Restoration of the Lake Fork of the Gunnison River,
Lake City, Colorado:
Feasibility and Planning Project

Final Report

Prepared by:

Lake Fork Valley Conservancy
P.O. Box 123
Lake City, CO 81235

And Black Creek Hydrology
10998 Patterson Court
Northglenn, CO 80234

Submitted to:

Colorado Water Conservation Board
ATTN: Chris Sturm
1313 Sherman St., Room 721
Denver, CO 80203
chris.sturm@state.co.us

PROJECT SUMMARY

The Lake City River Enhancement Project on Henson Creek and the Lake Fork of the Gunnison River will improve fishery habitat, stabilize sections of the streams and improve river function on two heavily used segments of stream channel. The project is located in the town of Lake City in Hinsdale County in southwestern Colorado (Figure 1, V*icinity Map*, and Figure 2, *Project Area*).

The concept for the Lake City River Enhancement Project on the Henson Creek and the Lake Fork of the Gunnison River was initiated in 2008 and was encouraged by a diverse group of members of the community who saw the need for a comprehensive plan for fishery enhancement, stream stabilization and recreation opportunities. Although the two streams and their confluence are at the heart of the town of Lake City, they have been impacted by more than a century of channelization, mining, dam failure, flood events, sedimentation and encroachment.

Initial efforts to develop an enhancement plan began with community meetings in 2008 to form committees, assign tasks and gather ideas and input from the public. Applications for grants to fund field data collection and to develop an enhancement design were submitted and approved in 2009. Field work including river assessment and topographic survey were started in October of 2009 and were completed in November of 2010 which allowed for the development of conceptual designs in 2011. Sediment transport and hydrologic studies were performed during spring runoff of 2010 and 2011. Hydraulic modeling of the project reaches was performed in 2012 which allowed final design of the proposed enhancements.

Throughout the development of the project's technical design, community input was obtained through survey, public meetings and presentations as well as through individual meetings with land owners and discussions around kitchen tables.

In anticipation of future work on the rivers, the scale of the overall project is much larger than will be constructed in Phase I starting in 2013. Topographic survey of the channel covered 2.6 miles of channel and LIDAR scanning and hydraulic modeling covered five miles of the stream systems.

Overall, the planning phase has had several outcomes:

1) strong community support for river improvement work in Lake City;
2) solid survey data collected on pre-construction conditions which have generated a detailed hydraulic model, which has further leveraged support from FEMA to remap the flood plains in Hinsdale County;
3) completion of a comprehensive conceptual plan for in-channel and out of channel improvements;
4) Procurement of over $400,000 in grants, donations and in-kind support for construction of Phase I of the project on lower Henson Creek.

PLANNING PHASE OBJECTIVES

Funding provided by the CWCB Watershed Restoration Program covered four major tasks, which are described in detail under Project Results Section:

1) Undertake baseline studies of flood plain configuration, bed load, and biological parameters (riparian/wetland assessment, fish and macro-invertebrate surveys)
2) Facilitate community and land owner involvement in planning and public education;
3) Complete the conceptual river restoration design based on outcome of studies and stakeholder inputs;
4) Prepare a long-term master plan that outlines future maintenance and recreational management strategies, roles and responsibilities.

PROJECT RESULTS

A summary of the lengths of channel reaches surveyed along with the physical and technical scope of the project is shown in the Table 1. Additional details of tasks performed for the various activities are included in later sections of this report. For reference and discussion purposes, Figure 3 shows the river reaches, stationing along these reaches, and outline of the Town of Lake City and Highway 149 that passes through Lake City and crosses Henson Creek.

Table 1. Summary of Data Collection, Design and Modeling

	Channel Length (ft)		
Activity	Henson Creek	Lake Fork	Total
Channel Topographic Survey	6,550	7,400	13,950
LIDAR	7,500	19,000	26,500
HECRAS Model	7,500	19,000	26,500
Hydraulic Analysis	7,500	19,000	26,500
Stream Enhancement Design	6,130	7,250	13,380
Phase I river construction	2,600		2,600
Sediment Transport Study	One site on Henson Creek		

Topographic Survey and Ground Surface LIDAR

An important component of stream restoration and enhancement design is the delineation of the existing physical condition of the river system. This delineation provides information about the geomorphological, geometric and hydrologic characteristics of the channel which is used for the design, in calculations and for construction planning. Channel geometry data collection is done with a survey of the topography of the river channel and floodplain. Surveys of cross sections and profiles provide details on specific features and channel characteristics.

Data collection began in October of 2009 commencing with a topographic survey of the active channel. The locations of the surveyed stream reaches relative to Lake City are shown in Figure 3. A total of 13,950 feet of channel was surveyed including 6,550 feet of Henson Creek, 1,300 feet of the Lake Fork upstream of Henson Creek and 6,100 feet downstream of Henson Creek. Over 24,000 survey points were utilized. Because LIDAR data was to be obtained of the entire project area, only the active channel was surveyed to provide detail of the submerged stream bed, stream banks and top of bank delineation as well as cross sections of the channel. The topographic survey was done from bank to bank within active channel.

In addition to traditional ground survey methods, aerial LIDAR (**LI**ght **D**etection **A**nd **R**anging) methods of topographic, vegetation and structure delineation were used in 2011 to delineate surface features in high resolution and to acquire high resolution aerial photography of the floodplain and broader project area. LIDAR was performed to obtain a high resolution scan of the dry portions of the channel, floodplain and upland areas. This data was accurate to 3 cm horizontally and 5 cm vertically. Control established for the LIDAR flight and scan ties the ground survey data to the LIDAR scan. LIDAR coverage included nearly five miles of the two streams. The stream reaches included in the LIDAR coverage and hydraulic modeling are shown in Figure 4.

The combined ground survey and LIDAR coverage provided very detailed topographic data of the stream channel and floodplain from which a detailed, computerized Digital Elevation Model (DEM) was developed. The DEM provided a means to extract cross section and detailed profile information from anywhere along the project reaches. It was created with contour intervals of 0.5'. Topographic information in the DEM is useful for examining floodplain elevations and channel widths. Channel profiles extracted from the DEM provide information on channel slope to identify reaches with potential sediment accumulation problems. In addition, the DEM is detailed enough to allow for relatively precise cut and fill analysis which will be useful during the final construction planning phase of the project.

Extraction of cross sections from the DEM was extremely useful for the hydraulic modeling phase of the project. The DEM was detailed enough so that cross sections as close as a few feet apart were extracted to define channel features that affect the river hydraulics. Hundreds of cross sections were extracted and used in the modeling which is discussed later in this report.

Sediment Study

Prior to settlement in the 1880's, the valley floor through Lake City was the confluence of two braided stream channels full of gravel bars and depositional features. The channel gradients at the confluence area are flatter than the upstream channel reaches for both the Lake Fork and Henson Creek and, therefore, a portion of the river gravel materials (bedload) transported by the streams into the confluence area is not easily transported through the confluence and can accumulate in the channels. The result was gravel bars that formed when sand, gravel and cobble materials (bedload) transported by the rivers were deposited by high flows. Following flood events on Henson Creek and the Lake Fork in the late 1800's and early to mid-1900's, efforts to contain the rivers included consolidating the braided channels and constructing levees along their banks. Those efforts have been reasonably effective at containing normal flows. However, the supply of bedload material from upstream sources continued and likely even increased due to upstream mining activities, road construction and multiple catastrophic dam failures. Because these natural and man-caused conditions have the potential to affect stream enhancements, at least some understanding of the quantity and size of bedload that the rivers deliver to the project reach.

Henson Creek is the primary source of suspended and bedload sediment to the project reach since bedload (sand, gravel and cobble) from the upper Lake Fork is captured by Lake San Cristobal and by an on-channel hydroelectric plant forebay located about 3,500 feet upstream of the project reach. Relatively small amounts of gravel are delivered to the upper Lake Fork reach by small tributaries and bank erosion. In contrast, Henson Creek transports a substantial quantity of bedload in size classes from sand through large cobble. Therefore, in order to assess the transport characteristics of bedload through the project reach, a sediment transport study was performed on Henson Creek during the 2010 and 2011 spring runoff periods. This study included measurements of steam flow, the development of a stage/discharge rating curve at the Henson Creek sampling site, collection of suspended sediment and collection of the transported sand and gravel load (bedload).

The Henson Creek sediment sampling site is located about 1.4 miles upstream of the confluence with the Lake Fork near the upstream end of the project reach. There is very little tributary inflow between the sampling site and the Lake Fork such that sampling at the site closely reflects the sediment load in the project reaches of Henson Creek and the Lake Fork. A low profile bridge exists at that site which allowed for stream flow velocity measurements and sediment collection from the bridge (Figures 5 and 6). Cross sections and a longitudinal profile of Henson Creek in the vicinity of the bridge were surveyed prior to spring runoff. A staff gauge and stage recorder were installed about 100 feet upstream of the bridge. The stage recorder was operated from April 2010 through July of 2010 during the spring runoff period.

Flow measurements were taken using either a Price AA or pygmy current meter depending on flow conditions. A discharge measurement was taken with each bedload sample in 2011 in order to correlate bedload transport with discharge. A staff gauge reading was recorded at the beginning and end of each discharge measurement and at the beginning and end of each bedload sample collection. The stage/discharge curve developed from the data is shown in Figure 7.

Suspended sediment was collected using a DH48 sampler. Bedload was collected in 2010 using a 3 inch Helley-Smith sampler or a 4x8 inch Elwah sampler. In 2011 bedload was collected using a 3 inch Helley-Smith sampler and a 6 inch Helley-Smith sampler. The flows at which suspended sediment and bedload samples were collected are indicated on the graph in Figure 7.

Henson Creek has a slope of about 1% through the sampling reach which creates high velocities during high flow. A rope belay was used to aid in handling the current meters and top-setting rod during high flow. In order to facilitate bedload collection, a steel frame was constructed in order to assist with lowering the bedload samplers into the river and to support the sampler against the forces generated by the high flows. The photos in figures 5 and 6 show the use of the Elwah sampler along with a custom-built sampling frame that allowed for use of the large sampler during high flow. Suspended sediment samples were sent to a lab for processing. Bedload samples were air-dried, split as needed, sieved and weighed to determine particle size distribution and transport rates.

The 2010-2011 sediment study included the collection of 17 discharge measurements at flows ranging from 90 cfs to 759 cfs. A total of 22 suspended sediment samples were collected at flows ranging from 101 cfs to 931 cfs and 26 bedload samples at flows ranging from 125 cfs to 888 cfs. Four of the bedload samples were collected at flows between 790 cfs and 888 cfs that exceeded estimated bankfull flow of 700 cfs. Bedload collection was discontinued at flows greater than 888 cfs because large amounts of large floating debris were being carried by the stream at that high of flow and the highest flows occur just after dusk. Under these conditions, sampling became too hazardous for both equipment and personnel. Figure 8 shows the bedload rating curve developed from the collected data. The bedload transport rate at bankfull was about 250 pounds per minute or about 180 tons per day which is nearly 18 dump truck loads of sand and gravel. The maximum measured bedload transport rate was 509 pounds per minute at 888 cfs which is about 367 tons per day or about 36 dump truck loads. The largest particles captured at the higher flows were 6" in diameter or larger. It is likely that even larger materials were transported by those high flows but capture was limited by the opening size of the sampler.

Table 2 shows the particle size distributions for the bedload samples. The table is sorted by discharge rate in order to demonstrate the increase in size and quantity of material transported with increasing flow. The D50 indicates the particle size (mm) where 50% of the sampled material was smaller than the size indicated. The D84 indicates the particle size (mm) where 84% of the sampled material was smaller than the size indicated. For example, at a flow rate of 888 cfs, 50% of the captured material was smaller than 36.1mm and 84% of the sample was smaller than 81.5mm. The table also shows, for comparison purposes, the size distribution of a gravel bar sample collected on Henson Creek using pebble counts.

It is uncommon that the opportunity to collect bedload data for a project presents itself. A structure such as a bridge or cableway needs to be present from which to suspend equipment to collect samples and flows must be high enough to provide meaningful data. Bedload data at flows less than bankfull is helpful but bedload samples collected at flows at or greater than bankfull are needed to fully describe the sediment transport of a system. For this study ten of the 26 bedload samples were collected during flows near or above bankfull.

When bedload data is not available, surrogates can sometimes be found through pebble counts and bar samples. A bar sample is simply the excavation material from an in-channel gravel bar thought to contain materials of a size distribution transported by bankfull discharge. Those excavated materials (typical a sample of 5 to 100 pounds) are dried and sieved to determine their size distribution (see bottom of Table 2). If the sample was taken at just the right location from a gravel bar, then there a chance that it reflects a bankfull bedload sample. Unfortunately it does not provide information on quantity of material transported at any flow rate. A bar sample was collected from a carefully selected depositional feature that formed in 2011 below the Hwy 149 bridge. The particle size distribution of that sample is shown in Figure 11. The values Table 2 show that the Henson Creek bar sample has a similar particle size distribution to bedload material captured at flows about around 600 to 620 cfs.

Table 2. Particle size distribution from bedload sampling compared to a bar sample on Henson Creek.

Particle Size Distribution (mm)							
For Bedload at Various Flow Rates							
Discharge (cfs)	D16	D35	D50	D84	D95	D100	Total Bedload Transport Rate (lbs/min)
95	0.9	1.5	2.0	5.5	9.3	16.0	1.5
121	0.9	1.5	2.0	6.0	10.6	18.0	0.7
233	0.9	1.5	2.0	5.5	9.3	16.0	1.5
258	0.4	0.7	1.7	21.3	24.5	26.0	1.5
334	1.7	18.7	32.0	40.2	42.8	44.0	2.9
361	0.5	0.8	1.1	3.6	9.7	12.0	2.1
361	1.0	1.9	3.4	14.6	25.4	31.0	3.1
392	0.7	1.0	1.5	5.3	14.5	26.0	2.9
437	0.9	1.5	2.2	10.0	29.8	46.0	7.3
469	0.9	1.9	4.5	23.8	31.4	34.0	26.0
491	1.6	5.2	13.2	47.2	59.4	65.0	45.0
500	1.4	6.5	32.7	58.2	69.5	86.0	43.3
505	1.4	3.8	11.6	44.3	60.3	78.0	48.6
522	1.3	3.5	7.0	26.0	38.5	58.0	62.7
557	1.5	4.2	9.4	39.9	62.9	75.0	73.8
579	2.7	13.8	23.3	51.5	64.7	70.0	222.5
603	3.3	15.8	32.3	88.6	106.8	115.0	199.2
603	1.4	3.7	14.3	66.9	74.5	78.0	93.2
606	1.8	12.9	23.7	48.0	62.5	70.0	232.1
619	1.1	2.8	7.2	58.2	84.6	95.0	116.9
654	1.5	3.9	9.7	67.4	76.1	80.0	219.3
674	0.9	2.2	7.9	56.9	90.7	108.0	129.0
790	1.4	6.8	17.4	52.1	80.1	103.0	314.3
790	1.9	7.9	21.2	89.7	126.2	145.0	473.8
872	1.1	2.5	5.8	42.1	99.2	142.0	455.2
888	2.8	17.7	36.1	81.5	121.8	125.0	509.4

For Henson Creek Bar Sample							
n/a	0.7	2.2	10.4	46.0	83.4	105.0	n/a

A pebble count is an examination and classification of the size of materials found on the surface of the stream bed. A “Wolman” pebble count is performed by walking back and forth across the channel and blindly reaching down to pick up whatever particle is first blindly touched with the index finger. The particle is measured to determine its diameter, the value written down and then that particle discarded. One hundred particles are sampled from the stream bed in this way over a short reach. The texture of a stream bed can vary widely over even short distances. Therefore, pebble counts are typically done at riffle locations to maintain a degree of consistency. It is up to the investigator to identify those riffles that seem to reflect what is observed in the stream system. Five pebble counts were performed for this project at the following locations: Lake Fork at 3rd St., Lake Fork at 6th St., Lake Fork about 100 ft upstream of Pete's Lake tributary near 8^{th} St., on Henson Ck at Silver St. and on Henson Ck about 500 feet upstream of the headgate (near Sta. 26+00)

A graph showing the results of these pebble counts is shown in Figure 9. Figure 9 contrasts the size of material in the pebble counts with the bar sample collected from Henson Creek. The bar sample has a D50 of only about 10 mm while the pebble counts show D50s of the stream bed surface ranging from about 45 mm to 55 mm. The bar sample would be expected to contain smaller material (sand and small gravel) than the pebble count since flows wash away smaller materials from the surface of the bed.

Hydraulic Modeling

Hydraulic modeling of the project reaches was needed due to sediment transport conditions and residential development along the river banks. FEMA rules that presently cover the project area dictate that no activity within the flood prone area can raise the 100-yr water surface more than one foot. Therefore, a hydraulic model of the project reaches was developed in order to test the effects of proposed habitat and stabilization structures on the 100-yr water surface elevation. In addition, the modeling was used to identify and confirm reaches that presently have difficulty transporting sediments delivered from upstream sources and identify and test the effects of proposed structures on sediment transport.

The hydraulic model was developed using cross sections extracted from a digital elevation model (DEM) prepared from the topographic survey and LIDAR data. Hundreds of cross sections at intervals of generally 20 feet to 70 feet were extracted. In some reaches of special concern where greater sensitivity was needed, the cross sections are only five to ten feet apart. The map in Figure 10 shows the locations of cross sections used in the HECRAS model while Figure 11 shows current and future 100 year floodplain boundaries.

Flows tested in the model included the FEMA-predicted 100-yr discharges and high flow conditions observed in 2011. The 2011 high flow of the Lake Fork at the USGS Gateview stream gage was 1578 cfs which is slightly greater than the estimated bankfull discharge of 1400 cfs. High flow stage was located at multiple locations along the project reaches in order to calibrate the hydraulic model. The FEMA 100-yr flows included 2300 cfs on Henson Creek, 3600 of the Lake Fork upstream of Henson Creek and 5800 on the Lake Fork downstream of Henson Creek. Table 3 shows the flows used to calibrate the model and the current FEMA-estimated flows on Henson Creek and the Lake Fork for various return intervals.

Table 3. Flow levels used in calibration for model.

	FEMA Flows (cfs)				Model Calibration Flows (cfs)
Stream Reach	10-yr	50-yr	100-yr	500-yr	6/17/2011
Henson Creek	1400	2000	2300	3300	761
Lake Fork Upstream of Henson Ck	2000	3100	3600	5600	887
Lake Fork Downstream of Henson Ck	3000	4800	5800	9500	1578

Once a model representing existing cross section conditions was developed, the cross sections were modified in order to represent proposed modifications to the river for habitat and stabilization. The objective of the proposed-conditions model was to cause no rise in the 100-yr water surface elevation that would impact habitable structures along the river. This was accomplished through numerous modeling iterations where the river bed and banks were adjusted. Examples of HECRAS cross sections are shown Appendix A. The top of each cross section figure contains the name of the stream channel (Henson or Lake Fork) and a river station "RS" number. For example on Figure A-4, "RS=810" on "River=HansenCreek" can be located on Henson Creek at station 8+10 in Figure 3 earlier in this report. (Please note that "Hansen" was inadvertently entered as the stream name for Henson Creek but quickly worked its way permanently into the model labeling.)

Figure A-1 shows a cross section where excess gravel will be removed from the stream bed in order to improve channel hydraulics. The darkened areas on some of the cross sections indicated obstructions added to the channel to represent and test the effects that sills, vanes or cross vanes have on water surface elevations. Figures A-7 and A-8 respectively show the typical vane and buried sill while Figure A-7 also shows stream bed excavation to improve hydraulics needed to accommodate an adjustment to the abnormally low left bank floodplain. Figures A-3 and A-6 show a sequence of cross sections modified with a cross vane. The cross section in Figure 6 is located at the downstream end of the proposed cross vane structure and shows how the bed will be substantially excavated to create a pool within the structure Figures A-9 through A-11 show stream bed, bankfull flow and 100-yr flow profiles of the Lake Fork and Henson Creek. The modeling demonstrated that either zero rise or reductions in the 100-yr water surface elevations can be realized where necessary. It was observed that much of the river system will require some removal of river bed materials in order to provide room for habitat and stabilization structures.

The data channel and floodplain topographic surveys as well as the HECRAS modeling results will be used to assist FEMA with remapping of flood plains in Hinsdale County.

Design

The river design was done to prepare plans to stabilize stream banks and enhance the fishery. Much of the stream bank along Henson Creek and the Lake Fork experiences some degree of erosion. Some areas have little or no existing protection. While others have had rock materials (rip rap) applied in the past, some of those treatments are presently failing and need additional work. Proposed bank stabilization will include rock structures that will direct flow energy off the stream banks. Proposed fishery enhancements will include structures designed to facilitate development of deep pool habitat. Banks stabilization structures will also enhance the fishery. Some reaches are over-widened and presently allow gravel materials to accumulate and fill in the channel. Of the 10,000 feet of river channel in the project reaches, there are presently only two pools of any significant size and few other pools. Long riffles make up most of the stream channel in the project reaches.

The original intent of the river enhancement design was to stabilize the channel where necessary and improve riverine habitat. Constraints to being able to implement such a plan include land ownership, river sediment loads, access issue, natural site conditions, channel geometry and potential flooding. Due to these constraints, some the proposed structures originally included in concept plans have been dropped from the design due to potential flooding during high flows and lack of interest by some land owners.

The confluence of the Lake Fork and Henson Creek is located in a glaciated valley with a slope that is flatter than the upstream reaches of either the Lake Fork or Henson Creek. Historically the streams were broad and braided. Development of the valley included channelization of the streams and construction of homes, businesses and resorts along the stream banks. High flow events have flooded adjacent structures and channel constriction now limits the amount of flow that can pass through the system within the river banks.

The proposed habitat improvement and stabilization measures will include boulder vanes, boulder cross vanes and boulder clusters. Buried sills will be installed at specific locations on the floodplain where the floodplain is lower than normal bankfull elevation and needs to be slightly elevated to develop normal bankfull channel function. The quantities of each treatment are shown in the below in Table 4. Examples of proposed of vane, cross vane, buried sill and boulder terrace treatments are shown in Figure 12. The proposed locations of in-channel structures for the entire project area are shown in Figure 13.

Figures 14 and 15 show Phase I of the project, which has successfully been funded by CWCB Water Supply Reserve Account (WSRA) and DPW Fishing is Fun grants. Construction will begin fall of 2013 and completed the following year. Figure 15 shows the boundaries of the proposed River Recreation Corridor, where enhancement of fishing access will take place as well as channel improvements.

Table 4.	Bank Stabilization Structures		Habitat Improvement	
	Vanes	Sills	Cross Vane Weirs	Boulder Clusters
Lake Fork Upstream of Henson Creek	0	0	0	10
Lake Fork Downstream of Henson Creek	20	15	4	20
Henson Creek	10	10	5	5

A boulder terrace will be constructed at the confluence of the Lake Fork and Henson Creek to stabilize the stream banks, provide access to the river, increase usable space at Memorial Park, and improve channel function. The boulder terrace will be installed along the left bank of the Lake Fork and the right bank of Henson Creek immediately upstream of the confluence as shown in Figures 15 and 16. An example of this type of treatment can be seen in Figure 12. Upstream of the confluence on the Lake Fork, repairs will be made to an old cross vane built at the fishing pier (see before and after images in Figure 17), and habitat rocks placed in strategic locations where gradient is too low for more aggressive structures.

Due to over-width conditions on parts of Henson Creek and the Lake Fork, the streams tend to allow sediment to collect and fill in the channel. Historically the town has periodically excavated and removed accumulated deposits of gravel; particularly in Henson Creek upstream of the confluence. Cleaning of the channel required moving heavy equipment and trucks through the adjacent park are that will so be developed and enhanced during the proposed project activities. The narrowing of the channel through the installation of rock structures will improve sediment transport through those treated areas and reduce the likelihood of gravel accumulation during bankfull flow conditions. However, gravel materials are expected to continue to accumulate in the Lake Fork immediately downstream of the confluence. This area allows easy equipment access from Second Street so that periodic gravel removal can be accomplished without impacting the park. Other gravel materials will be removed from the streams to improve channel hydraulics and facilitate installation of rock structures. In order to offset the fill affect of rock materials that will be installed in the channel, a certain amount of gravel will need to be removed. Preliminary estimate of 1,000 to 1,500 cu/yd of material will be excavated and removed from the channel.

The Lake Fork contains a short reach of channel with a bedrock control (shown in Figure 13) and it will not be possible to adjust the river bed to improve hydraulics through removal of gravel. However, modeling indicated that excavation of bedrock over a reach length of about 50 feet would significantly improve upstream hydraulics and sediment transport through the reach upstream of the control. Presently the 500 feet of channel upstream of the bedrock control experiences deposition and would benefit from improved hydraulics.

Below the bedrock control and below Ocean Wave Bridge at the north end of town presents a unique situation. In the early 1980's, temporary berms were constructed north of the bridge to divert flood waters from the highway so that the Colorado Department of Transportation could engineer the slope beneath to withstand high flows, completed in the 1990's (Figure 18, yellow). High flows in 2011 have eroded much of the berm on the northwest side of the river, threatening private property. To date no construction has occurred here and most of the critical properties in the flood plain are currently on the market. This area has great potential for restoration through the removal of the berms, realignment of the channel, and reestablishment of riparian forest and wetland vegetation. With public ownership, this area will also give residents and tourists greater access to the river, which is currently limited.

The LFVC now seeks funding for property and/or conservation easement acquisition for this segment of the river (approximately 2000 feet), where significant alteration and bank erosion has occurred, and properties are currently undeveloped. Working with the local community, the NPS

Rivers, Trails, and Conservation Assistance Program helped us visualize what this site could potentially look like (Figures 19 and 20).

Community Input and Participation in Design

The Lake Fork Valley Conservancy has spent four years coordinating a planning effort for this project. The process began when a group of local boaters approached the Town of Lake City government to construct a whitewater park on the Lake Fork, and the Town requested LFVC to take the lead in the planning and design phase. Since 2008, a community-based approach to river improvement planning has gained momentum with the support of several local organizations, businesses, and individuals. LFVC has raised over $20,000 through its Build a Trout a Home campaign.

In March 2012, the LFVC sent out a public survey to all box holders at the local post office, a group of approximately 400 local and seasonal residents. The LFVC also advertised the survey in the Lake City Silver World, including a web link where readers could respond online. 100 people (25% of the group) shared their opinions via our Survey Monkey site and the paper survey.

The survey made sure to delineate the needs of different stakeholder groups; respondents identified themselves as property owners on or near the river, full-time or seasonal residents, and/or as a Lake City business owner or occasional Lake City visitor. The subsequent questions gauged preferences with respect to possible outcomes of river enhancement work. These include improvements to fish habitat, boating, public access points, trails, bank stabilization, signage, and private property protection.

The survey is part of a two-pronged approach of public outreach with regard to the Lake Fork River Enhancement Project, which included both private landowners and the community at large in the conversation. Since 2008, LFVC has conducted 15 public meetings and two river tours, attended by 197 residents, tourists, target recreational users, local government, and river design experts, during which we have discussed results of surveys and channel design, as well as address issues such as liability and trespass. Because the river in town passes through mostly private property, we are reaching out to the 39 riverfront landowners who are within the river project study area. Of these, 28 have signed permission forms for survey access and three out of four are participating in Phase I of construction on Henson Creek. We have conducted individual meetings with most of these landowners to discuss their concerns and ideas. Within the Phase I area, discussions have been held with the three landowners affected by the improvements to ensure that any structures or changes on private property meet with the owner’s full approval, which will lead to landowner access agreements this spring.

The results made it clear that our community highly values its fisheries and appreciates protections afforded to private property owners, such as bank stabilization as well as the ability to control visitation on their land. These attitudes were confirmed with the survey's final question, which asked individuals to rate 11 different aspects of the project on a scale of 1-5: 1 being “extremely important,” 3 being “worth considering,” and 5 being “not a priority.” Figure 21 shows that more than 60% of respondents ranked “improve fish and wildlife habitat” as an extremely important objective. The second and third most important objectives were “improve bank and channel stability," and "protection of private property owners' rights," each of which were rated extremely important by more than 50% of respondents.

People who indicated that they were "Lake City Business Owners," of which there were a total of 17 respondents, were overwhelmingly in favor of increased recreation on the river. They would like to see more boating (76.5%) and more fishing (70.6%). Many respondents, usually full-time residents and business owners, also expressed enthusiasm for the local economic benefit of different aspects of the project. A desire for more open space was also apparent. More specifically, respondents anticipated the creation of mixed-use riverfront recreation areas that accommodate people of all ages and interests. During a later phase of this project, these areas will be marked with signs and guides that respondents believe would help visitors enjoy river resources without trespassing.

Overall, the survey results are not too surprising and closely mirror the feedback we have received from public meetings and focus discussions with special interest groups and individual land owners. In conjunction with public input, the survey has provided clear direction for design work. The primary concern of landowners has been issues of trespass. Ideas to address trespass issues include better signage marking private property, education programs, and trails maps that clearly show public access areas. We have assured landowners that we will not proceed with any project activity on their property without their full participation.

Ideas generated for "Out of Channel" Improvements

The following ideas have been generated through community input, which will be finalized as we enter construction phases of the River Enhancement Project:

- Stabilize newly reconstructed banks with riparian vegetation
- Revegetate adjacent barren areas (e.g. along public trail, Memorial Park)
- Construct additional trail areas connecting Pete's Lake with community garden and Waterdog trail
- Improve public access at Memorial Park, public roads/alleys
- Improve signage for private property boundaries
- Improve signage/maps for public fishing access
- Boating put-ins and take-outs (Memorial Park, Henson Creek trail, below water treatment facility

Master Plan

The Town of Lake City has taken on the lead responsibility to oversee long term maintenance and management of the public portions of the river restoration work. Liability concerns are to be covered under their general liability policy. The Town has agreed to allocate $2,000 annually with the assistance of the Lake Fork Valley Conservancy, who has pledged to raise half this through their various fundraising mechanisms. Private landowners who participate in the project will be responsible for long-term maintenance on their own property. LFVC is currently working on a Master River Recreation Corridor Plan that will describe these responsibilities in detail and be used by the Town to manage public spaces along the river.

Post Construction Monitoring Plan

Prior to construction, under low flow conditions, LFVC will select at least three cross- section locations in the project reach. At each cross section we will: 1) identify and monument cross section end points; 2) perform detailed survey of each cross section using same methodology used in the baseline survey; 3) perform a pebble count at each cross section; and, 4) establish photo points at each cross section (upstream, downstream and left and right bank directions).

Immediately following completion of construction and construction and annually for three years, LFVC will repeat the above survey methods. This will include Annual document of condition of treatments and identify any problems that may develop.

PROJECT EXPENDITURES

A complete summary of expenditures are contained within the Excel spreadsheet entitled "CWCB Final Expenditures".

Figure 1 . Vicinity Map

Figure 2. Feasibility Study and Survey Area

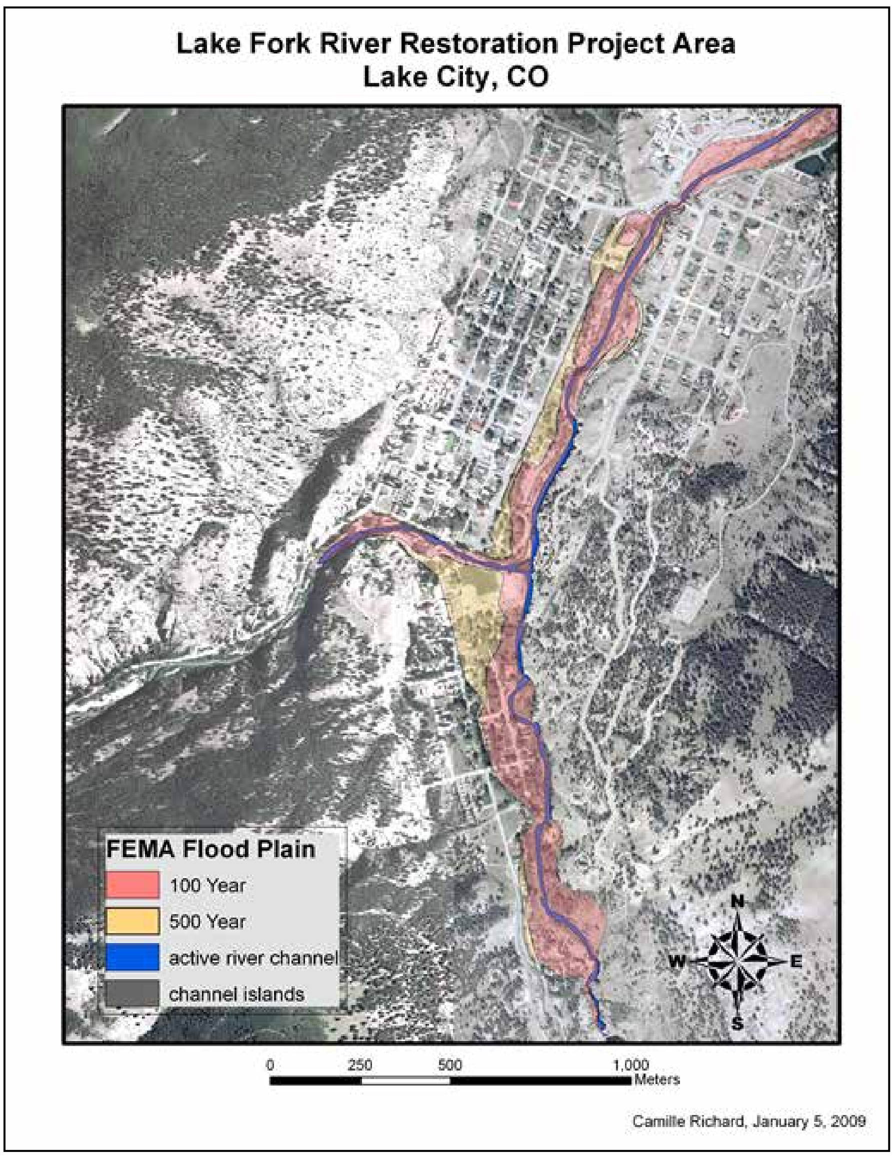


Figure 3. Survey Area with numbered river stations.

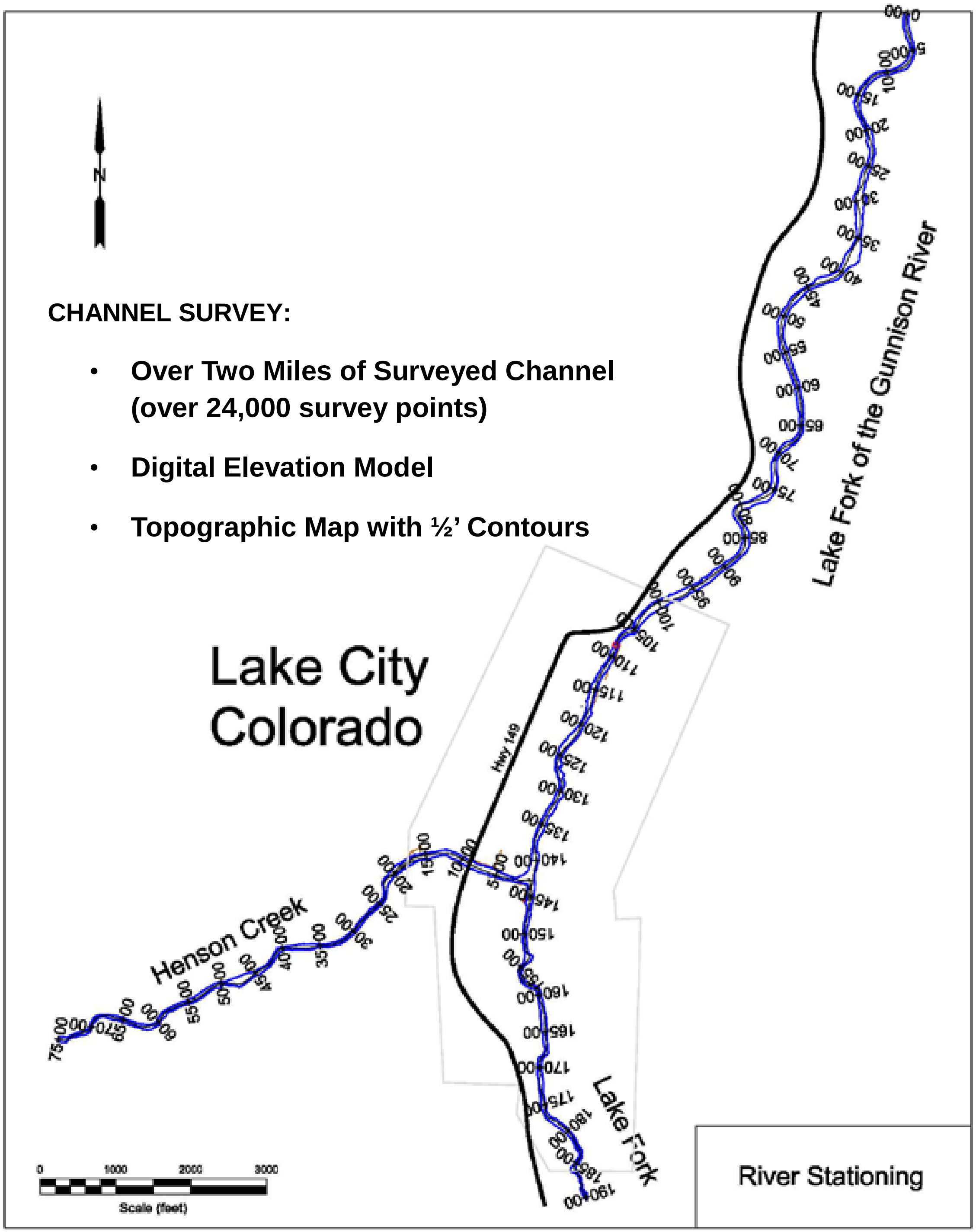
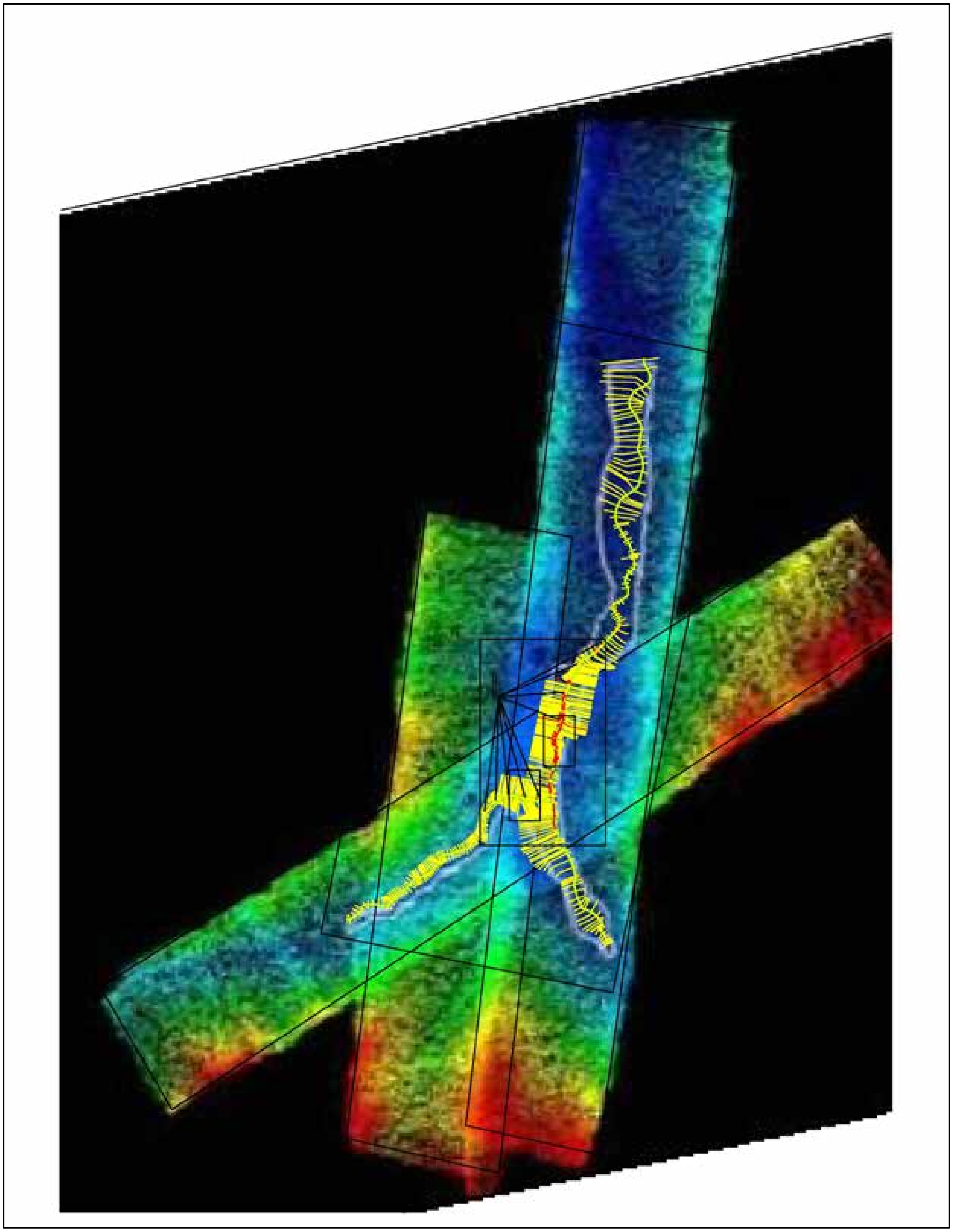


Figure 4. LiDAR flight lines and HECRAS coverage.



Figures 5 and 6. Henson Creek Bedload Sampling

Figure 7. Henson Creek Stage/Discharge Rating Curve

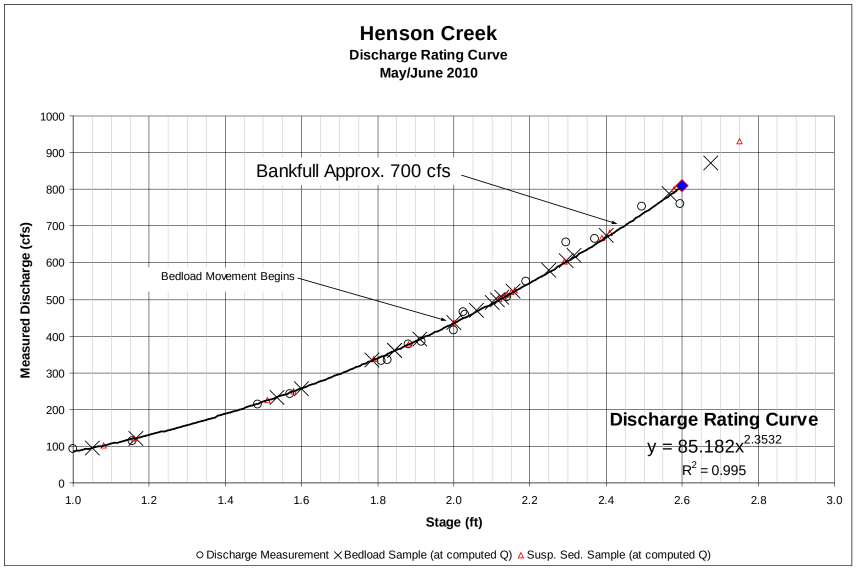


Figure 8. Henson Creek Bedload Transport Sampling Results.

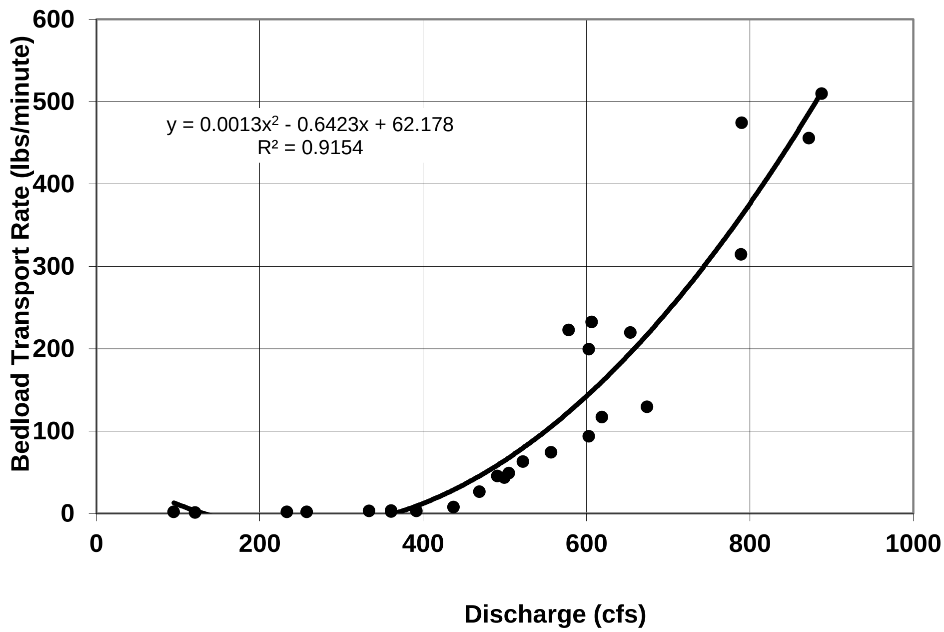


Figure 9. Results of Pebble Counts.

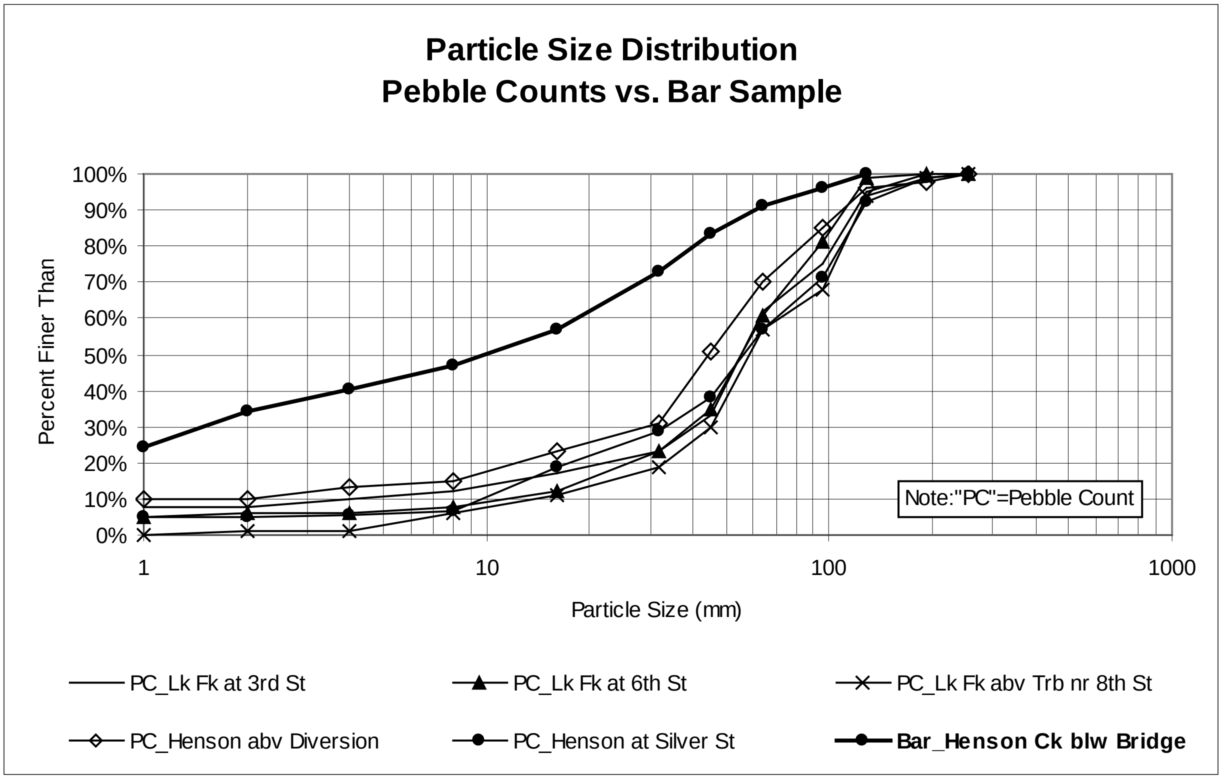


Figure 10. Locations of HECRAS Cross Sections.

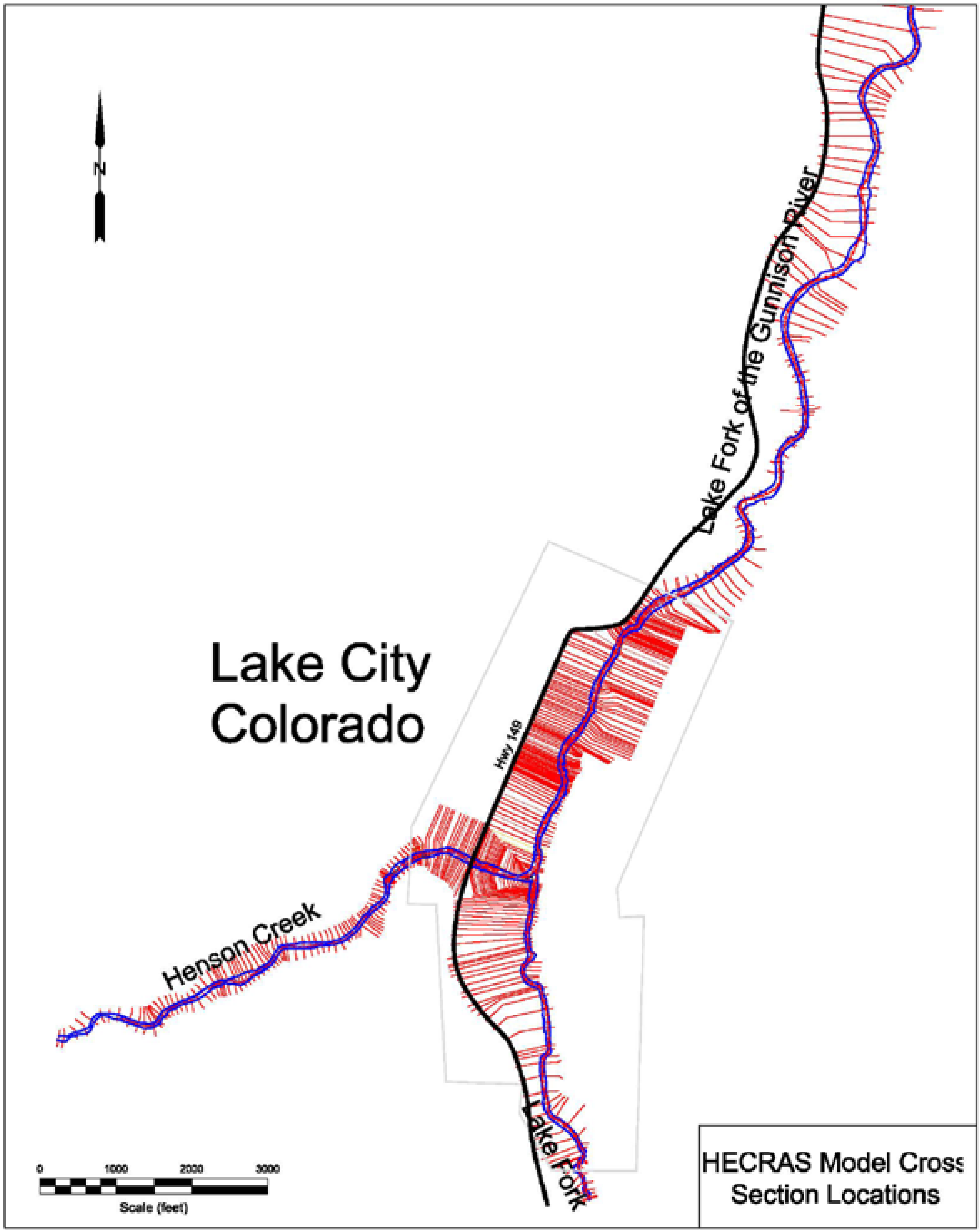


Figure 11. Results of HECRAS showing current 100 year flood plain in red and new 100 year flood plain resulting from proposed improvements.

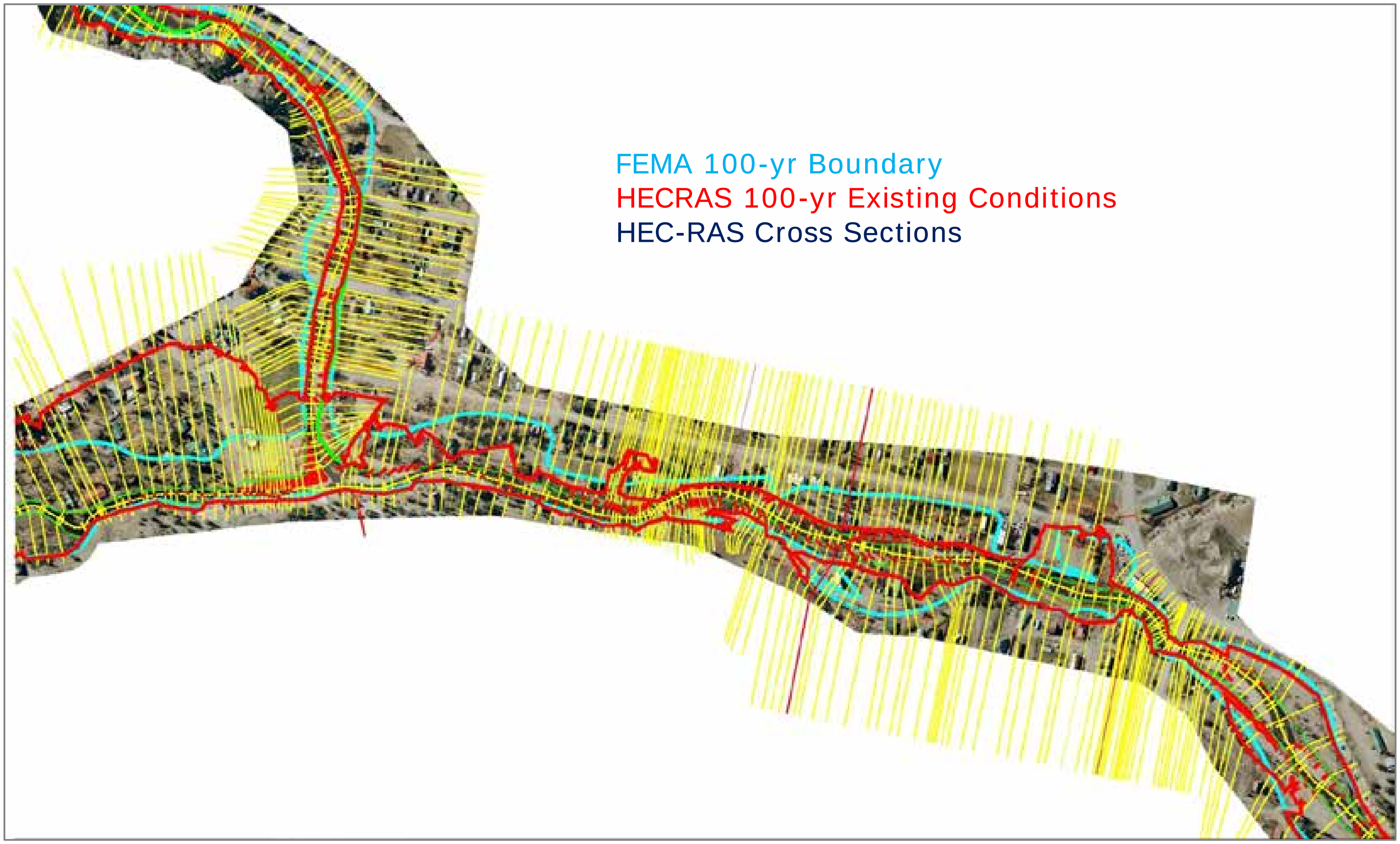


Figure 12. Examples of Vanes, Cross Vanes, Sills and Boulder Terrace.

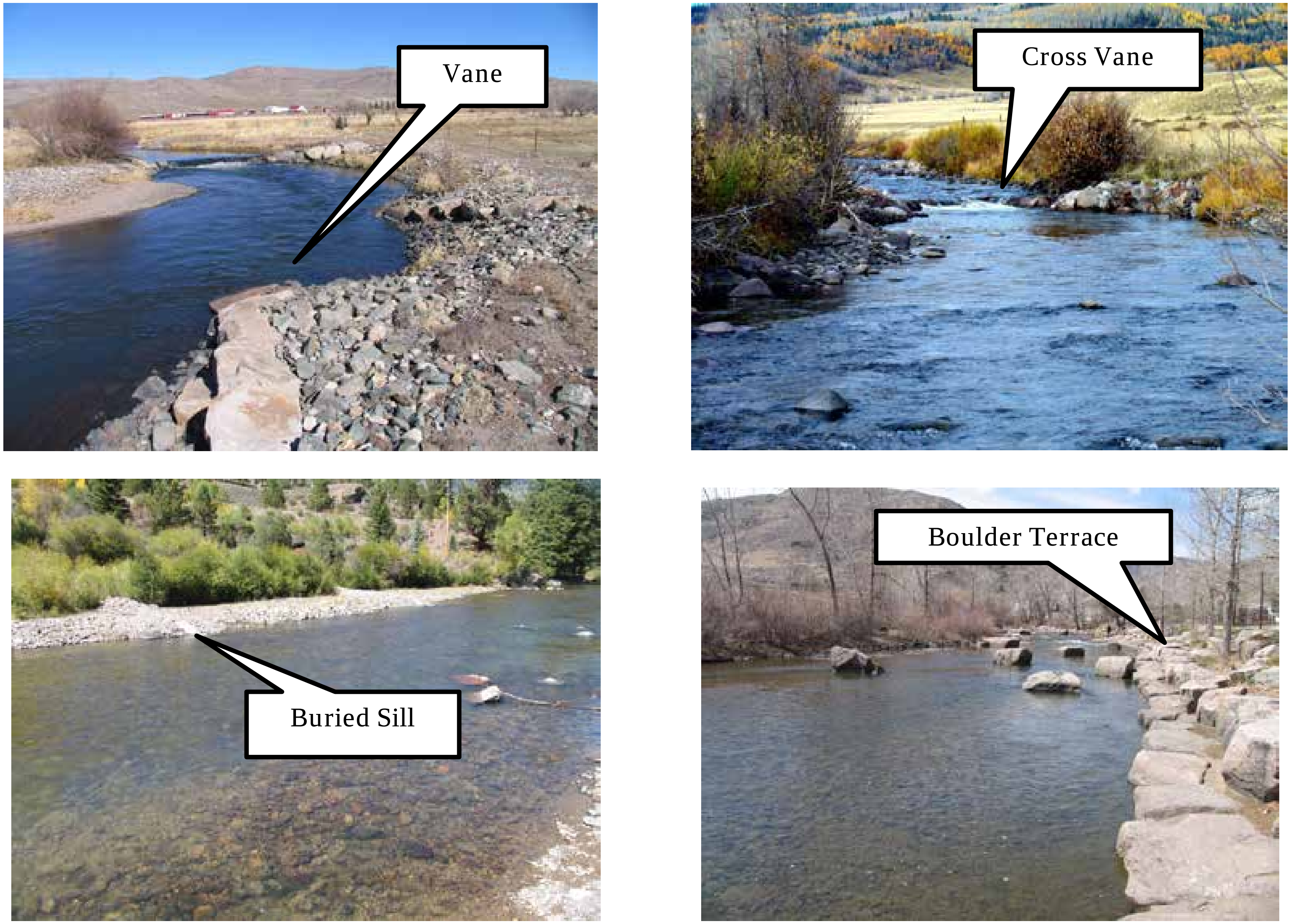


Figure 13. Proposed structures for entire project reach.

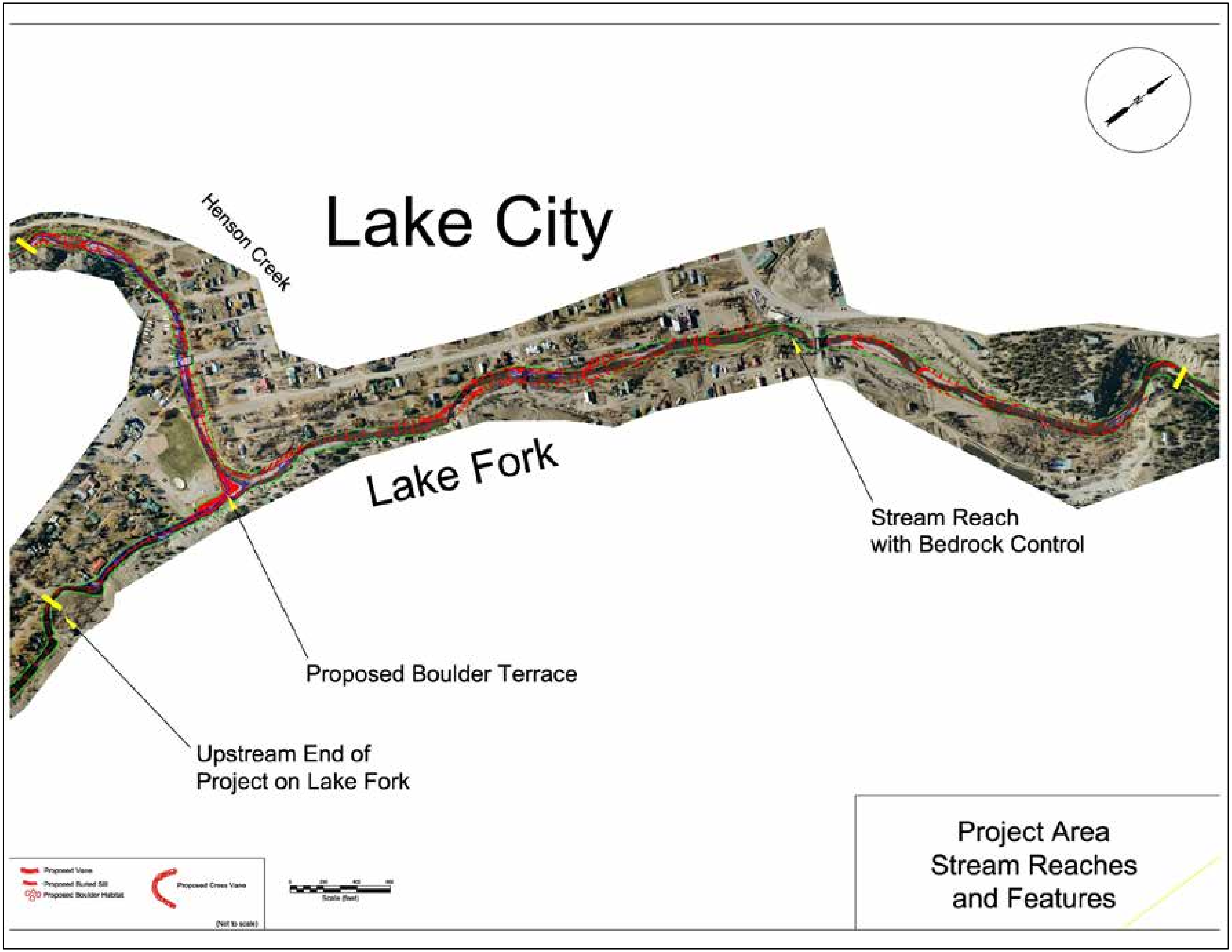


Figure 14. Phase I Construction Area to be primarily funded by CWCB Water Reserve Supply Account and Fishing is Fun grants.

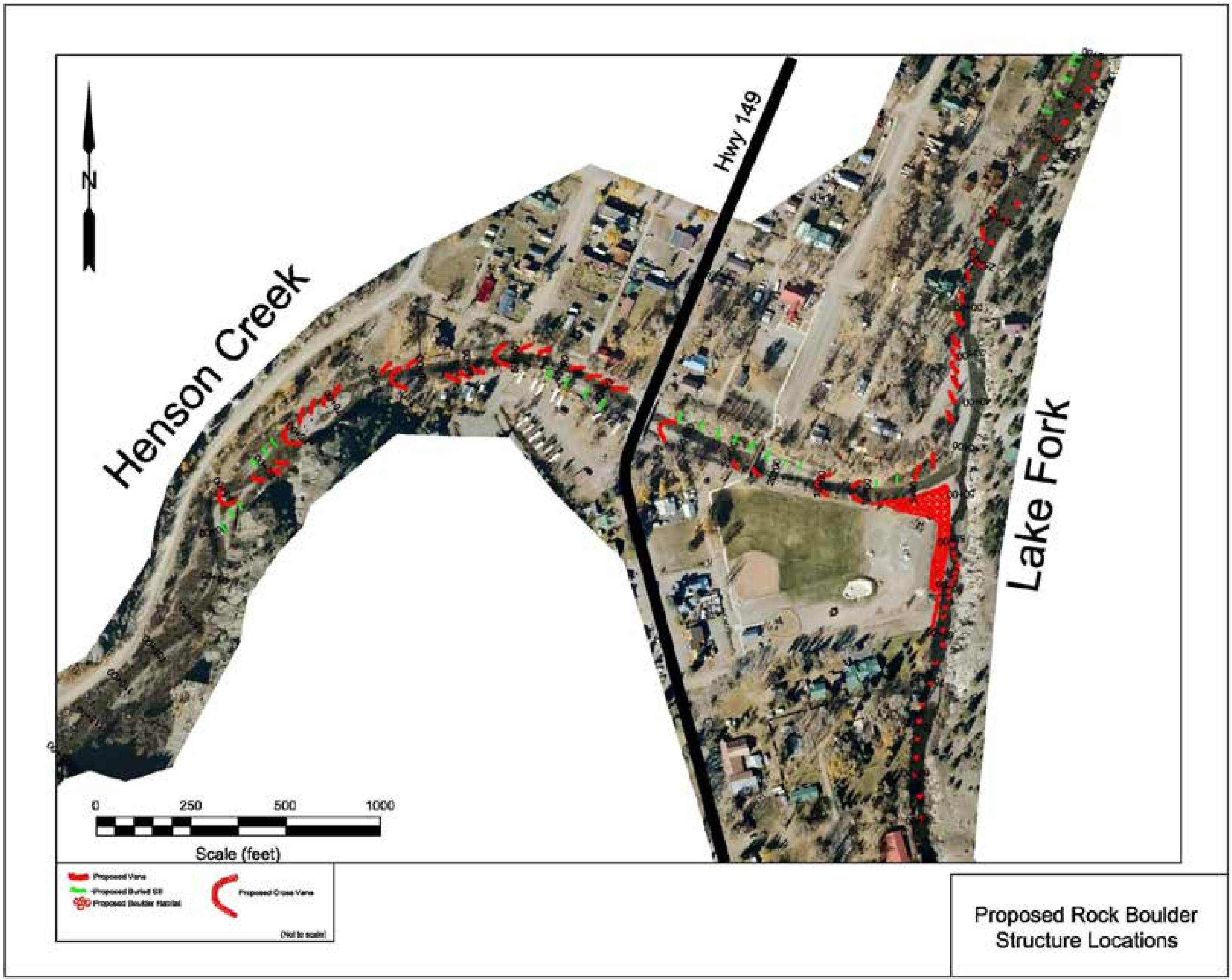


Figure 15. Proposed River Recreation Corridor to enhance recreation opportunities for Phase I construction area.

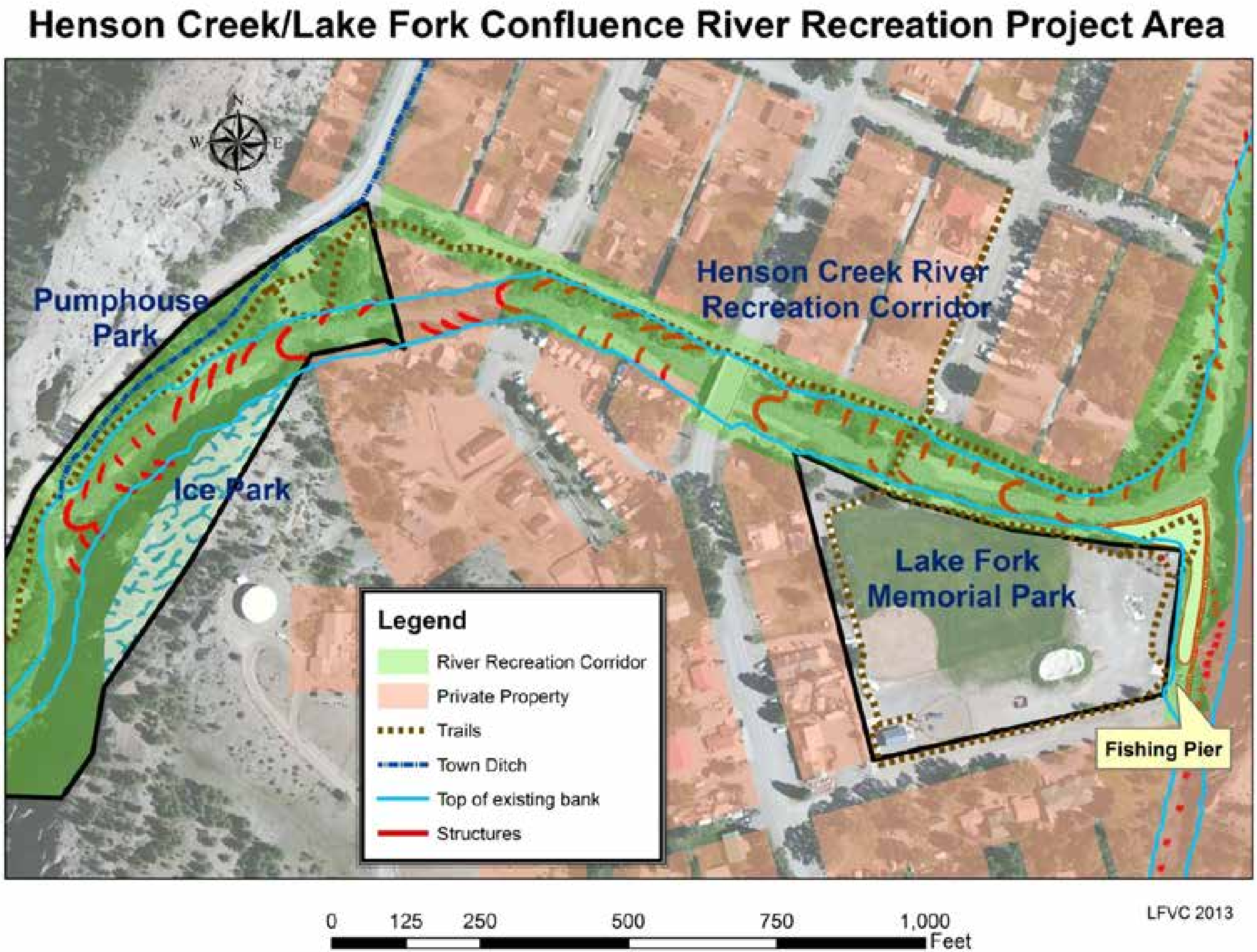


Figure 16. Improvements proposed at the confluence of Henson and the Lake Fork, to add 18,000 square feet of usable space at Memorial Park (LFVC 2012).

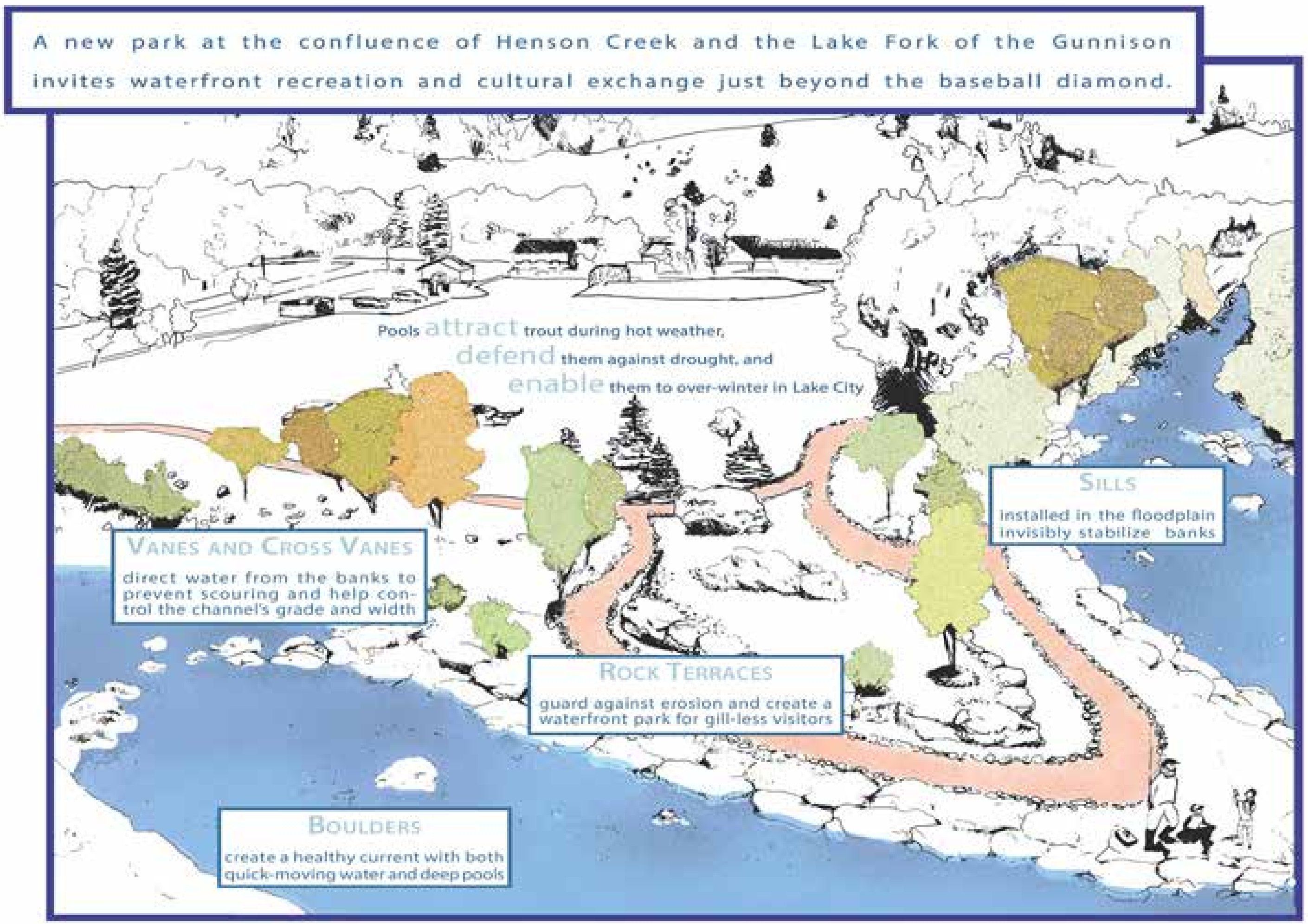


Figure 17. Before and after image of area near fishing peir at Memorial Park. Second image from RTCA 2010.

Figure 18. Area below Ocean Wave (8 ½ Street) Bridge, for acquisition of private property and restoration for an open space river park.

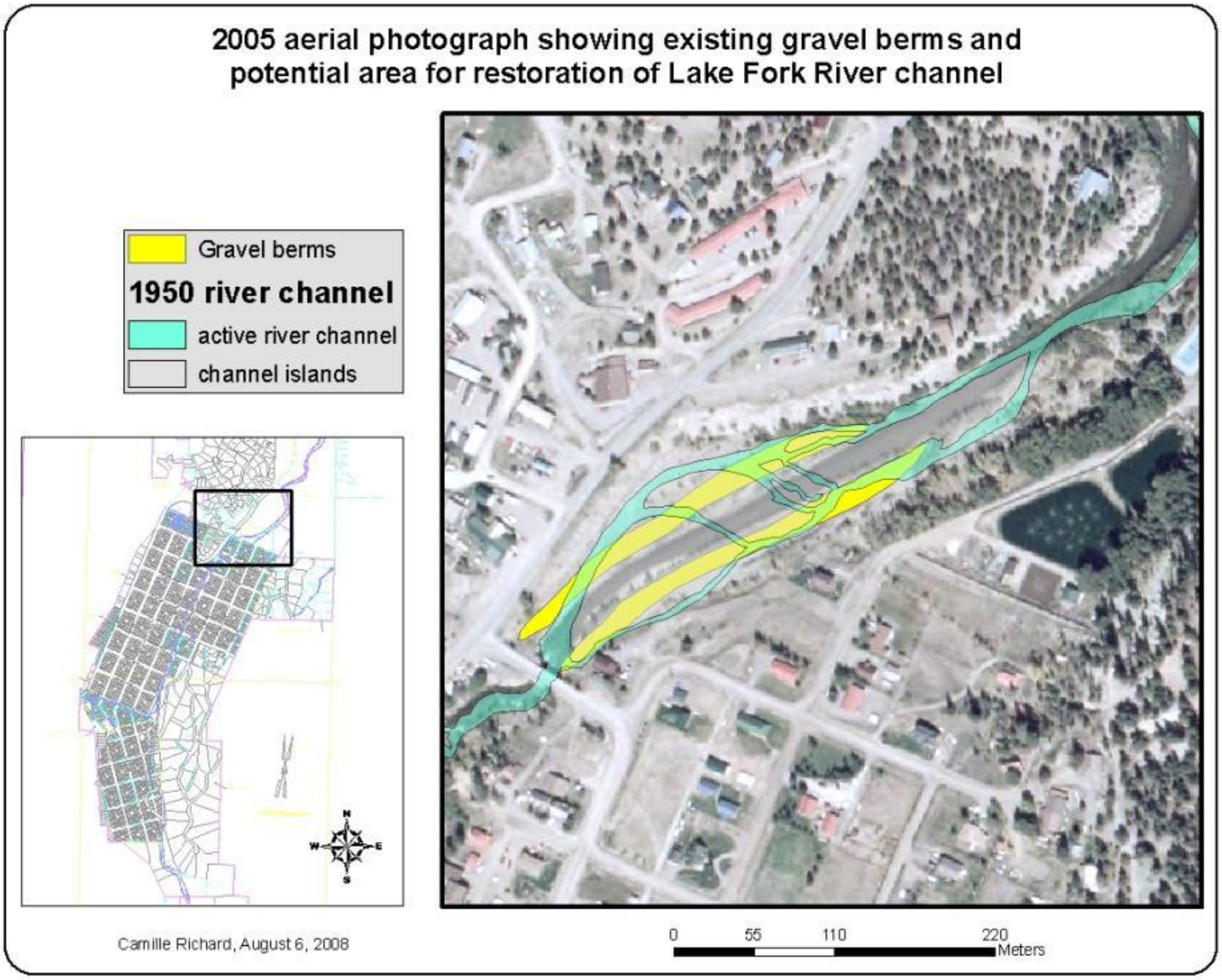
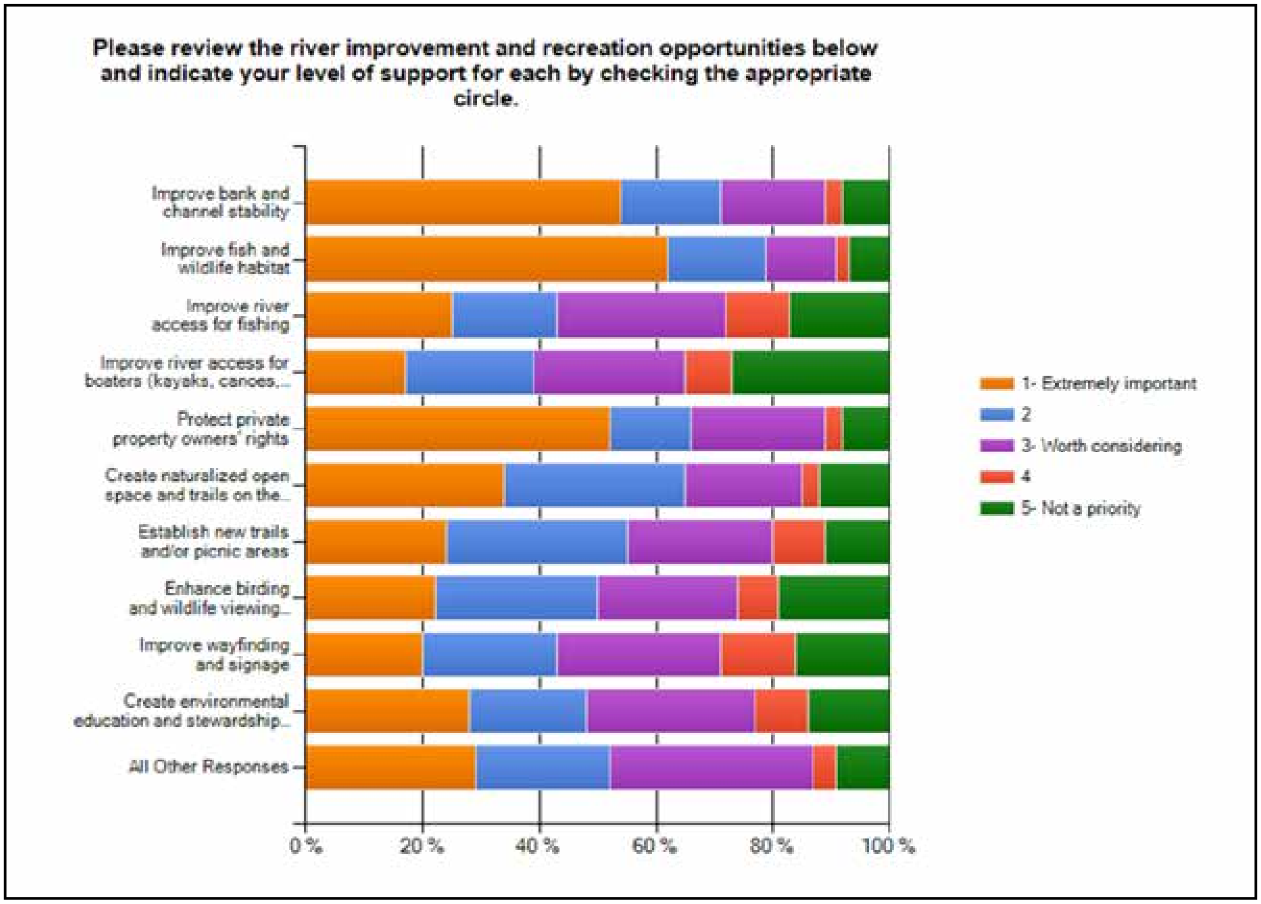


Figure 19. Before and after images of area below bridge. RTCA created the image for post project vision of the area.

Figure 20. Aerial view of open space river park design (RTCA 2010).

Figure 21. Survey results for Question 8, asking participants to prioritize river improvement and recreation opportunities. Full survey results can be found on the LFVC website (http://www.lfvc.org/river-enhancement-survey-results.html).



APPENDIX A: HECRAS Cross Sections.

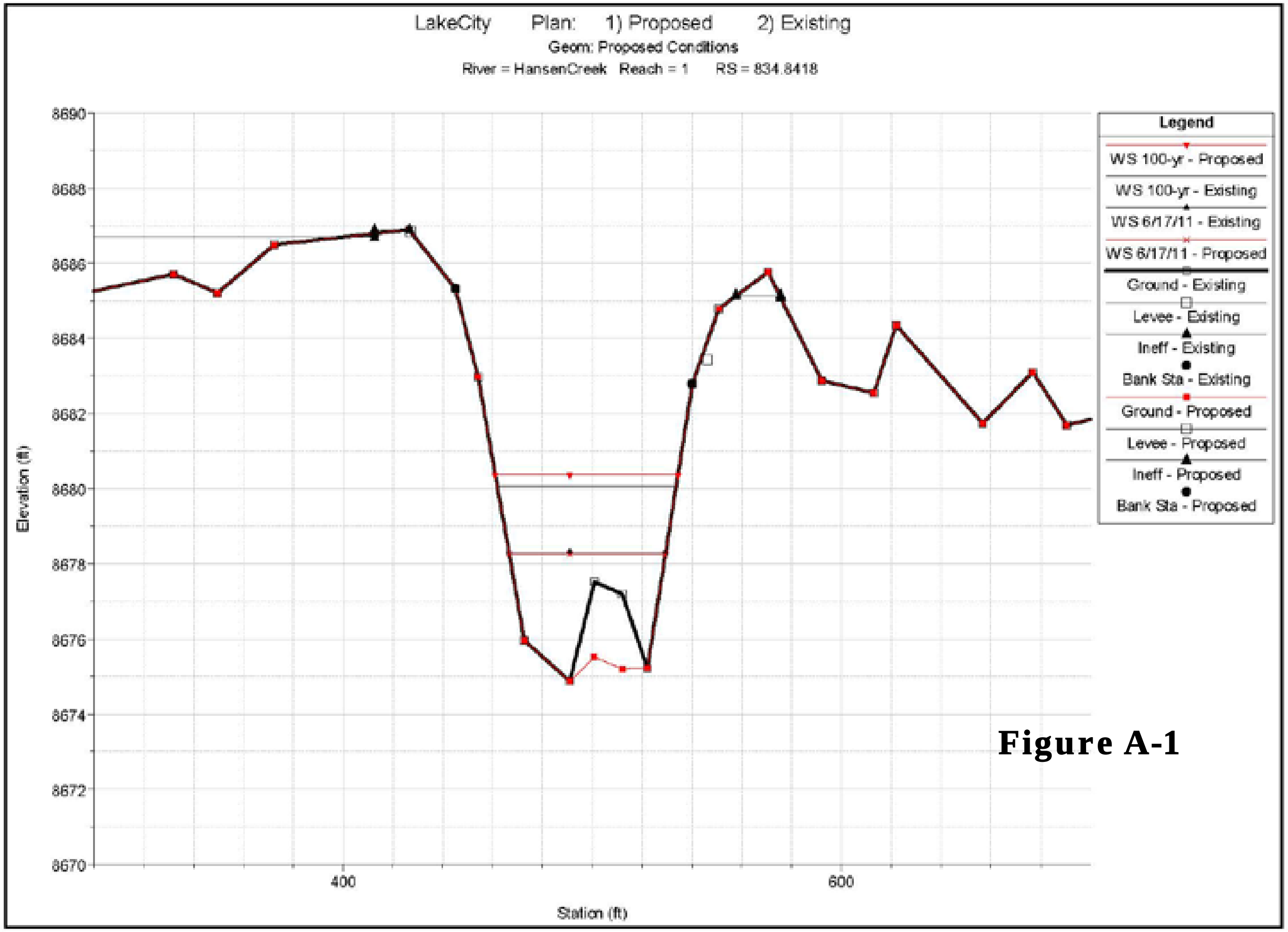


Figure A-1

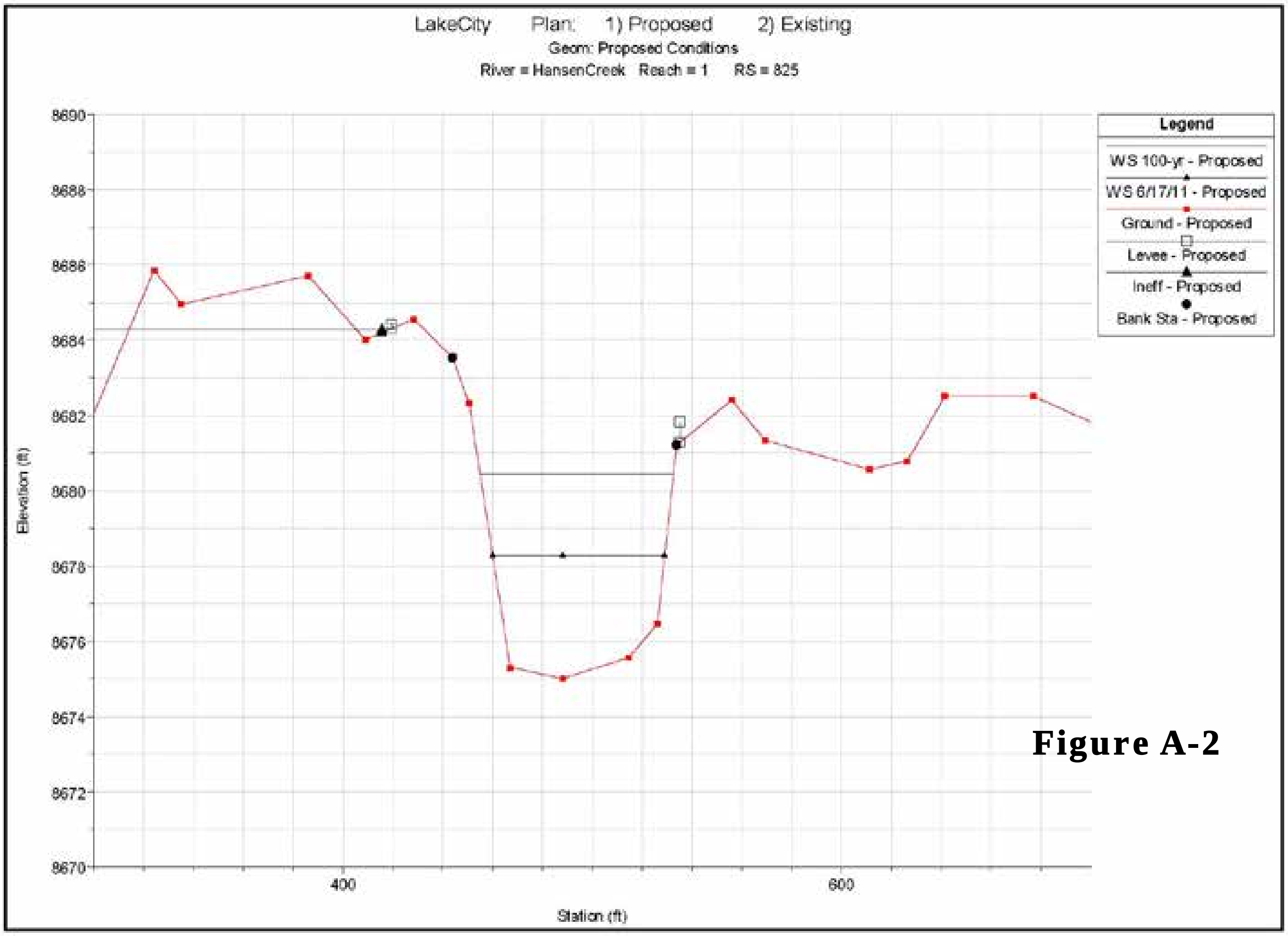

LakeCity Plan: 1) Proposed 2) Existing
Geom: Proposed Conditions
River = HansenCreek Reach = 1 RS = 825
Legend
WS 100-yr - Proposed
WS 6/17/11 - Proposed
Ground - Proposed
Levee - Proposed
Ineff - Proposed
Bank Sta - Proposed
Elevation (ft)
Station (ft)
8690
8688
8686
8684
8682
8680
8678
8676
8674
8672
8670
400
600

Figure A-2

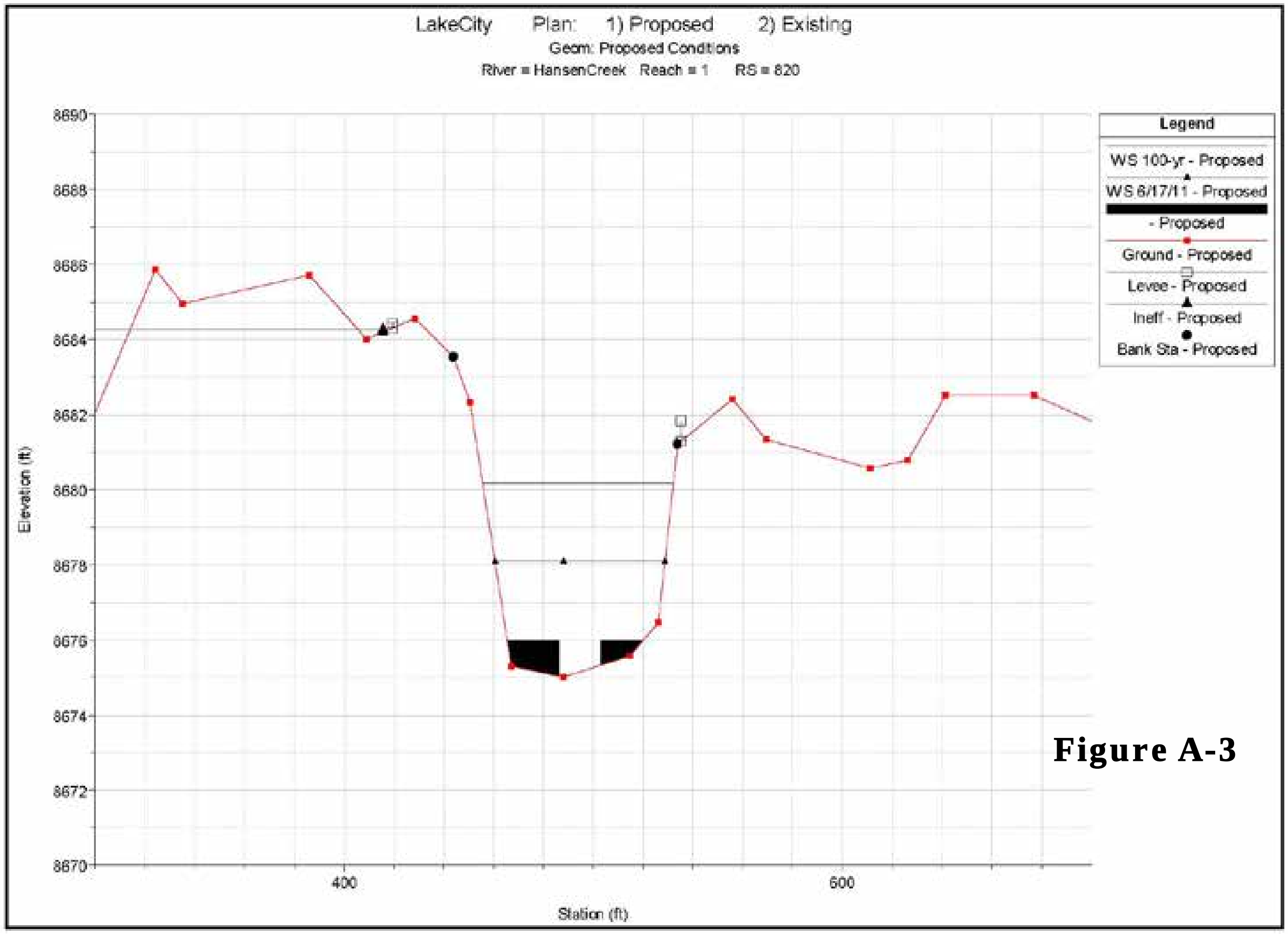
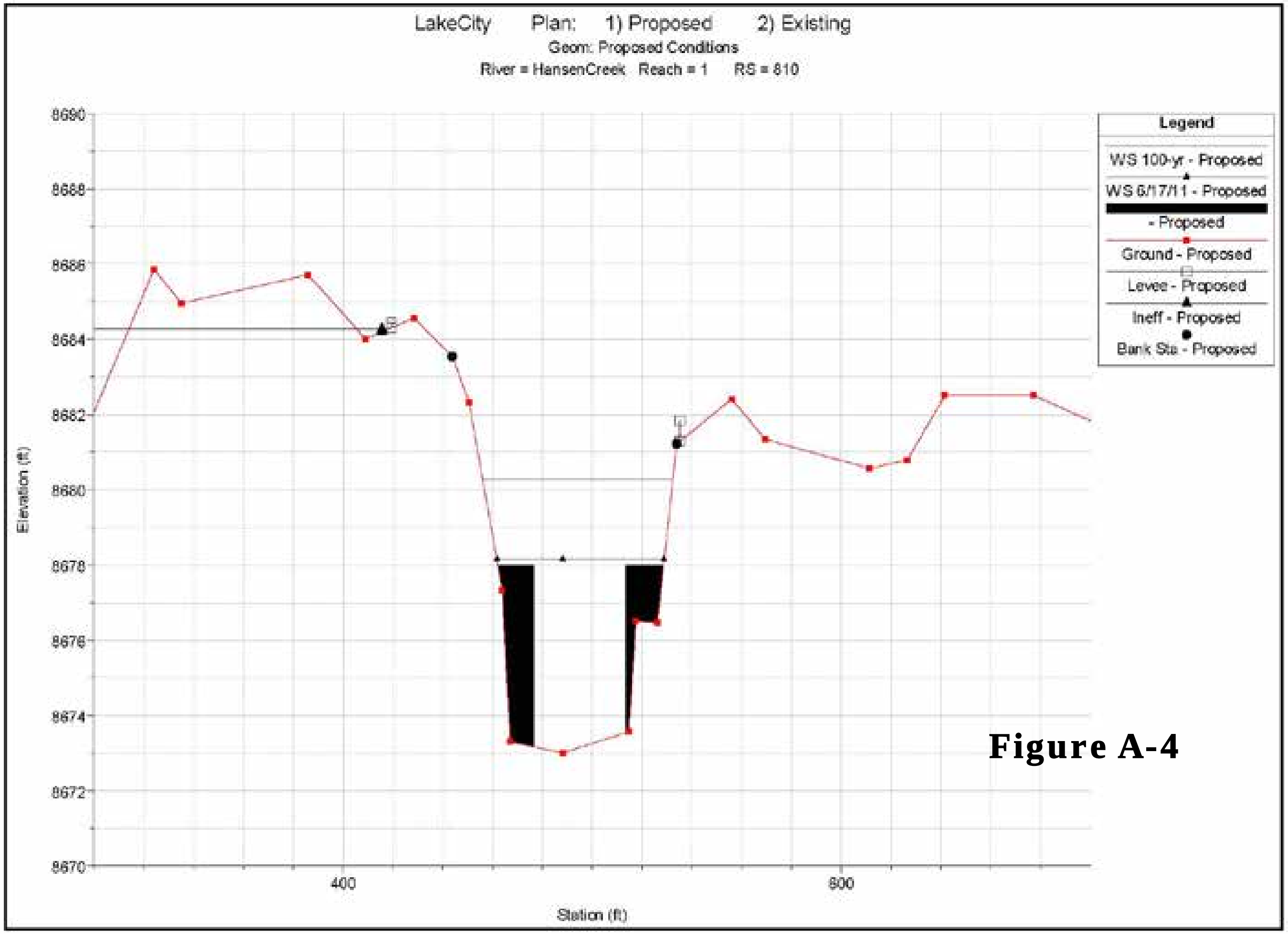
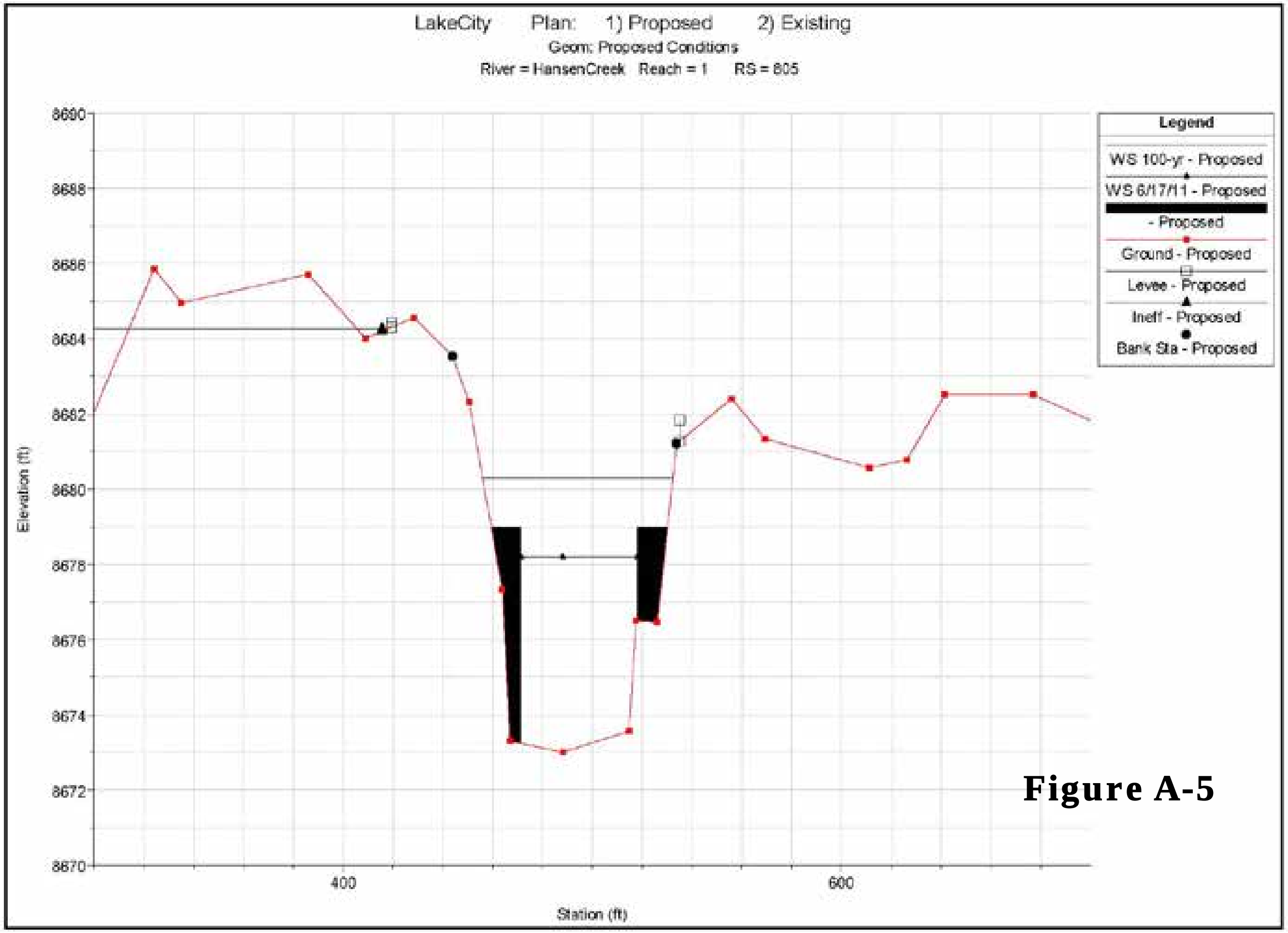

LakeCity Plan: 1) Proposed 2) Existing
Geom: Proposed Conditions
River = HansenCreek Reach = 1 RS = 820
Legend
WS 100-yr - Proposed
WS 6/17/11 - Proposed
- Proposed
Ground - Proposed
Levee - Proposed
Ineff - Proposed
Bank Sta - Proposed
Elevation (ft)
8690
8688
8686
8684
8682
8680
8678
8676
8674
8672
8670
400
600
Station (ft)

Figure A-3



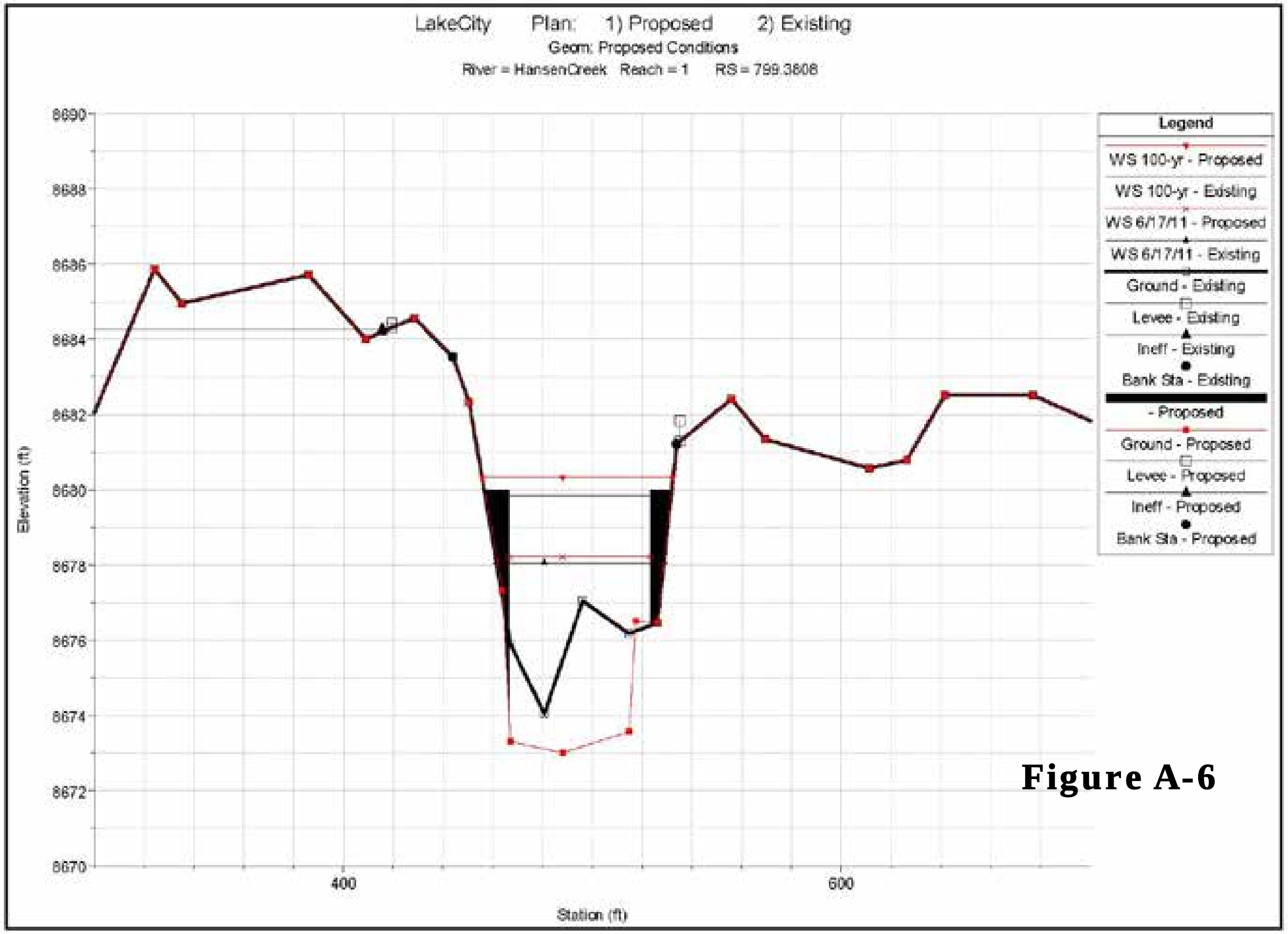
LakeCity Plan: 1) Proposed 2) Existing
Geom: Proposed Conditions
River = HansenCreek Reach = 1 RS = 810
Legend
WS 100-yr - Proposed
WS 6/17/11 - Proposed
- Proposed
Ground - Proposed
Levee - Proposed
Ineff - Proposed
Bank Sta - Proposed
8690
8688
8686
8684
8682
8680
8678
8676
8674
8672
8670
Elevation (ft)
400
600
Station (ft)

Figure A-4



LakeCity Plan: 1) Proposed 2) Existing
Geom: Proposed Conditions
River = HansenCreek Reach = 1 RS = 805
Legend
WS 100-yr - Proposed
WS 6/17/11 - Proposed
- Proposed
Ground - Proposed
Levee - Proposed
Ineff - Proposed
Bank Sta - Proposed
Elevation (ft)
8690
8688
8686
8684
8682
8680
8678
8676
8674
8672
8670
400
600
Station (ft)

Figure A-5



LakeCity Plan: 1) Proposed 2) Existing
Geom: Proposed Conditions
River = HansenCreek Reach = 1 RS = 799.3808
Legend
WS 100-yr - Proposed
WS 100-yr - Existing
WS 6/17/11 - Proposed
WS 6/17/11 - Existing
Ground - Existing
Levee - Existing
Ineff - Existing
Bank Sta - Existing
- Proposed
Ground - Proposed
Levee - Proposed
Ineff - Proposed
Bank Sta - Proposed
Elevation (ft)
Station (ft)
8690
8688
8686
8684
8682
8680
8678
8676
8674
8672
8670
400
600

Figure A-6

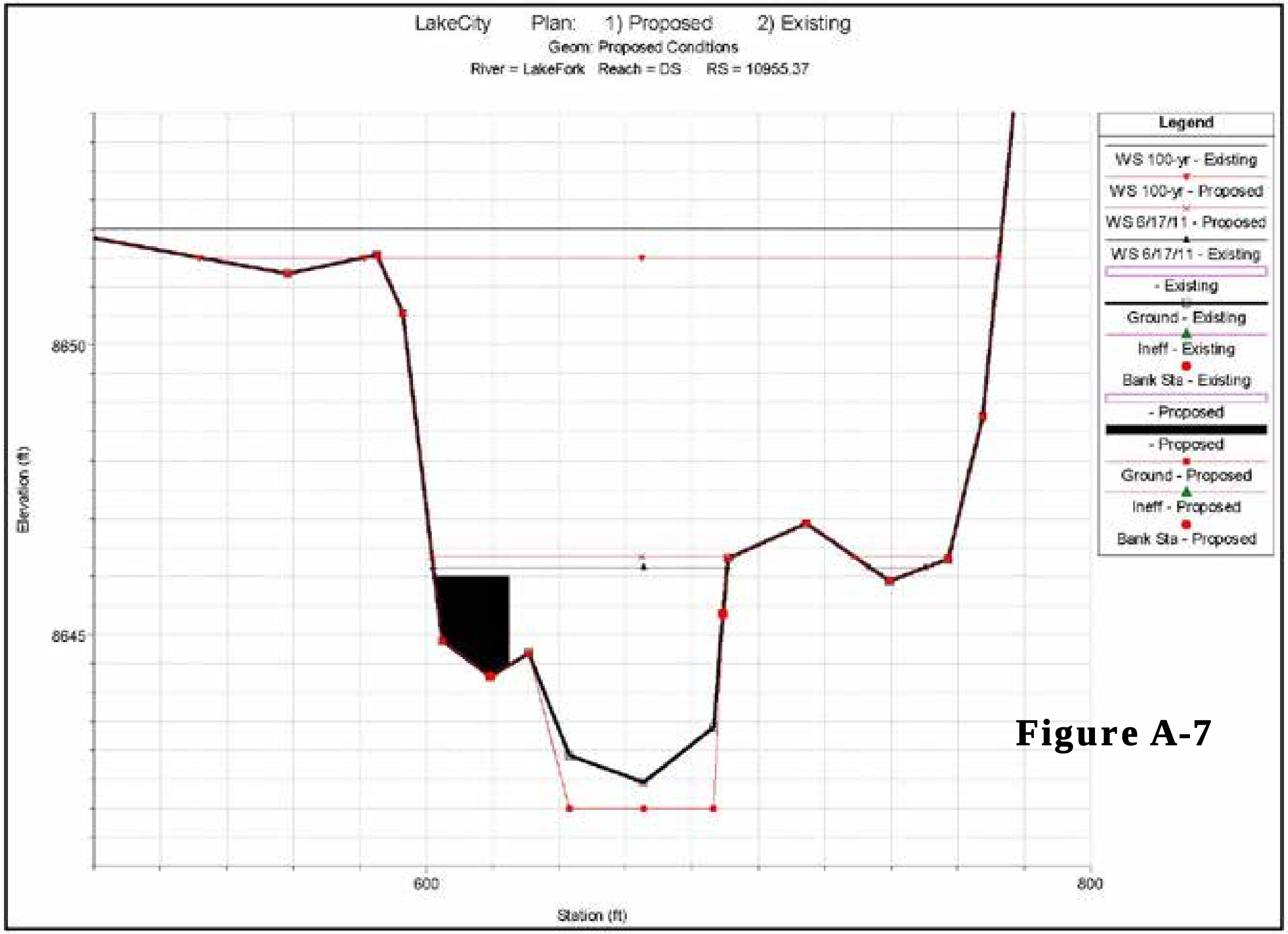

LakeCity Plan: 1) Proposed 2) Existing
Geom: Proposed Conditions
River = LakeFork Reach = DS RS = 10955.37
Legend
WS 100-yr - Existing
WS 100-yr - Proposed
WS 6/17/11 - Proposed
WS 6/17/11 - Existing
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing
- Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
8650
8645
Elevation (ft)
600
800
Station (ft)

Figure A-7

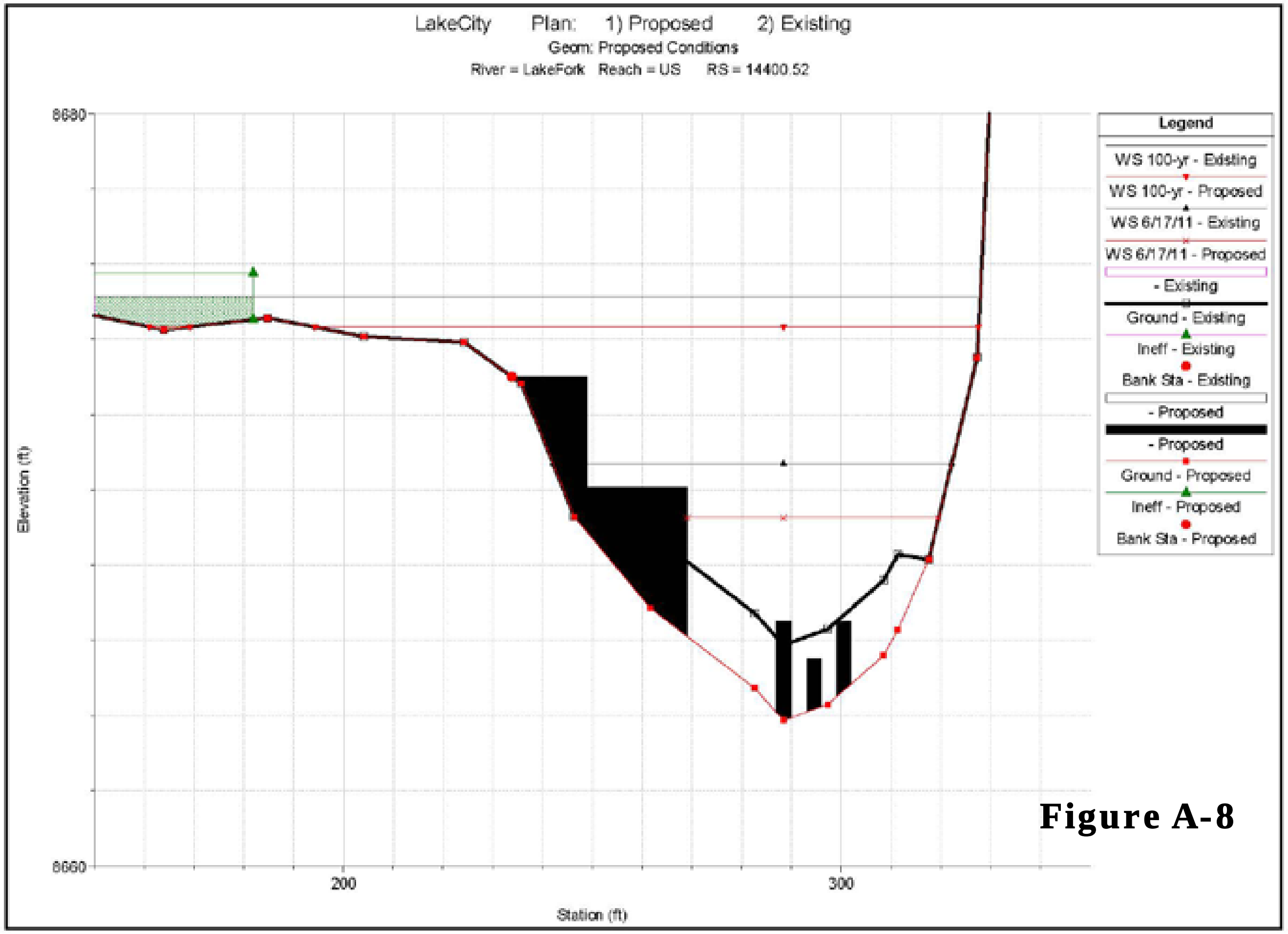
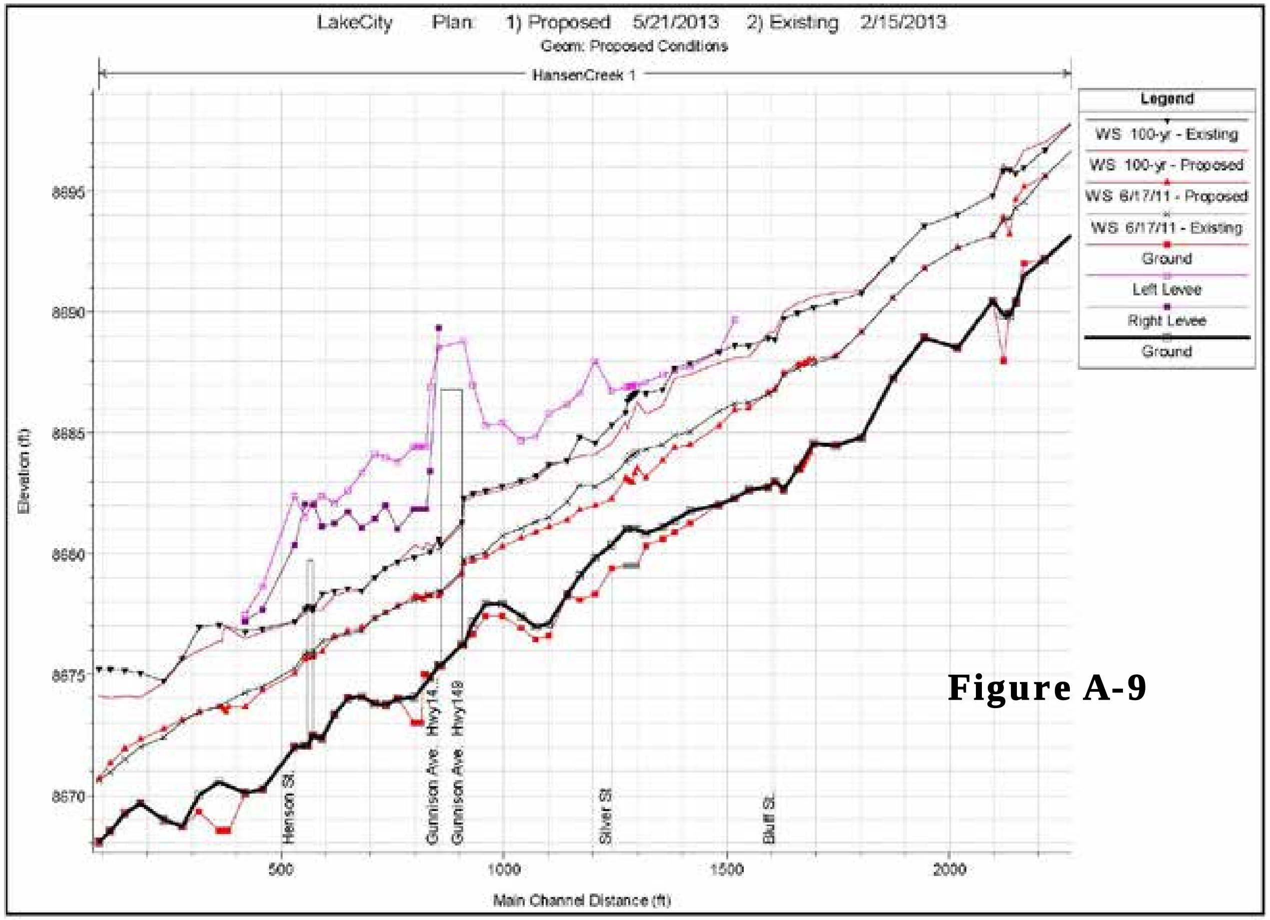

LakeCity Plan: 1) Proposed 2) Existing
Geom: Proposed Conditions
River = LakeFork Reach = US RS = 14400.52
Legend
WS 100-yr - Existing
WS 100-yr - Proposed
WS 6/17/11 - Existing
WS 6/17/11 - Proposed
- Existing
Ground - Existing
Ineff - Existing
Bank Sta - Existing
- Proposed
- Proposed
Ground - Proposed
Ineff - Proposed
Bank Sta - Proposed
8680
8660
Elevation (ft)
200
300
Station (ft)

Figure A-8


LakeCity Plan: 1) Proposed 5/21/2013 2) Existing 2/15/2013
Geom: Proposed Conditions
HansenCreek 1
Legend
WS 100-yr - Existing
WS 100-yr - Proposed
WS 6/17/11 - Proposed
WS 6/17/11 - Existing
Ground
Left Levee
Right Levee
Ground
Elevation (ft)
Main Channel Distance (ft)
Henson St.
Gunnison Ave. Hwy14...
Gunnison Ave. Hwy149
Silver St.
Bluff St.
Figure A-9

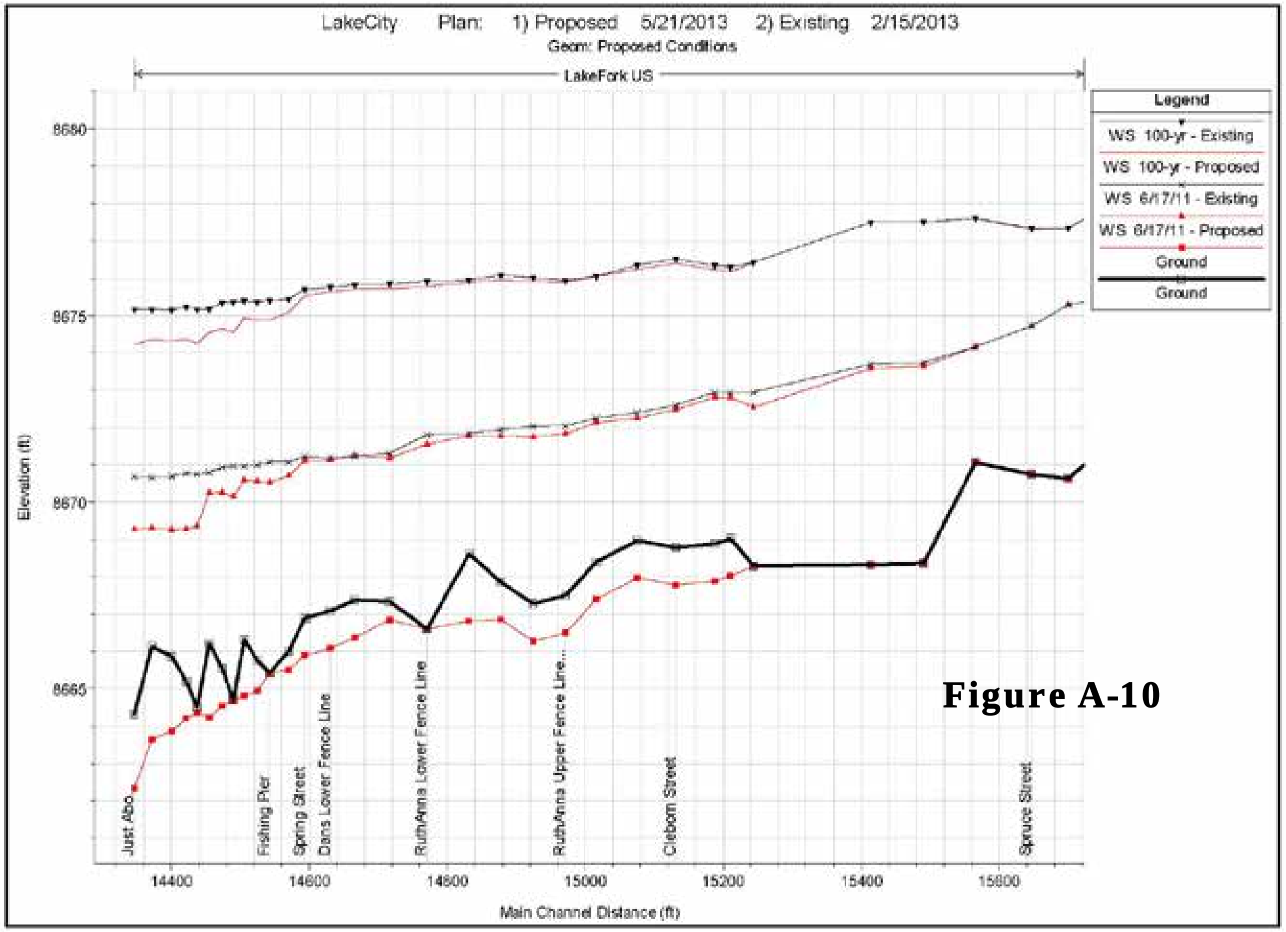
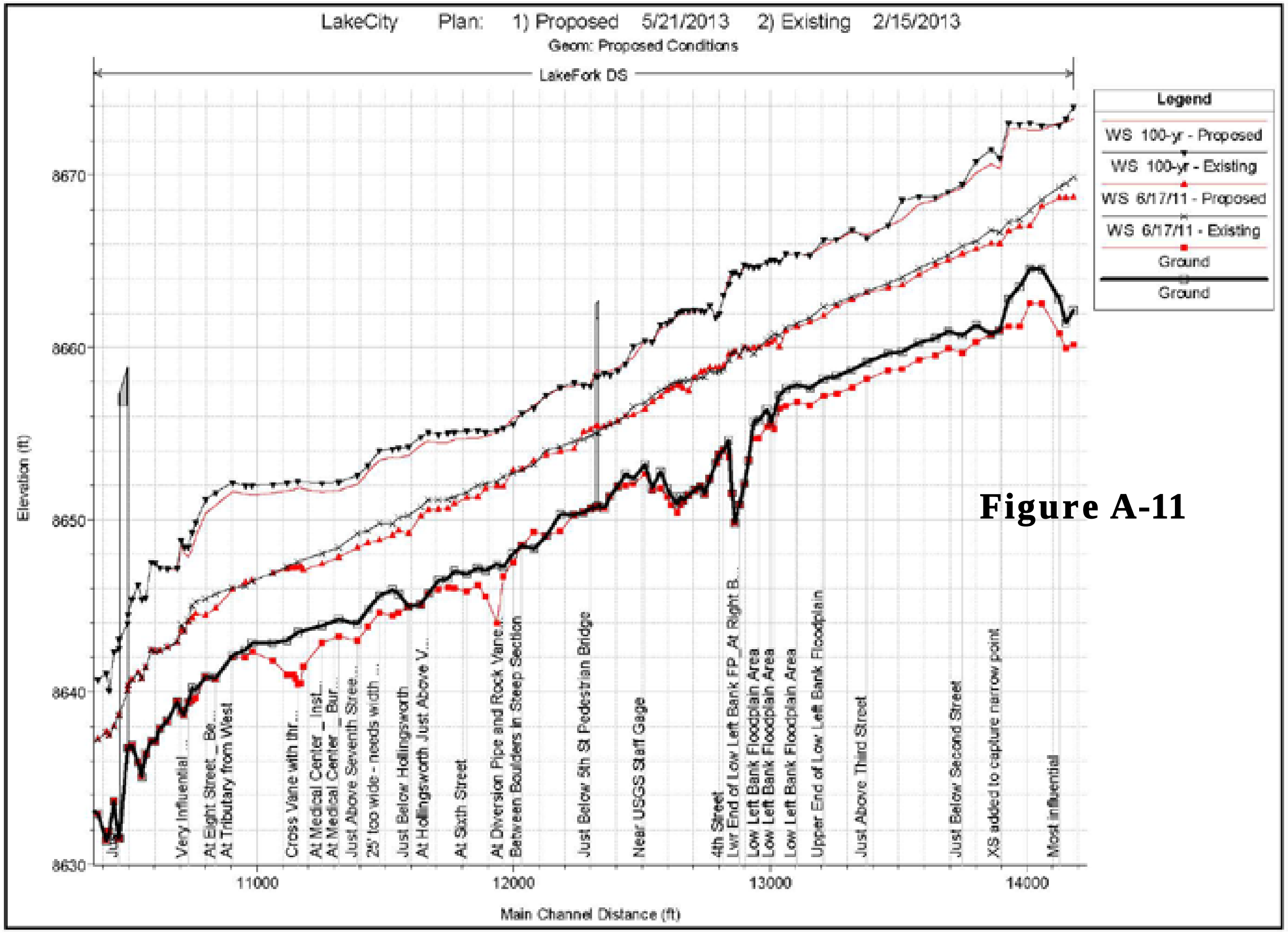

LakeCity Plan: 1) Proposed 5/21/2013 2) Existing 2/15/2013
Geom: Proposed Conditions
LakeFork US
Legend
WS 100-yr - Existing
WS 100-yr - Proposed
WS 6/17/11 - Existing
WS 6/17/11 - Proposed
Ground
Ground
Elevation (ft)
8680
8675
8670
8665
Just Abo
Fishing Pier
Spring Street
Dans Lower Fence Line
RuthAnna Lower Fence Line
RuthAnna Upper Fence Line...
Cleborn Street
Spruce Street
14400
14600
14800
15000
15200
15400
15600
Main Channel Distance (ft)

Figure A-10



LakeCity Plan: 1) Proposed 5/21/2013 2) Existing 2/15/2013
Geom: Proposed Conditions
LakeFork DS
Legend
WS 100-yr - Proposed
WS 100-yr - Existing
WS 6/17/11 - Proposed
WS 6/17/11 - Existing
Ground
Ground
Elevation (ft)
Main Channel Distance (ft)
Very Influential ...
At Eight Street _ Be...
At Tributary from West
Cross Vane with thr...
At Medical Center _ Inst...
At Medical Center _ Bur...
Just Above Seventh Stree...
25' too wide - needs width ...
Just Below Hollingsworth
At Hollingsworth Just Above V...
At Sixth Street
At Diversion Pipe and Rock Vane
Between Boulders in Steep Section
Just Below 5th St Pedestrian Bridge
Near USGS Staff Gage
4th Street
Lwr End of Low Left Bank FP_At Right B...
Low Left Bank Floodplain Area
Low Left Bank Floodplain Area
Low Left Bank Floodplain Area
Upper End of Low Left Bank Floodplain
Just Above Third Street
Just Below Second Street
XS added to capture narrow point
Most influential

Figure A-11