Appendix H

Quantitative Methods Worksheets

Water Quality Benefits

Water Supply Benefits

Flood Management Benefits

Environmental Benefits

Community Benefits

Example Calculations

Water Quality Benefits

Benefit WQ1

Reestablishment of Natural Water Drainage and Treatment

Metric: Volume of runoff reduced

Unit: Acre-feet per year (AFY)

Applicable LID Types:

- Infiltrating BMPs (including dry wells)

Description:

Infiltrating BMPs, including dry wells, reduce the volume of runoff discharged from a catchment through evapotranspiration, infiltration, and storage. The reduction of discharge volumes reduces the potential for excess sediment transport to streams; downstream erosion and sedimentation; increased flooding; disruption of natural drainage patterns, stream flows, and riparian habitat; and elevated water temperatures.

Conceptual Method:

The reduction in average annual volume of runoff from a project is the difference between the average annual volume of runoff discharged before the project (pre-project) and the average annual volume of runoff after the project is completed (post-project):

$$\Delta V = V_{pre} - V_{post} \qquad \text{Equation 1}$$

Where: ΔV = Average annual runoff volume reduced (AFY)
V_{pre} = Average annual pre-project volume runoff (AFY)
V_{post} = Average annual post-project volume runoff (AFY)

Calculation Steps:

The following steps are intended as very basic instructions. See the Example Calculations section (at the end of this document) for specific details in executing these steps.

Projects located within Sacramento Stormwater Quality Partnership (SSQP) boundaries

For projects located within the Sacramento Stormwater Quality Partnership (SSQP) agency boundaries (i.e., County of Sacramento or the cities of Elk Grove, Folsom, Galt, Rancho Cordova, or Sacramento), ΔV can be determined by running simulations with the Sacramento Area Hydrologic Model (SAHM; SSQP 2014). Because SAHM allows the modeling of dry wells, it may be used to determine ΔV for both infiltration BMPs and dry well projects.

SAHM Steps:

1. Run the pre-project scenario in the model.
2. Run the post-project (mitigated) scenario in the model.
3. Obtain the output values.
4. Calculate the average annual pre-project runoff volume (V_{pre}).
5. Calculate the average annual post-project runoff volume (V_{post}).
6. Calculate the average annual runoff volume reduced (ΔV).

Projects located elsewhere

For projects outside SSQP jurisdictions, ΔV can be determined using either the California Phase II LID Sizing Tool (OWP 2017) or the USEPA National Stormwater Calculator (USEPA 2016). Note that these tools do not model dry wells, so the ARB SWRP Dry Well Calculator (OWP 2017) should be used to calculate ΔV.

California Phase II LID Sizing Tool Steps:

1. Run the simulation on the LID Sizing Tool.
2. Obtain the output values.
3. Calculate the average annual runoff volume reduced (ΔV).

USEPA National Stormwater Calculator Steps:

1. Run the pre-project scenario in the model.
2. Run the post-project scenario in the model.
3. Obtain the output values.
4. Calculate the average annual pre-project runoff volume (V_{pre}).
5. Calculate the average annual post-project runoff volume (V_{post}).
6. Calculate the average annual runoff volume reduced (ΔV).

<u>Dry Well Projects</u>

ARB SWRP Dry Well Calculator

1. Input impervious area and dry well parameters.
2. Calculate the volumes.
3. Obtain the average annual runoff volume reduced (ΔV).

References and Resources:

Sacramento Stormwater Quality Partnership (2014). *Sacramento Area Hydrologic Model (SAHM)*.

http://www.beriverfriendly.net/Newdevelopment/

United States Environmental Protection Agency (2016). National Stormwater Calculator.

https://www.epa.gov/water-research/national-stormwater-calculator

Office of Water Programs (2017). *California Phase II LID Sizing Tool.*

http://www.owp.csus.edu/LIDTool/Start.aspx

Benefit WQ2

Increase in Filtration and/or Treatment of Pollutants in Runoff

Metric: Load of pollutants reduced

Unit: Kilograms per year (kg/yr) or most probable number per year (MPN/yr)

Applicable LID Types:

- Infiltrating BMPs (including dry wells)
- Non-infiltrating BMPs

Description:

Infiltrating BMPs—including dry wells—reduce runoff volumes that are discharged through evapotranspiration, storage, and infiltration, thereby preventing pollutants within the runoff from being discharged and reducing pollutant loads. Some infiltrating BMPs may include an underdrain that collects and discharges treated runoff that is not infiltrated. The treatment of the discharged runoff reduces pollutant loads. Non-infiltrating BMPs treat runoff prior to discharging it, resulting in reduced pollutant loads.

Conceptual Method:

The load reduced (ΔL) by implementing a BMP is the difference between the load discharged before and after implementation of the project (L_{pre} and L_{post}, respectively):

$$\Delta L = L_{pre} - L_{post}$$ Equation 2

Where: ΔL = Average annual average load reduced (kg/yr or MPN/yr)
L_{pre} = Average annual pre-project load (kg/yr or MPN/yr)
L_{post} = Average annual post-project load (kg/yr or MPN/yr)

L_{pre} is calculated by multiplying the average annual pre-project runoff volume (V_{pre}) by the pre-project runoff discharge concentration (C_{pre}) and accounting for unit conversions:

$$L_{pre} = V_{pre} * C_{pre} * F$$ Equation 3

Where: L_{pre} = Average annual pre-project load (kg/yr or MPN/yr)
V_{pre} = Average annual pre-project runoff volume (AFY)
C_{pre} = Pre-project discharge concentration (see Table 1 for units)
F = Appropriate unit conversion factor

L_{post} includes pollutant loads within post-project runoff volumes that overflow/bypass the BMP ($V_{o,post}$) as well as the runoff volume that is treated and discharged ($V_{t,post}$) by the BMP. L_{post} is therefore calculated by multiplying each of these component volumes by its respective discharge concentration ($C_{o,post}$ and $C_{t,post}$) and summing the resulting masses. Note that the overflow (untreated) concentration ($C_{o,post}$) can be assumed to be the same as to the pre-project discharge concentration (C_{pre}).

$$L_{post} = \left[(V_{o,post} * C_{o,post}) + (V_{t,post} * C_{t,pos}\right.$$ Equation 4

Where: L_{post} = Average annual post-project load (kg/yr or MPN/yr)
$V_{o,post}$ = 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 (See Table 1 for units)
$C_{o,post}$ = Post-project untreated discharge concentration (See Table 1 for units)
F = Appropriate unit conversion factor

Calculation Steps:

The following steps are intended as very basic instructions. See the Example Calculations section (at the end of this document) for specific details in executing these steps.

<u>Projects located within Sacramento Stormwater Quality Partnership (SSQP) boundaries</u>

For projects located within the Sacramento Stormwater Quality Partnership (SSQP) municipal boundaries (i.e., County of Sacramento or the cities of Elk Grove, Folsom, Galt, Rancho Cordova, or Sacramento), ΔV can be determined by running simulations with the Sacramento Area Hydrologic Model (SAHM; SSQP 2014).

SAHM Steps:

1. Run the pre-project scenario in the model.
2. Run the post-project (mitigated) scenario in the model.
3. Obtain the output values.
4. Calculate the average annual pre-project load (L_{pre}).
5. Calculate the average annual post-project load (L_{post}).
6. Calculate the average annual load reduced (ΔL).

<u>Projects located elsewhere.</u>

For projects outside SSQP jurisdictions, ΔL can be determined using either the California Phase II LID Sizing Tool (OWP 2017) or the USEPA National Stormwater Calculator (USEPA 2016).

California Phase II LID Sizing Tool Steps:

1. Run the simulation on the LID Sizing Tool.
2. Obtain the output values.
3. Calculate the average annual pre-project load (L_{pre}).
4. Calculate the average annual post-project load (L_{post}).
5. Calculate the average annual load reduced (ΔL).

USEPA National Stormwater Calculator Steps:

1. Run the pre-project scenario in the model.
2. Run the post-project scenario in the model.
3. Obtain the output values.
4. Calculate the average annual pre-project load (L_{pre}).
5. Calculate the average annual post-project load (L_{post}).
6. Calculate the average annual load reduced (ΔL).

References and Resources:

Larry Walker Associates (2017). *Memorandum: Quantification of American River Basin Stormwater Resource Plan Water Quality Benefits*. August, 2017.

See Benefit WQ1 for additional References and Resources.

Table 1. Constituent Discharge Concentration.

	TSS	Dissolved Copper	E. coli
Pre-project discharge concentration[1] (C_{pre})	42 mg/L	6.3 µg/L	4,900 MPN/100mL
BMP Type	**Post-project treated discharge concentration[2] ($C_{t,post}$)**		
	(mg/L)	**(µg/L)**	**(MPN/100mL)**
Constructed wetland basin	9.4	2.54	637
Pervious Pavement	24.5	5.05	4,900
Stormwater planter or bioretention (flow through only)	9.9	5.79	101
Vegetated filter strip [1]	19	5.28	4,180
Vegetated swale	21.6	5.64	4,180
Water quality detention basin (three types: wet, dry, or combination) [2]	23.3	2.86	3,000

Median influent data is based on Sacramento Stormwater Quality Partnership (SSQP) urban runoff data. (LWA 2017). Effluent data is based on International BMP Database (LWA 2017).

Water Supply Benefits

Benefit WS1

Increase in Groundwater Supply through Infiltration

Metric: Volume infiltrated to groundwater

Unit: Acre-feet per year (AFY)

Applicable LID Types:

- Infiltrating BMPs (including dry wells)

Description:

Infiltrating BMPs, including dry wells, capture runoff and allow it to infiltrate into underlying soils where it often percolates down, recharging groundwater basins for future water supply. The major assumptions associated with this benefit are that the infiltrated runoff enters an aquifer and that the captured water is eventually used for water supply.

Conceptual Method:

In general, the volume infiltrated to groundwater is obtained by running a continuous simulation of rain falling onto the BMP, runoff entering the BMP, evapotranspiration from the BMP, infiltration into unsaturated soil layers and/or groundwater below the BMP, and capture/retention of rainfall and runoff within the BMP. Using a mass balance approach, the volume entering the BMP over a specified time period will equal the volume leaving plus the volume stored in the BMP:

$$V_S = (V_P + V_{RO}) - (V_O + V_{ET} + V_T + V_{inf}) \qquad \text{Equation 5}$$

Where: V_S = Average annual volume stored within the BMP (AFY)
V_P = Average annual precipitation volume falling onto the BMP (AFY)
V_{RO} = Average annual runoff volume entering into the BMP (AFY)

V_O = Average annual volume overflowing and discharging from the BMP (AFY)
V_{ET} = Average annual volume evapotranspiring from the BMP (AFY)
V_T = Average annual volume treated by and discharging from the BMP (AFY)
V_{inf} = Average annual volume infiltrating below the BMP (AFY)

Equation 5 can be rearranged to solve for the volume infiltrated:

$$V_{inf} = (V_P + V_{RO}) - (V_O + V_{ET} + V_T + V_S) \qquad \text{Equation 6}$$

Calculation Steps:

The following steps are intended as very basic instructions. See the Example Calculations section (at the end of this document) for specific details in executing these steps.

<u>Projects located within Sacramento Stormwater Quality Partnership (SSQP) boundaries</u>

For projects located within the Sacramento Stormwater Quality Partnership (SSQP) municipal boundaries (i.e., County of Sacramento or the cities of Elk Grove, Folsom, Galt, Rancho Cordova, or Sacramento), V_{inf} can be determined by running simulations with the Sacramento Area Hydrologic Model (SAHM; SSQP 2014).

SAHM Steps:

1. Run the pre-project scenario in the model.
2. Run the post-project (mitigated) scenario in the model.
3. Obtain the output values.

4. Calculate the average annual runoff volume infiltrated (V_{inf}).

<u>Projects located elsewhere</u>

For projects outside SSQP jurisdictions, V_{inf} can be determined using either the California Phase II LID Sizing Tool (OWP 2017) or the USEPA National Stormwater Calculator (USEPA 2016).

California Phase II LID Sizing Tool Steps:

1. Run the simulation on the LID Sizing Tool.
2. Obtain the output values.

USEPA National Stormwater Calculator Steps:

1. Run the pre-project scenario in the model.
2. Run the post-project scenario in the model.
3. Obtain the output values.
4. Calculate the average annual runoff volume infiltrated (V_{inf}).

The USEPA National Stormwater Calculator requires two simulations—pre-project conditions and post-project conditions. V_{inf} can then be calculated by multiplying the value of "Annual Average Rainfall" depth, D_{rf}, by the percent of rainfall infiltrated and the footprint of the BMP. "Annual Average Rainfall" and percent of rainfall infiltrated can be found in the calculator's "Results" tab (see Figure 9 under Benefit WQ1 in the Example Calculation section).

References and Resources:

Sacramento Stormwater Quality Partnership (2014). *Sacramento Area Hydrologic Model (SAHM).*

http://www.beriverfriendly.net/Newdevelopment/

United States Environmental Protection Agency (2016). *National Stormwater Calculator.*

https://www.epa.gov/water-research/national-stormwater-calculator

Office of Water Programs (2017). *California Phase II LID Sizing Tool.*

http://www.owp.csus.edu/LIDToolBeta/ (effective 10/10/17 – 1/31/18)

http://www.owp.csus.edu/LIDTool/Start.aspx (effective 1/31/18)

Benefit WS2

Increase in Groundwater Supply through In-Lieu Recharge

Metric: Volume captured to offset demand

Unit: Acre-feet per year (AFY)

Applicable LID Types:

- Non-infiltrating BMPs

Description:

Non-infiltrating BMPs, such as cisterns, capture and store runoff for direct use (e.g., irrigation). In areas where groundwater basins serve as the primary water source and pre-BMP runoff does not infiltrate, the captured runoff is used in lieu of groundwater, thereby allowing groundwater to remain in storage.

Conceptual Methodology:

The methodology for this benefit is similar to that presented for Benefit WQ1. However, for non-infiltrating BMPs, there will be no infiltration; the volume captured and stored would represent in-lieu recharge.

Calculation Steps:

See calculation steps for Benefit WQ1

. Note that because the BMPs do not infiltrate, there is no average annual runoff volume infiltrated (V_{inf} = 0).

References and Resources:

See Benefit WQ1

.

Benefit WS3

Increase in Surface Water Supply through Direct Use

Metric: Volume captured to offset demand

Unit: Acre-feet per year (AFY)

Applicable LID Types:

- Non-infiltrating BMPs

Description:

Non-infiltrating BMPs, such as cisterns, capture and store runoff for direct use (e.g., irrigation). This increases water supply and reduces the demand on local surface water sources.

Conceptual Methodology:

The methodology for this benefit is similar to that presented for Benefit WQ1. However, for non-infiltrating BMPs, there will be no infiltration; the volume captured and stored would represent the increased water supply.

Calculation Steps:

See calculation steps for Benefit WQ1

. Note that because the BMPs do not infiltrate, there is no average annual runoff volume infiltrated (V_{inf} = 0).

References and Resources:

See Benefit WQ1.

Flood Management Benefits

Benefit FM1

Decrease in Flood Risk through Reduced Peak Flow Rates of Runoff

Metric: Reduction of peak flow rate for 2-, 10-, 25-, 50-, and/or 100-year storms, as appropriate

Unit: Cubic feet per second (cfs)

Applicable LID Types:

- Infiltrating BMPs (including dry wells)
- Non-infiltrating BMPs

Description:

BMPs can retain and/or detain the discharge of urban runoff. In doing so, peak flow rates are reduced. Flow rates evaluated for shorter return periods (e.g., 2 years and 1 year) would likely be evaluated for small, localized flooding occurrences (e.g., at the street level). Flow rates for longer return periods would be applicable to larger, regional flooding.

Conceptual Methodology:

The reduction of peak flow rate (ΔQ) is calculated from the pre- and post-project peak flow rates:

$$\Delta Q = Q_{pre} - Q_{post} \qquad \text{Equation 7}$$

Where: ΔQ = Peak flow rate reduced (cfs)
Q_{pre} = Pre-project peak flow rate (cfs)
Q_{post} = Post-project peak flow rate (cfs)

Calculation Steps:

Projects located within Sacramento Stormwater Quality Partnership (SSQP) boundaries

For projects located within the SSQP municipal boundaries, ΔQ can be determined by running simulations with the Sacramento Area Hydrologic Model (SAHM; SSQP 2014).

SAHM Steps

1. Run the pre-project scenario in the model.
2. Run the post-project (mitigated) scenario in the model.
3. Obtain the output values.
4. Calculate ΔQ using Equation 7.

Projects located elsewhere

For projects located elsewhere, an appropriate hydrologic or flood model can be used. Alternatively, SAHM may be used assuming the rainfall data available in SAHM are representative of those for the actual project location.

Other Model Steps

1. Run the pre-project scenario in the model.
2. Run the post-project (mitigated) scenario in the model.
3. Obtain the output values.
4. Calculate ΔQ using Equation 7.

References and Resources:

See Benefit WQ1.

Benefit FM2

Increase in Area Addressed for Flood Mitigation

Metric: Size of area addressed for flood mitigation

Unit: Acres

Applicable LID Types:

- Infiltrating BMPs
- Non-infiltrating BMPs

Description:

The risk of flooding can be mitigated by installing BMPs to retain and/or detain the volumes and flow rates of urban runoff discharged from catchments. The catchment area managed by an installed BMP can therefore serve as a measure of the reduction in flood risk.

Conceptual Methodology:

The increase in the area addressed for flood mitigation is measured as the area of the catchment managed by a BMP. The area may be estimated using:

- Existing hydrologic models
- Google Earth or other GIS tools
- Parcel maps
- Topographic site survey

Calculation Steps:

Use the above resources to determine relevant areas.

References and Resources:

Google Earth: https://www.google.com/earth/

Parcel Maps: contact relevant county

- Placer County: https://www.placer.ca.gov/departments/assessor
- Sacramento County: http://www.assessor.saccounty.net/Pages/ContactUs.aspx
- El Dorado County: http://www.edcgov.us/Assessor/

Benefit FM3

Decrease in Combined Sewer Overflows

Metric: Volume of runoff reduced to combine sewer systems

Unit: Acre-feet per year (AFY)

Applicable LID Types:

- Infiltrating BMPs (including dry wells)
- Non-infiltrating BMPs

Description:

The risk of flooding from combined sewer overflows can be mitigated by installing BMPs to reduce the volumes and flow rates of urban runoff directed to combined sewers. The volume captured by an installed BMP can therefore serve as a measure of the reduction in flood risk.

Conceptual Methodology:

The methodology for this benefit is similar to that presented in the Example Calculations for Benefit WQ1. Any runoff volume that is reduced due to BMP implementation reduces not only impacts from hydromodification, but also those from combined sewer overflows and resulting flood problems.

Calculation Steps:

See calculation steps for Benefit WQ1.

References and Resources:

See Benefit WQ1.

Environmental Benefits

Benefit E1

Protection, Enhancement, or Creation of Wetlands, Riparian Zones, and Aquatic Habitat

Metric: Size of area of wetland, riparian zone, or habitat protected, enhanced, or created

Unit: Acres

Applicable LID Types:

- Infiltrating BMPs (including dry wells)
- Non-infiltrating BMPs

Description:

BMPs reduce the volumes and flow rates of urban runoff that is discharged. In doing so, the potential for excess sediment transport to streams; downstream erosion and sedimentation; flooding; disruption of natural drainage patterns, stream flows, and riparian habitat; and elevated water temperatures is reduced. There is also a reduction in the transport of pollutants to these habitats. All these can result in the protection or enhancement of wetlands, riparian zones, and aquatic habitats. Some BMPs may also create such ecosystems.

Conceptual Methodology:

The area of wetland, riparian zone, or habitat protected, enhanced, or created may be estimated using:

- Google Earth or other GIS tools
- Parcel maps
- Topographic site survey

Calculation Steps:

Use the above resources to determine relevant areas.

References and Resources:

Google Earth: https://www.google.com/earth/

Parcel Maps: contact relevant county

- Placer County: https://www.placer.ca.gov/departments/assessor
- Sacramento County: http://www.assessor.saccounty.net/Pages/ContactUs.aspx
- El Dorado County: http://www.edcgov.us/Assessor/

Benefit E2

Increase in Urban Green Space

Metric: Size of area created

Unit: Acres

Applicable LID Types:

- Infiltrating BMP (including dry wells)
- Non-infiltrating BMPs

Description:

Implementation of BMPs can include creation or enhancement of urban green space, such as parks, forests, green roofs, streams, and community gardens.

Conceptual Methodology:

The area of green space that will increase due to project implementation may be estimated using:

- Google Earth or other GIS tools
- Parcel maps
- Topographic site survey

Calculation Steps:

Use the above resources to determine relevant areas.

References and Resources:

Google Earth: https://www.google.com/earth/

Parcel Maps: contact relevant county

- Placer County: https://www.placer.ca.gov/departments/assessor
- Sacramento County: http://www.assessor.saccounty.net/Pages/ContactUs.aspx
- El Dorado County: http://www.edcgov.us/Assessor/

Benefit E3

Improvement of Instream Flow Rate

Metric: Rate of instream flow rate improved

Unit: Cubic feet per second (cfs)

Applicable LID Types:

- Infiltrating BMPs
- Non-infiltrating BMPs

Description:

Depending on the project type and location, it may be desirable to either increase or decrease instream flow rates. Implementation of BMPs can improve instream flow rates by capturing and retaining runoff on site, thereby reducing flow rates and resulting erosion. Restoration projects such as removing invasive vegetation or silt can increase flow rates to improve aquatic habitat. The resulting flow rate improvements for such projects supports reestablishment of the natural hydrograph.

Conceptual Methodology:

Depending on the project objectives, the improvement of the instream flow rate (ΔQ) may be either an increase or decrease. The improvement is therefore represented as the cumulative, absolute value of the difference between the pre-project flow rate and the post-project flow rate (i.e., the desired/design flow rate) for individual time steps:

$$\Delta Q = \sum \left| Q_{pre} - Q_{post} \right|_t \qquad \text{Equation 8}$$

Where: ΔQ = Peak flow rate improved (cfs)
Q_{pre} = Pre-project peak flow rate (cfs)
Q_{post} = Post-project peak flow rate (cfs)
t = time increment (model specific)

Calculation Steps:

An appropriate hydrologic or flood model can be used.

1. Run the pre-project scenario in the model.
2. Run the post-project (mitigated) scenario in the model.
3. Obtain the output values.
4. Calculate ΔQ using Equation 8.

Benefit E4

Decrease in Energy Use

Metric: Energy use reduced

Unit: Kilowatt-hours per year (KWH/yr)

Applicable LID Types:

- Infiltrating BMPs
- Non-infiltrating BMPs

Description:

Capture and use of runoff can reduce the use of electricity, such as the reduction of runoff resulting in less pumping.

Conceptual Methodology:

Reductions in energy use are calculated by comparing pre-project and post-project electrical and gas energy use:

$$\Delta E_e = E_{e,pre} - E_{e,post} \quad \text{Equation 9}$$

Where: $\Delta E_e =$ Amount of electrical energy use reduced (KWH/yr)
$E_{e,pre} =$ Pre-project electric energy use (KWH/yr)
$E_{e,post} =$ Post-project electric energy use (KWH/yr)

Calculation Steps:

1. Determine $E_{e,pre}$
2. Determine $E_{e,post}$
3. Calculate ΔE_e using Equation 9.

References and Resources:

CA Public Utilities Commission Energy Division. (2007). *Water-Energy Measure Calculator*. June 2007

Benefit E5

Decrease in Greenhouse Gas Emissions

Metric: Mass of greenhouse gas emissions reduced

Unit: Tonnes of carbon dioxide (CO_2) per year (tonnes/yr)

Applicable LID Types:

- Infiltrating BMPs
- Non-infiltrating BMPs

Description:

Capture and use of runoff can reduce the use of electricity thereby reducing greenhouse gas emissions. An example is the reduction of runoff resulting in less pumping.

Conceptual Methodology:

The calculations presented assume that greenhouse gas (GHG) emissions reductions result from reduced electrical energy use. Emissions from greenhouse gases (carbon dioxide, methane, and nitrous oxide) are determined using methodologies from the Water-Energy Measure Calculator developed for the California Public Utility Commission Energy Division in 2007. The amount of emissions reduced is proportional to the amount of energy reduced:

$$\Delta GHG = \Delta E_e * (F_{CO2} + F_{CH4} + F_{N2O}) \qquad \text{Equation 10}$$

Where: ΔGHG = Weight of GHG emissions reduced (tonnes/yr)
ΔE_e = Reduction in electrical energy use (KWH/yr)
F_{CO2} = Energy-to-GHG Conversion Factor for carbon dioxide (CO_2 lbs/KWH)
F_{CH4} = Energy-to-GHG Conversion Factor for methane (CH_4 lbs/KWH)
F_{N2O} = Energy-to-GHG Conversion Factor for nitrous oxide (N_2O lbs/KWH)

Note that GHG reductions can also result from increasing carbon sequestration, such as when a wetland is restored or created. For this scenario, GHG reductions can be calculated using methodologies from the Intergovernmental Panel on Climate Change (IPCC) guidelines (see links below in References and Resources).

Calculation Steps:

1. Determine ΔE_e using the methods described for Benefit E4.
2. Determine F_{CO2} , F_{CH4} ,and F_{N2O} using the conversion factors listed in Table 2.
3. Calculate ΔGHG using Equation 10.

Table 2

Parameter	Unit	Value
F_{CO2}	lbs CO_2/kWh	0.610
F_{CH4}	lbs CH_4/kWh	0.0000067
F_{N2O}	Lbs N_2O/kWh	0.0000067

Source: Water-Energy Measure Calculator (2007). Typical conversion factors from PG&E

References and Resources:

CA Public Utilities Commission Energy Division. (2007). *Water-Energy Measure Calculator*. June 2007.

IPCC Guidelines (2006): http://www.ipcc-nggip.iges.or.jp/public/2006gl/

IPCC Wetland Update (2013): http://www.ipcc-nggip.iges.or.jp/public/wetlands/

Benefit E6

Improvement in Water Temperature

Metric: Degrees of water temperature improved

Unit: Degrees

Applicable LID Types:

- Infiltrating BMPs (including dry wells)
- Non-infiltrating BMPs

Description:

Capture and use of stormwater can help meet regional environmental goals for in-stream water quality, including temperature and dissolved oxygen levels that better support productive aquatic habitat.

Conceptual Methodology:

The ultimate goal of temperature improvements is to create in-stream temperatures beneficial for fish. Stormwater improvement projects will most likely target water temperature reductions. ΔT is therefore calculated as the difference between the pre-project and post-project temperatures:

$$\Delta T = T_{pre} - T_{post} \qquad \text{Equation 11}$$

Where: ΔT = Temperature improvement
T_{pre} = Pre-project temperature
T_{post} = Post-project temperature

Optimal temperature ranges vary by species, and targets should be set according to best available science.

In-stream temperatures can be assessed according to the maximum value (thresholds) of temperature that protects fish. Thresholds can be measured as an instantaneous value (maximum) or an average value over a specified time period. Temperature indices over a 7-day (weekly) period are common. Temperature threshold indices could report for either daily maximum or daily average temperatures (Stillwater Sciences 2002).

Thresholds are determined through experimental procedures, either in laboratories or field experiments, and can be calculated as the temperature producing some level of mortality (e.g., LT50 is the water temperature that results in 50% mortality of a species).

Generally, in-stream temperatures over 77°F can induce mortality for key species such as salmonids, but long-term average temperatures greater than 67°F can affect fish survival (Tate et. al 2005). However, temperature thresholds are specific to species found in a particular stream. For anadromous and migratory fish species, in-stream temperature during key periods, such as spawning, are most important. Analyses typically outline guidelines that are specific to particular species and river reaches, such as those in Table 3 for salmon and trout species in the Navarro River watershed.

In California, the State Water Resources Control Board is continuing to outline in-stream flow requirements (volumetric) for many freshwater rivers in the state. The California Department of Fish and Wildlife (CDFW) supports in-stream flow recommendations with scientific assessments. For the Sacramento River watershed spanning Butte, Colusa, Glenn, and Sutter counties, state agencies outlined in-stream flow recommendations for salmonid habitat in Butte Creek, which included considering effects of diversions on in-stream temperatures (CDFW 2009). Such considerations are likely to grow more prominent in water quality and rights permitting.

Table 3: Example of temperature assessments for two fish species in the Navarro River watershed (adapted from USEPA 2000)

Assessment	Temperature	
	Coho Salmon	***Steelhead Trout***
Good	<59°F	<63°F
Marginal	59°F - 63°F	63°F - 66°F
Poor	>63°F	>66°F

Calculation Steps:

1. Use the appropriate water quality model to determine ΔT.

References and Resources:

Tate, Kenneth, Lile, D., Lancaster, D., Porath, M., Morrison, J., and Sado, Y. (2005). Graphical analysis facilitates evaluation of stream-temperature monitoring data. *California Agriculture*, 59(3), 153-160.

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Community Benefits

Benefit C1

Increase in Public Education

Metric: Number of events conducted or outreach materials provided

Unit: Count

Applicable LID Types:

- Infiltrating BMPs (including dry wells)
- Non-infiltrating BMPs

Description:

Educating communities is an important strategy in protecting and enhancing watershed health. Offering people information about the impacts of urbanization on their environment may lead to modifications in behavior to support or improve watershed health. Developing brochures, websites, mobile applications, and signage and conducting public outreach events are a few ways to educate communities.

Conceptual Methodology:

The number of events conducted or outreach materials provided may be estimated by the sponsoring organization as a fraction of a goal or target to be achieved.

Calculation Steps:

1. Estimate the number of events conducted or outreach materials provided.
2. Divide the goal or target by the estimated number of events conducted or outreach materials provided.

Benefit C2

Increase in Public Involvement

Metric: Number of hours volunteered

Unit: Hours

Applicable LID Types:

- Infiltrating BMPs (including dry wells)
- Non-infiltrating BMPs

Description:

Involving communities in projects and programs is an important strategy in protecting and enhancing watershed health. People who participate in activities to restore and protect their local environment are more likely to modify their behavior to further support watershed health. Activities that both support watershed health and offer opportunities for community involvement include creek clean ups and outreach at community events (e.g., Earth Day fairs, farmers markets, and fun runs).

Conceptual Methodology:

The number of volunteer hours can be estimated by the sponsoring organization as a goal or target to be achieved. A recommended labor rate for converting hours into costs is provided below for budgeting purposes.

Calculation Steps:

1. Estimate the target number of volunteer hours appropriate for the project objectives.
2. Calculate the total volunteer labor value (in dollars) using the volunteer hours and an acceptable labor rate (2016 value for California is $28.46/hr; Independent Sector 2016):

$$Value_{VL} = Time_{VL} * Rate_{VL} \quad \text{Equation 12}$$

Where: $Value_{VL}$ = In-kind services value of volunteer labor ($)
$Time_{VL}$ = Total time of volunteer labor (hrs)
$Rate_{VL}$ = Labor rate for volunteer labor ($/hr)

References and Resources:

Independent Sector 2016 CA Volunteer Labor Rate

https://www.independentsector.org/resource/the-value-of-volunteer-time/

Benefit C3

Creation or Enhancement of Public Space

Metric: Size of area created or enhanced

Unit: Acres

Applicable LID Types:

- Infiltrating BMPs (including dry wells)
- Non-infiltrating BMPs

Description:

BMPs can often improve the aesthetics of an area through incorporation of vegetation, reduction of erosion, and expansion of public spaces.

Conceptual Methodology:

The area created or enhanced as part of project implementation may be estimated using:

- Google Earth or other GIS tools
- Parcel maps
- Topographic site survey
- Project maps or plans

Calculation Steps:

Use the above resources to determine relevant areas.

References and Resources:

Google Earth: https://www.google.com/earth/

Parcel Maps: contact relevant county

- Placer County: https://www.placer.ca.gov/departments/assessor
- Sacramento County: http://www.assessor.saccounty.net/Pages/ContactUs.aspx
- El Dorado County: http://www.edcgov.us/Assessor/

Example Calculations

Benefit WQ1

<u>Dry Well Calculator</u>

Scenario Description:

This example simulates a theoretical, 100% impervious, one-acre site in the Sacramento area. The site drains to a dry well with a 15-foot deep settling chamber over a 25-foot deep, rock-filled pervious shaft. The pervious shaft is in material with a saturated hydraulic conductivity of 5 inches/hour.

1. Input the parameters.

Open the spreadsheet and input the parameters shown in **Figure 1**.

Drywell Calculator - American River Basin Storm Water Resource Plan

Inputs	
Impervious area (acres)	1
Runoff coefficient	0.9
Settling chamber depth (ft)	15
Settling chamber diameter (ft)	4
Pervious shaft depth (ft)	25
Pervious shaft diameter (ft)	4
Pervious shaft porosity	0.35
Saturated hydraulic conductivity (in/hr)	5
Rain gauge	Sacramento AP

Results	
Years calculated	37.0
Inflow volume (ac-ft)	44.05
Infiltrated volume (ac-ft)	32.22
Bypassed volume (ac-ft)	11.83
Percent infiltrated	73.14
Average annual runoff volume reduced (ac-ft/year)	0.87

Calculate

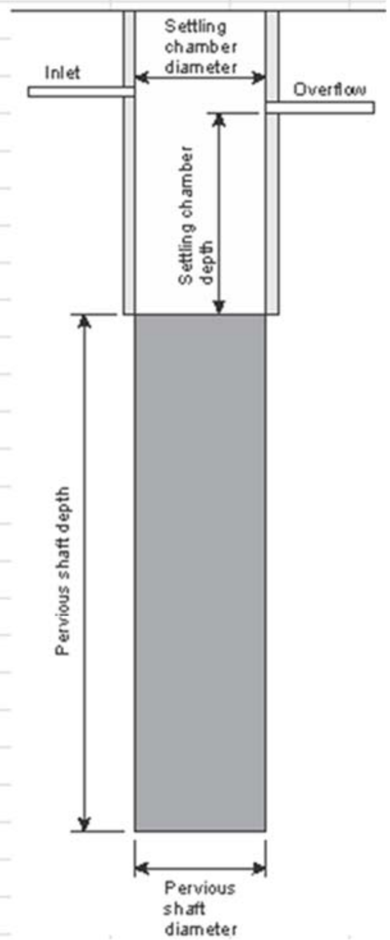


Figure 1. Input Parameters for the ARB SWRP Dry Well Calculator

2. Calculate the volumes.

Click on the calculate button

3. Obtain the annual average runoff volume reduced (ΔV).

The average annual runoff volume reduced is given as part of the results (see Figure 1).

ΔV = **0.87 AFY**

<u>Sacramento Area Hydrologic Model (SAHM)</u>

Scenario Description:

This example simulates a theoretical, moderately flat, 100% impervious, one-acre site in the Sacramento area. The site drains to a bioretention facility having a 4% capture ratio (i.e., a 0.04-acre footprint). See Figure 2 for specific layer depths.

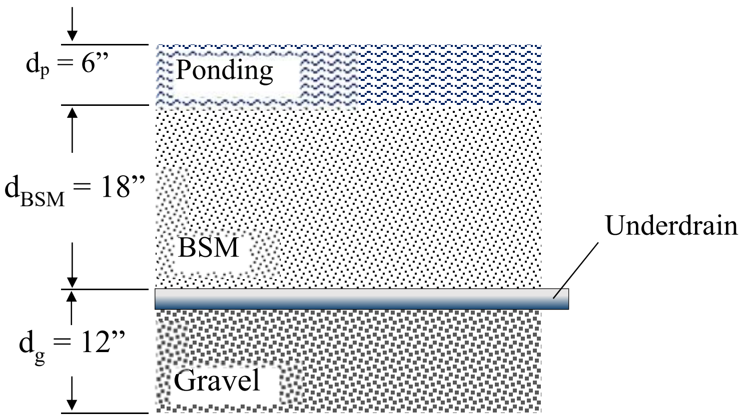


Figure 2. Layer depths and features of bioretention facility. *Note: BSM = Bioretention soil mix*

1. Run the pre-project scenario in the model.

Create and run the pre-project scenario in SAHM using the scenario input parameters shown in Figure 3.

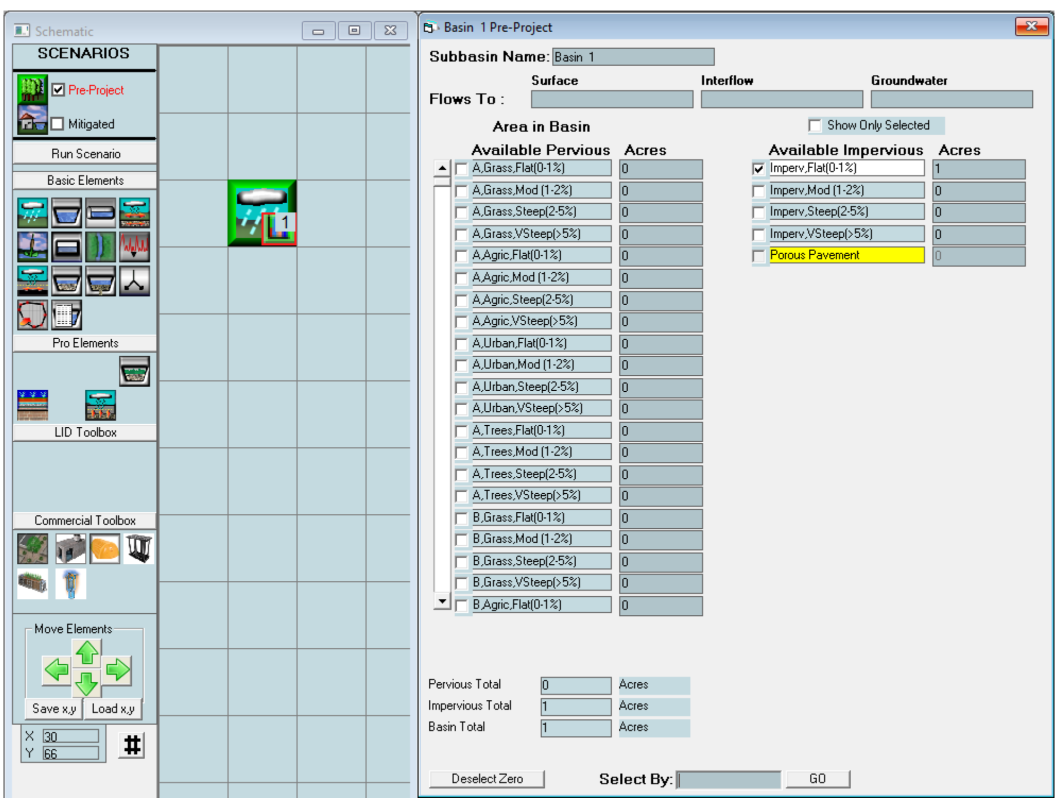


Figure 3. Pre-project scenario parameters and setup (SAHM).

2. Run the post-project (mitigated) scenario in the model.

Create and run the post-project (mitigated) scenario in SAHM. Figure 4 shows the scenario and its input parameters.

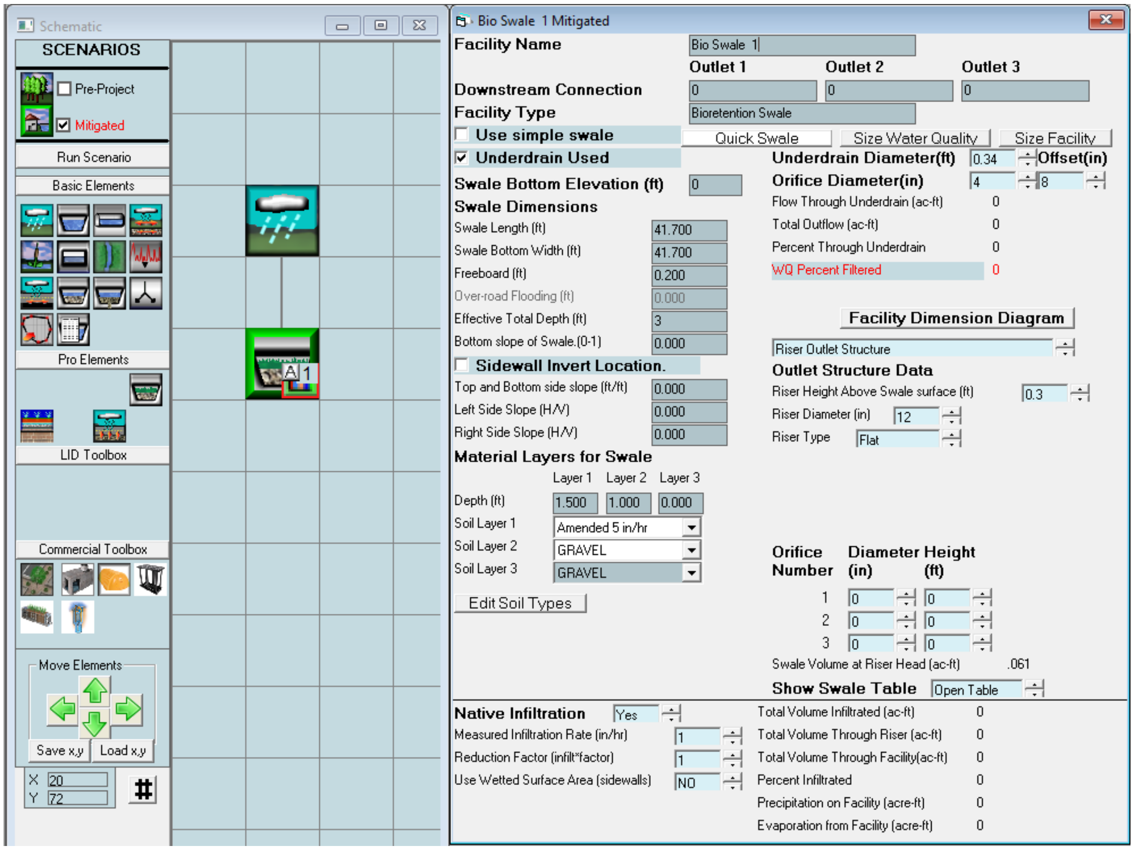


Figure 4. Post-project scenario setup (SAHM).

3. Obtain the output values.

The output values shown in Figure 5 are available from the "Text Report" option under SAHM's "Report" icon.

```
Infiltration rate: 1
Infiltration safety factor: 1
Total Volume Infiltrated (ac-ft.): 45.935
Total Volume Through Riser (ac-ft.): 3.165
Total Volume Through Facility (ac-ft.): 56.029
Percent Infiltrated: 81.98
Total Precip Applied to Facility: 1.832
Total Evap From Facility: 0.807
Underdrain used
Underdrain Diameter (feet): 0.34
Orifice Diameter (in.): 4
Offset (in.): 8
Flow Through Underdrain (ac-ft.): 6.929
Total Outflow (ac-ft.): 56.029
Percent Through Underdrain: 12.37
Discharge Structure
Riser Height: 0.3 ft.
Riser Diameter: 12 in.

Element Flows To:
```

Figure 5. Screenshot of SAHM project results with some relevant information highlighted (SAHM).

4. Calculate the average annual volume of pre-project runoff (V_{pre}).

Use Equation 13 to calculate the net precipitation (P_{net}) applied to the facility. The total volume of precipitation applied to the facility (P_{total}) and the total volume evaporated from the facility (E_{total}) can be found in the SAHM Project Report (Figure 5). Although not shown in Figure 5, the correct units for each variable in Equation 13 are acre-feet.

$$P_{net} = P_{total} - E_{total} \qquad \text{Equation 13}$$

Where: P_{net} = Net volume of precipitation applied to facility (ac-ft)

P_{total} = Total volume of precipitation applied to facility (ac-ft)

E_{total} = Total volume evaporated from facility (ac-ft)

P_{net} = (1.832 ac-ft) – (0.807 ac-ft) = 1.025 ac-ft

Next, calculate the total pre-project runoff volume (across the multi-year period) as follows:

$$TV_{pre} = TV_{in} - P_{net} \qquad \text{Equation 14}$$

Where: TV_{pre} = Total pre-project runoff volume (ac-ft)

TV_{in} = Total volume through facility (ac-ft)

TV_{pre} = (56.029 ac-ft) – (1.025 ac-ft) = 55.004 ac-ft

The parameters used Equation 13 are totals over the entire simulation, not annual averages, so total pre-project runoff volume must be divided by the duration of the simulation to get the average annual volume. Calculate the duration of the simulation using:

$$t = End\ date - Start\ Date \qquad \text{Equation 15}$$

Where: t = Duration of simulation (years)

t = 2004 – 1961 = 43 years

Calculate the average annual pre-project runoff volume as follows:

$$V_{pre} = \frac{TV_{pre}}{t} \qquad \text{Equation 16}$$

V_{pre} = (55.004 ac-ft) / (43 years) = 1.279 AFY

5. Calculate the average annual volume of post-project runoff (V_{post}).

Calculate the total post-project runoff volume using the equation below. The total volume of post-project treated ($TV_{t,post}$) and untreated ($TV_{o,post}$) runoff are found in the project report as "Flow Through Underdrain" and "Total Volume Through Riser", respectively.

$$TV_{post} = TV_{t,post} + TV_{o,post} \qquad \text{Equation 17}$$

Where: TV_{post} = Total post-project runoff volume (ac-ft)

$TV_{t,post}$ = Total post-project treated runoff volume (ac-ft)

$TV_{o,post}$ = Total post-project untreated runoff volume (ac-ft)

TV_{post} = (6.929 ac-ft) + (3.165 ac-ft) = 10.094 ac-ft

Again, as this is the total volume over the entire simulation, it must be divided by the duration of the simulation to get the average annual volume. Calculate average annual post-project runoff (V_{post}) as follows:

$$V_{post} = \frac{TV_{post}}{t} \qquad \text{Equation 18}$$

V_{post} = (10.049 ac-ft) / (43 years) = 0.235 AFY

6. Calculate the average annual volume of runoff reduced (ΔV).

The average annual reduced runoff volume is calculated using Equation 1:

$$\Delta V = V_{pre} - V_{post} \qquad \text{Equation 1}$$

ΔV = (1.279 AFY) – (0.235 AFY) = **1.0 AFY** (rounded)

California Phase II LID Sizing Tool

Scenario Description:

This example uses the same scenario as described in the Sacramento Area Hydrologic Model (SAHM) example calculation.

1. Run the simulation on the LID Sizing Tool.

Enter the parameters into Steps 1 through 7 of the LID Sizing Tool. The necessary output is only available using the tool's "80% Capture" and "Bioretention Equivalent" methods, as selected in Step 6 of the tool. Figure 6 shows a screenshot of these options.

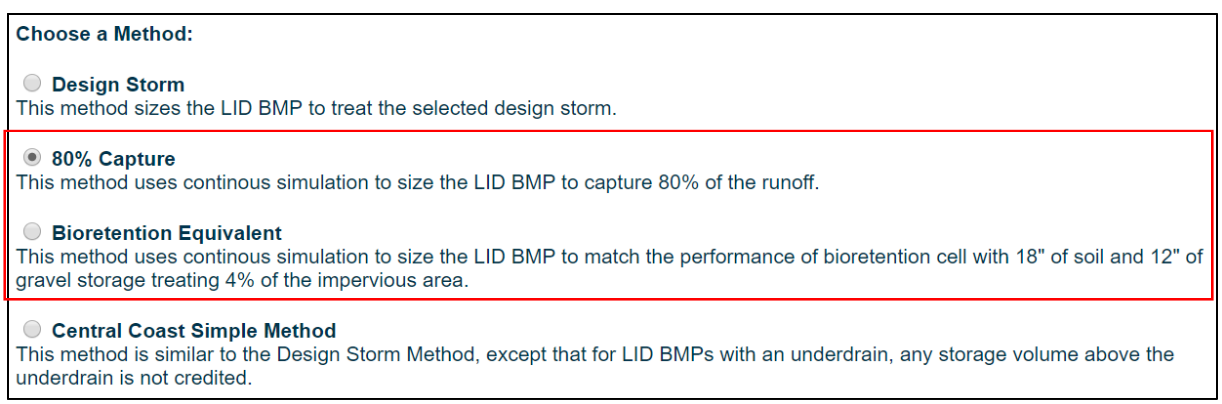


Figure 6. Screenshot of Storm Water Treatment Measure Methods (Phase II LID Sizing Tool).

2. Obtain the output values.

Output values are given in the LID Sizing Tool summary page. Screenshots of tables from the tool's summary page with relevant results are shown in Figure 7.

Summary

Climate station	SACRAMENTO 5 ESE
Saturated hydraulic conductivity	1 in/hr
Impervious area	1 acres
LID area	0.04 acres
Total area	1.04 acres
Percent Accomplished	100%
LID BMP	Bioretention Cell - 18" Soil - 12" Gravel Storage
Methodology	Baseline Bioretention or Equivalent Performance
Volume Evaporated	0.03 acre-ft/year
Volume Infiltrated	1.24 acre-ft/year
Volume passing through the underdrain	0.08 acre-ft/year
Volume of untreated runoff	0.15 acre-ft/year
Volume of pre-project impervious area runoff	1.43 acre-ft/year

Figure 7. Input and Results Summary (Phase II LID Sizing Tool)

3. Obtain the average annual pre-project runoff volume.

The average annual pre-project runoff volume is given in the LID Sizing Tool summary page as “Volume of pre-project impervious area runoff”.

V_{pre} = 1.43 AFY

4. Calculate the average annual post-project runoff volume.

The average annual post-project runoff volume is calculated using Equation 19. In the LID Sizing Tool, the average annual post-project treated and untreated runoff volume are given as “Volume passing through the underdrain” and “Volume of untreated runoff”.

$$V_{post} = V_{t,post} + V_{o,post} \quad \text{Equation 19}$$

Where: V_{post} = Average annual post-project runoff volume (AFY)

$V_{t,post}$ = Average annual post-project treated runoff volume (AFY)

$V_{o,post}$ = Average annual post-project untreated runoff volume (AFY)

V_{post} = (0.08 AFY) + (0.15 AFY) = 0.23 AFY

5. Calculate the average annual runoff volume reduced.

Calculate average annual runoff volume reduced using Equation 1:

$$\Delta V = V_{pre} - V_{post} \quad \text{Equation 1}$$

ΔV = (1.43AFY) – (0.23AFY) = **1.2 AFY**

USEPA National Stormwater Calculator

Scenario Description:

This example uses the same scenario as described in the Sacramento Area Hydrologic Model (SAHM) example calculation, but without the underdrain. The USEPA National Stormwater Calculator currently does not accommodate modeling of an underdrain.

1. Run the pre-project scenario in the model

Enter the pre-project values shown in Figure 8 into the calculator and save the results as the baseline scenario.

2. Run the post-project scenario in the model.

Enter the post-project values shown in Figure 8 into the calculator and refresh the results. The post-project values are shown under "Current Scenario".

3. Obtain the output values.

Output values are given in the calculator's summary page. Figure 9 provides a screenshot of the results.

4. Calculate the average annual pre-project runoff volume.

The annual average volume of runoff before construction (pre-project) is calculated as follows:

$$V_{pre} = D_{pre} * F_{ft-in} * A_{imp,pre} \qquad \text{Equation 20}$$

Where: V_{pre} = Average annual pre-project runoff volume (AFY)

D_{pre} = Average annual pre-project runoff depth (in/yr)

$F_{ft\text{-}in}$ = Unit conversion factor

$A_{imp,pre}$ = Pre-project impervious area (ac) (from Figure 8)

V_{pre} = (16.39 in/yr)*(0.0833 ft/in) *(1 acre) = 1.41 acre-feet

Parameter	Current Scenario	Baseline Scenario
Site Characteristics		
Site Area (acres)	1	1
Hydrologic Soil Group	B	B
Hydraulic Conductivity (in/hr)	0.25	0.25
Surface Slope (%)	2	2
Precip. Data Source	SACRAMENTO 5 ESE	SACRAMENTO 5 ESE
Evap. Data Source	SACRAMENTO 5 ESE	SACRAMENTO 5 ESE
Climate Change Scenario	None	None
Land Cover		
% Forest	0	0
% Meadow	0	0
% Lawn	0	0
% Desert	0	0
% Impervious	100	100
LID Controls		
Disconnection	0	0
Rain Harvesting	0	0
Rain Gardens	0	0
Green Roofs	0	0
Street Planters	100 / 4	0
Infiltration Basins	0	0
Porous Pavement	0	0
Analysis Options		
Years Analyzed	20	20
Ignore Consecutive Wet Days	False	False
Wet Day Threshold (inches)	0.10	0.10

Figure 8. Screenshot of the Site Description Report with the pre-project and post-project parameters (EPA National Stormwater Calculator).

5. Calculate the average annual post-project runoff volume.

The annual average volume of runoff after construction (post-project) is calculated as follows:

$$V_{post} = D_{post} * F_{ft-in} * A_{imp,post} \qquad \text{Equation 21}$$

Where: V_{post} = Average annual post-project runoff volume (AFY)

D_{post} = Average annual runoff depth (in/yr)

$F_{ft\text{-}in}$ = Unit conversion factor

$A_{imp,post}$ = Post-project impervious area (acre) (Figure 8)

V_{post} = (3.84 in/yr) * (0.0833 ft/in) * (1 acre) = 0.32 AFY

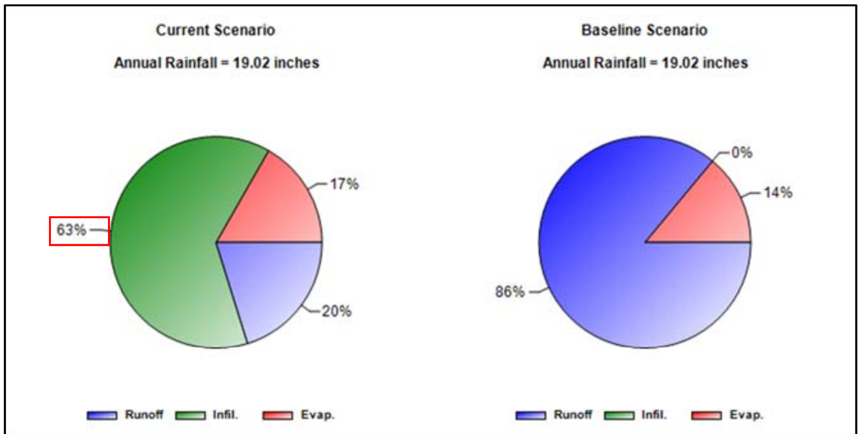
6. Calculate the average annual runoff volume reduced.

The annual average volume of runoff reduced is calculated using Equation 1:

$$\Delta V = V_{pre} - V_{post} \qquad \text{Equation 1}$$

.

ΔV = 1.41-0.32 = **1.1 AFY**



Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	19.02	19.02
Average Annual Runoff (inches)	3.84	16.39
Days per Year With Rainfall	36.87	36.87
Days per Year with Runoff	7.64	32.03
Percent of Wet Days Retained	79.27	13.14
Smallest Rainfall w/ Runoff (inches)	0.12	0.11
Largest Rainfall w/o Runoff (inches)	1.03	0.20
Max. Rainfall Retained (inches)	0.99	0.17

Figure 9. Screenshot of Results Page (USEPA National Stormwater Calculator).

Benefit WQ2

Sacramento Area Hydrologic Model (SAHM)

Scenario Description:

This example simulates a theoretical, moderately flat, 100% impervious, one-acre site in the Sacramento area. The site drains to a bioretention facility having a 4% capture ratio (i.e., a 0.04-acre footprint). See Figure 2 in the Water Quality Benefits

Benefit WQ1 example calculations for specific layer depths. Total suspended solids (TSS) serves as the example constituent for load reduction calculations.

1. Run the pre-project scenario in the model.

Create and run the pre-project scenario in SAHM. Figure 3 in the Benefit WQ1 example calculations shows the scenario including input parameters.

2. Run the post-project (mitigated) scenario in the model.

Create and run the post-project (mitigated) scenario in SAHM. Figure 4 shows the scenario including input parameters.

3. Obtain the output values.

Output values from the "Text Report" option under SAHM's "Report" icon are shown in Figure 5.

4. Calculate the average annual pre-project load (L_{pre}).

Calculate average annual pre-project runoff volume (V_{pre}) using the methods presented in the Benefit WQ1 example calculations.

P_{net} = 1.025 ac-ft

TV_{pre} = 55.004 ac-ft

t = 43 years

V_{pre} = 1.279 AFY

Look up the pre-project discharge TSS concentration (C_{pre}) from Table 1.

C_{pre} = 42 mg/L

Calculate the average annual pre-project load (L_{pre}) using Equation 3:

$$L_{pre} = (1.279\ AFY) * (42\ mg/L) * \left[\frac{43{,}560 ft^2}{acre} * \frac{kg}{10^6 mg} * \frac{year}{365\ days} * \frac{28.3168L}{ft^3}\right] = 66\ kg/yr$$

5. Calculate the average annual post-project load (L_{post}).

The total volume of treated ($TV_{t,post}$) and overflow ($TV_{o,post}$) runoff can be found in the Project Report as "Flow Through Underdrain" and "Total Volume Through Riser".

$TV_{t,post}$ = 6.929 ac-ft

$TV_{o,post}$ = 3.165 ac-ft

Calculate the average annual treated and untreated runoff volumes by dividing the total runoff volumes by the duration of the simulation (t).

$V_{t,post}$ = (6.929 ac-ft) / (43 years) = 0.161 AFY

$V_{o,post}$ = (3.165 ac-ft) / (43 years) = 0.074 AFY

Look up the treated post-project runoff concentration ($C_{t,post}$) from Table 1.

$C_{t,post}$ = 9.9 mg/L

Calculate the average annual post-project load (L_{post}) using Equation 4:

$$L_{post} = \left[(0.074\ AFY)*(42\ mg/L) + (0.161\ AFY)*(9.9\ mg/L)\right]*\left[\frac{43{,}560 ft^2}{acre} * \frac{kg}{10^6 mg} * \frac{year}{365\ days} * \frac{28.3168L}{ft^3}\right] = 5.8\ kg/yr$$

6. Calculate the average annual load reduced (ΔL).

Calculate ΔL using Equation 2:

ΔL = (66 kg/day) – (0.016 kg/day) = **0.16 kg/day**

<u>California Phase II LID Sizing Tool</u>

Scenario Description:

This example simulates a theoretical, moderately flat, 100% impervious, one-acre site in the Sacramento area. The site drains to a bioretention facility having a 4% capture ratio (i.e., a 0.04-acre footprint). See Figure 2 in the Water Quality Benefits

Benefit WQ1 example calculations for specific layer depths. Total suspended solids (TSS) serves as the example constituent for load reduction calculations.

1. Run the simulation on the LID Sizing Tool.

Enter the parameters into Steps 1 through 7 of the LID Sizing Tool. The necessary output is only available using the tool's "80% Capture" and "Bioretention Equivalent" methods, as selected in Step 6 of the tool. Figure 6 in the Benefit WQ1

example calculations shows a screenshot of these options.

2. Obtain the output values.

Output values are given in the LID Sizing Tool summary page. Screenshots of the output table from the summary page are shown in Figure 7.

3. Calculate the average annual pre-project load (L_{pre}).

The average annual pre-project runoff volume is given in the LID Sizing Tool summary page as "Volume of pre-project impervious area runoff".

V_{pre} = 1.43 AFY

Look up the pre-project discharge TSS concentration in Table 1.

C_{pre} = 42 mg/L

Calculate the average annual pre-project load using Equation 3:

$$L_{pre} = (1.43\text{ AFY}) * (42\text{ mg/L}) * \left[\frac{43{,}560 ft^2}{acre} * \frac{kg}{10^6 mg} * \frac{year}{365\ days} * \frac{28.3168 L}{ft^3}\right] = 74\text{ kg/yr}$$

4. Calculate the average annual post-project load (L_{post}).

The average annual treated and untreated runoff volumes ($V_{t,post}$ and $V_{o,post}$) are found in the tool summary table as "Volume Passing Through the Underdrain" and "Volume of untreated runoff".

$V_{t,post}$ = 0.52 AFY

$V_{o,post}$ = 0.31 AFY

Look up the post-project treated discharge TSS concentration in Table 1.

$C_{t,post}$ = 9.9 mg/L

Calculate the average annual post-project load using Equation 4:

$$L_{post} = [(0.31\text{ AFY})*(42\text{ mg/L}) + (0.52\text{ AFY})*(9.9\text{ mg/L})] * \left[\frac{43{,}560 ft^2}{acre} * \frac{kg}{10^6 mg} * \frac{year}{365\ days} * \frac{28.3168 L}{ft^3}\right] = 22\text{ kg/yr}$$

5. Calculate the average annual load reduced (ΔL).

Calculate the average annual load reduction using Equation 2:

ΔL = (74 kg/yr) – (22 kg/yr) = **52 kg/yr**

USEPA National Stormwater Calculator

Scenario Description:

This example uses the same scenario as described in the Sacramento Area Hydrologic Model (SAHM) example calculation, but without the underdrain. The USEPA National Stormwater Calculator currently does not accommodate modeling of an underdrain.

1. Run the pre-project scenario in the model.

Enter the pre-project values shown in Figure 8 in the Benefit WQ1

example calculations into the calculator and save the results as the baseline scenario.

2. Run the post-project scenario in the model.

Input the post-project values shown in Figure 8 into the calculator and refresh the results.

3. Obtain the output values.

Output values are given in the calculator's summary page. Figure 9 provides a screenshot of the results.

4. Calculate the average annual pre-project load (L_{pre}).

Calculate the average annual pre-project runoff volume using Equation 20 from the Benefit WQ1

example calculations.

V_{pre} = (16.39 in/yr) * (0.0833 ft/in) * (1 acre) = 1.41 ac-ft

Look up the pre-project discharge TSS concentration in Table 1.

C_{pre} = 42 mg/L

Calculate the average annual pre-project load using Equation 3.

$$L_{pre} = (1.41\ AFY) * (42\ mg/L) * \left[\frac{43{,}560 ft^2}{acre} * \frac{kg}{10^6 mg} * \frac{year}{365\ days} * \frac{28.3168 L}{ft^3}\right] = 73\ kg/yr$$

5. Calculate the average annual post-project load (L_{post}).

Underdrains cannot be modeled in the EPA Calculator. Therefore there is no value for treated runoff volume ($V_{t,post}$); there is only the overflow runoff ($V_{o,post}$), which can be used as the average annual runoff volume (V_{post}). This can be calculated using Equation 21 in Water Quality Benefits

Benefit WQ1.

V_{post} = (3.84 in/yr) * (0.0833 ft/in) * (1 acre) = 0.32 AFY

Calculate the average annual post-project load using Equation 4 and $V_{t,post}$ = 0:

$$L_{post} = \left[(V_{o,post} * C_{o,post}) + (V_{t,post} * C_{t,po.} \right. * F \qquad \text{Equation 4}$$

L_{post} = (0.32 AFY) * (42 mg/L) * $\left[\frac{43{,}560 ft^2}{acre} * \frac{kg}{10^6 mg} * \frac{year}{365\ days} * \frac{28.3168 L}{ft^3} \right]$ = 17 kg/yr

6. Calculate the average annual load reduced (ΔL).

Calculate the average annual load reduced using Equation 2.

ΔL = (73 kg/yr) – (17 kg/yr) = **56 kg/yr**

Benefit WS1

Sacramento Area Hydrologic Model (SAHM)

Scenario Description:
This example simulates a theoretical, moderately flat, 100% impervious, one-acre site in the Sacramento area. The site drains to a bioretention facility having a 4% capture ratio (i.e., a 0.04-acre footprint). See Figure 2 in the Water Quality Benefits

Benefit WQ1 example calculations for specific layer depths.

1. Run the pre-project scenario in the model.

Create and run the pre-project scenario in SAHM. Figure 3 in the Benefit WQ1

example calculations shows the scenario including input parameters.

2. Run the mitigated (post-project) scenario in the model.

Create and run mitigated (post-project) scenario in SAHM. Figure 4 shows the scenario including input parameters.

3. Obtain the output values.

Output values from the "Text Report" option under SAHM's "Report" icon are shown in Figure 5.

4. Calculate the average annual runoff volume infiltrated.

Look up the total runoff volume infiltrated from the Project Report (Figure 5).

TV_{inf} = 45.935 ac-ft

This is the total volume of runoff infiltrated over the entire simulation and not an annual figure. As such, it must be divided by the duration of the simulation (t) to get the average annual volume. Calculate t using Equation 15 from the Benefit WQ1

example calculations.

t = 2004 – 1961 = 43 years

Calculate the average annual runoff volume infiltrated as follows:

$$V_{inf} = \frac{TV_{inf}}{t} \quad \text{Equation 22}$$

Where: V_{inf} = Average annual runoff volume infiltrated (AFY)

TV_{inf} = Total runoff volume infiltrated (ac-ft)

t = Duration of simulation (years)

V_{inf} = (45.935 ac-ft) / (43years) = **1.1 AFY**

<u>California Phase II LID Sizing Tool</u>

Scenario Description:

This example simulates a theoretical, moderately flat, 100% impervious, one-acre site in the Sacramento area. The site drains to a bioretention facility having a 4% capture ratio (i.e., a 0.04-acre footprint). See Figure 2 in the Water Quality Benefits

Benefit WQ1 example calculations for specific layer depths.

1. Run the simulation on the LID Sizing Tool.

Enter the parameters into Steps 1 through 7 of the LID Sizing Tool. The necessary output is only available using the tool's "80% Capture" and "Bioretention Equivalent" methods, as selected in Step 6 of the tool. Figure 6 in the Benefit WQ1

example calculations shows a screenshot of these options.

2. Obtain the average annual runoff volume infiltrated from the output values.

The average annual runoff volume infiltrated is given in the LID Sizing Tool summary page as "Volume Infiltrated" (Figure 7).

V_{inf} = **1.2 AFY**

USEPA National Stormwater Calculator

Scenario Description:

This example simulates a theoretical, moderately flat, 100% impervious, one-acre site in the Sacramento area. The site drains to a bioretention facility having a 4% capture ratio (i.e., a 0.04-acre footprint). See Figure 2 in the Water Quality Benefits

Benefit WQ1 example calculations for specific layer depths.

1. Run the pre-project scenario in the model.

Enter the pre-project values shown in Figure 8 in the Benefit WQ1 example calculations into the calculator and save the results as the baseline scenario.

2. Run the post-project scenario in the model.

Enter the post-project values shown in Figure 8 into the calculator and refresh the results.

3. Obtain the output values.

Output values are given in the calculator's summary page. Figure 9 provides a screenshot of the results.

4. Calculate the average annual runoff volume infiltrated.

Calculate the average annual runoff volume infiltrated as follows:

$$V_{inf} = D_{rf} * F_{ft-in} * P_{inf} * A_{BMP} \quad \text{Equation 23}$$

Where: V_{inf} = Average annual runoff volume infiltrated (AFY)

D_{rf} = Average annual rainfall depth (in/yr)

$F_{ft\text{-}in}$ = 0.0833 ft/in

P_{inf} = Percent of average annual rainfall that infiltrated

A_{BMP} = Surface area of the BMP (ac)

V_{inf} = (19.02 in/yr) * (0.0833 ft/in) * (0.63) * (1 ac) = **1.0 AFY**

Benefit FM1

<u>Projects located in Sacramento County or the cities of Elk Grove, Folsom, Galt, Rancho Cordova, or Sacramento</u>

Scenario Description:

This example simulates a theoretical, 100% impervious, one-acre site in the Sacramento area. The site drains to a dry well with a 15-foot deep settling chamber over a 25-foot deep, rock-filled pervious shaft. The pervious shaft is in material with a saturated hydraulic conductivity of 5 inches/hour.

1. Run the pre-project scenario in SAHM.

Follow the example from Benefit WQ1.

2. Run the mitigated (post-project) scenario in SAHM.

Follow the example from Benefit WQ1.

3. Obtain the output values.

Output values are available from the pdf version of the "Text Report" option under SAHM's "Report" icon. A screenshot is shown in Figure 10.

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Pre-Project. POC #1

Return Period	**Flow(cfs)**
2 year	0.375015
5 year	0.565222
10 year	0.72007
25 year	0.842245

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.204814
5 year	0.347206
10 year	0.60568
25 year	0.768704

Annual Peaks

Figure 10. Screenshot of output values as shown in the SAHM Text Report (pdf option).

4. Calculate ΔQ

Use Equation 8 to calculate the peak flow rate reduced (ΔQ). The pre-project peak flow rate (Q_{pre}) and post-project peak flow rate (Q_{post}) can be found in the SAHM Text Report under "Flow Frequency Return Periods for Pre-Project. POC #1" and "Flow Frequency Return Periods for Mitigated. POC #1". For the 10-year return period, see Figure 10.

Q_{pre} = 0.72007 cfs

Q_{post} = 0.60568 cfs

ΔQ = 0.72007 - 0.60568 = **0.11 cfs**

<u>Projects located elsewhere</u>

For projects located elsewhere, a site-appropriate hydrologic or flood model can be used. Alternatively, SAHM may be used under the assumption that a rainfall record in SAHM is representative of the actual project location.