TWISP RM 0.5
CONCEPT DESIGN REPORT:

June 25, 2013 Draft

Provided for:
The Confederated Tribes and Bands of the Yakama Nation
P.O. Box 151, Fort Road
Toppenish, WA 98948

Twisp RM 0.5 – Concept Design Report:

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June 25, 2013

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Introduction

This conceptual design report describes restoration actions proposed along the Twisp River valley bottom between RM 0.2 and 0.7 (henceforth referred to as "the Project Reach"). The goal of the proposed work is to restore habitat conditions beneficial to ESA-listed salmon and steelhead populations in accordance with the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007), and the associated Biological Strategy (RTT 2013). This report summarizes analyses and conceptual designs, preliminary design criteria, previous assessment work completed in the reach, and regional objectives that guide habitat work in the Upper Columbia salmon recovery region. Following review and approval by affected landowners and interested parties, permit and final design construction drawings will be produced under the guidance of the Yakama Nation Upper Columbia Habitat Restoration Project.

Previous Assessments

The concepts provided in this report build off work conducted as part of the Methow Sub-basin Geomorphic Assessment (USBR 2008a), also known as the Tributary Assessment, and the Yakama Nation's Reach Assessment of the Twisp River from RM 0.0 to RM 7.8 (Inter-Fluve 2010). The Tributary Assessment provided a watershed and valley-scale context for primary controls on bio-physical processes and helped us to prioritize which reaches in the Methow Subbasin to focus on for salmon habitat restoration actions. The Reach Assessment describes conditions operating at the scale of individual river reaches and sub-reaches and proposes restoration project opportunities at distinct geographical locations to address priority ecological concerns impeding salmon recovery goals.

Regional Objectives

The Upper Columbia Salmon Recovery Board Regional Technical Team (RTT) has identified ESA listed (endangered) spring Chinook salmon and steelhead spawning and rearing habitat as a current use within the Project Reach (Lower Twisp Assessment Unit). ESA listed (threatened) Bull trout also use the Project Reach for rearing and migration, but not for spawning.

Factors affecting habitat conditions for salmonids in the Lower Twisp River Reach have been identified by the RTT as:

- Low instream flows and higher water temperatures affect salmonid rearing. (The lower Twisp is Washington State 303(d) listed for inadequate instream flow and temperature exceedance.)
- In several places, the Twisp River has been cut off from its floodplain and side channels by constructed dikes and riprap, resulting in a simplified channel
- Large wood and recruitment potential are well below geomorphic potential
- The MVID West Canal diversion annually disturbs salmonid rearing and spawning habitat by diverting the river with a push-up berm
- Development of riparian and floodplain areas has impaired channel migration, riparian condition, and floodplain function
- Residential development has impacted former riparian habitat

The above factors have cumulatively impacted several components of river ecology and salmonid habitat in the Project Reach. The RTT has prioritized a list of restoration actions to address key ecological concerns impeding salmon recovery goals in the Lower Twisp River, prioritized in summary below.

1) **Water quantity:** Improve water storage, floodplain function, and potential for beaver recolonization. Increase stream flow through improved irrigation practices.
2) **Channel structure and form** (bed and channel form): Remove levees to provide access to floodplain habitats. Reduce the amount of bank armoring where possible.
3) **Peripheral and transitional habitats** (side channel and wetland habitat conditions): Reconnect disconnected side channels and low areas where reduced wood loading has reduced inundation frequency. Improve wood complexity within side channels.
4) **Channel structure and form** (instream structural complexity): Install large wood jams to provide short-term habitat function and intermediate-term channel form benefit, consistent with geomorphic context and potential biological benefit.
5) **Riparian condition.** Restore degraded riparian areas associated with past logging or development. Fence off riparian areas and wetlands as necessary to recover and protect.
6) **Food** (altered primary production). Improve where possible.
7) **Sediment** (increase sediment quantity). Where possible, improve natural large wood and alluvial sediment transport rates from natural lateral channel migration processes.
8) **Species interactions** (introduce competitors and predators). Reduce or eliminate brook trout in Buttermilk and Little Bridge Creek.

The above recommendations of the RTT were used to guide development of the concepts provided in this report.

Design Criteria

Designs for the Project Reach were developed with consideration of the regional guidance as previously noted, and with physical and landowner constraints in mind. Our design criteria ensure that project objectives and constraints are clearly documented and understood. The design criteria used for restoration concepts are outlined below.

Geomorphology/Hydrology

- Design projects that are consistent with current and projected hydrologic and geomorphic patterns and processes
- Design projects that restore or mimic historical channel structure and complexity to promote juvenile rearing habitat
- Mimic natural large wood recruitment and retention processes to increase cover and roughness

Habitat

- Design projects to enhance ESA-listed spring Chinook salmon and steelhead populations:
  - Creation of off-channel habitat
  - Placement of large woody material
- Design projects to restore in-channel geomorphic processes and resulting habitat:
  - Pool scour near side channel or alcove inlets
  - Large wood recruitment and retention
  - Floodplain inundation
- Design projects to provide immediate and direct benefits to target fish species:
  - Cover
  - Channel complexity
  - Velocity refuge
  - Increased food sources

Engineering

- Design resilient project geometry that:
  - Maintains sediment transport continuity (e.g. through side channels)
  - Achieves desired levels of lateral channel stability
  - Achieves desired levels of vertical channel stability
  - Addresses potential beaver impacts, where possible
  - Maximizes surface water connectivity

- Accounts for residential land use, bridges, and infrastructure
- Maximizes low-flow habitat use and high-flow inundation habitat
- Maximizes flow for off-channel habitat function and connection to the Twisp River
- Do not jeopardize the 100-year flood capacity of existing flood protection levees
- Do not reduce the stability of existing riprap protecting levees

Safety

- Design projects that take recreational use and safety into account, including:
  - Appropriate visibility
  - Appropriate amount of channel encroachment by wood structures

Feasibility

- Minimize impacts to fish during the construction process
- Minimize impacts to intact wetland habitat

- Utilize onsite resources or plan channel alignments to take advantage of existing natural features where feasible (e.g. trees and beaver dam locations)
- Consider proximity to access routes and utilize existing access where possible

Project Existing Conditions

Land Use

Land ownership is private and public within the Project Reach. Houses, a mobile home park, a hotel, a major highway bridge, and a city park are land uses occurring within and adjacent to the Project Reach.

Reach-Scale Geomorphology

The Methow and Twisp Rivers have gradually incised into glacial river deposits (Konrad et al 2005) that had been transported into the valley and deposited during the last glacial retreat. This process left behind valley-wall terraces and historic river signatures. It is within these incised glacial terraces that the slope of the Twisp River flattens near the Methow River. A broad alluvial fan has been created over years of sediment deposition, extending from the Twisp/Methow confluence upstream to RM 0.5. Residential housing and park land are on this alluvial fan surface.

Alluvial fans are dynamic and unstable landscapes, where flooding and sediment deposition can cause frequent changes in channel course, channel braiding, and avulsions. An avulsion occurs when a channel shifts to a new location or to a previously abandoned channel. In the Project Reach, natural channel braiding and avulsion are now prevented by levees and riprap, which were built to allow residential development on the alluvial fan surfaces. Review of the historical photos records provides confirmation that relatively small degrees of channel movement have occurred where the levees and riprap have been installed.

However, two areas of recent change have occurred in areas of the Project Reach that are not controlled or influenced by riprap and levees. The first area is downstream of the levee protecting city park land near RM 0.2. Here, the channel segment has gradually migrated north. The second area of change is located between RM 0.45 and 0.6 where the channel has shifted between two alignments and experienced split-flow conditions in 1985 (USBR 2008a).

Ice flow conditions are known to exist within the Twisp River. Ice flows develop as river ice breaks up during the late winter and spring. The timing of breakup, river stage, and the volume of ice accumulated in the river before breakup are controlling factors that influence the energy and potential channel alterations that could occur. During large ice flows, ice jams can form and alter the course of the river, causing impact damage and scouring at existing trees, logjams, and banks. In many cases this natural process would limit the types and extents of large wood habitat projects in or adjacent to the river. While ice flows are known to exist in the Project Reach, the relative confinement within the Project Reach make it less likely that a large ice jam will form here compared to wider areas in the Twisp River Valley. Risk of ice damage to constructed logjams will be relatively low due to project location, proposed structure exposure, and ballasting techniques.

LOCAL CHANGES TO NATURAL PROCESSES

As noted, levees and riprap play a large role in existing river processes in the Project Reach. Currently, 2,800 feet of right bank levee and 1,000 feet of left bank levee line the banks within the Project Reach. Our survey and hydraulic model results show that the levee does appear to protect residential housing and city park land from flooding up to the 100-year flood, except at RM 0.5, where the model suggests that a short segment of left bank levee becomes overtopped for flows greater than 25-year flood.

While the levees have helped protect residential housing and city park land, the levee network has left the channel in a relatively static, simplified condition with scant and poor quality habitat for salmonids.

TWISP RIVER HYDROLOGY

The natural hydrologic regime of the Twisp River is driven by annual snowmelt runoff and low frequency rain-on-snow flood events. Natural stream flow patterns in the main stem are altered by flow diversions. Diversions reduce low-flow volume in the river during irrigation season, which typically runs from April through September.

Analysis of the peak-flow record provides estimates of discharge for flood return intervals of interest that provide a basis for hydraulic modeling and analysis. The Project Reach falls within previous peak-flow hydrologic analysis efforts completed by the Bureau of Reclamation near the mouth of the Twisp River. The Reclamation peak-flow analysis will be used for all hydraulic modeling efforts within the Project Reach. The modeled discharges include the 2-, 5-, 10-, 25-, 50- and 100-year recurrence interval floods (Table 1).

Low-flow hydrologic information was also collected to calibrate low-flow stage in the Project Reach. Low flows were taken from the nearby Twisp River USGS gage (RM 2.0) during topographic survey dates. Surveyed water surface elevations and USGS gage derived discharge were used to calibrate low-flow hydraulic model conditions.

Table 1 Peak Discharge Estimates

Flow Event	Discharge (cfs)
2-year	2,130
5-year	3,169
10-year	3,905
25-year	4,881
50-year	5,640
100-year	6,423

Existing Conditions Hydraulic Model

The existing conditions analysis was completed using the U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS 4.1.0). HEC-RAS is a computer program that models the hydraulics of water flow through natural rivers and other channels. The program is one-dimensional, meaning that there is no direct modeling of the hydraulic effect of cross-section shape changes, bends, and other two- and three-dimensional aspects of flow. The hydraulic model calculates channel and floodplain hydraulic parameters such as water velocities, depths, and shear stresses for various input flows.

Model Geometry

The model geometry was developed using bathymetric and topographic survey data collected by survey grade GPS and total station, as well as LiDAR. The projection is State Plane Washington North NAD83 USFT.

The model includes 23 surveyed and 10 interpolated cross sections extending over the 0.5-mile Project Reach. The upstream extent of the model is RM 0.7 and the downstream extent is RM 0.2. Cross-sections were surveyed at locations that characterize the Project Reach for hydraulic modeling. These locations included grade breaks on the river, changes in valley width, or significant changes in roughness, with additional detail at or near potential project sites.

Roughness

Roughness coefficients (Manning's n values) are used by the model to calculate flow energy losses – or frictional resistance – caused by channel bed materials, channel irregularity, and type and density of floodplain vegetation. Roughness coefficients were applied at each model cross-section to represent the various types and densities of vegetation or surface. The roughness delineations and locations were based on survey notes and recent aerial imagery. Roughness values were based on field observations and published methods (Arcement & Schneider 1989). Table 2 summarizes the roughness coefficients used in the existing conditions model.

Table 2: Roughness coefficients used in the existing conditions model

Description	Manning's n values
Channel, cobble bed and banks	0.045
Steep channel, boulder, bedrock	0.055
Gravel bars with willow and discontinuous LWD	0.06
Floodplain, tall grass	0.06
Floodplain, dense willow	0.08
Mature forest, dense understory vegetation, scattered LWD	0.10

Discharges

The modeled discharges include the 2-, 5-, 10-, 25-, 50- and 100-year recurrence interval floods with discharge magnitudes listed in Table 1. A flow of 280 cfs on 4-24-13 and 313 cfs on 4-26-13 were modeled to calibrate model water surfaces during relatively lower flows.

Boundary Conditions

HEC-RAS requires the entry of boundary conditions to begin computations. Boundary conditions are the starting water surface elevations associated with each discharge at the upstream and downstream ends of the model. For subcritical flow models, computations begin at the downstream end. In this case, only the downstream boundary needs to be defined. For mixed flow regime (sub- and super-critical) models, up- and downstream-boundary conditions must be defined. A normal depth boundary condition was chosen at the downstream end of the model using the measured water surface slope at the cross section.

Proposed Project Opportunities

The following three project opportunities would enhance fish habitat for ESA listed fish species. Each project will be described below along with alternative project approaches where appropriate. Conceptual design layouts for each project are presented in the attached drawings (Appendix A). Previously noted design criteria that include RTT recommendations were used to develop the following project opportunities.

Backwater Alcoves

An alcove is an abandoned channel segment that is relatively disconnected from river flow but is still connected to river at the alcove's downstream end. Typically water from the river backwaters into the alcove with little or no current, and even during small floods the alcove continues to have relatively quiet water. Alcoves with dense overhead vegetation, submerged plants, and woody debris provide important refuge and forage habitat for young fish.

Where there are high groundwater levels and adequate valley slope, an alcove can intercept groundwater and convey it as surface water during all or part of the year. Like side channels, alcoves should be constructed in wider areas of a river valley where they are less likely to be captured by the main river channel. Constructing an alcove involves excavation to form the channel and pools, placement of wood (trees and logs) at appropriate locations, and planting of riparian vegetation.

Backwater Alcove at RM 0.5

Description

Much of the Twisp River floodplain has been disconnected from the river by levees, but the RM 0.5 project site is located within a section of floodplain that still remains relatively connected to the river. The floodplain has a high-flow side channel that could be enhanced to create an alcove. The enhancement project would involve deepening approximately 300 ft of the side channel to a level similar to the existing main channel. The lowered side channel will then function as an alcove with seasonal groundwater flow. Several large log structures would be constructed to provide juvenile rearing habitat.

It may also be possible to construct a groundwater gallery to collect groundwater near the river at the west end of the project reach (RM 0.6) and convey it by pipe to the head of the alcove channel. This would provide extra flow to the alcove channel during periods of low-flow in the river. By collecting cold groundwater and transmitting it to the open channel, the gallery would enhance cold-water habitats for salmonids in the summer. A pump test during the lowest summer flows should be conducted to estimate groundwater yield and feasibility.

Potential Benefits

This project would create immediate rearing habitat along approximately 300 feet of new alcove channel. The alcove would have a two-tiered configuration with a deep low-flow channel for summer rearing, and a wider high-flow backwater area for spring runoff habitat.

Design Considerations/Constraints

Excavation will be required to deepen the existing side channel. The excavated material must be removed from the floodplain and hauled to an approved disposal site.

The design will be configured to provide habitat while also protecting adjacent properties from erosion.

The project design will include hydraulic modeling to determine the effect of enchantments on the 100-yr flood.

The attached drawing and planning cost estimates include options for the backwater alcove with and without a groundwater gallery.

Log Structure Habitats

Log structures naturally occur in the Twisp River as trees and branches fall into the river. Sometimes a fallen tree remains partially pinned to the riverbank where it fell, while others will float down to a woody debris collection point in the river. Naturally occurring wood in the river is generally transient and structures may shift, grow, shrink, or float to a new location with each flood. These natural log structures are critically important cover and rearing habitat for adult and juvenile salmonids.

When designing a log structure, the location and configuration of the structure must fit the geomorphic context of the river and floodplain, and the predicted hydraulic forces that will act on it. Therefore, each site will have unique characteristics that show whether the structures would be appropriate, and if so the location and configuration of each structure will vary in size, shape, and orientation to the river. In this manner, structures will be designed to function like natural log structures, but will be ballasted to remain stable during large floods. Additional factors that influence project location and configuration are the effect on flood levels and river user safety.

Due to extensive levee confinement, the preliminary hydraulic model findings suggest that only two sites are available for mainstem log structures that would not increase flooding or effect existing levee protection within the Project Reach. The two sites are at RM 0.25 and RM 0.62

Log Structure Habitat Site at RM 0.25

Description

The project at this site is a right bank log structure to be partially buried into the existing bank levee/riprap. The riverbank length of the structure be approximately 50 feet. The logs would be configured to not extend far into the waterway and be angled to shed and deflect floating objects.

Potential Benefits

The project would create immediate habitat benefit in the form of cover and complexity for salmonids through a range of life stages.

Design Considerations/Constraints

Whole trees, logs, and boulders would be utilized at this site. The ownership of the existing levee is unknown at the time of writing this report. To complete the proposed concepts, proper notification and permits would be required. This is especially true if it is under the jurisdiction of the United States Army Corp of Engineers.

The project design will include hydraulic modeling to determine the effect of enchantments on the 100-yr flood.

LOG STRUCTURE HABITAT SITE AT RM 0.62

Description

The project at this site is a left bank log structure to be partially buried into an existing natural riverbank. The riverbank length of the structure would be approximately 30 feet and occur at a location that is adjacent to an existing pool that currently has no existing cover habitat.

Potential Benefits

The project would create immediate habitat benefit in the form of cover and complexity for adult and juvenile salmonids.

Design Considerations/Constraints

Whole trees, logs, and boulders would be utilized for this work. Riparian re-vegetation will be an integral component.

The project design will include hydraulic modeling to determine the effect of enchantments on the 100-yr flood.

References

Konrad, C.P. (2002). River-Aquifer Exchanges in the Twisp River, Washington. In Proceedings of Ground Water/Surface Water Interactions Conference J. Kenny ed., 1-3 July 2002, American Water Resources Association, p 445-450.

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Reclamation, 2010. Geomorphology and Hydraulic Modeling for the Middle Methow River from Winthrop to Twisp, Technical Report No. SRH-2009-42. Bureau of Reclamation, Denver, CO.

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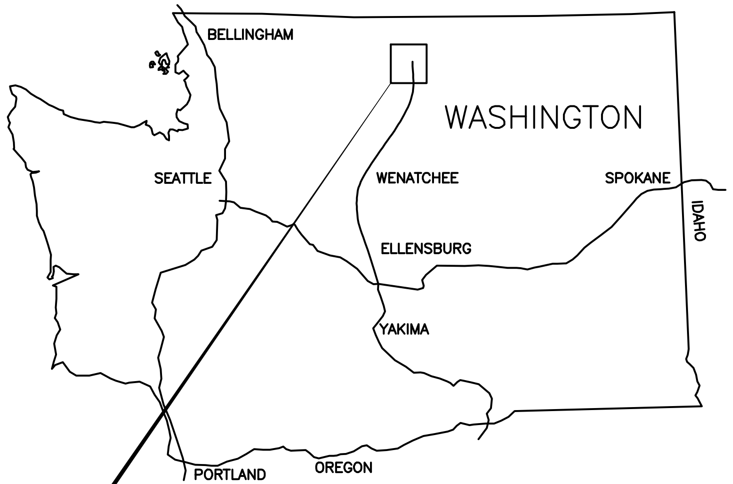
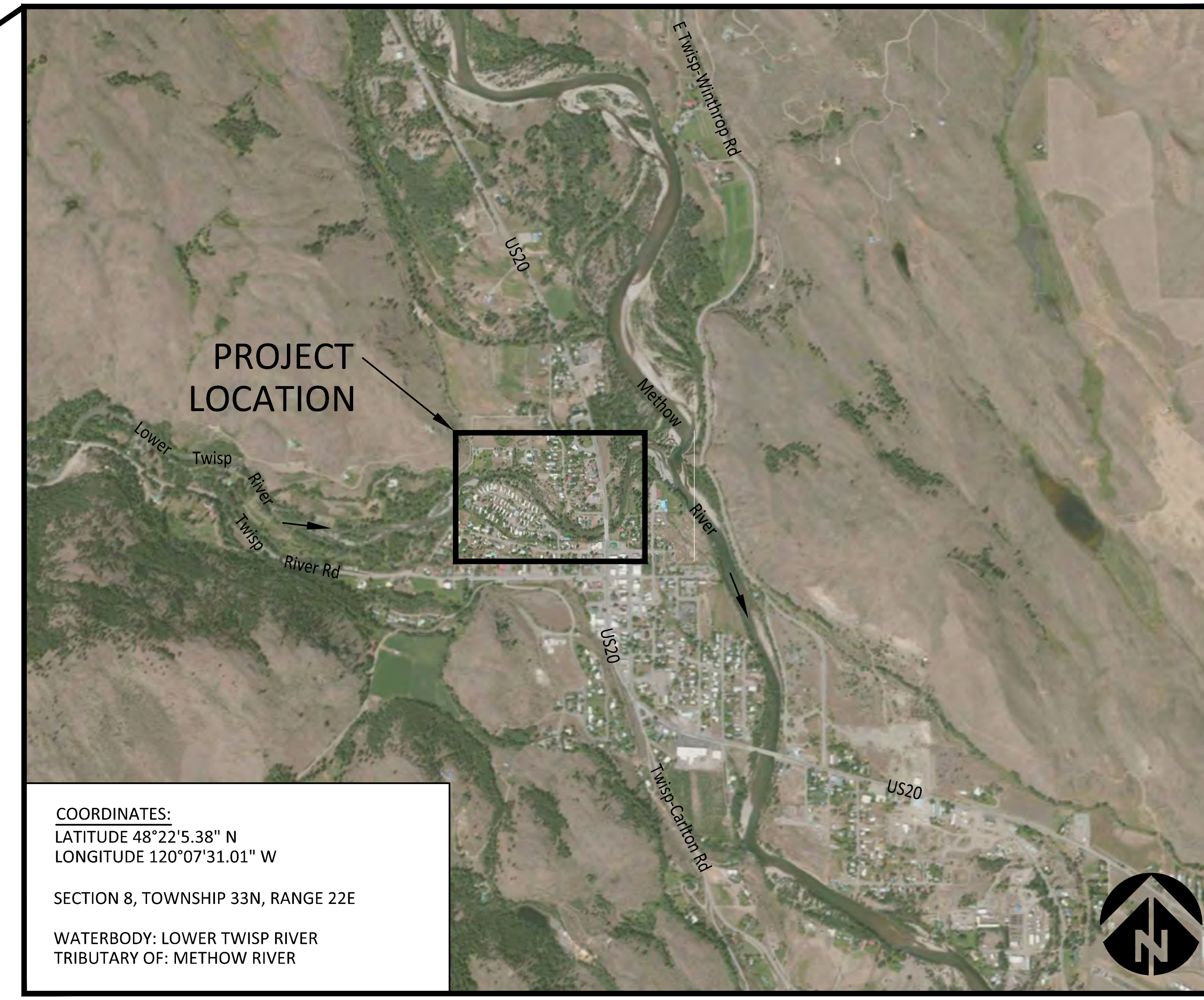
Appendix A: Drawings



LOCATION MAP
STATE OF WASHINGTON



SITE MAP
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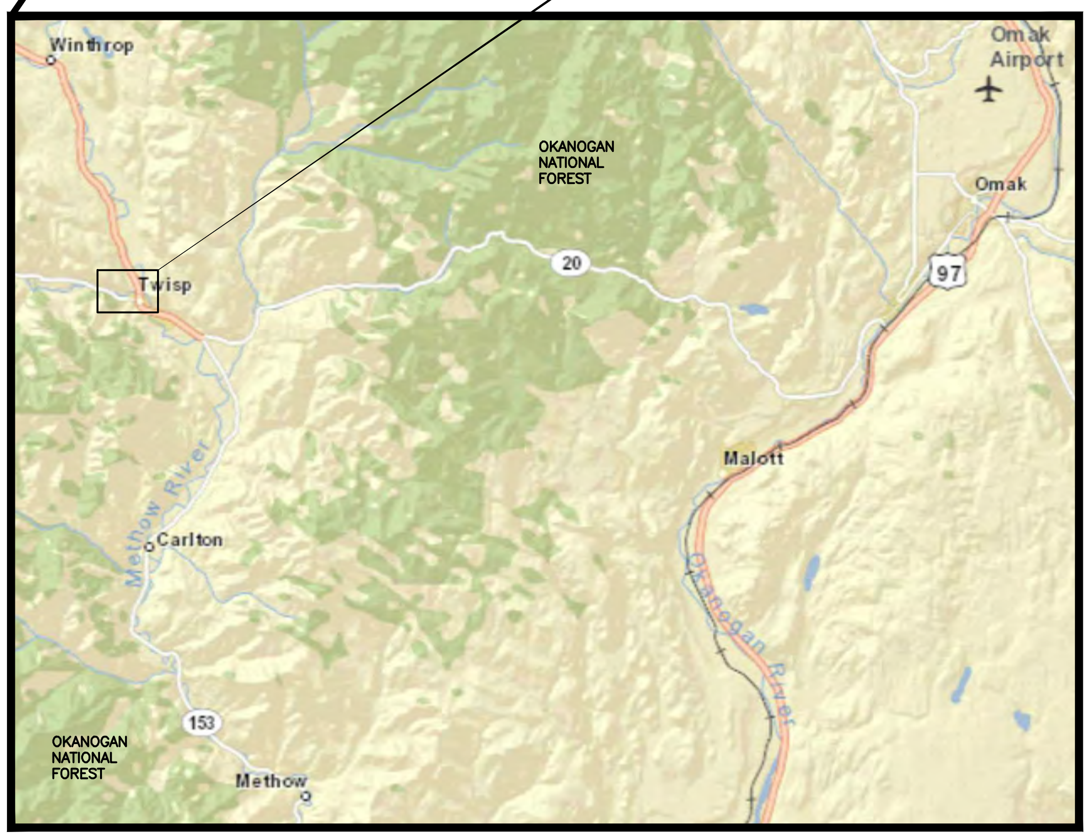

VICINITY MAP
NOT TO SCALE

CONFEDERATED TRIBES AND BANDS
YAKAMA NATION
TREATY OF 1855

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7 BANK LOGJAM ENHANCEMENT TYPICAL DETAILS

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Cover, Sheet Index and Vicinity Map

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Project Reach Showing Access and Proposed Project Areas

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Example of installed bank jam.

LEGEND

- RM 0.5 — RIVER MILE MARKER
- ORDINARY HIGH WATER
- TEMPORARY ACCESS
- GROUNDWATER GALLERY
- LIMITS OF DISTURBANCE
- LOG JAM CONSTRUCTION SITE AND POOL ENHANCEMENT

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Bank Logjam Habitat Concept RM 0.62

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LEGEND

- RM 0.5 — RIVER MILE MARKER
- OHW — ORDINARY HIGH WATER
- TEMPORARY ACCESS
- GROUNDWATER GALLERY
- LIMITS OF DISTURBANCE
- LOG JAM CONSTRUCTION SITE AND POOL ENHANCEMENT

0 50 100

SCALE IN FEET

NO.	BY	DATE	REVISION DESCRIPTION

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Backwater Alcove RM 0.5 With Groundwater Gallery Concept Design

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Backwater Alcove RM 0.5 Without Groundwater Gallery Concept Design

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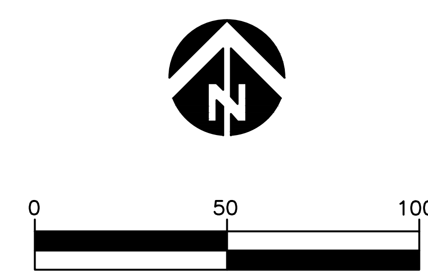
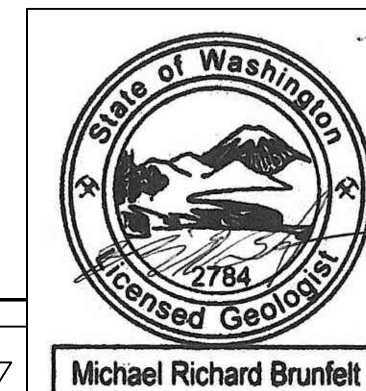
Example of installed bank jam.



LEGEND

RM 0.5	RIVER MILE MARKER
OHW	ORDINARY HIGH WATER
	TEMPORARY ACCESS
	LIMITS OF DISTURBANCE
	LOG JAM CONSTRUCTION SITE AND POOL ENHANCEMENT



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Bank Logjam Habitat Concept RM 0.25

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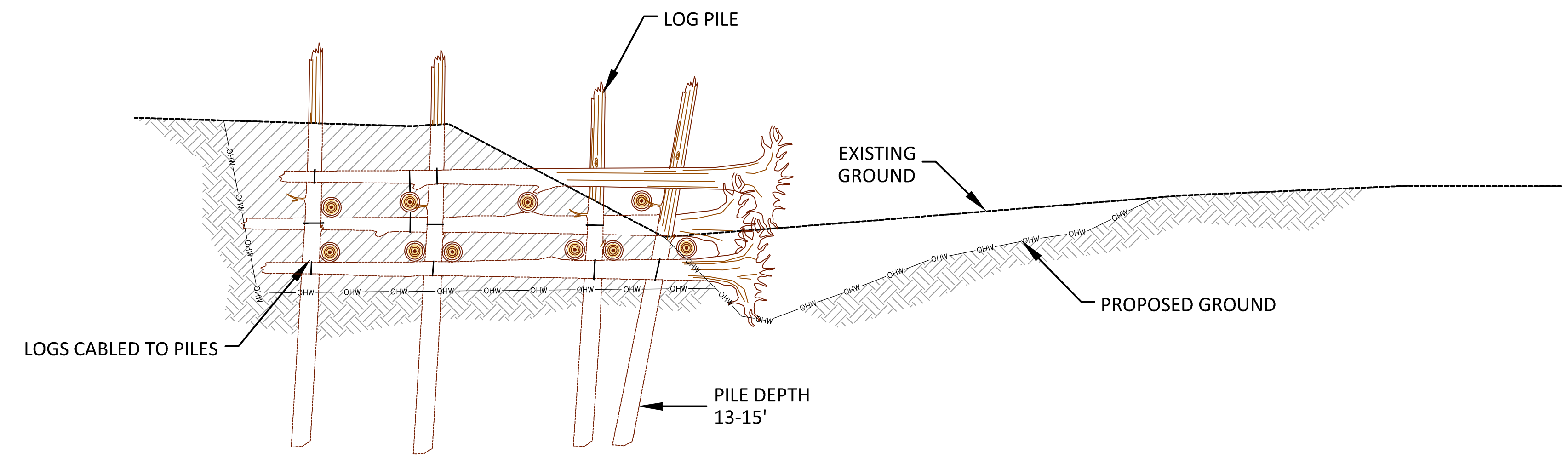


1/7 TYPICAL CROSS SECTION - PILE BALLAST

NOT TO SCALE

LEGEND

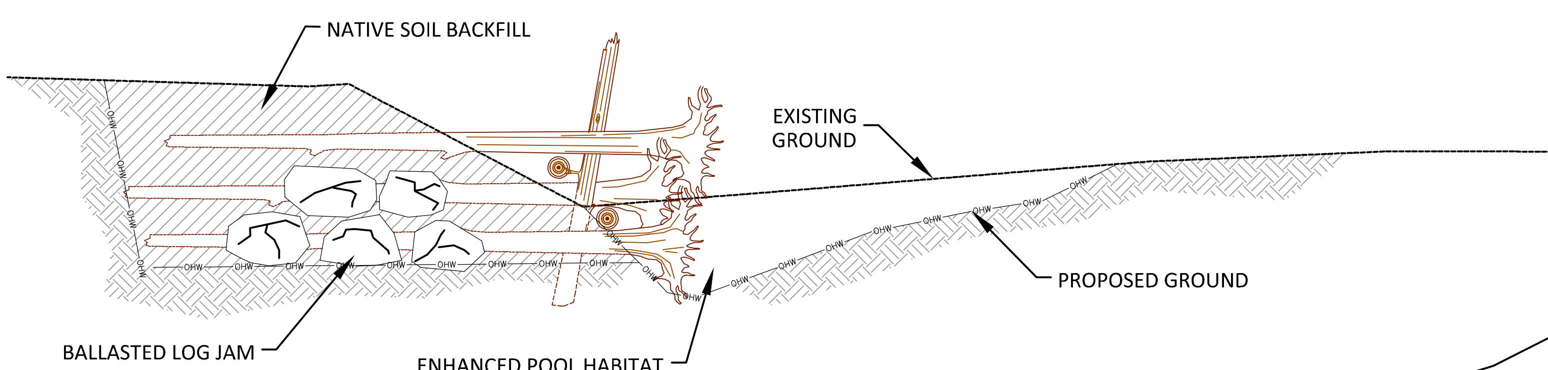
EXISTING SOIL

NATIVE SOIL BACKFILL

LOGJAM NOTES:

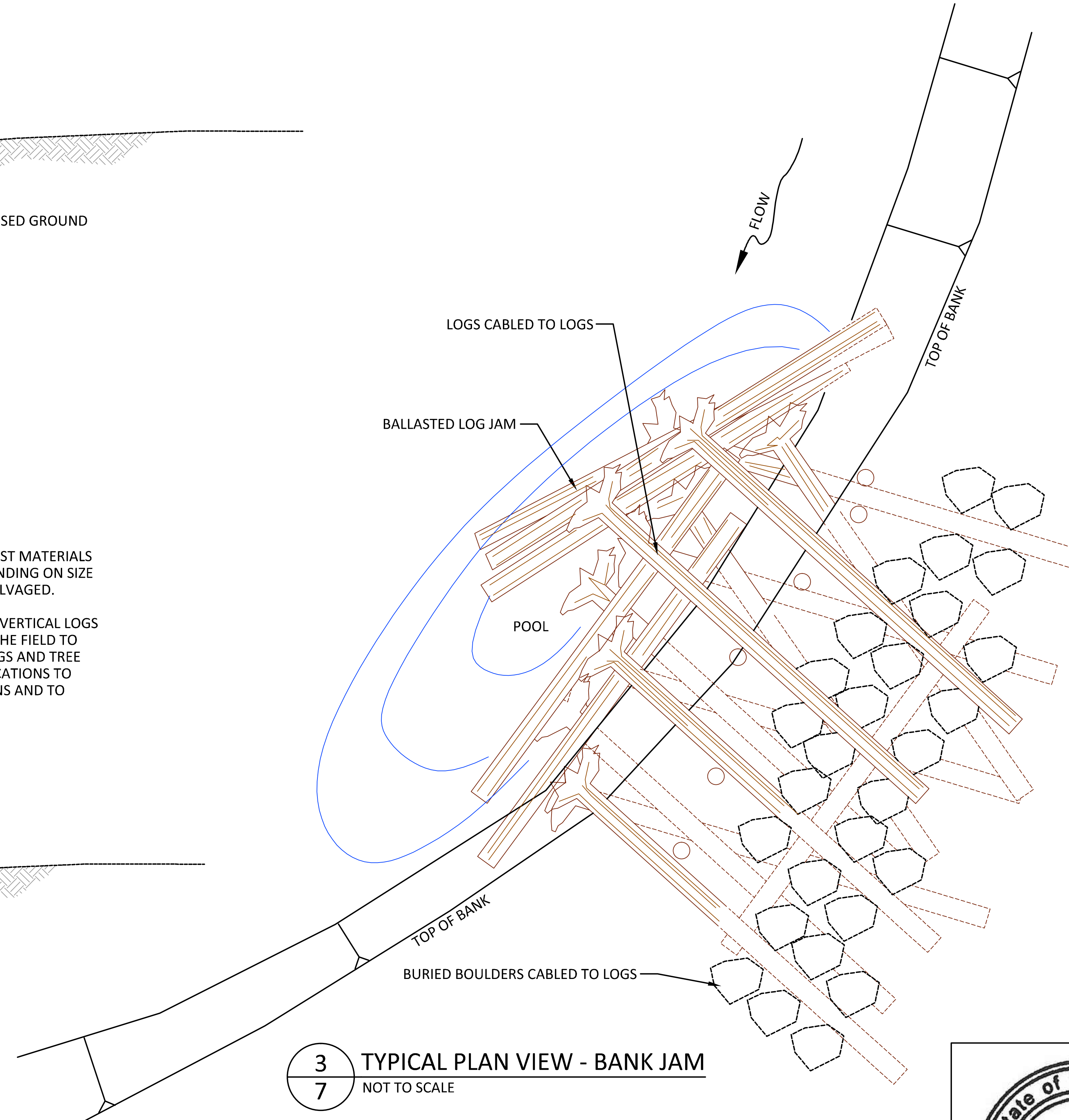
SPECIFIC ORIENTATION OF LOGS AND BALLAST MATERIALS MAY VARY FROM TYPICAL DRAWINGS DEPENDING ON SIZE AND SHAPE OF MATERIAL DELIVERED OR SALVAGED.

BRACING TO EXISTING TREES OR INSTALLED VERTICAL LOGS WILL OCCUR AT LOCATIONS IDENTIFIED IN THE FIELD TO PROVIDE HORIZONTAL STABILITY. FILLER LOGS AND TREE TOPS WILL BE INSTALLED AT "RACKING" LOCATIONS TO EMULATE NATURAL DEBRIS ACCUMULATIONS AND TO OPTIMIZE FISH HABITAT.



2/7 TYPICAL CROSS SECTION - BOULDER BALLAST

NOT TO SCALE



3/7 TYPICAL PLAN VIEW - BANK JAM

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Bank Logjam Habitat Enhancement Concept Typical Details

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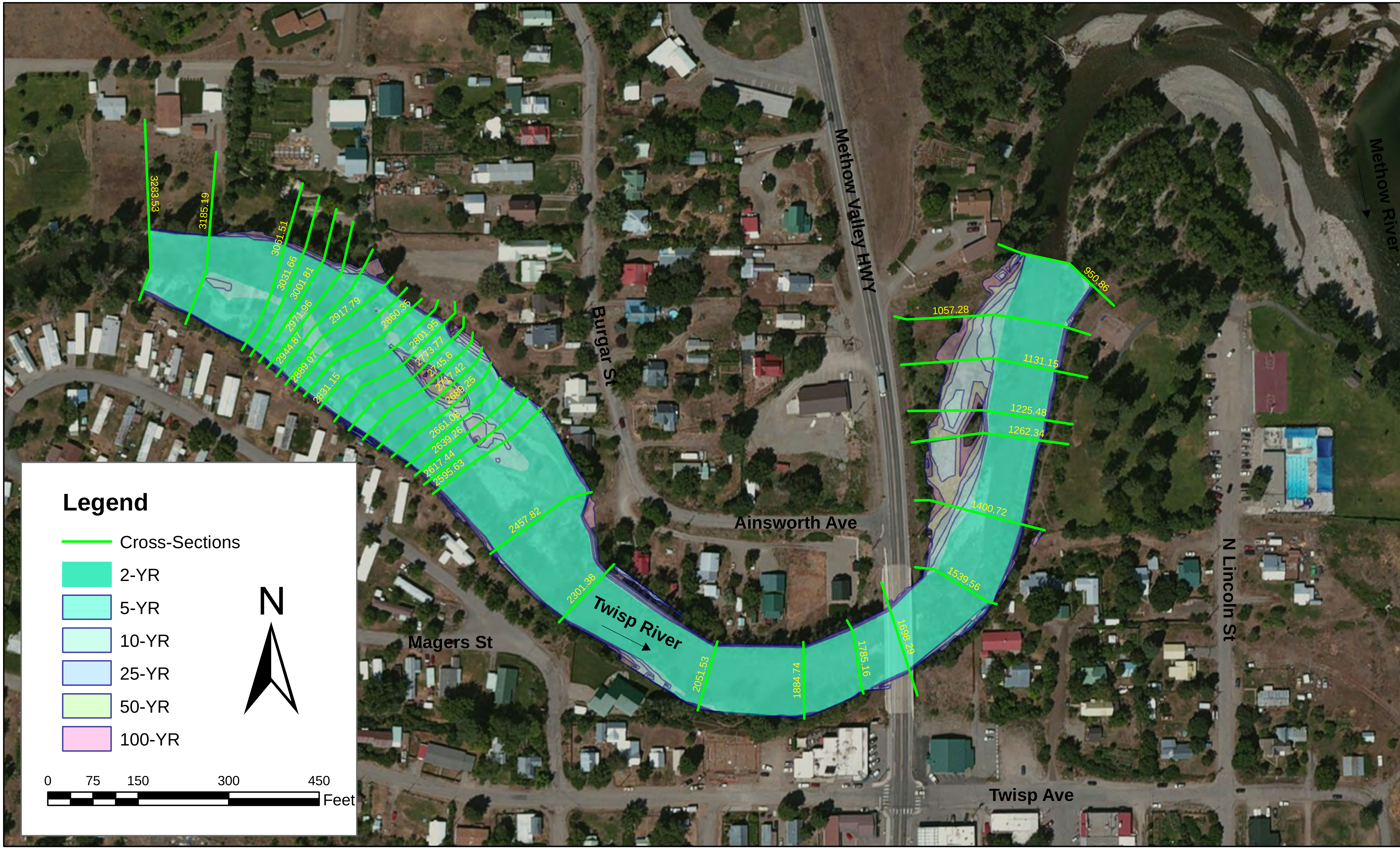
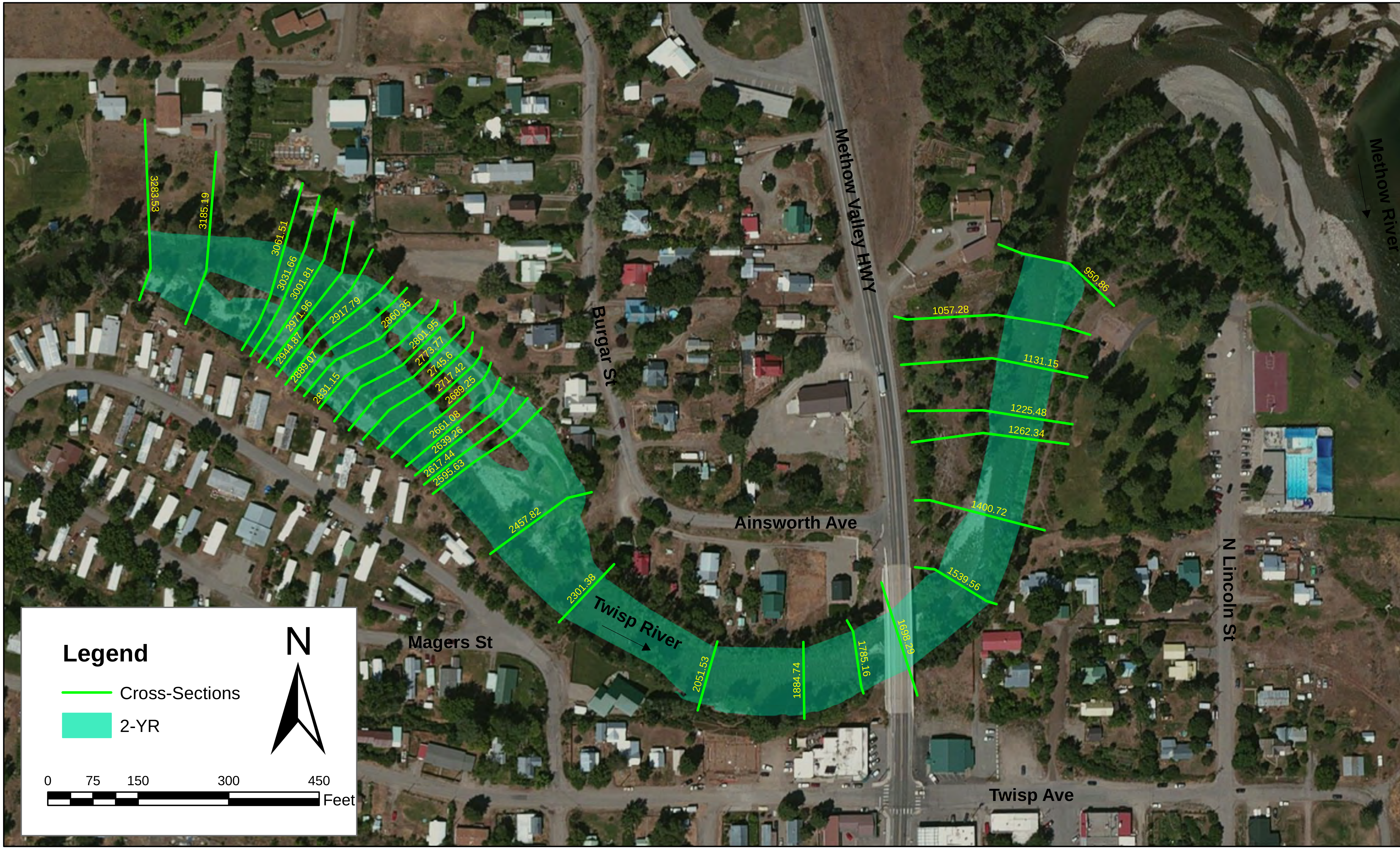
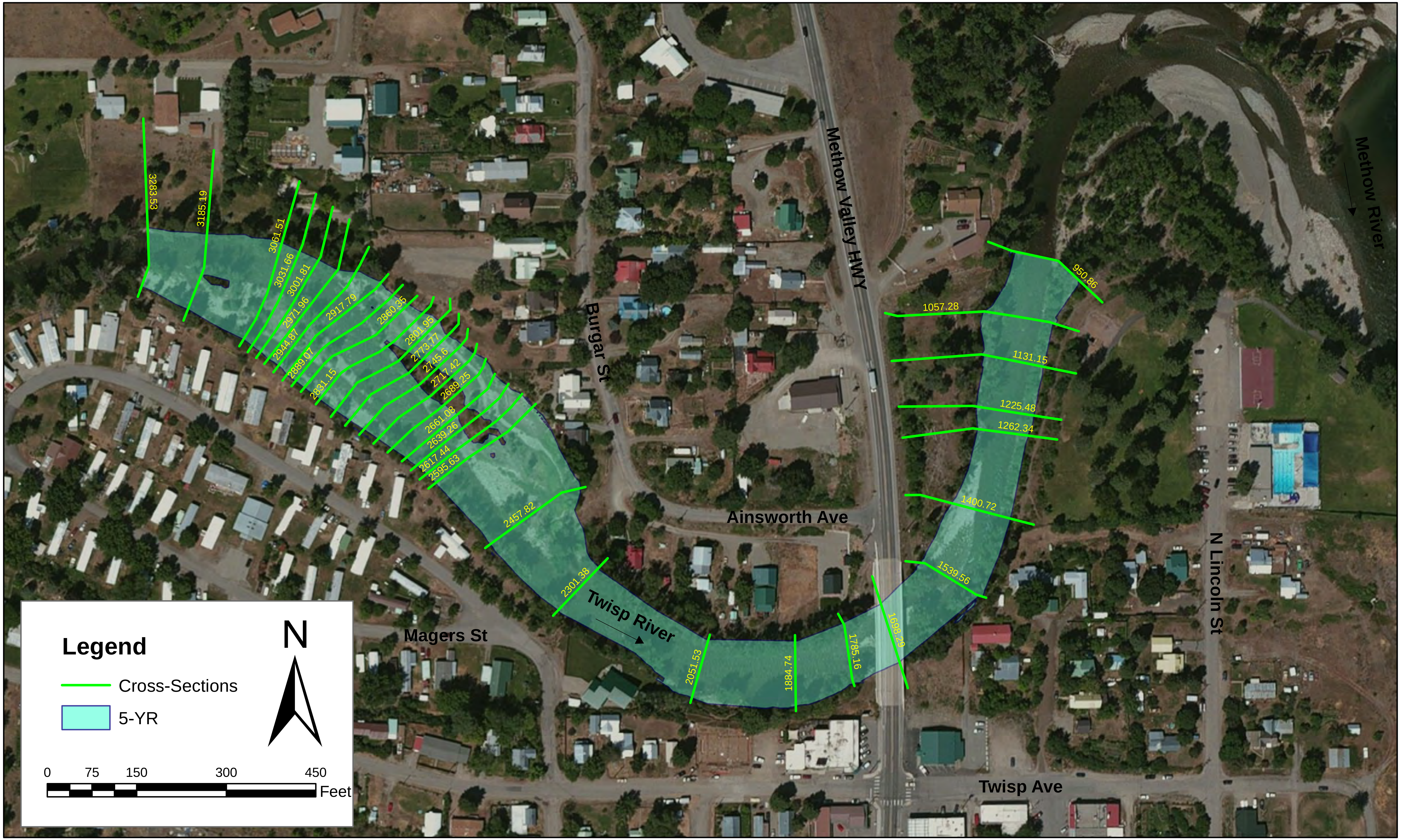
Appendix B: Hydraulics and Inundation



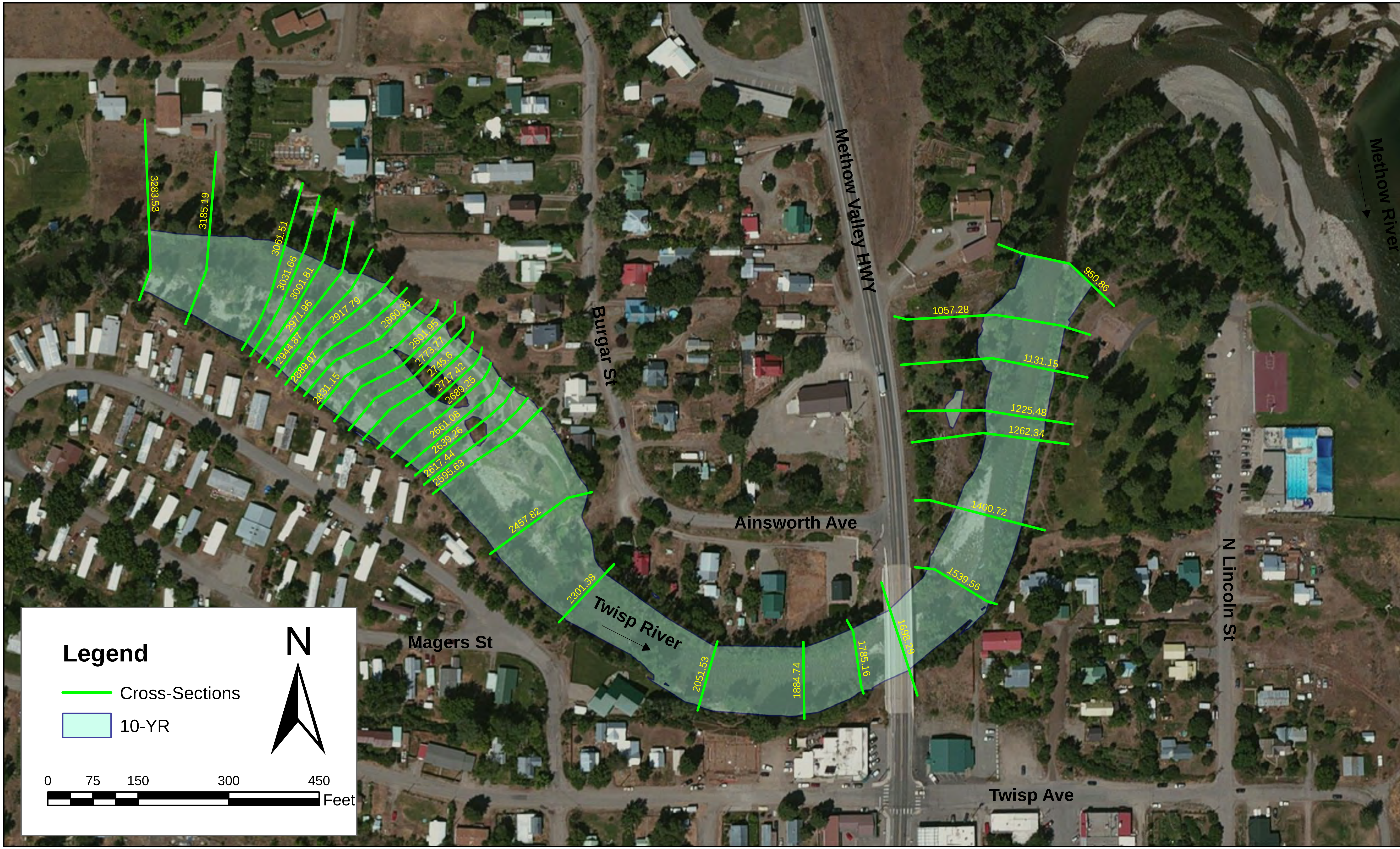
Plan View Showing Inundations



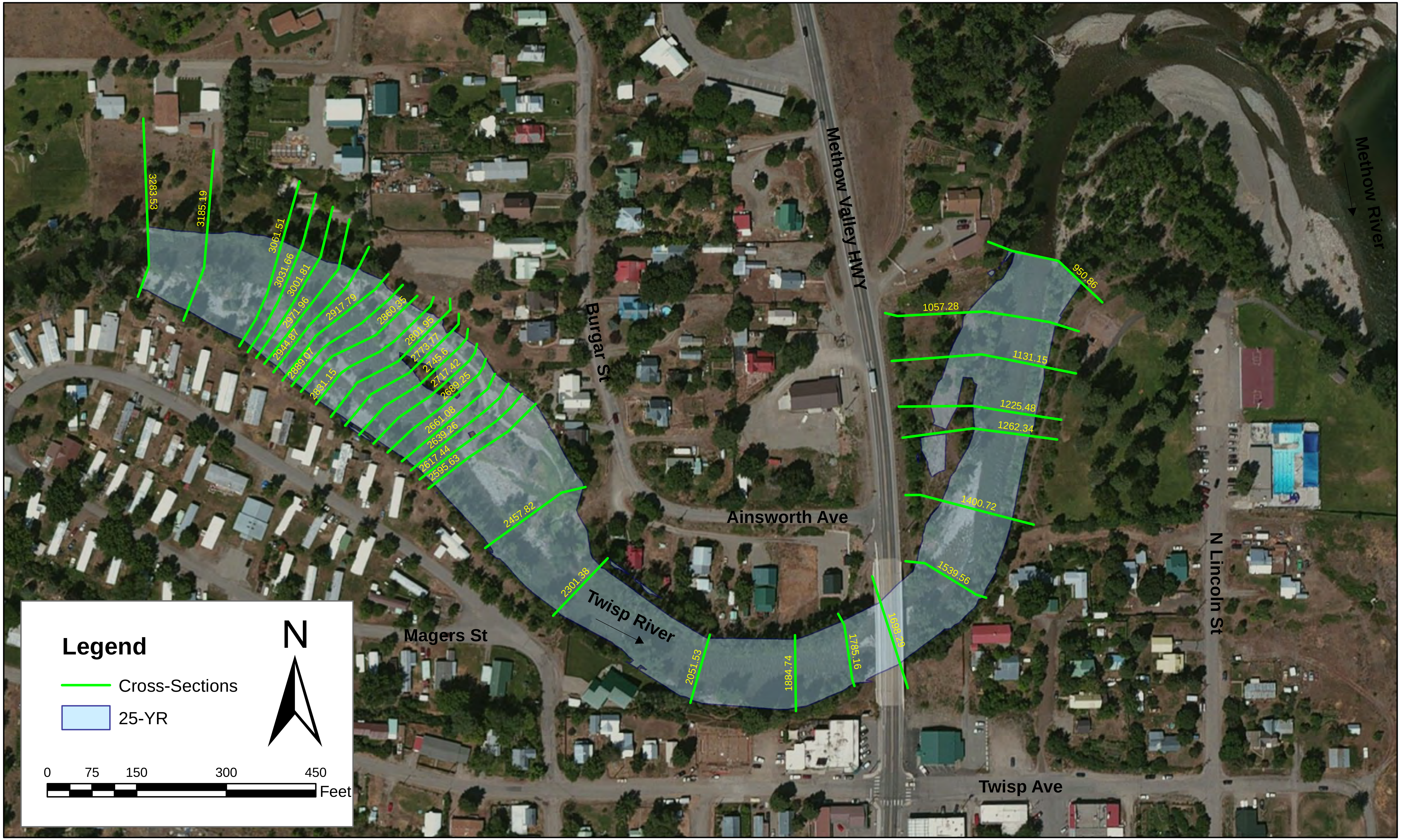
Plan View Showing Inundation - 2YR



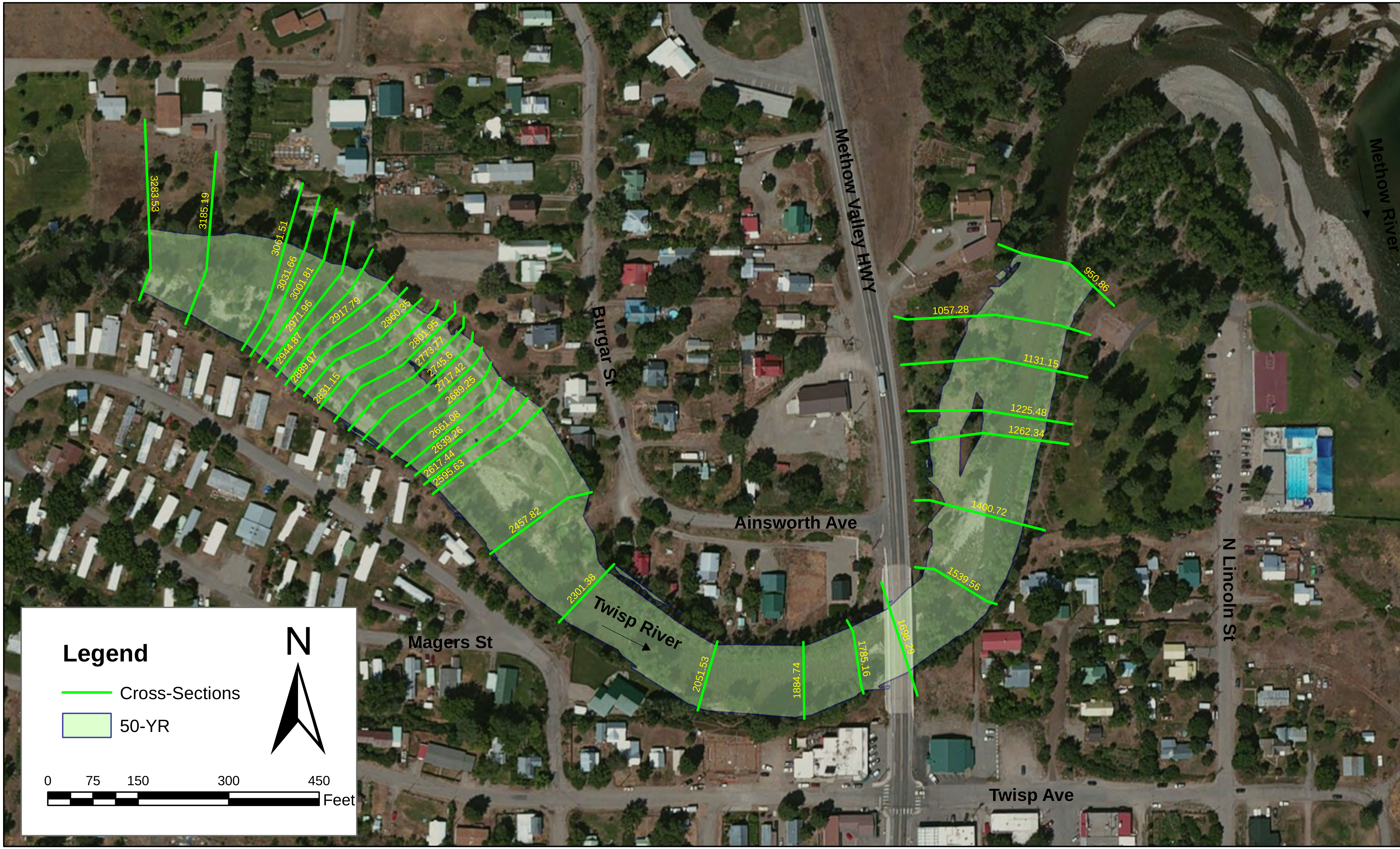
Plan View Showing Inundation - 5YR



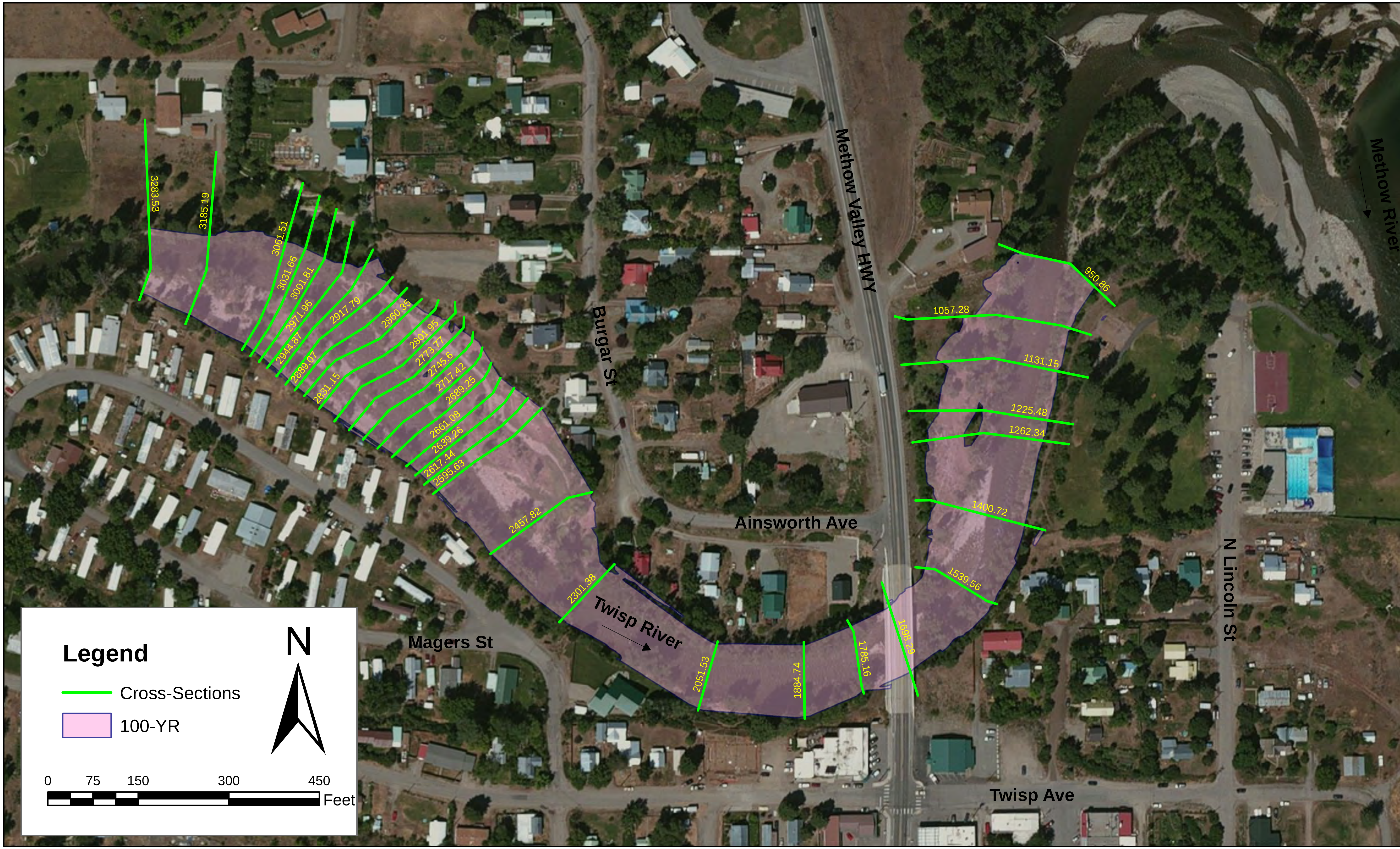
Plan View Showing Inundation - 10YR



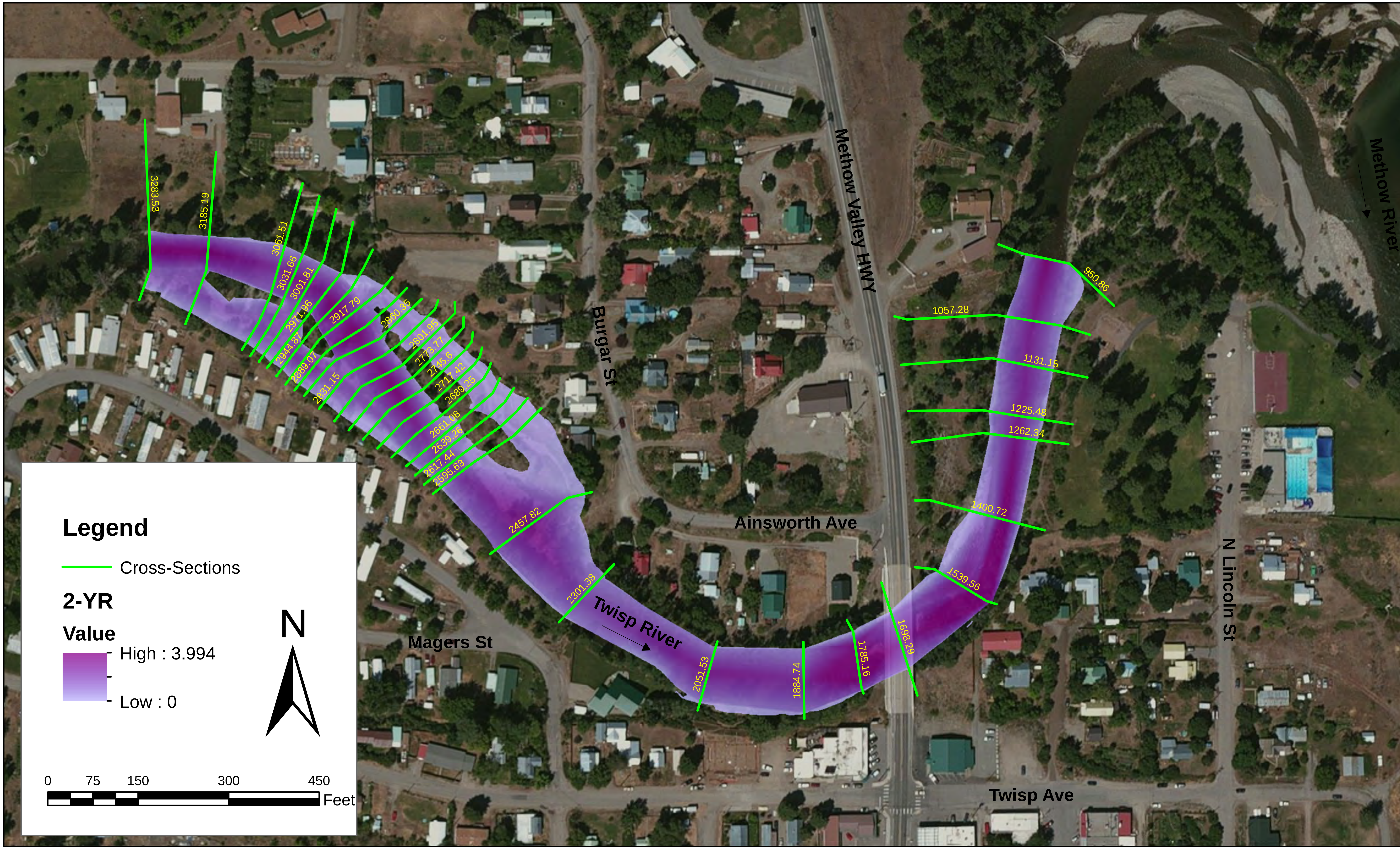
Plan View Showing Inundation - 25YR



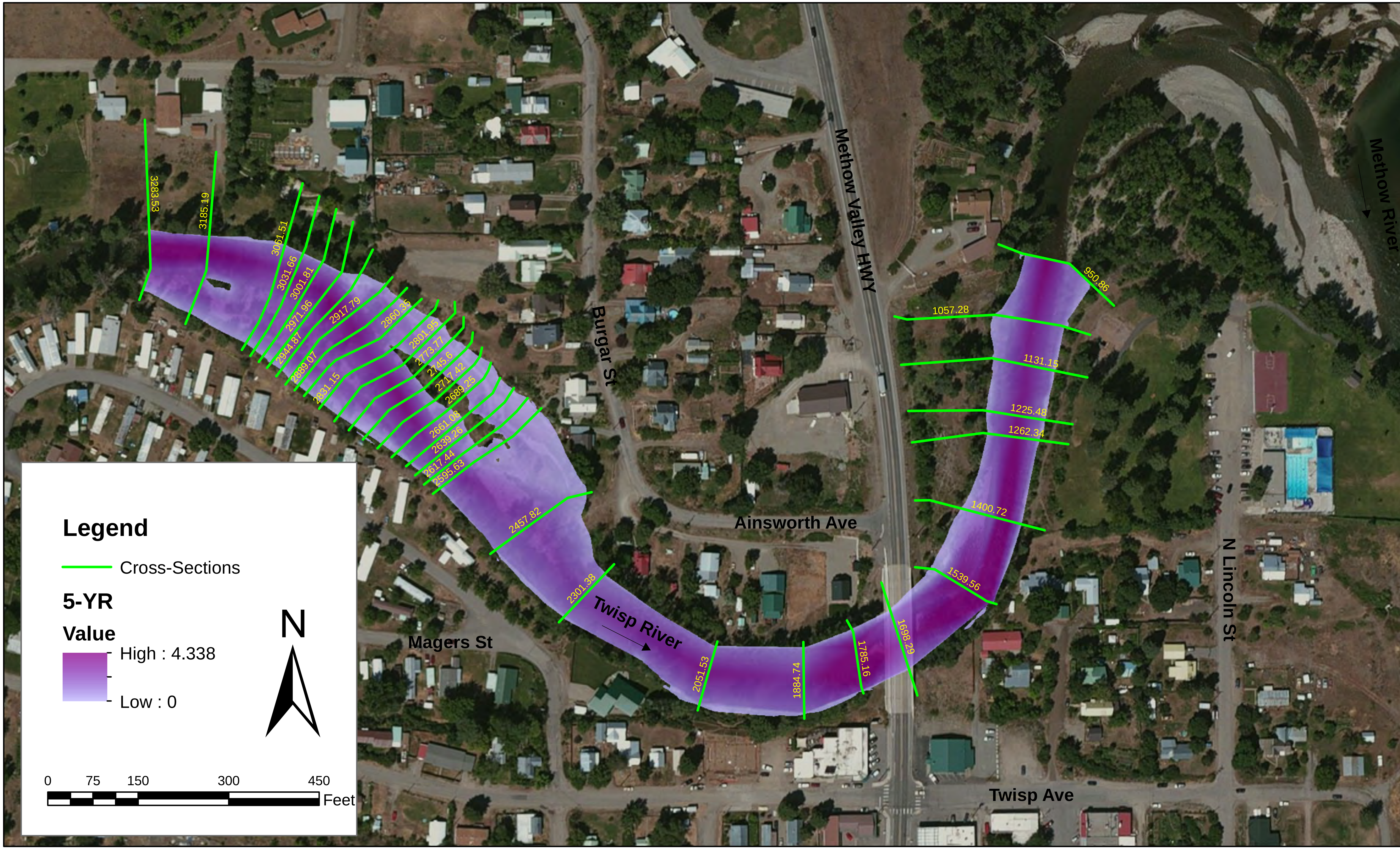
Plan View Showing Inundation - 50YR



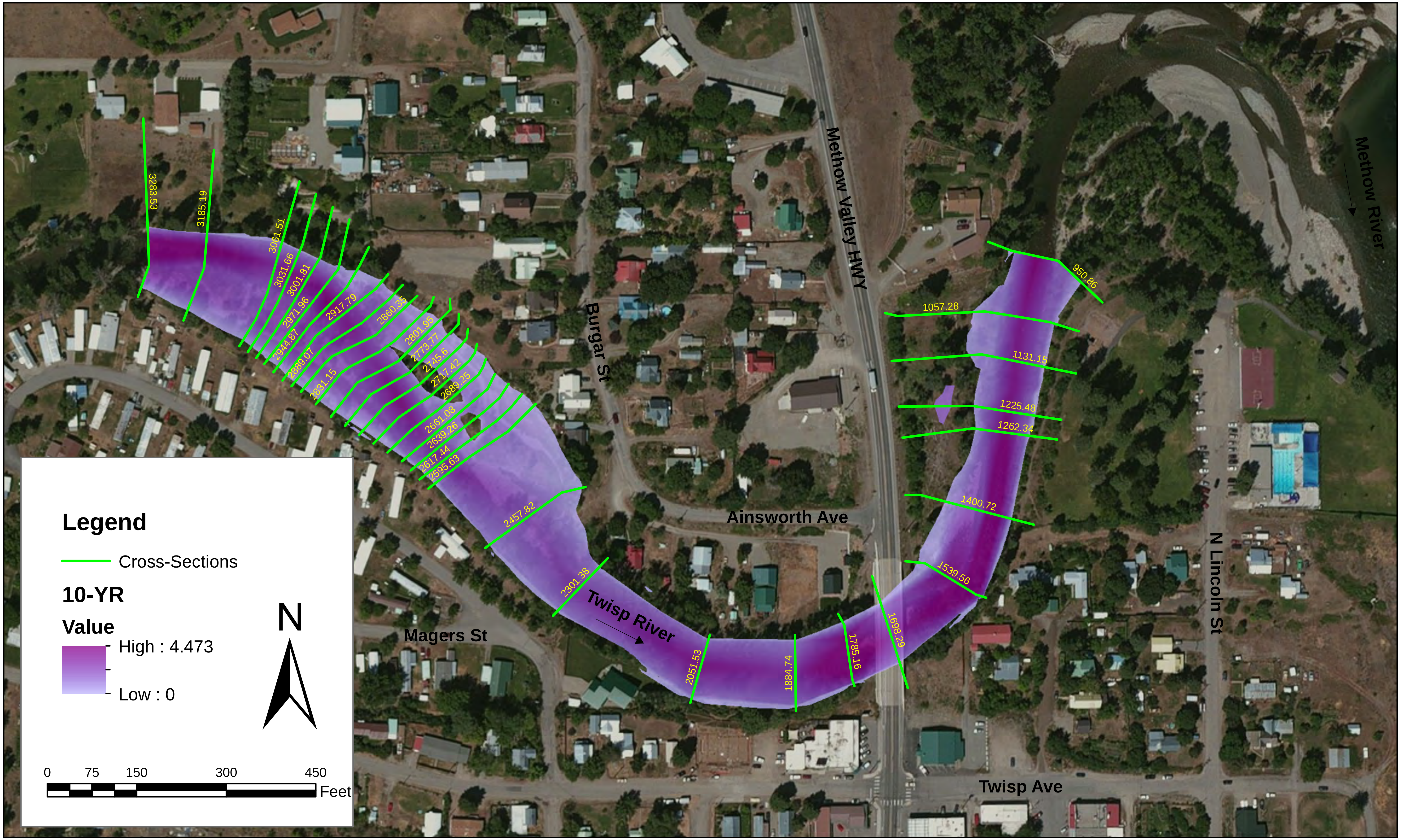
Plan View Showing Inundation - 100YR



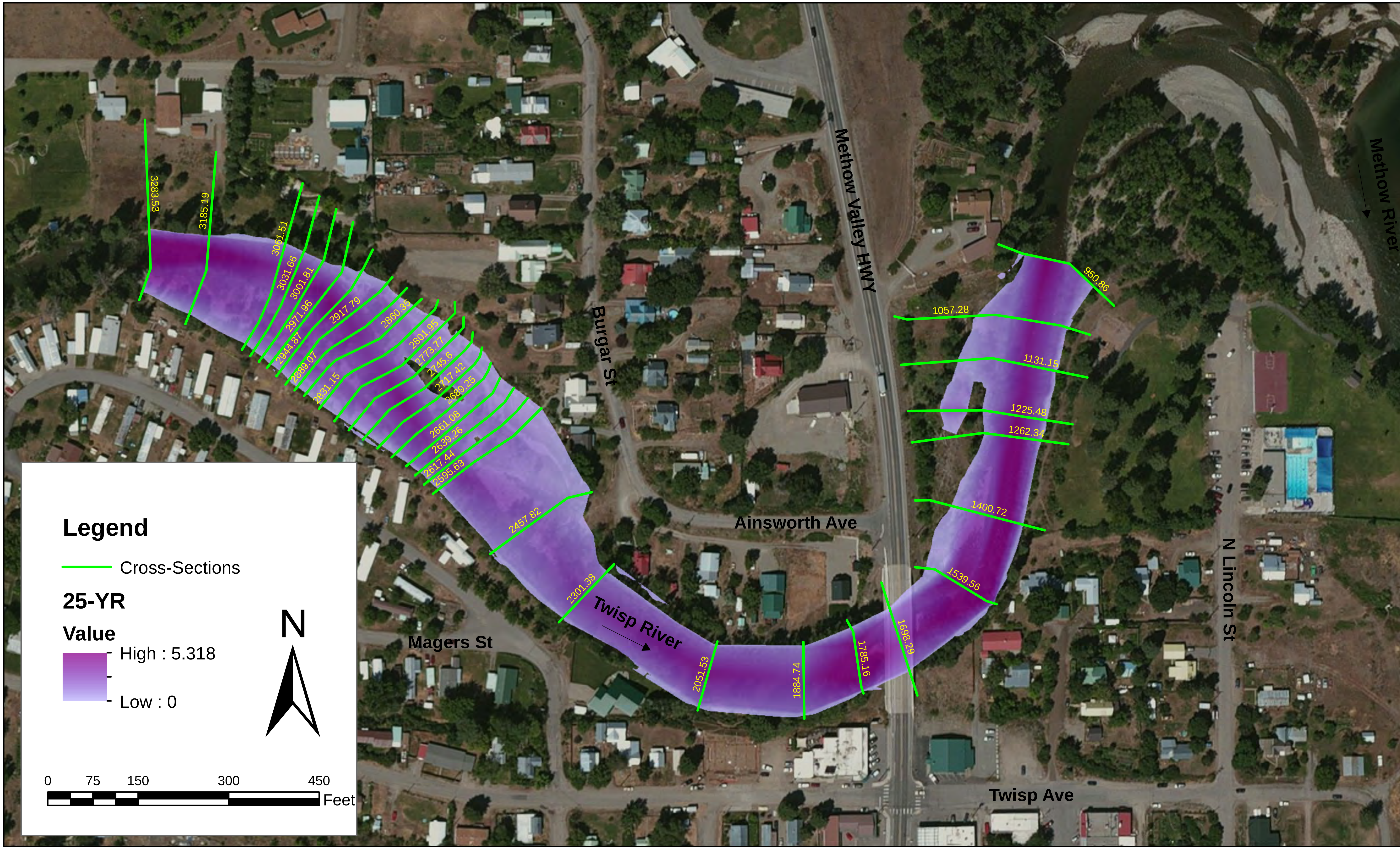
Plan View Showing Shear - 2YR



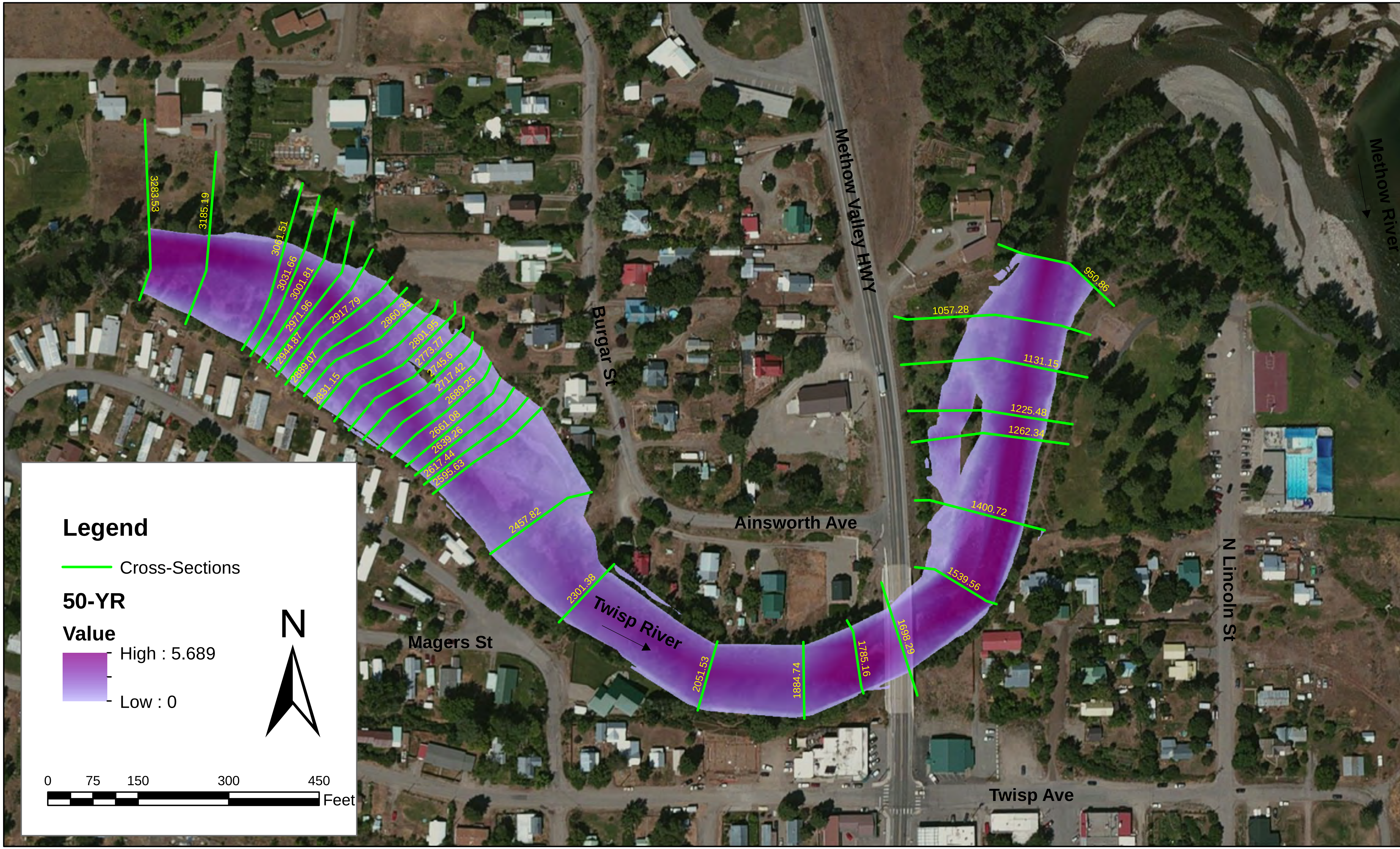
Plan View Showing Shear - 5YR



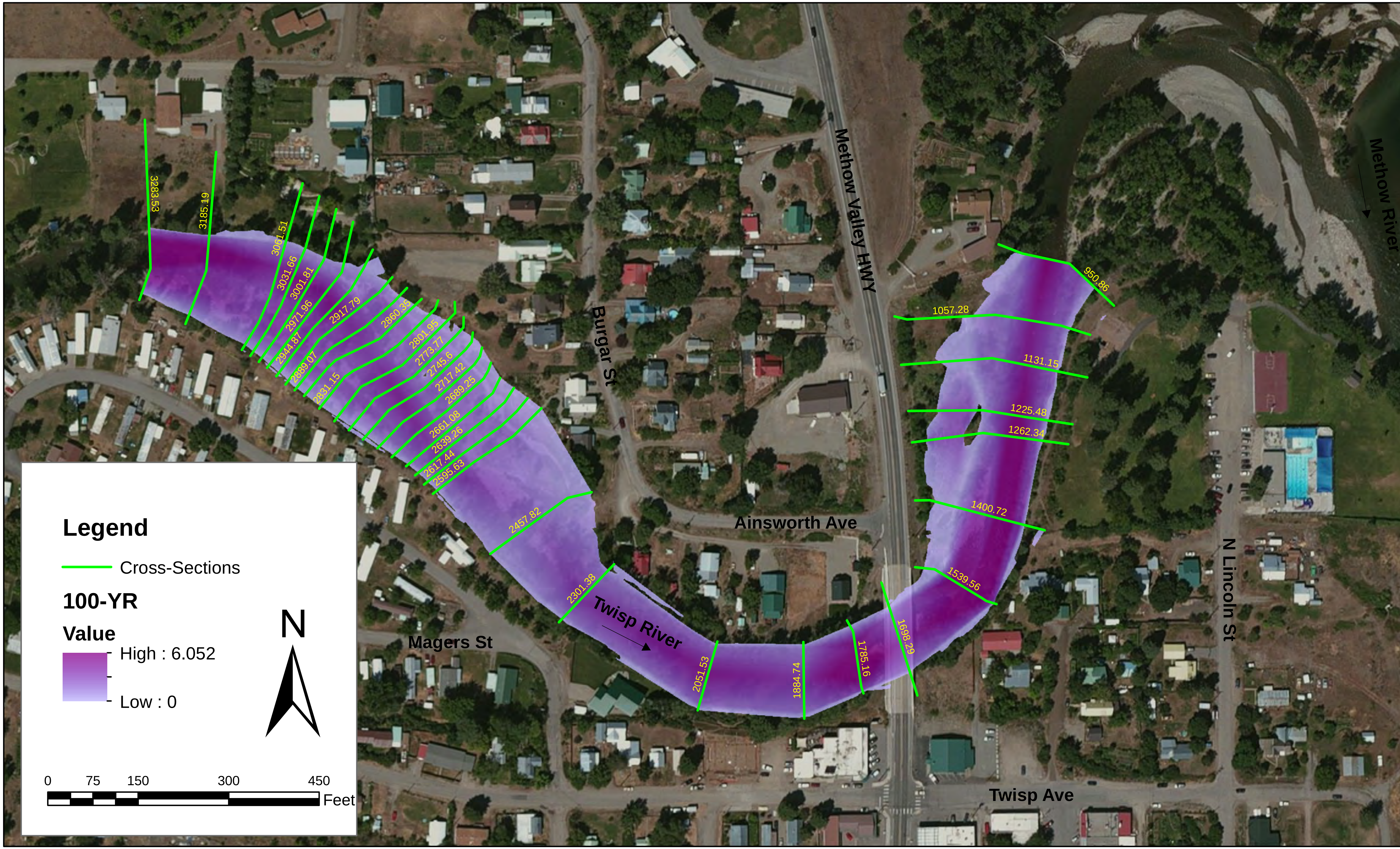
Plan View Showing Shear - 10YR



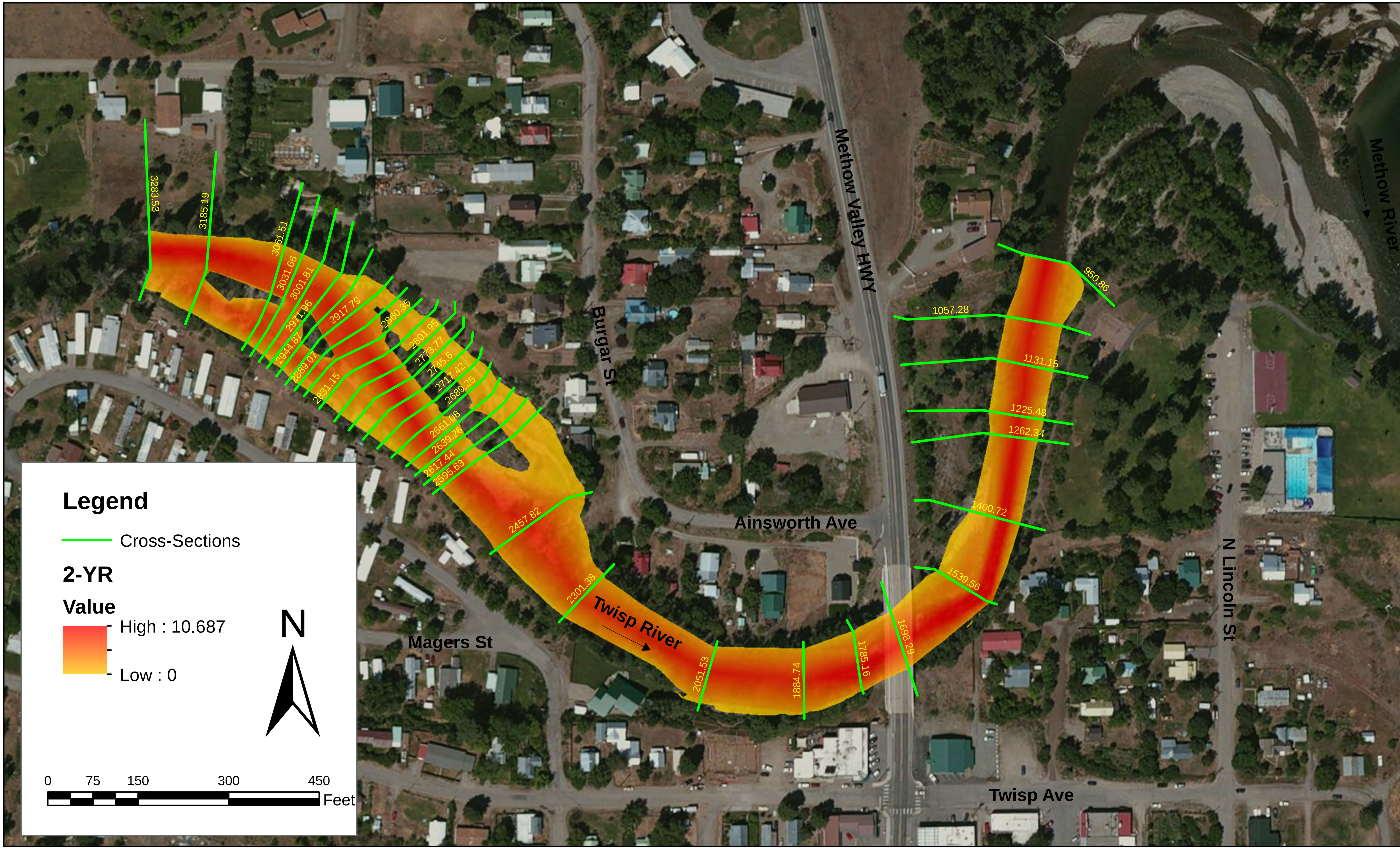
Plan View Showing Shear - 25YR



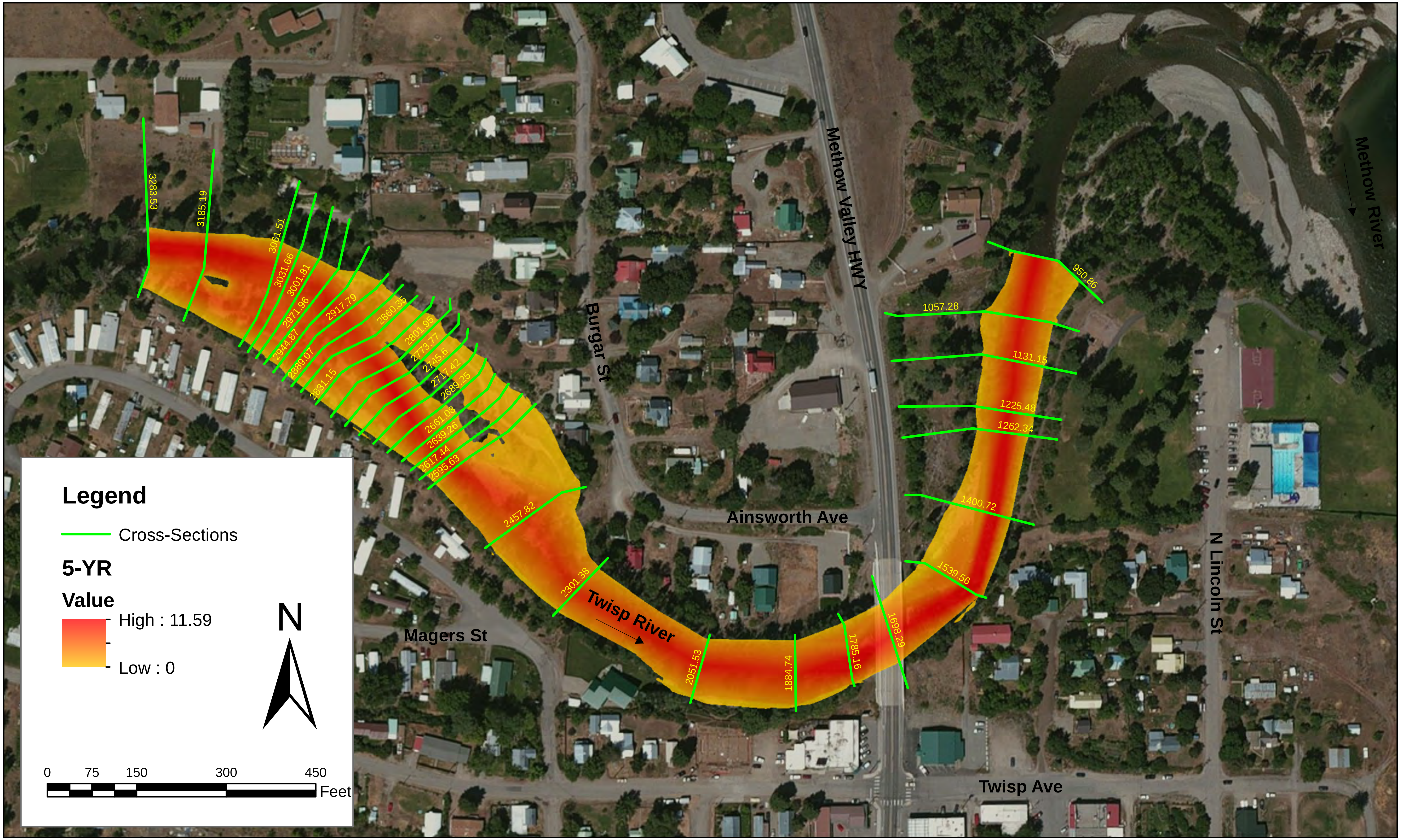
Plan View Showing Shear - 50YR



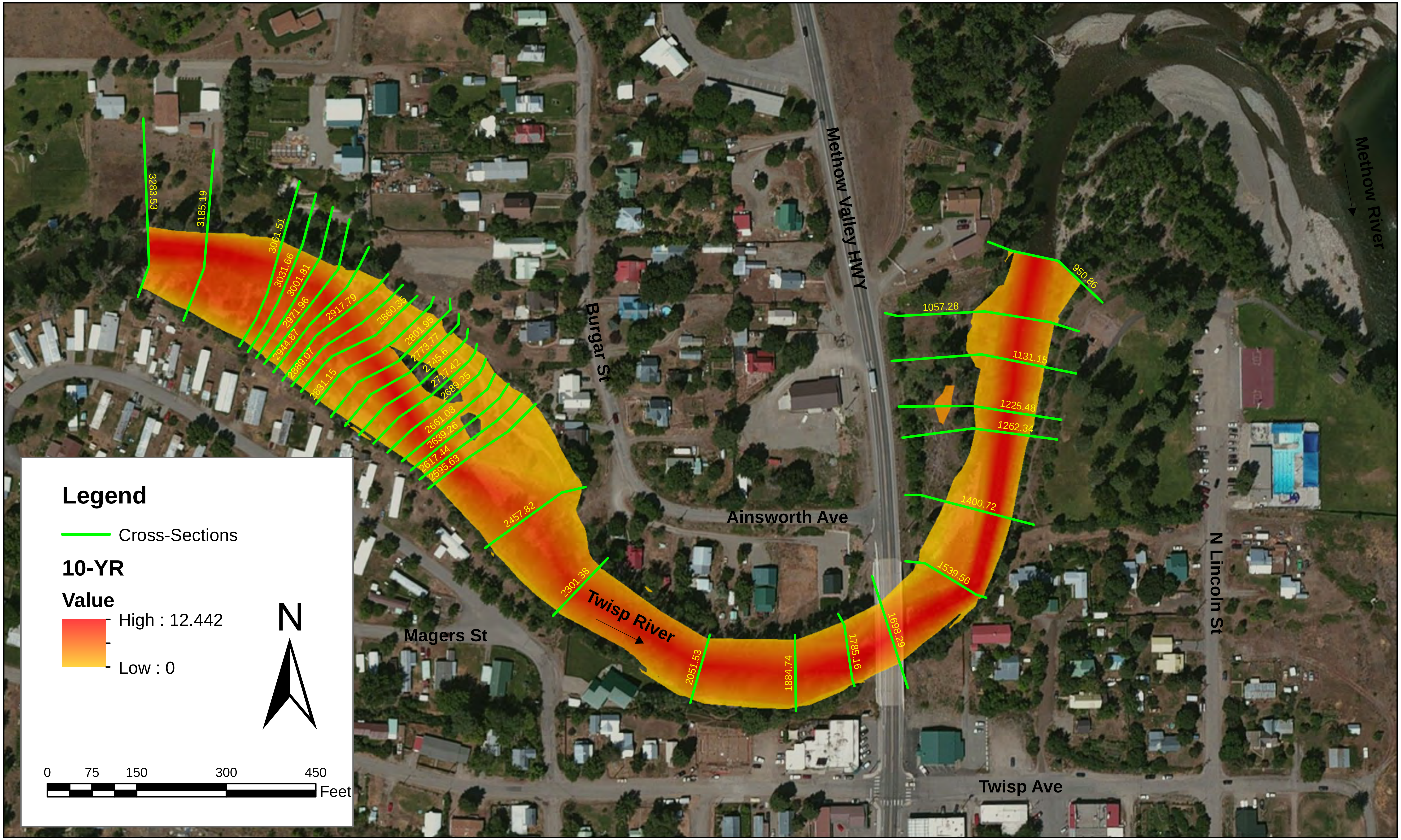
Plan View Showing Shear - 100YR



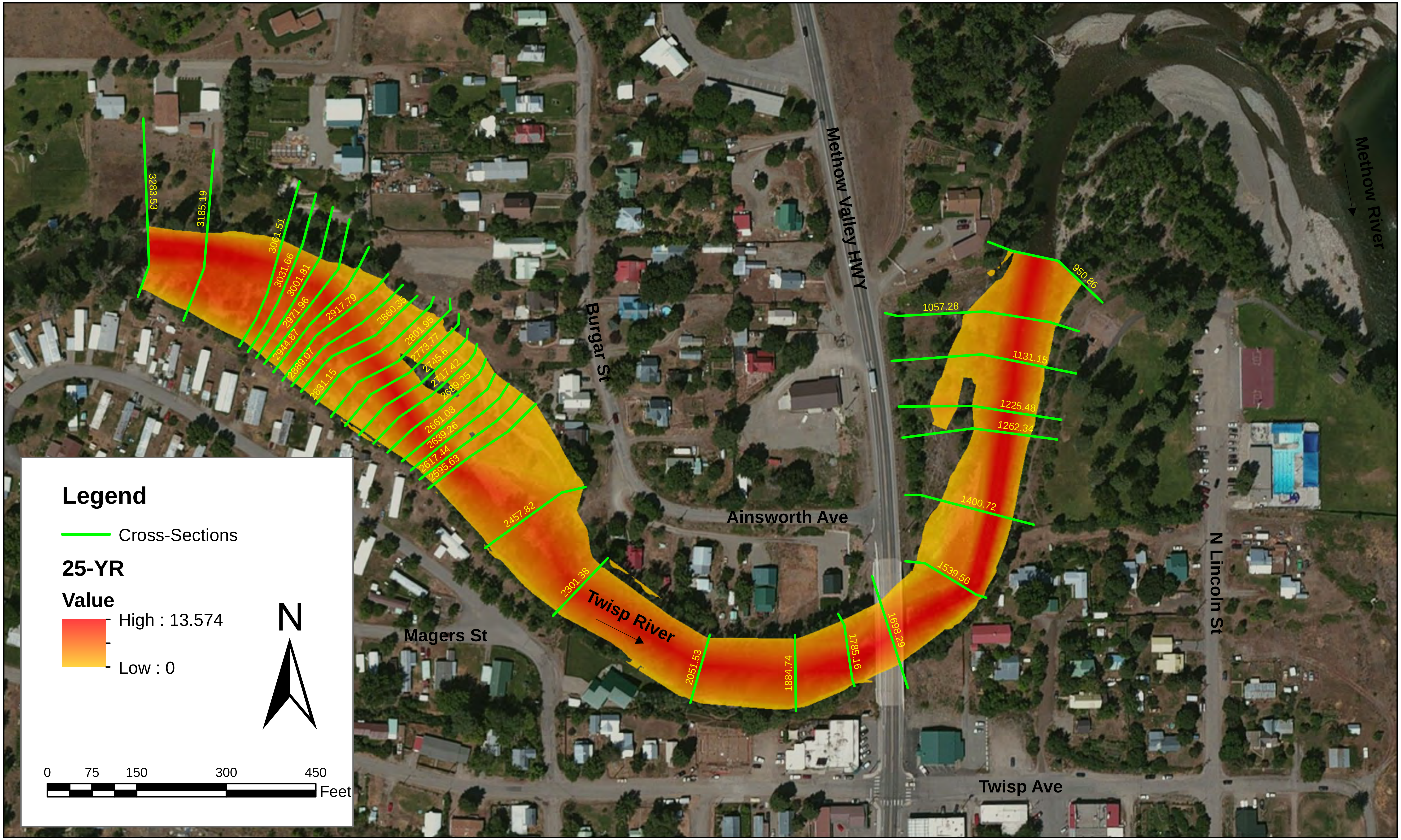
Plan View Showing Velocity - 2YR



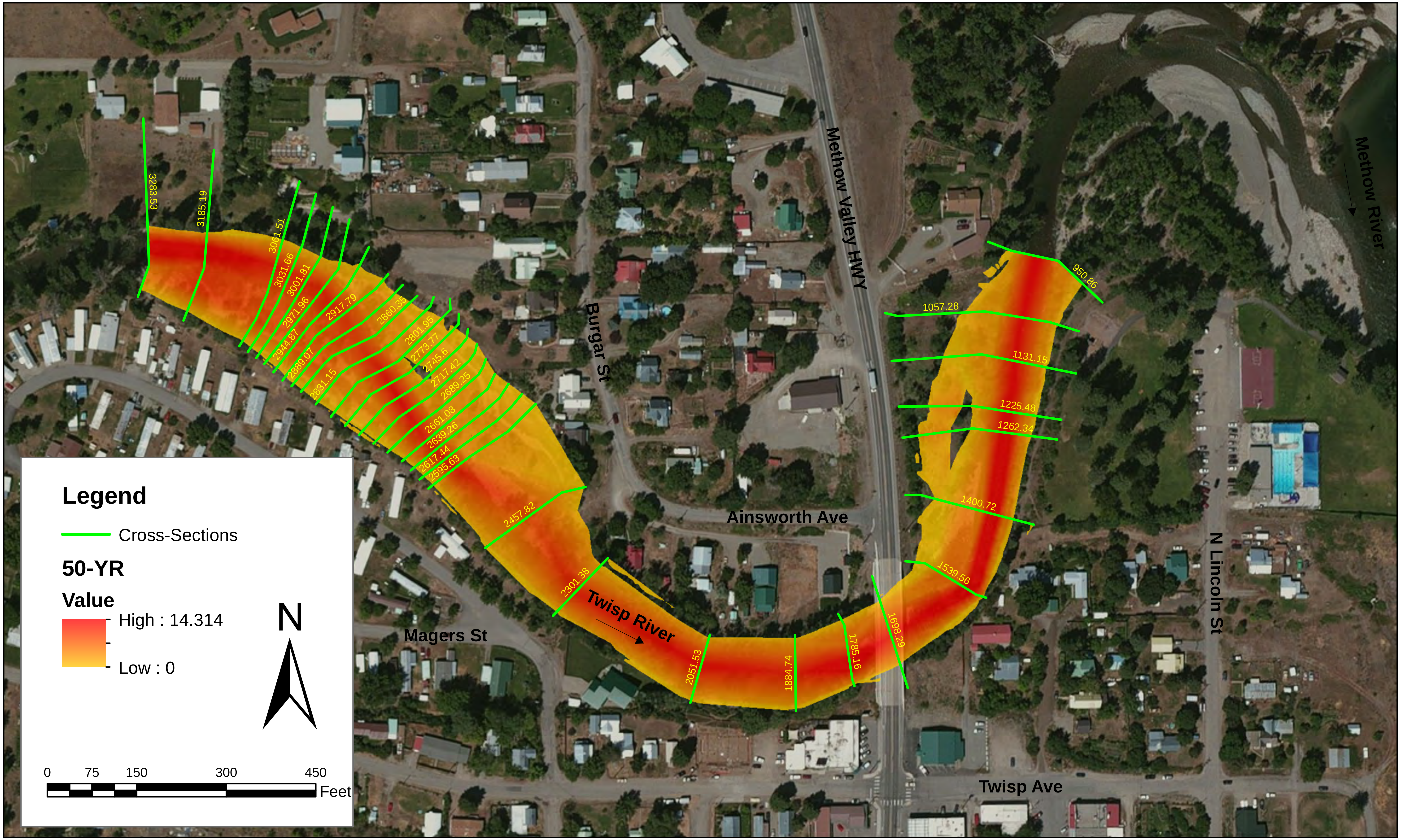
Plan View Showing Velocity - 5YR



Plan View Showing Velocity - 10YR



Plan View Showing Velocity - 25YR



Plan View Showing Velocity - 50YR

Appendix C: Planning Estimate

Lower Twisp RM 0.5 Construction Planning Estimate

Does not include permitting.
Pile ballast installation assumes vibratory pile driver is successful. If Piles cannot achieve design depth, boulder ballast will be required increasing cost.
Assumes wood is stockpiled near construction site.
Assumes revegetation stock/effort completed by others.

Location	Activity	Unit of Measure	Unit	Cost	Total
Site A	Large wood purchased and delivered to site	EA	34	$500	$17,000
	Mobilize (includes hauling logs from stockpile)	LS	1	$5,000	$5,000
Assumes bank length is 40 feet.	Dewatering sediment control	LS	1	$5,000	$5,000
Three layer bank jam.	Excavate to place jams and burial	CY	400	$6	$2,400
	Log jam construction	LS	1	$5,520	$5,520
	Off site fill haul and grade (excess cut material)	CY	200	$15	$3,000
	Construction oversight	HR	32	$127	$4,064
	Construction costs				$41,984
	Construction cost with 15% contingency				$48,282
Site B Backwater Alcove - Grd. Water Gallery	Large wood purchased and delivered to site	EA	126	$500	$63,000
	Mobilize (includes hauling logs from stockpile)	LS	1	$15,000	$15,000
Assumes five large log jams for bank stability and rearing habitat.	Dewatering sediment control - TESC, SPCC	LS	1	$10,000	$10,000
	Log jam construction	LS	5	$5,520	$27,600
	Excavate to grade. Native gravel haul within 2 miles.	CY	2000	$16	$32,000
Includes ground water gallery and pipe	Channel grading and large wood habitat construction	LF	300	$100	$30,000
	Seed and Mulch	AC	2	$6,000	$12,000
Backwater cut 6 deep btm width 15 with 2:1 slopes.	Ground Water Gallery 1200 LF	LF	350	$30	$10,500
30'X6'X300 includes inset channel off base cut.	Construction oversight	HR	240	$127	$30,480
	Construction costs				$230,580
	Construction cost with 15% contingency				$265,167
Site B Backwater Alcove	Large wood purchased and delivered to site	EA	126	$500	$63,000
	Mobilize (includes hauling logs from stockpile)	LS	1	$15,000	$15,000
Assumes five large log jams for bank stability and rearing habitat.	Dewatering sediment control - TESC, SPCC	LS	1	$10,000	$10,000
	Log jam construction	LS	5	$5,520	$27,600
	Excavate to grade. Native gravel haul within 2 miles.	CY	2000	$16	$32,000
Includes ground water gallery and pipe	Channel grading and large wood habitat construction	LF	300	$100	$30,000
	Seed and Mulch	AC	2	$6,000	$12,000
30'X6'X300 includes inset channel off base cut.	Construction oversight	HR	220	$127	$27,940
	Construction costs				$217,540
	Construction cost with 15% contingency				$250,171
	Large wood purchased and delivered to site	EA	55	$500	$27,500
Site C	Mobilize (includes hauling logs from stockpile)	LS	1	$5,000	$5,000
	Dewatering sediment control	LS	1	$5,000	$5,000
Assumes bank length is 50 feet.	Excavate to place jams and burial	CY	850	$6	$5,100
	Log jam construction	LS	1	$5,520	$5,520
Four layer bank jam.	Off site fill haul and grade (excess cut material)	CY	400	$15	$6,000
	Construction oversight	HR	40	$127	$5,080
	Construction costs				$59,200
	Construction cost with 15% contingency				$68,080