Draft Point Source Water Quality Offsets Guideline 2019

Queensland Government

Environmental Policy and Programs Division, Department of Environment and Science

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November 2019

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1. Purpose

The purpose of the draft Point Source Water Quality Offsets Guideline 2019 (the guideline) is to provide high level guidance to support the implementation of the Point Source Water Quality Offsets Policy 2019 (the policy). The scope[1] is limited to providing guidance to a point source regulated entity seeking to deliver an improvement in receiving water through a diffuse source offset action involving streambank or gully restoration.

2. Background

The type of actions that may provide a water quality offset include, for example:

- streambank or gully restoration
- constructed treatment wetlands
- improved fertiliser application management above any required minimum standards
- improved grazing and other land management practices above any required minimum standards.

Key reference documents for constructed treatment wetlands include:

- Wetland Technical Design Guidelines 2017, available on the Healthy Land and Water website.
- Design, Construction and Establishment of Constructed Wetlands: Design Manual 2017, available on the Melbourne Water website.

Other offset solutions approaches are encouraged and should be discussed with Queensland's Department of Environment and Science (DES).

2.1 Best practice approaches

Best practice environmental management under the *Environmental Protection Act 1994* (EP Act), Section 21, is defined as the 'management of the activity to achieve an ongoing minimisation of the activity's environmental harm through cost-effective measures assessed against the measures currently used nationally and internationally for the activity'.

Internationally, best management practices are used to avoid environmental harm, for example, in Germany lowland catchment areas, point source catchment offsets are used within agricultural practices where a point source can create a mixing zone, leading to point source pollution. The diffuse source of Total Nitrogen (TN), Total Phosphorus (TP) and Total Suspended Solids (TSS) are effectively controlled through the best management practices by creating models such as the Ecohydrological soil and water tools model. This ensures best land use management, grazing management practices, field buffer strips and a nutrient management plan.

In Victoria, Melbourne Water provides storm water quality offsets to target key pollutants such as TN, TP, TSS in catchment, riverine and estuarine areas. Following a set of criteria, the offset is calculated by looking at the concentration in kilograms required to meet best management practices. For healthy waters the catchment areas larger than five hectares must be treated in the area and cannot be treated offsite. The designs for the best management practices is developed by specific water quality offset rates. These are based on the combined cost of the works and the reduction in point source pollution and point of concern pollution.

[1] The guideline is published as draft, reflecting it is a work in progress that will be updated as other offset types are included.

Generally, with increasing land development and catchments urbanisation, the quantity and quality of water and resultant sediment accumulation in downstream urban areas has become more prominent. It is therefore important to look at water sensitive urban design approaches as this is a type of best management practice created by a planning and engineering design method applied in managing storm water runoff, reducing flooding as well as simultaneously improving water quality.

A calibrated hydrodynamic model was developed by using (Victorian) Environmental Protection Agency Storm Water Management Model to assist this process. For model calibration and validation, a rain gauge and a flow metre was used in the field and obtained rainfall and flow rate data. By selecting several mitigation types such as retention basins, vegetative swales and permeable pavements, it is possible to calculate their influence on peak flow rate and pollutant build-up, and wash off for TSS. The best management practice implementation in watershed, results in a decrease in the peak of the hydrograph and pollute-graph (TSS) and the total amount of surface water and TSS over the catchment (Gülbaz and Kazezyilmaz-Alhan, 2015).

2.2 Innovative approaches

There are several international examples of innovative water quality offsets approaches that have been used to improve and maintain the environment for riverine and estuarine systems.

a) Sediment: Nutrient budgeting in the Minnesota River basin

In the United States, the Minnesota River basin had 339 contributors to sediment and nutrients loads occurring in their waterways. Eighty to 90 per cent of these loads were travelling to the nearby Pepin Lake, where within the last 170 years sediment loads have increased tenfold. The Minnesota River basin is dominated by grass prairie and wetlands used for agricultural purposes, with 78 per cent of the catchment being flat agricultural land. Many farmers suggested that the high sediment and nutrient loads derived from high level hillslope erosion.

The National Centre for Earth Surface Dynamics and the Minnesota Government funded a sediment budget analysis which indicated 2880 square kilometres of the catchment was 70 per cent influenced by eroding hillslopes and banks. By using geochemical tracers in sediment cores from Lake Pepin, a major shift was seen from near channel sediment sources domination from 170 years ago, to the current agricultural field sediment domination where in the mid-20th century artificial drainage was created and precipitation increased and amplified near-channel sediment erosion (Belmont and Foufoula-Georgiou, 2017).

The innovative approaches taken in this case included the development of a reduced complexity model that focuses on transport and transformation in river systems which indicates the relationship with the agricultural land and the catchment outlet. By identifying geomorphic hotspots and bottlenecks, priority locations in need of restorative activities were identified. The reduced complexity morpho-dynamic model simulates how channels change with flow, sediment supply and the importance of flood flow events and channel adjustments. The model indicates that the installation of water detention features in only five per cent of the landscape could reduce sediment loading by half. Another innovative approach was to reintroduce a small percentage of the original wetland ecosystem which reduced the export of TN, TP and TSS (Belmont and Foufoula-Georgiou, 2017).

b) Agricultural drainage lines

Furthermore, controlled drainage strategies in agricultural lines such as spatially orientated low grade weirs show promise to significantly improve nutrient (for example, nitrate, NO3−N) reductions by expanding the area available for biogeochemical transformations and providing multiple sites for run-off retention. Taking into consideration that certain surface drainage lines are hundreds of metres long with variable slopes, the installation of low grade weirs within the drainage line at multiple spatial locations within the agricultural landscape created a continuous stepwise increase of water levels that improve retention and control of drainage. This concept provides drainage management on an annual and spatially gradated basis, rather than on a single slotted riser occurring during the dormant season. The location of the weirs has theoretical improvements over the conventional drainage line systems features of the agricultural landscape and act as major conduits for surface and subsurface nitrogen flows from agricultural lands to receiving waters.

Drainage lines are essential for wetlands as they are the link between agricultural fields and riverine and estuarine waterways (Moore et al. 2001). They possess hydric soils, support a diverse community of hydrophytes and are subject to the unpredictable changes in soil saturation because of hydrological variability. Controlled drainage practices such as flashboard risers (Evans et al. 1995), (Gilliam and Skaggs, 1986), controlled sub-irrigation (Bonaiti and Borin, 2010) and low grade weirs (Kröger et al. 2011) within drainage lines have been proposed as best management practices and an innovative approach primarily aimed at reducing nutrient concentrations and loads in lines reaching receiving waters by reducing total outflows (Kröger et al. 2012).

c) Queensland nutrient and sediment abatement pilots

In Queensland, the work to understand sediment sources is well advanced and the main contributors are understood in most of the east coast situations. Work is also underway to better understand the nutrient and sediment story in waterways with ground breaking research being delivered in partnership with DES and the Australian Rivers Institute. The Queensland Government encourages the development of pilot projects to achieve innovative nutrient and sediment outcomes.

The Beaudesert Pilot Program was the first in Queensland to use the initial version of the policy, Flexible options for managing point source water emissions: A voluntary markets based mechanism for nutrient management. The pilot uses an innovative approach to nutrient offsets using point source to diffuse source offsets option in the Point Source Water Quality Offsets Policy 2019. The pilot was developed to provide a lower cost alternative to meeting the Beaudesert Wastewater Treatment Plant license conditions using riverbank restoration rather than a more expensive treatment plant upgrade. It identified in the modelling that the total annual sediment load entering the Logan River was 13,771 tonnes per year for the section identified. Soil analysis and in-stream modelling techniques were employed to establish an annualised amount of nitrogen and phosphorous.

d) Other innovative approaches

A range of alternative innovative approaches to nutrient management may provide cost effective means to achieve improvements in the receiving water quality. For example, methods to reduce nutrients in discharges from aquaculture using treatment by algae has been demonstrated as a cost effective method to reduce nutrients from prawn farms. Proponents are encouraged to discuss innovative approaches with the DES to test whether these could be considered.

3. Policy considerations

A diagram of the policy is shown in Figure 1 below.

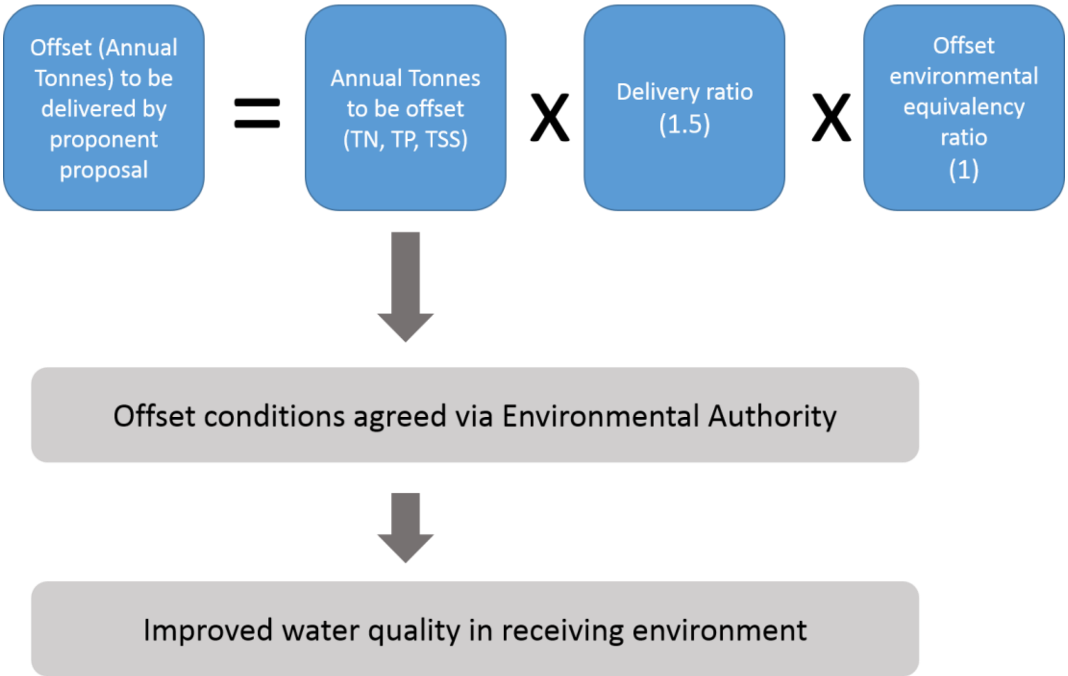

Figure 1: Point source water quality offsets policy 2019: A conceptual diagram.

3.1 Management hierarchy

Under the Environmental Protection Regulation 2019, Section 51 (1) (c) the administering authority must, for making an environmental management decision relating to an environmentally relevant activity, consider each of the following factors under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 :

- the management hierarchy,
- environmental values,
- quality objectives, and
- the management intent.

Section 15 of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 sets out a hierarchy of preferred measures for managing the release of ERA wastewater. The hierarchy covers avoidance, mitigation and release, and is designed to cascade so that each measure is triggered if the previous measure is insufficient to meet requirements:

a) firstly—reduce the production of waste water or contaminants by reducing the use of water;
b) secondly—prevent waste and implement appropriate waste prevention measures;
c) thirdly—evaluate treatment and recycling options and implement appropriate treatment and recycling;
d) fourthly—evaluate the following options for waste water or contaminants in the order in which they are listed—
   (i) appropriate treatment and release to a waste facility or sewer;
   (ii) appropriate treatment and release to land;
   (iii) appropriate treatment and release to surface waters or groundwaters.

In this section, appropriate treatment means:

a) for release to a sewerage service provider's waste facility or sewer—treatment that meets the service provider's requirements for the release to the waste facility or sewer
b) for release to land—treatment that ensures the release to land is ecologically sustainable; or
c) for release to surface waters or groundwaters—treatment that ensures, or the taking of other steps to ensure, that the release—
   (i) will not affect the environmental values for the waters; or
   (ii) is offset by undertaking an activity to counterbalance the impacts of releasing waste water or contaminants to waters, other than an offset to which the *Environmental Offsets Act 2014* applies.

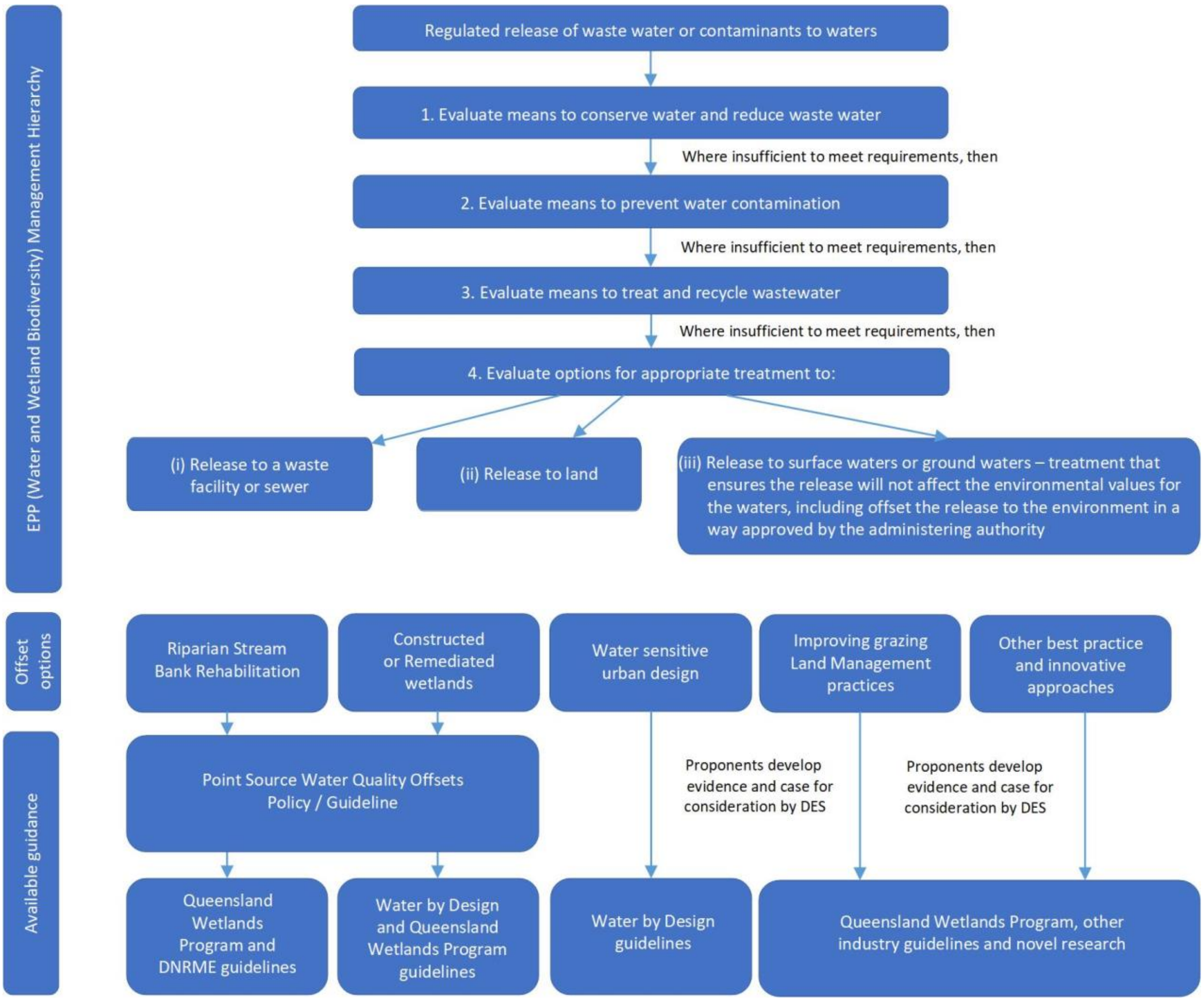

Figure 2: Offset options in the context of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 management hierarchy.

Note: In deciding and conditioning an offset proposal, the Administering Authority will consider the best practice environmental management for the activity (see the *Environmental Protection Act 1994* Section 21) and the management hierarchy re the proposed release of wastewater to receiving waters. An offset proposal may achieve a better water quality outcome in the receiving waters when linked to the best practice environmental management and at lower cost. Subject to avoidance of environmental harm at the release or discharge point, any such proposal must be discussed with the Administering Authority.

3.2 Policy principles

The principles that inform the policy are listed below, and are consistent with national and international schemes.

- Voluntary participation – new and existing environmental authority (EA) holders may voluntarily consider point source water quality offsets as a way to help manage environmentally relevant activities (ERAs).
- Regulatory requirements must be met – water quality offsets must comply with EA conditions, including the delivery and environmental equivalence ratios set by the administering authority. See Figure 1.
- Impacts must be first avoided using prevention and mitigation measures: in accordance with the management hierarchy under the Environmental Protection (Water and Wetlands Biodiversity) Policy 2019. See Figure 2.
- Improved water quality in the receiving environment – water quality offsets provide an opportunity to achieve improved environmental outcomes and improvements in receiving waters water quality, whilst avoiding environmental harm to the receiving waters environmental values.
- Alignment with catchment management priorities – water quality offsets proposals should be consistent with the overall management approach for the basin/catchment/waterway, aligning with and complementing government priorities; for example, under the Reef 2050 Water Quality Improvement Plan 2017-2022, total water cycle management plans and local government plans.
- Additionality of actions – water quality offsets must be additional to any actions already planned. Offsets cannot be used to meet approvals under other legislation.
- Measurable actions – water quality offsets and related actions must be measurable, based on the best available science.
- Appropriate time and duration – results of the water quality offsets should occur over the same timeframe as the ERA wastewater emission increase and for the duration, as set by the administering authority.
- Appropriately located – offset works are co-located, where possible, with works required under other legislative or policy instruments, such as the Land Restoration Fund.
- Verifiable, enforceable and accountable – water quality offsets must meet the requirements of the administering authority (under the EA conditions, the proponent remains accountable for the required duration, including if the offset was acquired through a market-based mechanism).
- Socially acceptable – information about water quality offsets should be transparent and acceptable to the community.

3.3 Wet weather

An EA may refer to wet weather days and dry weather days, as defined under the EA. **Dry weather day** means a day which less than 1 mm of rainfall is recorded at any rainfall measuring station recognised by the Commonwealth Bureau of Meteorology within the area connected to the point source location, or if no such measuring station exists, at the nearest such station to the point source location. The term also excludes days during which recorded rainfall over the 4 preceding days exceeds a cumulative rainfall of 50 mm. **Wet Weather Day** means a day which is not a dry weather day.

An EA condition may require the water quality offset to at least counterbalance the total point source discharge on wet weather days, with an offset solution designed to offset wet weather discharge such as erosion controls.

To establish a wet weather offset using the riverbank restoration approach to offsetting, it is necessary to understand the amount of nutrient and sediment needed to be provided for a valid offset. This can be obtained through careful consideration of the point source treatment capacity, the life of the treatment method, the cost of any potential upgrade to meet licensing conditions, and the license conditions themselves. Once the amount of nutrient and sediment potentially available for an offset approach is known, the next step is to identify candidates for a riverine restoration project. The process to achieve a valid offset site is set out in the Site Selection section below.

The Beaudesert Pilot Program and the Laidley Creek Wastewater Treatment Plant offset at Mulgowie are examples of approaches to wet weather offsets in riverine systems. The key pre-condition for such an offset solution is that the cause of the sediment and nutrient generation is wet weather related—with dry weather recycle. In the case of the above examples, the erosion was caused by major flow related events which could be measured and/or modelled to derive an annualised erosion rate. Once the erosion rate was understood, then an understanding of the soil chemistry provides the evidence for the nutrients contained within the sediment.

In all cases, the major benefits of these types of offset projects lie beyond just the nutrient and sediment aspects, the projects also provide stabilised streambanks, habitat and carbon benefits. Some of these benefits can be directly measured such as amelioration of soil loss in the case of the Mulgowie example. The adjoining farms lost over $1 million in soil during the 2011 event.

Stabilising the riverbanks and adding some cross-floodplain structures avoids the potential for such losses. The recent spotting of two platypus at the remediation site provides another clear example of the values which can be demonstrated in a well-designed offset solution.

3.4 All weather

The EP Act, Section 7.9 states that best practice environmental management should be addressed in all proposals.

Additionally, proponents are required to address the management hierarchy under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 evaluating wastewater avoidance or prevention and treatment or recycling or re-use options, before release to land or water (see Figure 2).

The process for identifying a suitable point source offset is similar to the riverine example that is set out below, in the wet weather licence condition approach. However, erosion may be caused by factors other than a wet weather major flow event. Examples of this include tidal areas where wave erosion may be attributable to a boat wake or wind.

4. Site selection—riverine and estuarine

Riverine sites are selected using historical and current imagery to show anomalies in creek banks and LiDAR where available to identify potential erosion sites. This helps in selecting badly eroded sites, for example, Laidley Creek in Mulgowie. The bed and banks at the Laidley Creek site have deepened and widened to sheer banks of up to six metres which during every major flow event causes more erosion. Through bank battering and intense revegetation, the energy from the flood waters is dissipated for that length of creek. As vegetation matures to 10 years or older, the dissipation of the water energy increases.

The first pass assessments are completed at the desktop level. The aim is to find potential sites with substantial and active erosion so that estimations of annualised erosion can be calculated. The most accurate method for this lies around different LiDAR captures on the same waterway with a reasonable time gap. Modern GIS techniques can be employed to identify the nature and size of potential erosion sites. By using BSTEM modelling, and/or change detection algorithms, the amount of sediment eroded per annum can be calculated. From this annualised estimate, an estimation of potential nitrogen yield can be made based on the amount of nitrogen bound to alluvium sediments in riverine or within estuarine situations.

Sites should be selected based on their likely contribution to a nutrient and sediment offset and will therefore likely require several thousand tonnes of sediment annualised to ensure a viable offset.

In estuarine scenarios, a boat wake is a major all-weather causing erosion impact as well as some wind-wave erosion. Site selection in the estuarine situation also requires allowance for tidal influences as it is this tidal pulsing nature of estuarine systems that allows the potential for an all-weather offset solution.

5. Technical considerations

Irrespective of whether estuarine, riverine (or wetland) based, the process to assess and develop a riverbank restoration offset solution requires careful soil testing, and erosion and sediment modelling. This ensures the TSS is assessed to provide a valid and evidenced based annualised erosion rate. The following sections set out the methodology to achieve an annualised erosion rate and resultant nutrient or sediment loads for use in conditioning a point source environmental authority with an offset.

A secondary consideration for a point source entity is the treatment of the offset solution financially. In designing a point source offset using a bank restoration offset method, the installation and commissioning of works may be considered to be a capital expenditure and the maintenance of the works out to the life of the licence conditions may be considered operational expenditure. For the accounting process, this financial treatment is important and the scoping of any project needs to consider which parts of the offset solution will be capital expenditure and which parts will be operational expenditure. This then forms an important aspect of the business case for such a project.

5.1 Riverine

The methodology developed as part of the Beaudesert Pilot Project (and employed in two other approved projects) is employed to ascertain the nutrient concentration of the soil profile along a proposed project area. In brief, the nutrient concentration of the soil profile is identified through the direct measurement of Total Carbon (TC), Total Nitrogen (TN) and Total Phosphorus (TP) concentrations in the soil at a range of locations along the target project area. These concentrations are assessed at 50 centimetre intervals to the depth of the erodible bank profile of the area modelled.

Sampling elements

The sampling technique needs to ensure the traceability of the samples taken in the soil profile from drilling, profile description and sample analysis to ensure the quality of the process. The aim is to measure at regular sites along the potential project bank length and where there is a clear change in soil type visible. To carry out this work, a qualified soil scientist with access to a calibrated geo-probe or a similar soil profiling device is critical. Usually, the sampling process is carried out with project management supervision to ensure the soil samples are appropriate for coverage of the site. The analysis should be carried out by a suitably accredited laboratory, applying analysis for TN, TKN, TP, TC and particle size. The result of the analysis should be a series of percentage content figures for each soil profile and an analysis of the profile particle size. From these results, the average percentage content for each nutrient can then be established and calculated to give the soil nutrient yield on an annualised basis. This work must be clearly documented to ensure the regulator and their science advisors can be assured that the methodology and results are credible.

Bulk density

The modelling and annualised erosion rates are calculated in cubic metres of sediment eroding. It is necessary to convert this into a tonnage to ensure the nutrient calculations can be made using the soil analysis results. To achieve this, the bulk density of the soil needs to be calculated using an accepted methodology. Again, the advice of a qualified soil scientist is helpful. Using the particle size analysis outlined above, samples are assessed to calculate an average particle size analysis. For example, a typical analysis of alluvium soils in the Laidley Creek systems is, 15.56 per cent coarse sand, 43.98 per cent fine sand, 20.17 per cent silt and 20.29 per cent clay.

The bulk density average percentage soil composition can be entered in soil texture triangles to interpret percentage soil composition into a known bulk density. The percentage soil composition of the samples, classified the soil type on average as a sandy clay loam with a bulk density average of 1.5.

The nutrient calculations

The framework depicted below describes the method used to calculate annual nutrient offset. From the modelling, the annual offset can be calculated, multiplied by the bulk density. The annual sediment offset is then multiplied by the nutrient concentration (see Figure 3).

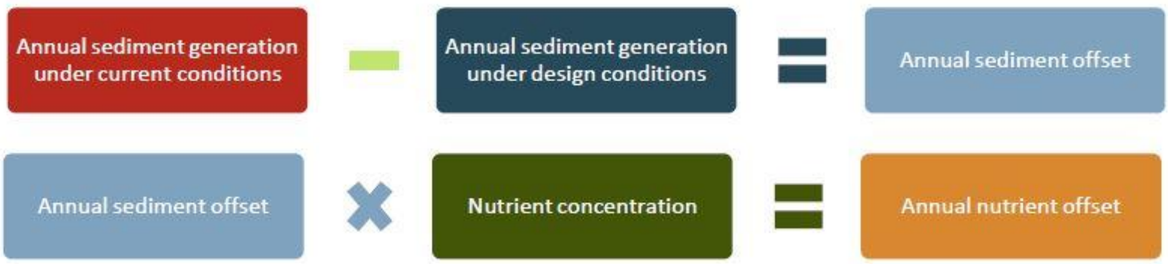

Figure 3: The conceptual framework for calculating annual nutrient offset

Using the above framework, the nutrient loads bound to the eroding sediment can be calculated. Using a delivery ratio of 1.5, the amount of TC, TP and TN can be calculated. An environmental equivalency ratio of 1:1 is assumed. The workings involved in arriving at the calculated annualised nutrient and sediment offsets must be clearly demonstrated and logically presented (usually as an appendix) to ensure the regulators can appropriately assess the potential offset solution.

5.2 Estuarine

While calculation methods for estuarine systems are similar to riverine systems, there are other potential considerations for estuarine nutrient and sediment offset solutions which need to be taken into account. Within estuarine systems, high turbidity can limit the growth of phytoplankton and favour the flow of nutrients through the estuary to costal zones. Concentration of forms of nitrogen and phosphorus correspond to the dynamics of suspended matter, and are characterised by retention during low river flow and the release during floods (Guillaud et al. 2008). Another study has found that nutrient transported by flood even can induce phytoplankton blooms in rivers, lakes and coastal waters.

Recreational boating in estuaries is the likely source of impacts which can result in the significant erosion of the river banks owing to the comparatively high energy and repetitive nature of the activity. As a vessel moves through the water it creates a complex series of waves (known as wake). The energy contained within the wave train from each boat passage can be transferred to adjacent river banks, and contribute to bank erosion. The wake characteristics produced by a vessel will depend on many inter-related factors including the displacement of the vessel, the length of the vessel in contact with the water (for example, whether or not the vessel is on the plane), the speed of the vessel, the shape of the hull and so on (Maynord. 2001, 2005).

How much energy is transferred from each boat passage to the bank will depend in turn on how close the boat is to the adjacent shore and the relationship between the wave characteristics produced by the boat passage and the topography of the river bottom (Maynord, 2005). The results of field testing by Glamore (2008) found the following:

- a wave train (that is, a group of fully formed boat waves) initially appears as an accumulation of super-imposed waves travelling away from the sailing line
- wake waves become fully developed (maximum wave height) at approximately 22 metres (2.5 to 3 boat lengths from the sailing line)
- as waves propagate further away from the sailing line, attenuation occurs resulting in a decreasing wave height while the wave period remains constant.

To estimate the likely wave energy associated with boat wakes, typical boat types and usage can be adopted to form the basis of modelling. In addition to boat wakes, wind generated waves can cause erosion for similar reasons.

Wind generated waves

Analysis of wind generated waves by the spectral model, suggests that wind generated waves are unlikely to cause substantial erosion in smaller estuaries. The main reason is that the area of water available to generate significant wave heights is negligible (under 0.1 metre) when wind speeds are less than 15 m/s, water levels are low and winds are not at an optimal angle to generate fetch. Strong (over 10 m/s) winds perpendicular to a potential estuarine site may need analysis, however, it is likely to be uncommon in Queensland estuaries with most perpendicular to the centreline waves are less than 0.2 metres.

Nutrient ratios

The nutrient calculations follow the same line as the riverine calculations, however, the final nutrient calculations require a slightly different approach to attenuation. Tidal flushing in many Queensland estuaries is slow due to the geo-morphology of the deltas of these systems. Typically, longer bank areas will be required due to the generally lower bank heights in estuarine areas, although nitrogen percentages can often be up to double that of riverine alluviums. For this reason, a nutrient modelling assessment (near field and far field) is needed to determine the delivery ratios for the proposed nutrient offsetting scheme involving riparian rehabilitation works in relation to the point source. This analysis is a critical input into the calculation of the attenuation factor for any potential offset solution. Models such as the CORMIX model can be used to predict both mid and slack (low water) tidal conditions with associated dilution factors and extent for the near field mixing zone. Again, engaging a nutrient modelling expert is important to the success of this process. Proponents, however, should discuss such proposals with the DES at the earliest opportunity and seek direction on the type of technical investigations required.

5.3 Wetland

The following information is based on work in the United States, and includes a brief outline of the science and method. Accumulation rates of sediment and associated carbon(C), nitrogen(N) and phosphorus(P) were measured in wetlands along the tidal Savannah and

Waccamaw rivers in south-east United States. The river spans an upstream to downstream salinification gradient, from upriver tidal freshwater forested wetland, through to moderately and highly salt-impacted forested wetlands, to oligo-haline marsh downriver. The tidal freshwater forested wetland, also known as tidal swamps, occur at the interface of watersheds and estuaries. Non-tidal freshwater floodplains occur upriver from tidal freshwater forested wetland, and downriver are typically a progression of tidal herbaceous wetlands along gradients of increasing salinity towards the coastal zone (Odum, 1988).

The tidal freshwater forested wetland floodplain ecosystems are extensive, and likely occupy more land surface than tidal freshwater marshes in the United States (Field et al. 1991). Their hydro-geomorphic position makes them sensitive to both coastal processes, such as higher water and salinification due to sea level rise and human modifications to estuaries and tidal rivers, as well as watershed processes that influence freshwater discharge and sediment availability. The changing chemical signature of deposited sediment firmly links wetlands along tidal rivers and estuaries to a changing source from watershed to coastal sediment (Noe et al. 2016).

This science was employed in an analysis of the Yandina Wetlands on Queensland's Sunshine Coast, by Unitywater in 2015-2016. By way of example, the analysis showed that based on conservative nutrient uptake rates, the modelling predicts that site will uptake 5.3 tonnes TN and 0.3 tonnes TP on an annual basis. The northern block is likely to retain approximately 72 per cent of the mass load due to its more persistent levels of inundation. Based on the scenario results, equivalency ratios for load reductions from the Yandina site and the Coolum Wastewater Treatment Plant were calculated. The marginal differences in the ratios suggested that the Yandina site would have approximately a similar impact on river water quality as load reductions from the Coolum plant.

The key to a potential offset using this methodology is advanced nutrient modelling in an estuarine system. Work will need to be carried out over time to measure and monitor the results of the Yandina Wetland approach.

5.4 Other options

Other options for viable nutrient offset solutions may include bioreactors which have been employed in agricultural settings to remove nitrogen using wood chip trenches which are anaerobic in nature. At this stage in Queensland, more work is needed to prove up the technique; however, areas in Queensland with suitable geo-morphology and soil structures may well provide a low cost and efficient method of nutrient offsets. As with all other methods, the attenuation factor and the delivery ratio must be taken into account should this method prove worthwhile.

Some of the other potential offset options which may be available in Queensland may include improving agricultural practice to reduce fertiliser use and/or capture runoff. While this approach has been long used in the Great Barrier Reef catchments, relating the point source opportunities from aquaculture, mining and agriculture based environment licences has not been trialled to prove the approach.

Other approaches include the use of micro-algae and macro-algae to ensure inorganic nitrogen is processed into bioavailable nitrogen for use in the food chain. Again, while some of the preliminary research is promising, the work is yet to be done to prove up the viability of these methods to mitigate or offset nutrient.

5.5 Diffuse source

Diffuse or non-point pollutants are sources that have been carried off land by stormwater or overland flow. Common non-point sources are agriculture, forestry, urban areas and historical mining sites (EP Act, 1994, Section 5). Nutrient related diffuse source pollutant inputs can enhance crop growth and improve soil eutrophication. Excessive nutrient and sediment input can, however, result in the impairment of water quality.

The potential for setting up nutrient and sediment trading schemes in suitable catchment systems may be possible in the future. Some examples, such as those in the Tully River system entering the Reef Lagoon, and Maryland in the United States, show promise, however, more work is needed to create a viable example which can apply across Queensland.

Diffuse source emissions of pollutants by surface runoff, lateral flow and percolation are impacted by catchment properties such as land use or cover types and therefore the area occupied by such land uses influences the loading of pollutants. To determine land use types which have considerable influences on pollutant concentrations in stream, a comparison that include the percentage of different land covers and their respective pollutant loads in different sub basins is considered (Lam et al. 2010).

5.6 Sediment offset considerations

While the work to establish the nutrient and sediment offsets relies on the analysis of sediment in many of the examples provided above, to develop a valid sediment offset the relationship between the point source for sediment (or impact site) and the offset site must be clearly established. Extensive scientific analysis methodology has been developed by the Australian Rivers Institute and other research institutions to establish a valid method for determining this relationship.

The method relies on the measurement of radionuclide, or a similar method of dating and identifying the sediment content, in the source and offset sites. Many of the sediment particles involved in these measurements are obtained through soil core samples at both sites. The result of this analysis then allows the ratio between the source and offset site to be determined. For example, in the Brisbane River system, approximately five per cent of the erosion within the catchment is transported to Moreton Bay past the Port of Brisbane. The analysis work shows about 78 per cent of this sediment passing the Port of Brisbane is generated from the Laidley or Lockyer Creek systems alone.

From this work, the ratio between the offset site sediment generated in Laidley Creek can be compared accurately to that being offset at the impact site. Again, it must be reduced to an annualised basis using an appropriate modelling approach.

6. Other legislative matters and construction requirements

While the Point source water quality offsets policy 2019 covers the relevant aspects of the EP Act, to deliver a successful nutrient and sediment offset solution using the riverbank protection processes may require compliance with legislation administered by other Commonwealth and Queensland Government departments.

The following matters therefore require consideration to deliver the offset solution.

Environmental management plans describe how an action might impact on the natural environment in which it occurs and sets out clear commitments from the person taking the action about how those impacts will be avoided, minimised and managed so that they are environmentally acceptable. The Commonwealth Department of the Environment and Energy is responsible for a range of regulatory functions under the *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act, Section 16, Subdivision B). Under the EPBC Act an approval is required from the responsible minister for any proposed action that is likely to have a significant impact on a matter protected by the EPBC Act. Most river restoration projects will not trigger provisions of the EPBC Act, however, potential project proposals need to address the EPBC Act as part of the due diligence phase.

Under the Vegetation Management Act 1999 a person must not do any of the following activities unless the person has a riverine protection permit to carry out the activities.

These include: destroying vegetation in a watercourse, lake or spring; and, excavation in a watercourse, lake or spring and place fill in a water course, lake or spring. During the interim period, the schedule, definition regrowth, watercourse and drainage feature area is also understood to mean that an area located within 50 metres of a watercourse or drainage feature located in the catchments, identified on the vegetation management watercourse and drainage feature map. An area management plan applies to the catchments mentioned in subsection (1)(a), (b) or (c) in the same way that it applies to the catchments mentioned in the definition regrowth, watercourse and drainage feature area, until the end of the plan period for the Vegetation Management Plan. Importantly, the requirements set out in Part 6 of the EPBC Act must also be satisfied.

Under the Water Act 2000, Section 218, a water use plan is a plan that applies to a part of the state and advances the sustainable management of Queensland's water by regulating water use if there is a risk of land and water degradation, because of rising underground water levels, increasing salinisation, deteriorating water quality, water-logging of soils, destabilisation of bed and bank watercourses, damage to riverine environment and increasing soil erosion.

A Riverine Protection Permit must be obtained to do any of the following activities: destroying vegetation in a watercourse, lake or spring; and excavation in a watercourse, lake or spring and place fill in a water course, lake or spring. Also, the application must include: the written consent of the registered owners of the land; contain the length of the water-course in which the activity is to take place or the part of the lake or spring where the activity is to take place, or adjoining the watercourse, lake or spring where the activity is to take place. The Riverine Protection Permit must be made to the chief executive in the approved form, state the proposed activity, the purpose of the activity and be accompanied by the fee prescribed by regulation.

A Riverine Protection Permit must be obtained for any works forming the basis of a point source offset project.

6.1 Construction permits and approvals

Queensland's Planning Act 2016, Section 4, facilitates the achievement of ecological sustainability. It includes state planning policies, regional plans, planning schemes, temporary local planning instruments, planning scheme policies and the development assessment system. In carrying out work in a riparian zone, care should be taken to ensure the proposed offset does not contravene any of the instruments listed in Section 4.

In the estuarine zone, provisions of the *Fisheries Act 1994, Coastal Protection and Management Act 1995* and *Planning Act 2016* should be taken into account. It is highly likely that a development application will be required and particular note needs to be made of the extra assessment required for fish habitat areas.

From the commencement, the authority has effect, as if the authority were a development permit; or if the authority is an aquaculture licence—a material change of use of premises; or if the authority is a permit for the performance of works in a declared fish habitat area or for the removal, destruction or damage of marine plants—operational works. If the currency period does not end within six months after the commencement, the chief executive must, as soon as practicable, issue the holder of the authority, a development permit; and if the development permit was applied for after the commencement, require a resource allocation authority for Queensland waters, unallocated tidal land or declared fish habitat area—a relevant resource allocation authority for the development. A development permit or resource allocation authority issued under subsection must state: the permit; the currency period for, and conditions of, the permit; or for the authority, the term and conditions of the authority.

Under the *Fisheries Act 1994*, Section 261, a person intending to make a development application for the construction or raising of a waterway barrier works in an area may apply to the chief executive for a fish movement exemption notice for the area. The application must be made in the approved form, accompanied by the prescribed fee and made before the person makes the development application. Under the Planning Act 2016, Section 65, the conditions imposed on a fisheries development approval may include environmental offset conditions to counterbalance the impacts of the development on fisheries resources or fish habitat including, an environmental offset to enhance or rehabilitate a fish habitat, the exchange of another fish habitat for a fish habitat affected by the development and a contribution to fish habitat research.

Some in-stream restoration projects may interfere with fish passage. In these instances, water barrier works in riverine or estuarine areas require extra attention. Provisions of the *Fisheries Act 1994*, Section 242, may require a development application to assess the potential fish passage aspects of the project.

6.2 Legislative duty of care issues

Compliance with the *Work Health and Safety Act 2011* Section 18 is critical. A potential project must consider and weigh up all relevant matters including the likelihood of the hazard or the risk concerned occurring; the degree of harm that might result from the hazard or the risk; that the person concerned knows, or ought reasonably to know, about the hazard or the risk; and the ways of eliminating or minimising the risk. To fully satisfy the requirement of the *Work Health and Safety Act 2011*, the project should ensure that all safe work methods, toolbox talks, start-up procedures and other workplace health and safety documentation is correctly applied.

In addition to the *Work Health and Safety Act 2011*, Section 319 of the EP Act outlines the general environmental duty which ensures the responsibility for the actions taken that affect the environment are taken into account. Any activity that causes or is likely to cause environmental harm must not be taken unless all reasonable and practicable measures to prevent or minimise the harm are taken.

To decide what meets the general environmental duty, consideration needs to be given to the:

- nature of the harm or potential harm
- sensitivity of the receiving environment
- current state of technical knowledge for the activity
- likelihood of successful application of the different measures to prevent or minimise environmental harm that might be taken
- financial implications of the different measures as they would relate to the type of activity.

6.3 Construction design and implementation

A project design requires a detailed geomorphic assessment of the project area. This includes a detailed digital terrain model, and the development of appropriate in-stream features such as grade control structures, bank stabilisation pile fields, and cross channel pile fields. Care must be taken to ensure a full fluvial geomorphic understanding of the active process causing the erosion on the stream are understood. Experience shows that qualified fluvial geomorphologists are best placed to fully understand the processes causing the erosion and make recommendations to address the causes.

The river restoration guidelines should be followed in any assessment and design work involving in-stream restoration offset projects. These guidelines are in the process of being upgraded by Queensland's Department of Natural Resources, Mines and Energy (DNRME). The guidelines will be a web based resource which can be tailored to different catchment types within the state. This guideline will be updated to include a link to the DNRME guidelines when they are available online.

All construction work—bank-battering, rock placement and pile installations—must:

- be done in accordance with appropriate approvals
- feature a fluvial geomorphologist and/or engineer's plan
- be reviewed by a registered professional engineer in Queensland (RPEQ).

Bank re-profiling is often required to provide a stable substrate for vegetation establishment and to reduce stream power and shear stress (and hence erosion) in the stream reaches (DSE, 2008). Usually, a profile of one (high) in three (wide) is preferable unless site specifics determine otherwise. It is always preferable to ensure project design work includes appropriate hold points for RPEQ sign-off once the site set-out is complete and at the end of construction.

Native vegetation establishment is a normal part of the construction process and, as much as possible, the regional ecosystem which typified the stream reach being remediated should be established with local provenance. A vegetation management plan should be developed specifically for the site. Weed management also needs to be factored and fully costed for the life of the licence. Every effort should be made to retain existing native vegetation if it can be factored into the design work, when this is feasible.

In many locations, large trees can be found on the edge of a steep bank. These trees and their root system can provide important structural reinforcement to the bank soils and hence are a local hard point in the stream system that limits erosion. In some instances, these trees may need to be removed to achieve a stable gradient suitable for vegetation establishment, however, in many instances the bank slope can be steepened to enable trees and their associated root networks to be maintained on the bank along with other vegetation stabilisation methods.

Significant management effort will be required in the vegetation establishment period to manage weeds to a level that allows the native vegetation community to capture the riparian zone. Given the likely weed load in the catchment, ongoing management will be required in the project reach to limit the ability of weeds to re-colonise the riparian zones. Weed management considerations should be a critical component of the revegetation plan.

Erosion sediment control work should be considered during any works. Depending on the situation (some streams are ephemeral), an erosion and sediment management plan may be necessary and comply with best practice guidelines.

Other considerations in the construction of a project include the need for soil health measures, as some soils in stream banks may not have been disturbed for millennia. Most importantly, it is highly likely that river restoration projects will be carried out on the land adjoining a private landholder's property. It is absolutely critical that the permissions and wishes of the adjoining landholders' (who have often given up some of their productive land for the project) are respected to ensure the viability of the project. Without landholder support, the project will likely not be deliverable.

6.4 Monitoring and evaluation options

The success of any potential in-stream restoration project hinges on the project being able to demonstrate that it is meeting the stated objectives of the approved conditions within the point source licence. The EP Act Section 7.9, makes it clear that the proponent is responsible for monitoring and reporting water quality effects at the point source location, offset location and other relevant locations specified in the proponent's EA, in order to demonstrate the efficacy of the water quality offset.

The type of monitoring that is required will depend on the water quality offset selected. The costs of all monitoring and reporting activities are to be met by the proponent and are not the responsibility of DES. However the department is responsible for reviewing performance and monitoring reports. Monitoring must be undertaken in accordance with the Monitoring and Sampling Manual under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019, published on the department's website.

The methodologies adopted for the monitoring aspects can include:

- LiDAR change and direct on-ground survey change for demonstrating no net erosion of sediment and bound nutrient from the offset site during the licence period
- photo point monitoring and direct vegetation measurement and assessment to ensure the vegetation is meeting expectations given its importance to long term success
- ambient and event based in-stream measurement of nutrient and sediment loads. Reporting frequency is set by the license regulator, most commonly for six month or annual periods. LiDAR data is collected either annually or bi-annually.

6.5 Enduring liability

In the EP Act Section 7.10, the proponent is responsible for ensuring that the water quality offset is implemented diligently, maintained and meets the design criteria. The proponent may contract manage actions to a third party (for example, land owner, natural resource management body, project manager or project broker), however, the legal responsibility for the source and delivery of the water quality offset will remain with the proponent as a requirement of the proponent's environmental authority.

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