Appendix I

Methodology for Selection of Quantifiable Constituents

Memorandum

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SUBJECT: **QUANTIFICATION OF AMERICAN RIVER BASIN STORMWATER RESOURCE PLAN WATER QUALITY BENEFITS**

The Sacramento Stormwater Quality Partnership (SSQP) is comprised of the County of Sacramento and the cities of Citrus Heights, Elk Grove, Folsom, Galt, Rancho Cordova, and Sacramento. The SSQP, along with a number of other agencies and stakeholders, are developing a Stormwater Resource Plan (SWRP) for the American River Basin (ARB) to manage stormwater and dry weather runoff on a watershed scale. The SWRP will satisfy the requirements in California Water Code section 10563 (as amended by Senate Bill 985) such that the participating agencies can receive grant funds from the State of California. This memorandum outlines the SWRP methodology for quantifying project water quality benefits. While this analysis is based on SSQP data from within Sacramento County and evaluations, it is expected that the information is also applicable to Placer County SWRP participants, unless other information is provided by these Placer County agency participants.

Volume reduction benefits will be evaluated using specific tools described in other SWRP documents, while this memorandum evaluates effluent concentration reductions that can be used along with the annual volume reductions to provide load reductions. This water quality benefit quantification is presented in three parts: 1) load reduction methodology, 2) identification of representative water quality constituents, 3) identification of structural treatment controls, and 4) influent, effluent, and treatment reduction recommendations.

1. LOAD REDUCTION METHODOLOGY

For the ARB SWRP, water quality benefits of a proposed project will be quantified as the difference between the pre-project and post-project annual effluent discharge loading (the mass removed from receiving water discharge).

The pre-project annual effluent discharge is estimated as the total runoff volume multipled by the median urban runoff concentration for each constituent of interest.

The post-project load is estimated using a mass balance across the proposed project feature assuming the project outflow (effluent to municipal separate storm sewer system (MS4) or receiving water) is the sum of the treated load and untreated overflow load. Overflow load is the untreated concentration (equivalent to median urban runoff concentration) multiplied by the annual overflow volume. This may include underdrain loads if they are considered to be untreated based on project design flows. Treated load is the treated (effluent) concentration multiplied by the annual treated volume.The post-project load discharged can be calculated as shown in **Equation 1**.

Equation 1. Post-Project Effluent Load Calculation

$$L_{post} = \left[\left(V_{o,post} * C_{o,post}\right) + \left(V_{t,post} * C_{t,post}\right)\right] * F$$

Where:

L_{post} = *Average annual post-project load (kg/day)*
$V_{o,post}$ = *Average annual post-project untreated runoff volume (AFY)*
$V_{t,post}$ = *Average annual post-project treated runoff volume (AFY)*
$C_{t,post}$ = *Post-project treated discharge concentration*
$C_{o,post}$ = *Post-project untreated discharge concentration*
F = *Appropriate unit conversion factor*

Influent, treated discharge, overflow, and infiltration volumes will be estimated from the Sacramento Hydrologic Model (SAHM), the USEPA National Stormwater Calculator, or the CA Phase II LID Sizing Tool as documented in the SWRP quantitative methodology worksheets. Influent concentration data will be based on historic SSQP data (discussed below in Section 3), which is assumed to also be representative of Placer County MS4 agency area urban runoff. Effluent concentrations and treatment performance will be based on literature data for select constituents of concern within the region, which represent structural best management practices (BMPs) used by the ARB municipalities (discussed below in Section 3).

Infiltrated load is the untreated (influent) concentration multiplied by the annual volume infiltrated, but is not specifically used in this water quality benefit calculation.

2. IDENTIFICATION OF PRELIMINARY CONSTITUENTS OF INTEREST

The SSQP agencies are subject to the General National Pollutant Discharge Elimination System (NPDES) Permit for Discharges from MS4s (NPDES No. CAS0085324, Order No. R5-2016-0040 or MS4 General Permit) issued by the Central Valley Regional Water Quality Control Board (Regional Water Board). The MS4 General Permit requires a robust assessment of water quality issues and the means of compliance through a "reasonable assurance analysis" (RAA). As required by the MS4 General Permit, the SSQP submitted an assessment of Priority Water Quality Constituents (PWQCs) to the Regional Board in May 2017.

Priority Water Quality Constituent Evaluation

The SSQP comprehensively evaluated relevant data and impairments with urban runoff influence in Sacramento County to identify PWQCs. This included an assessment of known Clean Water Act Section 303(d) impairments, comparisons of water quality data against specified water quality objectives (Basin Plan and California Toxics Rule), and consideration of known water quality issues (Trash Amendments, aquatic toxicity testing by the SSQP and others, bioaccumulation studies, and other case-dependent relevant information). It is assumed that the

constituents identified by the SSQP would also be generally applicable to the SWRP areas in Placer County. These PWQCs were used as a starting point for selecting constituents to be quantified for load reduction benefits for ARB SWRP projects.

Modelable Constituents

Reasonable estimates of treatment performance require more robust datasets from studies of each of the key structural controls considered. A compilation of available data from the International Stormwater BMP Database[1] was performed for the structural controls identified as most commonly used and described in the SSQP Stormwater Quality Design Manual[2]. The PWQC list was then considered in light of representativeness as issues of concern and available BMP performance data. Sediment/solid attached constituents are represented by total suspended solids (TSS), dissolved metals are represented by dissolved copper, and microbiological constituents are represented by *Escherichia coli* (*E. coli*) as shown in **Appendix A**.

Modelability based on the availability of urban runoff land use and treatment control performance data available and overall inclusion justification is summarized in **Table 1**.

Table 1. Modelable Pollutants

Constituent Group	Modeled Constituent	Representation and Basis for Inclusion
Pathogen Indicator	*E. coli*	Sufficient performance data for most all evaluated BMPs. Representative of biological and pathogenic constituents.
Dissolved Metals	Dissolved Copper	Sufficient performance data for most all evaluated BMPs. Representative of performance for dissolved phase constituents.
Solids/Sediment	Total Suspended Solids	TSS BMP performance data most available. Indicator of control efficiency and transport of solid-adhered contaminants. Representative of solid-adhered constituents.

Methylmercury, pyrethroids, and trash are SSQP's PWQCs that are not directly considered in the ARB water quality benefit calculation, primarily because of the lack of robust structural control data.While the SSQP has robust urban runoff (untreated) water quality datasets for methylmercury and pyrethroids, detected treatment control performance data are less available. However, the water quality benefits are adequately represented by the three modelable constituents (i.e., TSS, dissolved copper, and *E. coli*) along with added guidance to prevent generation of methylmercury or accumulation of pyrethroids and trash.

[1] http://www.bmpdatabase.org

[2] http://www.beriverfriendly.net/newdevelopment/stormwaterqualitydesignmanual/

Methylmercury

Total mercury and methylmercury were proposed as PWQCs based on inclusion in the Delta Methylmercury Total Maximum Daily Load (TMDL). Methylmercury and total mercury are not considered specifically for the SWRP water quality benefit quantification because: 1) solids and TSS have been shown to correlate with their presence and are a reasonable SWRP surrogate, 2) the Regional Board has identified solids control as a primary mercury control, and 3) there are insufficient available treatment control efficiency data to make reasonable assessments of all treatment controls without more complex assessments.

Methylation can occur in systems, especially those cycling wetting and drying periods, in the presence of organic matter, and under anoxic conditions. For this reason, design criteria should prevent these conditions, and exclude treatment controls that are known to methylate mercury.

Pyrethroids

Pyrethroids were proposed as a PWQC based on inclusion in the Central Valley Pyrethroid TMDL. Pyrethroids are not considered specifically for the SWRP water quality benefit quantification because: 1) pyrethroids are generally sediment bound and TSS is a reasonable surrogate for the purpose of the SWRP and 2) there are insufficient available treatment control efficiency data to make reasonable assessments of all treatment controls without more complex assessments. Design standards implemented by SWRP MS4 participants should require operation and maintenance specifications that require integrated pest management (IPM) practices to minimize impacts from pesticides.

Trash

MS4 agencies are required to remove all trash greater than 5 millimeters from "priority" land use (or the equivalent) discharges to surface waters. In lieu of establishing quantitative methods for trash reduction, the ARB SWRP will direct projects to follow jurisdictional design standards that are consistent with the "track" selected by the relevant jurisdiction for the project area..

3. INDENTIFICAITON OF STRUCTURAL TREATMENT CONTROLS

The SSQP and South Placer County prepared a Stormwater Quality Design Manual in May 2007 that was subsequently updated by the SSQP in May 2014 and revised as a public draft document in October 2017[3]. The manual identifies structural treatment controls for both flow and volume control. For the purpose of this evaluation, the infiltration water quality benefits are calculated as load reductions using the Sacramento Area Hydrology Model (SAHM) tool volume reduction and influent concentration. This evaluation considers only the water quality benefit of volumes leaving the treatment control.

[3]http://www.beriverfriendly.net/docs/files/File/NewDev/SWQ%20Design%20Manual%20Oct%202017/Stormwater%20Quality%20Manual%20Oct%202017.pdf

The following structural controls are evaluated for water quality benefits:

- Constructed wetland basin;
- Pervious pavement;
- Stormwater planter or Bioretention (overflow and underdrain discharged);
- Vegetated filter strip;
- Vegetated swale; and
- Water quality detention basin (three types: wet, dry, or combination).

4. INFLUENT, EFFLUENT, AND TREATMENT PERFORMANCE RECOMMENDATIONS

Influent Concentrations

Stormwater BMP influent concentrations are assumed to be observed median concentrations from SSQP urban runoff monitoring (2009-2017). The SSQP distinguishes old and new development for monitoring drainage land uses based on the age of development. It is assumed that potential SWRP projects will primarily be identified in areas developed before the implementation of design standards (i.e., pre-1996). Data from these characterization sites are used to establish median influent concentrations. Projects in areas of newer development (1996 and after) should only consider water quality benefits if the proposed project is not upstream from or replacing an existing properly functioning treatment control.

These median SSQP urban runoff concentrations values approximate proposed project conditions in Sacramento County. They may also reasonably approximate Placer County urban runoff, though no comparison was performed. **Table 2** includes the observed influent concentrations for the selected constituents of interest.

Treatment Control Effluent Concentrations and Performance

The SSQP does not currently have comprehensive water quality performance data available for each of the proposed structural control groups. To estimate potential load reductions, study data collected by the SSQP (such as through the North Natomas Detention Basin Effectiveness Study[4]) and data summarized in the International Stormwater BMP Database were used to calculate median concentrations for structural control effluent. The "efficiency" of the structural control was then calculated as the difference between the influent and effluent concentrations divided by the influent concentration, as shown in **Table 2**. Summary statistics are provided in **Appendix B**.

[4] Sacramento Stormwater Quality Partnership. *Wet Detention Basin Effectiveness Study***.** Prepared by Geosyntec Consultants. August 2010**.**

Table 2. Structural Treatment Control Typical Performance Efficiency Relative to Sacramento Stormwater Quality Partnership Urban Runoff Quality for Representative Constituents

	TSS		Dissolved Copper		*E. coli*	
Median Influent (SSQP Urban Runoff):	**42 mg/L**		**6.3 µg/L**		**4,900 MPN/100mL**	
	Median Effluent (mg/L)	**Removal Efficiency**	**Median Effluent (µg/L)**	**Removal Efficiency**	**Median Effluent (MPN/100mL)**	**Removal Efficiency**
Constructed wetland basin	12.9	69%	3.7	42%	307.2	94%
Pervious Pavement [1]	27.6	34%	3.0	52%	4,900	0%
Stormwater planter or bioretention (flow through only)	10.0	76%	9.36	-49%	183.7	96%
Vegetated filter strip [2]	17.9	57%	5.1	19%	2,365	52%
Vegetated swale	20.7	51%	5.5	13%	2,365	52%
Water quality detention basin (three types: wet, dry, or combination) [3]	27.9	34%	5.9	6%	3,000	39%

Notes:

[1] E. coli data are not available, and 0% efficiency is conservatively assumed.

[2] Data not available for E. coli, vegetated swale data assumed.

[3] North Natomas Study data are used only for the *E. coli* calculation as the International Stormwater BMP Database considers a range of water quality detention basin types, but does not include sufficient E. coli data.

Appendix A. 2017 Sacramento Stormwater Quality Partnership Proposed Constituent Groupings and Assessment of Stormwater Resource Plan Representative Constituents [1]

SSQP's PWQC Constiutent Group [2]	Included/ Excluded	Representative Constituent	Basis for Inclusion or Exclusion
Trash	*Excluded*	Non-organic material >5mm	Insufficient BMP performance and baseline data. Additional evaluation criteria should be considered (i.e., "removes all non-organic material greater than 5 mm").
Pyrethroid	*Excluded*	Bifenthrin	BMP performance data are limited. Central Valley TMDL focuses on sediment control BMPs and other non-structural controls.
Legacy OP Pesticide	*Excluded*	None	Urban sources are effectively removed and delisting for urban waters is likely.
Mercury	*Excluded*	Methylmercury and Total Mercury	Insufficient BMP performance data, especially for methylmercury. Delta TMDL relies on sediment control BMPs. Additional evaluation criteria should be considered (i.e., "does not generate methylmercury").
Fipronil	*Excluded*	Fipronil	Insufficient BMP performance data.
Pathogen Indicator	**Included**	***E. coli***	**Sufficient performance data for most all evaluated BMPs.**
Metal - Category 2	**Included**	**Copper, dissolved**	**Sufficient performance data for most all evaluated BMPs.**
Dissolved Oxygen	*Excluded*	None	Urban runoff dissolved oxygen issues are flow volume related (residence time) and are addressed through flow volume factors.
PAH - Category 2	*Excluded*	None	Insufficient BMP performance data.
Legacy OC Pesticide	*Excluded*	None	Insufficient BMP performance data and addressed through solids reductions.
OP Pesticide	*Excluded*	None	Addressed through other pesticide reduction assessments.
Trace Contaminant	*Excluded*	None	Insufficient BMP performance data and trace contaminant that is addressed through solids and flow reductions.
Metal - Category 3	*Excluded*	None	Addressed through Category 2 metals.
PAH - Category 3	*Excluded*	None	Trace contaminant that is addressed through solids and flow reductions.
Total Solids/Sediment	**Included**	**TSS**	**TSS BMP performance data most available. Indicator of control efficiency and transport of solid-adhered contaminants.**
Salinity	*Excluded*	None	Not considered a significant urban runoff issue and would be addressed through assessment of flow reductions.
Biostimulatory	*Excluded*	None	Biostimulatory effects are "system" managed and removal of nutrients does not ensure system response. Urban runoff is generally not a source of nutrients as flow and residence time are the more significant factors.

Notes: [1] Table provides the justification for inclusion or exclusion of SSQP's PWQCs in the SWRP water quality benefit calculation. The PWQC groupings are based on expected implementation of control strategies and their priority order. "Included" constituents were selected as representative constituents for the SWRP.
[2] SSQP's PWQC constituent groups are provided only for consistency with previous work. Groupings are not specifically considered for this ARB SWRP.

Appendix B-1. Summary Statistics for International Stormwater BMP Database Structural Treatment Control Typical Performance for Total Suspended Solids (mg/L)

SSQP Urban Runoff (n)	36						
	n	**% Detected**	**St. Dev.**	**Avg.**	**Range**	**25th%**	**75th%**
Constructed wetland basin	1,008	96.5	102.4	37.1	0.25-2,240	4.75	34.7
Pervious Pavement	210	96.7	110.8	58.4	5-940	12.2	62.4
Stormwater planter or bioretention (flow through only)	411	95.1	35.3	20.5	0.2-330	4.4	22.7
Vegetated filter strip	279	97.1	41.2	31.2	0.5-330	8.6	37.4
Vegetated swale	325	99.4	37.2	34.4	2.5-250	9.9	43.0
Water quality detention basin (three types: wet, dry, or combination)	377	100	95.0	56.4	1.3-1,140	12.5	62.2

Appendix B-2. Summary Statistics for International Stormwater BMP Database Structural Treatment Control Typical Performance for Dissolved Copper (µg/L)

SSQP Urban Runoff (n)	41						
	n	**% Detected**	**St. Dev.**	**Avg.**	**Range**	**25th%**	**75th%**
Constructed wetland basin	200	79.0	4.6	4.8	0.25-36	2.2	6.0
Pervious Pavement	181	92.8	3.8	5.5	0.01-17	1.2	7.5
Stormwater planter or bioretention (flow through only)	80	91.3	11.2	12.2	2.45-84.3	5.6	15.5
Vegetated filter strip	158	96.8	5.8	6.9	0.5-29	3.0	8.9
Vegetated swale	135	97.8	6.2	7.4	1.5-42	3.1	9.7
Water quality detention basin (three types: wet, dry, or combination)	149	96.0	7.9	8.8	1-44	3.1	11.4

Appendix B-3. Summary Statistics for International Stormwater BMP Database Structural Treatment Control Typical Performance for *E. coli* (MPN/100mL)

SSQP Urban Runoff (n)	36						
	n	**% Detected**	**St. Dev.**	**Avg.**	**Range**	**25th%**	**75th%**
Constructed wetland basin	139	99.3	5,550	2,492	2-36,540	57.3	1,646
Pervious Pavement	---	---	---	---	---	---	---
Stormwater planter or bioretention (flow through only)	96	84.4	31,714	7,826	1-288,833	18.1	1,867
Vegetated filter strip	---	---	---	---	---	---	---
Vegetated swale	39	100	12,324	8,993	11-40,000	501	11,159
Water quality detention basin (three types: wet, dry, or combination)	---	---	---	---	---	---	---