Capstone Project

A GIS-based Estimate of Sediment Input to the White River Associated with Changes in Land Use/Land Cover

King and Pierce Counties, Washington

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Abstract

The degree to which changes in land cover have increased sediment input to the White River in Washington State was evaluated using GIS-based hydrologic simulation and visualization at different spatial and temporal scales. Published datasets for basin topography, soil type, precipitation, and land cover were intersected using the Automated Geospatial Watershed Assessment (AGWA) interface to parameterize and execute hydrologic simulations for the 1,280 sq. km. White River Basin. Simulation results for the period 2001-2006 using the Soil Water Assessment Tool (SWAT) and KINematic Runoff and EROSion (KINEROS2) hydrologic models suggest that changes in surface runoff and rate of sediment yield in in the basin have resulted in an increase of between 0.023 and 0.153 percent in the annual sediment load of the White River downstream of the basin's 109 sq. km. Twin Creek Watershed. These results further suggest that the increase in White River sediment load during this period is primarily associated with land cover changes in the Twin Creek Watershed.

Acknowledgements

This capstone project is the culmination of my Master of Science degree program in the study of Environmental Science and Policy at Johns Hopkins University, and I have only been able to undertake it by drawing upon the knowledge and skills I have acquired in each of the program's preceding courses. My degree concentration is Environmental Monitoring and Assessment, and the project presented herein has provided the opportunity for me to synthesize my graduate coursework in foundational subjects such as geology, ecology, hydrology, and atmospheric sciences, along with the knowledge and technical skills I have developed at Johns Hopkins in the use of a range of technology-based monitoring and assessment tools, including geographic information systems, remote sensing imaging applications and data, and environmental computer models. I have been very fortunate to participate in such a program, and in doing so, to learn from some of the sharpest minds in their respective fields.

I would also like to acknowledge and express my deepest appreciation for the collective contributions of all of my classmates, who have enriched my JHU education with their perspectives, opinions, passions, wit, and humor.

Many thanks to my program advisor David Elbert, who in addition to teaching courses of his own, served Johns Hopkins well as the Acting Program Director for the Advanced Academic Programs Environmental Studies Program during most of my time at JHU. His academic counsel was reassuring and truly appreciated.

A very special thank you to my project Field Advisor Christiane Runyan for all of her guidance on this project. She provided expert assistance with the development and refinement of the project approach, and made numerous suggestions relating to both the content and format of the report. Her advice, input, and critical reviews were invaluable to me, and I truly appreciate her assistance.

Last, but not least, thank you to my wife Cha Cha Andersen, who has always been supportive of my studies and understanding of my graduate student schedule, no matter how many nights I spent next to my computer at the kitchen table.

With deepest respect and sincere appreciation,

- Chris Andersen

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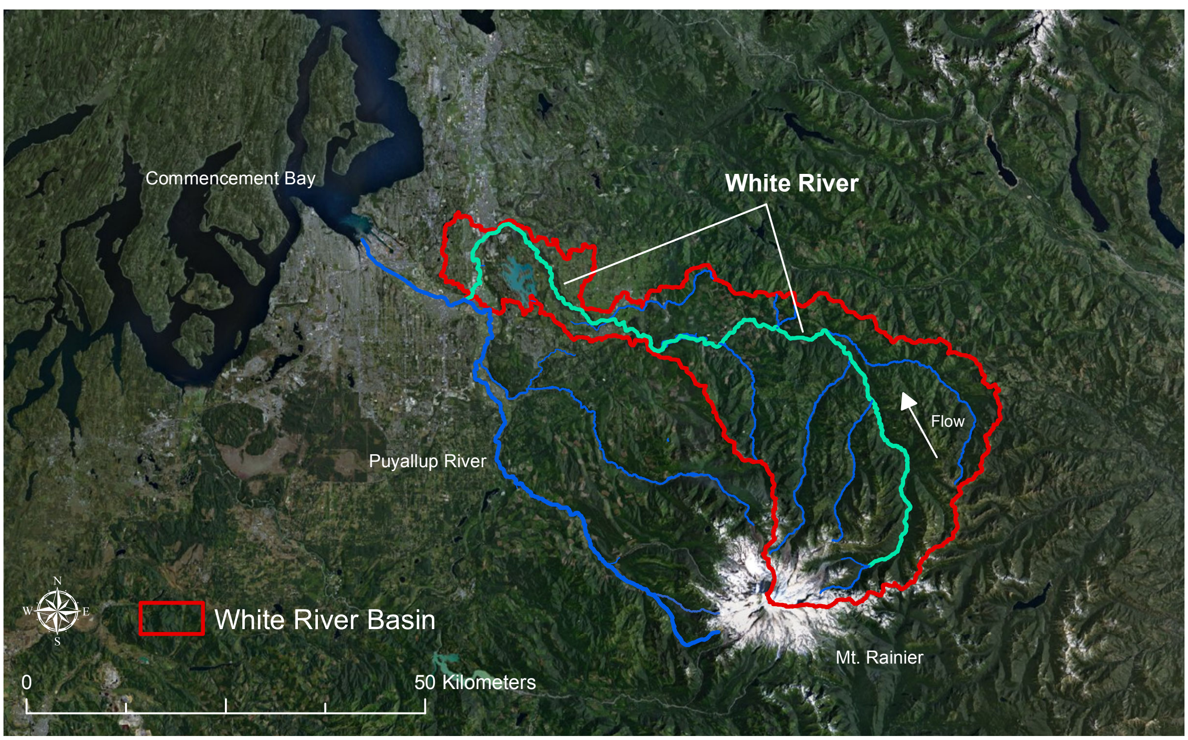
Introduction

The White River Basin is located in King and Pierce Counties in western Washington State. The basin covers some 1,280 square kilometers (494 square miles), and extends west from the Cascade Mountains to the Puget Sound lowlands. The principal drainage of the basin is the White River, which originates at an elevation of over 3,950 m (13,000 ft) at the terminus of the Emmons, Winthrop, and Fryingpan glaciers on the northern slope of Mt. Rainer (Gersib, R. et al, 2005). The White River flows in a generally northwesterly direction for approximately 112.7 km (70 miles) before turning south and joining the Puyallup River approximately 16.1 km (10 miles) upstream of the Puyallup's outlet to Commencement Bay in Tacoma, Washington (Pierce County, 2012).

Figure 1 shows the White River Basin and surrounding vicinity. The basin outline is shown in red, and the course of the White River is depicted with a teal color. The Puyallup River into which the White River flows, and major tributaries of both rivers, are shown in blue.

Figure 1: White River Basin and Vicinity



In the upper portion of the basin, the White River is a steep-gradient, high-energy mountain stream with the capacity to carry high sediment loads. In the western, lower portion of the basin, the gradient decreases dramatically, and the lower energy levels of the river in this portion of the basin allow much of its sediment load to settle out in the more urbanized Puget Lowland valleys (Czuba et. al, 2010). The balance of the river's sediment is transported out to Commencement Bay, approximately 16.1 km (10 miles) downstream of where the White River joins the Puyallup River.

There are two reservoirs on the White River, Mud Mountain Lake and Lake Tapps. Mud Mountain Lake was formed when the Army Corps of Engineers built the Mud Mountain Dam in 1948 as a flood control facility. Mud Mountain Lake has an area of 1,200 acres and 106,275 acre-feet of storage (Pierce County 2012). Lake Tapps is a man-made reservoir that was created by the construction of a diversion dam in 1911 at River Mile (RM) 24 near Buckley. An outlet from Lake Tapps discharges back to the White River near RM 3.5 (Kerwin, 1999).

In general, the main sources of river sediment are the landscape that drains to the river, and the bed and banks of river channels. Sediment originating from the landscape is the result of raindrops impacting the soil and water flowing across the ground (overland flow). In areas of growing population, increased intensities of development associated with urbanization in a watershed can increase impervious surfaces, thereby decreasing infiltration and increasing runoff (and the associated energy of that water) across the ground surface and into stream channels. This appears to be, at least in part, a factor in the lower White River Basin, where an earlier analysis of land cover change during the period 1990 to 2000 using remotely-sensed multispectral Landsat data suggests that nearly 25 percent (3.6 square kilometers) of the forested area in the 10.9 sq. km (4.2 sq. mi.) present day City of Auburn portion of the basin was converted to non-forest vegetation and developed surfaces (Andersen, unpublished).

In the upper White River Basin, the most significant sources of sediment input to the White River are timber harvest operations and associated road building, on- and off-road recreation, and landslides (Ketcheson and McGee, 2006; Brummer and Stypula, personal communication 2013). The removal of vegetation and road building associated with timber harvest in the upper basin generates increased sediment input, both during and years after those activities are performed (Beschta, 1978). Additionally, the removal of mature stands of forest decreases the amount of rainfall intercept and the amount of water storage and evapotranspiration previously provided by the trees, allowing more precipitation to fall to the ground. All of these conditions result in increased runoff and sediment input to streams. Depending on the soil type and slope, land use change can increase erosion and sediment production that can eventually result in mass earth movements such as landslides (Beschta, 1978). Increased stream volumes (particularly in high gradient streams) results in increased stream velocities, which in turn can increase the erosion of stream banks and the scour of stream beds, all of which result in the increased sediment loading of streams (Ward and Trimble, 2004).

Numerous studies during the past 50 years have provided estimates of sediment transport in the White River. Since 1966, annual sediment load estimates have ranged between 409,091 tonnes (450,000 tons) and 1,318,182 tonnes (1,450,000 tons). See Table 1. While much literature has been published documenting that the high volume of sediment originates in the steep upper portion of the basin, and specifically on the slopes of Mt. Rainier, there is little published information available that addresses how much of the sediment that is carried by the White River can be attributed to changes in land cover.

Table 1: Published Estimates of White River Sediment Transport

Estimate Source	Period	Remarks	Suspended Load (tons)	Bedload (tons)	Total Sediment Load (tons)
Dunne, 1986	1966-76	Average annual 10 year low 10 year high	500,000 146,000 1,400,000	20,000	520,000
Nelson, 1979	6/74-6/75 6/75-6/76		430,000 1,400,000	20,000 50,000	450,000 1,450,000
Czuba et. al, 2012	Water Year 2011 4/10-3/12	 Average annual	581,000 407,851	72,000 50,706	653,000 458,557

Prior to 1990, sediment removal activities in the White River were commonly conducted for river channel management and gravel resource use. Between 1974 and 1987, over 649,870 m^3 (850,000 yd^3) of sediment was removed from the river. However in recent years, concerns about the effects of sediment removal on federally listed fish stocks have served to all but eliminate sediment removal activities in the river. Since 1987, only 9,351 m^3 (12,230 yd^3) of sediment have been removed from the river, and none since 1998 (Czuba et. al, 2010). The lower White River, and the lower 16.1 km (10 mi.) of the Puyallup River into which it discharges, run through ten incorporated cities and many more unincorporated communities that are home to a total of more than 300,000 people (OFM, 2013). Today, in the absence of the sediment removal activities that have historically been undertaken on the White River, aggradation in depositional reaches of both river channels have raised channel migration and flooding concerns for many of these communities. A better understanding of not only the sediment transport dynamics of the river, but also the conditions and processes that affect its sediment supply, will assist watershed and river managers with the selection and implementation of sediment management practices in the future.

Study Objectives

This study employed widely available hydrologic modeling tools and initial input data sets that can be relatively easily integrated with GIS to evaluate how changes in land cover in the White River Basin may affect sediment loads in the White River. To that end, this project had three primary objectives.

Objective #1: To develop an estimate of the relative contribution to total sediment load in the White River that can be attributed to changes in land cover that have occurred throughout the basin during the simulation period. While this objective originally focused on the 15-year period from 1992-2006 for which input data were obtained, initial simulation results showed that sediment levels decreased within most sub-basins during the first 10 years from 1992 to 2001. In evaluating these preliminary results further, it was felt that the change outputs generated by the models were likely skewed for the 1992-2001 comparison by the differing methodologies used by for collection and classification of the NLCD 1992 and NLCD 2001 data sets used in the study (MRLC, 2013). For this reason, the 1992 simulation was run to provide information about the relative magnitude and distribution of sediment generating sub-basins within the White River Basin, however the analysis of relative changes in runoff and sediment yield within each sub-basin were subsequently focused on the last five years of the simulation period from 2001 to 2006 where the land cover data for each year were collected and processed using the same method, and the data are reported to be more directly comparable (MRLC, 2013).

Rationale: A number of management actions to address the reduction of sediment levels in the White River have been implemented in the basin over the last 50 years, principally for the purposes of flood control, facilitating the recovery of federally-listed fish stocks, and improving water quality (Czuba, et. al 2010, WDOE 2006). These actions range from restricting forest harvest practices in the upper basin, to gravel removal in the White River, and the establishment of stream buffers and other development regulations, the latter of which have been focused most heavily near the more urbanized areas in the lower basin. A better understanding of the relative magnitude of sediment input to the river associated with land cover change will provide resource managers in the basin with better information to help select and prioritize appropriate management practices and to determine the optimum level of resources to be used in applying those practices. This study objective was selected in anticipation that findings from the project could help resource managers prioritize and select between practices that minimize sediment input vs. management actions that are more reactive to removing sediment after it has been introduced into the river and its tributary waterways.

Understanding the relative degree to which land cover, and by extension the land use management practices that lead to those changes, effect sediment load within the basin will help managers quantify basin-wide management action objectives and performance metrics prior to undertaking those actions, and to evaluate the effectiveness of those actions during and after implementation. While it is relatively easy to arrive at a better-worse vector when considering management actions to address a singular goal (i.e. to do more of one thing or less of another to improve fish habitat), it is often more challenging to know both the kind of action that should be taken, and how much of it to take- especially when balancing seemingly competing objectives (i.e. to make trade-offs between the need to impose timber harvest restrictions to protect habitat, while not impairing the viability of the forest resources sector of the local economy).

<u>Objective #2</u>: To determine: a) the areas in the basin where hydrologic response may be most affected by land cover change, and b) to further evaluate one or more of those areas (sub-basins) to determine how land cover changes may affect single-event hydrologic response and sediment input.

<u>Rationale</u>: The White River is the primary drainage for a large basin that is diverse in terms of topography, climate, land uses, and resources. A better understanding of which areas in the basin are most sensitive to changes in land cover in terms of hydrologic response and the generation of sediment input will provide basin resource managers with better information by which to geographically focus management actions, prioritize the actions that may be most effective in a given area, evaluate land management proposals based on the specific conditions of the proposal site, and to concentrate ongoing monitoring efforts.

Similar to the benefits of having a better basin-wide understanding of how land cover change effects annual sediment inputs for some sub-basins, understanding the relative degree to which land cover change has effected sediment yields during individual storm events within those sub-basins will help managers to quantify management action objectives and performance metrics that better reflect the local conditions within those sub-basins prior to undertaking actions, and then to be able to evaluate the effectiveness of those actions, and if necessary make refinements during implementation.

<u>Objective #3</u>: To make the information developed through this project broadly available to White River Basin researchers, resource managers, community decision makers, and others who are addressing similar questions in other river basins, through publication of the study results in a peer-reviewed, scientific journal.

Rationale: AGWA, and the GIS framework within which it operates, offer robust visualization capabilities that allow for simulation results to be produced in both tabular and graphic output form, thereby allowing users to present model results to both technical and non-technical audiences with a minimum of additional preparation. The benefits of accomplishing Objectives #1 and #2 for this project and better understanding how land cover change affects river basin sediment input can only be realized if the information gained through the project is made available to others in a way that creates both an awareness of the information, and access to it. Publication in a scientific journal will provide for both.

Methods

General Approach

This study utilized a GIS-based approach to integrate basin land cover information with other physical watershed data (topography, soils, and precipitation) to parameterize two hydrologic models (SWAT and KINEROS2). These models were then used to simulate hydrologic response, and develop estimates of the relative changes in runoff and sediment yield at different spatial and temporal scales within the basin. The approach generally followed that used for the San Pedro and Willamette River Basin studies conducted by Hernandez et. al, 2003 and Kepner et. al, 2008a. One key difference from those studies is that this project did not use the US Environmental Protection Agency's (US EPA's) Analytical Tools Interface for Landscape Assessments (ATtILA) to develop landscape metrics, as that tool is not compatible with the GIS program used for the project (ArcGIS 10.1). This was not viewed as a shortcoming for the project however, as the primary goal of the project was to estimate the relative increment of White River sediment load that is attributable to land cover change, and not necessarily to enumerate or evaluate the activities that induce such change.

Computing Equipment and Software Applications

Computing Platform

The project was conducted using an Apple MacBook Pro outfitted with a 2.5 GHz processor, 8 GB of memory, and 750 GB hard drive. Parallels 7 hardware virtualization software was installed to run the native Mac OS X Lion operating system and a user-installed Microsoft Windows 7 operating system simultaneously.

Computing Software Applications

ESRI's ArcGIS 10.1 ESRI. ArcGIS 10.1 Desktop GIS served as the GIS program for the project. The ArcView/ArcGIS series of geographic information system applications is widely used by government, industry, and academia for, among other things, analyzing land use and natural resource spatial data, and visualization of data and analysis results at different spatial and temporal scales. It is available to the public for purchase via Internet download at http://www.esri.com. ArcGIS 10.1 is a desktop Geographic Information System (GIS) that can be run on PC with the Microsoft Windows operating system, or on an Apple machine using hardware virtualization software to support the installation and operation of the Microsoft Windows operating system. The ArcGIS Spatial Analyst extension is included in the suite of analysis tools provided in ArcGIS 10.1, and must be enabled to load and use the AGWA modeling interface.

The Automated Geospatial Watershed Assessment (AGWA). The AGWA interface, version 3.0.4 was used to integrate the data processing and visualization capabilities of ArcGIS with the specialized analyses employed by the project's hydrologic models. AGWA was jointly developed by USDA-ARS Southwest Watershed Research Center, in cooperation with the U.S. EPA Office of Research and Development Landscape Ecology Branch. AGWA is an add-in user interface module that can be downloaded from USDA-ARS. It was downloaded from http://www.tucson.ars.ag.gov/agwa/ and was installed in the ArcGIS Spatial Analyst Extension of ArcMap. The SWAT and KINEROS2 hydrologic models used for the project were included as components of the AGWA interface.

KINematic Runoff and EROSion (KINEROS2) Model. KINEROS2 is a public domain hydrologic model developed by the USDA Agricultural Research Service (USDA-ARS) Southwest Watershed Research Center. It is available via Internet download at: http://www.tucson.ars.ag.gov/kineros/. Although developed as a stand-alone model external to AGWA, the KINEROS2 model is also included as a component of the AGWA interface.

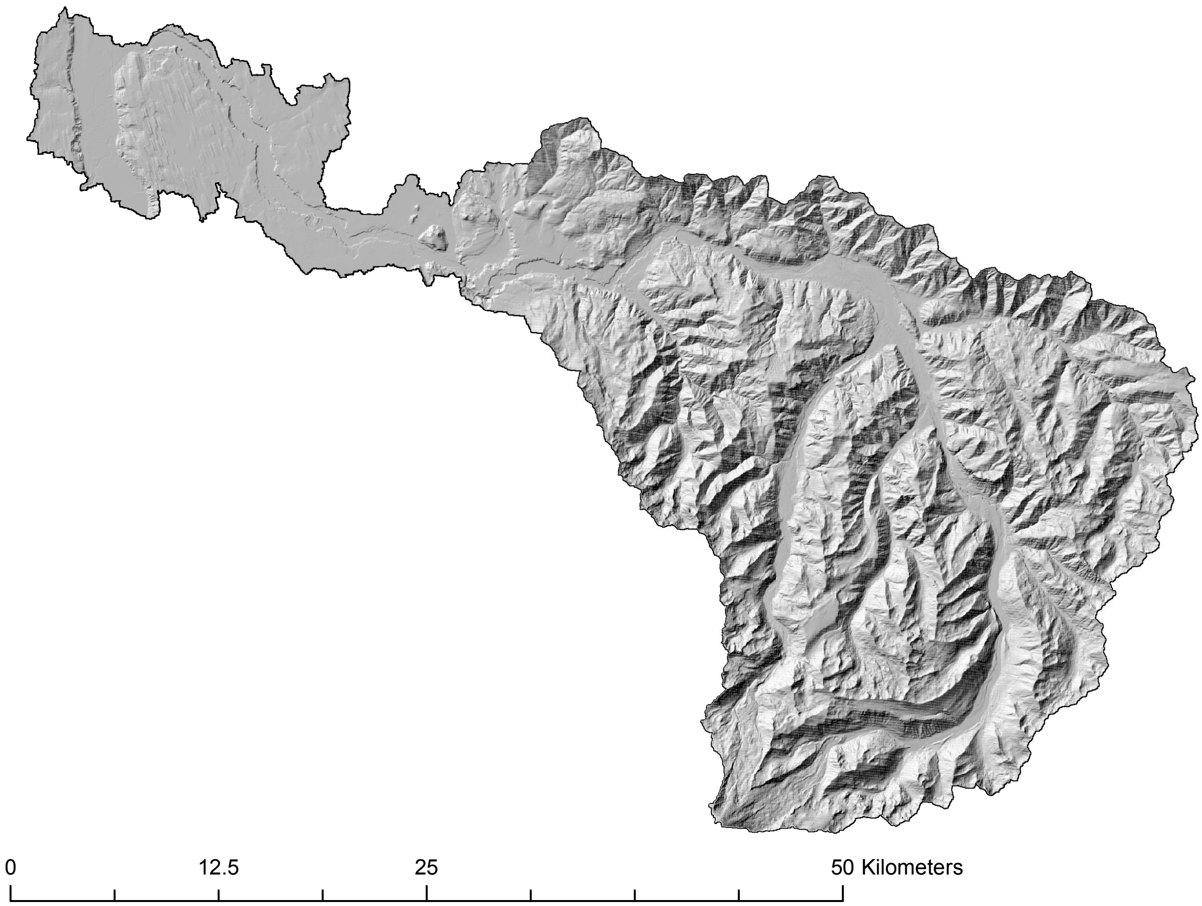
Soil Water Assessment Tool (SWAT). SWAT is a public domain hydrologic model, jointly developed by the USDA Agricultural Research Service (USDA-ARS) and Texas A&M AgriLife Research, affiliated with Texas A&M University. It is available via Internet download at: http://swat.tamu.edu. Although also developed as a stand-alone model external to AGWA, the SWAT model was included as a component of the AGWA interface as well.

Data Acquisition and Processing

Prior to hydrologic modeling, the following data was obtained, loaded into ArcGIS, and processed as described. All spatial data were projected to NAD 83 UTM Zone 10N.

Digital Elevation Model (DEM): The DEM is a raster format elevation data set that provides the grid structure required by AGWA to delineate the hydrologic boundaries of the basin or sub-basin being simulated. DEM data was obtained from the USGS National Elevation Dataset (NED) via Internet download (USGS, 2013a). The extent of the White River Basin covers four 1:100,000 scale NED tiles, so a single mosaic file of the four tiles was created to provide a DEM grid that covered (and extended beyond) the boundaries of the basin. Erroneous “sinks” (isolated depressions that do not truly reflect basin topography) in the DEM mosaic were filled using the AGWA interface. Additional grid files for flow direction, flow accumulation, and stream mapping were created from the DEM during basin delineation using a feature in AGWA designed for that purpose. Figure 2 shows a hillshade depiction of the DEM used for this project.

Figure 2: Hillshade View of Digital Elevation Model for the White River Basin



Land Cover Data: Land cover data for 1992, 2001, and 2006 were obtained via Internet download from the National Land Cover Database (NLCD) series of data products published by USGS (Vogelmann et al. 2001, Homer et al. 2007, and Fry et al. 2011). Information published with the data sets by USGS indicates that the 2001 and 2006 data are directly comparable, whereas the 1992 dataset was developed using a different methodology and should not be subjected to direct comparison (MRLC, 2013).

To provide a basis for more accurately determining land cover changes between 1992 and 2001, USGS has also published the 1992/2001 Land Cover Change Retrofit dataset (LCCR), which was developed using a hybrid change analysis process that incorporated both post-classification comparison and specialized ratio differencing change analysis techniques (Fry et al., 2009). The LCCR data were downloaded and used to develop a map layer of generalized ‘Change To’ land cover classes during the simulation period to assist with assessing how the nature and distribution of changes in land cover may correspond to changes in the rates of surface runoff and sediment yield identified by the simulations.

NLCD 2006 Land Coverage Change data were also obtained from USGS to provide land cover change information for the period 2001-2006. The land cover change data for this period were developed using change vector analysis to identify changed pixels, and decision tree classification trained from unchanged pixels to identify the updated land cover type for the changed pixels (Xian et al., 2009). Similar to the process used for the 1992-2001 period, the 2001-2006 change data were used to develop a generalized ‘Change To’ LU/LC layer to help interpret the comparison of modeling results between those two years.

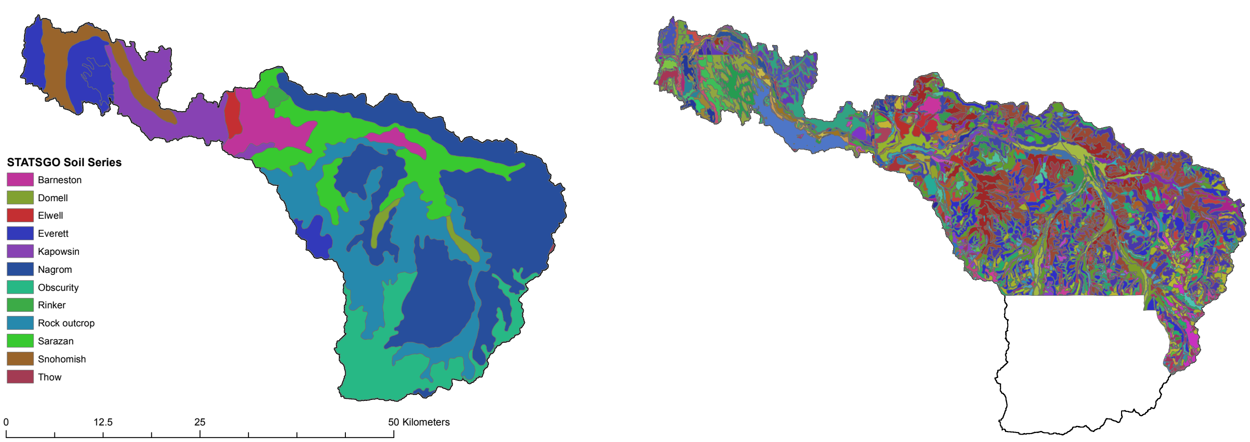
It should be noted that the generalized land cover change maps (shown in Figure 24 for basin-wide change between 1992-2001 and 2001-2006, and figures 26c and 27c for the change in the Twin Creek and Lower White River Sub-basins from 2001-2006) aggregate the USGS land cover change data into broad classes that capture higher order changes between land cover types (i.e. from Forest to Grassland or Grassland to Urban), but do not capture changes within these broad groups such as from Evergreen Forest to Mixed Forest, or the transition of existing urban uses to higher intensity urban uses.

Soils Data: Soils data was obtained from the USDA National Resource Conservation Service (USDA-NRCS) Soil Survey Geographic Database (SSURGO), and the USDA-NRCS Digital General Soil Map of the United States (STATSGO2) via Internet download from the Web Soil Survey (NRCS, 2013c). Prior to starting the project, SSURGO data was identified as the preferred data set as it was collected and mapped at a higher resolution scale (ranging from 1:12,000 – 1:63,360) than STATSGO2 (1:250,000) (NRCS 2013a), and comparative studies by others in basins with conditions similar to those of the White River Basin have found that SSURGO produced an overall slightly more accurate result when used with the SWAT model (Wang and Melesse, 2006). The soils data downloads included a series of spatial and tabular soil data files, and an empty SSURGO soils data geodatabase template that is provided for use with both SSURGO and STATSGO2 data. After downloading the data, the soil tables for both data sets were imported to the geodatabase template using Microsoft Access 2013.

SWAT parameterization requires that the soils data coverage extend beyond the boundaries of the watershed, and upon further review of the data coverage areas it was determined that the SSURGO data did not cover Mt. Rainier and areas immediately adjacent to it at the southern end of the basin. Because of this, the STATSGO soils data, which provided coverage of the entire basin, were used for the SWAT basin-wide simulation. The SSURGO soils data did cover the entirety of the smaller sub-basin areas selected for further evaluation; therefore to provide for greater resolution of differences in hydrologic response associated with the variation in soil conditions at this enhanced spatial scale, the finer resolution SSURGO soils data were used for the KINEROS2 simulations. The two soil data layers for the basin are shown in Figure 3.

Figure 3: Soils Data for the White River Basin

a) STATSGO Soils Data Coverage **b) SSURGO Soils Data Coverage**



Precipitation Data: Daily rainfall data and rain gage latitude and longitude information were obtained from the NOAA National Climatic Data Center (NCDC 2013). Rainfall data during the period 1992-2006 from seven gage stations located in or near the White River Basin were acquired in comma separated value (csv) format via Internet download. The gage stations where the data were recorded are listed in Table 2. The data was imported to Microsoft Excel for Mac 2011 to create an unweighted precipitation file, and each data set was scrubbed to identify and eliminate date gaps in the observed rainfall record as missing days have been found to adversely affect model results (USDA-ARS et al., 2007). For each gage station, all missing days were added and assigned a zero value for precipitation, where gages with a zero value are given a weighted depth = 0 in the precipitation area-weighting process (USDA-ARS et al., 2007).

Table 2: Rain Gage Stations

Station I.D.	Location/Name	Elevation (meters)	Period of Record (years)
GHCND:USC00450945	Buckley	208.8	1913-2012
GHCND:USS0021B13S	Corral Pass	1,828.8	1981-2013
GHCND:USC00454169	Kent	9.1	1912-2013
GHCND:USC00455224	McMillin Reservoir	176.5	1941-2013
GHCND:USS0021C17S	Morse Lake	1,645.9	1978-2013
GHCND:USC00455704	Mud Mountain Dam	398.7	1939-2013
GHCND:USS0021C35S	Paradise (Mt. Rainier)	1,560.6	1980-2013

Source: NCDC 2013

Upon adjusting the precipitation data so that each rain gage record included a value for all days between 1992 and 2006 (5,477 days), the .xlsx spreadsheet table was formatted to meet AGWA input requirements and imported to ArcMap. A Microsoft Office database engine was acquired via Internet download to facilitate ArcMap recognition of the Excel spreadsheet. The table was then converted to .dbf format using the file export function in ArcMap. Additional information regarding the precipitation file area weighting process is provided in the discussion of modeling Step 4 later in this section. The locations of the gaging stations are shown in Figure 7.

USGS Stream Gage Data: Stream flow data from selected USGS gaging stations in the basin was obtained and an ArcGIS shapefile for gage locations was created using the latitude and longitude coordinates published by USGS (USGS, 2012). See Figure 9a for the locations of gaging stations within the basin. The intent of acquiring this data and plotting the locations of the gage stations was to be able to calibrate the models and validate simulation outputs for stream discharge. However the lack of stream flow data for the White River and its principal tributaries for the simulation period did not allow for this, and field collection of stream flow data was beyond the scope of this project. As a result, the hydrologic simulations for this project were conducted using SWAT as an uncalibrated model, which has previously been suggested by others to provide acceptable results in comparative simulations of hydrologic response to different land cover/land use change scenarios (Kepner et al., 2008b).

<u>Assumptions:</u> For the purposes of this analysis, the White River was modeled as an unregulated drainage basin. No model adjustments were made for the existence or operation of Mud Mountain Dam in the Middle Basin, or the Buckley Diversion Dam that directs water to Lake Tapps in the Lower Basin.

Overview of the Modeling Process in ArcGIS with the AGWA Interface

For this project, SWAT was used to develop estimates of average annual stream discharge, surface runoff rate of sediment yield, and stream sediment load across the White River Basin for land cover data years 1992, 2001, and 2006, and to identify smaller drainage areas within the basin (referred to in this report interchangeably as sub-basins, watersheds, and SWAT model elements) that exhibited the most significant changes in hydrologic response with respect to changes in land cover. Then, in a subsequent series of model runs, KINEROS2 was used to simulate the hydrologic response of these areas in land cover data years 2001 and 2006 during an assumed high intensity, moderate duration storm event. A 25-year, 6-hour rainfall event was used to determine surface runoff, peak flow, sediment yield, and total sediment discharge for this simulation.

SWAT is a comprehensive, physically based, continuous time hydrology model that uses the empirically-derived Curve Number (CN) method developed by the USDA (USDA, 1972) to simulate runoff. The CN method in SWAT relates runoff to soil type and land use. While the user of the stand-alone version of SWAT has the option to use either the CN method or the Green-Ampt method (Green and Ampt, 1911), the SWAT2000 model version used for this project was integrated as a component of the AGWA interface and was not enabled with an option for selection of the Green-Ampt method, thus the CN method was used.

SWAT simulations using an annual time step were conducted for land cover data years 1992, 2001, and 2006. A separate land cover parameterization for each of the three years was performed using the NLCD land cover and NRCS soils input data. The basin was delineated and discretized into sub-basins (SWAT model elements), and a distributed rainfall file was be created using rain gage data from multiple gages in or near the watershed. Average annual rates of stream discharge, surface runoff and sediment yield were simulated for each sub-basin element. The simulated annual rates for each land cover data year were compared using a differencing function in the model to display the changes for the periods in terms of total change and percent change. Relative differences in hydrologic attributes (model outputs) between land cover data years could then be attributed to the differing inputs (changes) in land cover since all other inputs were the same for all years.

KINEROS2 is a physically-based model designed to simulate runoff and erosion for single storm events in watersheds less than approximately 100 square kilometers in size. The model utilizes a network of channels and planes to represent a watershed, and the kinematic wave method to route water through the watershed. The modeling process for KINEROS2 was similar to that used for SWAT. The sub-basins identified by SWAT as exhibiting the greatest change in hydrologic attributes in response to changes in land use inputs were re-delineated as new watersheds, and the sub-basins were then further divided into smaller Hydrologic Response Units (HRUs). Rates of runoff, peak flow, sediment yield, and total sediment discharge were determined for a 25-year, 6-hour precipitation event with a 10-minute time step. To determine infiltration and runoff, KINEROS2 uses the Parlange 3-Parameter model, in which the Green and Ampt Method and the Smith and Parlange Method (Smith and Parlange, 1978) are used to bracket the value for infiltration. As with SWAT, a differencing function in the model allowed the generation of both graphic and tabular data showing the differences in output for model geometric elements (channels and planes) between land cover data years 2001 and 2006.

Data input, basin delineation and discretization, soil and land cover parameterization, and preparation of precipitation files for both models was accomplished through the AGWA interface. AGWA was also used to prepare the model simulation files, run the models, and view model results. Hydrologic modeling through the AGWA interface consisted of the same six basic steps to run each of the hydrologic models (see Figure 4 for a generalized flowchart depicting the process). Each of the steps is further described below.

Figure 4: General Modeling Process Using the AGWA Interface

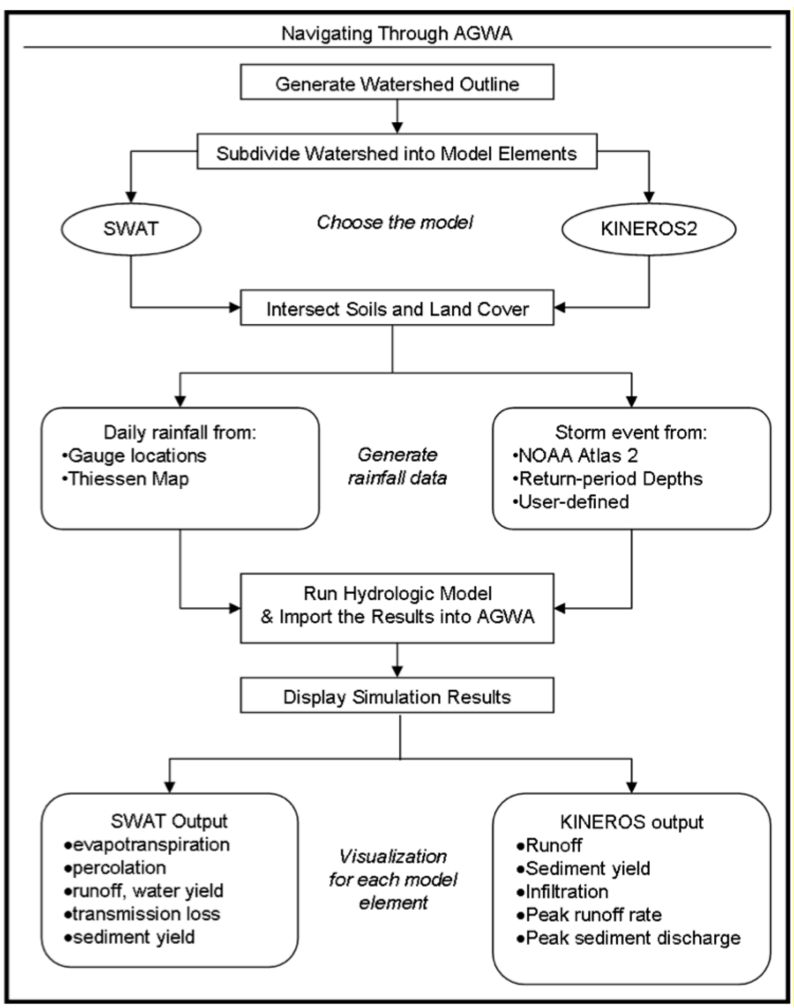


Image source: USDA-ARS et. al, 2007

Step 1) Watershed Delineation. An outline for the basin was established from the DEM grid based on accumulated flow to the designated outlet of the basin. After loading the pre-processed DEM file into AGWA, flow direction and flow accumulation grids and a stream network file were created from the DEM, and a watershed pour point (outlet) for the basin was selected manually using satellite imagery to locate the watershed outlet at the confluence of the White and Puyallup Rivers on the AGWA-generated stream network.

Step 2) Watershed Discretization. The basin delineated in Step 1was divided into 26 sub-basins (elements) and 17 stream segments for hydrologic modeling using the discretizer module of the AGWA interface. The contributing source area (CSA) for each element was set at the AGWA default setting of 2.5% of total basin area. Figures 5 and 6 show the SWAT sub-basin elements and stream segments developed in this step.

Figure 5: White River Basin Sub-basin Elements

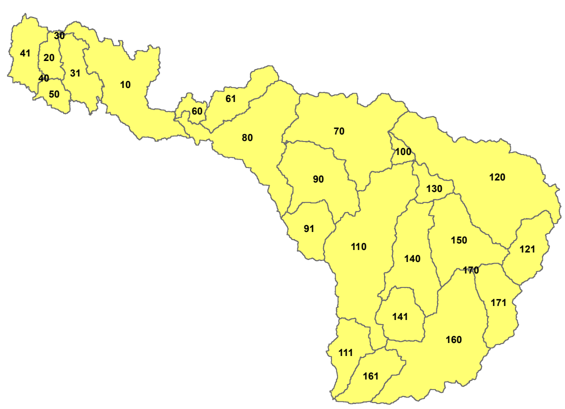
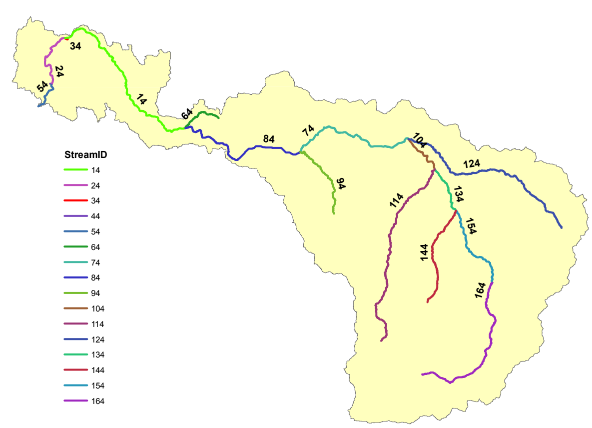


Figure 6: White River Basin Stream Segments



Step 3) Watershed parameterization. The sub-basins (model elements) generated during discretization were parameterized using the geo-referenced topographic, land cover, and soils information. Separate parameterizations were conducted for each land cover data year evaluated (e.g. 1992, 2001, and 2006 for the basin-wide assessment with SWAT, and 2001 and 2006 for each of the two sub-basins evaluated with

KINEROS2). For each parameterization, the element parameters for hydraulic geometry and channel type were set to the AGWA default settings. The STATSGO2 spatial and tabular data were input for SWAT parameterization, and the SSURGO datasets were used for KINEROS2. AGWA-supplied MRLC 1992 and 2001 look-up tables were used to intersect the watershed boundary with the land cover data.

Step 4) Writing the precipitation file. Rainfall input files for the models were built using rain gage locations and observed precipitation data. Because of the highly variable topography in the basin, distributed precipitation values from multiple gaging stations was determined to be preferred over a uniform precipitation scheme from a single rain gage. Precipitation data and rain gage location information from seven rain gaging stations located in or near the basin were selected to provide daily precipitation inputs for the project. Both a tabular unweighted precipitation data file and a geo-referenced gage location (point geometry) file are required to write precipitation files in AGWA. Existing GIS rain gage location data could not be located for the seven gages, so a GIS shapefile for rain gage locations was created in ArcMap using the latitude and longitude coordinates that NOAA publishes along the with precipitation data for each rain gage. A weighted precipitation file created from the rain gage data was then used to build a build a Thiessen polygon, which was intersected with the watershed boundary. See Figure 7. Area-weighted average annual sub-basin precipitation during the 15-year simulation period ranged from 1,063 mm (41.9 inches) in the lower basin to 3,170 mm (124.8 inches) in the upper basin. This is shown graphically in Figure 8.

Figure 7: Thiessen Polygon Layer for the White River Basin

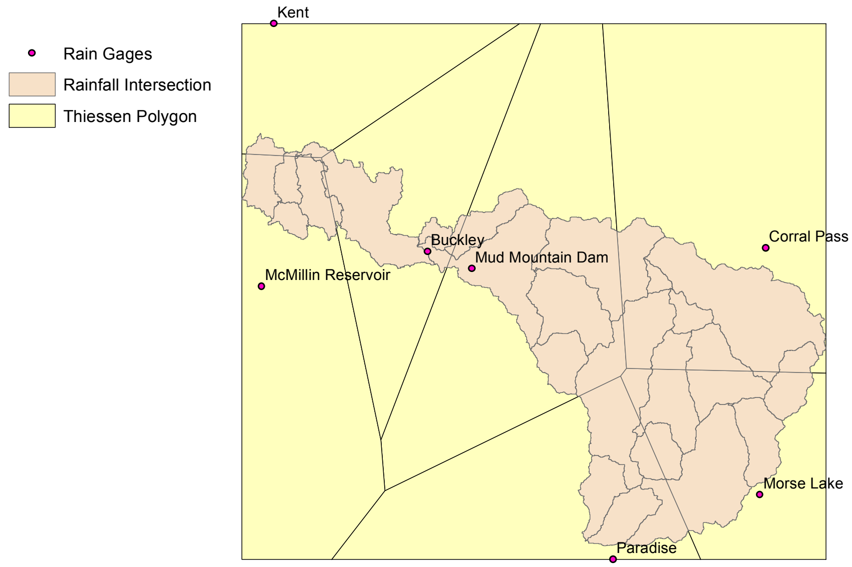
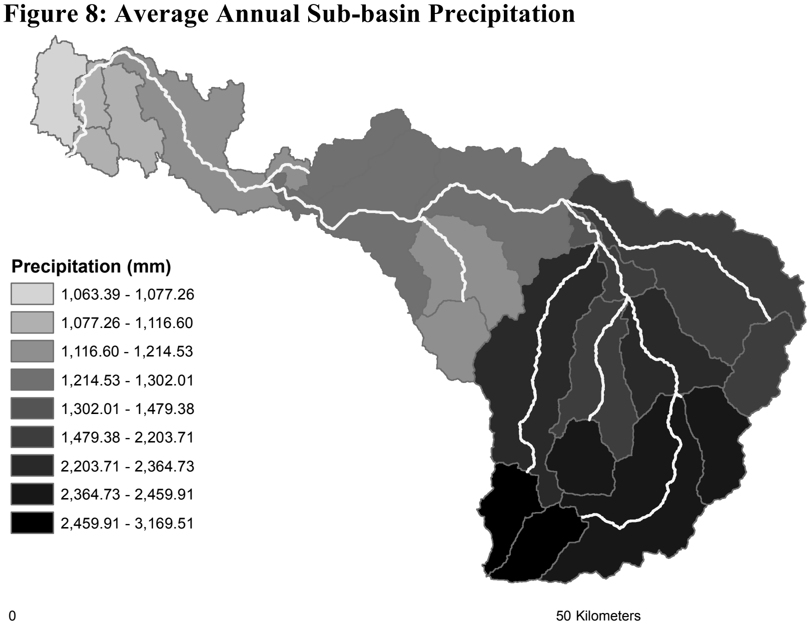


Figure 8: Average Annual Sub-basin Precipitation



Precipitation amounts for the 25-year, 6-hour event for each sub-basin were obtained from the NOAA Washington State Precipitation Frequency isopluvial map for that event (NOAA, 1973), and were based on using the precipitation value at the centroid of each sub-basin. The centroid of each sub-basin was determined using the zonal geometry function in ArcGIS, the centroid location was transferred to the isopluvial map, and the precipitation level at that location was selected.

Step 5) Model execution. Runoff and sediment loads were simulated for the basin. For each parameterization, a simulation file was written that incorporated the precipitation file and a simulation date range. The output frequency for all SWAT model runs was set to 'Annual', while the duration of a 25-year, 6-hour precipitation event with 15-minute time steps was used for the KINEROS2 model runs. Estimated temperature data generated from AGWA-supplied weather generation station files was also included as a simulation input.

Step 6) Viewing the results. Upon completing the model runs, model outputs were imported back into the AGWA interface for display. Outputs were provided as both spatial and tabular ArcGIS files that were generated and accessed via the AGWA interface. Comparisons of selected hydrologic attributes for each land cover data year simulation were created using the AGWA differencing function. For SWAT, comparisons were created between years 1992 and 2001, and between years 2001 and 2006. For KINEROS2, comparisons between the years 2001 and 2006 were created.

Validation and Calibration of SWAT

SWAT simulation results for total stream flow and total annual sediment load were compared to recorded discharge data obtained from USGS gaging stations in the basin, and previously published estimates of total White River sediment load. While outputs for total stream discharge of the main stem of the White River were somewhat lower than observed values but fairly consistent, simulated stream discharge outputs for tributary streams resulted in values that were both lower and higher than observed flows, and the differences between simulated and observed flows varied widely. Figure 9 shows this comparison for five gaging stations. In the Figure, no observed data shown for a given year indicates that data was not available for that year. No observed stream flow data was available for any year during the simulation period for USGS No.

12090490 White River at R Street, however stream flows for 2010-2012 at that gage are shown for reference.

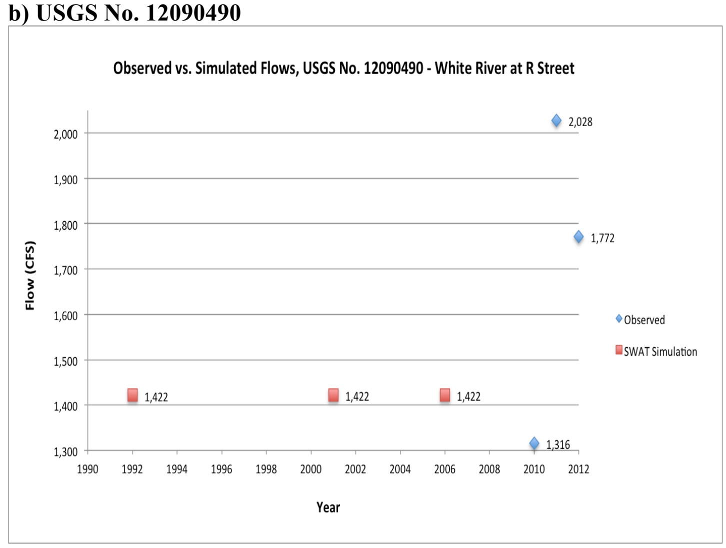
Simulation outputs for total annual sediment load were at least 50 percent lower than the lowest of the previously published estimates (see Table 1). The comparisons between simulated and observed stream flows, and simulated and previously estimated sediment loads, proved to be somewhat inconclusive, both because of the relative dearth of observed stream discharge data in the basin during the simulation period, as well as the wide range of published sediment load estimates for the White River.

Calibration of the model was attempted by adjusting model multiplier settings for monthly precipitation, and settings for base flow and groundwater delay, however these adjustments only resulted in minimal increases in simulated total discharge and sediment load in the White River main stem, and exacerbated the variations between the simulated and observed stream flow values for the tributary streams. Therefore, no further adjustments were made to the SWAT simulation parameters, and both SWAT and KINEROS2 were run as uncalibrated models.

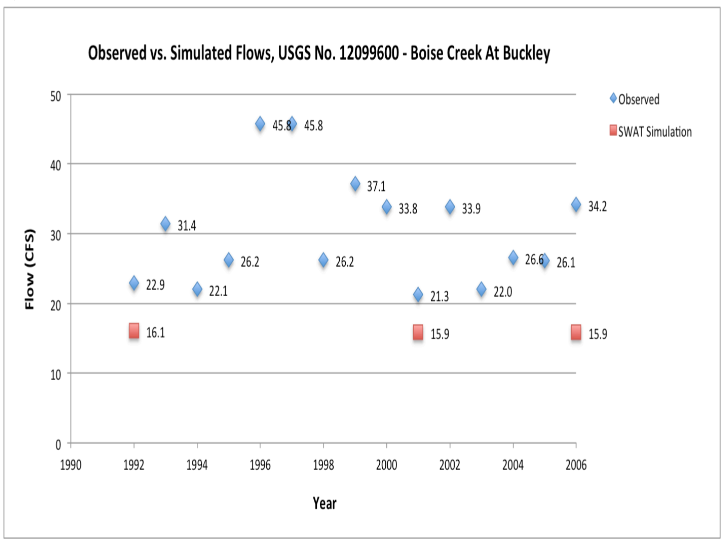
Figure 9: Observed vs. Simulated Stream Flow at Selected Stream Gages

a) USGS Stream Gage Locations

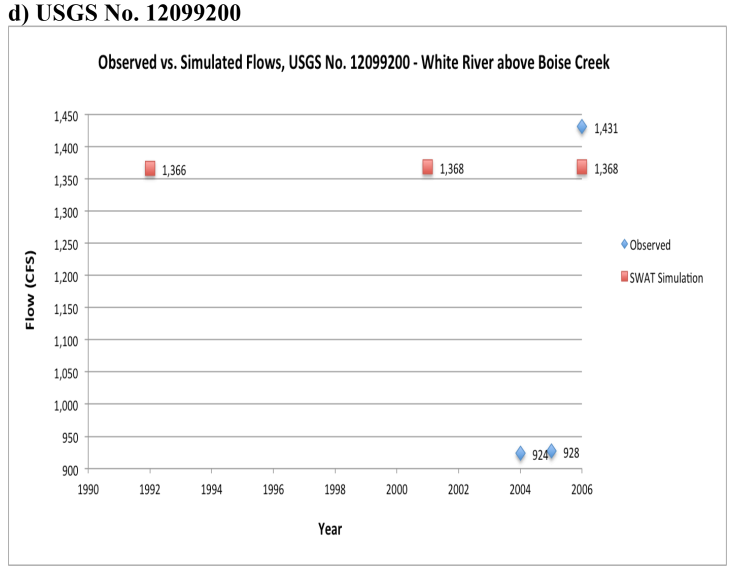
b) USGS No. 12090490



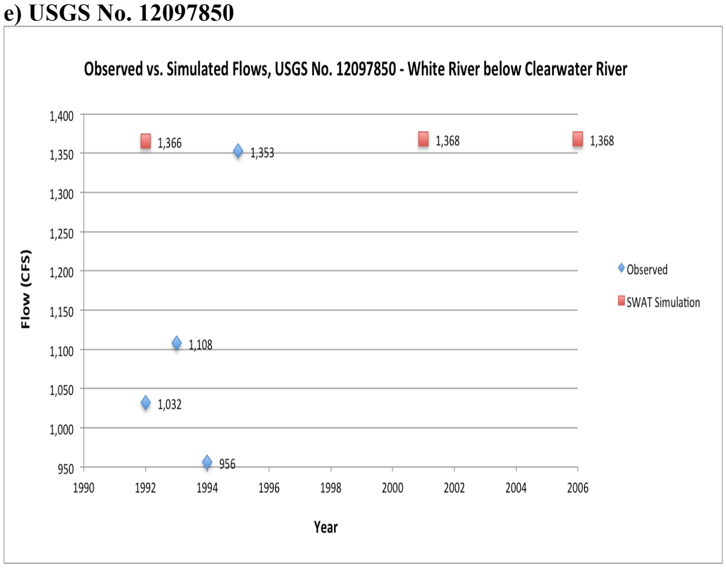
c) USGS No. 12099600



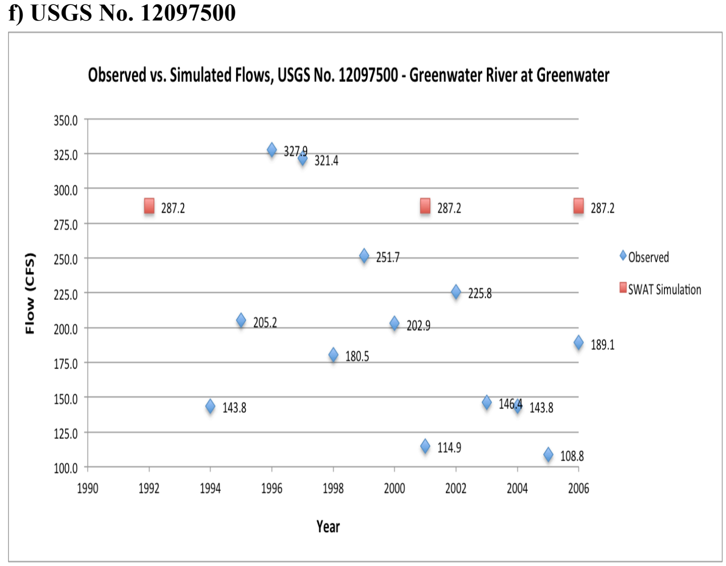
d) USGS No. 12099200



e) USGS No. 12097850



f) USGS No. 12097500



Results

Basin-wide Analysis

White River Stream Discharge and Sediment Load

The White River and its major tributaries were divided into 17 stream segments for SWAT modeling as shown in Figure 6. Simulated total stream discharge for the White River at the basin's outlet (SWAT Stream Segment 54) was comparable for all land use data years, ranging from 3,551,040 to 3,555,495 m^3/day (1,451 to 1,453 cfs).

The simulated annual sediment load for this stream segment ranged from 195,600 tonnes to 196,600 tonnes, with a decrease of 1,000 tonnes (-0.5%) from 1992 to 2001, and an increase of 300 tonnes (0.153%) from 2001 to 2006. Table 3 summarizes these results.

Table 3: SWAT Results, Average Annual Stream Channel Discharge at Basin Outlet

Simulation Year	Stream Channel Discharge m^3 per day/(ft^3 per second)	Sediment Yield tonnes (tons)
1992	3,551,040 (1,451)	196,600 (216,260)
2001	3,553,632 (1,452)	195,600 (215,160)
2006	3,554,495 (1,453)	195,900 (215,490)

Objective #1 of this project seeks to determine the relative increment of White River sediment load that can be attributed to changes in basin land cover. While simulated annual river sediment loads were found to decrease from 1992 to 2001, and to increase from 2001 to 2006, the small magnitude of change in each period (less than one percent of modeled total sediment load) suggests that the increment of river sediment load associated with basin land cover changes is relatively small. As previously indicated, the simulation results showing a decrease in sediment load from 1992 to 2001 were felt to be skewed as a result of using the NLCD 1992 and NLCD 2001 land cover datasets, which are not directly comparable. Therefore while the 1992 and 1992-2001 change results are presented in this report, the sediment load change analysis was focused on the period 2001-2006, which used comparable NLCD datasets. A suggested range of estimated relative change in sediment load associated with changes in land cover from 2001 to 2006 is developed and discussed further in the Discussion section of this report. Simulation outputs for stream channel discharge and annual sediment load for all basin stream segments are shown for 1992, 2001, and 2006 in Appendix Tables A3, A5, and A7, respectively.

Sub-basin Surface Runoff and Rate of Sediment Yield

The 26 sub-basins for SWAT modeling are shown in Figure 5. Simulated annual surface runoff values ranged from 37.7 mm (Sub-basin 91 in 2001 and 2006) to 1,717 mm (Sub-basin 111 in 1992). Rates of sediment yield in the basin ranged from 0.004 tonnes/ha (Sub-basin 31 in 1992) to 15.1 tonnes/ha (Sub-basin 171 in 1992). [Note: SWAT returned "0" values for sediment yield rate in Sub-basins 30 and 40, which may be due to the relatively small area of these sub-basins (10.6 and 6.2 hectares, respectively). The "0" values were not considered to be accurate and are not included in the ranges presented above].

Simulation results for surface runoff and rate of sediment yield for all sub-basins in land use data years 1992, 2001, and 2006, are shown graphically in Figures 10, 11, and 12. The SWAT data outputs are shown in Appendix Tables A2, A4, and A6.

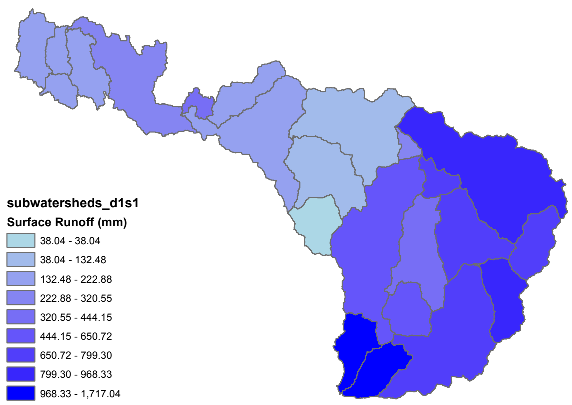
Sub-basin Total Annual Sediment Yield

The total annual sediment yield for each sub-basin is a product of the annual sediment rate (tonnes/hectare) for that sub-basin, and the area of the sub-basin. Total sub-basin annual sediment yield in all land use data years was lowest in Sub-basin 170, ranging from 2.9 tonnes in 1992 to 3.11 tonnes in 2001 and 2006. Total annual sediment yield was highest in Sub-basin 160, ranging from 163,425 tonnes in 1992 to 164,731 tonnes in 2001.

Total annual sediment yield for all sub-basins in each of the three land use data years is shown in Appendix Table A1.

Figure 10: White River Basin Simulated Hydrology 1992

a) Surface Runoff (mm)



b) Rate of Sediment Yield (tonnes/ha)

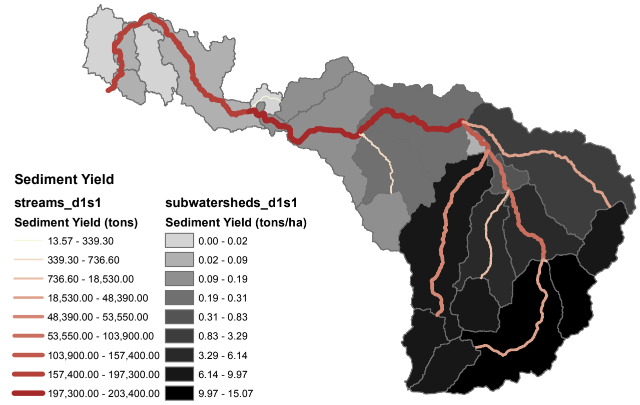
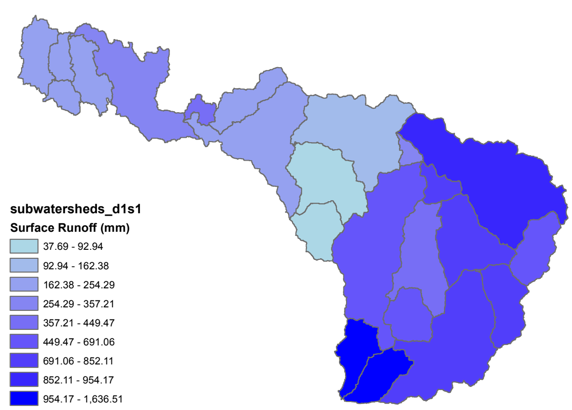


Figure 11: White River Basin Simulated Hydrology 2001

a) Surface Runoff (mm)



b) Rate of Sediment Yield (tonnes/ha)

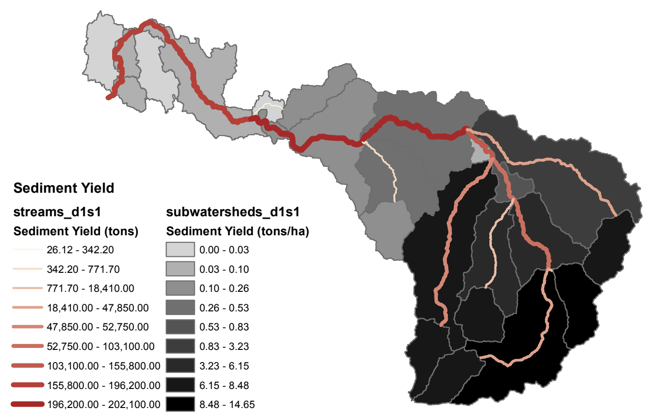
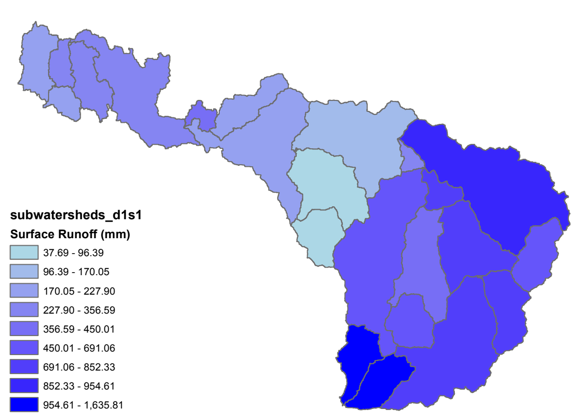
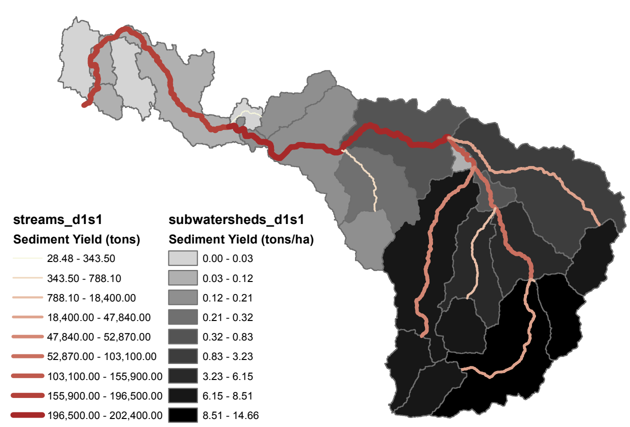


Figure 12: White River Basin Simulated Hydrology 2006

a) Surface Runoff (mm)



b) Rate of Sediment Yield (tonnes/ha)



Change in Sub-basin Surface Runoff and Rate of Sediment Yield

The differencing function in AGWA was used to determine the change in surface runoff and sediment yield for each sub-basin during the simulation period. As previously stated, the NLCD land cover information for the basin was developed using different methodologies in 1992 and 2001 that are not directly comparable. Therefore to provide for a better comparison, the changes in these hydrologic characteristics were evaluated for two time periods: 1992 to 2001, and 2001 to 2006.

For the period 1992 to 2001, the greatest changes in annual surface runoff occurred in Sub-basins 161, 170, and 31; and the greatest changes in the rate of annual sediment yield (tonnes per hectare) occurred in Sub-basins 161, 171, and 121. SWAT simulations for this period showed that surface runoff decreased 149.4 mm (-9.1%) for Sub-basin 161, and increased 102.6 mm (19.6%) for Sub-basin 170 and 95.4 mm (60.0%) for Sub-basin 31. The rate of sediment yield decreased 1.746 tonnes/ha (-17.5%) for Sub-basin 161, 0.414 tonnes/ha (-2.7%) for Sub-basin 171, and 0.258 tonnes/ha (-3.3%) for Sub-basin 121. Figures 13a and 13b show the changes in surface runoff and rate of sediment yield graphically for all sub-basins during this period. See Appendix Tables A8 and A9 for the differenced SWAT data outputs for each sub-basin.

For the period 2001-2006, the greatest changes in surface runoff were identified in Sub-basins 40, 20, and 100; and the greatest changes in the rate of sediment yield were found in Sub-basins 70, 110, and 20. Simulations for this period showed that surface runoff increased 41.3 mm (12.3%) for Sub-basin 40, 39.0 mm (15.6%) for Sub-basin 20, and 28.6 mm (9.8%) for Sub-basin 100. Annual sediment yield increased 0.143 tonnes/ha (27.1%) for Sub-basin 70, 0.023 tonnes/ha (0.3%) for Sub-basin 110, and 0.021 tonnes/ha (21.6%) for Sub-basin 20. Figures 14a and 14b show the SWAT graphical outputs for these changes for in all sub-basins. Appendix Tables A12 and A13 show the differenced data outputs for the period.

Table 4 summarizes the sub-basins showing the greatest change in surface runoff and sediment yield for both comparison periods.

Table 4: Sub-basins with Greatest Change, Surface Runoff and Sediment Yield, 1992-2006

SWAT Output	Change 1992 to 2001		Change 2001 to 2006	
	Sub-basin No.	Change	Sub-basin No.	Change
Surface Runoff (mm)	161	-149.4	40	+41.3
	170	+102.6	20	+39.0
	31	+95.35	100	+28.6
Sediment Yield (tonnes/hectare)	161	-1.746	70	+0.143
	171	-0.414	110	+0.023
	121	-0.258	20	+0.021

Relative Change in Sub-basin Surface Runoff and Rate of Sediment Yield

The AGWA differencing function was also used to determine the relative (percent) change in SWAT-simulated hydrologic characteristics for each sub-basin.

Between 1992 and 2001, the greatest relative changes in surface runoff occurred in Sub-basin 31 (60.0%), Sub-basin 20 (46.6%), and Sub-basin 41 (35.7%). The greatest relative changes in the rate of sediment yield occurred in Sub-basins 20 (185.3%), Sub-basin 70 (70.9%), and Sub-basin 41 (45.5%). Figures 15a and 15b show the relative changes in these simulated hydrologic characteristics for each sub-basin graphically. The AGWA-differenced data outputs are provided in Appendix Tables A10 and A11.

For the period 2001-2006, the greatest relative changes in surface runoff were identified in Sub-basins 20 (15.6%), Sub-basin 40 (12.3%), and Sub-basin 100 (9.8%). The greatest relative changes in the rate of sediment yield were found in Sub-basin 70 (27.1%), Sub-basin 20 (21.6%), and Sub-basin 31 (12.5%). Figures 16a and 16b show the relative changes in these simulated hydrologic characteristics for each sub-basin graphically. See Appendix Tables A14 and A15 for the 2001-2006 AGWA-differenced data outputs.

Table 5 summarizes the sub-basins showing the greatest relative change in surface runoff and sediment yield for both comparison periods.

Table 5: Sub-basins with Greatest Relative Change, Surface Runoff and Sediment Yield, 1992-2006

SWAT Output	Change 1992 to 2001		Change 2001 to 2006	
	Sub-basin No.	Change (%)	Sub-basin No.	Change (%)
Surface Runoff	31	+60.0	20	+15.6
	20	+46.6	40	+12.3
	41	+35.7	100	+9.8
Sediment Yield	20	+185.3	70	+27.1
	70	+70.9	20	+21.6
	41	+45.5	31	+12.5

Change in Sub-basin Total Annual Sediment Yield

Changes in total annual sediment yield for each sub-basin are a product of the change in annual sediment rate (tonnes/hectare), and the area of the sub-basin. From 1992 to 2001, the greatest changes in total annual sediment yield were in Sub-basins 161, 110, and 70. Annual sediment yield decreased by 5,732 tonnes (-17.5%) in Sub-basin 161 and 2,579 tonnes (-2.1%) in Sub-basin 110, and increased by 2,386 tonnes (70.9%) in Sub-basin 70.

For the period 2001-2006, the greatest changes in total annual sediment yield were increases in Sub-basins 70, 110, and 90. Total annual sediment yield increased by 1,558 tonnes (27.1%) in Sub-basin 70, 321 tonnes (0.27%) in Sub-basin 110, and 86 tonnes (4.2%) in Sub-basin 90.

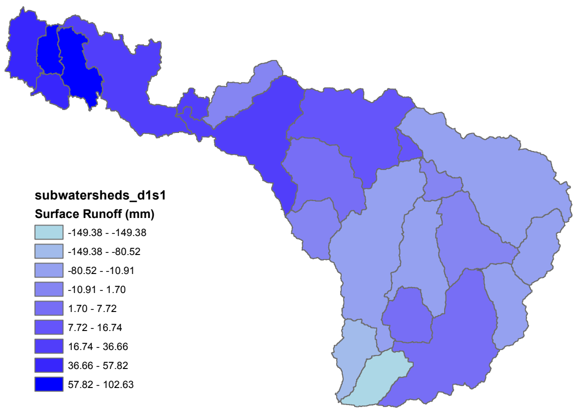
Table 6 summarizes the sub-basins that showed the greatest change in total annual sediment yield for the two comparison periods. Changes in total annual sediment yield for all sub-basins during the two periods are shown in Appendix Table A1.

Table 6: Sub-basins with Greatest Change, Total Annual Sediment Yield

Change 1992 to 2001		Change 2001 to 2006	
Sub-basin No.	Change (tonnes)	Sub-basin No.	Change (tonnes)
161	-5,732	70	+1,558
110	-2,579	110	+321
70	+2,386	90	+86

Figure 13: Change in Annual Surface Runoff Rate of Sediment Yield, 1992-2001

a) Change (mm)



b) Change (tonnes/ha)

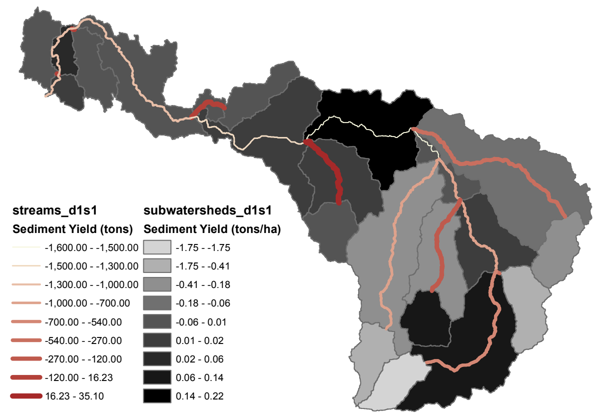
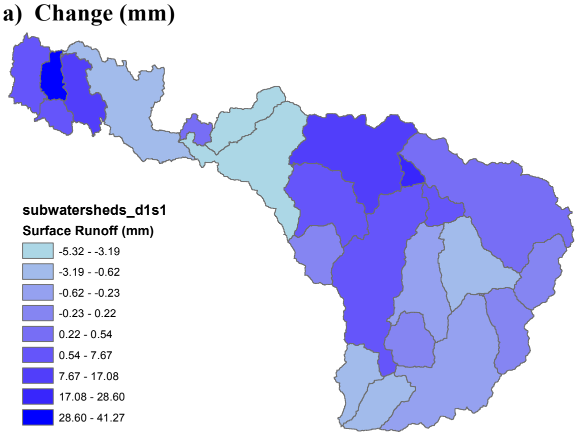


Figure 14: Change in Annual Surface Runoff Rate of Sediment Yield, 2001-2006

a) Change (mm)



b) Change (tonnes/ha)

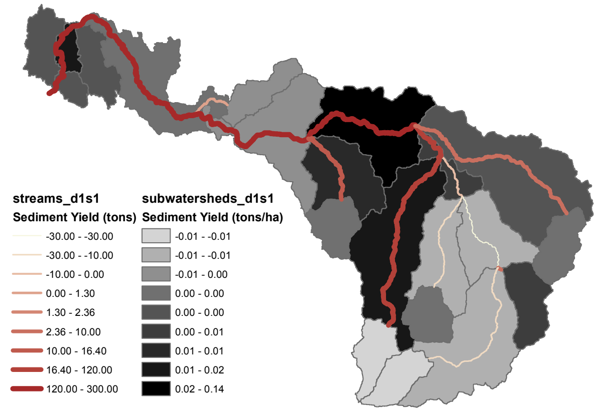
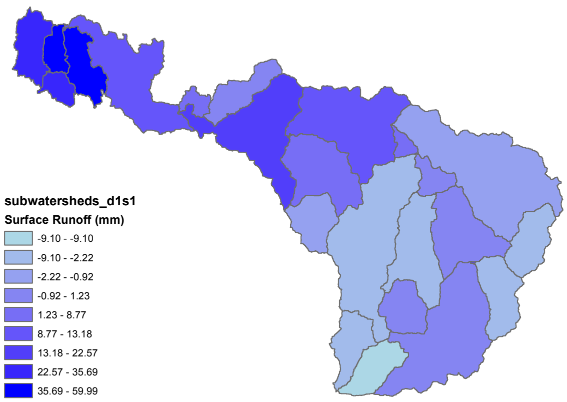


Figure 15: Relative Change in Annual Surface Runoff Rate of Sediment Yield, 1992-2001

a) Percent Change Surface Runoff



b) Percent Change 1992-2001 Sediment Yield

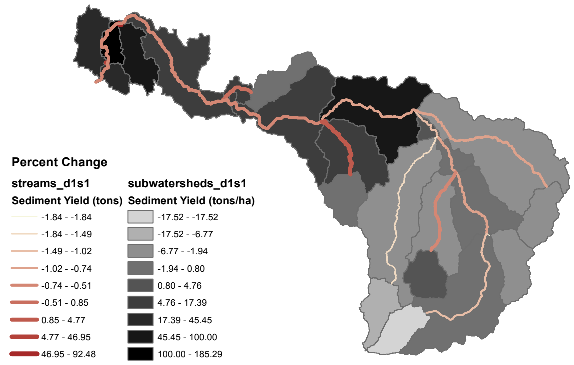
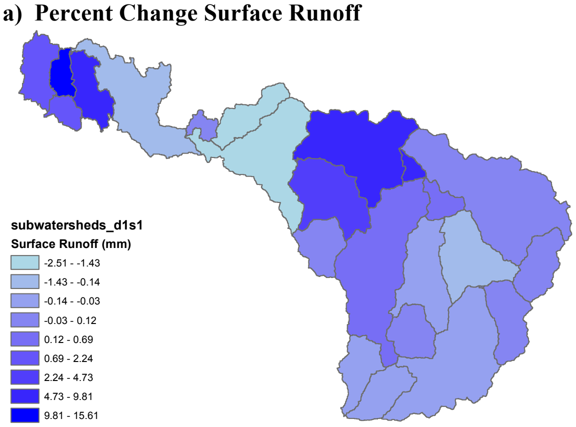
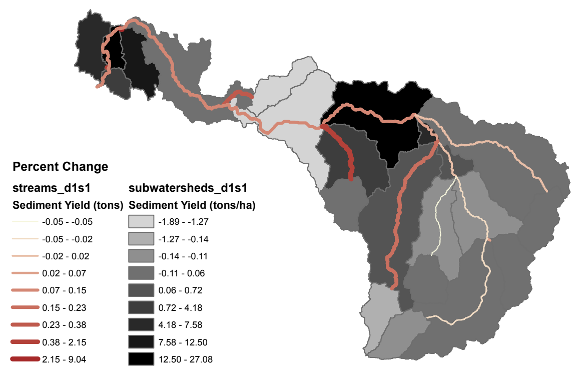


Figure 16: Relative Change in Annual Surface Runoff Rate of Sediment Yield, 2001-2006

a) Percent Change Surface Runoff



b) Percent Change 2001-2006



Single-event Hydrologic Response

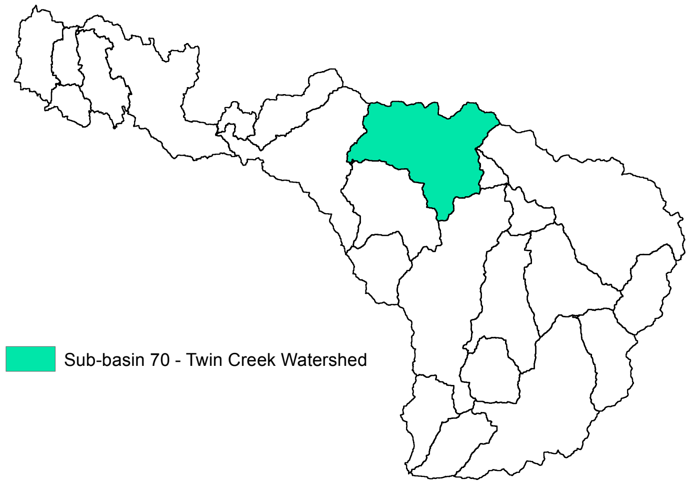
Basin-level simulations were run in SWAT for 1992, and the results were compared with both the NLCD 1992/2001 Land Cover Change Retrofit (LCCR) dataset and the SWAT model outputs for 2001. An initial review of the simulation outputs suggested that the results were not compatible for direct comparison with the simulation results for 2001 and 2006. This is consistent with the information published by USGS that indicates that the 1992 NLCD dataset was acquired and processed using different methodologies and is not directly comparable to the 2001 NLCD dataset (MRLC 2013). For this reason, the 1992 simulation results were not carried forward for single-event hydrologic response analysis using KINEROS2.

Objective #2 of the project was to determine areas of the White River Basin that may be most affected by changes in land cover, and to further evaluate those areas to understand how land cover changes may affect single-event hydrologic response and sediment input. The SWAT simulation identified that the two sub-basins that experienced the greatest relative change in annual rate of sediment yield for the period 2001-2006 were Sub-basin 70 (the Twin Creek Watershed) in the upper portion of the White River Basin which increased by 27.1%, and Sub-basin 20 (the Lower White River Watershed) in the lower portion of the basin which increased by 21.6%. Therefore, these two sub-basins were selected for further analysis of hydrologic response at a higher level of spatial and temporal resolution using the KINEROS2 model.

Twin Creek Watershed

The Twin Creek Watershed (SWAT Model Element 70) is a largely undeveloped 109 sq. km. watershed located at the lower margin of the upper White River Basin and has been identified by USGS with the 12-digit HUC No. 171100140401. The location of the Twin Creek Watershed is shown in Figure 17.

Figure 17: Location of the Twin Creek Watershed



The Twin Creek Sub-basin was divided into 57 smaller hydrologic response units (HRUs) and 23 stream channel segments. Simulation results for the 25-year, 6-hour precipitation event for the sub-basin HRUs are presented in Appendix Tables A16 through A19. Tables A16 and A18 show the simulation outputs for the KINEROS2 model plane surfaces for each HRU in land cover data years 2001 and 2006, and Tables A17 and A19 show the simulation outputs for KINEROS2 channel segments in 2001 and 2006, respectively.

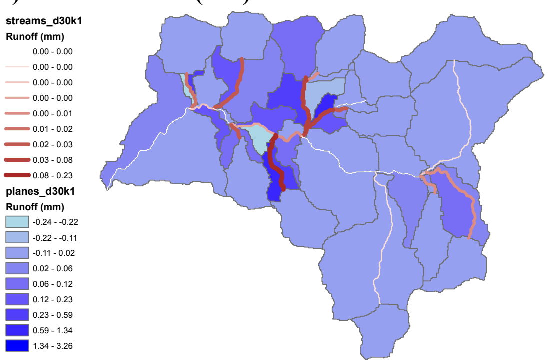
Again, the differencing function in AGWA was used to identify the relative change in hydrologic response in the HRUs from 2001 to 2006. The KINEROS2 simulation outputs indicate that there were increases in peak flow and peak sediment discharge in 26 of 57 (46%) HRU plane elements within the sub-basin from during the period, with 7 of these (13%) increasing by more that 50 percent for peak flow, and 13 (23%) increasing by more than half for peak sediment discharge.

Peak stream flow and peak sediment discharge both increased in 21 of 23 (91%) HRU stream channel segments (peak sediment discharge increased in all but one), with 9 stream segments (39%) increasing by more than 50 percent for peak flow, and 11 stream segments (48%) increasing by more than 50 percent for peak sediment discharge.

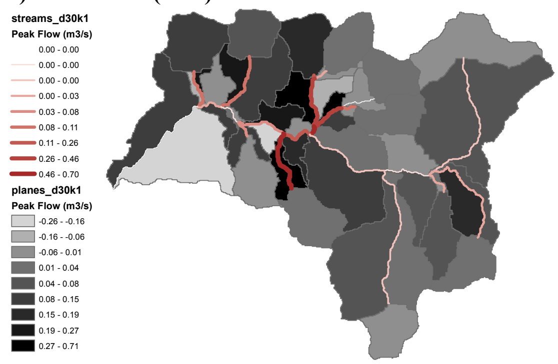
Graphic outputs that show total and relative change for surface runoff, peak flow, sediment yield, and peak sediment discharge for the 25-year, 6-hour event between 2001 and 2006 are provided in Figures 18 and 19. Appendix Tables A20 and A22 provide the data outputs for total change and percent change in KINEROS2 plane surfaces for each hydrologic attribute between the two model years, and Appendix Tables A21 and A23 present this information for the KINEROS2 channel segments in the sub-basin.

Figure 18: Twin Creek Watershed, Change 2001-2006

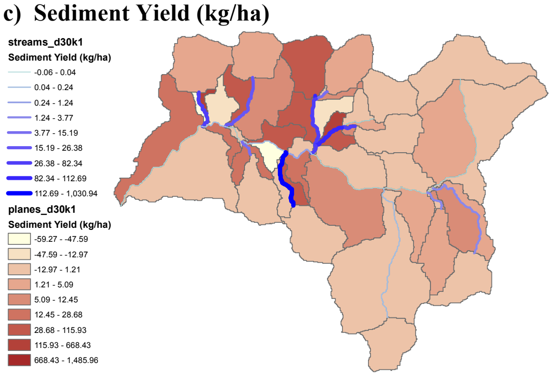
a) Surface Runoff (mm)



b) Peak Flow (m^3/s)



c) Sediment Yield (kg/ha)



d) Peak Sediment Discharge (kg/s)

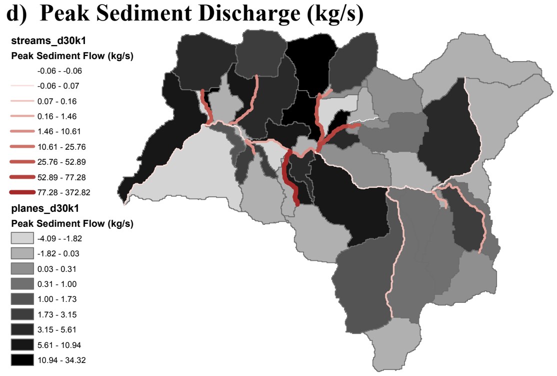
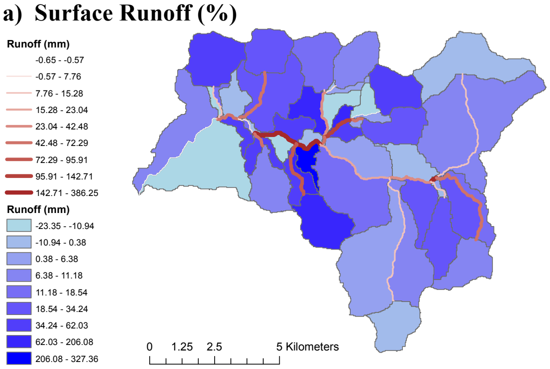
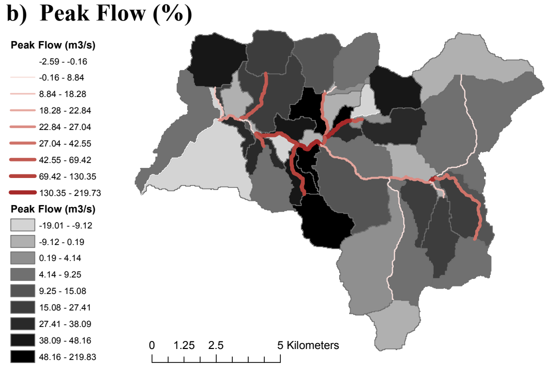


Figure 19: Twin Creek Watershed, Percent Change 2001-2006

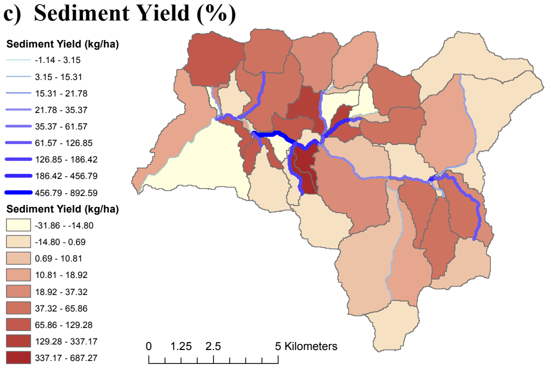
a) Surface Runoff (%)



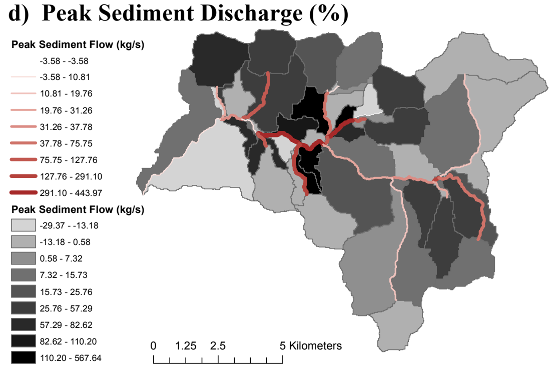
b) Peak Flow (%)



c) Sediment Yield (%)



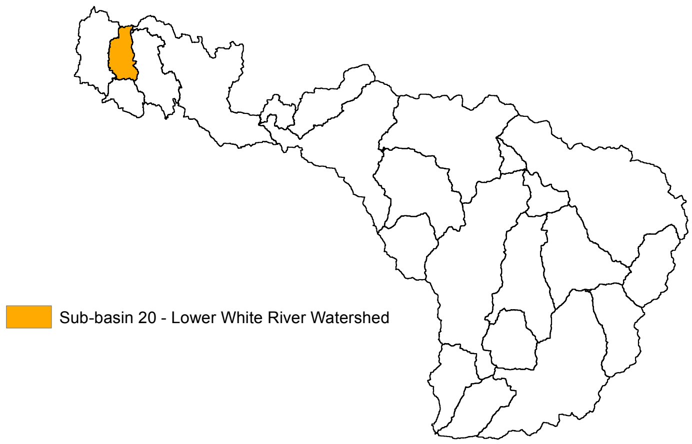
d) Peak Sediment Discharge (%)



Lower White River Watershed

The Lower White River Watershed (SWAT Model Element 20) is a 14.8 sq. km. portion of the more urbanized USGS Lower White River sub-basin (12-digit HUC No. 171100140404). The location of the Lower White River Watershed is shown in Figure 20.

Figure 20: Location of the Lower White River Watershed



The Lower White River Watershed was divided into 73 smaller HRUs and 29 stream segments. Simulation results for the 25-year, 6-hour precipitation event for the watershed are shown in Appendix Tables A24 through A27. Tables A24 and A26 show the simulation outputs for the KINEROS2 model plane surfaces for each HRU in model years 2001 and 2006, and Tables A25 and A27 show the simulation outputs for KINEROS2 channel segments for both years.

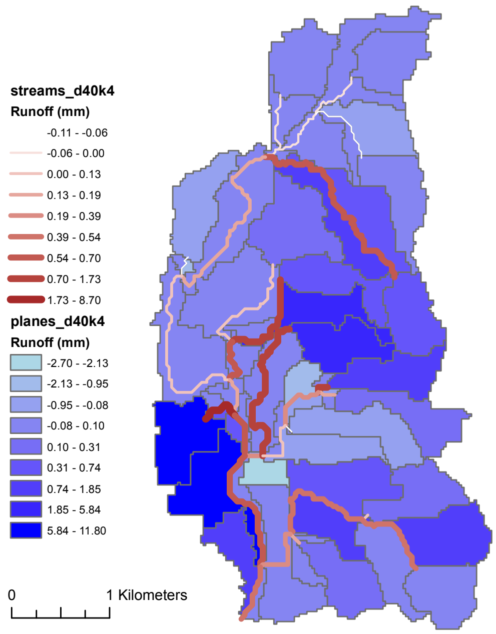
As with the Twin Creek Watershed, the differencing function in AGWA was used to identify the relative change in hydrologic response in the watershed from 2001 to 2006. The KINEROS2 simulation outputs indicate that there were increases in peak flow and peak sediment discharge in 30 of 73 (41%) HRU plane elements within the sub-basin from 2001 to 2006; 10 of these (14%) increasing by more that 50 percent for peak flow, and 12 (16%) increased by more than 50 percent for peak sediment discharge.

Peak stream flow and peak sediment discharge both increased in 24 of 29 (83%) stream channel segments, with 9 stream segments (31%) increasing by more than 50 percent for peak flow, and 10 stream segments (35%) increasing by more than 50 percent for peak sediment discharge.

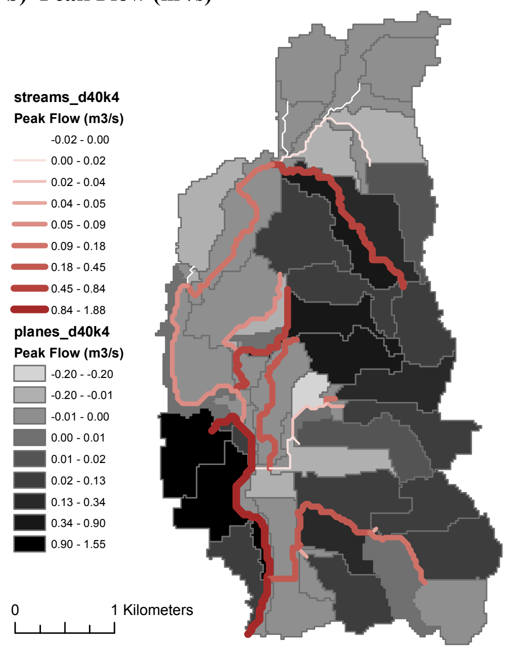
Graphic outputs that show the changes for surface runoff, peak flow, sediment yield, and peak sediment discharge are provided in Figures 21 and 22. Appendix Tables A28 and A30 provide the data outputs for total change and percent change in KINEROS2 plane surfaces for each hydrologic attribute between the two model years, and Appendix Tables A29 and A31 show this information for the KINEROS2 channel segments in the sub-basin.

Figure 21: Lower White River Watershed, Change 2001-2006

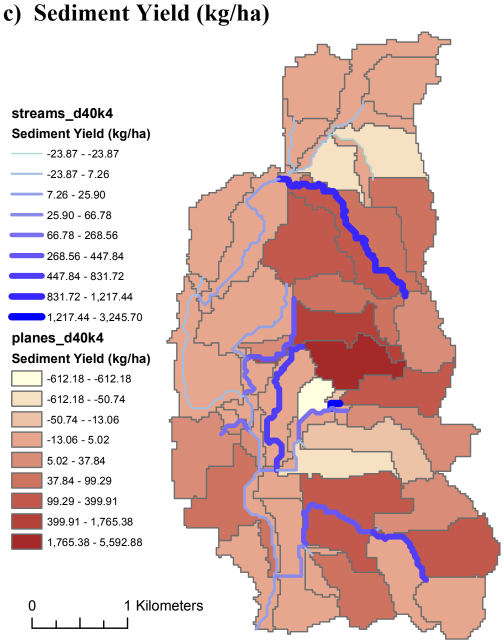
a) Surface Runoff (mm)



b) Peak Flow (m^3/s)



c) Sediment Yield (kg/ha)



d) Peak Sediment Discharge (kg/s)

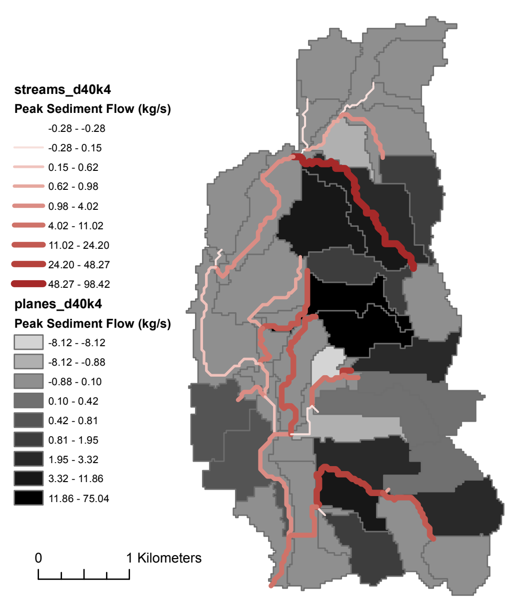
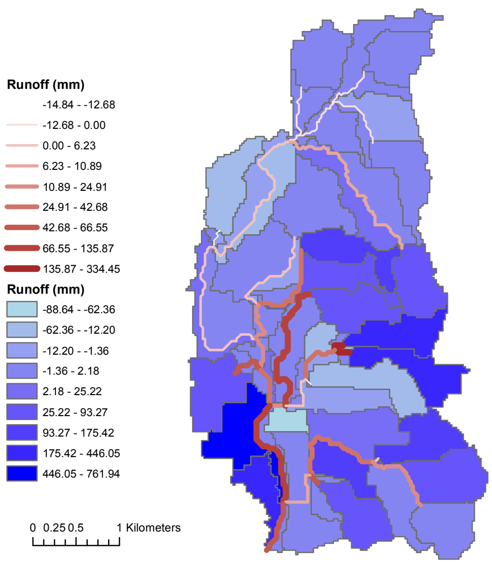
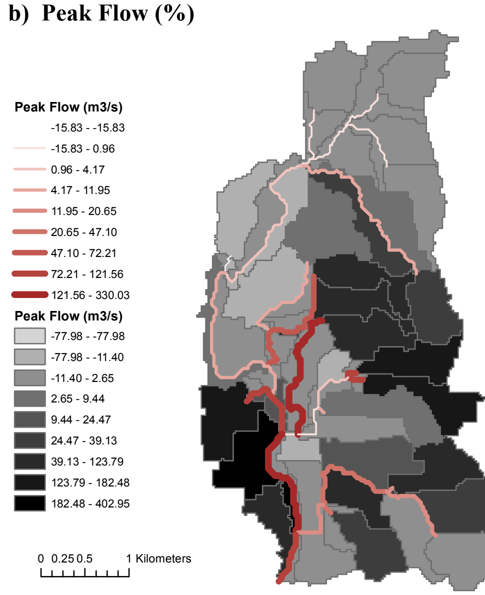


Figure 22: Lower White River Watershed, Percent Change 2001-2006

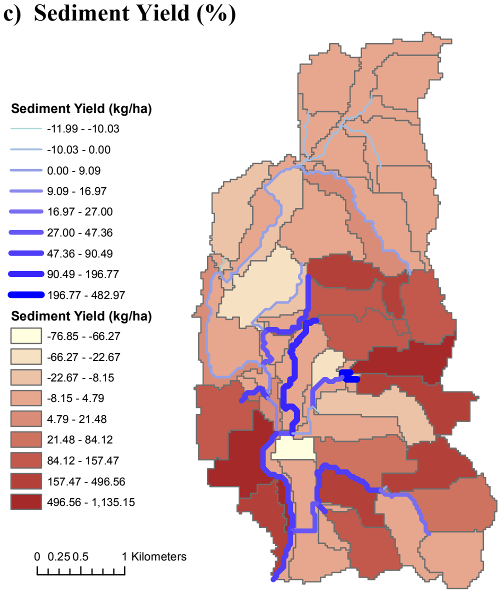
a) Surface Runoff (%)



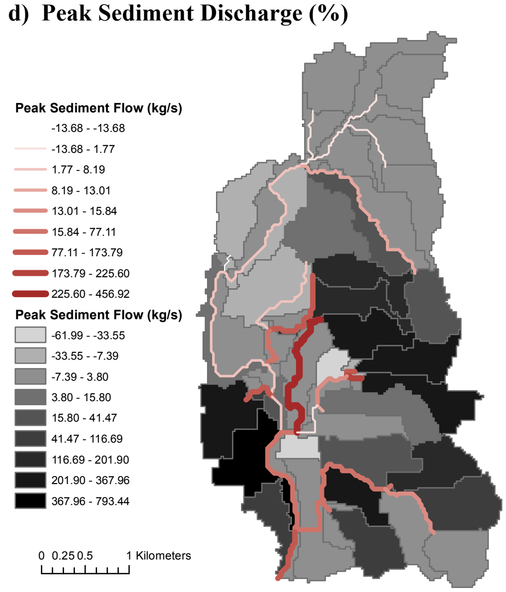
b) Peak Flow (%)



c) Sediment Yield (%)



d) Peak Sediment Discharge (%)



Discussion

Land Cover Change During the Simulation Period

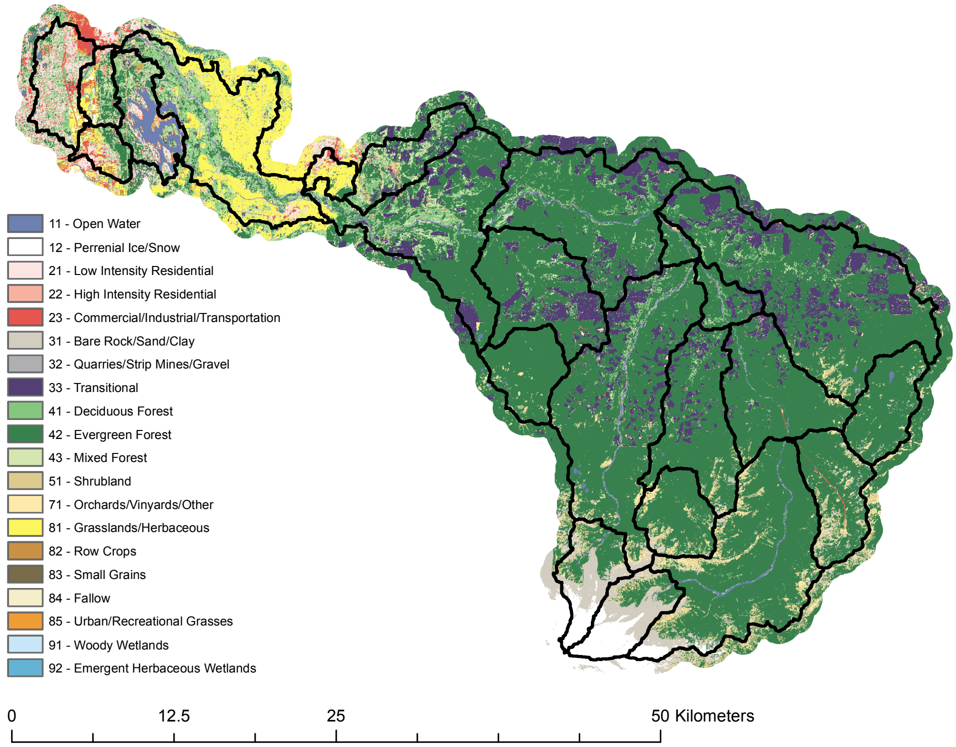
The White River Basin originates on the slopes of Mt. Rainier and extends northwest nearly 53 km (32.7 mi) to its outlet at the confluence of the White and Puyallup Rivers in the Puget Sound lowlands. While the predominant land cover for the Twin Creek Watershed and Lower White River Watershed are different, both sub-basins experienced significant changes in land cover from 2001 to 2006.

Land cover in the upper portion of the basin is predominantly evergreen and mixed forest with lesser areas of shrub/scrub and grassland vegetation. Much of the lower portion of the basin is located within designated urban growth areas in both King and Pierce Counties and includes portions of ten cities and towns. Land cover in the lower basin is a mix of pasture, crops, and impervious surfaces that are associated with agricultural and urban land uses. Figure 23a shows land cover in the basin at the beginning of the simulation period in 1992, and Figure 23b shows land cover at the conclusion of the 15-year period in 2006.

The primary land use activity in the upper basin is timber harvest and associated road building, and changes in land cover in the upper basin are primarily the conversion of forest to shrub/scrub and grasslands. The dominant land use activity in the lower basin is urbanization, and changes in land cover in the lower basin are primarily the conversion of vegetated areas to new urban uses, and the intensification of existing urban uses. Figure 24 shows the aggregated changes in land cover from 1992-2001, and from 2001-2006.

Figure 23: Land Cover in the White River Basin

a) 1992



b) 2006

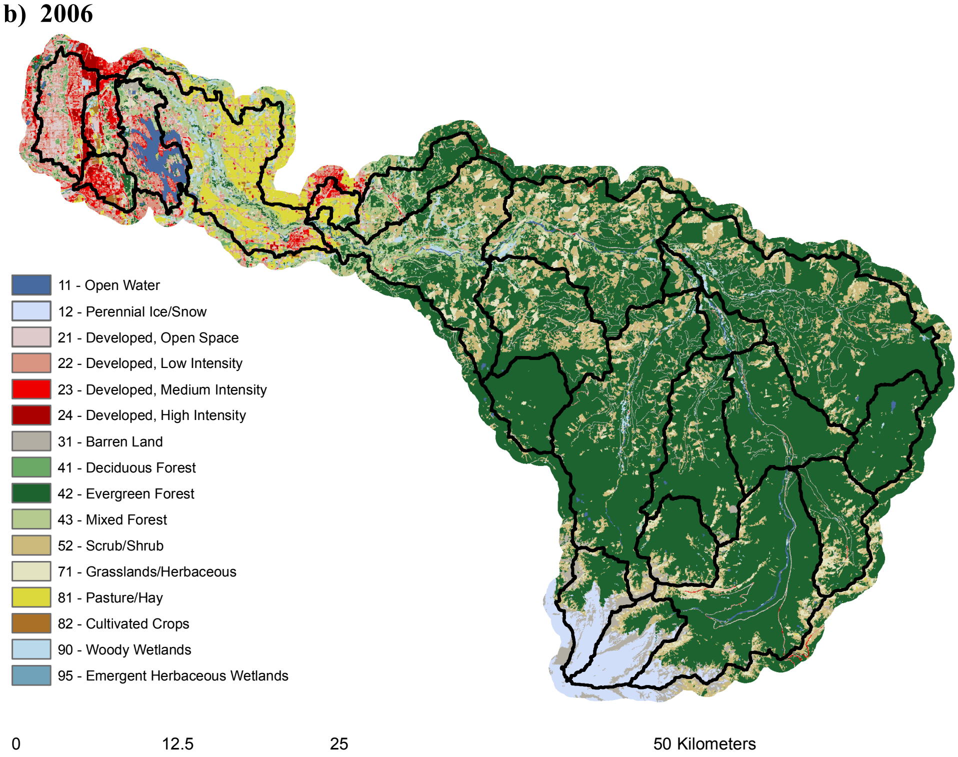
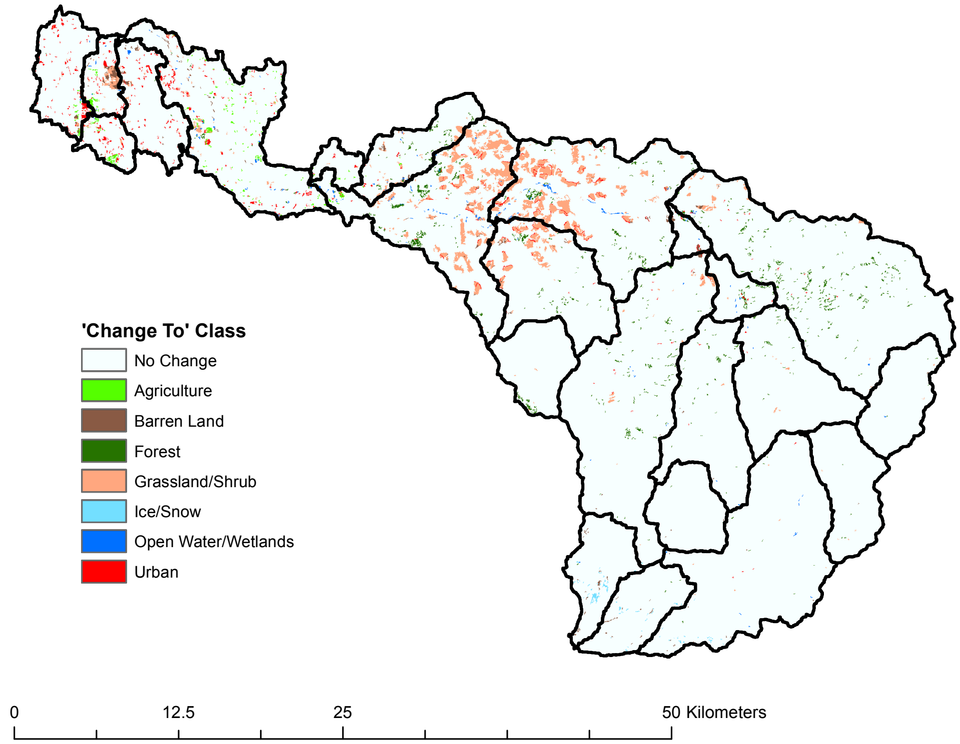
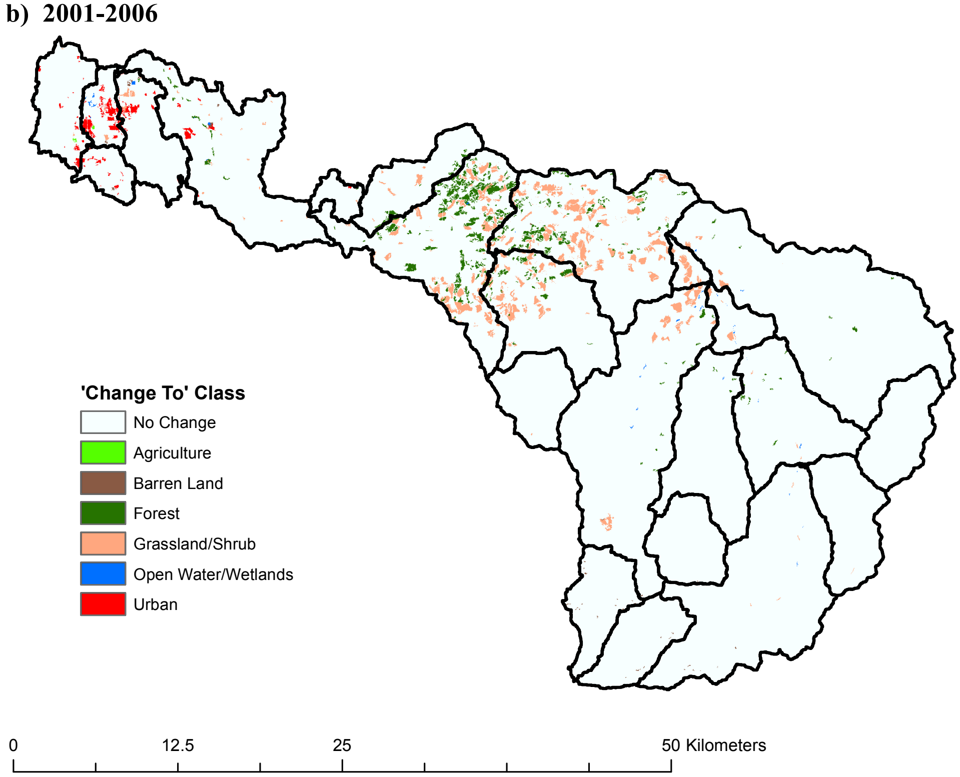


Figure 24: Land Cover Change in the White River Basin

a) 1992-2001



b) 2001-2006



White River Sediment Load

While land cover, topographic slope, soil type, and precipitation are all factors that determine runoff and sediment loads, the SWAT model inputs were held constant for the last three of these factors, and only the input for land cover was changed to reflect the observed land cover condition as reported in the NLCD datasets for each model year.

The SWAT simulations for White River sediment load during the simulation period were considerably lower than estimates developed by Nelson as reported in Table 1, ranging from approximately 48 percent of Nelson's low estimate of 409,091 tonnes (450,000 tons) for 1974-75, to approximately 15 percent of Nelson's high estimate of 1,318,182 tonnes (1,450,000 tons) for 1975-76. Nelson's estimates were based on the collection of over 700 sediment concentration samples obtained from the river in the upper basin from 1975 to 1976. While Nelson's estimates were based on field data collected approximately 20 years before the simulation period, and demonstrated considerable temporal variation (a variation of approximately 1,000,000 tonnes from one year to the next), it is unlikely that actual river sediment load would exhibit a decrease of the magnitude suggested by the SWAT results. Rather, it is more likely that Nelson's observation-based estimates reflect the sediment input to the river resulting from landslide activity associated with large, infrequent storm and flooding events, whereas the long-term yield SWAT simulation does not, as the model is not designed to simulate detailed, single-event flood routing (USDA-ARS et. al, 2007). Other researchers evaluating stream sediment source potential for the White River Basin have reported that such storm events can result in major hydrogeomorphic effects in the Basin's mountainous sub-basins that can in turn cause widespread landslide activity and release significant volumes of sediment into the river network (Czuba et al. 2012).

SWAT simulation results for 2001 and 2006 showed that the sediment load in the main stem of the White River downstream of the Twin Creek Watershed (Stream segments 14, 24, 54, 74, and 84) increased by 300 tonnes (330 tons) between the two years, an increase of 0.153 percent. Given the wide variation between previously published estimates of White River sediment load, and the magnitude of the difference between the SWAT simulation results and those estimates, the SWAT 2001-2006 total and relative change results were applied to the Nelson 1978 sediment load estimates to bracket an estimated range of sediment load increase associated with land use change. To develop an estimated range of total sediment load increase, the SWAT 2001-2006 relative increase of 0.153 percent was applied to the Nelson low (1974-75) and high (1975-76) estimates, producing projected annual increases of 615 tonnes (Nelson low) and 1,977 tonnes (Nelson high) in addition to the 300 tonne SWAT simulation result. Similarly, to develop an estimated range of relative increase, the SWAT 2001-2006 total increase of 300 tonnes was applied to the Nelson estimates to produce percentage increases of 0.023 percent (Nelson high) and 0.073 percent (Nelson low) in addition to the 0.153 percent SWAT result.

The resulting range of sediment load increase associated with land cover change between 2001 and 2006 is estimated to be from 0.023 to 0.153 percent, or a total change of between 300 and 1,977 tonnes (330 to 2,175 tons). To the extent that total sediment load is influenced by large, infrequent storm events not captured by the SWAT model, the change in sediment load will be closer to the low end of the range. Table 7 shows the relationship between relative and total sediment increase in this estimated range.

Table 7: Range of Estimated Sediment Load Increase, White River 2001-2006

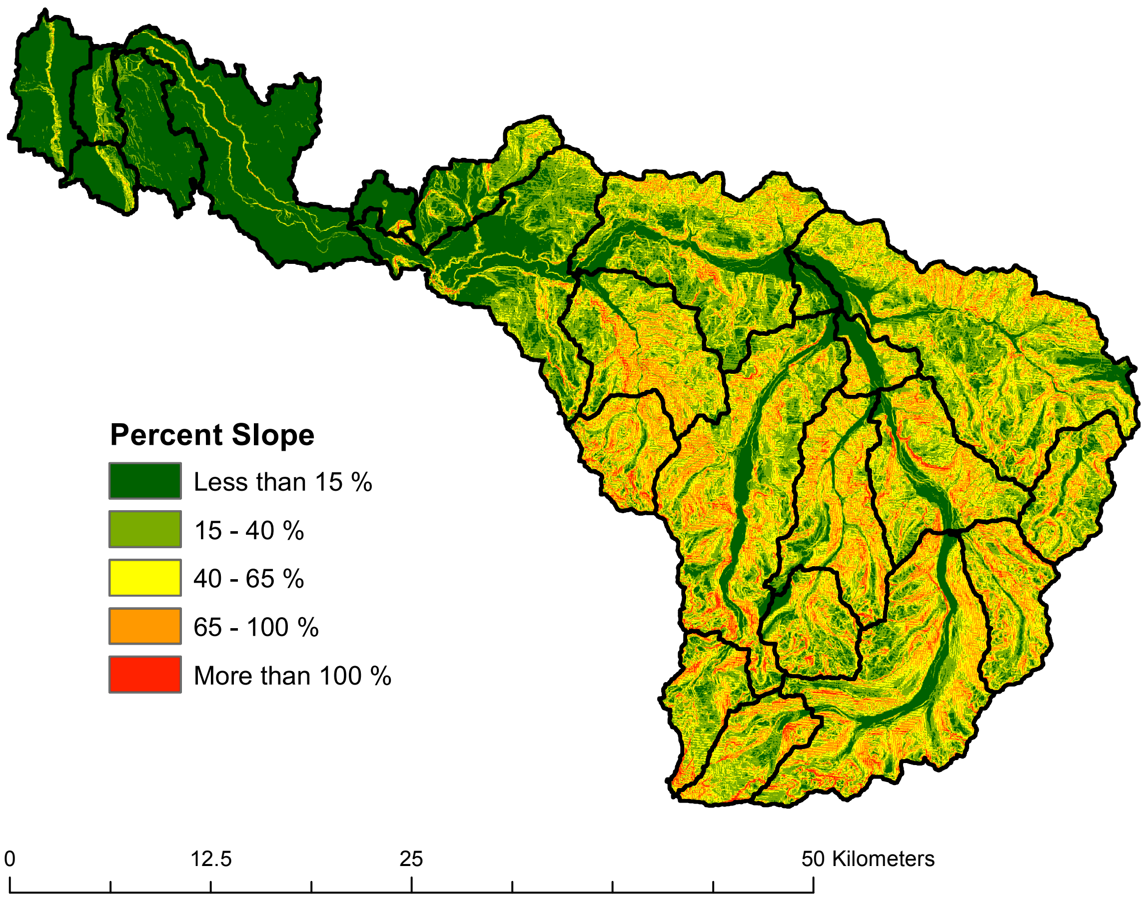
Estimates of White River Annual sediment Load Tonnes (Tons)	Projected Annual Total Increase based on simulated 0.153% increase Tonnes (Tons)	Projected Annual Percent Increase based on simulated 300 tonne total increase (%)
SWAT Simulation (2001) ------------- 195,600 (215,160)	300 (330)	0.153
Nelson 1978 - Low ------------- 409,091 (450,000)	615 (675)	0.073
Nelson 1978 - High ------------- 1,318,182 (1,450,000)	1,977 (2,175)	0.023

The simulated increase in total annual sediment yield of the Twin Creek Watershed from 2001 to 2006 is 1,558 tonnes (1,714 tons), which is the most of any sub-basin for the period and more than three times that of all other sub-basins combined (see Appendix Table A1). The large increase in sediment yield in the Twin Creek Watershed corresponds with the greatest area of land cover change for any of the sub-basins (conversion of forest vegetation to grassland/shrub vegetation), and more specifically, the greatest area of land cover change on slopes greater than 40 percent. The magnitude of sediment increase in the Twin Creek Watershed and its landscape position immediately upstream of the White River segments experiencing an increase in sediment load suggest that this sub-basin is the major source of increased river sediments associated with changes in land cover. The SWAT simulation results for White River sediment input suggest that sediment management efforts in the basin should generally focus on land use practices in areas with slopes of greater than 40 percent, and should specifically focus on such locations within the Twin Creek Watershed.

Sub-basin Annual Runoff and Rate of Sediment Yield

The SWAT simulation results for all three model years depicted in Figures 10, 11, and 12 show that the highest annual surface runoff and rates of sediment yield are consistently found in the uppermost reaches of the basin where topographic slopes are greatest (see Figure 25). This is consistent with previously published assessments that have found that the predominant sources of sediment in the basin are on its mountainous upper slopes (Czuba et al. 2010 and 2012).

Figure 25: Topographic Slope in the White River Basin



At the same time, the SWAT simulation also determined that the areas of greatest increase in annual runoff and rate of sediment yield between 2001 and 2006 are located lower in the basin where there has been greater human activity and changes in land cover have been the most significant (See Figures 14 and 16) Simulation results indicate that surface runoff and rate of sediment yield in the Twin Creek Watershed increased 6.9 and 27.1 percent, respectively, between 2001 and 2006.

Similarly, SWAT determined that these attributes in the Lower White River Watershed increased 15.6 and 21.6 percent, respectively (See Figure 16b and Appendix Table A14), though it is likely that the simulations of runoff and rate of sediment yield in this watershed are somewhat overstated from actual conditions as the models were not adjusted to recognize runoff storage and sediment trapping in Mud Mountain Lake and Lake Tapps.

Changes in Total Sediment Yield

The sub-basin with the greatest increase in total sediment yield (1,558 tonnes) was the Twin Creek Watershed, which is both relatively large (10,896.2 ha) and exhibited the highest increase in sediment rate (0.143 tonnes/ha). On the other hand, while the Lower White River Watershed had the second highest sub-basin increase in the rate of sediment yield at 0.021 tonnes/ha, it is a relatively small sub-basin (1,484.9 ha) and therefore was not estimated to be a major source of sediment input in the basin. By comparison, Sub-basin 90 had a significantly lower increase in the rate of sediment yield (0.013 tons/hectare) than the Lower White River Watershed, but a much larger overall area (6,618.4 hectares). As a result, the estimate of increase in total sediment yield using the SWAT simulation results for Sub-basin 90 found the increase in that sub-basin to be nearly three times that of the Lower White River Watershed. This data is summarized in Appendix Table A1.

Changes in Single-event Runoff and Rate of Sediment Yield

The KINEROS2 simulations for Twin Creek and Lower White River Watersheds found significant increases in runoff, peak flows, sediment yield, and peak sediment discharge in most of the HRUs in each sub-basin for the 25-year, 6-hour precipitation event between 2001 and 2006.

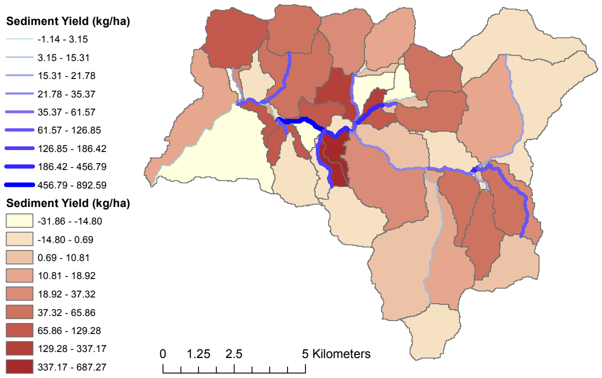
In the Twin Creek Watershed, some HRU planes and stream channel segments experienced increases of as much as several hundred percent or more. Large relative changes can be seen to be coincident with HRUs that experienced the greatest change in land cover. For example, HRU No. 163, which had more than 50 percent of its area change from forest to grassland/shrub during the period, increased 327 percent for runoff, 219 percent for peak flow, 687 percent for sediment discharge, and 587 percent for peak sediment discharge; and the sediment load in Stream Channel No. 134 immediately downstream increased 892 percent. Figure 26 shows the relationship of land cover change to HRUs within this sub-basin.

In the Lower White River Watershed, some HRU's and stream channel segments experienced an even greater rate increase. Similar to HRU's in the Twin Creek Watershed, HRUs in this sub-basin experiencing large increases in sediment yield were in locations of significant land cover change. For example, HRU No. 151 is located in an area that has largely been converted to urban uses and associated un-vegetated or impervious land cover types. The sediment yield in this HRU increased by 854 percent during the period, with the sediment load in Stream Channel No. 154 immediately downstream increasing by over 400 percent. KINEROS2 showed the largest in increase in the watershed in HRU No. 222, the majority of which transitioned from non-urban to urban uses during the period, with a resultant increase in sediment yield of over 1,135 percent. Figure 27 shows the relationship of land cover change to HRUs within this sub-basin.

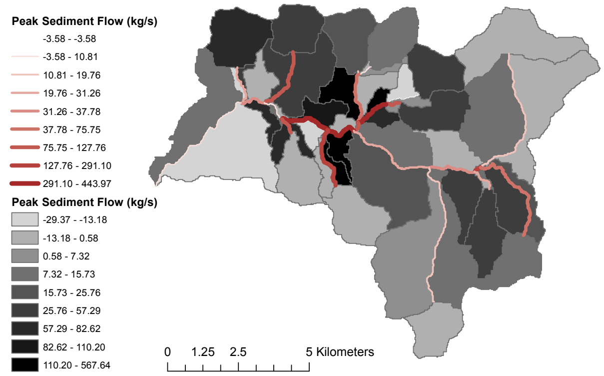
Figures 26 and 27 provide a useful visual comparison of the changes in sediment yield and peak sediment discharge, with the change in land cover within each watershed. While there are limitations in this comparison associated with the fact that the generalized land cover change maps developed for the project only capture the higher order changes between land cover classes and do not allow for analysis of the effects of changes within land cover classes, this comparison shows in general that the HRUs in each watershed exhibiting the greatest increases in peak flow and peak sediment discharge largely correspond with areas of greatest land cover change during the period. Specifically, that the areas of greatest increase in sediment yield in these watersheds correspond to the conversion of forest vegetation to grassland/shrub in the upper basin, and the conversion of vegetated areas to urban uses in the lower basin.

Figure 26: Sediment Yield and Land Cover Change, Twin Creek Watershed 2001-2006

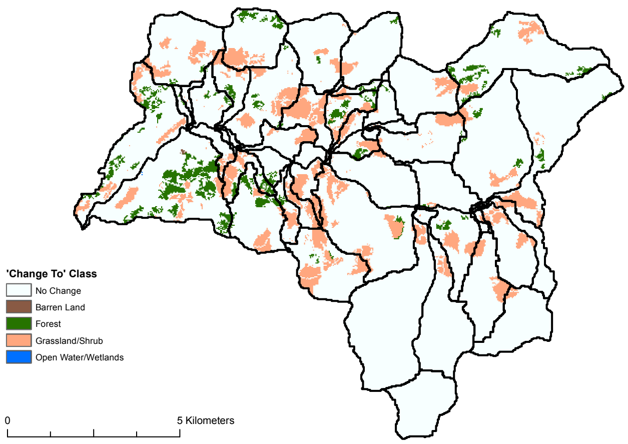
a) Percent Change in Sediment Yield 2001-2006



b) Percent Change in Peak Sediment Discharge 2001-2006



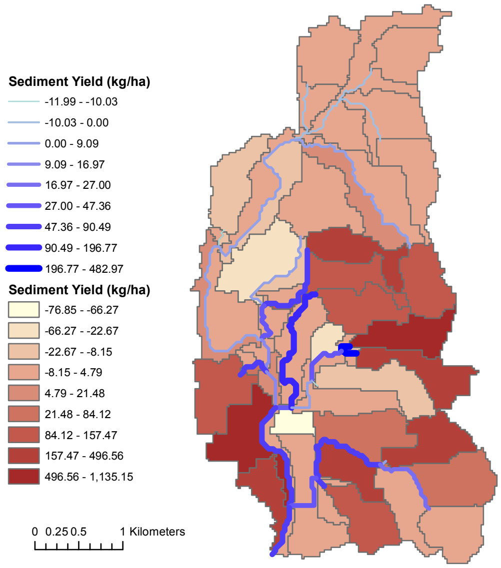
c) Land Cover Change 2001-2006



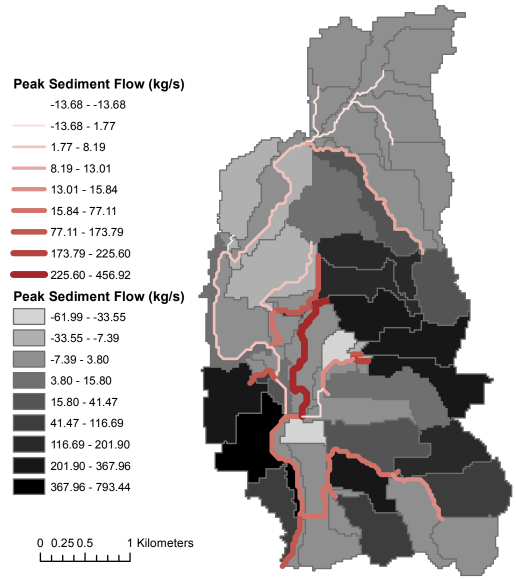
d) Aerial View of Land Cover in 2012

Figure 27: Sediment Yield and Land Cover Change, Lower White River Watershed 2001-2006

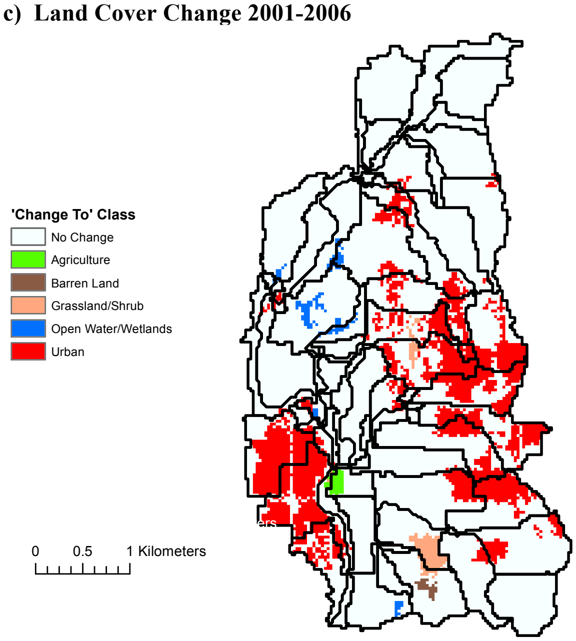
a) Percent Change in Sediment Yield 2001-2006



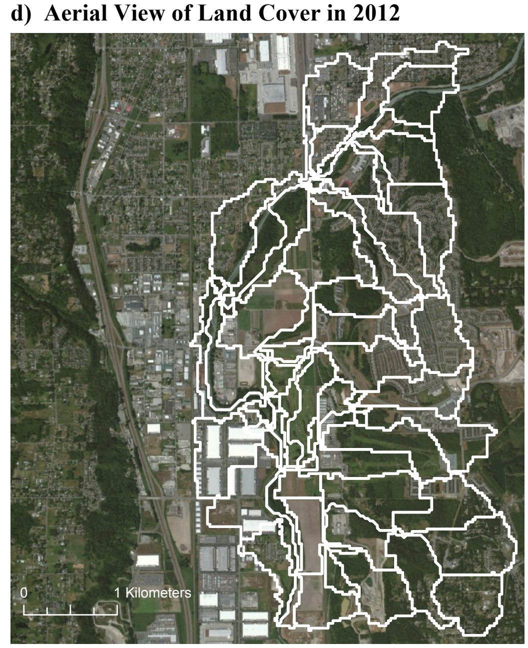
b) Percent Change in Peak Sediment Discharge 2001-2006



c) Land Cover Change 2001-2006



d) Aerial View of Land Cover in 2012



Summary

The SWAT and KINEROS2 simulations determined that the sediment load in the White River increased between 0.023 and 0.153 percent downstream of the Twin Creek Watershed between 2001 and 2006 as a result of changes in land cover throughout the basin. The Twin Creek Watershed experienced a 1,558-tonne (1,714 ton) increase in total annual sediment yield during the simulation period, which was more than three times the increase of all other sub-basins combined (509 tonnes). These results suggest that while land cover change is responsible for less than one percent of the sediment load increase in the White River during this period, the majority of sediment input associated with changes in land cover appears to have come from the Twin Creek Watershed. While the Lower White River Watershed also had a large increase in the rate of sediment yield, the magnitude of its sediment input to the White River appears to be limited by its relatively small size.

Conclusion

AGWA and its embedded SWAT and KINEROS2 hydrologic models provide the ability to consider multiple physical conditions and variables that can affect hydrologic response in a drainage basin, such as the topography, soils, precipitation, and land cover information used for this project. At the same time, this tool also provides a visualization capability that allows for scientist and non-scientist alike to understand, use, and convey simulation results that increase the understanding of river basin function, as well as to conduct alternative scenario and change analyses. The evaluation of the relationship between land cover change and river sediment input in the White River Basin reported here may serve as a good example of how such models can be employed by a broad array of users to better understand the relationship between river basin condition and some activity, process, or condition of interest.

This modeling approach was selected for the project because it offers a demonstration of the potential for a cost-effective, accessible, relatively rapid, and highly visual means to assess how land cover change may affect runoff and sediment input in a river basin at variable spatial and temporal scales. The GIS user interface and modeling applications utilize input data that is freely available to the public, and which can be subsequently updated by basin resource managers, planners, and scientists, when better quality, higher resolution, or additional basin-specific information become available. The continued development and refinement of reliable, affordable, and accessible analysis tools such as AGWA, SWAT, and KINEROS2, will help to ensure that the widespread use of such tools by communities to monitor and protect their natural resources becomes not only possible, but the norm.

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Appendix - Data Tables

Table A1: Sub-basin Changes in Sediment Yield, 1992-2006

Sub-basin No.	Sub-basin Area (hectares)	Rate of Sediment Yield (tonnes/hectare)			Total Sediment Yield (tonnes)			Change in Total Sediment Yield (tonnes)	
		1992	2001	2006	1992	2001	2006	Change 1992-2001	Change 2001-2006
10	9,201.8	0.092	0.1	0.1	847	920	920	74	0
20	1,484.9	0.034	0.097	0.118	50	144	175	94	31
30	10.6	*	*	*	*	*	*	*	*
31	3,239.0	0.004	0.008	0.009	13	26	29	13	3
40	6.3	*	*	*	*	*	*	*	*
41	3,221.7	0.011	0.016	0.017	35	52	55	16	3
50	1,306.9	0.041	0.055	0.056	54	72	73	18	1
60	930.5	0.023	0.027	0.027	21	25	25	4	0
61	3,239.0	0.158	0.158	0.156	512	512	505	0	-6
70	10,896.2	0.309	0.528	0.671	3,367	5,753	7,311	2,386	1,558
80	9,826.5	0.189	0.212	0.208	1,857	2,083	2,044	226	-39
90	6,618.4	0.289	0.311	0.324	1913	2,058	2,144	146	86
91	3,289.7	0.176	0.175	0.175	579	576	576	-3	0
100	739.5	0.063	0.066	0.071	47	49	53	2	4
110	13,938.2	8.667	8.482	8.505	120,802	118,224	118,544	-2,579	321
111	3,220.1	8.561	7.981	7.97	27,567	25,699	25,664	-1,868	-35
120	16,277.5	3.294	3.23	3.232	53,618	52,576	52,609	-1,042	33
121	3,588.6	7.818	7.56	7.56	28,055	27,130	27,130	-926	0
130	1,599.6	0.829	0.829	0.835	1,326	1,326	1,336	0	10
140	6,431.9	6.119	5.908	5.901	39,357	38,000	37,955	-1,357	-45
141	3,224.4	7.925	8.061	8.061	25,553	25,992	25,992	439	0
150	6,406.3	6.143	6.154	6.147	39,354	39,424	39,380	70	-45
160	12,671.6	12.897	13	12.995	163,425	164,731	164,667	1,305	-63
161	3,283.0	9.965	8.219	8.21	32,715	26,983	26,953	-5,732	-30
170	12.1	0.241	0.258	0.258	2.9	3.11	3.11	0	0
171	4,124.2	15.069	14.655	14.659	62,148	60,441	60,457	-1,707	16

* SWAT returned "0" values for sediment yield rate in Sub-basins 30 and 40, which may be due to the relatively small area of these sub-basins. The values were not considered to be accurate and were not used further in the analysis.

The following abbreviations are used for the SWAT data tables and graphic outputs.

ElementID = Sub-basin Number
StreamID = Stream Segment Number
Precip_mm = Precipitation (mm)
ET_mm = Evapotranspiration (mm)
Perc_mm = Percolation (mm)
SurQ_mm = Surface runoff (mm)
WatYld_mm = Water yield (mm)

Tloss_mm = Transmission loss (mm)
Tloss_m3/s = Transmission loss (m^3/s)
SedYld_t/h = Sediment yield (tonnes/ha)
SedYld_in = Sediment yield (inches)
SedYld_mm = Sediment yield (mm)
SedYld_mtn = Sediment yield (tonne)
Q_cmd = Stream discharge (m^3/day)

Table A2: White River Basin, 1992 Simulation Results, Sub-basins (Elements)

ElementID	ID_PARNAME	id	OID	Plane	NumYrsSim	Precip_mm	ET_mm	Perc_mm	SurQ_mm	Tloss_mm	WatYld_mm	SedYld_t/h	SedYld_in	SedYld_mm
10	10_p4	20	19	20	15	1185.180054	553.638	307.769989	320.550995	217.343994	396.580994	0.092	0.021642	0.549702
20	20_p4	23	22	23	15	1101.354004	678.713013	227.367004	170.522003	130.990997	181.401001	0.034	0.049563	1.258907
30	30_p4	22	21	22	15	1063.385986	658.338989	217.951004	132.475006	132.378006	171.604996	0	0	0
31	31_p4	21	20	21	15	1116.599976	521.096985	425.570007	158.936996	122.459999	369.980988	0.004	0.002673	0.067899
40	40_p4	25	24	25	15	1107.967041	683.924988	112.900002	305.316986	303.368988	110.632004	0	0	0
41	41_p4	24	23	24	15	1077.26001	514.804016	388.190002	162.014999	114.850998	328.096008	0.011	0.007391	0.187724
50	50_p4	26	25	26	15	1107.967041	702.039978	214.822998	166.962997	130.664993	150.988998	0.041	0.067908	1.724858
60	60_p4	19	18	19	15	1197.847046	575.929993	205.895004	413.243011	330.781006	286.14801	0.023	0.053505	1.359041
61	61_p4	18	17	18	15	1244.572998	663.950989	308.941986	222.882996	141.934998	363.496002	0.158	0.10559	2.681996
70	70_p4	16	15	16	15	1302.01001	646.452026	501.718994	122.412003	73.148003	461.257996	0.309	0.061386	1.559205
80	80_p4	17	16	17	15	1245.400024	672.913025	341.666992	181.533997	104.517998	355.768005	0.189	0.041633	1.057487
90	90_p4	2	1	2	15	1214.526978	750.642029	313.556	86.856003	53.205002	220.923996	0.289	0.09452	2.400804
91	91_p4	1	0	1	15	1214.526978	661.940002	419.181	38.042999	22.757999	311.483002	0.176	0.115807	2.941496
100	100_p4	15	14	15	15	1479.381958	715.22998	444.149994	274.682007	174.384995	519.356018	0.063	0.184401	4.683782
110	110_p4	6	5	6	15	2364.726074	579.187012	993.552002	650.724976	115.554001	1619.749023	8.667	1.346002	34.188514
111	111_p4	5	4	5	15	3169.512939	581.809998	653.939026	1717.035034	434.756989	2149.022949	8.561	5.754829	146.172961
120	120_p4	4	3	4	15	2199.52002	685.828003	510.585999	968.330017	114.984001	1284.543945	3.294	0.438053	11.126565
121	121_p4	3	2	3	15	2203.707031	655.262024	789.080017	706.734985	155.104996	1333.17395	7.818	4.715719	119.779502
130	130_p4	14	13	14	15	2018.482056	698.492004	506.174011	799.299011	153.171005	1075.902954	0.829	1.121813	28.494106
140	140_p4	8	7	8	15	2025.095947	600.632019	913.35199	444.14801	137.798004	1234.020996	6.119	2.059295	52.306189
141	141_p4	7	6	7	15	2402.923096	660.133972	1047.001953	629.15802	192.334	1522.938965	7.925	5.320197	135.133272
150	150_p4	13	12	13	15	2338.387939	663.28302	785.833008	769.559021	114.191002	1462.394043	6.143	2.075633	52.721183
160	160_p4	10	9	10	15	2459.914063	649.809998	1010.432007	730.830017	163.459	1591.33606	12.897	2.203032	55.957133
161	161_p4	9	8	9	15	2777.095947	571.804016	405.308014	1641.312988	531.609985	1669.962036	9.965	6.570278	166.88539
170	170_p4	12	11	12	15	2346.155029	728.117004	1052.781982	523.877014	292.540985	1290.19104	0.241	43.274011	1099.16209
171	171_p4	11	10	11	15	2457.320068	703.309998	815.255005	875.603027	178.716995	1493.437988	15.069	7.909009	200.88922

Table A3: White River Basin, 1992 Simulation Results, Stream Segments

StreamID	Sequence	SWAT_id	Storage_Loc	OID	ChanNum	NumYrsSim	WatYld_mm	Q_cmd	Tloss_m3/s	SedYld_mtn
34	14	22	60	21	22	15	368.922682	32849.27988	0.003959	13.57
44	16	25	65	24	25	15	327.376513	28952.63958	0.002017	34.57
24	15	23	63	22	23	15	1032.848376	3517343.9209	9.574	196700
54	17	26	68	25	26	15	1006.311764	3551039.86816	3.238	196600
64	12	19	55	18	19	15	345.012465	39407.038879	0.3288	339.299988
14	13	20	58	19	20	15	1062.459671	3478463.85498	22.059999	197300
74	10	16	50	15	16	15	1343.409601	3180384.11865	13.93	202400
84	11	17	53	16	17	15	1149.681894	3341952.02637	15.17	203400
104	9	15	47	14	15	15	1535.715385	2341440.03296	2.215	157400
134	8	14	44	13	14	15	1473.629194	1524095.94727	2.079	103900
94	1	2	28	1	2	15	249.760779	67798.077965	0.631	736.599976
124	2	4	30	3	4	15	1290.80173	702691.2323	3.49	44590
154	7	13	41	12	13	15	1551.809203	1126655.9967	4.025	84270
174	6	12	38	11	12	15	1492.165175	169084.801483	0.003208	14640
144	4	8	34	7	8	15	1328.261314	351388.792419	2.07	18530
114	3	6	32	5	6	15	1716.653572	807062.365723	5.821	53550
164	5	10	36	9	10	15	1605.469068	701567.990112	4.469	48390

Table A4: White River Basin, 2001 Simulation Results, Sub-basins (Elements)

ElementID	ID_PARNAME	id	OID	Plane	NumYrsSim	Precip_mm	ET_mm	Perc_mm	SurQ_mm	Tloss_mm	WatYld_mm	SedYld_t/h	SedYld_in	SedYld_mm
10	10_p4	20	19	20	15	1185.180054	550.695007	274.178986	357.209015	241.662003	380.372009	0.1	0.023524	0.597502
20	20_p4	23	22	23	15	1101.354004	670.737	159.789001	249.977005	190.222	189.121994	0.097	0.141401	3.591588
30	30_p4	22	21	22	15	1063.385986	656.588013	193.149994	162.375	162.177994	173.182007	0	0	0
31	31_p4	21	20	21	15	1116.599976	515.343018	337.393005	254.291	190.356995	372.61499	0.008	0.005346	0.135797
40	40_p4	25	24	25	15	1107.967041	677.276001	89.884003	335.279999	333.11499	93.041	0	0	0
41	41_p4	24	23	24	15	1077.26001	511.45401	334.682007	219.835007	152.587006	330.127991	0.016	0.01075	0.273053
50	50_p4	26	25	26	15	1107.967041	695.838989	167.804993	222.897003	173.487	157.024002	0.055	0.091096	2.313834
60	60_p4	19	18	19	15	1197.847046	569.825012	175.932007	449.466003	358.889008	266.996002	0.027	0.062811	1.595397
61	61_p4	18	17	18	15	1244.572998	663.942017	308.826996	223.016998	142.022995	363.463989	0.158	0.10559	2.681996
70	70_p4	16	15	16	15	1302.01001	646.106018	486.56601	138.544006	81.940002	460.367004	0.528	0.104892	2.664273
80	80_p4	17	16	17	15	1245.400024	671.463013	314.864014	212.046997	122.549004	356.665009	0.212	0.0467	1.186175
90	90_p4	2	1	2	15	1214.526978	750.382996	308.423004	92.942001	56.532001	221.160004	0.311	0.101715	2.583564
91	91_p4	1	0	1	15	1214.526978	661.942993	419.479004	37.693001	22.556999	311.455994	0.175	0.115149	2.924783
100	100_p4	15	14	15	15	1479.381958	714.708984	428.936005	291.425995	186.156998	519.330994	0.066	0.193181	4.906819
110	110_p4	6	5	6	15	2364.726074	579.247009	1007.354004	635.117981	108.936996	1619.366943	8.482	1.317271	33.458751
111	111_p4	5	4	5	15	3169.512939	583.713989	715.945007	1636.512939	405.54599	2175.284912	7.981	5.364945	136.269877
120	120_p4	4	3	4	15	2199.52002	686.536987	523.401978	954.16803	109.285004	1284.567993	3.23	0.429542	10.910385
121	121_p4	3	2	3	15	2203.707031	655.419006	803.784973	691.059021	149.479004	1333.514038	7.56	4.560097	115.826688
130	130_p4	14	13	14	15	2018.482056	698.484009	505.903992	799.583008	153.341003	1076.04895	0.829	1.121813	28.494106
140	140_p4	8	7	8	15	2025.095947	600.71698	923.554016	433.235992	133.692993	1234.094971	5.908	1.988285	50.502528
141	141_p4	7	6	7	15	2402.923096	660.04303	1039.762939	636.874023	195.003006	1522.827026	8.061	5.411496	137.452273
150	150_p4	13	12	13	15	2338.387939	663.257996	784.346008	771.263977	114.832001	1462.364014	6.154	2.07935	52.815585
160	160_p4	10	9	10	15	2459.914063	649.775024	1005.979004	735.572998	164.884995	1591.112061	13	2.220626	56.404026
161	161_p4	9	8	9	15	2777.095947	580.046021	514.695984	1491.93103	478.798004	1714.437988	8.219	5.419078	137.644855
170	170_p4	12	11	12	15	2346.155029	727.869019	953.690979	626.505981	372.562988	1220.874023	0.258	46.326533	1176.6963
171	171_p4	11	10	11	15	2457.320068	703.690979	837.012024	852.111023	171.091003	1493.006958	14.655	7.691719	195.370059

Table A5: White River Basin, 2001 Simulation Results, Stream Segments

StreamID	Sequence	SWAT_id	Storage_Loc	OID	ChanNum	NumYrsSim	WatYld_mm	Q_cmd	Tloss_m3/s	SedYld_mtn
34	14	22	60	21	22	15	371.639618	33091.198826	0.004119	26.120001
44	16	25	65	24	25	15	329.330421	29125.43993	0.002068	50.799999
24	15	23	63	22	23	15	1033.355805	3519071.96045	9.6	195600
54	17	26	68	25	26	15	1007.046362	3553632.09229	3.235	195600
64	12	19	55	18	19	15	340.700761	38914.559555	0.3236	342.200012
14	13	20	58	19	20	15	1062.723627	3479328.03955	22.129999	196200
74	10	16	50	15	16	15	1345.964294	3186432.09229	13.97	200900
84	11	17	53	16	17	15	1151.762488	3348000	15.2	202100
104	9	15	47	14	15	15	1539.682161	2347488.00659	2.213	155800
134	8	14	44	13	14	15	1477.806243	1528416.04614	2.088	103100
94	1	2	28	1	2	15	249.919931	67841.279984	0.6315	771.700012
124	2	4	30	3	4	15	1290.80173	702691.2323	3.51	44190
154	7	13	41	12	13	15	1556.569349	1130111.99341	4.063	83570
174	6	12	38	11	12	15	1491.402663	168998.397446	0.003202	14370
144	4	8	34	7	8	15	1328.261314	351388.792419	2.069	18410
114	3	6	32	5	6	15	1721.248083	809222.415161	5.865	52750
164	5	10	36	9	10	15	1614.366387	705455.996704	4.519	47850

Table A6: White River Basin, 2006 Simulation Results, Sub-basins (Elements)

ElementID	ID_PARNAME	id	OID	Plane	NumYrsSim	Precip_mm	ET_mm	Perc_mm	SurQ_mm	Tloss_mm	WatYld_mm	SedYld_t/h	SedYld_in	SedYld_mm
10	10_p4	20	19	20	15	1185.180054	550.747009	274.743011	356.589996	241.251999	380.670013	0.1	0.023524	0.597502
20	20_p4	23	22	23	15	1101.354004	664.559998	128.772995	289.002991	219.341003	193.559006	0.118	0.172013	4.369148
30	30_p4	22	21	22	15	1063.385986	655.971985	186.942001	170.048996	169.826996	173.576004	0	0	0
31	31_p4	21	20	21	15	1116.599976	513.84198	322.061005	271.375	202.296997	373.040009	0.009	0.006015	0.152772
40	40_p4	25	24	25	15	1107.967041	665.138977	61.137001	376.553009	374.084991	65.906998	0	0	0
41	41_p4	24	23	24	15	1077.26001	511.153992	330.988007	223.895004	155.201004	330.378998	0.017	0.011422	0.290119
50	50_p4	26	25	26	15	1107.967041	695.208984	163.679001	227.895004	177.330002	157.634003	0.056	0.092752	2.355904
60	60_p4	19	18	19	15	1197.847046	569.723999	175.494003	450.006989	359.319	266.678009	0.027	0.062811	1.595397
61	61_p4	18	17	18	15	1244.572998	664.142029	311.571991	219.824005	139.923996	363.894989	0.156	0.104254	2.648046
70	70_p4	16	15	16	15	1302.01001	645.903992	477.639008	148.046997	87.065002	460.445007	0.671	0.133301	3.385847
80	80_p4	17	16	17	15	1245.400024	671.749023	319.502014	206.729004	119.426003	356.427002	0.208	0.045819	1.163795
90	90_p4	2	1	2	15	1214.526978	750.232971	305.518005	96.388	58.404999	221.716995	0.324	0.105967	2.691559
91	91_p4	1	0	1	15	1214.526978	661.942993	419.479004	37.693001	22.556999	311.455994	0.175	0.115149	2.924783
100	100_p4	15	14	15	15	1479.381958	713.742981	403.036987	320.022003	206.871994	519.622009	0.071	0.207816	5.278548
110	110_p4	6	5	6	15	2364.726074	579.231995	1003.674011	639.278015	110.700996	1619.25	8.505	1.320843	33.549478
111	111_p4	5	4	5	15	3169.512939	583.76001	716.429016	1635.813965	405.199005	2175.577881	7.97	5.357551	136.082057
120	120_p4	4	3	4	15	2199.52002	686.513977	523.002014	954.609985	109.461998	1284.458008	3.232	0.429808	10.917141
121	121_p4	3	2	3	15	2203.707031	655.419006	803.784973	691.059021	149.479004	1333.514038	7.56	4.560097	115.826688
130	130_p4	14	13	14	15	2018.482056	698.31897	500.621002	805.137024	156.533005	1076.025024	0.835	1.129932	28.700336
140	140_p4	8	7	8	15	2025.095947	600.719971	923.874023	432.893005	133.563995	1234.079956	5.901	1.985929	50.442691
141	141_p4	7	6	7	15	2402.923096	660.04303	1039.762939	636.874023	195.003006	1522.827026	8.061	5.411496	137.452273
150	150_p4	13	12	13	15	2338.387939	663.27301	785.29303	770.177979	114.424004	1462.39502	6.147	2.076984	52.755509
160	160_p4	10	9	10	15	2459.914063	649.776001	1006.192993	735.346985	164.817001	1591.103027	12.995	2.219772	56.382331
161	161_p4	9	8	9	15	2777.095947	580.091003	515.393005	1490.987061	478.460999	1714.729004	8.21	5.413144	137.494134
170	170_p4	12	11	12	15	2346.155029	727.869019	953.690979	626.505981	372.562988	1220.874023	0.258	46.326533	1176.6963
171	171_p4	11	10	11	15	2457.320068	703.687988	836.807983	852.330994	171.162003	1493.385986	14.659	7.693819	195.423393

Table A7: White River Basin, 2006 Simulation Results, Stream Segments

StreamID	Sequence	SWAT_id	Storage_Loc	OID	ChanNum	NumYrsSim	WatYld_mm	Q_cmd	Tloss_m3/s	SedYld_mtn
34	14	22	60	21	22	15	372.02776	33125.759411	0.00412	28.48
44	16	25	65	24	25	15	329.525814	29142.720223	0.002072	51.889999
24	15	23	63	22	23	15	1033.609568	3519936.14502	9.603	195900
54	17	26	68	25	26	15	1007.291165	3554495.94727	3.235	195900
64	12	19	55	18	19	15	340.927708	38940.481281	0.3236	343.5
14	13	20	58	19	20	15	1062.987482	3480191.89453	22.139999	196500
74	10	16	50	15	16	15	1345.964294	3186432.09229	13.97	201200
84	11	17	53	16	17	15	1151.762488	3348000	15.22	202400
104	9	15	47	14	15	15	1539.682161	2347488.00659	2.214	155900
134	8	14	44	13	14	15	1477.806243	1528416.04614	2.088	103100
94	1	2	28	1	2	15	250.301883	67944.961739	0.6315	788.099976
124	2	4	30	3	4	15	1290.80173	702691.2323	3.509	44200
154	7	13	41	12	13	15	1556.569349	1130111.99341	4.063	83540
174	6	12	38	11	12	15	1491.402663	168998.397446	0.0032	14380
144	4	8	34	7	8	15	1328.261314	351388.792419	2.069	18400
114	3	6	32	5	6	15	1721.248083	809222.415161	5.862	52870
164	5	10	36	9	10	15	1614.366387	705455.996704	4.52	47840

Table A8: White River Basin, Change 1992-2001, Sub-basins (Elements)

ElementID	ID_PARNAME	id	OID	Plane	NumYrsSim	Precip_mm	ET_mm	Perc_mm	SurQ_mm	Tloss_mm	WatYld_mm	SedYld_t/h	SedYld_in	SedYld_mm
10	10_p4	20	19	20	15	0	-2.942993	-33.591003	36.65802	24.318008	-16.208984	0.008	0.001882	0.0478
20	20_p4	23	22	23	15	0	-7.976013	-67.578003	79.455002	59.231003	7.720993	0.063	0.091838	2.332681
30	30_p4	22	21	22	15	0	-1.750977	-24.80101	29.899994	29.799988	1.577011	0	0	0
31	31_p4	21	20	21	15	0	-5.753967	-88.177002	95.354004	67.896996	2.634003	0.004	0.002673	0.067899
40	40_p4	25	24	25	15	0	-6.648987	-23.015999	29.963013	29.746002	-17.591003	0	0	0
41	41_p4	24	23	24	15	0	-3.350006	-53.507996	57.820007	37.736008	2.031982	0.005	0.003359	0.085329
50	50_p4	26	25	26	15	0	-6.200989	-47.018005	55.934006	42.822006	6.035004	0.014	0.023188	0.588976
60	60_p4	19	18	19	15	0	-6.10498	-29.962997	36.222992	28.108002	-19.152008	0.004	0.009305	0.236355
61	61_p4	18	17	18	15	0	-0.008972	-0.11499	0.134003	0.087997	-0.032013	0	0	0
70	70_p4	16	15	16	15	0	-0.346008	-15.152985	16.132004	8.792	-0.890991	0.219	0.043507	1.105068
80	80_p4	17	16	17	15	0	-1.450012	-26.802979	30.513	18.031006	0.897003	0.023	0.005066	0.128689
90	90_p4	2	1	2	15	0	-0.259033	-5.132996	6.085999	3.327	0.236008	0.022	0.007195	0.18276
91	91_p4	1	0	1	15	0	0.002991	0.298004	-0.349998	-0.201	-0.027008	-0.001	-0.000658	-0.016713
100	100_p4	15	14	15	15	0	-0.520996	-15.213989	16.743988	11.772003	-0.025024	0.003	0.008781	0.223037
110	110_p4	6	5	6	15	0	0.059998	13.802002	-15.606995	-6.617004	-0.38208	-0.184999	-0.028731	-0.729763
111	111_p4	5	4	5	15	0	1.903992	62.005981	-80.522095	-29.210999	26.261963	-0.58	-0.389884	-9.903085
120	120_p4	4	3	4	15	0	0.708984	12.815979	-14.161987	-5.698997	0.024048	-0.064	-0.008511	-0.216181
121	121_p4	3	2	3	15	0	0.156982	14.704956	-15.675964	-5.625992	0.340088	-0.258	-0.155622	-3.952814
130	130_p4	14	13	14	15	0	-0.007996	-0.27002	0.283997	0.169998	0.145996	0	0	0
140	140_p4	8	7	8	15	0	0.084961	10.202026	-10.912018	-4.105011	0.073975	-0.211	-0.07101	-1.803661
141	141_p4	7	6	7	15	0	-0.090942	-7.239014	7.716003	2.669006	-0.111938	0.136	0.091299	2.319001
150	150_p4	13	12	13	15	0	-0.025024	-1.487	1.704956	0.640999	-0.030029	0.011	0.003717	0.094403
160	160_p4	10	9	10	15	0	-0.034973	-4.453003	4.742981	1.425995	-0.223999	0.103	0.017594	0.446892
161	161_p4	9	8	9	15	0	8.242004	109.38797	-149.381958	-52.811981	44.475952	-1.746	-1.1512	-29.240535
170	170_p4	12	11	12	15	0	-0.247986	-99.091003	102.628967	80.022003	-69.317017	0.017	3.052522	77.53421
171	171_p4	11	10	11	15	0	0.380981	21.757019	-23.492004	-7.625992	-0.43103	-0.414001	-0.217289	-5.519161

Table A9: White River Basin, Change 1992-2001, Stream Segments

StreamID	Sequence	SWAT_id	Storage_Loc	OID	ChanNum	NumYrsSim	WatYld_mm	Q_cmd	Tloss_m3/s	SedYld_mtn
34	14	22	60	21	22	15	2.716936	241.918945	0.00016	12.550001
44	16	25	65	24	25	15	1.953907	172.80035	0.000051	16.23
24	15	23	63	22	23	15	0.507429	1728.03955	0.026	-1100
54	17	26	68	25	26	15	0.734598	2592.22413	-0.003	-1000
64	12	19	55	18	19	15	-4.311704	-492.479324	-0.0052	2.900024
14	13	20	58	19	20	15	0.263956	864.18457	0.07	-1100
74	10	16	50	15	16	15	2.554693	6047.97364	0.04	-1500
84	11	17	53	16	17	15	2.080594	6047.97363	0.03	-1300
104	9	15	47	14	15	15	3.966775	6047.97363	-0.002	-1600
134	8	14	44	13	14	15	4.177049	4320.09887	0.009	-800
94	1	2	28	1	2	15	0.159152	43.202019	0.0005	35.100037
124	2	4	30	3	4	15	0	0	0.02	-400
154	7	13	41	12	13	15	4.760146	3455.99671	0.038	-700
174	6	12	38	11	12	15	-0.762511	-86.404037	-0.000006	-270
144	4	8	34	7	8	15	0	0	-0.001	-120
114	3	6	32	5	6	15	4.594511	2160.049438	0.044	-800
164	5	10	36	9	10	15	8.897319	3888.006592	0.05	-540

Table A10: White River Basin, Percent Change 1992-2001, Sub-basins (Elements)

ElementID	ID_PARNAME	id	OID	Plane	NumYrsSim	Precip_mm	ET_mm	Perc_mm	SurQ_mm	Tloss_mm	WatYld_mm	SedYld_t/h	SedYld_in	SedYld_mm
10	10_p4	20	19	20	15	0	-0.531574	-10.914321	11.43594	11.188719	-4.087181	8.695654	8.695654	8.695654
20	20_p4	23	22	23	15	0	-1.175167	-29.721992	46.595161	45.217613	4.256312	185.294111	185.294111	185.294111
30	30_p4	22	21	22	15	0	-0.265969	-11.379168	22.570291	22.511283	0.918977	0	0	0
31	31_p4	21	20	21	15	0	-1.104203	-20.719741	59.994845	55.444223	0.711929	100	100	100
40	40_p4	25	24	25	15	0	-0.972181	-20.386181	9.813739	9.805222	-15.900465	0	0	0
41	41_p4	24	23	24	15	0	-0.650734	-13.783971	35.688058	32.856491	0.619326	45.454553	45.454553	45.454553
50	50_p4	26	25	26	15	0	-0.883281	-21.886858	33.500839	32.772363	3.996982	34.146337	34.146337	34.146337
60	60_p4	19	18	19	15	0	-1.060021	-14.552562	8.765543	8.497465	-6.693043	17.391307	17.391307	17.391307
61	61_p4	18	17	18	15	0	-0.001351	-0.037221	0.060122	0.061998	-0.008807	0	0	0
70	70_p4	16	15	16	15	0	-0.053524	-3.020213	13.178449	12.019467	-0.193165	70.873794	70.873794	70.873794
80	80_p4	17	16	17	15	0	-0.215483	-7.844767	16.808422	17.25158	0.252131	12.169313	12.169313	12.169313
90	90_p4	2	1	2	15	0	-0.034508	-1.637027	7.006998	6.253171	0.106828	7.612451	7.612451	7.612451
91	91_p4	1	0	1	15	0	0.000452	0.071092	-0.920008	-0.883207	-0.008671	-0.568183	-0.568183	-0.568183
100	100_p4	15	14	15	15	0	-0.072843	-3.425417	6.095772	6.750583	-0.004818	4.761903	4.761903	4.761903
110	110_p4	6	5	6	15	0	0.010359	1.389157	-2.398401	-5.726331	-0.023589	-2.134527	-2.134527	-2.134527
111	111_p4	5	4	5	15	0	0.327253	9.481921	-4.689601	-6.718926	1.222042	-6.774909	-6.774909	-6.774909
120	120_p4	4	3	4	15	0	0.103376	2.510053	-1.462517	-4.95634	0.001872	-1.942923	-1.942923	-1.942923
121	121_p4	3	2	3	15	0	0.023957	1.863557	-2.218082	-3.627215	0.02551	-3.300075	-3.300075	-3.300075
130	130_p4	14	13	14	15	0	-0.001145	-0.053345	0.035531	0.110986	0.01357	0	0	0
140	140_p4	8	7	8	15	0	0.014145	1.116987	-2.456843	-2.979006	0.005995	-3.448275	-3.448275	-3.448275
141	141_p4	7	6	7	15	0	-0.013776	-0.691404	1.226402	1.387693	-0.00735	1.716084	1.716084	1.716084
150	150_p4	13	12	13	15	0	-0.003773	-0.189226	0.22155	0.561339	-0.002053	0.17906	0.17906	0.17906
160	160_p4	10	9	10	15	0	-0.005382	-0.440703	0.648986	0.872387	-0.014076	0.798633	0.798633	0.798633
161	161_p4	9	8	9	15	0	1.441404	26.98885	-9.101369	-9.934347	2.663291	-17.521327	-17.521327	-17.521327
170	170_p4	12	11	12	15	0	-0.034059	-9.4123	19.590279	27.354117	-5.372616	7.053938	7.053938	7.053938
171	171_p4	11	10	11	15	0	0.05417	2.668738	-2.682951	-4.267077	-0.028862	-2.747365	-2.747365	-2.747365

Table A11: White River Basin, Percent Change 1992-2001, Stream Segments

StreamID	Sequence	SWAT_id	Storage_Loc	OID	ChanNum	NumYrsSim	WatYld_mm	Q_cmd	Tloss_m3/s	SedYld_mtn
34	14	22	60	21	22	15	0.388142	34.560585	0.000001	2.359999
44	16	25	65	24	25	15	0.195394	17.280293	0.000004	1.09
24	15	23	63	22	23	15	0.253763	864.18457	0.002999	300
54	17	26	68	25	26	15	0.244804	863.85498	0	300
64	12	19	55	18	19	15	0.226947	25.921726	0	1.299988
14	13	20	58	19	20	15	0.263855	863.85498	0.01	300
74	10	16	50	15	16	15	0	0	0	300
84	11	17	53	16	17	15	0	0	0.02	300
104	9	15	47	14	15	15	0	0	0.001	100
134	8	14	44	13	14	15	0	0	0	0
94	1	2	28	1	2	15	0.381952	103.681755	0	16.399963
124	2	4	30	3	4	15	0	0	-0.001	10
154	7	13	41	12	13	15	0	0	0	-30
174	6	12	38	11	12	15	0	0	-0.000002	10
144	4	8	34	7	8	15	0	0	0	-10
114	3	6	32	5	6	15	0	0	-0.003	120
164	5	10	36	9	10	15	0	0	0.001	-10

Table A12: White River Basin, Change 2001-2006, Sub-basins (Elements)

ElementID	ID_PARNAME	id	OID	Plane	NumYrsSim	Precip_mm	ET_mm	Perc_mm	SurQ_mm	Tloss_mm	WatYld_mm	SedYld_t/h	SedYld_in	SedYld_mm
10	10_p4	20	19	20	15	0	0.052002	0.564026	-0.619019	-0.410004	0.298004	0	0	0
20	20_p4	23	22	23	15	0	-6.177002	-31.016006	39.025986	29.119003	4.437012	0.021	0.030613	0.77756
30	30_p4	22	21	22	15	0	-0.616028	-6.207993	7.673996	7.649002	0.393997	0	0	0
31	31_p4	21	20	21	15	0	-1.501038	-15.332001	17.084	11.940002	0.425018	0.001	0.000668	0.016975
40	40_p4	25	24	25	15	0	-12.137024	-28.747002	41.27301	40.970001	-27.134003	0	0	0
41	41_p4	24	23	24	15	0	-0.300018	-3.694	4.059998	2.613998	0.251007	0.001	0.000672	0.017066
50	50_p4	26	25	26	15	0	-0.630005	-4.125992	4.998001	3.843002	0.610001	0.001	0.001656	0.04207
60	60_p4	19	18	19	15	0	-0.101013	-0.438004	0.540985	0.429993	-0.317993	0	0	0
61	61_p4	18	17	18	15	0	0.200012	2.744995	-3.192993	-2.098999	0.431	-0.002	-0.001337	-0.033949
70	70_p4	16	15	16	15	0	-0.202026	-8.927002	9.502991	5.125	0.078003	0.143	0.028408	0.721574
80	80_p4	17	16	17	15	0	0.286011	4.638	-5.317993	-3.123001	-0.238007	-0.004	-0.000881	-0.022381
90	90_p4	2	1	2	15	0	-0.150024	-2.904999	3.445999	1.872997	0.556992	0.013	0.004252	0.107995
91	91_p4	1	0	1	15	0	0	0	0	0	0	0	0	0
100	100_p4	15	14	15	15	0	-0.966003	-25.899017	28.596008	20.714996	0.291016	0.005	0.014635	0.371729
110	110_p4	6	5	6	15	0	-0.015015	-3.679993	4.160034	1.764	-0.116943	0.023	0.003572	0.090727
111	111_p4	5	4	5	15	0	0.046021	0.484009	-0.698975	-0.346985	0.292969	-0.011	-0.007394	-0.18782
120	120_p4	4	3	4	15	0	-0.02301	-0.399963	0.441956	0.176994	-0.109985	0.002	0.000266	0.006756
121	121_p4	3	2	3	15	0	0	0	0	0	0	0	0	0
130	130_p4	14	13	14	15	0	-0.165039	-5.28299	5.554016	3.192001	-0.023926	0.006	0.008119	0.206229
140	140_p4	8	7	8	15	0	0.002991	0.320007	-0.342987	-0.128998	-0.015015	-0.007	-0.002356	-0.059837
141	141_p4	7	6	7	15	0	0	0	0	0	0	0	0	0
150	150_p4	13	12	13	15	0	0.015015	0.947021	-1.085999	-0.407997	0.031006	-0.007	-0.002365	-0.060076
160	160_p4	10	9	10	15	0	0.000977	0.213989	-0.226013	-0.067993	-0.009033	-0.005	-0.000854	-0.021694
161	161_p4	9	8	9	15	0	0.044983	0.697021	-0.94397	-0.337006	0.291016	-0.009	-0.005934	-0.150721
170	170_p4	12	11	12	15	0	0	0	0	0	0	0	0	0
171	171_p4	11	10	11	15	0	-0.002991	-0.204041	0.219971	0.070999	0.379028	0.004001	0.0021	0.053334

Table A13: White River Basin, Change 2001-2006, Stream Segments

StreamID	Sequence	SWAT_id	Storage_Loc	OID	ChanNum	NumYrsSim	WatYld_mm	Q_cmd	Tloss_m3/s	SedYld_mtn
34	14	22	60	21	22	15	0.388142	34.560585	0.000001	2.359999
44	16	25	65	24	25	15	0.195394	17.280293	0.000004	1.09
24	15	23	63	22	23	15	0.253763	864.18457	0.002999	300
54	17	26	68	25	26	15	0.244804	863.85498	0	300
64	12	19	55	18	19	15	0.226947	25.921726	0	1.299988
14	13	20	58	19	20	15	0.263855	863.85498	0.01	300
74	10	16	50	15	16	15	0	0	0	300
84	11	17	53	16	17	15	0	0	0.02	300
104	9	15	47	14	15	15	0	0	0.001	100
134	8	14	44	13	14	15	0	0	0	0
94	1	2	28	1	2	15	0.381952	103.681755	0	16.399963
124	2	4	30	3	4	15	0	0	-0.001	10
154	7	13	41	12	13	15	0	0	0	-30
174	6	12	38	11	12	15	0	0	-0.000002	10
144	4	8	34	7	8	15	0	0	0	-10
114	3	6	32	5	6	15	0	0	-0.003	120
164	5	10	36	9	10	15	0	0	0.001	-10

Table A14: White River Basin, Percent Change 2001-2006, Sub-basins (Elements)

ElementID	ID_PARNAME	id	OID	Plane	NumYrsSim	Precip_mm	ET_mm	Perc_mm	SurQ_mm	Tloss_mm	WatYld_mm	SedYld_t/h	SedYld_in	SedYld_mm
10	10_p4	20	19	20	15	0	0.009443	0.205714	-0.173293	-0.16966	0.078345	0	0	0
20	20_p4	23	22	23	15	0	-0.920928	-19.410602	15.61183	15.307905	2.346111	21.649482	21.649482	21.649482
30	30_p4	22	21	22	15	0	-0.093823	-3.214079	4.726095	4.716424	0.227505	0	0	0
31	31_p4	21	20	21	15	0	-0.29127	-4.544256	6.718287	6.272426	0.114064	12.49999	12.49999	12.49999
40	40_p4	25	24	25	15	0	-1.792035	-31.982334	12.310013	12.299057	-29.16349	0	0	0
41	41_p4	24	23	24	15	0	-0.05866	-1.103734	1.846839	1.71312	0.076033	6.250001	6.250001	6.250001
50	50_p4	26	25	26	15	0	-0.090539	-2.458802	2.242292	2.215153	0.388476	1.818186	1.818186	1.818186
60	60_p4	19	18	19	15	0	-0.017727	-0.248962	0.120362	0.119812	-0.1191	0	0	0
61	61_p4	18	17	18	15	0	0.030125	0.888846	-1.431726	-1.477929	0.118581	-1.265825	-1.265825	-1.265825
70	70_p4	16	15	16	15	0	-0.031268	-1.834695	6.859186	6.254576	0.016944	27.083335	27.083335	27.083335
80	80_p4	17	16	17	15	0	0.042595	1.473017	-2.507931	-2.548369	-0.066731	-1.886789	-1.886789	-1.886789
90	90_p4	2	1	2	15	0	-0.019993	-0.941888	3.707688	3.313163	0.25185	4.180068	4.180068	4.180068
91	91_p4	1	0	1	15	0	0	0	0	0	0	0	0	0
100	100_p4	15	14	15	15	0	-0.13516	-6.037968	9.812443	11.127702	0.056037	7.575762	7.575762	7.575762
110	110_p4	6	5	6	15	0	-0.002592	-0.365313	0.655002	1.619285	-0.007222	0.27116	0.27116	0.27116
111	111_p4	5	4	5	15	0	0.007884	0.067604	-0.042711	-0.08556	0.013468	-0.137829	-0.137829	-0.137829
120	120_p4	4	3	4	15	0	-0.003352	-0.076416	0.046318	0.161957	-0.008562	0.061922	0.061922	0.061922
121	121_p4	3	2	3	15	0	0	0	0	0	0	0	0	0
130	130_p4	14	13	14	15	0	-0.023628	-1.044267	0.694614	2.081636	-0.002223	0.723761	0.723761	0.723761
140	140_p4	8	7	8	15	0	0.000498	0.03465	-0.079169	-0.096488	-0.001217	-0.118483	-0.118483	-0.118483
141	141_p4	7	6	7	15	0	0	0	0	0	0	0	0	0
150	150_p4	13	12	13	15	0	0.002264	0.12074	-0.140808	-0.355299	0.00212	-0.113747	-0.113747	-0.113747
160	160_p4	10	9	10	15	0	0.00015	0.021272	-0.030726	-0.041237	-0.000568	-0.038462	-0.038462	-0.038462
161	161_p4	9	8	9	15	0	0.007755	0.135424	-0.063272	-0.070386	0.016974	-0.1095	-0.1095	-0.1095
170	170_p4	12	11	12	15	0	0	0	0	0	0	0	0	0
171	171_p4	11	10	11	15	0	-0.000425	-0.024377	0.025815	0.041498	0.025387	0.027299	0.027299	0.027299

Table A15: White River Basin, Percent Change 2001-2006, Stream Segments

StreamID	Sequence	SWAT_id	Storage_Loc	OID	ChanNum	NumYrsSim	WatYld_mm	Q_cmd	Tloss_m3/s	SedYld_mtn
34	14	22	60	21	22	15	0.10444	0.10444	0.024284	9.035217
44	16	25	65	24	25	15	0.059331	0.059331	0.193425	2.14567
24	15	23	63	22	23	15	0.024557	0.024557	0.031243	0.153374
54	17	26	68	25	26	15	0.024309	0.024309	0	0.153374
64	12	19	55	18	19	15	0.066612	0.066612	0	0.379891
14	13	20	58	19	20	15	0.024828	0.024828	0.045189	0.152905
74	10	16	50	15	16	15	0	0	0	0.149328
84	11	17	53	16	17	15	0	0	0.131582	0.148441
104	9	15	47	14	15	15	0	0	0.045184	0.064185
134	8	14	44	13	14	15	0	0	0	0
94	1	2	28	1	2	15	0.15283	0.15283	0	2.125173
124	2	4	30	3	4	15	0	0	-0.028488	0.02263
154	7	13	41	12	13	15	0	0	0	-0.035898
174	6	12	38	11	12	15	0	0	-0.062461	0.069589
144	4	8	34	7	8	15	0	0	0	-0.054318
114	3	6	32	5	6	15	0	0	-0.051147	0.227488
164	5	10	36	9	10	15	0	0	0.022127	-0.020899

The following abbreviations are used for the KINEROS2 data tables and graphic outputs.

ElementID = HRU (planes) Number
StreamID = Stream Channel Number
In_m3/km = Infiltration (m^3/km)
In_in = Infiltration (inches)
In_acft/mi = Infiltration (acre-feet/mile)
Runoff_mm = Runoff (mm)
Runoff_m3 = Runoff (m^3)
Sed_kg/ha = Sediment yield (kg/ha)
Sed_in = Sediment yield (inches)
Sed_mm = Sediment yield (mm)
QP_m3/s = Peak stream discharge (m^3/hr)
QP_mm/hr = Peak discharge (mm/hr)
SedP_kg/s = Peak sediment discharge (kg/s)

Table A16: Twin Creek Watershed, 2001 Simulation Results, HRU Planes

ElementID	Side	ID_PARNAME	TABID	OID	ID	Infilt_mm	Infilt_in	Runoff_mm	Runoff_m3	Sed_kg/ha	Sed_in	Sed_mm	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
11	<Null>	11_p38	2	47	11	59.475319	2.341548	0.025462	68.4	5.40573	0.000013	0.000328	0.210382	0.281938	5.156766	93.03
21	<Null>	21_p38	4	14	21	59.444038	2.340316	0.015108	84.5	2.68868	0.000006	0.000163	0.34295	0.220744	5.725231	96.88
31	<Null>	31_p38	6	31	31	59.429281	2.339735	0.098622	271	26.892978	0.000064	0.00163	0.4409	0.577627	15.15908	75.78
41	<Null>	41_p38	8	52	41	59.565368	2.345093	0.027202	99.6	3.918373	0.000009	0.000237	0.26311	0.258695	4.355937	90.26
51	<Null>	51_p38	10	34	51	59.114433	2.32734	0.557613	1630.6	312.934385	0.000747	0.018966	1.347197	1.658513	85.88814	19.41
71	<Null>	71_p38	13	26	71	59.768902	2.353106	0.002374	6.4	0.408169	0.000001	0.000025	0.027076	0.036149	0.412366	98.92
101	<Null>	101_p38	17	23	101	59.458595	2.34089	0.018447	49	1.340375	0.000003	0.000081	0.115383	0.156376	0.888613	94.84
141	<Null>	141_p38	22	0	141	59.393392	2.338323	0.012161	33.1	0	0	0	0.088346	0.11685	0	0
171	<Null>	171_p38	26	2	171	59.571604	2.345339	0.001632	5.2	0	0	0	0.020852	0.023562	0	0
181	<Null>	181_p38	28	11	181	59.542401	2.344189	0.059008	157.8	5.49537	0.000013	0.000333	0.287517	0.387051	3.205117	78.69
221	<Null>	221_p38	33	5	221	59.779901	2.353539	0.001052	2.8	0.099003	0	0.000006	0.011938	0.016147	0.115024	99.75
231	<Null>	231_p38	35	8	231	59.616247	2.347096	0.042946	115.6	4.050887	0.00001	0.000246	0.192811	0.257866	2.097582	84.09
52	-1	52_p38	36	35	52	57.747592	2.273527	2.341772	11.766	185.923493	0.000444	0.011268	0.019757	14.15614	0.176023	7.4
53	0	53_p38	37	36	53	58.82303	2.315867	1.327973	5.777	55.623552	0.000133	0.003371	0.011389	9.42453	0.049981	14.56
32	-1	32_p38	39	32	32	59.113231	2.327293	0.763322	45.244	59.362116	0.000142	0.003598	0.078809	4.786598	0.692402	24.5
33	0	33_p38	40	33	33	58.982907	2.322162	0.68393	237.94	162.125494	0.000387	0.009826	0.272377	2.818493	7.535139	19.98
43	0	43_p38	41	54	43	56.258691	2.214909	3.824346	884.18	1288.154683	0.003074	0.07807	1.094623	17.04448	42.08129	1.32
42	-1	42_p38	42	53	42	58.018448	2.284191	1.856859	436.26	285.897386	0.000682	0.017327	0.558199	8.55313	9.640435	6.81
13	0	13_p38	43	49	13	59.485492	2.341949	0.105158	350.8	12.836526	0.000031	0.000778	0.54754	0.590884	7.717794	80.14
12	-1	12_p38	44	48	12	59.042548	2.32451	0.568648	671.21	105.677326	0.000252	0.006405	0.89552	2.731258	19.10075	29.86
83	0	83_p38	46	51	83	59.470871	2.341373	0.477071	317.63	27.043055	0.000065	0.001639	0.339798	1.837322	2.179872	35.47
82	-1	82_p38	47	50	82	59.273143	2.333588	0.551774	709.5	168.084741	0.000401	0.010187	0.721331	2.019511	25.07981	21.01
73	0	73_p38	48	28	73	59.104203	2.326937	0.408991	137.6	25.610662	0.000061	0.001552	0.211537	2.263515	1.455691	50.82
72	-1	72_p38	51	27	72	59.47949	2.341712	0.087002	67.86	9.982707	0.000024	0.000605	0.169854	0.783963	2.220235	80.74
102	-1	102_p38	52	24	102	56.898165	2.240085	3.232198	77.942	503.230456	0.001201	0.030499	0.115675	17.269	2.068248	2.95
103	0	103_p38	54	25	103	59.139377	2.328322	0.568806	74.646	112.001344	0.000267	0.006788	0.115471	3.167624	2.624665	31.16
113	0	113_p38	55	46	113	59.853647	2.356443	0.325736	35.631	4.777211	0.000011	0.00029	0.082184	2.704751	0.109451	74.14
112	-1	112_p38	56	45	112	57.24762	2.253843	2.852744	329.974	7.149885	0.000017	0.000433	0.29113	9.060927	0.072928	19.31
63	0	63_p38	57	38	63	58.851776	2.316999	0.997718	1166.99	192.25116	0.000459	0.011652	1.097458	3.377781	23.93272	16.76
62	-1	62_p38	58	37	62	59.506724	2.342784	0.327371	488.2	34.7598	0.000083	0.002107	0.562707	1.358398	6.53529	42.77
122	-1	122_p38	59	29	122	58.927232	2.31997	0.996465	443.7	198.250695	0.000473	0.012015	0.518732	4.193898	11.69094	17.43
123	0	123_p38	60	30	123	59.40098	2.338621	0.521261	323.35	98.311638	0.000235	0.005958	0.393612	2.2843	8.33983	25.33
133	0	133_p38	61	44	133	58.753641	2.313135	1.153881	796.58	151.943903	0.000363	0.009209	0.957026	4.99066	14.45539	15.08
132	-1	132_p38	63	43	132	59.303179	2.334771	0.369078	430.1	45.333136	0.000108	0.002747	0.547546	1.691503	7.636206	46.84
152	-1	152_p38	64	39	152	59.743822	2.352119	0.041688	0.929	1.520143	0.000004	0.000092	0.003615	0.583976	0.012526	84.26
153	0	153_p38	65	40	153	59.191186	2.330362	0.056564	1.392	1.54615	0.000004	0.000094	0.00469	0.686073	0.012188	94.53
143	0	143_p38	66	1	143	59.493585	2.342267	0.251748	256.96	30.605797	0.000073	0.001855	0.27045	0.953871	3.730052	41.43
163	0	163_p38	68	42	163	59.667641	2.34912	0.032682	30.01	2.322384	0.000006	0.000141	0.082383	0.322982	0.614442	93.62
162	-1	162_p38	69	41	162	59.38168	2.337861	0.533384	231.85	74.100224	0.000177	0.004491	0.341262	2.826334	5.480881	21.68
22	-1	22_p38	71	15	22	59.476122	2.34158	0.106154	609.2	22.683739	0.000054	0.001375	1.184721	0.743179	30.82961	73.71
23	0	23_p38	72	16	23	59.561677	2.344948	0.059219	372.2	0	0	0	0.805134	0.461164	0	0
202	-1	202_p38	73	21	202	59.518286	2.34324	0.046593	126.9	3.41854	0.000008	0.000207	0.330831	0.437284	2.707609	88.8
203	0	203_p38	74	22	203	59.573049	2.345396	0.112415	636.1	25.663538	0.000061	0.001555	0.968177	0.615966	26.37841	75.56
213	0	213_p38	75	18	213	59.734066	2.351735	0.443242	7.716	0.988876	0.000002	0.00006	0.014714	3.042778	0.002896	78.27
212	-1	212_p38	76	17	212	60.385048	2.377364	0	0	0	0	0	0	0	0	0
192	-1	192_p38	77	19	192	59.433255	2.339892	0.015911	31.5	0.841318	0.000002	0.000051	0.090685	0.164902	0.485048	97.48
193	0	193_p38	78	20	193	59.649414	2.348402	0.085041	183.3	5.895976	0.000014	0.000357	0.299986	0.501039	2.321861	80.05
172	-1	172_p38	79	3	172	59.544252	2.344262	0.284852	181.71	20.919813	0.00005	0.001268	0.318413	1.796942	2.593701	52.1
173	0	173_p38	80	4	173	57.447915	2.261729	2.580885	1993.94	0	0	0	1.64875	7.682701	0	0
93	0	93_p38	81	56	93	59.489008	2.342087	0.15292	1031.9	11.662691	0.000028	0.000707	1.362247	0.72675	11.47167	63.42
92	-1	92_p38	82	55	92	59.20518	2.330913	0.604032	2762.7	151.86412	0.000362	0.009204	2.524622	1.987123	68.92249	17
233	0	233_p38	84	10	233	59.133302	2.328083	0.927542	90.287	49.748932	0.000119	0.003015	0.141819	5.244991	0.822176	19.79
232	-1	232_p38	85	9	232	57.114792	2.248614	2.997528	334.501	69.908954	0.000167	0.004237	0.291861	9.415522	0.715941	7.6
182	-1	182_p38	86	12	182	59.467589	2.341244	0.281844	349.36	13.59748	0.000032	0.000824	0.579359	1.682619	3.170644	56.77
183	0	183_p38	87	13	183	59.3073	2.334933	0.357609	790.6	25.874651	0.000062	0.001568	0.934657	1.521969	7.653813	44.08
222	-1	222_p38	88	6	222	59.497698	2.342429	0.031074	125.2	2.795369	0.000007	0.000169	0.365375	0.326463	3.424002	93.7
223	0	223_p38	89	7	223	59.346349	2.33647	0.110135	768.8	14.416579	0.000034	0.000874	1.241619	0.64033	19.63867	78.92

Table A17: Twin Creek Watershed, 2001 Simulation Results, HRU Stream Channels

StreamID	Sequence	OID	ID	In_m3/km	In_acft/mi	Runoff_mm	Runoff_m3	Sed_kg/ha	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
54	14	13	54	683.403611	0.891457	0.532745	1562.874	517.476325	1.303351	1.599407	130.3459	-0.01
34	13	12	34	310.71051	0.405302	0.120697	380.8043	119.564665	0.481738	0.549678	62.4405	-0.07
44	22	21	44	383.673533	0.500478	0.191994	792.47	288.37364	0.610935	0.532846	122.3942	-0.21
14	20	19	14	320.214784	0.4177	0.039521	284.651	20.800324	0.149723	0.074834	9.054829	0.15
84	21	20	84	1115.682445	1.455338	0.002075	187.308	0.087351	0.093933	0.003746	0.42774	0
74	11	10	74	115.934162	0.151229	0.013785	52.5605	5.125232	0.039862	0.037637	1.682936	0.21
104	10	9	104	133.829322	0.174572	0.045545	128.0563	73.194981	0.173912	0.222677	38.07342	-0.58
114	19	18	114	549.007696	0.716146	0.000306	24.7988	0.001709	0.014099	0.000626	0.007014	1.03
64	15	14	64	976.336188	1.273569	0.188018	1645.082	117.344349	0.950623	0.391131	81.51804	0.14
124	12	11	124	391.197861	0.510293	0.054817	421.5487	33.76092	0.237857	0.11135	17.40729	0
134	18	17	134	1377.099209	1.79634	0.000905	69.83	0.027112	0.047252	0.002205	0.154113	0.71
154	16	15	154	1158.13856	1.510719	0.098402	1622.308	50.725925	0.940369	0.205339	59.24084	0.08
144	1	0	144	211.95462	0.276482	0.039489	147.7889	10.605746	0.130461	0.125492	4.473528	-0.6
164	17	16	164	1471.144641	1.919016	0.003539	250.24	0.358889	0.120506	0.006135	1.178607	1.94
24	6	5	24	198.393751	0.258792	0.001649	29.049	0.174439	0.036375	0.007433	0.278068	12.36
204	9	8	204	215.877331	0.281598	0.000212	11.208	0.004401	0.009255	0.00063	0.021302	1.3
214	7	6	214	404.188508	0.527239	0.000357	8.4789	0.008863	0.007018	0.001062	0.022701	1.25
194	8	7	194	267.570236	0.349029	0.000168	5.1897	0.002514	0.004742	0.000554	0.007213	3.11
174	2	1	174	431.713663	0.563143	0.244285	1122.838	553.022524	0.604042	0.473096	182.3441	0
94	23	22	94	986.497599	1.286824	0.000755	79.823	0.034654	0.052928	0.001802	0.212687	4.69
234	4	3	234	298.715491	0.389656	0.08207	238.0625	18.969575	0.161678	0.200654	4.996886	0.23
184	5	4	184	292.394104	0.38141	0.014057	86.095	2.188488	0.058843	0.034588	0.984278	0.75
224	3	2	224	151.102678	0.197104	0.003061	41.8487	0.824942	0.03253	0.008566	0.925837	0.11

Table A18: Twin Creek Watershed, 2006 Simulation Results, HRU Planes

ElementID	Side	ID_PARNAME	TABID	OID	ID	Infilt_mm	Infilt_in	Runoff_mm	Runoff_m3	Sed_kg/ha	Sed_in	Sed_mm	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
11	<Null>	11_p38	2	47	11	59.530227	2.34371	0.032647	87.7	7.889653	0.000019	0.000478	0.261909	0.350991	7.456634	88.31
21	<Null>	21_p38	4	14	21	59.459289	2.340917	0.014768	82.6	2.613532	0.000006	0.000158	0.335632	0.216033	5.56237	96.88
31	<Null>	31_p38	6	31	31	59.270612	2.333489	0.109649	301.3	31.980126	0.000076	0.001938	0.47677	0.624619	17.54389	67.23
41	<Null>	41_p38	8	52	41	59.404503	2.33876	0.040066	146.7	7.16488	0.000017	0.000434	0.371004	0.364778	7.851698	91.18
51	<Null>	51_p38	10	34	51	58.961711	2.321327	0.637086	1863	399.959032	0.000954	0.02424	1.513649	1.863429	107.5083	22
71	<Null>	71_p38	13	26	71	59.558104	2.344807	0.003597	9.7	0.592932	0.000001	0.000036	0.038597	0.051531	0.58192	99.1
101	<Null>	101_p38	17	23	101	59.3894	2.338165	0.024696	65.6	2.084094	0.000005	0.000126	0.150203	0.203568	1.365565	93.81
141	<Null>	141_p38	22	0	141	59.48098	2.341771	0.01341	36.5	0	0	0	0.096519	0.127661	0	0
171	<Null>	171_p38	26	2	171	60.03803	2.363702	0.003923	12.5	0	0	0	0.045353	0.051248	0	0
181	<Null>	181_p38	28	11	181	59.394246	2.338356	0.063084	168.7	6.089405	0.000015	0.000369	0.302579	0.407327	3.510214	83.1
221	<Null>	221_p38	33	5	221	59.779901	2.353539	0.001052	2.8	0.099003	0	0.000006	0.011938	0.016147	0.115024	99.75
231	<Null>	231_p38	35	8	231	59.501156	2.342565	0.056357	151.7	6.107573	0.000015	0.00037	0.241325	0.322748	3.096537	82.28
52	-1	52_p38	36	35	52	55.383807	2.180465	4.842369	24.33	686.541279	0.001638	0.041609	0.044608	31.96164	0.771956	0.41
53	0	53_p38	37	36	53	58.82303	2.315867	1.327973	5.777	55.623552	0.000133	0.003371	0.011389	9.42453	0.049981	14.56
32	-1	32_p38	39	32	32	59.113231	2.327293	0.763322	45.244	59.362116	0.000142	0.003598	0.078809	4.786598	0.692402	24.5
33	0	33_p38	40	33	33	58.977331	2.321942	0.702814	244.51	168.878127	0.000403	0.010235	0.277841	2.875028	7.766376	20.09
43	0	43_p38	41	54	43	55.375724	2.180147	4.326643	1000.31	1768.902978	0.004221	0.107206	1.360535	21.18502	64.4918	2.06
42	-1	42_p38	42	53	42	58.307962	2.295589	1.613356	379.05	226.629668	0.000541	0.013735	0.498864	7.643958	7.81927	9.12
13	0	13_p38	43	49	13	59.505816	2.342749	0.137983	460.3	19.83767	0.000047	0.001202	0.680251	0.7341	11.42518	64.41
12	-1	12_p38	44	48	12	58.971663	2.321719	0.763325	901	175.279533	0.000418	0.010623	1.14102	3.480009	30.04382	14.96
83	0	83_p38	46	51	83	59.445608	2.340378	0.70127	466.9	51.895652	0.000124	0.003145	0.465389	2.516403	3.906732	19.74
82	-1	82_p38	47	50	82	59.123531	2.327698	0.523217	672.78	155.116996	0.00037	0.009401	0.698192	1.954728	23.67383	23.34
73	0	73_p38	48	28	73	59.341424	2.336277	0.43051	144.84	27.767939	0.000066	0.001683	0.220288	2.357158	1.562213	37.68
72	-1	72_p38	51	27	72	59.402783	2.338692	0.076233	59.46	8.505043	0.00002	0.000515	0.15437	0.712494	1.927696	82.18
102	-1	102_p38	52	24	102	53.823094	2.119019	6.4882	156.458	1989.18979	0.004746	0.120557	0.25449	37.99269	9.650539	0.32
103	0	103_p38	54	25	103	59.141038	2.328387	0.592908	77.809	119.891673	0.000286	0.007266	0.119165	3.268954	2.778894	28.16
113	0	113_p38	55	46	113	59.750928	2.352399	0.386137	42.238	5.513941	0.000013	0.000334	0.09458	3.112715	0.124921	71.16
112	-1	112_p38	56	45	112	57.24762	2.253843	2.852744	329.974	7.149885	0.000017	0.000433	0.29113	9.060927	0.072928	19.31
63	0	63_p38	57	38	63	58.900466	2.318916	0.888584	1039.34	163.02589	0.000389	0.00988	1.030066	3.17036	21.54729	11.25
62	-1	62_p38	58	37	62	58.910583	2.319314	0.760396	1133.96	150.691053	0.00036	0.009133	1.154739	2.787589	25.43094	18.93
122	-1	122_p38	59	29	122	57.685884	2.271098	2.263684	1007.96	866.685487	0.002068	0.052526	1.053396	8.51661	46.00948	5.16
123	0	123_p38	60	30	123	59.071668	2.325656	0.734246	455.47	175.405365	0.000419	0.010631	0.51764	3.004084	13.94829	20.24
133	0	133_p38	61	44	133	58.823316	2.315879	0.930893	642.64	104.352992	0.000249	0.006324	0.801975	4.182104	10.36822	22.48
132	-1	132_p38	63	43	132	59.018548	2.323565	0.598	696.87	103.937752	0.000248	0.006299	0.81122	2.506055	16.05096	28.73
152	-1	152_p38	64	39	152	59.743822	2.352119	0.041688	0.929	1.520143	0.000004	0.000092	0.003615	0.583976	0.012526	84.26
153	0	153_p38	65	40	153	59.191186	2.330362	0.056564	1.392	1.54615	0.000004	0.000094	0.00469	0.686073	0.012188	94.53
143	0	143_p38	66	1	143	59.387247	2.338081	0.368432	376.06	59.286258	0.000141	0.003593	0.373458	1.317174	6.811806	29.62
163	0	163_p38	68	42	163	59.561897	2.344957	0.139667	128.25	18.283384	0.000044	0.001108	0.263488	1.033	4.102285	68.4
162	-1	162_p38	69	41	162	59.383014	2.337914	0.535431	232.74	74.612051	0.000178	0.004522	0.34191	2.831697	5.51268	19.24
22	-1	22_p38	71	15	22	59.358189	2.336937	0.114657	658	25.723111	0.000061	0.001559	1.256902	0.788458	34.39645	71.67
23	0	23_p38	72	16	23	59.59598	2.346298	0.064088	402.8	0	0	0	0.858091	0.491497	0	0
202	-1	202_p38	73	21	202	59.615731	2.347076	0.049567	135	3.772813	0.000009	0.000229	0.349103	0.461436	2.977758	82.15
203	0	203_p38	74	22	203	59.421366	2.339424	0.12901	730	32.757703	0.000078	0.001985	1.086195	0.69105	32.96082	74.72
213	0	213_p38	75	18	213	59.734066	2.351735	0.443242	7.716	0.988876	0.000002	0.00006	0.014714	3.042778	0.002896	78.27
212	-1	212_p38	76	17	212	60.385048	2.377364	0	0	0	0	0	0	0	0	0
192	-1	192_p38	77	19	192	59.383148	2.337919	0.015406	30.5	0.814088	0.000002	0.000049	0.088464	0.160862	0.47146	97.66
193	0	193_p38	78	20	193	59.55013	2.344493	0.110048	237.2	8.780749	0.000021	0.000532	0.363746	0.607531	3.270889	79.24
172	-1	172_p38	79	3	172	58.906749	2.319163	0.871863	556.17	122.327739	0.000292	0.007414	0.772194	4.357821	12.36519	20.61
173	0	173_p38	80	4	173	55.798079	2.196775	3.917445	3026.54	0	0	0	2.354537	10.97146	0	0
93	0	93_p38	81	56	93	59.590016	2.346064	0.11722	791	7.946626	0.000019	0.000482	1.10323	0.588566	8.101931	71.18
92	-1	92_p38	82	55	92	59.194117	2.330477	0.646666	2957.7	171.364086	0.000409	0.010386	2.671288	2.102564	76.84987	14.32
233	0	233_p38	84	10	233	59.133302	2.328083	0.927542	90.287	49.748932	0.000119	0.003015	0.141819	5.244991	0.822176	19.79
232	-1	232_p38	85	9	232	56.870734	2.239005	3.06195	341.69	75.914494	0.000181	0.004601	0.307912	9.933316	0.807379	5.43
182	-1	182_p38	86	12	182	59.233013	2.332008	0.332354	411.97	17.636894	0.000042	0.001069	0.659373	1.915003	3.987379	57.44
183	0	183_p38	87	13	183	59.141522	2.328406	0.455854	1007.8	38.322017	0.000091	0.002323	1.129424	1.839123	10.80375	36.32
222	-1	222_p38	88	6	222	59.513037	2.343033	0.034425	138.7	3.218889	0.000008	0.000195	0.398587	0.356138	3.914253	91.8
223	0	223_p38	89	7	223	59.299246	2.334616	0.115822	808.5	15.625329	0.000037	0.000947	1.288411	0.664462	21.00845	78.72

Table A19: Twin Creek Watershed, 2006 Simulation Results, HRU Stream Channels

StreamID	Sequence	OID	ID	In_m3/km	In_acft/mi	Runoff_mm	Runoff_m3	Sed_kg/ha	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
54	14	13	54	733.82108	0.957224	0.614172	1801.751	630.166218	1.487819	1.825778	156.1087	-0.01
34	13	12	34	324.06646	0.422724	0.130068	410.3703	134.75078	0.514794	0.587396	69.18834	-0.09
44	22	21	44	402.848464	0.525491	0.211447	872.767	347.893902	0.722614	0.63025	160.6488	-0.59
14	20	19	14	382.278543	0.498658	0.068089	490.419	47.185199	0.240415	0.120164	19.66263	0.11
84	21	20	84	1309.495385	1.708155	0.003423	309.083	0.175857	0.118094	0.004709	0.585821	0
74	11	10	74	117.71879	0.153557	0.013707	52.261	5.066971	0.038828	0.03666	1.62263	0.26
104	10	9	104	165.01427	0.215251	0.074395	209.1708	155.537717	0.27754	0.355362	76.64282	-0.25
114	19	18	114	960.436396	1.252829	0.000322	26.1529	0.001763	0.014682	0.000651	0.007506	2.49
64	15	14	64	1078.634884	1.407012	0.254352	2225.479	187.453276	1.319582	0.542939	134.4108	0.14
124	12	11	124	522.214266	0.681196	0.133048	1023.147	142.743694	0.694077	0.324923	94.69044	-0.84
134	18	17	134	2211.974414	2.885382	0.0044	339.547	0.269112	0.108846	0.005078	0.691403	0.51
154	16	15	154	1422.04568	1.85497	0.163805	2700.584	109.344339	1.593182	0.347887	134.9298	0.16
144	1	0	144	254.34578	0.331778	0.064346	240.8163	22.476062	0.207095	0.199209	9.181623	-0.3
164	17	16	164	1949.568088	2.543089	0.01241	877.498	1.597222	0.385291	0.019616	5.455048	1.67
24	6	5	24	210.757488	0.27492	0.001861	32.787	0.210666	0.038227	0.007812	0.320519	11.54
204	9	8	204	244.24386	0.318601	0.000261	13.7904	0.005958	0.011369	0.000774	0.027855	0.74
214	7	6	214	543.459906	0.708909	0.001211	28.7908	0.049349	0.021748	0.003292	0.088784	0.96
194	8	7	194	319.363526	0.41659	0.00024	7.3941	0.004062	0.006023	0.000704	0.009938	2.88
174	2	1	174	567.8142	0.740678	0.478578	2199.748	1583.963098	1.299862	1.018075	555.1593	0
94	23	22	94	1038.63908	1.35484	0.00075	79.301	0.034956	0.052843	0.001799	0.223931	5.1
234	4	3	234	317.419701	0.414054	0.090494	262.4965	22.740383	0.188899	0.234438	6.456166	0.23
184	5	4	184	348.533936	0.454641	0.02344	143.56	4.464117	0.083883	0.049306	1.729828	0.61
224	3	2	224	159.752611	0.208387	0.003367	46.026	0.951208	0.035406	0.009323	1.078845	0.09

Table A20: Twin Creek Watershed, Change 2001-2006, HRU Planes

ElementID	Side	ID_PARNAME	TABID	OID	ID	Infilt_mm	Infilt_in	Runoff_mm	Runoff_m3	Sed_kg/ha	Sed_in	Sed_mm	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
11	<Null>	11_p38	2	47	11	0.054908	0.002162	0.007185	19.3	2.483922	0.000006	0.000151	0.051527	0.069053	2.299868	-4.72
21	<Null>	21_p38	4	14	21	0.015251	0.0006	-0.00034	-1.9	-0.075147	0	-0.000005	-0.007318	-0.00471	-0.162861	0
31	<Null>	31_p38	6	31	31	-0.158669	-0.006247	0.011027	30.3	5.087148	0.000012	0.000308	0.03587	0.046993	2.38481	-8.55
41	<Null>	41_p38	8	52	41	-0.160866	-0.006333	0.012864	47.1	3.246507	0.000008	0.000197	0.107894	0.106084	3.495761	0.92
51	<Null>	51_p38	10	34	51	-0.152723	-0.006013	0.079473	232.4	87.024648	0.000208	0.005274	0.166452	0.204916	21.62016	2.59
71	<Null>	71_p38	13	26	71	-0.210797	-0.008299	0.001224	3.3	0.184763	0	0.000011	0.011521	0.015382	0.169555	0.18
101	<Null>	101_p38	17	23	101	-0.069195	-0.002724	0.006249	16.6	0.743719	0.000002	0.000045	0.03482	0.047192	0.476952	-1.03
141	<Null>	141_p38	22	0	141	0.087588	0.003448	0.001249	3.4	0	0	0	0.008174	0.010811	0	0
171	<Null>	171_p38	26	2	171	0.466425	0.018363	0.002291	7.3	0	0	0	0.024501	0.027686	0	0
181	<Null>	181_p38	28	11	181	-0.148155	-0.005833	0.004076	10.9	0.594034	0.000001	0.000036	0.015062	0.020276	0.305097	4.41
221	<Null>	221_p38	33	5	221	0	0	0	0	0	0	0	0	0	0	0
231	<Null>	231_p38	35	8	231	-0.115091	-0.004531	0.013411	36.1	2.056685	0.000005	0.000125	0.048514	0.064883	0.998955	-1.81
52	-1	52_p38	36	35	52	-2.363785	-0.093062	2.500597	12.564	500.617785	0.001195	0.03034	0.024851	17.8055	0.595933	-6.99
53	0	53_p38	37	36	53	0	0	0	0	0	0	0	0	0	0	0
32	-1	32_p38	39	32	32	0	0	0	0	0	0	0	0	0	0	0
33	0	33_p38	40	33	33	-0.005576	-0.00022	0.018885	6.57	6.752634	0.000016	0.000409	0.005463	0.056535	0.231237	0.11
43	0	43_p38	41	54	43	-0.882967	-0.034762	0.502297	116.13	480.748295	0.001147	0.029136	0.265912	4.14054	22.41051	0.74
42	-1	42_p38	42	53	42	0.289514	0.011398	-0.243504	-57.21	-59.267718	-0.000141	-0.003592	-0.059335	-0.909172	-1.821165	2.31
13	0	13_p38	43	49	13	0.020324	0.0008	0.032824	109.5	7.001145	0.000017	0.000424	0.132711	0.143216	3.707386	-15.73
12	-1	12_p38	44	48	12	-0.070885	-0.002791	0.194678	229.79	69.602207	0.000166	0.004218	0.2455	0.748751	10.94307	-14.9
83	0	83_p38	46	51	83	-0.025263	-0.000995	0.224199	149.27	24.852597	0.000059	0.001506	0.125591	0.679081	1.72686	-15.73
82	-1	82_p38	47	50	82	-0.149613	-0.00589	-0.028557	-36.72	-12.967744	-0.000031	-0.000786	-0.023139	-0.064783	-1.40598	2.33
73	0	73_p38	48	28	73	0.237221	0.009339	0.02152	7.24	2.157277	0.000005	0.000131	0.008751	0.093643	0.106522	-13.14
72	-1	72_p38	51	27	72	-0.076707	-0.00302	-0.010769	-8.4	-1.477665	-0.000004	-0.00009	-0.015485	-0.071469	-0.292539	1.44
102	-1	102_p38	52	24	102	-3.075071	-0.121066	3.256001	78.516	1485.959334	0.003546	0.090058	0.138816	20.72369	7.582291	-2.63
103	0	103_p38	54	25	103	0.001661	0.000065	0.024102	3.163	7.890329	0.000019	0.000478	0.003694	0.10133	0.154229	-3
113	0	113_p38	55	46	113	-0.102719	-0.004044	0.060401	6.607	0.73673	0.000002	0.000045	0.012396	0.407964	0.01547	-2.98
112	-1	112_p38	56	45	112	0	0	0	0	0	0	0	0	0	0	0
63	0	63_p38	57	38	63	0.048689	0.001917	-0.109134	-127.65	-29.22527	-0.00007	-0.001771	-0.067392	-0.207421	-2.38543	-5.51
62	-1	62_p38	58	37	62	-0.596141	-0.02347	0.433025	645.76	115.931253	0.000277	0.007026	0.592032	1.429191	18.89565	-23.84
122	-1	122_p38	59	29	122	-1.241348	-0.048872	1.267219	564.26	668.434791	0.001595	0.040511	0.534664	4.322712	34.31854	-12.27
123	0	123_p38	60	30	123	-0.329312	-0.012965	0.212986	132.12	77.093727	0.000184	0.004672	0.124028	0.719784	5.60846	-5.09
133	0	133_p38	61	44	133	0.069675	0.002743	-0.222989	-153.94	-47.590911	-0.000114	-0.002884	-0.155051	-0.808556	-4.08717	7.4
132	-1	132_p38	63	43	132	-0.284631	-0.011206	0.228921	266.77	58.604616	0.00014	0.003552	0.263674	0.814552	8.414754	-18.11
152	-1	152_p38	64	39	152	0	0	0	0	0	0	0	0	0	0	0
153	0	153_p38	65	40	153	0	0	0	0	0	0	0	0	0	0	0
143	0	143_p38	66	1	143	-0.106338	-0.004187	0.116684	119.1	28.680461	0.000068	0.001738	0.103007	0.363303	3.081754	-11.81
163	0	163_p38	68	42	163	-0.105744	-0.004163	0.106986	98.24	15.961	0.000038	0.000967	0.181105	0.710018	3.487843	-25.22
162	-1	162_p38	69	41	162	0.001334	0.000053	0.002047	0.89	0.511828	0.000001	0.000031	0.000648	0.005363	0.031799	-2.44
22	-1	22_p38	71	15	22	-0.117933	-0.004643	0.008503	48.8	3.039371	0.000007	0.000184	0.072181	0.045279	3.56684	-2.04
23	0	23_p38	72	16	23	0.034303	0.001351	0.004869	30.6	0	0	0	0.052956	0.030332	0	0
202	-1	202_p38	73	21	202	0.097444	0.003836	0.002974	8.1	0.354272	0.000001	0.000021	0.018272	0.024152	0.270149	-6.65
203	0	203_p38	74	22	203	-0.151683	-0.005972	0.016595	93.9	7.094165	0.000017	0.00043	0.118018	0.075084	6.58241	-0.84
213	0	213_p38	75	18	213	0	0	0	0	0	0	0	0	0	0	0
212	-1	212_p38	76	17	212	0	0	0	0	0	0	0	0	0	0	0
192	-1	192_p38	77	19	192	-0.050107	-0.001973	-0.000505	-1	-0.027231	0	-0.000002	-0.002221	-0.004039	-0.013588	0.18
193	0	193_p38	78	20	193	-0.099285	-0.003909	0.025007	53.9	2.884773	0.000007	0.000175	0.06376	0.106492	0.949028	-0.81
172	-1	172_p38	79	3	172	-0.637504	-0.025099	0.587011	374.46	101.407926	0.000242	0.006146	0.453781	2.560879	9.771489	-31.49
173	0	173_p38	80	4	173	-1.649836	-0.064954	1.336561	1032.6	0	0	0	0.705787	3.288759	0	0
93	0	93_p38	81	56	93	0.101008	0.003977	-0.0357	-240.9	-3.716065	-0.000009	-0.000225	-0.259017	-0.138183	-3.369739	7.76
92	-1	92_p38	82	55	92	-0.011063	-0.000436	0.042634	195	19.499966	0.000047	0.001182	0.146666	0.115441	7.92738	-2.68
233	0	233_p38	84	10	233	0	0	0	0	0	0	0	0	0	0	0
232	-1	232_p38	85	9	232	-0.244058	-0.009609	0.064422	7.189	6.00554	0.000014	0.000364	0.01605	0.517794	0.091438	-2.17
182	-1	182_p38	86	12	182	-0.234577	-0.009235	0.05051	62.61	4.039414	0.00001	0.000245	0.080014	0.232384	0.816735	0.67
183	0	183_p38	87	13	183	-0.165777	-0.006527	0.098245	217.2	12.447366	0.00003	0.000754	0.194767	0.317154	3.149937	-7.76
222	-1	222_p38	88	6	222	0.015338	0.000604	0.003351	13.5	0.42352	0.000001	0.000026	0.033212	0.029675	0.490251	-1.9
223	0	223_p38	89	7	223	-0.047103	-0.001854	0.005687	39.7	1.208751	0.000003	0.000073	0.046792	0.024132	1.36978	-0.2

Table A21: Twin Creek Watershed, Change 2001-2006, Stream Channels

StreamID	Sequence	OID	ID	In_m3/km	In_acft/mi	Runoff_mm	Runoff_m3	Sed_kg/ha	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
54	14	13	54	50.41747	0.065766	0.081427	238.877	112.689893	0.184468	0.226371	25.7628	0
34	13	12	34	13.35595	0.017422	0.009371	29.566	15.186115	0.033056	0.037718	6.74784	-0.02
44	22	21	44	19.17493	0.025012	0.019454	80.297	59.520262	0.111679	0.097404	38.2546	-0.38
14	20	19	14	62.063759	0.080958	0.028569	205.768	26.384874	0.090692	0.04533	10.607801	-0.04
84	21	20	84	193.81294	0.252817	0.001349	121.775	0.088506	0.02416	0.000963	0.158081	0
74	11	10	74	1.784629	0.002328	-0.000079	-0.2995	-0.058261	-0.001034	-0.000977	-0.060306	0.05
104	10	9	104	31.184949	0.040679	0.02885	81.1145	82.342736	0.103628	0.132685	38.5694	0.33
114	19	18	114	411.428701	0.536683	0.000017	1.3541	0.000054	0.000583	0.000026	0.000491	1.46
64	15	14	64	102.298695	0.133442	0.066334	580.397	70.108927	0.368959	0.151807	52.89276	0
124	12	11	124	131.016405	0.170903	0.078231	601.5983	108.982774	0.45622	0.213573	77.28315	-0.84
134	18	17	134	834.875205	1.089042	0.003496	269.717	0.242	0.061593	0.002874	0.53729	-0.2
154	16	15	154	263.90712	0.34425	0.065403	1078.276	58.618414	0.652813	0.142548	75.68896	0.08
144	1	0	144	42.391159	0.055297	0.024857	93.0274	11.870316	0.076635	0.073716	4.708095	0.3
164	17	16	164	478.423447	0.624073	0.008871	627.258	1.238333	0.264785	0.013481	4.276441	-0.27
24	6	5	24	12.363737	0.016128	0.000212	3.738	0.036226	0.001852	0.000378	0.042451	-0.82
204	9	8	204	28.366529	0.037002	0.000049	2.5824	0.001557	0.002114	0.000144	0.006554	-0.56
214	7	6	214	139.271398	0.181671	0.000854	20.3119	0.040486	0.01473	0.00223	0.066083	-0.29
194	8	7	194	51.79329	0.067561	0.000072	2.2044	0.001548	0.001282	0.00015	0.002725	-0.23
174	2	1	174	136.100537	0.177535	0.234293	1076.91	1030.940575	0.69582	0.544979	372.8152	0
94	23	22	94	52.141481	0.068015	-0.000005	-0.522	0.000303	-0.000085	-0.000003	0.011244	0.41
234	4	3	234	18.70421	0.024398	0.008423	24.434	3.770808	0.027222	0.033784	1.45928	0
184	5	4	184	56.139833	0.073231	0.009383	57.465	2.275629	0.02504	0.014719	0.745551	-0.14
224	3	2	224	8.649933	0.011283	0.000306	4.1773	0.126266	0.002876	0.000757	0.153008	-0.02

Table A22: Twin Creek Watershed, Percent Change 2001-2006, HRU Planes

ElementID	Side	ID_PARNAME	TABID	OID	ID	Infilt_mm	Infilt_in	Runoff_mm	Runoff_m3	Sed_kg/ha	Sed_in	Sed_mm	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
11	<Null>	11_p38	2	47	11	0.09232	0.09232	28.216374	28.216374	45.949799	45.949799	45.949799	24.492103	24.492088	44.599037	-5.073632
21	<Null>	21_p38	4	14	21	0.025656	0.025656	-2.248521	-2.248521	-2.794957	-2.794957	-2.794957	-2.133722	-2.133742	-2.844619	0
31	<Null>	31_p38	6	31	31	-0.266987	-0.266987	11.180812	11.180812	18.916267	18.916267	18.916267	8.135541	8.135517	15.731891	-11.28266
41	<Null>	41_p38	8	52	41	-0.270066	-0.270066	47.289157	47.289157	82.853439	82.853439	82.853439	41.007237	41.007234	80.252791	1.019278
51	<Null>	51_p38	10	34	51	-0.258351	-0.258351	14.252422	14.252422	27.809232	27.809232	27.809232	12.355431	12.355405	25.172463	13.343637
71	<Null>	71_p38	13	26	71	-0.352687	-0.352687	51.5625	51.5625	45.266218	45.266218	45.266218	42.552547	42.552173	41.117547	0.181965
101	<Null>	101_p38	17	23	101	-0.116375	-0.116375	33.877551	33.877551	55.4859	55.4859	55.4859	30.178294	30.178269	53.673811	-1.08604
141	<Null>	141_p38	22	0	141	0.147472	0.147472	10.271903	10.271903	0	0	0	9.251703	9.251861	0	0
171	<Null>	171_p38	26	2	171	0.782966	0.782966	140.384615	140.384615	0	0	0	117.503129	117.503406	0	0
181	<Null>	181_p38	28	11	181	-0.248823	-0.248823	6.907478	6.907478	10.809726	10.809726	10.809726	5.238614	5.238609	9.51906	5.60427
221	<Null>	221_p38	33	5	221	0	0	0	0	0	0	0	0	0	0	0
231	<Null>	231_p38	35	8	231	-0.193053	-0.193053	31.228374	31.228374	50.771223	50.771223	50.771223	25.161428	25.161441	47.624121	-2.152456
52	-1	52_p38	36	35	52	-4.093304	-4.093304	106.782254	106.782254	269.260101	269.260101	269.260101	125.778826	125.779344	338.554223	-94.459459
53	0	53_p38	37	36	53	0	0	0	0	0	0	0	0	0	0	0
32	-1	32_p38	39	32	32	0	0	0	0	0	0	0	0	0	0	0
33	0	33_p38	40	33	33	-0.009454	-0.009454	2.7612	2.7612	4.165066	4.165066	4.165066	2.005859	2.005859	3.068782	0.550551
43	0	43_p38	41	54	43	-1.569477	-1.569477	13.134203	13.134203	37.320696	37.320696	37.320696	24.292565	24.292557	53.255283	56.060606
42	-1	42_p38	42	53	42	0.499004	0.499004	-13.11374	-13.11374	-20.730416	-20.730416	-20.730416	-10.629708	-10.629699	-18.890901	33.920705
13	0	13_p38	43	49	13	0.034167	0.034167	31.214367	31.214367	54.540805	54.540805	54.540805	24.237649	24.237616	48.036861	-19.628151
12	-1	12_p38	44	48	12	-0.120058	-0.120058	34.235187	34.235187	65.862952	65.862952	65.862952	27.414197	27.414144	57.291311	-49.899531
83	0	83_p38	46	51	83	-0.04248	-0.04248	46.994931	46.994931	91.900106	91.900106	91.900106	36.960386	36.960369	79.218413	-44.347336
82	-1	82_p38	47	50	82	-0.252413	-0.252413	-5.175476	-5.175476	-7.715004	-7.715004	-7.715004	-3.207846	-3.207856	-5.606023	11.089957
73	0	73_p38	48	28	73	0.40136	0.40136	5.261628	5.261628	8.423355	8.423355	8.423355	4.137058	4.137061	7.317624	-25.855962
72	-1	72_p38	51	27	72	-0.128964	-0.128964	-12.378426	-12.378426	-14.802243	-14.802243	-14.802243	-9.116332	-9.116335	-13.176038	1.783503
102	-1	102_p38	52	24	102	-5.404517	-5.404517	100.736445	100.736445	295.284062	295.284062	295.284062	120.005152	120.005154	366.604537	-89.152542
103	0	103_p38	54	25	103	0.002809	0.002809	4.237334	4.237334	7.044852	7.044852	7.044852	3.198893	3.198928	5.87614	-9.627728
113	0	113_p38	55	46	113	-0.171617	-0.171617	18.542842	18.542842	15.42177	15.42177	15.42177	15.083246	15.083237	14.134074	-4.019423
112	-1	112_p38	56	45	112	0	0	0	0	0	0	0	0	0	0	0
63	0	63_p38	57	38	63	0.082732	0.082732	-10.938397	-10.938397	-15.201609	-15.201609	-15.201609	-6.140736	-6.140747	-9.967233	-32.875895
62	-1	62_p38	58	37	62	-1.001804	-1.001804	132.273658	132.273658	333.521065	333.521065	333.521065	105.211525	105.211506	289.13254	-55.740005
122	-1	122_p38	59	29	122	-2.106577	-2.106577	127.171512	127.171512	337.166429	337.166429	337.166429	103.071453	103.071462	293.548166	-70.395869
123	0	123_p38	60	30	123	-0.554389	-0.554389	40.859749	40.859749	78.417702	78.417702	78.417702	31.510083	31.510047	67.249093	-20.094749
133	0	133_p38	61	44	133	0.118588	0.118588	-19.325115	-19.325115	-31.32137	-31.32137	-31.32137	-16.20138	-16.201384	-28.274367	49.071618
132	-1	132_p38	63	43	132	-0.479958	-0.479958	62.02511	62.02511	129.275451	129.275451	129.275451	48.155535	48.155516	110.195482	-38.663535
152	-1	152_p38	64	39	152	0	0	0	0	0	0	0	0	0	0	0
153	0	153_p38	65	40	153	0	0	0	0	0	0	0	0	0	0	0
143	0	143_p38	66	1	143	-0.178739	-0.178739	46.349626	46.349626	93.709244	93.709244	93.709244	38.087192	38.087182	82.619599	-28.505914
163	0	163_p38	68	42	163	-0.177222	-0.177222	327.357547	327.357547	687.267765	687.267765	687.267765	219.83283	219.832461	567.644411	-26.938688
162	-1	162_p38	69	41	162	0.002247	0.002247	0.383869	0.383869	0.690724	0.690724	0.690724	0.189766	0.189751	0.58018	-11.254613
22	-1	22_p38	71	15	22	-0.198286	-0.198286	8.010506	8.010506	13.3989	13.3989	13.3989	6.092658	6.092663	11.569527	-2.767603
23	0	23_p38	72	16	23	0.057593	0.057593	8.221386	8.221386	0	0	0	6.577299	6.577306	0	0
202	-1	202_p38	73	21	202	0.163721	0.163721	6.382979	6.382979	10.363267	10.363267	10.363267	5.523097	5.523094	9.977401	-7.488739
203	0	203_p38	74	22	203	-0.254618	-0.254618	14.76183	14.76183	27.642976	27.642976	27.642976	12.189667	12.189723	24.953778	-1.111699
213	0	213_p38	75	18	213	0	0	0	0	0	0	0	0	0	0	0
212	-1	212_p38	76	17	212	0	0	0	0	0	0	0	0	0	0	0
192	-1	192_p38	77	19	192	-0.084308	-0.084308	-3.174603	-3.174603	-3.236652	-3.236652	-3.236652	-2.449471	-2.449523	-2.801392	0.184653
193	0	193_p38	78	20	193	-0.166447	-0.166447	29.405346	29.405346	48.927828	48.927828	48.927828	21.254285	21.254289	40.873592	-1.011868
172	-1	172_p38	79	3	172	-1.070638	-1.070638	206.075615	206.075615	484.745852	484.745852	484.745852	142.513201	142.51317	376.739223	-60.441459
173	0	173_p38	80	4	173	-2.871881	-2.871881	51.786914	51.786914	0	0	0	42.8074	42.807328	0	0
93	0	93_p38	81	56	93	0.169793	0.169793	-23.345285	-23.345285	-31.862845	-31.862845	-31.862845	-19.013953	-19.013897	-29.374442	12.235888
92	-1	92_p38	82	55	92	-0.018686	-0.018686	7.058313	7.058313	12.840404	12.840404	12.840404	5.809424	5.809454	11.501877	-15.764706
233	0	233_p38	84	10	233	0	0	0	0	0	0	0	0	0	0	0
232	-1	232_p38	85	9	232	-0.427311	-0.427311	2.149171	2.149171	8.590516	8.590516	8.590516	5.499363	5.499366	12.771747	-28.552632
182	-1	182_p38	86	12	182	-0.394462	-0.394462	17.921342	17.921342	29.70708	29.70708	29.70708	13.81082	13.810851	25.759278	1.180201
183	0	183_p38	87	13	183	-0.279523	-0.279523	27.472805	27.472805	48.106413	48.106413	48.106413	20.83834	20.838401	41.155134	-17.604356
222	-1	222_p38	88	6	222	0.02578	0.02578	10.782748	10.782748	15.150762	15.150762	15.150762	9.089822	9.089829	14.31807	-2.027748
223	0	223_p38	89	7	223	-0.079369	-0.079369	5.163892	5.163892	8.38445	8.38445	8.38445	3.768628	3.768652	6.974912	-0.253421

Table A23: Twin Creek Watershed, Percent Change 2001-2006, Stream Channels

StreamID	Sequence	OID	ID	In_m3/km	In_acft/mi	Runoff_mm	Runoff_m3	Sed_kg/ha	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
54	14	13	54	7.377408	7.377408	15.28447	15.28447	21.776821	14.153363	14.153433	19.764948	0
34	13	12	34	4.298519	4.298519	7.764093	7.764093	12.701173	6.861889	6.861893	10.806832	28.571429
44	22	21	44	4.99772	4.99772	10.132497	10.132497	20.63998	18.279966	18.279991	31.255239	180.952381
14	20	19	14	19.381915	19.381915	72.287819	72.287819	126.848378	60.573206	60.573293	117.15076	-26.666667
84	21	20	84	17.371694	17.371694	65.01324	65.01324	101.322547	25.720777	25.718176	36.957206	0
74	11	10	74	1.539347	1.539347	-0.56982	-0.56982	-1.136747	-2.594702	-2.594801	-3.58338	23.809524
104	10	9	104	23.30203	23.30203	63.342842	63.342842	112.497789	59.586434	59.586513	101.302694	-56.896552
114	19	18	114	74.940425	74.940425	5.460345	5.460345	3.152276	4.133509	4.140026	7.001312	141.747573
64	15	14	64	10.477815	10.477815	35.280734	35.280734	59.746317	38.812337	38.812328	64.88473	0
124	12	11	124	33.491084	33.491084	142.711459	142.711459	322.80748	191.803951	191.803929	443.970026	-99
134	18	17	134	60.62564	60.62564	386.248031	386.248031	892.590822	130.349634	130.350177	348.63289	-28.169014
154	16	15	154	22.78718	22.78718	66.465554	66.465554	115.559084	69.420976	69.420962	127.764833	100
144	1	0	144	20.000111	20.000111	62.946135	62.946135	111.923446	58.741675	58.741692	105.243445	-50
164	17	16	164	32.52049	32.52049	250.662564	250.662564	345.046046	219.727897	219.728457	362.838588	-13.917526
24	6	5	24	6.231919	6.231919	12.867913	12.867913	20.767303	5.091092	5.09202	15.266446	-6.634304
204	9	8	204	13.140115	13.140115	23.040685	23.040685	35.367426	22.838712	22.834021	30.766234	-43.076923
214	7	6	214	34.457041	34.457041	239.558197	239.558197	456.791764	209.890141	209.902108	291.099952	-23.2
194	8	7	194	19.356895	19.356895	42.476444	42.476444	61.572222	27.035748	27.044593	37.780581	-7.395498
174	2	1	174	31.52565	31.52565	95.90965	95.90965	186.419274	115.193941	115.193986	204.456958	0
94	23	22	94	5.285515	5.285515	-0.653947	-0.653947	0.873362	-0.161163	-0.160923	5.286491	8.742004
234	4	3	234	6.261547	6.261547	10.263691	10.263691	19.878191	16.836954	16.836952	29.203788	0
184	5	4	184	19.200056	19.200056	66.746036	66.746036	103.981781	42.553987	42.554268	75.745966	-18.666667
224	3	2	224	5.72454	5.72454	9.981911	9.981911	15.306041	8.841766	8.841933	16.526502	-18.181818

Table A24: Lower White River Watershed, 2001 Simulation Results, HRU Planes

ElementID	Side	ID_PARNAME	TABID	OID	ID	Infilt_mm	Infilt_in	Runoff_mm	Runoff_m3	Sed_kg/ha	Sed_in	Sed_mm	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
262	-1	262_p41	108	4	262	37.136186	1.462055	2.910632	1409.48	301.763833	0.00072	0.018289	0.443458	3.296731	4.929187	1.81
293	0	293_p41	109	72	293	0.61687	0.024286	38.592945	1928.552	177.732641	0.000424	0.010772	0.485806	34.99792	0.370058	0.01
292	-1	292_p41	110	71	292	39.236699	1.544752	0.399953	103.23	1.526745	0.000004	0.000093	0.069649	0.971443	0.024599	44.06
11	<Null>	11_p41	2	40	11	36.94534	1.454541	3.206392	1198.35	172.76192	0.000412	0.01047	0.311697	3.002398	1.927197	0.77
21	<Null>	21_p41	4	45	21	10.225411	0.402575	30.025082	12206.43	191.66682	0.000457	0.011616	1.721583	15.24495	1.556062	0.07
31	<Null>	31_p41	6	37	31	15.404273	0.606467	24.827448	10242.72	6643.565981	0.015852	0.40264	1.59815	13.94559	55.82116	0.01
71	<Null>	71_p41	11	34	71	38.79596	1.5274	0.573629	215.54	10.185366	0.000024	0.000617	0.141662	1.357246	0.242639	13.45
81	<Null>	81_p41	13	52	81	39.490777	1.554755	0.550364	228.92	1.22077	0.000003	0.000074	0.090142	0.780183	0.019052	69.79
91	<Null>	91_p41	15	60	91	20.82995	0.820077	18.967386	10517.3	7075.847002	0.016883	0.428839	1.576741	10.23684	68.86133	0.01
101	<Null>	101_p41	17	57	101	39.316879	1.547909	0.257789	97.04	28.191712	0.000067	0.001709	0.095464	0.912968	1.110809	32.77
111	<Null>	111_p41	19	26	111	30.730678	1.209869	9.296583	3524.12	3551.785931	0.008475	0.21526	0.595191	5.652382	25.45166	0.06
151	<Null>	151_p41	24	19	151	39.502666	1.555223	0.401615	151.72	25.310205	0.00006	0.001534	0.121902	1.161664	0.789367	18.21
171	<Null>	171_p41	27	16	171	39.506464	1.555373	0.068106	27.32	2.281012	0.000005	0.000138	0.036478	0.327364	0.115824	68.5
181	<Null>	181_p41	29	31	181	26.504926	1.043501	13.466096	5934.3	28.876532	0.000069	0.00175	0.849633	6.940743	0.198875	3.43
211	<Null>	211_p41	33	13	211	39.112928	1.539879	0.723012	312.34	82.371309	0.000197	0.004992	0.152041	1.267015	1.758513	10.32
251	<Null>	251_p41	38	6	251	39.379111	1.550359	0.13635	52.96	6.560018	0.000016	0.000398	0.056606	0.524653	0.264418	69.65
261	<Null>	261_p41	40	3	261	36.050985	1.41933	3.961277	1501.46	374.159806	0.000893	0.022676	0.458531	4.355043	4.71084	1.43
281	<Null>	281_p41	43	0	281	39.333561	1.548565	0.549232	205.63	102.479782	0.000245	0.006211	0.148077	1.42383	2.900705	9.69
13	0	13_p41	45	42	13	37.869611	1.49093	1.891735	206.585	86.795511	0.000207	0.00526	0.132512	4.368365	0.636479	3.99
12	-1	12_p41	49	41	12	26.509705	1.043689	13.899068	4570.81	48.544156	0.000116	0.002942	0.604603	6.618582	0.242622	0.54
22	-1	22_p41	50	46	22	0.821942	0.03236	39.799247	1862.077	108.129889	0.000258	0.006553	0.708514	54.51649	0.262616	-0.13
23	0	23_p41	51	47	23	26.042291	1.025287	14.398648	1765.532	50.633937	0.000121	0.003069	0.599916	17.61325	0.249409	5.14
42	-1	42_p41	52	43	42	21.741849	0.855978	18.575558	669.128	37.478666	0.000089	0.002271	0.475083	47.47939	0.111081	0
43	0	43_p41	53	44	43	27.258894	1.073185	12.777484	2954.291	1872.572939	0.004468	0.113489	1.11192	17.31283	20.26553	0.21
52	-1	52_p41	54	48	52	26.29963	1.035418	14.304681	124.6125	184.788187	0.000441	0.011199	0.105154	43.45549	0.141113	-0.03
53	0	53_p41	55	49	53	29.91958	1.177936	10.431096	181.5527	111.340452	0.000266	0.006748	0.162519	33.61509	0.195976	2.49
33	0	33_p41	56	39	33	24.128171	0.949928	16.385242	1328.734	2438.116373	0.005817	0.147765	1.029299	45.69399	19.19788	0.04
32	-1	32_p41	57	38	32	28.906739	1.138061	10.956023	3748.44	2413.429081	0.005759	0.146268	0.656387	6.906606	16.41081	0.15
83	0	83_p41	58	54	83	20.090631	0.79097	19.68652	261.8754	30.856425	0.000074	0.00187	0.074903	20.27108	0.014679	0.15
82	-1	82_p41	59	53	82	38.950636	1.53349	0.691958	11.6357	2.412647	0.000006	0.000146	0.01022	2.187946	0.003473	2.94
72	-1	72_p41	60	35	72	17.478103	0.688114	22.815545	9447	3476.133158	0.008294	0.210675	5.210985	45.30637	98.55092	0.03
73	0	73_p41	61	36	73	30.1298	1.186213	9.83448	3258.11	1616.697646	0.003858	0.097982	2.213169	24.04931	43.65288	0.07
62	-1	62_p41	63	50	62	39.639945	1.560628	0.05589	15.1	0.102715	0	0.000006	0.032576	0.434064	0.006039	97.27
63	0	63_p41	64	51	63	39.840418	1.56852	0.001441	0.41	0.004615	0	0	0.001946	0.024623	0.000714	90.89
93	0	93_p41	65	62	93	37.930697	1.493335	1.094336	128.917	14.034671	0.000033	0.000851	0.133243	4.071799	0.154474	26.9
92	-1	92_p41	67	61	92	39.730796	1.564205	0	0	0.000123	0	0	0.000006	0.000045	0.000088	99.84
102	-1	102_p41	68	58	102	1.277085	0.050279	38.737052	3030.601	675.160158	0.001611	0.040919	1.155498	53.17036	2.727883	-0.17
103	0	103_p41	70	59	103	32.25716	1.269967	7.54769	2548.15	1594.029856	0.003803	0.096608	0.870992	9.287642	21.11103	0.21
122	-1	122_p41	71	63	122	38.215362	1.504542	0.000135	0.0031	0.00329	0	0	0.000009	0.00145	0.000054	99.98
123	0	123_p41	72	64	123	38.11238	1.500487	0.001219	0.105	0.011056	0	0.000001	0.000573	0.023935	0.00047	97.81
132	-1	132_p41	73	55	132	39.641336	1.560683	0.53247	107.74	5.768314	0.000014	0.00035	0.177721	3.161979	0.178258	19.56
133	0	133_p41	74	56	133	40.260365	1.585054	0	0	0	0	0	0	0	0	0
153	0	153_p41	75	21	153	37.649204	1.482252	2.40525	2.80659	90.07773	0.000215	0.005459	0.006213	19.16949	0.023474	3.3
152	-1	152_p41	76	20	152	36.37251	1.431989	3.396397	61.96	1168.211563	0.002787	0.070801	0.058358	11.51618	2.220614	1.18
173	0	173_p41	77	18	173	39.401367	1.551235	0.406051	6.9301	26.396456	0.000063	0.0016	0.013117	2.76669	0.095875	29.68
172	-1	172_p41	78	17	172	39.184615	1.542701	0.614377	6.3749	31.314653	0.000075	0.001898	0.012753	4.424506	0.071147	11.52
143	0	143_p41	80	66	143	39.108903	1.539721	0.000144	0.0029	0.001144	0	0	0.000012	0.002081	0.000014	99.99
142	-1	142_p41	81	65	142	39.003409	1.535567	0	0	0	0	0	0	0	0	0
182	-1	182_p41	82	32	182	0.806354	0.031746	39.096863	779.6978	30.989283	0.000074	0.001878	0.242848	43.83816	0.029777	0.01
183	0	183_p41	83	33	183	0.808894	0.031846	39.152029	1396.686	28.098583	0.000067	0.001703	0.363789	36.71192	0.039845	0.02
163	0	163_p41	84	23	163	32.060199	1.262213	8.075565	416.555	584.286037	0.001394	0.035411	0.386986	27.00834	2.7562	0.03
162	-1	162_p41	85	22	162	32.609699	1.283846	7.533098	923.032	2050.896024	0.004894	0.124297	0.814063	23.91758	24.18851	0.2
212	-1	212_p41	86	14	212	1.206321	0.047493	39.766888	13.46308	13.170146	0.000031	0.000798	0.005133	54.58549	0.00032	-0.04
213	0	213_p41	87	15	213	1.253501	0.04935	39.406796	92.30648	2.822886	0.000007	0.000171	0.035487	54.53975	0.000315	-0.08
193	0	193_p41	88	68	193	39.080489	1.538602	0.137923	6.371	1.034116	0.000002	0.000063	0.013083	1.019589	0.009346	87.23
192	-1	192_p41	89	67	192	0.682859	0.026884	38.541732	1806.757	166.479713	0.000397	0.01009	0.458848	35.23732	0.325196	0.01
232	-1	232_p41	90	29	232	0.927225	0.036505	39.019687	215.6462	218.971701	0.000522	0.013271	0.083755	54.55751	0.082307	-0.03
233	0	233_p41	91	30	233	35.229297	1.38698	4.32999	532.975	10.435822	0.000025	0.000632	0.068871	2.014264	0.016852	8.15
112	-1	112_p41	92	27	112	37.30514	1.468706	0.093387	13.782	0.713273	0.000002	0.000043	0.034818	0.849337	0.027359	96.14
113	0	113_p41	93	28	113	35.457922	1.395981	3.508627	946.61	118.194666	0.000282	0.007163	0.513844	6.856453	1.724743	4.77
202	-1	202_p41	94	24	202	1.304792	0.05137	37.998033	1813.8	290.443614	0.000693	0.017603	0.628244	47.38086	0.532506	0.01
203	0	203_p41	95	25	203	30.555242	1.202962	9.338159	2712.47	2946.638501	0.007031	0.178584	0.727902	9.021351	26.50869	0.1
252	-1	252_p41	96	7	252	32.018414	1.260567	8.547307	2482.75	3.955419	0.000009	0.00024	0.200787	2.488487	0.009333	21.98
253	0	253_p41	97	8	253	22.42084	0.88271	18.195687	7.6451	226.759354	0.000541	0.013743	0.005519	47.28699	0.007024	0.54
243	0	243_p41	98	10	243	38.481801	1.515032	1.441387	414.56	124.948698	0.000298	0.007573	0.336926	4.217257	3.096147	3.29
242	-1	242_p41	99	9	242	36.823872	1.449759	2.924269	1382.12	491.969853	0.001174	0.029816	0.554138	4.220776	9.808406	1.85
282	-1	282_p41	100	1	282	38.7522	1.525677	0.284832	5.7248	4.914585	0.000012	0.000298	0.009185	1.645146	0.015109	46.9
283	0	283_p41	101	2	283	37.27777	1.467629	0.111337	9.396	8.053248	0.000019	0.000488	0.014974	0.63875	0.111429	0
223	0	223_p41	102	70	223	39.573385	1.558007	0	0	0	0	0	0	0	0	0
222	-1	222_p41	104	69	222	37.919563	1.492896	1.548548	746.73	5.621863	0.000013	0.000341	0.29962	2.236839	0.102045	31.16
272	-1	272_p41	105	11	272	1.27282	0.050111	37.090947	8458.891	263.633565	0.000629	0.015978	1.311431	20.70153	1.361924	0.05
273	0	273_p41	106	12	273	35.609186	1.401936	3.786843	1119.77	298.846872	0.000713	0.018112	0.353661	4.305648	3.050445	1.57
263	0	263_p41	107	5	263	38.456711	1.514044	1.43678	478.24	156.604777	0.000374	0.009491	0.273092	2.953628	3.078502	4.08

Table A25: Lower White River Watershed, 2001 Simulation Results, HRU Stream Channels

StreamID	Sequence	OID	ID	In_m3/km	In_acft/mi	Runoff_mm	Runoff_m3	Sed_kg/ha	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
14	16	15	14	2551.196959	3.327877	5.406573	4389.051	104.259835	0.701535	3.111026	1.84501	-0.1
24	18	17	24	5762.279644	7.516533	21.073393	12137.13	258.971115	1.95933	12.24696	2.489961	-0.01
44	17	16	44	6704.515141	8.74562	8.733649	16723.33	1572.887421	3.225121	6.063473	55.4742	0.01
54	19	18	54	10768.769285	14.047185	10.822705	27239.44	704.574594	4.987552	7.133911	35.40994	0.01
34	15	14	34	2831.406018	3.693392	15.606124	13043.36	20374.038912	2.210675	9.522108	289.4525	-0.02
84	21	20	84	918.27225	1.197829	0.628762	280.4661	1.752055	0.095724	0.772555	0.031293	-0.13
74	14	13	74	1467.239725	1.913922	8.453184	9476.89	13395.111778	5.113823	16.42112	892.9016	-0.15
64	20	19	64	9740.969399	12.706484	4.150419	17401.36	432.175163	4.295798	3.688546	59.26886	1.16
94	24	23	94	4930.551864	6.431596	3.817353	4489.57	443.38255	0.922899	2.824974	11.90356	0.27
104	23	22	104	1921.384138	2.506325	4.524729	3584.821	494.885601	1.170913	5.320496	12.94064	0
124	25	24	124	4354.183215	5.679759	2.773834	5762.71	425.692591	0.866442	1.501397	14.29393	0.12
134	22	21	134	6714.321171	8.758411	0.939352	4918.53	70.361459	1.025803	0.705276	8.245514	3.75
154	8	7	154	176.078602	0.229684	0.482244	191.5398	795.064407	0.162337	1.471387	29.97722	-0.05
174	7	6	174	59.765107	0.07796	0.070012	30.00605	55.604665	0.042677	0.358476	4.703596	-0.13
144	26	25	144	8095.5348	10.560118	1.004219	7410.39	74.972839	1.20591	0.588308	10.43967	0.12
184	13	12	184	3763.580345	4.909355	13.07855	6490.892	190.972729	1.10465	8.012769	1.556935	-0.03
164	9	8	164	544.177503	0.709845	1.232739	1232.593	523.806871	0.987291	3.55467	47.29679	-0.05
214	6	5	214	1049.191094	1.368604	0.741536	322.3304	12.852087	0.142467	1.179905	0.380717	0.02
194	27	26	194	9989.920998	13.031226	1.38642	11047.87	63.029831	1.194549	0.539663	9.569138	-0.05
234	12	11	234	5567.24591	7.262124	2.091493	5642.5	138.699416	1.737686	2.318775	10.23154	0.01
114	11	10	114	1867.220478	2.435672	1.478269	1177.37	366.241782	0.20988	0.948665	5.29694	0.19
204	10	9	204	2403.220743	3.134851	2.663868	4722.417	396.649983	1.813566	3.682853	26.88391	-0.09
254	3	2	254	994.474308	1.297229	3.625267	2462.654	265.578031	0.219445	1.162959	2.026021	0
244	4	3	244	2051.547983	2.676116	1.569596	4136.974	767.008234	1.06785	1.458538	79.62566	0
284	1	0	284	661.631738	0.863057	0.287937	137.8892	8.732791	0.093911	0.705966	0.300523	0.39
224	28	27	224	8582.074484	11.194779	0.481939	5419.11	41.575596	0.569365	0.182288	5.89459	1.8
274	5	4	274	4897.503433	6.388486	2.886619	10502.5	181.190923	2.122435	2.100069	19.19852	0.01
264	2	1	264	865.966316	1.129599	2.178465	2605.754	3080.498804	0.859778	2.587654	143.7392	-0.12
294	29	28	294	10686.954879	13.940463	0.731387	11110.36	32.430879	1.500313	0.355552	3.909882	0.01

Table A26: Lower White River Watershed, 2006 Simulation Results, HRU Planes

ElementID	Side	ID_PARNAME	TABID	OID	ID	Infilt_mm	Infilt_in	Runoff_mm	Runoff_m3	Sed_kg/ha	Sed_in	Sed_mm	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
262	-1	262_p41	108	4	262	-3.988093	-3.988093	50.175242	50.175242	84.121651	84.121651	84.121651	29.221791	29.221796	61.876898	-40.883978
293	0	293_p41	109	72	293	0	0	0	0	0	0	0	0	0	0	0
292	-1	292_p41	110	71	292	-2.380026	-2.380026	307.720624	307.720624	289.747427	289.747427	289.747427	123.786442	123.786562	116.686654	-15.842034
11	<Null>	11_p41	2	40	11	0	0	0	0	0	0	0	0	0	0	0
21	<Null>	21_p41	4	45	21	0	0	0	0	0	0	0	0	0	0	0
31	<Null>	31_p41	6	37	31	-0.273952	-0.273952	0.086598	0.086598	1.271068	1.271068	1.271068	1.397991	1.398005	2.975485	0
71	<Null>	71_p41	11	34	71	-0.684136	-0.684136	93.27271	93.27271	97.060517	97.060517	97.060517	39.132513	39.132552	41.467949	20
81	<Null>	81_p41	13	52	81	0.196458	0.196458	-16.966626	-16.966626	-13.929901	-13.929901	-13.929901	-11.398213	-11.398162	-8.950147	-91.230835
91	<Null>	91_p41	15	60	91	-0.791163	-0.791163	1.012903	1.012903	4.793942	4.793942	4.793942	5.163752	5.163801	10.69047	100
101	<Null>	101_p41	17	57	101	-0.305876	-0.305876	175.422506	175.422506	280.812062	280.812062	280.812062	75.365112	75.365073	136.311463	-86.939274
111	<Null>	111_p41	19	26	111	-18.234845	-18.234845	62.809155	62.809155	157.466726	157.466726	157.466726	121.726508	121.726522	294.846544	-50
151	<Null>	151_p41	24	19	151	-3.789159	-3.789159	446.045347	446.045347	854.106395	854.106395	854.106395	153.654783	153.654671	367.962929	-85.227897
171	<Null>	171_p41	27	16	171	-0.146835	-0.146835	344.399707	344.399707	496.562329	496.562329	496.562329	157.792453	157.792483	265.797621	-70.744526
181	<Null>	181_p41	29	31	181	-36.318899	-36.318899	76.056485	76.056485	131.035705	131.035705	131.035705	182.475239	182.475234	367.825048	-95.626822
211	<Null>	211_p41	33	13	211	-13.176692	-13.176692	-19.264263	-19.264263	-15.850365	-15.850365	-15.850365	9.436969	9.437063	15.795959	-100
251	<Null>	251_p41	38	6	251	0.289632	0.289632	147.111027	147.111027	235.010084	235.010084	235.010084	84.291892	84.291916	160.365596	-75.879397
261	<Null>	261_p41	40	3	261	0	0	0	0	0	0	0	0	0	0	0
281	<Null>	281_p41	43	0	281	-0.444918	-0.444918	56.042406	56.042406	96.888449	96.888449	96.888449	34.961881	34.961899	67.352937	-59.855521
13	0	13_p41	45	42	13	0	0	0	0	0	0	0	0	0	0	0
12	-1	12_p41	49	41	12	0	0	0	0	0	0	0	0	0	0	0
22	-1	22_p41	50	46	22	0	0	0	0	0	0	0	0	0	0	0
23	0	23_p41	51	47	23	0	0	0	0	0	0	0	0	0	0	0
42	-1	42_p41	52	43	42	0	0	0	0	0	0	0	0	0	0	0
43	0	43_p41	53	44	43	-0.204013	-0.204013	0.801648	0.801648	-4.792256	-4.792256	-4.792256	-0.780722	-0.780693	-5.096486	0
52	-1	52_p41	54	48	52	0	0	0	0	0	0	0	0	0	0	0
53	0	53_p41	55	49	53	0	0	0	0	0	0	0	0	0	0	0
33	0	33_p41	56	39	33	0	0	0	0	0	0	0	0	0	0	0
32	-1	32_p41	57	38	32	0.635995	0.635995	-1.805018	-1.805018	-2.102277	-2.102277	-2.102277	-1.261787	-1.261792	-1.742266	13.333333
83	0	83_p41	58	54	83	4.807204	4.807204	-4.830351	-4.830351	-9.406386	-9.406386	-9.406386	-11.650637	-11.650539	-18.117225	-93.333333
82	-1	82_p41	59	53	82	0	0	0	0	0	0	0	0	0	0	0
72	-1	72_p41	60	35	72	-2.683854	-2.683854	2.161744	2.161744	1.634792	1.634792	1.634792	3.420121	3.420115	2.972961	-366.666667
73	0	73_p41	61	36	73	-4.935663	-4.935663	17.044544	17.044544	17.648084	17.648084	17.648084	28.651178	28.651217	27.162721	142.857143
62	-1	62_p41	63	50	62	-0.207194	-0.207194	-2.119205	-2.119205	-0.946633	-0.946633	-0.946633	-0.772041	-0.772167	2.033449	-0.380384
63	0	63_p41	64	51	63	-0.533819	-0.533819	-12.195122	-12.195122	-8.238018	-8.238018	-8.238018	-15.236382	-15.236003	-20.467918	9.957091
93	0	93_p41	65	62	93	1.318888	1.318888	-3.376591	-3.376591	-8.149024	-8.149024	-8.149024	-5.329369	-5.329315	-9.567559	-99.107807
92	-1	92_p41	67	61	92	0.111809	0.111809	0	0	-22.669252	-22.669252	-22.669252	-30.15873	-30.088496	-21.477273	0.020032
102	-1	102_p41	68	58	102	-0.904787	-0.904787	0.089124	0.089124	1.311479	1.311479	1.311479	0.772913	0.772855	2.136968	-11.764706
103	0	103_p41	70	59	103	-12.115722	-12.115722	55.921355	55.921355	110.749691	110.749691	110.749691	102.955712	102.955605	201.899955	-71.428571
122	-1	122_p41	71	63	122	0	0	0	0	0	0	0	0	0	0	0
123	0	123_p41	72	64	123	0	0	0	0	0	0	0	0	0	0	0
132	-1	132_p41	73	55	132	0.075477	0.075477	10.51977	10.51977	11.260753	11.260753	11.260753	6.108743	6.108706	6.19725	-24.437628
133	0	133_p41	74	56	133	-0.005722	-0.005722	0	0	0	0	0	0	0	0	0
153	0	153_p41	75	21	153	-0.159157	-0.159157	-88.641376	-88.641376	-76.849501	-76.849501	-76.849501	-77.984678	-77.984156	-61.993371	1032.727273
152	-1	152_p41	76	20	152	-0.120777	-0.120777	2.181246	2.181246	-1.9748	-1.9748	-1.9748	-2.618673	-2.618577	-7.38593	5.932203
173	0	173_p41	77	18	173	0	0	0	0	0	0	0	0	0	0	0
172	-1	172_p41	78	17	172	0.075752	0.075752	-13.184521	-13.184521	-14.003664	-14.003664	-14.003664	-7.227489	-7.227044	-8.752925	94.444444
143	0	143_p41	80	66	143	0	0	0	0	0	0	0	0	0	0	0
142	-1	142_p41	81	65	142	2.16985	2.16985	0	0	0	0	0	0	0	0	0
182	-1	182_p41	82	32	182	-1.608741	-1.608741	1.605289	1.605289	50.487451	50.487451	50.487451	24.466024	24.46599	83.59444	-900
183	0	183_p41	83	33	183	0.204464	0.204464	0.211644	0.211644	1.556408	1.556408	1.556408	2.647444	2.647451	3.797726	0
163	0	163_p41	84	23	163	1.099209	1.099209	-2.588614	-2.588614	-0.534893	-0.534893	-0.534893	1.417856	1.417858	3.166679	-466.666667
162	-1	162_p41	85	22	162	3.209747	3.209747	-16.919023	-16.919023	-29.849576	-29.849576	-29.849576	-23.984882	-23.98491	-33.554196	85
212	-1	212_p41	86	14	212	0	0	0	0	0	0	0	0	0	0	0
213	0	213_p41	87	15	213	0	0	0	0	0	0	0	0	0	0	0
193	0	193_p41	88	68	193	0.483595	0.483595	21.833307	21.833307	21.47838	21.47838	21.47838	16.211609	16.211042	13.261933	-33.153732
192	-1	192_p41	89	67	192	-0.518572	-0.518572	1.552395	1.552395	8.060915	8.060915	8.060915	22.682958	22.682968	27.743211	-100
232	-1	232_p41	90	29	232	1.555304	1.555304	-0.260241	-0.260241	8.561366	8.561366	8.561366	0.012059	0.012116	8.107967	133.333333
233	0	233_p41	91	30	233	-18.952224	-18.952224	-62.360148	-62.360148	-66.273856	-66.273856	-66.273856	-28.219153	-28.219141	-37.233039	-1740.613497
112	-1	112_p41	92	27	112	0	0	0	0	0	0	0	0	0	0	0
113	0	113_p41	93	28	113	-0.084253	-0.084253	0.614826	0.614826	0.772508	0.772508	0.772508	0.324301	0.324293	0.527267	7.756813
202	-1	202_p41	94	24	202	0	0	0	0	0	0	0	0	0	0	0
203	0	203_p41	95	25	203	0.380489	0.380489	-1.360752	-1.360752	-2.645696	-2.645696	-2.645696	-1.67366	-1.673663	-3.308462	-40
252	-1	252_p41	96	7	252	0	0	0	0	0	0	0	0	0	0	0
253	0	253_p41	97	8	253	0	0	0	0	0	0	0	0	0	0	0
243	0	243_p41	98	10	243	-4.826425	-4.826425	128.507333	128.507333	320.060039	320.060039	320.060039	101.360359	101.360363	274.750294	-62.613982
242	-1	242_p41	99	9	242	-1.661941	-1.661941	25.224293	25.224293	40.709305	40.709305	40.709305	16.693002	16.692997	33.812263	-59.459459
282	-1	282_p41	100	1	282	0	0	0	0	0	0	0	0	0	0	0
283	0	283_p41	101	2	283	0	0	0	0	0	0	0	0	0	0	0
223	0	223_p41	102	70	223	-0.162694	-0.162694	0	0	0	0	0	0	0	0	0
222	-1	222_p41	104	69	222	-28.740339	-28.740339	761.942067	761.942067	1135.145352	1135.145352	1135.145352	402.949067	402.949028	793.438673	-93.998716
272	-1	272_p41	105	11	272	0	0	0	0	0	0	0	0	0	0	0
273	0	273_p41	106	12	273	0.018234	0.018234	0.375077	0.375077	0.709242	0.709242	0.709242	0.362126	0.362152	0.694784	-1.910828
263	0	263_p41	107	5	263	-0.256318	-0.256318	1.647708	1.647708	3.20657	3.20657	3.20657	1.923052	1.923025	3.397724	-1.960784

Table A27: Lower White River Watershed, 2006 Simulation Results, HRU Stream Channels

StreamID	Sequence	OID	ID	In_m3/km	In_acft/mi	Runoff_mm	Runoff_m3	Sed_kg/ha	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
14	16	15	14	0	0	0	0	0	0	0	0	0
24	18	17	24	0	0	0	0	0	0	0	0	0
44	17	16	44	-0.310627	-0.310627	-0.085689	-0.085689	-0.186932	0.394931	0.394906	1.767272	0
54	19	18	54	-0.130845	-0.130845	-0.042916	-0.042916	-0.46517	0.235727	0.235719	-0.776759	0
34	15	14	34	-0.266736	-0.266736	-0.400817	-0.400817	-0.117158	0.557024	0.55702	0.98479	0
84	21	20	84	-7.796322	-7.796322	-12.679786	-12.679786	-11.994916	-15.834763	-15.834772	-13.676904	-223.076923
74	14	13	74	5.13417	5.13417	8.312854	8.312854	9.088718	11.949358	11.949368	11.022099	-6.666667
64	20	19	64	0.806678	0.806678	3.597765	3.597765	4.351065	4.173474	4.173487	5.254125	-23.275862
94	24	23	94	-0.415263	-0.415263	3.020779	3.020779	3.064281	7.027657	7.027675	8.185618	3.703704
104	23	22	104	10.787143	10.787143	38.286737	38.286737	90.494141	71.592424	71.592461	155.415343	-99
124	25	24	124	10.794662	10.794662	21.987155	21.987155	36.461753	72.207352	72.207351	77.109514	-33.333333
134	22	21	134	2.268645	2.268645	6.230317	6.230317	4.222638	7.129244	7.12922	6.625979	8.533333
154	8	7	154	140.793616	140.793616	334.44647	334.44647	408.231654	108.422746	108.422733	118.493609	-80
174	7	6	174	152.562156	152.562156	257.161306	257.161306	482.974422	114.471964	114.471856	225.601731	-146.153846
144	26	25	144	10.41936	10.41936	17.350504	17.350504	11.992719	7.769734	7.769706	7.28615	191.666667
184	13	12	184	13.130243	13.130243	66.546293	66.546293	68.884789	121.560494	121.560362	145.087046	0
164	9	8	164	48.028033	48.028033	31.914995	31.914995	39.834324	3.989359	3.989428	14.511069	-80
214	6	5	214	-12.865537	-12.865537	-14.835182	-14.835182	-10.028569	8.658087	8.65807	13.01101	-50
194	27	26	194	20.389757	20.389757	42.675104	42.675104	16.971083	100.18869	100.18871	6.430067	-20
234	12	11	234	5.402166	5.402166	18.293097	18.293097	47.361487	0.571565	0.571552	36.165621	200
114	11	10	114	31.457832	31.457832	100.585203	100.585203	196.767846	208.301335	208.301252	456.924375	-10.526316
204	10	9	204	5.305613	5.305613	4.996657	4.996657	4.223884	0.955411	0.955401	-0.172854	-33.333333
254	3	2	254	3.359807	3.359807	3.055322	3.055322	7.503275	20.651972	20.651975	40.778946	0
244	4	3	244	10.15323	10.15323	32.092273	32.092273	57.573436	41.845765	41.845739	60.622719	-99
284	1	0	284	29.445517	29.445517	65.697966	65.697966	83.08186	47.098624	47.098706	50.689831	-48.717949
224	28	27	224	29.400085	29.400085	135.866222	135.866222	62.302526	330.026884	330.026968	68.141906	-98.888889
274	5	4	274	8.533367	8.533367	10.892645	10.892645	36.855957	19.476922	19.476979	43.925417	-100
264	2	1	264	8.359739	8.359739	24.910256	24.910256	26.999382	15.405977	15.405962	15.840703	-25
294	29	28	294	25.578617	25.578617	64.410334	64.410334	68.543858	98.357876	98.35788	173.791383	-600

Table A28: Lower White River Watershed, Change 2001-2006, HRU Planes

ElementID	Side	ID_PARNAME	TABID	OID	ID	Infilt_mm	Infilt_in	Runoff_mm	Runoff_m3	Sed_kg/ha	Sed_in	Sed_mm	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
262	-1	262_p41	108	4	262	-1.481026	-0.058308	1.460417	707.21	253.848718	0.000606	0.015385	0.129586	0.963364	3.050028	-0.74
293	0	293_p41	109	72	293	0	0	0	0	0	0	0	0	0	0	0
292	-1	292_p41	110	71	292	-0.933844	-0.036765	1.230738	317.66	4.423706	0.000011	0.000268	0.086215	1.202515	0.028704	-6.98
11	<Null>	11_p41	2	40	11	0	0	0	0	0	0	0	0	0	0	0
21	<Null>	21_p41	4	45	21	0	0	0	0	0	0	0	0	0	0	0
31	<Null>	31_p41	6	37	31	-0.0422	-0.001661	0.0215	8.87	84.444232	0.000201	0.005118	0.022342	0.19496	1.66095	0
71	<Null>	71_p41	11	34	71	-0.265417	-0.010449	0.535039	201.04	9.885969	0.000024	0.000599	0.055436	0.531125	0.100618	2.69
81	<Null>	81_p41	13	52	81	0.077583	0.003054	-0.093378	-38.84	-0.170052	0	-0.00001	-0.010275	-0.088927	-0.001705	-63.67
91	<Null>	91_p41	15	60	91	-0.164799	-0.006488	0.192121	106.53	339.212027	0.000809	0.020558	0.081419	0.52861	7.3616	0.01
101	<Null>	101_p41	17	57	101	-0.120261	-0.004735	0.452221	170.23	79.165728	0.000189	0.004798	0.071946	0.688059	1.51416	-28.49
111	<Null>	111_p41	19	26	111	-5.603691	-0.220618	5.839105	2213.47	5592.881022	0.013345	0.338962	0.724505	6.880448	75.04334	-0.03
151	<Null>	151_p41	24	19	151	-1.496819	-0.05893	1.791386	676.74	216.176079	0.000516	0.013102	0.187308	1.784951	2.904577	-15.52
171	<Null>	171_p41	27	16	171	-0.058009	-0.002284	0.234556	94.09	11.326646	0.000027	0.000686	0.057559	0.516556	0.307858	-48.46
181	<Null>	181_p41	29	31	181	-9.626297	-0.378988	10.24184	4513.42	37.838567	0.00009	0.002293	1.550369	12.665137	0.731513	-3.28
211	<Null>	211_p41	33	13	211	-5.15379	-0.202905	-0.139283	-60.17	-13.056153	-0.000031	-0.000791	0.014348	0.119569	0.277774	-10.32
251	<Null>	251_p41	38	6	251	0.114054	0.00449	0.200586	77.91	15.416703	0.000037	0.000934	0.047714	0.44224	0.424035	-52.85
261	<Null>	261_p41	40	3	261	0	0	0	0	0	0	0	0	0	0	0
281	<Null>	281_p41	43	0	281	-0.175002	-0.00689	0.307803	115.24	99.291071	0.000237	0.006018	0.05177	0.497798	1.95371	-5.8
13	0	13_p41	45	42	13	0	0	0	0	0	0	0	0	0	0	0
12	-1	12_p41	49	41	12	0	0	0	0	0	0	0	0	0	0	0
22	-1	22_p41	50	46	22	0	0	0	0	0	0	0	0	0	0	0
23	0	23_p41	51	47	23	0	0	0	0	0	0	0	0	0	0	0
42	-1	42_p41	52	43	42	0	0	0	0	0	0	0	0	0	0	0
43	0	43_p41	53	44	43	-0.055612	-0.002189	0.10243	23.683	-89.738494	-0.000214	-0.005439	-0.008681	-0.13516	-1.03283	0
52	-1	52_p41	54	48	52	0	0	0	0	0	0	0	0	0	0	0
53	0	53_p41	55	49	53	0	0	0	0	0	0	0	0	0	0	0
33	0	33_p41	56	39	33	0	0	0	0	0	0	0	0	0	0	0
32	-1	32_p41	57	38	32	0.183846	0.007238	-0.197758	-67.66	-50.736975	-0.000121	-0.003075	-0.008282	-0.087147	-0.28592	0.02
83	0	83_p41	58	54	83	0.965798	0.038024	-0.950928	-12.6495	-2.902475	-0.000007	-0.000176	-0.008727	-2.36169	-0.00266	-0.14
82	-1	82_p41	59	53	82	0	0	0	0	0	0	0	0	0	0	0
72	-1	72_p41	60	35	72	-0.469087	-0.018468	0.493214	204.22	56.82754	0.000136	0.003444	0.178222	1.54953	2.92988	-0.11
73	0	73_p41	61	36	73	-1.487105	-0.058547	1.676242	555.33	285.316151	0.000681	0.017292	0.634099	6.89042	11.85731	0.1
62	-1	62_p41	63	50	62	-0.082132	-0.003234	-0.001184	-0.32	-0.000972	0	0	-0.000251	-0.003352	0.000123	-0.37
63	0	63_p41	64	51	63	-0.212676	-0.008373	-0.000176	-0.05	-0.00038	0	0	-0.000297	-0.003752	-0.000146	9.05
93	0	93_p41	65	62	93	0.500264	0.019695	-0.036951	-4.353	-1.143689	-0.000003	-0.000069	-0.007101	-0.216999	-0.014779	-26.66
92	-1	92_p41	67	61	92	0.044423	0.001749	0	0	-0.000028	0	0	-0.000002	-0.000014	-0.000019	0.02
102	-1	102_p41	68	58	102	-0.011555	-0.000455	0.034524	2.701	8.854582	0.000021	0.000537	0.008931	0.41093	0.058294	0.02
103	0	103_p41	70	59	103	-3.908188	-0.153866	4.220771	1424.96	1765.383141	0.004212	0.106993	0.896736	9.562148	42.62316	-0.15
122	-1	122_p41	71	63	122	0	0	0	0	0	0	0	0	0	0	0
123	0	123_p41	72	64	123	0	0	0	0	0	0	0	0	0	0	0
132	-1	132_p41	73	55	132	0.02992	0.001178	0.056015	11.334	0.649556	0.000002	0.000039	0.010857	0.193156	0.011047	-4.78
133	0	133_p41	74	56	133	-0.002304	-0.000091	0	0	0	0	0	0	0	0	0
153	0	153_p41	75	21	153	-0.059921	-0.002359	-2.132047	-2.4878	-69.224286	-0.000165	-0.004195	-0.004846	-14.949165	-0.014552	34.08
152	-1	152_p41	76	20	152	-0.04393	-0.00173	0.074084	1.3515	-23.069848	-0.000055	-0.001398	-0.001528	-0.30156	-0.164013	0.07
173	0	173_p41	77	18	173	0	0	0	0	0	0	0	0	0	0	0
172	-1	172_p41	78	17	172	0.029683	0.001169	-0.081003	-0.8405	-4.385199	-0.00001	-0.000266	-0.000922	-0.319761	-0.006227	10.88
143	0	143_p41	80	66	143	0	0	0	0	0	0	0	0	0	0	0
142	-1	142_p41	81	65	142	0.846316	0.03332	0	0	0	0	0	0	0	0	0
182	-1	182_p41	82	32	182	-0.012972	-0.000511	0.627617	12.5164	15.645699	0.000037	0.000948	0.059415	10.72544	0.024892	-0.09
183	0	183_p41	83	33	183	0.001654	0.000065	0.082863	2.956	0.437329	0.000001	0.000027	0.009631	0.97193	0.001513	0
163	0	163_p41	84	23	163	0.352409	0.013874	-0.209045	-10.783	-3.125306	-0.000007	-0.000189	0.005487	0.38294	0.08728	-0.14
162	-1	162_p41	85	22	162	1.046689	0.041208	-1.274527	-156.168	-612.183772	-0.001461	-0.037102	-0.195252	-5.73661	-8.11626	0.17
212	-1	212_p41	86	14	212	0	0	0	0	0	0	0	0	0	0	0
213	0	213_p41	87	15	213	0	0	0	0	0	0	0	0	0	0	0
193	0	193_p41	88	68	193	0.188991	0.007441	0.030113	1.391	0.222111	0.000001	0.000013	0.002121	0.165286	0.001239	-28.92
192	-1	192_p41	89	67	192	-0.003541	-0.000139	0.59832	28.048	13.419788	0.000032	0.000813	0.10408	7.99287	0.09022	-0.01
232	-1	232_p41	90	29	232	0.014421	0.000568	-0.101545	-0.5612	18.746969	0.000045	0.001136	0.00001	0.00661	0.006673	-0.04
233	0	233_p41	91	30	233	-6.676735	-0.262864	-2.700188	-332.364	-6.916222	-0.000017	-0.000419	-0.019435	-0.568408	-0.006274	-141.86
112	-1	112_p41	92	27	112	0	0	0	0	0	0	0	0	0	0	0
113	0	113_p41	93	28	113	-0.029875	-0.001176	0.021572	5.82	0.913064	0.000002	0.000055	0.001666	0.022235	0.009094	0.37
202	-1	202_p41	94	24	202	0	0	0	0	0	0	0	0	0	0	0
203	0	203_p41	95	25	203	0.116259	0.004577	-0.127069	-36.91	-77.959084	-0.000186	-0.004725	-0.012183	-0.150987	-0.87703	-0.04
252	-1	252_p41	96	7	252	0	0	0	0	0	0	0	0	0	0	0
253	0	253_p41	97	8	253	0	0	0	0	0	0	0	0	0	0	0
243	0	243_p41	98	10	243	-1.857295	-0.073122	1.852288	532.74	399.910852	0.000954	0.024237	0.341509	4.274627	8.506673	-2.06
242	-1	242_p41	99	9	242	-0.611991	-0.024094	0.737626	348.63	200.277506	0.000478	0.012138	0.092502	0.704574	3.316444	-1.1
282	-1	282_p41	100	1	282	0	0	0	0	0	0	0	0	0	0	0
283	0	283_p41	101	2	283	0	0	0	0	0	0	0	0	0	0	0
223	0	223_p41	102	70	223	-0.064384	-0.002535	0	0	0	0	0	0	0	0	0
222	-1	222_p41	104	69	222	-10.898211	-0.429063	11.799037	5689.65	63.816317	0.000152	0.003868	1.207317	9.013321	0.809664	-29.29
272	-1	272_p41	105	11	272	0	0	0	0	0	0	0	0	0	0	0
273	0	273_p41	106	12	273	0.006493	0.000256	0.014204	4.2	2.119546	0.000005	0.000128	0.001281	0.015593	0.021194	-0.03
263	0	263_p41	107	5	263	-0.098571	-0.003881	0.023674	7.88	5.021642	0.000012	0.000304	0.005252	0.056799	0.104599	-0.08

Table A29: Lower White River Watershed, Change 2001-2006, Stream Channels

StreamID	Sequence	OID	ID	In_m3/km	In_acft/mi	Runoff_mm	Runoff_m3	Sed_kg/ha	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
14	16	15	14	0	0	0	0	0	0	0	0	0
24	18	17	24	0	0	0	0	0	0	0	0	0
44	17	16	44	-20.826054	-0.027166	-0.007484	-14.33	-2.94023	0.012737	0.023945	0.98038	0
54	19	18	54	-14.090359	-0.01838	-0.004645	-11.69	-3.277472	0.011757	0.016816	-0.27505	0
34	15	14	34	-7.552374	-0.009852	-0.062552	-52.28	-23.869784	0.012314	0.05304	2.8505	0
84	21	20	84	-71.591458	-0.093387	-0.079726	-35.5625	-0.210158	-0.015158	-0.122332	-0.00428	0.29
74	14	13	74	75.330582	0.098264	0.702701	787.8	1217.443892	0.611069	1.96222	98.4165	0.01
64	20	19	64	78.578229	0.1025	0.149322	626.06	18.804224	0.179284	0.153941	3.11406	-0.27
94	24	23	94	-20.474765	-0.026708	0.115314	135.62	13.586487	0.064858	0.19853	0.97438	0.01
104	23	22	104	207.262457	0.270361	1.732371	1372.511	447.842473	0.838285	3.809074	20.11174	-0.12
124	25	24	124	470.019361	0.613111	0.609887	1267.056	155.214979	0.625635	1.084119	11.02198	-0.04
134	22	21	134	152.324103	0.198697	0.058525	306.44	2.97111	0.073132	0.050281	0.546346	0.32
154	8	7	154	247.907431	0.32338	1.612848	640.5981	3245.704576	0.17601	1.595318	35.52109	0.04
174	7	6	174	91.178935	0.118937	0.180044	77.16395	268.556312	0.048853	0.410354	10.611394	0.19
144	26	25	144	843.502879	1.100297	0.174237	1285.74	8.991282	0.093696	0.04571	0.76065	0.23
184	13	12	184	494.167235	0.64461	8.70329	4319.448	131.551161	1.342818	9.740351	2.258911	0
164	9	8	164	261.357751	0.340925	0.393429	393.382	208.654926	0.039387	0.141811	6.86327	0.04
214	6	5	214	-134.984071	-0.176078	-0.110008	-47.8183	-1.28888	0.012335	0.102157	0.049535	-0.01
194	27	26	194	2036.920663	2.657035	0.591656	4714.69	10.696845	1.196803	0.540682	0.615302	0.01
234	12	11	234	300.751838	0.392312	0.382599	1032.188	65.690105	0.009932	0.013253	3.7003	0.02
114	11	10	114	587.387081	0.76621	1.486919	1184.26	720.646065	0.437182	1.976082	24.20301	-0.02
204	10	9	204	127.505588	0.166323	0.133104	235.963	16.754035	0.017327	0.035186	-0.04647	0.03
254	3	2	254	33.412415	0.043584	0.110764	75.242	19.927049	0.04532	0.240174	0.82619	0
244	4	3	244	208.298378	0.271712	0.503719	1327.649	441.592992	0.44685	0.610336	48.27124	-0.01
284	1	0	284	194.820885	0.254132	0.189169	90.5904	7.255365	0.044231	0.332501	0.152335	-0.19
224	28	27	224	2523.137198	3.291274	0.654793	7362.74	25.902646	1.879058	0.601599	4.016686	-1.78
274	5	4	274	417.921929	0.545153	0.314429	1144	66.779649	0.413385	0.40903	8.43303	-0.01
264	2	1	264	72.392527	0.094432	0.542661	649.1	831.715632	0.132457	0.398653	22.7693	0.03
294	29	28	294	2733.575259	3.565778	0.471089	7156.22	22.229376	1.475676	0.349714	6.795038	-0.06

Table A30: Lower White River Watershed, Percent Change 2001-2006, HRU Planes

ElementID	Side	ID_PARNAME	TABID	OID	ID	Infilt_mm	Infilt_in	Runoff_mm	Runoff_m3	Sed_kg/ha	Sed_in	Sed_mm	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
262	-1	262_p41	108	4	262	-3.988093	-3.988093	50.175242	50.175242	84.121651	84.121651	84.121651	29.221791	29.221796	61.876898	-40.883978
293	0	293_p41	109	72	293	0	0	0	0	0	0	0	0	0	0	0
292	-1	292_p41	110	71	292	-2.380026	-2.380026	307.720624	307.720624	289.747427	289.747427	289.747427	123.786442	123.786562	116.686654	-15.842034
11	<Null>	11_p41	2	40	11	0	0	0	0	0	0	0	0	0	0	0
21	<Null>	21_p41	4	45	21	0	0	0	0	0	0	0	0	0	0	0
31	<Null>	31_p41	6	37	31	-0.273952	-0.273952	0.086598	0.086598	1.271068	1.271068	1.271068	1.397991	1.398005	2.975485	0
71	<Null>	71_p41	11	34	71	-0.684136	-0.684136	93.27271	93.27271	97.060517	97.060517	97.060517	39.132513	39.132552	41.467949	20
81	<Null>	81_p41	13	52	81	0.196458	0.196458	-16.966626	-16.966626	-13.929901	-13.929901	-13.929901	-11.398213	-11.398162	-8.950147	-91.230835
91	<Null>	91_p41	15	60	91	-0.791163	-0.791163	1.012903	1.012903	4.793942	4.793942	4.793942	5.163752	5.163801	10.69047	100
101	<Null>	101_p41	17	57	101	-0.305876	-0.305876	175.422506	175.422506	280.812062	280.812062	280.812062	75.365112	75.365073	136.311463	-86.939274
111	<Null>	111_p41	19	26	111	-18.234845	-18.234845	62.809155	62.809155	157.466726	157.466726	157.466726	121.726508	121.726522	294.846544	-50
151	<Null>	151_p41	24	19	151	-3.789159	-3.789159	446.045347	446.045347	854.106395	854.106395	854.106395	153.654783	153.654671	367.962929	-85.227897
171	<Null>	171_p41	27	16	171	-0.146835	-0.146835	344.399707	344.399707	496.562329	496.562329	496.562329	157.792453	157.792483	265.797621	-70.744526
181	<Null>	181_p41	29	31	181	-36.318899	-36.318899	76.056485	76.056485	131.035705	131.035705	131.035705	182.475239	182.475234	367.825048	-95.626822
211	<Null>	211_p41	33	13	211	-13.176692	-13.176692	-19.264263	-19.264263	-15.850365	-15.850365	-15.850365	9.436969	9.437063	15.795959	-100
251	<Null>	251_p41	38	6	251	0.289632	0.289632	147.111027	147.111027	235.010084	235.010084	235.010084	84.291892	84.291916	160.365596	-75.879397
261	<Null>	261_p41	40	3	261	0	0	0	0	0	0	0	0	0	0	0
281	<Null>	281_p41	43	0	281	-0.444918	-0.444918	56.042406	56.042406	96.888449	96.888449	96.888449	34.961881	34.961899	67.352937	-59.855521
13	0	13_p41	45	42	13	0	0	0	0	0	0	0	0	0	0	0
12	-1	12_p41	49	41	12	0	0	0	0	0	0	0	0	0	0	0
22	-1	22_p41	50	46	22	0	0	0	0	0	0	0	0	0	0	0
23	0	23_p41	51	47	23	0	0	0	0	0	0	0	0	0	0	0
42	-1	42_p41	52	43	42	0	0	0	0	0	0	0	0	0	0	0
43	0	43_p41	53	44	43	-0.204013	-0.204013	0.801648	0.801648	-4.792256	-4.792256	-4.792256	-0.780722	-0.780693	-5.096486	0
52	-1	52_p41	54	48	52	0	0	0	0	0	0	0	0	0	0	0
53	0	53_p41	55	49	53	0	0	0	0	0	0	0	0	0	0	0
33	0	33_p41	56	39	33	0	0	0	0	0	0	0	0	0	0	0
32	-1	32_p41	57	38	32	0.635995	0.635995	-1.805018	-1.805018	-2.102277	-2.102277	-2.102277	-1.261787	-1.261792	-1.742266	13.333333
83	0	83_p41	58	54	83	4.807204	4.807204	-4.830351	-4.830351	-9.406386	-9.406386	-9.406386	-11.650637	-11.650539	-18.117225	-93.333333
82	-1	82_p41	59	53	82	0	0	0	0	0	0	0	0	0	0	0
72	-1	72_p41	60	35	72	-2.683854	-2.683854	2.161744	2.161744	1.634792	1.634792	1.634792	3.420121	3.420115	2.972961	-366.666667
73	0	73_p41	61	36	73	-4.935663	-4.935663	17.044544	17.044544	17.648084	17.648084	17.648084	28.651178	28.651217	27.162721	142.857143
62	-1	62_p41	63	50	62	-0.207194	-0.207194	-2.119205	-2.119205	-0.946633	-0.946633	-0.946633	-0.772041	-0.772167	2.033449	-0.380384
63	0	63_p41	64	51	63	-0.533819	-0.533819	-12.195122	-12.195122	-8.238018	-8.238018	-8.238018	-15.236382	-15.236003	-20.467918	9.957091
93	0	93_p41	65	62	93	1.318888	1.318888	-3.376591	-3.376591	-8.149024	-8.149024	-8.149024	-5.329369	-5.329315	-9.567559	-99.107807
92	-1	92_p41	67	61	92	0.111809	0.111809	0	0	-22.669252	-22.669252	-22.669252	-30.15873	-30.088496	-21.477273	0.020032
102	-1	102_p41	68	58	102	-0.904787	-0.904787	0.089124	0.089124	1.311479	1.311479	1.311479	0.772913	0.772855	2.136968	-11.764706
103	0	103_p41	70	59	103	-12.115722	-12.115722	55.921355	55.921355	110.749691	110.749691	110.749691	102.955712	102.955605	201.899955	-71.428571
122	-1	122_p41	71	63	122	0	0	0	0	0	0	0	0	0	0	0
123	0	123_p41	72	64	123	0	0	0	0	0	0	0	0	0	0	0
132	-1	132_p41	73	55	132	0.075477	0.075477	10.51977	10.51977	11.260753	11.260753	11.260753	6.108743	6.108706	6.19725	-24.437628
133	0	133_p41	74	56	133	-0.005722	-0.005722	0	0	0	0	0	0	0	0	0
153	0	153_p41	75	21	153	-0.159157	-0.159157	-88.641376	-88.641376	-76.849501	-76.849501	-76.849501	-77.984678	-77.984156	-61.993371	1032.727273
152	-1	152_p41	76	20	152	-0.120777	-0.120777	2.181246	2.181246	-1.9748	-1.9748	-1.9748	-2.618673	-2.618577	-7.38593	5.932203
173	0	173_p41	77	18	173	0	0	0	0	0	0	0	0	0	0	0
172	-1	172_p41	78	17	172	0.075752	0.075752	-13.184521	-13.184521	-14.003664	-14.003664	-14.003664	-7.227489	-7.227044	-8.752925	94.444444
143	0	143_p41	80	66	143	0	0	0	0	0	0	0	0	0	0	0
142	-1	142_p41	81	65	142	2.16985	2.16985	0	0	0	0	0	0	0	0	0
182	-1	182_p41	82	32	182	-1.608741	-1.608741	1.605289	1.605289	50.487451	50.487451	50.487451	24.466024	24.46599	83.59444	-900
183	0	183_p41	83	33	183	0.204464	0.204464	0.211644	0.211644	1.556408	1.556408	1.556408	2.647444	2.647451	3.797726	0
163	0	163_p41	84	23	163	1.099209	1.099209	-2.588614	-2.588614	-0.534893	-0.534893	-0.534893	1.417856	1.417858	3.166679	-466.666667
162	-1	162_p41	85	22	162	3.209747	3.209747	-16.919023	-16.919023	-29.849576	-29.849576	-29.849576	-23.984882	-23.98491	-33.554196	85
212	-1	212_p41	86	14	212	0	0	0	0	0	0	0	0	0	0	0
213	0	213_p41	87	15	213	0	0	0	0	0	0	0	0	0	0	0
193	0	193_p41	88	68	193	0.483595	0.483595	21.833307	21.833307	21.47838	21.47838	21.47838	16.211609	16.211042	13.261933	-33.153732
192	-1	192_p41	89	67	192	-0.518572	-0.518572	1.552395	1.552395	8.060915	8.060915	8.060915	22.682958	22.682968	27.743211	-100
232	-1	232_p41	90	29	232	1.555304	1.555304	-0.260241	-0.260241	8.561366	8.561366	8.561366	0.012059	0.012116	8.107967	133.333333
233	0	233_p41	91	30	233	-18.952224	-18.952224	-62.360148	-62.360148	-66.273856	-66.273856	-66.273856	-28.219153	-28.219141	-37.233039	-1740.613497
112	-1	112_p41	92	27	112	0	0	0	0	0	0	0	0	0	0	0
113	0	113_p41	93	28	113	-0.084253	-0.084253	0.614826	0.614826	0.772508	0.772508	0.772508	0.324301	0.324293	0.527267	7.756813
202	-1	202_p41	94	24	202	0	0	0	0	0	0	0	0	0	0	0
203	0	203_p41	95	25	203	0.380489	0.380489	-1.360752	-1.360752	-2.645696	-2.645696	-2.645696	-1.67366	-1.673663	-3.308462	-40
252	-1	252_p41	96	7	252	0	0	0	0	0	0	0	0	0	0	0
253	0	253_p41	97	8	253	0	0	0	0	0	0	0	0	0	0	0
243	0	243_p41	98	10	243	-4.826425	-4.826425	128.507333	128.507333	320.060039	320.060039	320.060039	101.360359	101.360363	274.750294	-62.613982
242	-1	242_p41	99	9	242	-1.661941	-1.661941	25.224293	25.224293	40.709305	40.709305	40.709305	16.693002	16.692997	33.812263	-59.459459
282	-1	282_p41	100	1	282	0	0	0	0	0	0	0	0	0	0	0
283	0	283_p41	101	2	283	0	0	0	0	0	0	0	0	0	0	0
223	0	223_p41	102	70	223	-0.162694	-0.162694	0	0	0	0	0	0	0	0	0
222	-1	222_p41	104	69	222	-28.740339	-28.740339	761.942067	761.942067	1135.145352	1135.145352	1135.145352	402.949067	402.949028	793.438673	-93.998716
272	-1	272_p41	105	11	272	0	0	0	0	0	0	0	0	0	0	0
273	0	273_p41	106	12	273	0.018234	0.018234	0.375077	0.375077	0.709242	0.709242	0.709242	0.362126	0.362152	0.694784	-1.910828
263	0	263_p41	107	5	263	-0.256318	-0.256318	1.647708	1.647708	3.20657	3.20657	3.20657	1.923052	1.923025	3.397724	-1.960784

Table A31: Lower White River Watershed, Percent Change 2001-2006, Stream Channels

StreamID	Sequence	OID	ID	In_m3/km	In_acft/mi	Runoff_mm	Runoff_m3	Sed_kg/ha	QP_m3/s	QP_mm/hr	SedP_kg/s	Pct_Error
14	16	15	14	0	0	0	0	0	0	0	0	0
24	18	17	24	0	0	0	0	0	0	0	0	0
44	17	16	44	-0.310627	-0.310627	-0.085689	-0.085689	-0.186932	0.394931	0.394906	1.767272	0
54	19	18	54	-0.130845	-0.130845	-0.042916	-0.042916	-0.46517	0.235727	0.235719	-0.776759	0
34	15	14	34	-0.266736	-0.266736	-0.400817	-0.400817	-0.117158	0.557024	0.55702	0.98479	0
84	21	20	84	-7.796322	-7.796322	-12.679786	-12.679786	-11.994916	-15.834763	-15.834772	-13.676904	-223.076923
74	14	13	74	5.13417	5.13417	8.312854	8.312854	9.088718	11.949358	11.949368	11.022099	-6.666667
64	20	19	64	0.806678	0.806678	3.597765	3.597765	4.351065	4.173474	4.173487	5.254125	-23.275862
94	24	23	94	-0.415263	-0.415263	3.020779	3.020779	3.064281	7.027657	7.027675	8.185618	3.703704
104	23	22	104	10.787143	10.787143	38.286737	38.286737	90.494141	71.592424	71.592461	155.415343	-99
124	25	24	124	10.794662	10.794662	21.987155	21.987155	36.461753	72.207352	72.207351	77.109514	-33.333333
134	22	21	134	2.268645	2.268645	6.230317	6.230317	4.222638	7.129244	7.12922	6.625979	8.533333
154	8	7	154	140.793616	140.793616	334.44647	334.44647	408.231654	108.422746	108.422733	118.493609	-80
174	7	6	174	152.562156	152.562156	257.161306	257.161306	482.974422	114.471964	114.471856	225.601731	-146.153846
144	26	25	144	10.41936	10.41936	17.350504	17.350504	11.992719	7.769734	7.769706	7.28615	191.666667
184	13	12	184	13.130243	13.130243	66.546293	66.546293	68.884789	121.560494	121.560362	145.087046	0
164	9	8	164	48.028033	48.028033	31.914995	31.914995	39.834324	3.989359	3.989428	14.511069	-80
214	6	5	214	-12.865537	-12.865537	-14.835182	-14.835182	-10.028569	8.658087	8.65807	13.01101	-50
194	27	26	194	20.389757	20.389757	42.675104	42.675104	16.971083	100.18869	100.18871	6.430067	-20
234	12	11	234	5.402166	5.402166	18.293097	18.293097	47.361487	0.571565	0.571552	36.165621	200
114	11	10	114	31.457832	31.457832	100.585203	100.585203	196.767846	208.301335	208.301252	456.924375	-10.526316
204	10	9	204	5.305613	5.305613	4.996657	4.996657	4.223884	0.955411	0.955401	-0.172854	-33.333333
254	3	2	254	3.359807	3.359807	3.055322	3.055322	7.503275	20.651972	20.651975	40.778946	0
244	4	3	244	10.15323	10.15323	32.092273	32.092273	57.573436	41.845765	41.845739	60.622719	-99
284	1	0	284	29.445517	29.445517	65.697966	65.697966	83.08186	47.098624	47.098706	50.689831	-48.717949
224	28	27	224	29.400085	29.400085	135.866222	135.866222	62.302526	330.026884	330.026968	68.141906	-98.888889
274	5	4	274	8.533367	8.533367	10.892645	10.892645	36.855957	19.476922	19.476979	43.925417	-100
264	2	1	264	8.359739	8.359739	24.910256	24.910256	26.999382	15.405977	15.405962	15.840703	-25
294	29	28	294	25.578617	25.578617	64.410334	64.410334	68.543858	98.357876	98.35788	173.791383	-600