U.S. FOREST SERVICE
NATIONAL STREAM AND AQUATIC ECOLOGY CENTER

September 17, 2015

GOVERNMENT CREEK: STREAM RESTORATION ASSESSMENT

Client: Ashley National Forest

Location: Government Creek, in Government Park, Utah

Date of Visit: 8/25/2015

On-Site Participants: Ryan Mower, Hydrologist, Ashley National Forest
Gary Brown, Rangeland Management Specialist, Vernal Ranger District
Mark Muir, Hydrologist, Region 4
Steven Yochum, Hydrologist, National Stream and Aquatic Ecology Center

Summary: Government Creek in Government Park has a series of headcuts propagating along the channel that are creating incised channels, bank instability, channel widening, and drops in local water table levels, greatly reducing the areal extent of riparian-obligate vegetative species. As a result, wet meadows are being replaced by upland vegetative species on terraces. Without taking action, additional wet meadows will be lost as the headcutting continues.

Fortunately, these headcuts are relatively low and can be arrested with a reasonable amount of confidence for success. Additionally, as a small headwater stream the channel has lower stream power for widening and transporting sediment; the amount of eroded material is reasonable and could be replaced. It is feasible to fill these incised channels with local borrow material at a reasonable cost for excavation, restoring the local channel elevation and water table. Combined with grade-control structures, Government Park has the potential for restoration to what is assumed to be pre-settlement conditions of a relatively-wide wet meadow.

The following alternatives are suggested for consideration in Government Creek:

Alternative 1: No Action
Alternative 2: Livestock Grazing Exclusion
Alternative 3: Grade Control Structures, with Livestock Grazing Exclusion
Alternative 4: Full Wet Meadow Restoration, with Grade Control Structures and Livestock Grazing Exclusion

Recommendation: Considering the limited fill quantities needed to accomplish a full restoration, the potential local availability of such material, and the substantial amount of sedge mats present for transplant to protect the constructed channel banks, Alternative 4 is recommended for implementation.

Prepared by: **Steven E. Yochum, PhD, PE**
NSAEC Hydrologist
970-295-5285, steveneyochum@fs.fed.us

INTRODUCTION

A riparian meadow restoration is being considered along Government Creek in Government Park, Utah, on the Ashley National Forest (Figure 1). Government Creek is a tributary to Big Brush Creek, in the Green River watershed. This stream system has incised in some locations, with multiple headcuts present. The associated wet meadow through which Government Creek flows has been dried in places, with upland vegetation replacing riparian-obligate species. The goal for this riparian corridor restoration is to, at the least, arrest the active headcuts and eliminate any additional loss of wet meadow. If possible, reestablishment of much of the lost wet meadows is desired.

This stream restoration assessment report was developed to document site conditions, provide restoration alternatives, and recommend a restoration strategy. An overview of the hydrologic and geomorphic condition of Government Creek within this reach is provided, including approximate flow frequency estimates and a historic aerial image interpretation. Following this, a restoration strategy is provided, including restoration alternatives, with some details provided on what each alternative could consist of. This report is intended as a resource for the Ashley National Forest to make an informed decision on which restoration strategy to pursue, if any, for Government Creek in Government Park, and to help lay the groundwork for accomplishing this project. The National Stream and Aquatic Ecology Center will be available on a limited basis for future technical needs regarding this project, if it proceeds; staff will be available to consult on the implementation of this plan.

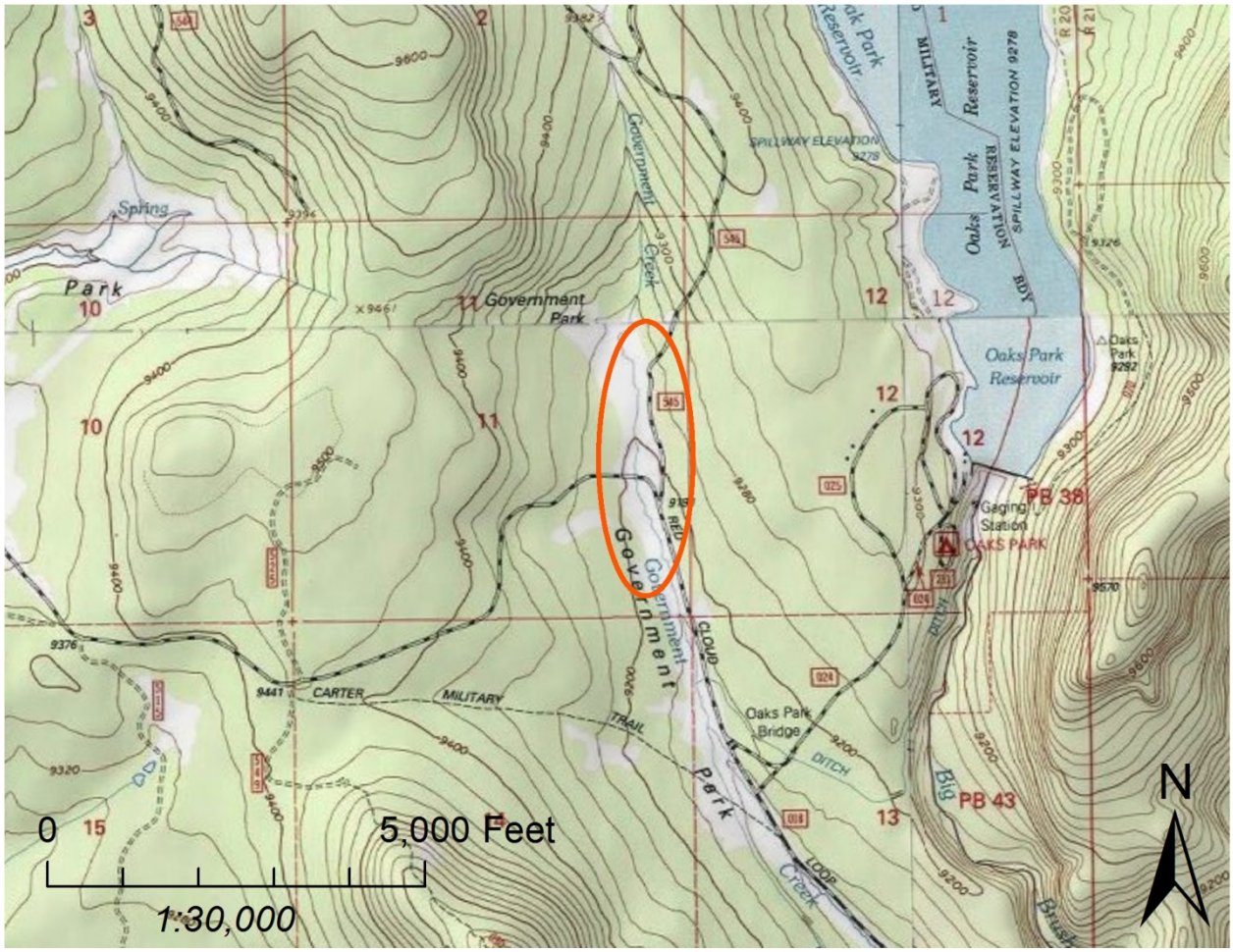

Figure 1: Reach of concern (orange oval) on Government Creek, in Government Park.

CURRENT CONDITIONS

The watershed (Figure 1) consists of 1.0 square mile at the road crossing of the stream and 2.5 square miles at the downstream end of the park. Average annual precipitation is 27 inches, from PRISM (Daly et al., 2008). The aerial photos in Figures 2, 8 and 11 show the primary reaches of concern along Government Creek. Figure 2 illustrates the downstream reach (just downstream of the road crossing and culvert) while Figures 8 and 11 illustrate the upstream reach. These aerial photographs were collected in September of 2014 (ESRI World Imagery). The locations and orientation of photographs collected during this field visit and presented in this report are illustrated in these figures.

The average slope in this reach, as computed from the 7.5-minute quadrangle maps, is 0.018 ft/ft. However, it was observed that the slope varied throughout the reach of concern, with the slope being lower downstream of the road crossing and steeper upstream.

Downstream of the road crossing (Figure 2) a wet meadow currently exists but is terminated by a headcut (Figure 3). This headcut appears to be actively moving upstream, successively drying up portions of the wet meadow from downstream to upstream. Upstream of the headcut (Figure 4) the

Figure 2: Government Creek downstream of road crossing, with a wet meadow terminated by headcut development (9/11/2014).

wet meadow appears to be healthy, with a prevalence of water sedge and beak sedge present. Very few willows were observed along the valley bottom. The width of the riparian-obligate vegetation in this meadow typically varies from 35 to 55 feet inside what appears to be a previously incised channel. Before this earlier incision occurred, the wet meadow may have been substantially wider than present. Other wet meadow areas exist outside of this primary channel, expanding the width to 200 feet. This area is visible in the aerial imagery (Figure 2). Much of this wetland area will dry as the headcut continues to move upstream and the local water table drops. Side springs, where present, can reduce the wetland area loss, as is the case to the immediate west of the current active headcut along this reach (Figure 2).

Figure 3: Headcut termination of wet meadow.

Figure 4: Wet meadow upstream of the headcut.

Figure 5 illustrates the channel evolution of Government Creek after the incision, with widening, a lower water table elevation, and a much narrower riparian width (typically 15 to 20 feet). This lowered riparian area has an abundance of sedge present. This feature would be considered stage IV in the channel evolution model (Schumm et al. 1984; Figure 6).

Figure 5: Downstream of headcut, with narrow wetland features evident at the lower water table elevation.

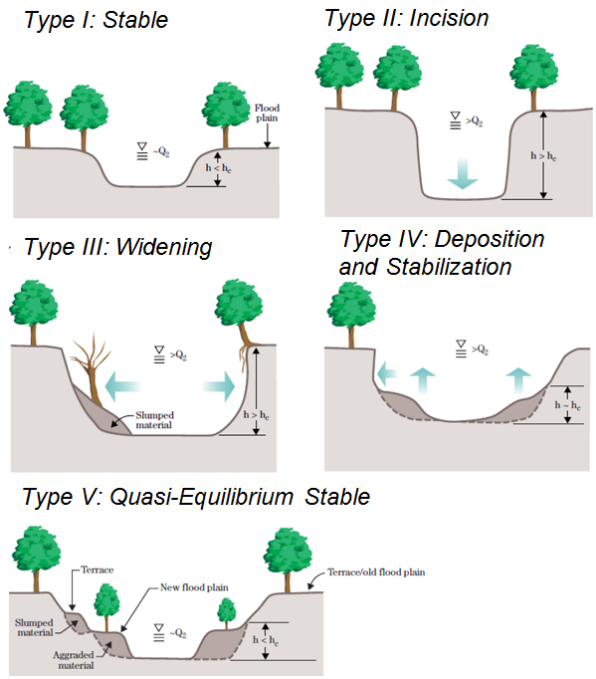

Figure 6: Channel cross sections illustrating the 5 Channel Evolution Model classes (NRCS 2007).

Figure 7 illustrates the existing wet meadow as viewed from the road crossing. Grazing cattle are also shown. The channel is very narrow, relatively deep, and has a sinuosity of 1.5 within this reach. It is an E-type stream in the Rosgen classification system. This sinuosity being in the low end of what is typically expected in this stream type may be due to the previous period of incision.

The road crossing of Government Creek has a single-culvert. This culvert's invert appears to be well placed for the current condition. The single culvert may cause periodic scour immediately downstream during larger flow events.

Figure 7: Wet meadow and cattle grazing, as viewed from road crossing at the culvert, looking downstream.

Upstream of the road stream and valley condition are illustrated in the aerial imagery presented in Figures 8 and 11. This reach appears to be steeper than the downstream reach. A previous period of incision is evident, with tendrils of incised riparian zones bounded by upland terraces across the valley width. Additionally, a contemporary series of small headcuts is occurring, dropping water table levels and drying parts of the wet meadow.

Figure 9 shows a relatively newly incised channel, with a raw cutbank and some active bank erosion, as well as deposition and sedge growth. The riparian zone has been reduced to about 15 feet in width, down likely an order of magnitude compared to pre-settlement conditions.

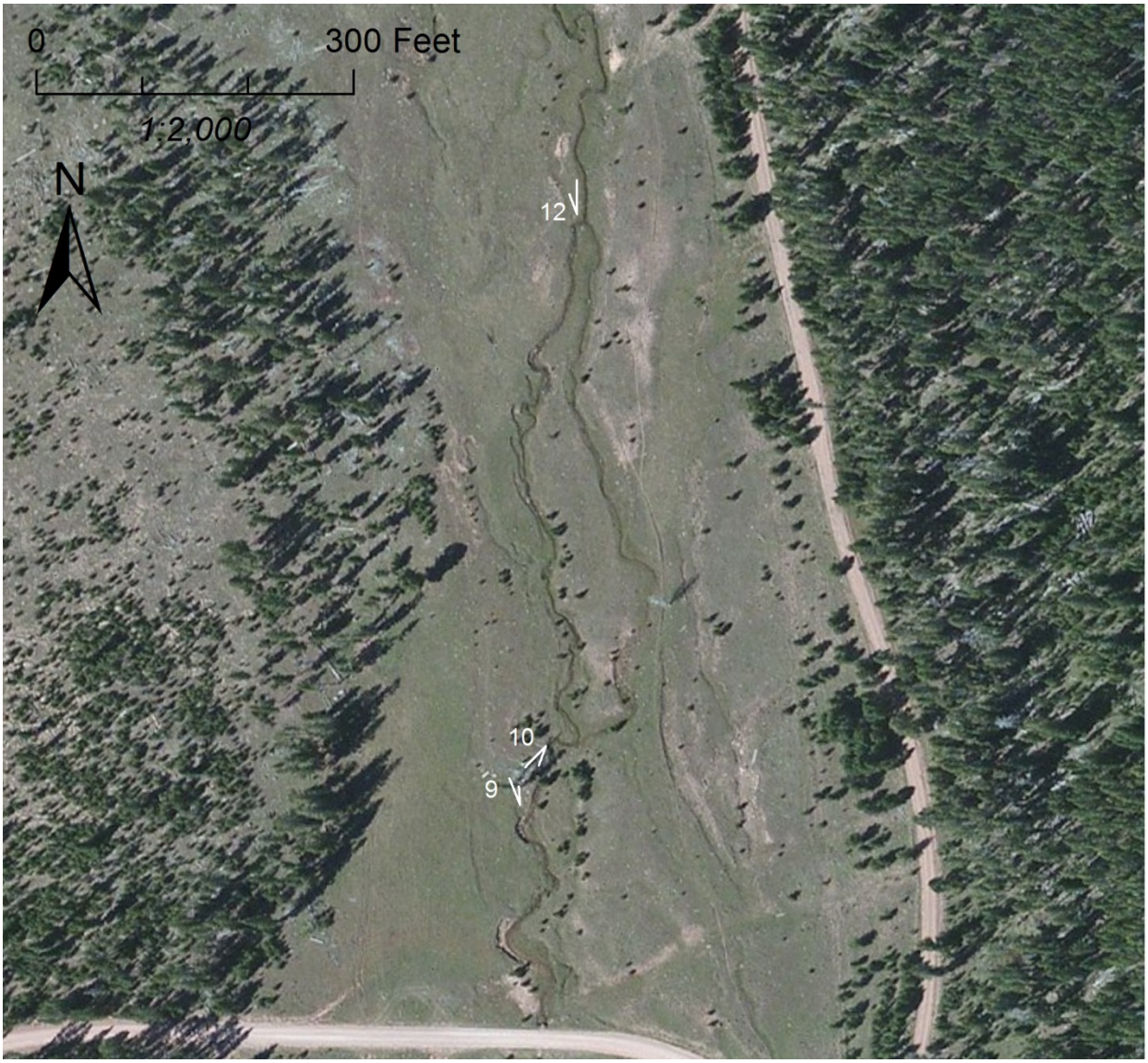

Figure 8: Government Creek upstream of road crossing (9/11/2014).

Figure 9: Incision just downstream of a headcut.

Figure 10 shows the active headcut just upstream of Figure 9. Upstream of this headcut the water table rises and riparian width increases. While this headcut is propogating upstream, it is moving at a rate slow enough so that the new floodplain surface downstream is being deposited and colonized by sedges without a substantial gap in form and vegetative protection. Further upstream,

Figure 10: An active headcut.

Figure 11: Government Creek upstream of the extent shown in Figure 8 (9/11/2014).

the meadow widens and returns to an E-type form (Figure 12).

Figure 12: Wet meadow, upstream of a headcut.

Continuing upstream (Figure 11), the pattern repeats, with an incised channel (Figure 13) with a lowered water table, redeveloped floodplain, raw cut banks, and narrowed riparian zone. Just upstream of this incised zone (Figure 14), the riparian zone is again wider, with a higher water table. This pattern repeats numerous times over the extent shown in Figures 8 and 11.

Figure 13: Another incised channel, just downstream of an active headcut.

Due to increased flashiness caused by the bare and less permeable roadway surface, headcuts have been forming at some locations downstream of culverts draining the roadway (Figure 15). Not all of the culverts draining the roadway have headcuts formed downstream, but a number of them do.

Figure 14: Just upstream of another active headcut.

Figure 15: Active headcutting downstream of a roadway culvert.

FLOW FREQUENCY

Flow frequency relationships for small high-elevation, snowmelt-dominated watersheds are difficult to estimate with any accuracy. The presence of compacted roadways that drain via culverts directly into the stream causes additional issues, since these roads can be mostly impermeable to runoff that then has direct access to the stream, magnifying rainfall response. Additionally, rain events can have non-linear relationships to runoff for larger-magnitude events, further complicating estimates.

Despite these problems, it is often necessary to have estimates of flow frequency relationships when designing stream restoration projects. As a first step, the results of a regional analysis can be helpful. Using USGS StreamStats, Table 1 provides flow frequency estimates at the road crossing of Government Creek (watershed area = 1.0 mi^2). This analysis was based on the methods documented in Kenney et al. (2007), *Methods for Estimating Magnitude and Frequency of Peak Flows for Natural Streams in Utah*. These estimates were developed using the variables drainage area, mean basin elevation, and average basin slope. No prediction errors were provided. With the small watershed size that is outside of the range used to develop the regional prediction equations, and the complicating factors discussed above, these estimates should be viewed with a substantial amount of skepticism, especially for less frequent events (>10 year return interval).

Table 1: Approximate flow-frequency relationship for Government Creek at the road crossing.

Return Interval (years)	Discharge (cfs)
2	28
5	41
10	62
25	61
50	69
100	78

HISTORIC AERIAL IMAGERY

Historic aerial imagery was obtained for 1949, 1953, 1959, 1965, 1976, and 1993. Figure 16 provides imagery from 1959. Using this 1959 image, as well as the 1953 image, an average headcut propogation rate of the primary headcut of concern (Figure 3) is 4 to 5 feet/year. If this rate has been more or less consistent, then this particular headcut initiation may have started in the 1870s, 1880's, or 1890's.

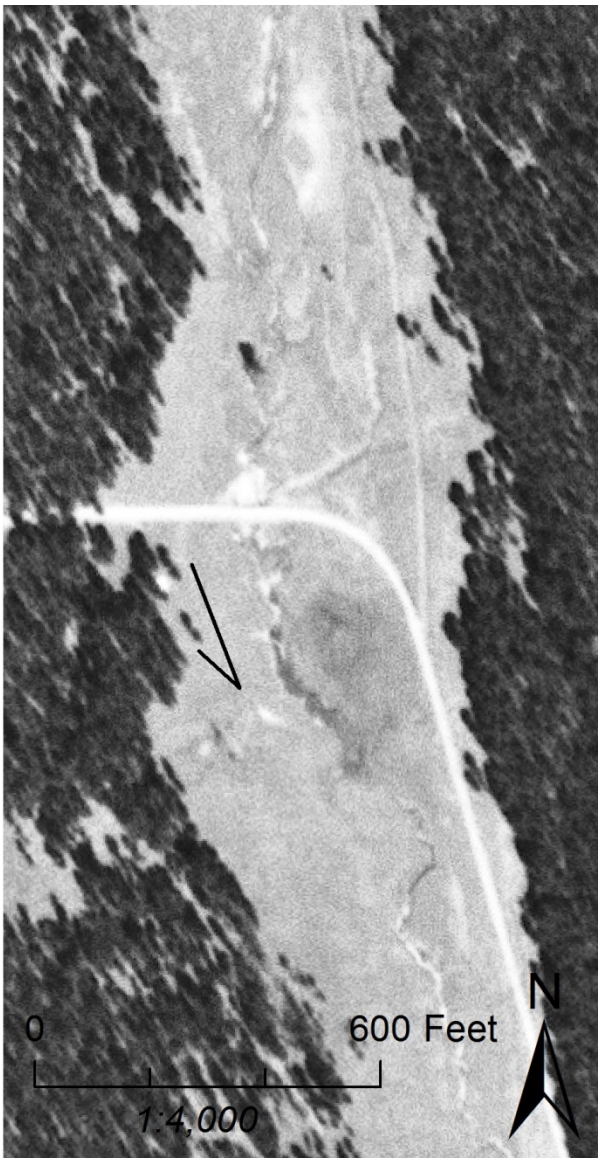

Figure 16: Historic aerial photograph of Government Park (9/2/1959).

CONDITION AND RESTORATION POTENTIAL SUMMARY

The condition of Government Creek in Government Park is impaired in many locations due to the existence of multiple headcuts that are dropping local water table elevations and shifting vegetative species composition across much of the valley width from riparian obligate to upland species. In less or unimpaired reaches, the stream channel is very narrow, relatively deep, and has a sinuosity of 1.3 to 1.5. It is an E-type stream in the Rosgen classification system. When a headcut propagates through a reach, a much more narrow floodplain and riparian zone results. Such headcuts continue to propagate upstream, drying up additional wet meadows and reducing the width of the riparian zone as the channel adjusts (Stage II through V) as detailed by the Channel Evolution Model (Figure 6). These headcuts are occurring at some locations where previous headcuts have occurred, creating a stepped cross section with multiple terraces created from former floodplain surfaces. Action will be needed to stop these headcuts from continuing.

Fortunately, these headcuts are relatively low (~2 feet in height), and can be arrested with a reasonable amount of confidence for success. Additionally, since Government Creek is a small headwater stream, the channel has lower stream power for widening and transporting sediment. Hence, the amount of eroded material is reasonable and could be replaced. It is feasible to fill these incised channels with local borrow material at a reasonable cost for excavation, restoring the local channel elevation and water table elevation. Using such a regraded approach, combined with grade control structures, the wet meadow has the potential for restoration to what is assumed to be pre-settlement conditions of a relatively-wide wet meadow throughout Government Park.

Historic livestock grazing practices may have likely initiated the headcutting and incision in Government Park. While current grazing practices are apparently being done much more thoughtfully, the legacy of past practices necessitates the exclusion of restored areas in all proposed action alternatives. Not excluding livestock, at least temporarily, may likely lead to project failure. It's recommended that this exclusion exist for a minimum of 10 years.

To understand the meadow condition potential with livestock exclusion, an existing exclusion at the lower end of Government Park can be used as a reference of a reach along the path to recovery 9 years after exclusion (Figures 17 to 19). Note the contrast between Figure 18 and Figure 19, just upstream and downstream of the fenceline, respectively. The implementation of a full restoration alternative can likely provide a condition similar to what is shown in Figures 17 and 18.

Figure 17: Typical channel and riparian zone condition of Government Creek within the grazing exclusion.

Figure 18: Condition of the riparian zone of Government Creek just inside the exclusion fence.

Figure 19: Condition of the riparian zone of Government Creek just outside the exclusion fence.

RESTORATION ALTERNATIVES

Four alternatives are proposed for Government Creek in Government Park. The alternatives are summarized within each following paragraph.

Alternative 1: No Action

The no action alternative will result in conditions being unchanged in Government Park, with each of the headcuts very likely continuing unabated at rates similar to current rates. Many of the wet meadows that currently exist will be eventually lost.

Alternative 2: Livestock Grazing Exclusion

Current livestock grazing practices in Government Park appear to not be heavily influencing the active channel form and sedge growth along the channel banks. Exclusion may allow healing of the channel form where it is impacted and could allow more willow growth, but the E type channel exists despite the grazing and sedge communities tend to minimize new willow recruitment. The headcuts and incision are more likely the result of historic grazing practices, with exclusion management alone likely having minimal effects on headcutting and the eventual loss of wet meadows.

Alternative 3: Grade Control Structures, with Livestock Grazing Exclusion

Combining grade control structures with livestock exclusion would likely be a successful strategy for retaining the existing wet meadows. The relatively low drop of each headcut combined with low stream power in such a headwater stream will enhance the durability of grade control structures, though periodic maintenance will be needed. Grade control structures could consist of numerous types (this is elaborated on in the Restoration Details section). Log structures would probably be the best fit for Government Park.

Alternative 4: Full Wet Meadow Restoration, with Grade Control Structures and Livestock Grazing Exclusion

The fill quantity needed to bring the stream and water table levels up to pre-disturbance or almost fully functioning levels is reasonable; lost wet meadows could be reestablished. This borrow material could be obtained onsite, from adjacent terraces (if this material is deemed suitable). The filled areas would first have their sedge matts removed and any existing armoring rock removed. The sedge would then be replanted along the banks of the new stream channel and armoring material placed in the constructed channel bottom. Combined with a series of grade stabilization structures, a full wet meadow restoration is feasible from both a technical and cost perspective (assuming local borrow material). Some maintenance of grade control structures may be needed, but likely less than what would be required under Alternative 3. With channel reconstruction, the channel sinuosity could be increased in places to best match the existing grade at the downstream limit of the restoration.

RESTORATION DETAILS

Some details regarding key features of Alternatives 3 and 4 are provided below, specifically on grade control structures for arresting the headcuts, and on fill volumes and potential borrow areas for the meadow restoration.

A general reference available for stream restoration planning and design is available here, from the National Stream and Aquatic Ecology Center.

Grade-Control Structures

Numerous types of grade-control structures have been used to provide grade control to arrest headcuts and retain constructed channel beds and floodplain surfaces. The best type for this situation is likely a log structure, similar to the structures presented in Figure 20. There are numerous approaches to constructing a log grade-control structure; the National Stream and Aquatic Ecology Center can help adapt a design for use in Government Park. Periodic maintenance may be needed for these structures, though less maintenance is expected for the full meadow restoration (Alternative 4) compared to the headcut arrest approach in Alternative 3.

Besides log structures, the following grade control structures have been utilized for arresting headcuts. These structures are less preferable in this wet meadow environment than log grade-control structures.

- Rock cross vanes
- Newbury riffles
- Gabions
- Loose rock structures
- Brush
- Earth check dams
- Concrete
- Sheet piling

Figure 20: Log grade control structures implemented downstream of the Waldo Canyon Fire (2012), Colorado.

Meadow Restoration

It is roughly estimated that 1400 cubic yards of fill would be required to fill the incised stream channel downstream of the road crossing, reestablishing the wet meadow. This was computed by assuming a 2 foot elevation drop throughout the delineated incised areas that are in a stage IV of the Channel Evolution Model (Figure 6). Additionally, roughly 2900 cubic yards of fill would be required to fill the most recent incised stream segments upstream of the road crossing. Portions or all of these segments could be restored. As a design is developed, it may be decided that more cut/fill is needed upstream of the road crossing to address earlier periods of incision.

Terraces (abandoned historic floodplain surfaces) that could be utilized for this borrow material (if this material and source areas are deemed suitable) are illustrated (Figure 21). Removing this borrow can potentially widen the wet meadows in these reaches. If all of these areas were utilized for borrow, an excavation depth of roughly 13 inches inches would be needed, though deeper excavation in some areas would likely be preferable, to widen the extent of wet meadow.

Figure 21: Potential borrow areas (cross hatched) in Government Park.

RECOMMENDED RESTORATION STRATEGY

Alternatives 1 and 2 are not recommended, since both would likely result in the loss of additional wet meadows. Alternative 3 could be a good solution if only limited funding is available. However, considering the limited fill quantities needed to accomplish a full restoration, the potentially local availability of such material, and the substantial amount of sedge material present for transplant to protect the constructed channel banks, Alternative 4 is recommended for implementation.

ACKNOWLEDGEMENTS

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