Queensland Wetland Delineation and Mapping Guideline

Version 2.0

Queensland Government
Queensland Wetlands Program

Queensland
Wetlands Program

Prepared by: the Queensland Wetlands Program Department of Environment and Science

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1 Introduction

The Queensland Wetlands Program (QWP) was established by the Australian and Queensland Governments in 2003 to support projects and programs that enhance the wise use and sustainable management of Queensland's wetlands. Having established a clear wetland definition (Environmental Protection Agency 2005; Department of Environment and Resource Management 2011), one of the first projects undertaken through the QWP was the development of a mapping and classification scheme for wetlands (Environmental Protection Agency 2005) as it was recognised that a consistent, standardised, and repeatable method to comprehensively map and classify wetlands at an appropriate scale was required to facilitate decision making and management activities across the diverse landscapes of Queensland. Knowing where wetlands are and the characteristics (classification) of those wetlands underpins their intrinsic values and the range of services they provide to stakeholders.

At over 1.7 million square kilometres, with approximately 7,000 kilometres of coastline and containing over 2,000 islands Queensland is a large state with diverse climate, geology, landform, rainfall, hydrological regimes, and ecosystems Wetlands are transition areas between land and water, comprising a continuum from episodically wet areas to purely aquatic ecosystems and are difficult to map.

1.1 Purpose of this document

This document builds on the original Queensland Wetland Definition and Delineation Guideline - Part B Delineation and Mapping Guideline (Department of Environment and Resource Management 2011) in 2011 providing information on how to apply the QWP Wetland Definition (the Definition) at a property scale to delineate and map the boundary of a wetland including defining its position, shape, and size. This guideline assists government agencies, land managers, natural resource managers, scientists, surveyors, consultants, and others wanting to delineate and map the boundaries of an identified wetland feature for decision-making and planning purposes. In some cases, requirements for development assessment may advise or stipulate the use of this and other guidelines for regulatory purposes. This document is a companion technical guideline accompanying the Queensland Wetlands Definition Guideline (Department of Environment and Science 2023).

1.2 Version history

Table 1 Document version history and publication record

Version	Year of Release	Description
1.0	2011	Queensland Wetland Definition and Delineation Guideline - Part B Delineation and Mapping Guideline. Provides information on how to apply the QWP Wetland Definition (the Definition) at a property scale to delineate and map the boundary of a wetland including defining its position, shape, and size. Department of Environment and Resource Management (2011) Queensland Wetland Definition and Delineation Guideline, Queensland Government, Brisbane.
2.0	2023	Provides minor updates to the previous document including reorganised content.

2 Requirements

2.1 Skills

In some situations where there is good existing information and the wetland boundary is clearly discernible, individuals with basic plant identification, or other relevant skills, may be able to identify, delineate, and/or map a wetland. However, in many cases, the identification and delineation of wetlands will require specialised field, laboratory, and desktop investigation skills. This requires individuals with skills encompassing plant identification, collection of vegetation structural and abundance data, soil survey, and/or the collection of fauna data. A strong understanding of wetland ecology is important, particularly the dynamic nature of wetlands and their response to both seasonal and longer-term climate variability. Field assessments will generally require more than one person to safely collect the required data. In addition to the above skills, an individual with skills in geographic information systems (GIS) is required to map the wetland after the identification and delineation process.

2.2 Resources

The time required for wetland identification and delineation will vary with the complexity of the site as well as the experience and knowledge of the people undertaking the process. Features that cover a small area with good existing information and boundaries that are clearly visible on existing imagery may be identified, delineated, and mapped from a brief desktop evaluation. A more complex but still simple identification, such as Eubenangee Swamp (Section 6.2), may only require two hours in the field (plus travel time) and half a day in the office (plus time to acquire imagery and data). Larger and more complex sites may take several days work in the field by vegetation, soils, and fauna scientists and several days in the office to identify, delineate, and map the wetland.

3 Application of the Queensland Wetland Program Wetland Definition and Delineation of the Wetland Boundary

This guideline sets out procedures to establish if an area is a wetland or not and if so to describe, to a specified accuracy, where the boundary between the wetland and non-wetland is. An area may have been identified as a wetland from pre-existing mapping (e.g., Queensland Wetland Data) or surveys and this guideline can be used to provide definitive verification and/or to improve delineation of the boundary at a larger scale.

The Definition (Section 3.1 of the Queensland Wetland Definition Guideline) consists of criteria for four wetland factors (i.e., hydrology, biota, soils, and non-soils/non-biota) that are used to test if a feature is a wetland or not. Each criterion is assessed by indicators that can be described by the collection of information or evidence from field survey or other sources. The Queensland Wetland Definition Guideline (Section 3) provides further information on wetland indicators for each criterion and sources of information.

Five steps to identify and delineate wetland boundaries are shown in Figure 1 and described in the following subsections. These steps ensure information is collected to identify and delineate wetlands in the most efficient and effective manner. There may be a variety of indicators that can be used to determine that a criterion has been met. More conclusive indicators can be used by themselves to determine that a criterion has been met. A final positive wetland determination and boundary delineation may be made whenever information for a positive wetland criterion has been collected. In many cases not all steps will be required to make a wetland determination and boundary delineation. Other less conclusive indicators can be used only to suggest a feature has some wetland characteristics and require additional supporting evidence to determine if a criterion has been met. Under these circumstances the more and varied information available for a particular site, the stronger the evidence base and the more likely it is that the Definition will be applied correctly. If the feature is then found to be a wetland, the more and varied information is also likely to contribute to more accurate field delineation.

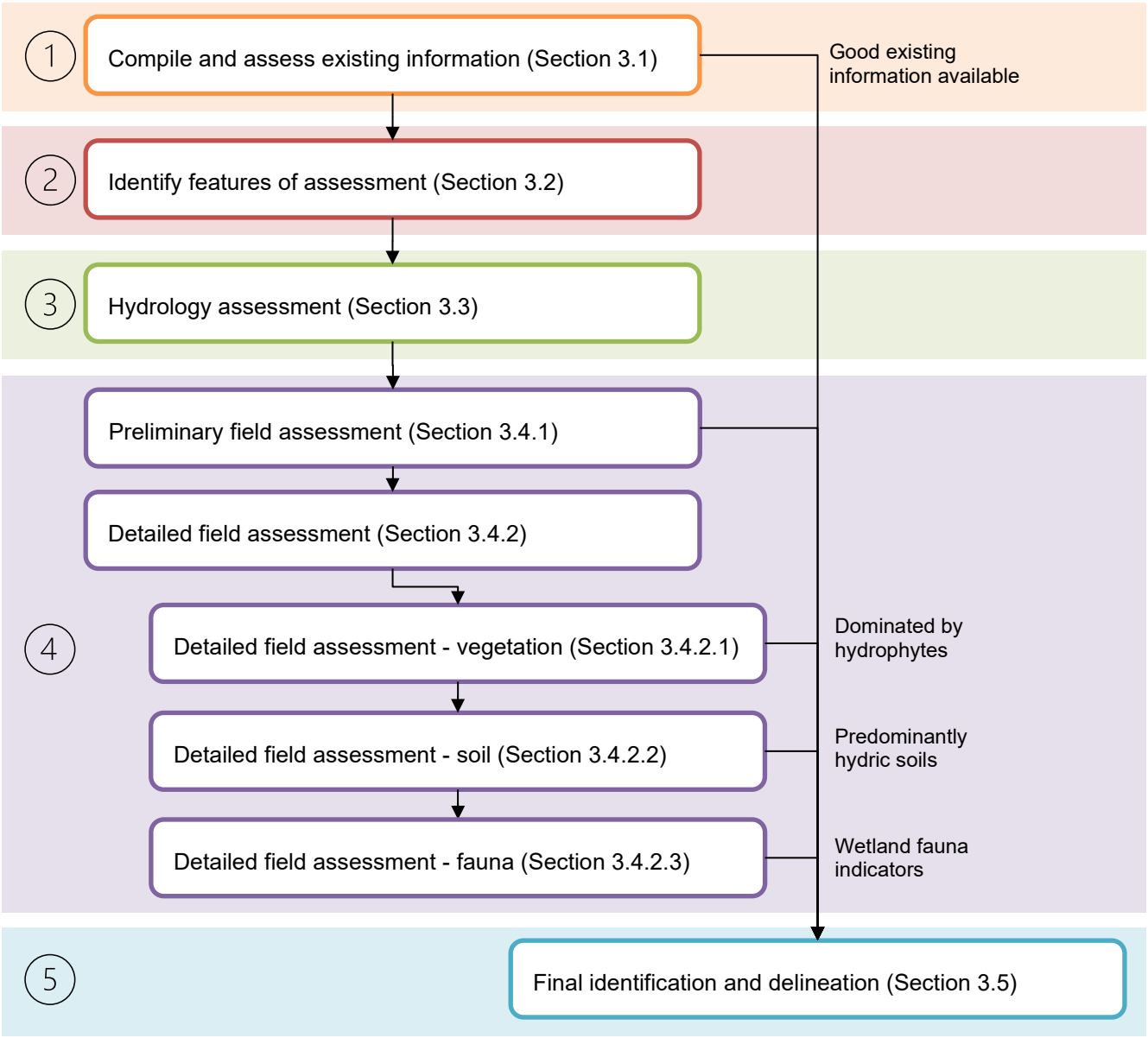


Figure 1 Wetland Identification, Assessment, and Delineation.

3.1 Step 1: Compile and assess existing information

The range of information that should be assessed and existing sources of information is outlined in the Queensland Wetland Definition Guideline (Section 5). An available property map of assessable vegetation, which identifies regional ecosystems at a property scale, may be used to delineate wetland boundaries where the site is covered by remnant vegetation by identifying each regional ecosystem present as a wetland or non-wetland based on the Regional Ecosystem Description Database.

Where good existing information is available (e.g., the site has been previously surveyed) or where an interim determination is adequate for the purposes of a particular assessment, a final identification and delineation can be made (Section 3.5) based on the information compiled during this step. For example, where an entire site comprises either a rocky ridge with no wetland features present or a flooded swamp wetland feature that is dominated by spike sedge (*Eleocharis* spp.), it is likely that a final wetland determination and delineation may be made with qualitative information and at a much earlier stage than a site comprising gradational boundaries between a mixture of wetland and non-wetland features.

If insufficient existing information is available, proceed to Step 2 (Section 3.2).

3.2 Step 2: Identify features for assessment

The different features present on the site must be identified to ensure any subsequent sampling covers the full range of variation present, especially for those larger and/or more variable sites. It may be possible to assess the variability of small (<1 ha) or relatively homogenous sites during a field inspection. However, generally this step will require the assessor to interpret imagery, including aerial photography and satellite imagery, and classify into uniform strata based on discernible vegetation, soils and/or topographic patterns for subsequent field assessment. Pre-existing wetland, regional ecosystem, soil, or other mapping will often be used in conjunction with image interpretation to support classification of observable patterns.

3.3 Step 3: Hydrological assessment

The hydrology criterion of the Definition is met when indicators provide conclusive evidence that the hydrology criterion has been met. Direct evidence of saturation or inundation may be used as a conclusive indicator, however direct evidence is often difficult to obtain due to the temporal and spatial variability in wetland hydrology. In the absence of direct hydrological information, the dominance of wetland plant or soil indicators, in conjunction with other indicators (e.g., landscape features and landform), may provide enough indirect evidence to determine that the hydrological criterion has been met. The hydrology criterion in the Definition is met when any indicators of inundation listed in the wetland hydrology assessment proforma (Section 5.3) are recorded as present.

The wetland hydrology assessment proforma (Section 5.3) lists the indicators and potential indicators that are used to gather evidence and establish the presence of inundation of a feature. In many cases the inundation will be assessed iteratively in conjunction with flora and soils indicators to determine whether the hydrology criterion has been met. Often a desktop assessment of hydrological information will be carried out from imagery and other available evidence before a field assessment (Section 3.4) to gather further direct evidence or other indicators.

3.4 Step 4: Field assessment

3.4.1 Preliminary field inspection

The preliminary classification of the site into uniform strata based on discernible vegetation, soils and/or topographic patterns in Step 2 (Section 3.2) should be verified by an initial field inspection. Additional features observed in the field that were not apparent in Step 2 may be added. The collection and identification of any plant species unfamiliar to the ecologist during this field inspection will facilitate more efficient and effective subsequent collection of detailed site data.

Where the site is small or uniform, a preliminary field inspection may be suitable to address information gaps and make an appropriate wetland determination. In other cases, a preliminary field inspection may be complemented with more detailed field assessments (Section 3.4.2) to make an appropriate wetland determination.

3.4.2 Detailed field assessment

The following subsections provide a guide for planning subsequent detailed field assessments of vegetation, soils, and fauna.

3.4.2.1 Vegetation assessment

Vegetation should be assessed to determine which areas are dominated by wetland plants and, therefore, whether the feature meets the biotic criterion of the Definition. The biotic criterion is met when the abundance of wetland indicator plants in the ecologically dominant layer is greater than 50 percent of the total abundance. Assessment procedures follow the site data collection method detailed in Appendix 2 of the Methodology for surveying and mapping regional ecosystems and vegetation communities in Queensland (Neldner et al. 2019). A curated list of wetland indicator plants (available on the Wetland*Info* website) has been prepared to facilitate the identification of vegetation dominated by wetlands species.

Qualitative assessment

Where the ecologically dominant layer is easily identifiable and the area is clearly dominated by wetland plant species (i.e., greater than 70 percent of the ecologically dominant layer is composed of wetland plant species), ecological dominance can be assessed into broad cover classes and species abundance can be recorded as relative dominance classes using the Part C-1: Qualitative wetland vegetation assessment proforma.

Quantitative assessment

Where the ecologically dominant layer is not easily identifiable and/or there is a mixture of wetland and non-wetland plant species, quantitative abundance data must be collected using the Part C-2: Quantitative wetland vegetation assessment proforma. Crown cover should be measured at a plot using the crown intercept method detailed in Appendix 2 of the Methodology for surveying and mapping regional ecosystems and vegetation communities in Queensland (Neldner et al. 2019). The crown intercept method is the preferred method for tree and shrub cover estimates (Neldner et al. 2019).

3.4.2.2 Soil assessment

The Soil Indicators of Queensland Wetlands: Field Guide (Department of Natural Resources and Water 2008) provides methods to identify indicators of wetland soils in the field. Areas identified as wetland by the hydrology (Section 3.3) and detailed vegetation assessment (Section 3.4.2.1) do not require final wetland determination, however, the collection of soils information for such areas could be required for inventory and evaluation purposes. Thus, soil samples may often only be required on the areas adjacent to the upland side of the wetland boundary identified by the vegetation assessment. The soil criterion in the Definition is met when a predominance of wetland soil indicators listed in the wetland soil assessment proforma (Section 5.3) are recorded as present.

3.4.2.3 Fauna assessment

The existence of some fauna species can not only identify a feature as a wetland but also delineate the wetland boundary. A curated list of wetland indicator fauna (available on the Wetland*Info* website) has been prepared to facilitate the identification of species whose presence can help identify and/or delineate a wetland. Features already identified as wetland through hydrological, vegetation and/or soils assessment do not require further assessment for positive identification, however, collection of fauna data for such features may be required for inventory and evaluation purposes. For features that have been subjected to hydrological modification, fauna may be a useful indicator of the degree of change (Section 3.6.2). In addition, for some wetland situations the absence of flora or soils means fauna can be the only assessment option to identify and/or delineate the wetland. Examples include rock pools with only algae and algae eating frogs and/or fish; superhaline waterbodies, which are too salty for plants, but support algae-eating brine shrimp; and tidal sand flats, which are free of plants, but when covered by the tide are feeding grounds for fish and crustaceans.

The type of fauna information to be collected will depend on the type of animals being surveyed as well as the type of wetland. When collecting fauna data and noting presence or absence, it is important to remember that some wetland indicator fauna species might not be always present. It is important to understand how a species depends on a wetland. Often information on the life cycle of fauna is required for the interpretation of wetland fauna indicators. In cases where large numbers of mobile fauna occur, such as colonies of breeding waterfowl, the abundance of fauna species associated with a particular vegetation community can identify a feature as a wetland. In other cases, individual point locations of each fauna record may be required for interpolation of the wetland boundary. Standard fauna survey methodologies for different groups are widely available although the specific methodology will depend on the specific target fauna and feature attributes.

3.5 Step 5: Final identification and delineation

Final wetland identification and delineation may be made at any step where there are conclusive indicator(s) that can be used to verify that the hydrology and one of the other criteria have been met. Wetland delineation is determined by a single line representative of the landward wetland extent relative to the site surveyed. The wetland boundary may initially be marked in the field with stakes, tape or by obvious describing features on the ground (e.g., the extent of a dominant vegetation types) (Plate 1). In some instances, the wetland extent may not be easily defined on the ground and may need to be produced by interpolation of data from sample sites and transects that span the wetland boundary. In these cases, it may be necessary to locate soil or vegetation assessment sites and transects so that the interpolated or estimated boundary can be spatially referenced to a geographic coordinate system.

Plate 1. River Red Gum (Eucalyptus camaldulensis) seeds illustrate the maximum extent of inundation in the field, Goondiwindi (B. Wilson)

3.6 Difficulties associated with applying the Queensland Wetlands Program Wetland Definition and Delineation of the Wetland Boundary

Sometimes using the criteria and indicators in this document to identify and determine wetland boundaries can be difficult or result in inconsistent determinations. Examples of situations where this can occur include wetlands that have been modified or are predominantly intermittent or ephemeral. The following sections provide further details on undertaking assessments in some of these situations.

3.6.1 Ephemeral wetlands

Many wetlands in Queensland, particularly in more arid parts of the state, are only intermittently or episodically inundated. While such areas may be vegetated or support wetland-dependent fauna when wet, between inundation events biota may be lacking or may change in composition to non-wetland species. These changes may be seasonal or, in some cases, can last for many years in association with longer term climatic cycles.

In such cases soils may provide indicators of wetland presence and extent. However, where soil indicators are absent or inconclusive, an assessment of biota that is normally present during the wet periods must be made, because this is the period that determines the wetland characteristics of a site. The following list outlines procedures that can be used to assess vegetation of sites during dry periods:

- assess only perennial long-lived species for positive wetland determination
- look for perennial, subterranean regenerating parts such as tubers
- assess aerial photography for landform and landscape position to compare with similar areas where floristic composition during wet times is known
- use the above information to equate to a regional ecosystem description and reference whether that ecosystem is listed as a wetland
- make a preliminary assessment that can only be confirmed when the area is wet again

3.6.2 Modified, disturbed, or artificial wetlands

3.6.2.1 Hydrological modification that increases inundation

Wetland plants and soils may be absent from hydrologically modified wetlands because the hydrological regime may not have been operating long enough. Soils will not generally be a useful indicator in such cases because hydric soils characteristics take many years to develop. Non-wetland plants can die very quickly (in a matter of weeks) when subjected to even minor waterlogging so the predominance of such plants can be used to indicate non-wetland areas. When vegetated, the boundary of modified wetlands may be established by observing where non-wetlands plants have died, or wetlands plants have colonised.

Table 2. Steps that can be used to determine wetland areas that have been modified or newly created. This list has, in part, been adapted from Part IV, Subsection 4 of the Wetland Delineation Manual (US Army Corps of Engineers 1987).

Step	Description
Identify whether hydrology has changed	Identification may use the presence of levees, dams, and other structures that increase the area and/or duration of inundation or water-logging as indicators of hydrological change.
Document when any changes occurred	Aerial and/or satellite imagery record, or other appropriate documentation may be used to determine when hydrological change occurred.
Assess vegetation and (if required) fauna	Vegetation qualitative assessment and fauna assessment may be used.
Quantify hydrological regime from available imagery or other appropriate source	Compare the observed hydrological regime with other known wetlands.

3.6.2.2 Hydrological modification that decreases inundation

Where modifications are associated with reduced inundation, the vegetation and soils indicators could be relictual. Common types of hydrological modifications that occur in Queensland include:

- dam construction that may make an area drier if it occurs downstream of a dam but may make an area

wetter if it occurs:
    - upstream of the dam wall within the dam lake
    - downstream of the dam but in a channel that the impoundment regularly supplies water to
- levees, dykes, bunds, and similar structures
- direct infilling or levelling of wetlands
- drainage ditch construction that is constructed to drain water from a wetland
- groundwater extraction

In some cases, the alteration may eliminate inundation from an area, such as spring wetlands that are now extinct due to groundwater extraction from the Great Artesian Basin. However, in many cases the alterations may have only partially changed the water regime. These cases require an assessment of the degree of alteration in hydrology. Ideally this assessment would be from quantified hydrological records but generally the assessment will be of indirect indicators of change such as those listed in Table 4.

Table 3. Steps that can be used to assess hydrological modification. This list has been adapted from Federal Interagency Committee for Wetland Delineation (1989).

Step	Conclusions
Examine current aerial and/or satellite imagery for signs of current inundation	Hydrology has been modified and needs further investigation
Compare vegetation on altered site to a similar neighbouring wetland that has not undergone hydrological modification	If the vegetation is similar, particularly in the understorey non-woody species, then the area is assessed as still a wetland
Compare fauna on altered site to a similar neighbouring wetland that has not undergone hydrological modification	Fauna will react to changes in hydrology and, therefore, if the composition has no or limited difference to the neighbouring wetland then the area is assessed as still a wetland
Direct assessment of the impact of modification to the hydrological regime	Determine whether the impact is localised (e.g., drainage channel) or widespread (e.g. diversion of all flooding into a wetland area)
Assess detailed groundwater studies (if available)	Detailed groundwater studies can be used to quantify hydrological regime before and after modifications were made and to compare with other neighbouring wetlands.

3.6.2.3 Disturbed vegetation

Vegetation indicators need to be assessed under normal conditions to identify and delineate wetlands. Therefore, in areas where vegetation is absent due to clearing or long-term climatic cycles, soils indicators may be used. However, where soils indicators are also lacking or inconclusive, the vegetation that would grow at the site under normal wet conditions needs to be determined. In cases where no hydrological modification is evident, it can be generally assumed that cleared vegetation would regrow. Areas where there has been hydrological modification require an assessment of the degree of modification and an interpretation of whether this impact would prevent or alter wetlands species regrowing.

Pre-clearing vegetation can be determined using the Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland (Neldner et al. 2019). Historical aerial photographs can be used to determine vegetation present before clearing by comparing the vegetation at uncleared sites that have a similar photo-pattern to the cleared area. Survey records and soils and other mapping can also assist in determining pre-clearing vegetation. Wetland areas that have been cleared of vegetation will often have a ground layer of regrowth species that can be used to indicate the type of vegetation that was originally at a site or is likely to regrow.

3.6.2.4 Artificial wetlands

Wetland plants and soils may be absent from newly created wetlands because the hydrological regime may not have been operating long enough. Soils will not generally be a useful indicator in such cases because hydric soils characteristics take many years to develop. Non-wetland plants can die very quickly (in a matter of weeks) when subjected to even minor waterlogging so the predominance of such plants can be used to indicate non-wetlands. When vegetated, the boundary of artificial wetlands may be established by observing where non-wetlands plants have died, or wetlands plants have colonised. Otherwise, the hydrology of similar natural wetlands can be used as a reference to assess the artificial wetland. Table 3 can be used to determine wetland areas that have been newly created.

4 Mapping of the Wetland Boundary

While the boundary of a wetland may be delineated in the field using prominent features, marking tape, or survey stakes, generally mapping of the boundary onto a coordinate system is the most effective and preferred way of communicating the extent of the wetland. Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland (Neldner et al. 2019) provides details on mapping regional ecosystems and vegetation communities including wetland regional ecosystems and vegetation communities. This section builds on that information providing specific details relevant to the mapping of wetlands.

4.1 Delineation of mapping from field survey data

The coordinates of wetland boundaries that have been identified in the field may be established using a global positioning system (GPS) to provide a track or list of waypoints that sit on the identified wetland boundary. Generally, a GPS will be used to record the location of a boundary defined by observable features, such as an abrupt change in vegetation or soils that have been identified during the vegetation or soils assessment.

Handheld GPS generally have an accuracy of ± 10 m, although this accuracy can be improved if using a differential GPS. If a greater accuracy is required, a surveyor may be required to locate a wetland boundary (or sample sites, transects, etc.) marked in the field by an ecological or soil scientist. Standard surveying practices generally describe features in relation to the cadastral boundary and/or man-made landmarks (e.g., old fence posts), however, the allotment and wetland boundaries need to be referenced to a geographic coordinate system.

4.1.1 Sampling intensity

The number of sites required to verify the vegetation or soil attributes of an identified feature will vary with the size of the feature, the scale at which the assessment is being conducted, and the heterogeneity of the vegetation and/or soils associated with the feature. The minimum number of ground observations per hectare that should be used for surveys at different scales is specified in Neldner et al. (2019) and McKenzie et al. (2008). For example, wetland determinations and delineation at a property level are generally carried out to delineate features with a minimum size of about 0.25 ha to 0.5 ha and, therefore, require a sampling intensity of about one site every 1 to 4 ha with a minimum of one site per feature.

These specifications should not be confused with the marking out of an actual wetland boundary. There needs to be adequate sampling or marking of an identified feature to meet the specified accuracy requirement or confidence interval for boundary delineation. Thus, for delineation purposes the density of sites will often be higher in the vicinity of the wetland boundary, than required in the general minimum specifications discussed above.

4.1.2 Sampling location

The location of sample sites should follow standard survey practices such as those outlined in Neldner et al. (2019) and McKenzie et al. (2008). Surveyed locations should include representative sites of each feature identified in Step 2 (Section 3.2) and orientating vegetation plots to minimise capture of environmental gradients. In cases where the features on the ground cannot be accurately identified on imagery or there are gradational boundaries, samples need to be located along multiple transects that cross the site perpendicular to the wetland boundary (generally 90 degrees to the contours). A greater density of sites should be placed around the actual boundary.

4.2 Delineation of mapping from aerial and/or satellite imagery

There is a variety of remotely sensed imagery available that are suitable for large scale wetland assessment and delineation. Imagery can be used as a base on which to map the boundary and this linework can then be transferred to a GIS using standard cartographic techniques. Alternatively, if the imagery is scanned and ortho-rectified then linework mapping the boundary can be captured by direct delineation within a GIS.

There are increasing sources of remotely sensed imagery to support large scale wetland mapping and each source has different advantages and limitations. The advantages and limitations of an imagery source should be considered in view of the purpose for mapping. Stereo pairs of colour aerial photography support wetland mapping at a 1:5,000 scale enabling stereoscopic assessment of topography and vegetation patterns; however, temporal resolution may be limited and the difficulty to transfer boundaries to a georeferenced map is higher. Contrastingly, ortho-rectified high-resolution satellite imagery (e.g., IKONOS, QuickBird, etc.) with pixel sizes less than 1 m supports wetland mapping at a 1:10,000 scale but is generally more expensive. Coarser resolution satellite imagery (e.g., SPOT) with pixel sizes between 1 and 5 m are more widely available, but their use is limited to wetland mapping at the 1:25,000 scale.

4.2.1 Georeferencing of imagery

Georeferenced remotely sensed imagery can be used as a base map, providing a backdrop for delineating features onto a map in conjunction with other available spatial information such as vegetation or soils mapping. This type of imagery has recently become more widely available through applications (e.g., Google Earth, Queensland Globe, etc.). If georeferenced imagery is used to map and delineate wetland boundaries, the accuracy of the geo-referencing (i.e., how close a point on the image is to that point on the ground) must be known and specified.

Generally georeferenced imagery can be purchased with a known level of spatial accuracy that will be listed in the metadata accompanying the imagery. In some cases, the purchaser can request a level of accuracy appropriate to the use. For example, if a wetland boundary is required to be located with an accuracy of ± 10 m then imagery with a spatial error less than this is required.

Alternatively, software programs can be used to carry out simple georeferencing. Simple georeferencing allows the user to allocate coordinates to a scanned image but does not correct for changes in elevation or the complex geometry of the image. The accuracy of such simple georeferencing is lower in more hilly terrain but more importantly difficult often to quantify without comparison with independent known points such as ground control points. Collection of control points is an example of information required to assess the accuracy of image georeferencing.

Assessment of georeferencing accuracy can be achieved by either providing five or more control points with a description of the fixed features that the points represent and the coordinates of each point in GDA94 coordinate system as acquired by a GPS. To ensure that the control points are as effective as possible they must; correspond to fixed features identifiable on either satellite imagery or aerial photography; be unambiguously defined and include an appropriately detailed description; and be scattered across the map (e.g., one in each corner and one in the middle) to provide spatial control across the map including its edges. Alternatively, you might identify the boundaries of the imagery on the ground, establish the coordinates using a GPS, and provide a track or list of waypoints that sit on the imagery boundary.

Ortho-rectification of imagery is a process that aims to remove the effects of aerial camera lens tip and tilt, image scale variations, and object displacements due to ground relief based on available digital terrain model or digital elevation models. This process is accomplished by reprocessing the imagery to conform to the orthographic projection, hence the name, ortho-photo. This type of rectification can produce very accurate georeferencing, for example, 1:25,000 ortho-photos often have a spatial accuracy about ± 2 m.

4.3 Mapping format, datum, and projection

Mapping may be created in a variety of formats. Preferably, digital mapping data should be captured for use in a GIS as it is the most suitable way of supplying mapping information including supporting information, such as the location of flora, fauna, and soil assessment sites. Mapping data may be formatted in any standard datum and projection, although the preferred datum to use is GDA94. Mapping information should be in a digital format with the following specifications:

- the data must be projected to a standard datum, preferably GDA94
- file format for vector data (i.e., points, lines, and polygon line-work) must be:
    - ESRI® Geodatabase,
    - ESRI® Shapefile,
    - MapInfo® TAB, or
    - Another common open file format (e.g., GeoPackage, Geographic JavaScript Object Notation)
- file format for raster data (e.g., aerial photography, satellite imagery, digital elevation models, etc.) must be:
    - American Standard Code for Information Interchange Grid,
    - ENVI® Band Sequential, Band-interleaved-by-pixel, or Band-interleaved-by-line,
    - ERDAS® IMAGINE,
    - ESRI® Grid,
    - Joint Photographic Experts Group,
    - Tagged Image File Format, or
    - Another common open file format
- wetland mapping must have a minimum of one attribute called ‘wetland’ that indicates if an area is a ‘wetland’ or ‘non-wetland’.

4.4 Mapping scale and accuracy

Scale and accuracy considerations when applying the Definition are discussed in the Queensland Wetland Definition Guideline (Section 5.3). Additionally, the following points to consider are:

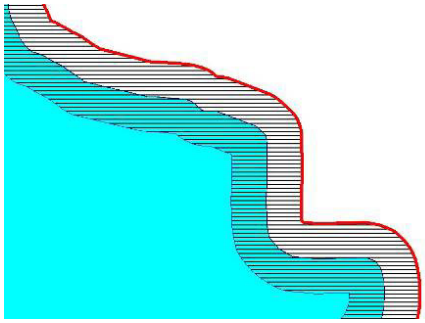
- the scale of delineation with respect to minimum size and level of detail in the boundary should be in accordance with the scale of definition application (usually 1:25,000–1:35,000) rather than the scale required to obtain an adequate level of accuracy for the location of the boundary
- a mosaic area containing a mixture or mosaic of features is considered a mosaic wetland area if features having wetland characteristics occupy greater than 50 percent of the area at the specified scale
- the method used to delineate the wetland boundary must be described and include an error estimate for the accuracy of the boundary
- to ensure a wetland is included in a defined boundary it must be assumed that the boundary delineated is buffered by the stated level of accuracy
- generally, for state-wide mapping purposes and to ensure consistency, an assessment or mapping scale of 1:25,000 that identifies areas to a minimum size of 0.25 ha is appropriate

4.4.1 Positional accuracy of mapped boundary

The positional accuracy of any point on a map is a measure of the distance between the location of the point on the map and the true location of that point. Wetland mapping requires an estimate of horizontal positional accuracy. Vertical positional accuracy can also be measured; however, wetlands are generally flat features and therefore vertical positional accuracy is not required. A formal estimate of positional accuracy requires analysis of sample data to estimate the mean value for the fit of the map being assessed to a reference layer, which is assumed to be correct often to some specified level of confidence measured by the standard error of the mean (Congalton and Green 2009; Greenwalk and Schultz 1998).

The positional accuracy of the spatial location of linework should be expressed as confidence limit in (ground) metres. For example, a wetland boundary that has an accuracy of ± 10 m means the actual boundary can be 10 metres either side of where the line is delineated. Therefore, to be sure of including the wetland within the area delineated then it must be assumed that the boundary is 10 m towards to upland area ().

Plate 2 Extent of the wetland boundary delineation (in blue) with the accuracy confidence interval indicated by horizontal hatching, therefore, the red line indicates the boundary that must be used in mapping to ensure the full wetland extent is captured.



Formal accuracy assessments are often reported as the root-mean-square error (RMSE), which is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source, of higher accuracy, for identical points. In addition, RMSE is usually reported at a specified confidence interval, often 95 percent. This confidence level means that 95 percent of the positions in the dataset will have an error with respect to true ground position that is equal to or smaller than the reported accuracy value (Federal Geographic Data Committee 1998).

The accuracy of the map will vary with the method used to describe it and is the sum of the errors from all sources. For example, where a boundary is delineated from ortho-rectified imagery, the final accuracy of the boundary is the accuracy of the image rectification to the ground plus the cartographic standards that determine how accurate features are delineated with respect to the image. The latter will vary with several factors including the scale of compilation, the degree that the feature can be seen on the image, and the care with which the lines are drawn.

An estimate of accuracy can be derived by comparing the mapping data with known ground locations. Ground locations can be located using a GPS, although the error in the GPS must be considered and added to the resulting error estimate. For small areas, an alternative to providing a formal estimate of accuracy is to provide an estimate based on the information and cartographic standards used to capture the mapping data. For example, a map could be given an estimated error of 15 m with the following justification:

Digital ortho-rectified imagery with a stated accuracy of 5 m was used as a base. The wetland boundary was associated with clearly visible features on the imagery and was digitised at a scale of 1:5,000 to within 2 mm of its actual location on the image (or 10 m on the ground). The final accuracy is therefore estimated as 15 m combining the error from the digitising (10 m) plus the error in the imagery that the mapping was digitised to (5 m).

The above claim would be difficult to verify if the mapped boundary was not associated with features that were clearly visible on the imagery. The method used to delineate the boundary must be described and include an error estimate for the accuracy of the boundary. To ensure a wetland is included in a defined boundary it must be assumed that the boundary delineated is buffered by the stated level of accuracy.

The final accuracy level required will depend on the purpose for which the survey is being made. For example, if a wetland is 300 m away from a proposed development, an accuracy of 50 m may be adequate to verify that the development will not impinge directly on the wetland. While wetland boundaries that cross or adjoin small lots may need to be delineated with greater accuracy.

4.4.2 Limits to the positional accuracy of mapped boundary

In some instances, the level of precision at which the wetland boundary can be delineated may limit the spatial accuracy at which the boundary can be defined. Wetlands are ecosystems that are defined by spatially connected groups of plants (and animals) and associated environmental factors. This limits the precision at which a boundary can be defined. For example, in the case of a palustrine wetland defined by the dominance of a tree species with crowns 5–10 m wide and separated from adjacent trees by at least the same distance (Plate 3), it is difficult to define the extent of the wetland community with a precision greater than about 10 m. Wetlands dominated by water or ground layer species may be defined at a greater level of precision but in all cases the accuracy of the wetland boundary must be commensurate with the precision that the boundary of the wetland can be described (Plate 4).

Plate 3. River Red Gum (Eucalyptus camaldulensis) fringing the Barcoo River, Welford National Park (Photo: B. Wilson). The red line indicates the top of the channel bank and the blue line indicates the edge of the River Red Gum crowns that are part of the fringing riverine wetland. Thus, in this case, the precision at which the wooded wetland vegetation can be delineated from the adjacent floodplain vegetation community is about 10 m.

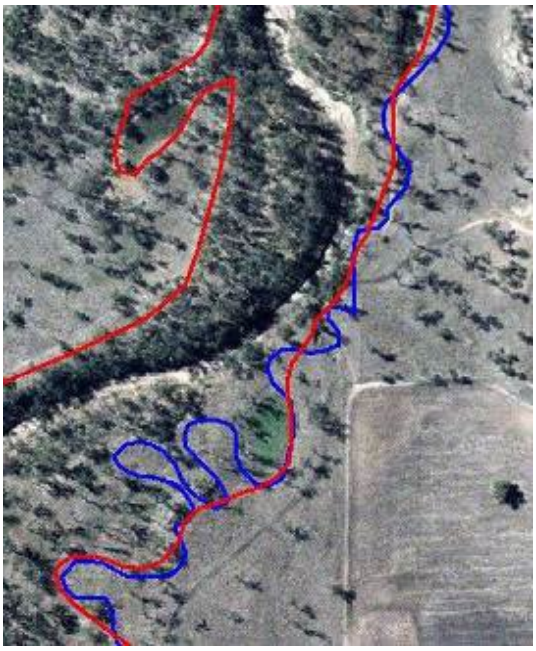


Plate 4. Wetland boundary of the Condamine River riverine wetland at a scale of 1:5,000. The red and blue lines were both drawn at a scale of 1:5,000 to delineate the wetland at the required linework accuracy of ± 10 m. The red linework has maintained an appropriate scale (1:25,000) for delineation of a wooded wetland boundary, while the blue linework has traced wetland features at a larger scale than is appropriate.

5 Resources

5.1 Recommended field equipment

Common equipment for assessments

- Camera
- GPS
- Pencils and erasers
- Proformas
- Water

Field equipment for vegetation assessments

- 3 x 1 m lengths of polyvinyl chloride (PVC) pipe with two elbows for quadrat
- 50 m tape
- Bitterlich stick,
- Clinometer and/or hypsometer
- Compass
- Metal site tags and wire
- Plant press
- Specimen collecting bag
- Tags

Field equipment for soil assessment

- 1 m tape
- Auger and/or shovel
- Australian Soil and Land Survey Field Handbook (National Committee on Soil and Terrain 2009)
- Australian Soil Classification (Isbell and National Committee on Soil and Terrain 2021)
- Soil pH test kit
- Soil colour chart (e.g., Munsell Soil Color Chart)
- Soil Indicators of Queensland Wetlands: Field Guide (Queensland Department of Natural Resources and Water 2008)

Field equipment for fauna assessment

- Various additional equipment depending on fauna group being surveyed

5.2 Recommended desktop equipment

- Aerial and/or satellite imagery (e.g., Queensland Globe, QImagery)
- Existing data (e.g., geological mapping, vegetation mapping, soils mapping, etc.)
- GIS software (e.g., ESRI ArcGIS®, QGIS®, MapInfo®, etc.)

5.3 Wetland assessment proforma

Part A: Summary

Summary of existing information and context

Summary of assessment methodology and survey outcomes

Site	Hydrology criterion	Biotic criterion (vegetation)	Biotic criterion (fauna)	Soil criterion	Wetland Assessment Outcome
	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	

Summary of hydrology assessment (details provided in Part B: Wetland hydrology assessment)
Summarise the results of the hydrology assessment recorded in Part B: Wetland hydrology assessment

Summary of wetland vegetation assessment (detail provided in Part C: Wetland vegetation assessment)
Summarise the results of the wetland vegetation assessment recorded in Part C: Wetland vegetation assessment

Summary of wetland soils assessment (detail provided in Part D: Wetland soil assessment)
Summarise the results of the wetland soils assessment recorded in Part D: Wetland soil assessment

Summary of wetland fauna assessment
Summarise the results of the wetland fauna assessment

Final wetland determination and boundary delineation
Record the results of the final wetland determination and boundary delineation

Part B: Wetland hydrology assessment

Site Number		Recorder		Date	
Locality					
MGA	Zone		E		N		:
GDA94	Longitude		.		Latitude		.	

Imagery Record

Type	Date(s) Observed

Indicators

Indicators of Inundation	Present	Not Present
Direct observation of water saturation/inundation.		
Topographical drainage patterns		
Vegetation dominated by wetland indicator plants		
Wetland soils (see Soil Indicators of Queensland Wetlands: Field Guide[1])		
Micro-relief landscape feature[2]		
Debil debil landscape feature		
Swamp hummock landscape feature		
Algal mats landscape feature[1]		
Aerial roots landscape feature[1]		
Floodmarks landscape feature[1]		
Water transported debris		
Silt lines		
Water marks		
Iron staining landscape feature[1]		

[1] Soil Indicators of Queensland Wetlands: Field Guide (Department of Natural Resources and Water 2008).

[2] Further information on landscape features can be found in Soil Indicators of Queensland Wetlands: Field Guide (page 10-11, Department of Resources and Water 2008).

Indicator of Potential Inundation	Observation
Landform pattern (e.g. floodplain)	
Landform element (e.g. swamp)	
Depth to groundwater[3]	

Notes
Provide details on applicable anecdotal evidence, direct observations, hydrological modelling, image interpretation, etc.

[3] Further information on landscape features can be found in Soil Indicators of Queensland Wetlands: Field Guide (page 11, Department of Natural Resources and Water 2008).

Part C: Wetland vegetation assessment

Part C-1: Qualitative wetland vegetation assessment

Use this section where the ecologically dominant layer is easily identifiable, and the area is clearly dominated by wetland plant species (i.e., greater than 70 percent of the ecologically dominant layer is composed of wetland plant species).

Site number	Easting (MGA) Longitude (GDA94)	Northing (MGA) Latitude (GDA94)	Dominant species	Wetland indicator species
	E	N		
	E	N		
	E	N		
	E	N		
	E	N		
	E	N		
	E	N		
	E	N		
	E	N		
	E	N		
	E	N		
	E	N		

Part C-2: Quantitative wetland vegetation assessment

Use this section where the ecologically dominant layer is not easily identifiable and/or there is a mixture of wetland and non-wetland plant species.

Site Number		**Recorder**		**Date**	
Locality					
MGA	**Zone**		**E**	**N**	**:**
GDA94	**Longitude**		**.**	**Latitude**	**.**

Structure

Stratum	Median canopy height	Range in strata height	Total crown cover
Emergent			
Tree 1			
Tree 2			
Tree 3			
Shrub 1			
Shrub 2			
Ground			

Plant species

Scientific name	Wetland indicator species	Cover						
		E	T1	T2	T3	S1	S2	G

Ecologically dominant layer

Structural form	
Ecologically dominant layer	
Proportion of wetland indicator species in the ecologically dominant layer	

Part D: Wetland soil assessment

It is recommended that this proforma be used in conjunction with Soil Indicators of Queensland Wetlands: Field Guide (Department of Natural Resources and Water 2008).

Site Number		**Recorder**		**Date**	
Locality					
MGA	**Zone**		**E**	**N**	**:**
GDA94	**Longitude**		**.**	**Latitude**	**.**

Climatic Region[4]

Arid	Semiarid	Subtropical	Temperate	Tropical/Equatorial

Wetland Soils[5]

Australian soil class[6]	Anthroposol	Dermosol	Kandosol	Podosol	Tenosol
	Calcarosol	Ferrosol	Kurosol	Rudosol	Vertosol
	Chromosol	Hydrosol	Organosol	Sodosol	
Peat horizon within 0.3 m of the soil surface			Present		Not present
Thickness of peat horizon	_____ . _____ cm / m				

Wetland Soil Indicators[7]

Organic Materials

Organic material within 0.3 m of soil surface			Present	Not present
Thickness of organic material	_____ . _____ cm / m			
Texture qualifier	Fibric	Hemic	Sapric	Streaked

Acid Sulfate Soil Materials

Hydrogen sulfide gas (rotten egg gas) within 0.3 m of soil surface	Present	Not present
Monosulfidic black ooze within 0.3 m of soil surface	Present	Not present
Sulfurous segregations within 0.3 m of soil surface	Present	Not present

[4] Further information can be found in Soil Indicators of Queensland Wetlands: Field Guide (page 7).

[5] Further information can be found in Soil Indicators of Queensland Wetlands: Field Guide (page 6).

[6] Further information can be found in the Australian Soil Classification (Isbell and National Committee on Soil and Terrain 2021).

[7] Further information can be found in Soil Indicators of Queensland Wetlands: Field Guide (page 8-10).

Gley Colours

Gley colours	Present	Not present
Thickness of gley layer	_____ . _____ cm / m	
Depth of gley layer	_____ . _____ cm / m	

Soil Water Interface

Soil water interface	Present	Not present
Depth to soil water interface	_____ . _____ cm / m	

Mottles

Mottles within 0.3 m of soil surface	Present	Not present

Segregations

Segregations within 0.3 m of soil surface	Present	Not present

Ferruginous Root Channel and Pore Linings

Ferruginous root channel and pore linings within 0.3 m of soil surface	Present	Not present

Soil Matrix Chroma

Are chroma values less than or equal to 2 in the wettest lowest lying area?	Yes	No
Do chroma values decrease moving into the wetland from sites considered outside?	Yes	No

6 Case Studies

The following case studies are examples of the information and format required to verify and delineate a wetland/non-wetland boundary at a specified accuracy. In the first case (Section 6.1) the wetland/non-wetland boundary of a previously identified wetland is adjusted to larger scale imagery. The second case (Section 6.2) shows how a simple obvious wetland/non-wetland boundary is verified with qualitative vegetation information. The third case (Section 6.3) details a larger more heterogeneous area featuring a mixture of wetland and non-wetland vegetation that required detailed vegetation and soil survey to identify and delineate a wetland.

6.1 Improving the scale of wetland delineation (Brigalow Creek, Goondiwindi)

Given that the wetland has already been identified and delineated, only Part A of the wetland assessment proforma was required.

Part A: Summary

Summary of existing information and context
The wetland has been identified and delineated in Queensland Wetland Data (Version 1.2) at a scale of 1:100,000.

Summary of assessment methodology and survey outcomes
The existing wetland/non-wetland boundary is in a location where ortho-rectified imagery is available at a greater level of accuracy.

Site	**Hydrology criterion**	**Biotic criterion (vegetation)**	**Biotic criterion (fauna)**	**Soil criterion**	**Wetland Assessment Outcome**
	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	

Summary of hydrology assessment (details provided in Part B: Wetland hydrology assessment)
Not applicable

Summary of wetland vegetation assessment (detail provided in Part C: Wetland vegetation assessment)
Not applicable

Summary of wetland soils assessment (detail provided in Part D: Wetland soil assessment)
Not applicable

Summary of wetland fauna assessment
Not applicable

Final wetland determination and boundary delineation
The boundary of the wetland was redrawn based on larger scale ortho-rectified imagery captured in 2003 that has an accuracy of ± 2.2 metres. The final wetland boundary accuracy is ± 7.2 metres. Plate 5 illustrates the improvement in wetland delineation.

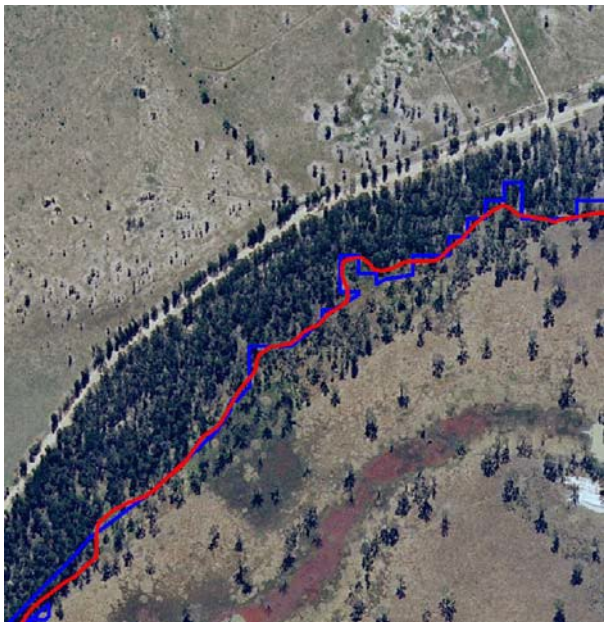


Plate 5. Simple improvement in the scale of wetland delineation of Brigalow Creek in Goondiwindi. The original wetland boundary delineation from Queensland Wetland Data (Version 1.2) is shown in blue and the updated wetland boundary delineation is shown in red, which has been drawn based on larger scale ortho-rectified imagery.

6.2 Verification of wetland delineation with quantitative and qualitative vegetation information (Eubenangee Swamp, Queensland)

Part A: Summary

Summary of existing information and context
The site is located at Eubanangee Swamp in north Queensland. The area surveyed was approximately 45 ha on the southern boundary of Eubanangee Swamp (Plate **6***) and is shown on Queensland Wetland Data (Version 1.3) as a Melaleuca quinquenervia open forest palustrine wetland on poorly drained peaty humic gley soils where the groundwater table is near or above the land surface for most of the year. The wetland boundary was delineated at a 1:25,000 scale based on available ortho-rectified aerial photography. The wetland boundary of Eubanangee Swamp in the Queensland Wetland Data appears to be associated with an abrupt change in topographic and geological mapping from the flat alluvial soils to the gently sloping basalt soils.* *Areas to the south are identified as non-wetland in Queensland Wetland Data and the complementary Biodiversity of Pre-Clearing and Remnant Regional Ecosystem (Version 5.0) identified those areas as cleared with pre-clearing vegetation Mesophyll vine forest on basalt.*

Summary of assessment methodology and survey outcomes
The site was stratified using 1:25,000 scale ortho-rectified aerial photography (Plate 7). The field survey collected qualitative vegetation sites along a transect across the boundary and verification sites along the boundary to verify the stratification. *A field inspection was undertaken to collect quantitative and qualitative vegetation data that were used to verify that the wetland boundary delineated is associated with the abrupt change from flat alluvial soils to the gently sloping basalt soils and finalise the preliminary wetland boundary.* *The field inspection collected quantitative data along a transect across the preliminary wetland boundary and qualitative data along the preliminary wetland boundary (Plate 7). Four sites were located along the transect across the preliminary wetland boundary and their vegetation described using the wetland vegetation assessment proforma (quantitative assessment) verifying the change in wetland dominated vegetation between sites three and four. Multiple sites were located along the preliminary wetland boundary and their vegetation described using the wetland vegetation assessment proforma (qualitative assessment) verifying the occurrence of similar vegetation along the boundary.* *Thus, the field survey confirmed the existing wetland boundary delineation for the site with minor shifts in the boundary location required.*

Site	Hydrology criterion	Biotic criterion (vegetation)	Biotic criterion (fauna)	Soil criterion	Wetland Assessment Outcome
1	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
2	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
3	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	

Site	Hydrology criterion	Biotic criterion (vegetation)	Biotic criterion (fauna)	Soil criterion	Wetland Assessment Outcome
4	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
5	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
6	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
7	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
8	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
9	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
10	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
11	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
12	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	

Site	Hydrology criterion	Biotic criterion (vegetation)	Biotic criterion (fauna)	Soil criterion	Wetland Assessment Outcome
13	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	
14	Yes	Yes	Yes	Yes	Wetland
	No	No	No	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	

Summary of hydrology assessment
The site is situated on a depression on a floodplain. Landsat satellite imagery from 1999 shows most of the floodplain to be inundated with water.

Summary of wetland vegetation assessment
Quantified vegetation assessment sites were established in a transect across the preliminary wetland boundary identified on satellite imagery (Plate 7). Additional qualitative vegetation assessment sites were also established at other locations along the wetland boundary (Plate 7). Quantitative sites 1, 2 and 3 were dominated by hydrophytic vegetation and, therefore, confirmed those sites as wetlands.

Summary of wetland soils assessment
Not applicable

Summary of wetland fauna assessment
Not applicable

Final wetland determination and boundary delineation
The final wetland boundary was digitised directly onto 1:25,000 scale ortho-rectified aerial photography (Plate 8) with an accuracy of ± 1.2 m at a scale of 1:5,000 with a cartographic positional accuracy of ± 5 m. Therefore, the final wetland boundary has a positional accuracy of ± 6.7 m.

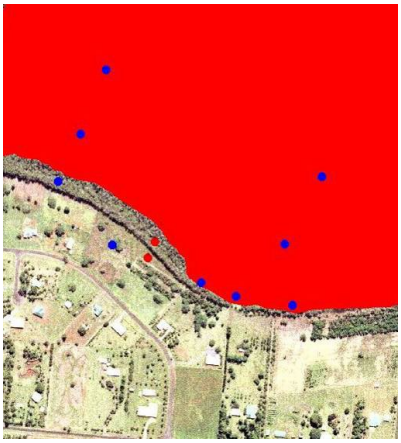


Plate 6. Existing delineation of the southern boundary of Eubanangee Swamp palustrine wetland shown in red bordered by non-wetland areas to the south (Queensland Wetland Data, Version 1.3). Points represent the location of vegetation assessment sites with red indicating quantitative vegetation assessment sites and blue indicating qualitative vegetation assessment sites.

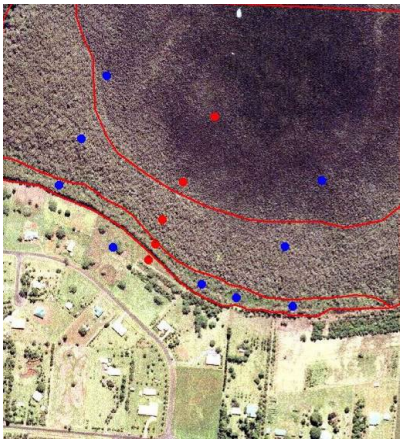


Plate 7. Preliminary stratification and field survey locations near the existing delineation of the southern boundary of Eubanangee Swamp palustrine wetland (Queensland Wetland Data, Version 1.3). Points represent the location of vegetation assessment sites with red indicating quantitative vegetation assessment sites and blue indicating qualitative vegetation assessment sites.

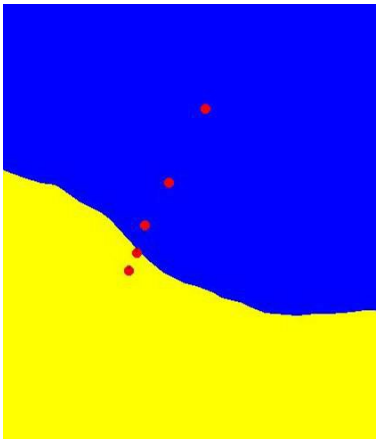


Plate 8. Final wetland boundary delineation of the southern boundary of Eubanangee Swamp palustrine wetland verified by hydrology and vegetation assessments. Wetland area shown in blue, non-wetland area shown in yellow, and quantitative vegetation assessments shown as red points.

Part B: Wetland hydrology assessment

Imagery Record

Type	Date(s) Observed
Landsat TM	*September 1992*

Indicators

Indicators of Inundation	Present	Not Present
Direct observation of water saturation/inundation.		
Topographical drainage patterns		
Vegetation dominated by wetland indicator plants		
Wetland soils (see Soil Indicators of Queensland Wetlands: Field Guide)		
Micro-relief landscape feature		
Debil debil landscape feature		
Swamp hummock landscape feature		
Algal mats landscape feature		
Aerial roots landscape feature		
Floodmarks landscape feature		
Water transported debris		
Silt lines		
Water marks		
Iron staining landscape feature		

Indicator of Potential Inundation	Observation
Landform pattern	*Floodplain*
Landform element	*Swamp*
Depth to groundwater	

Notes

Part C: Wetland vegetation assessment

Part C-1: Qualitative wetland vegetation assessment

Use this section where the ecologically dominant layer is easily identifiable, and the area is clearly dominated by wetland plant species (i.e., greater than 70 percent of the ecologically dominant layer is composed of wetland plant species).

Site number	Easting (MGA) Longitude (GDA94)	Northing (MGA) Latitude (GDA94)	Dominant species	Wetland vegetation
6	E	N	*Melaleuca quinquenervia, Lepironia articularis*	✓
7	E	N	*Melaleuca quinquenervia, Lepironia articularis*	✓
8	E	N	*Imperata cylindrica*	×
9	E	N	*Melaleuca quinquenervia, Lepironia articularis*	✓
10	E	N	*Melaleuca quinquenervia, Lepironia articularis*	✓
11	E	N	*Imperata cylindrica*	×
12	E	N	*Imperata cylindrica*	×
13	E	N	*Imperata cylindrica*	×
14	E	N	*Imperata cylindrica*	×
	E	N		
	E	N		

Part C-2: Quantitative wetland vegetation assessment

Use this section where the ecologically dominant layer is not easily identifiable and/or there is a mixture of wetland and non-wetland plant species.

Site Number	*1*	**Recorder**	*F. Smith, E. Brown, J. Green*	**Date**	*4/5/2007*
Locality					

MGA	**Zone**	*5*	*5*	**E**	*0*	*3*	*9*	*1*	*0*	*2*	*9*	**N**	*8*	*0*	*7*	*7*	*1*	*8*	*0*	**:**
GDA94	**Longitude**						**.**					**Latitude**							**.**	

Structure

Stratum	Median canopy height (m)	Range in strata height (m)	Total crown cover
Emergent			
Tree 1	*9.5*		*55*
Tree 2			
Tree 3			
Shrub 1			
Shrub 2			
Ground	*2.3*		*70*

Plant species

Scientific name	Wetland indicator species	Cover						
		E	T1	T2	T3	S1	S2	G
Melaleuca quinquenervia	✓		*50*					
Lophostemon suaveolens	✓		*5*					
Lepironia articularis	✓							*25*
Scleria polycarpa	✓							*40*

Ecologically dominant layer

Structural form	
Ecologically dominant layer	*Tree 1*
Proportion of wetland indicator species in the ecologically dominant layer	*100%*

Site Number	2	Recorder	F. Smith, E. Brown, J. Green	Date	4/5/2007
Locality					

MGA	Zone	55	E	0	3	9	1	0	1	6	N	8	0	7	0	6	7	5	:
GDA94	Longitude					.					Latitude			.					

Structure

Stratum	Median canopy height (m)	Range in strata height (m)	Total crown cover
Emergent			
Tree 1	9.5		30
Tree 2			
Tree 3			
Shrub 1			
Shrub 2			
Ground	2.3		50

Plant species

Scientific name	Wetland indicator species	Cover						
		E	T1	T2	T3	S1	S2	G
Melaleuca quinquenervia	✓		25					
Lophostemon suaveolens	✓		5					
Lepironia articularis	✓							35
Scleria polycarpa	✓							9

Ecologically dominant layer

Structural form	
Ecologically dominant layer	Tree 1
Proportion of wetland indicator species in the ecologically dominant layer	100%

Site Number	4	Recorder	F. Smith, E. Brown, J. Green	Date	4/5/2007
Locality					

MGA	Zone	5	5	E	0	3	9	1	0	1	6	N	8	0	7	0	6	7	5	:
GDA94	Longitude						.					Latitude					.			

Structure

Stratum	Median canopy height (m)	Range in strata height (m)	Total crown cover
Emergent			
Tree 1			
Tree 2			
Tree 3			
Shrub 1	1.8		1
Shrub 2			
Ground	0.7		65

Plant species

Scientific name	Wetland indicator species	Cover						
		E	T1	T2	T3	S1	S2	G
Glochidion sp.	×					0.1		
Ischaemum australe	✓							5
Imperata cylindrica	×							58

Ecologically dominant layer

Structural form	Tussock grassland
Ecologically dominant layer	Ground
Proportion of wetland indicator species in the ecologically dominant layer	< 10%

6.3 Delineation of wetlands using detailed vegetation and soil field assessments in large heterogeneous area (Goorganga Plain, Queensland)

Part A: Summary

Summary of existing information and context
The site is located at Goorganga Plain in north Queensland, which occurs on a seasonally inundated floodplain. The area surveyed was approximately 7 ha on the southern boundary of a swamp and is shown on Queensland Wetland Data (Version 1.3) as a palustrine wetland grading from a Melaleuca open-forest. The whole site is mapped as non-remnant vegetation in Biodiversity of pre-clearing and remnant regional ecosystem data indicating the vegetation at the site has been disturbed.

Summary of assessment methodology and survey outcomes
The site was stratified using coloured 2005 ortho-rectified aerial photography with reference to Biodiversity of pre-clearing and remnant regional ecosystem data (Version 6b) and stereoscopic examination of aerial photographs (Plate 11). The preliminary strata identified were verified in the field and surveyed. *Sites were located along a transect running across the gradient from wetter low-lying areas to higher less-inundated areas (Plate 11). Sites 1 and 2 were verified as wetland from the vegetation assessment, while site 3 was dominated by non-wetland exotic species. Soil sampling at site 3 identified the presence of wetland soil indicators including high organic carbon content, mottling and ferruginous root channel linings. Therefore, site 3 was verified as a wetland.*

Site	Hydrology criterion	Biotic criterion (vegetation)	Biotic criterion (fauna)	Soil criterion	Wetland Assessment Outcome
1	**Yes**	**Yes**	Yes	Yes	**Wetland**
	No	No	**No**	No	Non-wetland
	Not assessed	Not assessed	Not assessed	**Not assessed**	
2	**Yes**	**Yes**	Yes	Yes	**Wetland**
	No	No	**No**	No	Non-wetland
	Not assessed	Not assessed	Not assessed	**Not assessed**	
3	**Yes**	Yes	Yes	**Yes**	**Wetland**
	No	**No**	**No**	No	Non-wetland
	Not assessed	Not assessed	Not assessed	Not assessed	

Summary of hydrology assessment (details provided in Part B: Wetland hydrology assessment)
The site is situated on a floodplain. Landsat TM satellite imagery from 1999 wet season shows the area to be inundated with floodwaters, which was confirmed by anecdotal information from the landholder.

Summary of wetland vegetation assessment (detail provided in Part C: Wetland vegetation assessment)
Sites 1 and 2 are dominated by wetland vegetation species Melaleuca viridiflora var. viridiflora. The vegetation on site 3 has been cleared and is presently dominated by non-wetland exotic species.

Summary of wetland soils assessment (detail provided in Part D: Wetland soil assessment)
The soils at site 3 showed mottles in the upper layer (< 0.3 m from soil surface) and wetland soil indicators including ferruginous root channel and low chroma values. These are positive soil indicators as the site is seasonally inundated.

Summary of wetland fauna assessment
Not applicable.

Final wetland determination and boundary delineation
The final boundary (Plate 12) was digitised directly onto 1:25,000 scale ortho-rectified aerial photography with an accuracy of ± 2.2 m at a scale of 1:10,000 with a cartographic positional accuracy of ± 10 m. Therefore, the final boundary has a positional accuracy of ± 12.2 m.

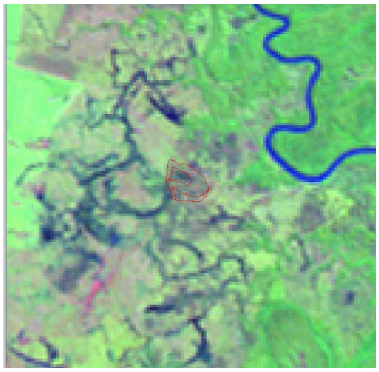


Plate 9. Landsat TM satellite imagery of the site from the 1990 wet season showing inundation across the area (outlined in red).

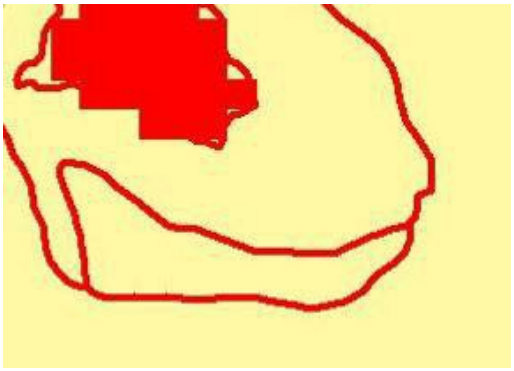


Plate 10. Existing wetland delineation in the Queensland Wetland Data (Version 1.3) for the area showing a palustrine swamp (outlined in red) bordered by non-wetland areas to the south.

Plate 11. Preliminary feature stratification (bordered in red) and location of quantitative vegetation assessment sites (blue points).

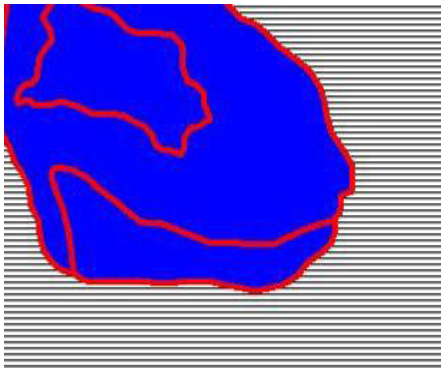


Plate 12. Final wetland boundary delineation with wetland area shaded blue. Non assessed areas are indicated by black hatch pattern.

Part B: Wetland hydrology assessment

Site Number	*1,2,3*	Recorder	*F. Smith, E. Brown, J. Green*	Date	*4/06/2007*
Locality					
MGA	Zone		E		N		:
GDA94	Longitude		.		Latitude		.	

Imagery Record

Type	Date(s) Observed
Landsat TM	*March 1990 (Plate 9)*

Indicators

Indicators of Inundation	Present	Not Present
Direct observation of water saturation/inundation.		
Topographical drainage patterns		
Vegetation dominated by wetland indicator plants		
Wetland soils (see Soil Indicators of Queensland Wetlands: Field Guide)		
Micro-relief landscape feature		
Debil debil landscape feature		✓
Swamp hummock landscape feature		✓
Algal mats landscape feature		✓
Aerial roots landscape feature		✓
Floodmarks landscape feature		
Water transported debris		✓
Silt lines		
Water marks		
Iron staining landscape feature		✓

Indicator of Potential Inundation	Observation
Landform pattern (e.g. floodplain)	
Landform element (e.g. swamp)	
Depth to groundwater	

Notes
Anecdotal evidence of inundation at site provided by landholder.

Part C: Wetland vegetation assessment

Part C-2: Quantitative wetland vegetation assessment

Use this section where the ecologically dominant layer is not easily identifiable and/or there is a mixture of wetland and non-wetland plant species.

Plate 13. Quantitative vegetation assessment at site 1, Goorgandra Plain, Queensland.

Plate 14. Quantitative vegetation assessment at site 2, Goorgandra Plain, Queensland.

Plate 15. Quantitative vegetation assessment at site 3, Goorgandra Plain, Queensland.

Site Number	1	Recorder	F. Smith, E. Brown, J. Green	Date	4/06/2007
Locality	Goorgandra Plain				

MGA	Zone	5	5	E	0	3	9	1	0	2	9	N	8	0	7	0	7	1	8	:
GDA94	Longitude						.					Latitude			.					

Structure

Stratum	Median canopy height	Range in strata height	Total crown cover
Emergent			
Tree 1	9.5 m		55
Tree 2			
Tree 3			
Shrub 1			
Shrub 2			
Ground	2.3 m		70

Plant species

Scientific name	Wetland indicator species	Cover						
		E	T1	T2	T3	S1	S2	G
Melaleuca viridiflora var. viridiflora	✓		50					
Lophostemon suaveolens	✓		5					
Cyperus gunnii subsp. novae-hollandiae	✓							25
Leersia hexandra	✓							40
Cyperus dactylotes	✓							
Cyperus lucidus	✓							

Ecologically dominant layer

Structural form	
Ecologically dominant layer	Tree 1
Proportion of wetland indicator species in the ecologically dominant layer	90%

Site Number	*2*	**Recorder**	*F. Smith, E. Brown, J. Green*	**Date**	*4/06/2007*
Locality					

MGA	**Zone**	*5*	*5*	**E**	*0*	*3*	*9*	*1*	*0*	*2*	*9*	**N**	*8*	*0*	*7*	*0*	*7*	*1*	*8*	**:**
GDA94	**Longitude**						**.**					**Latitude**							**.**	

Structure

Stratum	Median canopy height	Range in strata height	Total crown cover
Emergent			
Tree 1	*9.5 m*		*55*
Tree 2			
Tree 3			
Shrub 1			
Shrub 2			
Ground	*2.3 m*		*70*

Plant species

Scientific name	Wetland indicator species	Cover						
		E	T1	T2	T3	S1	S2	G
Melaleuca viridiflora var. viridiflora	✓		50					
Lophostemon suaveolens	✓		5					
Cyperus gunnii subsp. novae-hollandiae	✓							25
Leersia hexandra	✓							40
Cyperus dactylotes	✓							
Cyperus lucidus	✓							

Ecologically dominant layer

Structural form	
Ecologically dominant layer	*Tree 1*
Proportion of wetland indicator species in the ecologically dominant layer	*90%*

Site Number	*3*	**Recorder**	*F. Smith, E. Brown, J. Green*	**Date**	*4/06/2007*
Locality					

MGA	**Zone**	*5*	*5*	**E**	*0*	*3*	*9*	*1*	*0*	*2*	*9*	**N**	*8*	*0*	*7*	*0*	*7*	*1*	*8*	**:**
GDA94	**Longitude**						**.**					**Latitude**						**.**		

Structure

Stratum	Median canopy height	Range in strata height	Total crown cover
Emergent			
Tree 1	*9.5 m*		*2*
Tree 2			
Tree 3			
Shrub 1			
Shrub 2			
Ground	*0.5 m*		*55*

Plant species

Scientific name	Wetland indicator species	Cover						
		E	T1	T2	T3	S1	S2	G
Melaleuca viridiflora var. viridiflora	✓		50					
Lophostemon suaveolens	✓		5					
Cyperus gunnii subsp. novae-hollandiae	✓							25
Leersia hexandra	✓							40
Cyperus dactylotes	✓							
Cyperus lucidus	✓							

Ecologically dominant layer

Structural form	
Ecologically dominant layer	*Ground*
Proportion of wetland indicator species in the ecologically dominant layer	*< 10%*

Part D: Wetland soil assessment

It is recommended that this proforma be used in conjunction with Soil Indicators of Queensland Wetlands: Field Guide (Department of Natural Resources and Water 2008).

Site Number	*3*	**Recorder**	*F. Smith, E. Brown, J. Green*	**Date**	*1/05/2007*
Locality	*Goorgandra Plain*				

MGA	**Zone**			**E**	*6*	*7*	*1*	*0*	*1*	*0*		**N**	*7*	*7*	*4*	*0*	*9*	*9*	*3*	**:**
GDA94	**Longitude**						**.**					**Latitude**							**.**				

Climatic Region

Arid	Semiarid	Subtropical	Temperate	Tropical/Equatorial

Wetland Soils

Australian soil class	Anthroposol	Dermosol	Kandosol	Podosol	Tenosol
	Calcarosol	Ferrosol	Kurosol	Rudosol	Vertosol
	Chromosol	Hydrosol	Organosol	Sodosol	

Peat horizon within 0.3 m of the soil surface	Present	Not present
Thickness of peat horizon	_____ . _____ cm / m	

Wetland Soil Indicators

Organic Materials

Organic material within 0.3 m of soil surface			Present	Not present
Thickness of organic material	_____ . _____ cm / m			
Texture qualifier	Fibric	Hemic	Sapric	Streaked

Acid Sulfate Soil Materials

Hydrogen sulfide gas (rotten egg gas) within 0.3 m of soil surface	Present	Not present
Monosulfidic black ooze within 0.3 m of soil surface	Present	Not present
Sulfurous segregations within 0.3 m of soil surface	Present	Not present

Gley Colours

Gley colours	Present	Not present
Thickness of gley layer	_____ . _____ cm / m	
Depth of gley layer	_____ . _____ cm / m	

Soil Water Interface

Soil water interface	Present	Not present
Depth to soil water interface	_____ . _____ cm / m	

Mottles

Mottles within 0.3 m of soil surface	Present	Not present

Segregations

Segregations within 0.3 m of soil surface	Present	Not present

Ferruginous Root Channel and Pore Linings

Ferruginous root channel and pore linings within 0.3 m of soil surface	Present	Not present

Soil Matrix Chroma

Are chroma values less than or equal to 2 in the wettest lowest lying area?	Yes	No
Do chroma values decrease moving into the wetland from sites considered outside?	Yes	No

Plate 16. High organic carbon content, mottling, and ferruginous root channel linings are all positive indicators of periodic inundation at the Goorgandra Plain site.

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8 Acronyms and Abbreviations

Acronym or Abbreviation	Acronym or Abbreviation Name
E	Easting
GDA94	Geocentric Datum of Australia 1994
GPS	Global Positioning System
GIS	Geographic Information System
MGA	Map Grid of Australia
N	Northing
QWP	Queensland Wetlands Program
RMSE	Root-Mean-Square Error
subsp.	Subspecies
sp.	Species
spp.	Several species
var.	Variety

9 Units of Measurement

Unit of Measurement	Unit of Measurement Name
%	Percent
cm	Centimetre
ha	Hectares
m	Metre
mm	Millimetre

10 Glossary

Term	Definition
Accuracy	"The condition or quality of being accurate; precision or exactness" (Yallop 2005).
Acid Sulfate Soils	“Common name given to soils and sediments containing iron sulfides, the most common being pyrite” (Department of Natural Resources and Water 2008).
Aerial Root	Aerial roots are an adaptation of plants to a waterlogged environment (Department of Natural Resources and Water 2008).
Algal Mat	“Continuous crust of biologically stabilised soil material” (Department of Natural Resources and Water 2008).
Animals	See Queensland Wetland Definition Guideline (Section 3.2.2)
Anthroposol	See Isbell and National Committee on Soil and Terrain (2021)
Areas	See Queensland Wetland Definition Guideline (Section 3.2.1)
Artificial	“Made by human skill and labour, as opposed to natural” (Yallop 2005).
Artificial Wetland	Within this guideline the term ‘artificial wetland’ refers to a wetland that is human made to substantially provide the ecosystem services of a wetland.
Attributes	"Descriptive characteristics or features of…ecosystems" (Department of Environment and Science 2020a)
Auger	“tool for boring holes deep in the ground” (Yallop 2005)
Bank	"Very short, very wide slope, moderately inclined to precipitous, forming the marginal upper parts of a stream channel and resulting from erosion and aggradation by channelled stream flow" (National Committee on Soil and Terrain 2009).
Basal Area	"A measure of the total cross-section area of stems at breast height (1.3 metres above the ground)" (Neldner et al. 2019).
Basalt	“dark, dense igneous rock of a lava flow or minor intrusion” (Yallop 2005)
Biodiversity	"Biodiversity (or biological diversity) is the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes." (Aquatic Ecosystems Task Group 2012)
Biota	The total animal and plant life (Yallop 2005).

Bitterlich Stick	A Bitterlich Stick is an instrument measuring basal area and diameter.
Boundary	“Something that indicates bounds or limits; a limiting or bounding line” (Yallop 2005)
Bund	“An embankment” (Yallop 2005)
Cadastral	“Of or relating to the records of a cadastre” (Yallop 2005)
Cadastre	“An official register of property, with details of boundaries, ownership, etc.” (Yallop 2005)
Calcarosol	See Isbell and National Committee on Soil and Terrain (2021)
Cartographic	“The production of maps” (Yallop 2005)
Channel	"Linear, generally sinuous open depression in parts eroded, excavated, or built up by channelled stream flow. This element comprises stream bed and banks" (National Committee on Soil and Terrain 2009).
Channel bank	See 'Bank'
Chromosol	See Isbell and National Committee on Soil and Terrain (2021)
Classification	"A process of simplifying complex, and sometimes continuous, data and information and converting it into practical categories to make it more usable." (Department of Environment and Science 2020a)
Clearing	“Vegetation has been removed, cut down, ring-barked, pushed over, poisoned, or destroyed by burning flooding or draining, but does not include destroying vegetation by stock or lopping a standing tree.” (Neldner et al. 2019)
Clinometer	“An instrument used to determine inclination or slope” (Yallop 2005)
Community	An assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australia and New Zealand 2000).
Compass	“An instrument for determining directions” (Yallop 2005)
Contour	"A line joining points of equal elevation on a surface" (Yallop 2005)
Coordinate System (Geographic)	“Reference framework that defines the locations of features on a model of the earth. It’s shaped like a globe—spherical. Its units are angular, usually degrees.” (ESRI 2020)
Coordinate System (Projected)	“Converts a geographic coordinate system into a flat surface, using math (the projection algorithm) and other parameters. Its units are linear, most commonly in meters.” (ESRI 2020)
Criteria	See 'Criterion'.
Criterion	"An established rule or principle for testing anything" (Yallop 2005).
Crown	“The leaves and living branches of a tree” (Yallop 2005).
Crown Cover	″Sensu, Walker and Hopkins (1991) is the percentage of the ground surface covered by the vertical projection of the periphery of plant crowns. Crowns are treated as opaque meaning that small gaps within the crown are ignored. Crown cover (%) of a stratum is measured for the stratum as a whole i.e. ignoring crown overlaps within a stratum" (Neldner et al 2019).
Datum	“Part of the geographic coordinate system that determines which model (spheroid) is used to represent the earth’s surface and where it is positioned relative to the surface” (ESRI 2020)

Debil Debil	"Small hummocks rising above the planar surface. They vary from rounded, both planar and vertically, to flat-topped, relatively steep-sided and elongate. They are usually closely and regularly spaced, ranging from 0.06 m to 0.6 m in both vertical and horizontal dimensions." (National Committee on Soil and Terrain 2009).
Delineation	To trace the outline of; sketch or trace in outline; represent pictorially (Yallop 2005). In this document, delineation relates to the process of establishing and describing the boundary between wetland and non-wetland ecosystems.
Depression	"Landform element that stands below all, or almost all points in the adjacent terrain" (National Committee on Soil and Terrain 2009).
Dermosol	See Isbell and National Committee on Soil and Terrain (2021)
Digital Elevation Model	Modelled representation of the topographic surface of the earth excluding trees, building, and other surface objects.
Digital Terrain Model	Modelled representation of the topographic surface of the earth excluding trees, building, and other surface objects.
Dominant species	Species that contributes most to the overall aboveground biomass of a particular stratum. (Neldner et al. 2019)
Dyke	“a ridge or bank of earth as thrown up in excavating” (Yallop 2005).
Ecologically Dominant Layer	The layer or species making the greatest contribution to the overall biomass of the site and the vegetation community (National Land and Water Resources Audit 2001).
Ecosystem	"An ecosystem is a dynamic combination of plant, animal and micro-organism communities and their non-living environment (e.g. soil, water and the climatic regime) interacting as a functional unit." (Aquatic Ecosystems Task Group 2012)
Emergent Layer	The tallest layer/stratum is regarded as the emergent layer if it does not form the most above-ground biomass, regardless of its canopy cover (Neldner et al. 2019)
Emergent Stratum	See ‘Emergent Layer’
Emergent Vegetation	See 'Emergent Layer’
Ephemeral	Lasting only a day or a very short time; short-lived; transitory (Yallop 2005)
Episodic	Dry most of the time with rare and very irregular wet phases (Paijmans et al. 1985).
Fauna	See 'Animals'
Feature	Refers to the actual wetland feature
Ferrosol	See Isbell and National Committee on Soil and Terrain (2021)
Ferruginous Pore Linings	“Oxidised pore linings occur where oxygen has moved through pores in the soil matrix causing a coating of ferric iron to form” (Bryant et al. 2008)
Ferruginous Root Channel	“Plant root has pushed oxygen into the saturated soil forming a coating of ferric iron around the root channel” (Bryant et al. 2008)
Fibric	“Undecomposed or weakly decomposed organic materials” (Department of Natural Resources and Water 2008)
Flat	"Planar landform element that is neither a crest nor a depression and is level or very gently inclined" (National Committee on Soil and Terrain 2009)
Flooded	See Queensland Wetland Definition Guideline (Section 3.2.3)

Floodplain	Alluvial plain characterised by frequently active erosion and aggradation by channelled or over-bank stream flow. Unless otherwise specified, 'frequently active' is to mean that flow has average recurrence interval of 50 years or less (National Committee on Soil and Terrain 2009).
Geographic Information System	"Framework for gathering, managing, and analysing data" (ESRI n.d.)
Geologic	Of or relating to the earth, the rocks of which it is composed, and the changes which it has undergone or in undergoing (Yallop 2005).
Gleyed Soil Matrix	A gleyed soil matrix is a bluish-grey or grey colour that occupies 50 % or more of a layer starting within 0.3 m of the soil surface (Department of Natural Resources and Water 2008)
Groundwater	Water that is present in the pores and cracks of the saturated and capillary zones of soils, regolith and rocks and water that is present in caves (Glanville et al. 2015)
Hemic	"Moderately to well decomposed organic materials" (Department of Natural Resources and Water 2008)
Heterogeneous	"Composed of parts of different kinds" (Yallop 2005).
Homogenous	"Of the same kind or nature" (Yallop 2005).
Horizon	"Layer of soil, approximately parallel to the land surface, with morphological properties different from layers below and/or above it" (National Committee on Soil and Terrain 2009)
Hydric Soil	Soils that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part of the soil (Department of Natural Resources and Water 2007)
Hydrologic	Of or relating to water on the land, or under the earth's surface, its properties, laws, geographical distribution, etc. (Yallop 2005).
Hydrosol	See Isbell and National Committee on Soil and Terrain (2021)
Hypsometer	"Instrument for measuring altitude" (Yallop 2005).
Hummock	"Rises above a flat or planar surface. Sides vary from rounded to near vertical and tops from rounded to flat" (National Committee on Soil and Terrain 2009)
Indicator	Organism, ecological community, or structural feature so strictly associated with a particular environmental condition that its presence indicates the existence of the condition.
Intermittent	See Queensland Wetland Definition Guideline (Section 3.2.1)
Interpolate	"To introduce (something additional or extraneous) between other things or parts" (Yallop 2005).
Inundation	See Queensland Wetland Definition Guideline (Section 3.2.1)
Inventory	"Involves the recording of standardised data about a taxonomic group, habitat or ecosystem from available data sources or through survey" (Department of Environment and Science 2020a)
Kandosol	See Isbell and National Committee on Soil and Terrain (2021)
Kurosol	See Isbell and National Committee on Soil and Terrain (2021)
Landform	Any of the numerous features which make up the surface of the earth (Yallop 2005)
Landform Element	A landform element is a sub-component of a landform type that can be characterised mainly by its morphology (shape, steepness, orientation, moisture regime) (Macmillian & Shary 2009)
Latitude	"The angular distance north or south from the equator of a point on the earth's surface, measured on the meridian of the point" (Yallop 2005).

Levee	"Very long, very low, nearly level sinuous ridge immediately adjacent to a stream channel, built up by over-bank flow. Levees are built, usually in pairs bounding the two sides of a stream channel, at the level reached by frequent floods." (National Committee on Soil and Terrain 2009).
Life cycle	See Queensland Wetland Definition Guideline (Section 3.2.2)
Longitude	“Angular distance east or west on the earth’s surface, measured along the equator by the angle contained between the meridian of a particular place and some prime meridian” (Yallop 2005).
Map	Graphic representation that facilitate a spatial understanding of things, concepts, conditions, processes, or events in the human world (Harley and Woodward 1987).
Mapping	See 'Map'
Mean	“Obtained by adding several quantities together and dividing the sum by the number of quantities” (Yallop 2005).
Median	“Situated in or relating to the middle” (Yallop 2005).
Micro-Relief	"Microrelief refers to relief up to a few metres about the plane of the land surface" (National Committee on Soil and Terrain 2009)
Mobile	“Movable; moving readily” (Yallop 2005).
Monosulfidic Black Ooze	“Organic oozes enriched with monosulfides” (Department of Natural Resources and Water 2008)
Mosaic Area	See Queensland Wetland Definition Guideline (Section 5.3.1)
Mosaic Wetland	See Queensland Wetland Definition Guideline (Section 5.3)
Mottles	“Spots, blotches or streaks of subdominant colours different from the matrix colour and also different from the colour of the ped surface” (National Committee on Soil and Terrain 2009)
Mud	"Wet soft earth composed predominantly of clay and silt-fine mineral sediments less than 0.074 mm in diameter (Black 1968; Liu 1970)" (Cowardin et al. 1979).
Non-remnant	“All vegetation that is not mapped as remnant vegetation. May include regrowth, heavily thinned or logged and significantly disturbed vegetation that fails to meet the structural and/ or floristic characteristics of remnant vegetation. It also includes urban and cropping land. Non-remnant vegetation may retain significant biodiversity values” (Neldner et al. 2019).
Non-woody	“The vegetation in which the predominant stratum is composed of grasses and /or other non-woody vegetation.” (Neldner et al. 2019)
Organic Carbon	Generally carbon which is chemically bonded to other carbon atoms, although methane (one carbon atom only) and its derivatives are considered organic (Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australia and New Zealand 2000).
Organic Materials	These are plant-derived organic accumulations that are either: a) saturated with water for long periods or are artificially drained and, excluding live plant tissue, (i) have 18% or more organic carbon [Walkley-Black x 1.3 or a total combustion method. (Rayment and Higginson 1992, Methods 6A1 or 6B2).] if the mineral fraction is 60% or more clay, (ii) have 12% or more organic carbon if the mineral fraction has no clay, or (iii) have a proportional content of organic carbon between 12 and 18% if the clay content of the mineral fraction is between zero and 60%; or b) saturated with water for no more than a few days and have 20% or more organic carbon. (Isbell and National Committee on Soil and Terrain 2016)

Organosol	Soils that are not regularly inundated by saline tidal waters and either: i. Have more than 0.4 m of organic materials within the upper 0.8 m. The required thickness may either extend down from the surface or be taken cumulatively within the upper 0.8 m. or ii. Have organic materials extending from the surface to a minimum depth of 0.1 m; these either directly overlie rock or other hard layers, partially weathered or decomposed rock or saprolite, or overlie fragmental material such as gravel, cobbles or stones in which the interstices are filled or partially filled with organic material. In some soils there may be layers of humose and/or melacic horizon material underlying the organic materials and overlying the substrate. (Isbell and National Committee on Soil and Terrain 2016)
Palustrine system	See Queensland Wetland Definition Guideline (Section 4.5)
Peat	A mass of dark brown, partly decomposed, fibrous plant debris (Kearey 2001)
Periodic	See Queensland Wetland Definition Guideline (Section 3.2.1)
Perpendicular	“Meeting a given line or surface at right angles” (Yallop 2005).
pH	The negative log of the hydrogen (hydronium) ion concentration (Brinson 1993)
Plain	"Large very gently inclined or level [landform] element, of unspecified geomorphological agent or mode of activity" (National Committee on Soil and Terrain 2009).
Plants	See Queensland Wetland Definition Guideline (Section 3.2.2)
Podosol	See Isbell and National Committee on Soil and Terrain (2021)
Polygon	In mapping terminology, a polygon is an area enclosed by lines on a map. (Neldner et al. 2019)
Preclearing	“The vegetation present before clearing” (Neldner et al. 2019)
Predominantly	See Queensland Wetland Definition Guideline (Section 3.2.3)
Pro forma	“According to form; as a matter of form” (Yallop 2005).
Proforma	“Of or relating to a document which is issued pro forma” (Yallop 2005).
Projection	“A systematic drawing of lines representing the meridians of longitude and parallels of latitude on a plan surface; the earth’s surface (or celestial sphere) or some portion of it may be drawn on the grid so produced” (Yallop 2005).
Property Map of Assessable Vegetation	“Property-scale map that shows the boundaries of vegetation categories on the property”
Qualitative	“Relating to or concerned with quality or qualities” (Yallop 2005).
Quantitative	“Relating to the describing or measuring of quantity” (Yallop 2005).
Regional Ecosystem	A vegetation community or communities in a bioregion that is consistently associated with a particular combination of geology, landform and soil (Neldner et al. 2019).
Regrowth	“Non-remnant vegetation that has a significant woody component but fails to meet the structural and/or floristic characteristics of remnant vegetation. Includes vegetation that has regrown after clearing or been heavily thinned or logged and may retain significant biodiversity values” (Neldner et al. 2019).
Relict	Left remaining after some earlier activity or change (Yallop 2005).
Relief	“Difference in elevation between the high and low points of a land surface” (National Committee on Soil and Terrain 2009).
River	"A large natural stream of water (larger than a creek)" (Environmental Protection Agency 2005b).

Riverine system	See Queensland Wetland Definition Guideline (Section 4.6)
Root-Mean-Square Error	Square root of the mean of the square of all the error or differences between values predictors or estimated and values observed.
Rudosol	See Isbell and National Committee on Soil and Terrain (2021)
Salt	See Queensland Wetland Definition Guideline (Section 3.2.1)
Sapric	“Strongly to completely decomposed organic materials” (Department of Natural Resources and Water 2008).
Scale	The parameter that describes the level of geographic resolution and extent, the context of space and time and helps define the positional accuracy (Quattrochi and Goodchild 1997).
Seasonal	Alternatively, wet and dry every year according to season (Paijmans et al. 1985).
Shrub	Woody plant multi-stemmed at the base (or within 200 mm from ground level), or if single-stemmed less than 2 m tall (Walker and Hopkins 1990).
Site	Refers to an area for ground survey and may include surrounding non-wetland support areas.
Sodosol	See Isbell and National Committee on Soil and Terrain (2021).
Soil	"Pedologic organisation (McDonald et al. 1990) is used to distinguish soil materials. This is a broad concept used to include all changes in soil material resulting from the effect of the physical, chemical and biological processes that are involved in soil formation. Results of these processes include horizonation, colour differences, presence of pedality, texture and/or consistence changes" (Isbell and National Committee on Soil and Terrain 2016).
Soil Matrix	Solid matrix of the soil including particles.
Soil Matrix Chroma	“Method for describing soil colour that depicts the purity or strength of the colour” (Department of Natural Resources and Water 2008).
Species	A group of organisms that resemble each other to a greater degree than members of other groups and that form a reproductively isolated group that will not produce viable offspring if bred with members of another group (Australian and New Zealand Environment and Conservation Council, and Agriculture and Resource Management Council of Australia and New Zealand 2000).
Specimen	“A part or an individual taken as exemplifying a whole mass or number” (Yallop 2005).
Spring	Springs are hydrogeological features by which groundwater discharges naturally to the land surface or cave. This includes springs with permanent and non-permanent (i.e. intermittent or ephemeral) saturation regimes; dynamic or static spatial locations; and/or diffuse or point source spatial locations (Glanville et al. 2015).
Standard Error	Standard deviation of the sampling distribution.
Stereo Pairs	Stereoscopic pair of separate images, depicting left-eye and right-eye views of the same scene.
Stereoscopic	Relating to stereoscopy, a technique for creating an illusion of three-dimensional depth using binocular vision of two offset images.
Strata	See ‘Stratum’
Stratum	“Layer in a vegetation community produced by the occurrence at approximately the same level (height) of an aggregation of plants of the same habit (Beadle and Costin 1952).” (Neldner et al. 2019)
Streaked	“Soil is sandy and has dark stains (streaks) of organic materials” (Department of Natural Resources and Water 2008)
Subterranean	“Existing, situated, or operating below the surface of the earth” (Yallop 2005).

Sulfidic	Materials containing detectable inorganic sulfides that can exist as horizons or layers at least 0.03 m thick or as surficial features (Isbell and National Committee on Soil and Terrain 2016)
Swamp	An emergent wetland in which the uppermost stratum of vegetation is composed primarily of trees (Brinson 1993)
Swamp Hummock	“Steep sided hummocks rising above a flat surface” (Department of Natural Resources and Water 2008)
Tenosol	See Isbell and National Committee on Soil and Terrain (2021)
Texture	“Soil texture is determined by the size distribution of mineral particles finder than 2mm” (National Committee on Soil and Terrain 2009)
Tidal	"Of or pertaining to tides; caused by tides; having tides; periodically rising and falling, or following and ebbing; as, tidal waters" (Environmental Protection Agency 2005b).
Transect	“To cut across; dissect transversely” (Yallop 2005).
Tree	"Woody plant more than 2 m tall with a single stem or branches well above the base" (Neldner et al. 2019)
Understorey	“Any stratum below (i.e. lower height than) the predominant stratum” (Neldner et al. 2019)
Upper layers	See Queensland Wetland Definition Guideline (Section 3.2.3)
Vegetation	“The entirety of the plant cover at a point on the earth’s surface at a particular time. It is the spatial and temporal expression of the flora of an area, as expressed in plant assemblages (communities) which consist of individual species with varied lifeforms (Raunkiaer 1934). The present vegetation is a reflection not only of the site potential as determined by climatic, physiographic, edaphic and biotic factors (Webb et al. 1970; Gunn et al. 1988), but also the history of land use and disturbance. Irregular catastrophic events, e.g. intense fires, prolonged droughts and clearing, whether natural or human-induced, can be important factors determining the floristic composition and structure of present day vegetation (Mueller-Dombois and Ellenberg 1974; Neldner 1984).” (Neldner et al. 2019)
Vegetation Structural Formation	“The structural class combined with the dominant life form of a vegetation community” (Neldner et al. 2019)
Vegetation Structure	“The spatial arrangement of plants within a vegetation community (Beadle and Costin 1952).” (Neldner et al. 2019)
Vertosol	See Isbell and National Committee on Soil and Terrain (2021)
Waterbody	See Queensland Wetland Definition Guideline (Section 3.4)
Waypoints	A term commonly used in GPS units, referring to a point at which geographic coordinates are recorded.
Wet Conditions	See Queensland Wetland Definition Guideline (Section 3.2.2)
Wetland	See Queensland Wetland Definition Guideline (Section 3)
Wetland-dependent	See Queensland Wetland Definition Guideline (Section 3.2.2)
Wetland Indicator Plant	Plants that have adapted to living in wetlands and are dependent on them (WetlandInfo)
Wetland Plant	Plants that grow around and in wet areas (WetlandInfo)
Wetland Soil	"Under the Australian Soil Classification only Organosols can be called a wetland soil. The exception is Organosols present at higher altitudes which may not form under saturated conditions." (Department of Natural Resources and Water 2008)