**Shoshone River Water Resources II**

*Quantifying Sediment Input in the Shoshone River in Wyoming using the Soil and Water Assessment Tool for Enhanced Water Quality Monitoring*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:***

The Shoshone River Water Resources II project used remote sensing and environmental modeling to determine specific tributaries with high sediment input into the Shoshone River between the Buffalo Bill Dam and the Willwood Dam from January 2019 to October 2021. We used Earth observations to conduct a remote sensing analysis of sediment plumes, and the Soil and Water Assessment Tool (SWAT) to create a model of the watershed. The coupling of these results enabled our partners, the Wyoming Department of Environmental Quality, to determine high priority basins along the river for implementation of remediation.

***Abstract:***

The Willwood Dam, an irrigation diversion dam located on the Shoshone River (Wyoming, USA), has faced ongoing issues with sediment accumulation and needs frequent sediment flushing to remain operable. However, high suspended sediment levels during flushing events have negatively impacted downstream aquatic ecology and recreational opportunities. To address these problems, DEVELOP partnered with the Wyoming Department of Environmental Quality, Shoshone River Partners, and United States Geologic Survey. During term one, the team developed a workflow to map turbidity using PlanetScope imagery, analyze time series precipitation data, and create landcover maps. For this term, we focused on three methods to gain a better understanding of sediment sources: 1) improving remote sensing of turbidity, 2) modeling sediment transport within using the Soil and Water Assessment Tool (SWAT), and 3) conducting a snow cover time series analysis through remote sensing Suomi NPP VIIRS imagery. Through remote sensing, we found Dry Creek/Homesteader Creek and Penney Gulch had the highest concentration sediment plumes. SWAT+ created a high-resolution grid model of the watershed, identifying high sedimentation in the western and southern subbasins. The SWAT+ model displayed low-correlated calibration and validation results due to limited observed data. Remote sensing quantified snow cover extent was analyzed in a time series alongside other hydrologic variables. Snow melt events correlated with increases in suspended sediment concentration and turbidity values. Coupling remote sensing with hydrological modeling will give watershed managers a new perspective on high-priority regions for implementation of remediation to reduce the sediment build-up at the Willwood Dam.

***Key Terms:***

Suspended Sediment, Turbidity, SWAT+, PlanetScope, Snow Cover, Suomi NPP VIIRS, Shoshone River, Tributary

***National Application Area Addressed:*** Water Resources

***Study Location:*** Shoshone River, Wyoming

***Study Period:*** January 2019 to October 2021

***Community Concerns:***

* Concerns include ecological and economic impairments from the build-up and release of sediments at the Willwood Dam which induce hypoxic conditions.
* The sediment release results in mass fish kills and die off of aquatic insects which deters tourist recreation and fishing capabilities. Outdoor recreation in Park County, the location of Shoshone River, is largely attributed to tourism revenue and economic stimulation.
* Sediment build-up and releases impact the surrounding agriculture by altering irrigation needs and making seasonal crop planning for farmers more challenging.

***Project Objectives:***

* Conduct Soil and Water Assessment Tool (SWAT) analysis
* Improve plume detection via turbidity remote sensing
* Conduct snow cover analysis

***Previous Term:***

2022 Fall PUP – Shoshone River Water Resources

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Wyoming Department of Environmental Quality** | David Waterstreet, Watershed Protection Program Manager | End User |
| **Wyoming Department of Environmental Quality, Shoshone River Partners** | Carmen McIntyre, Watershed Coordinator | End User |
| **USGS, Wyoming-Montana Water Science Center** | Jason Alexander, Supervisory Hydrologist | Collaborator |

***Decision-Making Practices & Policies:***

Watershed managers have used in-situ turbidity data and time-lapse photography to identify tributaries contributing high amounts of sediment to the Shoshone River. Currently, there is an emphasis on the implementation of best management practices (BMPs) within the watershed. Examples of BMPs include stream restoration, riparian fencing, improving road crossings, improved irrigation infrastructure, and providing water for livestock outside of the riparian area. Local watershed managers are also involved with community education and outreach efforts to both gather local knowledge and empower improved watershed stewardship practices.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **PlanetScope** | Surface reflectance | High-resolution (3m) surface reflectance data were used to identify major contributing watersheds following surface runoff events. |
| **Suomi NPP VIIRS** | Snow cover | Snow cover extent data was used to conduct a snow cover time series of the region. |

***Ancillary Datasets:***

* University of Idaho Gridded Surface Meteorological (gridMET) – Precipitation, temperature, humidity, wind, and solar radiation for SWAT+ model
* USGS National Land Cover Database (NLCD) – Land cover raster for SWAT+ model
* USDA Soil Survey Geographic (gSSURGO) – Soil input for SWAT+ model
* USGS Digital Elevation Model (DEM) – Digital Elevation Model (10m) for SWAT+ input
* NOAA Climate Data Online – Daily climate data for time series analysis
* USGS Water Data – Daily stream data for time series analysis

***Modeling:***

* Soil and Water Assessment Tool (SWAT) -- Identify basins with high sediment input into the Shoshone River
* R-SWAT (Tam Nguyen) – SWAT+ model uncertainty and sensitivity analysis

***Software & Scripting:***

* QGIS 3.26.3 – Run SWAT and cartographic processes
* R 4.2.2 – Process and manipulate SWAT climate inputs
* Python 3.9 – Machine learning, random forest modeling, snow cover calculation, and SWAT soil manipulation
* ArcGIS Pro 3.0 – Cartographic processes

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Sediment Input by Channel Map** | N/A | Analyzing sediment input into the Shoshone River by channel and subbasin to determine areas of needed remediation | N/A |
| **Snow Cover Time Series** | Suomi NPP VIIRS  | Observing the extent of snow cover in the study area to relate changes in extent over time and the relationship between hydrologic variables with periods of increased sediment accumulation. | N/A |
| **Sediment Plume Analysis** | PlanetScope | Sediment plume maps will help identify tributaries contributing sediment at the Willwood Dam | N/A |

***Product Benefit to End User:***

We demonstrated the feasibility of using remote sensing and environmental modeling as a means of water quality monitoring in the Shoshone River. Analyzing turbidity trends on a large, high-resolution scale allows managers to focus on the implementation of best management practices (BMPs) in areas with the highest rate of sediment plumes and input. All three end products identify which regions are either contributing sediment, seeing high snow melt, or both. Knowing the high priority subbasins or channels within the watershed will allow the managers to focus their funds and volunteer efforts in the regions that need the most change.

**References**

Abbaspour, K., Yang, J., Maximov, I., Siber, R., Bogner, K., Mieleitner, J., Zobrist, J., & Srinivasan, R. (2007, February). Modelling hydrology and water quality in the pre-alpine/alpine Thur watershed using SWAT. *Journal of Hydrology*, 333(2-4), 413-439. <https://doi.org/10.1016/j.jhydrol.2006.09.014>

Bieger, K., Arnold, J., Rathjens, H., White, M., Bosch, D., Allen, P., Volk, M., and Srinivasan, R. (2017). Introduction to SWAT+, a Completely Restructured Version of the Soil and Water Assessment Tool. *Journal of the American Water Resources Association (JAWRA)* 53(1): 115– 130. <https://10.1111/1752-1688.12482>

Duan, P., Zhang, F., Liu, C., Tan, M.L., Shi, j., Wang, W., Cai, Y., Kung, H., &Yang, S. (2023) High-Resolution Planetscope Imagery and Machine Learning for Estimating Suspended Particulate Matter in the Ebinur Lake, Xinjiang, China. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing,* 16(1019-1032). <https://doi.org/10.1109/JSTARS.2022.3233113>

Riggs, G.A., Hall, D.K., & Román, M O. (2019). VIIRS/NPP CGF Snow Cover Daily L3 Global 375m SIN Grid, Version 1 (VNP10A1F). Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. <https://doi.org/10.5067/VIIRS/VNP10A1F.001>