

MEMORANDUM

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Coast Water Board

Cc:

From: Jon Butcher, Sujoy Roy

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Subject: Laguna de Santa Rosa:
Surrogate Measures (Revised)

**Project
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1.0 SURROGATE MEASURES AND TMDLS

1.1 INTRODUCTION

Achieving the loading capacity targets for nutrients and sediments in the Laguna de Santa Rosa will require large reductions in existing loads. Because of large amounts of sediment accumulation within the Laguna due to historic anthropogenic sources and continued supply of nutrients from those sediments to emergent macrophytes and to the water column, meeting the load and concentration targets will require a combination of reductions in new loading from the watershed and reduction of internal loads through restoration activities within the Laguna and its tributaries. The need for restoration activities is identified in the TMDL by a lack of assimilative capacity under current conditions and a need to reduce total loads beyond the total contributions from ongoing anthropogenic sources. Indeed, because the existing and internal loads for nutrients and sediments are several times greater than the loading capacity of the Laguna, extensive restoration efforts may be needed. Loading sources and restoration opportunities both occur in a dispersed manner across the Laguna and its watershed. To find the most feasible and cost-effective opportunities, a water quality trading framework for point-source phosphorus loads has been developed for the Laguna (NCRWQCB, 2018). However, a market for phosphorus alone may be an insufficient tool to meet restoration goals. Further, limiting the trading only to point sources may not create enough restoration opportunities. Therefore, a more general trading market that can fund restoration activities across different types of loading sources is needed. Because nutrient and sediment concentrations from all watershed activities are not measured systematically in the manner they are from point sources, it is also necessary to develop a metric or currency that can establish equivalencies between different types of load reduction activities and can track progress toward TMDL goals.

If the TMDL loading capacity could be met solely through reductions in upland source loads it might seem obvious to implement the TMDL directly in terms of phosphorus, nitrogen, and sediment loads. (The Laguna is currently listed as impaired by phosphorus and sediment, but not nitrogen; however, proposed targets for the Laguna also include nitrogen in agreement with the State Board's proposed draft biostimulatory policy.) However, implementing the reductions directly in terms of constituent loads is still

inconvenient for loads that arise from numerous dispersed sources across the watershed. There are several reasons for this: it is not possible to measure loads from every source area and loads will vary from year to year depending on hydrology or water year type, agricultural commodity markets, fire occurrence, and other factors. Therefore, it is desirable to have a simpler surrogate measure or measures that can be used to track progress and assign reductions to regulated entities.

Surrogate measures are useful for planning and tracking implementation of a TMDL and potentially for providing a readily interpretable “currency” for trading and funding of restoration projects that are needed as part of a holistic management plan to support beneficial uses in the Laguna.

A good surrogate for nutrient and sediment loads is one that is expected to be well-correlated with the loads and is straightforward to measure directly and can thus be tracked effectively across a complex watershed. A readily interpretable surrogate measure might also help to resolve the more difficult problem of establishing equivalencies between upland load reduction and instream restoration activities to generate assimilative capacity.

It is also the case that loading of nutrients and sediment to the Laguna are not independent or separable. Instead, it is the combined effects of alterations to morphology and hydrology (due to both intentional channel modifications and sediment accumulation) and elevated concentrations of nutrients that lead to biostimulatory conditions in the Laguna.

A TMDL can include “surrogate measures,” as provided under EPA regulations [40 CFR 130.2(i)]. The Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program (USEPA, 1998) includes the following guidance on the use of surrogate measures for TMDL development:

When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where impairment is identified but cannot be attributed to a single traditional pollutant, the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not.

The use of a surrogate parameter is also permissible under CWA Section 303(d)(1)(C) (33 U.S.C. 1313(d)(1)(C)), which requires that the TMDL load “shall be established at a level necessary to implement the applicable water quality standard,” but does not dictate the specific methodology for calculating or expressing the TMDL. A TMDL that achieves pertinent water quality standards using a surrogate parameter is permissible (See *Friends of the Earth v. U.S. Environmental Protection Agency*, 346 F. Supp. 2d 182, 200-01 (D.D.C. 2004), reversed and remanded on other grounds, 446 F.3d 140 (D.C. Cir. 2006), cert. denied sub nom *D.C. Water & Sewer Authority v. Friends of the Earth*, 549 U.S. 1175 (2007)).

This memorandum provides a review of TMDLs where surrogate measures have been successfully applied and proposes certain surrogates that are applicable to the Laguna nutrient and sediment TMDL.

1.2 EXAMPLE TMDLS WITH SURROGATE APPROACHES

Several different approaches have been taken to address complex TMDLs where a combination of watershed load reduction and instream restoration is needed to address restoration of uses, or where a standard TMDL formulation of loading rates by a pollutant is not sufficient.

Two approved TMDLs in New England (EPA Region 1) pioneered the use of surrogate measures, rather than loading rates, in TMDLs. The Potash Brook TMDL in VT (2006), addressing biological impairments,

uses the following rationale (https://www.epa.gov/sites/production/files/2015-09/documents/sw_pot_tmdl_final_epa_submittal.pdf):

The surrogate of stormwater runoff volume in place of the traditional “pollutant of concern” approach. The combination of stressors is represented by the surrogate of stormwater runoff volume. First, the use of this surrogate has the primary benefit of addressing the physical impacts to the stream channel caused by stormwater runoff such as sediment release from channel erosion and scour from increased flows. These physical alterations to the stream are substantial contributors to the aquatic life. Also, reductions in stormwater runoff volume will help restore diminished base flow (increased groundwater recharge), another aquatic life stressor. This surrogate is also appropriate because the amount of sediment load discharged from out of channel sources is a function of the amount of stormwater runoff generated from a watershed.

The Eagleville Brook TMDL in CT (2007), also addressing aquatic life impairments, used a surrogate measure of impervious cover extent to develop the TMDL (http://clear.uconn.edu/projects/tmdl/library/tmdl/reports/eaglevillefinal_TMDL.pdf). “The TMDL was developed using Impervious Cover (IC) as a surrogate parameter for a mix of pollutants conveyed by stormwater. The TMDL is established as the percent of impervious cover (% IC) throughout the watershed that must be achieved to meet the aquatic life criteria and attain the designated aquatic life uses.”

The Lower Grand River TMDL in Ohio (2012), also addressing biotic integrity impairments, uses a similar approach to establish a TMDL using changes in “flow regime” as a surrogate indicator (https://epa.ohio.gov/portals/35/tmdl/GrandLower_SurrogateTMDLFactSheet.pdf).

EPA’s Malibu Creek TMDL (CA, EPA Region 9, 2012) also addresses biological impairment based on benthic macroinvertebrate scores. The Clarks Creek TMDL (WA, EPA Region 10, 2015), addressing impaired DO and sedimentation in an urban stream, uses untreated urban stormwater runoff as a surrogate measure for implementing the TMDL (<https://fortress.wa.gov/ecy/publications/SummaryPages/1410030.html>). Both Malibu and Clarks Creek are west coast TMDLs and their details are discussed further below.

In contrast, the complex Chesapeake Bay nutrient and DO TMDL seeks to convert all implementation actions into a common currency based on nutrient loads that can encourage trading and adaptive management to meet improvement goals for the multiple jurisdictions involved. Loading rates from different land use categories in the Chesapeake Bay watershed are based on extensive rounds of watershed runoff modeling. Expert panels, convened over more than a decade and with thousands of hours of input, have strived to derive “consensus” estimates of load reduction for conventional and innovative management strategies. These have included proposed credit estimates of the nutrient load reduction associated with hard-to-model alternatives such as wetland restoration and channel restoration. For each land use and BMP type, expert panels have defined acceptable equivalencies of nutrient load reduction (https://www.chesapeakebay.net/who/group/bmp_expert_panels). For example, the wetland expert panel concluded based on literature that, for the purposes of accounting, each acre of new floodplain wetland within the Coastal Plain area would treat 2 acres of upland and achieve a removal rate of 40% for total phosphorus and 31% for sediment (Wetland Expert Panel, 2016). The panel recognized that results for individual wetlands could vary greatly but accepted this consensus rough estimate as adequate for evaluating overall progress toward restoration goals and providing a basis for trading.

While it is unlikely that something like the long and intensive process of the Chesapeake Bay program will be implemented for the Laguna, the work of the expert panels does provide insight into possible trading ratios between different types of restoration efforts. Perhaps one lesson is that it may be sufficient to simply promulgate trading ratios based on best professional judgment rather than calculating them exactly.

On the West Coast, the EPA-approved Clarks Creek dissolved oxygen TMDL (Region 10, Pierce Co., WA) determined that a 50% reduction in untreated stormwater runoff (either through treatment or diversion) would achieve the TMDL goals through eventual reduction of sediment oxygen demand (James et al., 2014). This surrogate was used to develop implementation plans, although the word “surrogate” was removed from the final text based on legal advice. Clarks Creek may be of particular interest for the Laguna as it is a system with multiple problems associated with existing sediment and nutrient loads with a prominent infestation by an invasive aquatic macrophyte (*Elodea* in the case of Clarks Creek). Determination of the 50% reduction goal was based on steady-state QUAL2Kw model runs and an interpretation of the needed reductions in loading of nutrients (to reduce macrophyte growth) and oxygen demanding organic matter.

For Clarks Creek, the DO TMDL itself is written in terms of needed reductions in dissolved oxygen deficit (relative to saturation), while the surrogate target is used for implementation. It is not claimed that the 50% reduction in untreated stormwater is an exact match to the TMDL loading capacity but rather that it approximates what is needed to move waterbody conditions in the right direction and will be re-evaluated periodically. The final combined nutrient and sediment TMDL calls for the City of Puyallup, which has jurisdiction over about 60 percent of the Clarks Creek watershed, Pierce County, and other MS4 permittees such as Washington DOT to achieve (1) a 50 percent reduction in stormwater flow or untreated stormflow volumes MS4 drainages relative to a specified (October 20–21, 2003) design storm event, and (2) a 66 percent reduction in sediment load from the City. In practice both targets can be evaluated in terms of the removal or treatment of MS4 runoff. This surrogate is used in the City’s Retrofit Plan (Brown and Caldwell, 2017) to address loading of nutrients and organic matter as well as the secondary effects of sedimentation that promote excess growth of *Elodea*. A similar retrofit plan was developed for the county MS4 (Pierce County, 2017). These plans take a top-down, centralized approach and do not discuss a water quality trading framework.

In California, the Malibu Creek sedimentation and nutrient TMDL (Los Angeles Co.) was developed to address impaired benthic biota based on California Stream Condition Index scores (USEPA Region IX, 2013). Poor CSCI scores are related to a variety of environmental conditions in the creek; however, a full stressor identification process suggested that the most important limiting factors were hydromodification and associated sedimentation caused by increased impervious area in the watershed, along with excess nutrient loads. Nutrient allocations followed a standard TMDL process based on seasonal target concentrations tied to monitoring of minimally impacted tributaries within the watershed (which has unique geology and chemical conditions). For sedimentation, the primary stressor was excess flow, but the TMDL regulations do not allow regulating [flow](#) or hydromodification directly (these stressors count as pollution but not pollutants). Instead, the sedimentation TMDL was written in terms of the estimated sediment carrying capacity within the mainstem (as tons of sediment per day), which is a function of flow but addresses sediment as a pollutant. While the final units are in terms of mass per day consistent with the TMDL regulation, the actual goal is to achieve long-term load reductions. Transported sediment loads and needed reductions were first calculated on the basis of change between current conditions and pre-settlement conditions (plus a Margin of Safety), then translated to a target load on an annual basis. A variable daily load expression is then provided as a conditional function of flow, satisfying the “daily”

requirement consistent with USEPA (2007). Specifically, “the TMDL is expressed first as an annual load... This was converted into a daily average load by calculating the annual flow-weighted concentration (the annual load divided by the total annual flow) and then multiplying by the daily flow. The daily expression of the maximum load is then calculated as the 95th percentile flow (for the appropriate season) ... times the seasonal concentration target, converted to tons per day.”

The sediment portion of the Malibu TMDL uses sediment transport capacity as a surrogate measure for degraded habitat conditions. The Malibu Creek sediment TMDL is implemented through the development of an Enhanced Watershed Management Plan or “EWMP” (MCWMMG, 2016). The EWMP in turn uses peak flow from the two-year storm event as a second-level surrogate for sediment transport capacity and developed a BMP implementation plan to address those flows. The EWMP does not attempt to address sediment and nutrient loads simultaneously and uses the peak flow surrogate only for sedimentation.

2.0 SURROGATE MEASURES FOR THE LAGUNA DE SANTA ROSA TMDL

2.1 GENERAL REQUIREMENTS

This section discusses requirements for potential surrogate measures that could be used in conjunction with the Laguna de Santa Rosa TMDL. The specific surrogate measure proposed for use is described in Section 2.2.

It is important to keep in mind the distinction between the TMDL itself (which is approved by EPA) and the accompanying implementation plan (which is a state responsibility not subject to EPA approval under current regulations). While some TMDLs have been written with allocations expressed directly in terms of surrogate measures (e.g., impervious cover in Eagleville Brook above) the odds of approval are likely much higher if the TMDL itself (including wasteload allocations for each permitted point source) is written in terms of pollutant loads. Surrogates can then be used in the implementation plan as a way to develop strategies to achieve those loads.

The development of surrogates is related to but separate from the existing Water Quality Trading Framework (WQTF) that has already been established for the Laguna (NCRWQCB, 2018). The WQTF lays out a method by which the permitted point source dischargers to the Laguna may establish credits to offset their phosphorus loads to the Laguna. The credits are derived from practices that either directly remove phosphorus from or reduce phosphorus loading to the Laguna. Various aspects of the WQTF are relevant to the discussion of surrogate measures for the Laguna, especially in relation to evaluating instream remedial or restoration activities. However, the surrogates discussed here are intended to complement rather than replace the WQTF, which is currently applicable specifically to the Santa Rosa and Windsor wastewater treatment plant NPDES permits, by providing a broader context that can be applied to other types of point and nonpoint sources.

It would also be advantageous to define surrogates that can address both sediment and phosphorus loads. (We have also proposed loading targets for nitrogen, but nitrogen is not required to be addressed in the TMDL based on the current 303(d) listing.) Section 5.2.1 in the Linkage Analysis for Nutrient Impairments (Tetra Tech, 2020b) demonstrated that total P loads calculated based on sediment potency (phosphorus mass per sediment mass) were similar to total P loads calculated from the Land Cover Loading Model. Further, phosphorus loading from diffuse sources occurs primarily in sediment-associated forms. It is therefore reasonable that a single surrogate would be applicable to both sediment and phosphorus in terms of upland loading. Delivered loads from various other pollutant sources from the

watershed, ranging from dairy manure piles to homeless encampments in the floodplain, are also likely to be correlated with the rate of runoff and delivery of solids from a particular area.

An initial approach considered as a surrogate measure for the delivery of diffuse sources of both sediment and phosphorus to the Laguna was the fraction or percentage of runoff that is subject to treatment or mitigation up to some desired level of performance. This is similar to the surrogate used in the Clarks Creek TMDL. The percentage of runoff treated could in turn be assumed to be proportional to the area that is treated. Calculation on the basis of area is essentially equivalent to assuming a 1:1 relationship between storm event runoff and total P (or sediment) load for a given land use type, but the area of land treated by mitigation measures is much easier to track than actual load generation. The relationship would not need to be exact if it is applied in the implementation plan, not the formal TMDL, and the implementation plan should contain a commitment to adaptive management with period reappraisal of progress toward achieving goals with adjustments as needed.

This candidate approach was rejected because it did not provide a strong basis for allocating responsibility to support restoration projects that will be needed to achieve support of beneficial uses in the Laguna. Selection of surrogate measures for the Laguna is more complicated than most of the examples in Section 1.2 because the Laguna TMDL must address sediment and nutrients already stored within the Laguna, not just ongoing loads from the watershed. Relationship to untreated runoff from anthropogenic land uses is an important component of the analysis, but there is also a need to incorporate concepts of change over time. Therefore, the proposed surrogate measure, as described in Section 2.2, was modified to reflect the change in storm event runoff from current anthropogenic land uses relative to natural conditions. In addition to incorporating the element of change over time this approach has the advantage of linking TMDL responsibilities to those land uses that have benefitted most from the hydromodification that has increased pollutant delivery to the Laguna. For example, urban development and associated impervious surfaces, in addition to increasing runoff rates, has required the construction of floodways that deliver pollutants directly to the Laguna instead of depositing them in wetlands and distributary channels on the Santa Rosa Plain. Agriculture has also increased runoff due to the removal of perennial vegetation cover, although to a smaller degree than urban development, and has benefited from drainage modification. Finally, using a surrogate that is based on changes in runoff will also naturally focus responsibility to areas where the changes have been most drastic.

2.2 PROPOSED SURROGATE FOR THE LAGUNA DE SANTA ROSA TMDL

Many details must be resolved to convert the general concept of change in storm runoff to a workable surrogate measure. The concept of calculating the contribution of a site or area to increases above natural, undeveloped storm event runoff has aspects in common with Maryland's Environmental Site Design (ESD), although ESD is applied only to new development and redevelopment in Maryland. Maryland's Stormwater Design Manual (MDE, 2009) provides the following summary of the ESD concept: "The criteria for sizing ESD practices are based on capturing and retaining enough rainfall so that the runoff leaving a site is reduced to a level equivalent to a wooded site in good condition as determined using United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) methods (e.g., TR-55)." The evaluation is made on the basis of the 1-year 24-hour storm event, eliminating the need for continuous simulation or total runoff volume calculations. The 1-year 24-hour event is selected because channel-forming flows in evolving urban streams are typically found to be in the 1 to 1.5-year recurrence range. The channel forming flow or dominant discharge is the flow that does the greatest work on the channel by integrating a moderately high shear stress with a high frequency of occurrence. Larger flows will do more work on the channel in an individual event but occur less

often. Bledsoe and Watson (2001) also recommend using the 1-year 24-hour event for stream stability analysis.

The NRCS TR-55 method is based on runoff curve numbers (CNs), which are a function of hydrologic soil group, impervious cover fraction, and condition of the land cover. Tables are widely available. The MDE ESD guidance lays out the calculation methods and also provides reduced curve numbers (RCNs) to be used to account for BMPs that reduce runoff from impervious surfaces. Evaluations can be made at the site, development, or larger scale through the calculation of area weighted CNs; however, for simplicity it is recommended that the analysis be conducted at the site or parcel level, removing the need to simulate downstream routing. CNs can also be modified to account for the presence of stormwater control measures.

The ESD calculation approach simplifies the analysis by focusing on a single design storm, which greatly increases ease of applicability and avoids the need for continuous simulation. Application to the Laguna watershed does require modification to local conditions for the design storm event, land use, and soils, but the necessary sources are readily available.

Design Storm: The 1-year, 24-hour storm for Santa Rosa is 2.87 inches as estimated in NOAA Atlas 14 but varies across the watershed. Interpolated grids for this event covering the whole watershed are available from the NOAA PFDS server (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_gis.html). Methods are also available to estimate how the design storm is likely to change under future climate (e.g., Butcher et al., 2021).

Land Use/Land Cover: High resolution LiDAR based spatial coverages of current land use and land cover, including impervious surface areas, have already been assembled for the Laguna watershed, as described in Tetra Tech (2020a) and can be used as the default basis for defining current condition CNs. Individual jurisdictions could be given the opportunity to revise these CNs based on factors such as presence of stormwater management controls. MDE (2009) provides techniques for accounting for such controls. The MDE ESD method assumes that the natural condition is woods in good condition. For application to the Laguna watershed we would instead use the pre-development land cover map developed by the Water Board (Butkus, 2011; based largely on Price et al., 2006). This identifies six classes of pre-development land cover: Open Water, Perennial Wetland, Riverine Wetland, Rangeland, Oak Savanna, and Forest.

Soils: For the CN approach the primary need is for Hydrologic Soil Group (HSG), which is a measure of infiltration capacity that is incorporated into the CN lookup tables. A gridded map of HSG has already been developed from soil survey data as part of the RUSLE analysis described in Tetra Tech (2020a).

In sum, the analysis of the surrogate measure would assume that the natural condition runoff is calculated using the 1-year, 24-hour storm and the CN for the appropriate pre-development soil group and land cover in good condition. The corresponding post-development runoff is then calculated with the CN appropriate to the present-day land cover and impervious fraction. The extra contribution or responsibility of the developed land area is then equal to the difference between these two numbers expressed as a volume by multiplying by area (e.g., as acre-feet of runoff). The analyses can readily be implemented on a high-resolution grid and aggregated to the level of a jurisdiction entity.

The method is readily applied to developed areas. It can also be applied to different types of agriculture, or even parks, based on their changes in land cover and impervious extent.

Use of this approach would yield a single runoff volume estimate for each parcel, development, or regulated entity. Creating this type of common currency will help provide a basis for credits and trading, as is explored further below.

2.3 PROPORTIONAL RESPONSIBILITY

It is assumed that load reductions will be required only for ongoing anthropogenic sources where some sort of regulatory authority exists. That means that for other watershed sources as well as load reductions needed for historic stored material within the Laguna it will be necessary to develop other mechanisms to promote and fund instream restoration efforts and reductions from non-regulated sources.

The surrogate measure based on runoff from the 1-year 24-hour event can be used to determine proportional responsibility for each regulated entity. Define Q_i as the post-development runoff rate, $Q_{0,i}$ as the natural condition runoff rate, A as the site area, and $\Delta Q_i = (Q_i - Q_{0,i}) \times A$ as the total excess runoff (relative to the natural baseline condition) that is attributed to entity i . This is equivalent to the sum of excess runoff calculated for each grid cell that makes up entity i . The proportional load reduction (RR_i) assigned to entity i is then $RR_i = \Delta Q_i / \sum \Delta Q_i$ – that is, the fraction of all excess flow from regulated entities that is attributed to entity i .

RR_i can then be multiplied by the total needed reduction in either phosphorus or sediment (after correcting for any additional load reductions to be obtained from wastewater treatment plant discharges or other regulated discharges) to determine the total load reduction responsibility of entity i . Because the needed load reductions are large, and a significant portion of the loads are due to sources not delivered by overland flow or point source discharges in the watershed or internal recycling within the Laguna, part of the obligation would need to be met by supporting restoration projects or arranging for load reductions elsewhere in the watershed. To do this it would be necessary to devise a way to establish equivalencies between various types of mitigation efforts.

2.4 TRADING AND CREDITING CONSIDERATIONS

Because the change in storm event runoff from natural conditions is used as a surrogate for load reduction responsibility it can also be used to track progress or create credits. For instance, if an MS4 installed stormwater BMPs that reduced runoff from the 1-year 24-hour event (represented through a change in the effective curve number), the calculated excess runoff would decrease and the responsibility of the MS4 would decrease proportionally. The same simple calculation could also be applied in a trading context; for instance, if the MS4 sponsored agricultural BMPs on farmland in the watershed.

Establishing equivalencies with other types of mitigation efforts that are not applied to upland runoff will be more complex and may need to be calculated in terms of avoided phosphorus and sediment load rather than through the excess runoff surrogate. Evaluating equivalences between projects could be done in site-specific detail or with more generic assumptions, as is done in the Chesapeake Bay TMDL accounting where credits for specific types of activities ranging from stream restoration to street sweeping, expressed as nutrient load reductions per unit of implementation, are developed by expert panels. The Water Board may also decide to impose a discount factor or “trading ratio” here to account for varying degrees of assurance that load reductions will be achieved, as is currently done in the point source trading framework.

Some examples of potential evaluations for different types of projects follow.

2.4.1 DIRECT SEDIMENT REMOVAL

Direct removal of phosphorus-containing sediment within the Laguna may result in less regeneration of total P into the water column. Consistent with the approved approach laid out in the Laguna Water Quality Trading Framework (WQTF; https://www.waterboards.ca.gov/northcoast/water_issues/programs/nutrient_offset_program), Sonoma Water in *Nutrient Offset Project Proposal, Laguna de Santa Rosa Reaches 1 and 2* calculated the total P mass that was within typical *Ludwigia* rooting depth and proposed this as a nutrient offset credit to be distributed over 3 years. The WQTF has also established pre-qualified practice guidelines that provide equations for estimating the change in phosphorus loading rates to the water column based on sediment removal, “provided adequate data and/or appropriate literature values are obtained” (https://www.waterboards.ca.gov/northcoast/water_issues/programs/nutrient_offset_program/pdf/2020/WQTF_PQP_SedRemove_RipRestore.pdf). Mesocosm experiments could be conducted to better quantify those rates, which will differ for areas with *Ludwigia* and open water.

Detailed evaluations such as the one described in the preceding paragraph may be appropriate for certain major projects and in the context of point – nonpoint trading. However, a simpler procedure that translates sediment removal back to the common currency of storm event runoff may be more useful for TMDL implementation across the whole watershed. To do this, approximate phosphorus loading rates from sediment could be defined for different parts of the Laguna based on factors such as sediment type and the presence of stands of *Ludwigia*. This could be compared to the total needed load reduction normalized to the amount of excess storm flow from all regulated entities ($\Sigma \Delta Q_i$) to establish the equivalent amount of excess storm flow reduction that is credited to the removal project.

For example, assume that the total reduction in phosphorus loading rate needed to achieve the TMDL loading capacity is 75,000 lb/yr and that a proposed sediment removal activity is estimated to reduce phosphorus loading by 500 lb/yr, which is equivalent to $500/75,000 = 0.667\%$ of the total needed load reduction. If the total excess flow volume from the 1-year 24-hour storm is $\Sigma \Delta Q_i = 5,000$ acre-feet (AF), then the proposed removal activity would be equivalent to an excess flow volume reduction of $0.667\% \times 5,000 \text{ AF} = 33 \text{ AF}$. This estimate might, however, be reduced by a safety factor to account for uncertainty in achieving the estimated load reduction.

2.4.2 STREAM RESTORATION

Historically in the Laguna watershed export of nutrients to the alluvial plain was an important mechanism for reducing concentrations in the mainstem Laguna. Stream restoration activities can reduce channel erosion as well as remove nutrients and sediment in ways that reduce downstream transport. Quantifying the nutrient removal effects of stream restoration is, however, challenging. This is an issue of considerable interest to the Chesapeake Bay Program, and their experience can help to develop an approach for the Laguna.

The Expert Panel evaluating nutrient removal for stream restoration in the Chesapeake Bay watershed (Schueler and Stack, 2014) defined five important nutrient removal mechanisms that can be evaluated additively for a stream restoration project:

1. Prevented sediment and associated nutrient load based on halting channel bank erosion, calculated with “BANCS¹ or other method” and measured N/P content in stream bed and bank sediment.
2. Instream denitrification reduction of total N load, calculated from hyporheic box volume and measured denitrification rates.
3. Credit for floodplain reconnection accounting for export of sediment and nutrients from the stream to the floodplain.
4. Dry channel regenerative stormwater conveyance (RSC) credit where an applicable part of the design. RSC involves restoration of ephemeral streams or eroding gullies using a combination of step pools, sand seepage wetlands, and native plants. These applications are often located at the end of storm drain outfalls or channels.
5. Restoration of wetland areas and low flow stream channels replacing constructed storm conveyance channels that serve as *Ludwigia* habitat and phosphorous “remobilization zones”.

Other factors could also be considered, such as groundwater recharge basins connected to stream channels or stream restoration activities that help reduce internal nutrient loading processes.

For items 3 and 4 in Schueler and Stack (2014) the Chesapeake Expert Panel developed nomographs that present removal rates as a function of various factors such as the flow level at which the stream expands into the floodplain. These are largely based on local studies from the Chesapeake Bay watershed and would not be directly applicable to the Laguna; nonetheless, the general concepts should apply.

The Water Board has already identified channel restoration as a pre-approved practice for the Laguna Water Quality Trading Framework. In some cases the translation is simple, as in the Pepperwood Preserve proposal which calculated the amount of sediment and associated nutrient load that would be avoided by some channel restoration projects

(https://www.waterboards.ca.gov/northcoast/water_issues/programs/nutrient_offset_program/pdf/2017/070614/Project_Information/Pepperwood/20120628_Credit_Proposal.pdf). The Water Board has also

identified methods to estimate both phosphorus mass removal and reductions in phosphorus loading rates to the water column associated with more complex stream restoration efforts

(https://www.waterboards.ca.gov/northcoast/water_issues/programs/nutrient_offset_program/pdf/2020/WQTF_PQP_SedRemove_RipRestore.pdf). Bledsoe et al. (2016) provide further guidance on the subject of evaluating stream restoration as a BMP.

These approaches establish estimates of changes in sediment and nutrient loads associated with a stream restoration project. As with direct sediment removal, these estimates can be converted back to a common accounting framework of proportional responsibility based on excess storm event runoff compared to natural conditions. That is, the avoided load from the restoration project could be compared to the total needed load reduction normalized to the amount of excess storm flow from all regulated entities ($\Sigma \Delta Q_i$) to establish the equivalent amount of excess storm flow reduction that is credited to the project.

¹ BANCS is an empirically based streambank erosion prediction analysis tool developed by Dave Rosgen that uses both qualitative and quantitative data. BANCS stands for “Bank Assessment for Non-point source Consequences of Sediment.”

2.4.3 WETLANDS

Creation or restoration of wetlands is another technique that can reduce loading of sediment and nutrients but is not yet a pre-approved practice under the Water Quality Trading Framework. The Chesapeake Bay approach to crediting for wetlands through a generic approximation was described above in Section 1.2. It may be that a more project-specific analysis would be needed for the Laguna.

Multiple other types of instream mitigation measures could be fit into the surrogate framework as they can be translated into a change in loading rate that allows a uniform basis for comparison. They can then be translated to a common summary measure or surrogate based on excess runoff from the 1-year 24-hour storm event, as described above.

2.4.4 JOINT CONTROL OF SEDIMENT AND PHOSPHORUS LOADS

The examples in previous parts of this section focused on calculated equivalences between different types of mitigation activities based on changes in phosphorus load. However, reductions in both phosphorus and sediment load are needed and projects such as stream restoration will reduce both phosphorus and sediment load.

One way to handle this is to evaluate the equivalence to the surrogate of excess storm event runoff based on both phosphorus and sediment and then select the lower credit to provide a margin of safety. In addition to being conservative, such an approach may also help encourage project designers to optimize for both phosphorus and sediment removal.

Alternatively, it may be sufficient to develop equivalencies/crediting for instream and restoration projects on the basis of the phosphorus reductions alone, at least in early phases of the restoration of the Laguna, with subsequent adjustments as additional data are collected. Current estimates of the TMDL do suggest that a larger percentage reduction may be needed for sediment load than for phosphorus load. On the other hand, BMPs and restoration projects are generally more efficient at removing sediment than phosphorus, so sediment may still be sufficiently addressed. It is also the case that the loading capacity estimate for sediment is less well constrained than that for phosphorus. It therefore may be reasonable to use phosphorus load reduction as the primary factor for calculating crediting and equivalences across different types of projects.

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