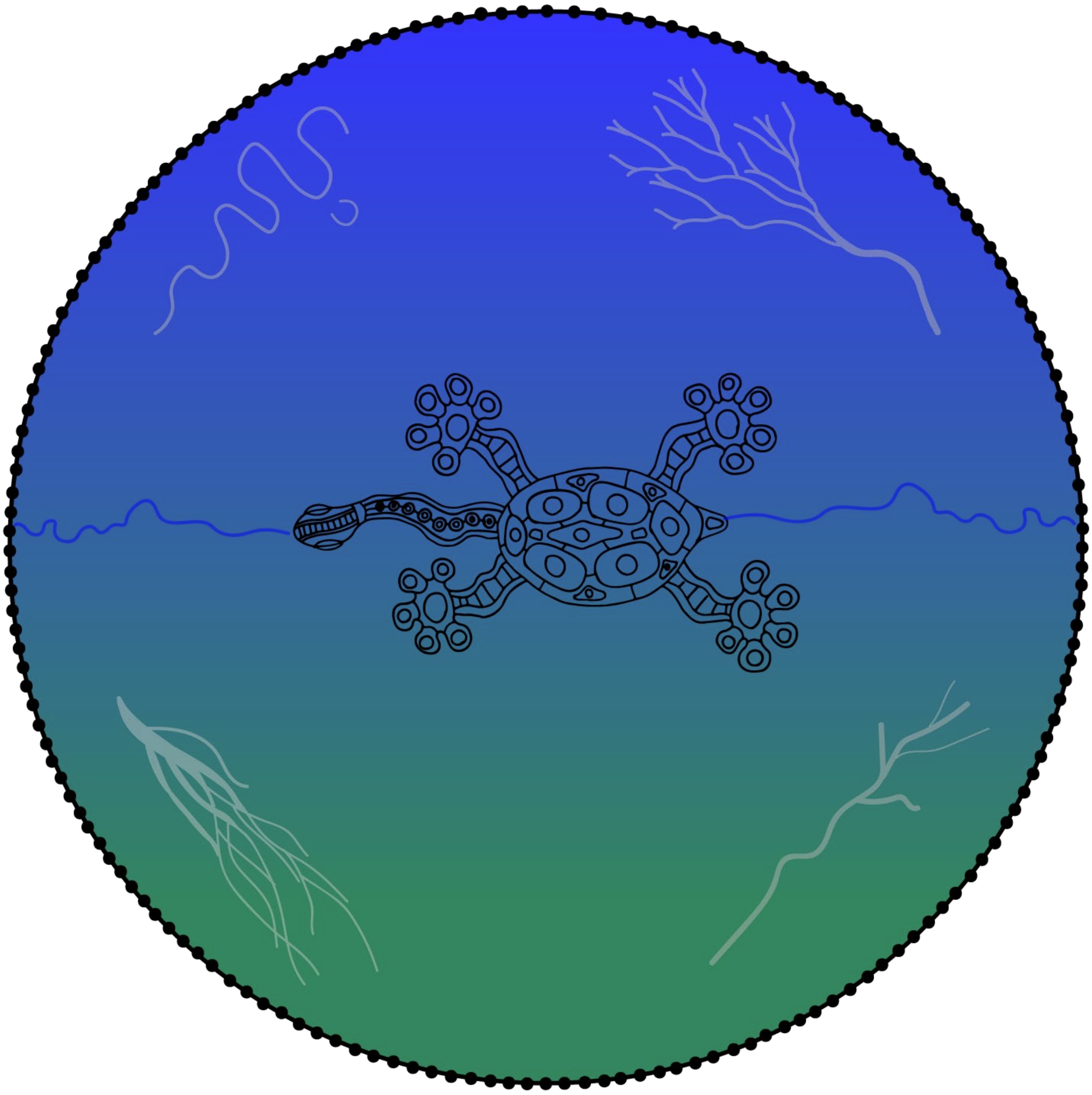

# Interim Queensland River Classification Scheme

Module 1 – Introduction to the River Classification Scheme

**Version 1.0**

Queensland Government

Prepared by: Grove, James [a]; Griffiths, Matthew [b]; Zann, Maria [b]; Burton, Joanne [c]; Heenan, Marijke [c]; Munns, Trent [d]; Newham, Michael [c]; Daley, James [e]; Ronan, Mike [b].

[a] School of Geography, Atmospheric and Earth Sciences, University of Melbourne

[b] Healthy Waters and Wetlands, Environment and Heritage Policy and Programs, Department of Environment and Science

[c] Soil and Catchment Science, Science Division, Department of Environment and Science

[d] Science Engagement and Impact, Science Division, Department of Environment and Science

[e] Coastal and Marine Research Centre, Griffith University.



*The Department of Environment and Science acknowledges Aboriginal peoples and Torres Strait Islander peoples as the Traditional Owners and custodians of the land. We recognise their connection to land, sea and community, and pay our respects to Elders past, present and emerging.*

*The department is committed to respecting, protecting and promoting human rights, and our obligations under the Human Rights Act 2019.*



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**Cover page artwork:** long neck freshwater turtle designed by John Locke and image compiled by Trent Munns.

The centre of this artwork is a sacred animal, the long-neck freshwater turtle. The long-neck freshwater turtle exists in two worlds, on land and in water (represented by green and blue colours). The long-neck freshwater turtle connects the two worlds together, as one whole functioning ecosystem. The long-neck freshwater turtle provides important information through its interactions with Country (environment). The sacred animal reminds us all to protect and care for Country for the future generations.

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# 1 Introduction to the Interim Queensland River Classification Scheme

The Interim Queensland River Classification Scheme (QRCS) was developed by the Queensland Department of Environment and Science (DES). The QRCS provides a framework for classifying and typing Queensland's rivers. It takes an attribute-based approach, identifying and describing physical, biological and chemical attributes of rivers, where an attribute is a descriptive characteristic or feature of an ecosystem. The scheme is adaptable and flexible and is based on and complements existing attribute-based classification schemes used within Queensland, including:

- the Queensland Intertidal and Subtidal Classification Scheme (DEHP, 2017a)
- the Queensland Wetland Mapping and Classification Method (EPA, 2005)
- the Groundwater Dependent Ecosystem (GDE) Mapping Method (DSITI, 2015, Glanville et al, 2016)
- the Queensland Waterhole Classification Scheme (DEHP, 2017b)
- the Australian National Aquatic Ecosystem Classification Scheme (ANAE) (AETG, 2012)
- the Queensland Wetlands Classification Scheme, Version 2.0 (DES 2023a).

There are many legislative processes associated with rivers - further information on these can be found under Programs, policy and legislation on Wetland*Info*. The QRCS is a biophysical classification and does not have legislative or statutory status. However, statutory or policy products may be derived from this classification. Rivers can be referred to by a range of terms (e.g. streams, creeks, waterways, water courses) with different terms and definitions used for legislative purposes. To avoid confusion with terms used in legislation the QRCS adopts the term 'water channel' (see section 4.2).

Many of the key concepts and principles within this document are derived from the Queensland Intertidal and Subtidal Classification Scheme, and the Queensland Waterhole Classification Scheme. Where content has been derived from these previous documents it has been italicised to highlight its provenance. As it is anticipated that the scheme will be updated and revised several times, this document is referred to as an interim version. To aid with comprehension a glossary of technical terms used in this document may be found at https://wetlandinfo.des.qld.gov.au/wetlands/resources/glossary.html.

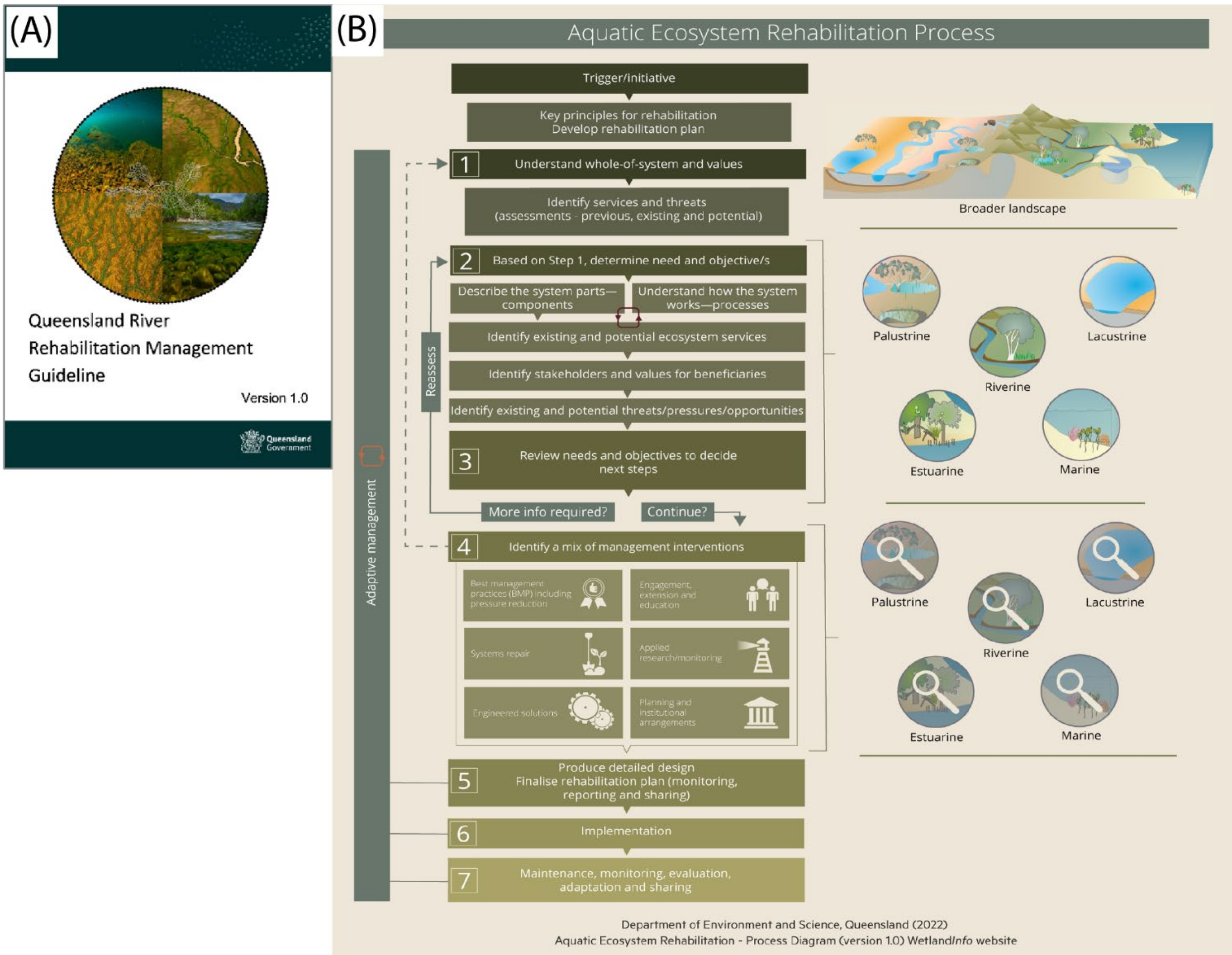


*Figure 1 Complementary products to support the QRCS: A) The Queensland River Rehabilitation Management Guideline (DES 2022a), B) the Aquatic Ecosystem Rehabilitation Process (AERP) (2022b).*

The QRCS complements the Queensland River Rehabilitation Management Guideline (QRRMG) (DES 2022a) and Aquatic Ecosystem Rehabilitation Process (AERP) (DES 2022b) and is a key tool for river management in Queensland (Figure 1). This suite of decision support tools are underpinned by the Whole-of-System, Values-Based Framework (DES 2022c) and facilitate a transparent, scientifically robust and uniform approach to management, decision-making, and research. A consistent approach to classification is just one of the tools needed for effective river management, and it should be used in combination with other information. The QRRMG outlines the inputs needed for river management including the importance of understanding both components (e.g., landforms) and processes of river systems at multiple spatial scales. The QRCS identifies and describes water channel (river) attributes, with a focus on components as these tend to be more enduring and easier to classify. However, some key processes, which can be quantified and categorised are also identified and described. Anthropogenic modifications to river systems are also included in the scheme, such as the extent of human-induced change. This provides the ability to describe artificial, modified and pristine areas.

This document outlines why an attribute-based classification scheme is needed for Queensland's rivers, and the scope of the classification approach. It also describes the steps used to develop the attribute-based classification and the process required to apply the QRCS for the purposes of typology development or attribute mapping. The spatial levels used for classifying Queensland's rivers are identified and described as are the attributes that can be used at these different levels.

## 1.1 The purpose of this document

This document describes the features and scope of an attribute-based classification scheme for Queensland rivers. It also provides an overview of how the classification could then be applied as a typology or for mapping purposes. Some, or all, of the following steps may be used during the process of attribute-based classification and typing of rivers. All of the steps are described in more detail, however the first two steps are the key outputs of this document.

- **The identification and definition of the hierarchical spatial levels that encompass the likely components (parts) and processes operating at different scales for river systems (Section 5.2).**
- **The creation of a set of attributes that describe components (parts) and processes that are quantifiable in rivers (Section 7).**
- The division of the attributes into categories that are meaningful for describing river ecosystems (Module 3).
- Deciding on the need, purpose, and scope for a typology, including whether the types need to be mapped.
- The selection of a sub-set of attributes, categories and qualifiers, and the creation of a hierarchical rule set for combining these to produce a set of types that address the purpose.
- The creation of a mappable typology.
- The compilation of data and the alignment with attributes and categories (note that this may be started when deciding on the purpose and scope) to make the collection of attribute data more consistent.
- The release of products, including quality assurance and approvals.

Module 2 (DES 2023b) provides a literature review of existing national and international biophysical attributes and spatial levels used for river classification. It provides context and inputs for setting up the attribute-based river classification scheme described here.

# 2 Why do we need this classification scheme?

Queensland's rivers are diverse and there can be significant variability within different parts of individual rivers. For example, an ephemeral multichannel river requires very different management to a large single-channel permanently flowing river. Understanding the parts (components) and processes of rivers enables optimisation of management, thereby increasing the likelihood of success. This understanding can be achieved through the development and application of a standardised and comprehensive classification scheme for rivers, which can be used throughout Queensland for multiple purposes. Integration and alignment of this scheme with the classification schemes for other aquatic systems in Queensland recognises the connectivity of aquatic ecosystems and enables whole-of-system management. The classification scheme integrates with the AERP and QRRMG, enabling the description of parts (components) of rivers (Figure 1B, Step 2) as well as the description and quantification of the processes operating in them. Once identified, both components and processes can be used to identify ecosystem services and subsequently appropriate management approaches (Figure 1B, Steps 2-4).

A review of the attributes used in existing classification systems has been undertaken, including those used in Australia, and globally (see Module 2, DES 2023b). The purpose of this review was to investigate which attributes have been used to classify and type river systems. It was not a comprehensive review of literature on river classification systems, as Kondolf et al. (2016) and Buffington and Montgomery (2022) have provided recent benchmark reviews on the state of river classification. Nor was it a justification for the use of the attribute-based classification scheme, as this has previously been undertaken (DES 2019). Instead, Module 2 quantitatively and qualitatively explores the range of biophysical attributes, metrics, and typologies used in existing river classification systems. This review was undertaken to help identify candidate attributes that could be used in this classification scheme.

Work by Buffington & Montgomery (2013) and Kasprak et al. (2016) shows the interrelationships between various schemes and attributes, and they recommend classifications: (1) consider different scales, (2) include a process understanding, and (3) are appropriate to the goals. The advantage of the QRCS compared to many of the reviewed classifications is its flexibility. This enables the creation of typologies at different scales and for varying applications.

# 3 What are the advantages and limitations of an attribute-based classification scheme?

*The principle of ecosystem-based management has been widely applied in Australia for managing ecosystems, species, and resources (Slocombe, 1998; Granek et al, 2010; Fletcher et al, 2011) and is at the core of the International Ramsar Ecological Character Framework (DEWHA, 2008). This approach considers the relationships within, and pressures on, a system and informs decision-making initiatives and actions for successful system management. Fundamental to such an approach is defining the location (mapping) as well as the characteristics (classification) of the systems and documenting these definitions within a recognised framework.*

*Classification provides a common language within a structured framework enabling synthesis and understanding of systems which can be grouped together based on similar characteristics. Such an approach can improve the knowledge of the factors that influence creation, maintenance, and the quality of the system.* However, the disaggregation of typologies or descriptors used in existing classifications, and in general use in different disciplines, can be a laborious process. The rigor needed to check and produce a comprehensive attribute list as well as the need to subsequently workshop typologies with experts means the process can be expensive both in terms of time and money. Classification only provides one of many pieces of information required to manage rivers, and often a more detailed understanding of the processes and trajectory of an area is needed.

*The collation of biotic and abiotic attributes at a range of spatial scales enables a transparent, scientifically robust and uniform approach to classification that can inform management, decision making and research.*

*The standardised classification of rivers based on a list of biotic and abiotic attributes provides a foundation and structure for:*

- *Consolidating knowledge into a consistent platform*
- *Developing a synthesis of current understanding and knowledge of components, to be used alongside an understanding of processes and drivers of each river type for managers*
- *Classifying habitats to identify vital aquatic refugia*
- *Facilitating communication about values and management with technical and non-technical audiences and stakeholders*
- *Providing the foundation for mapping (attributes and types)*
- *Prioritisation of management interventions at multiple scales*
- *Assisting with the assessment pressures or threats such as climate change impacts*
- *Tracking changes in ecosystem extent and type and designing monitoring programs*
- *Assessing the services and values for rivers with different characteristics*
- *Informing future environmental values and water quality objectives*
- *Providing the basis for the description of habitat types and the development of conceptual models*
- *Developing management guidelines for rivers based on key characteristics*
- *Assist with decision making for water allocation, regulation and catchment management to maintain rivers, floodplains and groundwater interactions.*

# 4 The scope of the classification

## 4.1 Geographic and spatial scope

This scheme includes all rivers within the state of Queensland. The diversity of rivers in Queensland (Figure 2) means that the scheme needs to be applicable for single and multichannel systems. It also needs to extend to the limit of tidal influence for those rivers that flow into the sea as well as to channels that have no outflows and end inland (endorheic).


*Figure 2 Queensland contains a wide variety of natural water channels including: (A) single channel and (B) multi-channel systems, and rivers that (C) flow to the sea, and (D) flow inland. (Photos by Gary Cranitch © Queensland Museum)*

## 4.2 Definition of water channel

Biophysical classification does not need to be limited by the definition of rivers used in a legislative or statutory context. Rivers are referred to by a variety of terms, such as rivers, streams, creeks, drains, waterways, or watercourses, which can cause inconsistencies and confusion. The uncertainty and different interpretations because of these terms means that a different definition has been sought.

The following definition was developed to provide the scope of this classification. It was the result of a literature review followed by refinement by a panel of experts.

**A 'water channel' is a wetland channel through which water flows.**

- **A channel is a 'morphometric class that is both linear and concave compared with its surrounding elevation.' (Modified from Kopačková et al, 2011)**
- **Water flow may be permanent, intermittent or ephemeral.**
- **Flow may be in one or both directions.**

While a range of terms may be used in practice, and within this document, this definition provides the basis for the classification scheme.

The classification scheme is designed to be a flexible system that can be adapted for a variety of needs. Some attributes are currently not able to be mapped if the necessary data resources are not available. However, users should be able to apply the classification scheme to classify the areas they are interested in. If applied across all of Queensland then users may only map a few attributes, whereas more attributes may be available for local scales.

# 5 Attribute-based Classification

## 5.1 Introduction

Classification of individual plants and animals is based on grouping them by shared characteristics *(e.g. by Family, Genus, Species) or according to shared characteristics. Such a classification enables generalisations to be made across groups. A similar principle can be applied to ecosystems, or ecosystem components. There are many approaches to classification schemes, which vary both in structure and implementation. Examples of such classification schemes include Delphic (expert-driven), statistical, self-organising, hierarchical, non-hierarchical, bottom-up, top-down and many more.*

*Classification involves simplifying complex, sometimes continuous data into practical, meaningful categories. While losing some of the detailed information (dimension reduction), the ability to convey information is enhanced. These simplifications are used in our everyday life, for example, while there are a range of eye colours in humans, we often refer to the colour of a person's eyes as brown, blue, grey etc, even though there is a continuum of colours.*

*The approach that will be used separates classifications, typologies and mapping (Figure 3). This flexibility also enables the classification to deal with dynamic ecosystems, typologies can be created that are sensitive to change (for example to enable condition assessment) or insensitive to change (for example in some baseline mapping applications). The classification incorporates relevant and readily obtained measurements. It also provides the basis for the establishment of a core knowledge base from which multiple decisions can be made.*

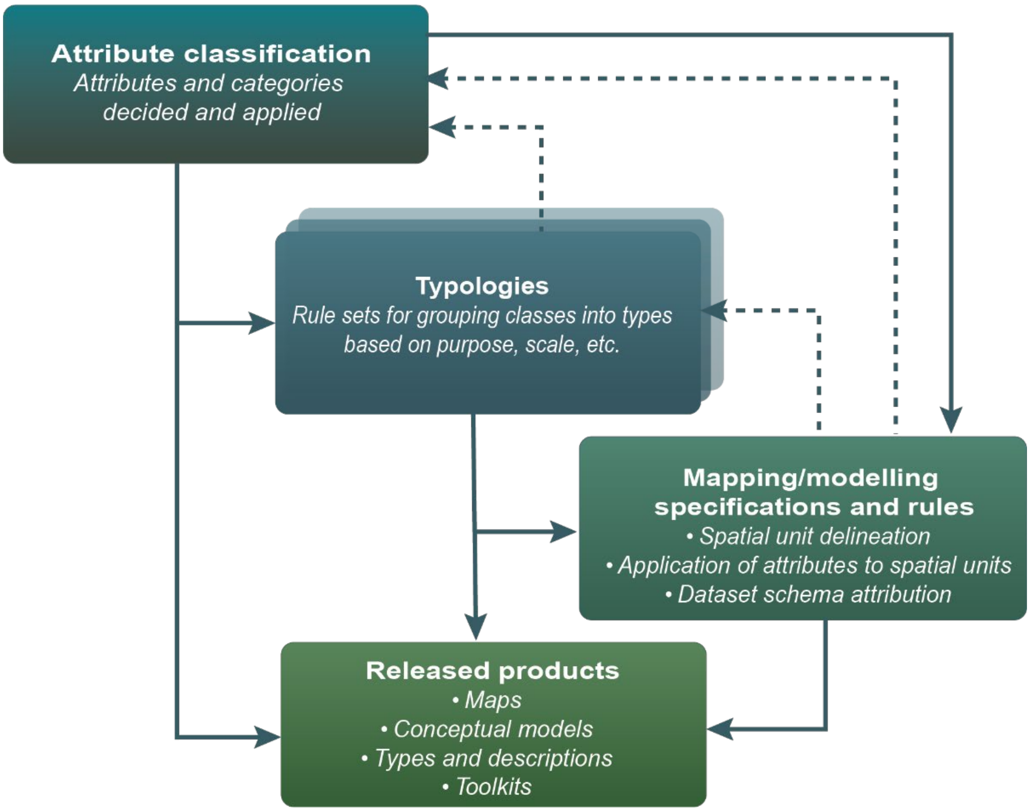


*Figure 3 The process steps involved in developing classification and typology schemes (DEHP. 2017a)*

The following sections define the different terms used in the processes of classification and typing so that they may be understood and consistently used.

## 5.2 Levels of scale

Levels relate to **scale**, defined as 'the parameter that describes the level of geographic resolution and extent, the context of space and time and helps define the positional accuracy' (Quattrochi & Goodchild 1997). It is essential before any classification process is initiated to determine what the scale(s) of the classification will be. The scale(s) should be directly related to the purpose of the classification and the method of acquisition used to obtain the data used to conduct the classification.

Attributes are applied to hierarchical, nested spatial levels, such as regional, landscape and habitat in the ANAE Classification Framework (AETG, 2012). The Intertidal and Subtidal, and Waterhole classification schemes added an extra two levels, subregion and community, to better describe the ecosystem components and processes. Only the relevant scales to the purpose of the typology need to be used. For example, when creating a typology of reach scale sediment supply it is unlikely that levels below the reach, such as site and patch, would be needed. See Section 6.2 for the details of the levels used for this classification scheme.

## 5.3 Themes, attributes, categories/metrics, and methods

**The hierarchy of the classification scheme uses the approach and terms shown in Figure 4. The terms used in the diagram will be described in this section.**

**Themes** are used to organise, broadly describe and group attributes together (see Table 4 to Table 11) (DEPH, 2017). General themes of this classification scheme include climate, terrain, geology, substrate (physical and chemical), hydrology (physical and chemical), and biota. Geology has been included as a separate theme as it may influence several of the other themes in a variety of ways. The biota theme uses attributes of flora and fauna to describe the ecosystem rather than using them to define the ecosystem. Hence, the presence of platypus burrows may be included as ecosystem modifiers as they can change the riverbank but fauna themselves are not included, such as threatened or endangered species as they do not define the components and processes of the ecosystem.

An **attribute** can be defined by the following criteria:

1. It describes a component or process of the environment that can be a physical, chemical or biological part of an aquatic ecosystem.
2. It can be a mathematical or statistical indicator, or a characteristic.
3. It can be broken into categories which are discrete. These can be measured using metrics that cover the entire possible range of the attribute, such as high, medium, low, and other. These categories can be derived based on ranges or thresholds that are ecologically or geomorphologically meaningful.
4. It should be measurable, but it does not have to be mappable.
5. It can be a typology, composed of multiple attributes (including spatial) and/or qualifiers, but only when those attributes and qualifiers are discoverable.
6. It can be derived after preliminary mapping of an initial attribute to provide a spatial attribute that describes patterns such as “distance from”.

Attributes have a stronger emphasis on components rather than processes. It is acknowledged in the QRRMG and AERP that consideration of both components and processes is necessary for management to be effective, however, components are often easier to classify, quantify and map. Some processes are also included where the form and arrangement of components provide supporting evidence that certain processes have occurred or are currently active.

Attributes must be able to be broken down into **categories**. For example, simple categories for precipitation may be extremely low, very low, low, mild, moderate, high, very high, extremely high, and unknown. Categories should be at a resolution appropriate to the **spatial level** that the attribute is being applied and should be based on environmentally relevant thresholds where possible. Precipitation at a regional level may be deemed high where it supports rainforest vegetation, medium for temperature vegetation, and low for arid vegetation.

A **metric** describes how the attribute is measured. Metrics can be continuous or categorical, qualitative, or quantitative, and are often informed by biological processes. A metric for precipitation would be millimetres per annum.

Finally, the **method** used to collect the attribute data (inventory) should be described. This allows for standardisation in the measurement of inventory data. In some circumstances the categories and metrics may already be set by a standard approach, such as an Australian or International Standard.

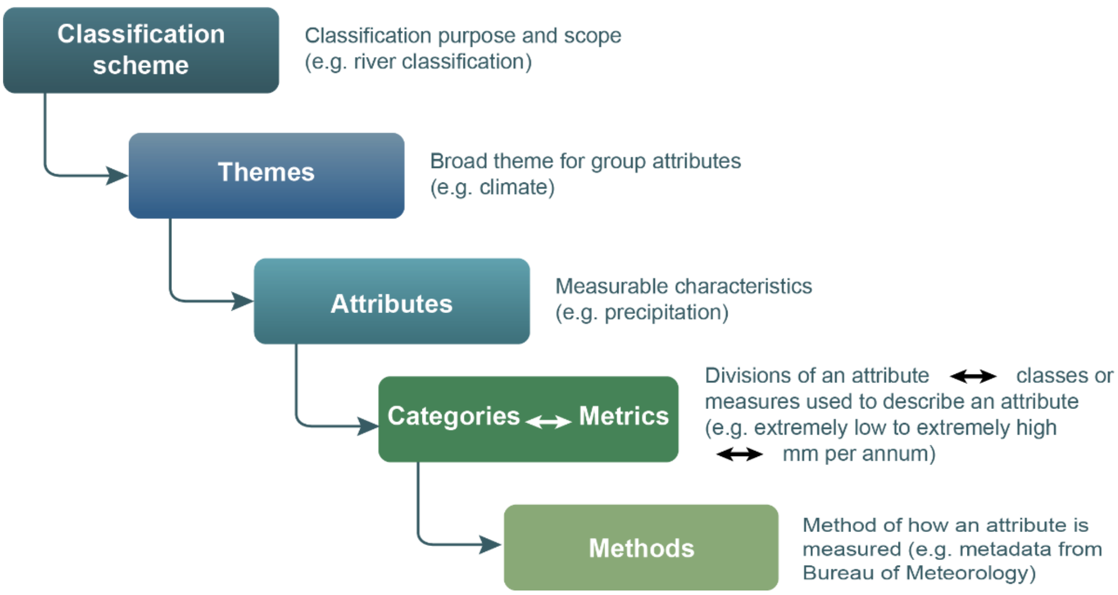


*Figure 4 Breakdown of key attribute terminology used in this classification scheme (adapted from DEHP, 2017a)*

## 5.4 Morphological attributes

Components are often described by their form, spatial relationships to another form, or through spatial patterns. For example, a manager might want to know about bar forms in a channel and whether they are attached to the riverbank or not. If a transparent and objective typology of bars exists, then this may be used as the categorisation of an attribute. If there is uncertainty or subjectivity in how bars are typed then a standardised set of morphological descriptions can be used. Terrain morphs have been adopted for this classification scheme based on work by Bolongaro-Crevenna et al. (2005). The terrain morphs are the basic shapes that constitute the landform (Figure 5). These shapes can be applied at multiple spatial levels so that a channel may constitute a valley, the river channel, or a channel in a riverbank. The different spatial levels mean that morphs can be nested, such as a channel in a valley.

Topographic high morphs include ridges (a linear high), peaks (a high that rises to a single or circular point), and other crests which do not form either a linear or point pattern. Terrain morphs that are topographic lows include channels (a linear low), pits (a low that descends to a single or circular point) and other depressions that do not form either a linear or point pattern. Planes are uniform in their elevation trend and are neither distinguished as a high or low (DES 2019).

Rivers that currently have similar forms could be the result of different processes of formation, which is known as equifinality (Goudie 1988). The hierarchical approach used in the classification may to some extent be able to help distinguish the different driving processes between areas of similar forms by showing variations in forms and processes at other spatial levels. This, however, is not always the case. Similar forms that result from either sediment removal or sediment accumulation may require information from another attribute such as the sediment budget to categorise them, in which case they become functional typologies. This example highlights that the QRCS is one tool that should be applied as part of a Whole-of-system values-based management approach to river management to ensure misinterpretation of processes does not occur.

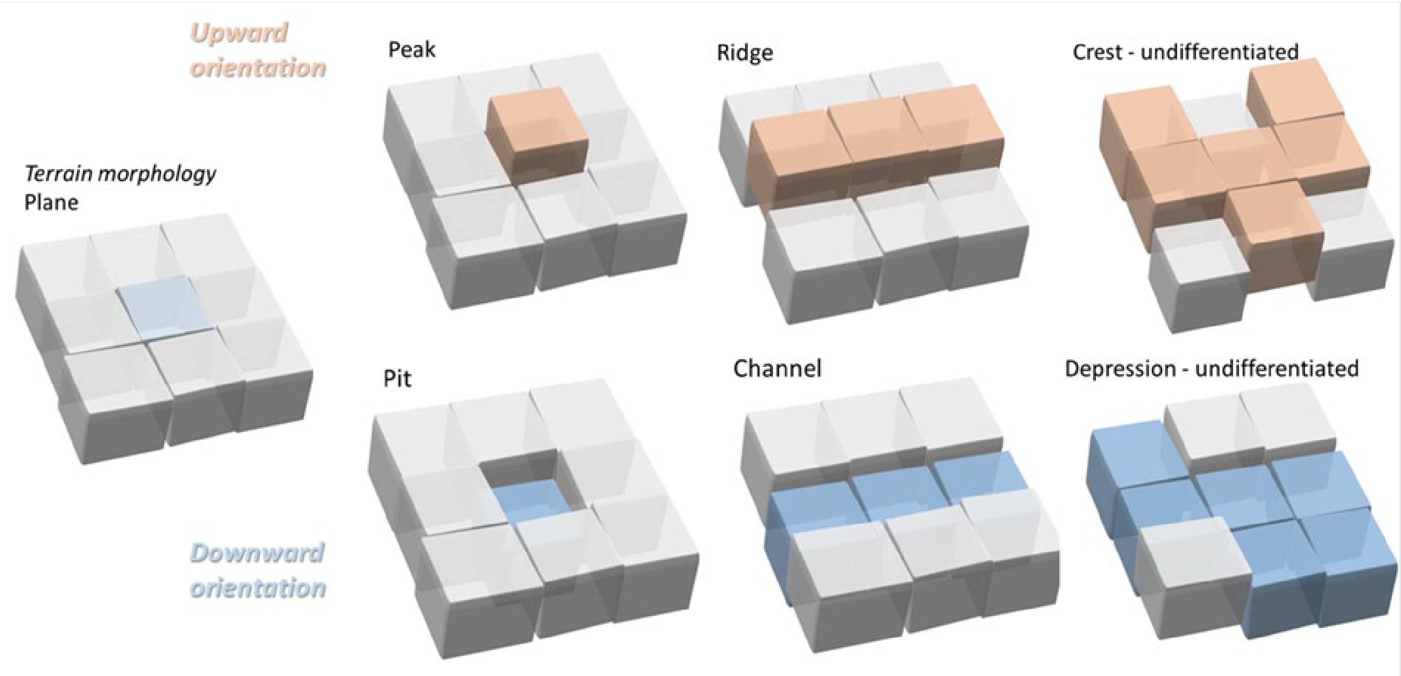


*Figure 5 Terrain morphs (Modified after Bolongaro-Crevenna et al 2005)*

## 5.5 Spatial attributes

A spatial attribute is one that can only be used when another entity such as an attribute or a typology has been mapped or can be spatially described. Spatial attributes use the spatial position, and patterns, of mapped or spatially described entities to create a new attribute. For example, the attribute of channel width requires the position of channel boundary to be determined and mapped before the width can be quantified.

*Landscape ecology provides a suite of tools and metrics to map spatial attributes (see review by Lausch et al. 2015) including: ‘distance from’; ‘proportionate distance from’; ‘falls within’; ‘relative location’; ‘neighbourhood of’; ‘enclosure by’; ‘proportions of’; ‘relative proportions of’. If landscape tools and metrics are used to determine spatial attributes, the user needs to understand properties of the relevant metric. This is because autocorrelation may exist between certain metrics. Attributes may no longer be independent, or there may also be dependencies based on data resolution and study area extent, inventory scale, units and completeness (Kupfer 2012).*

When using spatial attributes, it is important to clearly define the ecological or geomorphological purpose including the scale or level(s), components or pattern of components that are being investigated, how they will ‘nest’ within those levels above, and the order that each spatial attribute will be applied.

Those attributes that are spatial have been noted in Table 4 to Table 11.

## 5.6 Temporal attributes

Attributes may be the result of data derived or quantified over several time intervals. These can include attributes that indicate a rate, such as channel flow discharge. In some cases, an instantaneous measure of discharge may be used for the attribute but more often an average, maximum, or minimum derived from multiple measurements over time is required. Temporal attributes can also be used where there is a particular period of interest being defined. For example, the dominant timing of leaf drop during the year is the temporal period when the ground or water surface may have the greatest input of organic matter from leaves.

Those attributes that are spatial have been noted in Table 4 to Table 11.

## 5.7 Attribute qualifiers

*Ecosystems are dynamic and can undergo shifts in state and conditions. This may be natural variation or be influenced by anthropogenic pressures. In classifying and mapping ecosystems, consideration must be given to how* both *natural* and anthropogenic *variability influences their structure and function.*

*Attribute qualifiers* (Table 1) *provide extra information on the category of an attribute and are similar to modifiers in other classification schemes (Cowardin et al, 1979). These qualifiers are not standalone attributes but should be implemented, where appropriate, by attaching additional information to the categories of existing attributes.* For example, the 'naturalness' attribute qualifier describes the extent of human-induced change such as anthropogenic structures like dams and weirs placed in channels.

Qualifiers are also available to denote the variability of attributes and categories over time. 'Trend' is a temporal qualifier and provides information on the variability of a component over time. The 'period' attribute qualifier describes what period of time this variability is observed over. The degree of connectivity in a river can be further described using the qualifier of 'connections'. For example, an attribute describing nutrients may be observed to increase and decrease with seasons but may also be observed to be increasing over longer periods. These nutrients may be in a pool where there is no flow and little connectivity up and downstream, or the stream may be flowing and there is high connectivity. All these types of variation may be included in the data as attribute qualifiers.

*Table 1 Qualifiers*

| Qualifier name | Description |
|---|---|
| Commence to Fill | Commence to fill refers to the timing of water accumulation in the ecosystem. This can describe the timing of intermittent or ephemeral streams, channels on the floodplain, or floodplain wetlands. |
| Connections | This describes the likely strength of connections. For example, a river may be highly connected with its floodplain if frequent inundation of the floodplain occurs, whereas if it has incised or is in a macrochannel it may have a low connection with the floodplain. |
| Cover | Cover is the percentage of a surface that is covered by component. |
| Naturalness | Naturalness considers the integrity of a component and the degree of anthropogenic influence in describing the extent of human-induced change. |
| Naturalness vegetation | The naturalness of vegetation refers to the extent that vegetation has been altered by humans. This might be the introduction of exotic species or a change in the abundance of native species. |
| Period | Periodicity refers to the tendency of variations to reoccur through time. |
| Sensitivity | The sensitivity of an attribute to change between categories. Geology has a low sensitivity to change whilst sinuosity may more easily change from a low sinuosity type to a meandering one. |
| Spatial boundary | To describe if the likely boundaries of an attribute are sharp and clearly defined, ill-defined and transitional over a relatively short distance, or transition over a relatively long distance. |
| Timing Predictability | Timing predictability is a measure of the predictability of the commence to flow in a river. This can relate to the seasonality of rainfall in the area in which the river resides. This attribute is able to separate rivers found in the arid regions that experience extremely variable inflows from waterholes in the wet-dry tropics that experience predictable seasonal flow patterns. This attribute may need a trend or a period qualifier attached to it as timing predictability may exhibit longer-term dynamism. |
| Trend | Trend provides information on persistence and variability over time of an attribute. |

| Qualifier name | Description |
|---|---|
| Wetland Habitat Hydrological Modification | Wetland habitat modification is a typology incorporating anthropogenic activities at the habitat level that alter wetland hydrology, the affected wetland system and resultant wetland system. |
| Wetland Landscape Hydrological Modification | Landscape wetland modification is a typology incorporating anthropogenic activities at a landscape level that alter wetland hydrology. |

## 5.8 Enduring and non-enduring attributes

*In relative terms and for mapping purposes, attributes can be considered as either **enduring** or **non-enduring.** Enduring attributes are relatively more persistent over time (e.g. bedrock). Non-enduring attributes are more variable over time in terms of their persistence, duration and/or periodicity. Enduring attributes are easier to map as they are unlikely to change during the mapping period. Whether an attribute is considered enduring or not for a particular application will depend upon the timeframe and scale that the classification is applied at and the purpose of the classification.*

*The key points about how the classification deals with change are:*

- *Enduring attributes persist over time and are, therefore, mappable.*
- *A mapping period needs to be nominated (e.g. every ten years).*
- *Repetitive mapping of classified habitats can demonstrate changes.*
- *Not all attributes are mappable but they may still be very relevant (e.g. front or cline).*

## 5.9 Classification and typology

Attribute classification provides definitions and categorisation of the environment (attributes) and is the pre-cursor to a typology. A typology uses a subset of available attributes, depending on the purpose of the typology, to group similar parts of an ecosystem into **types**. As shown in the example below (Figure 6), a person can be described by various attributes. Some of those attributes may be used to develop a particular typology, while other attributes may not be needed. This provides flexibility and broad applicability, in contrast to some classification systems in which the typologies cannot be disaggregated into their attributes or changed for different purposes.

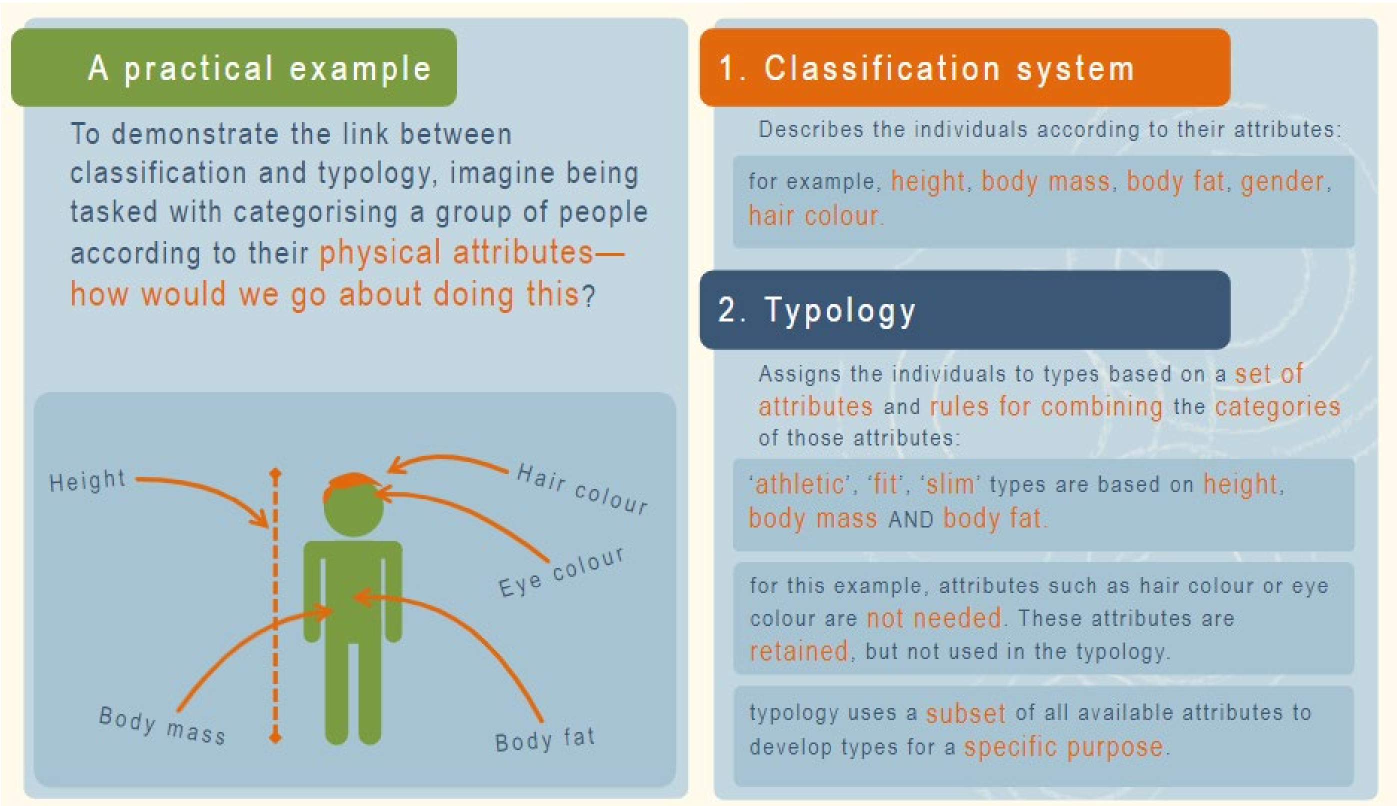


*Figure 6 An example of attribute-based classification and developing a typology (Source: DES 2015, WetlandInfo)*

Typologies effectively provide rules that are applied to attributes to group similar parts of an ecosystem into types for a particular purpose or function (AETG, 2012). The purpose or function needs to be clearly stated when assembling attributes at different spatial levels for a typology. Creating a typology that separates rivers based on their geomorphology without a clear purpose can result in a typology without a clear application. Using a conceptual model for a typology is useful to identify attributes required to produce the typology. This is especially the case in typologies that involve processes.

In some situations, existing typologies may be used as attributes, such as the trophic state of a waterbody, where different nutrient levels enable the types of eutrophic, mesotrophic or oligotrophic to be defined as categories. These are termed **functional typologies**. They also include situations where a spatial attribute is combined with another attribute, or combination of attributes, for example the maximum vegetation height (attribute) in a channel (spatial attribute).

In attribute-based classification schemes there are also **typologies** that fulfill the overall classification purpose, for example describing the sensitivity of a river system to climate change. Many different typologies may be produced from the same starting list of attributes. While attributes can be classified into categories, independent of one another, a typology must have a hierarchy in which the attributes are applied, based on its purpose and function.

A typology is formed by selecting relevant attributes, then devising the typology rules and hierarchy by arranging the attributes and categories (see Figure 7 and Figure 8 below). The outputs should be reviewed and revised if necessary.

The incorporation of expert advice, from expert panels throughout the process, is fundamental to the application of the classification scheme. Collaboration and consultation during the process provides robustness, transparency, and a scientifically defensible level of quality assurance in the final products (DES 2020).

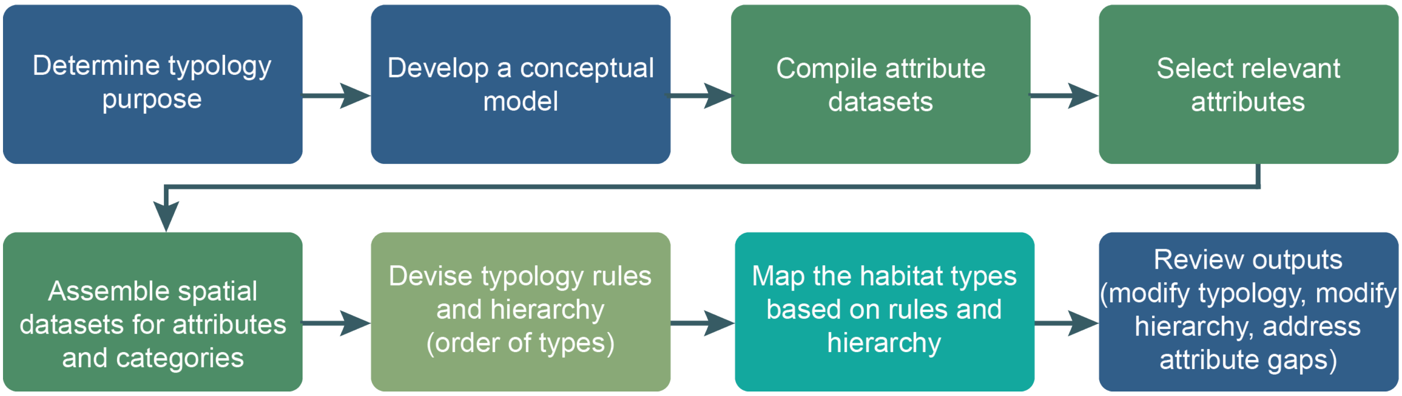


*Figure 7 Process of developing a typology and mapping the habitat types (based on DES 2020)*

One of the considerations in the building of the hierarchy is the sensitivity of categories to change over time. Changes may be as a result of the category bands being very close together in comparison to the variability in the metric. There are also cases where a small change in the attribute may switch from the boundary of one category into another. For example, a small change in the sinuosity of a river may mean it changes from being in a meandering category to being in a sinuous one. It is recommended that in these situations, the attribute is either removed, recategorised, or placed lower down in the hierarchy so it has less influence on the final types.

The typology based on all the required attributes may differ from what can be mapped. Not all attributes are mappable but those that are not should not be excluded from the initial typology as they can either be replaced by proxies that are measurable or be used to identify important data gaps. The typology and its mapped version are products of rulesets that then need to be reviewed and may need to be adjusted. This adjustment may require types to be merged or split. These processes occur iteratively until the final output is obtained. The rulesets need to be recorded in a transparent way that can be understood and replicated by technical experts. This includes capturing the order or hierarchy that will determine the way in which the typology rulesets are applied to different combinations of attributes and categories. This is shown in the typology tree in Figure 8.

The number of types contained within a typology needs to be fit for purpose. Module 2 (DES 2023b) identified that on average ten types have been created in existing typologies, and this probably resulted from ease of communication and also the flow-on effect to the resources required in their assemblage and application. A robust data schema should be able to support as many end uses as possible. For example:

- a manager may need a more generalised cartographic product with an aggregated list of types.
- general public users may require an online mapping tool that allows exploration and explanation (e.g. type and attribute descriptions).
- spatial professionals may require a technical database with a relational database model.

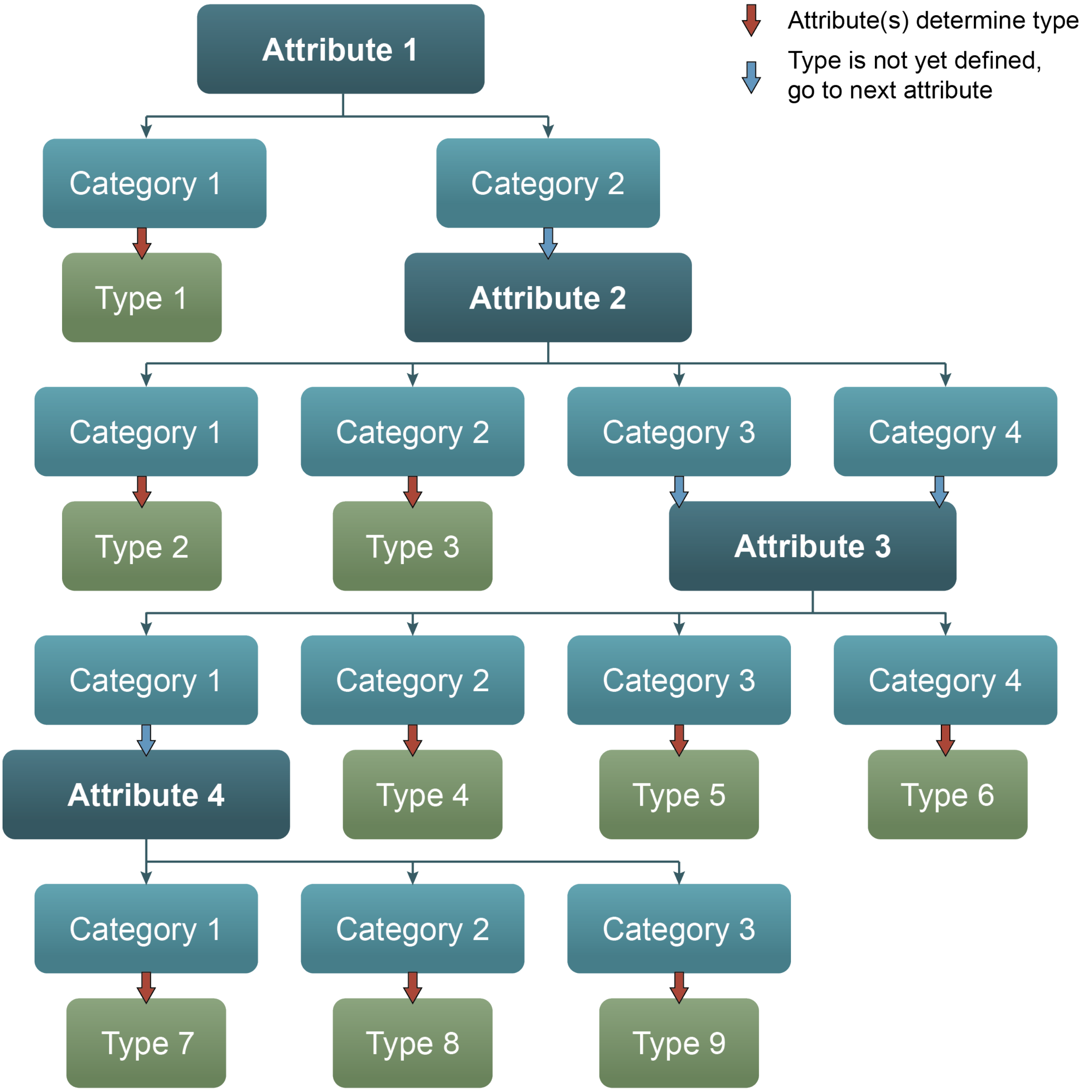


*Figure 8 An example of a typology tree. A typology provides a hierarchical set of rules to apply to the attribute classification to identify types. This typology is based on four attributes (dark blue boxes). Typically, there are many more available combinations not included here. Types (green boxes) are determined by choosing a category (light blue boxes) from one or more attributes. If the type is not determined by the first attribute category, then follow the blue arrow through to the next attribute. (Adapted from DES 2020)*

## 5.10 Data (Inventory)

An important part of an attribute-based classification is the collation of data, also termed 'inventory data'. The creation of a classification scheme provides guidance on the metrics and categories which can be used to collect data, with the aim to provide a state-wide standard. This helps bring together existing mapping products and other data sources and provides a standardised format for input in the classification and to guide any future inventory data collection. Data can be collected for many reasons: surveys, remote sensing or from existing data sets. Once collected, the standardised data can be entered into the classification scheme for it to be transformed into mapping, typologies or assessment products. For example, much of the existing mapped river network represents rivers as single lines, and could also be used to create attributes such as sinuosity, number of channels, or drainage density.

If the data has not been collected using the same metrics and categories as the classification scheme some of it may still be used, however, the process for translating it into attributes needs to be transparent and documented. The same is true when data has been used indirectly through modelling to inform attributes.

## 5.11 Dimension reduction

*The attribute-based approach to classification can involve several processes of simplification, termed 'dimension reduction'. Using a set of attributes to characterise the major components of a system reduces the inherent variability* *within ecosystems. Environments vary in space and time and when classification is conducted this often incurs dimension reduction (generalisation). Simplification is introduced through several stages of the classification scheme. The use of attributes, categories, and levels (scales) is the foremost of these.*

*The process of applying a typology to attribute classification has a simplifying effect on information. This is due to using rules to combine a selection of available attributes to define types. A type is not expected to represent the totality of all the components and their variation. Rather, a typology draws on selected attributes for a specific purpose to organise and classify the environment into relevant units (DEHP, 2017a, 2017b).*

*Within the steps of classification all information from the attribute classification should be retained in the final products, therefore reducing the risk of over-simplification, and providing information rich products. This provides contextual information and additional attributes that are not used in the final typology.*

## 5.12 Transparency in documentation

*Transparency is critical to the development of any classification scheme as the ability to demonstrate how classification, typologies and mapping has been arrived at increases acceptance of the final product. Transparency can be addressed in a number of ways:*

- *Documenting how attributes have been developed based on previous research.*
- *Documenting workshop consultation and outcomes, providing these to attendees and incorporating comments.*
- *Identifying and clarifying potential issues.*
- *Providing guidance on how to use the classification scheme.*
- *Providing confidence levels on the final products which recognises uncertainty in the process.*

*Documenting these issues will ensure that users can understand the implications and limitations of the classification scheme and its outputs. In addition, clearly documenting issues and components that have not been incorporated or require further work provides a strong foundation for ongoing improvement in the classification scheme (DEPH, 2017).*

## 5.13 Key principles

*To summarise the attribute-based classification approach a series of key principles have been identified that define its underpinnings, these are:*

- *It provides a strong **integrating framework** for **multiple disciplines** (e.g. ecology, environmental management and water quality) and forms the basis for the classification scheme.*
- *It can provide a **core knowledge base**, enabling the data collected by one group to be consistently used by others.*
- *The key terms are **defined**, for example:*
  - *Attributes*
  - *Levels (scales)*
  - *Categories*
- *There is a distinction between **classification**, **typology** and **mapping.***
- *While there needs to be a **purpose** for classification and the typology, the classification purpose should be **broad** to allow for multiple typologies to be generated from classified attributes.*
- *A typology must have a **hierarchy** in which rules for combination of the attributes are applied, based on the purpose of the typology.*
- *Not all **attributes** and categories are required for a classification and typology to be applied.*

# 6 Defining water channel attributes

## 6.1 Initial review of existing river attributes

The initial review of river attributes (Module 2, DES 2023b) identified over 400 different attributes that have been used. Many of these attributes were similar, with different terms used to describe similar process or component (form). These attributes were condensed into 46 different groupings based on the fact they were using different approaches to describe similar components or processes. These existing attributes and their groupings were then used as a guide for the generation of attributes for river systems. The attributes used in the current attribute-based classifications were also examined for their relevance to river systems.

## 6.2 The selection of different spatial levels

The original ANAE (AETG, 2012) levels of (1) regional, (2) landscape and (3) aquatic classes, systems and habitats were devised to provide information on drivers and processes operating at different scales. Levels 1 and 2 were intended to consider large scale, national regionalisation for landform, including climate, hydrology, and topography. Level 3 was included to separate out the classes of aquatic ecosystems (surface water and subterranean), major aquatic systems (e.g., estuarine, lacustrine, and riverine), and the attributes used to classify those systems into habitats. These levels were used as the starting point for the present riverine classification and were compared against other literature on river classification, notably the reviewed spatial scales in Gurnell et al. (2016).

Neither the original three ANAE (AETG, 2012) spatial levels or the five used in the Intertidal and subtidal classification (DEHP 2017a) adequately covered all of the different drivers and processes in riverine systems. They also did not allow enough flexibility for the development of typologies for all the different purposes envisaged. For the QRCS eight levels were defined that were related to both spatial and temporal scales of change (Table 2; Figure 9).

To illustrate the diversity of river forms that occur at the super-reach spatial scale several example scenarios are shown in Figure 10. Similarly, conceptual examples of likely variations at the micro-patch spatial level are shown in Figure 11.

*Table 2 A description of the different spatial levels and their indicative spatial and temporal scales. Adapted from Gurnell et al. 2016.*

| Spatial level | Indicative spatial scale | Indicative temporal scale | Indicative conditions, forms and processes |
|---|---|---|---|
| 1. Region | >$10^4$ km$^2$ | >$10^4$ years | Large scale climatic and topographic variations.<br>Indicative features are climate zones in the State of Queensland. |
| 2. Subregion | $10^2$ – $10^5$ km$^2$ | $10^3$ – $10^4$ years | Processes or forms that vary as a result of being constrained by topographic divides.<br>Indicative features are river basins or catchments. |
| 3. Landscape | $10^2$ – $10^3$ km$^2$ | $10^2$ – $10^3$ years | Portion of a catchment with similar landscape morphological characteristics (topography/landform assemblage).<br>Indicative features are sub-catchments. |
| 4. Super-reach | $10^1$ – $10^2$ km$^2$ | $10^1$ – $10^2$ years | Section of river subject to similar floodplain scale influences and energy conditions.<br>Includes the channel, or multiple channels, and floodplain.<br>Indicative features are valley sections defined longitudinally by a type of floodplain. |
| 5. Reach | $10^{-1}$ – $10^1$ km$^2$ | $10^1$ – $10^2$ years | A length of a single channel subject to similar channel boundary scale influences (bed and banks) and energy conditions.<br>Nominally this could be >20 channel bankfull widths.<br>Indicative features are channel lengths between tributary junctions. |
| 6. Site | $10^0$ – $10^2$ m$^2$ | $10^0$ – $10^1$ years | A length of channel characterised by a landform that is created by erosion or deposition, sometimes in association with vegetation.<br>Indicative features are channel lengths scaled by the bankfull width. 0.1 - 20 times the bankfull width is the site length, often presenting a meander wavelength or pool riffle sequence. |
| 7. Patch | $10^{-1}$ – $10^1$ m$^2$ | $10^{-1}$ – $10^1$ years | An in-channel area of relatively homogenous substrate, or velocity.<br>Indicative features are riffles or pools. |
| 8. Micro-patch | $10^{-2}$ – $10^1$ m$^2$ | $10^{-2}$ – $10^0$ years | In-channel features creating specific habitat types as a result of substrate, vegetation and hydraulics.<br>Indicative features are area of similar in-channel vegetation, or an area covered by leaf litter. |

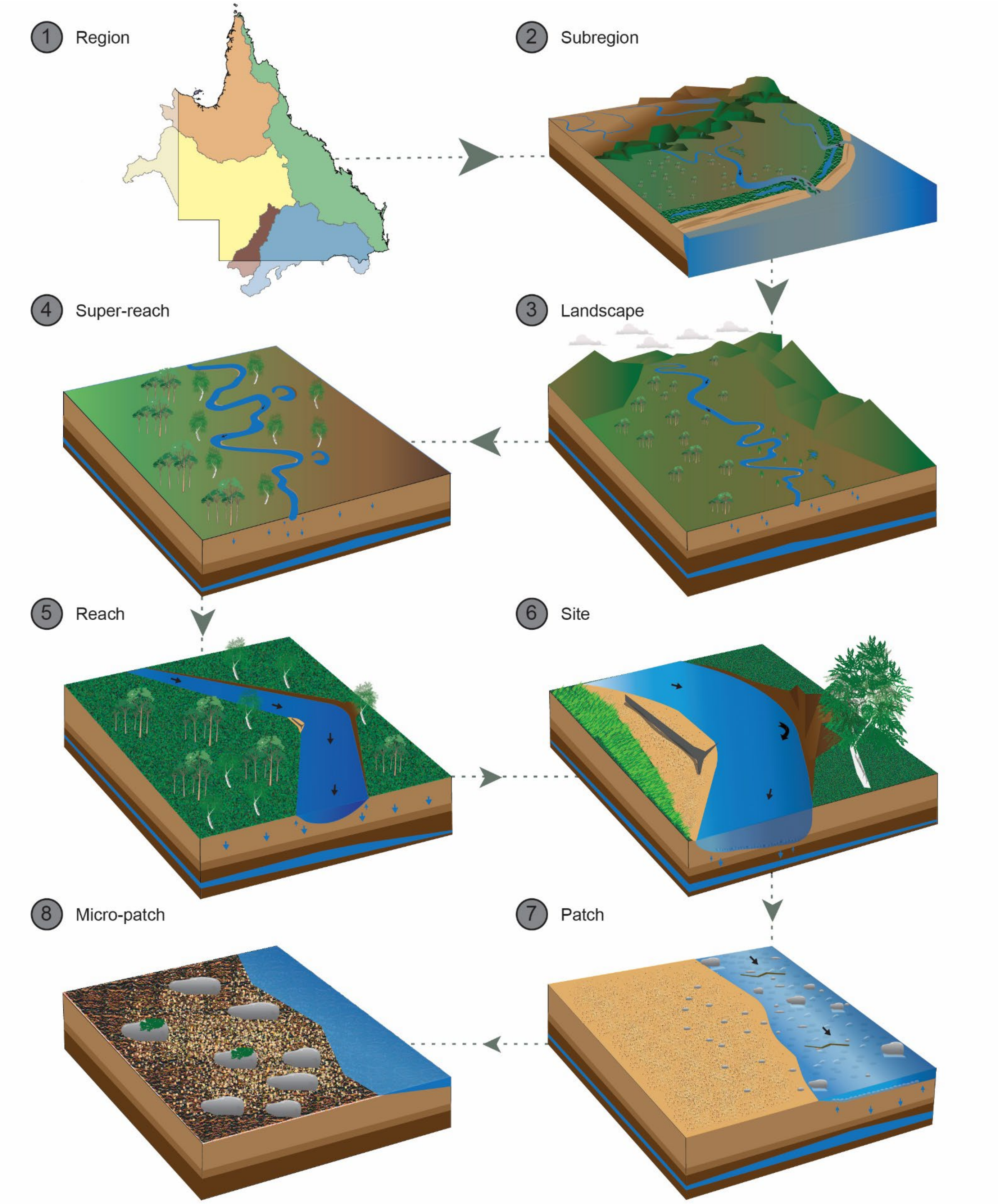


*Figure 9 Conceptual model for the spatial scales of riverine classification, showing each spatial level and the hierarchical flow between spatial levels.*

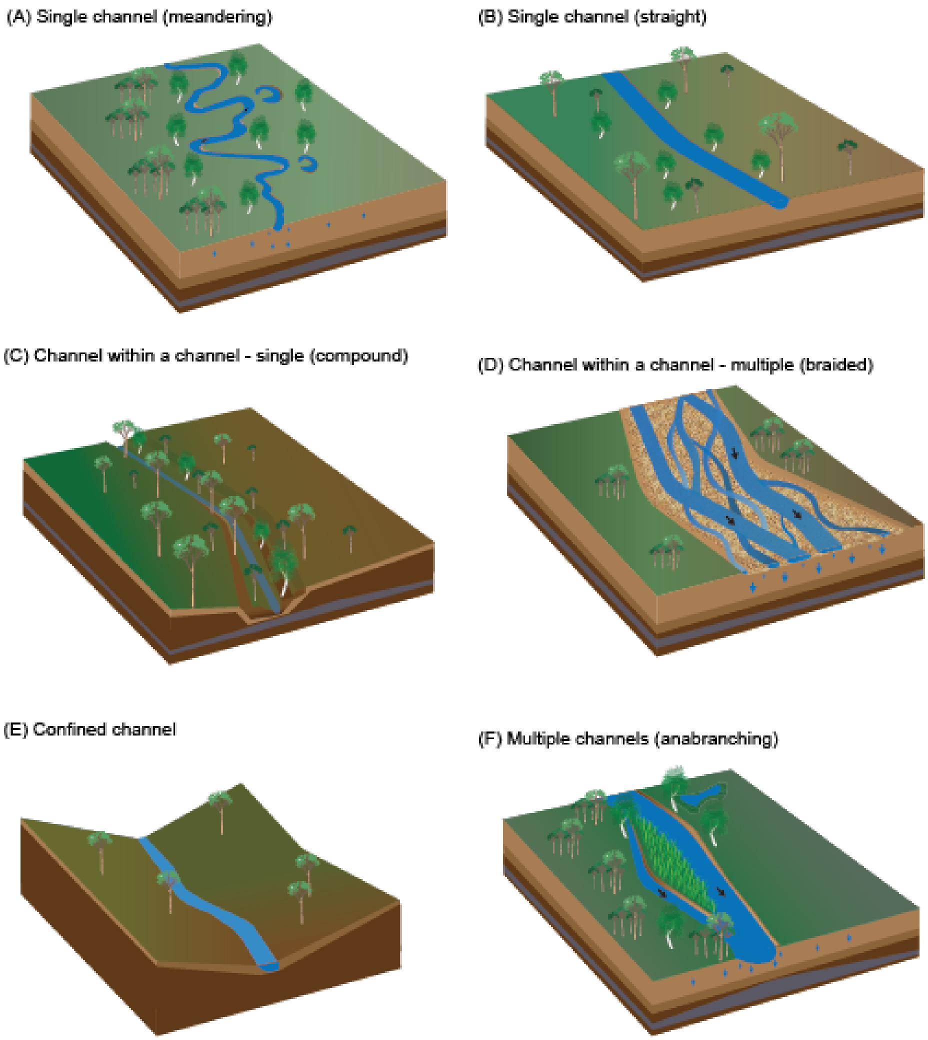


*Figure 10 Conceptual examples of river form at the super-reach spatial scale. (A) Super-reach with a single meandering channel; (B) Super-reach with a single straight channel; (C) Super-reach showing a single channel within a channel that has a compound form; (D) Super-reach showing multiple channels within a channel; (E) Super-reach with a confined channel; and (F) Super-reach with multiple channels (anabranching).*

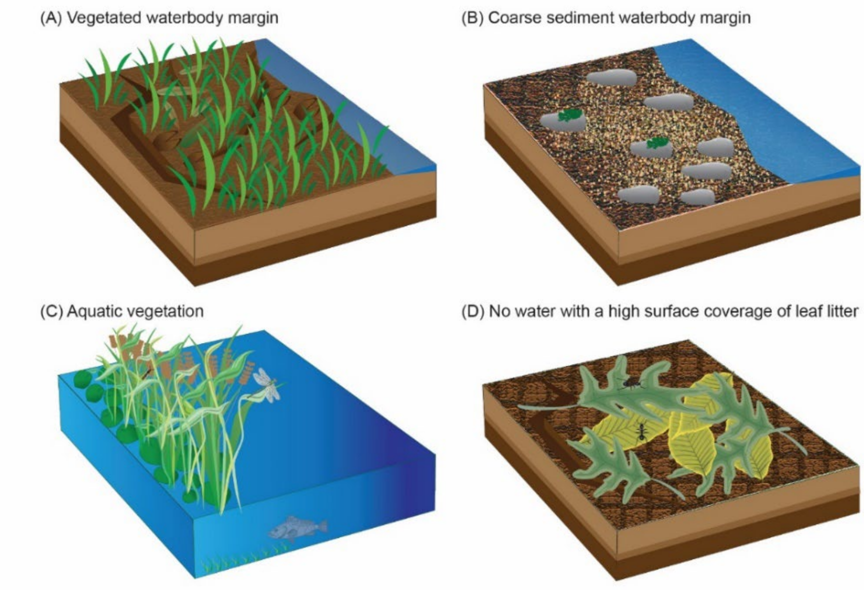


*Figure 11 Conceptual examples of forms at the micro-patch spatial scale. (A) Micro-patch showing a vegetated waterbody margin; (B) Micro-patch with a coarse sediment waterbody margin; (C) Micro-patch with aquatic vegetation; and (D) Micro-patch with no water but a high surface coverage of leaf litter.*

# 7 River classification attributes

This section provides a summary of nearly 200 biophysical attributes that can be applied to classify rivers. The attributes are derived from the literature review (Module 2), from existing attribute-based classifications, and recommendations from workshops and consultations with experts. The list is comprehensive but may be added to in the future as different purposes for classification and typologies are required and applied. Anthropogenic modifications are not included within the attributes as these are included as qualifiers. Not every attribute is required to type river ecosystems. The purpose for developing a river typology (or mapping), will determine which attributes are used.

Table 3 is a summary of the number of attributes developed for each of the eight themes. Attributes may be used at multiple scales. When considering all the available themes, the number of attributes suggested for different spatial levels ranges from 28 at the region level up to 164 for site. The high number of attributes applicable at the reach and site level indicates that these can be spatial levels with lots of potential for divergence into different types.

Table 4 to Table 11 provides details on the suggested spatial level(s) suitable for each attribute. There are two main ways that the attributes may be considered when suggesting applicable spatial levels. The first is the level at which the attribute may be usefully categorised. The second consideration are the levels that the attribute may be applied to. For most attributes the application and categorisation levels are the same, however, for some attributes there may be categorisation at one level but the attribute is still useful at the level above or, more often, below. A cross mark has been used to show where there is a suggested level that is not the same as the level of categorisation. For example, the attribute of precipitation may be applicable at the reach scale (shown with a cross) but the categories used may be more useful if they are derived at the region and landscape scales (shown with a circle).

The attributes in Table 4 to Table 11 have been separated based on the theme. Many can be used at multiple scales as indicated in the tables. It has also been indicated whether an attribute is a functional typology, spatial attribute or temporal attribute. In Table 1 above there is a list of qualifiers that may be applied to these attributes.

*Table 3 The number of attributes developed for each theme and the spatial levels over which they may be applied. A single attribute may be used at several different spatial levels.*

| Theme | Total number of attributes | Number of attributes suggested at each spatial level | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch |
| Biota | **20** | 1 | 3 | 9 | 9 | 11 | 17 | 13 | 12 |
| Climate | **17** | 16 | 16 | 17 | 17 | 16 | 15 | 15 | 15 |
| Geology | **1** | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| Hydrology (chemical) | **30** | 0 | 0 | 1 | 5 | 28 | 30 | 29 | 29 |
| Hydrology (physical) | **32** | 4 | 5 | 8 | 20 | 24 | 26 | 18 | 14 |
| Substrate (chemical) | **17** | 0 | 0 | 0 | 0 | 17 | 17 | 17 | 17 |
| Substrate (physical) | **18** | 0 | 2 | 3 | 17 | 17 | 18 | 15 | 12 |
| Terrain | **57** | 6 | 16 | 32 | 56 | 43 | 40 | 11 | 7 |
| **All themes** | 192 | 28 | 43 | 71 | 125 | 157 | 164 | 119 | 106 |

# 7.1 Biota theme attributes

*Table 4 Biota theme attributes*

| Biota theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Bare ground | The amount of bare ground in a given area. This does not include areas of biofilms and dead vegetation. | | | ● | ● | ● | ● | ● | ● | | ● | |
| Bioregion | Bioregions delineate regions with a similar set of major environmental influences (climate, geomorphology, landforms and lithology) that shape the occurrence of flora and fauna and their interaction with the physical environment. | ● | ● | ● | | | | | | ● | | |
| Crown cover | Crown cover, frequently referred to as canopy cover, is the percentage of the ground surface covered by the vertical projection of the periphery of plant crowns. | | | | ● | ● | ● | ● | ● | | ● | |
| Flora composition of dominant macro- and benthic algae | The dominant type of macro- and benthic algae that contributes most to the overall above-substrate biomass of the ecosystem. | | | | | | ● | ● | ● | ● | ● | |
| Flora composition of dominant plants | Flora composition refers to the genus of dominant or predominant flora, that is the species that contributes most to the overall above-ground biomass of the ecosystem. | | | ● | ● | ● | ● | ● | ● | | | |
| Flora growth form | Growth form refers to the growth form of vegetation in the ecologically dominant stratum. | | | ● | ● | ● | ● | ● | ● | ● | ● | |
| Flora growth height | Growth height refers to the height of vegetation in the ecologically dominant stratum relative to their growth form. | | | ● | ● | ● | ● | | | ● | ● | |
| Gross primary production (GPP) | The total amount of carbon that is fixed by primary producers during photosynthesis over a set time interval. This is usually evaluated over a 24 hour cycle. | | | | | | ● | ● | ● | | | ● |
| Net ecosystem metabolism | Overall metabolism of the system based on balance between gross primary production and respiration. This is usually evaluated over a 24 hour cycle. | | | | | | ● | ● | ● | ● | | |
| Presence of in-channel non-wetland indicator species | The presence of non-wetland indicator species growing in the channel. These plants are not specifically adapted to be wetland species. | | | | ● | ● | ● | | | ● | ● | |
| Regional Ecosystem | Vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. | | ● | ● | ● | | | | | ● | | |

| Biota theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Respiration | The conversion of organic carbon to carbon dioxide by metabolic processes. This is usually evaluated over a 24 hour cycle. | | | | | | ● | ● | ● | | | ● |
| Root density | The root density in a specified volume. | | | | | ● | ● | | | | ● | |
| Root depth | The root depth that plants penetrate into the riverbed or riverbank. | | | | | ● | ● | | | | ● | |
| Presence of bioengineered substrate | The presence of engineered substrate from fauna that modify substrate characteristics. Examples include atyid shrimp, crayfish, carp, platypus, bony bream and pigs. | | | | | | ● | ● | ● | | | |
| Timing of leaf drop | The dominant timing of leaf drop. | | | | | ● | ● | ● | ● | | | ● |
| Vegetation cover | Vegetation cover is the percentage of the ground or water surface covered by vegetation and biological crusts in contact with the soil surface or the vertical projection of the periphery of plant crowns. It incorporates crown cover and the foliage projective cover of the ground layer. | | | ● | ● | ● | ● | ● | ● | ● | ● | |
| Vegetation palatability | The likelihood that the vegetation will be consumed by fauna. | | | | | | ● | ● | ● | ● | | |
| Vegetation roughness | The cumulative roughness that vegetation places on flow in an area. | | | ● | ● | ● | ● | ● | | ● | | |
| Wetland Habitat | Wetland habitats represent a typology based on climate class, floodplain, flora composition, flora growth form, freshwater biogeographic province, groundwater flow system, permanence of water, salinity, source aquifer, substrate composition, substrate grain size, and wetland system. | | ● | ● | | | | | | ● | | |

## 7.2 Climate theme attributes

*Table 5 Climate theme attributes*

| Climate theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Air temperature | The temperature of the air. | ● | ● | x | x | x | ● | ● | ● | | | ● |
| Aridity index | Aridity index refers to an indicator of the degree of dryness of the climate at a given location based on mean annual precipitation and mean evapotranspiration. | ● | ● | x | x | x | x | x | x | ● | | ● |
| Climate class | Climate classes represent six major groups at the regional scale considering the climatic limitations of native vegetation. Climate classes at the landscape scale refine these major groups into 27 groups considering the seasonal distribution of temperature and precipitation. | ● | ● | ● | x | x | x | x | x | ● | | |
| Dominant energy source | The dominant source of energy within the system. | ● | ● | ● | ● | ● | ● | ● | ● | | | |
| Effective precipitation | The average amount of precipitation that reaches a stream channel as direct runoff. This is usually calculated by subtracting the amount of evapotranspiration in an area from the total precipitation over the same area and duration. | ● | ● | ● | x | x | | | | ● | | ● |
| Evaporation | A measure of the amount of surface liquid water transformed to water vapour. | ● | ● | x | x | x | x | ● | ● | | | ● |
| Evapotranspiration | A measure of the combined loss of water by evaporation and transpiration. | ● | ● | x | x | x | x | ● | ● | | | ● |
| Heat/terrestrial radiation | The average amount of heat emitted as surface terrestrial radiation. | ● | ● | x | x | x | x | ● | ● | | | ● |
| Kinetic energy of raindrops | As raindrops fall from the sky they gain kinetic energy due to gravity. | | | ● | ● | ● | ● | ● | ● | | | ● |
| Light/solar radiation | The amount of light or solar radiation. | ● | ● | x | x | x | ● | ● | ● | | | ● |
| Phase-offset | Phase-offset refers to the difference (in months) between the timing of maximum mean annual precipitation and mean potential evapotranspiration. | ● | ● | x | x | | | | | ● | | ● |
| Potential evapotranspiration | The transfer of water, as water vapour, to the atmosphere from vegetated and un-vegetated land surfaces. | ● | ● | x | x | x | x | ● | ● | | | ● |

| Climate theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Precipitation | The amount of precipitation that an area receives over a specified period of time. | ● | ● | ● | x | x | x | ● | ● | | | ● |
| Precipitation timing | The month that receives the highest monthly rainfall, whereby the monthly average is calculated using 30 years of monthly gridded rainfall data between 1981 and 2010. | ● | ● | ● | x | x | x | ● | ● | | | ● |
| Relative humidity | The amount of moisture in the air as a percentage of the amount the air can hold. | ● | ● | x | x | x | x | ● | ● | | | ● |
| Wind direction | The dominant wind direction based on the direction the wind originates from. | ● | ● | x | x | ● | ● | ● | ● | | | ● |
| Wind velocity | The speed of the wind in an area. | ● | ● | x | x | x | x | ● | ● | | | ● |

## 7.3 Geology theme attributes

*Table 6 Geology theme attributes*

| Geology theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Geology | Physical characteristics of underlying rock. | ● | ● | ● | ● | ● | ● | ● | | ● | ● | |

## 7.4 Hydrology (chemical) theme attributes

*Table 7 Hydrology (chemical) theme attributes*

| Hydrology (chemical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Alkalinity | Alkalinity is a measure of the capacity of water to neutralise added acid. | | | | | ● | ● | ● | ● | | | |

| Hydrology (chemical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Clarity | A measure of the transparency of water, typically measured using a Secchi disc. The depth to which the black and white markings on a Secchi disc can be clearly seen from the surface of the water provides an indication of light penetration. | | | | | ● | ● | ● | ● | | | |
| Colour | Colour is a measure of light 'quality' of water and results from light attenuation and scattering by dissolved matter and suspended particulates. True colour is colour of water with particulates (>0.45μm) removed. | | | | | ● | ● | ● | ● | | | |
| Hardness | A total measure of major cations in water, predominantly calcium and magnesium. | | | | | ● | ● | ● | ● | ● | | |
| Mixing state | Characterises the homogeneity of the water column. | | | | | | ● | ● | ● | ● | | |
| Suspended load | The portion of river sediment load carried suspended in the water column for a time. It may remain suspended or settle to the bed. | | | | ● | ● | ● | ● | ● | | | |
| Suspended sediment hysteresis | This describes the nonlinear relationship between discharge and suspended sediment concentration. | | | | ● | ● | ● | | | ● | | ● |
| Total dissolved load | The portion of the river sediment load carried in solution. Solutes may be organic and inorganic and are usually <0.45μm in diameter. | | | | ● | ● | ● | ● | ● | | | |
| Total Suspended Solids | Small particles of insoluble material (sediment, plankton, organic matter) suspended in water. | | | | ● | ● | ● | ● | ● | | | |
| Trophic state | A measure of the productivity of aquatic ecosystems, in terms of organic carbon produced per unit of time and surface. Waters with low productivity are termed oligotrophic and waters with high productivity eutrophic. | | | | | ● | ● | ● | ● | ● | | |
| Turbidity | A measure of the 'cloudiness' of water, often measured as light scattering by suspended particles in the water column. | | | | | ● | ● | ● | ● | | | |
| Wash load | The portion of river sediment load that does not interact with the bed. It is kept permanently in suspension. | | | | ● | ● | ● | ● | ● | | | |
| Water - ammonia nitrogen | A measure of ammonia nitrogen in water which includes both ionised ($NH_4^+$) and unionised ($NH_3$) forms of ammonia. | | | | | ● | ● | ● | ● | | | |

| Hydrology (chemical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Water - bioavailable nitrogen | The forms of nitrogen in water that directly support biological processes such as growth of phytoplankton. This includes dissolved and particulate inorganic nitrogen and mineralisable forms of organic nitrogen. | | | | | ● | ● | ● | ● | ● | | |
| Water - bioavailable phosphorous | The forms of phosphorus in water that directly support biological processes such as growth of phytoplankton. This includes filterable reactive phosphorus and mineralisable forms of organic phosphorus. | | | | | ● | ● | ● | ● | ● | | |
| Water - dissolved inorganic nitrogen | A measure of the dissolved (<0.45μm) forms of inorganic nitrogen in water. Calculated by addition of oxidised nitrogen and ammonia nitrogen. | | | | | ● | ● | ● | ● | ● | | |
| Water - dissolved organic carbon | A measure of the dissolved (<0.45μm) forms of organic carbon in the water. | | | | | ● | ● | ● | ● | | | |
| Water - Dissolved organic nitrogen | A measure of the dissolved (<0.45μm) forms of organic nitrogen in water. Calculated by subtracting dissolved inorganic nitrogen (DIN) from total dissolved nitrogen. | | | | | ● | ● | ● | ● | ● | | |
| Water - dissolved oxygen concentration | Dissolved oxygen in water is essential for life processes of most aquatic organisms, and is influenced by photosynthesis, respiration and atmospheric exchange processes. | | | | | ● | ● | ● | ● | | | |
| Water - dissolved oxygen saturation | Dissolved oxygen saturation in water is a measure of dissolved oxygen relative to the maximum concentration at equilibrium given salinity, temperature and atmospheric pressure. | | | | | ● | ● | ● | ● | ● | | |
| Water - electrical conductivity | A measure of the amount of dissolved salts in the water, and therefore an indicator of salinity. | | | | | ● | ● | ● | ● | | | |
| Water - filterable reactive phosphorus | A measure of all forms of phosphorus in water that pass through an 0.45μm filter and react with molybdenum blue reagent. This fraction is largely comprised of orthophosphate. | | | | | ● | ● | ● | ● | | | |
| Water - ionic composition | Describes the relative abundance of major anions and cations in the water. | | | | | ● | ● | ● | ● | ● | | |
| Water - oxidised nitrogen | A combined measure of the oxidised forms of nitrogen (nitrate and nitrite) in water. | | | | | ● | ● | ● | ● | | | |

| Hydrology (chemical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Water - pH | pH refers to the acidity or alkalinity of water on a scale of 0 to 14. | | | | | ● | ● | ● | ● | | | |
| Water - redox potential | A measure of the overall reducing or oxidising capacity of the water. | | | | | | ● | ● | ● | ● | | |
| Water - salinity | Salinity refers to the amount of dissolved salt in the water. | | | ● | | ● | ● | ● | ● | | | |
| Water - temperature | A measure of the degree of hotness or coldness of water. | | | | | ● | ● | ● | ● | | | |
| Water - total nitrogen | A measure of all forms of nitrogen in water. | | | | | ● | ● | ● | ● | | | |
| Water - total phosphorous | A measure of all forms of phosphorus in water. | | | | | ● | ● | ● | ● | | | |

## 7.5 Hydrology (physical) theme attributes

*Table 8 Hydrology (physical) theme attributes*

| Hydrology (physical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Aquifer confinement | Aquifer confinement is the level of interaction of the source aquifer with ground surfaces conditions (e.g. rainfall). Aquifers can range in their degree of confinement. | | | ● | | | | | | | ● | |
| Aquifer Groundwater Flow System | Aquifer Groundwater Flow Systems depict groundwater flow systems at a habitat scale based on their hydrogeological characteristics using a combination of geology, geomorphology and topographical information. | ● | ● | ● | | | | | | ● | ● | |
| Aquifer name | Name of the source aquifer or aquifer ecosystem. | ● | ● | ● | x | x | x | x | | ● | ● | |

| Hydrology (physical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Bankfull discharge | Discharge at a point in the river that occurs at bankfull water height. | | | | | • | • | | | | • | • |
| Catchment channel flow yield | The discharge for a time interval divided by the catchment area (volume/area). This is often calculated annually. | | • | • | • | • | • | | | • | • | • |
| Channel flood frequency | The frequency of floods that a channel experiences. This is frequently described as either the annual exceedance probability (AEP) or the average recurrence interval (ARI). | | | | • | • | • | | | | • | • |
| Channel flow discharge | The volume of water that flows through a point in the river in a specified period of time. It is often quantified annually as ML/year. It is also frequently calculated at the end catchment outlet. | | | | • | • | • | • | • | | • | • |
| Degree of hyporheic connectivity | Describes the degree of connection between the water column and the hyporheic zone. | | | | | • | • | • | | • | | |
| Degree of parafluvial connectivity | Describes the degree of connection between the water column and the parafluvial zone. | | | | • | • | x | x | | • | | |
| Energy | The energy that a body of water exerts on its boundary. One way this can be quantified is by stream power. | • | • | • | • | • | • | • | • | | | |
| Floodplain flood velocity | The velocity of water on the floodplain. | | | • | • | | | | | | • | |
| Flow response (lag) time | This is the elapsed time between peak precipitation in an event and peak discharge. Lag time can be influenced by a range of factors including catchment size, slope, vegetation coverage and surface permeability. | | | | • | • | • | | | | | • |
| Groundwater - surface water connectivity | Describes the connection and direction of flow between channel and groundwater. | | | | | • | • | x | | | • | |
| Hydraulic resistance | The degree of energy loss in fluid flow as a result of roughness. The roughness may be at differing scales including sediment grains, bedforms and channel form such as meander bends as well as vegetation. | | | | • | • | • | • | • | • | | |
| Length of time water is at bankfull | The average period of flows at or above bankfull. This could be the annual average. | | | | • | • | • | | | • | • | • |

| Hydrology (physical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Period of no flow | The length of time that there is no surface flow in the channel during a set time interval. There may still be standing water that is not flowing. | | | | • | • | • | • | • | | | • |
| Permanence of water in channel | Permanence of water refers to the length of time and how regularly a channel has water in it. | | | | • | • | • | • | • | | | • |
| Permanence of water in the broader landform unit | Describes the length of time and frequency that water is present in the larger landform unit of the floodplain. | | | • | • | • | • | | | | • | • |
| Photosynthetically active radiation (PAR) | A measure of the solar radiation available for photosynthesis. | | | | | | • | • | • | • | | |
| Proportion of flow (groundwater) | The ratio of groundwater volume to the total volume of channel discharge. | | | | • | • | • | | | | | • |
| Rate of recession | The rate of water surface elevation (stage) change over time as flows are decreasing after an event peak. | | | | • | • | • | • | • | | | • |
| Rate of rise | The rate of water surface elevation (stage) change over time as flows are increasing before an event peak. This is also referred to as the rising limb. | | | | • | • | • | • | • | | | • |
| Relative dominance of water source | The water source is the broad part of the environment that water is generated from, such as ground or surface waters. Dominance is defined as being the primary source of water for more than 70% of the time (based on Wetland Classification Scheme attribute). | | | | • | • | • | • | • | • | | |
| Shear stress | The force of water moving against the channel boundaries and/or broader landscape. This is calculated as force per unit area. It can be applied in the channel or floodplain, or can be applied as a bankfull shear stress. | | | | • | • | • | • | • | | | • |
| Time to sink | The length of time it takes for water to travel from the most distal point in the upper catchment to the catchment outlet or sink. This is commonly referred to as the time of concentration. | | • | • | | | | | | | • | |
| Topographic drainage (landscape) | Topographic drainage refers to where water flows and drains across the land surface based on drainage-enforced elevation models. At the landscape scale these equate to the drainage basins dataset. | | | | | | | | | | | |

| Hydrology (physical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Topographic drainage (region) | Topographic drainage refers to where water flows and drains across the land surface based on drainage-enforced elevation models. At the regional scale these equate to the drainage divisions determined by the Australian Water Resources Management Committee (WRMC). | ● | | | | | | | | | ● | |
| Water depth | The depth of water. This may be determined spatially such as over a reach or temporally over a year. | | | | | ● | ● | ● | ● | | ● | ● |
| Water source distance | Describes the maximum travel distance that the water source (e.g. groundwater, surface water, both groundwater and surface water) takes to deliver water to a point of interest. | | | | ● | ● | ● | | | | ● | |
| Water turbulence | A measure of the mixing of the water. Turbulence produces a three-dimensional flow field with eddies occurring due to morphology, grain roughness and vegetation. | | | | | | ● | ● | ● | | | |
| Water velocity | The variability in water velocities at an instant in time measured across an area of interest. This may be quantified using the coefficient of variation. | | | | ● | ● | ● | ● | ● | | | ● |
| Water velocity at bankfull | A measure of the channel cross-section velocities at bankfull discharge. | | | | | ● | ● | ● | ● | | | ● |

## 7.6 Substrate (chemical) theme attributes

*Table 9 Substrate (chemical) theme attributes*

| Substrate (chemical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Substrate - acid sulfate | The presence of potential or actual acid sulfate in the substrate. | | | | | ● | ● | ● | ● | | | |
| Substrate - ammonia nitrogen | A measure of ammonia nitrogen in the substrate which includes both ionised ($NH_4^+$) and unionised ($NH_3$) forms of ammonia. | | | | | ● | ● | ● | ● | | | |

| Substrate (chemical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Substrate - bioavailable nitrogen | The forms of nitrogen in the substrate that directly support biological processes such as growth of phytoplankton. This includes dissolved and particulate inorganic nitrogen and mineralisable forms of organic nitrogen. | | | | | • | • | • | • | • | | |
| Substrate - bioavailable phosphorous | The forms of phosphorus in the substrate that directly support biological processes such as growth of phytoplankton. This includes filterable reactive phosphorus and mineralisable forms of organic phosphorus. | | | | | • | • | • | • | • | | |
| Substrate - cation exchange capacity | A measure of the substrates capacity to hold positively charged ions, including important nutrients calcium, magnesium and potassium. | | | | | • | • | • | • | • | | |
| Substrate - electrical conductivity | A measure of the ability of the substrate (measured as a water-saturated extract) to conduct an electric current. It is often used as a metric of salinity. | | | | | • | • | • | • | | | |
| Substrate - filterable reactive phosphorus | A measure of all forms of phosphorus in the substrate that pass through an 0.45µm filter and react with molybdenum blue reagent, this fraction is largely comprised of orthophosphate. | | | | | • | • | • | • | | | |
| Substrate - inorganic nitrogen | A measure of the inorganic nitrogen in the substrate. Calculated by addition of oxidised nitrogen and ammonia nitrogen. | | | | | • | • | • | • | • | | |
| Substrate - ionic composition | Describes the relative abundance of major anions and cations in the substrate. | | | | | • | • | • | • | • | | |
| Substrate - organic nitrogen | A measure of the organic nitrogen in the substrate. Calculated by subtracting inorganic nitrogen from total dissolved nitrogen. | | | | | • | • | • | • | • | | |
| Substrate - oxidised nitrogen | A combined measure of the oxidised forms of nitrogen (nitrate and nitrite) in the substrate. | | | | | • | • | • | • | | | |
| Substrate - pH | A measure of the acidity or alkalinity of the substrate. | | | | | • | • | • | • | | | |
| Substrate - redox potential | A measure of the overall reducing or oxidising capacity of the substrate. | | | | | • | • | • | • | | | |

| Substrate (chemical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Substrate - salinity | The concentration of soluble salts in the substrate. | | | | | ● | ● | ● | ● | | | |
| Substrate - total carbon | The total carbon concentration in the substrate. | | | | | ● | ● | ● | ● | | | |
| Substrate - total nitrogen | A measure of all forms of nitrogen in the substrate. | | | | | ● | ● | ● | ● | | | |
| Substrate - total phosphorous | A measure of all forms of phosphorus in the substrate. | | | | | ● | ● | ● | ● | | | |

## 7.7 Substrate (physical) theme attributes

*Table 10 Substrate (physical) theme attributes*

| Substrate (physical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Large wood jams | A large wood jam is defined as 2 or more pieces of large wood touching each other whereby large wood is defined as pieces > 1m in length and 0.1 m in diameter. | | | | ● | ● | ● | | | | ● | |
| Large wood pieces | Large wood is defined as pieces > 1m in length and 0.1 m in diameter. | | | | ● | ● | ● | ● | | | ● | |
| Large wood volume | The volume of large wood (kg/m$^3$) in a given area. | | | | ● | ● | ● | ● | | | ● | |
| Material on substrate | The material sitting on top of the substrate, for example leaf litter. | | | | ● | ● | ● | ● | ● | | | |
| Soil texture | Soil texture refers to the relative proportion of clay, sand, and silt in the soil. | | ● | ● | ● | ● | ● | ● | ● | ● | | |
| Substrate cohesion | Cohesion refers to the bonding of fine grain particles via electrochemical forces. The proportion of silts and clays in the substrate can be used to indicate its cohesive properties. | | | | ● | ● | ● | ● | ● | | | |

| Substrate (physical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Substrate composition | Categorises the composition of land surface. | | | | ● | ● | ● | ● | ● | ● | | |
| Substrate consolidation | Consolidated substrates are those which are not friable and have become hardened into substrates such as rock. Consolidated substrates are enduring, whereas unconsolidated or mixed substrates are less enduring. Consolidated substrates provide attachment sites for a diversity of biota including coral reefs and other important bioconstructors. | | | | ● | ● | ● | ● | ● | ● | ● | |
| Substrate depth | The depth of the substrate. This may be the depth of mobile sediment in a riverbed. | | | ● | ● | ● | ● | ● | ● | | | |
| Substrate dispersion | The potential for the substrate to disaggregate when wet. This is often quantified using an Emerson test. | | | | ● | ● | ● | | | | | |
| Substrate hydraulic conductivity | A measure the of ease of the substrate to transmit fluid based on both properties of the substrate and the properties of the fluid. | | | | ● | ● | ● | ● | | | | |
| Substrate inorganic grain particle size | A categorisation of the particle size of inorganic material. | | | | ● | ● | ● | ● | ● | ● | | |
| Substrate lithology (geology) | A description of the different physical characteristics that can be used to separate out layers of substrate. These descriptors can include colour, texture and grain size. | | | | ● | ● | ● | ● | ● | ● | | |
| Substrate organic grain particle size | A categorisation of the particle size of organic material. | | | | | | ● | ● | ● | | | |
| Substrate permeability | A measure of the ease of rock to transmit fluid based on the properties of the substrate. | | ● | ● | ● | ● | ● | ● | ● | | | |
| Substrate resistance | The ability of the substrate to resist forces acting on it. | | | | ● | ● | ● | ● | ● | | | |
| Substrate roughness | This describes the roughness produced by the substrate which is characterised by the variability or irregularity in elevation within a spatial unit. | | | | ● | ● | ● | ● | ● | | ● | |

| Substrate (physical) theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Substrate slaking potential | The potential for a material to disintegrate when inundated by water or exposed to the atmosphere. It can be caused by the swelling of clays forcing out interstitial air. | | | | • | • | • | | | | | |

## 7.8 Terrain theme attributes

*Table 11 Terrain theme attributes*

| Terrain theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Abandoned channels | Channels that do not take bedload under typical flow conditions. This may be categorised by the number of abandoned channels on the floodplain or the length, surface area or relative volume that they cover. | | | • | • | | | | | | • | |
| Channel arrangement | The way that channels are positioned relative to each other. | | | | • | x | x | | | • | • | |
| Channel bed width | A measurement of the channel bed width, measured perpendicular to the centreline. | | | | • | • | | | | | • | |
| Channel cross-sectional area | A measurement of the area of a channel cross-section. This is usually standardised by measuring the area of the bankfull channel perpendicular to the channel centreline. | | | | • | • | • | | | | • | |
| Channel depth | A measure of the channel depth. This is often standardised by using the elevation difference between the deepest point in the channel (thalweg) and the elevation of the top of the bankfull channel. | | | | • | • | • | | | | • | |
| Channel direction | The cardinal direction that the channel flows in from upstream to downstream. | | • | • | • | | | | | | • | |
| Channel levee elevation | The elevation difference between the top of the channel levee and the adjacent floodplain surface. | | | | • | • | • | | | • | • | |
| Channel levee extent | The longitudinal extent of a channel levee compared to the length of the channel. | | | | • | • | • | | | • | • | |

| Terrain theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Channel levee presence | The presence or absence of ridge on the floodplain that is parallel and adjacent the banktop. | | | | ● | ● | ● | | | ● | ● | |
| Channel migration rate | The distance moved by a laterally migrating channel. It is often measured based on the change in channel centreline between two time periods perpendicular to the centreline, and can be quantified annually. | | | ● | ● | ● | | | | | ● | ● |
| Channel morphological sequences | Channel morphological sequences are functional typologies that include a spatial attribute. These common sequences consider spatial location, the sequence of morphs and the sediment size in the channel. | | | | ● | ● | ● | | | ● | ● | |
| Channel network pattern | The way channels are orientated and connected with each other. | | ● | ● | ● | x | x | | | ● | ● | |
| Channel perimeter | A measure of the length of the channel boundary surface. This is usually measured in a cross-section perpendicular to the channel centreline and standardised using the extent of the bankfull channel. | | | | ● | ● | ● | | | | ● | |
| Channel planform area | The total area of a channel over a specified distance, measured looking down on the channel (planform) and standardised by using the extent of the bankfull channel. | | | | ● | ● | ● | | | | ● | |
| Channel sediment accumulation/deposition features | A functional typology of the morphs of sediment accumulation in the channel that also considers spatial location. Commonly used categories include bars, benches and islands - further determination of these features by a typology process is still required. | | | | ● | ● | ● | ● | | ● | ● | ● |
| Channel sediment removal/erosion features | A functional typology of the morphs of sediment erosion in the channel that also considers spatial location. Commonly used categories include headcuts, scour holes, undercuts and mass failure scars - further determination of these features by a typology process is still required. | | | | ● | ● | ● | ● | | ● | ● | ● |
| Channel sinuosity | The length of the channel over a set distance divided by the length of the valley over the same distance. | | | ● | ● | | | | | ● | ● | |
| Channel width | The channel width, measured perpendicular to the centreline. This is often standardised by using the bankfull width. | | | | ● | ● | ● | | | | ● | |
| Confinement source | A functional typology that indicates the material or landform that generates the confinement in the surrounding landscape. | | ● | ● | ● | | | | | ● | ● | |

| Terrain theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Contiguity | The degree of disconnection. Indicates how much of the channel or network flows down a channel rather than overland or in wetlands, lakes or reservoirs. | | | ● | ● | ● | x | | | | ● | |
| Difference in slope of opposing riverbanks | The difference in slope of opposing riverbanks. Each side is measured from the top of bank to the bottom of the bank, perpendicular to the channel, and then compared. | | | | ● | ● | ● | | | | ● | |
| Dominant sediment source | The dominant source of sediment for a site. This considers a typology of landscape locations that can supply sediment. | | ● | ● | ● | ● | ● | | | | ● | ● |
| Dominant sediment source relative position | The relative position in the catchment from which the dominant source of sediment is derived. | | ● | ● | ● | ● | ● | | | | | |
| Drainage density | The ratio between the total length of all streams within the river catchment determined at a defined spatial resolution (e.g. 1:50,000) and the total area of the catchment. | | ● | ● | x | x | x | | | | ● | |
| Elevation differences between planar surfaces | The difference in elevations between two planar surfaces. This is often applied to different heights on the floodplain. | | | ● | ● | | | | | ● | ● | |
| Elevation/Altitude | Elevation/Altitude refers to the vertical distance between a feature and Australian Height Datum. | ● | ● | ● | ● | ● | ● | ● | ● | | | |
| Floodplain slope | The slope along the surface of a floodplain. This is often reported perpendicular to the channel. | | | ● | ● | | | | | | ● | |
| Floodplain vertical accretion rate | The rate of vertical accretion is the rate at which sediment is deposited on the floodplain from overbank flows. | | | ● | ● | | | | | | ● | ● |
| Floodplain width | The average width of the floodplain. | | | ● | ● | | | | | | ● | |
| Land zone (landscape) | Land zones represent major differences in geology and in the associated landforms, soils, and physical processes that give rise to distinctive landforms or continue to shape them. | x | x | ● | x | x | x | | | ● | ● | |
| Land zone (regional) | Land zones represent major differences in geology and in the associated landforms, soils, and physical processes that give rise to distinctive landforms or continue to shape them. | ● | ● | x | x | x | x | | | ● | ● | |
| Lateral confinement | The degree to which topographic features (e.g. hillslopes) limit the lateral extent of an active riverine system. | | ● | ● | ● | | | | | ● | ● | |
| Longitudinal slope morphology | A categorical description of the shape based on slopes in a long profile. This is often measured parallel to the channel centreline. | | | | ● | ● | ● | ● | ● | | ● | |

| Terrain theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Meander belt width | The width that the channel occupies in the floodplain when it has fully developed meanders. This is the amplitude of the fully developed meanders. | | | • | • | | | | | | • | |
| Number of channels | A count of the number of channels that are taking flow and bedload. This is applicable at the superreach scale. | | | | • | x | x | | | | • | |
| Physiographic province | Physiographic provinces distinguish major physiographic changes based on similarities in landform characteristics and/or processes. Each province is described in terms of geology, structure, and broad regolith types. | • | • | • | x | x | x | | | • | • | |
| Presence of morphs of sediment accumulation | The presence of a morphological shape in the channel formed by sediment accumulation/deposition. | | | | • | • | • | • | | • | • | • |
| Presence of morphs of sediment removal | The presence of a morphological shape formed by sediment removal/erosion. | | | | • | • | • | • | | • | • | • |
| River terrace continuity | Describes how continuous the terrace is longitudinally over a specified length and direction. | | | • | • | | | | | • | • | |
| River terrace formation process | The process through which the river terrace is formed. The terrace is planar and stands above the present level of the floodplain. | | | • | • | | | | | • | • | |
| River terrace width | The width of the terrace perpendicular to the stream. | | | • | • | | | | | • | • | |
| Riverbank erosion process | The process of bank erosion that produces that greatest volume of sediment. | | | | • | • | • | | | • | • | • |
| Riverbank slope | The slope of a riverbank, from the top of bank to the bottom of the bank, perpendicular to the channel. | | | | • | • | • | | | | • | |
| Sediment budget | The amount of sediment that is mobilised and deposited in a specified area over a set time interval. In channels this is often measured in the bankfull channel over a year and represented by the equation of net change equals volume of deposition less volume of erosion. | | • | • | • | • | • | | | | • | • |
| Sediment transport mode | The dominant process for sediment transport. | | | | • | • | • | | | • | | • |
| Slope morphology in cross-section | A categorical description of the shape based on the side slopes in a cross-section. This is often measured perpendicular to the channel centreline. Each side is assessed separately. | | | • | • | • | • | | | | • | |

| Terrain theme attribute | Short description | Suggested spatial level | | | | | | | | Functional typology | Spatial attribute | Temporal attribute |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Region | Subregion | Landscape | Super reach | Reach | Site | Patch | Micro-patch | | | |
| Slope of surface water | The angle of the water surface relative to the horizontal within a channel length from an upstream point to downstream point. | | | | ● | ● | | | | | ● | |
| Slope of upstream area | The slope of the upstream catchment area. | | ● | ● | ● | ● | ● | | | | ● | |
| Structural control | A structural control is a discontinuity (e.g. geological) that can alter channel form and processes. | | | ● | ● | ● | | | | | ● | |
| Subaerial area | This is the area that is not occupied by water in the channel at a specified water level. | | | | | | ● | ● | ● | | ● | |
| Terrain morphology | Terrain morphology describes basic shapes that constitute the landform surface as described in Bolongaro-Crevenna et al. (2005). These can be used at multiple spatial levels and can be used in combination to describe different features. | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | |
| Terrain slope | Indication of the general or dominant slope of a morphological feature. | ● | ● | ● | ● | ● | ● | ● | ● | | ● | |
| Upstream catchment area | The area upstream of a given point that the land surface drainage flows to topographically. | | ● | ● | ● | ● | ● | | | | ● | |
| Upstream network confinement (proportion) | Proportion of upstream channel network length with a laterally confining margin. | | | ● | ● | ● | ● | | | ● | ● | |
| Vertical confinement | This refers to the degree to which the substrate (e.g. bedrock) limits the vertical migration of an active riverine system. | | | ● | ● | ● | ● | | | ● | ● | |
| Wetted area | The total area of a channel that is occupied by water at a defined water level over a specified distance. This can be calculated in a cross-section to show the area of water in relation to the channel cross-sectional area. It may also be calculated in planform (looking down the channel) to show the proportion of a channel over a reach that has water. | | | | ● | ● | ● | ● | ● | | ● | |
| Wetted perimeter | The perimeter of a river channel in a cross section that is covered by water at a specific water level. | | | | ● | ● | ● | ● | ● | | ● | |

# 8 Conclusion

The Queensland River Classification Scheme (QRCS) provides a structured system for classifying riverine ecosystems. The QRCS was developed through expert workshops and consultation involving policy makers and scientists from state, local and federal government bodies, universities, and consulting firms with input from a wide range of disciplines. It is effectively a synthesis of concepts and ideas that are currently being applied to specific areas and datasets in less transferable ways.

The strengths of this product are that it enables integration across all aquatic ecosystems and it provides a classification scheme which can be used for a range of purposes rather than having significant investment every time a new classification purpose is identified. Government agencies, research organisations and consulting groups can all utilise the same classification scheme for whatever purpose they may need it for. When populating the attributes, the scheme also enables gaps to be identified where more research or data is needed across the state.

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