Annual Technical Report

2014 Matanuska-Susitna Watershed Hydrographic Mapping Program: A USGS-Compliant Update of Mat-Su Lakes, Rivers and Streams

Agreement Number: 15-027K
Agreement Name: *2014 Matanuska-Susitna Watershed Hydrographic Mapping Program: A USGS-Compliant Update of Mat-Su Lakes, Rivers and Streams*
Award Term: 7/1/14-06/30/2015
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Technical Progress Report

Introduction:

The purpose of this report is to identify progress on an ongoing, multi-agency effort to update the USGS National Hydrographic Database (NHD) and the Alaska Hydrographic Database (AK Hydro) in the Mat-Su basin. Specifically, this report focuses on work accomplished under Matanuska-Susitna Borough (MSB) agreement *15-027K 2014 Matanuska-Susitna Watershed Hydrographic Mapping Program: A USGS-Compliant Update of Mat-Su Lakes, Rivers and Streams.* Through this agreement, TNC has allocated MSB/CIAP funds supporting conflation of validated stream geometry to the USGS NHD and the Alaska Hydrographic Database in the Mat-Su Core Planning Area.

Two contractors were chosen to complete the tasks outlined in this agreement; St. Mary's University of Minnesota Geospatial Services Group (SMUMN) was engaged to conduct the systematic validation of elevation-derived flowlines and subsequent conflation to the NHD, and the Palmer Soil and Water Conservation District (PSWCD) was engaged to conduct field observations of modeled streams to support the validation process and assignation of stream classifications of intermittent, perennial and ephemeral. The following identifies progress for each of the tasks listed in this agreement.

Task List and Progress

1. Create digital elevation model and stream/drainage lines within the area of interest

100% complete. A Mat-Su basin-wide (~25,000 square mile), five meter resolution DEM was created by merging elevation data from the Mat-Su LiDAR and Statewide Digital Mapping projects (*Figure 1*). The basin-wide DEM was subsequently hydro-conditioned and hydro-enforced to ensure that modeled flows across the digital landscape accurately reflect ground conditions. Hydro enforcement and conditioning was assisted by refining geometry and positioning of the ADF&G Culvert Database. ADF&G culvert locations were compared against recent, high-resolution Mat-Su aerial photography and elevation data and edited to a) more accurately describe the location of each culvert and b) more accurately describe the geometry of each culvert. Once ADF&G culvert data were modified, each culvert was "burned" into the underlying DEM to ensure that modeled flow is as accurate as possible (See Appendix A for further information).

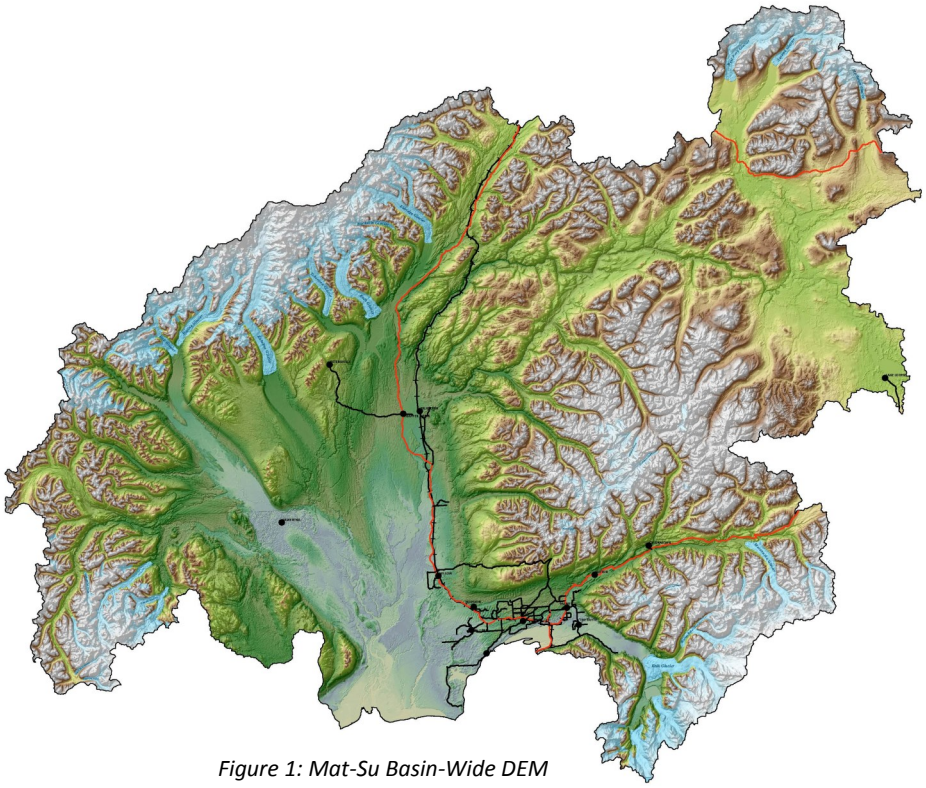


Figure 1: Mat-Su Basin-Wide DEM

Next, a preliminary draft of a Mat-Su basin-wide synthetic model of drainage lines was developed *(Figure 2).* The synthetic stream model presents over 100,000 lineal miles of streams in the Mat-Su basin. The modeled drainage lines were developed in a custom FORTRAN application by TerrainWorks, Inc. It should be noted that Mat-Su local experts and agency staff agree that the code and processing capability provided by TerrainWorks resulted in a flow model which is superior in accuracy to flowlines produced by commercial off the shelf modeling applications. As NHD Updates occur throughout Alaska following the availability of new elevation data from the Statewide Digital Mapping Initiative, we recommend this method of modeling elevation derived streams in the future.

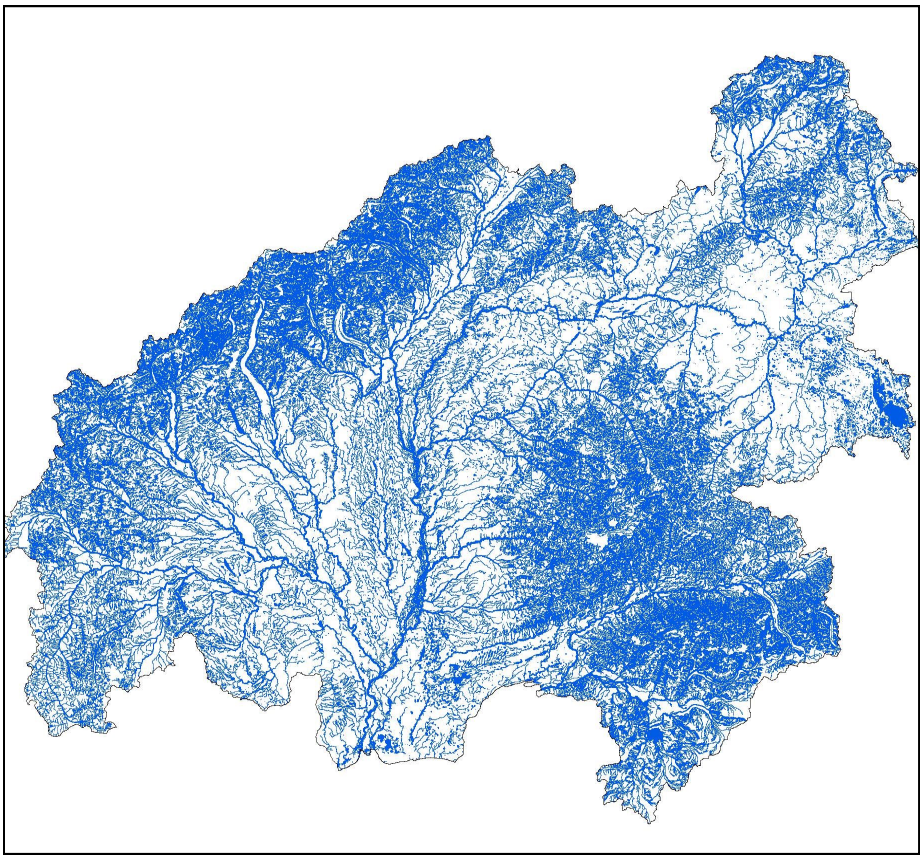


Figure 2: Mat-Su basin-Wide Synthetic Drainage Lines

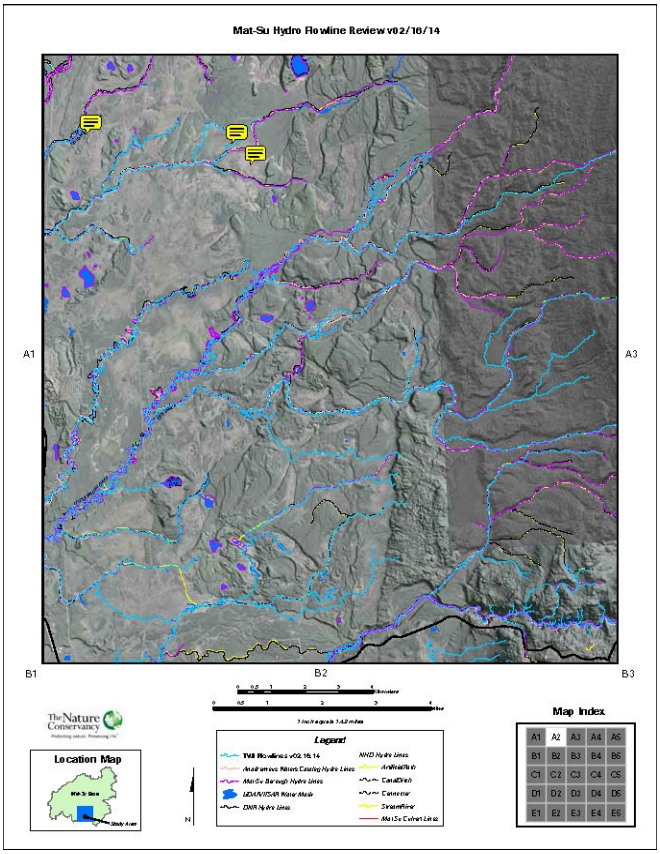


Figure 3: Data Used For Expert Review of Synthetic Stream Model

2. Compare new stream lines to existing stream lines for accuracy and calibrate model

100% Complete. Before the modeled drainage lines were considered ready for validation and conflation tasks, three iterations of the model were developed which were successively reviewed by a group of local experts familiar with Mat-Su hydrologic systems. During each iteration, local experts were provided with existing hydrographic data sets as well as high resolution aerial photography and topographic relief which were used as a comparison to the newly modeled drainage lines *(Figure 3).* Experts were invited to comment on situations where the model appeared to accurately place drainage lines and where the model needed improvement. After the third iteration of the model, it was agreed that model parameters were calibrated to the best of our ability and systematic validation of the model was initiated.

3. Perform quality control and assurance on the new stream lines by verifying with imagery stream locations, identify drainage vs. perennial streams, ensure topology and connectivity are consistent, create standard attributes and ensure streamlines conform to AK Hydro data model and NHD data model
Pilot Project Area: 100% Complete. Outlying Areas: Ongoing.

On July 1, 2014, SMUMN initiated a systematic validation of newly modeled Mat-Su stream lines, including review of the geometric configuration and the spatial accuracy of the derived line work using reference spatial datasets available for the Mat-Su basin including: SDMI SPOT 5, LiDAR, LiDAR collected reflectance imagery, Mat-Su LiDAR mission high resolution aerial imagery, IfSAR ORI and IfSAR DTM. The horizontal accuracy of the spatial datasets produced by this validation process meets the National Map Accuracy Standard (NMAS) of +/- 12 meters for 1:24,000 scale map data. Stream classifications "intermittent", "perennial" and "ephemeral" and validated initiation points are assigned to modeled hydrography throughout the project area based on conclusions, parameters and rules drawn from field validation exercises conducted by project staff and partnering organizations during the summer of 2014.

Once stream geometry is validated, SMUMN applies a series of QAQC, topological and database schema checks to ensure the data are prepared for the AK Hydro Database as well as applying the USGS NHD Edit Tools to ensure errorless conflation to the USGS National Hydrographic Database.

4. Perform targeted field verification during summer months
100% Complete. On July 1, 2014, the Palmer Soil and Water Conservation District (PSWCD) began field verification of modeled stream lines which progressed through the summer months of 2014. Field operations required that PSWCD staff navigate to stream locations previously identified by SMUMN (Figure 4) and make field observations in order to accurately assign stream initiation points as well as to collect data elements which guide the SMUMN team in the assignation of stream classifications intermittent, perennial and ephemeral. Further, during the week of July 18, 2014, staff from SMUMN joined PSWCD and TNC staff for one week of field observations. This week included one day of rotary wing, aerial reconnaissance in which data for 24 locations not approachable on the ground was collected by SMUMN staff.

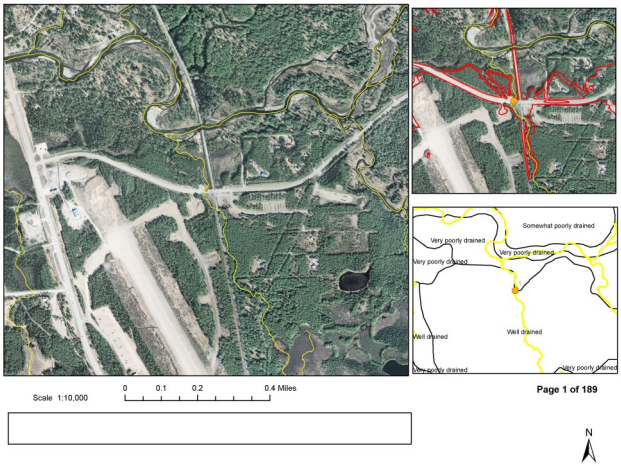


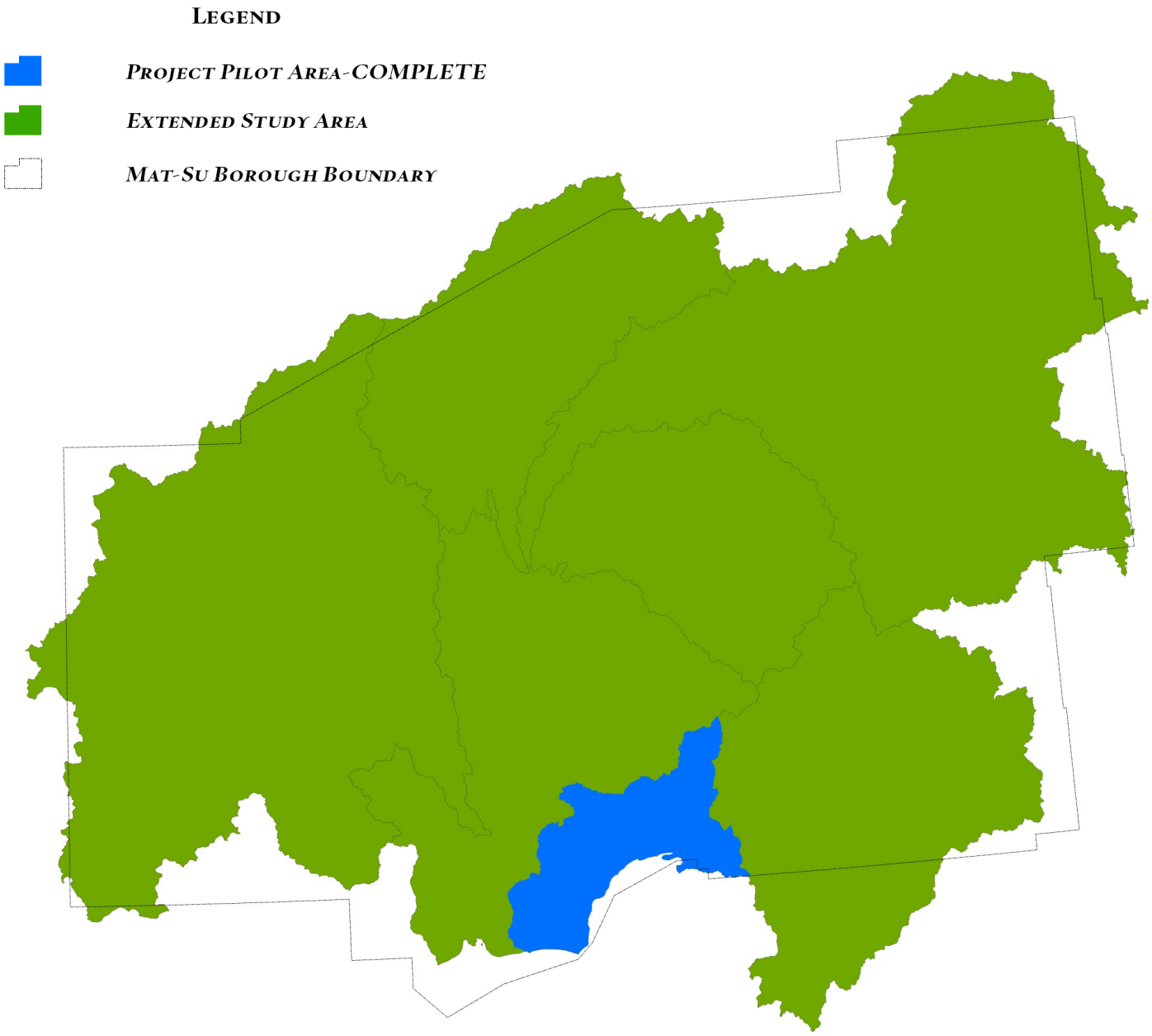
Figure 4: Field map Used for Stream Validation

5. Conflate the new stream layer to the USGS NHD
Pilot Project Area: 100% Complete. Outlying Areas: Ongoing. The pilot project area has been successfully conflated to the NHD without error. Outlying areas will be conflated to the NHD over the next several months, with project completion planned for December 31, 2015. It should be noted that the accuracy and resolution of the validated stream geometry is high enough to warrant a global replacement of existing NHD stream geometry throughout the entire Mat-Su basin, rather than retain existing stream geometry.

Progress Map

The following map demonstrates validation and conflation progress for the time period 07/01/14 to the present. TNC initially engaged St. Mary's University of Minnesota to perform validation and conflation tasks on a pilot area comprised of three, USGS HUC 10 polygons and covering the Mat-Su Borough "Core Planning Area". This pilot area is represented in blue in the graphic below and was chosen as a proof of concept, allowing SMUMN to accurately determine a budget and schedule to perform validation tasks on surrounding areas of the basin and to refine technical workflows for the validation and conflation tasks. All Validation and conflation tasks for the pilot area were completed in November, 2014.

Since then, an extended study area (in green below) was identified and SMUMN is progressing with validation and conflation of the extended study area on schedule .



Conclusions and Future Recommendations

Recent availability of high resolution elevation data in Alaska through the Statewide Digital Mapping Initiative as well as local LiDAR projects creates an opportunity to revolutionize mapping and analysis of Alaska freshwater resources. The process of modeling elevation-derived flow networks and subsequent validation of modeled streams through expert review, field observations and desktop analyses provides an accurate and cost efficient path to populate or update high resolution state and federal hydrographic mapping programs. Furthermore, by modeling elevation derived streams, we create a hydrologic network which is implicitly tied to the terrain; this is not the case for much of the nationwide NHD which causes an abundance of costly mapping problems and lowers the analytic potential of the data. The stream-to-landscape relationship in the Mat-Su NHD update creates prospects for several derivative mapping projects, two of which are already under consideration; populating the first USGS/EPA NHDPLus database of its kind in Alaska, and mapping of the Mat-Su Active River Area, or topographical floodplain.

NHDPLus

NHDPLus is a database managed by the USGS and EPA consisting of high resolution NHD, the USGS Watershed Boundary Database, hydro-conditioned DEMs and a suite of value added datasets and models. The vision behind NHDPlus is the development of "integrated hydrography": to ensure that hydrography and digital elevation models are derived from the same high resolution source, such as LiDAR or IfSAR, and to provide analytic capabilities which allow users to concurrently analyze characteristics of both hydrography and its corresponding terrestrial drainage area, or catchment. A network of users, including TNC, the Alaska Hydrography Technical Working Group, the Kenai Watershed Forum and Horizon Systems are currently collaborating to produce an NHDPlus pilot project in the Mat-Su. Funded through a multi-state National Fish Habitat Partnership grant, the Mat-Su NHDPLus pilot project shares the same geographic area as the Mat-Su NHD update pilot project. Once the NHDPLus pilot project is complete, sponsoring organizations will work to fund NHDPlus throughout the entire Mat-Su basin. In the meantime, TNC is preparing three additional NHDPLus "modules" which are thematic groups of data and business tables coupled with the basic NHDPLus framework to extend NHDPLus analytic capabilities and decision support. The modules are; salmon habitat, economic geography of Mat-Su salmon and Mat-Su land use/human activities.

Active River Area

The Mat-Su basin experiences periodic flooding events which have resulted in loss of human life and property. Further, Mat-Su riparian wetlands and flood prone areas which provide essential flood regulating services, water quality services and salmon habitat have not been mapped, making it difficult for Mat-Su planners and developers to design projects which avoid conversion of high value riparian wetlands. Building on the components of the Mat-Su NHD update and NHDPLus, TNC and partnering organizations are assembling a project plan to initiate an Active River Area mapping project in the Mat-Su basin. Active River Area is a concept developed by TNC scientists which uses high resolution terrain and highly accurate hydrography to simulate the extent of floodplains, meander belts, terraces, material contribution areas and riparian wetlands. Active River Areas include both the river channels and the drainage areas necessary to accommodate the physical and ecological processes associated with the river system. In other words, the Active River Area represents the geography required for the river to function in ways necessary for it to function and provide services to natural systems and human communities.

Mapping of Active River Areas has provided communities, planners, regulators, conservationists and agency staff with a planning tool supporting a wide range of decisions such as erosion and flood management, water quality, infrastructure, transportation and zoning.

Appendix A: DEM Conditioning Using Modified ADF&G Culvert Locations

Conditioning DEM's such that modeled hydrologic flows best represent ground conditions (and thus decrease validation labor costs) is an integral component of elevation-derived stream modeling. Without hydro-conditioned elevation data, modeled flowlines will require laborious editing and significantly increase validation and conflation costs.

DEM's for the Mat-SU NHD Update were hydro conditioned in the following manner:

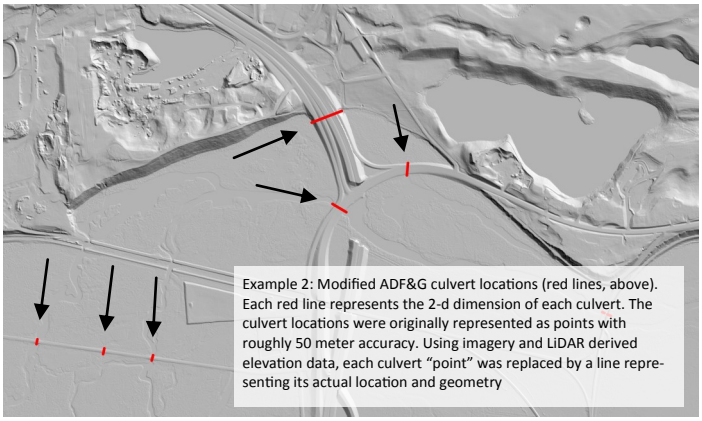
Hydro Breaklines: Elevation data from the Mat-Su LiDAR and SDMI projects were hydro flattened as a project deliverable. Hydro flattening requires that all lakes and streams meeting a minimum mapping area are hand-traced with closed polylines, or breaklines. Eventually, raw elevation data in water bodies are removed and replaced with synthetic elevations interpolated from vertices composing the hydro breaklines. The synthetic elevations are monotonic, they gradually decrease downstream.

Bridges: The Mat-Su LiDAR project encompasses the populated areas and road network of the Mat-Su basin. As a component of the Mat-Su LiDAR project, all major bridges spanning rivers were removed from the DEM's.

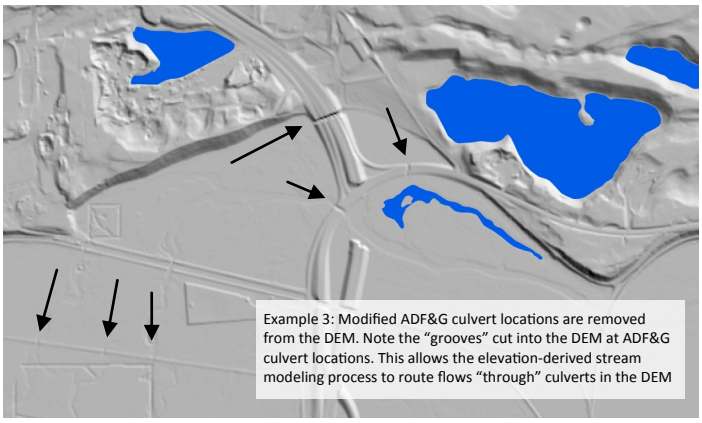
Culverts: Once ADF&G culvert locations were modified to best reflect their location and geometry (2-d dimensions), TWI, Inc., used custom FORTRAN code to remove a "notch" in the DEM at each culvert location. This allows flow to accumulate in culvert locations and ultimately results in the accurate placement of modeled flowlines.

Final, Hydro-Conditioned DEM: Once the DEM is fully hydro conditioned, it is the process of modeling elevation-derived flowlines, or synthetic streams, can begin. The custom FORTRAN code written by TWI, Inc. for modeling flowlines identifies flow direction and flow accumulation for each DEM cell and "builds" a flow network of lines which are placed on DEM channels where streams are likeliest to exist. This makes the validation process considerably simpler, and less expensive, as fewer modeled lines require pruning and editing. Further, by implicitly tying culvert locations to the flow network, we will be able to accurately conduct analyses on flows through specific culverts such as upstream aggregation of lineal stream miles. This can help agencies prioritize culverts for replacement and fish passage considerations.

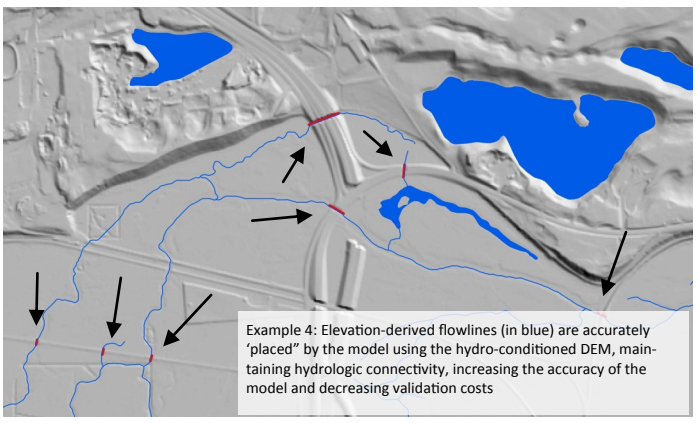
Example 1: Aerial Photo of Parks/Glenn Highway Interchange. There are multiple culverts in this area.



Example 2: Modified ADF&G culvert locations (red lines, above). Each red line represents the 2-d dimension of each culvert. The culvert locations were originally represented as points with roughly 50 meter accuracy. Using imagery and LiDAR derived elevation data, each culvert "point" was replaced by a line representing its actual location and geometry



Example 3: Modified ADF&G culvert locations are removed from the DEM. Note the "grooves" cut into the DEM at ADF&G culvert locations. This allows the elevation-derived stream modeling process to route flows "through" culverts in the DEM



Example 4: Elevation-derived flowlines (in blue) are accurately 'placed" by the model using the hydro-conditioned DEM, maintaining hydrologic connectivity, increasing the accuracy of the model and decreasing validation costs