WETLAND TRACKER

GREAT BARRIER REEF CATCHMENT WETLAND CONDITION MONITORING PROGRAM

DESKTOP METHODS GUIDE

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PART 2: DESKTOP METHODS GUIDE[1]

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Contents

Acronyms

ALUM	Australian Land Use and Management (classification system)
AOI	Area of Interest
DERM	Department of Environment and Resource Management (Queensland Government)
DES	Department of Environment and Science (Queensland Government)
DSITI	Department of Science, Information Technology and Innovation (Queensland Government)
FPC	Foliage Projective Cover
GBR	Great Barrier Reef
GIS	Geographic Information System
GPS	Global Positioning System
NFSWV	National Forest and Sparse Woody Vegetation
PC	Pressure Class
QWP	Queensland Wetlands Program
RE	Regional Ecosystems
REDD	Regional Ecosystems Descriptions Database
SLATS	Queensland Statewide Land and Trees Study
WEV	Wetland Environmental Value

Assessment methods glossary

Area of interest	Defines the spatial extent of the data from which the Wetland Tracker indicator scores will be calculated.
Australian Land Use and Management (ALUM) classification system	Provides a nationally consistent method to collect and present land use information across Australia. https://www.agriculture.gov.au/abares/aclump/land-use/alum-classification
Biotic integrity	The ability of an aquatic ecosystem to support and maintain a balanced and adaptive community of organisms with structural and functional composition/diversity comparable to a natural biota from a similar ecoregion Karr et al. (1986).
Bunding	The construction of a barrier (e.g. barrage, bund, dam, embankment, ridge, wall) within or outside of a channel to modify surface movement of water (Queensland Department of Environment and Science 2019b).
Ecologically dominant layer	The stratum (or layer) that contains the greatest amount of aboveground vegetation biomass.
Foliage projective cover (FPC)	A metric that is used in remote sensing as a direct estimate of the foliage on an area of vegetation when viewed from above. Herein, FPC refers to the foliage of woody plants only and is expressed as a percentage where: 0% FPC implies there is no woody plant foliage cover; and 100% FPC implies total or complete woody plant foliage cover (Queensland Department of Environment and Science 2018).
Floodplain	Land adjacent to a waterway that is naturally subject to occasional or periodic flooding. Floodplains can be narrow or wide and flat with steeper sides at the edges.
Hydrological modifier code	Codes used by the Queensland Wetland Program (QWP) to describe different types of structures and activities that modify the natural hydrological cycle of a wetland (e.g. bunds, partial drainage, excavation, pumping for irrigation) (Queensland Department of Environment and Science 2019b).
Indicator	A measurable entity or process whose existence in an area is strongly correlated with specific environmental conditions that are desired to be measured.
Lacustrine	Lake-like; referring to large, open, water-dominated systems.
Levee	An artificial embankment or structure which prevents or reduces the flow of overland flow water onto or from land.
Mapped wetland boundary	The boundary of the wetland as defined in Wetland*Info: https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/wetland-background* .
Non-woody plants	Plants that do not produce wood as primary structural tissue. Non-woody plants may include grasses, herbs, forbs, rushes, ferns, sedges and some vines.
Non-woody vegetation	Vegetation predominantly composed of non-woody plants. May contain areas of wooded vegetation that has FPC of under 10%.
Palustrine	Swamp-like; primarily vegetated, non-channel environments.
Pixel	In rasters derived from remote sensing, a pixel represents an area of space on the Earth's surface. Each pixel in a raster has the same dimensions and shape.

Polygon	An area enclosed by lines on a map.
Pressure	Human activities directly affecting the environment.
Pre-clearing regional ecosystem	Regional ecosystem present before clearing. While this roughly equates to 'pre-European', the Queensland Herbarium uses the term 'pre-clearing' because ecosystem boundaries are dynamic and no consistent imagery for the state exists prior to the early 1960s making it difficult to map 'pre-European' extent with any certainty.
Rapid assessment	An assessment giving a broad view of a subject at a particular time. A rapid assessment is conducted in the shortest time frame that will produce reliable and valid results for its intended purpose.
Raster	A raster consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information.
Regional ecosystems	Regional ecosystems are vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
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.
Remnant vegetation	Vegetation where the dominant canopy has >70% of the height and >50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy (Neldner et al., 2020).
State	The actual condition of an ecosystem and its components established in a certain area at a specific time that can be described based on physical, biological and/or chemical characteristics.
Wetland buffer zone	The transition zone between the wetland and the surrounding land use. Well-managed buffers support the functions and values of wetlands (Department of Environment and Resource Management 2011).
Wetland Environmental Values	Wetland Environmental Values (WEVs) are based on the physical and biological characteristics associated with a particular wetland. WEVs *support* the wetland's ecological processes and *underpin* its ecological, social and economic benefits. These benefits are sometimes referred to as ecosystem goods and services.
Woody plant	A plant that has wood as its primary structural tissue. Woody plants may be trees, shrubs or lianas (a type of climbing vine) and are usually perennial.
Woody vegetation	Vegetation for which the ecologically dominant layer is composed of woody plants. Herein woody vegetation refers to wooded vegetation that has an FPC of 10% or over. Vegetation height is not considered as it is not possible to reliably estimate from optical satellite imagery (Queensland Department of Environment and Science, 2018).

Introducing Wetland Tracker desktop methods guide

Wetland Tracker is a method developed for rapidly assessing the condition of freshwater palustrine and lacustrine wetlands and tracking changes in wetland condition over time within Queensland's Great Barrier Reef catchment area. Assessments are conducted at the individual wetland scale and completed in two stages: 1) a desktop assessment, based on remotely sensed data and aerial imagery and 2) a field assessment gathering on-ground data.

Four key wetland environmental values (WEVs) are targeted in Wetland Tracker assessments:

- WEV1: The biological health and diversity of the wetland ecosystem (biotic integrity)
- WEV2: The wetland's natural physical state and integrity (local physical integrity)
- WEV3: The wetland's natural hydrological cycle (local hydrology)
- WEV4: The natural interaction of the wetland with other ecosystems, including other wetlands (connectivity).

These four WEVs are assessed using Wetland Tracker 'state' indicators.

Human-induced pressure on wetlands is also assessed using Wetland Tracker 'pressure' indicators. The four Pressure Classes (PC) assessed are:

- PC1: Biological introductions (e.g. plant pests and animals changing the wetland)
- PC2: Habitat modification (e.g. loss of natural vegetation around the wetland)
- PC3: Changes to water regime (e.g. natural wetland water levels being altered by a dam or levee)
- PC4: Input pressures (e.g. chemicals and nutrients going into the wetland)

During an assessment each pressure or state indicator is given a categorical score on a scale of 1 to 5, where '1' represents the least disturbed state or the lowest degree of pressure and '5' represents the most disturbed state or the highest degree of pressure. Score class breaks have been optimised for the ability of indicators to discriminate across the range of disturbance. Scoring criteria vary according to indicator. More information on Wetland Tracker desktop assessment indicators is provided in later sections of this document and on the Wetland Tracker field datasheets.

At the end of each assessment, the desktop and field indicator scores are combined to calculate an overall pressure score and an overall state score, plus scores for each of the WEVs and PCs listed above, per wetland.

Wetland Tracker desktop methods guide provides instructions on how to complete a Wetland Tracker desktop assessment, including details of how to assess each pressure or state desktop indicator and the tools and data sources required. This desktop methods guide also contains instructions on how to generate key desktop resources required for use in the field assessment, including general field maps and other maps and reference materials used for field verification of selected desktop indicators.

Wetland Tracker desktop assessment overview

The table below lists all Wetland Tracker desktop indicators of (a) land use **pressure** on wetlands and (b) the **state** of wetland environmental values. The rationale for the indicator methods is discussed in a Wetland Tracker literature review of conceptual modelling and indicator development (Vandergragt et al, 2022, Part 4).

Table 1 Wetland Tracker desktop indicators

Pressure indicators		Area of interest	Pressure Class
P1	Land use associated with the introduction or perpetuation of pest species	Mapped wetland and 1 km buffer	PC 1 Biological introductions
P2*	Modification of native vegetation in the 200 m buffer	200 m buffer excluding mapped wetland	PC 2 Habitat modification
P3	Land use associated with pesticide residue inputs	Mapped wetland and 1 km buffer	PC 4 Input pressures
P4	Land use associated with nutrient inputs	Mapped wetland and 1 km buffer	PC 4 Input pressures
P5*	Number of septic systems within 200 m of wetland per ha of mapped wetland	Mapped wetland and 200 m buffer	PC 4 Input pressures
P10	Sediment supply (modelled, GBR)	Mapped wetland and 1 km buffer	PC 4 Input pressures
P14	Altered surface water flow due to vegetation cleared	1 km buffer excluding mapped wetland	PC 3 Changes to water regime
P16	Change in landscape hydrological integrity	Mapped wetland and 1 km buffer	PC 3 Changes to water regime
P20	Native vegetation cleared within 5 km of the wetland	Mapped wetland and 5 km buffer	PC 2 Habitat modification
P21	Loss of wetland regional ecosystems within 5 km of the wetland	Mapped wetland and 5 km buffer	PC 2 Habitat modification
State indicators		**Area of interest**	**Wetland Environmental Value**
S12*	QWP hydrological modifier code for the mapped wetland	Mapped wetland	WEV 3 Local hydrology
S13	Landscape vegetation connectivity	Mapped wetland	WEV 4 Connectivity
S14*	Native vegetation in the 200 m buffer	200 m buffer excluding mapped wetland	WEV 4 Connectivity
S15	Modified and artificial wetlands	1 km buffer excluding mapped wetland	WEV 3 Local hydrology
S16	Altered surface flow due to linear infrastructure	Mapped wetland and 1 km buffer	WEV 3 Local hydrology

* Indicators P2, P5, S12 and S14 are initially assessed using desktop methods, however field verification is required to finalise scores.

Requirements and preparation

Skills and knowledge

The interpretation and scoring of Wetland Tracker desktop indicators require expertise in GIS, aerial imagery interpretation and environmental sciences.

Software

The desktop assessment methods require GIS software and a GIS-enabled data repository, e.g., file geodatabase. Instructions throughout the document make generic reference to a GIS application so the user may choose the product that suits their circumstances. The designers of Wetland Tracker used ArcGIS Pro Advanced with Spatial Analyst extension with automation of data processing steps using Python scripts.

Data requirements and sources

Table 2 Information sources for the desktop assessment and fieldwork resources

Indicator / fieldwork resource relevance	Information required	Information source	Data description
All indicators, fieldwork resource	200 m wetland buffer 1 km wetland buffer 5 km wetland buffer	Create with a GIS application using mapped wetland as the input dataset	Spatial datasets of the areas of interest for many of the Wetland Tracker indicators.
P14	Built up areas	**Built up areas – Queensland** available from Queensland Open Data Portal <https://data.qld.gov.au/>	Provides extents of urban settlements (with more than 50 residential buildings where cadastral parcel size < 2 ha) (Queensland Department of Resources 2014).
S15	Canals lines	**Hydrographic features – Queensland series – Canal Lines** available from Queensland Open Data Portal <https://data.qld.gov.au/>	Spatial dataset of man-made open channels used in the distribution or removal of water for irrigation purposes, for significant infrastructure functions or as part of a residential canal estate within Queensland (Queensland Department of Resources 2021b).
S13	Connectivity index	**Connectivity index for Great Barrier Reef catchments** – internal dataset	Spatial raster dataset of connectivity index within Great Barrier Reef catchments for monitoring connectivity of natural areas. Produced by Wetland Science, Queensland Department of Environment and Science based on the methods used for the National Connectivity Index (discontinued at time of writing) (Australian Department of the Environment 2014) to give a connectivity score for each 100 m pixel. For the connectivity context at any location, the amount of remaining natural area, its condition, and spatial separation were assessed. Because connectivity applies across multiple scales, these measures were made within 7 circular regions ranging from 500 metres to 32 kilometres in radius. A single index of connectivity was developed by combining the three indices at all of the spatial scales.

Indicator / fieldwork resource relevance	Information required	Information source	Data description
Fieldwork resource	Contours	**Contours – 10 metre interval** available from Queensland Open Data Portal <https://data.qld.gov.au/>	Queensland-wide spatial dataset of 10m contours (Queensland Department of Resources 2019a).
P2, P14, P20, P21, S14, fieldwork resource	Current remnant regional ecosystems	**Biodiversity status of remnant regional ecosystems – Queensland** (most recent) available from Queensland Open Data Portal <https://data.qld.gov.au/>	Spatial dataset of Queensland current remnant vegetation communities (Department of Environment and Science 2021a). Remnant regional ecosystems are vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.
P5, fieldwork resource	Extent of sewer serviced areas	Online mapping available from some local government websites or data request from relevant local government	Local government information about extent of sewer serviced areas.
P2, P10, S14, fieldwork resource	Foliage projective cover (FPC) (See p.9 for data preparation required)	**Foliage projective cover** (most recent) available from Queensland Open Data Portal <https://data.qld.gov.au/>	Queensland-wide spatial raster dataset of woody foliage projective cover (FPC). FPC is a remotely sensed cover estimate of the foliage on vegetation as viewed from above. This data refers to the foliage of woody plants only. It is expressed as a percentage where: 0% FPC implies no woody plant foliage cover while 100% FPC implies total or complete woody plant foliage cover per pixel (Queensland Department of Environment and Science 2016).
P10	GBR Paddock to Reef sub-catchments boundaries	**GBR Paddock to Reef sub-catchments boundaries** – internal dataset	Spatial dataset of Paddock to Reef sub-catchments (mapping units) for modelling for the Reef Water Quality Report Card 2017 and 2018 (Queensland Department of Natural Resources and Mines 2016a, Australian and Queensland governments 2019).
P14, fieldwork resource	Historical aerial image	Available from QImagery <https://qimagery.information.qld.gov.au/>	Historical aerial imagery of Queensland used to investigate how the landscape has changed over time.
S15	Irrigation distribution infrastructure	**Sunwater irrigation distribution infrastructure series** available from Queensland Open Data Portal <https://data.qld.gov.au/>	Provides mapping of Sunwater Ltd irrigation infrastructure (channels, pipelines, drains, levees, embankments) centrelines in several water supply scheme areas in Queensland (Sunwater Ltd 2020).
P1, P3, P4, P10, P16, P20, S14, fieldwork resource	Land use mapping	**Land use mapping series – Queensland** (most recent) available from Queensland Open Data Portal <https://data.qld.gov.au/>	Spatial dataset of land use in Queensland (Department of Environment and Science 2019a). Land use is classified according to the Australian Land Use and Management (ALUM) classification (ABARES 2016).
P1, P3, P4, P10, P16, P20, S14	Land use pressures scores table	**Wetland Tracker land use pressures scores table** – internal dataset (pre-processed geodatabase table based on tables 5–8 of this document)	A table of Wetland Tracker pressure scores developed for GBR catchment-wide application based on *A landscape hazard assessment for wetlands in the Great Barrier Reef catchment* report (DSITIA 2015) associated with ALUM class land use classes (ABARES 2016). Includes pest, pesticide and nutrient change to natural surface water flow patterns pressure scores for land use classes as described in tables 5–8.

Indicator / fieldwork resource relevance	Information required	Information source	Data description
S12, fieldwork resource	Local hydrology disturbance modifier code	See 'Mapped Wetland' above	
All indicators, fieldwork resource	Mapped wetland	**Wetland data – wetland areas – Queensland** available from Queensland Open Data Portal <https://data.qld.gov.au/>	Spatial dataset of wetland boundaries. Wetlands are classified according to a range of criteria including type of ecological system (e.g. lacustrine, palustrine), type of local hydrology modifications (e.g. no modification, bunded) and whether the wetland is on a floodplain (Queensland Environmental Protection Agency, 2005, Queensland Department of Environment and Science 2019b, Queensland Herbarium 2019).
All indicators, fieldwork resource	Most recent aerial image	A range of Queensland imagery services are available through the spatial imagery subscription plan or publicly via Queensland Open Data Portal <https://data.qld.gov.au/>	Recent aerial imagery base maps across Queensland (Queensland Department of Resources 2021e).
P14, P20	National forest and sparse woody vegetation (NFSWV) (See p.9 for data prep required)	**National Forest and Sparse Woody Vegetation Data** (most recent) available from Australian Open Data website <https://data.gov.au/>	Spatial raster dataset of woody vegetation classified into forest, sparse woody and non–woody land cover (Department of Industry, Science, Energy and Resources 2019).
P10	P10 GBR sediment rates table	**P10 GBR sediment rates table** – internal dataset (pre-processed geodatabase table)	Tabular dataset prepared for the desktop methods P10 indicator. Contains the anthropogenic fine sediment values (kg/ha/yr) for each sub-catchment and land use type based on Great Barrier Reef catchment loads modelling program data prepared for the Reef Water Quality Report Card 2017 and 2018 (Queensland Department of Natural Resources and Mines 2016, Australian and Queensland governments 2019).
P10	P10 land use table	**P10 land use table** – internal dataset	Tabular dataset prepared for the desktop methods P10 indicator, which reclassifies the land use ALUM codes to the land use classes used in modelling for the Reef Water Quality Report Card 2017 and 2018 (Australian and Queensland governments 2019).
P2, P14, P20, P21, S14, fieldwork resource	Pre-clearing regional ecosystems (See p.9 for data preparation required)	**Biodiversity status of pre-clearing regional ecosystems – Queensland** (most recent) available from Queensland Open Data Portal <https://data.qld.gov.au/>	Queensland-wide spatial dataset of vegetation communities that were present before clearing (roughly equates to 'pre-European') (Queensland Department of Environment and Science 2021b).
P2, P14, P20, P21, S14,	Pre-clearing regional ecosystems with expected FPC range and cover type	See p.9 for data preparation required	

Indicator / fieldwork resource relevance	Information required	Information source	Data description
P1, P3, P4, P10, P16	Queensland foundation data*	**Queensland foundation data** web map service available via Queensland Open Data Portal <https://data.qld.gov.au/>	Feature service showing whole of state datasets (Queensland Department of Resources 2021d). It includes lot boundaries. This mapping is not part of the source data for indicator score calculations but may be used as a reference to verify source data.
P1, P3, P4, P10, P16, S16	Queensland topographic*	**Queensland basemap topographic** web map service available via Queensland Open Data Portal <https://data.qld.gov.au/>	Traditional topographic style map (Queensland Department of Resources 2020). This mapping is not part of the source data for indicator score calculations but may be used as a reference to verify source data.
S16, fieldwork resource	Railways	**Transport features – Queensland series – rail network** available from Queensland Open Data Portal <https://data.qld.gov.au/>	Spatial dataset of railway centrelines of Queensland. Attribution includes status (e.g. operational) and gauge (e.g. narrow: 1067mm, light railway) (Queensland Department of Resources 2019b).
P2, S14	Regional ecosystem FPC and cover type table (See p.9 for data preparation required)	**Regional ecosystem structural formation classes table** – internal dataset (a pre-processed geodatabase table based on published regional ecosystem structural formation classes)	Tabular dataset of cover types and expected ranges of woody FPC associated with RE structural formation categories. FPC values for woody structural formation classes are from projective foliage values in Table 28 of *Methodology for Survey and Spatial dataset of Regional Ecosystems and Vegetation Communities in Queensland* (Neldner et al., 2020). (Projective foliage cover is the same as FPC.) All non-woody structural formation classes have been given a woody FPC value of '<10%'. Structural formation types have been categorised as woody or non-woody. Woody cover type includes woody structural formation classes with projective foliage cover of 10% or over. Non-woody cover includes all non-woody structural formation classes and also includes woody structural formation classes with projective foliage cover under 10%.
P2, P14, P20, P21, S14, fieldwork resource	Regional ecosystems descriptions database (REDD) (See p.9 for data preparation required)	**Regional ecosystems descriptions database (REDD) with sub-unit information** – internal dataset (a pre-processed extract of the publicly available REDD database)	Tabular dataset of descriptions to accompany the regional ecosystem spatial dataset. Information includes RE code with sub-unit, vegetation description, structural formation category and wetland classification (Queensland Herbarium 2018).
S15	Reservoirs	**Hydrographic features – Queensland series – Reservoirs** available from Queensland Open Data Portal <https://data.qld.gov.au/>	Spatial dataset of man-made water bodies used for drinking, irrigation or watering of stock (greater than 625 sq metres at full supply level) within Queensland (Queensland Department of Resources 2021c).
S16, fieldwork resource	Roads and tracks	**Baseline roads and tracks – Queensland** available from Queensland Open Data Portal <https://data.qld.gov.au/>	Spatial dataset of road and track centrelines of Queensland (Queensland Department of Resources 2021a) with road type classification as described in *Queensland Digital Road Network Standard* (Queensland Department of Natural Resources, Mines and Energy 2018).

Indicator / fieldwork resource relevance	Information required	Information source	Data description
P16	Specified surface water management areas and regulated river reaches areas	**Specified surface water management areas and regulated river reaches areas in GBR catchments** – internal dataset	Spatial dataset prepared by Wetland Science, Queensland Department of Environment and Science for the desktop methods P16 indicator to identify the extent of floodplain areas potentially impacted by changes in flow in the Great Barrier Reef catchments (Queensland Department of Science, Information Technology, Innovation and the Arts 2014).
Fieldwork resource	Watercourse lines	**Watercourse lines** available from Queensland Open Data Portal <https://data.qld.gov.au/>	Queensland-wide spatial dataset of watercourses, which are flow directed. Other feature types include connectors (centrelines through waterbodies), culverts, DEM connector (connects watercourses across land where there is no defined watercourse) (Queensland Department of Resources 2021f).
S15	Wetland areas	See 'Mapped Wetland' above	

* Not required for indicator score calculations but useful as a reference when checking source data.

Coordinate system

For the purpose of calculating areas, all data used for scoring indicators are transformed to Albers Equal Area map projection customised for the program area, i.e., Great Barrier Reef catchments area. This allows areas to carry their correct relative weighting, regardless of location.

Creating area of interest layers

Wetland Tracker uses three buffer zones to define the areas of interest (AOIs) for its indicators. These are 200 metres, 1 kilometre and 5 kilometres. These areas are delineated in relation to mapped wetland boundaries derived from the Queensland Wetland dataset. For example, the 200 m buffer is the area within 200 m of a wetland's mapped boundary. This area encompasses but does not include the wetland itself, although for some Wetland Tracker indicators the area of interest might be the mapped wetland plus its 200 metres buffer.

Create the area of interest (AOI) layers listed in the table below using a GIS application.

Table 3 How to generate area of interest layers for indicators

Indicator relevance	AOI	How to generate
P5, S12, S13	 wetland only	N/A. Use the mapped wetland from the wetland areas dataset.
P2, S14	 200 m buffer only	Buffer the mapped wetland by 200 m and exclude the wetland polygon from the buffer.
P5	 200 m buffer and wetland combined	Buffer the mapped wetland by 1 km and include the wetland polygon with the buffer (wetland and buffer dissolved).
P14, S15	 1 km buffer only	Buffer the mapped wetland by 1 km and exclude the wetland polygon from the buffer.
P1, P3, P4, P10, P16, S16	 1 km buffer and wetland combined	Buffer the mapped wetland by 1 km and include the wetland polygon with the buffer (wetland and buffer dissolved).
P20, P21,	 5 km buffer and wetland combined	Buffer the mapped wetland by 5 km and include the wetland polygon with the buffer (wetland and buffer dissolved).

Converting raster source data to polygon format

Foliage projective cover (FPC), national forest and sparse woody vegetation (NFSWV) and connectivity index datasets are used for the vegetation-related indicators (P2, P14, P20, S14) and the connectivity indicator (S13). These datasets are provided in raster format but should be converted to vector format in preparation for overlay analysis with other vector polygon layers. For the purposes of converting from raster to polygon, an appropriate output extent should be defined based on the largest AOI of the indicators using the specific dataset. Store the output polygon layers until needed for input to specific indicators.

The following steps outline the procedures if using Esri ArcGIS Pro software with Spatial Analyst extension:

Step 1: create output extent layer.

Generate an appropriate temporary output extent layer for each of the three raster layers (FPC, NFSWV and connectivity index) in preparation for step 2.

a. Use the 'Buffer' tool to generate an output extent for the FPC dataset. Specify the mapped wetland as the input and select the full buffer side option, i.e., combine and dissolve the input wetland polygon and buffer. Specify a buffer distance of 1050m*.
b. Repeat step 1(a) to generate an output extent for the NFSWV dataset except specify a buffer distance of 5050m*.
c. Repeat step 1(a) to generate an output extent for the Connectivity index dataset except specify a buffer distance of 50m.

* The buffer distance should be slightly greater than the relevant indicator AOI to allow for inclusion of all pixels along the boundaries. (The polygons will later be clipped to precise AOI extents).

Step 2: make a raster layer limited to the appropriate extent.

Make a temporary raster layer for each input raster layer limited to the appropriate extent as generated in step 1. This will create a raster layer file that will be saved in temporary storage.

a. Use the 'Make Raster layer' tool to specify the input and the relevant output extent layer (see step 1) as the 'Envelope'.

Step 3: convert to polygon format.

Convert temporary raster to polygon format for each of the three raster layers.

a. Use the 'Raster to Polygon' tool <Conversion Tools – From Raster – Raster to Polygon> to specify the input as the layer created step 2 and select the non-simplified option so that polygons will conform exactly to the input raster's cell edges. The output will be a feature class or shapefile (depending on whether geodatabases are used).

Preparing pre-clearing RE data with expected FPC range and cover type

Scoring the vegetation-related indicators (P2, P14, P20, S14) needs information about expected woody FPC[2] ranges and cover form types for pre-clearing regional ecosystems (REs)[3]. In RE mapping there can be multiple RE codes attributed to a single polygon where the high spatial diversity of vegetation communities is beyond the scale of mapping. Five RE code fields (RE1 to RE5) are included in the attribute table. The percentage of the area of the polygon occupied by each RE code is recorded in five associated percentage fields (PC1 to PC5). The FPC and cover type information needs to be joined to each RE attribute field in the pre-clearing RE spatial dataset so that the overall lower and upper expected woody FPC range can be determined for each polygon. The resulting pre-clearing RE spatial dataset will contain the following attribute fields:

Fields	Description
RE	Combined RE codes attributed to a polygon
RE1, RE2, RE3, RE4, RE5	Individual RE codes attributed to a polygon (up to five RE codes may be attributed to a polygon)

[2] 'FPC' (foliage projective cover) is a metric that is used in remote sensing as a direct estimate of the foliage on an area of vegetation (typically 30 square meters) when viewed from above. Herein, FPC refers to the foliage of woody plants only and is expressed as a percentage where: 0% FPC implies there is no woody plant foliage cover; and 100% FPC implies total or complete woody plant foliage cover. (Department of Environment and Science, 2018).

[3] Pre-clearing regional ecosystem is defined as regional ecosystem present before clearing. While this roughly equates to 'pre-European', the Queensland Herbarium uses the term 'pre-clearing' because ecosystem boundaries are dynamic and no consistent imagery for the state exists prior to the early 1960s so therefore it is difficult to map 'pre-European' extent with any certainty.

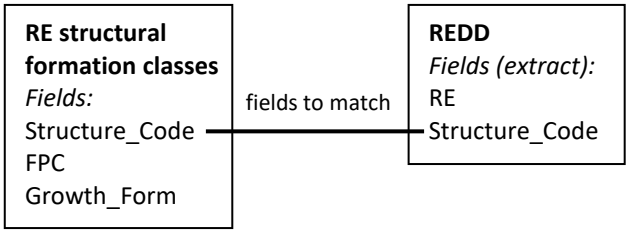
Fields	Description
PC1, PC2, PC3, PC4, PC5	The percentage of area of polygon occupied by each RE (corresponding to RE1 to RE5 fields)
RE1_FPC, RE2_FPC, RE3_FPC, RE4_FPC, RE5_FPC	Expected woody FPC range of each RE attributed to a polygon
RE1_Cover_Type, RE2_Cover_Type, RE3_Cover_Type, RE4_Cover_Type, RE5_Cover_Type	Cover type, i.e., woody or non-woody, of each RE attributed to a polygon
RE_FPC_Range	Overall expected woody FPC range attributed to a polygon (determined from the lowest and highest FPC range of all REs attributed to a polygon)
Dominant_ Cover_Type	Dominant RE cover type, i.e., historically woody or historically non-woody, attributed to a polygon (determined from percentage of area of polygon occupied by each RE cover type)

The following steps detail the procedure.

Step 1: Prepare FPC and cover type data.

a. Convert the REDD spreadsheet to a format compatible with GIS software, e.g. dbf or geodatabase table.

b. Join the FPC and cover type fields from the RE structural formation classes table to the REDD table using the structure code as join field.
Table relationship:



Step 2: Clip pre-clearing RE spatial dataset.

a. Clip the pre-clearing RE spatial dataset to the 5 km buffer and wetland combined AOI (see p. 5 for data preparation required).

Step 3: Add FPC and cover type data to the clipped pre-clearing RE spatial dataset.

a. Join the FPC and cover type fields from the joined REDD table (resulting from step 1) to each RE field within the pre-clear RE dataset (i.e., RE1 to RE2) using the structure code as join field. Rename the generic FPC and cover type fields to include the RE field name, e.g. rename FPC to RE1_FPC, cover_type to RE1_cover_type etc.

Table relationship:

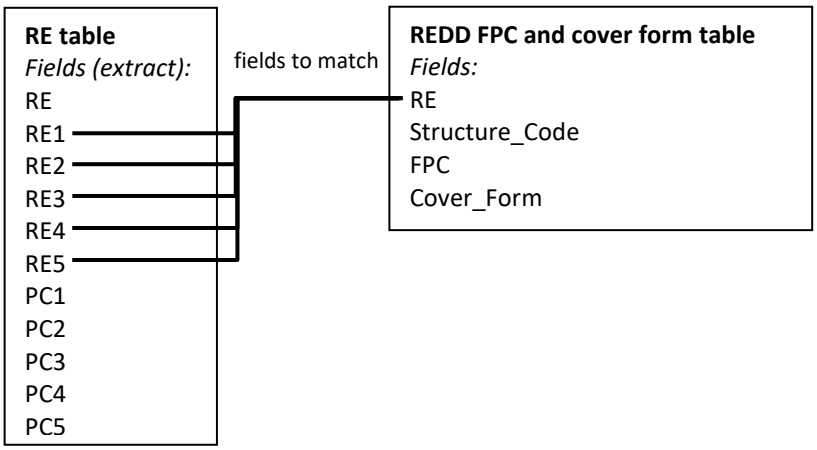


Table extract example showing RE and FPC & cover type before and after join:

RE

RE1	RE2	RE3	RE4	RE5
12.3.3	12.3.8	12.3.7		

FPC & cover type

RE	FPC	Cover_type
12.3.3	10–30%	woody
12.3.8	<10%	non-woody
12.3.7	<10%	non-woody

RE with FPC and cover type joined

RE1	RE2	RE3	RE4	RE5	RE1_ FPC	RE1_ cover _type	RE2_ _FPC	RE2_ cover _type	RE3_ FPC	RE3_ cover _type	RE4_ _FPC	RE5_ cover _type	RE5_ _FPC	RE5_ cover _type
12.3.3	12.3.8	12.3.7			10–30%	woody	<10%	non-woody	<10%	non-woody				

b. Add fields containing the lower and upper FPC range values from all REs within the polygon based on the joined REDD table. For example, if RE1 has FPC range of 10–30% but RE2 to RE5 have 30–70%, this gives a lower FPC value of 10% and upper FPC value of 70%.

Table extract example showing FPC range value calculated for a heterogeneous RE polygon:

RE1_FPC	RE2__FPC	RE3_FPC	RE4__FPC	RE5_FPC	RE_FPC_range
10–30%	<10%	<10%			0–30%

c. Add a field containing historic dominant cover type based on the cover type with the highest percentage within each polygon.

Table extract example showing dominant cover type calculated based on highest RE percentage (PC fields) for a heterogeneous RE polygon:

RE1_ cover_type	RE2_ cover_type	RE3_ cover_type	RE4_ cover_type	RE5_ cover_type	PC1	PC2	PC3	PC4	PC5	dominant_ cover_type
woody	non-woody	non-woody			40	30	30			historically non-woody

Preparing fieldwork resources

Checklist

The following desktop tasks should be completed prior to the field assessment:

- ☐ Historic imagery map
- ☐ RE long descriptions table
- ☐ Field-verified indicator scores and maps
  - ☐ Land use map
  - ☐ FPC map
  - ☐ Native, cleared or exotic vegetation map
  - ☐ Desktop scores for indicators that require field verification
- ☐ *A3 field map* for disturbance class mapping

Instructions for completing these tasks are provided below. Instructions for the field assessment are provided in the *Wetland Tracker Field Methods Guide*.

Prepare historic aerial imagery map

Use a GIS application to create a map with the oldest available aerial image. Refer to the earlier section on data requirements for information sources. Include the wetland at a scale between the 1 km and 200 m buffers which provides the best image quality. Insert image date. Discretionary additions to this photographic set include images that were taken before and after significant events such as clearing, draining, damming, other hydrological disturbance and flooding.

Prepare a table of REs and long descriptions

Use a GIS application to prepare a table listing four columns of:

1. All pre-clearing RE codes within the wetland and the 200 m buffer
2. All current remnant RE codes within the wetland and the 200 m buffer
3. All RE codes attributed to the mapped wetland
4. RE long descriptions

The lists of pre-clearing and current remnant REs can be made in a GIS application by clipping to the extent of 200 m buffer and wetland combined. Include all RE codes listed in the five RE code fields (RE1 to RE5) in the pre-clearing and current remnant RE attribute tables. Also include all RE codes listed in the wetland RE list fields of the mapped wetland attribute table. Join the RE long descriptions from REDD to the list using the RE code as the matching field. Export the information from GIS and save the table in a PDF document.

Prepare field-verified indicator scores and maps

While some desktop indicators are scored independent of the field assessment, some require ground-truthing. The following resources must be prepared prior to the field assessment.

- **Maps** produced during the desktop assessment process that require field ground-truthing:
  - *Land use map* (required for desktop indicators P1, P3, P4, P10 and P16) prepared as per pp. 21–22
  - *FPC map* and native, cleared or exotic map (required for P2 and S14 indicators), both prepared as per pp. 28–29

- **Desktop assessment scores and information** for indicators that require field validation:
  - P2 score prepared as per pp. 27–28
  - P5 score prepared as per p. 35
  - S12 score and hydromod code prepared as per p. 49
  - S14 score prepared as per p. 52
- **Wetland area and buffer area**, extracted from the GIS dataset (information required for several field indicators)

Refer to the later section on scoring methods for individual indicators to complete the map making and desktop assessment tasks.

Prepare A3 field map for disturbance class mapping

Use a GIS application to create an *A3 field map* for each wetland to be assessed. Refer to the information sources table in the earlier section on requirements and preparation. The map should include the following elements:

1. the most current aerial image of the wetland, including image date and source
2. the mapped wetland boundary
3. 200 m buffer boundary
4. watercourse lines including watercourses, centrelines through waterbodies (connectors), assumed drainage lines (DEM connector) and culverts, displayed in different colours
5. 10 m contours
6. outlines of the pre-clearing Regional Ecosystem (RE) polygons with labels
7. non-remnant REs, showing RE = ‘non-rem’ in black 10% hatching and the following categories in different coloured hatching: 'water', 'canal', ‘plantations’.
8. graticules to assist with determination of field position
9. if surveyed previously, include labelled waypoints for plots and other significant features (if relevant) along with the previous traverse track, in a contrasting colour
10. any notes about specific features warranting further investigation relating to P5 septic systems and S12 hydrological modifications (if relevant) and a checkbox for ticking when field investigation is completed.

Save the map as a PDF file with 300 dpi resolution. Optionally, save the file with georeferenced information. This will enable location tracking on a GPS-enabled tablet or phone with a PDF map app. (If using ArcGIS Pro, this option is located in the Export Layout dialog under Export Options.)

Export the aerial photo, wetland and 200 m buffer boundaries in preparation for use on GPS devices to assist in navigating the assessment area in the field.

Completing the desktop assessment

General information

There are 15 desktop indicators in total, with each identified by a unique name and pressure or state indicator number. Indicator numbers prefixed with a 'P' are pressure indicators, used to assess anthropogenic pressure on wetlands, while state indicators are prefixed 'S' and are used to assess the state of wetland environmental values.

The methods for scoring individual indicators are provided in later sections of this document. Detailed steps are broken down to identify data processing steps, which can be scripted (e.g. using Python within ArcGIS Pro), and steps that require manual processing, such visual data verification.

Recording desktop assessment score information

To complete the desktop indicator scoring, the information in the following table should be recorded in the GIS-enabled data repository.

Table 4 Desktop assessment scoring information to be recorded

Information to be recorded	Description
Assessment metadata	Date, wetland ID number and survey number.
Indicator code	Pressure or state indicator number prefixed with 'P' for pressure or 'S' for state.
Score class	Indicators scores ranging from a scale of 1 to 5, with lower numbers representing a more naturally functioning or more intact wetland (see the section on scoring methods for individual indicators).
Confidence	Confidence ratings in the assessment score class ranging from 1 to 4 with a rating of 1 reflecting the highest level of confidence and a rating of 4 the lowest (see the section on rating confidence in indicator scores).
Evidence	Evidence to support the score class and confidence ratings given (see the sections on scoring methods for individual indicators and confidence ratings).
Data source metadata	Name, author/source, version (if applicable) and date for all source datasets and the most recent and/or clearest aerial imagery used for data verification.
QA/QC	Date checked, QA flags and notes on issues that need to be addressed.

Correcting mapping and scores after field verification

If map errors have been detected during the field assessment:

- Make the **mapping corrections** if required for any of the following:
  - *FPC map* (required for P2 and S14 indicators)
  - *Native, cleared or exotic map* (required for P2 and S14 indicators)
  - *Land use map* (required for indicators P1, P3, P4, P10 and P16)
- **Recalculate the scores** for the relevant indicators following the methods.

Refer to the section on scoring methods for individual indicators to complete the tasks.

Scoring methods for individual indicators

P1: Land use associated with the introduction or perpetuation of pest species

Score class	Description	Desktop information
1	0 – 1 (total pest pressure score)	▪ 1 km buffer and wetland combined ▪ Land use mapping ▪ Land use pressures table ▪ Most recent aerial image
2	> 1 – 2	
3	> 2 – 3	
4	> 3 – 4	
5	> 4 – 5	

Area of interest (AOI):  1 km buffer and wetland combined

Areas classed as rivers, marsh/wetland or estuary/coastal waters in the land use mapping are not included in the calculations.

Method overview: Determine the proportions of land use classes* within the AOI and multiply each by their associated land use pest pressure values from the land use pressures table (also described in Table 5) to calculate area-weighted pressure values. Sum the area-weighted pressure values to calculate the total score.
* Land use classes are based on Australian Land Use and Management (ALUM) classification V8 (ABARES 2016).

Evidence: Retain the AOI land use spatial dataset, including details of any corrections following desktop and field checks. Save a scanned copy of the field map with field annotations. Retain a summary table of the land use breakdown with area-weighted pressure scores. Record the calculated total pressure value used for allocating the score class as a summary of the evidence.

Detailed methods:

Step 1: Data processing – prepare the land use dataset (pre field assessment)

a. Clip the land use data:
Using a GIS application, clip the land use data to the AOI.

b. Add a land use description attribute, which will later be used for labelling:
Add a new field in the AOI land use dataset for land use description. For residential ALUM classes insert the description from the 'Tertiary' field and for all other ALUM classes insert the description from the 'Secondary' field.

Step 2: Check data accuracy and correct any errors (pre field assessment)

a. View and compare land use mapping with aerial imagery and other spatial data:
Display the land use polygons and label/symbolise using the land use description field. Visually verify against the most recent aerial imagery. The class definitions are described in Australian Land use and Management Classification (ABARES 2016). Checking against Queensland basemap topographic and foundation data may also assist in detecting or verifying any inaccuracies. Use Google Street View where possible to help verify a potential land use update. Remain aware of the currency of each dataset by referring to metadata.

b. Verify that specific rural residential land use types have been identified:
Rural residential areas are not always classed as the more specific ALUM codes 5.4.2 'Rural residential without agriculture' and 5.4.3 'Rural residential with agriculture' but may instead be classed as the more general ALUM code 5.4.0 'Residential and farm infrastructure'. Therefore, it is important to interrogate the data to identify any rural residential areas are classed in the specific ALUM code 5.4.2 or 5.4.3.

c. Note areas that warrant further investigation if feasible during the field assessment, including details on the specific question and location.

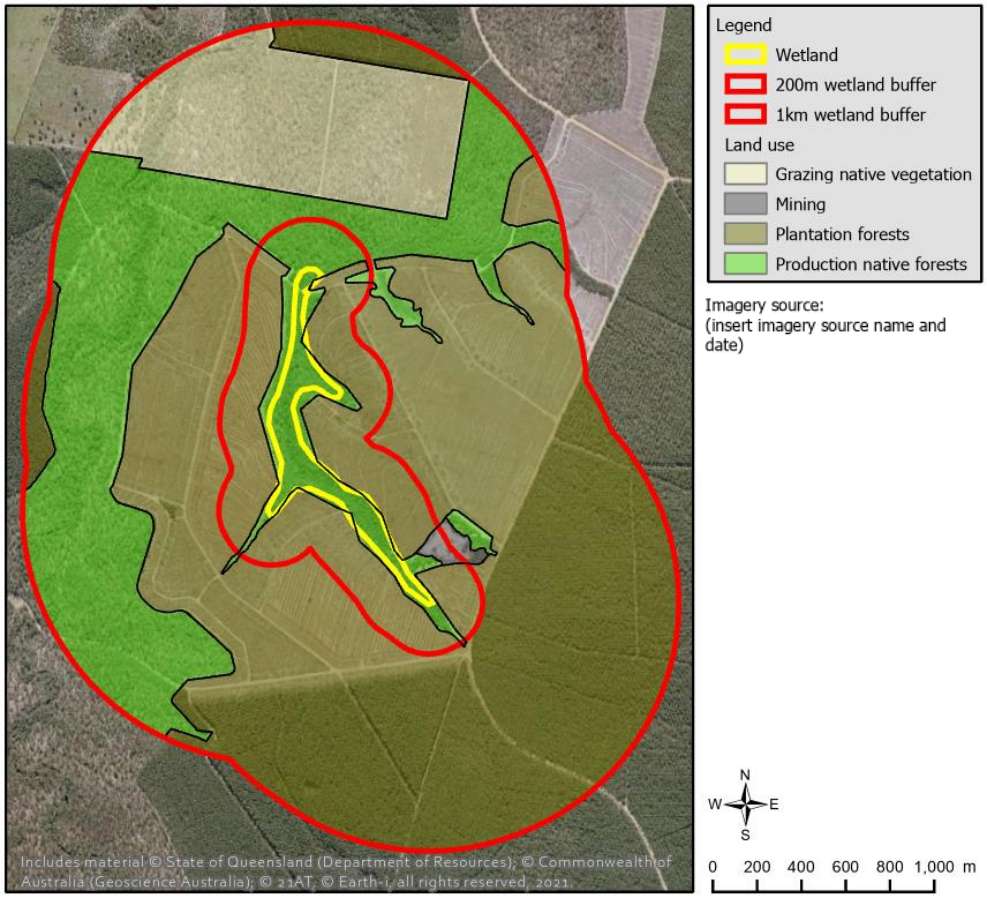
d. Update the AOI land use dataset:
If any land use mapping needs to be corrected, update the AOI land use dataset boundaries and/or ALUM Code and land use description fields. To update land use classes, add a new correction evidence field and detail evidence that supports the correction, including information source and date. Note if boundary has changed and describe location.

Step 3: Prepare a field map (pre field assessment)

a. Prepare a field map of land use classes and label using land use description field for ground truthing during the field assessment. Show outlines of the mapped wetland, 200 m buffer (i.e., field assessment area of interest) and 1km buffer overlaid on the most recent aerial imagery, including a legend to identify these features and date of imagery. Include any notes regarding areas that warrant further investigation (from step 2c) and a checkbox for ticking when ground truthing is completed. Export as a PDF file.

Example:

Land use map



Step 4: Correct any errors detected from ground truthing (post field assessment)

> **Note when editing polygons:** when creating a new boundary, split the polygon that already exists within the dataset. It is important that you do not create a new polygon over an existing one within the same dataset.

a. If any land use mapping errors were detected from ground truthing, update the AOI land use dataset boundaries and/or ALUM code and land use description fields. To update land use classes, add a new correction evidence field and detail evidence supporting the correction, including field date.

b. If areas warranted further investigation but were unable to be verified, reduce the confidence rating and note details in the confidence evidence. Refer to later section on rating confidence in indicator scores.

Step 5: Data processing– calculate proportions occupied by each land use (post field assessment)

An example of the calculations is given below the detailed instructions.

a. Sum the area of each land use class:
Use a summary statistics tool to create a land use summary table with the summed area of each the ALUM codes in the AOI.

b. Calculate total area:
Sum the total area, excluding records where ALUM code includes 6.3.0–6.3.3 (marsh/wetland), 6.5.0–6.5.4 (marsh/wetland) or 6.6.0–6.6.3 (estuary/coastal waters).

c. Calculate the land use class proportions:
Add a α of AOI (A) field to the land use summary table and calculate for each land use class by dividing the area field by the total area (calculated in step 5b).

Step 6: Data processing– calculate the total pest pressure and allocate score class (post field assessment)

a. Provide the pest pressure values for each land use class:
Join P1 pressure (P) field from land use pressures table to the land use summary table (created in step 5a) by matching the ALUM code fields.

b. Exclude rivers, marsh/wetland and estuary/coastal waters land use classes:
Exclude records from the land use summary table where ALUM code includes 6.3.0–6.3.3 (marsh/wetland), 6.5.0–6.5.4 (marsh/wetland) or 6.6.0–6.6.3 (estuary/coastal waters).

c. Multiply the proportion by the pressure value:
Add a P x A field to the land use summary table and calculate by multiplying the proportion figure (A) by the pest pressure value (P).

d. Calculate the total pest pressure:
Sum the numbers in the P x A field of the land use summary table.

e. Allocate a score class:
Match the total pest pressure to the appropriate score class range.

Example of score class calculation:

	Land use	**Area (ha)**	**P1 Pest Pressure (P)***	**α of AOI (A)**	**P x A**
2.1.0	Grazing native vegetation	75.81	4	0.11	0.44
2.2.0	Production native forests	176.21	4	0.26	1.04
3.1.2	Plantation forests	420.34	3	0.62	1.86
5.8.2	Mining	2.86	2	0.00	0.00
Total		**675.22**			**3.34 (score class = 4)**

* Pest Pressure values from land use pressure table (also described in Table 5).

Table 5 Pest pressure: Land use pressure characterisation (DSITIA 2015), ALUM class land use classes (ABARES 2016)

Hazard assessment land use group	Land use description	ALUM class name	ALUM class code	Pest pressure (P)	α of AOI (A)	P x A
Conservation and natural environments	Land designated for nature conservation and other minimal uses (e.g. national parks, habitat/species protection areas, managed indigenous uses and defence land-natural areas).	Nature conservation	1.1.0–1.1.7	Mod (3)		
		Managed resource protection	1.2.0–1.2.5			
		Other minimal use	1.3.0–1.3.4			
Extensive grazing	Grazing by livestock on native vegetation where there has been little/no deliberate pasture modification.	Grazing native vegetation	2.1.0	High (4)		
Intensively managed grazing	Grazing on significantly and actively modified pastures with or without irrigation (e.g. dairy farms and fodder crops)	Grazing modified pastures	3.2.0–3.2.5	High (4)		
		Grazing irrigated modified pastures	4.2.0–4.2.4			
Production from natural forests	Wood (sawlogs and pulpwood) and other forest production (e.g. firewood, fence posts and wildflowers) from natural forests.	Production forestry	2.2.0–2.2.2	High (4)		
Plantation forestry	Plantations of trees or shrubs, for production or resource protection, established on cleared and managed land.	Plantation forestry	3.1.0–3.1.4	Mod (3)		
		Irrigated plantation forestry	4.1.0–4.1.4			
Dry land cropping and horticulture	Cropping (e.g. sugar cane, cereals, cotton, etc.), perennial (e.g. tree fruits/nuts, citrus, grapes, perennial flowers/vegetables, etc.) and seasonal horticulture (e.g. seasonal vegetable fruits/flowers, etc.) on non-irrigated land. Involves a relatively high degree of nutrient, weed and moisture control.	Cropping (dry land)	3.3.0–3.3.8	Minor (2)		
		Perennial horticulture	3.4.0–3.4.9			
		Seasonal horticulture	3.5.0–3.5.4			
		Land in transition	3.6.0–3.6.5			
Irrigated cropping and horticulture	Cropping (e.g. sugar cane, cereals, cotton, pulses, rice, etc.), perennial (e.g. tree fruits/nuts, citrus, grapes, perennial flowers/vegetables, etc.), seasonal (e.g. seasonal vegetable fruits/flowers, etc.) and intensive horticulture (glasshouses, shade houses, etc.) on irrigated land. Involves a relatively high degree of nutrient, weed and moisture control and where water is applied to promote additional growth.	Cropping (irrigated)	4.3.0–4.3.9	Minor (2)		
		Irrigated perennial horticulture	4.4.0–4.4.9			
		Irrigated seasonal horticulture	4.5.0–4.5.5			
		Irrigated land in transition	4.6.0–4.6.5			
		Intensive horticulture	5.1.0–5.1.4			
Aquaculture	Aquaculture installations for cultivating fish and crustaceans (lobsters, yabbies, etc.), molluscs (oysters and mussels) or crocodiles.	Aquaculture	5.2.6	High (4)		
Intensive animal production	Intensive animal production or holding yards (including dairy sheds, cattle/sheep feedlots, piggeries, poultry farms, horse studs, etc.).	Intensive animal production (excluding aquaculture)	5.2.0, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.7, 5.2.8, 5.2.9, 5.6.9	Mod (3)		
Manufacturing and industrial	Manufacturing and industrial (including general/food production factories, industrial complexes, bulk grain storage, oil refineries, sawmills, abattoirs, etc.).	Manufacturing and industrial	5.3.0–5.3.8	Very minor (1)		
Waste treatment and disposal	Waste treatment and disposal (includes sewage treatment infrastructure, landfill, waste transfer and incinerators).	Waste treatment and disposal	5.9.0–5.9.5	Very minor (1)		
Urban	Urban/rural residential (houses, flats, domestic gardens and hobby farms), farm infrastructure (farm buildings, sheds, etc.) commercial and public services (shops, schools, parks, sportsgrounds, etc.) and utilities (e.g. power/ water/ gas infrastructure).	Residential and farm infrastructure	5.4.0–5.4.5	Very high (5)		
		Services	5.5.0–5.5.5			
		Utilities	5.6.0–5.6.6			
Transport	Transport (roads, railways, airports and ports) and communications infrastructure (radar stations, beacons, etc.)	Transport and communication	5.7.0–5.7.5	Mod (3)		
Mining	Mines (open cut and deep shaft mines), quarries (for extraction of stone, gravel, clay, sand, soil, etc.) and tailings (dumps and dams for storage and treatment of mining/quarrying waste) and disused mines.	Mining	5.8.0–5.8.4	Minor (2)		
Water (artificial)	Reservoir/dams (reservoirs, farm-dams evaporation basins) and artificial channels/aqueducts (for the supply, distribution or removal of water for irrigation, land reclamation or drainage).	Reservoir/dam	6.2.0–6.2.4	Mod (3)		
		Channel/aqueduct	6.4.0–6.4.3			
Total pest pressure = sum of last column						

P2: Modification of native vegetation in the 200 m buffer

<table>
<tr><th colspan="6">Measure and score class</th><th>Desktop information</th></tr>
<tr><td colspan="6">% area of the 200 m buffer, excluding the mapped wetland, with cleared, regrowth vegetation with an FPC* outside the range expected for the pre-clearing RE type† or exotic.</td><td rowspan="6">▪ 200 m buffer only
▪ Pre-clearing regional ecosystems (RE) with expected FPC ranges
▪ Current remnant REs
▪ Current foliage projective cover (FPC)
▪ Exotic vegetation (if captured from previous assessments)
▪ Most recent aerial image</td></tr>
<tr><td rowspan="5">Lineal % of mapped wetland boundary that adjoins buffer vegetation mapped as: cleared, regrowth with FPC* outside range expected for pre-clearing RE type, or exotic.</td><td>Lineal %</td><td colspan="4">% vegetation cleared in buffer</td></tr>
<tr><td></td><td><20%</td><td>20 – 50%</td><td>>50 – 90%</td><td>>90%</td></tr>
<tr><td><20%</td><td>1</td><td>1</td><td>2</td><td>3</td></tr>
<tr><td>20–50%</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>>50–90%</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>>90%</td><td>3</td><td>4</td><td>5</td><td>5</td></tr>
<tr><td colspan="7">Area of interest (AOI): 200 m buffer only, excluding ocean and estuaries</td></tr>
</table>

Method overview: Determine the percentage modification of native vegetation within: the whole AOI (area %); and along the buffer side of the mapped wetland (lineal %). Match the percentages to the appropriate score class range above.

This method uses the lower and upper expected woody FPC range values for the structural formation type of the pre-clearing RE and compares this with the current FPC data.

P2 modification of native vegetation includes areas that are:

- **Historically woody but current FPC* is outside the expected historic range**, i.e., woody in the pre-clearing† RE mapping and the latest FPC value is outside the FPC range for the structural formation type of the pre-clearing RE
- **Historically non-woody but currently woody with FPC > 10%**, i.e., non-woody in the pre-clearing RE mapping and current FPC value ≥ 10% indicating conversion to woody
- **Areas dominated by exotic vegetation or bare due to human activity**, including urban built-up areas, horticulture, plantation, cropping, modified pasture, exotic weed infestations (identified from field surveys), cultivated areas, mine sites.

The desktop score for this indicator requires field verification.

***** 'FPC' (foliage projective cover) is a metric that is used in remote sensing as a direct estimate of the foliage on vegetation when viewed from above. Herein, FPC refers to the foliage of woody plants†† only and is expressed as a percentage where: 0% FPC implies there is no woody plant foliage cover; and 100% FPC implies total or complete woody plant foliage cover. (Queensland Department of Environment and Science, 2018).

† Pre-clearing regional ecosystem is defined as regional ecosystem present before clearing. While this roughly equates to 'pre-European', the Queensland Herbarium uses the term 'pre-clearing' because ecosystem boundaries are dynamic and no consistent imagery for the state exists prior to the early 1960s so therefore it is difficult to map 'pre-European' extent with any certainty.

†† A Woody plant has wood as its primary structural tissue. Woody plants may be trees, shrubs or lianas and are usually perennial.

Evidence: Retain the prepared AOI spatial datasets: (1) pre-clearing RE with FPC ranges; (2) current FPC; (3) native cleared or exotic vegetation; and (4) P2 status, including updates and details of any corrections following desktop and field checks. After the field assessment save a scanned copy of annotated field maps: (1) current FPC classes; and (2) native, cleared or exotic vegetation. Retain a table of total P2 modification of vegetation area and AOI area. Record the lineal and area percentages for P2 used for allocating the score class as a summary of the evidence.

Detailed methods:
FPC spatial dataset and pre-clearing RE data must be prepared as per instructions on pages 13 to 15.

Step 1: Data processing – prepare the datasets for verification (pre field assessment)

a. Extract pre-clearing RE and current FPC data to the extent of the AOI:
   i. Clip pre-clearing RE and current FPC polygon dataset to the 200 m buffer only
   ii. Filter the current RE dataset where RE includes 'ocean', 'estuary', 'shallow' and erase these areas from the clipped RE and current FPC datasets.

b. Classify FPC values into ranges:
   Add a field to the AOI FPC dataset to classify FPC values to ranges: > 70%; >30–70%; 10–30%; and <10% FPC, e.g. if the polygon has a gridcode attribute (FPC) value of 5, give the FPC range field a value of <10%.

c. Dissolve the current FPC dataset to aggregate features based on FPC ranges.

d. Intersect the pre-clearing RE and FPC datasets to create the P2/S14 status dataset (intersect tool in ArcGIS).

e. Add a field to the intersected dataset (output from the previous step) and classify vegetation as 'native, cleared or exotic vegetation' with the following criteria: (Note: exotic vegetation will be identified in a later step.)
   - cleared (historically woody) – expected pre-clearing RE FPC ≥ 10% and current FPC < 10%
   - native woody – current FPC > 10%
   - native non-woody – expected pre-clearing RE FPC < 10% and current FPC < 10%
   - native woody / non-woody mix – expected pre-clearing RE includes < 10% FPC and > 10% FPC

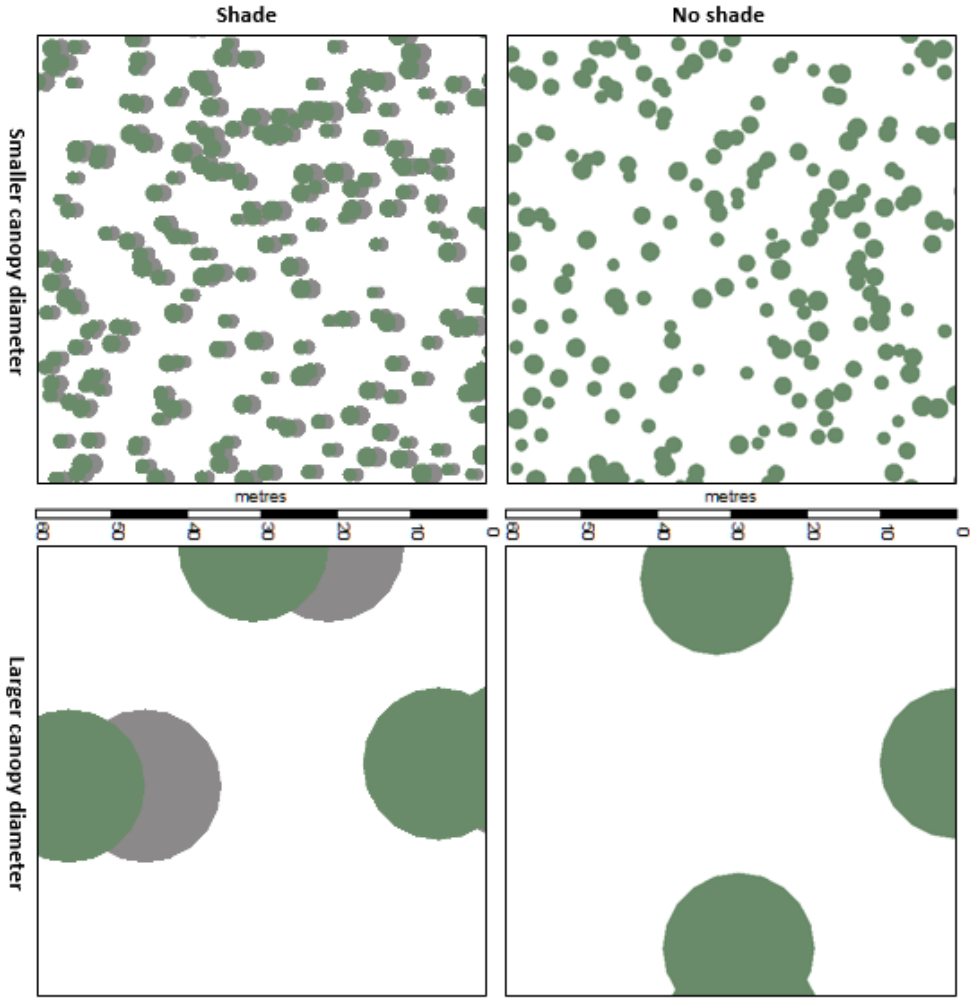
f. If exotic vegetation was captured during an assessment from a previous reporting year:
   i. Overlay exotic vegetation with the dataset created in previous step to create an updated 'native, cleared or exotic vegetation' dataset (identity tool in ArcGIS).
   ii. In the updated 'native, cleared or exotic vegetation' dataset, select records where the exotic field equals 'exotic' and update the native, cleared or exotic vegetation field (added in step 1e) to equal 'exotic vegetation'.

g. Dissolve P2/S14 status dataset to aggregate features based on the 'native, cleared or exotic' attribute (dissolve tool in ArcGIS).

Step 2: Visually check current FPC and native, cleared or exotic vegetation against aerial imagery and correct any errors (pre field assessment)

> **Note when editing polygons:** when creating a new boundary, split the polygon that already exists within the dataset. It is important that you do not create a new polygon over an existing one within the same dataset.

a. Using a GIS application, visually check the correlation between the current FPC and the vegetation in the most recent aerial imagery. FPC mapping has a high level of accuracy where FPC > 20%. Focus on non-woody or sparse woody vegetation within the imagery to make sure areas with <10% FPC have been correctly mapped. Refer to the 'ten percent FPC reference diagram' for assistance in estimating FPC. If the FPC layer is clearly in error—usually overestimating woody cover in open pasture areas or woody cover was recently cleared—correct the FPC dataset accordingly.



10 percent FPC reference diagram: Schematically represents the appearance, in aerial imagery, of woody vegetation of large and small canopy diameter, with shade (low sun angle) and without shade (sun overhead).

b. Visually check the 'native, cleared or exotic vegetation' dataset against the imagery to identify any areas mapped as 'native' that are clearly dominated by exotic vegetation or bare due to human activity, such as cultivation. Focus on any areas mapped as 'native'. Note: it is not necessary to identify exotic vegetation if the area has already been mapped as cleared. The purpose of identifying exotic vegetation is to pick up areas where the vegetation is within expected historic FPC range but not native. If any exotic vegetation is identified:
   i. update mapping in 'native, cleared or exotic vegetation' dataset. Reclassify polygon as 'exotic vegetation'.
   ii. Select all 'exotic vegetation' features and export to create a new exotic vegetation spatial dataset for use in future assessment periods.

c. Note areas warranting further investigation—for example to check if historically non-woody areas are currently dominated by native or exotic vegetation). Include details on the specific question and location and a checkbox for ticking when ground truthing is completed. (These notes should be added to the field maps produced in step 6).

d. If corrections were made to the FPC data, re-run steps 1d to 1g. If FPC was not corrected but exotic vegetation was found and added to the mapping, it is only necessary to re-run steps 1f – 1g.

Step 3: Data processing – Prepare the P2 modification of vegetation data (pre field assessment)

a. Prepare the P2/S14 status dataset for calculations of areas of modified or exotic vegetation:
   i. Add a new field for P2 and S14 status (a state indicator showing native vegetation in the wetland's 200 m buffer zone) and classify by querying the attribute fields based on the following criteria:
   P2 modification of vegetation – current FPC range does not fall within pre-clearing RE FPC range; OR 'native, cleared or exotic vegetation' attribute is exotic.
   ii. Create the dataset required for the lineal calculations. Clip the P2/S14 status dataset to the 10 m buffer of the mapped wetland.

Step 4: Visually check areas classed as P2 modification of vegetation against aerial imagery (pre field assessment)

a. If any areas within the AOI do not appear to be correctly classified as P2 modification of vegetation, check and compare with historic imagery and the remnant vegetation status to help investigate any possible changes to the vegetation. Check the P2 status attributes to compare the RE (historic) FPC in relation to the SLATS (current) FPC.

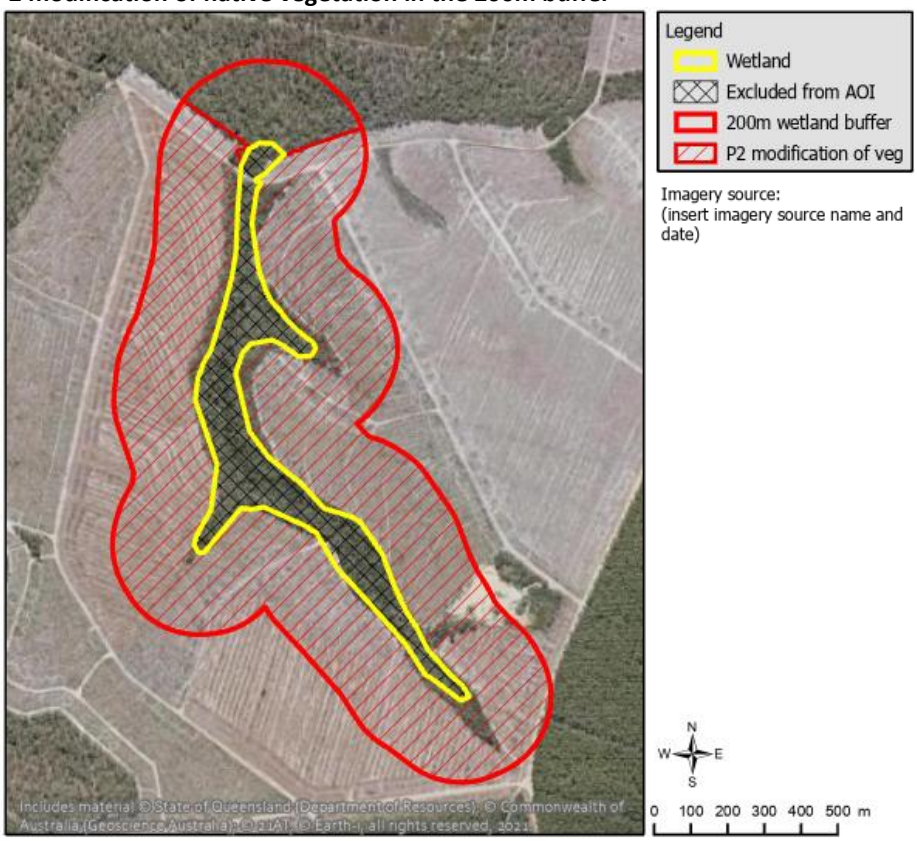
b. Note areas that warrant further investigation if feasible during the field assessment. These notes should be added to the current FPC field map or native cleared or exotic vegetation field map produced in Step 6. Clearly specify the following details and actions:

   i. Location and pre-clear RE code
   ii. The expected pre-clear FPC range
   iii. Action

   Recommend spot checks to access the accuracy of the current FPC in the area warranting further investigation. If the current FPC is higher than the expected pre-clear FPC, recommend checking for signs of past fires and considering if this could it be due to fire regime.

Example visualisation:

P2 modification of native vegetation in the 200m buffer



Step 5: Data processing – Calculate percentage areas and allocate score class (pre field assessment)

An example of the calculations is given below the detailed instructions.

a. Calculate the total area of the AOI (summary statistics tool in ArcGIS).

b. Calculate the sum of P2 modification of vegetation areas (summary statistics tool in ArcGIS).

c. Calculate the percentage of areas of P2 modification of vegetation within the AOI:
   Divide the answer of step 5b by the answer of step 5a and multiply by 100.

d. Calculate the lineal percentage of P2 modification of vegetation areas intersecting the wetland boundary using a 10 m buffer. Follow steps 5a to 5c above using a 10 m P2/S14 clipped dataset instead of the total P2/S14 status dataset.

e. Allocate a score class by matching the percentages from the 200 m buffer (Area %) and 10 m buffer (Lineal %) results with the appropriate score class range.

Example of score class calculation:

P2 area	Area (ha) within total AOI	Area %
Area % of P2 modification of native vegetation (current FPC is outside expected range or dominated by exotic vegetation)	82.03	92.79
Total AOI (200 m buffer excluding mapped wetland and any ocean/estuary)	**88.40**	

P2 lineal	Area (ha) included in lineal calculation	Lineal %
Lineal % of P2 modification of native vegetation (current FPC is outside expected range or dominated by exotic vegetation)	3.79	96.19
Total (10 m external wetland buffer)	**3.94**	

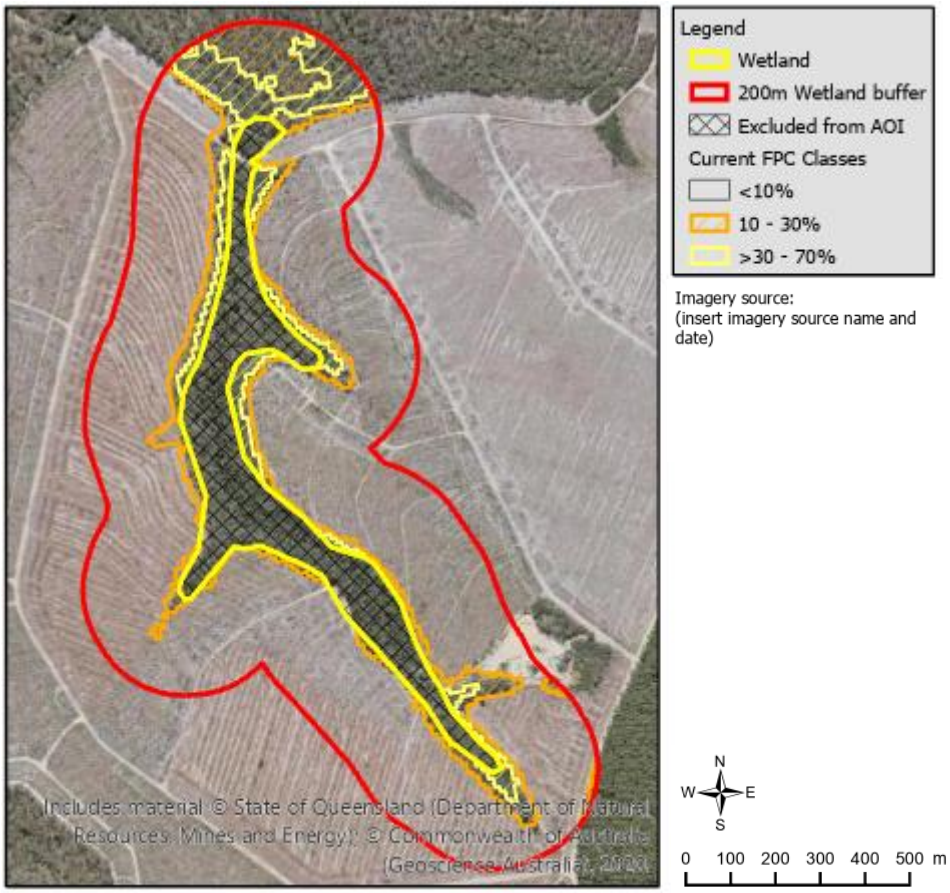
P2 modification of vegetation is 68.50% (within >50–90% lineal range) and 73.91% (within >50–90% area range), which gives a score class of 4.

Step 6: Prepare field maps (pre field assessment)

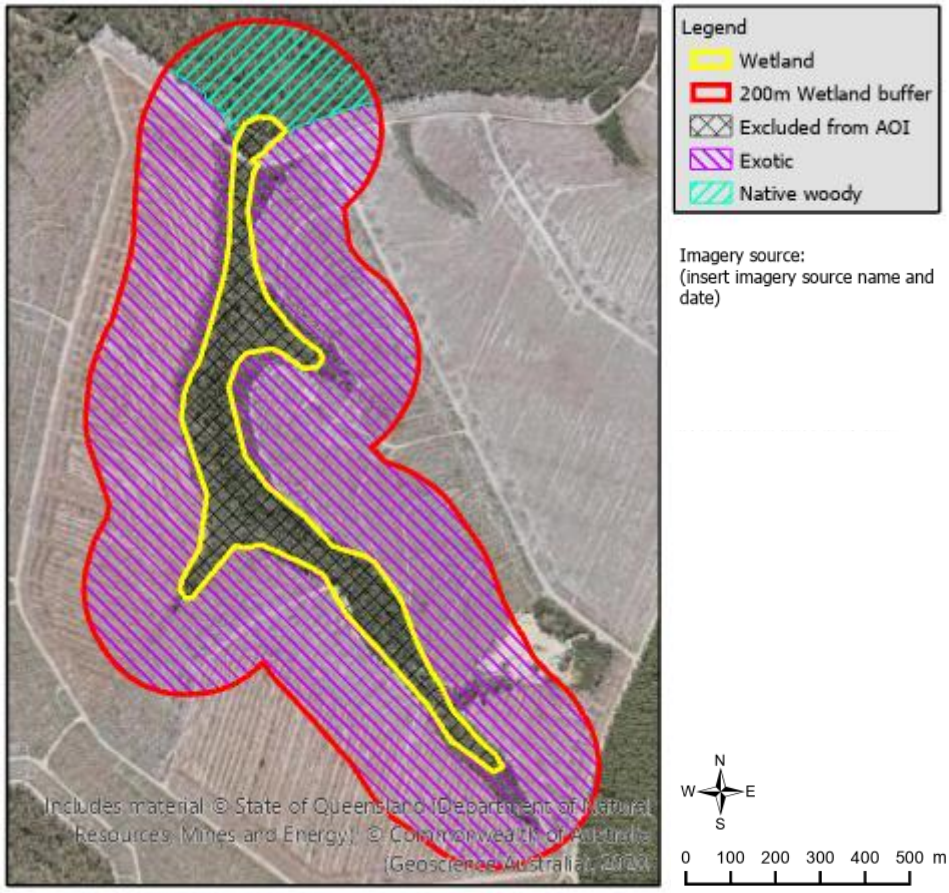
a. Prepare two field maps of (1) FPC categorised as follows: > 70%; >30–70%; 10–30%; and <10%, (2) native, cleared or exotic vegetation. Use hatch symbols in different colours and overlay with the most recent aerial imagery. Show outlines of the mapped wetland, 200 m buffer and areas of ocean and estuary. Include a legend to identify these features and date of imagery. Include any notes detailing areas that warrant further investigation (noted while checking the data in steps 2 and 4) with a checkbox to tick when it has been checked. Export as a PDF file (for field verification).

Example field maps:

Current FPC field map



Native, cleared or exotic vegetation field map



Step 7: Ground truthing (field assessment)

Ground truth the current *FPC map* and *native, cleared or exotic vegetation map*, as described in the *Wetland Tracker Field Methods Guide.*

Step 8: Correct if errors were detected (post field assessment)

a. Correct mapping errors:
   If FPC mapping errors have been detected during ground truthing, correct the FPC dataset accordingly. If any exotic vegetation is identified:
   i. update the mapping in the 'native, cleared or exotic vegetation' dataset and reclassify polygon as 'exotic vegetation'.
   ii. Select all 'exotic vegetation' features and export to create a new exotic vegetation spatial dataset.

b. If the current FPC mapping has been confirmed accurate but areas appear to be incorrectly identified as P2 modification of vegetation, the error may be an artefact of pre-clear RE mapping scale issues. For example, there may be patches of small areas that are beyond the scale of the RE mapping or near the boundary between two RE polygons. If this issue is suspected and the areas in question are large enough to affect the score class, carefully compare the data with time series historical imagery. If there is evidence to support no modification to the vegetation, correct the P2/S14 status dataset and note details of the issue and evidence used to support the correction.

c. If corrections were made to the FPC data, re-run data processing steps 1d onwards. If FPC was not corrected but exotic vegetation was found and added to the mapping, it is only necessary to re-run data processing steps 1f onwards. If corrections have been made to the P2/S14 status dataset only, re-run step 5.

d. If areas warranted further investigation but were unable to be verified or data was judged to have mapping scale issues, reduce the confidence rating and note details in the confidence evidence. Refer to later section on rating confidence in indicator scores.

P3: Land use associated with pesticide residue inputs

Score class	Description	Desktop information
1	0 – 1 (total pesticide pressure score)	▪ 1km buffer and wetland combined ▪ Land use mapping – Queensland current ▪ Land use pressures table ▪ Most recent aerial image
2	> 1 – 2	
3	> 2 – 3	
4	> 3 – 4	
5	> 4 – 5	

Area of interest (AOI):  1 km buffer and wetland combined

Areas classed as rivers, marsh/wetland or estuary/coastal waters in the land use mapping are not included in the calculations.

Method overview: Determine the proportions of land use classes* within the AOI and multiply each by their associated land use pesticide pressure values from the land use pressures table (also described in Table 6) to calculate area-weighted pressure values. Sum the area-weighted pressure values to calculate the total score.
* Land use classes are based on Australian Land Use and Management (ALUM) classification V8 (ABARES 2016).

Evidence: Retain the AOI land use spatial dataset, including details of any corrections following desktop and field checks. Save a scanned copy of the field map with field annotations. Retain a summary table of the land use breakdown with area-weighted pressure scores. Record the calculated total pressure value used for allocating the score class as a summary of the evidence.

Detailed methods:

Steps 1 to 5: Prepare data, perform desktop checks and corrections, prepare field map, correct any errors detected from ground truthing and calculate land use area proportions

a. These steps are completed during the processing for indicator P1. Refer to P1 indicator methods steps 1–5 for details.

Step 6: Data processing – calculate the total pesticide pressure and allocate score class

An example of the calculations is given below the detailed instructions.

a. Provide the pesticide pressure values for each land use class:
Join P3 pressure (P) field from land use pressures table (also described in Table 6) to the land use summary table (created in step 5a of the P1 indicator methods) by matching the ALUM code fields.

b. Exclude rivers, marsh/wetland and estuary/coastal waters land use classes:
Exclude records where ALUM code includes: 6.3.0–6.3.3 (marsh/wetland), 6.5.0–6.5.4 (marsh/wetland) or 6.6.0–6.6.3 (estuary/coastal waters).

c. Multiply the proportion by the pressure value:
Add a P x A field to the land use summary table and calculate by multiplying the proportion figure (A) by the pesticide pressure value (P).

d. Calculate the total pesticide pressure:
Sum the numbers in the P x A field of the land use summary table.

e. Allocate a score class:
Match the total pesticide pressure to the appropriate score class range.

Example of score class calculation:

ALUM	Land use	Area (ha)	Pesticide Pressure (P)*	α of AOI (A)	P x A
2.1.0	Grazing native vegetation	75.81	1	0.11	0.11
2.2.0	Production native forests	176.21	0	0.26	0.00
3.1.2	Plantation forests	420.34	3	0.62	1.86
5.8.2	Mining	2.86	0	0.00	0.00
Total		**675.22**			**1.97 (score class = 2)**

* Pesticide Pressure values from land use pressure table (also described in Table 5).

Table 6 Pesticide pressure: Land use pressure characterisation (DSITIA 2015), ALUM class land use classes (ABARES 2016)

Hazard assessment land use group	Land use description	ALUM CLASS name	ALUM class code	Pesticide pressure (P)	α of AOI (A)	P x A
Conservation and natural environments	Land designated for nature conservation and other minimal uses (e.g. national parks, habitat/species protection areas, managed indigenous uses and defence land–natural areas).	Nature conservation	1.1.0–1.1.7	None (0)		
		Managed resource protection	1.2.0–1.2.5			
		Other minimal use	1.3.0–1.3.4			
Extensive grazing	Grazing by livestock on native vegetation where there has been little/no deliberate pasture modification.	Grazing native vegetation	2.1.0	Very minor (1)		
Intensively managed grazing	Grazing on significantly and actively modified pastures with or without irrigation (e.g. dairy farms and fodder crops)	Grazing modified pastures	3.2.0–3.2.5	Moderate (3)		
		Grazing irrigated modified pastures	4.2.0–4.2.4			
Production from natural forests	Wood (sawlogs and pulpwood) and other forest production (e.g. firewood, fence posts and wildflowers) from natural forests.	Production forestry	2.2.0–2.2.2	None (0)		
Plantation forestry	Plantations of trees or shrubs, for production or resource protection, established on cleared and managed land.	Plantation forestry	3.1.0–3.1.4	Moderate (3)		
		Irrigated plantation forestry	4.1.0–4.1.4			
Dry land cropping and horticulture	Cropping (e.g. sugar cane, cereals, cotton etc.), perennial (e.g. tree fruits/nuts, citrus, grapes, perennial flowers/vegetables, etc) and seasonal horticulture (e.g. seasonal vegetable fruits/flowers, etc.) on non–irrigated land. Involves a relatively high degree of nutrient, weed and moisture control.	Cropping (dry land)	3.3.0–3.3.8	High (4)		
		Perennial horticulture	3.4.0–3.4.9			
		Seasonal horticulture	3.5.0–3.5.4			
		Land in transition	3.6.0–3.6.5			
Irrigated cropping and horticulture	Cropping (e.g. sugar cane, cereals, cotton, pulses, rice, etc.), perennial (e.g. tree fruits/nuts, citrus, grapes, perennial flowers/vegetables, etc.), seasonal (e.g. seasonal vegetable fruits/flowers, etc.) and intensive horticulture (glasshouses, shade houses, etc.) on irrigated land. Involves a relatively high degree of nutrient, weed and moisture control and where water is applied to promote additional growth.	Cropping (irrigated)	4.3.0–4.3.9	Very high (5)		
		Irrigated perennial horticulture	4.4.0–4.4.9			
		Irrigated seasonal horticulture	4.5.0–4.5.5			
		Irrigated land in transition	4.6.0–4.6.5			
		Intensive horticulture	5.1.0–5.1.4			
Aquaculture	Aquaculture installations for cultivating fish and crustaceans (lobsters, yabbies, etc.), molluscs (oysters and mussels) or crocodiles.	Aquaculture	5.2.6	High (4)		
Intensive animal production	Intensive animal production or holding yards (including dairy sheds, cattle/sheep feedlots, piggeries, poultry farms, horse studs, etc.).	Intensive animal production (excluding aquaculture)	5.2.0, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.7, 5.2.8, 5.2.9, 5.6.9	High (4)		
Manufacturing and industrial	Manufacturing and industrial (including general/food production factories, industrial complexes, bulk grain storage, oil refineries, sawmills, abattoirs, etc.).	Manufacturing and industrial	5.3.0–5.3.8	Very minor (1)		
Waste treatment and disposal	Waste treatment and disposal (includes sewage treatment infrastructure, landfill, waste transfer and incinerators).	Waste treatment and disposal	5.9.0–5.9.5	Very minor (1)		
Urban	Urban/rural residential (houses, flats, domestic gardens and hobby farms), farm infrastructure (farm buildings, sheds, etc.) commercial and public services (shops, schools, parks, sportsgrounds, etc.) and utilities (e.g. power/ water/ gas infrastructure).	Residential and farm infrastructure	5.4.0–5.4.5	Moderate (3)		
		Services	5.5.0–5.5.5			
		Utilities	5.6.0–5.6.6			
Transport	Transport (roads, railways, airports and ports) and communications infrastructure (radar stations, beacons.)	Transport and communication	5.7.0–5.7.5	Very minor (1)		
Mining	Mines (open cut and deep shaft mines), quarries (for extraction of stone, gravel, clay, sand, soil, etc.) and tailings (dumps and dams for storage and treatment of mining/quarrying waste) and disused mines.	Mining	5.8.0–5.8.4	None (0)		
Water (artificial)	Reservoir/dams (reservoirs, farm dams and evaporation basins) and artificial channels/aqueducts (for the supply, distribution or removal of water for irrigation, land reclamation or drainage).	Reservoir/dam	6.2.0–6.2.4	Very minor (1)		
		Channel/aqueduct	6.4.0–6.4.3			
Total pesticide pressure = sum of last column						

P4: Land use associated with nutrient inputs

Score class	Description	Desktop information
1	0 – 1 (total nutrient pressure score)	▪ 1 km buffer and wetland combined ▪ Land use mapping – Queensland current ▪ Land use pressures table ▪ Most recent aerial image
2	> 1 – 2	
3	> 2 – 3	
4	> 3 – 4	
5	> 4 – 5	

Area of interest (AOI):  1km buffer and wetland combined

Areas classed as rivers, marsh/wetland or estuary/coastal waters in the land use mapping are not included in the calculations.

Method overview: Determine the proportions of land use classes* within the AOI and multiply each by their associated land use nutrient† pressure values from the land use pressures table (also described in Table 7) to calculate area–weighted pressure values. Sum the area-weighted pressure values to calculate the total score.
* Land use classes are based on Australian Land Use and Management (ALUM) classification (ABARES 2016).
† Nutrients for the purposes of this indicator are nitrogen and phosphorus. DSITIA 2015, describes the nutrient inputs pressure as 'Increases in the levels of nitrogen and phosphorus (as limiting nutrients in aquatic ecosystems) caused by human activities'.

Evidence: Retain the AOI land use spatial dataset, including details of any corrections following desktop and field checks. Save a scanned copy of the field map with field annotations. Retain a summary table of land use break-down with area-weighted pressure scores. Record the calculated total pressure value used for allocating the score class as a summary of the evidence.

Detailed methods:

Steps 1 to 5: Prepare data, perform desktop checks and corrections, prepare field map, correct any errors detected from ground truthing and calculate land use area proportions

a. These steps are completed during the processing for indicator P1. Refer to P1 indicator methods steps 1–5 for details.

Step 6: Data processing – calculate the total nutrient pressure and allocate score class (post field assessment)

An example of the calculations is given below the detailed instructions.

a. Provide the nutrient pressure values for each land use class:
   Join P4 pressure (P) field from land use pressures table to the land use summary table (created in step 5a of the P1 indicator methods) by matching the ALUM code fields:
b. Exclude rivers, marsh/wetland and estuary/coastal waters land use classes:
   Exclude records where ALUM code includes: 6.3.0–6.3.3 (marsh/wetland), 6.5.0–6.5.4 (marsh/wetland) or 6.6.0–6.6.3 (estuary/coastal waters).
c. Multiply the proportion by the pressure value:
   Add a P x A field to the land use summary table and calculate by multiplying the proportion figure (A) by the nutrient pressure value (P).
d. Calculate the total nutrient pressure:
   Sum the numbers in the P x A field of the land use summary table.
e. Allocate a score class:
   Match the total nutrient pressure to the appropriate score class range.

Example of score class calculation:

	Land use	**Area (ha)**	**Nutrient Pressure (P)***	**α of AOI (A)**	**P x A**
2.1.0	Grazing native vegetation	75.81	3	0.11	0.33
2.2.0	Production native forests	176.21	2	0.26	0.52
3.1.2	Plantation forests	420.34	2	0.62	1.24
5.8.2	Mining	2.86	2	0.00	0.00
Total		**675.22**			**2.09 (score class = 3)**

* Nutrient Pressure values from land use pressure table (also described in Table 5).

Table 7 Nutrient pressures: Land use pressure characterisation (DSITIA 2015), ALUM class land use classes (ABARES 2016)

Hazard assessment land use group	Land use description	ALUM CLASS name	ALUM class code	Nutrient pressure (P)	α AOI (A)	P x A
Conservation and natural environments	Land designated for nature conservation and other minimal uses (e.g. national parks, habitat/species protection areas, managed indigenous uses and defence land-natural areas).	Nature conservation	1.1.0–1.1.7	None (0)		
		Managed resource protection	1.2.0–1.2.5			
		Other minimal use	1.3.0–1.3.4			
Extensive grazing	Grazing by livestock on native vegetation where there has been little/no deliberate pasture modification.	Grazing native vegetation	2.1.0	Moderate (3)		
Intensively managed grazing	Grazing on significantly and actively modified pastures with or without irrigation (e.g. dairy farms and fodder crops)	Grazing modified pastures	3.2.0–3.2.5	Very high (5)		
		Grazing irrigated modified pastures	4.2.0–4.2.4			
Production from natural forests	Wood (sawlogs and pulpwood) and other forest production (e.g. firewood, fence posts & wildflowers) from natural forests.	Production forestry	2.2.0–2.2.2	Minor (2)		
Plantation forestry	Plantations of trees or shrubs, for production or resource protection, established on cleared and managed land.	Plantation forestry	3.1.0–3.1.4	Minor (2)		
		Irrigated plantation forestry	4.1.0–4.1.4			
Dry land cropping and horticulture	Cropping (e.g. sugar cane, cereals, cotton etc.), perennial (e.g. tree fruits/nuts, citrus, grapes, perennial flowers/vegetables, etc) and seasonal horticulture (e.g. seasonal vegetable fruits/flowers, etc.) on non-irrigated land. Involves a relatively high degree of nutrient, weed and moisture control.	Cropping (dry land)	3.3.0–3.3.8	High (4)		
		Perennial horticulture	3.4.0–3.4.9			
		Seasonal horticulture	3.5.0–3.5.4			
		Land in transition	3.6.0–3.6.5			
Irrigated cropping and horticulture	Cropping (e.g. sugar cane, cereals, cotton, pulses, rice, etc.), perennial (e.g. tree fruits/nuts, citrus, grapes, perennial flowers/vegetables, etc.), seasonal (e.g. seasonal vegetable fruits/flowers, etc.) and intensive horticulture (glasshouses, shade houses, etc.) on irrigated land. Involves a relatively high degree of nutrient, weed and moisture control and where water is applied to promote additional growth.	Cropping (irrigated)	4.3.0–4.3.9	Very high (5)		
		Irrigated perennial horticulture	4.4.0–4.4.9			
		Irrigated seasonal horticulture	4.5.0–4.5.5			
		Irrigated land in transition	4.6.0–4.6.5			
		Intensive horticulture	5.1.0–5.1.4			
Aquaculture	Aquaculture installations for fish & crustaceans (lobsters, yabbies, etc.), molluscs (oysters, mussels) or crocodiles.	Aquaculture	5.2.6	Very high (5)		
Intensive animal production	Intensive animal production or holding yards (including dairy sheds, cattle/sheep feedlots, piggeries, poultry farms, horse studs, etc.).	Intensive animal production (excluding aquaculture)	5.2.0, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.7, 5.2.8, 5.2.9, 5.6.9	Very high (5)		
Manufacturing and industrial	Manufacturing and industrial (including general/food production factories, industrial complexes, bulk grain storage, oil refineries, sawmills, abattoirs, etc.).	Manufacturing and industrial	5.3.0–5.3.8	Moderate (3)		
Waste treatment and disposal	Waste treatment and disposal (includes sewage treatment infrastructure, landfill, waste transfer and incinerators).	Waste treatment and disposal	5.9.0–5.9.5	Moderate (3)		
Urban	Urban/rural residential (houses, flats, domestic gardens and hobby farms), farm infrastructure (farm buildings, sheds, etc.) commercial and public services (shops, schools, parks, sportsgrounds, etc.) and utilities (e.g. power/ water/ gas infrastructure).	Rural residential without agriculture	5.4.3	Moderate (3)		
		Residential and farm infrastructure	5.4.0, 5.4.1, 5.4.2, 5.4.4, 5.4.5	High (4)		
		Services	5.5.0–5.5.5			
		Utilities	5.6.0–5.6.6			
Transport	Transport (roads, railways, airports and ports) and communications infrastructure (radar stations, beacons, etc.)	Transport and communication	5.7.0–5.7.5	Very minor (1)		
Mining	Mines (open cut and deep shaft mines), quarries (for extraction of stone, gravel, clay, sand, soil, etc.) and tailings (dumps and dams for storage and treatment of mining/quarrying waste) and disused mines.	Mining	5.8.0–5.8.4	Minor (2)		
Water (artificial)	Reservoir/dams (reservoirs, farm dams and evaporation basins) and artificial channels/aqueducts (for the supply, distribution or removal of water for irrigation, land reclamation or drainage).	Reservoir/dam	6.2.0–6.2.4	Moderate (3)		
		Channel/aqueduct	6.4.0–6.4.3			
Total nutrient pressure = sum of last column						

P5: Number of septic systems within 200 m of the wetland per ha of mapped wetland

Score class	Description	Desktop information
1	0 septic systems per ha of mapped wetland	▪ Mapped wetland ▪ 200m buffer and wetland combined ▪ Most recent aerial image ▪ Local government information about the extent of sewered areas
2	> 0 – 2 per ha of mapped wetland	
3	> 2 – 4 per ha of mapped wetland	
4	> 4 – 8 per ha of mapped wetland	
5	> 8 per ha of mapped wetland	

Area of interest (AOI):  200 m buffer and wetland combined

Method overview: Determine the number of septic systems in the AOI and divide this by the area of mapped wetland. The wetland area is used for area-weighting because differences in the area of the wetland will affect the dilution and processing rates of the input. The desktop assessment score for this indicator requires field verification.

Evidence: Record the count of dwellings or buildings that contain a toilet and are not connected to an urban sewerage network, and the calculated value (septic systems within 200 m of the mapped wetland /ha of mapped wetland) used to allocate the score class.

Detailed methods:

Step 1: Assess and count unsewered dwellings based on aerial imagery and local government data (pre field assessment)

a. Identify and count unsewered dwellings:
   Using a GIS application and the most recent aerial imagery, count the number of unsewered dwellings within the AOI. (Note: If the imagery is unclear, search for alternative clearer imagery.) Do not count dwellings in mains-connected sewered areas. Local government information about the extent of sewered areas may be useful. High resolution aerial imagery may also be useful to locate septic tanks.

b. Note buildings that warrant further investigation during the field assessment, e.g. those where it may be difficult to distinguish between a dwelling or a shed in the imagery. These notes should be inserted on the *A3 field map* – refer to the earlier section on preparing fieldwork resources.

Step 2: Data processing – calculation and allocation of score class ready for field verification (pre field assessment)

a. Calculate the number of septic systems in the AOI per hectare of mapped wetland:
   Divide the count from step 1 by the area of mapped wetland.
   Allocate a score class:
   Match the answer to step 2a to the appropriate score class range.

Step 3: Ground-truth – field assessment.

Refer to the *Wetland Tracker Field Methods Guide*.

P10: Sediment supply (modelled, GBR)

Score class	Description	Desktop information
1	0 – 9.78 modelled fine sediment supply kg/ha/yr	▪ Mapped wetland ▪ 1 km buffer and wetland combined ▪ Foliage projective cover (FPC) ▪ Land use mapping – Queensland current ▪ GBR Paddock to Reef sub-catchments boundaries ▪ P10 land use table ▪ P10 GBR sediment rates table
2	> 9.78 – 38.57	
3	> 38.57 – 123.28	
4	> 123.28 – 372.55	
5	> 372.55	

Area of interest (AOI):  1 km buffer and wetland combined

Areas outside the modelling sub-catchments, i.e., estuary/ocean, are not included in the calculations.

Method overview: This method uses average yearly anthropogenic fine sediment production for each Reef land use group and each sub-catchment based on the Great Barrier Reef catchment loads modelling program data. Prepare a land use dataset for the AOI to match the modelling land use groupings by intersecting with FPC data and joining the P10 land use table. Intersect the land use dataset with the modelling sub-catchments and join the sediment rates table. Calculate proportional land use loads within the AOI and sum these values to give the modelled fine sediment supply.

Evidence: Retain the AOI P10 spatial dataset. Retain a summary of the land use breakdown with total areas and proportional sediment loads. Record the calculated modelled fine sediment supply kg/ha/yr value used for allocating the score class as a summary of the evidence.

Detailed methods:

Wooded extent and foliage projective cover (FPC) dataset must be prepared as per instructions on page 13.

Step 1: Verification of AOI land use spatial data (post field assessment)

Verification of land use is completed during the processing for indicator P1. Refer to P1 indicator methods steps 1–4 for details.

Step 2: Data processing – prepare the land use groupings dataset

a. Clip the FPC data in preparation for identifying the closed grazing / open grazing Reef land use groupings:
Clip the FPC polygon dataset (prepared as per instructions on page 14) to the AOI (clip tool in ArcGIS).

b. Extract areas of closed forest cover (FPC ≥ 20%) and dissolve polygons:
Filter the FPC dataset for FPC ≥ 20% using query gridcode ≥ 20 (query definition in ArcGIS) and dissolve features (dissolve tool in ArcGIS) to create a FPC ≥ 20% dataset.

c. Add attribute to identify 'closed forest cover':
Add a field named FPC to the dissolved FPC dataset attribute table and calculate all records as 'FPC >= 20%'.

d. Reclassify land use mapping with 'Reef land use' groupings:
Join the 'reefscape_landuse' field from P10 land use table to the land use spatial dataset by matching the ALUM codes (add join tool in ArcMap).

e. Overlay Reef land use with closed forest cover:
Intersect the reclassified land use and closed forest cover datasets (identity tool in ArcGIS)

f. Prepare attribution for final Reef land use groupings:
In the intersected land use and FPC dataset (output from step 2e) add a new field named 'ReefLU' and calculate the values to be equal to the joined 'reefscape_landuse' field.

g. Add open grazing to final Reef land use groupings:
Select records where the reefscape_landuse = 'Grazing' and FPC <> 'FPC >= 20%' and calculate ReefLU = 'Grazing Open'.

h. Add closed grazing to final Reef land use groupings:
Select records where the reefscape_landuse = 'Grazing' and FPC = 'FPC >= 20%' and calculate ReefLU = 'Grazing Closed'.

Step 3: Data processing – prepare P10 sediment dataset (loads within each sub-catchment and land use within the AOI)

a. Overlay Reef land use groupings with sub-catchments to create the P10 sediment spatial dataset:
Intersect Reef land use groupings (created in previous step) and GBR Paddock to Reef sub-catchments

datasets (intersect tool in ArcGIS). Note: the intersection should remove areas outside the sub-catchments, i.e., areas of estuary and ocean.

b. Add attribute to identify Reef land use groupings and sub-catchment combination:
Create another field called Region_SC_LU by combining the fields RegionSubCats and ReefLU.

c. Add the fine sediment load values to P10 sediment dataset:
Join FS_kg_ha_yr field from the P10 sediment rates table with the intersected dataset created in step 3b using Region_SC_LU as the join field (join field tool in ArcMap).

d. Calculate area in hectares:
Add an area_ha field to the P10 sediment dataset and calculate area in hectares.

e. Calculate final load value proportional to each sub-catchment land use area:
Add field named FSValueByArea to the P10 sediment dataset and multiply FS_kg_ha_yr by area_ha.

Step 4: Data processing: calculate the sub-catchment modelled mean fine sediment supply value and score class
An example of the calculations is given below the detailed instructions.

a. Calculate the total land use load and total area within the AOI:
Sum the (1) FSValueByArea field and the (2) Area_ha field from the P10 sediment dataset.

b. Divide total land use load by the total area of the AOI:
Divide the sum of FSValueByArea by sum of Area_ha to obtain mean kg/ha/yr.

c. Allocate a score class:
Match the modelled mean fine sediment load result with the appropriate score class range.

Example of score class calculation:

Land use grouping within region sub-catchment (Region_SC_LU)	**Area (Area_ha)**	**Fine sediment rates (FS_kg_ha_yr)**	**Proportional land use loads (FSValueByArea)**
BM SC #457 Forestry	1.47	28.84	42.49
BM SC #457 Grazing Forested	0.89	16.77	14.93
BM SC #458 Forestry	546.43	40.13	21,928.24
BM SC #458 Grazing Forested	64.05	60.17	3,853.88
BM SC #458 Grazing Open	10.86	80.03	869.52
BM SC #458 Other	2.86	442.54	1,265.01
BM SC #565 Forestry	48.64	28.52	1,387.42
Total	**675.20**		**29,361.45**

Sum of FSValueByArea divided by total area (29,361/675.20) gives a modelled fine sediment supply of **43.49 kg/ha/yr** within the AOI**. Score class = 3**.

P14: Altered surface flow due to vegetation cleared

Score class	Description	Desktop information
1	>85 – 100% of the buffer is mapped as remnant vegetation, regrowth, established plantation forestry (>25 years of age) or historically non-woody.	▪ 1km buffer only ▪ Pre-clearing regional ecosystems (RE) with cover type ▪ Current remnant REs ▪ National forest and sparse woody vegetation (NFSWV) ▪ Land use mapping ▪ Built up areas ▪ Historic and most recent aerial image
2	>65 – 85%	
3	>35 – 65%	
4	>10 – 35%	
5	0 – 10%	

Area of interest (AOI):  1 km buffer only, excluding ocean and estuaries

Method overview: Determine the percentage area of vegetation relevant for scoring P14 within the AOI.
Vegetation relevant for scoring P14 includes areas that are:

- ☑ **Remnant vegetation**, i.e., remnant in the current RE mapping.
- ☑ **Woody regrowth**, i.e., woody in the latest NFSWV mapping AND NOT production from agriculture and plantations or intensive uses (except rural residential without agriculture) in the land use mapping.
- ☑ **Historically non-woody,** i.e., non-woody* in the pre-clearing† RE mapping AND NOT production from agriculture and plantations or intensive uses (except rural residential without agriculture) in the land use mapping.
- ☑ **Established plantation forestry (>25 years of age)** determined by visual assessment of recent and historic aerial imagery.

* Non-woody includes structural formation classes where the ecologically dominant layer is composed of grasses or other non-woody vegetation or FPC is under 10%. Structural formation classification used in RE mapping are described in Neldner et al., 2020.
† Pre-clearing regional ecosystem is defined as regional ecosystem present before clearing. While this roughly equates to 'pre-European', the Queensland Herbarium uses the term 'pre-clearing' because ecosystem boundaries are dynamic and no consistent imagery for the state exists prior to the early 1960s so therefore it is difficult to map 'pre-European' extent with any certainty.

Evidence: Retain the AOI P14 spatial dataset, including details of any corrections made. Retain a table of the total P14 vegetation area and AOI area. Record the percentage area identified as P14 vegetation used for allocating the score class as a summary of the evidence.

Detailed methods:

The National Forest and Sparse Woody Vegetation (NFSWV) and pre-clearing RE datasets must be prepared as per instructions on pages 13 to 15.

Step 1: Data processing– prepare the input data

a. Prepare the current RE dataset:
   Clip current RE dataset to the 1km buffer only (clip tool in ArcGIS)
b. Prepare the current woody vegetation dataset:
   i. Clip the National Forest and Sparse Woody Vegetation (NFSWV) data to the 1km buffer only (clip tool in ArcGIS).
   ii. Extract forest cover from the NFSWV polygon dataset, using the query gridcode = 2.
   iii. Extract cropping from land use mapping, using the following query: SECONDARY includes the values ('Cropping', 'Irrigated cropping').
   iv. Erase cropping (output of step 2c) and built-up areas from forest cover (erase tool in ArcGIS).
c. Prepare the historically non-woody dataset:
   i. Clip the pre-clearing RE dataset with cover type to the 1km buffer only.
   ii. Extract historically non-woody from pre-clearing RE, using query Dominant_ Cover_Type = 'historically non-woody'.

Step 1: Data processing– prepare the AOI P14 vegetation dataset

a. Overlay the 3 outputs of step 1 (union tool in ArcGIS) to create the P14 vegetation dataset.
b. Filter the current RE dataset where RE includes 'ocean', 'estuary', 'shallow' and erase these areas from the P14 vegetation dataset.
c. Add a field to the AOI P14 dataset to identify vegetation type and classify with the following criteria. (This information may be used to assist with data verification.)
   - remnant – RE does NOT include the values 'non-rem', 'water', 'plantation', or 'canal'
   - regrowth – gridcode is equal to 2 (current forest cover) and vegetation type is not equal to remnant
   - historically non-woody – dominant cover type (pre-clearing RE) = 'historically non-woody'
d. Add a P14 status field to identify areas of P14 vegetation using the criteria vegetation type is not null.

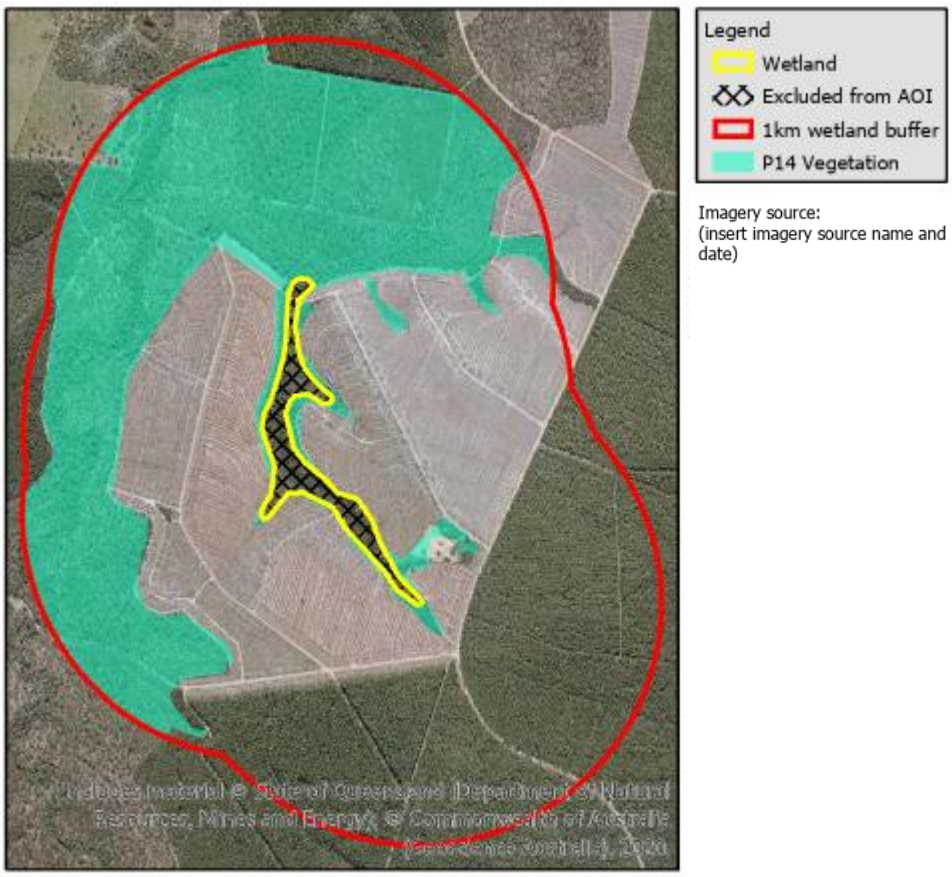
Step 2: Visually assess whether the data requires any modifications

Note when editing polygons: when creating a new boundary, split the polygon that already exists within the dataset. It is important that you do not create a new polygon over an existing one within the same dataset.

a. Check against the most recent aerial image for areas within the AOI that have not been correctly identified as P14 vegetation and are clearly in error.
b. Using current and historical aerial imagery to identify any plantation forestry areas planted > 25 years ago.
c. If any modifications are required, create a new dataset and add polygons covering the extent of any modifications and note correction evidence in the attribute table. Intersect the modifications dataset with the P14 dataset to create an updated P14 dataset and update the P14 status field appropriately based on corrections.

Example visualisation:

Note: data should be checked within the GIS app. Map export is not required.



Step 3: Data processing – calculate percentage area and allocate score class

An example of the calculations is given below the detailed instructions.

a. Calculate the area percentage of P14 vegetation:
   i. Calculate the sum of the total area of the AOI from the P14 dataset (summary statistics tool in ArcGIS).
   ii. Select by attribute P14 status where status is equal to 'P14 cleared' and calculate the sum of the areas (summary statistics tool in ArcGIS).

b. Divide the answer of step 5(b) by the answer of step 5(a) and multiply by 100 to give the percentage of P14 vegetation.

c. Allocate a score class by matching the percentage of P14 vegetation to the appropriate score class range.

d. If any modifications have been made, re-calculate percentage of P14 vegetation and re-allocate score class if necessary, as detailed in step 1.

Example of score class calculation:

P14	Area (ha)	Percentage
Area identified as P14 vegetation	239.51	36.25 (score class = 3)
Total AOI (1 km buffer excluding mapped wetland and any ocean/estuary)	660.75	

P16: Change in landscape hydrological integrity

Description						Desktop information
Floodplain hydrology and water management	Land use pressure score (change to natural surface water flow pattern)					▪ Mapped wetland, including the floodplain attribute ▪ 1 km buffer and wetland combined ▪ Land use mapping – Queensland current ▪ Land use pressures table ▪ Specified surface water management areas and regulated river reaches areas
	0 – 1	> 1 – 2	> 2 – 3	> 3 – 4	> 4 – 5	
The mapped wetland is located outside of specified surface water management and regulated river reaches areas	1	2	3	4	5	
The mapped wetland is a non-floodplain wetland located within a specified surface water management and regulated river reaches areas	2	2	3	4	5	
The mapped wetland is a floodplain wetland located within a specified surface water management and regulated river reaches areas	4	4	4	4	5	

Overall method overview: Determine the (A) land use pressure class and (B) floodplain hydrology and water management class as described in further detail below and match to the appropriate score class range.

PART A – Land use pressure on surface flows

Area of interest (AOI):  1 km buffer and mapped wetland combined

Areas classed as rivers, marsh/wetland or estuary/coastal waters in the land use mapping are not included in the calculations.

Part A method overview: Determine the proportions of land use classes* within the AOI. Multiply each by their associated pressure values due to *change to natural surface water flow pattern*, from the land use pressures table (also described in Table 8), to calculate area-weighted pressure values. Sum the area-weighted pressure values to calculate the land use pressure score.

* Land use classes are based on Australian Land Use and Management (ALUM) classification (ABARES 2016).

PART B – Floodplain hydrology

Area of interest (AOI):  Wetland only

Part B method overview: Determine whether the mapped wetland falls within specified surface water management areas and regulated river reaches, which are mapped in the specified surface water management areas and regulated river reaches areas†.

† The specified surface water management areas and regulated river reaches areas dataset contains regulated river reaches, gauging stations and areas potentially impacted by changes in flow.

Evidence: Retain the AOI land use spatial dataset, including details of any corrections following desktop and field checks. Save a scanned copy of the field map with field annotations. Retain a summary table of the land use breakdown with area-weighted pressure scores. Record a summary of the evidence, including a) whether the mapped wetland is floodplain/non-floodplain, b) whether the mapped wetland falls within or outside specified surface water management areas and regulated river reaches and c) calculated total pressure value.

Detailed methods:

Steps 1 to 5: Prepare land use data, perform desktop checks and corrections, prepare field map, correct any errors detected from ground truthing and calculate land use area proportions

a. These steps are completed during the processing for indicator P1. Refer to P1 indicator methods steps 1–5 for details.

Step 6: Data processing – calculate the total land use pressure and allocate score class (post field assessment)

An example of the calculations is given below the detailed instructions.

a. Provide the 'Change to natural surface water flow patterns' pressure values for each land use class.
Join P16 pressure (P) field from land use pressures table (also described in Table 6) to the land use summary table (created in step 5a of the P1 indicator methods) by matching the ALUM code fields.

b. Exclude rivers, marsh/wetland and estuary/coastal waters land use classes.
Exclude records where ALUM code includes: 6.3.0–6.3.3 (marsh/wetland), 6.5.0–6.5.4 (marsh/wetland) or 6.6.0–6.6.3 (estuary/coastal waters).

c. Multiply the proportion by the pressure value.
Add a P x A field to the land use summary table and calculate by multiplying the proportion figure (A) by the P16 land use pressure value (P).

d. Calculate the total land use pressure.
Sum the numbers in the P x A field of the land use summary table.

Example of score class calculation:

	Land use	**Area (ha)**	**P16 Pressure (P)***	**α of AOI (A)**	**P x A**
2.1.0	Grazing native vegetation	75.81	3	0.11	0.33
2.2.0	Production native forests	176.21	1	0.26	0.26
3.1.2	Plantation forests	420.34	3	0.62	1.86
5.8.2	Mining	2.86	5	0.00	0.00
Total		**675.22**			**2.45 (score class = 3)**

* P16 pressure values from land use pressure table (also described in Table 5).

Step 7: Data processing – determine floodplain hydrology and water management status

a. Determine if wetland is floodplain or non-floodplain.
Interrogate the FLOODPLAIN field in the wetland mapping to determine if it is attributed as floodplain 'F' or non-floodplain '–'.

b. Determine if the wetland falls within the managed area.
Perform overlay analysis to determine if the mapped wetland intersects with the managed area (specified surface water management areas and regulated river reaches areas in GBR catchments dataset)

Step 8: Data processing – allocate score class

a. Match the answers from steps 6 and 7 to the appropriate score class.

Example of a summary of evidence:

The mapped wetland is located outside of specified surface water management and regulated river reaches areas. Change to natural surface water flow patterns (land use based) pressure score is 2.49. This gives a score class of 3.

Table 8 Change to natural surface water flow patterns: Pressure characterisation (DSITIA 2015), ALUM CLASS land use classes (ABARES 2016)

Hazard assessment land use group	Land use description	ALUM CLASS name	ALUM class code	Pressure (P)	α of AOI (A)	P x A
Conservation and natural environments	Land designated for nature conservation and other minimal uses (e.g. national parks, habitat/species protection areas, managed indigenous uses and defence land-natural areas).	Nature conservation	1.1.0–1.1.7	None (0)		
		Managed resource protection	1.2.0–1.2.5			
		Other minimal use	1.3.0–1.3.4			
Extensive grazing	Grazing by livestock on native vegetation where there has been little/no deliberate pasture modification.	Grazing native vegetation	2.1.0	Moderate (3)		
Intensively managed grazing	Grazing on significantly & actively modified pastures with or without irrigation (e.g. dairy farms and fodder crops)	Grazing modified pastures	3.2.0–3.2.5	High (4)		
		Grazing irrigated modified pastures	4.2.0–4.2.4			
Production from natural forests	Wood (sawlogs and pulpwood) and other forest production (e.g. firewood, fence posts and wildflowers) from natural forests.	Production forestry	2.2.0–2.2.2	Very minor (1)		
Plantation forestry	Plantations of trees or shrubs, for production or resource protection, established on cleared and managed land.	Plantation forestry	3.1.0–3.1.4	Moderate (3)		
		Irrigated plantation forestry	4.1.0–4.1.4			
Dry land cropping and horticulture	Cropping (e.g. sugar cane, cereals, cotton etc.), perennial (e.g. tree fruits/nuts, citrus, grapes, perennial flowers/vegetables, etc) and seasonal horticulture (e.g. seasonal vegetable fruits/flowers, etc.) on non-irrigated land. Involves a relatively high degree of nutrient, weed and moisture control.	Cropping (dry land)	3.3.0–3.3.8	Moderate (3)		
		Perennial horticulture	3.4.0–3.4.9			
		Seasonal horticulture	3.5.0–3.5.4			
		Land in transition	3.6.0–3.6.5			
Irrigated cropping and horticulture	Cropping (e.g. sugar cane, cereals, cotton, pulses, rice, etc.), perennial (e.g. tree fruits/nuts, citrus, grapes, perennial flowers/vegetables, etc.), seasonal (e.g. seasonal vegetable fruits/flowers, etc.) and intensive horticulture (glasshouses, shade houses, etc.) on irrigated land. Involves a relatively high degree of nutrient, weed and moisture control and where water is applied to promote additional growth.	Cropping (irrigated)	4.3.0–4.3.9	Very high (5)		
		Irrigated perennial horticulture	4.4.0–4.4.9			
		Irrigated seasonal horticulture	4.5.0–4.5.5			
		Irrigated land in transition	4.6.0–4.6.5			
		Intensive horticulture	5.1.0–5.1.4			
Aquaculture	Aquaculture installations for cultivating fish and crustaceans (lobsters, yabbies, etc.), molluscs (oysters and mussels) or crocodiles.	Aquaculture	5.2.6	High (4)		
Intensive animal production	Intensive animal production or holding yards (including dairy sheds, cattle/sheep feedlots, piggeries, poultry farms, horse studs, etc.).	Intensive animal production (excluding aquaculture)	5.2.0, 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.2.7, 5.2.8, 5.2.9, 5.6.9	Minor (2)		
Manufacturing and industrial	Manufacturing and industrial (including general/food production factories, industrial complexes, bulk grain storage, oil refineries, sawmills, abattoirs, etc.).	Manufacturing and industrial	5.3.0–5.3.8	Very minor (1)		
Waste treatment and disposal	Waste treatment and disposal (includes sewage treatment infrastructure, landfill, waste transfer and incinerators).	Waste treatment and disposal	5.9.0–5.9.5	Minor (1)		
Urban	Urban/rural residential (houses, flats, domestic gardens and hobby farms), farm infrastructure (farm buildings, sheds, etc.) commercial and public services (shops, schools, parks, sportsgrounds, etc.) and utilities (e.g. power/ water/ gas infrastructure).	Rural residential with agriculture	5.4.2	High (4)		
		Rural residential without agriculture	5.4.3	Moderate (3)		
		Residential and farm infrastructure	5.4.0, 5.4.1, 5.4.4, 5.4.5	Very high (5)		
		Services	5.5.0–5.5.5			
		Utilities	5.6.0–5.6.6			
Transport	Transport (roads, railways, airports and ports) and communications infrastructure (radar stations, beacons)	Transport and communication	5.7.0–5.7.5	Very high (5)		
Mining	Mines (open cut and deep shaft mines), quarries (for extraction of stone, gravel, clay, sand, soil, etc.) and tailings (dumps and dams for storage and treatment of mining/quarrying waste) and disused mines.	Mining	5.8.0–5.8.4	Very high (5)		
Water (artificial)	Reservoir/dams (reservoirs, farm dams and evaporation basins) and artificial channels/aqueducts (for the supply, distribution or removal of water for irrigation, land reclamation or drainage).	Reservoir/dam	6.2.0–6.2.4	Very high (5)		
		Channel/aqueduct	6.4.0–6.4.3			
Total changes to water flow pattern pressure = sum of last column						

P20: Native vegetation cleared within 5 km of the wetland

Score class	Description	Desktop information
1	0% of native vegetation in the AOI is cleared	▪ 5 km buffer and wetland combined ▪ Pre-clearing regional ecosystems (RE) with cover type ▪ Current remnant REs ▪ National Forest and Sparse Woody Vegetation (NFSWV) ▪ Land use mapping ▪ Most recent aerial image
2	> 0 – 10%	
3	> 10 – 35%	
4	> 35 – 65%	
5	> 65 – 100%	

Area of interest (AOI):  5 km buffer and wetland combined, excluding ocean and estuaries

Method overview: Determine the percentage of native vegetation within the AOI that has been cleared. P20 cleared vegetation includes areas that are:

Not mapped as remnant in the current RE data AND EITHER:

☑ **Historically woody but currently non-woody**
Woody cover type* in the pre-clearing† RE mapping AND not woody in the latest National Forest and Sparse Woody Vegetation (NFSWV) mapping OR

☑ **Agriculture, plantations, urban residential areas**
Production from agriculture and plantations or urban residential in the land use mapping.

* Woody cover type includes woody structural formation classes, described in the methodology for Survey and Mapping of Regional Ecosystems (Neldner et al., 2020), with projective foliage cover of 10% or over.
† Pre-clearing regional ecosystem is defined as regional ecosystem present before clearing. While this roughly equates to 'pre-European', the Queensland Herbarium uses the term 'pre-clearing' because ecosystem boundaries are dynamic and no consistent imagery for the state exists prior to the early 1960s so therefore it is difficult to map 'pre-European' extent with any certainty.

Evidence: Retain the AOI P20 spatial data, including any corrections made. Retain a table of the total P20 cleared area and AOI area. Record the percentage area identified as P20 native vegetation cleared used for allocating the score class as a summary of the evidence.

Detailed methods:

The National Forest and Sparse Woody Vegetation (NFSWV) and pre-clearing RE datasets must be prepared as per instructions on pages 13 to 15.

Step 1: Data processing – prepare dataset of areas that are non-remnant

a. Clip the current RE data to the 5km buffer and wetland combined (clip tool in ArcGIS).

b. Using a GIS application, extract areas that are not remnant from the current RE data, using query RE includes the values ('non-rem', 'water', 'canal', 'plantation').

Step 2: Data processing – prepare a dataset of historically woody areas that are currently non-woody

a. Clip pre-clearing RE data with cover type to the 5km buffer and wetland combined.

b. Extract historically woody from pre-clearing RE using query: Dominant_ Cover_Type = 'historically woody'.

c. Extract non-forest cover from the NFSWV, using the query gridcode is not equal to 2.

d. Intersect the output from (a) and (b) to give historically woody areas that are currently non-woody.

Step 3: Data processing – prepare the agriculture, plantations, urban residential areas

a. Clip land use to the 5km buffer and wetland combined.

b. Using a GIS application, extract agriculture, plantations and urban residential areas from Queensland land use data, using the query: PRIMARY includes the values ('Production from dryland agriculture and plantations', 'Production from irrigated agriculture and plantations ') or TERTIARY = 'Urban residential'.

Step 4: Data processing – prepare the P20 cleared dataset for calculations

a. Overlay the three outputs from steps 1–3 (union tool in ArcGIS).

b. Remove ocean and estuary areas from the P20 cleared dataset:
Filter the current RE dataset where RE includes 'ocean', 'estuary', 'shallow' and erase these areas from the P20 cleared dataset.

c. Add a field for the AOI P20 cleared status.

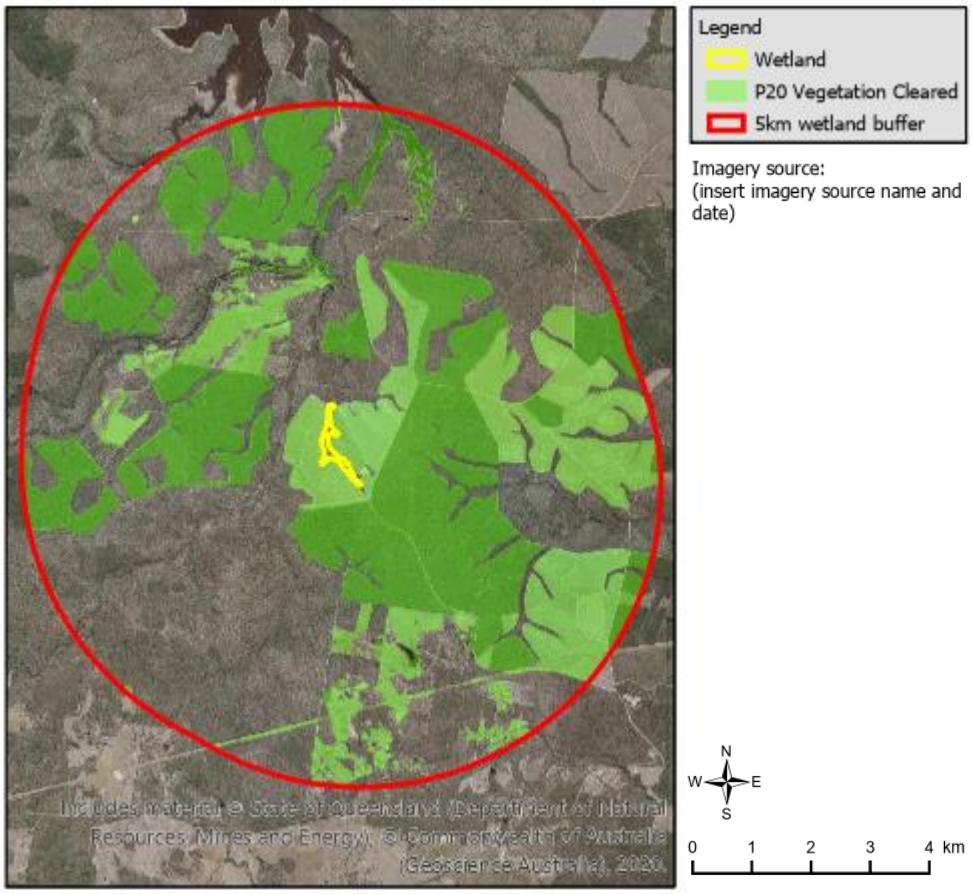
d. Select cleared areas:
Select records using query: RE includes the values ('non-rem', 'water', 'canal', 'plantation') and ((Dominant_ Cover_Type = 'historically woody' AND gridcode <> 2) or PRIMARY includes the values ('Production from dryland agriculture and plantations', 'Production from irrigated agriculture and plantations ') or TERTIARY = 'Urban residential' or RE IN ('water', 'canal')).

e. Enter attribute to identify P20 cleared areas:
Calculate for selected records P20 status = 'P20 cleared' (calculate field tool in ArcGIS).

Step 5: Visually check data against aerial imagery and correct if required

a. Use the latest aerial imagery to identify any additional areas of clearing not identified from the National Forest and Sparse Woody Vegetation (NFSWV) and remnant RE datasets. Exclude cleared patches less than 0.25 hectares and minor road clearings where the remaining area of interest is entirely native vegetation. These small amounts of clearing are likely to have minor impact on landscape connections and excluding them helps to maintain consistency in scoring where there is variation in imagery resolution and source mapping scales.

Example visualisation:
Note: data should be checked within the GIS app. Map export is not required.



b. If any modifications are required, create a new dataset and add polygons covering the extent of any modifications. Note correction evidence in the attribute table. Intersect this modifications dataset with the P20 dataset (identity tool in ArcGIS) to create an updated P20 dataset. Update the P20 status field appropriately based on corrections (i.e. 'P20 cleared' or null).

Step 6: Data processing - calculate the area percentage of P20 cleared and allocate score class

An example of the calculations is given below the detailed instructions.

a. Calculate the sum of the total area from the P20 dataset (summary statistics tool in ArcGIS).
b. Select by attribute P20 status where status = 'P20 cleared' and calculate the sum of the areas (summary statistics tool in ArcGIS).
c. Divide the answer of step 6b by the answer of 6a and multiply by 100 to give percentage of P20 cleared.
d. Allocate a score class by matching the percentage of P20 vegetation to the appropriate score class range.

Example of score class calculation:

P20	Area (ha)	Percentage
Area identified as P20 vegetation cleared	3858.95	40.52 (score class = 4)
Total AOI	**9523.63**	

P21: Loss of wetland regional ecosystems within 5 km of the wetland

Score class	Description	Desktop information
1	0% of wetland regional ecosystem area lost within AOI.	▪ 5km buffer and wetland combined ▪ Regional ecosystems (RE) mapping – pre-clearing with cover type and current remnant ▪ REDD
2	> 0 – 10%	
3	> 10 – 50%	
4	> 50 – 99%	
5	> 99%	

Area of interest (AOI):  5 km buffer and wetland combined

Method overview: Use the REDD table to identify the palustrine, lacustrine, riverine and estuarine REs in the current remnant and pre-clearing* datasets and calculate the total wetland RE area. Calculate the total wetland RE area within each polygon based on the percentages of each RE within the polygon by the total polygon area (RE polygons can be heterogeneous and contain up to 5 different REs). Divide the total remnant wetland RE area by the total pre-clearing wetland RE area, then subtract that value from 1 and multiply by 100 to calculate the percentage lost.

* Pre-clearing regional ecosystem is defined as regional ecosystem present before clearing. While this roughly equates to 'pre-European', the Queensland Herbarium uses the term 'pre-clearing' because ecosystem boundaries are dynamic and no consistent imagery for the state exists prior to the early 1960s so therefore it is difficult to map 'pre-European' extent with any certainty.

Evidence: Retain the AOI pre-clearing and remnant RE areas spatial dataset with wetland code attribution. Retain a table of the total pre-clearing RE area and remnant wetland RE area. Record the percentage reduction of wetland RE used for allocating the score class as a summary of the evidence.

Detailed methods:

Step 1: Data processing – prepare the AOI pre-clearing RE and current RE datasets

a. Prepare RE datasets for storing required attributes:
   Use the pre-clearing and current RE datasets that have been previously clipped to the 5 km buffer and wetland combined (as described for indicator P20) and add the following fields in the attribute tables:
   a. Area_ha double field (polygon area)
   b. Wet1, Wet2, Wet3, Wet4 and Wet5 text fields (wetland codes)
   c. <RE/PC>AreaHa1, <RE/PC>AreaHa2, <RE/PC>AreaHa3, <RE/PC>AreaHa4, <RE/PC>AreaHa5 double fields, use 'RE' for Current REs and 'PC' for Pre-clearing REs (percentage area of RE within polygon)

b. Filter the REDD table to include only palustrine, lacustrine, riverine and estuarine REs:
   Apply a query definition to filter the REDD table wetland_code to include values 'E', 'L', 'P', 'P/L', 'R'.

c. Join information from the filtered REDD table:
   In the attribute table of current RE mapping, join the filtered REDD table to the attribute table, using the RE1 field from the current RE attribute table and the RE field from the REDD table.

d. Insert the wetland code for the RE:
   Calculate the Wet1 field to equal the wetland_code field from the joined table.

e. Calculate proportional areas for palustrine, lacustrine, riverine and estuarine REs:
   Create a new selection where Wet1 is not null and calculate the REAreaHa1 field to equal the PC1 field divided by 100 and multiplied by shape area (sq m) divided by 10,000.

f. Enter a zero value for area where the polygon includes no palustrine, lacustrine, riverine and estuarine REs:
   In the attribute table of current RE mapping, select records where Area_ha is null and enter zero.

g. Repeat steps 1c to 1f for the remaining RE numbered fields, i.e., RE2 & REAreaHa2; RE3 & REAreaHa3; RE4 & REAreaHa4; and RE5 & REAreaHa5.

h. Sum the proportional areas to get the total wetland RE area for each polygon:
   Calculate the Area_ha field to equal REAreaHa1 + REAreaHa2 + REAreaHa3 + REAreaHa4 + REAreaHa5.

i. Find the total wetland RE area for the AOI:
   Use a summary statistics tool to sum the Area_ha field.

j. Repeat steps 1c to 1i for the pre-clearing RE data.

Step 2: Data processing – calculate the percentage area and allocate score class

An example of the calculations is given below the detailed instructions.

a. Find the total remnant wetland RE left in the AOI as a proportion of the total pre-clearing wetland RE in the AOI:
   Divide the result from step 1i for remnant RE by the result from step 1i for pre-clearing RE.

b. Find the percentage of wetland RE lost
   Subtract the answer to step 2a and multiply by 100.

c. Allocate a score class by matching the resulting percentage to the appropriate score class range.

Example of score class calculations:

P21	Area (ha)
Total remnant wetland RE	506.10
Total pre-clearing wetland RE	1452.50
% lost wetland RE, i.e., (1-(506.10/1452.50))*100	43.76 (score class = 3)

S12: QWP hydrological modifier code for the mapped wetland

Score class	Description	Desktop information
1	QWP code indicating no discernible earthworks in the wetland influencing the water regime: **H1** –no local hydrological modification observed	▪ Mapped wetland ▪ Local hydrology disturbance modifier code ▪ Most recent aerial image
3	QWP codes indicative of at least a moderately altered water regime, including: **H2M2a** –bunding has raised and stabilised water levels **H2M2c** – excavation within wetland (excluding gravel and sand extraction and excavation causing conversion to tidal) **H2M2d** – constructed drains partially remove water by gravity (note: complete removal of water is classified as a loss of wetland) **H2M5** – there is cropping or cultivation (not irrigated) where the inundation/saturation regime still meets the wetland definition	
4	QWP code indicative of broader-scale surface water regulation that has altered wetland water regime: **H2M8** – palustrine/lacustrine wetlands with no obvious structures but where the local hydrology is altered by irrigation activity (i.e., pumping, use as water storage or balancing area)	
5	QWP codes indicative of a changed wetland system (including from palustrine to lacustrine, or from palustrine/lacustrine to a regulated water supply channel or to tidal): **H2M2e, H2M2f, H2M6a** and **H2M7**	

Area of interest (AOI): Wetland only

Method overview: Use the local hydrology modifier (hydromod) code from the wetland mapping (Queensland Department of Environment and Science, 2019b). The QWP codes described in the score table above are sourced from version 5 of the data series. The desktop assessment score for this indicator requires field verification.

Evidence: Retain the wetland area spatial dataset. Record the local hydrology modifier code as a summary of the evidence.

Detailed methods:

Step 1: Visually check against aerial imagery (pre field assessment)

a. Check for hydrological modification features using most recent aerial imagery.
b. Note any features that are or could be inconsistent with the hydromod code for investigation during the field assessment, including location of features in question. These notes should be inserted on the *A3 field map* – refer to the earlier section on preparing fieldwork resources.

Step 2: Data processing – allocate score class (pre field assessment)

a. Use the wetland's local hydrology modifier (hydromod) code to allocate a score class based on the descriptions above. This code can be found in the hydromod field of the wetland mapping attribute table.

Step 3: Ground truthing (field assessment)

a. Refer to *Wetland Tracker Field Methods Guide*.

S13: Landscape vegetation connectivity

Score class	Description	Desktop information
1	> 95 – 100 (wetland connectivity score)	▪ Mapped wetland ▪ Connectivity index
2	> 85 – 95	
3	> 75 – 85	
4	> 65 – 75	
5	≤ 65	

Area of interest (AOI): Wetland only*

* The mapped wetland is the AOI for the connectivity index data. Every pixel within the connectivity index data assesses connectivity at multiple scales across the landscape.

Method overview: Determine the area-weighted mean connectivity score per ha for the wetland.
The connectivity index dataset uses the Australian connectivity index method (Australian Department of the Environment 2014) to give a connectivity score for each 100 m pixel (1 ha) across GBR catchments.

Evidence: Retain the AOI connectivity spatial dataset. Record the wetland connectivity score used for allocating the score class as a summary of the evidence.

Detailed methods:
The connectivity dataset must be prepared as per instructions on pages 12 and 13.

1. Clip the connectivity polygon dataset to the AOI.
2. Find proportion of each polygon within the wetland:
   Add a field to the AOI connectivity dataset attribute table and calculate the area (of each polygon) divided by the AOI area.
3. Find area-weighted connectivity index values:
   Add a field to the AOI connectivity dataset attribute table and calculate the proportion multiplied by connectivity index value.
4. Calculate the wetland's mean connectivity score per ha:
   Sum the area-weighted connectivity index values calculated in the previous step.
5. Allocate a score class by matching the wetland's connectivity score to the appropriate score class range

S14: Native vegetation in the 200 m buffer

Score class	Description	Desktop information
1	> 65 – 100% of the AOI contains native vegetation with an FPC* within the range expected for the pre-clearing RE† type.	▪ 200m buffer only ▪ Pre-clearing regional ecosystems (RE) with expected FPC ranges ▪ Current remnant REs ▪ Foliage projective cover (FPC) ▪ Exotic vegetation (if captured from previous assessments) ▪ Most recent aerial image
2	> 35 – 65%	
3	> 10 – 35%	
4	> 0 – 10%	
5	0% native vegetation with an FPC within the range expected for the pre-clearing RE type* (200 m buffer cleared or dominated by exotic vegetation)	

Area of interest (AOI): 200m buffer only, excluding ocean and estuaries

Method overview: Determine the percentage of native vegetation within the AOI. S14 native vegetation includes areas that are:

- ☑ **Woody native vegetation with an FPC* within the expected historic range** i.e. woody in the pre-clearing † RE mapping and the latest FPC value is within the FPC range for the structural formation type of the pre-clear RE
- ☑ **Non-woody native vegetation**, i.e. non-woody in the pre-clearing RE mapping and currently non-woody

The desktop assessment score for this indicator requires field verification.

* The FPC range for the structural formation type is described in the methodology for Survey and Mapping of Regional Ecosystems (Neldner et al., 2020).

† Pre-clearing regional ecosystem is defined as regional ecosystem present before clearing. While this roughly equates to 'pre-European', the Queensland Herbarium uses the term 'pre-clearing' because ecosystem boundaries are dynamic and no consistent imagery for the state exists prior to the early 1960s so therefore it is difficult to map 'pre-European' extent with any certainty.

Evidence: Retain the prepared AOI spatial datasets: (1) pre-clearing RE with FPC ranges; (2) current FPC; (3) native cleared or exotic vegetation; and (4) S14 status, including updates and details of any corrections following desktop and field checks. After the field assessment save a scanned copy of annotated field maps: (1) current FPC classes; and (2) native, cleared or exotic vegetation. Retain a table of total S14 native vegetation area and AOI area. Record the S14 percentage area used for allocating the score class as a summary of the evidence.

Detailed methods:
FPC spatial dataset and pre-clearing RE data must be prepared as per instructions on page 13 to 15.

Steps 1 & 2: Data processing – prepare and verify the current FPC datasets and native, cleared or exotic vegetation datasets (pre field assessment)

These steps are completed during the processing for indicator P2. Refer to P2 indicator methods steps 1–2 for details.

Step 3: Data processing – Prepare the S14 native vegetation data (pre field assessment)

a. Prepare the P2/S14 status dataset for calculations of areas of modified or exotic vegetation:
Add an attribute to identify S14 native vegetation data, classifying by querying the attribute fields based on the following criteria:
S14 native vegetation – current FPC range falls within pre-clearing RE FPC range.

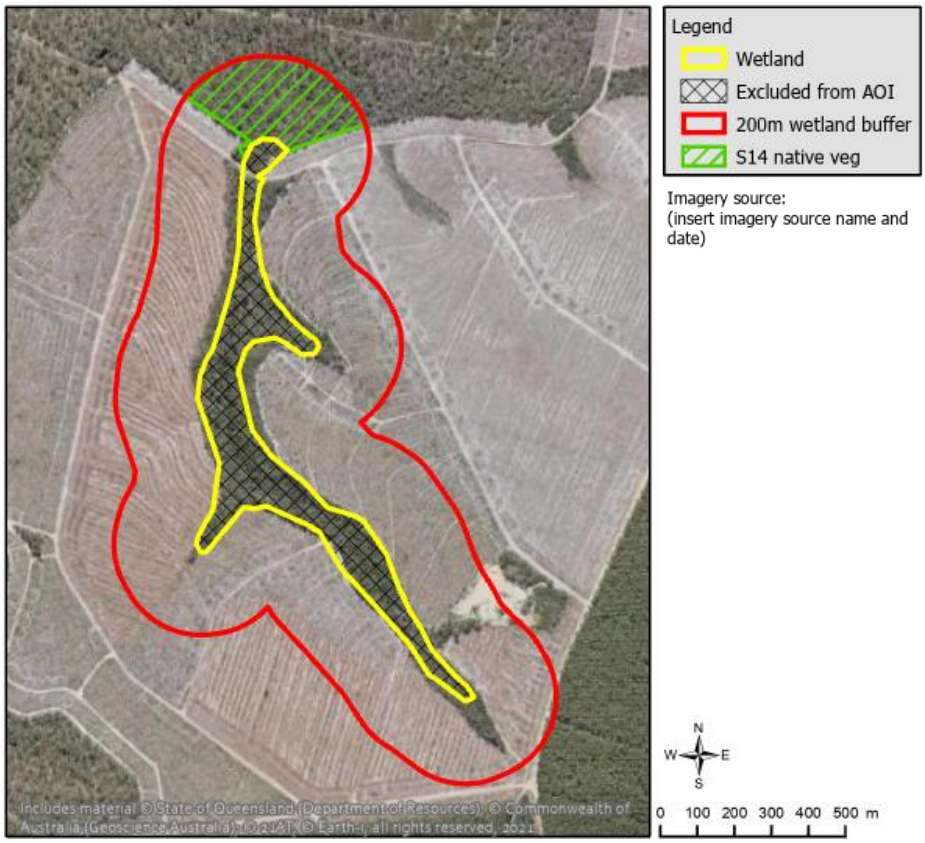
Step 4: Visually check areas classed as S14 native vegetation data against aerial imagery (pre field assessment)

a. If any areas within the AOI do not appear to be correctly classified as S14 native vegetation, check and compare with historic imagery and the remnant vegetation status to help investigate any possible changes to the vegetation. Check the P2/S14 status attributes to compare the RE (historic) FPC in relation to the SLATS (current) FPC.

b. Note areas that warrant further investigation if feasible during the field assessment. These notes should be added to the current FPC field map or native cleared or exotic vegetation field map produced in step 6 of the P2 indicator method. Clearly specify the following details and actions:
   i. Location and pre-clear RE code
   ii. The expected pre-clear FPC range
   iii. Action
   Recommend spot checks to access the accuracy of the current FPC in the area warranting further investigation. If the current FPC is higher than the expected pre-clear FPC, recommend checking for signs of past fires and considering if this could it be due to fire regime.

Example visualisation:

S14 native vegetation in the 200m buffer



Step 5: Data processing – calculate percentage area and allocate score class (pre field assessment)

An example of the calculations is given below the detailed instructions.

a. Calculate the total area of the AOI (summary statistics tool in ArcGIS).
b. Calculate the sum S14 native vegetation areas (summary statistics tool in ArcGIS).
c. Calculate the percentage of areas of S14 native vegetation within the AOI:
   Divide the answer of step 5b by the answer of step 5a and multiply by 100.
d. Allocate a score class by matching the percentage of areas of S14 native vegetation with the appropriate score class range.

Example of score class calculation:

S14 area	**Area (ha) within total AOI**	**Area %**
Area % of S14 native vegetation (current FPC is within expected range)	6.37	7.21
Total AOI (200 m buffer excluding mapped wetland and any ocean/estuary)	**88.40**	

S14 native vegetation is 7.21% (within >0–10% area range), which gives a score class of 4.

Step 6: Prepare field maps (pre field assessment)

This step is completed during the processing for indicator P1. Refer to P1 indicator methods step 6 for details.

Step 7: Ground truthing (field assessment)

Ground truth the current *FPC map* and 'native, cleared or exotic vegetation' map, as described in the *Wetland Tracker Field Methods Guide*

Step 8: Correct if errors were detected (post field assessment)

a. If FPC and exotic vegetation mapping corrections are required these are completed during the processing for indicator P2. Refer to step 8 of P2 methods for details.
b. If any corrections were made, re-run data processing step 3 and step 5.
c. If corrections have been made to the P2/S14 status dataset only, re-run step 5.
d. If areas warranted further investigation but were unable to be verified, reduce the confidence rating and note details in the confidence evidence. Refer to later section on rating confidence in indicator scores.

S15: Modified and artificial wetlands

Score class	Description	Desktop information
1	0 – 10% of the perimeter of wetlands within the AOI is composed of modified and artificial wetlands	▪ 1 km buffer only ▪ Wetland areas ▪ Reservoirs ▪ Canal lines ▪ Irrigation distribution infrastructure ▪ Most recent aerial image
2	>10 – 30%	
3	>30 – 55%	
4	>55 – 80%	
5	>80 – 100%	

Area of interest (AOI):  1 km buffer only

Method overview: Determine the total perimeter of modified and artificial wetlands within the AOI as a percentage of the total perimeter of all wetlands. Wetlands are categorised as modified, artificial or no local hydrological modification, using the data summarised in the table below.

Wetland type	Description	Data source
Modified	Earthworks in the wetland, such as bunding, excavation or drains	Features from the wetland areas dataset with a H2 modifier code*
Artificial	Constructed water storages, channels or drains	Features from the following datasets: • wetland areas with a H3 modifier code • reservoirs • canal lines • irrigation distribution infrastructure (channels and drains)
No local modification	No discernible earthworks in wetland	Features from the wetland areas dataset with a H1 modifier code (no local hydrological modification)

* Hydrological modifier codes describe different types of structures and activities within a wetland that modify its natural hydrological cycle (e.g. bunds, partial drainage, excavation, pumping for irrigation) (Queensland Environmental Protection Agency, 2005, Queensland Department of Environment and Science, 2019b).

Evidence: Retain the AOI S15 spatial dataset. Retain a table of the total perimeters of (1) modified and artificial wetlands and (2) all wetlands with the AOI. Record the calculated percentage value used for allocating the score class as a summary of the evidence.

Detailed methods:

Step 1: Data processing – prepare the AOI S15 dataset

a. In GIS, remove reservoirs that intersect H2 or H3 hydromod code features in the wetland areas mapping to avoid double counting.
b. Create areas from the mapped lines:
    i. Buffer the canals and irrigation distribution polyline datasets by 1m.
c. Merge the reservoirs, canals, irrigation distribution and wetland area datasets.
d. Clip all wetlands to the AOI.
e. Add a field to the AOI S15 to identify artificial and modified wetlands.
    - modified or artificial – reservoirs, canals, irrigation distribution, hydromod codes from wetland areas mapping starting with 'H2' or 'H3'
    - no local modification – H1 hydromod codes from wetland areas mapping

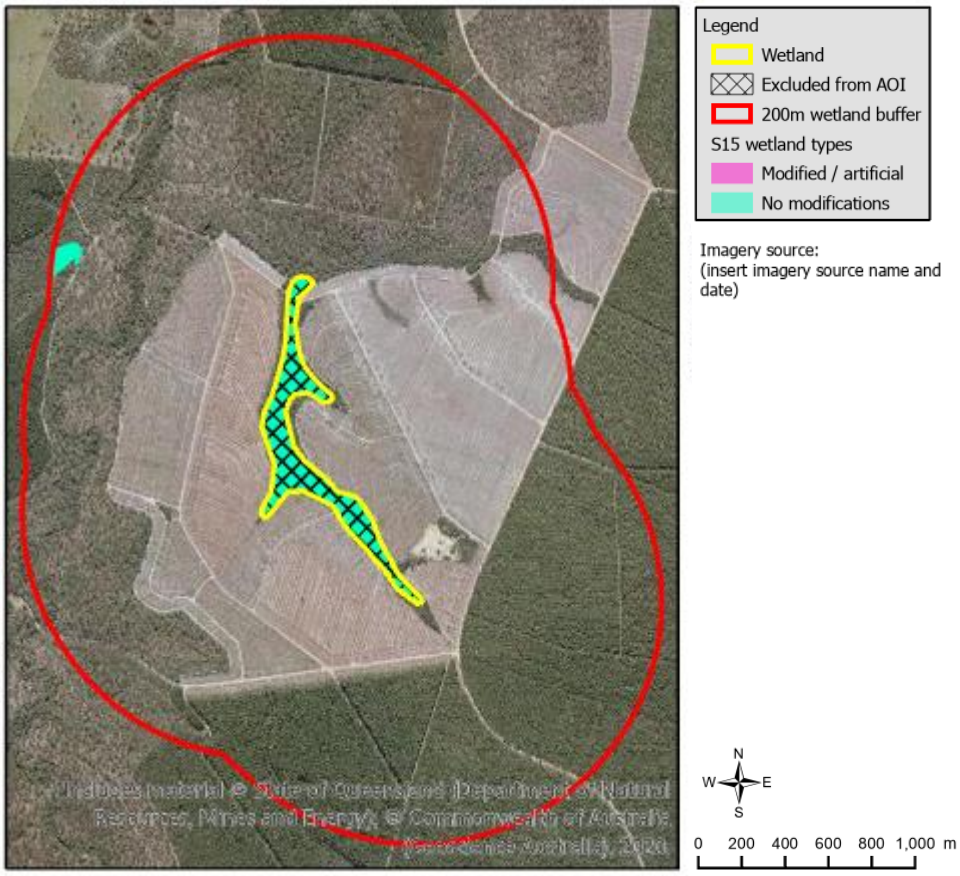
Step 2: Visually check data against aerial imagery and correct if required

a. View and compare all wetlands with aerial imagery and other spatial data:
Display the wetland polygons and label/symbolise to display modified/artificial or no modifications categories. Visually verify against the most recent aerial image and historic imagery that the wetlands are mapped and categorised correctly. Check for earthworks such as bunding, excavation or drains in the wetlands that can be

clearly observed in imagery. Also check that features, such as irrigation channels, are not duplicated (i.e., from more than one data source). Note: reservoirs are only included if greater than 625 sq m at full supply level.

Example visualisation:
Note: data should be checked within the GIS app. Map export is not required.

Modified and artificial wetlands



b. If there is strong evidence that data is in error, correct the polygon or attribute in the AOI S15 dataset. Add a new 'Correction Evidence' field and detail evidence that supports the correction, including information source and date. Note if boundary has been changed and describe location.

Step 3: Calculate and allocate score class

An example of the calculations is given below the detailed instructions.

a. Calculate the total perimeter (shape length) of artificial or modified wetlands as a percentage of the total perimeter of all wetlands.
b. Allocate a score class by matching the answer to step 3a to the appropriate score class range.

Example calculation:

S15	Length (m)	Percentage
Perimeter of artificial or modified wetlands	0	0 (score class = 1)
Total perimeter of all wetlands	**524.31**	

S16: Altered surface flow due to linear transport infrastructure

Score class	Description	Desktop information
1	≤ 1.04 (sum of transport class lengths (m) per ha with weightings applied)	▪ 1 km buffer and wetland combined ▪ Roads and tracks ▪ Railways ▪ Most recent aerial image
2	> 1.04 – 3.81	
3	> 3.81 – 8.84	
4	> 8.84 – 19.23	
5	> 19.23	

Area of interest (AOI):  1 km buffer and wetland combined

Method overview: Determine the length (m) of each transport class within the AOI divided by the AOI area (ha) and then multiply by the associated weightings detailed in the table below.

Transport class	Data source attribute criteria	Weighting
Railway	Status: Operational Gauge: is not light	1.00
Light railway	Status: Operational Gauge: is light	0.25
Freeways/motorways	Road type code: 1 (freeways/motorways)	1.00
Major roads	Road type codes: 2 (highways); 3 (secondary roads); 4 (local connector roads); 8 (malls); 13 (busways)	0.50
Local roads	Road type code: 5 (street/local)	0.25
Major tracks*	To be identified from the most recent aerial imagery	0.25

* Major tracks are defined as unpaved and bladed.

Evidence: Retain the AOI S15 spatial dataset. Retain a summary table of transport class breakdown with total length and proportional, weighted scoring values. Record the calculated (sum of transport class lengths (m) per ha with weightings applied) value used for allocating the score class as a summary of the evidence.

Detailed methods:

Step 1: Data processing – prepare the AOI S16 linear transport infrastructure dataset

a. Clip the roads and tracks dataset and the railways dataset to the AOI.

b. Merge the roads and tracks dataset and the railways dataset.

c. Add a field for transport classes and categorise using the criteria from the table in the above method overview.

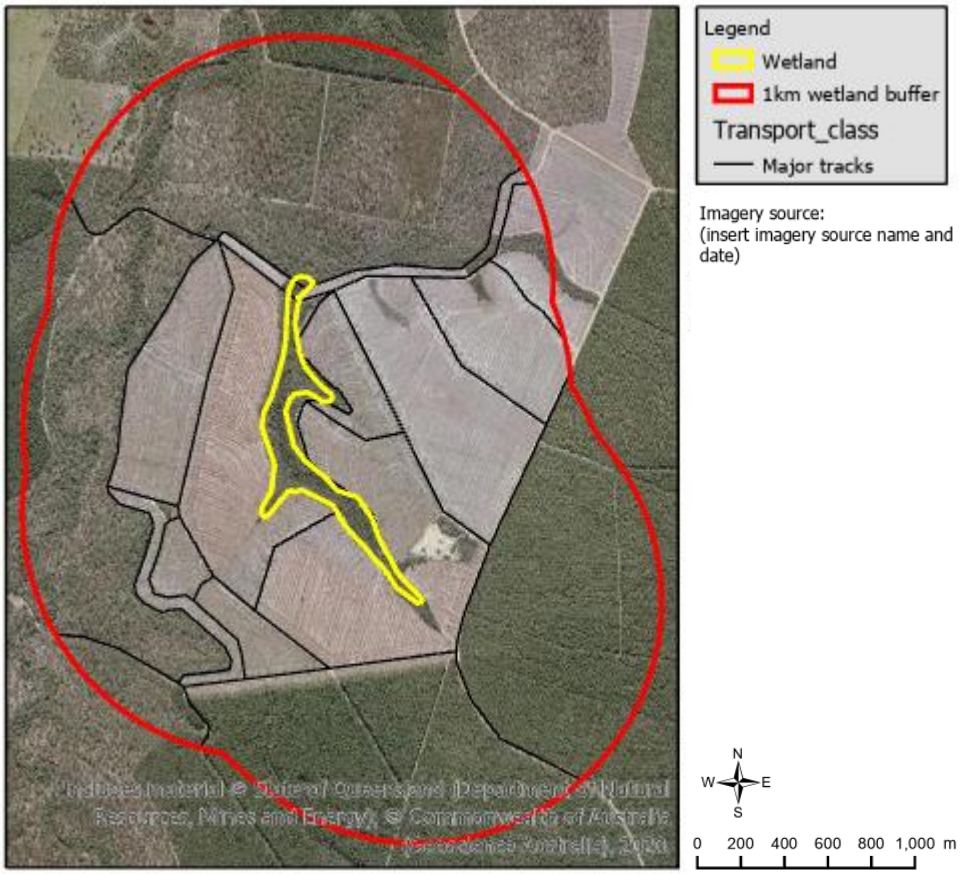
Step 2: Visually check data against aerial imagery and correct if required

a. View and compare AOI S16 linear transport infrastructure data with aerial imagery and other spatial data: Display the mapping and label/symbolise with the transport class attribute. Visually check against the most recent aerial imagery to verify the features are mapped and assigned to the appropriate transport class. Checking against Queensland basemap topographic and foundation data may also assist in detecting or verifying any inaccuracies.

b. Identify any major (unpaved and bladed) tracks, which should be included in the dataset and add this to the mapping with the appropriate attribute for transport class. Note: these lines may already be included in the mapping but attributed as another road type, such as 4WD and Tracks, in which case simply update the transport class attribute value.

Example visualisation:
Note: data should be checked within the GIS app. Map export is not required.

Linear transport infrastructure



c. If any mapping errors were detected from ground truthing, update the AOI S16 linear transport infrastructure dataset lines and/or transport class attribute field. To update transport classes, add a new 'Correction Evidence' field and detail evidence that supports the correction, including information source and date.

Step 3: Data processing - Calculate and allocate score class

An example of the calculations is given below the detailed instructions.

a. Determine transport class lengths per AOI area (m/ha):
   i. Calculate the length (m) of each transport class within the S16 dataset (summary statistics tool in ArcGIS).
   ii. Calculate the AOI area (ha) (summary statistics tool in ArcGIS).
   iii. Add a field in the summary table of transport classes (created in the step i) and insert m/ha for each transport class by dividing the lengths (from step i) by the AOI area (from step ii).

b. Determine the transport class lengths (m) per ha with weightings applied:
   i. Add a field in the summary table of transport classes (created in step 3a) and insert the transport class weightings described in the table from the methods overview above.
   ii. Add a field in the summary table of transport classes (created in step 3a) and multiply the transport class lengths (m) per ha value (from step 3a) by the transport class weighting.

c. Sum the transport class lengths (m) per ha with weightings applied:
   Calculate the sum of the values obtained for each transport class in step 3b.

d. Allocate a score class:
   Match the result of the step 3c to the appropriate score class range.

Example of score class calculation:

S16 transport classes	Length (m)	AOI area (ha)	Weighting	Value
Major tracks	22,390	675.21	0.25	8.29
Total	22,390			8.29 (score class = 3)

Rating confidence in indicator scores

To assess confidence in indicator scores, the following mapping criteria should be met:

1. The most up to date information available is to be used.
2. Use time series data with temporal resolution that allows the detection of change.
3. Data must have good spatial coverage and replication across the program area, which allows detection of change. Data from different locations must be comparable.
4. High quality data is collected according to international, national or state recommended protocols.
5. Strict quality assurance and quality control measures are in place.

The general approach to data quality assurance and quality control is to compare the mapping data relevant for each indicator with the *best quality most recent* aerial imagery and, for some indicators, data is also ground-truthed. Detected errors are corrected where needed.

Confidence ratings depend on clarity and currency of the aerial imagery. Ratings may also depend on whether verification has judged the data accurate or whether there is a level of uncertainty that affects which score class is appropriate, despite good clarity and currency of the aerial imagery. For mapping data that is ground-truthed, the confidence rating is reassessed. Note: the confidence rating relates to certainty in the score class allocation and not necessarily in the certainty of the mapping data. For example, with indicator P1, if there is a large proportion of the AOI which has been identified as cropping but you are uncertain if this is irrigated or dryland, the confidence in the score class may remain very high because the pressure score is the same for both land use classes. Detailed information for rating confidence is provided below.

For all indicators

Make a note in the appropriate data field of which aspect caused reduction in confidence rating. (e.g. *'Imagery is 4 years old. Aerial imagery impacted by cloud cover. Uncertainty in mapping data to such an extent that either score class 2 or 3 may be applicable.'*)

Refer to the table immediately below for further confidence rating instructions.

Table 9 Assessor confidence scoring instructions by indicator.

Indicator	Instructions for confidence scoring	
P1, P3, P4, P10, P14, P16, P20, P21, S12, S15, S16	Go to table 10a. Judge uncertainty of accuracy of data first to determine which matrix is relevant (i.e. i, ii, iii or iv) and then assess clarity of image against age of imagery in the matrix.	
P2, S12 and S14	Is the available aerial imagery more recent than the last field trip or is this the first assessment?	If yes, go to table 10a
	Is the available imagery older than the last field trip?	If yes, go to table 10b
S13	Go to table 10c	
P5	Go to table 10d. Judge uncertainty of accuracy of data first to determine which matrix is relevant (i.e. i, ii, iii or iv) and then assess clarity of image against age of imagery in the matrix.	

Table 10a Matrices for determining confidence ratings for indicators P1, P3, P4, P10, P14, P16, P20, P21, S12, S15 and S16. Also for P2, S12and S14, unless directed to table 10b.

i). **The mapping data is judged accurate when compared with the aerial imagery** (irrespective of mapping data age or whether visual interpretation was required to rectify errors): Conf ≥ 1

	Age of imagery			
Clarity of imagery	≤2 yo	>2 yo	≥5 yo	≥10 yo
Clear and in focus, no clouds no shadows	1	2	3	4
Cloud cover/shadow >0% to ≤5% AOI	2	2	3	4
Blurred (e.g. difficult to discern a tree from its shadow)	3	3	3	4
Cloud cover/shadow >5% to ≤10% AOI	3	3	3	4
Very blurry	4	4	4	4
Cloud cover/shadow >10% AOI	4	4	4	4

ii). **There is some minor uncertainty in the accuracy of the mapping data, which could affect the certainty of the score class applied but there is evidence to support the final choice.** (irrespective of mapping data age): Conf ≥ 2

	Age of imagery			
Clarity of imagery	≤2 yo	>2 yo	≥5 yo	≥10 yo
Clear and in focus, no clouds no shadows	2	2	3	4
Cloud cover/shadow >0% to ≤5% AOI	2	2	3	4
Blurred (e.g. difficult to discern a tree from its shadow)	3	3	3	4
Cloud cover/shadow >5% to ≤10% AOI	3	3	3	4
Very blurry	4	4	4	4
Cloud cover/shadow >10% AOI	4	4	4	4

iii). **There is moderate uncertainty in the accuracy of the mapping data, which affects the certainty of the score class applied such that two score classes could be potentially applicable** (irrespective of mapping data age): Conf. ≥ 3

	Age of imagery			
Clarity of imagery	≤2 yo	>2 yo	≥5 yo	≥10 yo
Clear and in focus, no clouds no shadows	3	3	3	4
Cloud cover/shadow >0% to ≤5% AOI	3	3	3	4
Blurred (e.g. difficult to discern a tree from its shadow)	3	3	3	4
Cloud cover/shadow >5% to ≤10% AOI	3	3	3	4
Very blurry	4	4	4	4
Cloud cover/shadow >10% AOI	4	4	4	4

iv). **There is substantial uncertainty in the accuracy of the mapping data, which affects the certainty of the score class applied such that three or more score classes appear potentially applicable.** (irrespective of mapping data age): Conf. = 4

	Age of imagery			
Clarity of imagery	≤2 yo	>2 yo	≥5 yo	≥10 yo
Clear and in focus, no clouds no shadows	4	4	4	4
Cloud cover/shadow >0% to ≤5% AOI	4	4	4	4
Blurred (e.g. difficult to discern a tree from its shadow)	4	4	4	4
Cloud cover/shadow >5% to ≤10% AOI	4	4	4	4
Very blurry	4	4	4	4
Cloud cover/shadow >10% AOI	4	4	4	4

The following examples relate to indicators P1, P3, P4, P10, P14, P16, P20, P21, S12, S15, S16, P2, S12 and S14 (look-up Table 10a).

The confidence rating is the *worst* rating which supports a statement relating to the indicator in question. For example:

- If there is substantial uncertainty in the accuracy of the mapping data to such an extent that three or more score classes appear potentially applicable (rating 4), the imagery is 3 years old (rating 2) and clear and in focus (rating 1) and then the final confidence rating is 4.
- If the mapping data is judged accurate (rating 1), the imagery is 6 years old (rating 3) and has cloud cover impacting 8% of the AOI (rating 2) then the final confidence rating is 3.
- If there is some minor uncertainty in the accuracy of the mapping data (rating 2), the imagery is 1 year old (rating 1) and clear and in focus (rating 1) then the final confidence rating is 2.
- If the mapping data is judged accurate (rating 1), the imagery is 1 year old (rating 1) and blurred (rating 3) then the final confidence rating is 3.

For field verified indicators *P2, S12 and S14* there is an additional component to the confidence rating process relating to how long it has been since a field assessment was completed and whether any change has been detected (look-up Table 10b may be needed).

Table 10b Determining confidence rating for indicators P2, S12 and S14 if available imagery is older than the last field trip.

For field verified indicators where aerial imagery is older than the last field trip, use the classes below to obtain confidence rating (if imagery is more recent than the last field trip, use look-up table 9a).			
Mapping data evidence for indicator does not appear to have changed since previous field verification (no matter how long ago that was).	Data field verified in the last 2 years and evidence for indicator score does appear to have changed enough to change the score class.	Data field verified in the last 6 years and evidence for indicator score does appear to have changed enough to change the score class	Data field verified >6 years ago and evidence for indicator score does appear to have changed enough to change the score class
1	2	3	4

Confidence rating criteria for S13 – landscape vegetation connectivity (look-up Table 10c)

Confidence rating for indicator S13 relies on the source year of the National Forest and Sparse Woody Vegetation (NFSWV) data (Table 4). Rating class breaks reflect that.

Table 10c Determining confidence rating for indicator S13

S13 confidence rating criteria			
The data source year is ≤2 yo.	The data source year is >2 yo and < 5 yo.	The data source year is ≥5 yo and <10 yo.	The data source year is ≥10 yo.
1	2	3	4

Examples for rating P5 – number of septic systems within 200 m of the wetland per hectare of mapped wetland (look-up Table 10d)

If the aerial imagery is clear and in focus but you are in an urban or peri-urban environment and do not have council mapping data, then you cannot be confident of the score (confidence rating of 4).

If you have aerial imagery that is 6 years old (Confidence rating of 3) and council sewer mapping that is 1 year old (confidence rating of 1) then overall confidence rating is 3. You need to be able to visually assess how many houses/potential septic systems are on each lot.

Table 10d Matrices for determining confidence rating for indicator P5

i). The wetland is in a remote or rural area AND evidence for indicator does not appear to have changed since previous field verification (no matter how long ago). No new or upgraded housing areas. Conf. ≥ 1.

	Age of imagery			
Clarity of imagery	≤2 yo	>2 yo	≥5 yo	≥10 yo
Clear and in focus, no clouds no shadows	1	2	3	4
Cloud cover/shadow >0% to ≤5% AOI	2	2	3	4
Blurred (e.g. difficult to discern a tree from its shadow)	3	3	3	4
Cloud cover/shadow >5% to ≤10% AOI	3	3	3	4
Very blurry	4	4	4	4
Cloud cover/shadow >10% AOI	4	4	4	4

ii). The wetland is in an urban or peri-urban area with council sewer mapping ≤2 years old AND evidence for indicator does not appear to have changed since previous field verification (no matter how long ago that was). No new or upgraded housing areas. Conf. ≥ 1.

	Age of imagery			
Clarity of imagery	≤2 yo	>2 yo	≥5 yo	≥10 yo
Clear and in focus, no clouds no shadows	1	2	3	4
Cloud cover/shadow >0% to ≤5% AOI	2	2	3	4
Blurred (e.g. difficult to discern a tree from its shadow)	3	3	3	4
Cloud cover/shadow >5% to ≤10% AOI	3	3	3	4
Very blurry	4	4	4	4
Cloud cover/shadow >10% AOI	4	4	4	4

iii). The wetland is in an urban or peri-urban area with council sewer mapping ≥2 years old OR the indicator has been field verified in the last 2 years and evidence for indicator score *does* appear to have changed enough to change the score class. Conf. ≥ 2.

	Age of imagery			
Clarity of imagery	≤2 yo	>2 yo	≥5 yo	≥10 yo
Clear and in focus, no clouds no shadows	2	2	3	4
Cloud cover/shadow >0% to ≤5% AOI	2	2	3	4
Blurred (e.g. difficult to discern a tree from its shadow)	3	3	3	4
Cloud cover/shadow >5% to ≤10% AOI	3	3	3	4
Very blurry	4	4	4	4
Cloud cover/shadow >10% AOI	4	4	4	4

iv). The wetland is located in an urban or peri-urban area with council sewer mapping ≥5 years old OR the indicator has been field verified in the last 6 years and evidence for indicator score *does* appear to have changed enough to change the score class. Conf. ≥ 3.

	Age of imagery			
Clarity of imagery	≤2 yo	>2 yo	≥5 yo	≥10 yo
Clear and in focus, no clouds no shadows	3	3	3	4
Cloud cover/shadow >0% to ≤5% AOI	3	3	3	4
Blurred (difficult to discern a tree from its shadow)	3	3	3	4
Cloud cover/shadow >5% to ≤10% AOI	3	3	3	4
Very blurry	4	4	4	4
Cloud cover/shadow >10% AOI	4	4	4	4

v). The wetland is located in an urban or peri-urban area with council sewer mapping ≥10 years old OR no council sewer mapping data is available OR the indicator has been field verified > 6 years and evidence for indicator score *does* appear to have changed enough to change the score class. Conf. = 4.

	Age of imagery			
Clarity of imagery	≤2 yo	>2 yo	≥5 yo	≥10 yo
Clear and in focus, no clouds no shadows	4	4	4	4
Cloud cover/shadow >0% to ≤5% AOI	4	4	4	4
Blurred (difficult to discern a tree from its shadow)	4	4	4	4
Cloud cover/shadow <10% AOI	4	4	4	4
Very blurry	4	4	4	4
Cloud cover/shadow >10% AOI	4	4	4	4

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