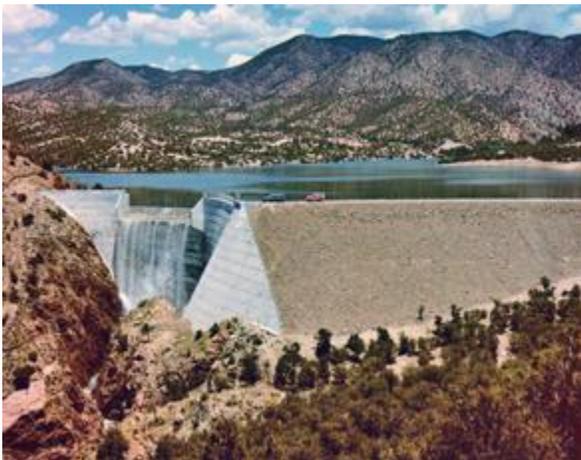


RECLAMATION

Managing Water in the West

Use of a Continuous Simulation, Process-based Model to Predict Sediment Inflow in Unsurveyed Reservoirs

**Research and Development Office
Science and Technology Program
Final Report ST-2015-01-8653**



Joel G. Murray



**U.S. Department of the Interior
Bureau of Reclamation
Research and Development Office
Science and Technology Program**

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Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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ACRONYMS AND ABBREVIATIONS

AGWA – Automated Geospatial Watershed Assessment Tool

ARS – Agricultural Research Service

DEM – Digital Elevation Model

EPA – Environmental Protection Agency

KINEROS2 – Kinematic Runoff and Erosion Model

MRLC – Multi-Resolution Land Characteristics Consortium

NED – National Elevation Dataset

NLCD – National Land Cover Database

NOAA – National Oceanic and Atmospheric Administration

STATSGO – Digital General Soil Map of the United States

SWAT2005 – Soil & Water Assessment Tool

USDA – United States Department of Agriculture

USGS – United States Geological Survey

WEPP – Water Erosion Prediction Project Model

INTRODUCTION

This research project was conducted to investigate the capability of using a continuous simulation, process-based model to predict annual sediment inflow in unsurveyed reservoirs. Verification of a watershed sediment yield model would allow estimates of reservoir sedimentation where no survey data are available and help prioritize reservoir sedimentation survey needs. I reviewed two models, WEPP and SWAT, to address my research question. I also identified three small reservoirs with uncomplicated upstream hydrography that have had resurveys conducted since initial filling to test the model(s):

1. Bully Creek Reservoir, Malheur County, OR
2. Nambe Falls, Santa Fe County, NM
3. Paonia Reservoir, Gunnison County, CO

WEPP

While researching the WEPP model, I discovered that it was only suitable to model watersheds that were less than 300 ha in size (Flanagan and Nearing, 1995). Thus, I excluded this model from consideration as my watersheds are more than an order of magnitude larger.

SWAT

While researching the SWAT model, I discovered the AGWA Tool (Miller et al., 2007). AGWA is a Geographic Information Systems (GIS) interface jointly developed by the U.S. Environmental Protection Agency, the U.S. Department of Agriculture (USDA) Agricultural Research Service, and the University of Arizona to automate the parameterization and execution of the SWAT and KINEROS2 hydrologic models¹. Following a review of documentation, gathering input data and validating model output using the AGWA interface, I was able to verify that SWAT is an appropriate model for predicting annual sediment inflow in unsurveyed reservoirs.

MATERIALS AND METHODS

Bathymetric data for Bully Creek and Nambe Falls were collected using sonic depth recording equipment interfaced with a global positioning system (GPS) that gave continuous sounding positions throughout the underwater portions of the reservoir covered by the survey vessel. Bathymetric data for Paonia were collected using a range line survey technique; employing sounding weights at regular intervals to record depth. These data were then used to develop a topographic map to calculate reservoir capacity loss (i.e. observed values) due to sediment accumulation since dam closure. The time period over which the sediment accumulation was calculated can be found in Table 1.

¹ EPA. 2014. *Automated Geospatial Watershed Assessment Tool*. Retrieved July 7, 2015 from <http://www.epa.gov/esd/land-sci/agwa/>

Table 1. Sediment Accumulation Time Period for Selected Reservoirs.

Reservoir	Time Period	Location
<i>Bully Creek</i>	1963 - 2000	Malheur County, Oregon
<i>Nambe Falls</i>	1976 - 2004	Santa Fe County, New Mexico
<i>Paonia</i>	1962 - 1969	Gunnison County, Colorado

AGWA uses commonly available GIS data layers to fully parameterize, execute, and spatially visualize results from both SWAT and KINEROS2. Through an intuitive interface, users select an outlet from which AGWA delineates and discretizes the watershed using a Digital Elevation Model (DEM) based on the individual model requirements. The watershed model elements are then intersected with soils and land cover data layers to derive the requisite model input parameters². Specific input parameters used for this project to calculate sedimentation rates are as follows:

1. DEM
 - a. Source: NED (USGS)
 - b. Format: Raster
 - c. Resolution: 30m
2. Land Cover
 - a. Source: NLCD (MRLC)
 - b. Format: Raster
 - c. Resolution: 30m
3. Soils
 - a. Source: STATSGO2 (USDA)
 - b. Format: Vector
 - c. Resolution: 1:250,000
4. Climate
 - a. Source: ARS (USDA / NOAA)
 - b. Format: Tabular
 - c. Resolution: Point Location

² EPA. 2014. *Automated Geospatial Watershed Assessment Tool*. Retrieved July 7, 2015 from <http://www.epa.gov/esd/land-sci/agwa/>

RESULTS

Bully Creek Dam and Reservoir

Bully Creek Dam is located on Bully Creek about 8 miles northwest of the confluence with the Malheur River and 9 miles northwest of Vale, Oregon in Malheur County. The dam is a zoned earthfill structure with a crest length of 3,070.0 ft and total height of 121.0 ft. Bully Creek Reservoir has a total capacity of 24,400.0 ac-ft at an elevation of 2516.0 ft. The contributing area to the reservoir is roughly 550.0 sq mi. Results from the SWAT2005 model over the time period from 1963-2000 suggest an average annual sediment yield of 312.5 ac-ft (Figure 1), which is an overestimate of approximately 61% from the observed value of 193.6 ac-ft (Ferrari, 2001).

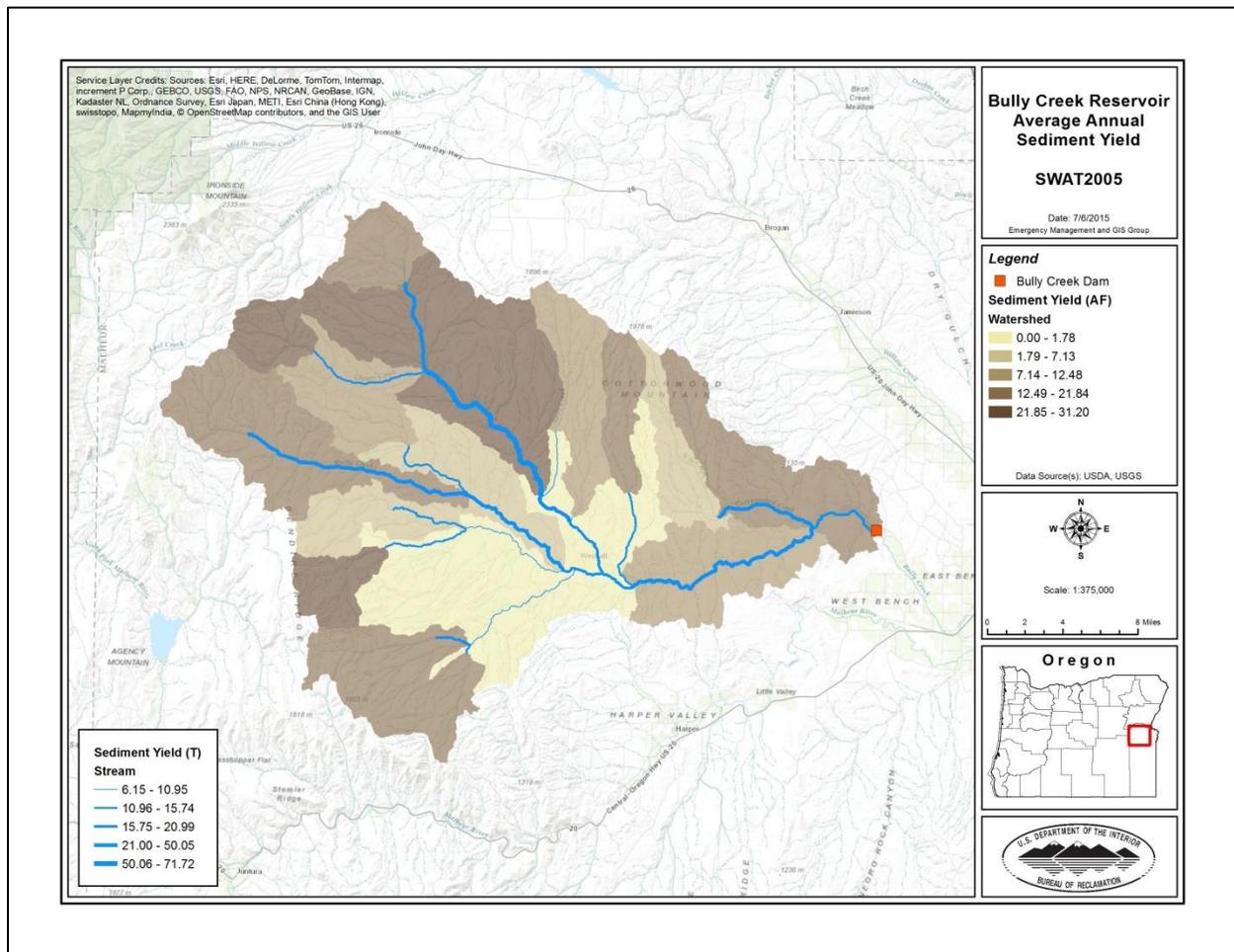


Figure 1. Average Annual Sediment Yield for Bully Creek Reservoir (1963-2000), SWAT2005 Model.

Nambe Falls Dam and Reservoir

Nambe Falls Dam is located on Rio Nambe about 300 feet upstream from Nambe Falls and 25 miles north of Santa Fe, New Mexico in Santa Fe County. The dam is a concrete and earth embankment structure with a crest length of 1,021.0 ft and total height of 150.0 ft. Nambe Falls Reservoir has a total capacity of 2,023.0 ac-ft at an elevation of 6826.6 ft. The contributing area to the reservoir is roughly 35.0 sq mi. Results from the SWAT2005 model over the time period from 1976-2004 suggest an average annual sediment yield of 6.3 ac-ft (Figure 2), which is an overestimate of approximately 66% from the observed value of 3.8 ac-ft (Ferrari, 2004).

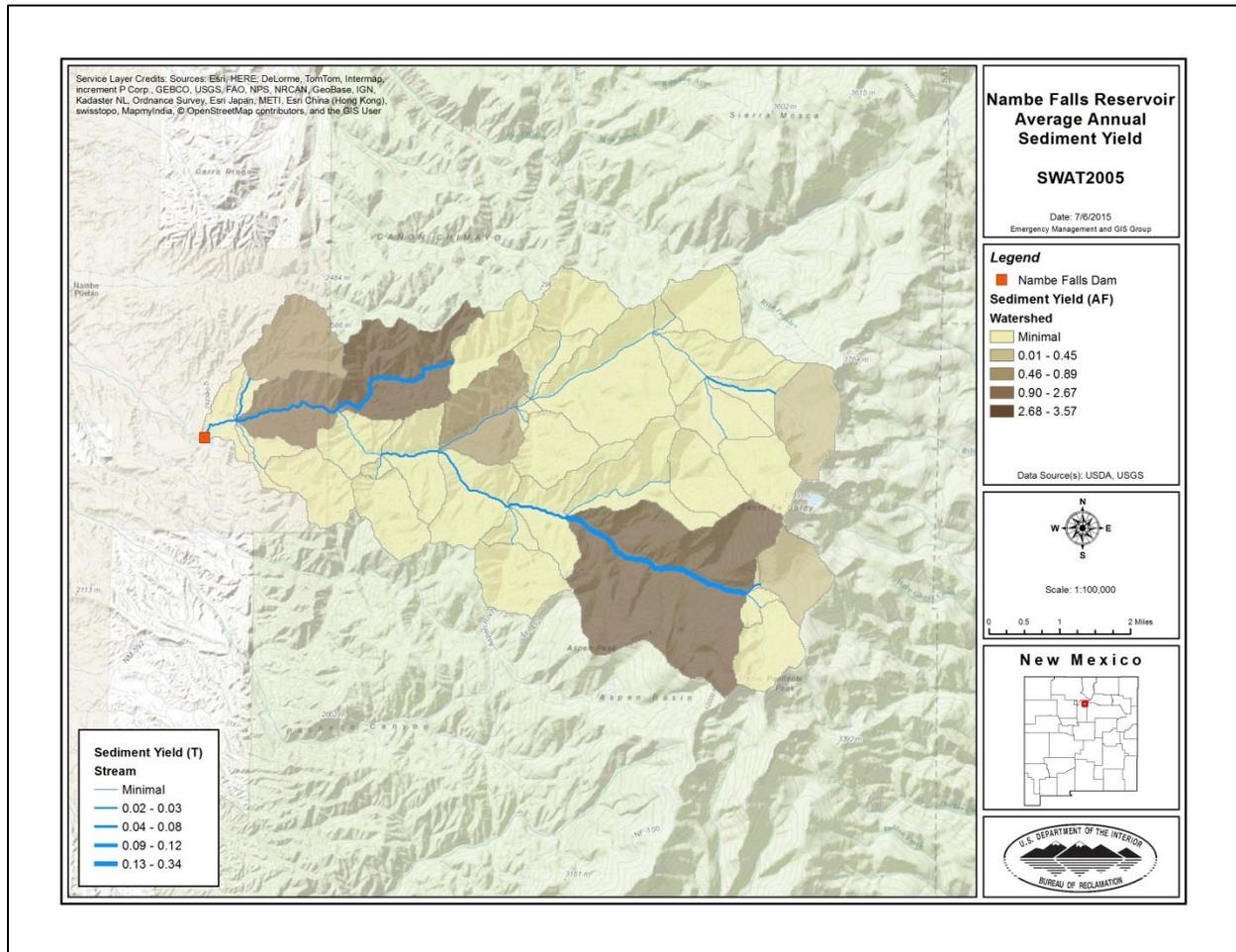


Figure 2. Average Annual Sediment Yield for Nambe Falls Reservoir (1976-2004), SWAT2005 Model.

Paonia Dam and Reservoir

Paonia Dam is located on Muddy Creek about 1 mile upstream of the confluence with Anthracite Creek and 16 miles northeast of Paonia, Colorado in Gunnison County. The dam is a zoned earthfill structure with a crest length of 770.0 ft and total height of 199.0 ft. Paonia Reservoir has a total capacity of 29,950.0 ac-ft at an elevation of 6454.1 ft. The contributing area to the reservoir is roughly 255.0 sq mi. Results from the SWAT2005 model over the time period from 1962-1969 suggest an average annual sediment yield of 165.1 ac-ft (Figure 3), which is overestimate of approximately 62% from the observed value of 102.0 ac-ft (Bellport, 1969).

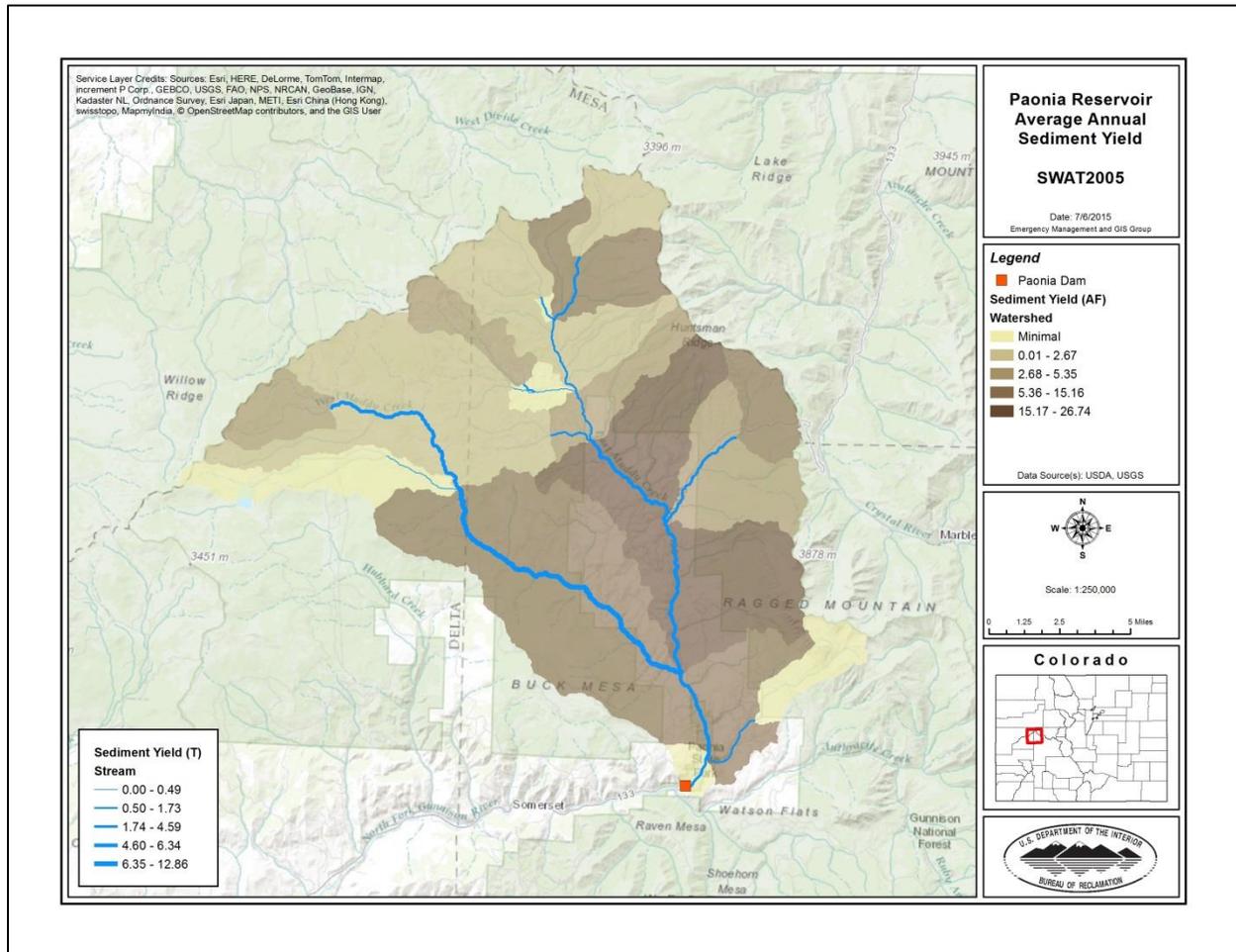


Figure 3. Average Annual Sediment Yield for Paonia Reservoir (1962-1969), SWAT2005 Model.

DISCUSSION

The SWAT2005 model consistently overestimated the observed values by approximately 63% (Figure 4). Possible causes for magnification of the model output may include:

- 1) Data Resolution – As data resolution increases, model results may improve.
- 2) Land Cover Change – Consideration of wildfires or other land cover changes may influence model results.
- 3) Interpolated Climatic Data – Some of the precipitation and temperature data were interpolated which may inflate the estimated sedimentation rates.

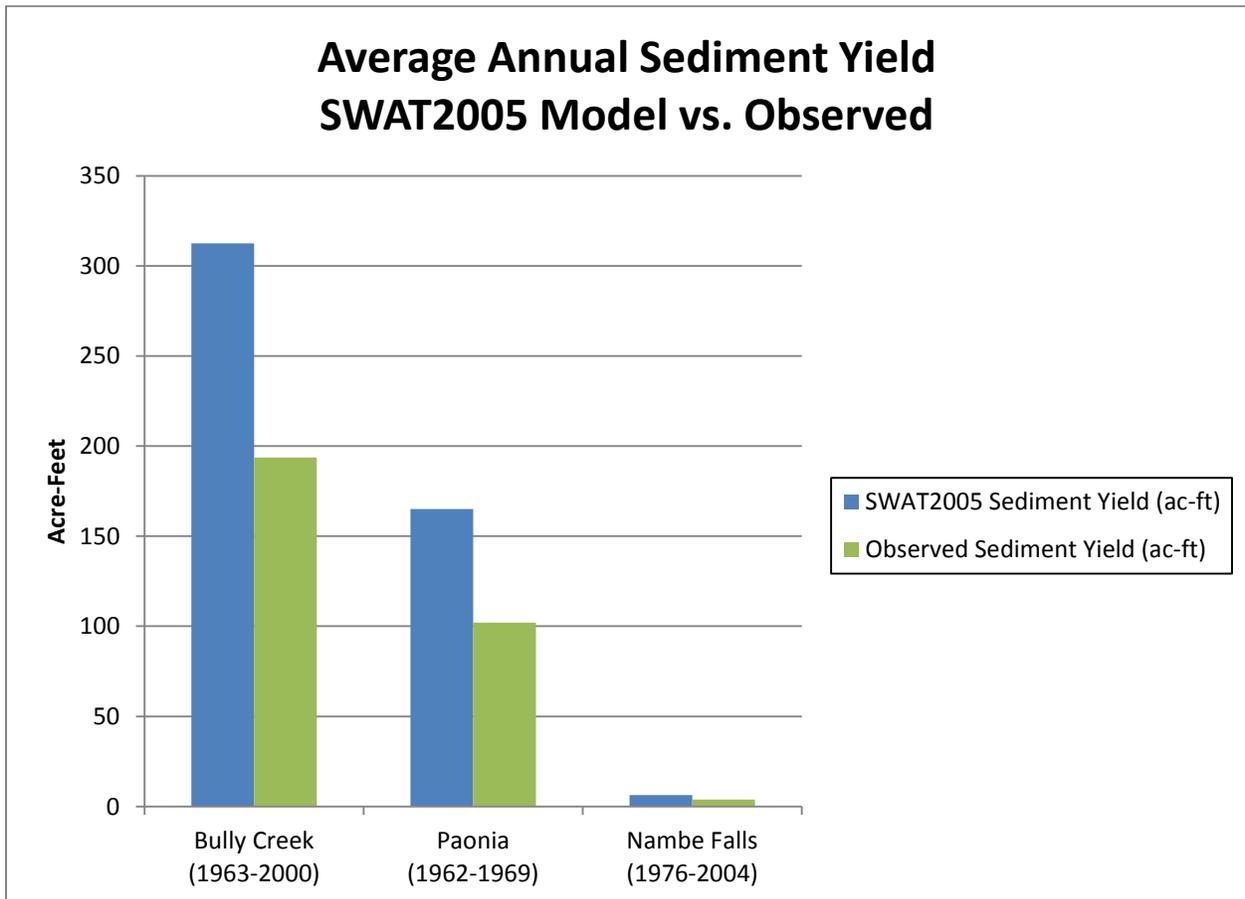


Figure 4. Average Annual Sediment Yield for Selected Reservoirs, SWAT2005 Model vs. Observed.

Calibration of SWAT2005 using AGWA should improve the accuracy of the estimated values; therefore, I am requesting an additional \$21,600 in FY2016 to continue my modeling efforts with SWAT. This will include the investigation of using the AGWA Land Cover Modification Tool to create new land cover grids to study the impacts of fire. Using the Burn Severity component, AGWA users can create a new

surface with land covers based on explicit transitions from one land cover type to another based on burn severity. Many USBR reservoir are located in watersheds that experience frequent and extensive wildfires, thus this may be an extremely useful calibration tool.

I will also use the FY2016 funding to develop my own model based on the Pacific Southwest Interagency Committee (1968) sediment yield classification procedure as described in Chapter Two of the USBR Erosion and Sedimentation Manual (2006). The model will be GIS-based and predicts sediment yield as a function of nine individual drainage basin characteristics. These include: surface geology, soils, climate, runoff, topography, ground cover, land use, upland erosion, and channel erosion which are generally readily available in a GIS format. Each characteristic is given a subjective numerical rating based on observation and experience where the sum of the ratings determines the drainage basin classification and annual sediment yield per unit area.

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DATA SETS THAT SUPPORT THE FINAL REPORT

Share Drive folder name and path where data are stored:

\\BOR\DO\GIS\Research and Development\ST-2015-01-8653

Point of Contact name, email and phone:

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Short description of the data:

SWAT Input Files, SWAT Output Files, Digital Maps

Keywords:

Sedimentation / SWAT / Unsurveyed Reservoir / WEPP

Approximate total size of all files:

1.43 GB