Groundwater-Dependent Ecosystems Inventory and Monitoring Protocols

Business Requirements Analysis

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Table of Contents

Page

I. Overview…… 1

II. Analysis Process……..…….. 3
- A. Business Requirements……... 4
- B. Inventory and Monitoring Intensity…… 8
- C. GDE Feature Types ……..……... 10
- D. Protocol Development Framework……...…… 11
- E. Summary…….. 12

III. Management Requirements…….. 13
- A. Groundwater-Dependent Resource Management……..…… 13
- B. Planning and Environmental Compliance……... 16
- C. Resource Information Management……...…….. 18
- D. Summary…… 26

IV. Inventory and Monitoring Intensity…… ……..…. 27
- A. Data Analysis and Evaluation…….…….. 27
- B. Intensity Level Definitions & Procedural Template..……..…… 34

V. Management Questions……...…… 38
- A. Location and Description…… 40
- B. Ecological Context……...…… 41
- C. Hydrogeologic Setting…… 42
- D. Natural and Anthropogenic Disturbances…… 43

VI. Groundwater-Dependent Ecosystem Type Definitions……..…. 44
- A. Groundwater-Dependent Ecosystem Types…… 46
- B. GDE Definitions and Descriptions…… 48

VII. Protocol Development Framework and Scope…… 51

VIII. References…….. 52

Appendix A – Authors and Contributors……... 54
Appendix B – Management Question Organization Structure…… 55
Appendix C – Key Resource Information Management Concepts……. 60
Appendix D – GDE Types and Definitions…… 63

I. Overview

The USDA Forest Service depends on inventory and monitoring data and information to carry out its mission. However agency capacity to meet groundwater-related business requirements and customer needs through existing inventory and monitoring programs is inadequate. Previous and ongoing inventories often have ignored groundwater-dependent ecosystems, leaving management at risk as the agency faces an increasing number and size of projects involving or affecting groundwater. The Forest Service needs to develop groundwater-dependent ecosystem (GDE) inventory and monitoring protocols to improve the credibility and efficiency of groundwater resource management throughout the agency. The field has repeatedly called for protocols and guidance on inventorying and managing groundwater resources, particularly GDEs.

Regional units need highly professional quality-assured data collected using well-documented national and regional standards and guides to better inform staff and decision-makers who write and approve Forest Plans and who advise regulators on the adverse effects of water development, mining, off-road vehicles, and other activities on National Forest System (NFS) lands. The lack of business rules and sampling protocols related to spring and other GDE inventory and monitoring is affecting the Agency's ability to effectively collect and apply essential corporate resource information (see NRIS life cycle plan).

Forest Service Groundwater Program staff members have heard repeated calls from the field for protocols and guidance on inventory and monitoring of springs, fens and other GDEs. Presently, a significant amount of staff time is wasted in trying to find or develop and field test protocols applicable to groundwater issues.

Examples of GDEs include springs, perennial streams, fens, caves, and many riparian areas and wetlands. They encompass many of the regionally- and nationally-significant ecosystems on NFS lands and are crucial to management of many threatened and endangered species. Given the increasing pressure on NFS lands to supply the water, minerals, and energy needed for human activities in the semi-arid to arid West and elsewhere, it is becoming critical to the agency's mission to identify existing groundwater-dependent ecosystems so that they can be addressed consistently across the spectrum of agency decision making.

GDE protocols will employ a series of integrated components:

1. A groundwater-dependent feature types and definitions.
2. GDE feature inventory and monitoring protocols, with an initial focus on:
    (a) Springs/Seeps and
    (b) Peatlands and other discharge wetlands.
3. Guidelines and methods for determining environmental water requirements for GDE features.

GDE inventory and monitoring protocols by their nature must be highly interdisciplinary and support several Forest Service program areas. The protocols will be flexible enough to be used for many different purposes. The data will be used by planners, geologists, botanists, hydrologists, range conservationists, and others. It is expected that 10% of the workload of many NFS administrative units deals with GDE inventory and monitoring per year.

With groundwater as a relatively new resource management emphasis for the Forest Service, this protocol is not expected to replace any other existing protocol. These protocols will be conveniently available tools that a unit can use as part of the normal schedule of work and will be designed for use by field personal. The protocols are expected to be implementable within existing agency budgets.

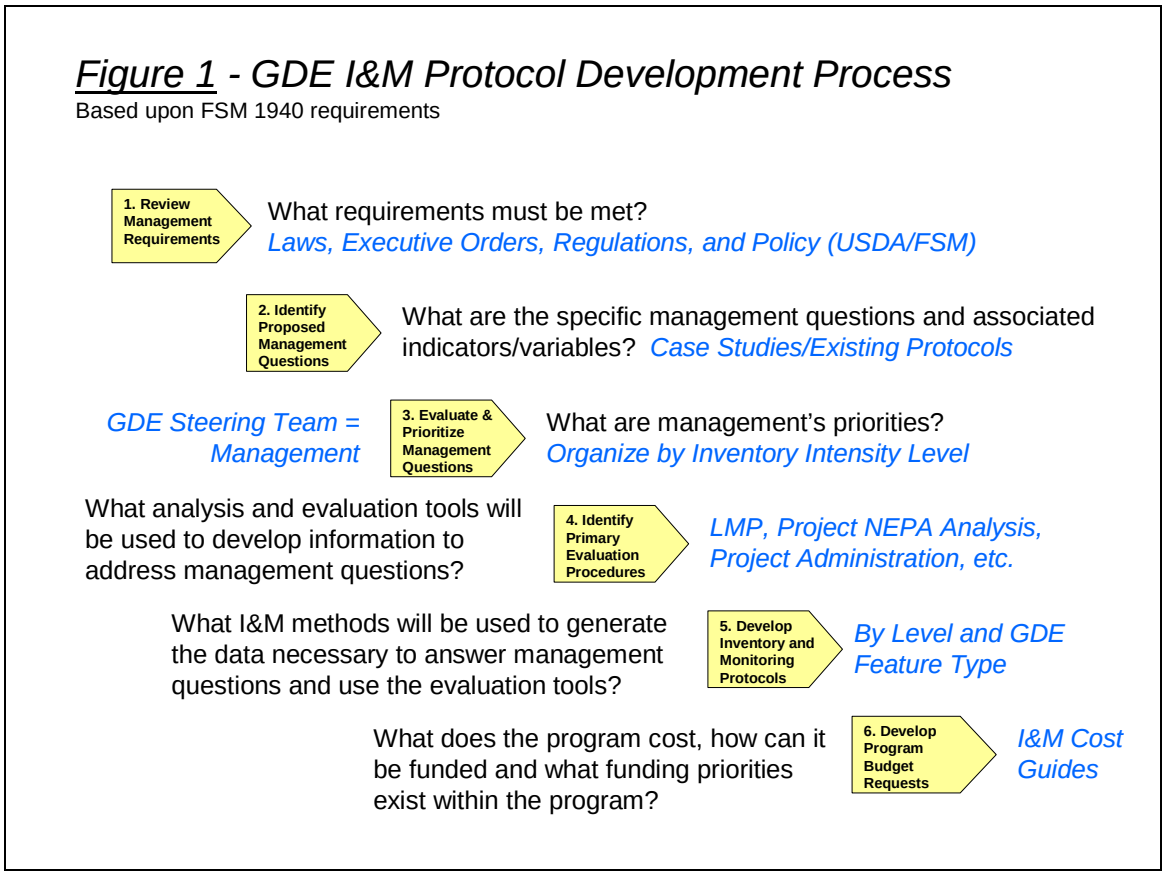
This document describes the procedures used to identify agency business requirements related to GDEs and defines the scope of the initial protocol development effort. Appendix A identifies the authors and contributors to this effort.

II. Analysis Process

A structured inquiry is essential to the identification and evaluation of business requirements supported by GDE inventory and monitoring protocols. A detailed review of management requirements and questions addressed provides both transparency and the ability to reexamine requirements being addressed and their priorities over time.

A six-step process is used to develop inventory and monitoring protocols as illustrated in Figure 1. This process conforms to direction in FSM 1940 and procedures established by the USDA and Forest Service Chief Information Officers. Use of these procedures avoids a common problem-solving trap experienced by many organizations: beginning problem-solving or development activities before the problem and requirements are properly framed. From a practical perspective, this makes perfect sense, but requires organizational discipline to accomplish.

The initial steps of the process outlined in Figure 1 focus on the identification of agency business requirements. Business requirements originate from laws, regulations and policy as well as management issues and concerns.



Once business requirements are documented and understood, the next steps in the analysis are to determine management's priorities for addressing these requirements and an evaluation of how data collected will be used to address these requirements and questions.

During the next step in the process it becomes possible to identify inventory and monitoring methods best suited to gather the data needed to address priority business requirements. In this instance, the goal is to develop protocol components that allow local units to mix and match inventory and monitoring methods to meet their local business needs. Because of the variation of business requirements across the NFS, this approach is essential.

To facilitate the development of program budgets, the final step of the development effort involves the creation of cost guides. The purpose of cost guides is to assist local NFS units with the development of realistic budgets requests and estimates for costs associated with proponent-generated activities affecting GDEs.

A. Business Requirements

Adaptive management requires a clear understanding of the underlying business requirements for practicing conservation. In some instances policy and direction limit management's ability to respond to identified needs. Business requirements stem from two primary sources (1) Regulatory and policy requirements and (2) Management questions and concerns associated with land and resource management plans and ongoing and proposed projects/activities. Table 1 illustrates these relationships.

Table 1 – Business requirement sources

Management Requirements	Management Questions
▪ **Laws –** A variety of Federal statutes establish Forest Service authority for managing GDEs and procedural requirements. ▪ **Executive Orders and Presidential Directives** – Specify procedures and requirements applicable to all government agencies for the management and protection of GDEs and associated resources. ▪ **Regulations** – Establish the processes and policy for conducting land and resource management activities affecting GDEs. ▪ **Departmental Policy** – Establish procedures and policies for USDA agencies responsible for or potentially affecting GDEs. ▪ **Agency Policy** – Establish agency-specific procedures for regulatory requirements if not addressed directly.	▪ **Land Management Plans** – Establish desired outcomes (goals and objectives), standards and guidelines, and monitoring requirements. Includes: - **Ecological Context** – Are ecological systems functioning and disturbance processes operating within the natural or desired range of variation? Are human pressures or changes in ecological systems inducing changes to the ecological context in which species reside? - **Species Context** – Are habitat relationships affected by management or ecological factors creating risk to species persistence? ▪ **Resource or Area Plans** – Refine interpretations and requirements for specific resources or areas. ▪ **Monitoring** – Includes: - **Implementation** – Are projects and activities being implemented as designed? - **Effectiveness** – Are mitigation measures, best practices and design features effective in mitigating anticipated effects? - **Validation** - Are conservation actions achieving desired outcomes?

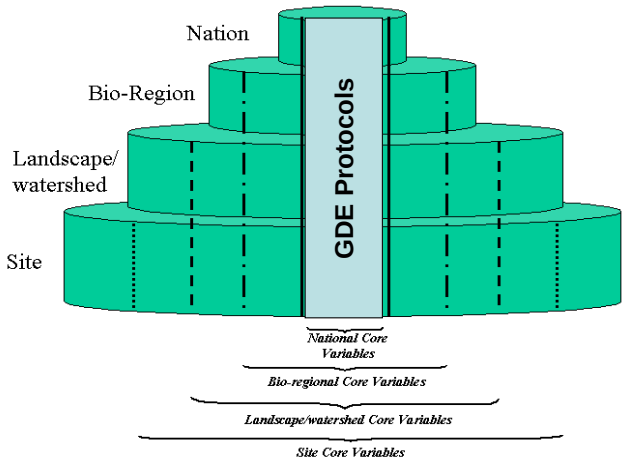
1. Management Requirements

Within the NFS legal requirements and management issues are highly variable so it is difficult to define a discrete set of business requirements applicable to all NFS lands. In several instances, laws and regulations provide the opportunity for States and Tribes to establish additional regulations for the protection of resources associated with GDEs. This creates an even more complex relationship between management requirements and the NFS. As a result, protocols must be designed to allow for local additions within a national framework.

To accommodate this need, GDE protocols will be developed using the "core variable concept" depicted in Figure 2. This concept is employed in a number of national inventory and monitoring protocols, most notably the Forest Inventory and Analysis Program. Use of this concept allows for regional and local additions to meet specific information needs within a national protocol.

Figure 2 – Core Variable Concept

National GDE protocols will be developed to provide flexibility to respond to localized business requirements.



Forest Service business processes related to the management of groundwater-dependent resources are organized into three primary groups of management requirements:

A. GDE Resource Management
B. Planning and Environmental Compliance
C. Resource Information Management

These groups will be used to identify business requirements originating from laws, regulations and policy.

2. Management Questions

Management questions are intended to focus management's efforts on refining operating assumptions and reducing risk and uncertainty associated with decision making. Limited resources make it essential to establish priorities and focus management intervention on those questions with the highest degree of risk and uncertainty and where actions are likely to influence the sustainability of ecological systems or species diversity.

Cost and cost efficiency are critical factors in the agency's ability to initiate conservation measures and practices. Therefore, it is essential to establish clear priorities and, when possible, relationships among management questions to focus agency and partner resources.

Designing an effective adaptive management system involves the following key steps:

1. Evaluate proposed management questions to determine if they are appropriate for consideration.
2. Review management questions to determine potential data collection needs.
3. Stratify management questions based on the intensity of data collection required and its application in NFS business processes.

Management questions, which include environmental issues, monitoring questions, and management concerns, are organized into groups derived from the themes and sub-themes used in the Forest Service Monitoring and Evaluation Framework (USFS 2007). Table 2 displays the organization used within the Monitoring Evaluation Framework. Use of this organization allows individual NFS administrative units to select appropriate national protocols to address their local management requirements and questions. A more detailed description of this framework is included in Appendix B.

Because many management questions span jurisdictional boundaries, the ability to organize data and conduct analyses across administrative boundaries is also facilitated by the use of a common framework. This is especially true as issues evolve over time and migrate across the landscape.

When appropriate, the standardized outline can include additional sub-themes within each Theme or subdivisions within a Sub-theme. Themes and sub-themes can also be collapsed into more generalized categories.

A more detailed evaluation of the relationships between management questions and the themes/sub-themes will be conducted as part of the business requirements analysis. However, it is apparent from preliminary analysis that several sub-themes may be collapsed into more general groupings.

Table 2 – Monitoring and evaluation framework components

Theme 1: Conservation of Biological Diversity
Vegetation Diversity
Species Diversity
Theme 2: Maintenance of Land Health and Vitality
Invasive Species
Resilience to Wildland Fire Disturbance
Native Insects and Pathogens
Theme 3: Conservation and Maintenance of Soil, Water, and Air Resources
Watershed Health
Theme 4: Maintenance and Enhancement of Social Benefits
Diversity of Opportunities and Settings
Theme 5: Maintenance and Enhancement of Economic Benefits
Provision of Goods and Services
Theme 6: Infrastructure Capacity
Roads and Trails

B. Inventory and Monitoring Intensity

As described above it is essential to develop a protocol "package" consisting of integrated modules or components that can be matched to local NFS business requirements. The use of different inventory and monitoring "intensity levels" is designed to support this functionality.

To provide this flexibility and ensure appropriate use of the resulting protocols, the relationship between business requirements (why data are collected) and inventory and monitoring protocols (how data are collected) must be clearly described. In addition, an understanding of how data are analyzed and evaluated to address management requirements and questions is necessary to assure associated costs and required skills are recognized in program formulation and development of cost estimates.

1. Evaluation and Assessment

Data analysis and evaluation are critical components of the adaptive management cycle. Evaluation is a critical phase of the adaptive management process and often overlooked or ineffective in practice. The resulting assessment assists managers' understanding relationships between conservation actions (or inaction) and their consequences relative to desired outcomes.

An important consideration in developing inventory and monitoring protocols is an examination of the primary tools or methods for evaluating data collected to address business requirements. In general, very few management questions are addressed directly by data collected in the field. Often multiple measurements and observations over time are required to develop trend or baseline information. In some instances data collected must be compared with other data sets from other inventory programs to develop correlations and/or investigate cause-effect relationships.

Cause-and-effect relationships are much more difficult to determine and require a structured investigation to isolate causal factors. The ability of these monitoring systems to directly provide information needed to determine cause-and-effect relationships is limited. A research or administrative study design is typically required to determine true cause-and-effect relationships. Monitoring can serve as an indicator of the need to invest in these more detailed, expensive investigations.

An examination of primary evaluation tools is important to ensure that data inputs necessary to "drive" models are being collected as part of the overall program or are readily available from other sources. This examination also assists managers' understanding of the nature of the information developed and report on the success of adaptive management programs.

The use of classification systems, models and analysis tools adopted for use within the Forest Service or documented and maintained by other organizations is preferred over development of new analysis tools and methods. This practice will result in lower analysis costs and provide the ability to rely upon documentation and reviews associated with published/adopted methods.

2. Inventory and Monitoring Intensity Levels

A similar relationship exists between the types of management requirements and questions being addressed and the data needed to address those questions. The amount of effort or intensity of inventory and monitoring can be categorized into three levels. Table 3 describes the level of effort and focus of these levels.

Table 3 – Inventory and monitoring intensity level descriptions

Inventory and Monitoring Intensity Level	Description
Level I	Conducted to qualitatively characterize GDEs within an administrative unit. GDE location and extent are spatially referenced. Serves as the basis for determining when GDEs may be affected by proposed actions or activities
Level II	Serves as the foundation for identification of design measures and assessment of project and activity effects. Describes major attributes including: Hydrogeologic setting, aquatic habitat, aquatic and riparian vegetation communities, and disturbances affecting GDEs. Can be used to determine ecological significance of the GDE and associated resources.
Level III	Usually conducted in relation to a major activity or set of activities affecting GDE's and their characteristics. Compiles highly quantitative information that describes spatial and temporal variation in physiochemical characteristics of GDEs. Often used in the administration of projects or activities.

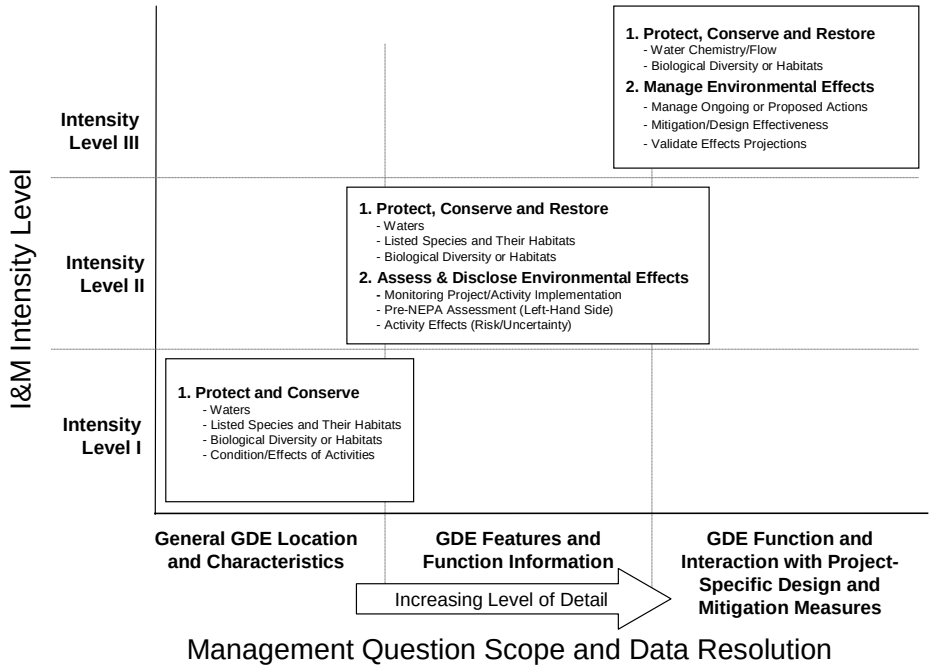
There are also logistical reasons for the use of inventory and monitoring intensity levels to organize protocols. Available time and skills may limit a unit's ability to conduct inventories of GDEs. By providing a variety of inventory and monitoring intensity levels, individual units can make a determination on how many GDE features to inventory and the scope and resolution of data collected.

It is also common for NFS managers and specialists to focus on the field data collection activities associated with protocol implementation. This narrow focus often ignores a significant amount of work and the need for specialized skills to facilitate data analysis and evaluation in addition to other tasks. For this reason, a common template is used to describe the business requirements, data elements or indicators and inventory procedures used for each intensity level. Again, the purpose of this documentation is to provide for regional and local augmentation of national protocols in response to localized business requirements.

3. Relationship between Business Requirements & Intensity Levels

A distinct relationship exists between business requirements and GDE inventory and monitoring intensity levels. These general relationships are illustrated in Figure 3.

Figure 3 - General Relationships Between Business Requirements and Inventory Intensity Levels



The number of management questions considered and the level of detail needed to address these questions increases in association with increases in inventory and monitoring intensity. Specific management questions will be identified and associated with business requirements as part of the analysis. Each of the boxes on this diagram represents a grouping of management requirements. The level of detail and resolution for data elements needed to support the business requirements increases from Level I to Level III. For example, the types of information collected in Level I for vegetation would be more general than those collected for Level III.

C. GDE Types

No consistent set of definitions or classification system exists within the Forest Service for GDE features. Different classification systems and definitions are used by a variety of different organizations in response to their particular mission or focus. Examples include the Federal Geographic Data Committee's (FGDC) Classification of Wetlands and Deepwater Habitats of the United States (FGDC-STD-004, Cowardin et al 1979), the FGDC's National Vegetation Classification Standard, Version 2 (FGDC-STD-005, FGDC 2008), or the wetlands classification system used in Canada (National Wetlands Working Group 1997).

Many GDEs can be considered to be a specific type of wetland. The National Research Council defined wetlands in the following manner:

> *"A wetland is an ecosystem that depends on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical, and biological features reflective of recurrent, sustained inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where specific physicochemical, biotic, or anthropogenic factors have removed them or prevented their development" (National Research Council 1995).*

Methods for identifying and defining GDEs must be described and correlated with other Forest Service ecological classification systems, including the hierarchy of terrestrial ecological inventory units used in EcoMap (Cleland et al. 1997) and the hierarchy of aquatic ecological inventory units (Maxwell et al. 1994). Both of these mapping systems conform to standards adopted by the Federal Geographic Data Committee.

D. Protocol Development Framework

GDE inventory and monitoring protocols will be framed using two factors:

1. **GDE Types** included within the scope of the protocol and their relationship to the Forest Service hierarchy of aquatic and terrestrial ecological mapping units.

   GDE features are consistently defined using nationally or internationally accepted definitions of GDE features allowing field users to match the appropriate protocols/intensity level to specific GDE type.

2. **Inventory Intensity Levels** which define the general purpose of data collection and the corresponding level of accuracy and precision for observations and measurements.

   Intensity levels define core variables that must be collected for national consistency and comparability of data. Local variables must utilize national data standards and definitions whenever possible to allow data collected to be used for multiple purposes over time.

   Protocols developed for Intensity Level I are envisioned to apply to a broader range of GDE features types than those focused on in this effort (and in some instances non-GDE features). For Intensity Level III, development of comprehensive national protocols may be impractical. At this level, guidance for conducting inventory and monitoring for a more limited range of feature types is expected and may only apply to a narrow band of management questions and issues (usually associated with specific types of resource management projects or activities).

This conceptual framework allows for the incremental development of GDE inventory and monitoring protocols over time. As a result, some management requirements and questions will not be addressed during this protocol development because they are beyond the scope

the initial development effort. As additional protocols are developed, this business requirements analysis can be reviewed and, if necessary, amended to include additional management requirements and questions.

GDE protocols will also be developed to improve efficiency and will recognize practical considerations regarding inventory and monitoring of GDE features. In some instances the specific type of feature and appropriate method for characterizing it will not be known until an inventory crew visits a site. As a result, the option to select the appropriate method for data collection must be provided to the field crew. This will require alignment of basic data collected at different inventory levels between protocols, including protocols for non-GDE resources.

As an example, the collection of vegetation data in conjunction with GDE hydrogeologic setting and other information is done as a matter of efficiency. An integrated effort to collect these data during a single site visit will also provide analysts/ecologists with a more complete perspective of resources dependent on groundwater dependent ecosystems and activities affecting those systems.

In response to the need for a practical approach and efficiency, data collected for GDEs will need to utilize data definitions and standards adopted for use by the Forest Service. The GDE inventory and monitoring protocol will gather basic (observed and measured) vegetation data consistent with data standards and methods adopted by the Forest Service. Existing vegetation types and classes used in GDE protocols will be consistent with Forest Service standards for mid-scale vegetation (Brohman and Bryant 2005).

Riparian and aquatic vegetation data collected in the GDE protocol will use published data standards and methods for collection used in the Natural Resource Information System and other Forest Service Natural Resource Applications.

Riparian vegetation data will be consistent with the riparian vegetation inventory protocol currently under development by the national Forest Service “Stream Team”. Members of the Stream Team’s riparian protocol technical team are included within the project and core teams to provide this connection.

E. Summary

In summary, a thorough evaluation of business requirements for GDEs establishes a sustainable and flexible inventory and monitoring system that:

- Provides high quality data to support decision making;
- Acquires data needed to address priority management questions; and
- Provides data necessary for key agency assessment and evaluation needs.

With this foundation the Forest Service and its partners will be in a better position to use adaptive management approaches to address current and future management issues affecting groundwater-dependent ecosystems.

III. Management Requirements

The following section identifies key management requirements associated with GDEs. This information was gleaned from the Forest Service Directives System. The "zero chapters" of Forest Service Manuals 1900, 1940, 2560 were the primary sources consulted. The information summarized below is intended to focus on the principal management requirements applicable to GDEs. It is not intended to be an exhaustive or comprehensive listing of all management requirements that might be construed to apply to GDEs.

A. Groundwater-Dependent Ecosystem Resource Management

The importance of groundwater-dependent ecosystems' ability to sustain ecological systems and species dependent on groundwater is evident in many NFS locations. The suite of management requirements related to the management of water and water uses is further evidence of the importance of GDEs. Protection, conservation and restoration of GDEs are often key aspects of decision making on NFS lands.

Several statues and regulations summarized below provide States and Tribes the authority to promulgate laws and regulations related to water uses and development on federal lands. Because of the variability associated with water rights and uses requirements within the National Forest System, no attempt has been made to summarize those requirements as part of this analysis. Readers are encouraged to consult FSM Chapter 2540 and appropriate Regional supplements to this Chapter to review those requirements.

1. Statutes

A number of Federal statutes direct or authorize water or watershed management on NFS (FSM 2501). Several of these statutes grant authority or provide direction to the Forest Service for the management of groundwater resources:

a. Organic Administration Act (16 U.S.C. §§ 473-475, 477-482, 551). This act contains the basic authority for watershed management on NFS lands. The act provides for improvement and protection of the national forests and securing favorable conditions of water flows. The act also authorizes use of water within national forests for domestic, mining, milling and irrigation purposes under applicable State or Federal law.

b. Weeks Act (16 U.S.C. §§ 480, 500, 513-19, 521, 552, 563). This act authorizes the Secretary of Agriculture to recommend the sale of forested, cut-over, or denuded lands in the watersheds of navigable streams as necessary to regulate the flow of navigable streams.

c. Clarke-McNary Act (16 U.S.C. § 568 *et seq.*). This act authorizes the Secretary of Agriculture to identify Federal lands that are primarily valuable for streamflow protection and that can be economically administered as part of the national forests.

d. Bankhead-Jones Farm Tenant Act (7 U.S.C. §§ 1010-1012). This act authorizes the acquisition of damaged or non-productive agricultural lands and requires development of a program of land conservation to control soil erosion, preserve natural resources, protect fish and wildlife, mitigate floods, conserve surface and subsurface moisture, and protect the watersheds of navigable streams.

e. Domestic Water Supply Act (16 U.S.C. §§ 552a-552d). This act provides for special management of watersheds on NFS lands to protect municipal water supplies.

f. Multiple Use-Sustained Yield Act (MUSY) (16 U.S.C. §§ 528-531). This act provides that watershed protection is one of the five co-equal purposes for which NFS lands were established and are to be administered.

g. Forest and Rangeland Renewable Resources Planning Act (FRRRPA) (16 U.S.C. § 1600 *et seq.*). This act emphasizes the need for Forest Service programs to protect and improve the quality of soil, water, and air resources on NFS lands. This act defines the NFS to include all national forest and grassland lands and other lands, waters, or interests therein, which are administered by the Forest Service. This act also requires the development and maintenance of a comprehensive inventory of all NFS lands and renewable resources, including water. Additionally, FRRRPA mandates consideration of the physical, biological, economic, and other applicable sciences in the development and maintenance of land management plans for units of the NFS.

h. Federal Land Policy and Management Act (FLPMA) (43 U.S.C. § 1701 e*t seq.*). This act authorizes issuance of rights-of-way for water diversions, including wells, on NFS lands. This act requires terms and conditions in authorizations for these rights-of-way to minimize damage to scenic and aesthetic values and fish and wildlife habitat and otherwise protect the environment, Federal property, and the public interest.

i. Safe Drinking Water Act (SDWA) (42 U.S.C. § 300f *et seq.*). This act provides for the safety of public drinking water supplies. The SDWA establishes safe drinking water standards and protects surface and groundwater supplies from contamination (FSM 7420). Pertinent sections include: Wellhead Protection (42 U.S.C. § 300h-7); Source Water Assessment (42 U.S.C. § 300j-13); Drinking Water Standards (42 U.S.C. § 300g-1(b)); and Underground Injection Control (42 U.S.C. §§ 300h–300h-5).

j. Clean Water Act (CWA) (33 U.S.C. § 1251 *et seq.*). This act provides for restoration and maintenance of the chemical, physical and biological integrity of waters in the United States (FSM 7430 and 7440). The CWA regulates the discharge of pollutants into waters through point sources. In addition, the CWA provides for management of non-point source pollution by States. Pertinent sections include Water Quality Standards and Implementation Plans (33 U.S.C. § 1313), Certification (33 U.S.C. § 1341), National Pollutant Discharge Elimination System (33 U.S.C. § 1342), and Permits for Dredged or Fill Material (33 U.S.C. § 1344).

k. Resource Conservation and Recovery Act (RCRA) (42 U.S.C. § 6901 *et seq.*). This act regulates the generation, management, transportation, treatment, storage, and disposal of waste materials, including hazardous waste (FSM 2130, 2160, and 7460).

l. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. § 9601 *et seq.*). This act authorizes the United States Environmental Protection Agency (EPA) and other Federal agencies, including the United States Department of Agriculture (USDA), to respond to actual and threatened releases of hazardous substances, pollutants, and contaminants (FSM 2160). CERCLA can be used to assign liability to potentially responsible parties (PRPs) for response and restoration costs, including cleanup of existing water contamination.

m. Surface Mining Reclamation and Control Act (SMCRA) (30 U.S.C. § 1201 *et seq.*). This act provides authority to the United States Department of the Interior, Office of Surface Mining (OSM), and other Federal agencies to mitigate the environmental, health, and safety effects of abandoned surface mines, primarily those used to recover coal resources.

2. Regulations, Executive Orders and Departmental Policy

a. National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR part 300). The NCP establishes procedures and standards for responding to oil spills and releases of hazardous substances, pollutants, and contaminants. The NCP implements the response and restoration provisions of the CWA, CERCLA, and the Oil Pollution Act (33 U.S.C. 2701, *et seq*.). The NCP also defines "natural resources" to include water, groundwater, and drinking water and designates the Federal Trustee for the natural resources located "on, over, or under" land administered by the United States as the responsible land management agency.

b. Compensatory Mitigation for Losses of Aquatic Resources (40 CFR Part 230). These regulations establish performance standards and criteria for the use of permittee-responsible compensatory mitigation, mitigation banks, and in-lieu programs to improve the quality and success of compensatory mitigation projects for activities authorized by Department of the Army permits (Corps of Engineers 404 permits). This rule improves the planning, implementation and management of compensatory mitigation projects by emphasizing a watershed approach in selecting compensatory mitigation project locations, requiring measurable, enforceable ecological performance standards and regular monitoring for all types of compensation and specifying the components of a complete compensatory mitigation plan, including assurances of long-term protection of compensation sites, financial assurances, and identification of the parties responsible for specific project tasks. These regulations have recently been extensively revised (73 Federal Register 19593-19705), but the revisions have not yet been incorporated into Forest Service policy and practice.

c. Executive Order 12580. This executive order delegates the President's authority under CERCLA to the Secretary of Agriculture to perform investigations, conduct response activities, seek cost recovery, enter into agreements with PRPs to perform investigations and conduct response actions, and issue unilateral administrative orders, subject to certain conditions and limitations, with respect to actual and threatened releases on lands administered by USDA. This executive order also delegates authority to the Forest Service, as natural resource trustee, to assess damages to natural resources on NFS lands, recover costs, and enter into agreements with PRPs to conduct restoration actions on NFS lands.

d. Executive Order 11990. This executive order requires Federal agencies to minimize the destruction, loss, and degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands in carrying out their responsibilities.

e. Executive Order 11988. This executive order requires Federal agencies to restore and preserve the natural and beneficial values of floodplains.

f. Executive Order 12088. This executive order requires Federal agencies to comply with applicable pollution control standards and to take all necessary actions for the prevention, control, and abatement of environmental pollution with respect to Federal facilities and activities under their control.

g. Executive Order 13423. This executive order requires Federal agencies to reduce the intensity of water consumption, implement environmentally sustainable practices affecting water quantity and quality, and implement environmental management systems to address the aspects of agency operations that affect the environment. This executive order also requires Federal agencies to ensure that all future written authorizations require the holder to address as appropriate provisions of the executive order that fall within the scope of their operations.

h. USDA Manual 5600-001 (DM 5600-001). This manual provides direction on prevention, control, and abatement of environmental pollution from all facilities and lands administered by USDA and activities conducted by USDA.

i. USDA Departmental Regulation 9500-8 (DR 9500-8). This Departmental Regulation provides direction for all USDA agencies on protection and enhancement of groundwater quality. DR 9500-8 provides for protection of water users and the natural environment from exposure to harmful substances in groundwater and enhancement of groundwater quality where appropriate through prudent use and careful management of potential contaminants and promotion of programs and practices that prevent contamination.

j. Forest Service Directives. FSM 2540 establishes procedures for complying with Federal policy and State water rights laws. FSM 2542 establishes procedures for management of watersheds on NFS lands with municipal water supplies. FSH 2509.16 establishes procedures for inventorying water resources. FSM 2880 provides direction on inventorying and monitoring groundwater resources. FSH 2709.11 establishes procedures for administering special uses.

B. Planning and Environmental Compliance

Policy and procedures for land management planning and environmental compliance activities are outlined in FSM Chapters 1920 and 1950 respectively. Depending on the "vintage" of the land and resource management plan for a NFS administrative unit, different requirements apply.

In general, most existing land and resource management plans within the NFS are consistent with the requirements of 36 CFR 219 promulgated in 1982. In these instances a two-staged decision process is used to comply with various statutes and regulations in the planning process. Land and resource management plan decisions identify where activities are excluded and provide standards and guidelines for activities and projects within certain areas. Project and activity decisions must either be consistent with the plan's requirements or propose an amendment to the plan.

Plans issued using the 2008 version of 36 CFR 219 provide a framework of plan components and desired condition descriptions. The regulations provide a different approach to meeting the requirements of the National Forest Management Act. In general, project and activity environmental compliance utilize plan components, including desired conditions and design standards to develop proposed actions, consider environmental consequences and decide on a course of action.

1. Statutes

The following laws set forth the requirements for Forest Service planning:

a. The National Environmental Policy Act (NEPA) of 1969 (16 U.S.C. 4321 et seq.). This act sets forth requirements to consider the environmental impact of proposed actions; identify adverse environmental effects which cannot be avoided; consider alternatives to the proposed action; consider the relationship between local short-term uses and long-term productivity; and identify any irreversible and irretrievable commitments of resources (FSM 1950).

b. The Forest and Rangelands Renewable Resources Planning Act (RPA) of 1974 (16 U.S.C. 1601 et seq.). This act directs the Secretary of Agriculture to periodically assess the national situation of the forest and rangeland resources. This assessment is called the Forest and Rangelands Renewable Resources Planning Act (RPA) assessment. See FSM 1906 and FSM 1910 for detailed requirements.

c. The National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1600 et seq.). This act amends the Renewable Resource Planning Act (RPA) and sets forth the requirements for plans (for the National Forest System). See FSM 1920 for specific requirements.

d. Forest and Rangeland Renewable Resources Research Act of 1978 (16 U.S.C. 1641 et seq.). This act directs the Secretary of Agriculture to include, as appropriate, research activities when managing forest and rangeland resources.

e. Cooperative Forestry Assistance Act of 1978 (16 U.S.C. 2101 et seq.). This act provides authority for financial, technical, and related assistance to states for forest resource planning.

f. Agriculture and Food Act of 1981 (7 U.S.C. 4201 et seq.; 16 U.S.C. 590, 3401 et seq.). Title XVI of this act requires joint planning of forestry research among the Forest Service; Cooperative State Research, Education, and Extension Service; and the Nation's 61 forestry schools.

g. The Government Performance and Results Act (GPRA) of 1993 (5 U.S.C. 306). This act provides for the development of agency long-term strategic plans, annual performance plans, and annual performance reports. The Forest Service Strategic Plan (Strategic Plan) provides the national framework for all agency operations and activities. The Strategic Plan uses information from the periodic Renewable Resource Planning Act (RPA) assessment of the Nation's forest and range resources.

h. Endangered Species Act of 1973 (ESA). (P.L. 93-205, 87 Stat. 884, as amended; 16 U.S.C. 1531-1536, 1538-1540). This act charges Federal agencies to utilize their authorities to achieve the purposes of the ESA by carrying out programs and activities for the conservation of endangered and threatened species and the ecosystems upon which they depend, and ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any endangered, threatened or proposed species, or result in the destruction or adverse modification of designated critical habitat.

2. Regulations, Executive Orders and Departmental Policy

a. Title 36, Code of Federal Regulations, Part 219, Subpart A. This regulation provides direction on land management planning procedures on National Forest System lands.

b. Title 40, Code of Federal Regulations, Sections 1500 through 1508.28. This regulation directs the Forest Service to apply environmental analysis to environmentally significant decision points during National Environmental Policy Act (NEPA) activities.

C. Resource Information Management

Requirements related to resource information management are extensive and apply to a wide variety of agency procedures and management functions. The Department of Agriculture and Forest Service Chief Information Officers have established policy and provide oversight of agency activities in this arena. Key resource information management concepts used in this business requirements analysis are summarized in Appendix C.

Forest Service Natural Resource Applications (FSNRA) such as the Natural Resource Information System, Infra, and the Automated Lands Project, provide agency-wide systems that comply with the CIO's requirements. Conformance with agency resource information management requirements in development of GDE inventory and monitoring protocols will be met by using existing data definitions, classification systems, information security provisions, and FSNRAs whenever possible.

Compliance with procedures established by the Forest Service CIO and FSM Chapter 1940 satisfies the provisions of the Data Quality Act and USDA implementing regulations as well as information security requirements associated with HSPD-7 regarding public water systems.

1. Statutes

Major statutory authorities that direct the overall management of information include:

a. Paperwork Reduction Act of 1980, as amended by the Paperwork Reduction Act of 1995 (44 USC 35). Directs Federal agencies to perform information resources management activities in an efficient, effective, and economical manner; to follow uniform and consistent information resources management policies; to apply information management principles, standards, and guidelines; to evaluate information resources management practices according to adequacy and efficiency; and to comply with policies, principles, standards, and guidelines promulgated by the Office of Management and Budget.

b. Federal Managers Financial Integrity Act of 1982 (31 USC 3512). Directs Federal agencies to design management structures to help ensure accountability for results and include appropriate cost–effective controls.

c. Government Performance and Results Act of 1993 (GPRA, P.L. 103-62). Establishes for Federal agencies the goal of integrating budget and performance by directing those agencies to establish performance plans containing indicators upon which measurement of success will occur; to ensure, to the extent practicable, information relevancy, accuracy, and timeliness; and to assess program performance primarily according to outcome goals, rather than output goals, including outcome goals associated with cost, understandable dissemination, and mission achievement.

d. Clinger-Cohen Act of 1996 (P.L. 104-106). Establishes that Federal agencies will manage information technology and information resources by using sound management principles, including project planning, and will improve the efficiency and effectiveness of

agency operations and the delivery of agency services through effective use of information technology.

e. Information Quality Act of 2001 (Data Quality Act, P.L. 100-554, section 515). Directs Federal agencies to ensure and maximize the quality, objectivity, utility, and integrity of information disseminated including statistical information, to ensure the information is useful, clear, and sound.

Major authorities specific to coordination and collaboration associated with resource inventory, monitoring, and assessments include:

f. Cooperative Funds Act of June 30, 1914 (16 USC 498 as amended by Public Law 104-127). This Act authorizes the Forest Service to accept money received as contributions toward cooperative work in forest investigations or protection, management, and improvement of the National Forest System (FSM 1584.11).

g. Granger-Thye Act of April 24, 1950 (16 USC 572). Section five of this Act authorizes the Forest Service to perform work to be done for the benefit of the depositor, for administration, protection, improvement, reforestation, and such other kinds of work as the Forest Service is authorized to do on lands of the United States: (a) on State, county, municipal, or private land within or near national forest land, or (b) for others who occupy or use national forests or other lands administered by the Forest Service.

h. Sikes Act of September 1, 1960 (16 USC 670g-6701, 670o, Public Law 86-797, as amended). This Act authorizes the Forest Service to cooperate with State wildlife agencies in conservation and rehabilitation programs for fish, wildlife, and plants considered threatened or endangered.

i. Intergovernmental Cooperation Act of 1968, as amended by the Intergovernmental Cooperation Act of September 13, 1982 (31 USC 6501-6508, Public Law 97-258). Title III of this Act authorizes the Forest Service to provide special or technical services to States or subdivisions of States.

j. Federal Advisory Committee Act (FACA) of 1972, as amended (5 U.S.C. Appendix 2). This Act regulates the establishment, use, and reporting of advisory committees.

k. Cooperative Funds and Deposits Act of December 12, 1975 (16 USC 565a1-a3, Public Law 94-148). This Act authorizes the Forest Service and partners to perform work from which they would accrue mutual non-monetary benefit.

l. Cooperative Forestry Assistance Act of 1978, as amended (16 USC 2101-2114, Public Law 95-313). This Act authorizes the Forest Service to work through and in cooperation with state foresters or equivalent agencies, and other countries in implementing technical programs affecting non-federal forest lands.

m. 1990 Farm Bill (PL 101-624). This Bill authorizes Federal financial assistance for forest pest prevention and suppression on forested lands in all ownerships for the purposes of promoting healthy sustainable forests, forest stewardship, and sustainable economic development.

n. Interior and Related Agencies Appropriations Act of 1992 (Public Law 102-154, (Challenge Cost Share)). This Act authorizes the Forest Service to cooperate with others in developing, planning, and implementing mutually beneficial projects that enhance Forest Service activities, where the partners provide matching funds or in-kind contributions. Partners may be public or private agencies, organizations, institutions, or individuals (FSM 1587.12). The Act also gives the agency the authority to provide non-monetary awards and to incur necessary expenses for the non-monetary recognition of individuals and organizations (FSM 6511.13e).

o. The Freedom of Information Act of 1966 (5 U.S.C. 552) as amended 1996 (P.L. 104-231, 1105 at 3048). This Act requires agencies of the Federal Government to make certain agency information available for public inspection and copying, and to establish access to the records of such agencies, subject to statutory exemptions, for any public or private purpose.

p. Secure Rural Schools and Community Self-Determination Act of 2000 (Public Law 106-393; also called "Payments to States"). This Act establishes resource advisory committees as a mechanism for local community collaboration on certain types of projects.

q. Stewardship Contracting, Revised 2003 (P.L. 108-7, 16 U.S.C. 2104 Note). This Act provides the Forest Service and the Bureau of Land Management ten-year authority to enter into stewardship contracts and agreements to promote collaborative working relationships with local communities, improve land conditions, and help develop sustainable rural economies.

r. Title 41, Code of Federal Regulations, Part 102-3 – Federal Advisory Committee Management Regulations (41 CFR part 102-3). This regulation defines policies, sets up minimum requirements, and provides guidance for the establishment, operation, administration, and duration of advisory committees subject to the Federal Advisory Committee Act, as amended.

Major authorities specific to resources include:

s. Organic Administration Act of June 4, 1897 (30 Stat. 34), as amended (16 U.S.C. 473 § § *et. seq.*). This Act authorizes the Secretary of Agriculture to establish regulations governing the occupancy and use of forests and to protect national forests from destruction. This Act contains the initial basic authority for watershed management on national forest lands. The purpose for the establishment of national forests, as stated in the Act, includes securing favorable conditions of water flows. The Act directs the completion of surveys to show distribution of the forests.

t. Weeks Law Act of March 1, 1911 (P.L. 61-435, Ch. 186, 36 Stat.961), as amended. Section six of the Act authorizes the Secretary of Agriculture to examine, locate, and purchase lands within the watersheds of navigable streams necessary to the regulation of the flow of navigable streams or for the production of timber.

u. Mineral Leasing Act, February 25, 1920 (P.L. 66-146, 41 Stat. 437), as amended. Section 8A of this Act authorizes the Secretary to conduct a comprehensive exploratory program to obtain sufficient data and information to evaluate the extent, location, and potential for developing the known recoverable coal resources within the coal lands subject to this chapter.

v. McSweeney-McNary Forest Research Act of 1928 (P.L. 70-466). This is enabling legislation for inventory, monitoring, and assessment activities in the Forest Service.

w. Fish and Wildlife Coordination Act of 1934 (Ch. 55, 48 Stat. 401, as amended; 16 U.S.C. 661, 662(a), 662(h), 663(c), 663(f)). This Act authorizes surveys and investigations of the wildlife of the public domain lands including lands and waters of interest therein acquired or controlled by any agency of the United States.

x. Federal Water Pollution Control Act of June 30, 1948 (P.L. 80-845; as amended; 33 U.S.C. 1251). This Act authorizes the conduct of investigations, surveys, and studies relating to the causes, effects, extent, prevention, reduction, and elimination of pollution.

y. Watershed Protection and Flood Prevention Act of August 4, 1954 (P.L. 566), as amended (68 Stat. 666, 16 U.S.C. 1001; FSM 1021.2). This Act authorizes the Secretary of Agriculture to cooperate with the States and their political subdivisions and local public agencies to conduct surveys and investigations of watersheds and rivers to prepare plans for works of improvement for watershed protection and flood prevention.

z. Fish and Wildlife Act, August 8, 1956 (P.L. 84-1024, Ch. 1036, 70 Stat 1119, 16. U.S.C. 742a, d, e, i and j). This Act authorizes the Secretary to conduct investigations and prepare periodical reports related to production and flow of fish to market and biological requirements of fish and wildlife resources.

aa. Multiple-Use Sustained-Yield Act of June 12, 1960. (16 U.S.C. 528-531; FMS 1021.2). The Secretary of Agriculture is directed to develop and administer the renewable surface resources of the national forests for multiple-use and sustained-yield of the several products and services obtained there from, with due consideration to the relative values of the various resources in particular areas and without impairment of the productivity of the land.

bb. Joint Surveys of Watershed Acres Act of September 5, 1962 (P.L. 87-639, 76 Stat. 438; 16 U.S.C. 1009). This Act authorizes the Secretaries of the Army and Agriculture to make joint investigations and surveys of watershed areas to identify works needed for flood prevention and control.

cc. Wilderness Act of 1964 (P.L. 88-577, 78 Stat. 890; 16 U.S.C. 1121 (note), 1131-1136). Section four of the Act requires each agency administering any area designated as wilderness shall be responsible for preserving the wilderness character of the area. To comply requires agencies to monitor and inventory wilderness attributes to identify and evaluate how selected actions and conditions related to wilderness character are changing. Administering agencies are to monitor compliance with the wilderness responsibility to preserve the wilderness character of an area designated as wilderness.

dd. Federal Water Project Recreation Act of July 9, 1965. (16 U.S.C. 460). This Act provides uniform policies for investigating, planning, and constructing Federal water projects to protect and enhance where possible, recreation and fish.

ee. Water Quality Act of 1965. (79 Stat. 903). This is an amendment to the Federal Water Pollution Control Act of July 9, 1956. It provides for the Federal Government to cooperate with State agencies or municipalities preventing or controlling pollution of waters over which they have jurisdiction (FSM 2542.3).

ff. Wild and Scenic Rivers Act of 1968 (P.L. 90-542, U.S.C. 1271-1287) as amended 1996. This Act establishes a National Wild and Scenic Rivers System for the protection of rivers with important scenic, recreational, fish and wildlife, or other values. Rivers are classified as wild, scenic, or recreational. The Act designates specific rivers for inclusion in the system and prescribes the methods and standards by which additional rivers may be added.

gg. Wild and Scenic Rivers Act of October 2, 1968 (P.L. 90-542) – Title 16, Conservation, Chapter 28. Section 1283). The head of any agency administering a component of the national wild and scenic rivers system shall cooperate with the Administrator, Environmental Protection Agency and with the appropriate State water pollution control agencies for the purpose of eliminating or diminishing the pollution of waters of the river.

hh. National Environmental Policy Act of 1969 (NEPA) (P.L. 91-190, 83 Stat. 852; U.S.C. 4321 (Note), 4321, 4331-4335, 4341-4347). Section 102 directs that all agencies of the Federal Government shall utilize a systematic, interdisciplinary approach to insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making, which may have an impact on the human environment. See Forest Service Handbook (FSH) 1909.14-Resource Inventory Handbook, and FSH 1909.15-National Environmental Policy Act Handbook, for Council on Environmental Quality (CEQ) regulations implementing NEPA. See 40 CFR sections 1502.3 and 1505.3 for regulations on monitoring decisions.

ii. Environmental Quality Improvement Act of April 3, 1970, as amended (P.L. 91- 224, Title II; P.L. No. 97-258, September 13, 1982; and P.L. No. 98-581, October 30, 1984. 42 USC § 4372). Section a...d(3) calls for reviewing the adequacy of existing systems for monitoring and predicting environmental changes in order to achieve effective coverage and efficient use of research facilities and other resources; and d(7) calls for collecting, collating, analyzing, and interpreting data and information on environmental quality, ecological research, and evaluation.

jj. Water Quality Improvement Act of 1970 (84 Stat. 91). Title I requires Federal agency compliance with water quality standards.

ll. Wild Horses and Burros Protection Act of December 15, 1971 (P.L. 92-195, as amended; 16 U.S.C. 1331-1338, 1338a, 1339, 1340). This Act directs the Secretary of Interior to maintain a current inventory of wild free-roaming horses and burros on given areas of public lands, for the purpose of making determinations as to existence of overpopulation, and to determine appropriate management levels on these areas of public lands.

mm. Federal Water Pollution Control Act amendments of October 18, 1972 (P.L. 92-500; 86 Stat. 816; 33 U.S.C. 1251 *et. seq.*). This amendment to the Clean Water Act has a primary objective to restore and maintain the chemical, physical, and biological integrity of the Nation's waters, including water quality that is both "fishable and swimmable." Federal and State agencies are directed to develop comprehensive programs for prevention, reduction, or elimination of water pollution.

nn. Endangered Species Act of 1973 (ESA). (P.L. 93-205, 87 Stat. 884, as amended; 16 U.S.C. 1531-1536, 1538-1540). This act charges Federal agencies to utilize their authorities to achieve the purposes of the ESA by carrying out programs and activities for the conservation of endangered and threatened species and the ecosystems upon which they depend, and ensure that any action authorized, funded, or carried out by the agency is not

likely to jeopardize the continued existence of any endangered, threatened or proposed species, or result in the destruction or adverse modification of designated critical habitat.

oo. Forest and Rangeland Renewable Resources Planning Act of 1974 (P.L. 93-378, 88 Stat. 476, as amended; 16 U.S.C. 1601 (Note), 1600-1614). This Act directs the Secretary of Agriculture to periodically assess the national situation of the forest and rangeland resources, and to submit to Congress, at regular intervals, recommendations for long-range Forest Service programs essential to meet future resource needs. This assessment is called the Forest and Rangelands Renewable Resources Planning Act (RPA) assessment. The law requires a comprehensive and appropriately detailed inventory of all National Forest System lands and renewable resources be maintained on a continuing basis (section five).

pp. Safe Drinking Water Act of December 16, 1974 (P.L. 93-523). This Act and all applicable amendments provide for safe drinking water and direct the Environmental Protection Agency (EPA) to establish national drinking water regulations. The Act directs the identification of protection areas, and the preparation of impacts on quality and quantity of groundwater, requiring inventory of source areas.

qq. Federal Noxious Weed Act of 1974 (January 3, 1975, P.L. 93-629, as amended, 81 Stat. 2148; 7 U.S.C. 2801 (note), 2801-2814). This Act directs the management of undesirable plants on Federal lands, requiring Federal agencies to establish an undesirable plants management program. Departmental policy requires providing periodic land and aquatic resource inventories compatible among agencies to identify and classify noxious weeds and their infestations.

rr. National Forest Management Act of 1976 (P.L. 94-588, 90 Stat. 2949, as amended; 16 U.S.C. 472a, 476, 500, 513-516, 518, 521b, 528 (Note), 576b, 594-2 (Note), 1600 (Note), 1601 (Note), 1600-1602, 1604, 1606, 1608-1614). Sections two 2, 6(f)(3), and 6(g)(2), emphasize the stipulations of the Renewable Resources Planning Act of 1974. The Act also requires that the Forest Service establish quantitative and qualitative standards and guidelines for land and resource planning and management. The Act directs the Forest Service to "insure research on and (based upon continuous monitoring and assessment in the field) evaluation of the effects of each management system...."

ss. Federal Land Policy and Management Act of 1976 (P.L. 94-579, 90 Stat. 2743, as amended; 43 U.S.C. 1701 (Note), 1701, 1702, 1712, 1714-1717, 1719, 1732b, 1740, 1744, 1745, 1751-1753, 1761, 1763-1771, 1781, 1782; 7 U.S.C. 1212a; 16 U.S.C. 478a, 1338a). This Act requires that public lands and their resources be periodically and systematically inventoried, and that an evaluation of the current natural resource use and values be made of adjacent public and nonpublic land.

tt. Soil and Water Conservation Act of 1977 (P.L. 95-192, 91 Stat. 1407; 16 U.S.C. 2001-2009). This Act authorizes the Secretary of Agriculture to obtain and maintain information of the current status of soil, water, and related resources. The Act further requires an integrated system capable of using combinations of resource data to determine the quality and capabilities for alternative uses of the resource base and to identify areas of local, State, and national concerns.

uu. Clean Water Act of 1977 (December 27, 1977, 91 Stat. 1566, P.L. 95-217) and the 1977 amendments, December 1977, NO. 95-12. Title 33 Navigation and Navigable Waters, Chapter 26 Water Pollution Prevention and Control. Section 1256 prohibits grants to States

without established water quality monitoring procedures. Section 1271 directs the Administrator and Secretary to conduct a program of monitoring and assessing aquatic sediment quality, and to identify and assess sources, extent and effect of aquatic sediment pollutants. Section 1288 directs the development of Best Management Practices programs

vv. Forest and Rangeland Renewable Resources Research Act of 1978 (P.L. 95-307, 92 Stat. 353, as amended; 16 U.S.C. 1600 (Note), 1641-1647). This Act directs the Secretary of Agriculture to make and keep current a comprehensive survey and analysis of the conditions and requirements of the forests and rangelands of the United States.

xx. Public Rangelands Improvement Act of 1978 (P.L. 95-514, 92 Stat. 1806; 43 U.S.C. 1752-1753, 1901-1908; 16 U.S.C. 1333(b)). Section four directs the Secretary of Agriculture to maintain a current inventory of range conditions and trends of rangeland conditions on the public rangelands.

zz. Fish and Wildlife Conservation Act of September 29, 1980 (P.L. 96-366, 96 Stat. 1322, 16 U.S.C. 2901 (note), 2901-2904; 16 U.S.C. 2905-2911). This Act encourages States to develop a plan for the conservation of fish and wildlife, particularly those species indigenous to the State. The Act recommends these plans provide for an inventory of the nongame fish and wildlife and provide for the monitoring, on a regular basis, of the plan species and the effectiveness of conservation actions.

aaa. Forest Ecosystems and Atmospheric Pollution Research Act of 1988 (P.L. 100-521, 102 Stat 2601; 16 U.S.C. 1642 (Note). Section three directs the Forest Service to increase the frequency of forest inventories in matters that relate to atmospheric pollution and conduct such surveys as are necessary to monitor long-term trends in the health and productivity of domestic forest ecosystems. This is also enabling legislation for the Forest Health Monitoring (FHM) program.

bbb. Healthy Forest Restoration Act of 2003 (117 Stat 1887, 16 U.S.C. 6501 (note)). Title VI requires the Secretary of Agriculture to establish an “early warning system” for potential catastrophic threats to forests (including insect, disease, invasive species, fire, weather-related risks, and other episodic events) to isolate and treat a threat before it gets out of control.

2. Executive Orders, Regulations and Departmental Policy

a. Executive Order 11991, (May 24, 1977) (Amended Executive Order 11514 of March 5, 1970). Directs Federal agencies to monitor, evaluate, and control, on a continuing basis, their agencies’ activities so as to protect and enhance the quality of the environment.

b. Executive Order 11990 (May 24, 1977), (42 FR 26961, 3 CFR, 1977). Requires each agency to take action to minimize destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands.

c. Executive Order 12962, June 7, 1995. Establishes the National Recreational Fisheries Coordination Council and directs the Council to develop a Recreational Fishery Resources Conservation Plan. This plan details actions to be taken by identified Federal agencies and includes a method of ensuring agency accountability and comprehensive mechanism to evaluate achievements. The plan will, to the extent practicable, be integrated with existing plans and programs, reduce duplication, and will include recommended actions for

cooperation with States, Tribes, conservation groups, and the recreational fisheries community.

d. Executive Order 12088, (October 13, 1978, amended Jan. 23, 1987, EO 12580). Establishes agency responsibility for ensuring prevention, control, and abatement of environmental pollution with respect to Federal facilities and activities under the control of the agency.

e. Executive Order 12906 – Coordinating Data Acquisition and Access (59 FR 71, p. 17671, April 13, 1994) as amended by Executive Order 13286 (68 Fed Reg 43, p. 10619, March 5, 2003): Directs Federal agencies to document in a standardized manner all new geospatial data collected or produced. Directs the Federal Geographic Data Committee (FGDC) to establish documentation standards for geospatial data, and directs Federal agencies to provide public access to geospatial data, to the extent permitted by law and current policies, according to procedures established in conjunction with the FGDC.

f. Homeland Security Presidential Directive (HSPD) 7. Requires certain Federal agencies to identify and prioritize critical national infrastructure and resources for protection from terrorist acts that could cause catastrophic health impacts or mass casualties; undermine public confidence; or disrupt essential government functions, essential services, or the economy. HSPD-7 designates EPA as the Sector-Specific Agency for the Water Sector. Disclosure of information related to public water systems authorized or permitted on NFS lands is subject to the implementing regulations.

g. Title 36, Code of Federal Regulations, Section 200. Describes the agency functions towards which inventory, monitoring, and assessment activities are directed.

h. Title 36, Code of Federal Regulations, Section 212. Establishes that responsible officials at local units, shall monitor the effects of motor vehicles on the environment, consistent with the applicable land management plan.

i. Title 36, Code of Federal Regulations, Section 219. Establishes the evaluation and monitoring requirements associated with land management planning, including, establishing three types of evaluations, roles for inventory and assessment activities in those evaluations, the expected commensurability between evaluations and expected risks or benefits, and requiring a plan monitoring program that addresses four specific purposes.

j. Title 36, Code of Federal Regulations, Section 222. Requires analysis of range allotments and that such analyses occur jointly with affected individuals and groups.

k. Office of Management and Budget Final Government-wide Information Quality Guidelines, February 1, 2002. Implements section 515 of the Treasury and General Appropriations Act for fiscal year 2001 (P.L. 106-554) by requiring each agency to establish implementing guidelines for ensuring and maximizing the quality, objectivity, utility, and integrity of information, including statistical information, disseminated by Federal agencies.

l. Memorandum M-05-03, Office of Management and Budget. Establishes that important scientific information shall be peer reviewed by qualified specialists before dissemination by the Federal Government, including before disseminating influential scientific information or results from scientific assessments, and that each agency shall have the discretion to select a particular peer review mechanism based on benefits and costs of the review options,

including the option of relying on existing findings of the National Academy of Sciences or on findings published in a refereed journal.

D. Summary

This collection of management requirements applicable to GDE's can be summarized into the following general objectives:

1. Support an affirmative agency obligation to protect, conserve, and restore waters, watersheds, listed wildlife and plant species and their habitats, and to conserve biological diversity.

2. Assess and disclose environmental effects associated with ongoing and proposed actions and activities.

3. Use the best available information and science to support agency decision making. Collect and maintain resource data with known data standards and data quality for use in agency decision making processes. Provide for information security.

The basic relationships of these management requirements are illustrated in Figure 4.

Figure 4 - Management Requirement Relationships

1. Protect, Conserve and Restore
- **Waters**
  - Groundwater Discharge Ecosystems
- **Listed Species and Habitats**
  - Aquatic Biota
  - Riparian Vegetation
- **Biological Diversity**
  - T&E and Sensitive Species (1982 Rule)
  - Species of Concern/Interest (2008 Rule)

2. Planning/Environmental Compliance
- **Ongoing Activities**
  - Monitoring Project/Activity Implementation
  - Mitigation/Design Effectiveness
  - Validation Monitoring
- **Proposed Actions**
  - Pre-NEPA Assessment (Left-Hand Side)
  - Design and Mitigation Measures
  - Activity Effects (Risk/Uncertainty)

3. Utilize Best Available Information and Science

USDA/FS Data Quality Standards
- Information Resources Investment Procedures
- CIO Application/Protocol Development Standards (FSM 1940, etc.)

Documented Data Standards and Data Collection Procedures
- Utilize Corporate Data Standards (TEUI, AEUI, Existing Veg. Classification, FIA/CSE)
- Geo-referenced Data and Coverage/Federal Geographic Data Committee (OMB) Standards
- Groundwater Discharge Ecosystems Inventory and Monitoring Protocol

-FS Resource Information Systems
- FS Natural Resource Applications (NRIS, Infra, ALP)
- National FS Research Library

Requirements for resource information and data management establish a foundation for the use of data in Forest Service business processes and provide for standardized approaches to data quality, data standards, and data systems within the agency.

IV. Inventory and Monitoring Intensity

Inventory and monitoring intensity levels are used to describe the relative effort and detail associated with data collection for different business needs. As described in previous sections, the use of different intensity levels provides the ability to develop GDE inventory and monitoring protocols using a modular, nested approach.

Inventory levels are used by a variety of groundwater protocols (e.g., Sada and Pohlmann 2006) for similar purposes. Unfortunately, although these protocols are labeled using a similar numbering scheme, specific procedures and underlying requirements do not mean they address equivalent business requirements.

A. Data Analysis and Evaluation

Two principal forms of analysis and evaluation are generally conducted in association with GDEs:

1. The characterization and function of an individual GDE feature, and
2. The assessment and evaluation of a feature's relationship to and support of ecological systems within an assessment area.

1. GDE Characterization and Classification[1]

Because many management questions span jurisdictional boundaries, the ability to organize data and conduct analyses across administrative boundaries is also a consideration. One of the principal tools used to compare data on GDEs is the use of classification systems.

The characterization of a GDE feature using an adopted classification system is often used to help understand its ecology and function. Classification systems have evolved to support a variety of business needs and are used to interpret basic field data consistently between different GDEs in different locations and jurisdictions. Data inputs needed to use these classification systems for analysis and comparison are important considerations in the development of GDE inventory and monitoring protocols.

An examination of the data inputs necessary to use these classification systems for understanding and comparing GDEs within and between administrative units or different land ownerships will assist in identifying data collection priorities.

Below is a summary of the principle classification systems in use and data inputs used in each classification. Following the summary, Table 4 provides a comparison of data inputs necessary to utilize various classification systems.

a. Cowardin, et al. (1979) Classification of Wetlands

The Cowardin et al. (1979) classification of wetlands is a hierarchical classification. The following table summarizes levels used within this hierarchy:

[1] The information presented below is based on the classifications in the original publications as well as summaries of the classifications found in "Wetlands" by Mitsch and Gosselink (2007).

Level	Categories or Description
Systems	Marine, Estuarine, Riverine, Lacustrine, and Palustrine based on physiogeographic location
Subsystems	There are 0 to 4 for each System based on physiogeographic location
Classes	Varies by subsystem and are defined by substrate material and flooding regime, or on vegetative life form (subclasses can also be defined)
Modifiers	Developed by individual users of the classification based on water regime, water chemistry, and soil information. Dominant plant species (dominance types) can also be used to further classify.

This system was used as the foundation for the Forest Service's "Hierarchical Framework of Aquatic Ecological Units" (Maxwell et. al. 1994). The Forest Service hierarchy expands the Cowardin classification which has been adopted by the Federal Geographic Data Committee as its standard.

The Palustrine System of Cowardin et al. (1979) is the most applicable to GDE protocol development. "The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%" as well as some non-vegetated wetlands. The Palustrine System has no subsystems. The class level avoided "terms such as such as marsh, swamp, bog, and meadow…because of wide discrepancies in the use of these terms."

The Palustrine System has the following 8 classes:

1. Rock Bottom
2. Moss-Lichen Wetland
3. Unconsolidated Bottom
4. Emergent Wetland
5. Aquatic Bed
6. Scrub-Shrub Wetland
7. Unconsolidated Shore
8. Forested Wetland

Data required to classify a wetland according to the Cowardin et al (1979) classification are:

- Location or physiographic setting (marine, riverine, etc.)
- Substrate (general)
- Vegetation (dominant life form)

b. Canadian Wetland Classification System

The Canadian Wetland Classification System (National Wetlands Working Group 1997) contains three hierarchical levels: (1) class, (2) form, and (3) type. Five classes are recognized on the basis of the overall genetic origin of wetland ecosystems. Forms are differentiated on the basis of surface morphology, surface pattern, water type and morphology of underlying mineral soil. Types are classified according to vegetation physiognomy.

Data required to classify a wetland using the Canadian Wetland Classification include:

- Water table elevation, general information such as presence of surface water
- Location or physiographic setting (marine, riverine, etc.)
- Water characteristics: whether rich in dissolved minerals (minerogenous or groundwater-dependent) or not (ombrogenous or precipitation dependent); alkalinity
- Peat accumulation
- Vegetation types (bryophytes, graminoids, trees, shrubs, forbs, and submerged or floating aquatic plants)

c. Springer, et al. (2008) Springs Classification System

This system for classification of springs by Springer et al. (2008) is based on a number of criteria, which they list in Appendix 4.1. The major categories of characteristics that need to be determined to classify springs are:

Data Category	Characteristics
Geomorphic Considerations	a. Hydrostratigraphic unit type (sedimentary, igneous, metamorphic, mixed) b. Emergence environment (cave, sub-glacial, etc.) c. Orifice geomorphology d. Sphere of discharge e. Spring channel dynamics
Flow Characteristics	a. Persistence b. Flow consistency c. Flow rate d. Flow variability
Water Quality	a. Water temperature b. Geochemistry
Ecological	a. Habitat (Synoptic climate, surrounding ecosystems, biogeographic location, habitat size, microhabitat diversity) b. Biota (species composition, vegetation, faunal diversity)
Management	Management activities affecting the spring

Significant data on the five categories listed above are required to classify springs using this system.

d. Hydrogeomorphic Classification (HGM) by Brinson (1993)

The HGM classification is based on geomorphic and hydrologic properties of wetlands. The classification does not consider vegetation, although vegetation is often an indicator of the abiotic properties that are used. HGM has three core components to the classification:

Data Category	Characteristics
1. Geomorphology	Depressional, riverine, fringe, and extensive peatlands
2. Water Source	Precipitation, surface or near-surface flow and groundwater discharge
3. Hydrodynamics	Direction and strength of water movement within a wetland

Of the three components of wetlands listed above, the first (geomorphology) is relatively easy to determine. The other two components -- dealing with hydrology – would likely be more difficult to determine and could require significant field data.

e. US Army Corps of Engineers Wetlands Delineation Manual (1987)

This Manual (US Army Corps of Engineers 1987) is used to determine whether a site is a jurisdictional wetland. A wetland must have hydrophytic vegetation, hydric soils, and wetland hydrology to qualify as jurisdictional. Determinations for each factor and necessary data inputs are described as:

Vegetation: It is necessary to establish whether the prevalent vegetation is hydrophytic vegetation. This requires a measure of the abundance of the dominant plant species at a site.

Soils: It must be determined whether hydric soils are present. This requires evaluation of the soil (surface and/or profile) to determine if there are features indicative of saturated soil conditions.

Hydrology: It must be determined whether the site is periodically inundated or has soils saturated to the surface at some time during the growing season. A variety of characteristics can be identified to determine wetland hydrology, which includes observations at the site or recorded data (such as gage data).

g. Fen Classification Systems

The following regional fen classifications have been identified:

- Fens of Grand Mesa, Colorado: Characterization, impacts from human activities, and restoration (Austin 2008)
- Fens of Yellowstone National Park, USA: Regional and local controls over plant species distribution (Lemly 2007)

These studies classified fens for a given area, but they do not provide classifications that can be readily applied to other sites.

Table 4 - Summary of data requirements for various classification systems.

Data Category	Attribute Description
Hydrology	General - Location information - Physiographic setting (marine, riverine, etc.) Physical description - Hydrology - Water table elevation - Water characteristics (dissolved minerals, alkalinity, etc.) - Flow characteristics - Water quality - Water source - Hydrodynamics - If wetland hydrology
Geology and Soils	Substrate (general) Peat accumulation Geomorphic considerations related to springs (including sphere of discharge) If hydric soils (hydrologic indicators) Soil characteristics
Ecological	Vegetation - Dominant life form - Types (bryophytes, graminoids, trees, shrubs, forbs, and submerged or floating aquatic plants) - Species list - Species abundance (cover, basal area, etc.) - Hydrophytic (wetland vegetation) or not Aquatic biota - Presence - Abundance
Management	Management activities and impacts

2. Assessment and Evaluation of GDEs

The second type of analysis involves understanding the context of individual GDE features and how they and other GDEs function and sustain ecological systems. Assessment of the biological significance and role of a feature in sustaining biological diversity is a common business need within the NFS.

The Nature Conservancy has developed a methods guide for integrating groundwater needs of ecosystems and species into conservation planning (Brown et al. 2007). "TNC's Methods Guide" identifies a variety of data and information inputs needed to identify the types and locations of GDEs at a coarse scale across the landscape

Collection of data needed to conduct assessments using TNC's Methods Guide or similar approaches will strengthen understanding of GDEs and the function of ecological systems dependent on groundwater. These assessments are usually conducted within a defined watershed or groundwater system.

Table 5 illustrates principal data inputs identified in TNC's Methods Guide.

Table 5 – Data inputs needed for assessment of GDE relationships to sustaining biological diversity using TNC's Methods Guide

Data Category	Attribute Description
Hydrologic Regime	- Quality and quantity (timing, location and duration) of water delivery
Water Chemistry & Temperature	- Water quality or specific water chemistry - Water temperature regime
Hydrogeologic Setting	- Topography and slope of land surface in the watershed - Composition, stratigraphy, and structure of subsurface geological materials in the watershed and underlying the ecosystem - Position of the ecosystem in the landscape with respect to surface and subsurface-groundwater flow patterns - Aquifer recharge zones
Ecological Setting	- Wetlands - Springs - Lakes - Streams
Groundwater-Dependent Species	- Groundwater-dependent species present - Habitat restricted to locations with groundwater discharge or maintained or associated with groundwater discharge or a shallow water table - Water chemistry or quality conditions provided by or influenced by groundwater

Many of these data are analyzed within a geographic information system which requires analytical skills beyond traditional expertise in ecology and hydrogeology to execute.

A variety of condition assessment methods exists and can be used to compare conditions between different GDE features of the same type. Observed or measured data are the

preferred inputs to these condition assessments vs. interpreted classes or ratings because they can be repeated more accurately over time and between different sites.

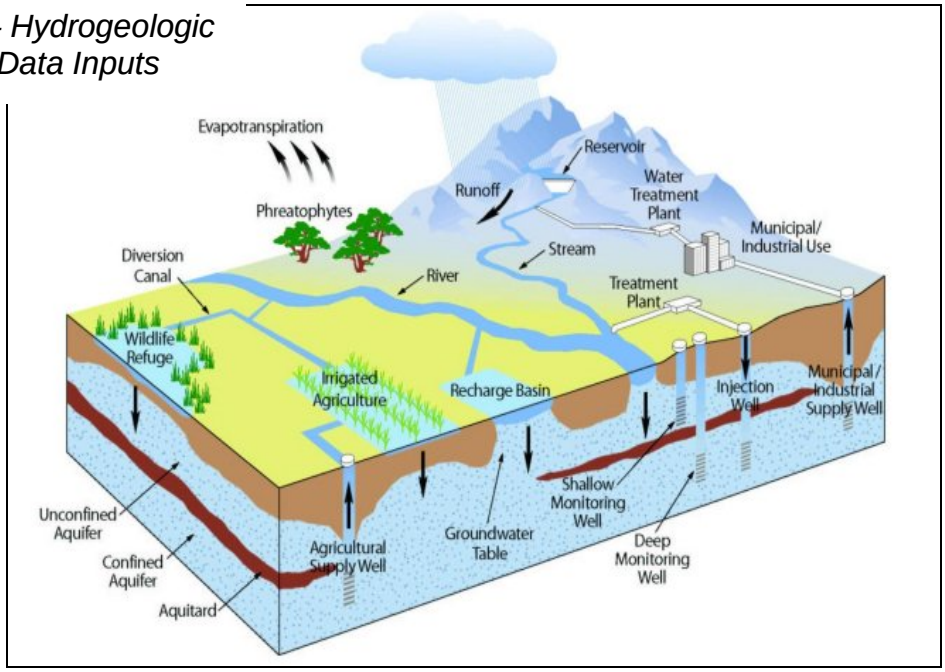
Data inputs needed to utilize complex groundwater models and linked groundwater-surface water models must also be considered. A number of methods may be employed to model groundwater systems both separately and explicitly linked with surface waters; however, they can require extensive common data inputs. The primary differences involve scale and numerical methods, which affect the required data resolution. Table 6 summarizes these data inputs.

Table 6 – Data inputs commonly required for groundwater models

Data Category	Attribute Description
Hydrogeologic Setting	- Detailed hydrography for area of interest - Detailed ground surface elevation for area of interest - Borehole stratigraphic information for area of interest - Groundwater head information for area of interest - Data or estimates of hydrogeologic parameters for each hydrostratigraphic unit (porosity, hydraulic conductivity, storage, saturated thickness, etc.) - Stream flow, precipitation, and estimates of evapotranspiration and/or groundwater recharge for area of interest
Soils	- Detailed soils, including type, extent, and depth of hydric soils
Disturbances & Land Use	- Road and other constructed feature locations, including reservoirs and wells, with information on their effects on the hydrology for area of interest

Figure 5 illustrates common processes within the hydrologic cycle and data inputs used in hydrogeologic monitoring.

Figure 5 – Hydrogeologic Modeling Data Inputs



The determination of environmental water requirements needed to sustain ecological systems and species can be determined using an estimate of the water budget or key indicators or parameters can be used to estimate those requirements. A variety of data inputs could be used in the determination of environmental water requirements. These data inputs are described in row 1 of Table 6 and row 1 of Table 7 and are based on preliminary work associated with the Antelope Allotment pilot study in Region 6 being conducted in partnership with The Nature Conservancy.

Table 7 – Data inputs required for determining environmental water requirements for a GDE

Data Category	Attribute Description
Hydrologic budget of the GDE (see Figure 5)	- Volume and timing of water inputs to the GDE as groundwater discharge, precipitation, surface water inflow - Volume and timing of water lost from the GDE as groundwater recharge, surface water outflow, and evapotranspiration - Volume and timing of water withdrawals or inputs due to anthropogenic activities (e.g., watering cattle)
Groundwater System Characteristics	- Characterization of the contributing surface and ground watershed land surface types, vegetation, and land uses
Hydrologic regime within the GDE	- Position of water table over time - Locations, extent, and timing of groundwater discharges
Hydrologic requirements of groundwater-dependent species	- Water table fluctuation thresholds for indicator plant species (especially forbs and sedges) - Water table fluctuation thresholds for obligately dependent animal species (e.g., amphibians, invertebrates)

B. Intensity Level Definitions and Procedural Template

Forest Service GDE inventory and monitoring protocols are structured into three intensity level categories. The levels and their general purposes are described in Table 8.

There are also practical logistical considerations associated with the organization of inventory and monitoring activities by intensity level. In general, many managers and specialists focus on field data collection as the primary activity associated with this work. In actuality only half of the total cost is associated with field data collection. The other half of the cost comes from setting goals, selecting an appropriate inventory design, training, quality assurance and control, administration, and most importantly, the analysis and evaluation of the data collected.

Because of this tendency, inventory and monitoring activities associated with each level will utilize a common procedural template. This template assists with the identification of activities and skills required to accomplish all phases of inventory or monitoring ensuring that budget requests or cost estimates provide a complete ‘package’ and do not focus solely on field data collection. Table 9 illustrates the template that will be used during protocol development. This template integrates Level I and Level II activities.

The use of this template provides flexibility needed for field crews to employ the appropriate protocol if the preliminary GDE type identification is incorrect or if a non-GDE feature is encountered.

Table 8 - Inventory and monitoring Intensity level descriptions

Intensity Level	Description and General Purpose
I	Conducted to qualitatively characterize GDEs within an administrative unit or ecological unit. GDE location and extent are documented and spatially referenced. Data collected serves as the basis for determining when GDEs may be affected by proposed actions or activities. Office-based data and image analysis coupled with field data collected assist in the conservation and protection of GDE resources by providing the location, condition and basic characteristics of the GDEs.
II	Data and information collected serve as the foundation for planning and environmental compliance during the design and assessment of project and activity effects. Information is used to describe major attributes including: hydrogeologic setting, aquatic biota, aquatic and riparian plant communities, and disturbances affecting the GDE and associated resources. Data can be used to determine ecological significance of the GDE when combined with similar data for other features and other characteristics of the assessment area. Data is used in association with projects and activities to protect, conserve, or restore GDEs by developing information used to describe the affected environment, design proposed actions (design measures), describe project effects, including a characterization of risk and uncertainty, monitoring requirements, and to provide decision support.
III	Data collection is usually conducted in relation to a major activity or set of activities affecting GDE's and their associated resources. The protocol compiles highly quantitative information that describes spatial and temporal variation in physicochemical, biological, and other characteristics associated with GDEs. The data or analyses of data are often used in the administration of projects or activities and may involve monitoring of specific attributes or conditions, audits of compliance and effectiveness of design and conservation measures, and information used for compensatory measures or restoration costs.

Table 9 - GDE inventory and monitoring procedural template

Phase	What	Where	Activity Description/Data Elements
1	Goal-Setting and Inventory Design	Office	- Management goals for inventory - Management questions needing answers - Design inventory and select protocol(s) appropriate to answer questions and meet goals - Determine scope of project: ecosystems, geographic areas, administrative units, timeframes - Coordinate with other agencies, other Forest Service units
2	Site Selection	Office	- Identify Preliminary Feature Location(s) via remote sensing, aerial photo interpretation, or other means - Inventory Scheduling or Sampling Scheme - Travel and Access Requirements - Resource Photography/Primary Base Series Maps/Locally Generated Maps
3a	Preliminary Site Characterization	Office	- Preliminary GDE Type designation - Preliminary Hydrogeologic Setting - Watershed (HUC), River Basin (NHD) - Eco-region/Section/Subsection - General geology, e.g., geomorphology/landform, structure, parent material - General climate, e.g., Precipitation patterns and influences, temperature regime - Elevation, Aspect, Slope Position - Activities, Disturbances and Adjacent Land Uses
3b	Site Characterization	Field	- Validate Preliminary Site Characterization; collect other Site Characterization information
4	Quality Control & Assurance	Field and Office	- Field crew training and identification guides - Field data forms, data recorder templates, pick lists, and error checks - Repeat sampling and spot-checks of sites for data accuracy and precision
5	Data Collection	Field	- Field measurements and observations - Photo transects and photo points - Water and other samples
6	Sample and Data Analysis	Lab or Office	- Analysis of water, soil, and other samples - Calculation of site statistics (average cover, total live cover, diversity indices, etc.) - Calculation or derivation of assessment values
7	Data Entry	Office	- Transfer Field Data to Appropriate Forest Service Natural Resource Applications
8	Evaluation and Reporting	Office and Field	- Report to management addressing management goals and questions (see Phase 1) - Report to partners and associated agencies, including data transfer - Report analysis results to other interested parties (EPA, States, NGOs, etc.) - Report GDE features to NHD and others for mapping, etc. - Coordination with Forest Service Research and Development - Field demonstrations for partners, interested groups, congressional staff, etc.

This template will be used to describe the activities and data collection associated with each inventory and monitoring intensity level, and where necessary by GDE feature type.

Phases described are not ordered within a strict temporal sequence. For example Data Entry, Phase 6 may not occur prior to Sample and Data Analysis, Phase 8. Similarly, the results of Quality Control and Assurance, Phase 4 ,may alter a number of other activities, including Goal Setting and Inventory Design, Phase 1.

As a general rule, the intensity of inventory or monitoring is determined based on the management questions being addressed. Approximations of the amount of field data collection associated with each intensity level are described in Table 10.

Table 10 – General guidelines regarding field data collection by intensity level

Intensity Level I	Intensity Level II	Intensity Level III
- Substantial work is completed in the office and includes analysis of existing data, image/photo analysis and mapping. - Data collection is accomplished in 2-3 hours or less per GDE site. - Two to three sites are expected to be inventoried per day unless extensive travel is involved.	- Data collection is accomplished in 4-6 hours. Data may be collected at multiple points in time using a sampling system to determine overall trends for an area of interest or type of GDE feature. - Travel time will generally limit the number of sites inventoried to one per day.	- Multiple inventory and monitoring activities are expected in association with project and activity planning and administration. Data often collected at several to many points in time, over a year or at longer intervals. - The complexity of the environmental issues associated with a project or activity, as determined by the Responsible Official, will dictate the total time needed.

V. Management Questions

Management questions, which include environmental issues, monitoring questions, and management concerns, are organized using the Forest Service's Monitoring and Evaluation (M&E) Framework (US Forest Service 2007) themes and sub-themes.

A distinct relationship exists between management questions and GDE inventory and monitoring intensity levels. Data and information typically collected consists of four distinct types:

- **A** Observations of general conditions or settings
- **B** Presence/Absence of key species, features, or activities
- **C** Data Collected using defined measurement methods and standards
- **D** Information collected using an audit or review procedure

The detailed business requirements analysis identified the general relationship between the type of information collected for an expanded set of M&E sub-themes business requirements and intensity levels for GDEs. This relationship is illustrated in Table 11.

Table 11 - Relationships between business requirements and intensity levels

<table>
<tr><th>M&E Sub-Theme</th><th>Intensity Level I</th><th>Intensity Level II</th><th>Intensity Level III</th></tr>
<tr><td>Watershed Health</td><td>C</td><td rowspan="2">C</td><td rowspan="3">C</td></tr>
<tr><td>Vegetation Diversity</td><td rowspan="2">B</td></tr>
<tr><td>Species Diversity</td></tr>
<tr><td>Invasive Species</td><td rowspan="14">A</td><td rowspan="14">B</td><td rowspan="11">D

Highly Variable Depending on the Activity or Project Involved</td></tr>
<tr><td>Wildland Fire</td></tr>
<tr><td>Insects/Pathogens</td></tr>
<tr><td>Other Disturbances</td></tr>
<tr><td>Timber/Biomass Removal</td></tr>
<tr><td>Recreation Use/Mgmt.</td></tr>
<tr><td>Range/Livestock</td></tr>
<tr><td>Water Use/Diversions</td></tr>
<tr><td>Minerals/Energy</td></tr>
<tr><td>Special Uses</td></tr>
<tr><td>Adjacent Land Uses</td></tr>
<tr><td>Roads and Trails</td></tr>
<tr><td>Recreation Facilities</td></tr>
<tr><td>Fences/Structures</td></tr>
</table>

The business requirements analysis identified that the development of standardized protocols for Intensity Level III is likely to be problematic given the wide range of requirements encountered and may be limited to the development of guidelines for:

1) Determining environmental water requirements and
2) Conducting inventory and monitoring for specific sets of projects or activities.

It is also apparent from this analysis that several M&E Framework sub-themes may be collapsed into more general groupings. Three GDE sub-themes were developed using the similarity of management questions and type of data collected to address those questions.

Sub-theme groupings used in the GDE protocol development and their relationship to the M&E sub-themes and additional sub-theme categories used in the detailed analysis are shown in Table 12.

Table 12 - GDE sub-theme relationship to M&E Framework sub-themes

GDE Sub-Theme	M&E Sub-Themes	Sub-Categories of Other Disturbances Considered
Ecological Context	Vegetation Diversity Species Diversity	
Hydrologic Setting	Watershed Health	
Natural and Anthropogenic Disturbance Processes	Other Disturbances → Invasive Species Wildland Fire Insects/Pathogens Roads and Trails	Timber/Biomass Removal Recreation Use/Management Range/Livestock Use Water Use/Diversions Special Uses Minerals/Energy Special Uses Adjacent Land Uses Recreation Facilities Fences/Structures

Management questions and associated data/indicators for each GDE Sub-theme are described in subsequent sections.

A. Location and Description

A substantial amount of data and information regarding a GDE feature's location and setting can be obtained through the analysis of existing data, map interpretation or image analysis.

For all inventory levels management questions about basic information concerning a GDE feature is consistent, which are listed in Table 13.

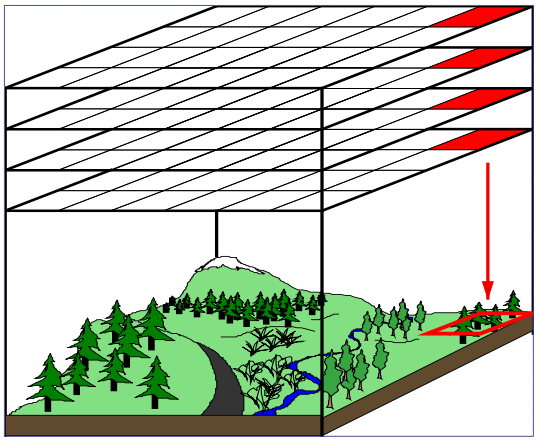
Table 13 – Location and description information requirements

Intensity Level	Management Questions	Data/Indicators
All	Where are GDE features located?	- Spatial location/coordinates - Administrative unit
	Does the feature have a geographic name?	- Formal geographic name - Assigned name or identifier
	Is a GDE feature present and if so, what type of GDE is present?	- GDE Type and/or Sub-type - Photo points and transects
	What is the GDE's physical and hydrogeologic setting?	See Table 9 - Phases 2 and 3a
	What is the ecological setting of the GDE?	See Table 9 - Phases 2 and 3a

Use of GIS to Assist Field Data Collection

The use of Geographic Information System (GIS) capabilities can reduce the amount of contextual information that needs to be collected on site, reducing data collection costs. For example, given the spatial coordinates of a GDE feature, administrative unit and other data fields can be populated within the data system.

Initial site characterization and other data about the site can also be generated using preliminary location data and validated based on filed observation.



B. Ecological Context

The ecological context of a GDE influences water quantity and quality as well as the vegetation and species diversity associated with the feature. Numerous management requirements establish the need to protect, conserve and when appropriate restore ecological conditions necessary to sustain biological diversity, threatened and endangered species, and waters.

Table 14 displays the management questions for each inventory intensity level and the types of data collected to address these questions.

Table 14 – Ecological context management requirements

Intensity Level	Management Questions	Data/Indicators
I	What dominant plant species and life forms are present?	-Cover Type -Major Species Represented
	What species are present?	-Species Presence/Absence
	What aquatic biota are present and what is the aquatic habitat setting?	-Aquatic Habitat Description -Species Presence/Absence
	What type of GDE feature is present?	-See Table 4
II	Are species of concern/species of interest or their habitats present that could be affected by changes to or have effects on GDEs?	-Aquatic and terrestrial habitats -Invasive or noxious species -Species abundance -Vegetation/community structure -See Table 4
	Are Threatened, Endangered or Sensitive Species or habitats present?	
	What is the ecological significance of the GDE?	-See Table 5
III	What are the environmental water requirements need for Species of Concern and Species of Interest?	-See Table 7
	What is the nature of their dependence on groundwater and associated GDEs?	
	How do groundwater and dependent ecosystems affect ecosystem services?	-See Table 5 -See Table 7 -Water Quality -Nutrient removal -Water uses and storage
	What role do GDEs play in the carbon cycle – greenhouse gas emissions and carbon sequestration?	-Green house gas emissions -Carbon sequestration
	What role do GDEs play in the mercury cycle?	-Storage and removal -Transmission/fluxes
	What are existing groundwater system conditions and what are the potential effects of an activity on groundwater and associated GDEs?	-See Table 6

B. Hydrogeologic Setting

Understanding the hydrogeologic setting and relationship of individual GDE features within the groundwater system is related to management requirements to protect and conserve biological diversity, threatened and endangered species, provide clean water and to sustain ecological systems. The dependence of ecological conditions on groundwater and groundwater systems requires an understanding of the hydrogeologic setting in which an individual GDE feature resides. Table 15 describes these management requirements.

Table 15 – Hydrogeologic management requirements

Intensity Level	Management Questions	Data/Indicators
I	What is the geologic and physical setting of the GDE?	Size, Physical Description, Geomorphology, Soils, Substrate
	What is the water flow and/or depth of the GDE feature?	Water Flow/Volume Depth to Water Table
	What is the water quality/chemistry of the GDE feature?	Water Chemistry Grab Samples
II	What is going on at the **landscape level**?	See summary notes below[2]
	What geologic features are affecting quality, temperature or flow? Nature of variability/seasonal variation, etc.	- See Table 4 - See Table 5
	Geologic Setting? Where is this water coming from and where is it going?	- See Table 4 - See Table 5
	Location of proposed activity relative to GDEs and past activities and facilities that affect GDEs? Is the GDE and water affected by the activity?	- See Table 4 - See Table 5
	What is going on at the **site-level?**	- See summary notes below
	Where is this water coming from and where is it going?	- See Table 4 - See Table 5
	What is the water quality and temperature?	- See Table 4
	Hydrologic Regime - What is the Water Budget?	- See Table 4 - See Table 5
	Is this a jurisdictional wetland?	- See Table 4
	What are the effects of past and current activities and uses on the GDE and its condition?	- Existing on-site activity effects - Existing land uses and effects - Condition Assessment Factors
III	What are the potential effects of an activity on GDEs?	- See Table 6 -
	Response time of system – distribution and timing of inputs to system	- See Table 6
	What are the environmental water requirements necessary to sustain Species of Concern and Species of Interest?	- See Table 7
	What is the detailed water budget/balance of the system? What processes affect the flow regime?	- See Table 6

[2] **Springs and Seeps** will use Spring Mountains NRA protocol as starting point; **Peatlands & Other Wetlands** will use GMUG Fen Tier 2 protocol as a starting point

C. Natural and Anthropogenic Disturbances

Natural and anthropogenic disturbances affect a GDE's ability to support ecological systems and individual species. As described in the Management Requirements section, the Forest Service has an obligation to protect, conserve and restore resources, including GDEs, that provide for and sustain ecological systems and habitats for specific species.

An exhaustive list of potential natural and anthropogenic disturbance processes is informative but not required to assess the direct and cumulative effects of past and ongoing activities on GDE resources and their function. In some cases cumulative effects may make it impossible to identify specific disturbance process affecting the condition of a GDE. Table 16 describes the management questions associated with natural and anthropogenic disturbances.

Table 16 – Natural and anthropogenic disturbance management requirements

Intensity Level	Management Questions	Data/Indicators
I	What activities and uses are affecting the GDE?	- Pick-list of activities
	What is the extent and severity of activities and uses affecting the GDE?	- Photo Points/Transects - Field assessment of severity and extent by disturbance kind
	What is the general condition of the GDE?	- Condition class - Average disturbance intensity
II	What specific activities are affecting the GDE?	- Pick-list of activities
	What is the extent and severity of the effect of past and ongoing activities?	- See Table 5 - Description of conditions, severity of effects at the site
	What are the effects of past and ongoing disturbances on the GDE?	- See Table 5 - Condition Assessment Factors
III	What are the adjacent land uses and management activities and what are their effects on groundwater and the GDE?	- See Table 6 - See Table 7 - Activity/Land Use descriptions adjacent to the GDE
	Are there specific uses and activities within the GDE contributing to groundwater withdrawals and depletion and the GDE?	- See Table 6 - Description of activities and uses and use of groundwater or affecting the GDE
	Are natural disturbance processes affecting the function of GDE's or potentially placing these systems at risk?	- See Table 6 - Invasive species/noxious weeds - Wildland fire or suppression Insects and pathogens - Climate change
	Will a proposed activity affect this GDE? Is there a connection between proposed activity and the GDE?	- See Table 6 - See Table 7

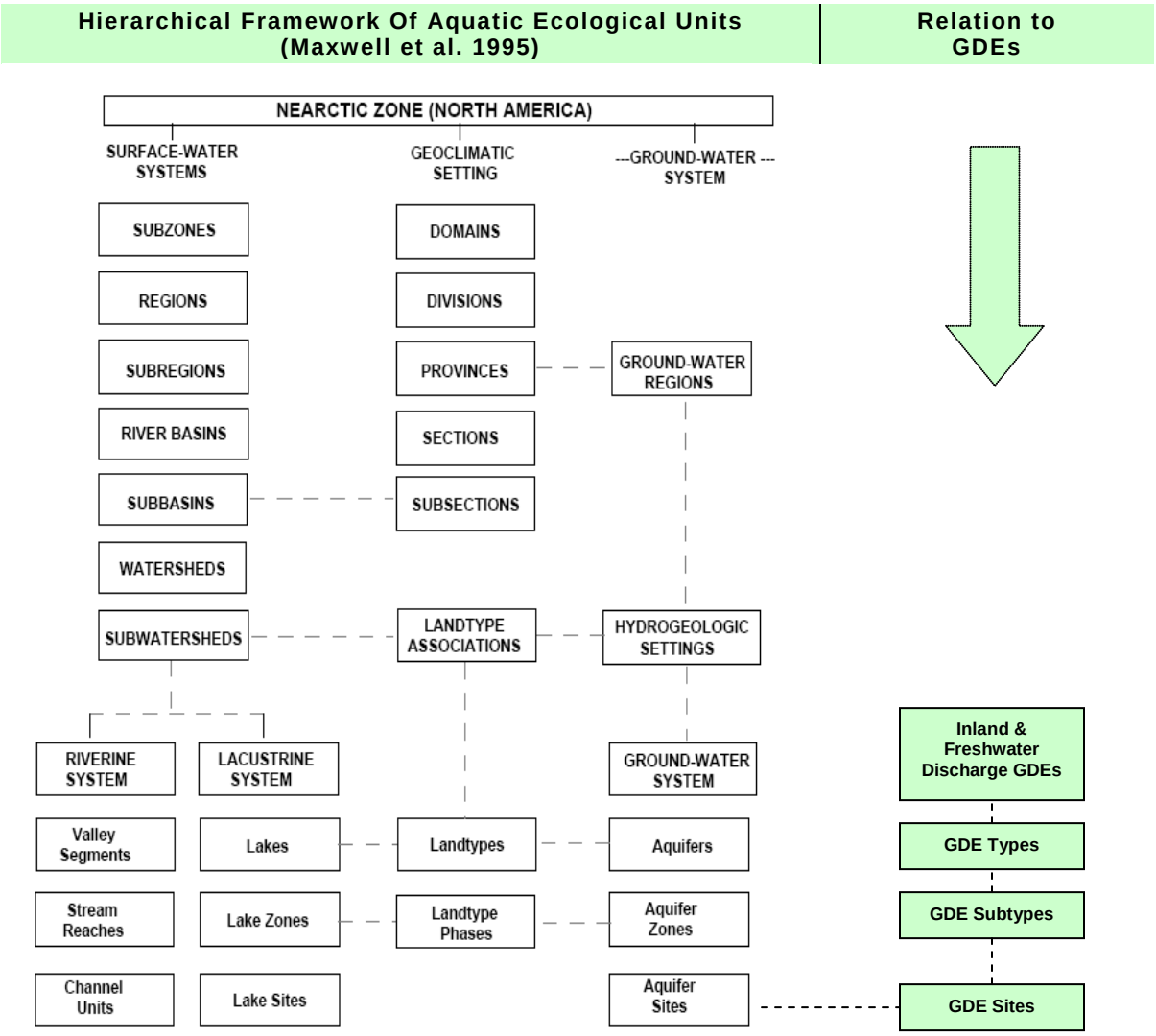
VI. Groundwater-Dependent Ecosystem Type Definitions

The scope of this GDE protocol development applies to a specific set of GDE types. The following section describes and defines GDE types that are the focus of this inventory and monitoring protocol development effort and their relationship to other GDE and wetland types. Appendix D contains more detailed descriptions and definitions for GDE types.

"A Hierarchical Framework of Aquatic Ecological Units" developed by the Forest Service (Maxwell et al. 1995) includes the following general mapping units for GDE's:

- Aquifers, which are "based on their geology, hydrology, and water quality";
- Aquifer zones, which "distinguish recharge areas from discharge areas"; and
- Aquifer sites, which "delineate springs and sinks where the water table intersects the land surface."

These map units correspond to GDE types described in Figure 6 as shown below:



On National Forest System (NFS) lands the classification of wetlands is commonly defined by the National Wetland Inventory System (Cowardin et al. 1979), where most groundwater-dependent wetlands are likely included in the Palustrine System. However, little is said in that system to distinguish fens or other groundwater-dependent wetlands as unique entities. One of the main purposes of this protocol development is to provide a uniform framework for the characterization and description of groundwater-dependent wetlands throughout the US.

This protocol development focuses on minerogenous wetland systems, which are normally situated at positions in the landscape lower than adjacent mineral terrain such that water and mineral elements are introduced by groundwater.

These minerogenous hydrological systems have a strong linkage with the regional groundwater system and the physical and chemical nature of their geological setting. In contrast, ombrogenous hydrological systems are not dependent on groundwater.

Minerogenous: Water that originates on the land surface or as groundwater where it comes in contact with mineral soils and bedrock. The water is rich in total dissolved solids (National Wetlands Working Group 1997).

Ombrogenous: Water that originates exclusively from precipitation (rain or snow) and has a low concentration of dissolved minerals (Warner et al. 1997); "Literally rain fed, referring to wetlands that depend on precipitation as the sole source of water" (Mitsch and Gosselink 2007).

Ombrogenous hydrological systems are restricted geographically because of local climatic conditions. Minerogenous systems are not generally restricted by local climatic conditions because the groundwater source is generally sufficient to maintain soil saturation and therefore wetland processes.

In summary, the primary basis for determining which systems to include in the GDE protocol is hydrology, specifically water source. This is not a classification based on geography, meaning that it is not a classification of specific site or location characteristics. It is also not a vegetation classification, although vegetation is helpful in distinguishing the GDE types.

The Spring-Wetland Continuum

Nearly all permanent springs have associated wetlands of many different types. Springs and wetlands are intimately intertwined across the landscape. The emergent water at a spring orifice merely represents one point in the hydrologic and ecologic continuum of groundwater discharge. This interrelationship is immediately apparent to anyone who tries to inventory these features in the field. Wetland classification systems have historically been dependent on vegetation type, soil type, or hydrologic conditions, and thus there has been no distinct category for springs. For this reason, springs have not generally been included in wetland classification schemes but have been treated as a distinct group of groundwater discharge features to be classified separately. The hazard of this separate classification is that field workers interested in springs ignore the rich ecology of wetlands associated with springs, while wetland specialists ignore the rich ecology of springs associated with wetlands.

The interrelationship between springs and wetlands is evident in wetland classification terms like spring fen, spring swamp, spring marsh, and spring-seepage peatlands that are used to denote that an obvious spring is visible within a wetland. In reality, fens for example can be thought of as simply springs with a blanket of peat draped over the top. Spring occurrence in some geomorphic settings can be far more complicated than wetlands (e.g., cliff walls),

creating a wide array of microhabitats not observed in wetlands (Springer and Stevens 2008).

The study of springs and wetlands is inherently interdisciplinary, because they occupy the nexus between groundwater, surface water and ecology. Hence they have been studied by both physical and biological scientists. Because research is typically conducted by experts from only one specialty or locality, there has grown a proliferation of different and varying classification and description systems specific to specialties and localities. We hope to present a logical description of the GDE types that span the continuum from springs to groundwater-dependent wetlands.

A. Groundwater-Dependent Ecosystem Types

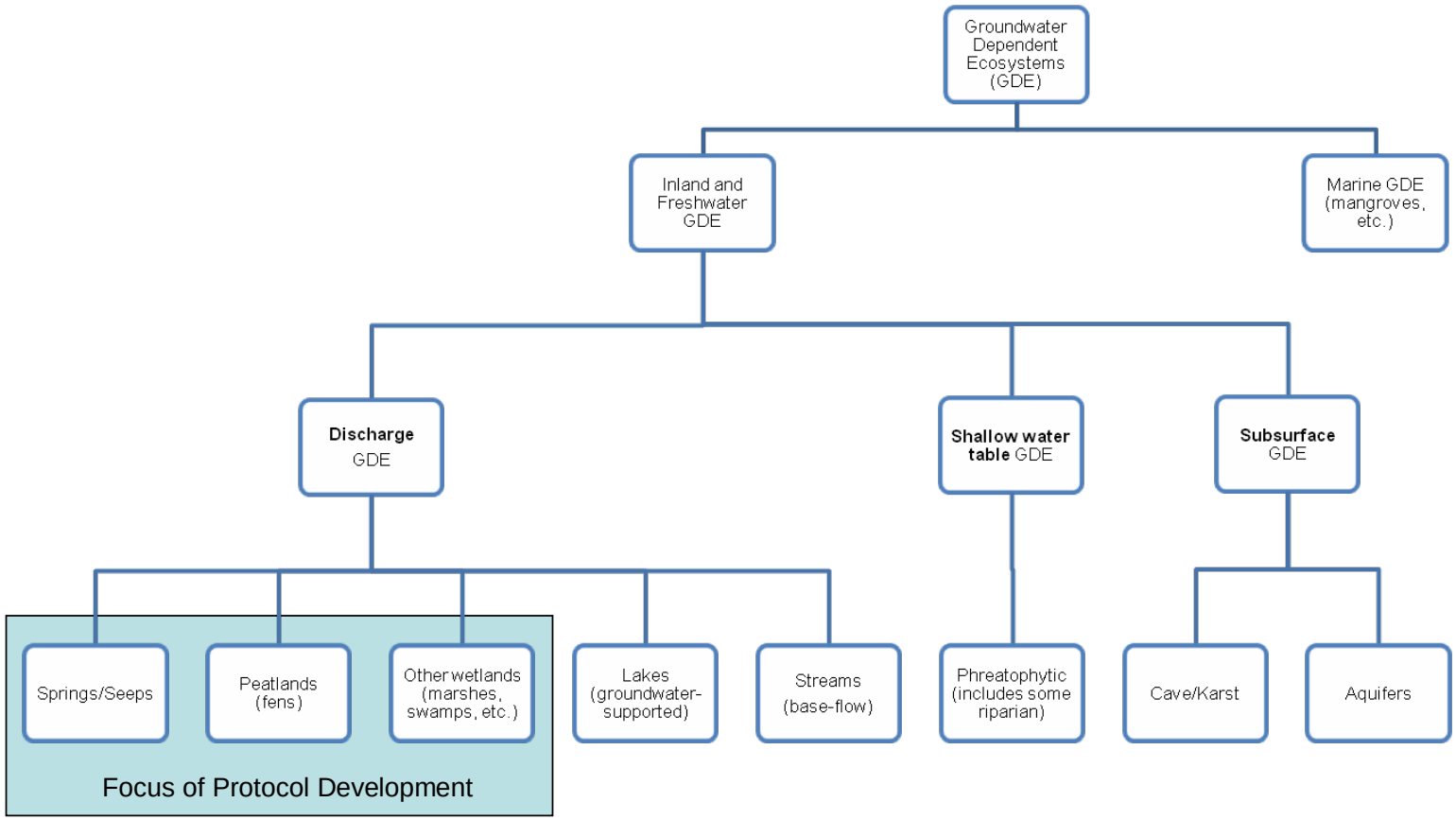
This GDE protocol will focus on three classes used in the Canadian Classification -- fens, swamps and marshes -- which are typically groundwater-dependent, at least to some degree. The Canadian Classification includes spring types within some of those classes (such as “spring fen” and “spring swamp”), but for the purposes of this protocol we distinguish springs as a distinct type, recognizing that there is a gradient from springs to the other wetland types (as discussed above).

Bogs, peatlands that are supported by precipitation, are excluded because they are not groundwater-dependent although the protocol might well be useful to inventory and monitor bogs (see Fens vs. Bogs box below). The “Shallow Water Wetlands” class of the Canadian Classification would largely be encompassed by the “Lakes” and “Streams” types in our scheme, which is presented in Figure 6.

The Lake and Stream systems are not within the scope of this GDE protocol, but we anticipate that those features could also be inventoried with the Level 1 protocol, which would entail determining their location and collecting basic information about the GDE feature.

The groundwater-dependent ecosystem types to be in this protocol development effort are also represented in Figure 7.

Figure 6 – Groundwater-Dependent Ecosystem Types



B. GDE Definitions and Descriptions

The following is a general description of the three main ecological types covered by this GDE protocol development. GDE systems that will not be covered by this protocol include lakes, streams, caves, and phreatophytic systems. The relationship of these GDE types to various classification systems discussed previously are also described. Table 17 provides a summary of GDE types addressed in this protocol development effort and their characteristics.

1. Springs/Seeps

Springs and seeps are hydrologic features (and ecosystems) where groundwater discharges at the earth's surface. At the point of emergence, the physical geomorphic setting allows some springs to support large arrays of aquatic, wetland, and terrestrial species and assemblages (Springer and Stevens 2008). There is no straightforward way to make a clear distinction between springs and wetlands in all situations (see Appendix D discussion of "The Spring-Wetland Continuum"). Therefore it is important to include both springs and groundwater-dependent wetlands in the same protocol for inventory and monitoring GDE's.

2. Peatlands

Peatlands are "any wetland with accumulated partially decayed plant matter (peat)" (Mitsch and Gosselink 2007). The Canadian Wetland Classification (National Wetlands Working Group 1997) refers to peatlands as "organic wetlands." Fens are a type of peatland that have a relatively constant supply of groundwater which saturates the soil and slows decomposition to the point that peat accumulates. Fens and other peatlands supported by groundwater are included in this protocol development effort. Some peatlands are not supported by groundwater, such as bogs, and therefore are not the focus of this protocol although the protocol might have some utility for such systems.

There are two lines of thinking for peatlands. From a biological perspective the distinction occurs at the level of water chemistry. Bogs and "poor" fens group together functionally because they have similar water chemistries that are low in pH and base cations and so are quite ombrotrophic. Bogs are this way because most of their water comes from precipitation. Poor fens are this way because they get water from geologic deposits with low solubility like granite. "Medium", "rich", and "extreme rich" fens group together because the biology is controlled by the higher pH, more buffered waters with higher concentrations of base cations – and this minerotrophic water all comes from groundwater.

From a landscape/hydrogeologic perspective, it is important to divide fens from bogs in terms of their water sources (precipitation vs. groundwater). Groundwater head reversals can happen in peatlands. At certain times of the

Fens vs. Bogs – The Hydrologic Distinction

Peatlands are generally divided into two main categories, bogs and fens, although the usage of these terms varies (Bedford and Godwin 2003). A **bog** is "a peat-accumulating wetland that has no significant inflows or outflows and supports acidophilic mosses, particularly *Sphagnum*" (Mitsch and Gosselink 2007). A **fen** is "a peat-accumulating wetland that receives some drainage from surrounding mineral soil and usually supports marshlike vegetation" (Mitsch and Gosselink 2007).

Fens are separated from bogs based upon their hydrologic characteristics; bogs are fed almost entirely by atmospheric precipitation, while fens are fed primarily by groundwater, although they may receive precipitation and surface water as well. Fens are wetlands distinguished by their strong connection to groundwater. A wetland whose vegetation, water chemistry, and soil development are not determined, in large part, by the nearly continuous flow of groundwater is not a fen.

year there could be an upward gradient where groundwater discharges to the rooting zone. At other times a downward gradient could occur. So while it seems tidy to divide the hydrology into sources, the interactions of groundwater and precipitation may be more complicated. Because bogs are not groundwater discharge features and are also rather rare in the US outside of Alaska, they will not be considered in this protocol.

Fens are minerotrophic peatlands with the water table slightly below, at, or just above the surface. Usually there is slow internal groundwater seepage in these systems, but sometimes they have over-surface outflow of water. Peat thickness is variable, although a common criterion for fens is that they have at least 40 cm of peat (National Wetlands Working Group 1997; Weixelman and Cooper 2009).

The following definition of fens by Bedford and Godwin (2003) is consistent with this protocol:

> *…wetlands that develop where a relatively constant supply of ground water to the plant rooting zone maintains saturated conditions most of the time and the water chemistry reflects the mineralogy of the surrounding and underlying soils and geological materials. …like many factors structuring ecosystems, the degree to which ground water dominates the fen water budget is a continuum. In all cases used here, the influence of ground water exceeds that of precipitation and surface water, either in quantity or in terms of effects on water chemistry in the plant rooting zone.*

c. Other Wetlands

Wetlands in this category are those that have no (or minimal) peat accumulation, also described as “mineral wetlands” by the National Wetlands Working Group (1997). These non-peat groundwater dependent wetlands would include what often are referred to as swamps and marshes. Wetlands referred to as “depressional wetlands” in the southeastern US, if they are groundwater-dependent, would probably fit in this category as well.

Swamps and marshes that are groundwater-dependent have a variable water table, which is above, at or below the surface. They are either seasonally or permanently flooded and vary widely in the volume of groundwater inflow. There is usually little or no peat accumulation, except in the case of some swamps (discussed below). Woody vegetation is a characteristic that is commonly used to distinguish swamps from marshes, with swamps typically being forested (with coniferous or deciduous trees) or sometimes thicketed (with shrubs), whereas marshes typically have submerged, floating or emergent vegetation (graminoids such as rushes, reeds, grasses, and sedges). When swamps have a water table that is well below the surface the soil is aerated which leads to accumulations of wood-rich peat (National Wetlands Working Group 1997; Mitsch and Gosselink 2007).

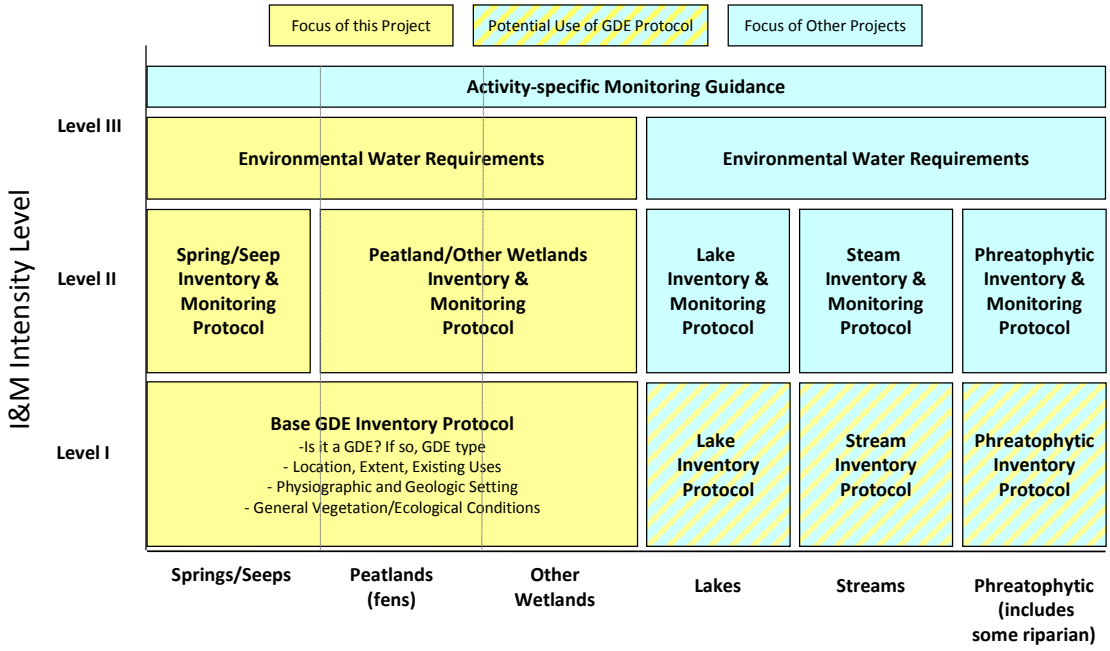
Table 17 – Groundwater-dependent ecosystem types and their characteristics

GDE Type/ Characteristics	Springs/ Seeps	Peatlands	Other wetlands
Water Sources	Completely groundwater-dependent	may be groundwater-dependent (bogs are peatlands and they are not GDEs)	Groundwater and precipitation, commonly with surface inflow,
Source Water Chemistry	Minerogenous (nature of dissolved minerals depends on surficial and bedrock geology through which groundwater travels)	Minerogenous or ombrogenous (if a fen, nature of dissolved minerals depends on surficial and bedrock geology through which groundwater travels)	Minerogenous (nature of dissolved minerals depends on surficial and bedrock geology through which groundwater travels)
Position of Water Table	At ground surface	At or near ground surface	At, above, or below surface; fluctuates dramatically; periodic standing water
Soils and Peat Depths	Mostly mineral soils; rarely accumulation of peat	Accumulation of peat, up to several meters; little or no mineral soil	Little or no accumulation of peat. Can have some wood-rich peat.
Surface Conditions	Standing or flowing water	Anoxic conditions begin slightly below surface layer; surface generally level or depressed; firm or floating mats	Mineral to organic soils; periodic standing or slowly moving water
Oxygen Conditions	Usually oxygenated	Anoxia develops slightly below the surface, leading to the accumulation of peat	Temporary soil anoxia during times of high water table
Water movement within the GDE	Standing or flowing water	Water table may be slightly below the surface, or may have flowing water	Standing or flowing water, at least seasonally
Water Chemistry within the GDE	Highly variable; from acidic to basic, Various temperatures, can be thermal	Ombrotrophic to Minerotrophic. Acidic (poor fens) to basic (circumneutral or strongly alkaline), can be iron-rich or calcareous, depending on local geology	Highly variable; from acidic to basic; mineral-rich
Vegetation	Graminoids, forbs, shrubs and trees; rarely qualifies as wetland vegetation	Bryophytes, graminoids (sedges and grasses), low shrubs; lichens, sometimes trees. Always wetland vegetation	Tall woody plants as well as forbs (swamps) or graminoids and sometimes emergent or floating aquatic macrophytes (marshes)

VII. Protocol Development Framework and Scope

Figure 7 depicts the conceptual framework for identifying the scope of inventory and monitoring protocols development associated with this effort.

Figure 7 – Conceptual Framework for GDE Protocol Development



GDE types and other water-dependent ecological types are represented along the bottom axis. Although the focus of the GDE protocols for Level I are focused on the business requirements associated with springs/seeps, peatlands and other wetlands, they are expected to have utility for inventory of other ecological types as well.

Level II protocols will focus on specific inventory and monitoring protocols for springs/seeps, peatlands and other wetlands.

Level III protocol development will be limited to the development of guidelines applicable to GDEs for determining environmental water requirements and, if possible, guidelines for inventory and monitoring associated with specific activities (e.g., mineral development and extraction).

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Appendix A – Authors and Contributors

Authors

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Appendix B - Management Question Organizational Structure

Management questions, which include environmental issues, monitoring questions, and management concerns, are organized using the Forest Service's Monitoring and Evaluation Framework (USFS 2007) themes and sub-themes. Table 1 displays the organization used within the Monitoring and Evaluation Framework:

Table 1 – Monitoring and Evaluation Framework Components

Theme 1: Conservation of Biological Diversity
Vegetation Diversity
Species Diversity
Theme 2: Maintenance of Land Health and Vitality
Invasive Species
Resilience to Wildland Fire Disturbance
Native Insects and Pathogens
Theme 3: Conservation and Maintenance of Soil, Water, and Air Resources
Watershed Health
Theme 4: Maintenance and Enhancement of Social Benefits
Diversity of Opportunities and Settings
Theme 5: Maintenance and Enhancement of Economic Benefits
Provision of Goods and Services
Theme 6: Infrastructure Capacity
Roads and Trails

This standardized organization can include additional sub-themes within each Theme or subdivisions within a Sub-Theme. The use of this structure is recommended in Land Management Plans to facilitate development of monitoring plans and corresponding program budgets.

A more detailed description of each theme and associated sub-themes as well as their relationship to desired conditions and associated monitoring questions is provided in the following section.

Theme 1: Conservation of Biological Diversity

This theme addresses NFS contributions to securing the nation's heritage of plant and animal species in the plan area. Disturbance processes are included under maintenance of land health and vitality theme (T-2) In addition, abiotic plan components for ecosystem diversity are included under the conservation and maintenance of soil, water, & air resources theme (T-3)

Sub-element NFS Generic Desired Condition	***T1.1 Vegetation Diversity:*** *Contributing to securing the nation's heritage of plant species and related habitats for T&E, SOC, & SOI in the plan area.* Vegetation composition, structure, abundance, distribution, and successional processes contribute to the diversity of native plant and animal species in the plan area.
Monitoring Questions	What are the current condition and trend of key characteristics for vegetation identified in the desired conditions (DC) for the plan area? How are management actions maintaining or making progress toward DC for the key characteristics of vegetation in the plan area?

Sub-element NFS Generic Desired Condition	***T1.2 Species Diversity:*** *Contributing to securing the nation's heritage of animal species and related habitats for T&E, SOC, & SOI in the plan area.* Appropriate ecological conditions are provided throughout the plan area to contribute to the recovery of T&E species, to avoid federal listing of SOC, and to achieve SOI resource goals.
Monitoring Questions	How are ecological conditions for selected T&E species, SOC, or SOI maintaining or making progress toward the LMP desired conditions and objectives? How are management actions for the recovery of T&E species, conservation of SOC, and management of SOI achieving LMP objectives?

Potential GDE Refinement: Combine into one sub-theme: **Ecological Context**

Theme 2: Maintenance of Land Health and Vitality

This theme addresses ecological disturbance processes affecting social, economic, and ecological conditions within LMP plan areas.

Sub-element NFS Generic Desired Condition	***T2.1 Invasive Species*** The National Forest/Grassland has reduced the potential for introduction, establishment, and spread of invasive species and has reduced existing infestations in priority areas.
Monitoring Questions	What are the status and trends of areas infested by aquatic and terrestrial invasive species on the unit's plan area relative to the desired condition? How effective were our management activities including partnerships in preventing or controlling targeted invasive species (some of which may be Species of Interest)?

Sub-element NFS Generic Desired Condition	***T2.2 Resilience to Fire Disturbance***. Fire-adapted ecosystems in the plan area contribute to sustainable environmental, social, and economic benefits, i.e., Fire Regime Condition Class (FRCC) 1.
Monitoring Questions	What is the distribution and trend in Fire Regime Condition Class on the National Forest/Grassland? How effective are management actions in moving the National Forest/Grassland toward FRCC 1?

Sub-element NFS Generic Desired Condition	***T2.3 Native Insects & Pathogens***. National Forest/Grassland ecosystems have the capacity for renewal and recovery from outbreaks caused by native insects and pathogens while meeting desired values, uses, products, and services.
Monitoring Questions	What are the status and trends of outbreaks of native insects and pathogens on the National Forest/Grassland? What are the trends in areas at risk to future outbreaks of native insects and pathogens on the National Forest/Grassland?

Potential GDE Add-on: Climate Change and other Disturbance Processes

Theme 3: Conservation and Maintenance of Soil, Water, and Air Resources

This theme addresses the ecological condition (for soil, air, and water) of watersheds to protect the physical, chemical and biological integrity; the productive capacity of NFS land; water quality and quantity; and opportunities for beneficial uses. It also addresses the related capacity of watersheds to respond resiliently to flooding and to reach or sustain their aquatic ecosystem potential.

Sub-element NFS Generic Desired Condition	***T3.1 Watershed Health*** Ecological function operates in its natural role within watersheds of the plan area while resource management activities sustain human needs and uses.
Monitoring Questions	What is the ecological condition and trend of watershed health, including the aquatic ecosystem potential, for watersheds identified in the desired condition and/ or objectives of the plan area? How effective are management actions in moving the National Forest/Grassland toward improving watershed health?

Potential GDE Refinement: Hydro-geologic Setting (Water Regime, Water Chemistry, and Temperature Regime)

Theme 4: Maintenance and Enhancement of Social Systems

This theme addresses the opportunities, settings, suitable uses for multiple-use provided by the NFS, including opportunities for market and non-market activities. Related goods and services derived from the opportunities and settings provided are reflected in the economic theme (T-5).

Sub-element NFS Generic Desired Condition	***T4.1 Diversity of Opportunities and Settings*** *(including 'Access' & 'Opportunity for Commodity Production')* Settings available on the NFS unit deliver multiple social opportunities that contribute to the sustainability of social, ecological, and economic systems in the plan area (219.10.a.b).
Monitoring Questions	What is the status and trend of settings and opportunities provided by the NFS unit compared to Desired Conditions stated in the LMP? How are management actions maintaining or improving Desired Conditions for settings and opportunities provided by the NFS unit, including contributions to sustaining social systems within the unit's LMP analysis area? How do people involved in the adaptive planning process interpret settings and opportunities provided by the NFS unit compared with Desired Conditions? Do they think there is a need for change?

Theme 5: Maintenance and Enhancement of Economic Systems

Given the opportunities and settings, suitable uses, and activities designed to make progress towards desired conditions, there are goods and services that come off the land. This theme is about goods and services derived from the opportunities and settings referenced the social theme (T-4). Key contributions of goods and services include revenue and jobs associated with recreation, tourism, resident amenities, environmental services, and commodities such as AUMs and the potential for timber production.

Sub-element NFS Generic Desired Condition	***T5.1 Provision of Goods and Services*** Goods and services provided by or derived from [the NFS unit] contribute to sustaining economic systems in the plan area.

Monitoring Questions	What are the status and trends of goods and services provided from the unit with regards to progress towards desired conditions? How do these goods and services contribute to key opportunities for sustaining economic systems relevant to the plan area?

Potential GDE Refinements:

Recreation Use and Management
Timber and Biomass Removals
Range Management/Livestock Use (includes wild horses and burros)
Water Use/Diversions (includes small hydro)
Minerals and Energy Development (includes geothermal)
Special Uses and other Authorizations (not covered by above categories)
Adjacent Land Uses

Theme 6: Infrastructure Capacity

This theme addresses NFS infrastructure's ability to contribute to the aspirations characterized in the LMP.

Sub-element NFS Generic Desired Condition	***T6.1 Roads and Trails*** The road and trail system on the NFS unit is safe, reflects appropriate access, considers needs of adjacent landowners, and meets public demand.
Monitoring Questions	How many miles of the designated roads and trails are maintained to standard? Where is unauthorized use occurring on or off the road and trail system? Are the impacts from the road and trail system on soils, water quality, wildlife, and other natural and cultural resources sustainable and within acceptable tolerance? Is the road and trail system serving its intended purposes and addressing recreational demands?

Potential GDE Add-ons:

Recreation Facilities
Fences and Protective Structures
Water Use and Diversion Structures

Appendix C – Key Resource Information Management Concepts

Information management is a structured process to bring quality information in the right form to the right people at the right time to support sound and deliberate decisions and to generate ideas. (U.S. Forest Service. 1992. Information Management: A Framework for the Future. USDA Forest Service, Washington, DC.)

For information to best support the mission and business of the organization, information management must be driven by Forest Service strategic goals and business requirements. As a result, it is important to define business needs or requirements that support the purpose of collecting data in the field, definition of data standards, development of methods or protocols for data collection, storage of data in accessible data systems, quality control and assurance, information security, and management of the information system over time.

Business Requirements Analysis

A structured inquiry is essential to the identification and evaluation business requirements. A detailed review of management requirements and management questions addressed provides both transparency and the ability to reexamine requirements being addressed and their priorities over time.

Business requirements originate from laws, regulations and policy as well as management issues and concerns. Once business requirements are documented and understood, the next phase of the analysis is to determine management's priorities for addressing these requirements and an evaluation of how data collected will be used to address questions.

At this stage in the process it becomes possible to identify inventory and monitoring methods best suited to gather the data needed to address priority business requirements. Data storage and analysis are also supported by the business requirements analysis.

Over time business requirements and priorities are expected to change. A structured business requirements analysis is needed to provide a benchmark for evaluating the effects of changing requirements.

Basic Data Collection vs. Interpreted Data

Information needed to support decision making takes many forms. **Basic data** consists of "raw" data collected in the field that has not been processed or interpreted. This data provides the foundation for a variety of interpretations and persists over time. **Interpreted data**, although valuable, is often developed for specific purposes, can not be transferred to other users, and may not persist overtime. Information management systems must focus on the storage of basic data to provide long-term utility.

Data Standardization

To ensure the compatibility and utility of information across the agency we need consistent **data standards** and **protocols** that support agency business needs. Common data standards and data collection protocols allow data to be collected once and used multiple times for multiple purposes.

This issue is compounded by the need to address future threats to the nation's forests and rangelands in a multi-jurisdictional environment. Data sharing can not occur without common data standards. As a result data standards are often set by other entities. Examples include the Federal Geographic Data Committee and agencies with government-wide responsibilities assigned by Statue or Executive Order.

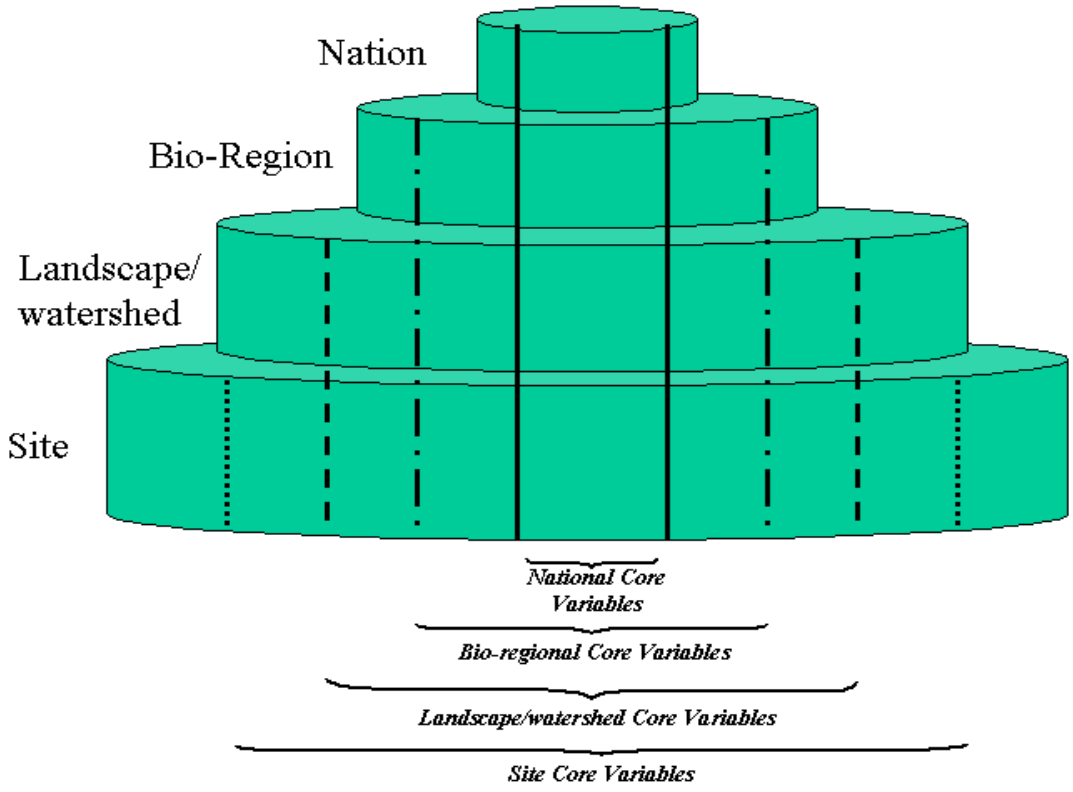
As geographic information systems have matured and become the principle method of analyzing and assessing data, geospatial location has become an essential component of our data standards that increases the utility of data within an information management system.

Standardization Increases Utility

There are numerous examples we take for granted every day that are the product of standardization. The impetus for these standards often had its roots in the need to integrate across organizations and various mission areas. Notable examples include railroad "gauges", fire hose fittings, and ammunition standards used by NATO forces. All aimed at one goal; increase the ability to integrate different organizations around common goals or efforts.

Core Data Concepts

The more basic the data (inventory, personnel records, business processes) the larger the proportion of standardized and shared information. Conversely, the more specialized, interpretive, or external the information system, the less the proportion of standardized, shared information. Beyond the standardized, shared information, each data system would continue to have flexibility for other data needs. Data standardization within this context is often referred to as **core data or variables** and is often represented in the following diagram:



Change Management

Information systems must adapt to changing requirements and technology. A defined change management system that considers changing business requirements, management priorities, the results of research and development, and changes in technology is essential if an information system is to be sustained overtime.

A change management system needs to be established that provides order and organization to requests for improvement and problem resolution encountered as deployment proceeds. Without an established system, the governance body cannot establish a version control process and manage the system – in its absence these pressures begin to fragment the system and competing views and interests will dominate the future. Elements of this change management system include:

Governance - A clearly defined and established governance group is required. The GDE Inventory and Monitoring Protocol Development Charter established an organization to serve this purpose. Following protocol development, the Steering Team and Core Team will need to transition to longer term roles associated with governance of the change management process.

Data Stewardship/Quality Control and Assurance - Data stewardship is a vital part of the system's QA/QC process and necessary to meet the requirements of the Data Quality Act. A network of data stewards that includes all organization levels is essential to create linkages between locally derived and verified data and national data sets. This role is necessary to maintain alignment between administrative unit level data and national data as well as between system components.

An integrated change management system informs the executive governance group in two primary arenas:

Version Control – this is the process of making fundamental changes in the information system. Versions typically change when the underlying computing infrastructure or primary program language change, data distribution systems are updated, or a fundamental approach to modeling or computing fire behavior, as an example, affects the system. These changes are usually the result of basic research and development work. Versions are typically labeled in the following fashion – v1.0 or v2.0.

Updates – this is the process of incorporating corrections or updates to a component of the system. In most instances user requests are the source of most updates and are initiated to support those needs. Updates are typically labeled as – v1.3 or v2.5.

In practice a routine evaluation of user requests generated from a help desk or other input source coupled with an evaluation of innovations and improvements resulting from research and development are evaluated. The executive oversight group's decision to change versions or initiate an update involves looking at the synchronization of changes across all components and considers the schedule for release.

Appendix D – GDE Types and Definitions

Scope and Definition of Wetland Types to be Covered by the Groundwater-Dependent Ecosystems Protocol Development[3]

June 5, 2009

Prepared by: Joe Gurrieri and Marc Coles-Ritchie

Contributors: Barry C. Johnston, Devendra M. Amatya, Christopher P. Carlson, Steve Solem

Introduction

The USDA Forest Service has funded the development of a protocol for the inventory and monitoring of wetlands that are dependent on groundwater, or groundwater-dependent ecosystems (GDE's). This document outlines the scope of the GDE protocol and provides general definitions of the ecosystems intended for this protocol.

The National Academy of Sciences defined wetlands in the following manner:

> A wetland is an ecosystem that depends on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. The minimum essential characteristics of a wetland are recurrent, sustained inundation or saturation at or near the surface and the presence of physical, chemical, and biological features reflective of recurrent, sustained inundation or saturation. Common diagnostic features of wetlands are hydric soils and hydrophytic vegetation. These features will be present except where specific physicochemical, biotic, or anthropogenic factors have removed them or prevented their development (National Research Council 1995).

On National Forest System (NFS) lands the classification of wetlands is commonly defined by the National Wetland Inventory System (Cowardin et al. 1979), where groundwater-dependent wetlands are included in the Palustrine System, but little is said to distinguish fens or other groundwater-dependent wetlands as unique entities. One of the main purposes of this protocol is to provide a uniform framework for the characterization and description of groundwater-dependent wetlands throughout the US.

This protocol focuses on minerogenous wetland systems (see text box below) which are normally situated at positions in the landscape lower than adjacent mineral terrain such that water and mineral elements are introduced by groundwater.

> **Minerogenous**: Water that originates on the land surface or as groundwater where it comes in contact with mineral soils and bedrock. The water is rich in total dissolved solids (National Wetlands Working Group. 1997).

These minerogenous hydrological systems have a strong linkage with the regional groundwater system and the physical and chemical nature of the geological environment. In contrast, ombrogenous hydrological systems (see text box below) are not dependent on groundwater.

[3] This appendix is designed as a stand-alone document and will be updated as the protocol development effort proceeds.

Ombrogenous: Water that originates exclusively from precipitation (rain or snow) and has a low concentration of dissolved minerals (National Wetlands Working Group. 1997); "Literally rain fed, referring to wetlands that depend on precipitation as the sole source of water" (Mitsch and Gosselink 2007).

Ombrogenous hydrological systems are restricted geographically because of local climatic conditions. Minerogenous systems are not restricted by local climatic conditions because the groundwater source is generally sufficient to maintain soil saturation and therefore wetland processes.

In summary, the primary basis for determining which systems to include in the GDE protocol is hydrology, specifically water source. This document provides a very general classification of wetlands in order to indicate which types of wetlands will be covered by the GDE protocol. This is not a classification based on geography, meaning that it is not a classification of specific sites or locations. It is also not a classification based on vegetation, although vegetation can be helpful in distinguishing the GDE types.

The Spring-Wetland Continuum

Nearly all permanent springs have associated wetlands of different types. Springs and wetlands are intimately intertwined across the landscape. The emergent water at a spring orifice merely represents one point in the hydrologic and ecologic continuum of groundwater discharge. This interrelationship is immediately apparent to anyone who tries to inventory these features in the field. Wetland classification systems have historically been dependent on vegetation type, soil type, or hydrologic conditions and thus there has been no distinct class for springs. For this reason springs have not been included in wetland classification schemes but have been treated as a distinct group of groundwater discharge features to be classified separately. The hazard of this separate classification is that field workers interested in springs ignore the rich ecology of a wetlands associated with springs, while wetland specialists ignore the rich ecology of springs associated with wetlands.

The interrelationship between springs and wetlands is evident in wetland classification terms like spring fen, spring swamp, spring marsh, and spring-seepage peatlands that are used to denote that an obvious spring is visible within a wetland. In reality, fens for example can be thought of as simply springs with a blanket of peat draped over the top. Spring occurrence in some geomorphic settings can be far more complicated than wetlands (e.g., cliff walls), creating a wide array of microhabitats not observed in wetlands (Springer and Stevens 2008).

The study of springs and wetlands is inherently interdisciplinary, because they occupy the nexus between groundwater, surface water and ecology. Hence they have been studied by both physical scientists and by biologists. Because research is typically conducted by experts from only one specialty or locality, there has grown a proliferation of different and varying classification and description systems specific to that specialty or locality. We hope to present a logical description for the continuum from spring to groundwater-dependent wetland.

Groundwater-Dependent Ecosystem Types

"A Hierarchical Framework Of Aquatic Ecological Units" has been developed by the Forest Service (Maxwell et al. 1995) that includes the following general hierarchy of GDE mapping units:

- Aquifers, which are "based on their geology, hydrology, and water quality";
    - Aquifer zones, which "distinguish recharge areas from discharge areas";
        - Aquifer sites, which "delineate springs and sinks where the water table intersects the land surface."

The GDE types described in this document would characterize wetlands at the scale of the "aquifer sites" described by Maxwell et al. (1995).

Three primary classes of GDEs have been proposed by Eamus et al. (2006): (1) aquifer and cave ecosystems; (2) all ecosystems dependent on the surface expression of groundwater; and (3) all ecosystems dependent on the subsurface presence of groundwater. This GDE protocol will focus on the second type, ecosystems dependent on the surface expression of groundwater.

Another wetland classification is the Canadian Wetland Classification System (National Wetlands Working Group 1997) that separates wetlands into various classes, forms and types. Wetland classes are recognized on the basis of the overall genetic origin of wetland ecosystems and the nature of the wetland habitat. The Canadian System presents the following general classes:

- Fen
- Swamp
- Marsh
- Shallow water wetlands
- Bog

This GDE protocol will focus on the first three classes listed above for the Canadian Classification, which are those that are typically groundwater-dependent, at least to some degree. The scope of this GDE protocol is outlined in Figure 1. The Canadian classification includes spring types within some of these classes (such as "spring fen" and "spring swamp"), but for the purposes of this protocol we distinguish springs as a distinct type, recognizing that there is a gradient from springs to the other wetland types (as discussed above). We exclude bogs, because they are not groundwater-dependent (although the protocol might well be useful to inventory and monitor bogs). The "Shallow water wetlands" class of the Canadian Classification is similar to the classes of groundwater-dependent "Lakes" and "Streams" types in our scheme (Figure 1). Bog, lake, and stream systems are not within the scope of this GDE protocol, but we anticipate that they could be inventoried with this protocol. The ecosystem types to be covered by the GDE protocol are summarized in Table 1.

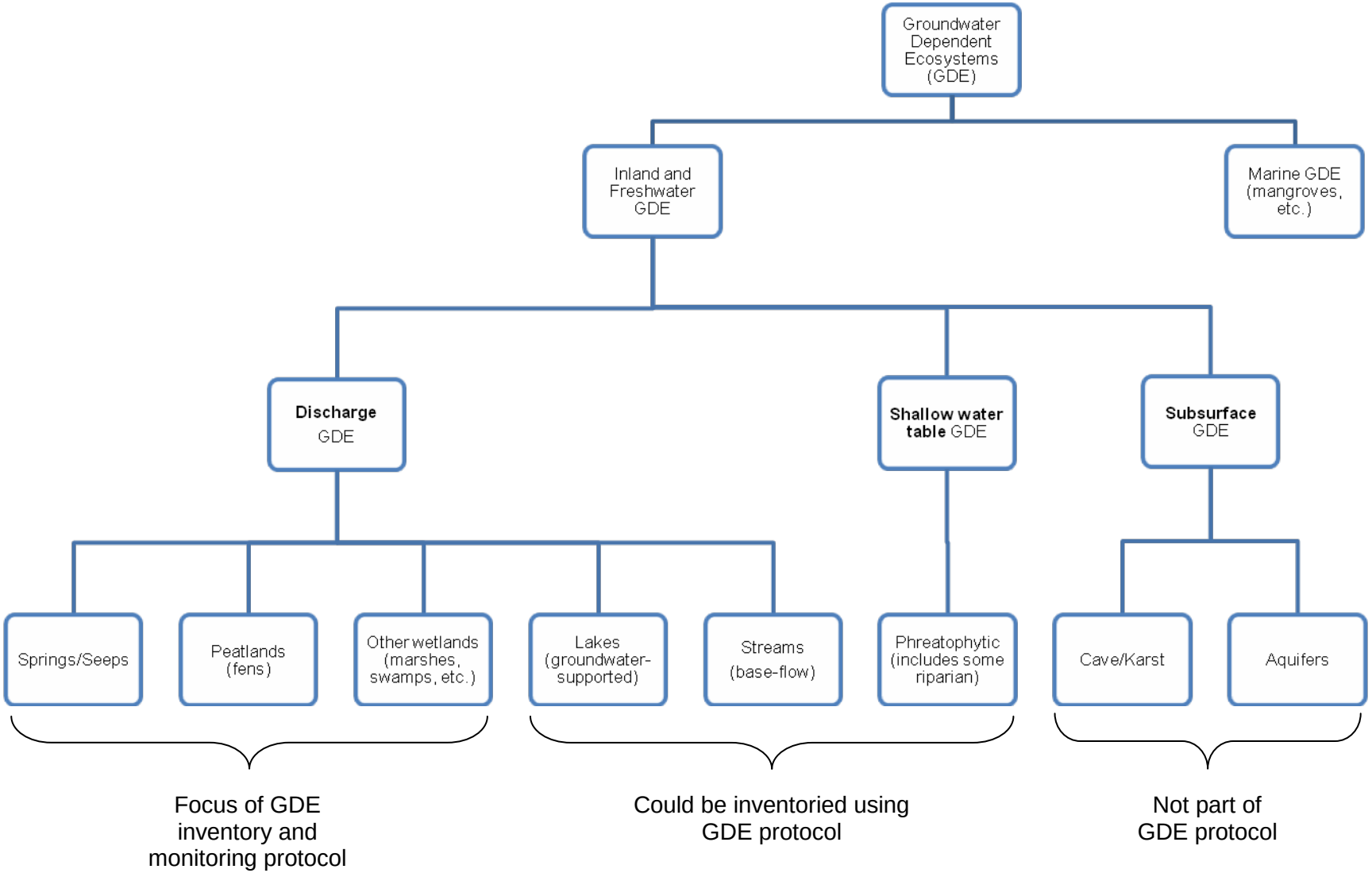


Figure 1. Diagram of ecosystem types covered by the groundwater-dependent ecosystems inventory and monitoring protocol.

Table 1. Groundwater-dependent ecosystem types to be covered by the GDE protocol.

GDE Type	Hydrology	Position of Water Table	Soils and Peat Depths	Oxygen conditions	Water movement within wetland	Water Chemistry	Vegetation
Springs/ Seeps	**Minerogenous; completely groundwater-dependent**	**At ground surface**	**Mostly mineral soils; rarely accumulation of peat**	**Oxygenated**	**Standing or flowing water**	**Highly variable; from acidic to basic, temperatures vary, can be thermal**	**Graminoids, forbs, shrubs and trees; rarely qualifies as wetland vegetation**
Peatlands (dependent on groundwater)	**Minerogenous; always groundwater-dependent**	**At ground surface**	**Accumulation of peat up to several meters; little or no mineral soil**	**Anoxia develops slightly below the surface, leading to the accumulation of peat**	**Water table usually slightly below the surface, so no water movement detectable**	**Minerotrophic, acidic (poor fens) to basic (circumneutral or strongly alkaline), can be iron-rich or calcareous**	**Bryophytes, graminoids (sedges and grasses), low shrubs; lichens, sometimes trees. Always wetland vegetation**
Other wetlands (dependent on groundwater)	**Minerogenous; depend on groundwater, precipitation and sometimes stream inflow**	**At, above, or below surface; fluctuates dramatically; periodic standing water**	**Usually little or no peat accumulation; sometimes wood-rich peat**	**Temporary soil anoxia during times of high water table**	**Periodic standing or flowing water**	**Highly variable; from acidic to basic; mineral-rich**	**Tall woody plants and forbs (swamps) or emergent graminoids and floating aquatic macrophytes (marshes)**

Wetland types not covered by this protocol

Certain groundwater-dependent ecosystems (GDE's) are not intended for this protocol, such as:

- Groundwater-dependent lakes;
- Base-flow streams; and
- Phreatophytic systems (including some riparian areas).

Because of the distinct characteristics of those systems it is not practical to include them in this protocol. It is hoped that other protocols will cover those systems. Protocols do exist, or are in development, for inventorying and monitoring those systems, although they focus on surface water and not groundwater conditions and processes.

In addition, some wetland systems that look similar to some GDE's, but are not dependent on groundwater, will not be covered by this protocol, such as:

- Bogs;
- Pocosins, a type of bog in the southeastern US (described in Richardson 2003);
- Carolina bays, of the southeastern US coastal plain (described in Sharitz 2003); and
- Other wetlands not supported by groundwater.

Because of the similarities between these systems and GDE's, this GDE protocol may have some utility for inventorying such systems, and perhaps for monitoring certain components of those systems.

Descriptions of wetlands intended for the GDE protocol

The following wetland ecological systems will be covered by the GDE protocol:

- Springs/Seeps;
- Peatlands supported by groundwater, and
- Other groundwater-supported wetlands (such as swamps and marshes).

Below is a general description of these GDE systems.

Springs/Seeps

Springs are ecosystems in which groundwater reaches the earth's surface. At the point of emergence the physical geomorphic setting allows some springs to support large arrays of aquatic, wetland, and terrestrial species and assemblages (Springer and Stevens 2008). There is no clear distinction between springs and wetlands (as described above in the section called "The Spring-Wetland Continuum"). Therefore it is important to include both springs and groundwater-dependent wetlands in the same protocol for inventory and monitoring GDE's.

While not a classification itself, a useful system for classifying spring types has been proposed by Springer et al. (2008) who list the various settings of springs or "spheres of discharge" as:

- cave,
- exposure,
- fountain,
- geyser,

- gushet,
- hanging garden,
- helocrene,
- hillslope,
- hypocrene,
- limnocrene,
- mound form, and
- rheocrene.

References on springs include:
Sada et al. (2001); Barquín and Scarsbrook (2008); Springer and Stevens (2008); Springer et al. (2008).

Peatlands

Peatlands are “any wetland with accumulates partially decayed plant matter (peat)” (Mitsch and Gosselink 2007). The Canadian Wetland Classification (National Wetlands Working Group 1997) refers to peatlands as “organic wetlands.” Fens are a type of peatland that have a relatively constant supply of groundwater which saturates the soil and slows decomposition to the point that peat accumulates. Fens and other peatlands supported by groundwater are a focus of this protocol. Some peatlands are not supported by groundwater, such as bogs, and therefore are not the focus of this protocol although the protocol might have some utility for such systems.

Swamps (and less commonly marshes) have a little peat development, but would not be considered as peatlands for this protocol.

Fens Verses Bogs

Peatlands are generally divided into two main categories, bogs and fens, although the use of these terms varies (Bedford and Godwin 2003). A **bog** is “a peat-accumulating wetland that has no significant inflows or outflows and supports acidophilic mosses, particularly *Sphagnum*” (Mitsch and Gosselink 2007). A **fen** is “a peat-accumulating wetland that receives some drainage from surrounding mineral soil and usually supports marshlike vegetation” (Mitsch and Gosselink 2007).

Fens are separate from bogs based upon their hydrologic characteristics; bogs are fed almost entirely by atmospheric precipitation, while fens are fed primarily by groundwater, although they receive precipitation and surface water as well. Fens are wetlands distinguished by their strong connection to groundwater. A wetland whose vegetation, water chemistry, and soil development are not determined, in large part, by the flows of groundwater is not a fen.

There are two lines of thinking for peatlands. From a biological perspective the distinction occurs at the level of water chemistry. Bogs and poor fens group together functionally because they have similar water chemistries that are low in pH and base cations and so quite ombrotrophic. Bogs are this way because most of their water comes from precipitation. Poor fens are this way because they get water from geologic deposits with low solubility like granite. Medium, rich, and extreme rich fens group together because the biology is

controlled by the higher pH, more buffered waters with higher concentrations of base cations – this minerotrophic water all comes from groundwater.

From a landscape/hydrogeologic perspective, it is important to divide fens from true bogs in terms of their water sources (precipitation vs. groundwater). Groundwater head reversals can happen in peatlands. At certain times of the year there is an upward gradient where groundwater discharges to the rooting zone. At other times a downward gradient develops. So while it seems tidy to divide the hydrology into sources, the interactions of groundwater and precipitation may be more complicated. Because bogs are not groundwater related features and are also rather rare in the US outside of Alaska, they will not be considered in this protocol.

A wetland that is similar to a bog is a "pocosin" which is a specific type of wetland in the southeastern US coastal plain. A **pocosin** is a "peat-accumulating, nonriparian freshwater wetland, generally dominated by evergreen shrubs and trees and found on the southeastern coastal plain of the United States" (Mitsch and Gosselink 2007). Pocosins are supported by rainfall (Richardson 2003) and therefore like bogs are not included in this GDE protocol.

Fens

Fens are minerotrophic peatlands with the water table slightly below, at, or just above the surface. Usually there is slow internal groundwater seepage in these systems, but sometimes they have over-surface flow. Peat thickness is variable, although a common criteria for fens is that they have at least 40 cm of peat (National Wetlands Working Group 1997; Weixelman and Cooper 2009). Two broad fen types are basin fens and sloping fens. Fens are usually open but can be wooded where transitioning into a swamp forest. The dominant vegetation is bryophytes, graminoids or low shrubs. The surface may be firm or with floating or quaking mats. They can be acidic to basic.

The primary characteristics of fens are: (1) an accumulation of peat; (2) surface is level with the water table, with water flow on the surface and through the subsurface; (3) fluctuating water table which may be at, or a few centimeters above or below, the surface; (4) minerogenous; (5) decomposed sedge or brown moss peat; and (6) graminoids and shrubs characterize the vegetation cover.

The following definition of fens by Bedford and Godwin (2003) is consistent with this protocol:

> …wetlands that develop where a relatively constant supply of ground water to the plant rooting zone maintains saturated conditions most of the time and the water chemistry reflects the mineralogy of the surrounding and underlying soils and geological materials. …like many factors structuring ecosystems, the degree to which ground water dominates the fen water budget is a continuum. In all cases used here, the influence of ground water exceeds that of precipitation and surface water, either in quantity or in terms of effects on water chemistry in the plant rooting zone.

The following is a list of field tools for identifying fens:

1. Determine if organic peat soils are saturated year-round.
2. Look for indicator species (especially bryophytes).
3. Check the landscape position where you might expect fens to develop.

4. Measure groundwater discharge into the rooting zone using nested piezometers (not a quick field tool, but this is obviously the definitive way to do it).
5. Measure pH and conductivity (can be used to differentiate between poor fens/bogs and med-rich-extreme rich fens).

Examples of fen sub-types based largely on National Wetlands Working Group (1997) include:

- riparian fen,
- slope fen,
- string fen,
- basin fen,
- horizontal fen,
- spring fen,
- poor fen,
- rich fen,
- intermediate rich fen,
- extreme rich fen, and
- iron fen.

References on fens include:
National Wetlands Working Group 1997; Cooper 1998; Mitsch and Gosselink 2007; Vitt 2000; Bedford and Godwin. 2003; Lemly 2007; Austin 2008; NatureServe 2008; Weixelman and Cooper 2009.

Other Wetlands

Wetlands in this category are those that have no (or minimal) peat accumulation, also described as “mineral wetlands” by the National Wetlands Working Group (1997). These non-peat groundwater dependent wetlands would include what often are referred to as swamps and marshes. Wetlands referred to as “depressional wetlands” in the southeastern US, if they are groundwater-dependent, would probably fit in this category as well.

Swamps and marshes that are groundwater-dependent have a variable water table, which is above, at or below the surface. They are either seasonally or permanently flooded and vary widely in the volume of groundwater inflow. There is usually little or no peat accumulation, except in the case of some swamps (discussed below). Woody vegetation is a characteristic that is commonly used to distinguish swamps from marshes, with swamps typically being forested (with coniferous or deciduous trees) or sometimes thicketed (with shrubs), whereas marshes typically have submerged, floating or emergent vegetation (graminoids such as rushes, reeds, grasses, and sedges). When swamps have a water table that is well below the surface the soil is aerated which leads to accumulations of wood-rich peat (National Wetlands Working Group 1997; Mitsch and Gosselink 2007).

Examples of swamp and marsh sub-types include:

- discharge swamp,
- flat swamp,
- inland salt swamp,
- mineral-rise swamp,
- riparian swamp,

- slope swamp,
- tidal swamp,
- cypress domes and strands (described by Florida Department of Environmental Protection),
- wet meadow,
- spring marsh,
- slope marsh,
- riparian marsh,
- hummock marsh,
- lacustrine marsh,
- basin marsh,
- estuarine marsh,
- tidal marsh, and
- Carolina bays.

References on swamps and marshes include:
National Wetlands Working Group 1997; Cooper 1998; and Mitsch and Gosselink 2007.

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