



# Analyzing the Hydrologic Condition of Watersheds

An Online Continuing Education Course for Engineers

**Course Number: C-3027**

**Credit: 3 Hours / 3 PDH / 3 CPD**

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## Introduction

While natural resources are diverse, they are also interrelated, which means the management actions pertaining to one resource will impact the others. Water is one resource that has the potential to impact numerous other resources.

An important part of resource management is gaining an understanding of the physical processes that govern the flow (F), quality (Q), and/or timing (T) of water. Understanding these processes requires, among other things, information about precipitation, ground cover, vegetation, soils, geology, runoff, channels, floodplains, and riparian areas for each watershed.

Watersheds are characterized by meteorological, surface- and ground-water, and physical and biological factors functioning within the context of natural and human disturbance regimes. The flow, quality, or timing of water within a watershed is regulated by these factors. Watershed characteristics must be analyzed and interpreted using known scientific principles about hydrologic and hydro meteorological processes to describe hydrologic condition. The analysis and interpretation require basic hydrologic knowledge, knowledge of the area, and competency in using hydrologic tools and making judgments regarding hydrologic processes.

Hydrologic interpretations provide fundamental information about the linkages between terrestrial features or processes and associated aquatic or biological resources. They are intended to be combined with information developed by other disciplines to achieve an integrated and comprehensive analysis of the watershed. When merged and integrated with other resource information, hydrologic condition becomes part of the basis for identifying management opportunities and priorities, and for developing alternatives to maintain, enhance, or restore watershed function.

The purpose of this course is to provide a framework for hydrologic analysis and related protocols as components of more comprehensive interdisciplinary watershed analysis. This course outlines a process for identifying the essential factors needed to describe hydrologic condition from a vast array of possible factors. The information assembled during the process enables those who conduct hydrologic analyses to participate effectively with other interdisciplinary team members in addressing ecosystem and resource management planning issues. The process helps to organize existing information about a watershed in the form of a watershed case file, which displays and interprets critical hydrologic information and supplements other resource information during decision-making processes.

## Overview of the Analysis Process

Hydrologic condition analysis results in an understanding of the interrelationships among meteorological, surface- and ground-water, and physical and biological factors that influence the flow, quality, and/or timing of water. The magnitude, direction, and rate of change are the expression of hydrologic condition. The determination of hydrologic condition should, therefore, focus on the analysis of the factors that most directly influence changes in the specific watershed of interest. Watershed characteristics that are not subject to change by management activities (e.g., geology, landform, precipitation) are fundamental in defining physical limits within which management actions can be expected to influence water flow, quality, or timing. Analysis and documentation of these characteristics are needed to support interpretations of hydrologic condition and to defining the limits of management influence over the physical system.

Because watersheds vary tremendously across the country, analysts need the flexibility to select the watershed characteristics that are most relevant for the watershed they are considering. The analysis procedure outlined in this course is intended to provide the needed flexibility. The focus is on a process of analysis rather than on a prescribed or fixed set of factors that drive the analysis. This approach allows analysts to use existing tools (e.g., regional curves, nomographs) and to adapt the process based on available information (local watershed case files) and local or regional conditions and needs. It is expected that standard procedures will be used to analyze factors indicative of hydrologic condition.

Use of existing information brings with it a wide range of reliability and confidence in the values. It is very important for analysts to document the level of confidence and the reliability of their estimates and conclusions. It is important to document data voids that have decreased the reliability of conclusions. The analysis steps follow a logical sequence that will provide the basis for supporting professional estimates and judgments resulting in credible conclusions. The products of one step provide information for subsequent steps. The following steps presume that some pre-work has been accomplished, including delineating the watershed and assembling pertinent data:

- Step 1. Characterize the watershed
- Step 2. Rate factors
- Step 3. Identify important factors
- Step 4. Establish current levels
- Step 5. Establish reference levels
- Step 6. Identify changes and interpret results

The analytic process will provide a starting point for discussion of hydrologic issues, related resource issues, and questions to be addressed through ecosystem and resource management planning. The analysis is intended to be watershed-specific, dealing only with factors associated with the specific watershed being analyzed.

It is likely that the analytic factors will differ between watersheds, especially watersheds in substantially different geographic settings. The expectation, however, is that within a common landscape unit, such as those defined by Bailey (1995) or Maxwell et al. (1995), the suite of important processes will likely be similar. This means that the knowledge gained in one analysis may be used to shape the next.

## **Analysis Preparation**

### **Delineating Watersheds**

Ecosystem analysis requires thinking about processes and characteristics at a variety of scales. Geographic areas are often used as the basis for analysis. Since watersheds are hierarchical, they provide a convenient structure for the analysis of hydrologic condition at a variety of geographic scales (Seaber et al. 1987).

An excellent standard to use for delineating hydrological units comes from the federal government. The U.S. Bureau of Land Management (BLM) and the U.S. Forestry Service (FS) delineate hydrological unit/watersheds through the fifth code, and as necessary, the sixth code, at a scale of 1:24,000. Protocols are based on surface watershed divides. The boundaries are coordinated across state boundaries.

Analysis of hydrologic condition at larger geographic scales, such as the sub basin (fourth-level hydrologic unit), provides a broader view of conditions and important processes or factors. Analysis at larger geographic scales provides valuable context for subsequent analyses of smaller areas. Data used for analysis at the sub-basin scale is more general than that used at smaller scales. Patterns and the distribution of characteristics or conditions are evident at larger scales.

The process outlined in this course is intended to be used to assess hydrologic condition of fifth- or sixth-level-code hydrologic units during land and resource management planning efforts. It is possible to complete an analysis of hydrologic condition at the watershed scale using information that is available anywhere in the United States (Core Hydro meteorological Data and Information Protocols, Appendix A). The process is intended to provide the broad context and to point to specific data and information needed for subsequent project investigations, design, prescriptions, and implementation. Analysts should resist the notion that project- or site-level data is required to complete an analysis at the watershed scale.

## Developing Case Files for Core Hydro Meteorological Data

Core hydro meteorological data needs to be assembled in order to gain a basic understanding of the hydrologic cycle for a watershed (see Appendix A). Principles and concepts of fundamental hydrologic processes and hydro meteorological facts are usually published and generic (i.e., change in water yield due to vegetation management). The information (e.g., annual precipitation) is universally available for larger basins and ecoregions containing important watersheds located within Federal forests and rangelands. The published principles, concepts, and hydro meteorological facts and/or their sources need to be identified, assessed, and incorporated into a watershed case file so that they can be managed on a watershed basis.

A permanent watershed case file should be developed and maintained for each watershed. These case files build a picture of the basic characteristics of the watershed. They should include trip reports; studies that relate to hydrology, geology, geomorphology, soils, or use activities; flood or storm reports; research reports; and other information that would be helpful to the analyst. The core hydro meteorological information should be included in this file, along with the hydrologic condition analysis when it is completed. The case file provides a vital source of information to current and future analysts and should be permanently maintained.

Case files should be numbered by the hydrologic unit code and a watershed name. Each watershed case file should contain an index that describes the contents of the file and directs the hydrologist to additional information (e.g., large documents, maps, and access to electronic data files) (Figure 1). All data and analyses should be referenced by author, date, or location. Data collection standards and procedures should be explained. All data and analyses should provide a “version,” sequence identifier (e.g., date). The files will evolve as each watershed analysis is performed. Developing full descriptive case files may take years or decades depending on the level of activity in a watershed and the priorities and resources that can be devoted to analysis.

The watershed case file will be used as a data source to assess hydrologic changes resulting from land management actions. The core hydro meteorological data is intended to improve the effectiveness of analysts as members of interdisciplinary teams, and help them provide credible advice and counsel to other interested publics in a timely manner.

Office Location: \_\_\_\_\_  
 Watershed File Number/Name: \_\_\_\_\_  
 Hydrologic Unit Code: \_\_\_\_\_

WATERSHED CASE FILE INDEX					
	Data Gaps	Data Format	Data Location & File Name	Data Quality	Analysis Methods
<b>METEOROLOGY</b>					
Precipitation					
Air Temperature					
Evaporation					
Wind					
<b>SURFACE WATER</b>					
Quality					
Quantity					
<b>GROUND WATER</b>					
Springs and Wells					
Aquifers					
<b>DRAINAGE BASIN CHARACTERISTICS</b>					
Watershed Morphometry					
Wetlands/Riparian Areas					
Soils					
Geology					
Vegetation					
Human Influence					
<b>OTHER WATERSHED-SPECIFIC DATA</b>					

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**Figure 1.** Watershed cas