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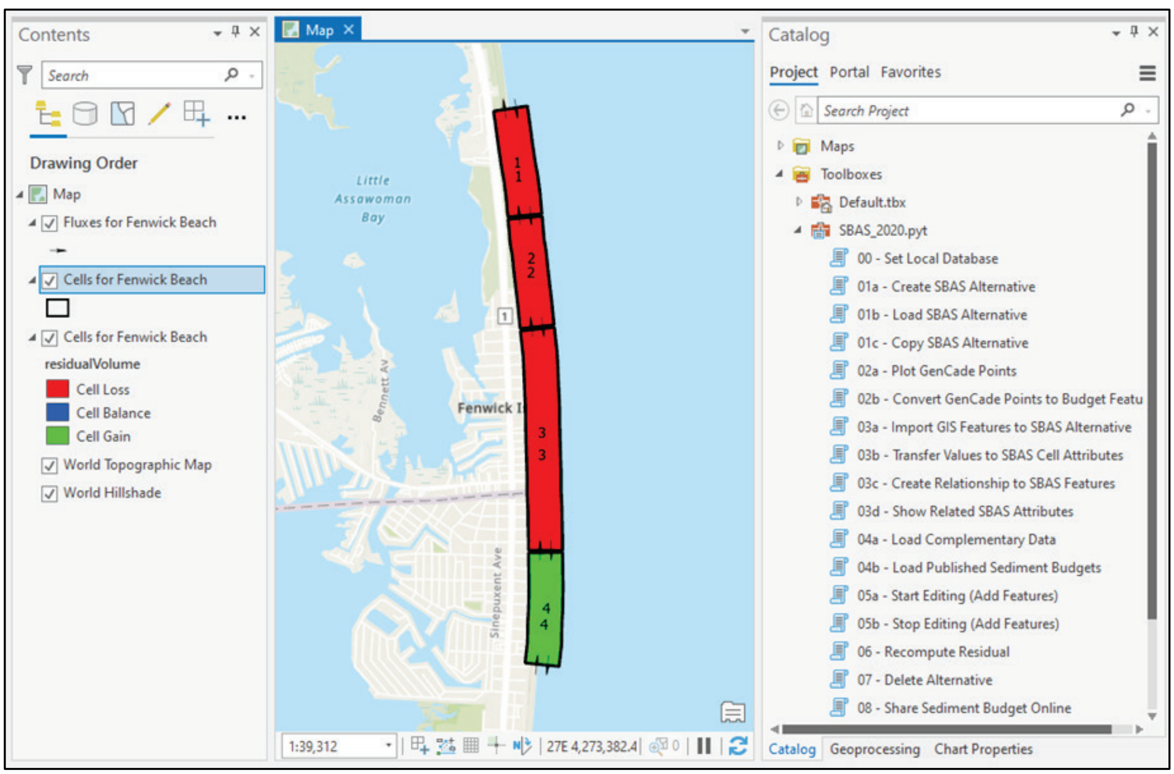
Regional Sediment Management Program

Sediment Budget Analysis System (SBAS) 2020 User's Guide

Version 1.0

Sean P. McGill, Eve R. Eisemann, and Rose Dopsovic

April 2022



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Abstract

This special report acts as a user's guide for the Sediment Budget Analysis System (SBAS) toolbox within ArcGIS Pro. The SBAS toolbox is a free toolset that allows the user to create and visualize a sediment budget using ArcGIS Pro. Included in this report are instructions on how to download the toolbox and create a sediment budget.

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Preface

This study was conducted for the US Army Engineer Research and Development Center under the Regional Sediment Management (RSM) Program, Funding Account Code 99G762; AMSCO Code 08303. The RSM program manager was Dr. Katherine E. Brutsché.

The work was performed by the Coastal Engineering Branch of the Navigation Division, US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL). At the time of publication, Ms. Lauren M. Dunkin was branch chief; Ms. Ashley Frey was division chief; and Mr. Charles E. Wiggins was the technical director for Navigation. The deputy director of ERDC-CHL was Mr. Keith Flowers, and the director was Dr. Ty V. Wamsley.

The commander of ERDC was COL Teresa A. Schlosser, and the director was Dr. David W. Pittman.

1 Introduction

1.1 Background

A sediment budget is an account of sediment sources and sinks, providing a conceptual and quantitative model of sediment distribution within an environment over time. The spatial scale of the budget can range from micro (local, hundreds to thousands of meters) to macro (regional, tens to hundreds of kilometers) scale. The components of a sediment budget are budget cells (compartmentalized areas of interest), sediment sources (paths of sediment input to a cell), and sediment sinks (paths of sediment removal from a cell). Sediment sources and sinks are relative to individual budget cells (i.e., sources of sediment to “Cell X”). For the purposes of a sediment budget, it is assumed sediment cannot be created or destroyed, and an equation conserving sediment volume is utilized to balance the budget of each cell (Equation 1).

$$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = Residual \quad (1)$$

where

Q_{source}=Input of sediment into cell
Q_{sink}=Loss of sediment from cell
V=Volume change within cell
P=Placement into cell (e.g., beach fill or dredged material)
R=Removal from cell (e.g., dredging or mining)
$Residual$=0 for a balanced cell.

The sum of sediment sources minus the sum of sediment sinks ($\sum Q_{source} - \sum Q_{sink}$) should be equalized by the observed sediment volume change in the cell (ΔV) where no engineering sediment placement or removal has occurred. The scope and purpose of a sediment budget can range from providing an initial understanding of a region (Rosati et al. 2015) to being used for planning and project management (URS Group and Moffat & Nichol 2010).

The Sediment Budget Analysis System (SBAS) is an open-source sediment budget creation, visualization, and calculation toolset for ESRI ArcGIS, with versions compatible with ArcMap 10.x versions and ArcGIS Pro. Once installed, this toolbox allows users to define a conceptual budget visually by creating a series of cells and arrows that represent fluxes into and out of cells (sources and sinks).

The SBAS was initially developed in the late 1990s for creating, calculating, and visualizing sediment budgets (Rosati and Kraus 1999). Previous updates have made SBAS compatible with various ESRI products such as ArcView (Dopsovic et al. 2002) and ArcMap (ERDC-SAM 2012). The focus of this special report is the update for ArcGIS Pro.

1.2 Objective

The goal of this report is to provide users with a guide to the SBAS toolbox. This report contains step-by-step instructions on how to download and install the SBAS toolbox, create a sediment budget, and share or access data online if desired. Additional information in the appendix is included to provide more details about the toolbox that are not required to create a sediment budget.

1.3 Approach

This special report was written with the goal to provide the user with a reference on how to use the toolbox. Due to the various ways sediment budgets can be created using SBAS, the subsections are written in the order of the tools within the toolbox, not in the order that they are required to be used. User comments and issues from previous trainings, as well as user experiences by the authors, influenced the level of detail for each tool's instructions.

2 Installing and Launching Sediment Budget Analysis System (SBAS)

The SBAS for ArcGIS Pro is designed as an ArcToolbox written in Python 3, and installation requires unzipping the distribution file to a local drive. As of April 2022, the zip file can be downloaded from here: https://www.arcgis.com/home/item.html?id=90576370d48f491fbddc7a15bbfb40d7. The zip file includes the toolbox (SBAS_2020.pyt), layer packages (_.lyrx), a settings file (SBAS_settings.txt), and a template geodatabase (SBAS.gdb). The settings file is used by the SBAS tools to easily find the local SBAS database and must stay in the same directory as the toolbox file. To launch SBAS, create a new project in ArcGIS Pro and use "Add a Folder Connection" to add SBAS_2020.pyt to your project in the catalog pane. Within the toolbox are the individual tools used to create a sediment budget (Figure 1; Table 1).

Figure 1. Sediment Budget Analysis System (SBAS) 2020 toolbox viewed in the catalog pane.

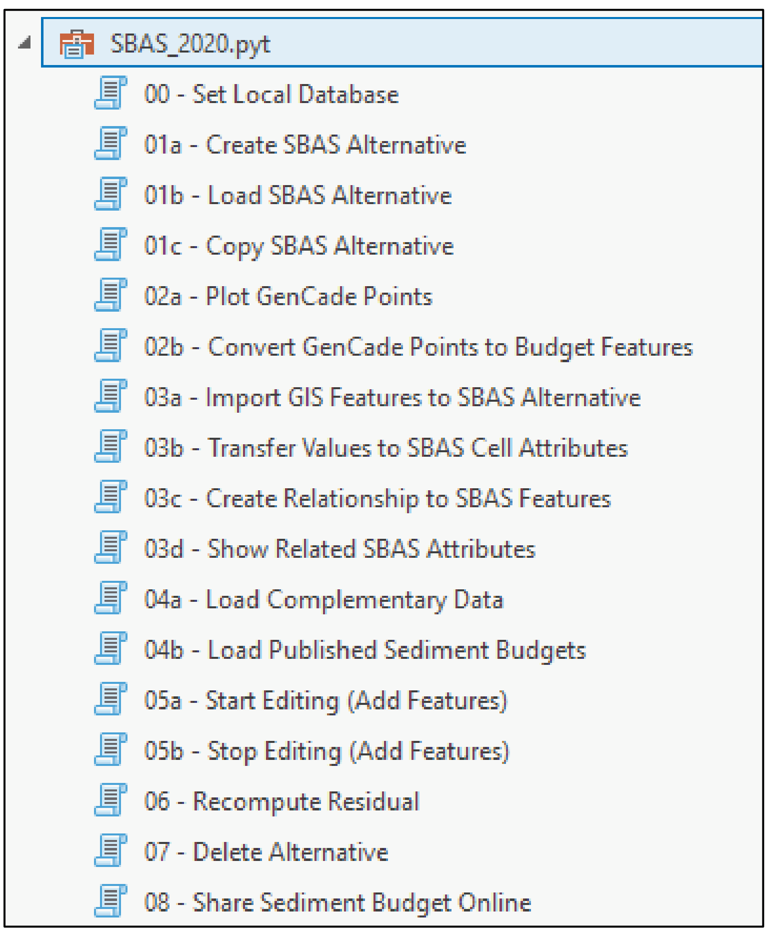


Table 1. Description of SBAS tools.

Tool Name	Tool Description
00 – Set Local Database	Designates location for SBAS data to be stored
01a – Create SBAS Alternative	Creates a sediment budget
01b – Load SBAS Alternative	Loads an existing sediment budget
01C – Copy SBAS Alternative	Copies an existing sediment budget
02a – Plot GenCade Points	Plots shoreline points from GenCade data
02b – Convert GenCade Points to Budget Features	Converts GenCade data into budget cells and fluxes
03a – Import GIS Features to SBAS Alternative	Imports GIS features into the sediment budget
03b – Transfer Values to SBAS Cell Attributes	Transfers sediment budget values from a different file into the budget alternative
03c – Create Relationship to SBAS Features	Joins data based on spatial relationship
03d – Show Related SBAS Attributes	Creates a layer file to hold a relationship between SBAS features and additional attribute data
04a – Load Complementary Data	Loads complementary data
04b – Load Published Sediment Budgets	Loads a sediment budget that is published on USACE AGOL
05a – Start Editing (Add Features)	Starts editing session to create features
05b – Stop Editing (Add Features)	Stops editing session
06 – Recompute Residual	Recalculates residual volume, transport removal, and transport placement
07 – Delete Alternative	Deletes Sediment Budget
08 – Share Sediment Budget Online	Publishes sediment budget to ArcGIS Online

3 Creating a Sediment Budget

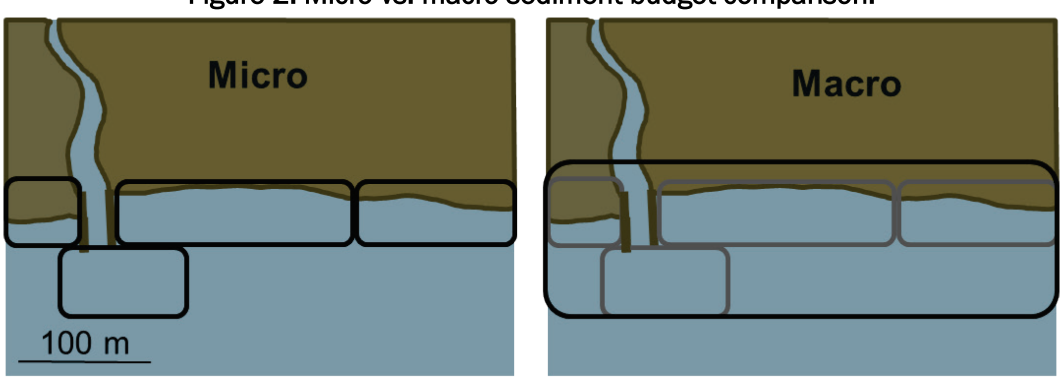
3.1 Set local database

Tool *00 - Set Local Database* is used to designate a known file locality for the user's local SBAS database and provides the flexibility to have one or more local SBAS databases. Behind the scenes, this tool is simply writing a string value into the file "SBAS_settings.txt". Each time SBAS needs to locate the SBAS database in the data processing, it will put the value listed in this file.

3.2 Create SBAS alternative

Sediment budget data are grouped into alternatives, which are representations of one set of assumed conditions for a sediment budget. Creating a new alternative is the first step in building the geometry container to hold littoral cell and flux features. The user has an option to create a micro (<200-meter cell lengths) or macro (>200-meter cell lengths) budget type (Figure 2). Each alternative has its own set of littoral cells (with delta volume, placement/input volume, and removal/output volume) and fluxes. Alternatives may be created to reflect different assumptions about sediment-transport paths/rates and engineering activities, or they may reflect different time periods. Alternatives hold all values applied to littoral cells and fluxes, and the data are written to the alternative table in the local geodatabase.

Figure 2. Micro vs. macro sediment budget comparison.

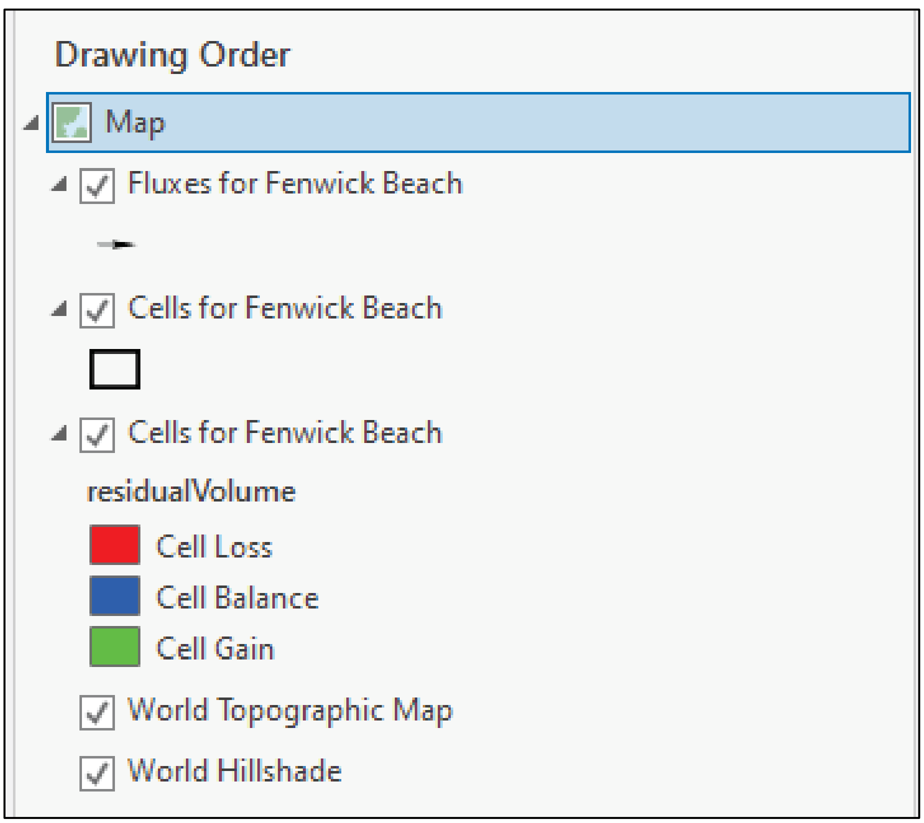


Tool *01a - Create SBAS Alternative* is used to create a new alternative for a sediment budget. Basic information is collected to assist in building metadata for the alternative. The following pieces of data are required:

a. Budget Type (micro or macro)
b. Alternative Name
c. Alternative Description
d. Geographic Area Name or Description
e. Date From (epoch)
f. Date To (epoch)
g. Flux Q Units (cubic year/year or cubic meters/year)
h. Cell Volume Units (cubic yards or cubic meters).

There is a checkbox to load a new alternative immediately, which if selected will add three new layers to the Table of Contents. One layer will be named "Fluxes for Alternative Name," and the other two will be named "Cells for Alternative Name." One of the cell layers displays the cell boundaries while the other displays the residual volume change for the cell (Figure 3). As different alternatives are created, each is assigned a unique identifier (ID). This value is stored in the "scenarioIDPK" attribute field. When added to the Table of Contents, the SBAS tool pulls the supplied layer files (Cells.lyrx, AllCells.lyrx, and Flux.lyrx) and applies a definition query to the items that filters only on the assigned unique ID for the active alternative.

Figure 3. Table of Contents view containing components of the alternative.



3.3 Load SBAS alternative

Tool *01b – Load SBAS Alternative* is an optional step to load any alternative and its respective feature layers into the Table of Contents. All available alternatives are listed in the drop-down menu that are stored in your local SBAS database, and multiple alternatives can be loaded at the same time.

3.4 Copy, change, and delete alternatives

Tool *01c – Copy SBAS Alternative* is used to copy any existing alternative into a new alternative. This tool allows the user to reuse feature geometry for a new alternative. The user also has the ability to change specific alternative details such as "Name," "Description," "Start," and "End Date."

1. In the Catalog pane, browse and expand the "SBAS.gdb".
2. Right-click on the alternative table and select "Add to Current Map."
3. In the Table of Contents pane, right-click on the alternative table and select "Open."
4. In the attribute window, click the row/column value to modify and enter any changes.
5. Enter any changes, and when finished click the "Save" button on the Edit ribbon.

3.5 Sketching SBAS feature geometry

Creating new feature geometry in SBAS follows much of the same process inherent in ArcGIS Pro, however in SBAS, the user must first start an "SBAS Edit Session" so geometry is related to the correct alternative.

1. To begin, launch tool *05a - Start Editing (Add Features)*.
2. A list of all alternatives in the Table of Contents will be in the drop-down list. Choose the desired alternative and click "un."
3. Zoom to your area of interest, click on ArcGIS Pro's Edit ribbon, and click on "Create."
4. To sketch littoral cells, click on the symbol in front of the "Cells for Alternative Name" layer in the "Create Features" panel. This will expand to show the sketch options. Click on the first icon, which will turn on the sketch tool. Click in the map to drop vertices for your littoral cell polygon. Double-click to complete sketch. For sketching flux cells, select "Fluxes for Alternative Name" layer in the "Create

Features" panel and create vertices for a flux line in the direction of flux with the sketch tool. Fluxes may represent a sink for one cell and a source for another, so all fluxes are symbolized the same way and given a positive magnitude and direction.

5. When sketching all of the new littoral cell features is completed, launch tool *05b - Stop Editing (Add Features)* to accept changes.
6. To modify location of vertices, click on the "Modify" button from ArcGIS Pro's Edit ribbon, then click on "Reshape," then "Edit Vertices." Click on the vertices to move to new location or right click to remove. Save changes when complete.

3.6 Importing SBAS feature geometry from GenCade data

GenCade is a one-dimensional numerical model that calculates the shoreline change based on longshore sediment transport rates. After creating and calibrating a GenCade grid, the user can create sediment budget cells and fluxes and run the model. In the GenCade results file (_.prt) under "SBAS OUTPUT," the results for volume change and rate for the fluxes and cells will be used with SBAS. A GenCade special report (Munger and Frey 2015) provides more information for new users on how to use GenCade, and a technical note (Frey 2015) is available for more detail on incorporating GenCade and SBAS data.

When importing GenCade data, geometry for both "Cells" and "Fluxes" is created. Tools *02a - Plot GenCade Points* and *02b - Convert GenCade Points to Budget Features* are used for this data transformation. For the data transformation to a sediment budget, the associated GenCade files, _.gen (GenCade control file), _.slo (shoreline position file), _.prt (sediment fluxes file), and _.map(GenCade coverage file) are required. These steps below need to be run only once as the tool will import the littoral cells and fluxes at the same time.

1. First run tool *02a - Plot GenCade Points*. This will plot the shoreline point locations documented in the _.slo file. The output shapefile is needed for the input into tool *02b - Convert GenCade Points to Budget Features*. The starting coordinate, azimuth, and distance between points are collected from the _.slo file. If "Use Only First Date in Point Plot" is selected in the tool, only the first row of the _.slo is used for the plot.
2. Next open tool *02b - Convert GenCade Points to Budget Features*. The three GenCade files and the newly created GenCade shoreline points will need to be supplied. Set the temporary placeholder feature classes

for the "Cells" and "Fluxes," set the design distant variables, and choose the alternative that will be the home for these features.

3.7 Importing SBAS feature geometry from existing geographic information system (GIS) layers

If geographic information system (GIS) layers are already created that represent littoral cells or fluxes, but were created outside of the SBAS toolbox, these features can be imported into SBAS. The steps for importing SBAS Feature Geometry from existing layers are below.

1. Using tool *03a - Import GIS Features to SBAS Alternative*, browse to an existing feature class or shapefile, then provide field mapping to connect the original field names to the SBAS values.
2. If importing littoral cells, the required fields for mapping include the following: Name, Description, Placement Volume, Removal Volume, and Volume Change. If importing flux cells, the required fields for mapping include: "Name," "Description," and "Q Value."
3. Check the "Duplicate Geometries OK" checkbox to use the same cells/fluxes for multiple alternatives.

3.8 Manually add SBAS feature values

Sediment budget values linked to cell volumes and fluxes can easily be added to geometry as feature attributes. Tables A-2 and A-3 in the appendix contain the values available to edit for the littoral cells and fluxes. Within the littoral cell there are three dynamic fields: "residualVolume," "transportRemoval," and "transportPlacement." The values within these fields do not need to be manually updated, as they can be automatically recalculated using tool *06 – Recompute Residual*.

To manually add feature values, follow these steps:

1. From the Edit ribbon, click the "Attributes" button to open the Attribute pane.
2. Select a budget feature (cell or flux) on the map with the Selection Tool. The attribute pane will display the values for the selected feature.
3. Click on the value next to the attribute to edit. Enter the new value.
4. When finished, click the "Save" button on the Edit ribbon.

3.9 Transfer values into SBAS cell attributes

If sediment budget geometries and values exist outside of your local SBAS database in a feature class with identical geometry, the attributes can be transferred into the selected Alternative using tool *03b – Transfer Values to SBAS Cell Attributes*. To use this tool, the geometries in both datasets must match. All values from the input feature class will be used to update the littoral cell layer, and a record of all transferred values will be listed in the Results Window. Tool *06 – Recompute Residual* does not need to be run as the residual is automatically recalculated.

3.10 Create relationship to SBAS features

Additional attribute data may be stored outside of the SBAS local database in feature classes. Contents from supplemental databases can be related to SBAS features using tool *03c – Create Relationship to SBAS Features*. This tool uses spatial and nonspatial relationships to determine how to connect the data attributes to the sediment budget. If there are feature geometry and values created outside of the SBAS toolbox, this tool will create a spatial relationship to join the datasets together. This tool should be used when a table join cannot easily be performed, such as when there is no consistent field between the tables that can be referenced for the join. This tool does not support Grouped Layers.

3.11 Load complementary data and published sediment budgets

SBAS is configured to work with sediment budgets and complementary data that have been published online (Dunkin et al. 2020). Use tool *04a – Load Complementary Data* to connect to online content (map services or feature services) that have been appropriately tagged in ArcGIS Online (AGOL) item descriptions or published through the SBAS 2020 toolbox (see tool *08 – Share Sediment Budget Online*).

3.12 Share sediment budget online

Users with an AGOL account can request access to the SBAS ArcGIS Hub (https://sbas-usace.hub.arcgis.com) to publish sediment budgets online. Using tool *08 – Share Sediment Budget Online*, budgets will be published as a feature web service to the SBAS Hub. Extraneous datasets need to be removed from the Table of Contents as the tool includes all contents in the web service. Content with multiple display options for a single dataset need to be reduced to one visualization per dataset. When publishing a budget, consider the following:

- Any existing web service with the same name will be overwritten.
- If more than one alternative is loaded in the Table of Contents, all alternatives will be combined into a single feature service, but as separate layers.
- Do not publish any datasets containing personally identifiable information or other sensitive information.
- Do not publish datasets that are already available online.

4 Conclusion

Sediment budgets are the keystone of the Regional Sediment Management process and are an essential first step when investigating feasibility of engineering projects and understanding the sediment transport in a region. The SBAS toolbox for ArcGIS Pro is an efficient and standard way to create a sediment budget utilizing existing data or model results from GenCade. SBAS can guide the user through the creation of sediment budgets on various scales, from individual projects to regions, and provides an opportunity for the user to explore possible sediment budget scenarios with different tiers of data availability for the region. This report guides the user through the steps necessary to create a new sediment budget, edit an existing one, and publish the budget online in ArcGIS Pro.

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Appendix: Definitions and Descriptions

Table A-1. Definitions.

Term	Definition
Alternative	Representation of a sediment budget. Contains fluxes, cells, and associated values.
Attribute	Specific information related to a feature layer
Attribute Table	Table that stores the attributes related to a feature layer.
Confidence	The certainty level that the values assigned to littoral cells and fluxes are accurate.
Feature	A point, line, or polygon in a coverage, shapefile, or geodatabase feature class.
Feature Layer	A collection of similar features and their associated properties.
Flux	The movement of sediment into or out of a littoral cell. Flux features are a representation of the input and output of sediment into a littoral cell. Each cell requires both eastward and westward transport rates.
Littoral Cell	A delineated area that acts as a source or sink of sediment. Littoral Cell features are collection of information describing similar physical, biological, and cultural characteristics within a particular area along a river, lake, sea, or ocean.
Macro Budget	A sediment budget for a region; it may consist of multiple micro budgets.
Micro Budget	A sediment budget for a specific local area.
Sediment Budget	A measure of sediment (usually sand) “sources” (inputs), “sinks” (outputs), and net change within a specified “control volume” (a cell or series of connecting cells) over a given period of time.
Shapefile/Feature Class	A vector data storage format for storing the shape, location, and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class.
Sink	The destination of sediment that is moved from its original location.
Source	The point of origin of sediment that is moved to a different location.

Table A-2. Sediment flux attributes. Highlighted rows represent editable cells.

Field Name	Field Type	Character Limit (if applicable)	Field Description
sedimentTransportDirectionIDPK	Text	50	Primary Key. This value is auto-generated by SBAS and provides a unique identifier for each flux
sdsFeatureName	Text	50	Name or label of the flux
sdsFeatureDescription	Text	255	Description of the flux
scenarioIDFK	Text	50	Foreign Key. Value to the relative alternative (or scenario)
qValue	Double	-	Volume of sediment moving in or out of cell
transportUom	Text	50	Units of measure for sediment transport rates. Cubic yards/year or cubic meters/year
alternativeLabel	Text	50	Name of alternative

Table A-3. Littoral cell attributes. Highlighted rows represent editable cells.

Field Name	Field Type	Character Limit (If Applicable)	Field Description
littoralCellIDPK	Text	50	Primary key. This value is auto-generated by SBAS and provides a unique identifier for each littoral cell.
sdsFeatureName	Text	50	Name or label of the littoral cell
sdsFeatureDescription	Text	255	Description of the littoral cell
scenarioIDFK	Text	50	Foreign Key. Value to the related alternative (or scenario)
removalVolume	Double	-	Volume of sediment removal (per littoral cell and alternative)
placementVolume	Double	-	Volume of sediment placement (per littoral cell and alternative)
deltaVolume	Double	-	Change in volume per littoral cell and alternative
valConfidence	Text	255	Determine level of data confidence. Assigned by sediment budget author as low, medium, or high
residualVolume*	Double	-	Computed residual volume per littoral cell and alternative
transportRemoval**	Double	-	Sum of transport removal per cell
transportPlacement***	Double	-	Sum of transport placement per cell
volumeUom	Text	50	Units of measure for volume change, volume removal, volume placement, and residual volume. Cubic yards or cubic meters
transportUom	Text	50	Units of measure for sediment transport rates. Cubic yards/year or cubic meters/year
alternativeLabel	Text	255	Name of alternative
mediaIDPK	Text	50	ID to hold links to related media documentation. The SBAS application does not reference or write to this field
sdsMetadataID	Text	50	Holds unique metadata ID
projectID	Text	50	Optional project ID for internal management purposes. The SBAS application does not reference or write to this field
sdsID	Guid	-	This value is auto-generated by SBAS and provides a unique identifier for each alternative (or scenario). Value can be used to link to items in other enterprise GIS

*Residual volume is computed by Equation 1. SBAS tools will compute the residual volume based on the values assigned to SBAS features. SBAS determines the direction of sediment fluxes and automatically identifies each as either a “source” or “sink” for each cell.

**Transport removal is found by SBAS where the starting point of sediment fluxes intersects a littoral cell (classified as a sink). All sink volumes are summed and values are reported to this field.

***Transport placement is found by SBAS where the ending point of the sediment fluxes intersects a littoral cell (classified as a source). All source volumes are summed and values are reported to this field

Table A-4. Alternative table. Holds basic metadata information related to individual sediment budgets.

Field Name	Field Type	Character Limit (If Applicable)	Field Description
scenarioIDPK	Text	50	Primary Key. This value is auto-generated by SBAS and provides a unique identifier for each alternative (or scenario)
sdsID	Guid	-	This value is auto-generated by SBAS and provides a unique identifier for each alternative (or scenario). Value can be used to link to items in other enterprise GIS
scenarioAuthor	Text	100	Author of the alternative. Name of author is pre-determined by the user login to ArcGIS Pro. Name is listed as the AGOL username
sdsFeatureName	Text	50	Name or label of alternative
sdsFeatureDescription	Text	255	Description of alternative
geoAreaDescription	Text	255	Description of location of sediment budget
projectID	Text	50	Optional project id for internal management purposes. The SBAS application does not reference or write to this field
dateScenarioCreated	Date	-	Date alternative created in the SBAS database
budgetType	Text	50	Type of sediment budget (Micro-local, Macro-regional)
dateIntervalStart	Date	-	Start date of alternative epoch
dateIntervalEnd	Date	-	End date of alternative epoch
cellUnits	Text	255	Units of volume for littoral cells (Cubic Yards or Cubic Meters)
qUnits	Text	255	Units of volume for sediment transport rate (Cubic Yards/Year or Cubic Meters/Year)
uncertaintyMethods	Text	50	List of uncertainty methods used in sediment budget. The SBAS application does not reference or write to this field
mediaIDPK	Text	50	ID to hold links to related media documentation. The SBAS application does not reference or write to this field
sdsMetadataID	Text	50	ID to hold unique metadata ID

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14. ABSTRACT
This special report acts as a user's guide for the Sediment Budget Analysis System (SBAS) toolbox within ArcGIS Pro. The SBAS toolbox is a free toolset that allows the user to create and visualize a sediment budget using ArcGIS Pro. Included in this report are instructions on how to download the toolbox and create a sediment budget.

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