SLRT

STREAM LOAD REDUCTION TOOL V2

USER GUIDANCE

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2NDNATURE
ecosystem science + design

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SLRT VERSION 2 USER GUIDANCE

Below is the step-by-step user guidance to calculate the average annual mass of fine sediment particles (FSP; < 16 µm) reduced as a result of morphologic modifications to a stream enhancement zone (SEZ) using the Stream Load Reduction Tool (SLRT). SLRT version 2 includes a number of updates and improvements to the templates and user guidance to improve the accuracy of the FSP load reduction estimates and consistency across users.

A series of templates and instructions provided to simplify the data input and calculations required by the user to model the average annual FSP loads estimated at the downstream boundary for both the pre and post SEZ configuration. A digital MS Excel spreadsheet tool (*SLRTv2_Template.xlsx)* is available for direct input by the user and once all necessary input data are entered, the *SLRTv2_Template.xlsx* preloaded equations and algorithms automate all the necessary the calculations for the user, providing standardized results.

All relevant digital templates, examples and technical documentation can be downloaded from http://www.2ndnaturellc.com/client-access/slrttrout-creek/. While these products are available for use, they may contain bugs, particularly if not used in the exact manner outlined in this guidance. SLRT users must QA/QC all calculations, as changes to cell references or equations may result in erroneous and unintended outputs. SLRTv2 is focused solely on FSP load reductions, but the intent is that future versions could expand the SLRT methodology to other pollutants such as total suspended sediment (TSS), total nitrogen (TN) or dissolved nitrogen (DN), for example.

SLRTV2_TEMPLATE.XLSX

SLRTv2_Template.xlsx is a blank macro-enabled spreadsheet that auto-generates the SLRT calculations using required data inputs to estimate an average annual FSP load reduction as a result of SEZ physical modifications. The calculation template contains 5 active worksheets described below.

Cell Codes

BLUE CELLS = USER INPUT REQUIRED
GREY CELLS = SLRT CALCULATED VALUE
WHITE CELLS = INFORMATION, INTERMEDIATE CALCULATION, UNIT CONVERSION, ETC.

Worksheets

- *USER INPUTS*: Any and all user input values are entered here for both pre- and post-restoration scenarios. Once all user data inputs are completed, all of the calculations in the remaining 4 worksheets below are auto-generated.
- *HYD FSP IN*: SLRT estimates of contributing average annual catchment hydrology and FSP loading in required formats.
- *RFPfsp*: SLRT estimates of average annual FSP loads delivered to and retained upon the SEZ floodplain for both pre- and post-restoration scenarios.
- *SCEfsp*: SLRT estimates of average annual FSP loads generated from channel erosion for both pre- and post-restoration scenarios.
- *SLRT Results*: SLRT estimate of average annual FSP load reduction as a result of restoration. A series of additional physical differences between pre- and post-restoration conditions are provided as additional support for restoration effectiveness.

Each worksheet has a pre-defined *Print* view that will generate a single page report summary. Collectively these five (5) pages provide the critical inputs and outputs of the SLRT estimates for the SEZ of interest.

SLRT INPUT DATA NEEDS

SLRTv2_Template.xlsx* worksheet: *USER INPUTS

This section provides the detailed guidance to the user on how to generate SLRT load reduction estimates. The SLRT method requires the use of available data to quantify a number of catchment and morphologic attributes that are necessary inputs to estimate the average annual pollutant load reduction. The *SLRTv2_Template.xlsx USER INPUTS* worksheet contains all required input parameters and associated units to complete SLRT calculations (Figure 1). Potential data sources and considerations for determination of each value are provided below. Once the user has populated the required fields in Figure 1, all of the SLRT calculations are automatically conducted by the embedded macros.

The user should "save as" the SLRT v2_template.xlsx file with the name of the restoration project in the title.

SLRT USER STEPS

The following describe the sequence of steps the user takes to complete SLRTv2 INPUT tab (Figure 1). Once the INPUT tab is populated in entirety, the MS Excel template will automatically calculate results and generate standardized summary tables and graphics.

1. Obtain each of the SLRT user input values to complete all of the required inputs from 'User Name' vertically through 'Floodplain Condition Score' in the SLRTv2 USER INPUTS tab for both pre and post restoration conditions. These inputs generate a number of the SLRT estimates, including site hydrology that is a critical input for Step 2, bank erosion modeling.
2. Complete the required BSTEM dynamic model runs to populate the 'unit erosion rates' at the bottom of the SLRTv2 INPUT tab.
3. Once all of the fields in the USER INPUT tab are populated, the user can review SLRTv2 results.

METADATA

In order to identify the site and user the SLRT input table includes a collection of metadata including user, SEZ catchment, and reach names and date of estimate (see Figure 1). It is recommended the user generate a SEZ location map that identifies the region, contributing catchment boundary and clear delineation of the areal extent of restoration actions.

The user should complete all of the META DATA fields as required.

STREAM LOAD REDUCTION TOOL (SLRTv2)

User Inputs

META DATA

USER NAME	2NDNATURE
WATERSHED/CATCHMENT	UPPER TRUCKEE RIVER
REACH NAME	**UTR GOLF COURSE**
Date of Estimate	2/7/2014

CATCHMENT CHARACTERISTICS

CATCHMENT TYPE	Non Urban	
REGION	Mainstem UTR	
SUB-REGION	Southwest	
CATCHMENT AREA	42.4	
AREA UNITS	Sq-miles	
CATCHMENT % IMPERVIOUS		Urban Only
CATCHMENT LAND USE CONDITION		Urban Only

SEZ ATTRIBUTES

	PRE-RESTORATION		POST-RESTORATION
Channel length (m)	1829	l_c	2143
Channel slope (m/m)	0.0021	s	0.0018
Outside BEND length (m)	841	l_{ob}	984
BEND bank height (m)	2.8	h_{ob}	1.3
BEND bank angle (degrees)	50	a_{ob}	18
BEND toe length (m)	1	tl_{ob}	0.9
BEND toe angle (degrees)	39	ta_{ob}	6
STRAIGHT length (m)	988	l_{str}	1159
Bank height of STRAGHT reaches (m)	1.9	h_{str}	0.6
Bank angle of STRAIGHT reaches (degrees)	23	a_{str}	31
STRAIGHT reach toe length (m)	3	tl_{str}	2.3
STRAIGHT reach toe angle (degrees)	4	ta_{str}	6
Manning's roughness value of channel	0.03	*n*	0.03
Fines to bulk sediment ratio (0-1 value)	0.0174	FSP:BS	0.0174
Channel capacity (cfs)	1900	Q_{cc}	550
Floodplain length (m)	1221	l_{fp}	1221
Floodplain condition score	3	FPC	5
Effective cohesion (kPa)	3.8	c'	3.8
Angle of internal friction (degrees)	30.9	ϕ'	30.9
Bulk unit weight (kN/m^3)	17.1	γ	17.1
Matric suction parameter (degrees)	10.0	ϕ^b	10.0
Bank - Critical shear stress (Pa)	3.00	τ_c	3.00
Bank - Erodibility coefficient (cm^3/Ns)	0.645	*k*	0.645
Toe - Critical shear stress (Pa)	21.4	τ_c	21.4
Toe - Erodibility coefficient (cm^3/Ns)	0.127	*k*	0.127

BSTEM Dynamic OUTPUT

	PRE-RESTORATION		POST-RESTORATION	Q_{md-p}
Outside bend unit erosion rate (m^3/m/yr)	18.18	e_{ob-99}	1.04	99th
	0.139	e_{ob-75}	0.478	75th
	0.057	e_{ob-50}	0.239	50th
	0	e_{ob-25}	0.103	25th
Straight reach unit erosion rate (m^3/m/yr)	7.67	e_{str-99}	0.27	99th
	0.24	e_{str-75}	0.06	75th
	0.146	e_{str-50}	0.04	50th
	0.036	e_{str-25}	0.01	25th

SLRTv2 created by 2NDNATURE LLC 2014

USER INPUT [2/24/2014]

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SLRTV2 USER INPUT WORKSHEET

Figure 1

CATCHMENT CHARACTERISTICS

The catchment characteristic inputs (see Figure 1) are used to estimate the incoming site hydrology and FSP yield from the catchment. The user must determine if contributing catchment is non-urban or urban using criteria provided in Table 1. Once the catchment type is determined, obtain the information/data shown in Table 2 using GIS tools and available land use layers (recommended: TMDL Land Use GIS Layer, available at http://www.waterboards.ca.gov/lahontan/water_issues/programs/tmdl/lake_tahoe/index.shtml).

Table 1. Definitions of SLRT catchment types.

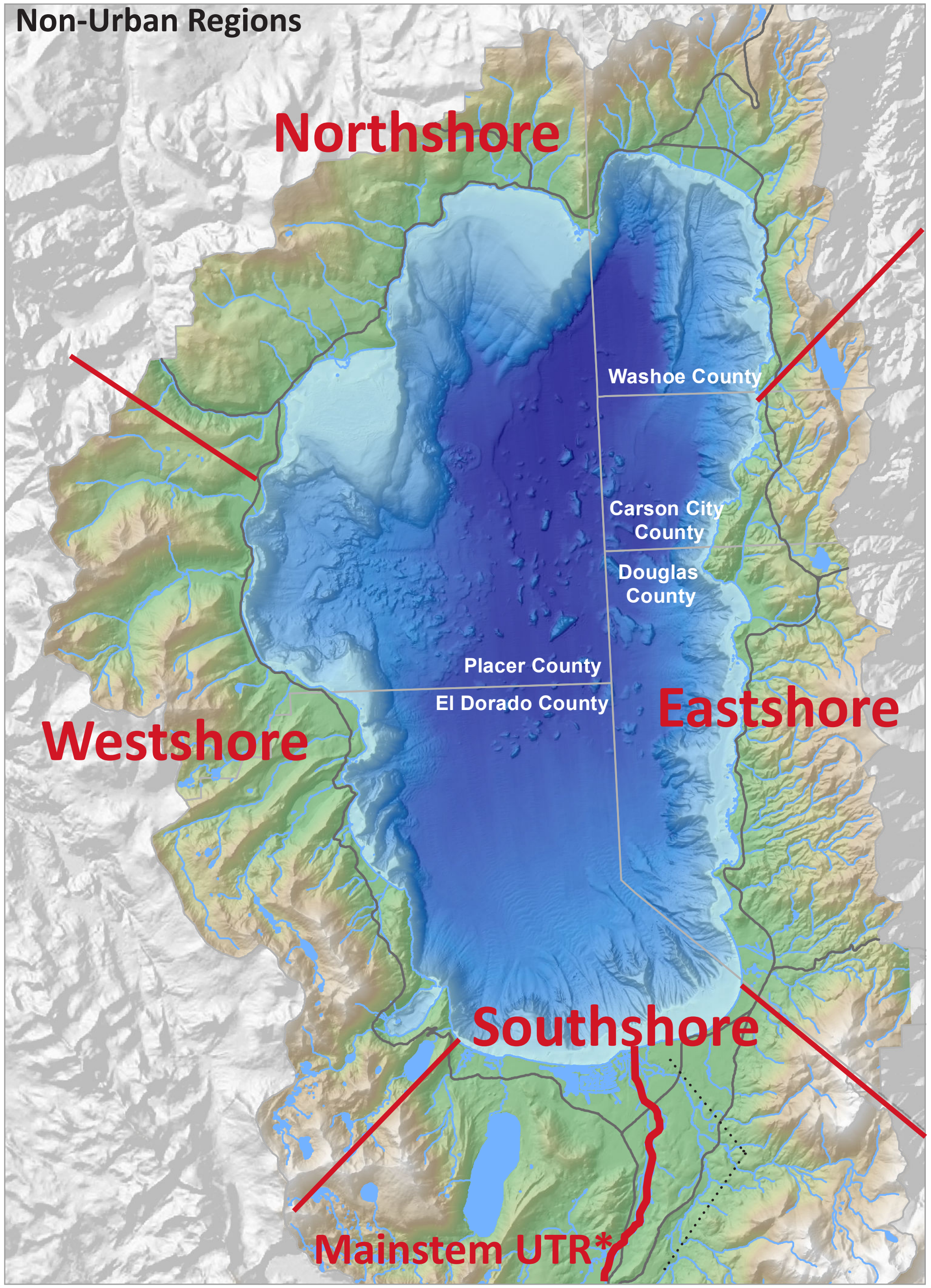
Catchment Type	Characteristics
Urban	• Large amount of development and impervious surfaces (> 10% impervious) • Typically smaller than 0.5 square mile (or 320 acres) • SEZ is not located on an LTIMP stream • Can be modeled by the Pollutant Load Reduction Model (PLRM; nhc et al 2009)
Non-urban	• Large amount of forest and undeveloped lands (<10% impervious) • Size can vary but typically larger than 1 square mile (or 640 acres) • SEZ located on LTIMP stream or tributary • Can NOT be modeled by PLRM

It is critical that the user designate an urban catchment area in acres and a non-urban catchment in square miles to properly estimate catchment hydrology. The catchment percent impervious and land use condition determinations are only required for urban catchments.

Table 2. Catchment characteristic inputs for each SLRT catchment type.

Catchment Type	Variable	Units	Description
Urban	Region	n/a	Region where urban SEZ is located; Figure 2A
	Sub-region	n/a	Sub-region where urban SEZ is located: see Figure 2A
	Catchment area	Acres	Contributing urban catchment area to upstream boundary of SEZ, reported in **acres**.
	% Impervious	%	Percent of catchment area with impervious surfaces
	Urban catchment land use condition		Estimated catchment condition with respect to average annual generation and transport of fine sediment particles to SEZ.
Non-urban	Region	n/a	Region where non-urban SEZ is located; Figure 2B
	Sub-region	n/a	Sub-region where non-urban SEZ is located: see Figure 2B
	Catchment area	mi^2	Contributing catchment area to upstream boundary of SEZ, reported in **square miles**.

The FSP catchment load for an urban catchment is generated using an estimate of the catchment characteristic runoff concentration (FSP CRC) based on the % impervious and user-defined relative catchment condition. Given that SLRT is focused on providing the estimated pollutant load reduced as a result of SEZ morphologic changes, the same catchment FSP incoming loads must be used for both pre- and post-restoration scenarios and therefore SLRT only requires a single user input. PLRM is the recommended platform to estimate the urban catchment water quality benefits of source control and treatment actions conducted upstream of an urban SEZ (nhc et al 2009; http://www.tiims.org/TIIMS-Sub-Sites/PLRM.aspx). The default urban catchment condition is 3 in the *SLRTv2_Template.xlsx*, but Table 3 provides considerations to assist the user in determining if the catchment condition may deviate from the expected average.



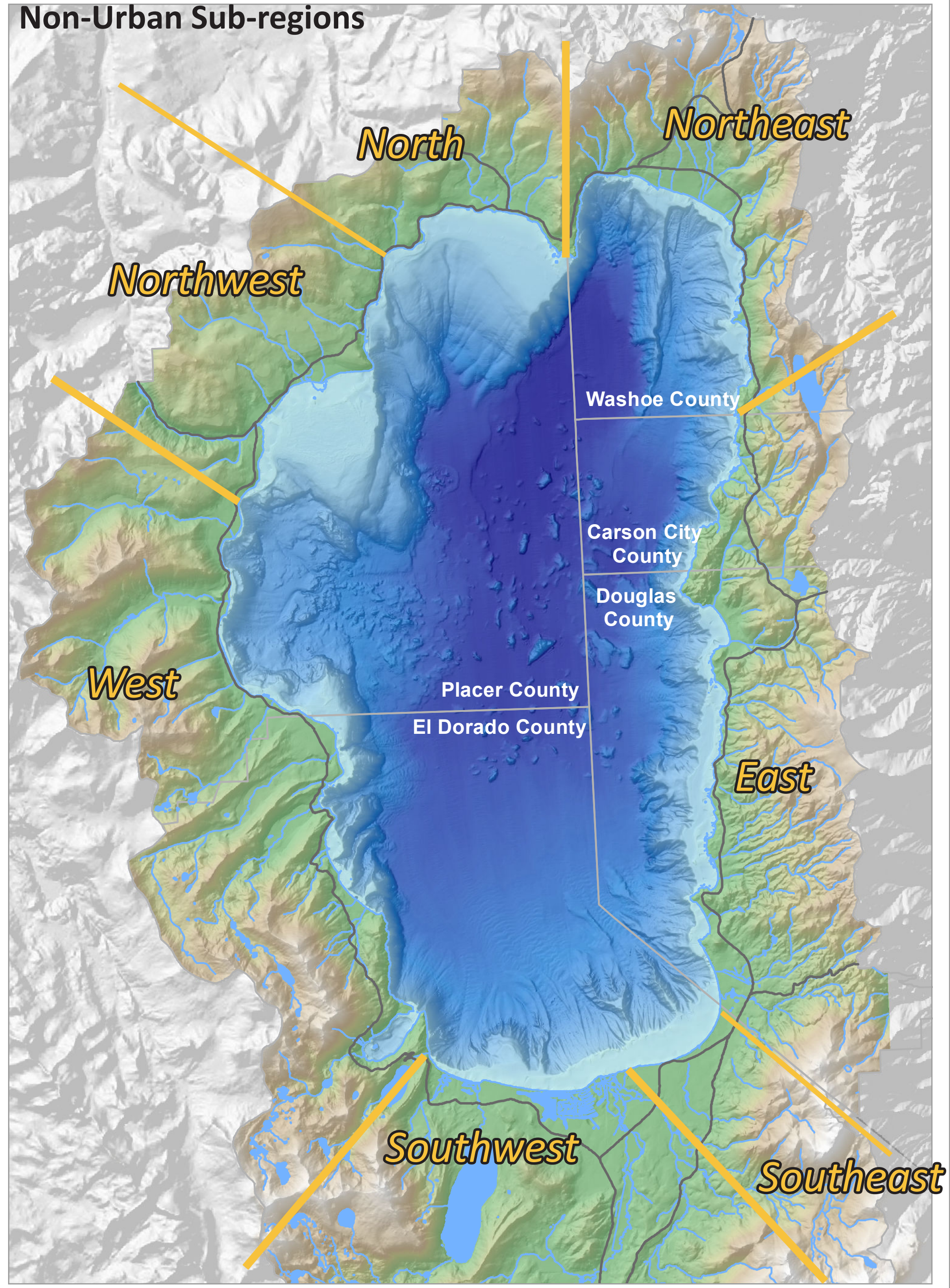


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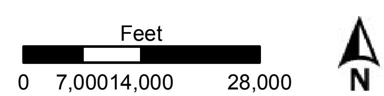
Figure2a: Non-urban regions (5, shown on left in red) and sub-regions (7 shown on right in yellow) delineations for SLRT inputs. *Note: The Upper Truckee River mainstem is treated as its own region, separate from Southshore, due to differences in hydrology.



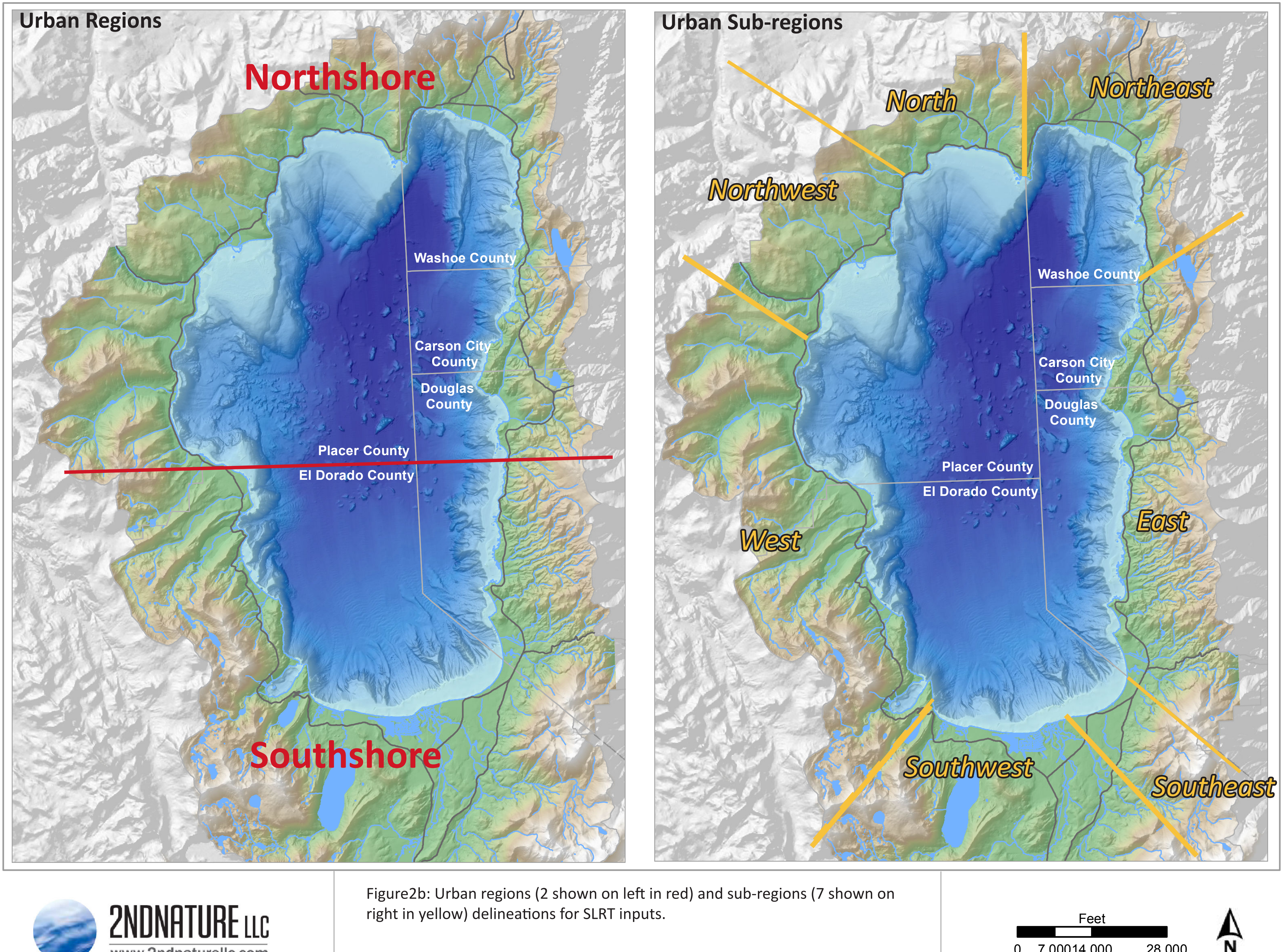


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Figure2b: Urban regions (2 shown on left in red) and sub-regions (7 shown on right in yellow) delineations for SLRT inputs.

Table 3. Urban catchment condition considerations to assist user with determination that the subject catchment deviates from the assumed Tahoe Basin average.

Urban catchment condition	Considerations
5	Above average: Significant water quality improvements have been implemented within the catchment to minimize FSP source generation (particularly on roads) and significantly reduce the hydrologic connectivity of the catchment; the majority of stormwater volumes generated within the catchment are routed to an effective and maintained WQIP; annual inspections and maintenance are conducted regularly on WQIP and private parcel BMPs.
3	Average: Urban catchment land use practices typical of Tahoe Basin and include winter road abrasive application, implementation of WQIP and erosion control projects over past decade, and reasonable private parcel BMP implementation. Catchment hydrologic connectivity is moderate; annual maintenance and inspections are conducted but are not high priority due to funding limitations; average catchment stormwater FSP concentrations are typically below 300 mg/L.
1	Poor: Source control and water quality improvement actions are below Basin average; catchment may be highly connected; maintenance and inspections are minimal; relatively elevated FSP concentrations in urban stormwater (> 300 mg/L) are expected.

SEZ ATTRIBUTES

A series of SEZ attributes are required as inputs to SLRT (see Figure 1). The user should utilize available field data to quantify each of the values which may include, but are not limited to, topographic surveys, cross-sections, geomorphic surveys, aerial photos, ground photos, and other information that would allow reasonable quantification of the required attributes for both pre- and post-restoration conditions. Table 4 describes each attribute in detail and provides a number of potential data sources and considerations for generating values. There will be inherent challenges faced by the user in generating these values. For instance, pre-restoration data is extremely limited from an SEZ that was restored many years ago. If restoration was recently completed, the current post-restoration condition may be expected to be temporary as the morphology and supporting vegetation tend toward a future equilibrium that will better represent average annual post-restoration condition. Given that SLRT may be used at varying stages of restoration including planning and design, immediately following, or many years post-restoration, a general recommendation is to reasonably estimate and represent the SEZ attributes 10-years post restoration. While potentially challenging, the representation of a future desired condition provides a better estimate of the expected average annual load reduction once the restored site has reached a new equilibrium. In all instances, the user is encouraged to compile and leverage available data, document the data sources, clearly articulate any assumptions in generating the required inputs, and critically evaluate the expected implications of using different input values prior to final selection. Guidance is provided to assist the user with the application of best professional judgment when selecting each SLRT input.

In order to meet a number of the SLRT objectives of providing a reliable yet relatively simple approach to estimating the average annual pollutant load reductions, the method requires a simplification of the inherent spatial complexity of any SEZ into a series of representative attribute values. For each of the attributes in Table 4 the user should rely upon the best available and relevant datasets. At a minimum, field geomorphic surveys with a stadia rod, clinometer, survey tape and camera can be used to obtain relevant site specific data to generate the morphologic values required for the existing/current condition of the subject SEZ. Regardless of the data source, when estimating a single representative value for an attribute, consider generating a

Table 4. Descriptions and potential data sources to generate, SLRT geomorphic attributes. Note the order provided below differs from the order of data input in the *SLRTv2_Template.xlsx USER INPUTS* worksheet.

Variable	Attribute	Units	Description	Potential data source (s)	Considerations
l_c	Channel length	m	Length of channel as measured at thalweg between upstream and downstream SEZ boundary.	Google Earth USGS map GIS calculation Longitudinal survey	Select a length of channel over which channel geometry and material types are relatively consistent. Distinct changes in bank height, vegetation characteristics, etc. should be modeled as separate reaches.
s	Channel slope	m/m	Elevation difference of the upstream boundary thalweg and downstream boundary thalweg divided by reach length.	Topographic survey DEM and field survey depth from top of bank to thalweg in each boundary	Ensure channel slope is measured at the thalweg and extended over a length equivalent to at least 6-20 bankfull channel widths, a complete meander wavelength or two-pool riffle sequences.
l_{ob}	Outside bend length	m	Length of channel (measured at the thalweg) located along a meander bend.	Aerial photograph Topographic survey Field surveys using survey tape	Be consistent with determination of start and finish of each bend, such that angles are consistent when designating each start/finish boundary.
l_{str}	Straight reach length	m	Length of channel (measured at the thalweg) that is a straight reach.	Calculate $l_{str} = l_c - l_{out}$	Can be verified using: aerial photograph; topographic survey; field surveys using survey tape
h_{ob}	Bank height of outside bends	m	Average height from top of bank to thalweg at midpoint of curvature of outside bends.	Topographic surveys Cross-sections Field surveys using stadia rod and survey tape	Obtain and average multiple measurements that represent range of heights to generate a reasonable average bank height of reach. Consider aligning number of measurements included in average with spatial distribution of each height value within reach.
h_{str}	Bank height of straight reaches	m	Average height from top of bank to thalweg of straight reaches.		
a_{ob}	Bank angle of outside bends	deg	Average angle from top of bank to bank toe at midpoint of curvature of outside bends	Topographic surveys Cross-sections Field surveys using stadia rod, level and inclinometer (or iPhone app)	Obtain and average multiple measurements that represent range of angles to generate a reasonable average bank angle of reach. Consider aligning number of measurements included in average with spatial distribution of each angle value within reach.
a_{str}	Bank angle of straight reaches	deg	Average angle from top of bank to bank toe of straight reaches		

Variable	Attribute	Units	Description	Potential data source (s)	Considerations
tl_{ob}	Toe length of outside bends	m	Average length of toe measured along entire slope length of toe for outside bends	Topographic surveys Cross-sections Field surveys using stadia rod and survey tape	Obtain and average multiple measurements that represent range of lengths to generate a reasonable average toe length of reach. Consider aligning number of measurements included in average with spatial distribution of each length value within reach.
tl_{str}	Toe length of straight reaches	m	Average length of toe measured along entire slope length of toe for straight reaches		
ta_{ob}	Toe angle of outside bends	deg	Average angle from top of toe to bottom of toe outside bends	Topographic surveys Cross-sections Field surveys using stadia rod, level and inclinometer (or iPhone app)	Obtain and average multiple measurements that represent range of angles to generate a reasonable average toe angle of reach. Consider aligning number of measurements included in average with spatial distribution of each angle value within reach.
ta_{str}	Toe angle of straight reaches	deg	Average angle from top of toe to bottom of toe straight reaches		
n	Mannings roughness of channel value	n/a	A coefficient that represents the relative resistance of the bed of a channel to the flow of water in it.	Recommended *n* values for SLRT inputs based on channel substrate and riparian vegetation density are provided below (Table 5).	
FSP:BS	% FSP in banks	0-1 fraction	Fraction of SEZ bank/bed material that is < 16µm.	Bank material data from Tahoe (see Table 7 provided below) Sample bank material and submit to laboratory	Table 7 data is best available data to estimate the % of the bulk sediment that is < 16µm in Tahoe soils. If bank material is sampled, ensure samples are spatially representative of locations susceptible to erosion within SEZ, and obtain at least one field triplicate. Analyze for % < 16 µm. Analytical costs will be higher, but more accurate than use of Table 7.
Q_{cc}	Channel capacity	cfs	Average channel capacity of reach expressed as discharge measured at upstream boundary. *Note that units are English rather than metric for most other SLRT inputs.*	HEC-RAS model Cross-section surveys Field geomorphic surveys Manning's equation	Complete and average multiple measurements from the riffle/runs reaches that represent a range to generate a reasonable average channel capacity of the reach. Do not include capacity of pools in sample population. Consider aligning number of measurements included in average with spatial distribution of each channel capacity within reach.

Variable	Attribute	Units	Description	Potential data source (s)	Considerations
l_{fp}	Floodplain length	m	Longitudinal linear distance from upstream to downstream boundary of floodplain adjacent to subject reach.	Google Earth USGS map GIS calculation	Measured the distance between the upstream and downstream boundaries of the subject SEZ. Unless the channel is straight, l_{fp} should be shorter than l_c.
FPC	Floodplain condition score	1, 3, 5	Presence and distribution of floodplain attributes that increase the relative particulate retention efficiency during overbank conditions. Expressed as a score of 1,3 or 5.	Visual surveys Ground photos Aerial photograph HEC-RAS model Floodplain topographic surveys	FPC is expressed as a relative score (1-5) with 5 representing a floodplain that is highly complex and possesses many of the attributes theorized to retain a higher fraction of FSP during relatively small overbank flows. Additional guidance is provided in Table 6.
c', ϕ', γ, ϕ^b	Effective cohesion, friction angle, bulk unit weight, matric suction parameter	kPa, °, kN/m^3, °	Geotechnical-resistance data focus on those attributes of the bank materials that control failure due to gravity.	Default values are recommended based on available Tahoe datasets (see Table 9, 10 and Figure 6) Sample bank material and submit to laboratory.	Default values are reasonable estimates for Tahoe SEZs based on existing datasets (Simon et al., 2003; 2006; 2009) to reduce the effort of the user. If SEZ specific data is used, spatially representative observations of bank material composition are needed. Data collection and analysis may not improve accuracy of model given the level of effort needed to obtain site specific values. If bank material is sampled, ensure samples are spatially representative of locations susceptible to erosion within SEZ, and obtain at least one field triplicate.
T_c, k	Critical shear stress, erodibility coefficient	Pa, cm^3/Ns	Hydraulic-resistance data focus on those parameters that quantify resistance to particle-by-particle erosion.		

population of values that represent the reach. The user should critically evaluate if each value generated is reasonable and QA/QC each estimate with knowledge of the reach. It is recommended the user clearly document the data sources used and the assumptions associated with data integration to generate the SLRT inputs. Additional guidance each specific attribute is provided below.

Channel Morphology

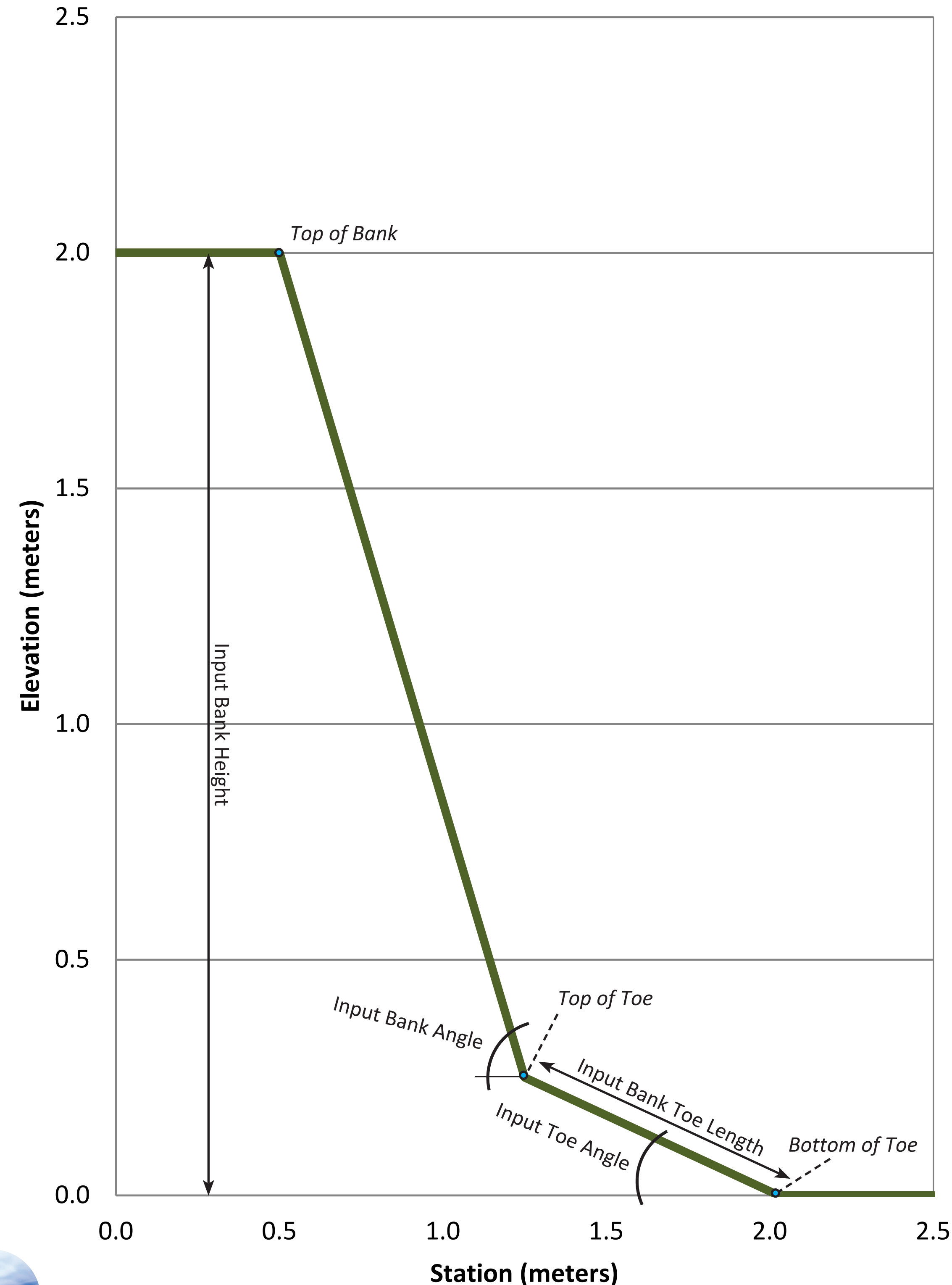
In order to accurately model a stream reach, it is necessary to translate a cross section into simple morphologic attributes. The user will need a representative cross section for each project condition (pre, post) and stream reach type (straight, bend). This representative cross section will later be used as an input to the NDA_SLRT_TroutCreek_Pre_Bend_99. Ideally the cross section will identify where the top of bank, top of toe and bottom of toe are located. If these have not been delineated, best professional judgment of cross section morphology will have to be used to identify these points. Figure 3 illustrates each simple morphologic features used by BSTEM. For straight reaches each morphologic attribute should be calculated for each side of the channel and averaged, while in bend reaches all values are calculated from outside bend. The following steps provide guidance to convert a representative cross section into simple morphologic inputs that are ready to be input into BSTEM.

1. Calculate the bank height of either outside bend or straight reaches (h_{ob}, h_{str}) by subtracting the elevation of the bottom of toe from the top of bank elevation to obtain bank height. Note that straight reaches average both sides of the bank for use in BSTEM.
2. The bank angle (a_{ob}, a_{str}) is calculated by taking the ArcTAN of the (elevation change between top of bank and top of toe)/(Station change between top of bank and top of toe). Convert this number to degrees.
3. The toe angle (ta_{ob}, ta_{str}) is calculated by taking the ArcTAN of the (elevation change between top of toe and the bottom of toe)/(Station change between top of toe and bottom of toe). Convert this number to degrees.
4. Toe length (tl_{ob}, tl_{str}) is calculated by taking the square root of ((Change in toe elevation)^2+ (Change in station between bottom and top of toe)^2).

Mannings n

Table 5 provides a collection of recommended Manning's n values for the SLRT user. Technically, the roughness values will differ depending upon discharge, with higher flow perhaps experiencing higher resistance due to greater interaction with vegetated banks. Because relative roughness varies with depth, it is recommended that the user estimate n values at bankfull conditions for the reach of interest. Pre-restoration condition should be represented based on bed substrate and the vegetation density to reflect the conditions of the decade prior to restoration. Similarly the SLRT user should determine the post-restoration Manning's *n* value as the reasonable expectation of vegetation density 10 years post-restoration. All assumptions by the user to justify these determinations should be documented. Note that BSTEM results are highly sensitive to the Manning's value used. In most applications of BSTEM for SLRT to date on Tahoe south shore SEZs, a value of 0.03 has been used unless extensive manual bank hardening was present.

Example BSTEM Bank Geometry



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BSTEM BANK GEOMETRY

FIGURE 3

Table 5. Recommended Manning's *n* values for input to SLRT. Recommended values based on information provided in http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm, http://www.fhwa.dot.gov/bridge/wsp2339.pdf and A. Simon (2013 pers. comm). To be consistent with BSTEM inputs, Manning's values should only be provided to the nearest hundredth.

Vegetation Density	Channel dominant substrate type				Vegetation density comments
	Coarse sand	Firm soil (i.e. clay bed)	Gravel	Cobble	
None	0.03	0.03	0.04	0.05	A channel with no vegetation
Low	0.03	0.04	0.05	0.06	Turf grass/weeds; young flexible tree seedlings; no vegetation on channel bed
Medium	0.04	0.05	0.05	0.06	Brushy, moderately dense vegetation (e.g., 1-to-2-year-old willow trees in the dormant season) growing along the banks, with no significant vegetation evident on channel bed.
High	0.04	0.06	0.06	0.08	E.g., 8-to-10-years-old willow or cottonwood trees with some weeds and brush.

FSP content of banks

The objective of the sediment load reduction tool is to evaluate the potential reduction in fine sediment particle loads (< 16µm) to the lake, the amount of FSP in the banks is an important input parameter. The SLRT user can either:

1. Utilize the recommended FSP (< 16µm) % of Tahoe bank materials in SLRT based on the frequency distributions derived from previously sampled Tahoe bank materials by USDA, ARS-National Sedimentation Laboratory (NSL) (Simon et al., 2003) or,
2. Directly sample and analyze a collection of representative bank material samples from the SEZ.

The regional averages of the % silt/clay of bank material samples obtained from 63 streams within the Tahoe Basin (Simon et al 2003) are presented in Table 6. Tools supporting the Lake Tahoe TMDL estimate the fraction of stream derived silt/clay material that is < 16µm to be on the order of 20%, and used to estimate the % of bank materials by region that are < 16µm in size. Based on the regional location of the SEZ, the SLRT template auto-populates the FSP:BS (% of the bank materials < 16 µm) using the FSP:BS values in Table 6.

Should the user choose to sample the SEZ directly the user should obtain a distribution of samples from both the bank face and internal bank material from a series of locations that are susceptible to erosion. Both outer meander bend and straight reaches should be sampled. The samples should be submitted to a geotechnical laboratory and analyzed for % of material < 16 µm. The average value can then be directly entered into the SLRT USER INPUT sheet for the FSP:BS value.

Table 6. Bank material % silt + clay and % < 16 µm by region.

Grain size	REGION			
	East	Northwest, North & Northeast	Southwest & Southeast	West
% silt and clay (Simon et al 2003)	4.0	3.3	8.7	8.1
% < 16 µm (FSP:BS)	0.8	0.7	1.7	1.6

Channel Capacity (Q_{cc})

Channel capacity will vary throughout a subject reach so it recommended that the user obtains a series of Q_{cc} estimates and integrates the values in a manner that will generate a representative average. SLRT requires channel capacity to be entered into SLRT as cubic feet per second rather than meters per second. Various hydraulic models will provide Q_{cc} estimates based on user inputs and where models are available this approach is recommended to estimate the channel capacity. Below we provide guidance to manually estimate Q_{cc} using available cross sections and the Manning's equation.

1. Select a representative cross section(s) for the reach, preferably at riffle or run locations, rather than a pool as pools will overestimate the capacity of the reach during flood conditions.
2. Calculate cross sectional area (A_{xs}) at channel capacity (top of banks) in units of ft^2.
3. Calculate wetted perimeter (WP) at channel capacity (top of banks) (ft) which is the total length of the channel in contact with water. The WP of a trapezoidal channel is simply the length of each bank plus the width of the bed. As the geometry of the channel is more complex (like a surveyed cross-section) a series of distance formulas can be found on the internet to obtain the appropriate distance formula along cross section.
4. Calculate slope (s) of reach within which each cross section exists by measuring the elevation difference between the start/end of the reach and divide by the measured channel length (aerial photo or GIS or survey).
5. Using Table 5, estimate Manning's n value for stream channel within reach (dimensionless).
6. Calculate velocity (*v*) at channel capacity (top of banks) using Manning's equation where:
   Velocity (ft/sec) = (1.486/n) x (A/WP)^$^{0.66}$ * $s^{0.5}$
7. Calculate discharge (cfs) at channel capacity where: $Q_{cc} = v * A_{xs}$
8. If multiple cross sections were selected, then average all Q_{cc} values to generate a reach wide channel capacity estimate.

Floodplain condition

Determining the relative floodplain condition is based on three characteristics: average stage to discharge relationship once flows exceed the channel capacity and access the floodplain, topographic complexity of the floodplain; vegetation density, distribution and height of the vegetation on the floodplain. Of the three criteria, the most critical is the stage to discharge relationship as flows on the floodplain incrementally exceed the defined channel capacity. The stage to discharge relationship of the floodplain surface is controlled by the morphology of the floodplain, where a functional floodplain results in incremental increases in effective depth as discharge increases. A stage to discharge rating curve can be developed if data is available, and a desired shape of the rating curve is asymptotic showing a reduction in the slope of water depth as a function of discharge as soon as channel capacity is exceeded. This shape would suggest a vertically expansive floodplain and subsequently relative low effective depths for flows between the channel capacity and 3 times that discharge. In contrast, an inset or constrained floodplain surface or a relatively short length of channel modifications will have a much greater rate of increasing floodplain depth as a function of discharge. In these instances, it is expected the FSP retention coefficient will be relatively low even at relatively smaller overbank flow conditions (i.e. less than 2 times Q_{cc}).

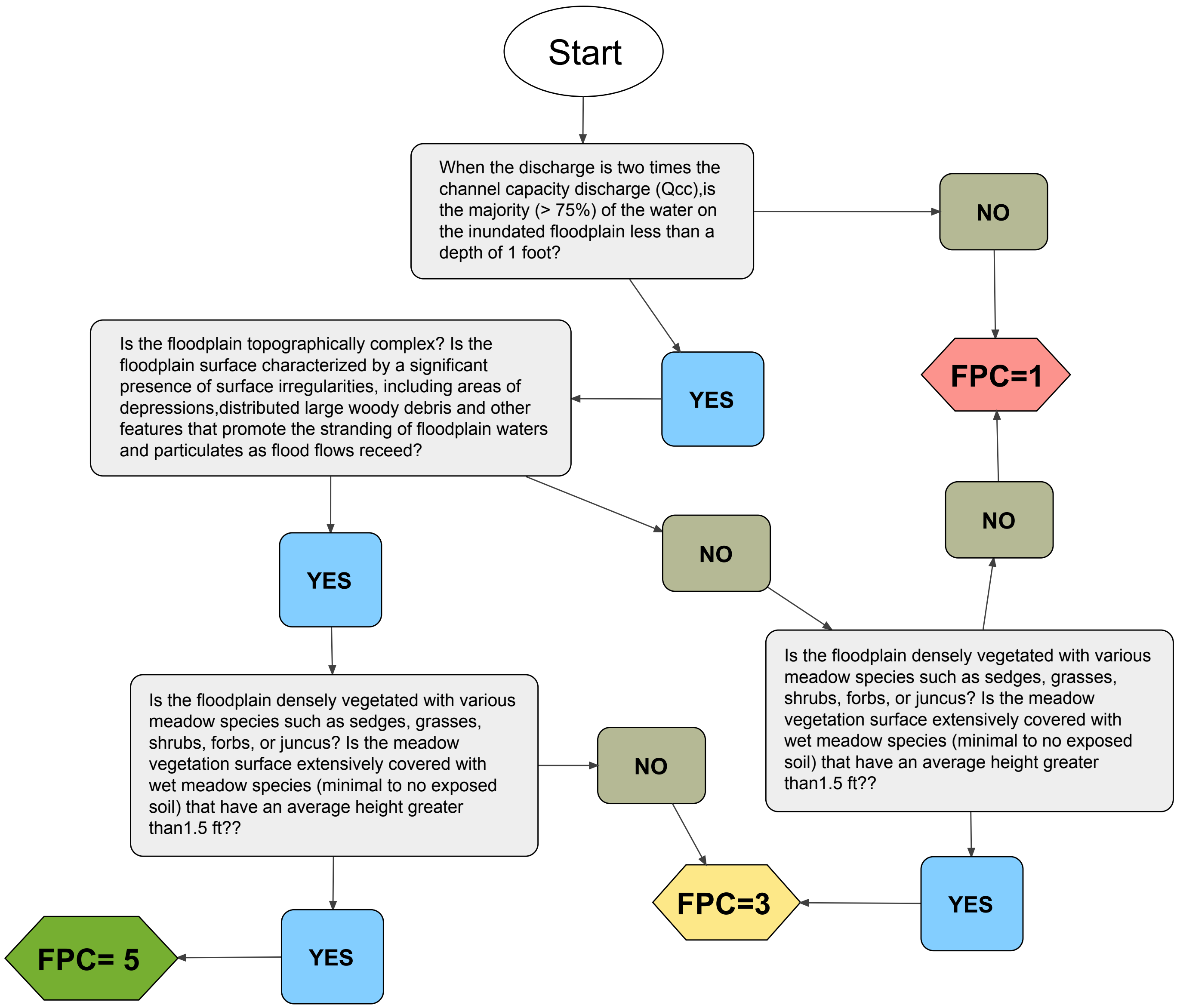
Topographic complexity, such as surface irregularities, wood and other features, increase roughness of the floodplain surface and reduce the effective velocity of flood waters, and as flows recede the low spots and flow barriers can strand and store sediment-laden waters. Vegetation density, as well as spatial and vertical distribution, also reduce flow velocities and provide surfaces to which FSP can adhere, and vegetation density has a much greater influences on FSP retention when flow depths are below the vegetation height and flow velocities on the floodplain do not result in flattening the vegetation. It must be noted that the measured retention coefficients were developed by evaluating two low gradient well vegetated stream systems with optimal stage to discharge relationships when overbank. The retention coefficient curves as a function of floodplain condition for moderate or poor floodplain condition are based on the theoretical understanding of floodplain function, available data and best professional judgment (2NDNATURE 2013).

Figure 4 is a decision tree to guide SLRT users through these criteria to determine the floodplain condition score (FPC) for input into SLRT. As a general rule, if the floodplain topographic complexity, vegetation community and stage to discharge do not all align with a single condition, assign the condition best represented by two of the three factors. Figure 5 provides visual examples of topographic complexity and vegetation structure. Table 7 provides additional guidance to select the appropriate floodplain condition (FPC) score.

Given the expected improvement of floodplain condition over time following restoration actions, if SLRT is applied when the subject SEZ has been restored but is less than a decade post-restoration, it is suggested the user reasonably estimate the expected floodplain condition 10 years post-restoration. The user will need to document cause and effect assumptions associated with how the specific restoration configuration and actions reasonably support the future FPC vision. Documentation of restoration actions, such as placement of woody debris on the floodplain or channel/floodplain revegetation efforts that are assumed to lead to future assigned floodplain condition, should also be included.

Table 7. SLRT user considerations of floodplain characteristics representative of floodplain condition (FPC).

FPC Score	Condition	Stage to discharge relationship	Topographic complexity	Vegetation community
1	Poor	Water depth on the floodplain increases rapidly as a function of increasing discharge. Typical of an inset floodplain or other configuration where lateral migration of overbank flow is constrained.	Minimal: simplified floodplain surface.	Sparse: typical of a meadow with low soil moisture and drought tolerant plant species. Bare dry soil present in summer.
3	Fair	Moderate lateral or longitudinal floodplain confinement, where perhaps lower flood flows have shallow depths on floodplain but for flows greater than 2 time Q_{cc}, water depth rapidly increases with increasing discharge.	Moderate	Intermediate
5	Good/ desired	Incremental increase in floodplain depth as discharge increases due to little lateral confinement of overbank flows. Water depth on floodplain remain below 2 ft for flows approaching 3 times Q_{cc}.	High: characterized by presence of large wood, surface irregularities and other features that promote water and particulate stranding.	Dense: well vegetated with meadow species such as grasses, sedge, willows, etc. Coverage is extensive with little to no unvegetated areas.



The floodplain condition (FPC) for each site assesses 3 specific characteristics of the floodplain dynamics that contribute to fine sediment retention during overbank events. The decision tree above asks a series of 'Yes' or 'No' questions that will produce a FPC score of 1, 3, or 5, with 5 representing optimal conditions and 1 representing the poor floodplain conditions to retain FSP.

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FLOODPLAIN CONDITION SCORE DECISION TREE

FIGURE 4

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TOPOGRAPHIC COMPLEXITY AND VEGETATION STRUCTURE

FIGURE 5

BANK UNIT EROSION RATES

The final SLRT input requirements in the *USER INPUT* worksheet (*SLRTv2_Template.xlsx*) are unit erosion rates obtained using BSTEM Dynamic. Prior to initiating the tasks outlined below, the user should ensure all of the required META DATA, CATCHMENT CHARACTERISTICS and SEZ ATTRIBUTE inputs have been populated in the SLRT USER INPUTS tab for both pre and post restoration conditions.

The BSTEM Dynamic outputs are used by SLRT to estimate the average annual FSP loads generated from channel erosion for each pre and post restoration scenario. The user may need to run BSTEM-Dynamic up to a maximum of 16 times per Table 8 to obtain an SLRT load reduction estimate. Since the magnitude of bank erosion significantly reduces with discharge, the user should obtain bank erosion rates sequentially, beginning with the higher flow probabilities (i.e., 99th percentile). Should any BSTEM results be < 0.0000 m^3/m/yr the remaining lower flow conditions need not be modeled. Should the results of a specific flow condition indicate negligible bank erosion for the bend or straight reach, a value of 0 is be assumed for the remaining smaller annual hydrographs for that specific morphology.

Table 8. BSTEM-Dynamic model runs for SLRTv2 are completed sequentially from high to low flow conditions. Should a specific morphology result in <0.0000 m/m of may eliminate the need for lower percentile analyses.

Percentile	Pre-Restoration		Post-Restoration	
	Outer Bend	Straight Reach	Outer Bend	Straight Reach
99th	x	x	x	x
75th	If necessary	If necessary	If necessary	If necessary
50th	If necessary	If necessary	If necessary	If necessary
25th	If necessary	If necessary	If necessary	If necessary

The obtainment of BSTEM Dynamic OUTPUT values requires the user to populate all of the required input fields in the USER INPUT tab with only the BSTEM Dynamic OUTPUT values remaining blank. Once the SLRT USER INPUT sheet is complete, each BSTEM Dynamic OUTPUT value is obtained by 4 steps. It is recommended that the user begin with estimating the unit erosion rate for 99th percentile flows for the pre and post restoration scenarios and then continue sequentially with the next highest annual hydrograph. The guidance below takes the user through the process required to obtain the pre-restoration straight 99th percentile unit erosion rates.

The same steps to run BSTEM Dynamic are repeated for all other morphology and flow conditions.

1. Extract the site specific annual hydrographs
2. Translate the annual hydrographs of discharge to stage time series
3. Set up Dynamic BSTEM for model run
4. Run Dynamic BSTEM
5. Validate Dynamic BSTEM results

1. Extract the site specific annual hydrographs

SLRT auto generates 4 annual hydrographs that drive the BSTEM Dynamic hydrology introduced to the site cross sections. Go to the HYD FSP IN tab and locate the mean daily hydrographs in Column V to obtain the daily discharge representing the 99th percentile flow conditions estimated at the site (Q_{md-99}). This data is a direct input to the *NDA_SLRTTemplate.xlsx (Figure 6)* which translates the daily discharge to daily stage at the site, step 2.

NORMAL DEPTH APPROXIMATION (NDA) TEMPLATE

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A. ANNUAL HYDROGRAPH INPUTS FROM SLRT HYD FSP IN WORKSHEET

	R	S	T	U	V
1					
2					
3					
4	ANNUAL PERCENTILE HYDROGRAPHS				
5	DAY OF YEAR	Q_{md-25} (m^3/s)	Q_{md-50} (m^3/s)	Q_{md-75} (m^3/s)	Q_{md-99} (m^3/s)
6	1-Oct	0.14	0.23	0.34	0.52
7	2-Oct	0.14	0.23	0.34	0.52
8	3-Oct	0.14	0.24	0.35	0.52
9	4-Oct	0.14	0.23	0.32	0.51
10	5-Oct	0.14	0.23	0.36	0.50
11	6-Oct	0.15	0.23	0.36	0.50
12	7-Oct	0.15	0.23	0.34	0.50
13	8-Oct	0.15	0.22	0.33	0.49
14	9-Oct	0.14	0.22	0.33	0.48

B. INSTRUCTIONS WORKSHEET

	A	B	C	D	E	F	G
1	**STEPS:**						
2	1. Enter Site name in Cell A1						
3	2. Enter FULL cross-section in cells A3, B3 onwards. The data must be listed in ascending order by x (column A)						
4	3. Enter top bank elevation for left and right banks in cells E14 and E15 below.						
5	4. Edit Cell C1 so that the slope is that of your study reach.						
6	5. Copy and paste daily discharge values for your flow year into column R						
7	6. Execute the FlowArea macro and then the WettedPerimeter Macro (the order doesn't actually matter).						
8							
9							
10							
11							
12							
13		MINIMUM ELVATION			0.000		
14		TOP BANK ELEVATION LEFT BANK			0.3048		
15		TOP BANK ELEVATION RIGHT BANK			0.3048		
16		INCREMENTS OF STAGE INCREASE			0.003		
17							

C. X-SEC WORKSHEET

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Bristlecone Pre	SLOPE	0.008					Q (for given n)							
2	x	y		Stage (increment	Area	W.P.	R	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
3	0	0.3048		0.003048	0.002796	0.921764	0.003034	0.000175	0.000131	0.000105	8.74E-05	7.49E-05	6.55E-05	5.82E-05	5.24E-05
4	0.3048	0.3048		0.006096	0.005611	0.929137	0.006039	0.000555	0.000416	0.000333	0.000277	0.000238	0.000208	0.000185	0.000166
5	0.6096	0		0.009144	0.008445	0.936521	0.009017	0.001091	0.000818	0.000654	0.000545	0.000467	0.000409	0.000364	0.000327
6	1.524	0		0.012192	0.011297	0.943914	0.011968	0.001762	0.001322	0.001057	0.000881	0.000755	0.000661	0.000587	0.000529
7	1.8288	0.3048		0.01524	0.014168	0.951318	0.014893	0.002557	0.001918	0.001534	0.001278	0.001096	0.000959	0.000852	0.000767
8	2.1336	0.3048		0.018288	0.017057	0.95873	0.017791	0.003466	0.002599	0.002079	0.001733	0.001485	0.0013	0.001155	0.00104
9				0.021336	0.019965	0.966153	0.020664	0.004482	0.003362	0.002689	0.002241	0.001921	0.001681	0.001494	0.001345
10				0.024384	0.022891	0.973585	0.023512	0.005601	0.004201	0.003361	0.002801	0.002401	0.002101	0.001867	0.00168
11				0.027432	0.025836	0.981026	0.026336	0.006818	0.005114	0.004091	0.003409	0.002922	0.002557	0.002273	0.002046
12				0.03048	0.0288	0.988477	0.029136	0.00813	0.006098	0.004878	0.004065	0.003484	0.003049	0.00271	0.002439
13				0.033528	0.031782	0.995937	0.031912	0.009533	0.00715	0.00572	0.004767	0.004086	0.003575	0.003178	0.00286
14				0.036576	0.034783	1.003405	0.034665	0.011025	0.008269	0.006615	0.005513	0.004725	0.004134	0.003675	0.003308
15				0.039624	0.037802	1.010883	0.037395	0.012603	0.009453	0.007562	0.006302	0.005401	0.004726	0.004201	0.003781
16				0.042672	0.04084	1.01837	0.040103	0.014266	0.010699	0.00856	0.007133	0.006114	0.00535	0.004755	0.00428
17				0.04572	0.043897	1.025866	0.04279	0.016011	0.012008	0.009607	0.008005	0.006862	0.006004	0.005337	0.004803
18				0.048768	0.046972	1.03337	0.045455	0.017837	0.013378	0.010702	0.008918	0.007644	0.006689	0.005946	0.005351
19				0.051816	0.050065	1.040883	0.048099	0.019742	0.014806	0.011845	0.009871	0.008461	0.007403	0.006581	0.005923
20				0.054864	0.053178	1.048405	0.050722	0.021725	0.016294	0.013035	0.010862	0.009311	0.008147	0.007242	0.006517
21				0.057912	0.056309	1.055935	0.053326	0.023784	0.017838	0.014271	0.011892	0.010193	0.008919	0.007928	0.007135
22				0.06096	0.059458	1.063474	0.055909	0.025919	0.019439	0.015552	0.01296	0.011108	0.00972	0.00864	0.007776
23				0.064008	0.062626	1.07102	0.058473	0.028129	0.021096	0.016877	0.014064	0.012055	0.010548	0.009376	0.008439
24				0.067056	0.065813	1.078576	0.061018	0.030411	0.022809	0.018247	0.015206	0.013033	0.011404	0.010137	0.009123
25				0.070104	0.069018	1.086139	0.063544	0.032767	0.024575	0.01966	0.016383	0.014043	0.012288	0.010922	0.00983
26				0.073152	0.072241	1.09371	0.066052	0.035194	0.026395	0.021116	0.017597	0.015083	0.013198	0.011731	0.010558
27				0.0762	0.075484	1.10129	0.068541	0.037692	0.028269	0.022615	0.018846	0.016154	0.014134	0.012564	0.011307
28				0.079248	0.078745	1.108877	0.071013	0.04026	0.030195	0.024156	0.02013	0.017254	0.015097	0.01342	0.012078
29				0.082296	0.082024	1.116472	0.073467	0.042897	0.032173	0.025738	0.021449	0.018384	0.016086	0.014299	0.012869

	P	Q	R	S	T	U	V	W	X	Y	Z
1						STAGE (use if lowest value in crossection >0)					
2		Date	Q (cms)	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
3		10/1/1999	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4		10/2/1999	0.03	0.067	0.079	0.091	0.101	0.110	0.119	0.128	0.137
5		10/3/1999	0.00	0.021	0.024	0.027	0.030	0.034	0.037	0.040	0.043
6		10/4/1999	0.02	0.052	0.061	0.070	0.076	0.085	0.091	0.098	0.107
7		10/5/1999	0.03	0.058	0.070	0.079	0.088	0.098	0.107	0.113	0.122
8		10/6/1999	0.00	0.018	0.024	0.027	0.030	0.034	0.037	0.040	0.043
9		10/7/1999	0.00	0.018	0.021	0.024	0.027	0.030	0.034	0.034	0.037
10		10/8/1999	0.01	0.037	0.046	0.052	0.058	0.064	0.067	0.073	0.079
11		10/9/1999	0.02	0.046	0.055	0.064	0.070	0.076	0.082	0.088	0.094
12		10/10/1999	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13		10/11/1999	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14		10/12/1999	0.01	0.021	0.027	0.030	0.034	0.037	0.040	0.043	0.046
15		10/13/1999	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16		10/14/1999	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17		10/15/1999	0.02	0.058	0.067	0.076	0.085	0.094	0.104	0.110	0.119
18		10/16/1999	0.00	0.021	0.024	0.027	0.030	0.034	0.037	0.040	0.043
19		10/17/1999	0.04	0.082	0.098	0.113	0.125	0.137	0.146	0.158	0.168
20		10/18/1999	0.00	0.021	0.024	0.027	0.030	0.034	0.037	0.040	0.043
21		10/19/1999	0.04	0.082	0.098	0.110	0.125	0.134	0.146	0.158	0.168
22		10/20/1999	0.00	0.018	0.024	0.027	0.030	0.034	0.037	0.040	0.040
23		10/21/1999	0.00	0.018	0.021	0.027	0.030	0.034	0.034	0.037	0.040
24		10/22/1999	0.00	0.021	0.024	0.027	0.030	0.034	0.037	0.040	0.043
25		10/23/1999	0.07	0.104	0.122	0.140	0.158	0.171	0.186	0.198	0.213
26		10/24/1999	0.02	0.052	0.064	0.073	0.079	0.088	0.094	0.104	0.110
27		10/25/1999	0.02	0.046	0.055	0.064	0.070	0.079	0.085	0.091	0.098
28		10/26/1999	0.02	0.055	0.064	0.073	0.082	0.088	0.098	0.104	0.110
29		10/27/1999	0.03	0.064	0.076	0.088	0.098	0.107	0.116	0.125	0.134

	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ
1						DEPTH (use if lowest values in crossection = 0)				
2		Q (cms)	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
3		0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4		0.031	0.067	0.079	0.091	0.101	0.110	0.119	0.128	0.137
5		0.005	0.021	0.024	0.027	0.030	0.034	0.037	0.040	0.043
6		0.020	0.052	0.061	0.070	0.076	0.085	0.091	0.098	0.107
7		0.025	0.058	0.070	0.079	0.088	0.098	0.107	0.113	0.122
8		0.004	0.018	0.024	0.027	0.030	0.034	0.037	0.040	0.043
9		0.004	0.018	0.021	0.024	0.027	0.030	0.034	0.034	0.037
10		0.012	0.037	0.046	0.052	0.058	0.064	0.067	0.073	0.079
11		0.017	0.046	0.055	0.064	0.070	0.076	0.082	0.088	0.094
12		0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14		0.005	0.021	0.027	0.030	0.034	0.037	0.040	0.043	0.046
15		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16		0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17		0.024	0.058	0.067	0.076	0.085	0.094	0.104	0.110	0.119
18		0.005	0.021	0.024	0.027	0.030	0.034	0.037	0.040	0.043
19		0.044	0.082	0.098	0.113	0.125	0.137	0.146	0.158	0.168
20		0.005	0.021	0.024	0.027	0.030	0.034	0.037	0.040	0.043
21		0.044	0.082	0.098	0.110	0.125	0.134	0.146	0.158	0.168
22		0.004	0.018	0.024	0.027	0.030	0.034	0.037	0.040	0.040
23		0.004	0.018	0.021	0.027	0.030	0.034	0.034	0.037	0.040
24		0.005	0.021	0.024	0.027	0.030	0.034	0.037	0.040	0.043
25		0.065	0.104	0.122	0.140	0.158	0.171	0.186	0.198	0.213
26		0.021	0.052	0.064	0.073	0.079	0.088	0.094	0.104	0.110
27		0.017	0.046	0.055	0.064	0.070	0.079	0.085	0.091	0.098
28		0.022	0.055	0.064	0.073	0.082	0.088	0.098	0.104	0.110
29		0.030	0.064	0.076	0.088	0.098	0.107	0.116	0.125	0.134

NDA TEMPLATE TAB

Figure 6

2. Translating discharge to stage

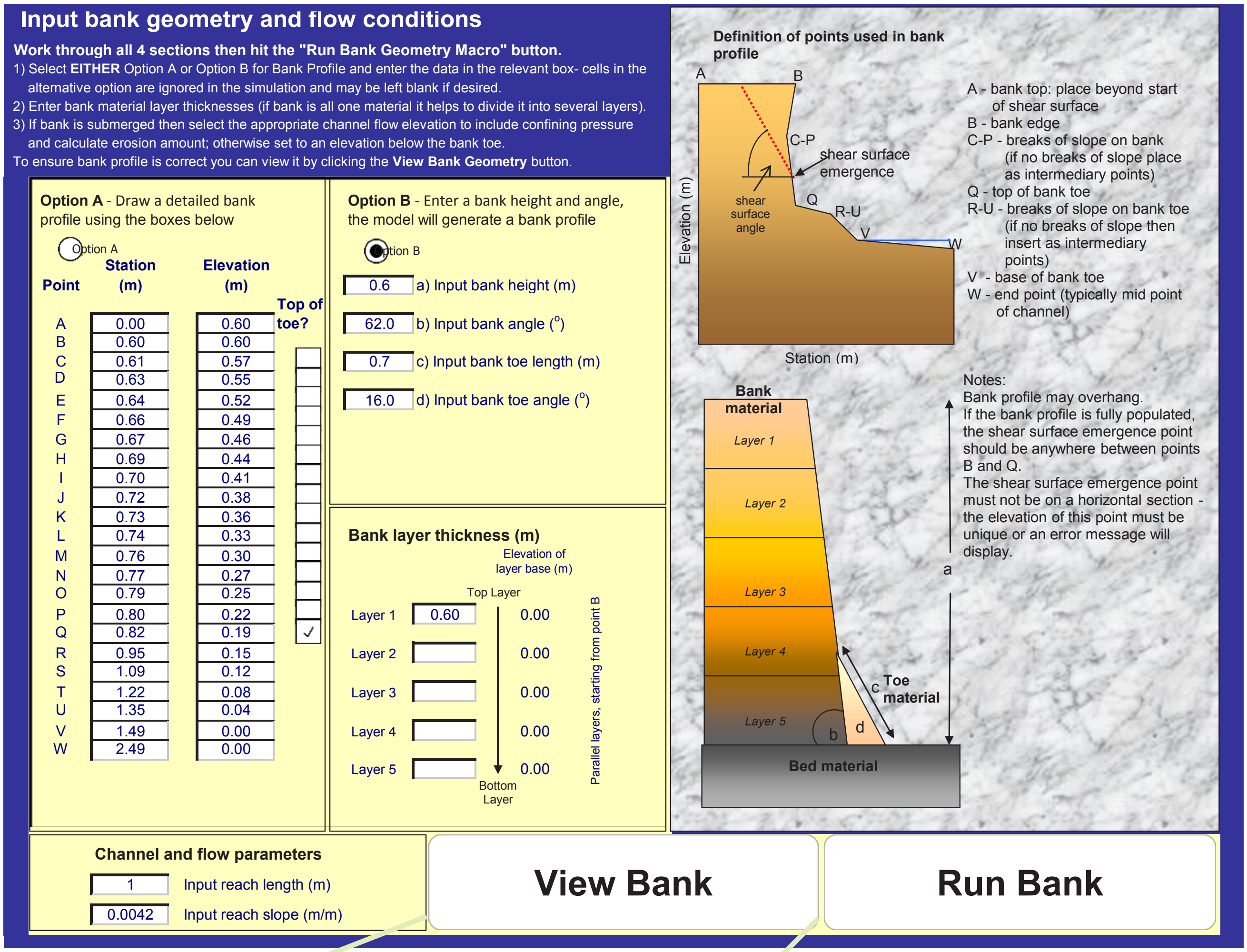
- Open NDA_SLRTTemplate. xlsm and enable macros. *INSTRUCTION* worksheet provides instructions.
- Save the NDA_SLRTemplate. xlsm with the following format; spreadsheet name, Site Name, Pre or Post restoration, bend or straight reach, annual percentile hydrograph (*e.g. NDA_Trout Creek_Pre_bend_99. xlsm*)
- In *INSTRUCTION* worksheet (Figure 6B):
  - Enter the top bank elevation for the left and right bank in cells E14, E15 (flow cannot exceed the lower of these two values without going out of bank). The top bank elevation is usually noted in the representative cross section. Use the same values that were used to calculate bank heights (h_{ob}, h_{str}) for the BSTEM Inputs.
- In *X-SEC* worksheet (Figure 6C):
  - Enter representative cross-section data (as x-y coordinates in meters) into columns A and B, starting in A3, B3. This will provide stage values over the range of elevations provided and for a range of Manning's roughness coefficients (n-values). The cross section data is automatically graphed in rows 104-125.
  - Enter channel slope (m/m) in cell C1. Value is populated in SLRT USER INPUTS C18;
  - Enter daily discharge values from the annual percentile hydrographs (Figure 6A) in Column R (highlighted in blue). Start by using the 99th percentile hydrograph for the bend reach.
- Run the two workbook macros. This is done by selecting View Macros in this workbook. The two macros are "FlowArea "and "NDA_SLRTTemplate.xlsm!WettedPerimeter" and can be run in either order. The calculated stage values will be used later as inputs into the calculations tab of BSTEM_Dynamic. The stage time series values have been created for a range of manning's numbers for the 99th percentile hydrograph within the straight reach pre-restoration condition.
- The remaining hydrographs (25th, 50th, 75th) can be created by pasting the Annual Percentile Hydrographs from the SLRTv2.xlsx HYD FSP IN page into column R of the NDA_SLRTTemplate.xlsx. The values for stage and depth will update automatically.

3. Setup BSTEM-Dynamic

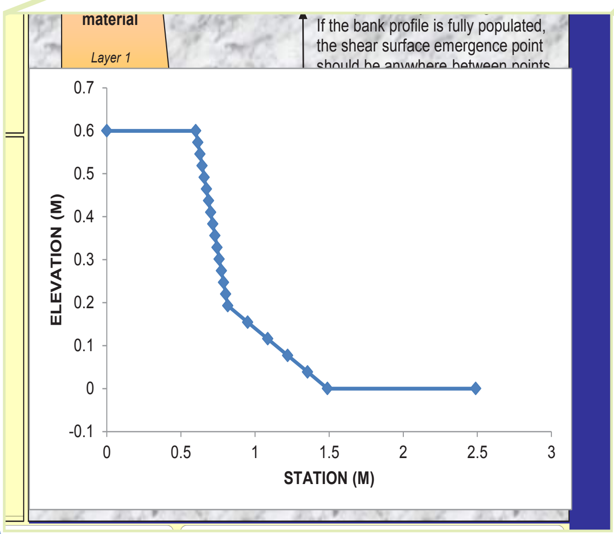
For each model run, the user will setup the BSTEM-Dynamic file as follows. For this example, we will describe instructions for how to model pre-restoration, outside bend 99th percentile flow conditions for Trout Creek.

Method:
- Open *BSTEM_Dynamic_Template.xlsm* and enable macros.
- Save BSTEM_Dynamic_Template.xlsm in folder a specific to the reach in a format that will describe the simulation. (*e.g. BSTEM_Dynamic_TroutCreek_Pre_Bend_99.xlsm*)
- In *INPUT GEOMETRY* worksheet (Figure 7):
  - Select option B and enter the following bank geometry data from SLRTv2 *USER INPUTS* worksheet to each empty cell beneath option B.
    - a) Input bank height – Bend bank height (h_{ob})
    - b) Input bank angle – Bend bank angle (a_{ob})
    - c) Input bank toe length – Bend toe angle (tl_{ob})
    - d) Input bank toe angle – Bend toe angle (ta_{ob})

BSTEM INPUT GEOMETRY



Point	Station (m)	Elevation (m)	Top of toe?
A	0.00	0.60	
B	0.60	0.60	
C	0.61	0.57	
D	0.63	0.55	
E	0.64	0.52	
F	0.66	0.49	
G	0.67	0.46	
H	0.69	0.44	
I	0.70	0.41	
J	0.72	0.38	
K	0.73	0.36	
L	0.74	0.33	
M	0.76	0.30	
N	0.77	0.27	
O	0.79	0.25	
P	0.80	0.22	
Q	0.82	0.19	✓
R	0.95	0.15	
S	1.09	0.12	
T	1.22	0.08	
U	1.35	0.04	
V	1.49	0.00	
W	2.49	0.00	



After running the "Run Bank" macro, a bank profile the user will be automatically be moved to the next worksheet. The user has the option to return to the *Input Geometry Worksheet* and select the "View Bank" macro. This creates a bank profile of the "Option B" input geometry that can be used to verify that bank attributes are correct.

- Under bank layer thickness, enter the input bank height value for layer 1 thickness adjacent layer 1. Values on the right side of inputs should automatically change to 0 when layer 1 is changed to equal input bank height.
- In the "Channel and flow parameters" enter 1 for input reach length to signify desired output of m^3 per 1 meter) and input the reach slope (m/m) from *SLRTv2 USER INPUTS*.
- Once all the information is entered select "Run Bank Geometry". A dialogue box pops up with a preset of 2 as the initial index of the top bank point. Select "OK" and the macro automatically moves the user to the BANK MATERIAL tab.
- Select the *INPUT GEMOETRY* worksheet and click on the "View Bank Geometry" button to ensure bank geometry is correct.

• In *BANK MATERIAL* worksheet (Figure 8):

Available data from the Tahoe Basin (Table 9 are used to provide recommended hydraulic resistance (for surface sediments) and geotechnical resistance (for in situ materials) resistance of the banks. If users desire, reach specific data can be obtained by direct field samples and submission to a geotechnical laboratory.

Table 9. Recommended bank and toe model inputs, based on analysis of Tahoe-specific data.

Material Descriptors (BSTEM Row #)	**Bank Model Input Data**				**Toe Model Input Data**	
	Friction angle φ' (degrees)	*Cohesion c' (kPa)*	*Saturated unit weight (kN/m³)*	*ϕ^b (degrees)*	τ_c (Pa)	*k* (cm^3/Ns)
Own data layer 1 (row 25)	30.9	3.80	17.1	10.0	3.00	0.645
Own data Bank Toe (row 35)	-	-	17.1	-	21.40	0.127

• For most SLRTv1 users, no data will be input into *GRAIN SIZE DISTRIBUTION* worksheet.
• For most SLRTv1 users, no data will be input into *BANK VEGETATION* worksheet. However, :

- If the user wishes to account for post-restoration root-reinforcement, Table 4.11 provides the estimated values for a typical Tahoe Basin species/vegetation types. The root-reinforcement value for the selected species is entered into cell I29.

Table 10. Estimated root-reinforcement values for typical Tahoe Basin species, 10-years post-channel restoration. Values obtained using the RipRoot algorithm, assuming a silt bank material, and a 1m rooting depth.

Species/ Vegetation type	Root-reinforcement (kPa)
Dry meadow grasses	1.36
Wet meadow grasses	1.90
Lodgepole pine	2.74
Geyer's willow	3.75
Lemmon's willow	2.22
Alder	2.09

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BSTEM BANK MATERIAL

Select material types (or select "own data" and add values below)

Bank Material					Bank Toe Material
Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	
Own data	Own data	Resistant si	Resistant si	Resistant si	Own data

Bank and bank-toe material data tables.

These are the default parameters used in the model. Changing the values or descriptions will change the values used when selecting soil types from the list boxes above. Add your own data using the white boxes.

Material Descriptors			Bank Model Input Data					Groundwater Model Input Data			Toe Model Input Data	
Bank material type	*Description*	*Mean grain size, D_{50} (m)*	*Friction angle ϕ' (degrees)*	*Cohesion c' (kPa)*	*Saturated unit weight (kN/m^3)*	*ϕ^b (degrees)*	*Chemical concentration (kg/kg)*	*Hydraulic Conductivity k_{sat} (m/s)*	*van Genuchten α (1/m)*	*van Genuchten n*	τ_c (Pa)	*k* (cm^3/Ns)
1	Boulders	0.512	42.0	0.0	20.0	15.0	-	1.745E-03	3.5237	2.3286	498	0.004
2	Cobbles	0.128	42.0	0.0	20.0	15.0	-	1.745E-03	3.5237	2.3286	124	0.009
3	Gravel	0.0113	36.0	0.0	20.0	15.0	-	3.160E-03	3.5237	2.3286	11.0	0.030
4a and 4b	Angular sand	0.00035	36.0	0.0	18.0	15.0	-	7.439E-05	3.5237	3.1769	Coarse (0.71 mm) or	
5a and 5b	Rounded sand	0.00035	27.0	0.0	18.0	15.0	-	1.130E-06	4.0563	2.3286	Fine (0.18 mm)	
6a, 6b and 6c	Silt	-	30.0	3.0	18.0	15.0	-	5.064E-06	0.6577	1.6788	Erodible (0.100 Pa),	
7a, 7b and 7c	Soft clay	-	25.0	10.0	18.0	15.0	-	9.473E-07	1.5812	1.4158	Moderate (5.00 Pa), or	
8a, 8b and 8c	Stiff clay	-	20.0	15.0	18.0	15.0	-	1.708E-06	1.4962	1.2531	Resistant (50.0 Pa)	
	Own data layer 1		30.9	3.80	17.1	10.0		5.064E-06	0.6577	1.6788	3.000	0.645
	Own data layer 2		30.9	3.80	17.1	10.0		5.064E-06	0.6577	1.6788	21.400	0.127
9	Own data layer 3											
	Own data layer 4											
	Own data layer 5											
	Own data Bank Toe				17.1						21.40	0.127

Need to know the critical shear stress (τ_c) ?		Need to know the erodibility coefficient (*k*) ?		
Input non-cohesive particle diameter (mm)	1.000	Input critical shear stress τ_c (Pa)	3.000	
Critical Shear Stress τ_c (Pa)	0.71	Erodibility Coefficient (cm^3/Ns)	0.645	0.037529331

BSTEM "BANK MATERIAL" TAB

Figure 8

- In *CALCULATION* worksheet (Figure 9):
  - Dates and values for the one-year depth series (from the *NDA_Trout Creek_Pre_bend_99. xlsm*) will be input in columns A and B, rows 66 onwards (these cells are highlighted in blue). Rows 66 downward should be empty for all columns in this worksheet prior to data being added. Delete values in all rows below row 65 as necessary.
  - Copy the date values starting in column Q3 *X-SEC* worksheet of *NDA_Trout Creek_Pre_bend_99*. xlsm and paste into cell A66 downward.
  - Select stage or depth data. If the lowest value in the cross section (column B) in the *X-SEC* worksheet is greater than 0, the stage values (columns S-Z in *X-SEC* worksheet) should be used instead of the depth (columns AC-AJ in *X-SEC* worksheet).
  - Select appropriate column based on the appropriate Manning's n value for the study reach (see Table 5 for guidance; enter value in SLRTv2 *USER INPUTS*). For either stage or depth, the columns correspond to various Mannings n values as shown in row 2. Select the data column associated the appropriate Manning value and copy from row 3 downward and paste into cell B66 downward. For this example we would select column S from the *NDA_Trout Creek_Pre_bend_99. xlsm*.

4. Run BSTEM-Dynamic

Now that the BSTEM files are populated with the correct input data, follow these steps to run the model.

Data requirements:

- Manning's n (from SLRTv2 *USER INPUTS*)
- Location of bank edge (from cross section data)
- Initial Groundwater elevation (set equal to the initial Stage/Depth)

Method:

- In *RUN MODEL* worksheet:
  - Click on the "RUN MODEL" button and follow prompts (Figure 10), including:
    - which x,y point represents bank top-edge (when using "Option B in the Input Geometry worksheet, accept default value of "2"),
    - Manning's n value (from SLRTv2 *USER INPUTS*)
    - The range of dates to be analyzed (CALCULATIONS select cell A66 downward)
    - Groundwater elevation depth should be changed. Set as the "in-channel water surface elevation" provided at the bottom of the dialogue box. (should be equal to the Stage/Depth value in cell B 66 of the *Calculations* worksheet. See Figure 9)
    - Once all prompts are answered, model will likely take anywhere from30 seconds to 5 minutes to run.

Average annual volume of bank material eroded per meter of bank length (m^3/m/yr) for hydraulic, geotechnical and total erosion will be output on the CALCULATIONS page in Cell BJ58 (see Figure 9B), along with the initial and simulated bank geometries (see Figure 9C). The final unit erosion rates are also displayed in Cell A60 for simplicity (see Figure 9A). These values are entered into the *User Input* worksheet (*SLRTv2_Template.xlsx)* for the PRE 99th percentile bend reach (cell 50). As additional BSTEM runs are completed be sure to manually input the correct bank erosion rate for the appropriate scenario (pre- or post-restoration) and percentile flow (i.e., 99th, 75th, 50th, or 25th). Note: if the model results indicate that unit erosion rates are negligible (<0.0000), then no additional runs are necessary for the lower percentile flows. For example, if the post-restoration straight reach model for the 75th percentile flow yields unit erosion rate (e_{str-75}) <0.0000, then the 50th and 25th flows do not need to be modeled. However, the post-restoration outer bend simulations may still be necessary.

BSTEM CALCULATIONS

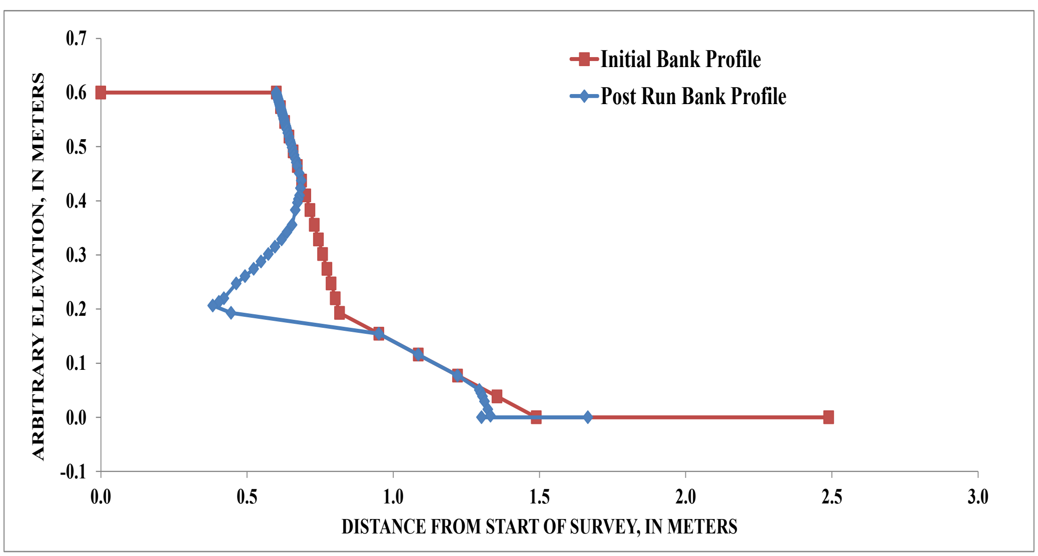
A. DEPTH TIME SERIES INPUTS & FINAL EROSION OUTPUT

	A	B	C
58			
59	**Unit Erosion Rates (m3/m/yr)**		
60	**0.0113808**		
61			Manning's n =
62	**Force Equilibrium Calculations**		
63	**Date and Time**	**Stage**	**Groundwater t**
64		**(m a.s.l.)**	**(m a.s.l.)**
65			
66	10/1/1999	0.000426	0.000425598
67	10/2/1999	0.0793	0.0793

B. HYDRAULIC, GEOTECHNICAL & TOTAL EROSION OUTPUTS

	BD	BE	BF	BG	BH	BI	BJ	BK	BL	BM
57										
58							**0.0113808**	-4.272034675		
59										
60						2.98				
61				0.0000000		0.477972603				0.0113808
62			**Bank Model**					**Toe Model**		
63	Failure base	Failure angle	Failure width	Failure volume	Sediment loading	**Average boundary shear stress**	Maximum Lateral Retreat	Eroded Area- Bank	Eroded Area- Toe	Eroded Area- Total
64	m	degrees	cm	m3	kg	**Pa**	cm	m2	m2	m2

C. INITIAL & SIMULATED BANK GEOMETRIES



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BSTEM "CALCULATIONS" TAB

Figure 9

BSTEM RUN MODEL

A. RUN MODEL WORKSHEET

Bank model output

Verify the bank material and bank and bank-toe protection information entered in the "Bank Material" and "Bank Vegetation and Protection" worksheets. Once you are satisfied that you have completed all necessary inputs, hit the "Run Bank-Stability Model" button.

Bank Material Properties

Layer 1	Layer 2	Layer 3	Layer 4	Layer 5
Own Data	Silt	Silt	Silt	Silt

Toe Model Output

Verify the bank material and bank and bank-toe protection information entered in the "Bank Material" and "Bank Vegetation and Protection" worksheets. Once you are satisfied that you have completed all necessary inputs, hit the "Run Toe-Erosion Model" button (Center Right of this page).

Bank Material Properties					Bank Toe Material	
Layer 1	Layer 2	Layer 3	Layer 4	Layer 5		
Own data	Resistant cohesive	Resistant cohesive	Resistant cohesive	Resistant cohesive	Own data	**Material**
3.00	50.00	50.00	50.00	50.00	21.40	**Critical shear stress (Pa)**
0.645	0.014	0.014	0.014	0.014	0.127	**Erodibility Coefficient (cm^3/Ns)**

Account for:

Effective stress acting on each grain ☑

Run Model!

B.TOP BANK POINT

Microsoft Excel

Enter the initial index of the top bank point

OK

Cancel

2

C. MANNINGS N

Input a value for Manning's n

Enter a cross-sectional average value for Manning's n.
Typical values range from 0.0156 to 0.2.

OK

Cancel

0.03

D. DATE RANGE

10/3/1999	0.23	0.22780821
10/4/1999	0.23	0.22780821
10/5/1999	0.23	
10/6/1999	0.22	
10/7/1999	0.22	
10/8/1999	0.22	
10/9/1999	0.22	
10/10/1999	0.22	
10/11/1999	0.22	
10/12/1999	0.22	0.21549425
10/13/1999	0.22	0.21549425
10/14/1999	0.22	0.21549425

Input

Select a range of dates that you want to model

$A$66:$A$918

OK

Cancel

E. STARTING GROUNDWATER ELEVATION

Stage/Depth (m a.s.l.)	Groundwater table (m a.s.l.)
0.23	0.22780821
0.23	0.22780821
0.23	0.22780821

Input an initial groundwater elevation

Please enter the initial groundwater elevation. The top of the bankis at an elevation of 0.6 m and the in-channel water surface is at an elevation of 0.228 m.

OK

Cancel

.228

5. Validate BSTEM-Dynamic Results

Once the 16 BSTEM-Dynamic runs have been completed for a selected reach, it is important to validate the results. Dynamic BSTEM is a complicated model that is sensitive a number of the input parameters. The following will help to determine whether the results from a run are a realistic model of the given stream reach by looking at specific results from completed models. It is important to consider the results BSTEM-Dynamic runs in the greater context of the SLRT before focusing too specifically on a single result.

The final erosion rate located in cell A60 in SLRT v2 CALCULATIONS tab only represent a single flow condition (i.e., 99th, 75th, 50th, or 25th percentile) for either the straight or bend bank profiles. The final SLRT v2 erosion rate for a stream reach integrates each percentile flow for both outside bend and straight reaches (Table 11). Once the USER INPUTS page of SLRT v2 has been populated, the SCEfsp tab of SLRT v2 auto generates a weighted value for the entire modeled stream section (Table 11). The trapezoid method is used to weight each erosion rate by its probability of occurrence so that lower probability (e.g. 99th) annual percentile hydrographs are appropriately represented in the average annual estimates. Cell S12 and S13 of the SCEfsp tab display the Ave Annual Load (MT/yr) and bank erosion rate (m^3/km) for pre restoration morphology. These values can be used to QA/QC initial BSTEM erosion rate outputs with other erosion data for a particular reach (e.g. repeated cross sections in the same location). The erosion rates for the 99th percentile flow are an estimate of the maximum erosion over an 18 yr time period. However, the probabilistically weighted values can be compared with other estimates of average bank erosion rates or loading (Table 11). Table 12 displays a range of representative BSTEM erosion rates in (m^3/km/yr) estimated for implemented or planned stream restoration projects on the Upper Truckee River and Trout Creek (2NDNATURE 2014) for comparison.

Table 11. Example of the trapezoid method being utilized to accurately weight erosion rates for entire reach.

BULK SEDIMENT							
PRE RESTORATION				POST RESTORATION			
Coordinates for Trapezoid Method				Coordinates for Trapezoid Method			
	x	y	Trapezoid		x	y	Trapezoid
1	0.00	0.00	15.51	1	0.00	0.00	27.14
2	0.25	124.04	88.84	2	0.25	217.15	98.61
3	0.50	586.64	202.18	3	0.50	571.76	204.30
4	0.75	1030.78	6494.24	4	0.75	1062.68	472.61
5	0.99	53087.92	530.88	5	0.99	2875.77	28.76
6	1.00			6	1.00		
Ave Annual Load (MT/yr)			**1466.33**	Ave Annual Load (MT/yr)			**166.29**
Bank Erosion Rate (m^3/km/yr)			**459.77**	Bank Erosion Rate (m^3/km/yr)			**52.14**

Running BSTEM models is an iterative process. We one option is to compare initial results of a single BSTEM run (e.g. 99th percentile) to a site or two with similar conditions where BSTEM Dynamic values exist (e.g. 2NDNATURE 2014 on 7 projects in the Upper Truckee River). If you seem to have values either much higher or lower than expected, a series of troubleshooting steps can be taken to improve the model.

Table 12. Input bank profile attributes and hydrology for 99th percentile flow for select bend reaches.

Predicted bank erosion rate (m^3/km/yr)		
Project	**PRE-RESTORATION**	**POST-RESTORATION**
UTR Sunset Reach 6	1.4	0.0
Angora Sewer	3.6	1.2
Trout Creek Upper	14.9	*3.84*
Angora SEZ	18.6	1.0
UTR Sunset Reach 5	61.0	9.4
UTR Middle Reach	237.1	28.5
UTR Golf Course	459.8	52.1

Another simple diagnostic is to graph the results of each BSTEM run. The DYNAMIC BSTEM model creates a new bank profile as erosion and the geometry after the model run can be graphed using the data in the *CALCULATIONS* tab. There are two common types of errors. The first is where erosion results are influenced by faulty input geometry. An example of this would be entering an input bank height that does not match the bank layer thickness. Any error, even as simple as incorrectly recording the reach slope, will completely change the output unit erosion rate. Another common issue is a complete unraveling of the bank, resulting in unit erosion rates of 2 to 3 orders of magnitude for the 99th percentile flow. This issue occurs when the entire toe is eroded away, and only the weak bank material remains. To fix this problem the bank can be modeled as two separate layers. Under the Bank Layer Thickness heading in the Input Geometry tab, give layer 2 a height equal to the top of toe elevation. Change layer 1 so that the entire bank thickness remains the same as the Input bank height (m). The parameters have already been input into the Bank Material page so that the second layer will have the bank parameters of the toe. Rerun option B and run the model again. It is critical that every row 64 down in the BSTEM CALCULATIONS tab is cleared and new dates and stage/depth values are pasted in prior to running the model again.

Once the user is confident in the BSTEM results, the contents of cell A60 of the BSTEM CALCULATIONS tab can be input into SLRT v2 template and all remaining SLRT estimates and calculations will be automatically generated.

Below provides a simple review of each the results summarized in SLRTv2.

CATCHMENT HYDROLOGY AND FSP LOADS

SLRTv2_Template.xlsx* worksheet: *HYD FSP IN

Using available data, SLRT provides default flow frequency datasets and annual hydrographs by region and catchment types that are adjusted based on catchment characteristics for the specific SEZ of interest. Once the SLRT user completes the required "catchment characteristics" user inputs (see Figure 1) in the SLRTv2_Template.xlsx, estimates of catchment hydrology in the appropriate formats necessary for SLRT are automatically generated and presented in HYD FSP IN worksheet. The average annual hydrologic estimates provided from SLRT are estimates based on limited datasets and clearly documented assumptions, and there are known deviations from the predicted and observed hydrology. The SLRT user is welcome to generate estimated average annual flow frequency distributions and the appropriate percentile annual hydrographs independently, but the SLRT method requires the use of same incoming hydrology for both pre-and post-restoration scenarios to estimate the average annual pollutant load reductions. In addition, it is recommended that the catchment hydrology used is based on, or comparable to, the hydrologic conditions that occurred between WY89–WY 06 to maintain consistency with the Pollutant Load Reduction Model (PLRM; nhc et al. 2009) estimates to the extent possible.

The SLRTv2_Template.xlsx will auto-generate estimates of the required hydrologic datasets based on the user catchment characteristic inputs. The discharge frequency distribution outputs includes the frequency of occurrence (number of days per year) and the median mean daily discharge (cfs) for each of the standardized 50 bin intervals of the predicted average annual hydrograph for the upstream boundary of the subject SEZ. The average annual frequency distribution hydrograph is used to estimate incoming average annual FSP loads (IN_{fsp}) and estimates of the average annual pollutant floodplain retention (RFP_{fsp}). Four annual percentile hydrographs are generated for direct input into the BSTEM-Dynamic platform to estimate a series of unit erosion rates given an expected range of annual discharge conditions. The discharge frequency distribution and annual hydrograph estimates are presented in both graphical (Figure 11) and tabular formats. The user is encouraged to compare the estimates to any measured discharge values or other records to verify the hydrology estimates are reasonable for the SEZ of interest.

FLOODPLAIN RETENTION

SLRTv2_Template.xlsx* worksheet: *RFPfsp

The SLRT method estimates the fraction of the average annual FSP mass delivered to the floodplain as function of discharge. For each bin where overbank flow is expected to occur, the tool calculates the daily FSP load less the load contained within the channel and multiplies the difference by the frequency of occurrence for that flow. The sum of the loads for all overbank flows is the estimated average annual mass of FSP delivered to the SEZ floodplain (DFP_{fsp}; MT/yr).

The worksheet calculates the average annual FSP mass retained on the floodplain based on the estimated DFP_{fsp} and user inputs of floodplain condition (FPC). The retention coefficient is determined based on floodplain condition and the corresponding R_{fsp} (Q:Q_{cc}) rating curve. The appropriate retention coefficient is applied to the FSP mass delivered to the floodplain to determine the fraction of the mass retained. SLRT sums the masses for all overbank flows to estimate the average annual mass of FSP retained on the SEZ floodplain (RFP_{fsp}; MT/yr). The floodplain delivery and retention metrics are generated automatically and displayed in both graphical (Figure 12) and tabular formats for both pre and post restoration scenarios in the *RFPfsp* worksheet.

BANK EROSION

SLRTv2_Template.xlsx* worksheet: *SCEfsp

SLRT auto-generates the average annual FSP generated from streambank erosion for pre- and post-restoration scenarios based on the BSTEM-Dynamic outputs for up to 16 spatial and temporal conditions. Two channel bank profiles are modeled to account for spatial variations in hydraulic forces: a representative straight reach and a representative outside meander bend. Four annual probability hydrographs are modeled to represent a range of percentile flow years (25th, 50th, 75th and 99th percentiles).

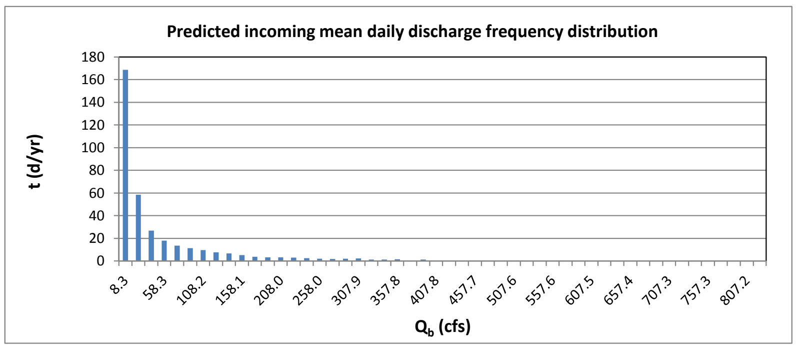
BSTEM-Dynamic provides an annual unit bulk sediment erosion rate per length of feature (m^3/m/yr) that is assumed to be representative of the straight and outside bend reaches within the subject SEZ modeled for a given annual hydrograph. For each hydrograph, the annual bulk sediment generation rates are multiplied by

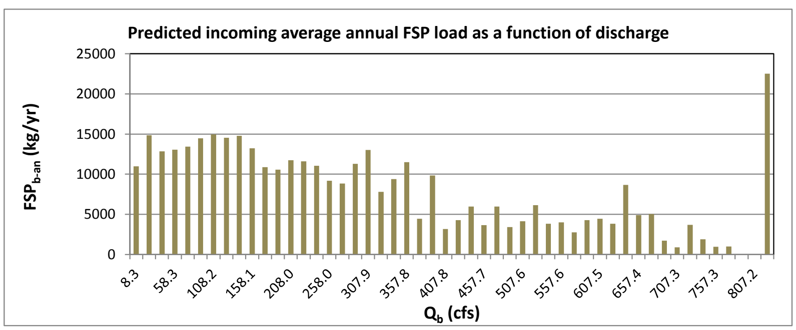
STREAM LOAD REDUCTION TOOL (SLRTv2)
Predicted catchment hydrology and FSP loads

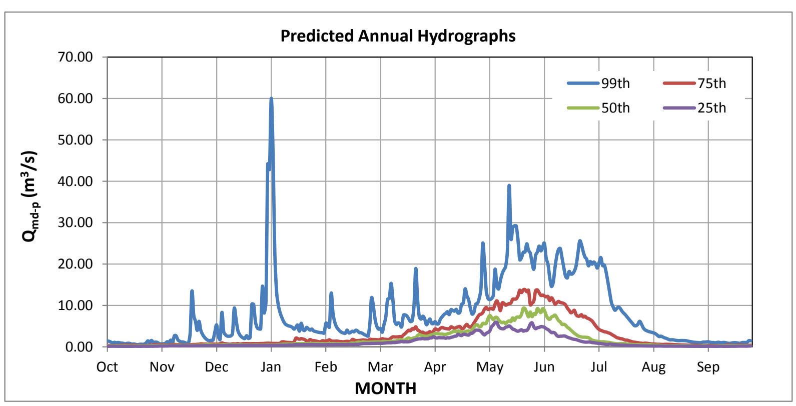
SEZ NAME: **UTR GOLF COURSE**

CALCULATIONS

NAME	VALUE	VARIABLE
Mean Annual Precip (in)	29.91	P
Total Area (sq mi or acres)	42.4	A
Total Impervious Area (acres)- urban only	0.0	A_i
Bin Interval (cfs)	16.643	Q_{bi}
Regional Coefficient	0.003	R
Max Mean Daily Q (cfs)	2434.91	Q_{max}
Bin 50 Value (cfs)	1625.22	$Q_{b\text{-}50}$
FSP CRC (mg/L) - Urban only	n/a	V_{in}
Bin Interval (cfs)	16.64	Q_{bi}
FSP CRC (mg/L) - Urban only	n/a	FSP_C
Average annual discharge volume (ac-ft/yr)	42854.0	V_{in}
Average annual FSP load into SEZ (MT/yr)	389.3	FSP_{in}







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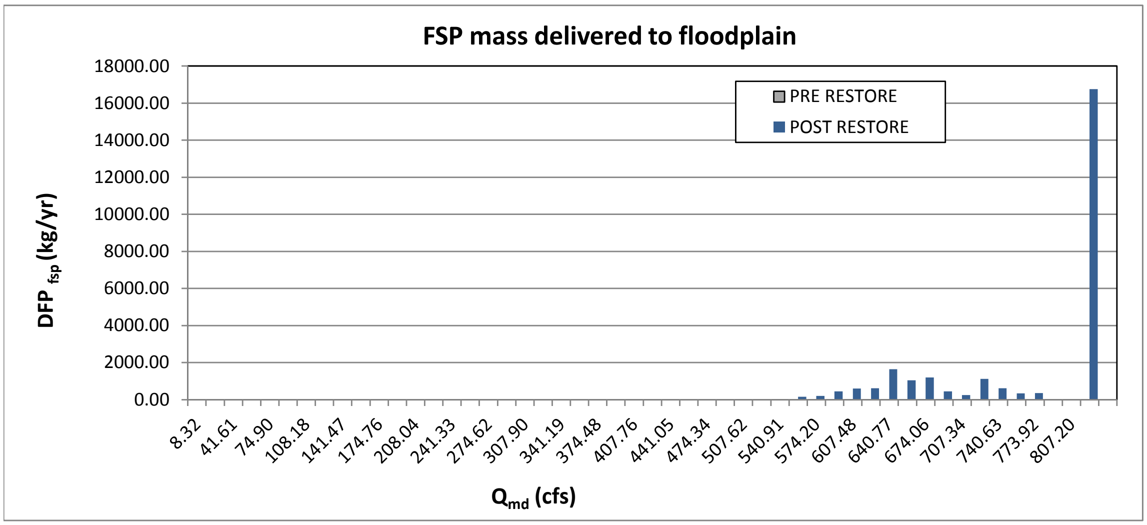
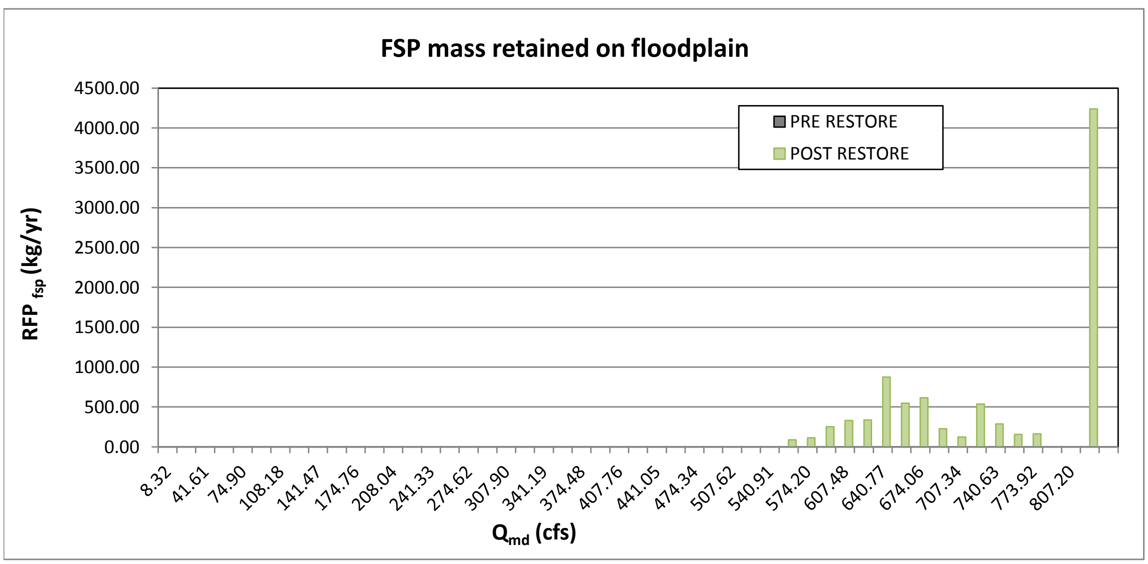
SLRTV2 "HYD FSP IN" TAB

Figure 11

STREAM LOAD REDUCTION TOOL (SLRTv2)
FLOODPLAIN RETENTION ESTIMATES

REACH NAME	UTR GOLF COURSE		
Date of estimate	2/7/2014		
	PRE RESTORE	**POST RESTORE**	VARIABLES
Channel length (m)	1829	2143	*l*
Channel slope (m/m)	0.0021	0.0018	*s*
Channel capacity (cfs)	1900	550	Q_{cc}
Floodplain condition score	3	5	FPC
Average days overbank (d/yr)	0.0	3.9	t_{ob}
Channel FSP load (kg/d)	45043	11513	FSP_{cc}
Catchment FSP load (MT/yr)	389.25		FSP_{in}
Delivered to floodplain (MT/yr)	0.00	25.77	DFP_{fsp}
Retained on floodplain (MT/yr)	0.00	8.88	RFP_{fsp}





SLRTv2 created by 2NDNATURE LLC (2014)

Average annual floodplain retention estimates [2/24/2014]

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SLRTV2 "RFPFSP" TAB

Figure 12

the respective total contributing lengths (e.g., straight reach, outer bend) and bulk unit sediment weight to calculate the annual bulk sediment mass (MT/yr) generated for each probability flow year. These values are converted to FSP load based on the regional FSP to bulk sediment ratios. To estimate the average annual sediment and FSP loads, each annual probability hydrograph is weighted based on its probability of occurrence, and these load values are averaged to calculate the average annual bulk sediment and FSP. The pre- and post-restoration values are compared to estimate the average annual FSP load reduction as a result of decreased instream erosion. The stream channel erosion metrics values are generated automatically and displayed in both graphical and tabular formats (Figure 13) for both pre and post restoration scenarios in the *SCEfsp* worksheet.

FSP LOAD REDUCTIONS

SLRTv2_Template.xlsx **worksheet:** ***SLRT RESULTS***

The SLRT outputs an average annual pollutant load reduction that is calculated as the difference between the pre- and post-restoration average annual FSP load as estimated at the downstream boundary of the SEZ.

$$\text{SEZ-LR}_{fsp}\,(\text{MT/yr}) = \text{OUT}_{fsp\text{ -pre}} - \text{OUT}_{fsp\text{ -post}} \qquad \text{(EQ1)}$$

where:

$$\text{OUT}_{fsp}\,(\text{MT/yr}) = \text{IN}_{fsp} - \text{RFP}_{fsp} + \text{SCE}_{fsp} \qquad \text{(EQ2)}$$

The *SLRTv2_Template.xlsx SLRT RESULTS* worksheet is a summary table that includes the SEZ average annual pollutant (SEZ-LR_{fsp}) load reduction, in addition to a series of simple quantitative comparisons between the pre- and post-restoration scenarios to collectively document the effectiveness of the restoration actions as represented in SLRT (Figure 14).

SLRT SUMMARY

Once the inputs and calculations within SLRT are acceptable to the user, the user can systematically print pre-defined summary reports for each of the 5 worksheets. Collectively, these 5 pages contain all of the relevant inputs, calculations and outputs from SLRT necessary for communication to others. It is recommended that (1) a site location map that clearly denotes the upstream and downstream boundary of the SEZ, the pre- and post-restoration channel alignment, and contributing catchment and (2) a table summary of the data sources and assumptions used to determine the input values accompany the SLRT summary pages. Section 5 provides explicit examples of SLRTv1 application, results and products for two Tahoe Basin SEZs

STREAM LOAD REDUCTION TOOL (SLRTv2)
SEZ CHANNEL EROSION ESTIMATES

REACH NAME	**UTR GOLF COURSE**	
Date of estimate	2/7/2014	
	PRE RESTORE	**POST RESTORE**
Channel length (m)	1829	2143
Outside BEND length (m)	841	984
STRAIGHT length (m)	988	1159
Fines to bulk sediment ratio (0-1 value)	0.0174	0.0174

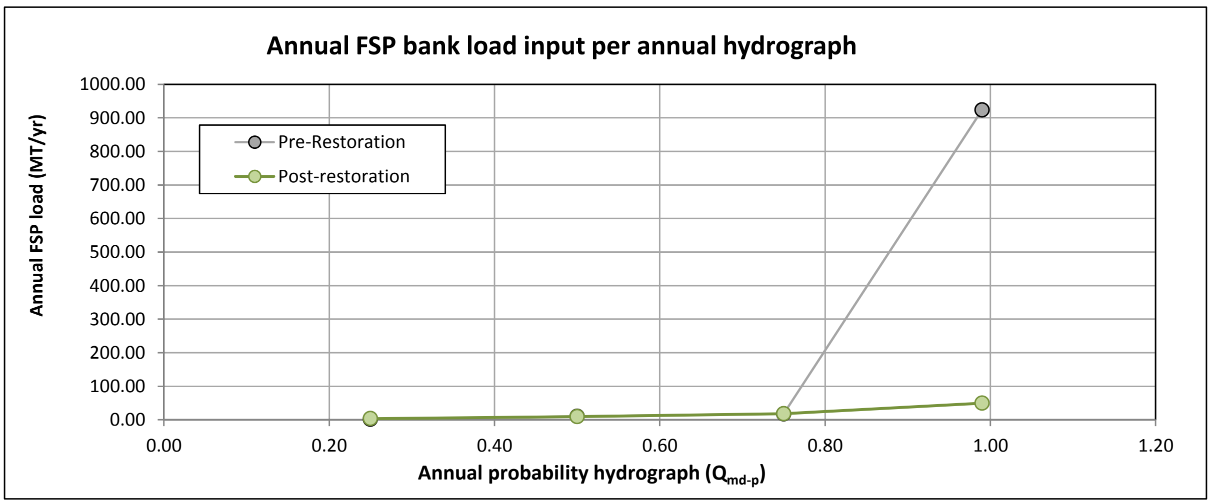
Dynamic BSTEM results

	PRE RESTORE	POST RESTORE	Q_{md-p}
Bulk sediment Outside bend unit erosion rate (m3/m/yr)	18.1800	1.0400	99th
	0.1390	0.4780	75th
	0.0570	0.2390	50th
	0.0000	0.1030	25th
Bulk sediment Straight reach unit erosion rate (m3/m/yr)	7.6700	0.2700	99th
	0.2400	0.0600	75th
	0.1460	0.0400	50th
	0.0360	0.0100	25th

	PRE RESTORE	POST RESTORE
Average annual bank erosion rate (m^3/km/yr)	459.77	52.14

SEZ Channel Erosion Results

	PRE RESTORE	POST RESTORE	% reduction
Average annual bulk sediment generated (MT/yr)	1466.33	166.29	89%
Average annual FSP load generated (MT/yr)	25.514	2.893	
Average annual FSP load reduction (MT/yr)	22.621		



SLRTv2 created by 2NDNATURE LLC and A. Simon 2014

Average annual channel erosion estimates [2/24/2014]

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SLRTV2 "SCEFSP" TAB

Figure 13

STREAM LOAD REDUCTION TOOL (SLRTv2)
Results Summary

USER NAME	2NDNATURE
WATERSHED/CATCHMENT	UPPER TRUCKEE RIVER
REACH NAME	UTR GOLF COURSE
Date of Estimate	2/7/2014
CATCHMENT TYPE	Non Urban
REGION	Mainstem UTR
SUB-REGION	Southwest
CATCHMENT AREA	42.4
AREA UNITS	Sq-miles
CATCHMENT % IMPERVIOUS	
CATCHMENT LAND USE CONDITION	0

USER INPUTS

	PRE-RESTORATION	POST-RESTORATION	*CHANGE*	*% CHANGE*
Channel length (m)	1829	2143	314	17%
Channel slope (m/m)	0.0021	0.0018	-0.0003	-14%
Outside BEND length (m)	841	984	143	17%
BEND bank height (m)	2.8	1.3	-1.5	-54%
BEND bank angle (degrees)	50	18	-32	-64%
STRAIGHT length (m)	988	1159	171	17%
Bank height of STRAGHT reaches (m)	1.9	0.6	-1.3	-68%
Bank angle of STRAIGHT reaches (degrees)	23	31	8	35%
Manning's roughness value of channel	0.03	0.03	0	0%
Fines to bulk sediment ratio (0-1 value)	0.0174	0.0174	0	0%
Channel capacity (cfs)	1900	550	-1350	-71%
Floodplain length (m)	1221	1221	0	0%
Floodplain condition score	3	5	2	2

SLRT OUTPUTS

AVERAGE ANNUAL ESTIMATES	PRE-RESTORATION	POST-RESTORATION	*CHANGE*	*% CHANGE*	
Predicted FSP catchment load (MT/yr)	389.25	389.25	0	0%	IN_{fsp} (MT/yr)
Predicted FSP load delivered to floodplain (MT/yr)	0.00	25.77	25.8	#DIV/0!	DFP_{fsp} (MT/yr)
Predicted FSP load retained on floodplain (MT/yr)	0.00	8.88	8.9	#DIV/0!	RFP_{fsp} (MT/yr)
Predicted FSP load from channel erosion (MT/yr)	25.51	2.89	-22.62	-89%	SCE_{fsp} (MT/yr)
Predicted FSP load at downstream boundary (MT/yr)	414.77	383.27	-31.50	-8%	OUT_{fsp} (MT/yr)

31.50 **Average annual FSP Load Reduction (MT/yr)** SEZ LR_{fsp} (MT/yr)

14.70 **Average annual FSP Load Reduction (MT/yr/km)**

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SLRTV2 "RESULTS" WORKSHEET

Figure 14