

## CHAPTER 2

# OVERVIEW OF THE HYDROGEOMORPHIC APPROACH

### 2.1 The Hydrogeomorphic Approach

The HGM approach to assessment of functions of waters/wetlands has four essential elements (Brinson 1993, Brinson 1995, Brinson 1996). These are listed below.

1. Classification of waters/wetlands based upon hydrogeomorphic factors.
2. Identification, definition, and description of the functions for the subclass of waters/wetlands under consideration.
3. Development of a reference system that includes descriptive information about the subclass and the range of variation in structure and function observed within the subclass.
4. Development of an assessment model, associated protocols, and definition of functional indices which established criteria for the background information necessary to perform a functional assessment.

Each of these four elements is described in detail in the sections 2.2 through 2.5. Procedures for development of regional guidebooks that incorporate the essential elements of HGM and synthesize them into a standardized assessment approach for a particular subclass of waters/wetlands have been outlined by the Environmental Protection Agency and the US Army Corps of Engineers (*e.g.*, Brinson 1993, Smith *et al.* 1995, U. S. Army Corps of Engineers 1997).

### 2.2 Classification of Waters / Wetlands *First Essential Element of HGM*

The first essential element of the HGM approach is the classification of waters/wetlands based upon hydrogeomorphic factors (Brinson 1993). The purpose of the HGM classification is to provide an interdisciplinary mechanism to account for the natural variation inherent in waters/wetlands. Classification of waters/wetlands is based upon their position in the landscape, or geomorphic setting, dominant source of water, and flow and fluctuation of the water in the waters/wetlands. Such intrinsic features are sources of the natural variation within each class of waters/wetlands. Classification criteria are described in greater detail in Brinson (1993).

Seven broad hydrogeomorphic classes have been identified: riverine, depression, slope, mineral soil flats, organic soil flats, estuarine fringe, and lacustrine fringe. Each of these classes is defined in Table 2.1. Identification of subclasses of waters/wetlands logically follow (*e.g.*, the Depression class can be subdivided into perched, shallow surface, and subsurface flow-through depressions.) This variation is often attributable to factors such as geomorphic setting, dominant water source, and hydrodynamics (Brinson 1993). This *Draft Guidebook* will focus on the riverine class, and three of the four identified subclasses within the South Coast region of Santa Barbara County.

**Table 2.1 Definitions of HGM Classes (Whigham et al *in prep.*)**

HGM CLASS	DEFINITION	EXAMPLES
Riverine	<p>Riverine waters/wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and waters/wetlands. Additional water sources may include groundwater discharge from surficial aquifers, overland flow from adjacent uplands and tributaries, and precipitation.</p> <p>Riverine waters/wetlands lose surface water by flow returning to the channel after flooding and saturation flow to the channel during precipitation events. They lose subsurface water by discharge to the channel, movement to deeper groundwater, and evapotranspiration.</p>	<p>Bottomland Hardwood floodplain waters/wetlands in the Southeastern U.S.; Riparian waters/wetlands in the annually flood prone area of Prairie rivers.</p>
Depressional	<p>Depressional waters/wetlands occur in topographic depressions on a variety of geomorphic surfaces. Dominant water sources are precipitation, groundwater discharge, and surface flow and interflow from adjacent uplands. The direction of flow is normally from surrounding non-wetland areas toward the center of the depression. Elevation contours are closed, allowing for the accumulation of surface water.</p> <p>Depressional waters/wetlands may have any combination of inlets and outlets or lack them completely. Dominant hydrodynamics are vertical fluctuations, primarily seasonal. Depressional waters/wetlands lose water through intermittent or perennial drainage from an outlet, evapotranspiration, or contribution to groundwater.</p>	<p>Prairie Potholes; Vernal Pools in the California Central Valley; Depressions on valley alluvium in the Pacific Northwest</p>
Slope	<p>Slope waters/wetlands normally occur where there is a discharge of groundwater to the land surface. They usually exist on sloping land surfaces, from steep hillslopes to nearly level terrain. Slope waters/wetlands are usually incapable of depressional storage. Principal water sources are groundwater return flow and interflow from surrounding non-waters/wetlands as well as precipitation. Hydrodynamics are dominated by downslope unidirectional flow.</p> <p>Slope waters/wetlands can occur in nearly level landscapes if groundwater discharge is a dominant source to the waters/wetland surface. Slope waters/wetlands lose water by saturation subsurface and surface flows and by evapotranspiration. Channels may develop but serve only to convey water away from the waters/wetland.</p>	<p>Fens; Swales in the California Central Valley; Forested wetlands on toeslopes adjacent to, but above floodprone areas of western streams</p>

Table 2.1 cont.

HGM CLASS	DEFINITION	EXAMPLES
Mineral Soil Flats	<p>Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces where the main source of water is precipitation. They receive virtually no groundwater discharge, distinguishing them from depressions and slopes.</p> <p>Dominant hydrodynamics are vertical fluctuations. They lose water by evapotranspiration, saturation overland flow, and seepage to underlying groundwater. They are distinguished from flat upland areas by their poor vertical drainage and low lateral drainage.</p>	Pine Flatwoods of the Southeastern U.S.
Organic Soil Flats	<p>Organic soil flats, or extensive peatlands, differ from mineral soil flats, in part, because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Organic flats often expand beyond the areas where they started to form (usually depressions) to adjacent areas that were non-wetland or mineral soil flats.</p> <p>Water source is dominated by precipitation, while water loss is by saturation overland flow and seepage to underlying ground water. Raised bogs share many of these characteristics, but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants.</p>	Pocosin wetlands in eastern North Carolina; Portions of the Everglades
Estuarine Fringe	<p>Tidal fringe waters/wetlands occur along coasts and estuaries and are under the influence of sea level. They usually intergrade landward with riverine or slope waters/wetlands where tidal currents diminish and other sources of water (<i>e.g.</i>, river flow; groundwater discharge) dominate.</p> <p>Tidal fringe waters/wetlands seldom dry for significant periods. They lose water by tidal exchange, by saturation overland flow to</p>	<i>Spartina alterniflora</i> Salt Marshes

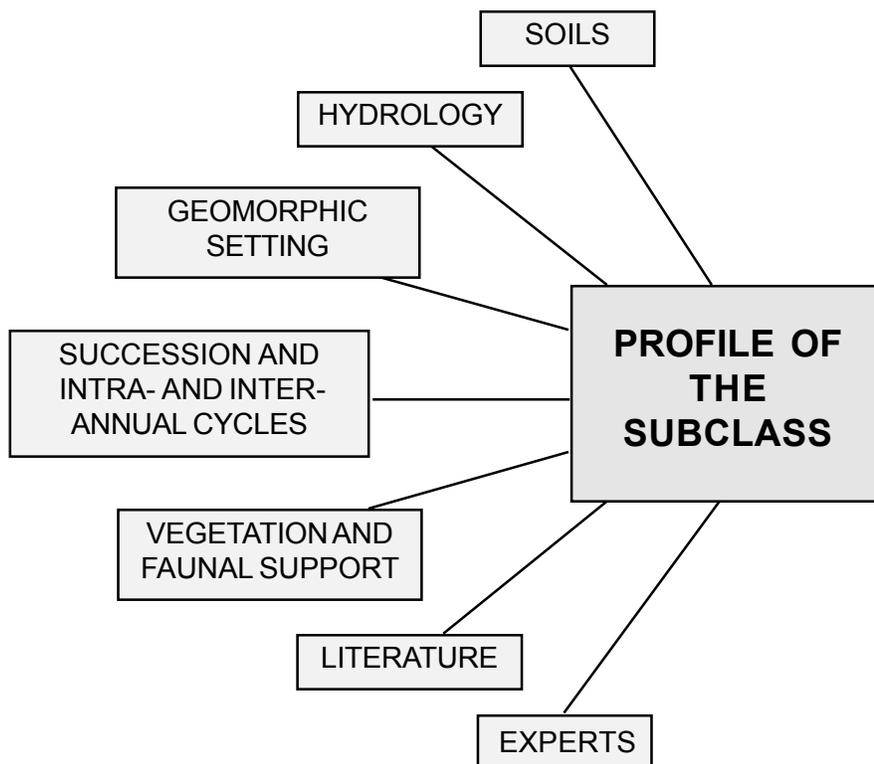
**2.3**  
**Identification, Definition and Description of Functions**  
*Second Essential Element of HGM*

The second essential element of the HGM approach is identification, definition, and description of the functions of the waters/wetlands of concern. For the purposes of HGM, “functions” are defined as “processes that are necessary for the maintenance of an ecosystem, such as primary production, nutrient cycling, decomposition, *etc.*” In the context of HGM, the term “functions” is used primarily as a means to highlight the distinction of ecosystem functions from socioeconomic values. The term “values” is associated with society’s perception of ecosystem functions. Functions occur in ecosystems regardless of whether or not they have value to society. HGM guidebook authors typically choose to group functions according to logical classes such as hydrologic, biogeochemical, plant community, and faunal support/habitat.

**2.4**  
**Reference Systems**  
*Third Essential Element of HGM*

The third component of the HGM approach is establishment and use of a reference system (Brinson 1995, Brinson 1996). The structure of an HGM reference system is shown in Figure 2.1.

**Figure 2.1**  
 HGM Reference System Structure



To apply the use of reference systems in the context of HGM, it is important to understand the standard definitions presented in Table 2.2. To the extent possible, the authors have used HGM nomenclature in this *Draft Guidebook* that is known to be consistent with developing national standards. However, a national HGM nomenclature is still evolving and use of some terms may be inconsistent from region to region.

**Table 2.2 HGM Reference Definitions**

REFERENCE TERM	DEFINITION
Reference Domain	All waters/wetlands within a defined geographic region that belong to a single hydrogeomorphic subclass.
Reference Wetlands	Waters/wetland sites within the reference domain that encompass the known variation of the subclass. Reference waters/wetlands are used to establish the ranges of variation.
Reference Standard Sites	Those sites within a reference waters/wetland data set from which reference standards are developed. Among all reference waters/wetlands, Reference Standard Sites are judged by an interdisciplinary team to have the highest level of functioning.
Reference Standards	Conditions exhibited by a group of reference waters/wetlands that correspond to the highest level of functioning (highest sustainable capacity) across the suite of functions of the subclass. By definition, reference standard functions receive an index score of “1.0”.
Site Potential	The highest level of functioning possible given local constraints of disturbance history, land use, or other factors. Site potential may be equal to or less than levels of functioning established by reference standards.
Project Target	The level of functioning identified or negotiated for a restoration or creation project. This target must be based on reference standards and/or site potential and be consistent with restoration or creation goals. Project targets are used to evaluate whether a project is developing toward reference standards and/or site potential.
Project Standards	Performance criteria and/or specifications used to guide the restoration or creation activities towards the project target. Project standards should include and specify reasonable contingency measures if the project target is not being achieved.

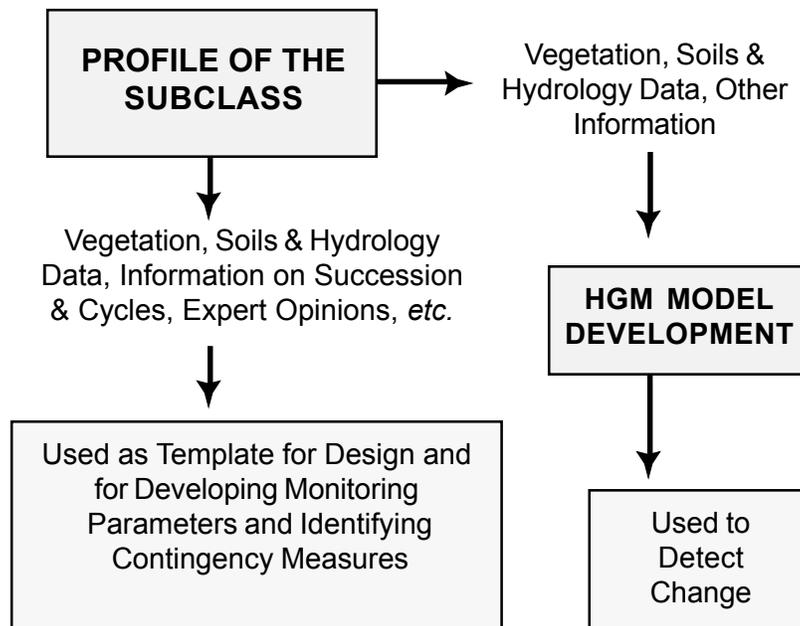
As illustrated in Figure 2.1 the subclass profile is the highest organizational element of the HGM reference system. Users of HGM reference systems commonly access information included in the subclass profile to establish standards for comparison among members of the subclass (e.g., sites of the same subclass within the Domain (Smith *et al.* 1995). Typically HGM users will use reference systems:

*Uses of Reference Systems*

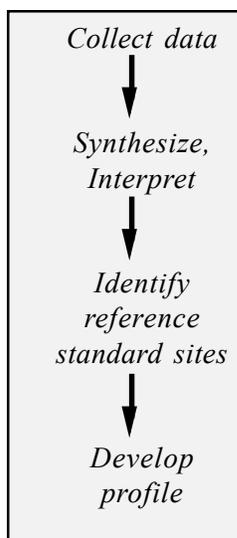
1. To apply HGM models and thus detect changes in waters/wetland ecosystem functioning,
2. As design templates, and
3. To set monitoring targets as well as to specify contingency measures (Figure 2.2).

The principle of reference in the context of HGM is useful because everyone uses the same standard of comparison, and relative rather than absolute measures allow efficiency in time and consistency in measurements.

**Figure 2.2**  
Use of the HGM  
Subclass Profile



### Building a Reference System



Standards and details concerning development of HGM reference systems are given in the National Reference Guidebook (Whigham *et al.* in prep.) Briefly, to develop an HGM reference system, an interdisciplinary assessment team (A-team) visits reference sites in a range of conditions (*i.e.*, relatively pristine to highly degraded) in the same biogeographic region and hydrogeomorphic subclass. At each site, the team collects data on physical, hydrologic, biogeochemical, vegetation, and faunal support/habitat community attributes. When synthesized, interpreted, and combined with the best scientific judgment of the interdisciplinary team, these data serve to indicate the range of ecosystem conditions, functions, and responses to perturbation witnessed by the team within the subclass.

In addition to developing a subclass profile, the A-team uses best scientific judgment to determine whether each site is a “reference standard site.” Reference standard sites are those that are determined by the A-team to be functioning at the highest level (*i.e.*, highest sustainable capacity) across the suite of functions exhibited within the subclass. “Reference standards” are articulated from data collected at the reference standard sites. Reference standards are those conditions exhibited by the reference standard sites that correspond to the highest level of functioning. In the HGM approach, reference standards are used to construct functional profiles of the waters/wetlands subclass, and to set the standards that allow development of HGM models.

Ideally, all of the waters/wetlands within a defined geographic region that belong to a single hydrogeomorphic subclass constitute the “reference domain.” However, practical limitations of funding, personnel, and access usually do not allow sampling of all waters/wetlands within the defined region. Therefore, the reference domain is envisioned as both the actual waters/wetlands sampled to build the reference system, and the geographic area within which reference sites for a regional waters/wetlands subclass have been sampled. Where sampling of additional reference sites could be used reasonably to expand the sampled reference domain (*e.g.*, within a single biogeographic region), one can infer a “potential reference domain.” The potential reference domain thus constitutes the sampled reference domain plus the pool from which additional reference sites might be selected to expand the sampled reference domain.

## 2.5

### HGM Assessment Model, Protocols and Definition of Functional Indices *Fourth Essential Element of HGM*

The fourth essential element of the HGM approach is development of an assessment model, with associated functional indices and protocols. After defining the ecosystem functions that waters/wetlands within a subclass perform, the assessment models and definition of functional indices can be developed. A functional capacity index (FCI) is an estimate of the capacities of the waters/wetlands within a subclass to perform those functions (Smith *et al.* 1995, see Chapter 5). The assessment protocol is the how-to portion of the model, defining minimum information requirements and sampling techniques.

#### **Variables:**

*Those attributes that influence the capacity of a waters/wetland to perform a given function.*

To develop assessment models for the functions associated with a regional waters/wetlands subclass, “**variables**” must be identified, defined, and scaled using data from the reference system. Variables are defined as the attributes or characteristics of a waters/wetland ecosystem or the surrounding landscape that influence the capacity of a water/wetland to perform an ecosystem function or a set of functions. For example, in SCSBC, macro and micro topographic complexity affect the hydrologic function “surface and near-surface water storage.” At each project assessment area, a variable may be operating or expressed to a greater or lesser degree, depending upon land uses, degree of disturbance, *etc.* Hence, variables are usually observed to relate directly to the degree of anthropogenic perturbation extent on a particular site. In the field, variable conditions are either measured directly (*e.g.*, tree stem density) or indirectly through the use of **field indicators** (*e.g.*, microtopographic roughness ~ number of pits of a certain size capable of storing ponded water). Specifically, field indicators are observable characteristics of the water/wetland that correspond to identifiable variable conditions in the water/wetland or in the surrounding landscape.

#### **Field Indicators:**

*Observable characteristics of waters/wetlands that correspond to identifiable variable conditions.*

#### **Functional Capacity Indices (FCI):**

*Derived from a simple formula that combines all variables for a given function. FCI's range from 0.0 to 1.0.*

Finally, variables must be combined into assessment models. An HGM model for a particular function is usually expressed as a simple formula that combines variables in certain ways to yield an estimate of a “**functional capacity index**” or **FCI**. In a complete guidebook, the relationships among variables that are combined to develop an FCI have been established clearly, and they are based on analyses of reference system data developed for the subclass (Figure 2.3). By definition, reference standard sites yield FCI's of 1.0, and FCI values range from 0.0 to 1.0. Therefore, highly degraded waters/wetlands may yield FCI's of 0.0 (*i.e.*, unrecoverable loss of ecosystem function). Thus, an FCI is an estimate of the function performed by a water/wetland with respect to reference standard conditions.

**Assessment Protocol** The final step in development of an assessment model is development of an assessment protocol for users of the HGM model. The assessment protocol establishes criteria for the background information necessary to perform a functional assessment, and provides instructions for the measurement of variables in the field and subsequent calculation of FCI's. Use of an assessment protocol establishes minimum requirements for valid use of models and thus helps ensure their unbiased, consistent application. More details on the assessment protocol developed in the guidebook are presented in the "HGM Applications" section of this *Draft Guidebook* (Chapter 3)

**Figure 2.3**  
Structure of an HGM Model

