STEP-BY-STEP MONITORING METHODOLOGY FOR INDICATOR 6.3.2

PROPORTION OF BODIES OF WATER WITH GOOD AMBIENT WATER QUALITY

1. MONITORING CONTEXT

1.1 INTRODUCTION

Target 6.3 **By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally**

Indicator 6.3.2 **Proportion of bodies of water with good ambient water quality**

This indicator provides a mechanism for determining whether water quality management measures are contributing to the improvement of water quality in inland waterbodies. At the national level, more waterbodies should achieve good water quality with increasing levels of wastewater treatment and reuse of wastewaters. Integrated management of river and lake catchments will also contribute to better water quality. Good ambient water quality is essential for preserving aquatic ecosystems and the services they provide, such as fisheries. It is also essential for protecting human health during recreational use and in situations where the water is used for drinking and domestic activities without prior treatment. It is, therefore, in the interests of national authorities, to aim for all waterbodies to be classified as being of “good water quality”. This methodology suggests a process for introducing regular monitoring of waterbodies in order to determine their quality status. Over time, or with increased availability of resources, the monitoring programme can be expanded to give a more detailed description of water quality that will provide better information for management and the development of water-related policy.

The indicator is defined as the proportion of all waterbodies in the country that have good ambient water quality. Ambient water quality refers to natural, untreated water in rivers, lakes and groundwaters and represents a combination of natural influences together with the impacts of all anthropogenic activities. Consequently, it enables the impact of human development on ambient water quality to be evaluated over time and it provides an indication of the services that can be obtained from the aquatic ecosystems, such as clean water for drinking, preserved biodiversity, sustainable fisheries, water for irrigation, etc. The indicator is also directly linked to indicator 6.3.1 on wastewater treatment because inadequate wastewater treatment leads to degradation in quality of the waters receiving the wastewater effluents. It directly informs progress towards target 6.3 and is strongly linked to target 6.6 on water-related ecosystems.

A global framework for water quality monitoring is already in place within UN Environment GEMS/Water programme, which will be further developed within the Integrated Monitoring Initiative GEMI. The proposed methodology recognizes that countries have different levels of water quality monitoring, and allows countries to begin monitoring efforts in line with their national capacity and available resources. From there they can advance progressively with the development of their national monitoring system, whilst still maintaining a basis for aggregation of datasets at the regional and global level. As a baseline for global monitoring, core parameters have been selected which are easily measured and present few technical difficulties. In order to establish a monitoring and reporting system for this indicator, data for these parameters can be reported for existing monitoring sites but, over time, countries are encouraged to progress to a greater number of monitoring locations, with greater frequency of measurements, and the inclusion of more water quality parameters.

1.2 Target-setting for the indicator

The 2030 Agenda for Sustainable Development specifies that all SDG targets "a*re defined as aspirational and global, with each Government setting its own national targets guided by the global level of ambition but taking into account national circumstances*." The global ambition of target 6.3 is to "improve water quality". In order to determine whether an improvement has been achieved, it is necessary to monitor water quality and to compare the results with either water quality standards, the quality before implementing any form of management (i.e. baseline conditions), or against reference quality conditions. Due to the natural variability in waterbodies, it is not practical to set standards or targets for specific water quality parameters that are globally applicable. It is, therefore, recommended that each country should determine and define "good ambient water quality" and set their own targets against which it can be assessed. However, where several countries are monitoring the same trans-boundary waterbody, efforts should be made to harmonise the targets for all countries.

For the purpose of determining good ambient water quality, the standards or targets should ensure the aquatic ecosystem is not damaged and that there is no unacceptable risk to human health arising from intended use of the water without prior treatment. In practice, therefore, the same understanding of "good quality" is globally applicable but the parameters used to determine whether the target of "good quality" is being met can be different depending on the type of waterbody, the natural variations in water quality and the intended uses of the water. More countries have existing standards or target values for particular water quality parameters in relation to water use, such for drinking water and irrigation, than for the natural quality of the aquatic ecosystem. Therefore, to assist countries without existing targets, suggested approaches to defining national targets are described in Section 5.4 below. Some detailed examples of the derivation of national targets and guidelines have also been published (e.g. ANZECC and ARMCANZ, 2000) and are available on-line. Water quality that supports good ecosystem quality is usually assessed by the inclusion of some biological parameters or monitoring methods, such as chlorophyll a, species diversity and abundance, or by the presence or absence of specific indicator organisms. Such approaches require detailed knowledge of natural, unimpacted aquatic communities, which may be lacking in many countries. Nevertheless, the inclusion of biological methods in the assessment of "good ambient water quality" can be included as the development of monitoring networks progresses and additional information becomes available. For the purpose of enabling all countries to report on indicator 6.3.2, a simple approach based on physical and chemical parameters is recommended as the minimum starting point.

2. Monitoring methodology

2.1 Monitoring concept and definitions

Water quality is assessed by means of physical, chemical and biological parameters that reflect natural water quality related to climatological and geological factors, together with major impacts on water quality.

The basic core parameters selected here are not direct measures of water quality for ecosystem or human health, but are included to characterise the waterbody and because deviation from normal ranges (e.g. for electrical conductivity and pH) may be symptomatic of impacts on water quality.

The monitoring concept is based on a water quality index using key water quality parameters. For the first step of progressive monitoring, parameters are compared to target values and either meet, or do not meet, these values. These results are then aggregated over time and combined into the index for each monitoring location. The index results for each monitoring location in the waterbody are then aggregated to provide a waterbody status of “good” or “not good”. Actual target values are set by each country based on experience from their own water quality monitoring networks or from published values from similar waterbodies elsewhere (See section 4.4 below).

For the purpose of reporting the indicator, countries need to define their waterbodies. For rivers, a waterbody is a coherent sub-region in a river basin that is discrete (does not overlap with another waterbody) and is significant rather than arbitrarily designated. The geographical area of a river basin is related to the hydrological system and not state boundaries or management units. Lake waterbodies are usually more straightforward to delineate but, as with river waterbodies, a harmonised monitoring approach is needed for lakes which cross national borders.

Surface water monitoring programmes are more straightforward to implement than groundwater programmes, but they still rely on a thorough understanding of the hydrological regime and pressures that affect water quality. Groundwater monitoring programmes require a high degree of expertise to implement and the results are more difficult to interpret. Groundwater includes all water below the surface in the saturated zone and in direct contact with ground or subsoil. A groundwater body is distinct but may comprise one or more aquifers. Groundwater flow systems are often very heterogeneous, so that samples from wells in close proximity can produce very different results, especially if samples are taken from different depths. Additionally, groundwater monitoring results are strongly influenced by the sampling methods and protocols and, therefore field personnel need to be trained to a high level of competence to ensure representative samples are obtained.

2.2 Recommendations on spatial and temporal coverage

Spatial coverage of monitoring locations and the proportion of waterbodies assessed can be increased as country capacity and resources improve. Starting with existing locations and measurements, countries can increase the number of monitoring locations to provide more statistically representative measurements. Where resources are limited and there are few existing monitoring locations, it is recommended to focus initially on locations of drinking water abstraction.

Temporal coverage depends on the waterbody and the parameters being measured. Temporal resolution of monitoring can range from continuous measurements to random or regular measurements, with frequencies from weekly to annual. In each case, natural parameter variability has to be taken into account, together with seasonal variations. Furthermore, the level of precision and desired level of confidence should be accounted for in designing a monitoring programme. In general, it is recommended to sample at least once each season but preferably no less than four times per year for surface waterbodies. For groundwater bodies a minimum frequency of one sample per year is required but where possible more frequent measurements are recommended.

2.3 Steps for progressive monitoring

There are three separate components to progressive monitoring: increasing the number of samples collected; expanding the range of parameters by including toxic substances and biological approaches; and developing the complexity of the method used to calculate the indicator.

The indicator to be reported is the "*proportion of bodies of water with good ambient water quality"*. The objective would be the proportion of **all** bodies of water in the country meeting the criteria for "good quality". This may not be realistic initially and therefore it is suggested that, unless full national coverage is possible, monitoring effort focuses on selected key waterbodies for which reliable, scientifically-sound data can be delivered. The progressive steps in this case would be to expand spatial coverage and temporal intensity of sample collection as resources become available and capacity develops. This may also include the development and implementation of a groundwater monitoring programme if not currently in place.

The core physico-chemical and nutrient parameters, given by waterbody type in Table 2.1, are the suggested starting point. Progressive monitoring parameters, such as emerging contaminants or biological indices can be included depending on national capacities and requirements, and according to country-specific legislation, or regional and local requirements in relation to specific pressures or pollutants. These parameters can be reported separately and analysed over time to identify the improvement or degradation of water quality, but they are not included at this stage of the global reporting process.

There are several methodological steps which can be taken to increase the relevance, and ultimately the value, of the indicator. These include the delineation of smaller waterbody units as resources allow and an increase in the collection of spatial samples. For national monitoring and reporting, the application of more comprehensive classification schemes and water quality indices may be included that allow for the assessment of water quality specific to the local and national conditions and requirements. Many composite indices have been developed for determining the fitness of waters for different uses and the assessment of the biological integrity of aquatic ecosystems. These indices typically include the transformation of the selected parameters with different units and scales to a common scale using different mathematical functions, statistical techniques or more advanced mathematical models. Often weightings are assigned to parameters to express the greater importance of some parameters over others. The resulting subindices are aggregated by additive, multiplicative, logical or other aggregation methods to produce a final index score (Abbasi and Abbasi, 2012).

Two national water use specific indices: the US National Foundation's Water Quality Index (Brown *et al*., 1970) and the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) (CCME, 1999), have been used in several other countries as a basis for the development of national indices. Similar to the simple index used for the global indicator, the CCME WQI does not include weightings for the selected parameters and allows for the inclusion of additional parameters. In addition to the frequency of parameters not meeting the target values it also takes into account the number of non-compliant parameters and the amplitude of excursions. It has also been used as a template for developing global water quality indices for drinking water (Rickwood and Carr, 2009) and freshwater in general (Srebotnjak *et al*., 2012).

2.3.1 Physico-chemical and nutrient core parameters

To facilitate comparability of the indicator between countries a number of core parameters have been suggested for the different waterbody types. The reason for inclusion and a description of each is given below.

Rivers

Dissolved oxygen (DO) is important for aquatic organisms. Levels of dissolved oxygen fluctuate naturally with temperature and salinity. Turbulence at the surface of a river, at riffles or at waterfalls can increase dissolved oxygen concentrations. Photosynthetic activity of aquatic flora and respiration by aquatic organisms can also affect concentrations diurnally and seasonally. Very low oxygen concentrations may suggest the presence of biodegradable organic matter, such as sewage. Ideally, DO is measured *in situ* using an oxygen probe, but methods are available where the oxygen in the water sample is chemically fixed for analysis in the laboratory.

Electrical conductivity (EC) is a simple measure of dissolved substances, such as salts, that help characterise the waterbody. Values of EC change naturally, especially during periods of increased flow. The inclusion of EC as a core parameter is due to its simplicity of measurement and because deviation from normal ranges can be used as an indicator of pollution, such as wastewater inputs to the waterbody. The most accurate method to measure EC is using a conductivity meter *in situ*, because values can change during the time between collection in the field and analysis in the laboratory.

Table 2.1 Core and progressive monitoring parameters for each type of waterbody

	Parameter	River	Lake	Groundwater
Core Parameter	Dissolved Oxygen	x	x	
	Electrical Conductivity	x	x	x
	Total Oxidised Nitrogen	x	x	
	Nitrate*			x
	Orthophosphate	x	x	
	pH	x	x	x
Progressive Monitoring Parameter	Temperature	x	x	x
	Turbidity	x	x	
	Transparency		x	
	Hardness	x		x
	Suspended Solids	x		
	Alkalinity	x	x	
	Major anions (HCO_3^-,SO_4^{2-},Cl^-,NO_3^-)			x
	Major cations (Na^+,K^+,Mg_2^+,Ca_2^+)			x
	Total Phosphorus	x	x	
	Orthophosphate			x
	Total Nitrogen	x	x	
	Nitrite	x	x	x
	Ammoniacal Nitrogen	x	x	x
	BOD/COD	x		
	Non-heavy metals (e.g. arsenic or fluoride)	x	x	x
	Heavy metals	x	x	x
	Hydrocarbons	x	x	x
	Pesticides	x	x	x
	Volatile Organic Carbons	x	x	x
	Emerging Pollutants	x	x	x
	E. coli	x	x	x
	Faecal coliforms	x	x	x
	Faecal Streptococci	x	x	x
	Chlorophyll a		x	

	Biological Index	x	x	
	* Nitrate is suggested for groundwater due to associated human health risks			

pH is included as a core parameter because, like EC, it is useful to help characterise the waterbody. pH is one of the most widely measured parameters due to its influence on many biological and chemical processes. It is a measure of the activity of the hydrogen ion in the water which can fluctuate naturally especially with changing hydrological conditions as the composition of the water at the sample site changes between groundwater, subsurface flows and surface runoff during rain events. Changes outside of natural ranges indicate possible pollution from industrial or other wastewater sources. pH is most accurately measured *in situ* using a potentiometric probe because values can change during the time between collection in the field and analysis in the laboratory.

Orthophosphate (OP) is a bioavailable dissolved inorganic form of phosphorus which is an essential nutrient for aquatic life. Additional inputs from human activities, such as wastewaters or agricultural run-off, can increase concentrations such that they support excessive plant growth which affects the balance of the aquatic ecosystem and impairs water quality for human uses. Orthophosphate can be measured in the field using test kits, but the greatest accuracy and limits of detection are achieved in the laboratory. OP concentrations can change over time if the sample is not fixed and therefore it is suggested that samples are analysed within 24 hours.

Total Oxidised Nitrogen (TON) is a combined measure of both nitrate and nitrite which are forms of dissolved inorganic oxidised nitrogen. Like phosphorus, nitrogen is a nutrient essential for aquatic life where additional inputs can have detrimental impacts on freshwater ecosystems. Total Oxidised Nitrogen, rather than nitrate, is suggested because the analytical method is more straightforward and doesn't require the reduction step needed to measure nitrate alone. In most instances the nitrite fraction of TON in surface waters comprises less than one percent of the total, so that for practical purposes, total oxidised nitrogen and nitrate are the same. As with OP there are kits available for *in situ* monitoring of TON.

Note on nutrient analyses - There are many fractions of phosphorus and nitrogen which countries may be already routinely monitoring, including inorganic, organic, particulate and dissolved forms. For example, total phosphorus (TP) can be a more useful measure of water quality affected by wastewater discharges than orthophosphate but it is more complex to measure because a digestion phase is needed during analysis. Countries should include the fraction which is most relevant in the national context.

Lakes

The core parameters for lakes are the same as for rivers but the results need careful interpretation if the lake stratifies. Temperature, DO and EC measured through a vertical profile of the lake will identify whether the lake is stratified. A vertical profile monitoring design, integrating samples from fixed depths at regular frequencies is preferred (Chapman, 1996).

Groundwaters

EC and Salinity are included together because the method of measurement is often the same but in most cases only one is relevant for a particular groundwater body. As with surface waterbodies, EC is useful for characterising groundwaters. For many countries saltwater intrusion into groundwater is a problem and in these cases measuring salinity is more useful if the water is used for drinking or irrigation. For the most accurate results both EC and salinity are measured at the wellhead.

Nitrate has been included for groundwater rather than TON, because there are specific health concerns associated with nitrate if the waterbody is used as a drinking water source. The nitrate ion is highly mobile and readily reaches groundwater bodies. Elevated nitrate concentrations may arise from agricultural sources;

hence it is included as a core parameter because it may be useful to establish baseline nitrate conditions. It is suggested that the WHO drinking water guideline value (WHO, 2011) is used in this instance rather than a target aimed at preserving good ecosystem water quality.

2.3.2 Progressive Monitoring parameters

The parameters selected for progressive monitoring should be based on national objectives and implemented as capacity increases. These chosen parameters could be tailored to reflect the use of the waterbody. Microbiological parameters have been omitted from the core parameters because, although they are of particular concern for human health, they are not routinely monitored in ambient water quality programmes. However, where waterbodies are used directly for drinking water without treatment, inclusion of microbiological parameters is recommended.

Progressive monitoring parameters can also be included to reflect particular pressures on water quality in each country. For example, if mining is of particular relevance, a programme which monitors downstream concentrations of heavy metals may be appropriate to determine the degree and extent of the pollution problem. In lakes additional parameters, such as chlorophyll a, are needed to assess trophic status or quality requirements for particular uses such as drinking water or recreation.

Two parameters of particular concern for groundwater which is used for drinking are arsenic and fluoride. These are not included in the core parameters because they are of regional concern, being derived from geogenic sources rather than anthropogenic activities. Although the major cations and anions are included in the progressive parameter list, routine monitoring of these parameters is encouraged because they allow characterisation of the groundwater and permit an ionic balance calculation on analytical results as a form of quality assurance check.

2.3.3 Biological and ecological approaches

Although the use of biological and ecological approaches is introduced here as an advanced step in the progression of monitoring water quality, it is acknowledged that many countries already have such methods in place on which they base their judgement of water quality. Some of these have been modified and improved over many years (e.g. Dickens and Graham 2002; WFD-UKTAG 2014). In a few countries the results of biological approaches are combined with physical and chemical measurements to obtain an overall judgement of water quality (EPA 2008). All countries are encouraged to consider developing a biological system where resources are available and to include such methods when reporting water quality for rivers and lakes. No single method has been tried and tested at a global level, but there are some general approaches that can be used to develop indices that are useful for spatial or temporal evaluation of water quality (Chapman and Jackson 1996).

Plants and animals in rivers and lakes have adapted to live in balanced communities under preferred physical and chemical conditions. When these conditions change, either naturally or as a result of human activities, the plants and animals become stressed and either move away or struggle to survive, and may even disappear. The presence or absence of certain species, or combinations of species, in different types of aquatic environments can therefore indicate the current state or quality of the aquatic ecosystem or waterbody. Thus, having a good knowledge of the species that occur in natural aquatic habitats, and understanding their physical and chemical requirements, can be used to determine the quality of the waterbody. Over time a waterbody may be subject to multiple impacts, lasting different lengths of time that may not be captured by taking discrete water samples for physical or chemical analysis at infrequent intervals. By contrast, plant and animal species survive in waterbodies for periods of time ranging from days to years and integrate all impacts on a waterbody over their lifetime. As with physical and chemical measures of water quality, targets can be set for biological water quality based on a numerical value representing undisturbed water quality through to severely impaired ecosystems or not fit for human use.

There are two main approaches that enable the simple use of biological communities to indicate water quality. One approach is based on determining the presence, absence or relative abundance of indicator organisms and the other is based on the general principle that a healthy aquatic ecosystem has a diversity of species rather than a dominance of one or two species.

In order to use the concept of indicator organisms, detailed scientific knowledge is required about the level of tolerance of specific species to a variety of impacts, such as oxygen concentrations, suspended or deposited material, nutrient availability and specific toxic compounds. The selected species may show a range of effects, including death (i.e. complete absence), reduced population numbers (due to impacts on reproductive capacity) and abnormal growth (e.g. due to lack of suitable food or toxic impacts). Presence or absence of specific species in samples can be scored to create a numeric index of grades of water quality (Ziglio *et al.* 2006). Such indices require expert judgement and should be based on testing of the indicator over a wide range of waterbodies.

The basic principle that impacted environments tend to show a diminished range of species (diversity) with only the most tolerant species able to multiply significantly in numbers (high abundance), has been used to develop mathematical diversity indices, often referred to as biotic indices, such as the Shannon's Diversity Index, Simpson Index and others (Friedrich *et al*., 1996). Such indices do not give an absolute measure of the quality of a waterbody and cannot be used to make comparisons between waterbodies of different natural qualities, but can be used to determine changes in quality at the same locations over time or between sites within the same waterbody. Use of these indices does not require detailed understanding of the biology of the species present but is it necessary to be able to separate and count individual species.

Some toxic compounds are accumulated in aquatic plant and animal tissues to concentrations that exceed the ambient water concentration. Therefore, where there is a need to determine whether toxic substances are present in a waterbody, but resources are not available to collect water samples and analyse low concentrations of the toxic substances, selected species can sometimes be used as biomonitors (Schafer *et al.* 2015). The results indicate whether or not the organisms have been exposed to the toxic compound but will not directly indicate the concentrations in the ambient water. Toxicity-based assessments, using aquatic organisms and ambient water samples, can also indicate the presence of toxic compounds and the results used to suggest good, poor or unacceptable water quality (although the precise toxic compounds are not necessarily known) (e.g. Environment Agency 2007).

3. Data sources and collection

3.1 Data requirements to compute the indicator

The computation of the indicator requires the regular collection of water quality data from representative monitoring locations for selected waterbodies. Further details and recommendations on monitoring frequency and monitoring location selection are given in sections 3.2 and 4.3. Supplementary information on the monitoring locations should be assembled, such as geographical coordinates, waterbody name and the local identification code for the monitoring location, when available. For the identification of waterbodies, countries need to prepare an inventory of surface waters, and possibly groundwaters, in their territory comprising either a list of surface waters and aquifers with geographical coordinates in the simplest case, or a geographical information system (GIS)-dataset of river systems, lakes and other water systems. For the classification of water quality countries need to define target values which should be met in order to qualify a waterbody as having "good" water quality. These target values could be general thresholds of the core parameters, or they can be defined individually for each waterbody type (e.g. river, lake or groundwater) or even for each waterbody. Finally, the water samples taken at the selected monitoring locations should be analysed for the core parameters, as defined in section 3.3.1, and the results of the analyses recorded for each monitoring location (see example in Section 5).

3.2 Sources of data – short and long term

Water quality monitoring data are typically collected by national and subnational water quality monitoring programmes that include *in situ* sensors and samples collected and transported to laboratories for chemical and microbiological analysis. In addition to national monitoring programmes, measurements may be made by water companies or industries testing raw water prior to use or prior to treatment for drinking water supplies, and in waterbodies subject to discharges of wastewaters. Environmental research organizations and non-governmental organizations also monitor water quality parameters in the context of research studies and citizen science monitoring programmes.

The core parameters recommended in this indicator for determining general water quality do not require expensive or advanced laboratory facilities, and field measurement kits are also available. The range of measurement and accuracy of the field kits should be appropriate for the waterbodies in which they are used. For more advanced monitoring, the complexity of the methods for analysing chemical and microbiological parameters increases, with associated needs for more advanced analytical facilities.

There is potential to include additional biological approaches and biotic indices, some of which are readily adaptable to citizen and NGO monitoring programmes, thereby increasing the potential for greater spatial coverage and the frequency of data collection.

The use of Earth Observation data (EO) for water quality monitoring is currently advancing but limited to optically detectable water quality parameters like turbidity and chlorophyll. Given the high spatial and temporal resolution of current and upcoming satellite missions, EO data could provide an important and cost-effective additional data source for monitoring of large rivers and lakes in future.

3.3 Recommendations on data management

Quality assurance and effective quality control procedures during sampling, analyses and data handling are essential to produce reliable monitoring data for the indicator. Where possible international standards should be applied at all stages.

3.3.1 Sampling quality assurance

Careful consideration should be given to the collection site, to the method used to take *in situ* measurements, and to the way in which water samples for laboratory or field analysis are collected, in order to avoid any interference from activities that might affect measurements or analytical results. Examples of interference are discharges at the site of sampling, operator disturbance of sediment, and operator contamination of samples during or after collection. Sampling equipment or sample collection bottles may need preparation in advance of sampling. It is recommended that instructions for preparation of sample containers, the time and temperature for storage of samples after collection, and the maximum time for storage prior to analysis, be followed according to the relevant standard method chosen. Samples for phosphate analysis must be processed within 24 hours of collection and, if they cannot be brought to the laboratory within this timeframe, use of a field method or kit should be considered bearing in mind that it may have a limited range of detection. Sample blanks can be used to check for possible contamination in the field for any samples requiring transport to the laboratory. Sensors or probes used to take *in situ* field measurements need a calibration check before each use in the field.

3.3.2 Analytical quality assurance

It is recommended that a laboratory quality assurance programme is in place and, where possible, laboratories should be accredited to national or international standards, and/or take part in inter-laboratory quality control or performance evaluation exercises in order to assure their analytical results. Analytical methods should adhere to the standard procedures selected, and any deviations from the methods should be noted and taken into consideration during review and reporting of results.

3.3.3 Data quality assurance

Quality assurance procedures for data should also follow generally accepted standards. Laboratories should comply with their quality assurance and quality control mechanisms regarding confidence limits, and detection levels (instrument detection level (IDL), method detection level (MDL), practical quantification limit (PQL) etc. Terminology and guidance is available in APHA (20**).

A review of results to check for correct value ranges and for any apparently incorrect measurements, for example negative values of a concentration or mistakes introduced due to typing errors, should be done as a final step before data are transferred to the database for use in the calculation of the indicator

3.3.4 Data management

The establishment of a suitable system for data collection at national level is required. All countries are encouraged to submit their data using the template available from UN Environment GEMS/Water (see http://web.unep.org/gemswater/what-we-do/freshwater-quality-agenda-2030) with the assistance and support of existing resources within statistical or environmental agencies, government offices or Ministries. National focal points, such as those that represent the GEMS/Water programme could be appointed to fulfil this function. The UN Environment GEMS/Water database, GEMStat, was endorsed at the first session of the United Nations Environment Assembly in 2014 and is now available to take raw data for calculation of the indicator, as well as indicator values with the associated metadata. Data submission guidelines are available from GEMStat which also describe the necessary metadata requirements for each station and sample, such as location and analysis methods.

4. Step-by-step data collection and computation of indicator

4.1 Step 1 Assessment of Existing Capacity

A formal assessment of existing water quality monitoring activity should be performed nationally. This may extend beyond the Ministry or water authority that holds overall responsibility for monitoring, to include institutions such as universities or the private sector, that may collect water quality data which could be useful for reporting on Indicator 6.3.2. Other institutions may be able to contribute historical data, laboratory facilities, or field work capacity.

4.2 Step 2 Identification of waterbodies

For the purpose of indicator 6.3.2 three general types of waterbodies are being differentiated:

- Running or lotic waterbodies including rivers, streams and canals
- Standing or lentic waterbodies including lakes and reservoirs
- Groundwater bodies including one or more aquifers

Physical characteristics, including hydrological and geomorphological features, climatic factors and geochemical characteristics, as well as pollution from point and non-point sources can result in large spatial differences in water quality in river systems, lakes and aquifers. This variability should be reflected in the waterbodies that are considered within the scope of Indicator 6.3.2. A sub-division of waterbodies of different categories into discrete units with similar characteristics is recommended to allow for a meaningful assessment of their quality. Many countries have developed frameworks for waterbody types based on physical, chemical and related characteristics that can be applied for the delineation of waterbodies. Where no framework is in place, information on the physical characteristics of the waterbodies, pressures from pollution sources and designated uses can be used to further sub-divide large waterbodies.

4.2.1 Delineation of surface waterbodies

In a first step, the surface waters should be divided into waterbodies according to their type (i.e. river or lake). If, for instance, a river is interrupted by a lake in its course, the boundaries between the lake and the river stretches upstream and downstream of the lake would act as boundaries between three individual waterbodies (Figure 4.1).

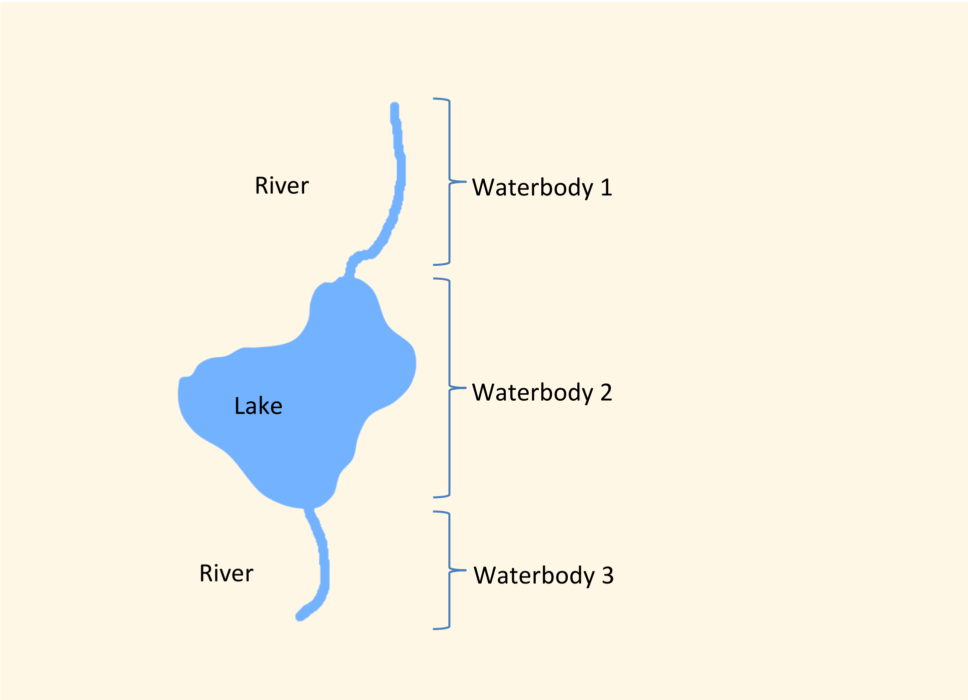

Figure 4.1 Identification of surface waterbodies based on boundaries between types of surface water

While this first step would already fulfil the requirement of providing distinct and significant elements, a further sub-division of waterbodies could be necessary in order to allow for a sufficiently accurate monitoring of the progress towards SDG target 6.3. Therefore, hydromorphological features, such as river confluences, could act as boundaries for a further sub-division of waterbodies in a second step (Figure 4.2).

Although the above mentioned criteria alone are sufficient for the identification of waterbodies, there are further considerations that could help with refinement of surface waterbodies to enable an accurate monitoring of the progress towards SDG target 6.3. For this, areas with designated pressures and impacts (e.g.

diffuse source of nutrient input from agriculture or point source of industrial water discharge) could be taken into account as well as areas designated for specific uses (e.g. drinking water, recreational waters and fishery). Furthermore, the identification of waterbodies could incorporate special areas for the protection of nature. In many countries, these considerations already are an integral part of the water management and monitoring strategies and can therefore be carried over to the SDG indicator 6.3.2 reporting process.

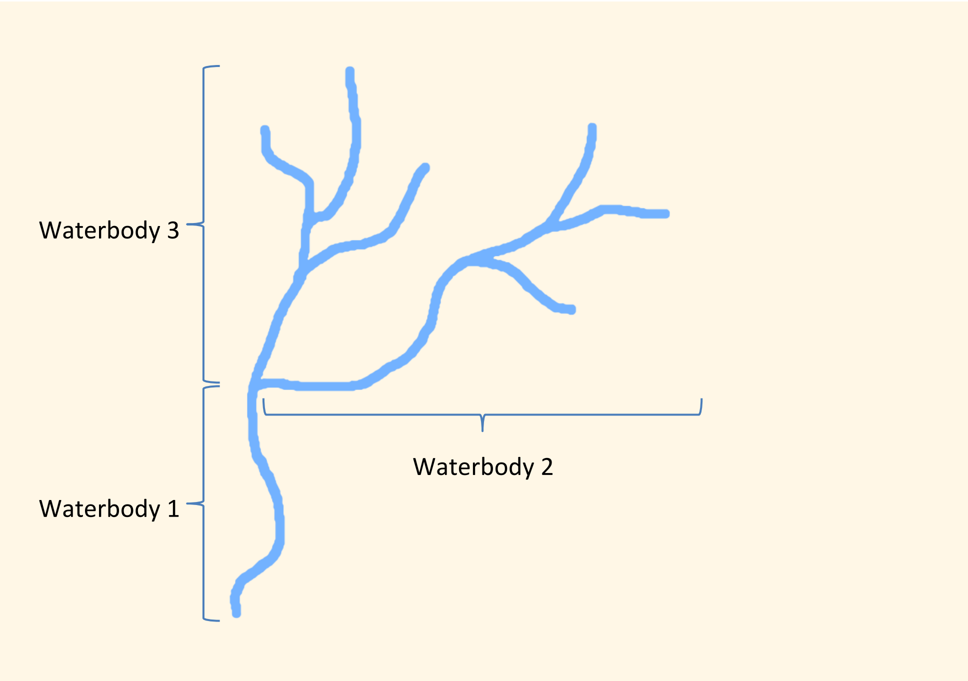

Figure 4.2 Sub-division of a river waterbody using river confluences as hydromorphological boundaries, dividing the system into three waterbodies

4.2.2 Delineation of groundwater bodies

The elements identified as bodies of groundwater should allow for an appropriate description of the general and chemical status of groundwater. Therefore, the extent of a groundwater body should be confined by groundwater flow divides, using surface water catchments and geological boundaries as proxies where information is limited. If a further sub-division is necessary it should be based on groundwater level or on groundwater flow lines, where necessary.

4.3 Step 3 Monitoring Location Selection

The preceding steps provide an understanding of waterbody types and propose methods to delineate each waterbody into discrete units. The quantity and distribution of sample locations within each waterbody needs careful consideration to ensure the waterbody is adequately assessed. Sample collection and analysis require personnel and laboratory resources; where resources are limited a compromise between spatial coverage and sample collection frequency may be necessary.

Three stages are used to select monitoring locations: firstly the preferred Indicator 6.3.2 monitoring locations are defined, then an assessment of monitoring locations currently used in existing programmes is undertaken, and lastly the final Indicator 6.3.2 monitoring locations are defined by aligning, as well as possible, existing locations with preferred monitoring locations. Monitoring locations should reflect typical pressures in the waterbody and should not be restricted to un-impacted locations. Site surveys may be needed to verify proposed location suitability. Below are the key steps for the three waterbody types.

4.3.1 Rivers

Monitoring locations should be distributed throughout the river network, including headwater sites which are typically less impacted by anthropogenic activities, mid-catchment locations which may be exposed to a variety of pressures, and at the most downstream confluence with another river, lake or estuary. A minimum of one monitoring location is suggested per river waterbody, but this is dependent on the waterbody size and may, therefore, be insufficient to represent water quality in large and diverse systems, and additional locations may be needed. Figure 4.3 shows the location of five possible monitoring locations, with two in headwater locations, two mid-catchment with each representing a major tributary and one at the most downstream point.

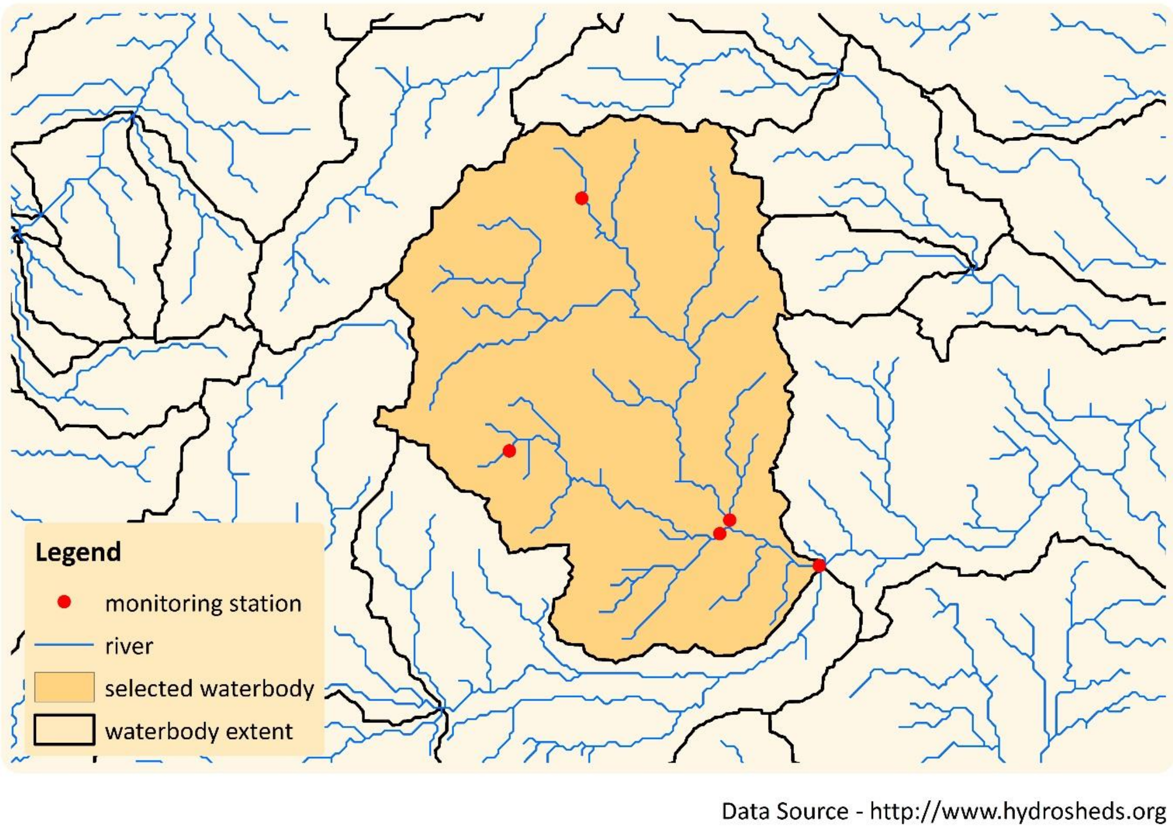

Figure 4.3 Monitoring location examples in a river waterbody

Once the monitoring locations at the broad waterbody-scale have been identified, consideration needs to be given to the location at the site level. The degree of water mixing at the location should be known. If the location is in close proximity to a confluence of two tributaries or a wastewater effluent, the water may not be sufficiently mixed. Mixing can be slow if flow is laminar or if waters are of different temperatures. Mixing of water is dependent on the river width and depth. If there is uncertainty, this can be checked by measuring temperature or conductivity at points across the river at different depths.

Bridges are convenient locations for river monitoring locations as they are easily identifiable, generally accessible, they allow the centre of the river to be sampled and also allow estimation of flow, if all flow is constrained under the bridge structure and the bridge has a staff gauge.

4.3.2 Lakes

The number of samples needed to assess the water quality of a lake is heavily dependent on the size and depth. Small, shallow lakes can be assessed using a single mid-lake sample whereas, large, deep lakes will require an understanding of the bathymetry and water residence time. It may be necessary to sample at numerous locations and multiple depths. Figure 4.4 below provides examples of monitoring locations for different types of lake.

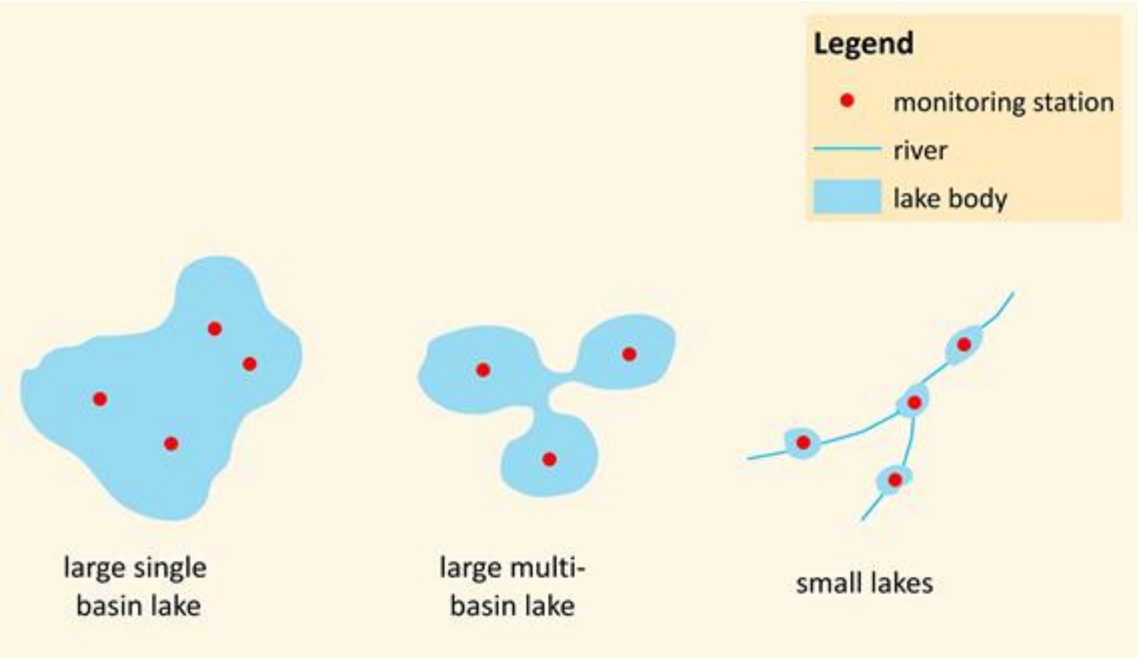

Figure 4.4 Lake monitoring location examples for different lake types. Integrated vertical sampling may be needed at each location

4.3.3 Groundwaters

The relative importance of groundwaters as a proportion of a country's water resource varies widely. This should be assessed in determining the resources allocated to groundwater monitoring. National groundwater quality monitoring programmes require a full understanding of the hydrogeology of the country to be effective. If existing monitoring wells are in place, the characteristics of the well must be known such as the depth, depth to perforated casing, length of perforated casing and well recharge rate. In the absence of existing monitoring wells; springs or existing drinking water wells can be used.

4.4 Step 4 Data Collection for Target Setting

Countries may fall into one of three potential categories with regard to target setting: (i) national ambient water quality standards exist for all parameters; (ii) data exists but national target values do not; (iii) insufficient water quality data are available to generate target values. If countries fall into the first category, this step of the methodology is not necessary and existing water quality standards can be used as target values. If countries fall into the second category and water quality data are available for the selected parameters, a systematic review is needed to determine whether sufficient data exist to set nationally relevant target values. Countries in the third category will need to implement a water quality monitoring programme to collect sufficient data to generate target values. In reality countries may find themselves between categories, and may have sufficient data to set target values for some parameters and not others.

Target values can be national values that apply to all waterbodies of one type, for example an annual average phosphate concentration of 0.035 mg P/l applies for rivers in Ireland (See Annex 8.1). Alternatively target values can be waterbody specific. For example, a national target value for phosphate of 0.035 mg P/l may not be achievable in all waterbodies due to local geological characteristics, and therefore a number of samples would be needed from sites unimpacted by anthropogenic sources of phosphate to derive an achievable local target value. Published water quality target values from other countries can be used as an alternative, but they may not be completely appropriate at the national level. Additionally, efforts should be made to align target values for transboundary waterbodies amongst all bordering countries. Examples of published water quality guidelines and targets are included in Annex 8.1.

4.4.1 Target Value Setting Method

A minimum of one year's data is needed to generate target values using samples collected during different seasons and hydrological regimes. An increase in sample collection frequency during this phase is advisable to ensure the most suitable target values are generated. A minimum of four data points are needed, but a more relevant target value would be generated if a greater the number of samples are used. As with any monitoring programme it is imperative to note the hydrological conditions during sampling because atypical hydrological conditions can affect some parameter results. Unimpacted monitoring locations should be used to determine target values for good water quality within the waterbody. For example, a headwater site in a river waterbody could be used to set target values for the whole waterbody.

Target values can be of three types depending on the parameter being measured. Some parameters will have "upper" target values meaning the value should not be exceeded. As an example, a phosphate target concentration of 0.035 mg P/l should not be exceeded. Some will be "lower" target values, meaning the measured value should not fall below the target. An example would be dissolved oxygen in rivers where a target value of 9.5 mg/l is a lower target value for waters below 20 °C. Lastly some parameters will have a "range", which is the normal acceptable range of values for that parameter. For example, a range of electrical conductivity between 500 and 700 µS/cm may be acceptable for a particular lake, and a deviation from this range may be symptomatic of a water quality issue which may need further investigation.

4.5 Step 5 Data Collection For Indicator Calculation

The minimum data requirements for calculating this indicator are measurements obtained by analysing water samples for all of the core parameters appropriate to the type of waterbody (Table 2.1). Samples should be taken routinely, at prescribed intervals, or the same time of year each year, from the same locations. Even if new monitoring stations are introduced, data should continue to be collected from the original locations. This ensures that results are comparable from year to year, thereby enabling trends to be established over time. The monitoring data needed for the indicator calculation may be collected by different monitoring programmes involving different agencies and organizations. It is therefore important to establish and maintain centralized data repositories at the national level that collate the data from the various stakeholders, ensuring compatibility in reporting units between all agencies submitting data. Data should be compiled for each core parameter at each sampling location in order to calculate the indicator as shown in the example given below in Section 5.

The central data repository should also keep all relevant metadata associated with the water quality measurements. This includes the location of the monitoring locations, described with geographical co-ordinates for each site from which samples are taken within a waterbody. The type of waterbody should be recorded together with other information that might affect the analytical results obtained (e.g. unusual water levels or disturbance of the waterbody).

For final submission of the data, it is also necessary to report the national target values or ranges that have been used to determine whether good status has been reached at each monitoring station. If target values vary for different waterbodies, the appropriate target values should be reported with the data from the relevant waterbodies.

4.6 Step 6 Classification of water quality

For the first step of progressive monitoring, a simple index based on the compliance of the monitoring data for the core parameters with the selected target values is used to classify the quality of waterbodies. For all monitoring locations within a waterbody, the monitoring values for all core parameters are compared with the target values. The index is defined as the percentage of monitoring values that comply with the target values:

$$C = \left(n_{comply} / n_{measure}\right) * 100$$

Where
n_{comply} is the number of monitoring values in compliance with the target values
$n_{measure}$ is the total number of monitoring values

It is recommended that only data from a maximum of the last three years be used for the calculation of the indicator to ensure that the results are up-to-date and globally comparable.

The monitoring data are inevitably prone to errors resulting from the sampling, analyses and subsequent processing of data. Therefore, a threshold value of 80% compliance is defined to classify waterbodies as “good” quality. Thus, a body of water is classified as being of good quality if at least 80% of all monitoring data from all monitoring stations within the waterbody are in compliance with the respective targets.

4.6.1 Subsequent Levels of progressive monitoring

On the subsequent levels of progressive monitoring, countries may report an extended set of water quality parameters describing the chemical and ecological quality of waterbodies. These parameters are treated independently from the core parameters and are currently not used for the global reporting of Indicator 6.3.2. This may, however, change in the future when the capability of the majority of countries to monitor chemical and biological parameters increases.

For chemical substances in aquatic ecosystems that pose a risk to human health and aquatic life, especially toxic substances, it is recommended to set and apply target values that take their negative effects into account. When applied to the classification of waterbodies, these target values should not be exceeded for a waterbody to qualify as having good quality.

For the classification of the ecological quality it is difficult to give recommendations regarding the necessary steps and parameters needed to classify a waterbody as having a “good” ecological status. This is due to the abundance of existing ecological indices and the variability of reference conditions, which need to be assessed independently for each individual waterbody. Therefore, it is recommended that countries develop their classification criteria with the necessary level of detail to rate waterbodies as having a “good” or “not good” ecological status.

4.7 Step 7 Calculation of the proportion of bodies of water with good quality

The results of the classification of single waterbodies with respect to their general status are aggregated to the national level by calculating the proportion of classified waterbodies holding a good general status as the percentage of the total number of classified waterbodies:

$$Percentage\ of\ water\ bodies\ with\ good\ quality\ = \left(n_g \div n_t\right) \times 100$$

Where:

n_g is the number of classified waterbodies holding a good general status

n_t is the total number of classified waterbodies.

4.8 Step 8 Programme Review

As with all water quality monitoring programmes, a systematic review of the programme's effectiveness should be routinely performed. This review should include all stages of the programme from design through to reporting with the intention of improving efficiency and ensuring the collected data are of the highest possible standard. Monitoring programmes are rarely static in nature and they need to evolve as new information becomes available or new pressures to water quality arise in the waterbody.

An overview of the assumptions upon which the programme is based should be performed. During this process the need for further survey work may be identified. For example, insufficient lake bathymetry data could mean that monitoring locations were not sited optimally, and a detailed bathymetry survey would be needed. Furthermore, a comprehensive analysis of all monitoring locations used in the programme can identify whether all locations are relevant or whether additional sample points are needed.

The operating procedures applied during sample collection, transfer to laboratory, sample analysis, reporting of results and data management should also be reviewed to identify areas for possible improvement. As an example, this process may identify that the time from sample collection to sample analysis is beyond the recommended limit for certain parameters. As a result, an optimised sampling route may be needed to reduce transport time.

A key activity during the review period is the assessment of measured values against target values. This should highlight whether targets are either too stringent and not realistically achievable or are too lenient and therefore not serving to encourage measures to improve water quality at the national level.

5. Example of first level of monitoring for rivers

In this example, the process of identification and subsequent classification of waterbodies, as well as the computation of the indicator is presented for the basin of a river, as shown in Figure 5.1. The map depicts the course of a fictional river, together with five monitoring locations that are part of a monitoring network. The river has a main arm, which is draining into an ocean and has a monitoring location at its outlet. The river could, however, drain into a lake, or even a different country. This point or boundary qualifies the river as a waterbody. Further upstream a confluence of two main tributaries is located; both tributaries have a monitoring location close to the confluence and in one of their head catchments.

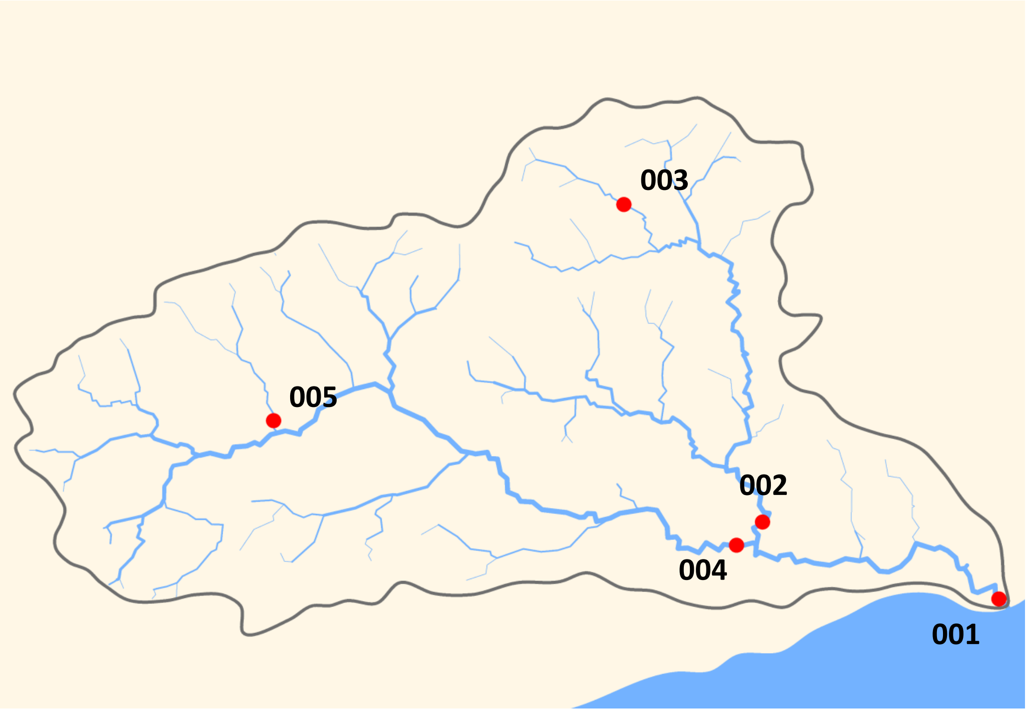

Figure 5.1 River basin used for the example, together with monitoring locations along its course

While the whole river system could be identified as one single waterbody, the monitoring locations and the confluence of two main tributaries are considered as significant enough to sub-divide the river system into three distinct waterbodies at the point of confluence (see Figure 5.2). The head catchments are not identified as separate waterbodies because they are not considered significant enough to be incorporated separately in the reporting target 6.3. However, a further sub-division could be considered in the future if, for example, more monitoring locations become available and a more detailed analysis of pressures on, and uses of, individual stretches of the river system could be performed.

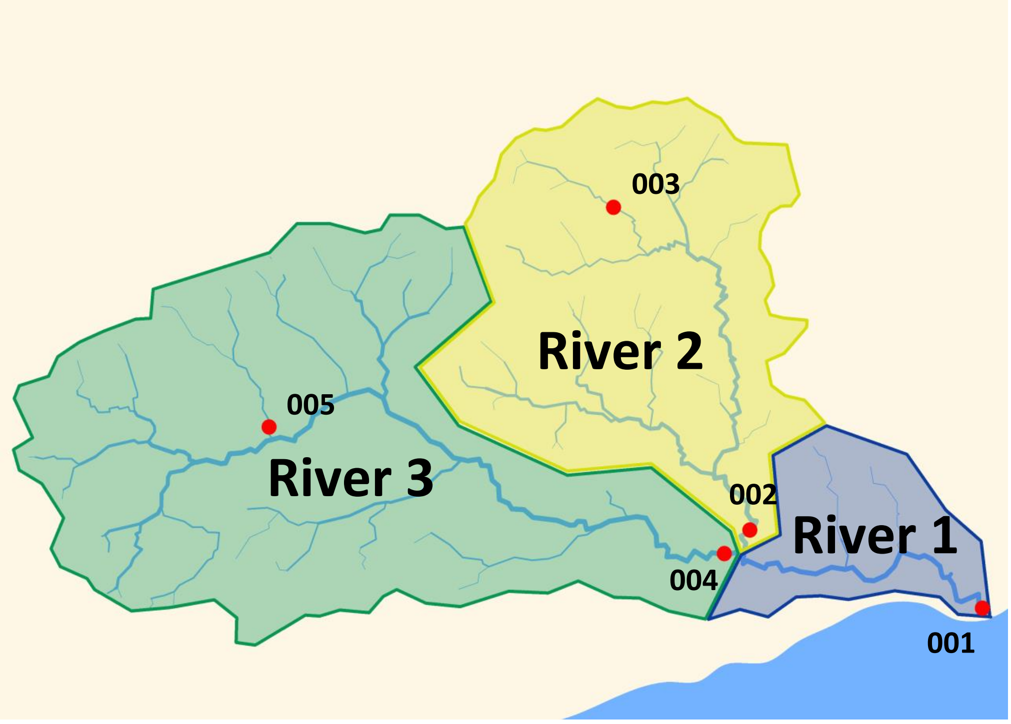

Figure 5.2 Subdivision of the example river basin in Figure 5.1 into three waterbodies

Thus, the identification process results in three distinct and significant waterbodies as reporting units during the calculation of indicator 6.3.2.

After countries have identified their waterbodies, in the next step target values need to be defined in order to classify the waterbodies as having good water quality. While it is possible to provide different target values for different waterbody types (e.g. for rivers, lakes or groundwater bodies), the fictional country in this example has only defined one set of target values for all of its three waterbodies, as presented in Table 5.1. The table also contains a definition of the target type, i.e. whether it is an upper threshold, which must not be exceeded, a lower threshold, below which values must not fall, or a range of values within which the measurements should fall in order to qualify the waterbody as “good”.

Table 5.1 Target values for the fictional country used in the indicator calculation example

Parameter Name	Parameter Short name	Target Value	Unit	Target Type
Dissolved Oxygen	DO	6	mg/l	Lower
Electrical Conductivity	EC	300 - 500	µS/cm	Range
pH	pH	6 - 8	-	Range
Orthophosphate	OP	0.035	mg P/l	Upper
Total Oxidised Nitrogen (Nitrate + Nitrite)	TON	1.8	mg N/l	Upper

This methodology defines a waterbody as having “good” water quality if 80% of the analysis results for the core parameters taken from the waterbody meet their target values. For this, the analysis results of each monitoring location inside the waterbody have to be rated according to their compliance with the target values. The percentage of analysis values meeting their target then has to be calculated for each waterbody. For the sake of replicability, a stepwise approach to the calculation of the indicator is presented here.

Table 5.2 shows the analysis results for the five core parameters sampled at “Station 001” for a reporting period covering the year 2016. Table 5.2 only covers the data from waterbody “River 1”, which has only one monitoring location. For the other monitoring locations in this example, the data have been compiled in a similar fashion. If multiple monitoring locations are located in the same waterbody, they should be grouped accordingly.

Table 5.2 Fictional analysis values for the core parameters of a waterbody with one monitoring location

	River 1 Station 001				
Date	DO (mg/l)	EC (µS/cm)	pH	OP (mg P/l)	TON (mg N/l)
2016-01-23	5.2	410	7.0	0.16	0.71
2016-02-20	8.0	450	6.8	0.18	1.09
2016-04-04	5.4	432	7.0	0.20	0.43
2016-05-10	5.8	455	7.0	0.26	0.62
2016-06-12	6.9	429	7.1	0.15	1.90
2016-08-04	9.0	401	7.3	0.07	2.10
2016-09-21	7.2	434	7.2	0.10	2.50
2016-10-19	7.2	398	7.1	0.16	1.06
2016-11-15	7.9	389	6.9	0.18	0.46
2016-12-24	6.6	390	7.0	0.25	0.04

**Note highlighted cells indicate that the target is not met*

Table 5.3 Rating of compliance with the target values for the values of the core parameters in Table 5.2 together with the percentage of values that meet their target for each core parameter (last row)

	River 1 Station 001				
Date	**DO**	**EC**	**pH**	**OP**	**TON**
2016-01-23	0	1	1	0	1
2016-02-20	1	1	1	0	1
2016-04-04	0	1	1	0	1
2016-05-10	0	1	1	0	1
2016-06-12	1	1	1	0	0
2016-08-04	1	1	1	0	0
2016-09-21	1	1	1	0	0
2016-10-19	1	1	1	0	1
2016-11-15	1	1	1	0	1
2016-12-24	1	1	1	0	1
Percentage Compliance	**70**	**100**	**100**	**0**	**70**

Based on the analysis results, compliance with the target values will be assessed in the next step where individual analysis values are compared with the target values and their compliance is rated. The easiest way to do this is to compile a separate table, where each analysis result for every core parameter gets a score based on their value relative to the target, i.e.:

- Assign a "1" if the target value is met
- Assign a "0" if the target value is violated

The results of this process for "Station 001" of the waterbody "River 1" are shown in Table 5.3. Every analysis value meeting its target has been rated with a "1", or "0" where the target is not met. Based on these ratings, the percentage of analysis values that meet their targets can be calculated for each core parameter, as has been done in the last row of Table 5.3. None of the values for Orthophosphate (OP) meet their target, resulting in zero per cent compliance for that core parameter. Dissolved Oxygen (DO) and Total Oxidized Nitrogen (TON) meet their targets 70% of the time, while Electrical Conductivity (EC) and pH values are 100% compliant with their targets.

The same procedure has been performed for the remaining monitoring locations ("Station 002" through to "Station 005") but, because the working steps are the same, they are not presented here.

Based on the compliance for each monitoring location, the percentage of values meeting their targets can be calculated for the whole waterbody. Table 5.4 shows the percentage of compliance values for every core parameter, calculated for each of the five monitoring locations, and grouped by waterbody. For every monitoring location, the percentage compliance for all five core parameters is averaged to get the percentage compliance for the individual core parameters with the target value (row "% Compliance per Station"). In the next step, the compliance with target values has to be calculated for the waterbody level (row "% Compliance per Waterbody"). If a waterbody contains only one monitoring location, the value in row "% Compliance per Station" can be taken directly (see Table 5.4, column "River 1"). However, if more than one monitoring location is present for the waterbody, the percentage of compliance on the waterbody level can be calculated by averaging the percentages of compliance of each monitoring location (see Table 5.4, column "River 2" and "River 3"). In both cases the row "% Compliance per Waterbody" amounts to the percentage of values for all core parameters that meet their targets in the reporting period.

Finally, the water quality of the waterbodies is classified as "good", if the values taken from the waterbody meet their targets at least 80% of the time, or as "not good" if the targets are met less than 80% of the time (see Table 5.4, row "Waterbody Classification").

Table 5.4 Classification of waterbodies based on the percentage of analysis values meeting their target

Percentage of Compliance per Core Parameter	River 1	River 2		River 3	
	Station 001	Station 002	Station 003	Station 004	Station 005
DO	70	90	90	70	90
EC	100	100	100	100	100
pH	100	90	90	100	80
OP	0	90	80	10	40
TON	70	100	100	100	100
% Compliance per Station	68	94	92	76	82
% Compliance per Waterbody	68	93		79	
Waterbody Classification	**NOT GOOD**	**GOOD**		**NOT GOOD**	

In the last step, the indicator is expressed as the percentage of waterbodies with “good” water quality:

$$6.3.2 = \frac{n_g}{n_t} \times 100 = \frac{1}{3} \times 100 = 33.3\%$$

The country from the example can report indicator 6.3.2 as 33.3% of waterbodies having “good” water quality.

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7. ADDITIONAL SOURCES OF INFORMATION

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8. Annexes

8.1 Glossary

The concepts and definitions used in the methodology have been based on existing international frameworks and glossaries ((WMO 2012) unless where indicated otherwise below).

Aquifer: Geological formation capable of storing, transmitting and yielding exploitable quantities of water

Groundwater: Subsurface water occupying the saturated zone

Lake: Inland body of standing surface water of significant extent

Non-point-source pollution: Pollution arising from dispersed sources such as fertilizers, chemicals and pesticides used in agriculture practices

Point source pollution: Pollution arising from a precisely located origin

Pollution: Introduction into water of any undesirable substance which renders the water unfit for its intended use

Pollutant: Substance which disrupts and interferes with the equilibrium of a water system and impairs the suitability of using the water for a desired purpose

River: Large body/stream of running water which serves as the natural drainage for a land basin

River basin: Geographical area having a common outlet for its surface runoff

Surface water: Water which flows over, or lies on, the ground surface

Toxic substance: Chemical substance which can disturb the physiological functions of humans, animals and plants

Transboundary waters: Surface or ground waters which mark, cross or are located on boundaries between two or more States; wherever transboundary waters flow directly into the sea, these transboundary waters end at a straight line across their respective mouths between points on the low-water line of the banks (UNECE, 1992)

Waterbody: Mass of water distinct from other masses of water

8.2 Examples of Target Value

Country/State	Alaska	Australia and New Zealand	Canada	Ireland [2]	South Africa
Purpose of regulations	Fish and aquatic life	Protection of aquatic ecosystems [1]	Protection of aquatic life	Good ecological status	Good quality aquatic ecosystems
pH	6.5 - 8.5	6.0-8.0	6.5-9.0	4.5 or 6.0 [3] – 9.0	Max 5% deviation from background
Dissolved oxygen (% saturation)	< 110	80-120		80-120	80-120
Dissolved oxygen (mg/)l	7 - 17				
Total ammonia-N (mg/l)				0.065	.007
Unionized ammonia NH_3 (µg/l)			19		
Ammonium NH_4^+ (µgN/l)		6 - 100			
Nitrate (NO_3^-) mg/l			13		
Total N (µg/l)					500-2500
upland rivers		100 - 480			
lowland river		200 - 1200			
lakes		350			
Phosphate (mg/l)		0.004 – 0.040		0.035 [4]	0.005 – 0.025
Total P (µg/l)					
upland rivers		10 – 30			
lowland river		10 – 100			
lakes		10 – 25			
Conductivity (µS/cm)					Max 15% deviation from unimpacted
rivers		20 – 2200			
lakes		90 – 1500			
Phytoplankton chlorophyll a (µg/l)					
rivers and streams		3 – 5			
lakes and reservoirs		3 – 5		<9.0 or <10.0 [5]	

Source reference	Department of Environmental Conservation (2016)	ANZECC and ARMCANZ (2000)	CCME (undated)	Minister for the Environment (2009)	Department of Water Affairs and Forestry (1996)
[1] Default trigger values. Different regions have specific ranges for different waterbodies within the overall range given here; [2] Based on the EU Water Framework Directive requirements for good status in rivers and lakes (EU 2000); [3] Depends on water hardness; [4] Applies to rivers only [5] Depending on lake type					