Government of **Western Australia**
Department of **Water and Environmental Regulation**

SOUTH-WEST
INDEX OF RIVER CONDITION

# River Science

## technical series


# South-West Index of River Condition

Method summary for the assessment of river health for south-west Western Australian rivers

Report 1 | December 2020

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River Science Technical Series

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Cover image: Graphic – South-West Index of River Science themes (Tim Storer)

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# Preface

The South-West Index of River Condition (SWIRC) is a toolkit of data collection and analysis methods for identifying and assessing the values, threats and condition of rivers and streams within south-west Western Australia.

The SWIRC was designed to enable an integrated assessment of river health through incorporating information across the range of pressures and stressors, such as those identified in Figure 1, facing rivers in the region, to support their management.

This is the standard assessment method for rivers within the Department of Water and Environmental Regulation's (the department) Healthy Rivers program. For further information on the program go to rivers.dwer.wa.gov.au or contact the department's River Science team.


Figure 1 Pressures on rivers in south-west Western Australia

# 1 South-West Index of River Condition

The South-West Index of River Condition (SWIRC) is a toolkit developed for the assessment of river health in south-west Western Australia. It was designed to be applied across the various system types, conditions and management needs in the region. The SWIRC incorporates standardised methods for collecting field and desktop data, and a suite of indicators designed to help in describing and interpreting river condition.

The SWIRC condition assessments are designed to:

- identify important ecological values and the threats to these values
- provide outputs that are easy to interpret (e.g. using indicators that respond predictably to impacts caused by humans)
- work at spatial and temporal scales that are appropriate for management, are cost-effective, easily replicated and scientifically defensible.

This document summarises the development, intended use and general principles of the SWIRC, and is the first document in a series describing the data collection and analysis methods across each of the SWIRC themes, outlined below.

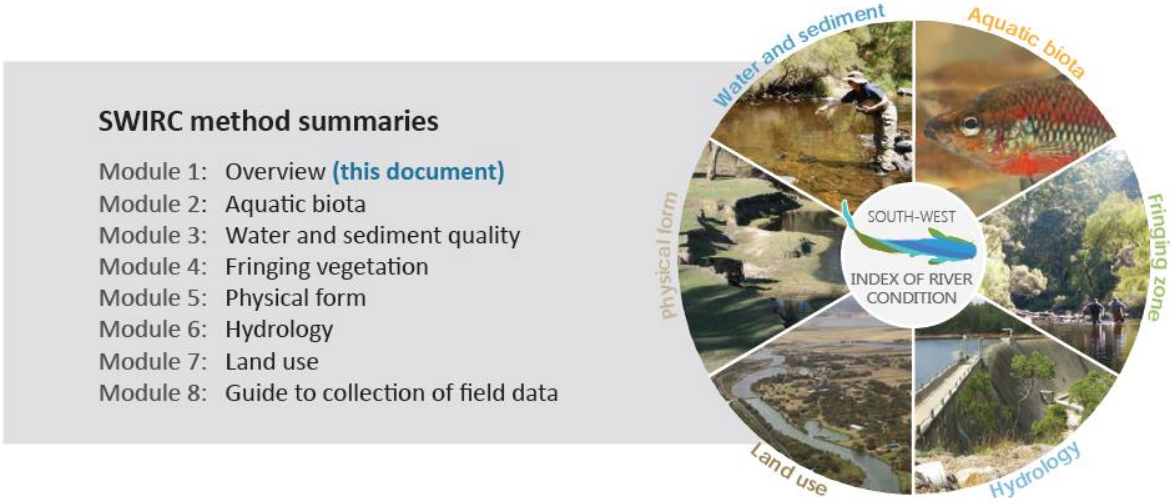


*Figure 2 Modules in the SWIRC method series*

## 1.1 Development and use of the SWIRC

The SWIRC was created by the department to help in determining management requirements to support rivers of south-west Western Australia (based on the assessment of values and threats) and to evaluate actions to enable adaptive management.

The SWIRC is appropriate for a range of common applications including:

- establishing baseline condition
- evaluating effectiveness of management actions
- assessing impacts from various land uses or stream alterations
- understanding ecological requirements
- prioritising investment into protection or restoration.

The SWIRC was developed in consultation with experts from across Australia and follows the national framework for the assessment of river and wetland health (Storer et al. 2011) to allow comparable reporting of river condition at the national level.

The SWIRC is designed to be adaptive, allowing for additional indicators to be added as technology develops and as new management issues arise.

## 1.2 Standard methodology

The SWIRC provides standardised methods for data collection and analysis.

A key goal in developing the SWIRC was to provide a robust data collection methodology that could be used by a range of practitioners for multiple purposes. Having standard methods means that sampling results can be directly compared, no matter who collected them or where they were collected. In turn, this allows data collected from different monitoring programs to be pooled, enabling investigations that require large spatial and/or temporal datasets to be undertaken.

This could include assessing the impact of climate change on different system types and under different conditions or determining best management approaches to minimise impacts from common land uses and activities. Collecting sufficient data to investigate these types of questions is typically unachievable through discrete projects, given funding constraints and the time required to collect data.

By 2020, over 400 sites had been assessed using the SWIRC methods and this data is available from the department on request.

# 2 Scope of assessments

The SWIRC is a toolkit for assessing river condition in south-west Western Australia based on an integrated ecological assessment. An integrated assessment refers to the use of multiple lines of evidence that, when considered together, can increase the ability to identify impacts and their associated cause(s).

The scope of SWIRC assessments can be broadly categorised across six themes of ecological health:

- Water quality
- Physical form
- Fringing vegetation
- Hydrology
- Land use
- Aquatic biota

Data collected across the themes incorporates measures of pressure, stress, and response.

A general summary of each of the SWIRC themes follows. Refer to separate modules to be published for each theme for a detailed description of data collection requirements and analytical methods used in generating condition assessments.

## 2.1 SWIRC themes


Land use indicators measure the degree of anthropogenic (human) disturbance in a catchment, such as from land use and infrastructure. Assessments target the overarching pressures on rivers; those with the potential to influence all other SWIRC themes. For example, a change in land use may incorporate clearing of fringing zone vegetation and affect water quality and biota through increased runoff of sediments, nutrients and other contaminants. Under the SWIRC, impacts of different land uses are weighted according to their varying influences on river health, and how recently land use changes occurred.

Hydrology indicators assess the flow regime of rivers. Flows have a critical role in maintaining ecosystem form, function and biodiversity. The flow regime influences or is influenced by all SWIRC themes through direct and indirect relationships with nutrient and sediment transport, connectivity and maintenance of dry-season refugia, and river geomorphology. The SWIRC assesses hydrological change by comparing the current hydrological pattern (e.g. magnitude of high flows or period of no flow) against modelled expectations of flow without the influence of dams or vegetation clearing. This provides a catchment-scale assessment of changes in flow regime. Also, under the SWIRC flow data is collected at a site and from flow gauges and is manually assessed to interpret river condition. To determine flow requirements, assessments are typically made by comparing flow data with water quality data. For example, this may be determining the minimum flows required to maintain water quality within acceptable levels or to allow migration of fish at critical times.


Fringing vegetation indicators assess the structure and condition of streamside vegetation. Fringing vegetation can influence the health of rivers in several ways. These include filtering of overland flow, buffering inputs from adjacent land use, stabilising banks, providing shade and organic material for habitat, and supporting the aquatic food web. As the structure and condition of fringing vegetation is both an indicator of catchment development and has a significant bearing on the health of the aquatic environment, it is a critical component of a river health assessment. Fringing vegetation is assessed based on the extent of vegetation cover (width and longitudinal continuity) at a reach scale and the proportion of exotic species present at a site.


Physical form indicators were designed to assess the state of aquatic habitat and its ability to support aquatic life. These indicators include measures of bank stability, naturalness of river form and connectedness (as influenced by artificial in-stream barriers). The SWIRC physical form indicators examine aspects of aquatic habitat at different spatial scales: erosion (extent and bank stability) measured at a field site; extent of alterations to channel form measured at a river reach; and naturalness of connectivity (for fish passage and flushing) considering the presence of dams, road and rail crossings; and other in-stream structures.


Water and sediment indicators encompass a range of chemical and physical attributes that can reflect catchment and riverine transport and biochemical processes. As such, data on water and sediment quality are a key diagnostic tool within the SWIRC, used to identify and explain impacts from various pressures on the system (e.g. land use and hydrological change). Similarly, as aquatic biota has specific water quality tolerances, data can be used to assess risk to biota or to explain impacts seen in biota. The selection of SWIRC water quality indicators was based on assessment of conditions that are relevant across all systems of the south-west, such as temperature, dissolved oxygen and salinity. Water quality data is compared against guidelines based on the tolerances of south-west aquatic biota. Data for other contaminants (not included in the standard SWIRC condition assessment) is collected as required based on site-specific risk assessment, and compared with established guidelines (e.g. ANZG 2018).


Aquatic biota is the primary response indicator of the SWIRC. Biota responds to acute and chronic changes in land use and flow regime, and the resulting changes to fringing zone, in-stream habitat and water quality. Aquatic biota is assessed by comparing observed communities of fish, crayfish and macroinvertebrates (richness, abundance and the presence of exotic species) with the expectations of communities under natural conditions. A range of data pertaining to habitat needs to be collected for interpretation of results.

# 3 Data sources – field and desktop

The SWIRC incorporates data collected in the field and data derived through desktop analysis. Field data is collected at 'sites' and desktop data is collected at 'river reaches'. A 'reach' is a specified length of a river and its corresponding catchment. The nature and extent of these assessment areas are described in Field assessments and Desktop assessments.

Data generated at the reach level is used to indicate general conditions across a broad area, such as the type and extent of land use existing in the catchment of the reach or the intactness of the riparian zone along the reach. This desktop-derived data also provides context for interpreting field data.

The type of data collected within the SWIRC has been chosen based on factors that consider the ability to accurately describe environmental conditions, and the cost and skill level required to collect the information. Minimising costs was a key driver in developing the SWIRC, to maximise uptake and to increase sustainability for long-term sampling programs.

A more detailed description of data collection and analysis requirements is provided in each method document.

## 3.1 Field assessments

The SWIRC field data collection methods are applicable for assessing large, permanent-flowing systems through to smaller, seasonally isolated sections of rivers and streams, including pool habitats. Methods may be applicable to some intermittent streams but, as with all scenarios, the appropriateness of expectations used to score each indicator should be assessed on a case-by-case basis.

A SWIRC field site is nominally set at a 100 m length of river (Figure 3), with data collected at different scales within the site. For example:

- **Logged water quality data** is collected at one point within a site, typically at the upstream end (away from any disturbance that may be produced from samplers entering the system downstream to collect other data).
- **Macroinvertebrates** are collected through a 10 $m^2$ zone within the site in an area that is representative of conditions across the entire site.
- **Fish** are collected using box traps and fyke nets. Box traps are deployed throughout the site and fyke nets are typically placed back-to-back to capture fish moving into the area from upstream and downstream (see Module 2 for variations on this approach because of site-specific constraints).
- **Condition of the fringing vegetation** is assessed along the entire length of the site on both banks.


*Figure 3 SWIRC field site (~100 m length of river)*

## 3.2 Desktop assessments

Desktop SWIRC assessments are conducted at the reach level, providing information about pressures and stressors that may be influencing conditions at any site on the reach. River reaches can be defined in different ways; however, the standard approach for the SWIRC is to define a reach as 'a section of waterway between two confluences as mapped at 1:250,000 scale' (Figure 4). Broadly speaking, rivers outside of this mapping scale are expected to dry each year. Consequently, SWIRC methods are often not appropriate for waterways outside the 1:250,000 scale. While systems outside this mapping scale may dry, they can still have important ecological value, such as providing temporary habitats for fish, and can still influence conditions downstream.

Desktop data is collected along the length of the reach. This includes the extent of fringing vegetation (Figure 5), the extent of artificial channel and the number of potential barriers to flow (Figure 6). Data is also collected within the catchment of each reach, such as the land use (Figure 6) or the area cleared of vegetation.

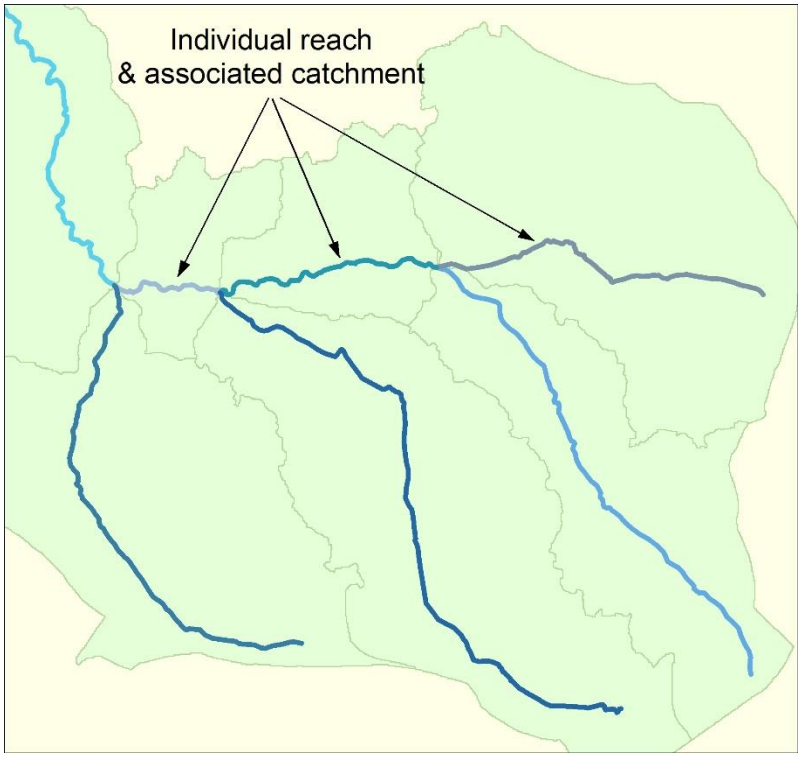


*Figure 4 SWIRC reaches and catchments*

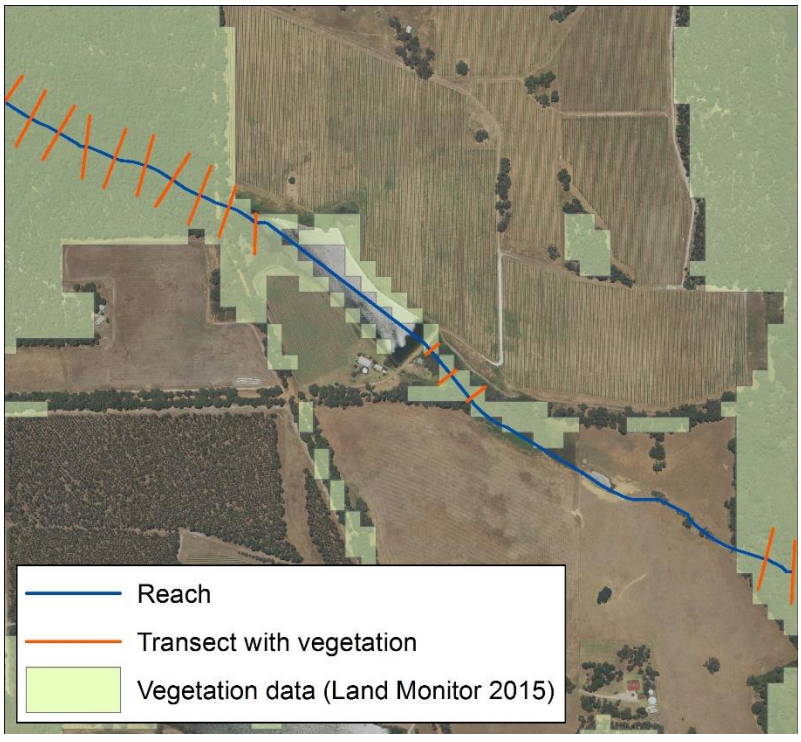


*Figure 5 Assessment of vegetation extent in 50 m stream corridor (both banks)*

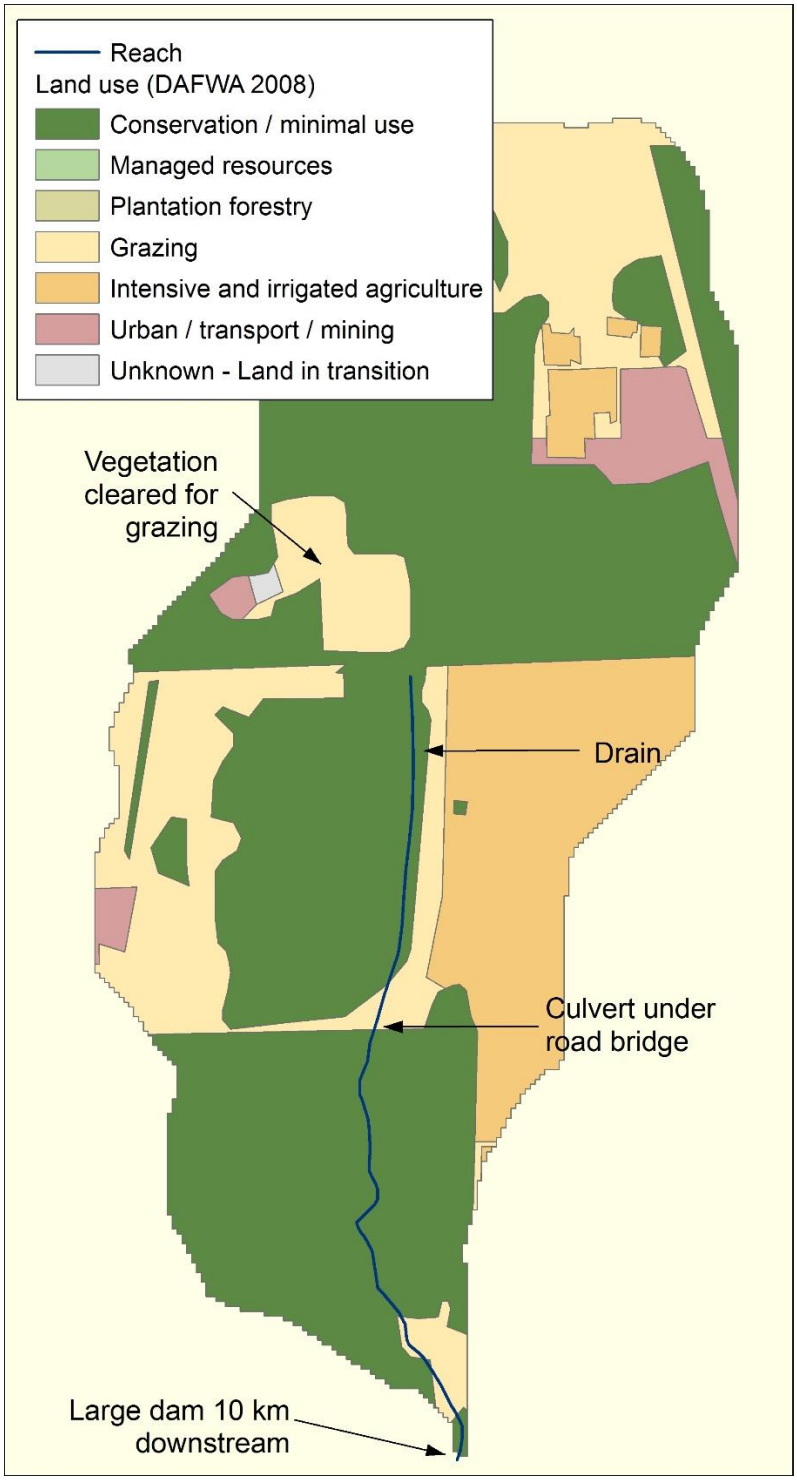


*Figure 6 Example of land use and physical form data assessed in catchments*

# 4 SWIRC indicators

The SWIRC provides a suite of protocols for analysing field and desktop data, incorporating indicators for each of the SWIRC themes and a standardised system for scoring river condition (see Condition scores).

SWIRC indicators represent a cross-section of physical, chemical and biological information. They are designed to represent the current condition of the aquatic ecosystem and the pressures and stressors acting on it.

The SWIRC indices are based on a referential approach whereby condition is determined by comparing the current state with our expectations under a minimal-disturbance scenario. This does not suggest that the management goal is to return conditions to a state that may have been seen in the absence of human disturbance – which is often unrealistic. Rather, the SWIRC is designed to establish current condition along a defined impact scale, which will provide both a statement of status relative to 'natural condition' and a benchmark or baseline which could be used to assess positive or negative changes over time. For example, the fish community could be comprised of all natives through to all exotics.

SWIRC indicators (and data collection methods) were developed with a focus on producing an accurate assessment of river condition across different users, systems and conditions, while minimising costs and time. Factors considered were the:

- ability to accurately describe condition (including the ability to define reference)
- ability to detect a relevant change in condition (that is, sufficient sensitivity to distinguish changes outside of natural variability)
- relevance to management issues and the system types and conditions in the south-west
- cost of training (to collect and analyse data), consumables, equipment and maintenance, including analysis to determine sampling effort required to return a confident assessment (e.g. power and sensitivity analysis)
- speed of assessment (for collection and analysis of data)
- consistency in assessments made by different users (confidence in comparability).

A list of the current SWIRC indices is provided below. See the related method documents for a description of how each of these is calculated. The current list of indicators represents only a fraction of the data collected under field assessments. Each method document includes information on the additional data and other indices that may be appropriate for specific purposes.

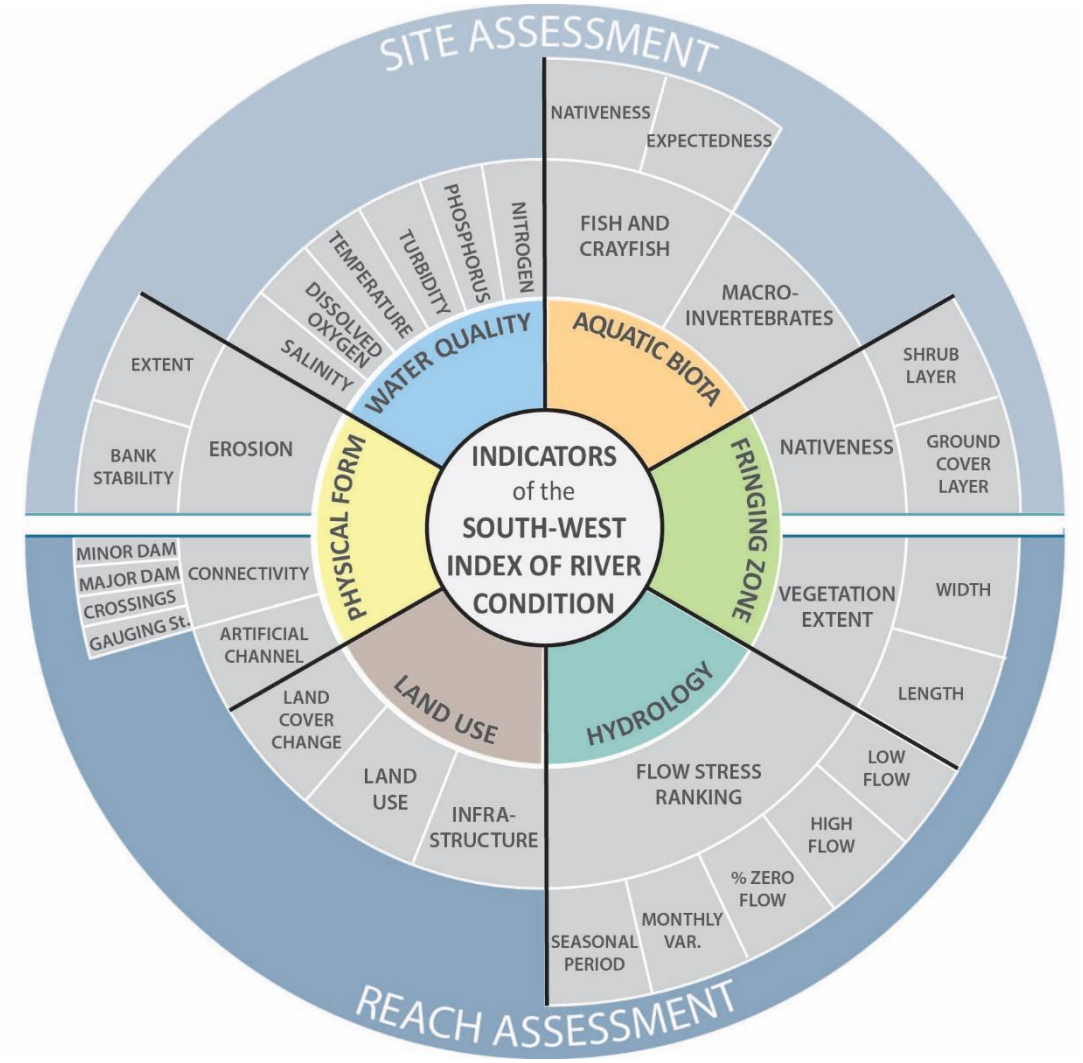


*Figure 7 SWIRC indicators*

## Tailoring condition assessments

Condition assessments can use a subset of the SWIRC indices (e.g. tailored to a specific management question) or the entire complementary suite of SWIRC indicators. Using the entire suite maximises the ability to interpret changes, such as whether a change in biota is related to water quality flow, habitat change fringing vegetation or a combination of factors.

# 5 Condition scores

SWIRC scores are designed to provide a broad indication of condition status for each indicator, allowing results to be easily compared within and between river systems across south-west Western Australia. Scores are designed to be used as a first-pass assessment, identifying the potential relationships between response variables (such as aquatic biota) and the variables indicating stress or pressure on the system (such as level of catchment disturbance). SWIRC scores can help to determine where more detailed assessment may be required (e.g. to investigate the possible threats to a loss in fish species). Examples of SWIRC scores are provided in Comparing condition scores.

Desktop indicators enable rapid assessment of large areas, so these can be effective in identifying priority areas for the more costly field assessments.

The scoring system used for the SWIRC complies with the *National Framework for the Assessment of River and Wetland Health* (Storer et al. 2011a) and thus can be used to generate data for national comparison and reporting purposes.

The scoring protocols are based on a reference condition approach, with each score providing a measure of the departure of the observed values from the expected values. The expected values are those typically anticipated under minimal disturbance conditions, and can be derived from historical data, as well as data from minimally disturbed sites or expert opinion. Modules 2–7 describe how the expectations were derived for each indicator.

SWIRC scores are calculated on a scale between 1 and 0. The lower the score, the poorer the river condition. The scores are divided into several condition bands (Figure 8).

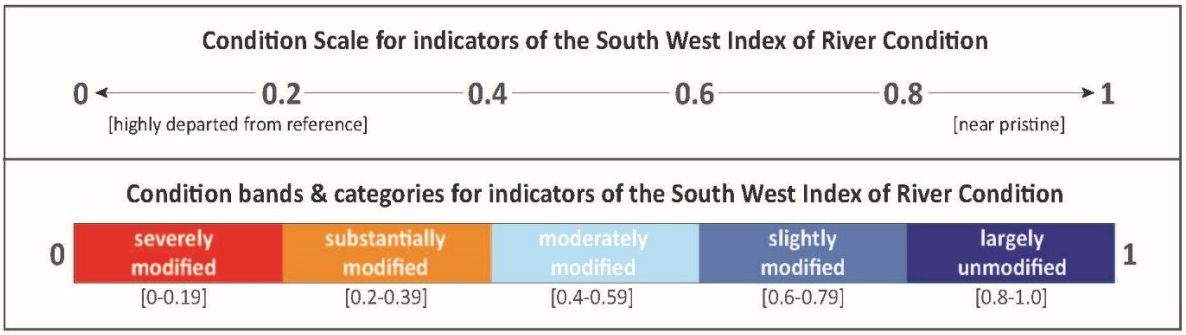


*Figure 8 Condition scores*

The SWIRC indicators follow a nested structure (see diagram in Figure 7). Each of the six themes are represented by a single index score which is comprised of scores from one or more subindices. Some subindices are derived from scores of several

component indicators. Modules 2–7 provide detailed explanation on how indicators are combined to form index and subindex scores.

## 5.1 Management targets

Targets and triggers for management are not included in the SWIRC standard methodology as these need to be determined on a case-by-case basis, relative to the specific management question for the condition assessment. However, incorporating these levels on the SWIRC condition scale can be an effective management and communication tool. For example, these can be used to reflect a state we want to achieve (target) or the point at where intervention needs to occur. See the example below for a hypothetical assessment of water quality.

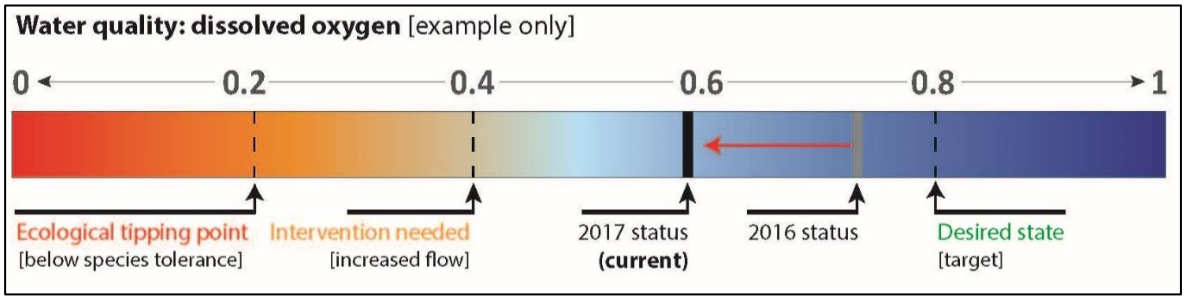


*Figure 9 Representation of using management targets with SWIRC scores*

## 5.2 Comparing condition scores

The following examples illustrate options for using the SWIRC scores to compare conditions between sites and reaches.

### Single-indicator scores

The example in Figure 10 shows SWIRC scores for fringing zone width for all south-west river reaches (mapped at 1:250,000). This is a reach-based indicator that reflects the percentage cover of vegetation within a 50 m corridor on both banks of the river.

This level of assessment could help in understanding the effect of broad-scale pressures such as land use type or climate change or used to identify areas requiring more detailed investigation. When combined with information on values (e.g. biodiversity), this can be an effective tool in prioritising management effort.

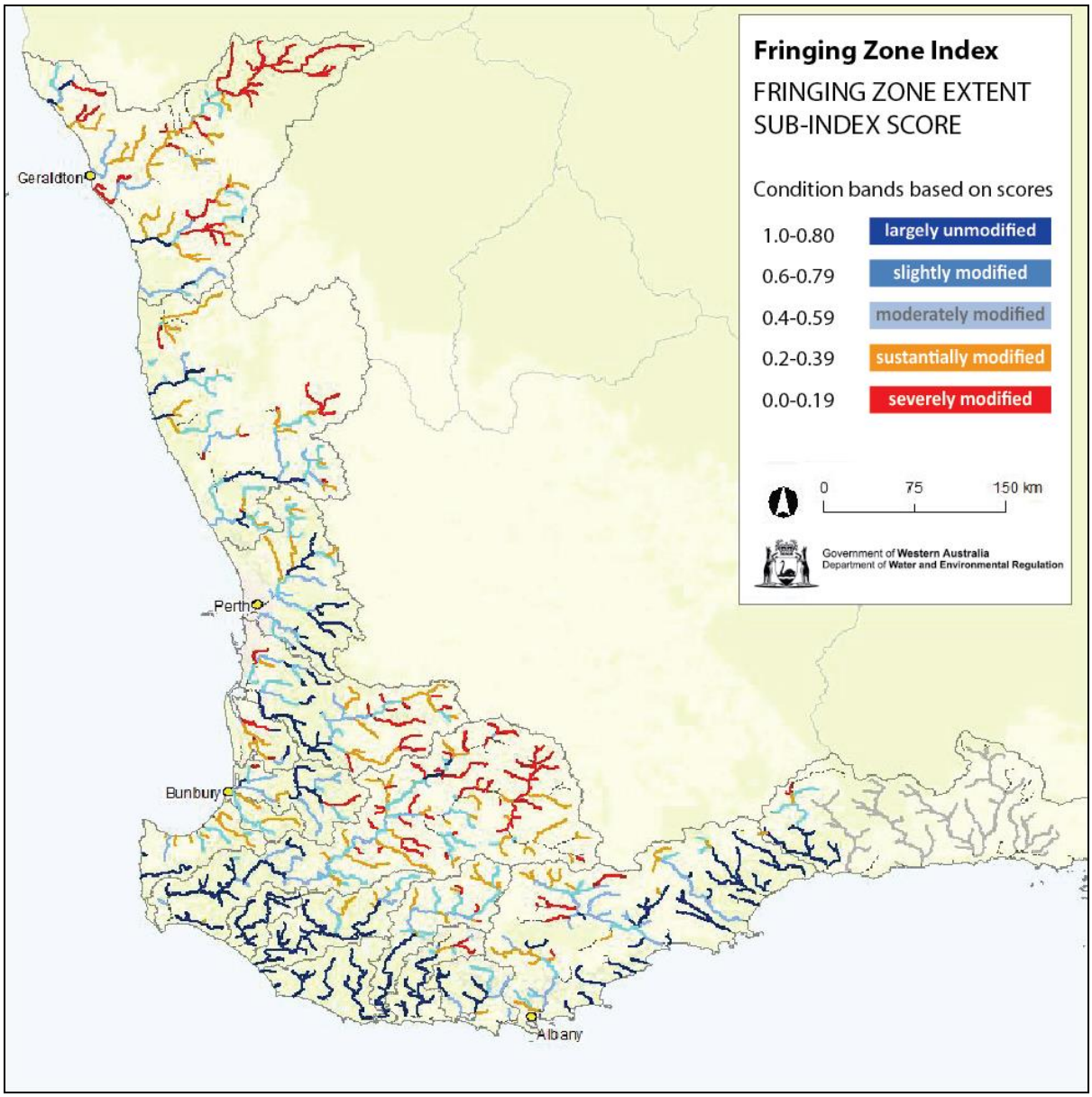


*Figure 10 Single-indicator scores*

## Integrated condition scores

The example in Figure 11 shows the results of a full SWIRC assessment – with all indicators – of five sites and their respective reaches.

As with the previous example, this level of assessment can be used to identify areas of concerns, while enabling a degree of interrogation. For example, a reduction in the quality of water or aquatic biota could be linked with stressors associated with changes in fringing zone, hydrological connectivity, or land use.

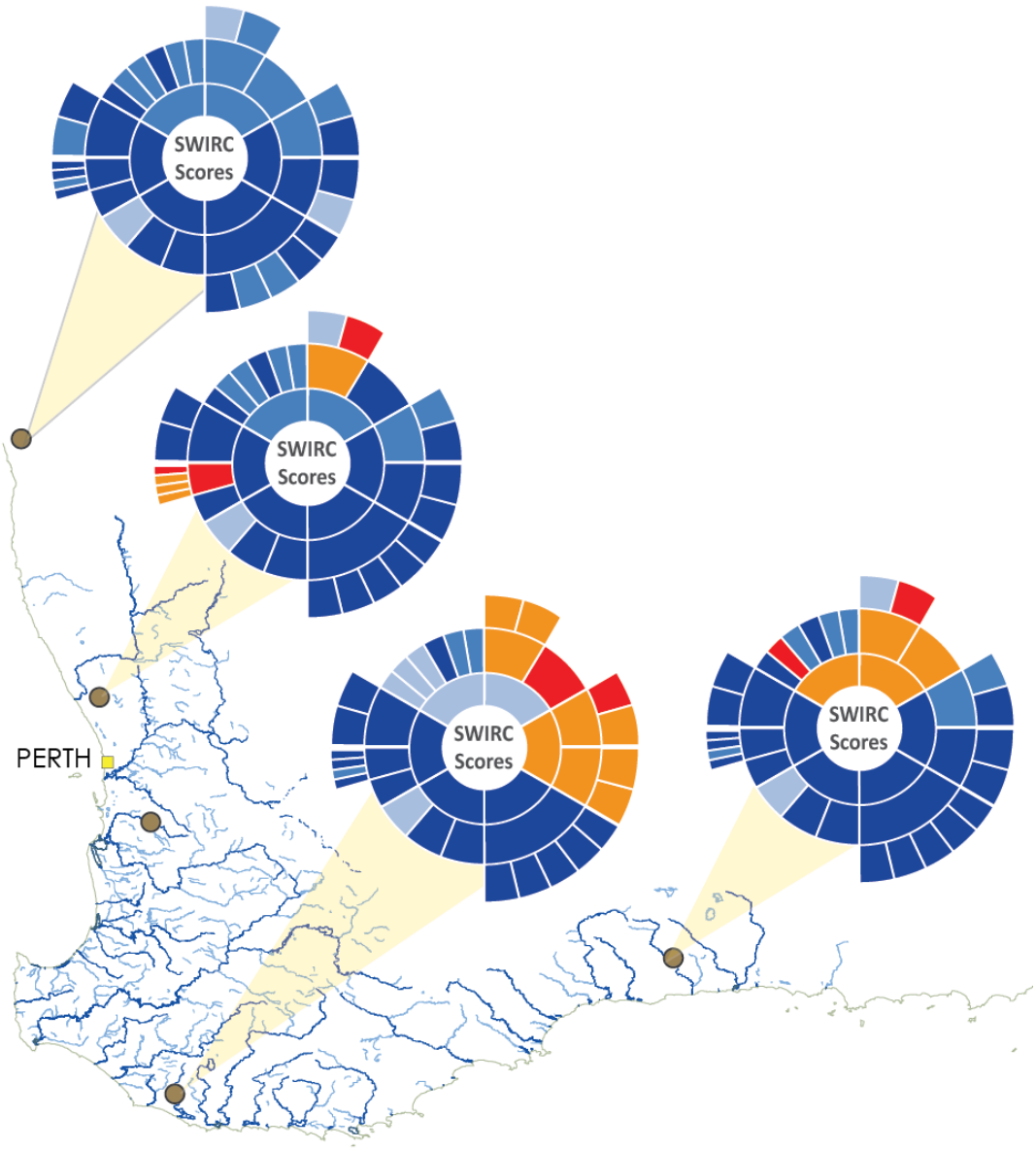


*Figure 11 Integrated condition scores*

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ANZG 2018. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz-guidelines

Storer T, White G, Galvin L, O'Neill K, van Looij E & Kitsios A 2011, The Framework for the Assessment of River and Wetland Health (FARWH) for flowing rivers of south-west Western Australia: method development, final report. *Water Science Technical Series*, report no. 40, Department of Water, Perth.

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