Cookhouse Meadow Restoration

Five-Year Effectiveness Assessment

USDA Forest Service

Lake Tahoe Basin Management Unit

November 2013

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Executive Summary

The Cookhouse Meadow Restoration Project was constructed in the summers of 2005 and 2006, restoring the stream-meadow connectivity that had been disrupted by manmade changes to the stream channel decades earlier. To restore connectivity between the stream and adjacent floodplain, 2,400 feet of new stream channel was constructed. The new channel's geomorphic form (depth, width, gradient, and sinuosity) was designed so that the stream would flood the adjacent meadow frequently, allowing the meadow to function more effectively in slowing floodwaters and filtering out sediment.

A report produced two years after completion of the project, documented that many attributes of meadow and stream function had improved (Norman and Immeker, 2009).

At five years post-project, the hydrology and biology of Cookhouse Meadow were studied again. The results of those analysis efforts are provided in this report. The update on the hydrology of Cookhouse Meadow discusses changes in flood frequency, sediment deposition and scour, and stream cross-sections. The update on the biology of Cookhouse Meadow makes comparisons of the vegetation and wildlife present pre-project to those found at five years post-project. The results are summarized below.

- Hydrology data documents that overbank flows continue to flood the meadow at the desired frequency of 1.5 year recurrence interval. Sediment sampling in 2012 provides a rough quantitative estimate of the degree to which meadow surfaces are being replenished with sediments deposited by overbank floods; approximately 40 tons total, of which a little more then half consist of silt/clay sized particles.
- Point bar accretion with little or no outer-bend scour, or bed elevation loss, continues to maintain a stable channel form
- Results suggest there has been an increase in meadow plant species indicative of wet meadow conditions, although the dominant wet meadow grass species present is an invasive species found widely throughout the Basin.
- Because of the increase in meadow wetness, desirable wildlife habitat has also increased, resulting in positive trends in presence and species richness of some desired wildlife species (butterflies, reptiles/amphibians, and birds).

The next analysis and report of long term restoration effectiveness in this project is currently scheduled for 2022.

I. Introduction

The Cookhouse Meadow Restoration Project was constructed in the summers of 2005 and 2006. The project restored the stream-meadow connectivity that had been disrupted by manmade changes to the stream channel decades earlier.

To improve grazing in the early 1900's, the stream channel had been moved from its historic location along the southern perimeter of the meadow to a new path through the middle of the meadow. The re-located channel was much straighter (less sinuous), which increased the velocity of the stream flowing through the meadow. The faster flows eroded the streambed, down-cutting and incising the stream channel deeply into the meadow. In many areas, the stream channel resembled a steep-walled gully much more than a natural watercourse (Figure 1).

Figure 1 Steep-walled streambank in 1981.

By the Rosgen Classification system (Appendix A), the stream channel was classified "G4", which meant it was deeply entrenched though it had moderate sinuosity. The Forest Service stabilized the streambanks in the 1980's. However, the streambed remained two to ten feet deeper than its natural position. The incised stream channel continuously drained the adjacent meadow, reducing meadow wetness and flooding patterns, vegetation and wildlife diversity, and sediment retention.

To restore connectivity between the stream and adjacent floodplain, 2,400 feet of new stream channel was constructed. The new channel's geomorphic form (depth, width, gradient, and sinuosity) was designed so that the stream would flood the adjacent meadow frequently, allowing the meadow to function more effectively in slowing floodwaters and filtering out sediment. Most of the old stream channel was filled in with soil that came from digging the new channel. Portions of the old channel were left unfilled to serve as ponds for amphibians. The bare ground surfaces of the filled channel reaches were re-vegetated with a combination of sod mats and sod plugs harvested from the meadow. Two years after completion of the project, many attributes of meadow and stream function had improved (Norman and Immeker, 2009).

At five years post-project, the hydrology and biology of Cookhouse Meadow were studied again. The results of those analysis efforts are provided in this report. The update on the hydrology of Cookhouse Meadow discusses changes in flood frequency, sediment deposition and scour, and stream cross-sections. The update on the biology of Cookhouse Meadow makes comparisons of the vegetation and wildlife present pre-project to those found at five years post-project.

Data were collected to answer the following questions:

1. **Hydrology/Sedimentation** - Is the meadow now flooding as frequently as planned (e.g., averaging a 1.5 year reoccurrence interval)? Are significant amounts of sediments deposited in the meadow during floods? Are expected changes occurring within the new stream channel, such as the formation of point bars?

2. **Channel Condition** - Is the new stream channel maintaining its constructed characteristics of a slightly entrenched gravel-bed stream with moderate to high sinuosity (e.g., Rosgen C4)? Or is the channel evolving to a more sinuous form (e.g., Rosgen E4)?

3. **Vegetation Response** - Are dry-meadow grasses and trees being pushed out of the central meadow by wet-meadow species? Is the ground water there now sufficiently shallow to support the wet-meadow species?

4. **Wildlife Response** - Are diversity and complexity of riparian and meadow habitat increased? Are wildlife communities that depend on these habitats also more diverse and abundant?

II. Methods

a. Monitoring Question 1 - Hydrology

Spring snowmelt runoff potential for Cookhouse is based on the April 1st percent-of-median snow water content, obtained from the Echo Peak SNOTEL Station # 463 located five miles west of Cookhouse Meadow in the Upper Truckee River Watershed.

Runoff stage was measured by the LTBMU at Cookhouse meadow, using a stage plate and automated stage recorder located near the downstream end of the project (which recorded stage every 60 minutes). Stage data were converted to discharge using a stage-discharge regression developed from discharge measurements collected at this site. A total of fifteen discharge measurements (using a Marsh-McBirney flow meter) were collected at this site between 5/17/2007 and 6/20/2011.

In Water Year 2012, the snow melt discharge pattern had to be estimated (due to an equipment malfunction at the Cookhouse stage recorder). Estimation was done by developing a regression equation of the 15 discharge measurements taken at Cookhouse Meadow versus data recorded at USGS Gage #103366092 on the Upper Truckee River. The latter were recorded on the same day and at approximately the same times as those measured at Cookhouse Meadow. USGS data were collected at 15 minute intervals, so 15 minutes is the maximum error in time separating data points from the two sites.

The USGS gage is located several miles downstream of Cookhouse Meadow. The drainage it measures includes the Big Meadow watershed and all of the Upper Truckee River headwaters above Christmas Valley. The total drainage area discharging streamflow at the USGS Upper

Truckee gage is much larger than at Cookhouse Meadow (14.1 vs. 4.8 square miles, respectively). There is a strong statistical relationship (R^2=0.965) in spring snowmelt discharge at the two locations (Figure 2), which suggests they measure a single unified watershed.

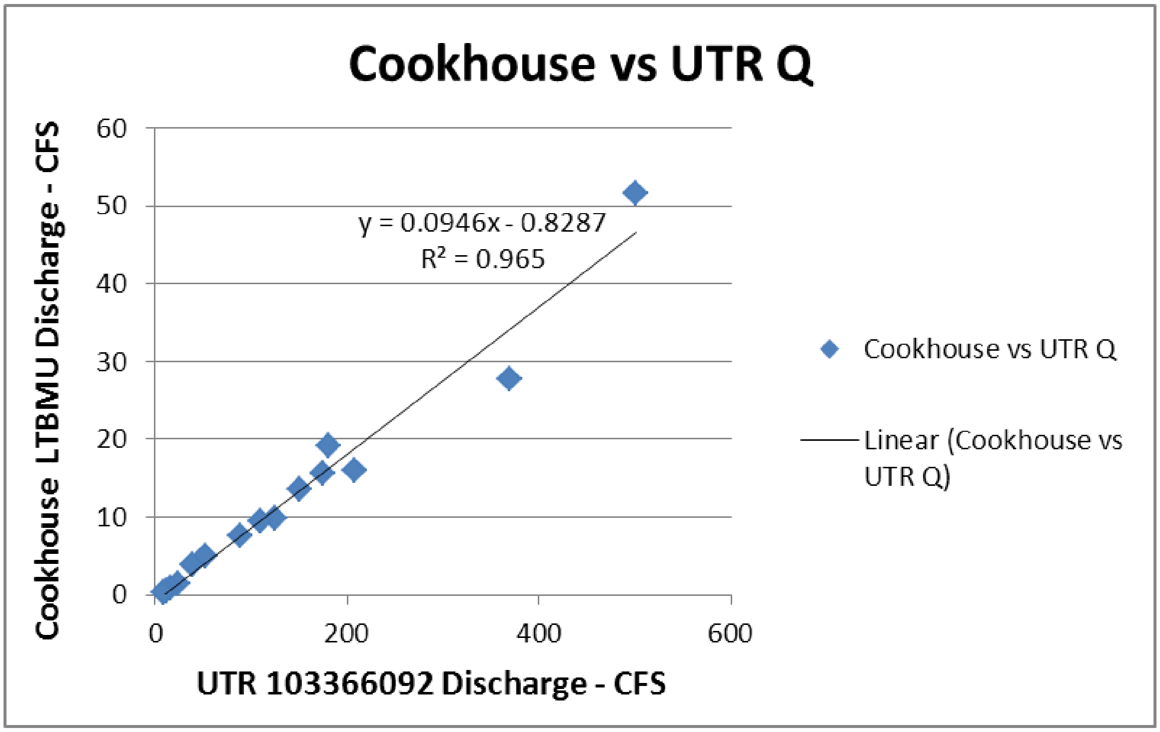

Figure 2 – Relationship between Cookhouse and Upper Truckee Discharges

Stage- discharge measurements and calculations were used to determine the frequency and duration of flows that would exceed the desired (design) channel capacity of 30 cfs. At the desired capacity, streamflows were expected to overtop the streambanks and spread onto the meadow.

b. Monitoring Question 1 – Sedimentation

Prior to 2011, the amount of sedimentation was documented through visual observations. The spring of 2011 was the highest and longest duration snowmelt discharge since project completion (Figure 3). Approximately midway through the snowmelt runoff in 2011, we mapped observed meadow sediment deposition patterns and extent of flooding. We also measured the depths of sediment deposits and collected sediment samples, to estimate tons of sediment added to the floodplain and channel margins.

Figure 3 – June 21, 2011 view of channel and overbank flow at 75 cfs (facing downstream)

Observations and measurements were made on June 18-19, 2011, when gaged flow ranged from 50 to 60 CFS, which is twice the bank full discharge. Floodplain and channel margin deposits were identified visually as fresh surfaces forming a veneer over the previous year's vegetative growth. We also identified newly deposited sediments accumulating along channel margins.

Areal extent of the deposits was mapped using a GPS. Sediment depths were measured concurrently using a steel measurement rod with machined 1-cm increments; each polygon of sediment was probed in 6 to 12 points distributed evenly throughout to get an average depth. With these data we were able to estimate the volume of sediment deposited. Additionally, we classified depositional polygons as either being predominantly sand or fines. The perimeter of the overflow paths and ponded water areas were mapped using a GPS to document wetted extent during sediment measuring and sampling.

We calculated depositional tonnages based on floodplain and channel margin deposits. Sample sites were chosen based on sediment type (sand or fines) and position in project. We collected six grab samples by scooping sediment out of the selected deposit using a wide-mouthed one-liter container. Two sediment samples were collected in a sandy channel margin deposit near the upstream end of the project, another two were collected in a sandy overflow deposit path at mid-project, and two were from a fines deposit in a ponded area at mid project. Each pair of samples was consolidated for a total of three samples. Soil textures were analyzed by the sedimentation lab at the University of Nevada-Reno Desert Research Institute (DRI) for fine earth (sand, silt, and clay) content.

c. Monitoring Question 2- Channel Condition

In the summer of 2012, the project area cross section and thalweg deposition and scour patterns were evaluated by Erin Altick, a Humboldt State University student, using repeat geomorphic surveys, to produce a post project channel stability assessment (Altick, 2012). Altick resurveyed and analyzed geomorphic changes occurring in the three monitoring segments last surveyed in 2008 (Figure 4). Additional visits were made by LTBMU staff in 2010, 2011, and 2013 to document visual observations of channel adjustments occurring outside the survey areas.

d. Monitoring Question 3- Vegetation Response

Five status Forest Service Region 5 Range monitoring plots (Wiexelmann, 2011) were established pre-project implementation in 2004 and 2005 (Figure 5). Measurements per standard protocols were taken at the monitoring plots one year (2007), three years (2009), and five years (2011) post project implementation.

e. Monitoring Question 4- Wildlife Response

Monitoring for comparison of pre- to post-restoration riparian and meadow habitat was initiated through an agreement with Texas A&M University (Michael Morrison, Principal Investigator). Pre-restoration surveys were conducted 2004-2006, and post-restoration surveys were conducted 2007-2009. Avian point counts, avian nest success, small mammal, bat, herpetofauna and butterfly surveys were conducted. Additionally, post-restoration surveys included surveys of meadow wetness. Methods specific to each survey are detailed in an LTBMU internal document (Borgmann and Morrison, 2008).

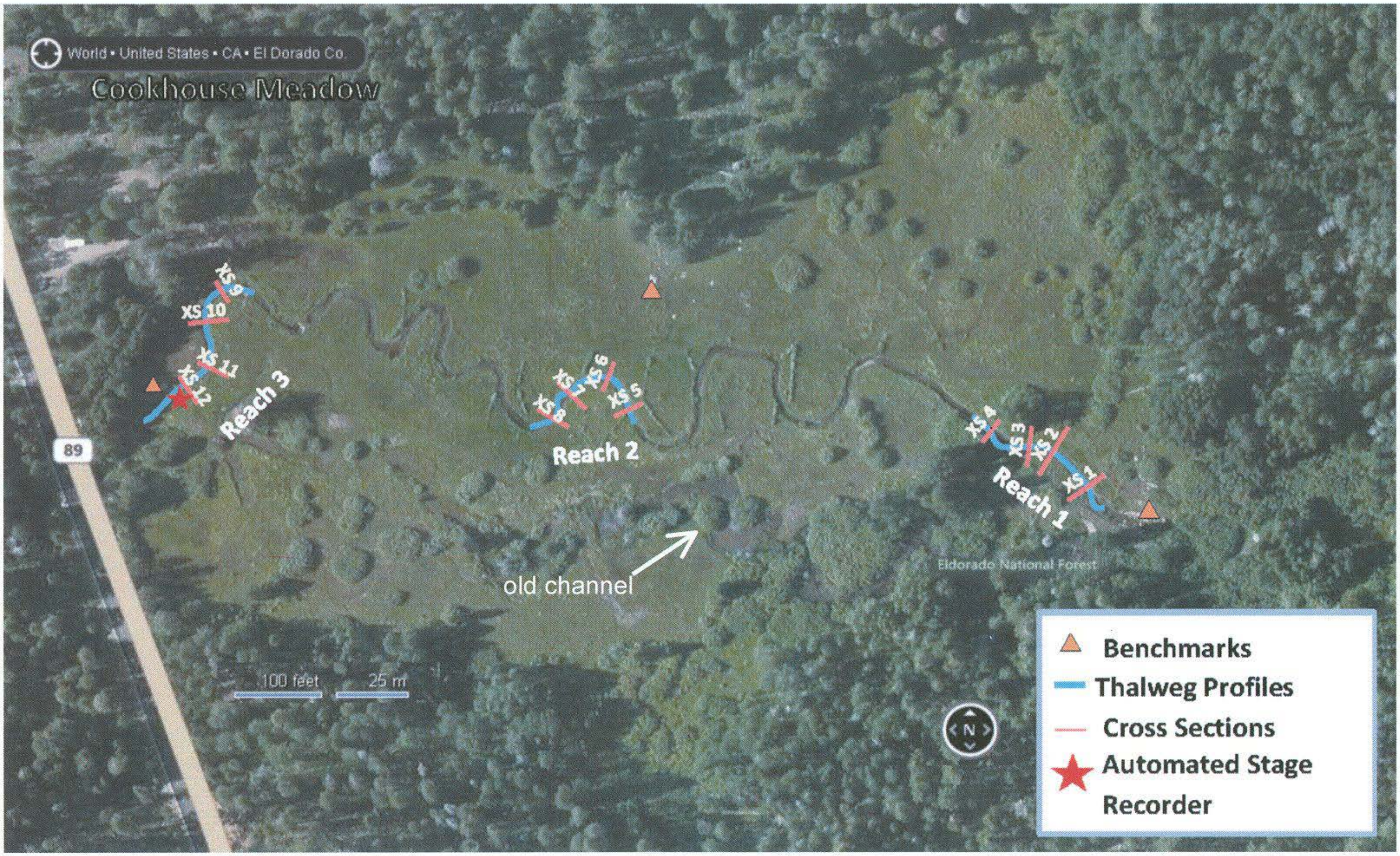

Figure 4 – Cookhouse Cross Section and Thalweg Profile Site Map (from Altick, 2012)

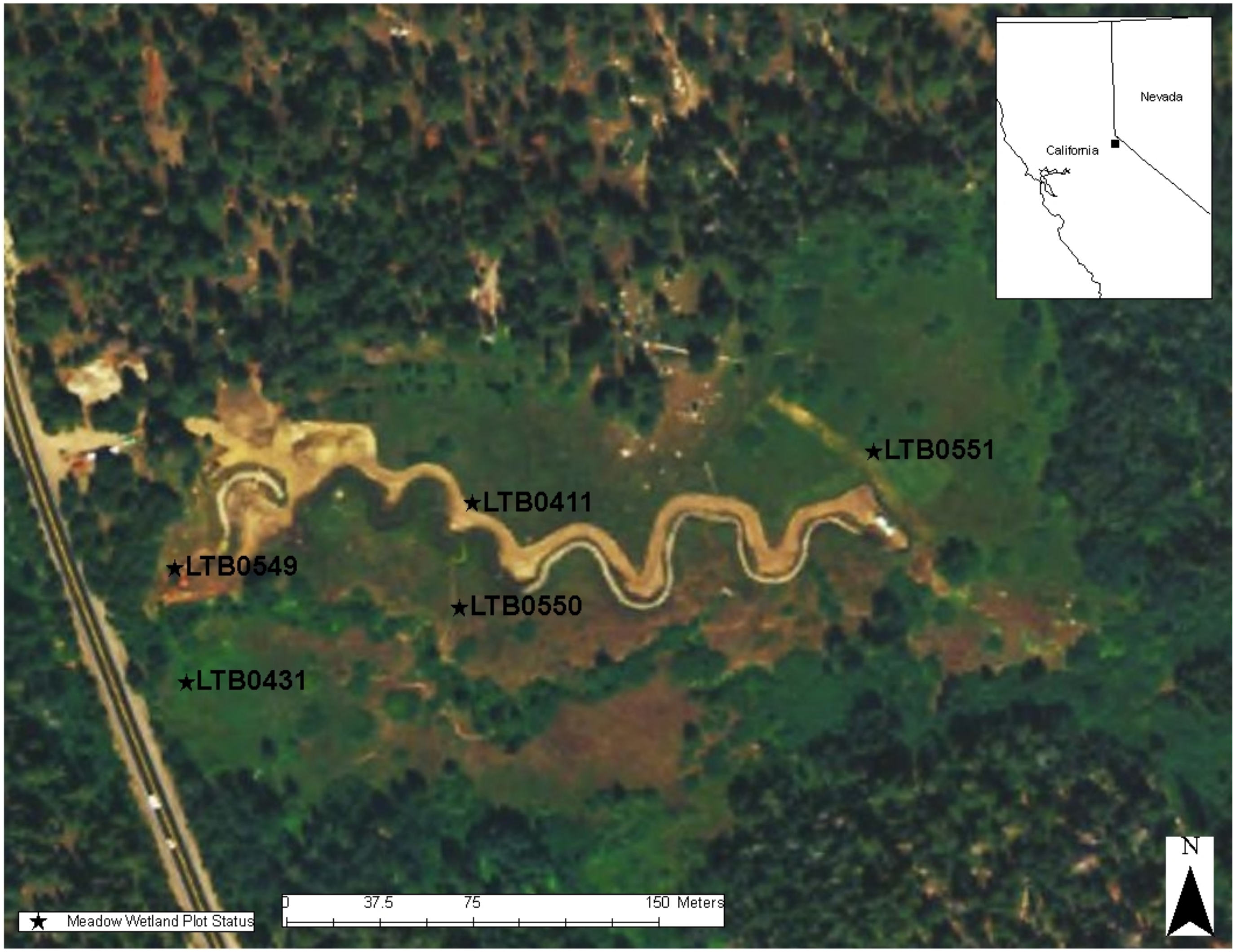

Figure 5 - Locations of the five vegetation meadow plots at Cookhouse Meadow. Aerial imagery is from 2005.

III. Results

a. Monitoring Question 1- Hydrology

Since project completion in 2006, snow melt runoff has been the primary driver in terms of channel shaping, point bar accretion, meadow surface sediment and nutrient supply, and water availability for meadow vegetation. April 1st median snow water content measured at the Snowtel site is ~40 inches. The data indicate Water Year 2010 was 105% of median snow water content; whereas, 2011 and 2012 were 170% and 59%, respectively.

The channel was designed so that streamflow would overtop the channel banks onto the floodplain in two out of every three years (at approximately 30 cfs). The streamflow in the creek was at or exceeded 30 cfs 16 days in 2010, 76 days in 2011, and one day in 2012 (Figure 5). Snowmelt runoff generated peak flows of 69 CFS on June 5 2010, 94 CFS on June 29 2011, and 55 CFS on April 24 2012. The 2012 flood peak was triggered by a spring rain-on-snow event. Two other notable fall runoff events resulted in elevated discharge levels at Cookhouse. The first in Water Year 2010 occurred on October 14 when a 48-hour 6-inch rain event that resulted in a 12 CFS flow. The second in Water Year 2011 occurred on October 23 when a 24-hour 8-inch rain event, under unusually wet antecedent conditions, triggered a measured flow at the Cookhouse Meadow station of 80 CFS.

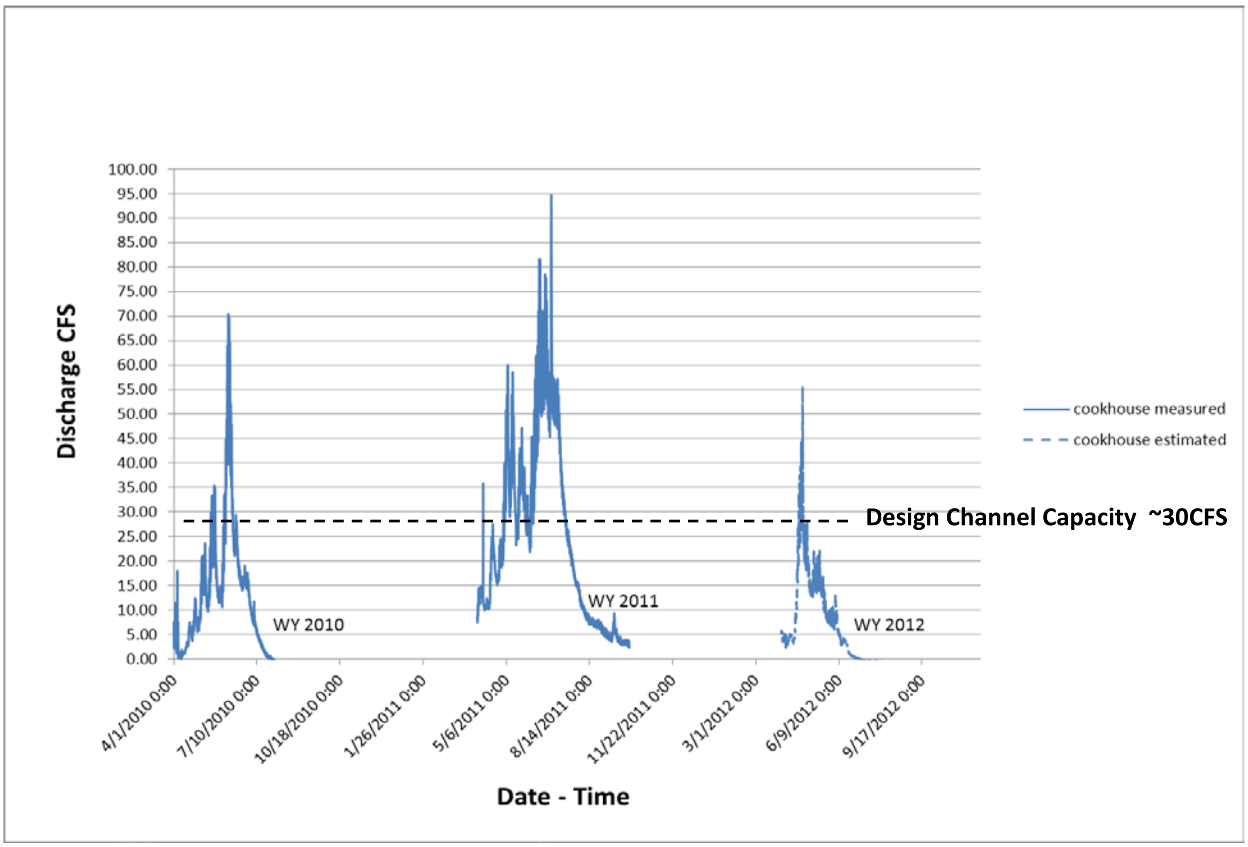

Figure 6. Big Meadow Spring Runoff Discharge, Water Year 2010-2012

b. Monitoring Question #1- Sedimentation

Visual observations prior to Spring 2011 revealed that minor floodplain sediment deposition did occur. Some deposits were accumulating at channel margins (defined as the inside edge of constructed point bars) and some fines were probably carried out and deposited into ponding areas between meanders at the midpoint of the project; particularly in spring 2009 when the channel exceeded bank full capacity for 21 days (as documented in the 2009 Cookhouse Meadow monitoring report). Sedimentation area, volume, and character were not documented in 2009, but were measured, and mapped during spring runoff of 2011, and the results are presented below.

Mapping results (Figure 7) indicate the wetted extent as a result of the restored stream overbanking (ponding and over bank flow) was 3.82 acres at twice the bank full discharge (60 cfs). Total area of sedimentation identified was approximately 0.69 acres, and the depth of deposits ranged from 0.001 to 0.6 meters (Appendix B: Table 1 & 2). Lab analysis (Appendix B: Table 1) indicates that sand was the dominant particle size for channel margin samples and silt was the dominant particle size for floodplain samples. Utilizing the sediment volume field data and DRI particle distribution analysis (Appendix B: Tables 2, 3) we estimate 16.5 tons of sediment deposited in the channel margin and 39.7 tons deposited in the floodplain, of this the silt/clay fraction was 4.1 tons on the channel margins, and 20.7 tons on the floodplain.

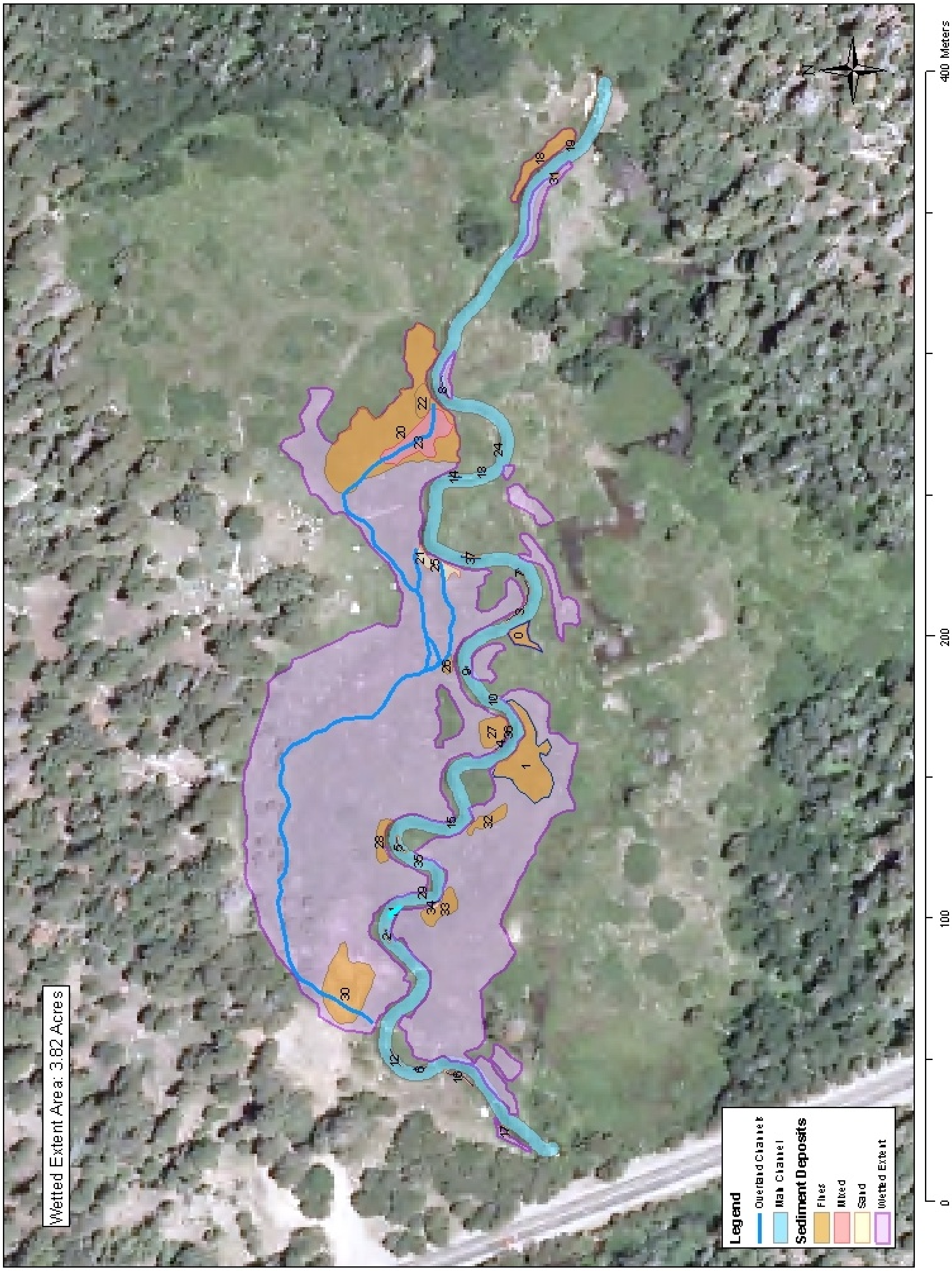

Figure 7 – Cookhouse Meadow Wetted Extent and Sediment Deposits (June, 2011)

c. Monitoring Question #2 -Channel Condition

Results of Alticks analysis shows channel forming processes resulting in net aggradation, mostly in the form of point bar accretion (Figures 8 and 9).

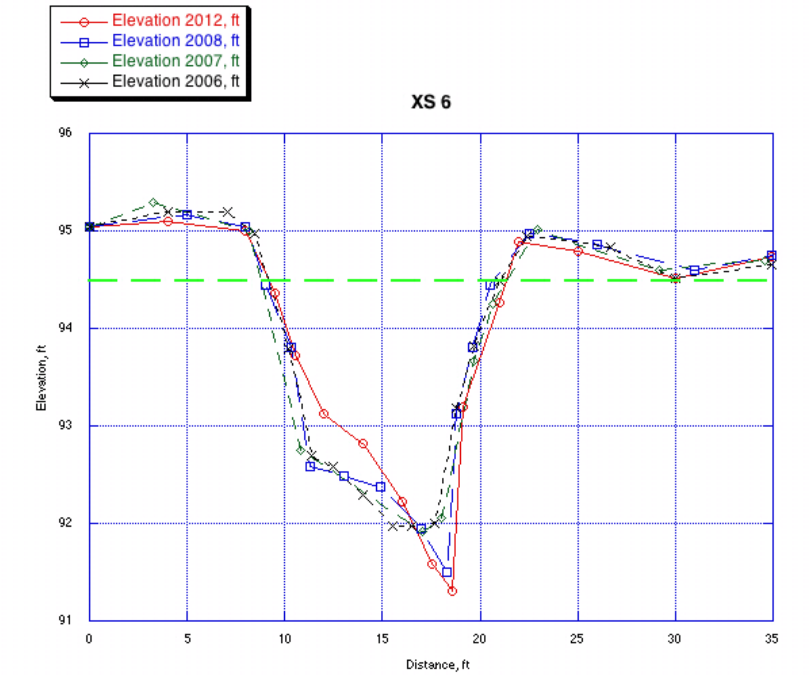

Figure 8 – Magnitude of Point Bar Accretion at XS 6, mid-project. The green dashed line is the elevation where cross section shape analysis begins

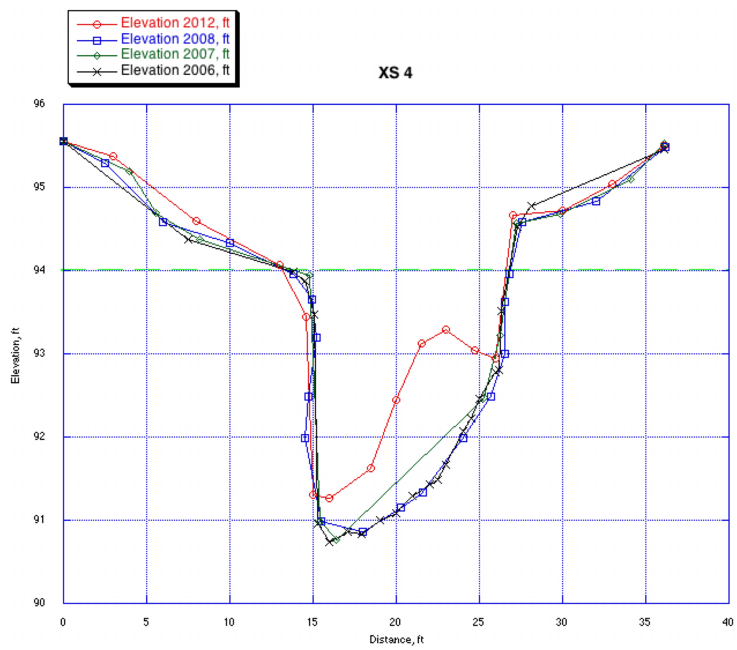

Figure 9 – Magnitude of Point bar accretion at XS 4, downstream end of project. The green dashed line is the elevation where cross section shape analysis begins

Figure 10 illustrates the change in overall thalweg elevations. The thalweg is the deepest point of the channel at any given point. Plots show that minor changes in the thalweg have occurred since 2008, with one noticeable area of riffle scour to a downstream shift in pool – riffle position as shown in the Reach 1 thalweg survey. Change in mean bed elevation (Figure 11) shows net aggradation of the channel since 2008, once again mostly in the form of point bar formation. The photo in Figure 12 illustrates this process of point par formation.

Bank erosion is occurring along the outer bend of one meander within the project area. Currently the area of channel erosion is approximately 20 feet in length and 5 feet in width. The streambed and streambanks upstream and downstream of this area are stable, and this appears to be holding bed elevation and stream bank erosion in check currently, requiring no additional action at this time. The Forest Service will continue to monitor this site and take corrective if necessary in the future.

The location of the deepest part of the channel (the thalweg) through the riffles is also evolving, being re-positioned by the depositional bars and small pools that are taking shape. Generally speaking, most riffles appear to be at or close to their constructed elevation throughout the project.

These results indicate that the channel form in the restored reach is in a state of dynamic equilibrium. While changes are occurring, channel geomorphology is stable, and not exhibiting excessive destabilizing erosional or depositional processes. Point bar accretion is occurring with little or no outer-bend scour, or bed elevation loss.

The constructed morphology of the new channel was that of a C4 channel type using the Rosgen channel classification. This channel type is described as a slightly entrenched, meandering, gravel dominated riffle/pool channel with a well developed floodplain. A C4 channel form would tend to persist in systems with a relatively high natural sediment supply. We have hypothesized that the constructed channel will gradually evolve to an E channel type, based on our assumption the channel will adjust to having a relatively low natural sediment supply. Both channel forms can exist in a stable form and provide good quality aquatic habitat. However, in comparison to the C4 channel type, an E4 channel is much narrower, resulting in a lower width/depth ratio, and is much more resistant to plan form adjustments and more resilient in terms of channel stability. The undercut banks that form in E type channels provide optimal cover for fish. It is too early tell if a Rosgen C to E evolution is occurring, although the narrow rectangular channel shape typical of E channel types in meadow streams is starting to develop in a few isolated areas. Response to a larger flood such as winter rain-on-snow may be needed to judge what the constructed form may evolve into in the long term.

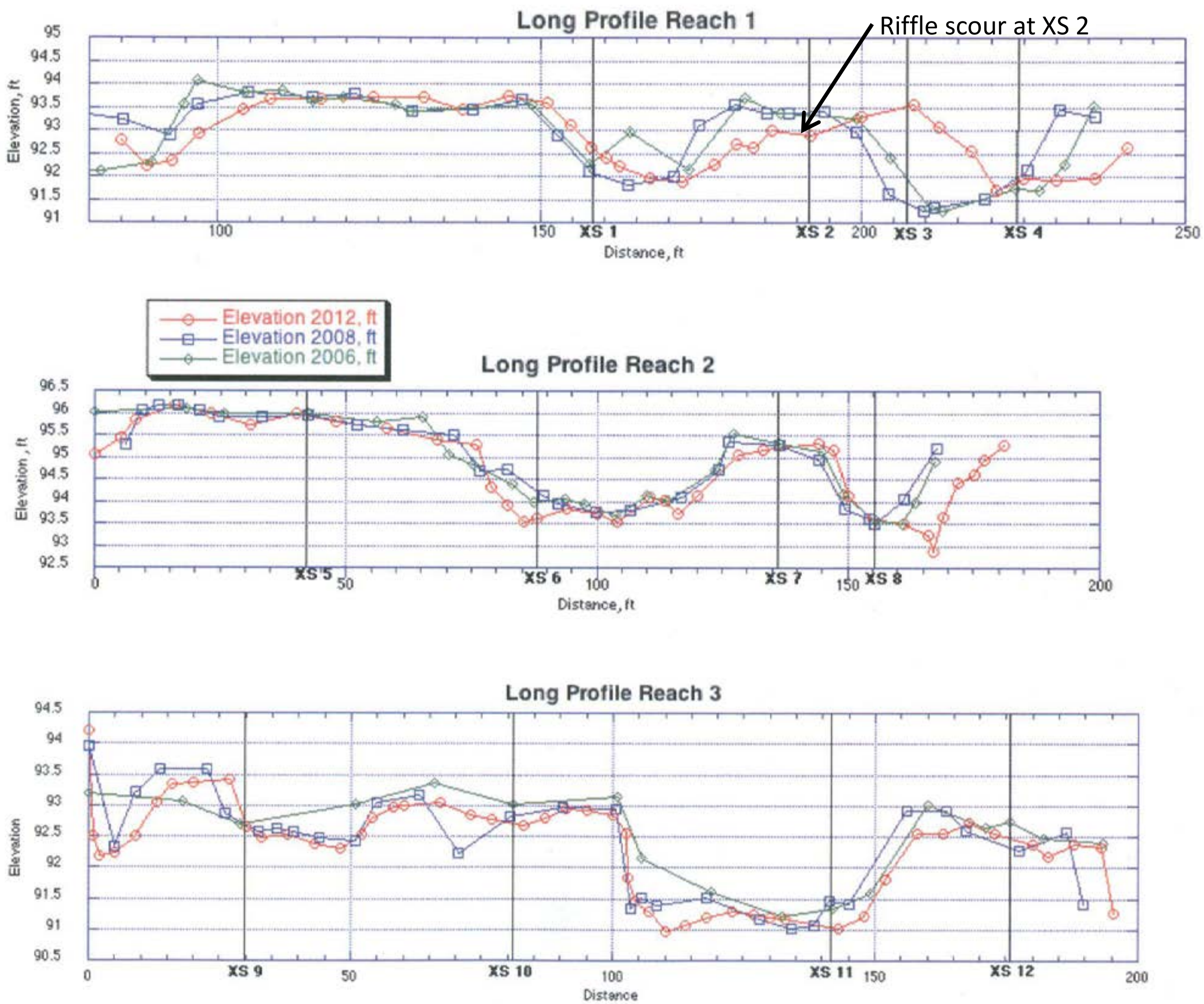

Figure 10 – Big Meadow Creek thalweg measurements (from Altick, 2012)

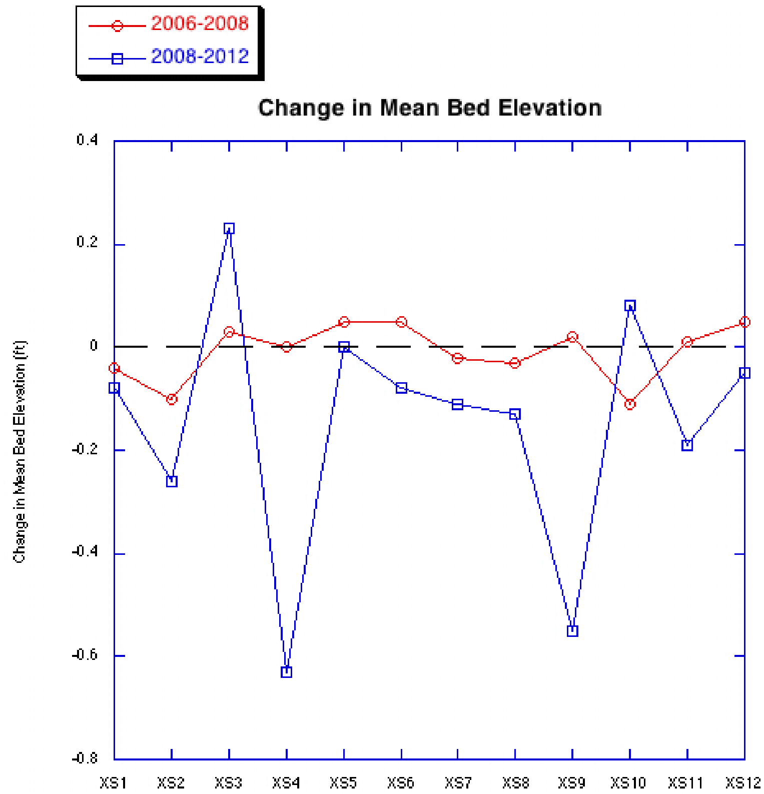

Figure 11 – Change in Big Meadow Creek mean bed elevation (from Altick, 2012). Negative values indicate loss in area (aggradation), positive values indicate increase in area (degradation).

Figure 12 – Point bar formation in Cookhouse Meadow in May, 2012

c) Monitoring Question #3- Vegetation Response

In the original Cookhouse Meadow Report (USFS, 2009) vegetation response was evaluated only in terms of the success of restoration practices in establishing vegetation along the stream bank for stabilization. In this update we provide analysis to answer the larger vegetation response questions.

Cookhouse Meadow has a diverse vegetation community, containing approximately one third of all species recorded in Lake Tahoe Basin meadow plots. During monitoring visits from 2004 to 2012 we identified 111 vascular plant species and seven non-vascular plant species in 30 families. Two native meadow species, *Achillea millefolium* and *Juncus balticus*, were the most common species found during each monitoring visit at each of the five Cookhouse Meadow plots (Gross et al 2013). Twenty-five percent of the species observed in the Cookhouse Meadow plots were annual or biennial species; these are ruderal species with a high tolerance for disturbance due to a short live cycle and fast reproduction. In general, diversity increased while the average frequency of each individual species decreased. While the number of ruderal species increased pre to post-restoration, the average frequency of these species decreased as longer lived competitor and intermediate-competitor species increased. The increase in these longer lived species corresponds to the increased number of rhizomatous sedges and statistically significant increase (α=0.10) in rhizomatous grasses (p=0.06) (Gross et al 2013). We hypothesize that the functional score, based on Region 5's 2013 meadow scorecard protocol (Figure 13) (Gross et al 2013), will increase over time due to the increase in frequency of the longer lived rhizomatous species.

While the increase in rhizomatous (clonal) grasses is functionally beneficial for withstanding erosion and increasing plant cover, much of the increased frequency can be attributed to *Poa pratensis* (Kentucky blue grass) - the only invasive species identified in Cookhouse Meadow plots. Five years post restoration, the only plot without ground disturbing activity was also the only plot without *Poa pratensis*. It is unknown if the project activities increased the spread of this species, or simply reduced competition so that this species was able to colonize.

This trend in Cookhouse Meadow is similar to trends throughout the Sierra's. Kentucky bluegrass (*Poa pratensis*) has been identified as the most common non-native species in Sierra Nevada meadows is and appears to be increasing (Menke et al. 1996). Research suggests that the abundance of *Poa pratensis* may increase during drought years in sites with lower soil moisture (Kluse and Diaz 2005). There is no research currently that would indicate whether *Poa pratensis* might decrease as wetland species increase, or whether native wetland species may be able to out compete *Poa pratensis* in the long run.

Unfortunately, we are unable to say anything conclusive about the presence and frequency of *Pinus contorta* in the established long term meadow plots; managers removed lodgepole seedlings in 2007 and 2011 throughout the meadow, including within the permanent plots. A count of *Pinus contorta* seedlings within Cookhouse meadow proper in the spring of 2012 suggests that conifer cover is almost four times greater in areas that experienced some soil compaction compared to areas of open undisturbed meadow. We counted 40 seedlings in old roads, seven in willow hedge rows, ten in sod stacked along the stream, 18 in open meadow sod, three in channel fill areas, two in sod harvest areas, and ten in dirt storage areas compared to 24 in open meadows (excludes areas along the meadow edge where natural conifer encroachment would occur).

Results suggest that the overall vegetation community has an increased number of wetland species. As vegetation recovery continues we hypothesize that we will see an increase in the frequency of the wetland vegetation. Five years post restoration there was a statistically significant increase ($\alpha=0.10$), in the number of obligate wetland species ($p=0.06$) (Figure 14) (Gross et al). Based on Region 5's 2013 meadow scorecard protocol wetland scores (based on the number of obligate and facultative species) increased at four of the five meadow plots post-restoration (Figure 15) (Gross et al 2013). At one of the meadow plots this increase in wetland score was above the ecologically significant threshold value of >19, which suggests that change can be attributed to more than inter-annual variability (Gross et al 2013).

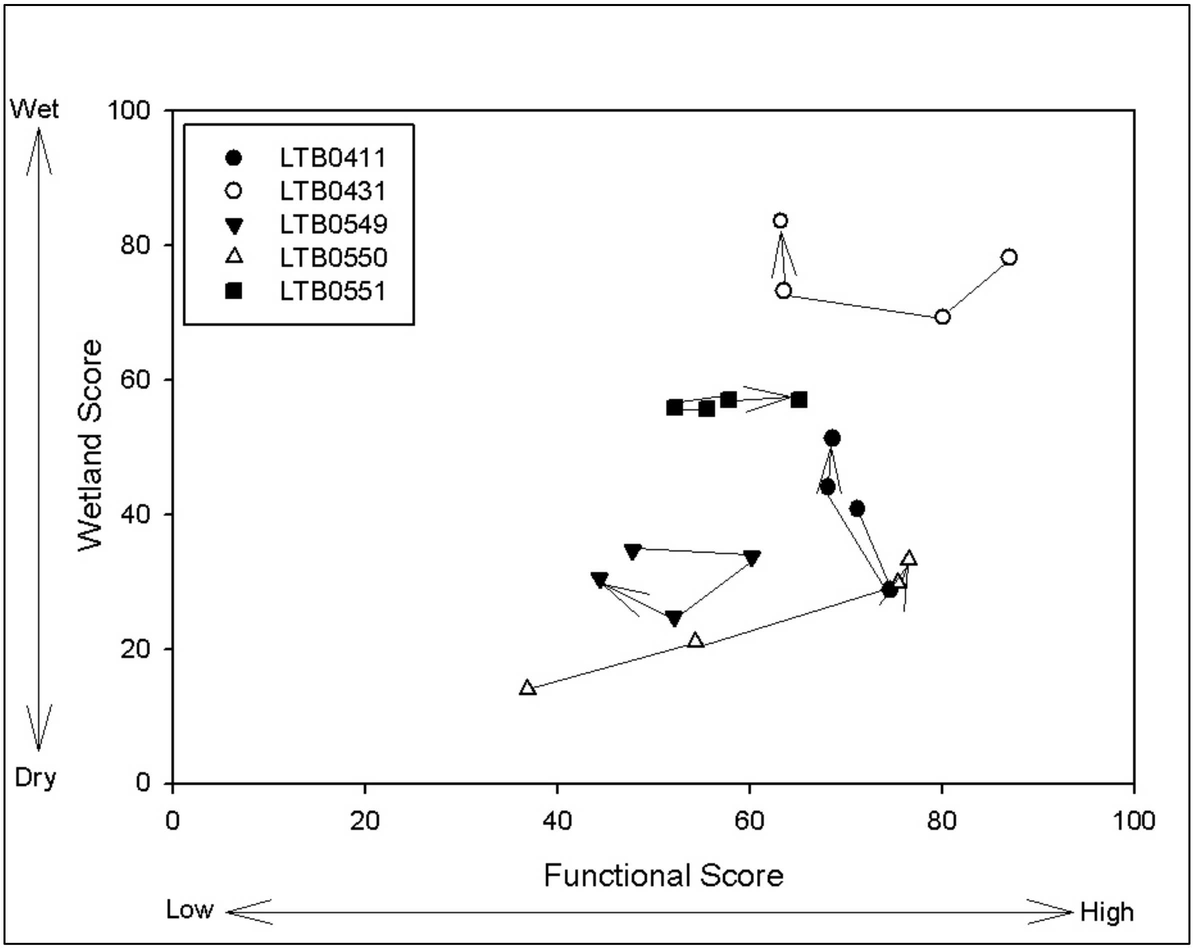

Figure 13: Cookhouse meadow functional matrix for five meadow plots
Pre-restoration (2004/2005), one year post restoration (2007), three years post restoration (2009), and five years post restoration (2011).

The functional score on the x axis ranges from low function (0), where there would be a high proportion of R inidicator species, to high function at (100), where there would be a high proportion of C indicator species. The wetland score on the y axis ranges from dry (0) where there would be a high proportion of upland species, to wet (100) where there would be a high proportion of obligate wetland species. Arrows indicate plot score through time, with arrows identifying five year post restoration score (Gross et al 2013).

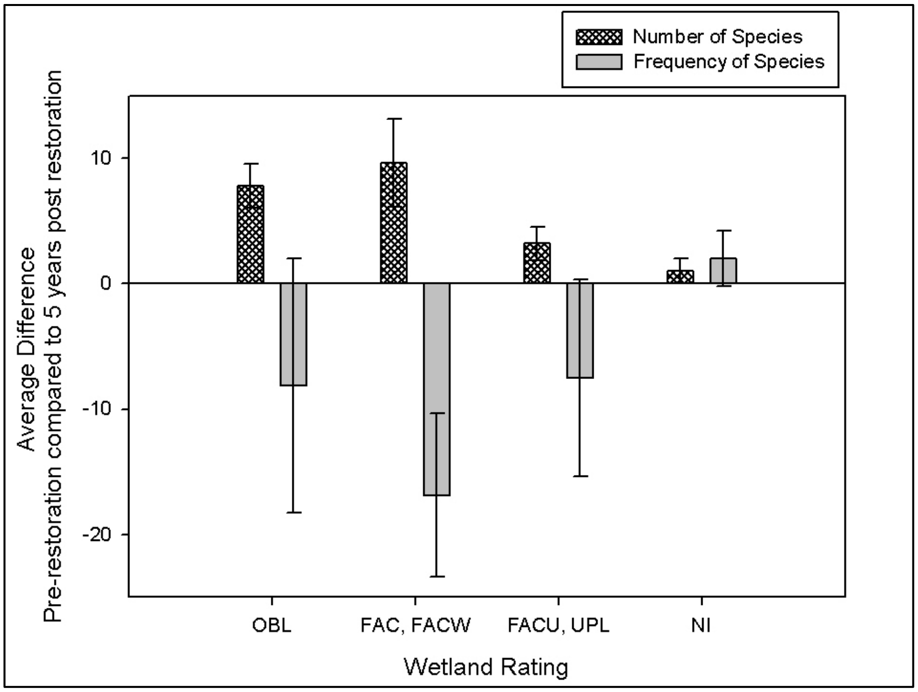

Figure 14: Average difference in number of species and frequency
Of those species found at Cookhouse meadow pre (2004, 2005) and post (2011) restoration, none of the differences observed were statistically significant. (Nonvascular plants are not included because surveys for nonvascular species were not consistent in 2004 and 2009 (Gross et al 2013)).

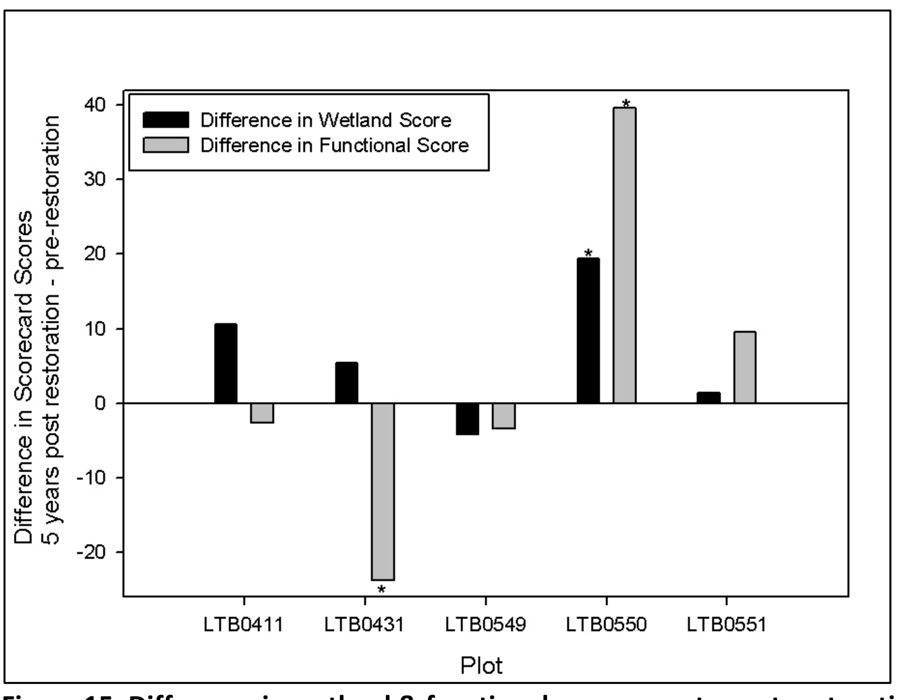

Figure 15: Difference in wetland & functional scores pre- to post-restoration.
Pre-restoration scores obtained 2004/2005; post-restoration scores obtained 2011. Negative values indicate a decrease in score while positive values indicate an increase. Plots identified with an * experienced a change in meadow score greater than the identified threshold value of 19 (Gross et al 2013).

d) Monitoring Question #4 - Wildlife Response

Meadow wetness was not reported from pre-restoration surveys (2004-2006), presumably because the meadow was known to be dry. Post-restoration surveys (2007-2009) found the majority of points to be either saturated or have standing water in early June, which gradually became mostly dry by late July.

The average butterfly abundance during post-restoration surveys was 50% greater than that of pre-restoration.

Post-restoration herpetofauna surveys found seven species as opposed to four species detected during pre-restoration surveys. The species found during post-restoration surveys that were not present during pre-restoration surveys were common garter snake (Thamnophis sirtalis), Long-toed salamander (Ambystoma macrosactylum) and southern alligator lizard (Elgaria multicarinata). No species that were found during pre-restoration surveys were absent from post-restoration surveys.

Avian species richness increased 11% from pre to post restoration and included four native species not previously recorded at Cookhouse Meadow: yellow warbler (Dendroica petechia), spotted sandpiper (Actitis macularia), Swainson's thrush (Catharus ustulatus), and black-headed grosbeak (Pheucticus melanocephalus). Yellow warbler was also detected during all four 2012 and 2013 willow flycatcher surveys. These surveys did not record number of yellow warbler detected but rather tallied species richness throughout the survey. Additionally, a single willow flycatcher (Empidonax traillii, a USFS Region 5 sensitive species) was detected at Cookhouse Meadow in 2013. This was the first willow flycatcher found at this site post-restoration. Pre-restoration detections include only three detections from 2002.

Avian nest success declined post-restoration compared to pre-restoration however the same was observed at the control site (Big Meadow) so these results may not be related to the project. Similarly cowbird parasitism increased at both sites post-restoration as compared to pre-restoration.

Pre- and post-restoration bat population trends are difficult to assess due to low numbers of species detected but it appears that bat species richness did not increase post-restoration.

Although absolute richness of desired small mammal species did not increase post-restoration the number of individuals captured per 100 trap nights did increase following restoration suggesting that restoration is having a slight positive impact on desired small mammal species.

Wildlife surveys were originally intended to continue post-restoration 1, 2, and 3 years (2007-2009 then) post and then on an every other year basis after the initial three year (2011, 2013, and 2015), however the 2011 and 2013 surveys did not occur due to workload constraints. The 2015 surveys are not likely to occur due to budget constraints. Willow flycatcher surveys are likely to continue at this site on the four year rotation detailed in the Sierra Nevada Forest Plan Revision Record of Decision (2004). The four year rotation was completed in 2013 so the next survey of this site would occur in 2016 as the budget allows. In 2014 a summary report will be completed on wildlife monitoring at restoration projects. That report will identify areas where monitoring should focus; at this time no other wildlife monitoring is planned for Cookhouse Meadow.

IV. Key Findings Summary

1. **Hydrology/Sedimentation - Is the meadow now flooding as frequently as planned (e.g., averaging a 1.5 year reoccurrence interval)? Are significant amounts of sediments deposited in the meadow during floods? Are expected changes occurring within the new stream channel, such as the formation of point bars?**

   Hydrology data documents that overbank flows continue to flood the meadow at the desired frequency of 1.5 year recurrence interval. Sediment sampling in 2012 provides a rough quantitative estimate of the degree to which meadow surfaces are being replenished with sediments deposited by overbank floods; approximately 40 tons total, of which a little more then half consist of silt/clay sized particles.

   The results provide a conservative estimate of total sediment storage since project construction, given the data doesn't account for 1) deposits that were hidden by rapidly emerging meadow grasses at the time sampling occurred, and 2) sediment trapping on biofilms forming on matted and emerging meadow grasses within the wetted extent. While this analysis doesn't account for variables such as sediment remobilization in future events, it is reasonable to assume that most of this sediment remains sequestered given that all deposits outside the main channel were colonized and became part of a thick, dense vegetation layer as soon as flows receded later.

2. **Channel Condition - Is the new stream channel maintaining its constructed characteristics of a slightly entrenched gravel-bed stream with moderate to high sinuosity (e.g., Rosgen C4)? Or is the channel evolving to a more sinuous form (e.g., Rosgen E4)?**

   Point bar accretion with little or no outer-bend scour, or bed elevation loss, continues to maintain a stable channel form, currently fitting the description of a Rosgen C4 channel classification. In some locations, channel erosion and deposition processes are beginning to form a more rectangular cross section, a stable channel form indicative of a Rosgen E4 stream classification, which manifests in meadow systems with a relatively low natural sediment supply. It is too early tell if a C to E evolution is occurring. Response to larger floods such as winter rain-on-snow may be needed to judge what the long term constructed form may evolve into.

Channel cross section and thalweg measurements are scheduled to be repeated in 2022, to continue to track the evolution of channel form in the restored reach.

3. **Vegetation Response - Are dry-meadow grasses and trees being pushed out of the central meadow by wet-meadow species? Is the ground water there now sufficiently shallow to support the wet-meadow species?**

Quantitative and qualitative (Figure 16) results suggest there has been an increase in meadow species indicative of wet meadow conditions. Future monitoring could determine if either conifer encroachment or increasing frequency of *Poa pratensis* continues; this may provide some insight into management consideration for future projects. Potential considerations could include better sub-soiling of compacted soils to reduce conifer encroachment and potentially increase the spread of sod or native seed within the project area to reduce *Poa pratensis*.

Figure 16: Cookhouse Meadow Vegetation Monitoring Plot #0431 (2004, 2011).

4. **Wildlife Response - Are diversity and complexity of riparian and meadow habitat increased? Are wildlife communities that depend on these habitats also more diverse and abundant?**

   Results from the monitoring effort and willow flycatcher surveys indicate an increase in meadow wetness and therefore wildlife habitat. Additionally, species richness and presence of desired condition species has increased for three (butterflies, herpetofauna and avian species richness) of six metrics surveyed. Avian nest success, bats and small mammals may all show positive trends if monitoring is continued.

The next analysis and report of long term restoration effectiveness in this project is currently scheduled for 2022. That monitoring will be scheduled as part of the LTBMU's ongoing stream condition inventory program, using the standard suite of indicators described in the USFS Region 5 stream channel condition inventory protocols (USFS, 2005, or as updated). In 2014, a summary report will be completed on wildlife monitoring at restoration projects that will identify areas where monitoring should focus; until that time, no other wildlife monitoring is planned for Cookhouse Meadow.

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VI. Appendix A: Rosgen Classification of Natural Rivers

□he Key to theRosgen Classification of Natural Rivers

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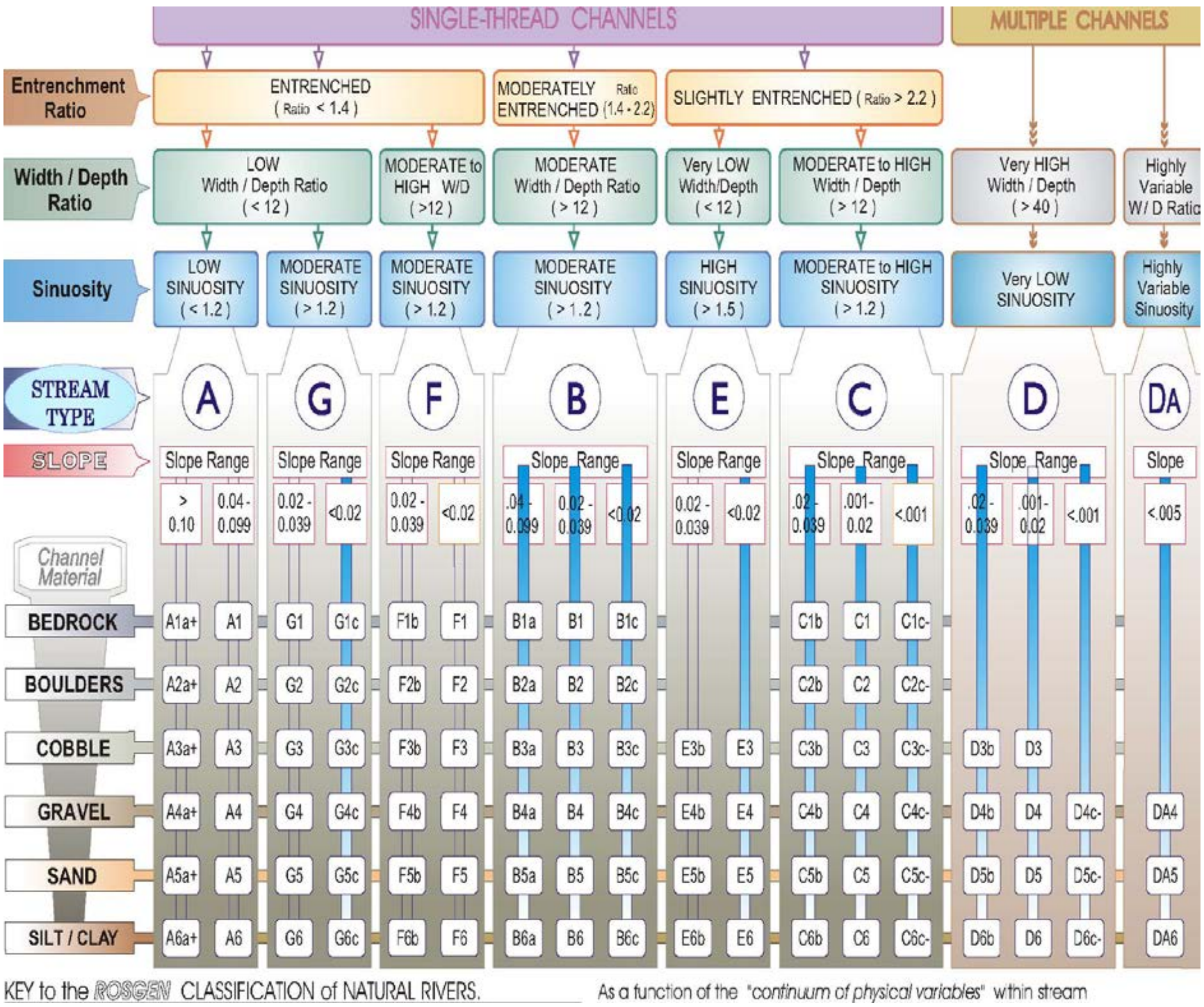

VII. Appendix B: Floodplain Deposition Analysis Tables

Table 1: DRI Sediment Sample Analysis

Field ID	**Total Solids**	**Sediment Concentration**	**Gravel**	**SAND**	**SILT**	**CLAY**
	- g -	- g/L -	- % -	- % -	- % -	- % -
#1 Right Bank Low AND #5 Low Left Bank	332.17	673.43	**2.7**	**71.7**	**23.0**	**5.3**
#3 Right Bank Back Wtr AND #6 Backwater Left Bank	60.14	97.18	**7.1**	**29.3**	**63.4**	**7.3**
#2 Right Bank Up AND #4 UP Left Bank	594.18	1197.81	**1.5**	**84.4**	**12.5**	**3.1**

Table 2: Channel Margin Deposits

CHANNEL MARGIN DEPOSITS														
					Sediment density (kg/m3) =		2650		% fine earth sample distribution			Tons fine earth distribution		
FID	Comment	type	Area_sq_m	Depth (mm)	Depth (m)	volume (cubic meters)	sediment density (kg/m3)	tons	sand	silt	clay	sand	silt	clay
2	sand point bar .12m d, 1m w	sand	5.4	120	0.120	0.7	1729.1	1.9	78.1	17.7	4.2	1.49	0.34	0.08
3	sand point bar, 1m wide, .08m d	sand	17.7	80	0.080	1.4	3744.3	4.1	78.1	17.7	4.2	3.22	0.73	0.17
4	sand tob, 1m w, .04m d	sand	7.5	40	0.040	0.3	791.3	0.9	78.1	17.7	4.2	0.68	0.15	0.04
5	sand point bar, .07m d, .9m w	sand	7.2	70	0.070	0.5	1336.2	1.5	78.1	17.7	4.2	1.15	0.26	0.06
6	sand point bar .03m d, .4m w	sand	2.2	30	0.030	0.1	177.1	0.2	78.1	17.7	4.2	0.15	0.03	0.01
7	sand point bar, .1m deep, .5m w	sand	1.8	100	0.100	0.2	479.2	0.5	78.1	17.7	4.2	0.41	0.09	0.02
8	sand point bar, .05m d, .5w	sand	4.6	50	0.050	0.2	609.0	0.7	78.1	17.7	4.2	0.52	0.12	0.03
9	sand point bar .6m w, .03m d	sand	1.6	30	0.030	0.0	123.9	0.1	78.1	17.7	4.2	0.11	0.02	0.01
10	sand point bar .04m d, .6m w	sand	1.3	40	0.040	0.1	132.9	0.1	78.1	17.7	4.2	0.11	0.03	0.01
11	sand point bar, .6m w, .04m d	sand	2.5	40	0.040	0.1	265.3	0.3	78.1	17.7	4.2	0.23	0.05	0.01
12	sand point bar .04m d, .5m w	sand	3.7	40	0.040	0.1	396.2	0.4	78.1	17.7	4.2	0.34	0.08	0.02
14	sand dep, .25m wide, .05m deep	sand	1.4	50	0.050	0.1	191.1	0.2	78.1	17.7	4.2	0.16	0.04	0.01
15	sand point bar, .04m d, .2m w	sand	0.7	200	0.200	0.1	395.1	0.4	78.1	17.7	4.2	0.34	0.08	0.02
16	sand point bar, 1m w, .08m d	sand	12.2	80	0.080	1.0	2591.5	2.9	78.1	17.7	4.2	2.23	0.51	0.12
18	some fines 1mm	fines	130.6	1	0.001	0.1	346.1	0.4	29.3	63.4	7.3	0.11	0.24	0.03
19	sand point bar 0.08m	sand	1.1	80	0.080	0.1	233.8	0.3	78.1	17.7	4.2	0.20	0.05	0.01
24	sand dep, .3m wide, .06m deep	sand	0.5	60	0.060	0.0	84.5	0.1	78.1	17.7	4.2	0.07	0.02	0.00
29	sand point bar, .1m d, .5m w	sand	1.1	100	0.100	0.1	300.8	0.3	78.1	17.7	4.2	0.26	0.06	0.01
31	fines 2 mm	fines	5.4	2	0.002	0.0	28.7	0.0	29.3	63.4	7.3	0.01	0.02	0.00
32	fines	fines	53.9	1	0.001	0.1	142.7	0.2	29.3	63.4	7.3	0.05	0.10	0.01
33	fines 2mm	fines	78.2	2	0.002	0.2	414.4	0.5	29.3	63.4	7.3	0.13	0.29	0.03
35	sand point bar,1sq m, .03m d	sand	1.1	30	0.030	0.0	87.8	0.1	78.1	17.7	4.2	0.08	0.02	0.00
36	sand point bar, 1sqm, .12m d	sand	1.1	120	0.120	0.1	336.8	0.4	78.1	17.7	4.2	0.29	0.07	0.02
											TOTAL =	**12.4**	**3.4**	**0.7**

Table 3 – Floodplain Deposits

FLOODPLAIN DEPOSITS														
					Sediment density (kg/m3) =		2650		% fine earth sample distribution			Tons fine earth distribution		
FID	Comment	type	Area_sq_m	Depth (mm)	Depth (m)	volume (cubic meters)	sediment density (kg/m3)	tons	sand	silt	clay	sand	silt	clay
0	wetted extent and fines 2mm	fines	53.7	2	0.002	0.1	284.5	0.3	29.3	63.4	7.3	0.09	0.20	0.02
1	fines dep to chan, 2mm	fines	337.6	2	0.002	0.7	1789.3	2.0	29.3	63.4	7.3	0.58	1.25	0.14
13	sand dep, .3m wide, .04m deep	sand	0.6	40	0.040	0.0	62.6	0.1	78.1	17.7	4.2	0.05	0.01	0.00
17	sand dep, 1m w, .04m d	sand	4.5	40	0.040	0.2	479.8	0.5	78.1	17.7	4.2	0.41	0.09	0.02
20	some fines	fines	1225.0	1	0.001	1.2	3246.3	3.6	29.3	63.4	7.3	1.05	2.27	0.26
21	sand dep at st of side ch .05m	sand	7.8	50	0.050	0.4	1034.6	1.1	78.1	17.7	4.2	0.89	0.20	0.05
22	fine sediment .02m	fines	49.7	20	0.020	1.0	2634.1	2.9	29.3	63.4	7.3	0.85	1.84	0.21
23	fines and sands .02m	mixed	213.8	20	0.020	4.3	11332.0	12.5	29.3	63.4	7.3	3.66	7.92	0.91
25	sand deposit, .07m	sand	62.0	70	0.070	4.3	11503.5	12.7	78.1	17.7	4.2	9.90	2.24	0.53
26	fines dep 1mm	fines	17.5	1	0.001	0.0	46.5	0.1	29.3	63.4	7.3	0.02	0.03	0.00
27	fines 1mm	fines	89.5	1	0.001	0.1	237.3	0.3	29.3	63.4	7.3	0.08	0.17	0.02
28	fines dep, .01m d	fines	53.2	10	0.010	0.5	1411.0	1.6	29.3	63.4	7.3	0.46	0.99	0.11
30	fines	fines	324.9	1	0.001	0.3	861.1	0.9	29.3	63.4	7.3	0.28	0.60	0.07
32	fines	fines	53.9	1	0.001	0.1	142.7	0.2	29.3	63.4	7.3	0.05	0.10	0.01
33	fines 2mm	fines	78.2	2	0.002	0.2	414.4	0.5	29.3	63.4	7.3	0.13	0.29	0.03
34	sands tob, .05m d, 4sq m	sand	4.0	50	0.050	0.2	532.0	0.6	78.1	17.7	4.2	0.46	0.10	0.02
											TOTAL =	**19.0**	**18.3**	**2.4**