# External Scientific Peer Review of:

## Proposed (1) Wetland Definition and (2) Delineation Method For the California State Water Control Board

**James D. Gregory, Ph.D., CPSS, PWS**
**Professor Emeritus**
**Department of Forestry & Environmental Resources**
**North Carolina State University, Raleigh, NC**

**July 9, 2011**

## Introduction

The excellent work accomplished by the California State Water Resources Control Board (State Water Board), the State Water Board staff, the Technical Advisory Team (TAT) and the staff of the Aquatic Science Center of the San Francisco Estuary Institute in reviewing the federal wetland definition and jurisdictional wetland delineation methodology provides the opportunity to develop a much more structured and scientifically based system of identifying and delineating jurisdictional wetlands. Therefore, my review is in three parts: (1) recommendation for development of a wetland classification system and monitoring of reference wetland sites, (2) an overview of scientific shortcomings of the U.S. Army Corps of Engineers' (Corps) wetland definition and delineation methodology and recommendations for addressing those shortcomings and (3) specific review comments on each of the twelve statements in Attachment 2 of the Peer Review Request. In each part of the review, I have also addressed specific items in the State Water Board Draft Staff Report (Staff Report) and in the TAT Memoranda. Throughout my review report the term "wetland delineation" or just "delineation" refers to the methodology applied in the field to identify a jurisdictional wetland and locate its boundaries.

Throughout my review report are numerous references to the report of the Committee on Characterization of Wetlands of the National Research Council (CCWNRC), Wetlands: Characteristics and Boundaries (NRC 1995). Though published in 1995, that thorough review of policy and scientific issues related to jurisdictional wetlands and particularly the recommendations of that outstanding panel of experts related to wetland delineation are very pertinent today. The U.S. Army Corps of Engineers (Corps) has adopted some of those recommendations in the regional supplements but has not adopted others that would strengthen the scientific base of the Corps' wetland delineation methodology. I recommend that the State Water Board consider all of the CCWNRC's recommendations (summarized on pp. 144-148) in the course of developing the California wetland delineation program. I understand the need for the State Water Board to develop and adopt a wetland delineation methodology that does not deviate too far from current Corps practice. However, the State Water Board has an opportunity to lead rather than follow in the field of jurisdictional wetland delineation. Lead on!

## Wetland Classification: The Key to An Effective Wetland Delineation Methodology

Throughout the TAT Memoranda and the Staff Report are references to the complexity of the widely varied wetland types in California and the challenges to applying an effective delineation methodology that result from that complexity and variability. I recommend the development of a classification system for California wetlands that organizes the known descriptive information about the state's wetland types and provides the framework for developing a system of reference wetlands with standard monitoring protocols. The TAT noted in Memorandum No. 4 (p. 4) that a "forthcoming TAT memorandum will focus on wetland classification and its relationship to wetland identification, delineation, and assessment." I strongly support that effort and recommend that the proposed classification system be based on the hydrogeomorphic (HGM) classification system, the concepts of which were developed by Dr. Mark Brinson for the Corps (Brinson 1993, Smith et al. 1995). The typology of wetlands in the California Rapid Assessment Method (CRAM) for Wetlands (Collins et al. 2008) provides a starting point.

Since the HGM wetland types are based on geomorphology and hydrology, they provide the best functional classification for the first level of a wetland classification system. One or two sublevels (or more if needed) in the classification then are based on other ecosystem characteristics that logically separate the variability among wetland subtypes. Vegetation types should constitute the lowest level in the classification since

- similar vegetation types often exist among wetland types that are different in geomorphology, hydrologic functions or soil type or
- wetlands that are similar in geomorphology, hydrologic functions and soil type often support different vegetation types.

Using Level IV Ecoregions as a level in the classification is likely not an appropriate tool since some HGM wetland types, e.g. riverine wetlands, occur in all ecoregions of a state.

I recommend that as funding permits, the State Water Board develop and implement a system of reference wetlands with long term hydrologic monitoring to provide the data needed to develop wetland hydrology criteria and indicators for wetlands in California. As discussed in more detail below, the wetland delineation factor with the poorest science base is the hydrology factor. Note CCWNRC's recommendations 2-10 regarding hydrologic analyses and the use of hydrology data to assess the hydrology factor (NRC 1995, p. 146). Dr. R. Wayne Skaggs Professor of Agricultural and Biological Engineering at North Carolina State University and member of CCWNRC, and his research team have developed an application of Skagg's water management model DRAINMOD that is an excellent tool for analyzing hydrologic data for wetland delineation applications (Hunt, et al. 2001).

## Terminology

I have comments and recommendations on certain items in the glossary of the Staff Report and several other terms that relate to discussions later in this report. Since some definitions in the Staff Report differ somewhat from definitions of the same terms in the TAT Memoranda, I presume that the definitions in the Draft Staff Report will be the form used in the final staff report.

**factors vs. parameters** - Note my use of the term "factors" in this report in place of "parameters" as used in the 1987 Manual and as used throughout the Staff Report and the TAT Memoranda. I recommend that wherever the term "parameters" occurs in the Staff Report and TAT memoranda that it be replaced with "factors" in the final form of these reports. As noted by the CCWNRC (NRC 1995), the term "parameter" is a mathematical term that refers to a component of a mathematical function and is not appropriate to describe the three ecosystem factors, water, soil, and vegetation, that constitute the basis for the definition and delineation methodology for jurisdictional wetlands. As defined by the CCWNRC (NRC 1995), "criteria" refers to the states or conditions of the three factors of the wetland definition. Criteria represent measurable characteristics of the ecosystem for each of the elements of the definition that can be tested by collecting data in the ecosystem, often over some specified time period. Testing the criteria thus tests the definition. Indicators are observable characteristics of the ecosystem that can be rapidly detected or measured and <u>that provide evidence toward a professional judgment regarding whether the criteria are met.</u>

**altered circumstances** and **new normal circumstances** - Both of these terms and their use in the State Water Board delineation methodology are scientifically sound and quite descriptive. I have two suggestions: (1) drop "altered conditions" from use since it is a synonym for altered circumstances and (2) provide more specific guidance for application of "altered circumstances" vs. "new normal circumstances" due to natural processes. What is meant by "practitioners must use supplementary identification/delineation procedures to characterize the pre-alteration condition?" The Corps' approach to attempting to determine the pre-alteration condition where anthropogenic alterations seemed purposely designed to convert a wetland to a non-wetland are certainly appropriate. But when a natural process converts a wetland to a non-wetland or a wetland is sufficiently altered by a natural process to convert it to another type, I see no regulatory need to try to ascertain the pre-alteration condition. The ecosystem is what it is for regulatory purposes even if the wetland happens to be in a transition state moving toward new normal circumstances that are different than at some recent time in the past.

**aquatic support areas** - The concept of aquatic support areas is scientifically sound, however, the verbiage in the definition and the definition of "riparian areas" seems to overlap and has some confusing elements. I recommend that the use of "riparian areas" be limited to the transition zone abutting streams and waterbodies and that the use of "aquatic support areas" be limited to the transition zone to non-wetlands that abuts wetlands. If another wetland or a stream or waterbody abuts a wetland, that abutting area is simply another aquatic area not an aquatic support area. Following that concept, aquatic support areas in my experience in the Southeast are zones up-gradient from the hydric soils boundary of a wetland (i.e. the Corps boundary). If that slope gradient is relatively small, the transition zone will have hydrophytic vegetation. If that slope gradient is relatively large, the transition zone may not have hydrophytic vegetation. In no case will the aquatic support area have wetland hydrology or hydric soils. But in all instances, the aquatic support area is a zone of hydrologic and ecologic connection to the surrounding landscape. My suggested definition for aquatic support area is "a non-wetland transition zone abutting the boundary of a wetland that is the hydrologic and ecologic connection to the surrounding landscape." I have some additional suggestions about determining the outer boundary of the aquatic support area below in my discussion of Statement 12.

**channels** - Excellent definition!

**growing season** - The definition of growing season in the context of new plant growth is a good one except that I suggest that "hydrophytes" be replaced with "plants". See the section, ***Statement 7,*** below for a discussion of the growing season issue.

**hydric substrate conditions** - I recommend that this term be eliminated from use by the State Water Board. Taken literally, the term means wet soil which is soil that is not necessarily anaerobic. So why use a redundant term that is defined to mean "anaerobic conditions" when "anaerobic conditions" can be used. See below for my comments and recommendations concerning the definition of upper substrate.

**inundation** - I recommend that the standard Natural Resources Conservation Service (NRCS) soil water term "inundation" be used in place of "surface water". Add the definitions of flooding and ponding. See below.

**return flow** - I recommend that the standard hydrologic term "exfiltration" be used as a substitute for "return flow" which is not a standard soil water term and engenders confusion as noted in the definition. **exfiltration** - discharge to the surface of saturated or unsaturated soil water flow. The term "groundwater discharge" is the standard hydrologic term for discharge of water from groundwater zones into streams, water bodies or wetlands.

**runoff** - I recommend that the term "surface runoff" (overland flow) be used instead of just "runoff". The definition is excellent. "Runoff" as used in the field of hydrology refers to the combination of surface and subsurface water fluxes by which rainfall becomes streamflow.

**saturated** - The definition of saturation in the 1987 Manual is wrong. The definition of saturation in the regional supplements is a little better but still wrong in the reference to saturation above the water table. The definition in the Draft Staff Report has a few correct elements but much is wrong with it. "Saturation" is a general soil water term that applies anywhere in a soil or substrate at or near the surface or deep within an unconsolidated sedimentary layer. See my discussion regarding the Corps' scientifically untenable description that the soil is saturated above the water table in the section ***Hydrology Criterion*** below. Soil at field capacity is <u>not</u> saturated. Field capacity is the soil water state when a saturated soil has drained for several days and water in the macropores (gravitational water) has drained due to the pull of gravity. Therefore, at field capacity, the micropores are water filled (except for trapped air) and the macropores are mostly air filled. I strongly recommend that the State Water Board adopt the definition of saturation that has always been the standard definition in the fields of soil science and hydrology. See recommended definition below.

**upland** - I recommend that the term "upland" be used only in its geomorphic sense when referencing an area of the surface at higher elevation than a lowland. I strongly recommend that the very clear term "non-wetland" be used to refer to areas that are not wetlands. Many wetland ecosystems are located on mid or upper slope positions and thus are also uplands.

**upper substrate** - I strongly recommend that the depth criterion for the upper substrate be changed to "a depth of 30 cm (12 in) below the substrate surface" to correspond with the Corps' water table depth criterion. As the current draft State Water Board wetland definition now reads "within the upper substrate", it could be interpreted to mean that a soil with saturation and anaerobic conditions at and below 48 cm (19 in) would meet the definition. Many species of non-hydrophytic plants would be quite happy in that situation. The justification for extending the upper substrate to 50 cm (20 in) as described in the last sentence of p. 44 of the Staff Report is faulty. There is nothing in the regional supplements that refers to "experience in the western United States on the depth of the major portion of the root zone (i.e. the zone containing more than 50 percent of the living root mass of the dominant wetland plant species)." The fine roots (≤ 1 mm in diameter) that are active in water and nutrient uptake for all plants (including large trees) are concentrated very near the soil surface for all but a few species of plants, usually in the top 20-30 cm (8-12 in) and often in a shallower zone than that for most hydrophytic plants. The fine roots are those that are most sensitive to extended periods of anaerobiosis. The exceptions are alfalfa and some native grasses of the midwestern and western prairie ecosystems that will grow fine roots to depths of as much as 1 m in Mollisol soils with A horizons that are 1 m or more deep.

The section in the regional supplements, **Observe and Document the Soil** in Chapter 3 **Hydric Soil Indicators** is taken almost verbatim from Field Indicators of Hydric Soils in the United States, A Guide for Identifying and Delineating Hydric Soils, Version 7.0, 2010 (USDA, NRCS 2010). The instructions to observe and describe the soil up to 50 cm deep are based on the fact that a few of the indicators may have soil layers that are part of the indicator that extend to that depth. But such indicators, e.g. A12 Thick Dark Surface, begin at or very near the soil surface indicating that they are the result of recurrent, sustained saturation and anaerobiosis to the surface.

I recommend that the following definitions be added to the glossary.

**aerobic conditions** – in soil water, refers to the presence of adequate dissolved oxygen for aerobic bacteria to flourish in the soil solution; aerobic bacteria utilize $O_2$ in soil solution as the terminal electron acceptor in respiration; aerobes are the dominant bacterial type under aerobic conditions; occurs when the soil is unsaturated, i.e., some pores are filled with air and diffusion of air from the surface maintains adequate oxygen levels in the soil solution for aerobic bacteria to flourish.

**anaerobic conditions (reducing conditions)** – in soil water, refers to conditions in which $O_2$ in the soil solution is depleted and aerobic bacteria (as well as fungi) rapidly die off or enter resting stages; anaerobic or facultative anaerobic bacteria that can utilize molecules other than $O_2$ as the terminal electron acceptor in cell respiration begin to flourish; anaerobes preferentially use different oxidized molecules as the electron acceptor in respiration (i.e., chemically reduce those molecules); occurs in soil zones that are saturated or close enough to saturation that maintenance of air diffusion from the surface is nil.

**capillary fringe** – thin zone of soil above a water table in which water from the zone of saturation rises in response to a potential gradient (capillary gradient) into the vadose zone, i.e., the soil water content is higher than it would be without the water table present; the water potential in the capillary fringe is less than zero (i.e., the water is under tension) and the soil water content is less than saturation.

**field capacity** – soil water content at which water is held in the soil micropores against the force of gravity and the macropores are mostly air-filled; water remaining in the soil 2-3 days after saturation when free drainage due to gravity can occur.

**ground water zone** (zone of saturation) – soil or geologic substrate is saturated; soil pores are filled with water, except for trapped air; soil water potential is zero or positive compared to atmospheric pressure.

**inundation** - A condition in which water from any source temporarily or permanently covers a land surface.

> **ponded** - A situation in which water stands in a closed depression. The water is removed only by infiltration, evaporation, or transpiration.
>
> **flooded** - A condition in which the soil surface is temporarily covered with flowing water from any source, such as overflowing streams or rivers, surface runoff from adjacent slopes, inflow from high tides, or any combination of such sources.

**saturation** – condition in a soil or other substrate in which all pores are completely filled with water. In a soil zone of fluctuating water table, the soil is nominally considered to be saturated when all pores are filled with water except for a small volume of micropores that have trapped air (this condition is often called satiation).

**soil macropores** – 0.08 to 5 + mm in diameter; usually found between peds (structural units). Channels or pipes formed from decayed roots are often up to 25 mm in diameter and occasionally larger. Water drains from macropores rapidly due to gravity, usually 2-3 days after rainfall.

**soil micropores** – less than 0.08 mm in diameter; larger ones are usually found between soil peds (structural units), smaller ones are inside the peds. Micropores retain water after drainage of gravitational water due to soil adsorptive forces and surface tension of water.

**soil moisture** (soil water) – refers to the total volume of water present in the zone of unsaturated soil; by convention, soil water content equals the volume (or weight) of the water removed from a soil sample by drying to constant weight (24-48 hours) at 105 °C, "oven-dry soil".

**vadose zone** (soil water zone, zone of aeration) – soil is unsaturated, soil pores contain both water and air; the water content is usually between the content at field capacity and the content at the permanent wilting point; water content very seldom reaches saturation except in soil layers with fluctuating water tables; soil water potential is usually less than zero compared to atmospheric pressure; water is also referred to as soil moisture.

**water table** - level in the substrate (1) at which the pore water potential is zero compared to atmospheric pressure and (2) to which water will rise in a open bore hole or well. The water table is the top of the zone of saturation (ground water) and the bottom of the vadose zone (soil water).

## The Structure of a Wetland Delineation Methodology

The concept of a jurisdictional wetland subject to regulatory management constraints is a policy construct. Wetlands are ecosystems and are a component of highly variable natural ecosystems that don't neatly fit the sideboards of that policy construct. Therefore, the science of wetlands in the regulatory context must be guided by a structured methodology that provides the sideboards to identify and delineate the natural ecosystems that fit the policy construct.

The structure of the Corps' wetland delineation methodology as originally published in the Corps of Engineers Wetlands Delineation Manual (1987 Manual)(Corps 1987) consists of several tiers: (1) definition (1987 Manual, p. 9), (2) diagnostic environmental characteristics (1987 Manual, pp. 9-10), (3) criteria for each of the three factors of the delineation methodology, and (4) indicators for each of the three factors of the delineation methodology. The Committee on Characterization of Wetlands of the National Research Council (CCWNRC) (NRC 1995) proposed a more structured organization of a wetland definition plus elements of the delineation methodology (NRC 1995, fig. 3.1, p. 60, see next page) consisting of four tiers: wetland definition, criteria for each of the three diagnostic factors, general indicators and specific indicators for each of the three diagnostic factors. I recommend that the State Water Board develop and adopt a wetland delineation structure similar to that recommended by CCWNRC. I recommend that the State Water Board draft a wetland delineation supplement that describes the scope and application of the specific State Water Board wetland definition, the criteria for each of the three factors, references the indicators in the Corps manuals and describes elements of the delineation process that differ from Corps methodology.

In my view, collecting data to test the criteria should always take precedence over a professional judgment made on the basis of indicators when needed to settle a disagreement about a wetland delineation. With the introduction of the regional supplements, the Corps has purposefully downgraded the importance of criteria and made the use of indicators the primary means of making jurisdictional wetland decisions. That policy is clear in the last sentence in the last paragraph of Chapter 5, *g. Long Term Hydrologic Monitoring,* in each supplement that refers to collecting data to test the Technical Standard for Wetland Hydrology (Corps 2005): "This standard is not intended (1) to overrule an indicator-based wetland determination on a site that is not disturbed or problematic, or (2) to test or validate existing or proposed wetland indicators." I confirmed the policy of using indicators only and not allowing testing of the criteria on sites that are not disturbed or problematic in a conversation with Dr. James Wakeley[1] when I read the first draft of the Atlantic and Gulf Coastal Plain Regional supplement. In my view, that policy is scientifically untenable and I recommend that the State Water Board establish wetland delineation criteria that can be tested by collecting data when a landowner or consultant wishes to challenge a wetland delineation decision made by a regulator or simply to confirm that the wetland in question meets the wetland definition.

---

[1] Personal Communication: Dr. James S.Wakeley, Project Leader, Regional Supplements; Wetlands Regulatory Assistance Program, Wetlands and Coastal Ecology Branch, Environmental Laboratory, Engineer Research and Development Center, U.S. Army Corps of Engineers, Vicksburg, MS.

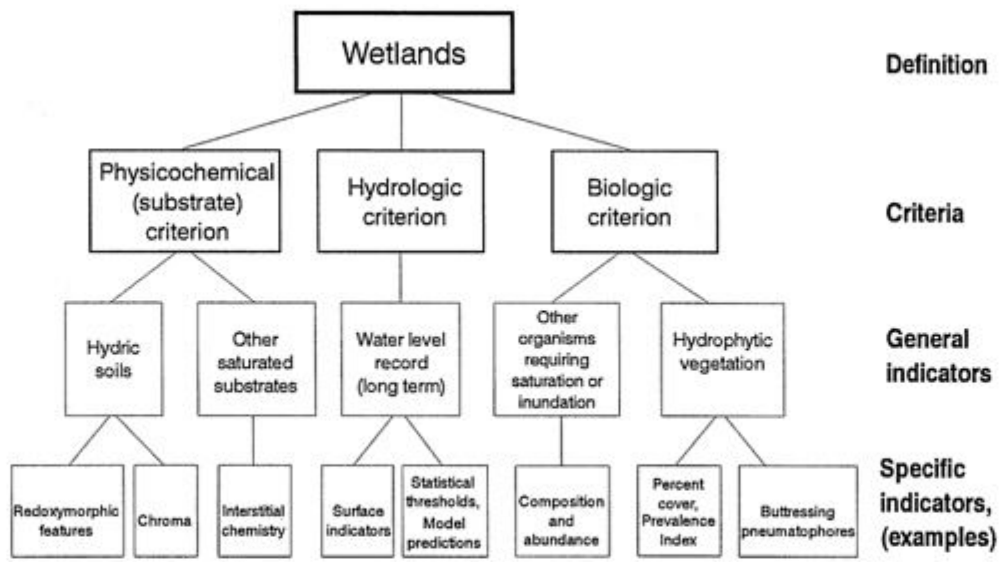


FIGURE 3.1 Diagram of relationships between the reference definition, criteria, general indicators, and specific indicators for wetlands.

### *Wetland Definition*

The wetland definition proposed by the State Water Board will be discussed later in the context of the 12 statements in Attachment 2 of the Review Request.

### *Hydrology Criterion*

The concept of wetland hydrology, i.e. the characteristic hydrologic functions of a wetland ecosystem, is that those functions result in recurrent, sustained soil saturation in the zone of proliferation of fine plant roots very near the surface in the growing season resulting from inundation or a water table very close to the surface. The hydrology factor in the Corps methodology has a weak scientific base and the hydrology criterion has been the subject of constant tinkering for policy reasons rather than scientific reasons since the publication of the 1987 Manual. To my knowledge, the Corps has never conducted any long term wetland hydrology studies to develop a science-based hydrology criterion. The hydrology indicators are based on observation and experience of various Corps staff members but have never been scientifically tested to determine which, if any, have a high correlation with wetland hydrology.

The wetland hydrology definition in the 1987 manual contains the phrase "areas that are periodically inundated or have soils saturated to the surface at some time during the growing season." The defining term "saturated to the surface" was almost immediately disavowed as the Corps unofficially began to use "water table within 12 inches of the surface" as the soil saturation element of the hydrology criterion. As noted by the CCWNRC (NRC 1995, pp. 75-76), that change was based on the "rationale that capillary action saturates the upper surface of the soil above the water table." That rationale has been supported by the Corps by introducing the contradictory concept of the "tension saturated zone" in the capillary fringe above the water table. The concept of tension saturation is contradictory in that a saturated zone in the soil, i.e. a zone below a water table, has all pores filled with water, except those with trapped air, and has water potential greater than zero compared to atmospheric pressure.

The concept of a water content equal to saturation at a water potential below zero, i.e. under tension, comes from the groundwater literature where textbook authors have predicted capillary rise in a theoretical sediment of very uniform particle size with uniformly distributed very small pores based on the equation that predicts the height of capillary rise of water in small glass tubes (e.g., Fetter 1994, pp. 180-183). The heterogeneity of native soils and non-soil substrates with random mixtures of particle sizes and random mixtures of micropores (< 0.08 mm diameter) that hold water against gravity and macropores (> 0.08 mm diameter) that rapidly drain most of their water due to gravity augurs against the entire soil volume being saturated to the surface above a water table at 12 inches depth (NRC 1995, pp. 93-94; Richardson and Vepraskas 2001, pp. 39-42). That the soil peds likely are close to saturation in internal water content that is mostly anaerobic for several inches above the water table is recognized as a common situation in hydric soils by the Hydric Soil Technical Standard of the National Technical Committee for Hydric Soils (NTCHS) (http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html). In that situation with the macropores filled mostly with air, the entire soil volume is not saturated. A fluctuating water table thus creates the conditions for the simultaneous or alternating oxidation and reduction reactions that form redoximorphic features (Vepraskas 1992).

Whether the Corps has a current hydrology criterion and what that criterion may be is unclear and confusing. Paragraphs 46-48 in the 1987 Manual that contain the original definition of wetland hydrology, the original wetland hydrology criteria of Table 5 and the revised wetland hydrology criterion published in 1992 (User Notes on p. 30 of the 1987 Manual) are still in effect. Those paragraphs were not deleted by the regional supplements. As noted above, the Corps adopted the Technical Standard for Wetland Hydrology (Corps 2005) in the regional supplements for use only in assessment of atypical or problem sites.

I recommend that the State Water Board cut through the current confused state of the Corps hydrology criterion by implementing several hydrology concepts in the structure of the State Water Board Wetland Delineation Methodology:

1. Define wetland hydrology as an element of the wetland definition as the draft wetland definition does. I have a suggestion later in this report to make that element of the definition more specific.

2. As recommended by the TAT (TAT Memorandum No. 4, p.8), adopt the Corps' Technical Standard for Wetland Hydrology (Corps 2005) as the State Water Board hydrology criterion until research in California wetlands provides better data:

   *The site is inundated (flooded or ponded) or the water table is ≤12 inches below the soil surface for ≥14 consecutive days during the growing season at a minimum frequency of 5 years in 10 (≥50% probability). Any combination of inundation or shallow water table is acceptable in meeting the 14-day minimum requirement. Short-term monitoring data may be used to address the frequency requirement if the normality of rainfall occurring prior to and during the monitoring period each year is considered.*

3. As recommended by the TAT, adopt the Corps hydrology indicators in the regional supplements until research in California wetlands provides better data.

### *Hydric Substrate Criterion*

The NTCHS is the proponent agency for hydric soils and has promoted and guided an extensive research program on hydric soils by a large cadre of research soil scientists in the Natural Resources Conservation Service (NRCS) and universities around the country. By virtue of that research base and the Hydric Soil Technical Standard (NTCHS no date) (http://soils.usda.gov/use/hydric/ntchs/tech_notes/index.html) developed by the NTCHS for testing hydric soil indicators, the hydric soil factor has by far the best scientific base of the three wetland delineation factors.

I recommend as did the TAT that the State Water Board adopt the definitions, criteria, and indicators for hydric soils developed and published by the NTCHS on their web page http://

soils.usda.gov/use/hydric/). There are several different criteria for which field data can be collected to test for the presence of a hydric soil.

Testing the definition of a hydric soil, i.e. testing for the presence of substrate saturation and anaerobic conditions near the surface is described in the Hydric Soil Technical Standard. Criteria to test for the presence of anaerobic conditions include:

1. Water table data to demonstrate that the water table is within 25 cm of the surface more than 50 % of years during normal rainfall conditions for a continuous period of at least 14 days during the year. Note that there is no growing season caveat on the hydrology criterion.

2. Redox potential data to demonstrate that the soil is anaerobic within 25 cm of the surface during the period when the water table is within 25 cm of the surface. Accurately measuring redox potential is difficult and requires experience with the methodology, so the NTCHS provides the alternative to conduct an alpha-alpha-Dipyridyl test.

3. Positive alpha-alpha-Dipyridyl test for the presence of reduced (ferrous) iron, Fe++, in soil solution within 25 cm of the surface during the period when the water table is within 25 cm of the soil surface. That test has the potential for false negatives: (1) the soil is anaerobic but ferric iron, Fe+++, compounds have not been reduced to Fe++ in solution or (2) the soil is anaerobic and contains no Fe+++ compounds

Three of the four criteria developed by the NTCHS to search the NRCS national database of soil mapping unit data to produce lists of mapping units that may contain hydric soils are also criteria for field determination of the presence of hydric soils. Those criteria were adopted by the Corps by reference to the NTCHS web site in guidance letters published in 1991 and 1992 (1987 Manual, p. 21) but were not printed in detail in the 1987 Manual nor in the regional supplements. As with the hydrology factor, the Corps' has downplayed the use of hydric soil criteria in favor of use of hydric soil indicators for jurisdictional wetland delineations. However, those three criteria provide a means of collecting data to test for the presence of hydric soil conditions:

1. *All Histels except Folistels and Histosols except Folists*. Organic soils are likely rare in California wetlands but this criterion is tested by sampling the depth and carbon content of the organic layer to confirm the presence of a Histel or Histosol.

2. *Soils that are frequently ponded for long duration or very long duration during the growing season.* This criterion is easily tested by collecting water table data. "Frequently" is more than a 50 percent chance in any one year or more than 50 times in 100 years; "long duration" is inundation from a single event for 7 days to 1 month; and "very long duration" is inundation from a single event for more than 1 month.

3. *Soils that are frequently flooded for long duration or very long duration during the growing season.*

It is presumed that inundation for a minimum of 7 days will produce the saturation and anaerobic conditions requirements of the Hydric Soils Technical Standard. Note that all three criteria above apply to soils and thus cannot be used to test for hydric soil conditions in non-soil substrates.

The use of the more general term "substrate" in place of "soil" in the wetland definition and other published materials regarding the State Water Board wetland delineation methodology is scientifically sound and will not cause any contradictions in regard to the NTCHS definitions, criteria, and indicators for hydric soils. I predict that the State Water Board will, however, face some challenges in testing the hydric soil conditions status of potential wetland ecosystems with non-soil substrates. Since those ecosystems will, in most cases, not develop hydric soil indicators, the presence of anaerobic conditions must be tested by utilizing one of the methods for testing for the presence of anaerobic conditions described in the Hydric Soil Technical Standard. Of course, long term research in reference wetlands may elucidate some indicators of anaerobic conditions usable in non-soil substrates.

### *Hydrophytic Vegetation Criterion*

The hydrophytic vegetation criterion, the dominance test, has long been used by the Corps as the standard field assessment methodology for the presence of hydrophytic vegetation. The science base of the hydrophytic plant list is relatively good though many of the plants on the regional lists and all of the hydrophytic classifications of individual plant species were based on the opinions and experience of the large group of botanists who served on the regional and national advisory committees that developed the plant lists. The TAT noted that there are some inaccuracies in the regional plant list that applies to California and the lack of revision for more than 30 years has prevented a number of changes in plant nomenclature from being incorporated into the lists. The previously recommended reference site research can also address the questions about plant list accuracy. As with the hydrology indicators, the hydrophytic vegetation indicators listed in the 1987 manual are based on the opinions of Corps staff members and have never been systematically tested for degree of correlation with wetland hydrology.

## Review Comments – 12 Statements of the Peer Review Request

I applaud the tremendous amount of work accomplished by all of the professionals involved with reviewing a large assortment of wetland definitions and developing a succinct definition that adheres to the tested science of jurisdictional wetlands and their characteristics while fitting the needs of the wetland regulatory program in California. I am also quite cognizant of the many animated discussions that have transpired among the professionals who developed this draft definition and the desire among those professionals to get it adopted with minimal additional word-smithing. However, I do have some suggestions for revisions that I feel will add clarity to the definition and make a more direct linkage to the criteria and indicators of a structure for wetland delineation. My comments refer to the format of the definition in Statement 6.

Two general recommendations regarding the definition are:

1. I recommend that the beginning phrase of the definition emulate the beginning of the reference definition of wetlands developed by the blue-ribbon panel of wetland experts that was the CCWNRC: " A wetland is an ecosystem that, under normal circumstances,"
2. I recommend that each paragraph of the definition use a definitive term for the diagnostic factor that is then defined and is referenced in the criteria and indicators for each factor.

### *Statement 1*

As noted earlier, I recommend the use of the term "factors" when referring to wetland hydrology, anaerobic substrates, and hydrophytic vegetation. Statement 1 is not correct in regard to anaerobic substrates. The extensive research on hydric soils referred to above focused on soils. The presence of hydric soil in an ecosystem with no recent hydrologic alteration is the key indicator of a wetland ecosystem and the key wetland boundary indicator. Whether ecosystems with non-soil substrates will develop anaerobic conditions in the pore water during extended periods of saturation at or near the surface has not been extensively researched. I agree with expanding the reach of the wetland definition to include ecosystems without vegetation and ecosystems with non-soil substrates. However, that is an experimental expansion and research on potential wetlands with non-soil substrates and no vegetation may show that many of those ecosystems do not meet the wetland hydrology plus anaerobic conditions minimum requirements of the definition.

### *Statement 2*

My comments in this paragraph refer only to the hydrology portion of the statement; the anaerobic conditions part is addressed in the comments regarding Statement 4. The phrase "saturated by groundwater or inundated by shallow surface water for a duration sufficient" has needlessly redundant elements. Water in a saturated zone is groundwater. Conversely, a near surface saturated zone can easily achieve that status by input of infiltrating rainfall or lateral interflow. Shallow surface water is inundation. In addition, this sentence has both a hydrology component and an anaerobic conditions component. See suggested revision in the section, ***Statement 6***.

### *Statement 3*

The term "hydric substrate conditions indicative of such hydrology" is redundant since hydric conditions means anaerobic conditions and anaerobic conditions are referred to in the hydrology paragraph. See suggested revision in the section, ***Statement 6***.

### *Statement 4*

I disagree with Statement 4. "Anaerobic conditions within the upper substrate" is not consistent with the scientific understanding of wetland characteristics. As "the upper substrate" is currently defined, that statement basically means anaerobic conditions occurring anywhere within 50 cm of the soil surface. The Hydric Soil Technical Standard, which is based on a very extensive base of research, specifies that (paraphrased): A soil meets the anaerobic conditions part of the standard if (1) the redox potential $Eh \leq 595 - 60\ (pH)$ within 25 cm of the surface for loamy and clayey soils or within 12.5 cm of the surface for sandy soils or (2) a positive reaction to alpha-alpha-Dipyridyl is the dominant (60 % or more) condition of a layer above the depth of Eh measurement.

The phrase "cause anaerobic conditions" in the first paragraph is quite descriptive of the most common result of wetland hydrology but may not occur in many of the unvegetated ecosystems that the State Water Board proposes to bring under the umbrella of the wetland definition. Moving shallow water that is constantly aerobic near the surface may prove to be the norm in many point bar and mud flat ecosystems.

### *Statement 5*

There is ample scientific support for including areas that have wetland hydrology and anaerobic substrate conditions but are without vegetation or that have vegetation for only part of the year in the definition of wetland.

### *Statement 6*

I recommend the following revised version of the wetland definition:

**A wetland is an ecosystem that, under normal circumstances; (1) exhibits wetland hydrology which is recurrent, sustained shallow inundation or saturation within the upper substrate; (2) exhibits anaerobic conditions within the upper substrate caused by such hydrology; and (3) has vegetation that is dominated by hydrophytes or lacks vegetation.**

Note that this form of the definition:

- Specifies that both saturation and anaerobic conditions must simultaneously exist within the upper substrate, which conforms the definition to the Hydric Soils Technical Standard.
- Allows for "upper substrate" to be separately defined as part of the wetland hydrology and anaerobic conditions criteria and to be revised as warranted by research data.

### *Statement 7*

The proposed revisions to the Corps' field methodology for wetland delineation to accommodate the expansion of the wetland definition to include wetland ecosystems that are not vegetated or that have non-soil substrates are scientifically valid. In effect, the State Water Board is proposing to expand the types of ecosystems included in the policy construct that is a regulatory jurisdictional wetland.

As noted earlier, certain ecosystems that exhibit wetland hydrology and have non-soil substrates may not form anaerobic conditions and thus, would not meet the wetland definition above. In my view, such ecosystems do not meet the widely accepted scientific definition of wetlands, i.e. ecosystems that simultaneously exhibit wetland hydrology and anaerobic conditions.

I recommend that the State Water Board delete the "during the growing season" requirement when adopting the Corps' Technical Standard for Wetland Hydrology (Corps 2005). Use of the period of active growth of plants as the growing season for the hydrology criterion does not account for long periods of inundation/saturation and anaerobiosis during the cool season when plants are dormant. Developing regionally appropriate wetland hydrology criteria for California will also mean that a regionally appropriate system for specifying when during the year the hydrology criterion must be met will also be needed. Note that for purposes of defining hydric soil conditions, the National Technical Committee for Hydric Soils (NTCHS) does not consider the classical concepts of growing season but considers that anaerobic conditions occur when soil microbes are active (The Hydric Soil Technical Standard, ftp://ftp-fc.sc.egov.usda.gov/NSSC/Hydric_Soils/note11.pdf). Thus determining the presence of anaerobic conditions in accordance with the specifications of The Hydric Soil Technical Standard will also suffice for determining when the hydrology factor in the draft State Water Board wetland definition is met. The NTCHS is basically using an "anaerobic conditions season" that is influenced by water table hydroperiod and soil temperature. Since soil temperature is easily measured, I recommend that research on wetland hydrology in California always include soil temperature measurements to develop correlations of anaerobic conditions in the upper substrate with soil temperature and water table depth.

### *Statement 8*

The new terms proposed to be used in the State Water Board wetland regulatory program, including "altered circumstances", "new normal circumstances" and "difficult to resolve areas" are quite useful and are scientifically appropriate.

### *Statement 9*

I agree with the provision for wet season delineations in wetland types where dry season delineations are known to be problematic. However, in situations where hydrophytic vegetation is present, one or more well-developed hydric soil indicators are present and there is no evidence of recent hydrologic alteration, the hydric soil indicator(s) can be used to determine the wetland boundary. Because of the very strong science base of the hydric soil indicators, they are good indicators of wetland hydrology.

### *Statement 10*

I begin my comments on Statement 10 with the Gregory Axioms of Wetland Hydrology: (1) wetland hydrology is complex, (2) wetland hydrology is usually more complex than meets the eye and (3) wetland hydrology for a specific ecosystem becomes more complex the more data is collected on that ecosystem. Recording information on the landscape position and hydrologic character of a wetland ecosystem as part of the delineation process certainly provides useful information and I recommend doing so. However simply recording information on water sources has several pitfalls:

1. Water sources are only part of the story of the hydrology of a wetland. The water balance of the wetland and the geomorphic, soil, and geologic factors that influence the water inputs and outputs are the full story. Wetlands are wet because water inputs exceed outputs for some period of time in most years. One cannot stand in a wetland and accurately estimate the water sources, let alone estimate the inputs and outputs of the water balance.

2. Field personnel for regulatory agencies and consulting firms who deal with wetland delineations are typically relatively young and inexperienced professionals who know very little about wetland hydrology. Expecting such personnel to accurately estimate the hydrologic character of wetland ecosystems is unrealistic.

3. Misinformation about the hydrologic character of wetlands in the gray literature of government agencies abounds.

I recommend an alternative approach and that is to develop a wetland classification system for California wetlands that includes a detailed geomorphic and hydrologic description for the subtypes at the lowest level of the classification system. Then train field personnel on the classification system and include classifying the wetland as part of the delineation process. Notes on the delineation form could then be used to note any obvious hydrologic alterations or deviations from the hydrologic character of the subtype.

### *Statement 11*

Supplemental delineation guidance by ecoregions can be quite useful and I support this recommendation.

### *Statement 12*

As noted in the section on **Terminology** above, the concept of aquatic support area as described in the Draft Staff Report and TAT Memorandum No. 3, Sec. 2.3 is somewhat confusing. The concept that an aquatic support area can exhibit wetland hydrology but not anaerobic soil conditions or can exhibit anaerobic soil conditions but not wetland hydrology while abutting a wetland that does exhibit both wetland hydrology and anaerobic soil conditions is nonsensical. Zones abutting wetlands that are up-gradient of the hydrology and hydric soil boundary do commonly exhibit hydrophytic vegetation. In such zones, near surface water tables may temporarily move up-gradient during periods of unusually high rainfall. But if the wetland hydrology criterion is met, then anaerobic soil conditions will also be met and the wetland boundary will have moved up-gradient.

My suggested definition for aquatic support area is “a non-wetland transition zone abutting the boundary of a wetland that is the hydrologic and ecologic connection to the surrounding landscape.” Keep the conceptual definition simple. Also, I recommend that a minimum width criterion be established for the aquatic support area in relation to the size of the wetland. The conceptual maps of aquatic support areas in the aerial photos of Figures 4-7 in TAT Memorandum No. 3 show that the areas denoted as aquatic support areas by the photo interpreter are zones of elevation transition. Thus the aquatic support area so designated is relatively wide in areas of low slope gradient and relatively narrow to non-existent in areas of high slope gradient. However, groundwater input to the wetland is likely greater along the wetland boundaries with high-gradient transitions to adjacent non-wetland uplands than along boundary zones with low-gradient transitions to adjacent non-wetland uplands. If the aquatic support area is meant to be a protection zone for the hydrologic transition to the wetland, then that area should have a minimum width around the entire boundary of the wetland.

## References Cited


Brinson, M. M. 1993. A hydrogeomorphic classification for wetlands. U.S. Army Corps of Engineers, Waterways Experiment Station. Wetlands Research Program Technical Report WRP-DE-4.

Collins, J. N., E. D. Stein, M. Sutula, R. Clark, A. E. Fetscher, L. Grenier, C. Grosso, and A. Wiskind. 2008. California Rapid Assessment Methods (CRAM) for Wetlands, v. 5.0.2.

Fetter, C. W. 1994. Applied Hydrogeology. 3rd ed. Prentice Hall, NJ.

Hunt, W. F., III, R. W. Skaggs, G. M. Chescheir, and D. M. Amatya. 2001. Examination of the Wetland Hydrologic Criterion and Its Application in the Determination of Wetland Hydrologic Status. Water Resources Research Institute of the University of North Carolina, NC State University, Raleigh, NC. Research Report No. 333. Available in pdf at: http://www.ncsu.edu/wrri/reports/wrri_301-350.html

National Research Council. 1995. Wetlands: Characteristics and Boundaries. Committee on Characterization of Wetlands, National Research Council. National Academy Press, Washington, DC.

Richardson, J. L. and M. J. Vepraskas, ed. 2001. Wetland Soils: Genesis, Hydrology, Landscapes, and Classification. Lewis Publishers, Boca Raton, FL.

Smith, R. D., A. A. Ammann, C. Bartoldus, and M. M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. U.S. Army Corps of Engineers, Waterways Experiment Station. Wetlands Research Program Technical Report WRP-DE-9.

U.S. Army Corps of Engineers. 1987. Corps of Engineers Wetlands Delineation Manual. Waterways Experiment Station, Environmental Laboratory, Wetlands Research Program Technical Report Y-87-1 (on-line edition).

U.S. Army Corps of Engineers. 2005. Technical Standard for Water-Table Monitoring of Potential Wetland Sites. Wetlands Regulatory Assistance Program. ERDC TN-WRAP-05-2.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2010. Field Indicators of Hydric Soils in the United States, Version 7.0. L. M. Vasilas, G. W. Hurt and C. V. Noble (eds.). USDA, NRCS in cooperation with the National Technical Committee for Hydric Soils.

Vepraskas, M. J. 1992. Redoximorphic Features for Identifying Aquic Conditions. North Carolina Agricultural Research Service, Raleigh, NC. Technical Bulletin 301.