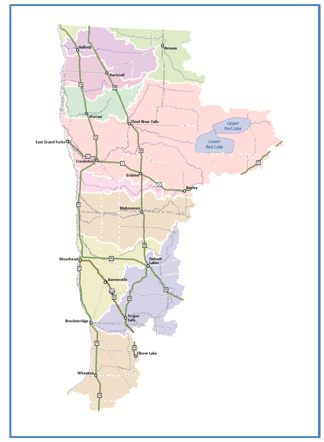
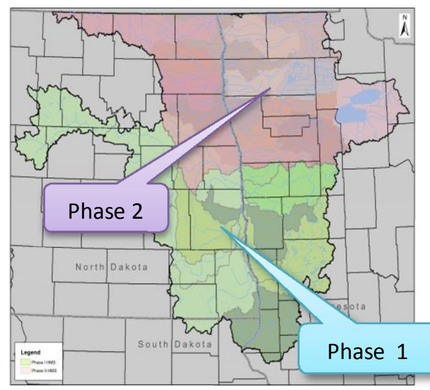
LiDAR-derived products in the Red River Basin: Overview of available products and those in development.

Prepared by Henry VanOffelen and Grit May, July 15, 2013



Hydrologically conditioned 5m DEMs and associated data for Minnesota and North Dakota watersheds in the Red River Basin

Conditioned DEMs were complete for the entire Red River Basin in Minnesota and North Dakota in 2012 and 2013. This work was conducted by engineering firms in the region as part of the U.S. Army Corps of Engineers Red River Watershed feasibility study (http://www2.mvp.usace.army.mil/fl_damage_reduct/default.asp?pageid=1237). The project area was divided into watersheds generally based on the Hydrologic Unit Code (HUC) level 8 basins of the Red River Basin. Original boundaries used for HEC-HMS model development varied slightly from the HUC 8 basins in some areas to better align with existing jurisdictional units of government (watershed district boundaries). Final watershed boundaries for HEC-HMS models and associated data products (Table 1) were derived during model development. The purpose of creating these conditioned 5m DEM was to develop HEC-HMS hydrologic models for each watershed area (see http://www.hec.usace.army.mil/software/hec-hms/ for information on the HEC-HMS model).



The conditioning process was completed in two phases. Conditioning of watersheds upstream of Halstad, Minnesota, was completed in 2012. Conditioning of watersheds downstream of Halstad, Minnesota was completed in 2013.

A standardized approach to the conditioning process was used in all watersheds. The process included creating vector data for "burn" lines, "breach" lines, and "wall" lines and using the lines to condition a base 5m DEM utilizing ArcHydro and spatial analyst tools. (see http://www.rrbdin.org/resources/hydrologymodels).

List of key LiDAR-derived grids produced in Red River Basin HEC-HMS modeling efforts
5m Raw DEM (based on model key points)
Prefilled DEM (2 acre DA threshold)
Filled DEM
Conditioned DEM (Agree DEM)
Burn Lines (lines following a flow path such as a defined stream or ditch)
Breach Lines (lines cutting through an embankment such as roadway embankments)
Wall Lines (lines which refine a flow path between two or more competing flow paths, for example, where a cross-country ditch intersects a lower capacity roadway ditch)
Flow Accumulation
Flow Direction
Slope
Stream definition (2 sq. km threshold)
Stream Link
Catchment
Travel Time
Non-Contributing Areas (100-yr 24 hour storm event)

These data products are available for each HEC-HMS derived watershed boundary and will be posted on www.rrbdin.org by fall 2013. Please note that the watershed boundaries were derived watershed by watershed for this hydrologic modeling and were not edge-matched to resolve overlaps and gaps between neighboring watershed boundaries.

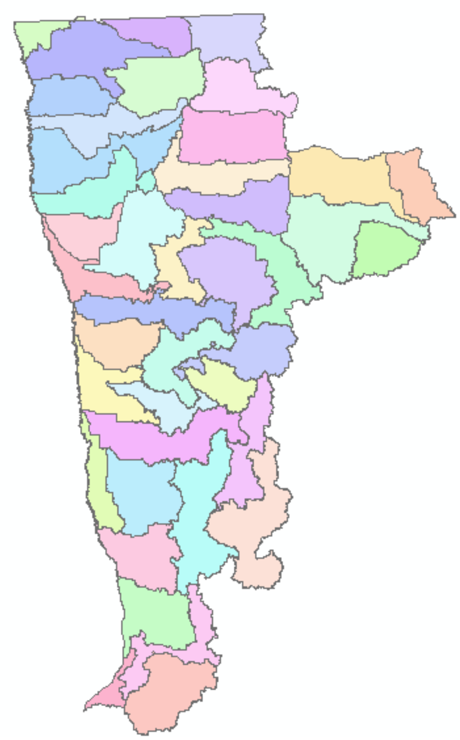
For information contact Zach Herrmann (zherrmann@houstoneng.com, 701.499.2054) or Ted Shannon (tshannon@hdrinc.com, 763.278.5942).

Hydrologically conditioned 3m DEMs and associated data for the Minnesota portion of the Red River basin

Two separate efforts have resulted in a complete set of hydrologically conditioned 3m DEMs for the Minnesota portion of the Red River Basin.

1. Houston Engineering (HEI) has completed an intensive "re-conditioning" of the conditioned 5m DEM in the Buffalo-Red River and Sand Hill River watershed districts. These DEMs were created as part of a Watershed Restoration and Protection Plan (WRPP) and through two BWSR-based Clean Water grants. The goal of these efforts was to develop an intensively conditioned 3m product in order to create a suite of LIDAR-derived data for prioritizing areas of the landscape to implement activities to improve water quality i.e. overland catchment sediment yield through Stream Power Index (SPI) and Revised Universal Soil Loss Equation (RUSLE), see http://www.bwsr.state.mn.us/projects/Upper%20South%20Branch%20Buffalo%20River.pdf. The HMS-based conditioning products (burn, breach, and wall lines) were used as a basis for the more intensive conditioning process than the HMS effort . This more intensive conditioning effort reviewed much finer scale catchment boundaries. For information contact Zach Hermann (zherrmann@houstoneng.com, 701.499.2054).

2. The International Water Institute (IWI) in collaboration with the Minnesota Center for Environmental Advocacy and Minnesota DNR have created hydrologically conditioned 3m DEMs for all remaining watersheds in the Red River Basin. These DEMs were created as part of a BWSR Clean Water Accelerated Implementation grant whose goal is to create a suite of LIDAR-derived data for prioritizing areas of the landscape to implement activities to improve water quality (i.e. landscape retention analysis, overland catchment sediment yield, and stream power index described later). These DEMs simply used the HMS-based conditioning products (burn, breach, and wall lines) to condition a 3m DEM using a prefill threshold of 0.17 acres. Unlike the conditioning efforts described in item 1, no additional conditioning was done due to project funding limitations. The Red River Basin was divided into 42 different watersheds for this analysis. These boundaries were based on the Hydrologic Unit Code (HUC) level 10 watershed subregions. Some neighboring subregions were merged to increase processing efficiency. For information contact Grit May (grit@iwinst.org, 701-261-0330) or Henry Van Offelen (henry.van.offelen@state.mn.us 218-849-5270).



42 Project Watersheds – Red River Basin in MN

Landscape Retention Analysis

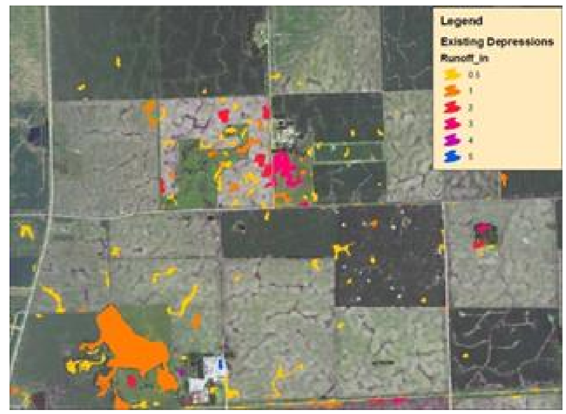
Landscape retention analysis is the process developed in the Red River Basin to use LiDAR data and standard raster-based analysis methods to systematically assess the landscape's topography to identify depressional features with capacity to retain runoff from their drainage areas.

These retention layers are available for viewing at http://gis.rrbdin.org/pptviewer/ under the "project planning tool" set of data. The analysis used the 3m hydrologically conditioned DEMs as a foundation for the following set of data products:

Existing depressions

Existing depressions are depressional areas on the landscape that currently retain runoff. These areas were identified using standard raster-based analysis methods in ArcGIS utilizing spatial analyst tools. The analysis first identified all existing depressions resulting in a dataset known as "base depressions" which includes a basic set of attributes for individual depressions including their volume, depth, area, and drainage area. These base depressions were further analyzed using a landscape fill and spill process to characterize depressions by the volume of runoff they could retain (assume Cn= 100). The result of this analysis is a set of polygons categorized by runoff volume (0.5-1", 1"-2", 3"-4", 4" – 5", 5+") and their associated drainage area polygons.

Existing Depressions classified by Inches of Runoff retained



Existing road-associated depressions

Road-associated depression analysis identifies areas on the landscape that would retain runoff if culverts were plugged and current roads were used to retain water. The intent of this analysis is to identify areas with topography conducive for temporary water storage. These areas were identified using standard raster-based methods in ArcGIS utilizing spatial analyst tools. The analysis first identified all "base road depressions" which includes a basic set of attributes for individual depressions including their volume, depth, and area. These base depressions were further analyzed using a landscape fill and spill process to characterize depressions by the volume of runoff they could retain (assume Cn= 100). The result of this analysis is a set of polygons categorized by runoff volume (0.5-1", 1"-2", 3"-4", 4" – 5", 5+") and their associated drainage areas. Drainage areas of the road-associated depressions are based on a 3-meter conditioned DEM and thus represent the true drainage area for the site (not one confined by road features). The data is filtered to only include depression areas with more than 200 acre-feet of storage capacity.

Existing Road Depressions in rose

Raised road-associated depressions

Raised road-associated depression analysis identifies areas on the landscape that would retain runoff if culverts were removed and current road beds were raised 3 meters (~10 feet) to retain water on the upstream side of the road. The intent of this analysis is to identify areas with topography conducive for temporarily storing water such as some of the recent water detention projects implemented by watershed districts. These areas were identified using standard raster-based methods in ArcGIS utilizing spatial analyst tools. Since raising all roads would result in many cells with no drainage area (similar to a waffle), raised road analysis is conducted twice in each watershed – once with North-South oriented roads and once with East-West oriented roads. These analyses first identified all “base raised road depressions” which includes a basic set of attributes for individual depressions including their volume, depth, and area. The East-West and North-South base depressions were further analyzed using a landscape fill and spill process to characterize depressions by the volume of runoff they could retain (assume Cn= 100). The result of this analysis is a set of raised road polygons categorized by runoff volume (0.5-1”, 1”-2”, 3”-4”, 4” – 5”, 5+”) and their associated drainage areas. Drainage areas of the raised road depressions are based on a 3-meter conditioned DEM and thus represent the true drainage area for the site (not one confined by road features). The data is filtered to only include depression areas with more than 200 acre-feet of storage capacity.

Raised Road Depressions in blue

Typical Water Retention Site During Spring Operation

Water Quality Related Data

A suite of water quality related LiDAR-derived data products will be created for the entire Red River Basin as part of the WRPP processes and the BWSR Clean Water Accelerated Implementation grants described above. The foundation for this analysis are the hydrologically conditioned 3-meter DEMs. For each of the product categories described below, raw and ranked raster data will be available for the entire Red River Basin as well as data summarized for each “overland catchment” (e.g. mean SPI for catchment). Overland catchments were derived using raster-based GIS methods. They include all areas where a flow path had a contributing area of less than 0.5 square kilometers (~124 acres).

Ongoing coordination among the International Water Institute, Houston Engineering Inc., and DNR staff will ensure consistent generation of standard products throughout the Red River Basin - see ‘Upper South Branch BMP Strategic Plan’ for more detailed methods and examples.
http://www.bwsr.state.mn.us/projects/Upper%20South%20Branch%20Buffalo%20River.pdf
http://www.brrwd.org/pdf/cwf/2011-10-04%20Report%20combined.pdf

Stream Power Index (SPI)

Two versions of a “stream power index” are planned to be generated for the entire Red River Basin. The first version will be the traditional stream power index (SPI) based on slope and flow accumulation. The second version is currently being tested to determine whether it provides additional information to help prioritize clean water implementation activities. This modified version will consider storm event volume accumulation and the length-slope related factors rather than single cell slope and flow accumulation. More details on these products will be forthcoming soon and data should be available by mid-summer 2013.

Revised Universal Soil Loss (RUSLE)

A RUSLE grid will be created for the entire Red River Basin. The grid will be developed using standard methods and the best available input data. A sediment delivery ratio will be applied to also develop estimates of sediment delivery to each overland catchment pour point. More details on these products will be forthcoming soon and data should be available by mid-summer 2013.

Overland Catchment Sediment Load

Ranked values of RUSLE and SPI will be combined to create a composite sediment yield score for each overland catchment. Overland catchments were derived using raster-based GIS methods. They include all areas where a flow path had a contributing area of less than 0.5 square kilometers (~124 acres).

Example of Sediment Load Scores Ranked for Overland Catchment