Friends of the Teton River
2002 Habitat Assessment Project

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Introduction:

The Teton River is located in Southeastern Idaho along the West Side of the Teton Mountain Range. One hundred years of settlement has drastically altered the hydrological regime of the watershed through the removal of beavers and their dams, flood irrigation, sprinkler irrigation, livestock grazing, farming and urban development. To begin assessing, enhancing and restoring the watershed the Upper Teton River was surveyed during the summer of 2002. The Habitat Assessment and Restoration Project (HARP) was designed to assess and improve aquatic habitat conditions (Benjamin, 2002). HARP consists of a visual channel assessment survey and site specific stream survey. A multi-disciplinary team was assembled to prioritize survey sites. The team conducted visual surveys during several float trips over 15.2 km of stream between South Bates Bridge and Rainer State Park (please see figure 1). The visual surveys provided information to prioritize 15 restoration, recovery and reference sites. A stream survey was designed to furnish detailed base-line data for each site. Of the 15 sites selected, 11 were surveyed in 2002. Surveyed sites included 6 restoration sites, 2 recovery sites and 3 reference sites. The sites averaged about 150 m in length adding up to a total of 1.65 km of stream surveyed.

Several surveys have been conducted on the Teton River from 1988 to 2001. In 1992, Idaho Cooperative River Basin Program published the Teton River Basin Study (TRBS). The study examined stream bank degradation, stream channel siltation, fisheries concerns, water quality concerns and provided potential restoration mitigation projects. Between 1988 and 1996 the Natural Resources Conservation Service (NRCS) and the Idaho Association of Soil Conservation Districts collected data on 75 eroded bank sites. The same bank site numbers were used for the HARP surveys. From 1999 to 2000 Idaho State University measured nutrients, nutrient dynamics, and biotic conditions (Myler and Minshall, 2000). In 2001, the Idaho Department of Environmental Quality (IDEQ) surveyed water quality in their Subbasin Assessment.

According to the TRBS, Teton Valley is a broad, lake-like valley floor. Volcanic uplands at the north end of the valley caused a dam effect on the river basin. The Upper Teton is generally an alluvial system with some clay control. The Teton has alluvial runoff tributaries and spring fed tributaries.

The channel is fairly straight, wide and flat in the beginning and becomes more sinuous and braided downstream. Substrates consist of small gravel, silt, sand and clay. Macrophtyes cover most of the channel. Predominate understory consists of grasses and sedges. Predominant overstory consists of willow. The banks consist of clay and easily eroded silt and loam. The stream seems to possess both spring-dominated and runoff-dominated characteristics depending on spatial and temporal conditions.

Methods:

The HARP visual survey collected information on current channel, bank and riparian conditions and restoration strategies (Benjamin, 2002) (please see *Appendix A* for forms).

Reference sites chosen by the team displayed the most ideal characteristics of the stream. In general, reference sites had healthy riparian, diverse fish habitat, low Width to Depth (W/D) ratios and occasionally islands and gravel bars. The reference sites were the controls used to compare changes overtime to restoration and recovery sites. Recovery sites were originally listed as eroded bank sites by the NRCS but appeared to be recovering. The formerly eroded banks had nearly reached the angle of repose. There was little sign of recent erosion and most banks were fully vegetated. There were many recovery sites along the surveyed portion of the stream. Restoration sites displayed eroded banks and a significant loss of vegetation, particularly willow. One restoration site was chosen to enhance an island in the early stages of development. Sites were prioritized through cost benefit analysis. The highest priority sites were smaller sites with healthy riparian immediately up and down stream of the site and with easy access for restoration machinery.

The HARP stream survey collected detailed information on channel geomorphology, in-stream habitat, riparian vegetation and bank stability (please see *Appendix A* for forms and *Appendix B* for detailed survey methods). The boundaries of each site were determined by examining site characteristics, up stream controls and potential downstream changes. Five monumented x-sections distributed equally across the site were installed. Surveys, using an automatic level, collected detailed information on the banks, water surface elevation and any significant change in streambed elevation. The average percentage of macrophytes was determined along two x-sections using a grid box. Wolman pebble counts were conducted when possible. Temperature readings were recorded at one location. Information was collected on bank conditions including percent bank erosion, bank material, predominate vegetative over and understory, percent overhanging vegetation, and percent undercut banks. Habitat type data was recorded using R1/R4 Habitat Inventory methods. NRCS Stream Visual Assessment Protocol and IDEQ Stream Erosion Condition Inventory surveys were performed following standard methods. Notes were made on substrates, fish observations, and unique site features. Photos were taken of each site and of the banks at each x-section. A sketch was drawn of each site.

Data analysis was performed for each x-section, each site and for all sites combined (please see *Appendix B* for data analysis methods). The x-sections were analyzed to determine bankfull width, maximum depth, average depth, W/D ratios and gradient. Pebble count data was analyzed to determine the D50 and D84 pebble size. Macrophyte data was analyzed to determine the percentage of macrophyte cover.

Discussion of All Data:

The stream survey was designed to collect baseline information of specific sites –information that can be used to display trends over time through comparative analysis. This is not a randomized survey nor is it a survey of uniform reaches. It is a detailed snap shot of selected stream sections. However, since the survey covered a wide variety stream characteristics, some geomorphic inferences and comparisons can be drawn (please see *Appendix C* for data analysis tables and *Appendix D* for x-section data and graphs). Analysis of the 55 x-sections surveyed revealed detailed channel characteristics.

The W/D ratios ranged from 12.99 to 107.59 and had a mean of 38.55. This number should be slightly higher since 4 sites were located on only one channel in braided sections. The W/D ratios for these sites would probably be higher if the entire channel was taken into consideration.

Whiting and Stamm measured W/D ratios on spring-dominated streams in eastern Idaho, southwestern Montana and south central Oregon. Their W/D ratios ranged from 9 to 63 with a mean of 33. They state that these values are typical of alluvial channel in general (Whiting and Stamm, 1995). Whiting and Moog measured W/D rations on spring-dominated streams in volcanic areas of Idaho and Oregon. Their W/D ratios ranged from 4 to 98 with a mean of 34. They state that W/D ratios seem to be higher for spring-dominated channels than run-off channels (Whiting and Moog, 2001). For 39 runoff-dominated streams in the Salmon River Basin Idaho, Emmett found a mean W/D ratio of 19 (Emmett, 1975).

Data compiled from the Henry's Fork Assessment Survey (HFAS) for spring-dominated streams in the Henry's Lake Flats, Upper Henrys Fork, Caldera, Warm and Robinson river basins had a W/D range from 2.8 to 146.3 and a mean of 30.5. Data compiled from the HFAS for runoff-dominated streams in the Henry's Lake, Henry's Lake Flats, Upper Henrys Fork, Caldera, Warm and Robinson river basins had a W/D range from 4.6 to 53 and a mean of 15.91. Some of these streams had bedrock controlled reaches which could have different W/D than alluvial reaches.

The W/D comparative analysis suggests that the Upper Teton is slightly wider and shallower than some spring-dominated streams and significantly wider and shallower then some run-off streams. High W/D ratios may be due to excessive sediment causing the bed to elevate, sending flow into erodable banks. Excessive sediment could have also filled in some pools.

Average gradient for all sites was .00078. Whiting and Stamm had a range of .000019 to .041 and a mean of .0078 for spring-dominated streams (Whiting and Stamm, 1995). Whiting and Moog had a range of .00011 to .049 and a mean of .003 for spring-dominated streams (Whiting and Moog, 2001). Compiling HFAS data yielded an average of .014 for spring-dominated streams and .032 for runoff dominated streams. The data suggests that the Upper Teton is significantly lower gradient than mean gradient for spring and runoff-dominated streams. Some of these streams had bedrock controlled reaches which could have different gradients than alluvial reaches.

Sediment consisted of silt, sand, clay, small gravel and embedded small gravel. The embedded gravel was often encrusted with calcium deposits especially in low gradient areas. Sediment sources come from agricultural lands, forestlands, mass wasting events along tributaries, roads, trails, and bank erosion. According to the TRBS in 1992, "the total sediment delivered to the Teton River from all sources is approximately 182,600 tons per year while the natural sediment yield to the river, prior to human impacts is estimated at 32,600 tons per year." Most of this sediment is probably silt and sand (pers. comm. Ray, 2002).

Most of the gravels observed in the study area were very embedded, and some were encrusted with calcium deposits especially in the low gradient areas. High percentages of embeddedness are often caused by an excessive supply of sediment (Georgia Pacific, 1996). Trout will not be able to spawn in 50% or more embedded gravel areas. Areas with more than 30% embeddedness are considered poor habitats for nesting trout. In a system with enough sediment to cause embeddedness the fine material will smother trout eggs. High levels of embeddedness may inhibit certain species of macroinvertebrates causing a loss in diversity (Kalma, 1998). According to the TRBS, the excessive sediment in the Teton has adversely effected the ability of trout to survive. "There are few clean gravels available for juvenile trout refuge in the winter or for spawning. In addition, sediment has filled the pools that the larger fish use in both summer and the more critical winter months." The embeddedness found in the Teton is very different from other spring-dominated streams in the region whose gravel beds lack fines (Whiting and Stamm, 1994).

For all pebbles counted, the D50 was 10.5 mm and the D84 was 35.5 mm. Whiting and Moog had a median D50 of 6.94 mm and D84 of 33.18 mm for spring-dominated streams (Whiting and Moog, 2001). The data suggests that Upper Teton transports larger size substrates than some spring-dominated streams –probably due to proportionately larger run-off events.

Several habitat types were found within the sites. Of the 1.65 km of stream surveyed 45% was a lateral scour pool, 43% was a glide, 9% was a mid-channel scour pool, and 3% was a low gradient riffle. The high amount of lateral scour pools is most likely an indication of numerous stream meanders. The lateral scour pools are probably an indication of the runoff component of the stream. The high percentage of glides probably represents the spring component of the stream. The glide reaches probably provide little adult fish habitat. The small amount of mid channel scour pools probably indicates a lack of in-stream structure such as large woody debris or bedrock. The small amount of low gradient riffles is probably due to low stream power. The excessive amount of sediment in the system has probably filled in some pools. According to locals, a large, deep pool located at the confluence of braided channels down stream of site 6-15,16 filled in with sediment after the 1997 floods (Fenger, 2002 pers. comm.). It appears that thick clay deposits have armored the bed in some areas preventing the formation of pools. The deepest pool (Big Eddy) encountered in the survey area was located at the up stream end of Rainey State Park. The pool appears to have formed when a clay layer eroded away exposing highly erodable material and creating a mid-channel scour pool.

Macrophyte coverage averaged 46.59% over all the sites. According to locals the macrophytes have been rebounding since the flood of 1997 (Fenger, 2002 pers. comm.). The macrophytes were surveyed during the peak of their growing season.

Bank conditions were considered for all sites combined. 22% of banks were eroded. 16% of banks were undercut. 27% of the banks had overhanging vegetation.

There are signs that some dominate understory has been lost due to bank erosion, grazing and weed invasion especially at restoration sites. Understory vegetation types depend on soil types, proximity to water and land use.

The dominant overstory, willow, has been lost over some surveyed portions of the stream especially at restoration sites. Willows were removed to expand grazing and haying areas and to save water. The processes of bank erosion have caused willow to fall into the stream. There are areas adjacent to the stream that lack willows due to poor soil types, clays, lack of proximity to water and soils saturated with water. If the bank is too far above the water level it is unlikely that willows will prosper. Willows probably won't propagate if the banks have too much clay or dry soils.

The Teton has flashy runoff-dominated hydrograph compared to some of the damped spring-dominated stream hydrograghs (Whiting and Moog, 2001). The flood with a 2-year recurrence interval is 1460 cfs for the 1962-1997 period of record, and the mean annual flow is 403 cfs for the period of record (USGS, 2001). For this data the mean annual flow averages 28% of bankfull flow. This figure would probably be lower if tributary diversions didn't occur during spring runoff. Whiting and Stamm found that for spring-dominated Browns Creek the mean annual flow averaged 80% of the bankfull discharge (Whiting and Stamm, 1995). Emmett found the mean annual flow averaged 25% of bankfull flow for runoff streams in the Salmon River drainage (Emmett, 1975). Whiting and Moog found that for spring-dominated streams the mean annual flow averages 72% of the flood with a 2-year recurrence interval and 18% for runoff-dominated streams (Whiting and Moog, 2001). This comparative analysis suggests that the geomorphology of the surveyed portion of the stream is predominately runoff-dominated. The Upper Teton seems to experience more dramatic bankfull events than some spring-dominated streams –events similar to runoff streams.

Discussion of Data by Site Type:

Sites can also be compared to each other based upon site types. Gradients, W/D ratios, pebble counts, habitat types, and bank conditions were compared and contrasted (please see *Appendix C* for data tables). Site 3-70.75 (Katie's Island) was not considered with other restoration sites. Site 3-70.75 is an island enhancement site with very different characteristics than the bank restoration sites. The Bates Bridge was used to separate sites. During the visual surveys it was noted that channel conditions seemed to change at the bridge.

Reference sites had a W/D of 41.13. Recovery sites had a W/D of 48.39. Restoration sites had a W/D of 26.81. 3 out of 4 sites located on one channel in braided sections were restoration sites. These 3 out of the 5 restoration sites would probably have higher W/D if the entire channel was taken into consideration. Even considering the possibly low numbers for restoration sites the data suggests that restoration sites have lower W/D ratios then other site types.

W/D was 51.06 above Bates Bridge and 28.14 below Bates Bridge. W/D appears to decrease down stream; however, 3 out of the 4 sites located on one channel in braided sections were located below the bridge.

Reference sites had a gradient of .00050. Recovery sites had a gradient of .00060. Restoration sites had a gradient of .00114. The data infers that the restoration sites had a significantly higher gradient and therefore more shear stress and more stream power assuming that all other factors remain the same. Shields Stress, the ability of a stream to move sediment, is directly related to gradient (Whiting and Moog, 2001). Stream power is directly related to gradient and sediment transport rates are directly related to stream power (SCR, 1998). With an increase in ability to move sediment at stream bends during higher flows, it is likely that most of the sediment that originates at the eroded bank of a stream bend is transported past the bend to a location where lower stream power deposits the sediment. Most of the sediment that makes it to the stream bend from reaches with lower gradient that doesn’t deposit on the inside of the stream bend will probably be transported past the bend. All of the restoration sites with low gradient riffles and site 5-10,11 (highest gradient site) had fairly clean non-embedded gravels. This could indicate that, at these sites, the stream has enough power to flush out the silt. All of the restoration sites except 3-69,70 had fairly clean gravels. Reference Site 4-4.5 had some fairly clean non-embedded gravel. Clay lined streambeds can also lead to increased or decreased gradients. The clay can act much like bedrock containment especially in stream with low power.

All the reference sites were located below sharp bends on fairly straight stretches of the stream. 2 out of the 3 sites had center gravel bars and/or islands present. It appears that excessive sediment probably derived from up stream bank erosion is depositing in this reaches. According to SCR, central sediment bars are caused by an increase in sediment. The sediment transported by the high energy stream bend is deposited as soon as the stream begins to straighten and loose energy.

The recovery sites were all located along fairly straight stretches of stream with one site located downstream from a braided channel confluence. The site locations would indicate that the straight channels probably had stable banks at one point in time but were disturbed by grazing and removal of willow.

The restoration sites were all located on bends. The bends were probably caused by channel migrations. It appears that the tighter the bend the higher the gradient and subsequent stream power. According to SCR in a meandering stream, “at higher depths the flow follows a straighter course, which increases slope.” The higher stream power at the sharper bends could have scoured the streambed and caused the higher gradients.

The gradient above Bates Bridge was .00044 and .00106 below the bridge. Gradients appear to increase down stream however, there were more restoration sites below the bridge, which tended to have higher gradients than other sites.

Pebble size seemed to be dependent upon gradient. Site 3-69,70 had a D50 of 12.7 mm and a gradient of .00091. Site 3-70.75 had a D50 of 3.4 mm and a gradient of .00013.

Reference sites were 41% mid-channel scour pool, 34% lateral scour pool, 21% glide and 4% low gradient riffle. Recovery sites were 100% glide. Restoration sites were 72% lateral scour pool, 24% glide and 4% low gradient riffle. Reference sites had the greatest habitat diversity and were dominated by mid-channel scour pools. The scour pools were probably caused by the mid-channel gravel bars. Recovery sites are located along some of the straightest stream reaches, which tended to be glides. Lateral scour pools dominated the restoration sites. The pools are probably related to the bends that the sites are located on. Sites up stream from the bridge were 57% glides, 24% lateral scour pools and 19% mid-channel scour pools. Sites below the bridge were 80% lateral scour pools, 11% glides, 7% low gradient riffles and 2% mid-channel scour pools. It seems that as sinuosity and gradient increases and W/D ratios decrease down stream, dominant habitats change from glides to lateral scour pools. All four low gradient riffles were located below the bridge. 3 out of the 4 low gradient riffles are located at the down stream end of severely eroded banks –restoration sites on bends. One low gradient riffle was located at the downstream end of reference site 4-4.5. This site is located directly down stream from a restoration site on bends and has 3 mid-channel gravel bars.

Macrophytes covered 39.35% of the reference sites, 76.42% of the recovery sites and 35.89% for restoration sites. It appears that the higher the W/D the higher the percentage of macrophytes when sorted by site type. Above the bridge macrophytes averaged 62.10% and below the bridge they averaged 35.89%. This would imply that macrophytes decrease as gradient increases, W/D decreases and glides decrease. More stream power down stream may scour out areas that would other wise produce macrophytes. Recovery Site 2-67 had the highest percentage of macrophytes, 89.20% and was one continuos glide. This site had one of the highest W/D at 65.95 and lowest gradients at .00039. Reference Site 4-4.5 had the lowest percentage of macrophytes, .55%, and had a mid-channel and lateral scour pool, a low gradient riffle and 50% undercut banks. This site also had the most mid-channel gravel bars and most well defined side channels. This site had mid-range W/D of 34.36 and gradient of .00074.

Reference sites had 2% eroded banks, 41.67% undercut banks and 42.5% overhanging vegetation. Recovery sites had 16.25% eroded banks, 2.75% undercut banks and 10% overhanging vegetation. Restoration sites had 41% eroded banks, 8.6% undercut banks and 12.4% overhanging vegetation. Reference sites had the highest amount of undercut banks. In the case of Site 3-70.5 and 4-4.5 both banks were undercut by an average of 42.5%, generally a sign of excessive sediment. These sites had well defined side channels around mid-channel gravel bars.

There are significantly more undercut banks at all 3 reference sites. The undercutting is probably due to excessive sediment in the form of mid-channel gravel bars (islands) diverting flow and narrowing the channel, increasing velocities and stream power near the bank. The 2 reference sites with mid-channel gravel bars were located on the first straight stretch of stream down stream of bends with restoration sites. The other reference site was located down stream from rainbow bend, a stable bend with healthy riparian and only undercut banks (disturbance site 1-66).

Through analysis of infrared and ortho photos and the Teton Valley Soil Survey restoration projects sites were prioritized. The information gathered from the maps is only a macro tool. For example, there are probably many localized areas within the Zu (dry meadow) soil types that have good riparian productivity characteristics. All potential restoration sites should have a soil survey to determine if the soils are suitable for growing riparian vegetation. The proximity of the banks to water should also be examined. It is imperative that sites selected for willow plantings have productive soils, good porosity (not clay) and proximity to water. Nearly all of the 8 restoration and recovery sites contained Zu soils that were high and dry and had clay banks.

Restoration Site 4-1,2 has Zc (wet meadows) soils along Site 4-2 and fairly wet Zu soils at the up stream end of Site 4-1, however the down stream end of Site 4-1 had high and dry Zu soils. Some willows are located on both banks.

Restoration Site 5-10,11 contained Zu soils that appeared to be fairly wet. This site looked better for growing riparian vegetation then all the other sites with Zu soils. This should be a high priority site since willows down stream from the eroded bank were beginning to fall in. It appears that willow along the bank (where grazing occurred) were either removed or damaged by grazing or fell into the stream. This bank should have good willow productivity since willows are already present. The bank downstream from the grazing area is fenced off and is full of willows. The bank appears to be rapidly eroding –evident by a 15-year-old fence that recently fell into the stream.

Recovery site 6-15,16 has Zd (wet meadow) soils, which should be good for willow production. This site contains numerous willows on both banks. There may have already been some willows planted on the west bank.

Even though restoration site 6-20 has Zd soils, it appears to be fairly dry. Willows are present along the right bank, which may indicate good willow growing potential despite the dry soil appearance. This should be a high priority site since eroding banks are causing willows to fall into the stream.

Island enhancement site 3-70.75 has TsA and Te soils, which will have to be researched to see if they have good riparian growth properties. Riparian health should be closely examined before the island enhancement project begins. If the riparian appears to be marginal increasing land area in the middle of the stream could displace flow towards the banks starting bank erosion processes.

Restoration sites that were not prioritized during the visual surveys may need to be reexamined for soil types. Some sites might have highly productive soils and close proximity to water. Such potential sites might be easily restored.

Gradient as it relates to stream power may also play a role in selecting sites for restoration projects. Stream bank restoration sites that have poor riparian productivity soils and high stream gradients should not be considered at this time. Sites 3-69,70 and 5-11.5,12 appear to have poor riparian productivity soils. This combined with gradients of .00091 and .00090 respectively may make these difficult sites to restore. A close examination of the soil and proximity to water should be examined before restoration is considered at these sites.

Soils appear to change near the Bates Bridge. The stream passes through more Zu soils below the bridge.

Addressing aspects of stream health, sites seem to function quite differently. Concerning bank stability, it appears that the reference sites could be unstable depositional sites. If mid-channel gravel bars continue to grow due to excessive sediment there may be increased bank undercutting leading to loss of vegetation and bank erosion creating new sediment sources. It seems that some of the bank restoration sites may actually be natural areas of bank erosion due to poor riparian productivity soils, although erosion may be accelerated at these sites by bank disturbance. Sediment transportation seems to be most efficient at the bank restoration sites probably due to higher stream power. The gravels at these sites were the cleanest of all sites. The up stream end of reference site 4-4.5 had some clean gravels which could be an indication of stream power coming out of a series of tight stream bends just up stream of the site. The best fish habitat occurred at restoration sites 3-69,70 and 6-20. It appears from initial soil analysis that site 3-69,70 may have poor riparian vegetation productivity soils. Eroding banks at this site may be natural. Site 6-20 may also have naturally eroding banks based upon initial soil analysis. Both sites have fairly clean gravels, diverse fish habitat and possible naturally eroding banks. Some sites may have to be reclassified based upon healthy stream conditions. For example Site 3-69,70 might be considered a healthy site and reclassified as a reference site. Reference Site 4-4.5 might be considered a restoration site or a deposition site since it appears that mid-channel gravel bars are causing bank erosion.

Conclusions:

The Upper Teton has characteristics of spring and runoff dominant streams dependent upon spatial and temporal conditions. The channel up stream from Bates Bridge seems to have more spring-dominated characteristics then the channel below the bridge. The hydrology of the system seems to seems to have more spring-dominated characteristics during low flow periods. The system seems to have more runoff-dominated characteristics during runoff and precipitation events.

There are more spring fed tributaries in the southern end of the valley. These spring tributaries probably contribute to the spring-dominant characteristics of the up stream end of the Teton. The up stream end of the Teton is fairly straight and wide which could be characteristic of a spring-dominant reach. This section needs to be surveyed. The streambed of the reach is supposedly buried in silt. Run-off tributaries transporting excessive sediment to the reach combined with low stream power could have caused such a sediment build up.

The surveyed channel down stream of Rainbow Bend and above the Bates Bridge seems to have characteristics of a spring dominant stream. The channel is fairly straight, there is no discernable thalweg, the W/D ratios are high, gradients are low and there are few riffles and gravel bars. Below the bridge the sinuosity and braiding increases, there is a discernable thalweg, gradient increases, W/D ratios decrease and gravel bars and riffles are more numerous. Below the bridge there are less spring-fed streams. The change in characteristics below the bridge can probably be attributed to higher gradients and different soils.

The geomorphology has probably been effected by spring inputs and by runoff and precipitation events. Spring-dominated systems tend to have higher baseline flow and less low flow days then runoff-dominated systems. There is probably more low flow work exerted on the Teton then runoff-dominated streams due to higher baseline flows. According to the Groundwater Survey the groundwater table averages a 10 foot higher elevation then pre-settlement (Nicklin, 2002). The high water table could be maintaining an artificially high baseline flow in the Teton. It appears that channel forming flow magnitudes are similar to run-off dominant systems.

Pre-settlement sediment delivery to the Teton was probably greatly attenuated by beaver dams that most likely lined the lower gradient portions of the tributaries. These beaver dams probably burst from time to time sending pulses of sediment into the Teton River. After the removal of beaver dams and before extensive flood irrigation, tremendous amounts of sediment could have been delivered to the Teton. The initial sediment loading could have started some of the braided channels and could have widened out channels. According to SCR, braided streams typically result when an increase in sediment creates mid-channel gravel bars. With development, annual sediment delivery has probably increased. According to TRBS in 1992, "estimated sediment yield to the Teton River in the historic spawning area, is currently 294% over natural conditions." Peak runoff events have been greatly reduced ever since water from the tributaries has been diverted to irrigation. Higher then natural sediment delivery along with reduced peak runoff events could have lead to sever sedimentation of the Teton River. The sedimentation probably shows up in wider then normal channels, embedded gravels and mid-channel gravel bars.

The combination of possibly high W/D ratios, embedded substrates, delivery of over 5x more sediment then normal, disturbed banks and riparian vegetation and diverted spring flood flows seem to point towards a system that has been disturbed by development. It appears that the Teton receives more sediment then it has the power to transport. This excessive sediment has probably adversely effected fish habitat and water quality. Embedded gravels have probably prevented fish from spawning successfully. Pools might have filled in causing a not loss of fish habitat. Disturbance of banks and riparian vegetation might have accelerated the disturbance of the Teton.

Recommendations:

Watershed Restoration:

This discussion of watershed restoration is based purely upon a scientific wish list. No funding, economic, political or cost/benefit analyses have been conducted at this time.

Priority One: Determine all sediment inputs into the system and mitigate to reduce sediment delivery to the Teton. This will probably require the acquisition of all stream data collected on the tributaries and additional surveys of the tributaries. All development activities in the riparian areas of tributaries and the Teton should probably be ceased. Only limited development in the floodplain of the tributaries and Teton should be allowed and only after thorough examination of environmental impacts.

Priority Two: Determine the ability of the Teton to transport sediment. The results of such research will probably show that the Teton needs sufficient peak flows during spring runoff to effectively transport the sediment received. All diversion of water from tributaries during springtime flooding will probably have to cease to accomplish this. Other sources for irrigation such as groundwater should be explored.

Priority Three: Determine the stability of the Teton River and begin restoration. Surveys should be designed to determine the natural variability of the Teton. Natural W/D ratios, sedimentation, eroded banks, channel migration, riparian and fisheries should be determined. Once the natural variability of the Teton has been determined and modified for the current hydrologic regime restoration of appropriate channels, banks and riparian areas should begin. Water diverted from tributaries during the summer may also need to be restored to aid in the ability of the Teton to transport sediment. The connectivity issues of fish habitat will also need to be explored. Letting water flow through the tributaries all summer may enhance the fisheries. The Teton River should be restored to pre-settlement conditions tailored for current conditions.

Teton River Restoration:

Restoration should begin by determining the natural variability of the system. Areas deemed to be detrimentally altered by development should be evaluated to determine if conditions are suitable for restoration both environmentally and economically. Highest priority should be given to sites with unnaturally eroding banks. For example, a bank that is unraveling (i.e. willows falling into the stream) due to grazing impacts should have a high restoration priority. Riparian vegetation that has been adversely effected by overgrazing should be restored. If a stream reach is determined to have an unnaturally high W/D ratio, the channel might be narrowed. In this type of restoration as with all types of restoration, down stream effects should be carefully considered. For example, narrowing a reach may aid sediment transport through the reach, but it may cause excessive sediment deposition down stream. Sites that appear to be initial stages of degradation such as areas with excessive deposition should be monitored and evaluated for possible restoration work.

Potential restoration sites need to be examined for soil types, bank types, land use and proximity to water. There are probably many stretches of bank along the Teton that never historically had willow due to soil types, and/or lack of proximity to water or too much water. Certain soils, the Zu dry meadow soil in particular, are not generally productive soils for growing willow. Some soil may also be high in calcium carbonate, which creates poor willow growing conditions. Other soils may be too saturated with water for willow to survive. Clay banks are probably not very productive sites for willow due to low porosity. Some of these clay banks may be sufficiently armored to prevent much loss of soil and may even be maintaining the channel. Often clay banks are steep and incised. Clay banks should be avoided for restoration sites. Adjacent land use needs to be address to insure longevity of the restoration project. All grazing and agriculture should be suspended at restoration areas. Banks with wet Zc and Zd soil types should be good riparian vegetation production sites. All sites should have a soil survey to determine if the soils can support the target vegetation types.

Sites recommended for possible restoration are both recovery sites 2-67, 6-15,16, the island enhancement project (site 3-70.75) and restoration sites 4-1,2, 5-10,11 and 6-20. Sites 5-10,11 and 6-20 may be the highest priority since the banks show obvious signs of unraveling (i.e. willows falling into the stream). All sites need to be closely examined for soil types, clay formations, proximity to water, stability and land use before restoration begins. Sites should be restored starting up stream and working down stream so downstream effects of restoration projects can be examined.

Survey Recommendations:

The HARP stream survey sites should be revisited next season. The x-sections should be resurveyed to increase accuracy and to examine any changes in channel geometry. If funding allows all the noted potential pebble count sites should be surveyed. Other data that could be collected include % embeddedness, core samples, subsurface particle size, clay formations, flow measurements, eroding bank composition and riparian soil types. X-sections should be re-surveyed at least every 3 years after the 2003 season.

The life-cycle of fish, especially cutthroat in the Upper Teton River Basin needs to be studied. A survey should be designed to examine the spawning grounds, historic and present connectivity to tributaries and the effects of sedimentation and loss of habitat on fisheries populations.

A new survey should be implemented with the object of randomly surveying the entire Upper Teton River Basin to highway 33 to gain comprehensive information of form and function. The survey should be designed to examine sediment sources and transportation, streambed surface and subsurface particle size, embeddedness, channel geometry, habitat types, eroded banks, soil types, riparian stability, fisheries and the hydrologic regime –past, present, and future.