of energy and mineral resources or deposits and the rational substantiating conclusions regarding mineral potential or lack thereof. For instance, if there is no mineral or energy potential, the report should contain a sufficient, but brief discussion or rationale to support the conclusion. It is particularly important to support opinions of low or no potential for energy or mineral resources or deposits.

If the property has a moderate or high potential, prepare either a mineral appraisal or a supplementary report discussing sampling and the economic evaluation.

b. Cave Resources. If the report addresses caves, cave resources, or cave ecosystems, include the following:

(1) "Significance findings" and completed cave nomination forms.

(2) Sensitivity of the cave to human disturbance and potential dangers posed to the public.

(3) Management goals and list of permitted and prohibited human activities for the cave.

8. Conclusions. Describes the conclusions drawn from the analysis.

9. Recommended Actions. Describes the actions that should be taken based on the report's conclusions, as well as the potential consequences of not taking action.



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10. References. Lists, in proper scientific citation format, the references used and consulted in preparation of the report.

## **2886 - MONITORING**

### **2886.02 - Objective**

The objectives of monitoring geologic resources, hazards, or services activities are to assess the effectiveness of management strategies to protect and conserve geologic resources and to protect human life and property from the effects of geologic hazards.

### **2886.03 - Policy**

1. Monitoring activities must be consistent with direction, criteria, and standards specified in forest plans and be identified and analyzed with due consideration of costs.
2. Selected strategies must be technically sound, applicable to the problem, and produce quantifiable results which can be timely applied to similar situations.
3. Using applicable geoindicators, Forest Service managers shall identify geologic features and processes to be used to evaluate the condition of the environment, how ecosystems are changing, and how and whether management activities are affecting them.
4. Monitoring data and reports must be stored as directed in FSM 2885.2.

### **2886.1 - Geoindicators**

Geologic changes occur not only over spans of geologic time, but also at observable intervals of time that can be monitored or measured. Geoindicators have been developed by the International Union of Geological Sciences as high-resolution measures of short-term changes in the geologic environment, which are significant for environmental monitoring and assessment for use in environmental reporting and ecosystem management (FSM 2880.61, paragraph 2). The geoindicators useful for measuring and predicting the consequences of management activities on National Forest System lands are:

1. Desert surfaces and crusts.
2. Dunes.
3. Frozen-ground activity.
4. Glacial fluctuations.
5. Ground-water quality and quantity.

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6. Karst activity.
7. Shoreline position and erosion.
8. Sediment sequence and composition.
9. Slope failure and general erosion.
10. Stream channel morphology.
11. Wetlands extent.
12. Landslide episodes.
13. Cave conditions.

**2886.2 - Plans**

Monitoring of geologic conditions must be conducted under a plan containing:

1. Clear statement of purpose and objectives.
2. Assigned administrative and technical responsibility.
3. Timetable showing frequency, type of measurements, and duration of the study.
4. Sample design protocol including sampling frequency, collecting procedures, data requirements, monitoring locations, analytical standards and procedures, and data accuracy requirements.
5. Procedures for data storage, analysis, evaluation, and reporting.
6. Personnel requirements.
7. Instructions for reporting.
8. Instructions for appropriate response actions when data indicate major deviation from standards.
9. Provision for periodic evaluation of the monitoring to determine if parameters measured and frequency of sampling meet planned objectives.
10. Estimated annual financial requirements.
11. Use and distribution of findings.

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## **2887 - TECHNICAL DEVELOPMENT AND APPLICATION**

### **2887.02 - Objective**

The objective of technical development and application is to provide and maintain a high level of geologic skill and knowledge applicable to Forest Service work and to enhance the safety, economy, and efficiency of projects.

### **2887.03 - Policy**

1. Promote and maintain a free exchange of technical geologic information between forests, regions, Federal and State agencies, and private industry.
2. Encourage development, evaluation and formal presentation of geologic services procedures, methods, and techniques to other Earth science, resource, and engineering disciplines.
3. Identify opportunities for research to enhance understanding of geology and its application to land management practices. Recruit cave and karst ecosystem management specialists.
4. Identify annual training needs and provide geologic training opportunities.