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TECHNICAL REPORT

Basis of Design for Restoration of James Creek between Jamestown and the Left Hand Creek Confluence, Boulder County, Colorado

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Technical Report: Basis of Design for Restoration of James Creek

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1 Introduction

Reach 16 of James Creek begins at the intersection of Lefthand Canyon Drive and extends upstream along James Canyon Drive for approximately 7,000 feet (1.3 miles). The upstream extent of Reach 16 is at an elevation of approximately 6600'. The lower extent is at 6300'. The creek falls approximately 300 vertical feet over 7,000 horizontal feet at a 4% slope. For the purpose of this memo, the Site is defined as the area contained within the 100-year floodplain, including any aquatic, wetland, riparian or adjacent upland areas. Reach 16 is confined by the existing steep canyon topography, as well as by the roadway.

1.1 Setting

1.1.1 Geology

The canyon in which Reach 16 sits has a V-shaped morphology. Stream erosion and deposition, wind erosion, and atmospheric weathering formed and continue to alter the watershed topography in this section of the creek. This mountainous portion of the Upper Left Hand Watershed is comprised of Pre-Cambrian metamorphic and granitic rocks including intrusive stocks and dikes. Crystalline rocks within the watershed contain gold, fluorite, lead, silver, uranium, tungsten, and copper in extractable quantities. These minerals were deposited with intrusions of molten igneous rocks during periods of mountain uplift. Soils in the Upper Watershed are fairly thin and are identified by the Cryboralfs-Rock outcrop.

1.1.2 Hydrography

As part of the St. Vrain Creek basin (HUC 10190005), the Left Hand Creek watershed lies northwest of Boulder, Colorado on the eastern slope of the Rocky Mountain Front Range (Wood et al., 2005). The primary streams in the watershed are James Creek, Little James Creek, and Left Hand Creek (see Figure 2). The watershed area is approximately 85 sq. miles (54,400 ac) at the confluence with the St. Vrain Creek near Longmont, Colorado, and ranges in elevation from 13,800 ft near the continental divide to 4,900 ft. on the eastern plains (Wood et al. 2005). Left Hand Creek has an average annual discharge of 29,000 af (40 cfs) (Wood et al. 2005). Monthly average flows for Left Hand Creek near the canyon mouth are presented in Figure 1.

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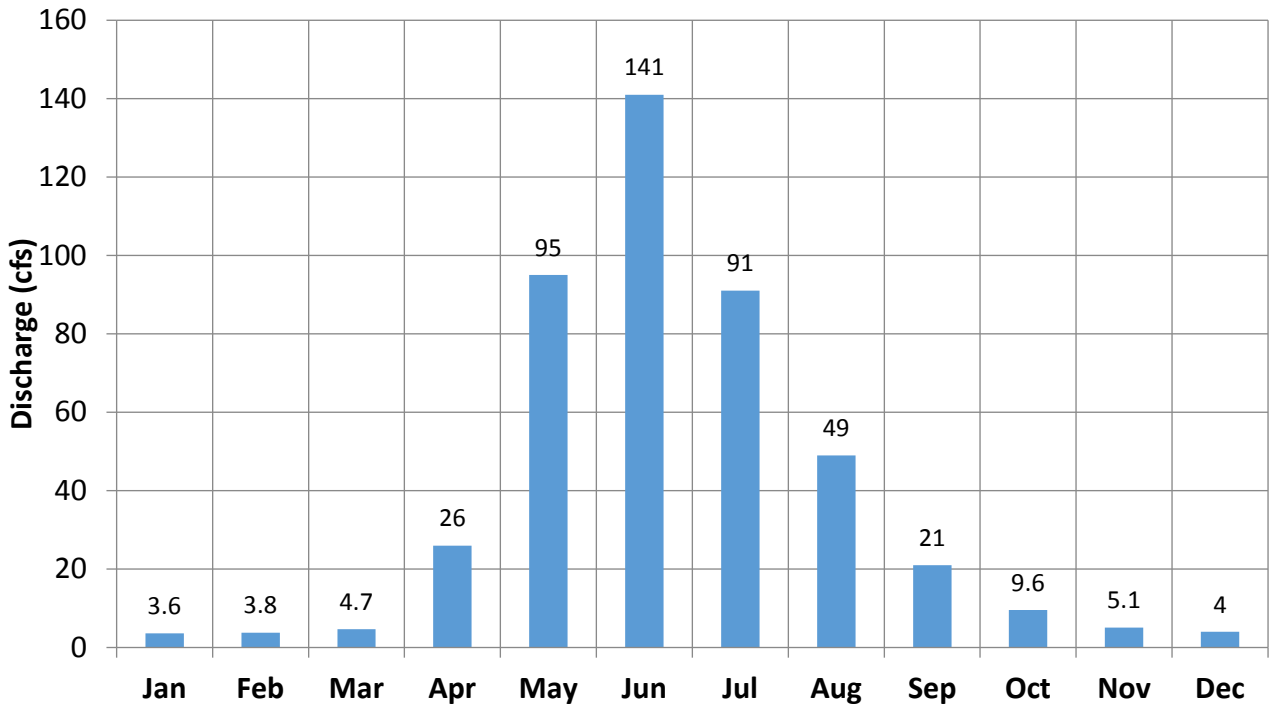

[1]Gauge no longer in service
[2]Monthly average flow calculated from 6/1/1929 to 9/30/1980

Figure 1. Left Hand Creek Hydrograph. Monthly Average Flow at USGS 0624500 Left Hand Creek near Boulder, CO.

The largest tributary to Left Hand Creek is James Creek, which drains 18.5 sq miles of subalpine and alpine forest (Wood et al. 2005). A diversion of flow from South St. Vrain Creek to James Creek contributes nearly all of the flow in James Creek during the summer months (Wood et al. 2005, CDWR 2002, Colorado River Watch, 2004). The headwaters of the South St. Vrain Creek are made of up glacial-melt fed lakes near the continental divide, and snow melt in the South St. Vrain creates unnaturally high flows in James Creek due to the diversion. A tributary to James Creek, Little James Creek meets James Creek at a confluence in Jamestown, Colorado. Little James Creek drains approximately 5.8 sq. miles of alpine and subalpine land cover (Wood et al. 2005).

1.1.3 Debris Flows

Reach 16 is impacted by debris and hyperconcentrated mud flows flowing in to the reach from Upper Left Hand Creek watershed (i.e., above Reach 16). Reach 16 is itself directly flanked by steep slopes that are prone to landslide processes, including failure of slopes, rockfall, and likely occasional mud and debris flows, although the latter were not experienced on adjacent slopes here during the 2013 flood. All of these processes can deliver significant and occasionally (during and immediately after large

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storms) massive amounts of sediment to this Reach. Reach 16 certainly was severely impacted by the erosive and eventually depositional nature of in-channel debris flows during the 2013 flood, as evidenced in several sub-reaches where boulder berms and thick (>3 ft) veneers of sediment have been deposited.

Gravity is the primary driving force for these landslides to occur, but there are other contributing factors affecting the original slope stability. Pre-conditional factors build up specific sub-surface conditions that make a hillslope prone to failure, whereas the actual landslide often requires a trigger before being released. A large rainfall event such as the September 2013 storm can cause a slope stability threshold to be crossed, this being the trigger to release a landslide or debris flow. This study will not facilitate a detailed geotechnical study of the canyon slopes immediately adjacent to Reach 16, but rather will include a desktop approach to assess the general hazard to the Reach for landslide using information such as the project DEM and maps of previous burns. Once conditions are dry and safe in late April, a rapid field reconnaissance will be conducted on the side slopes if Reach 16 to validate this assessment

1.1.4 Fire History

In the past 50 years several fires have burned portions of the Left Hand Creek watershed above and sometimes immediately adjacent to Reach 16, affecting runoff, water quality, landslides and flooding. On October 29th, 2003, the Overland fire occurred northwest of Jamestown. A map of significant fires in the Left Hand Creek watershed is shown below in Figure 2.

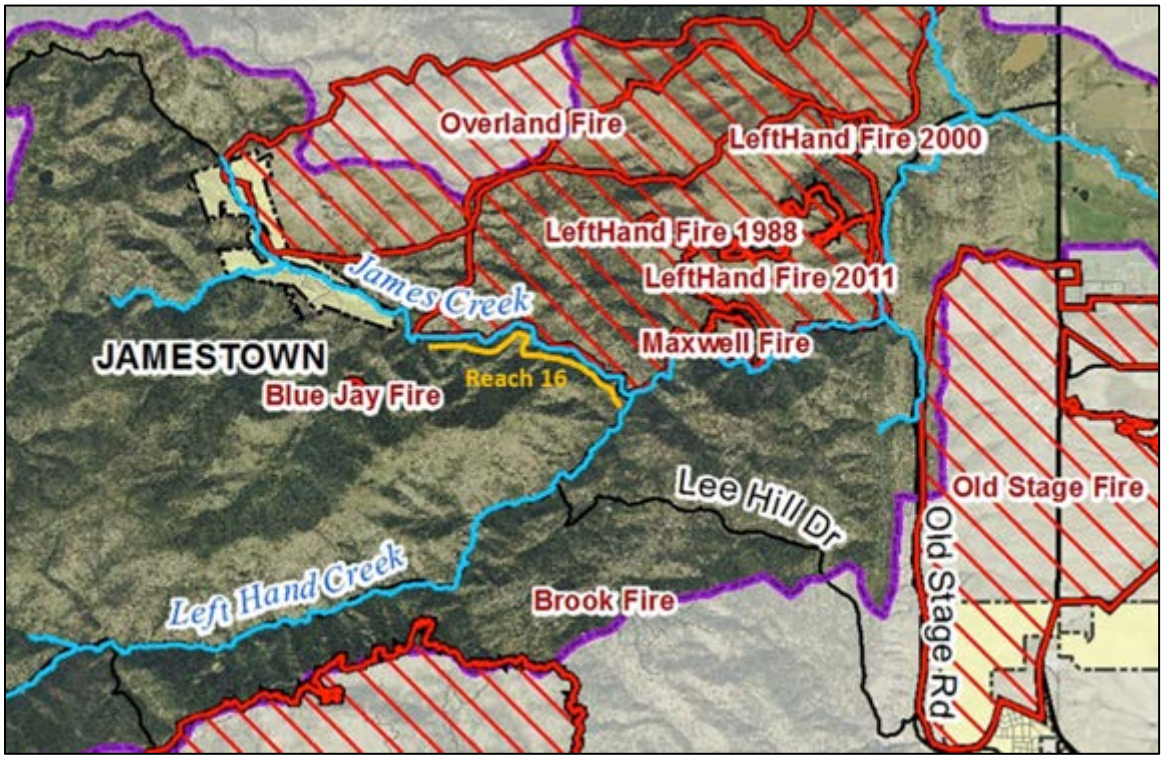

Figure 2. Recent fires potentially impacting Reach 16

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1.1.5 Water Quality

Reach 16 is one of many stream segments in the Left Hand Creek watershed that have designated uses for aquatic life, recreation, water supply, and agriculture. CDPHE sets quantitative standards for acceptable levels of pollutants and contaminants in water. In 1998 some segments of Left Hand Creek were placed on Colorado's list of impaired waters for failing to meet water quality standards for supporting aquatic life (Left Hand Water District Source Water Protection Plan). The Creek watershed was once a very active mining area and there are some 344 mines within the Left Hand Water District source water protection area (Left Hand Water District SWPP), all but thirteen of which are abandoned.

Over 100 years of mining activity have resulted in heavy metal and other mining-related contamination in the Left Hand Creek watershed (EPA 2003). Left Hand Creek was unable to support life by the 1930s, and was considered a dead creek until the 1950s (EPA 2003). James Creek drains the Jamestown and Golden Age mining districts, and Little James Creek drains many areas of former hard rock mining and processing activities. Little James Creek was listed on the State of Colorado's 303(d) list of impaired streams in 1998 with a high ranking (Wood et al. 2005). The Water Quality Control Division of the State - CDPHE - developed Total Maximum Daily Loads (TMDL) for cadmium, zinc, iron, manganese and pH (WQCD, 2002, Wood et al., 2005).

Wildfires can also contribute to contamination by increasing sediment loads in streams. Post-wildfire areas have less vegetation to anchor the soil, and burned soils can be hydrophobic. This can lead to sedimentation in streams, erosion, mudslides, and debris flows. Stormwater runoff is another potential contaminant source. Stormwater runoff also increases turbidity, causing water treatment concerns. Stormwater can also carry pollutants from the adjacent roadway where automobile chemicals may be present.

Site reconnaissance identified locations in Reach 16 where water quality has been obviously impaired by leaching of minerals from potentially mine-waste contaminated sediment deposited alongside the creek. The leaching appears to be promoted by a perched channel forcing flow through unconsolidated flood deposits into adjacent floodplain areas with shallow depressions and poor drainage (Figure 3). Mitigating forced leaching and reducing opportunities for water to stand after higher flows recede will be our main design approach to mitigating this issue. Our preliminary design channel dimensions (see below) and subsequent floodplain modifications (including channel realignment) and bank lining in these areas will aim to lower the channel bed, encourage deposition of sediment with sufficient caliber to line the bed, and will elevate and grade the adjacent floodplain for drainage.

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Figure 3. Seepage ponds in Reach 16 containing standing orange-tinted water with thick slurry bed.

The following information is summarized from the Status Report on Water Quality Monitoring (LWOG 2016):

Part of the mission of the Lefthand Watershed Oversight Group (LWOG) is to assess the quality of the Left Hand Creek Watershed, including its perennial tributaries, James Creek and Little James Creek. A primary factor that led to the founding of LWOG in 2003 was concern regarding impacts of acid mine drainage and metals contamination from abandoned mining sites in the mountainous part of the watershed. The primary means by which LWOG carries out this part of its mission is through participation in the Colorado Department of Parks and Wildlife River Watch citizen volunteer monitoring program.

Total Maximum Daily Load Assessment of Left Hand Creek Watershed

In 2015 The Colorado Department of Public Health and Environment developed a TMDL assessment for the Left Hand Creek Watershed. The TMDL was based partly on River Watch data and partly on data collected by others. In the TMDL assessment, the parameters and dissolved constituents found to be in need of improvement in various reaches, based on exceedances of chronic aquatic life standards, are shown in Table 1. James Creek below Little James Creek is highlighted in Table 1 below as it includes the Site.

Table 1. Parameters and constituents in need of improvement, by reach, in the TMDL assessment.

Reach	pH	Cadmium	Copper	Lead	Zinc
Left Hand Cr from Peak to Peak Hwy to James Cr	x		x		x
James Cr above Little James Cr			x		
Little James Cr		x	x	x	x
James Cr below Little James Cr		x	x	x	x
Left Hand Cr from James Cr to Hwy 36			x		

The chronic aquatic life standards against which ambient concentrations are compared are listed by reach in Table 2. For pH, the standard is consistent, with a goal of being in the range of 6.5 to 9.0 standard pH units. For metals, Colorado uses standards based on hardness, since increasing hardness has been found to provide increasing protection for aquatic life against damage from toxic metals. Since

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hardness varies some by reach, the standards also vary somewhat by reach. A summary of ambient conditions is also included in the table. James Creek below Little James Creek is highlighted in Table 2 below as it includes the Site.

Table 2. Chronic aquatic life standards and attainment summary for various reaches in the Left Hand Creek Watershed, as reported in the 2015 TMDL Assessment.

Segment	**Assessed Reach**	**Hardness** mg/L (n)	**Cadmium** µg/l (n)		**Copper** µg/l (n)		**Lead** µg/l (n)		**Zinc** µg/l (n)		**pH** s.u. (n)	
			std	**amb**	**std**	**amb**	**std**	**Amb**	**Std**	**amb**	**std**	**amb**
COSPSV04a	Left Hand Creek from Hwy 72 to the Captain Jack Mine	18.6 (3)	0.6	0.0 (8)	**2.1**	**3.96 (18)**	0.4	0.32 (16)	**28.4**	**37.8 (16)**	**6.5-9.0**	**5.3-6.0 (11)**
COSPSV04a	Left Hand Creek from the Captain Jack Mine to Slide Mine	39.8 (35)	1.1	0.97 (20)	**4.1**	**25.1 (125)**	0.9	0.44 (118)	**54.1**	**256 (121)**	**6.5-9.0**	**5.0-6.0 (92)**
COSPSV04a	Left Hand Creek from Slide Mine to James Creek	54.1 (22)	1.4	0.06 (19)	**5.3**	**7.08 (57)**	1.3	0.19 (56)	**70.2**	**36.8 (55)**	**6.5-9.0**	**6.2-7.5 (32)**
COSPSV04b	James Creek, Little James Creek	61.53 (109)	**0.29**	**1.69 (105)**	**5.91**	**13.04 (99)**	**1.48**	**2.11 (107)**	**82.16**	**365.9 (105)**	6.6	6.6-7.7
COSPSV04c	Left Hand Creek from James Creek to Hwy 36	60.6 (23)	0.29	0.0 (30)	5.84	4.9 (114)	1.45	0.3 (34)	81.1	29.2 (37)	6.5-9.0	7.2-8.2 (106)

Summary of Water Quality Results from LWOG River Watch Sites

For this analysis, all River Watch data from the 10 LWOG sites, plus one of the JCWI sites, for the five parameters and constituents mentioned in the TMDL, were retrieved, plotted, and examined. In general, all five of the parameters and constituents showed exceedances of the chronic aquatic life standards at various times and places. James Creek is the cleanest of the three monitored creeks, showing exceedances upstream of Jamestown only for lead, and downstream of Jamestown only for pH.

pH

pH values at a site on James Creek near Cushman-Bar K, monitored by James Creek Watershed Initiative, were safely within the aquatic life standards, but also showed a decreasing trend.

Cadmium

In James Creek, both at Cushman-Bar K and just upstream of Left Hand Creek, dissolved cadmium concentrations were near or below detection limits since 2011 or earlier.

Copper

In James Creek, dissolved copper was present but below aquatic life standards at Cushman-Bar K, and, since 2011, present but below aquatic life standards at the site above Left Hand Creek.

Lead

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In James Creek, dissolved lead consistently exceeded aquatic life standards at the Cushman- Bar K site above Jamestown, but was below detection limits farther downstream, at the site just above the confluence with Left Hand Creek.

Zinc

Zinc is fairly ubiquitous in the mining-impacted parts of Left Hand Creek Watershed. On James Creek, dissolved lead was near or below the detection limit at the Cushman-Bar K site prior to 2004. Then, between 2004 and 2010, concentrations were consistently in excess of the aquatic life standard. Since 2010, they have again dropped below the aquatic life standard. Farther downstream on James Creek just above the confluence with Left Hand Creek, concentrations of dissolved zinc were above the detection limit but below the aquatic life standard. Trends were downward.

Hardness

In the mountainous reaches of the watershed hardness is generally low to moderate, in the range of 10-100 mg/L.

Summary

In summary, Left Hand Creek and its tributaries continue to violate chronic aquatic-life standards for pH, copper, and zinc. Trends for pH have been decreasing, indicating a tendency for creek water to become more acidic over time. Trends for metals have generally been decreasing, indicating a tendency for less metal contamination over time. The violations of aquatic life standards appear to be confined to the mountainous reaches

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2 Geomorphic Basis of Design

2.1 Surveying and Site Visits

Personnel from Lynker, Otak, AMEC-FW and Ecos have visited and surveyed the site several times since the start of the project. Site analysis has included:

- Field notes of observations
- Pebble counts
- Measurements of particle sizes observed in bars
- Photographs
- Vegetation and soil surveys

2.2 Hydrology and Hydraulic Model

Hydrology
The flood flows that will be used for the 10-, 50-, 100-, and 500 year will be the currently effective Flood Insurance Study (FIS) flows. The current effective flows, used in the CLOMR, are more conservative than the newest hydrology and were brought forward into this assessment. For the design the team will be working with an estimated bankfull discharge of 151cfs, and a low flow discharge value of 39cfs. These flows have been adapted by AECOM from those developed for the prior EWP work and reported in the Watershed Master Plan in order to support roadway design. These values appear reasonable to the Lynker team and given the collaboration on natural (LWOG) and roadway (Boulder County) design projects it makes sense for us to use exactly the same bankfull and low flows used by our colleagues so we can more readily compare results. The effective FIS flow range for each event through Reach 16 is shown in Table 3. Range of flow discharges used in base model for designbelow.

Table 3. Range of flow discharges used in base model for design.

	10-year	50-year	100-year	500-year
Minimum (cfs)	355	2,180	3,930	10,880
Maximum (cfs)	420	2,657	4,800	13,540

Hydrology and hydraulics for this natural stream channel design are based on the same principles as traditional open channel design, but will use a natural/irregular cross-section in lieu of the trapezoidal cross-section. The design will also use a variety of data to validate the hydraulic design, including gage data, regional curves, and field survey during spring runoff.

The Lynker Team obtained the following hydraulic data from AECOM to inform the base hydraulic model to use in channel design:

1. Conditional Letter of Map Revision (CLOMR) Draft Hydraulic Model and Draft Submittal Package from AECOM;
2. Draft model geometry from the Colorado Water Conservation Board (CWCB) from with survey cross-sections incorporated from AECOM;
3. Survey Cross Section points collected by AECOM for the CWCB model.

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The Draft CLOMR submittal (1) contained a HEC-RAS model with the proposed roadway alignment and grading with the 2014 LiDAR data incorporated within the geometry file. The CWCB HEC-RAS model (2) contained the 2014 LiDAR with survey cross section data (3). On first inspection the CWCB model with a more defined channel appeared to be more detailed than the CLOMR model geometry. However, when the survey data was examined the spacing between collected cross section data was such that only bridge cross-sectional data had been collected in detail with few or no natural valley cross sectional information collected, at least within Reach 16. The two model geometries were compared. The cross-sections for each model are not at the same model stations, however there were some cross-sections that were close to each other. Figure 4 shows an example of two of these geometries (the pink line is from the CWCB model and the black line if the geometry of one of the CLOMR model cross-sections – proposed conditions).

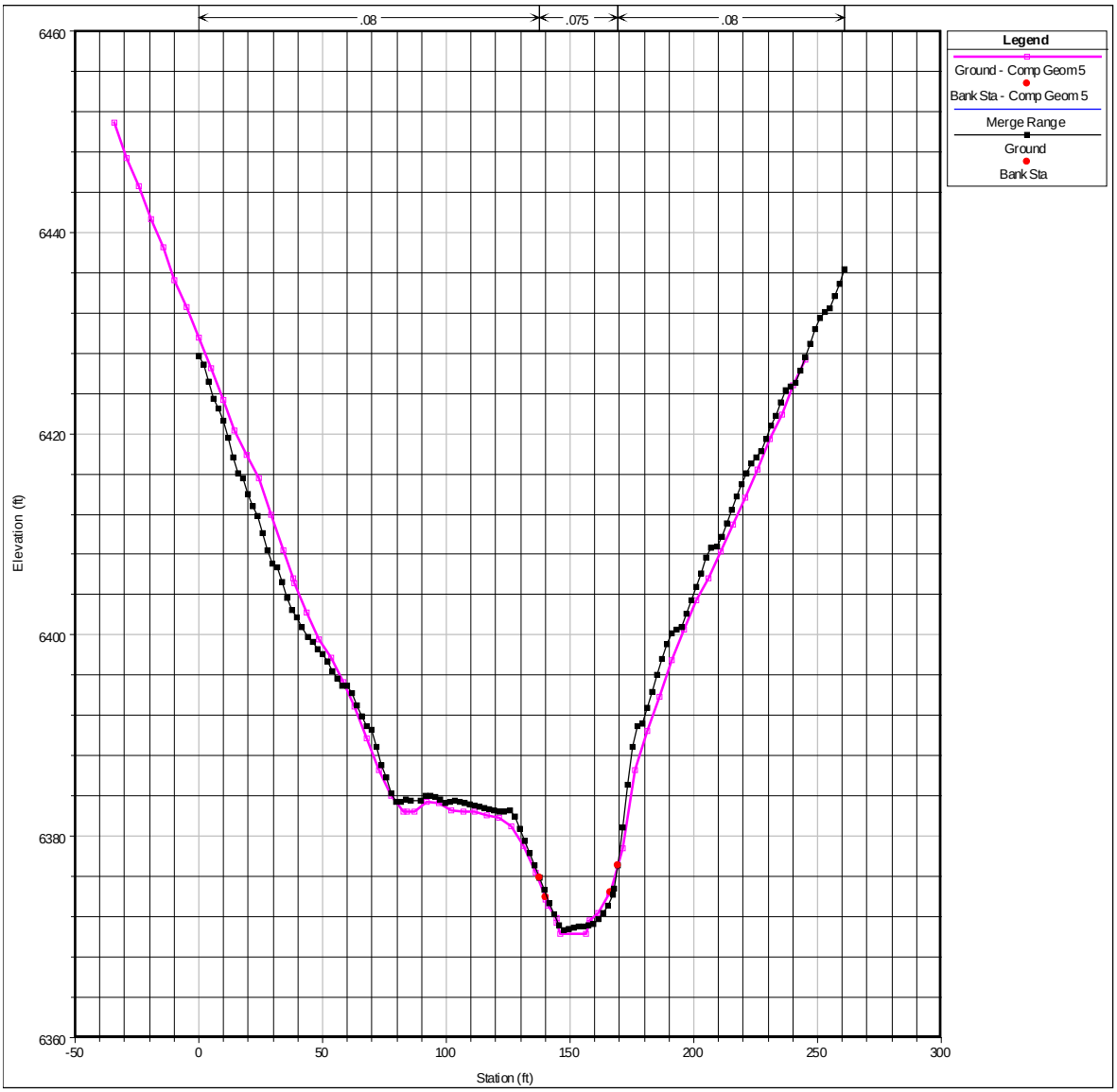

Figure 4. James Creek Reach 16 Model Comparison.

It was decided that the CLOMR model with the topography for the proposed road alignment has the best available geometry for this design work. If the survey data collected for the CWCB model had been denser and had captured the current existing natural channel geometry this data would have been incorporated.

2.3 Geomorphology

The geomorphic variables developed for design are a product of a desktop assessment of historic and contemporary geospatial data, site and field assessments performed in February and March 2016, coordination with other projects taking place on James Creek, and a review of the Left Hand Creek Watershed Master Plan. The purpose of this task was to define the geomorphic properties prevalent in Reach 16 that will be used to guide the design of the channel and floodplain to meet the project goals. This document first summarizes the relevant work from the master plan and subsequently builds upon it with a geomorphic characterization and quantitative channel dimensioning for basis of design. Key points from the master plan are re-visited below as much of the foundation for channel restoration can be pulled straight from the document. Those insights were then evaluated and expanded upon in the field. An appropriate design approach is then detailed, including preliminary channel dimension calculations in Section 2.0.

Following the field assessment, Reach 16 was split into smaller reaches based on channel slope and valley confinement to support future design calculations (Table 4) as different channel-valley configurations exert a strong control on channel morphology. Figure 5 shows the spatial extents of the subreaches. The geomorphic assessment includes a review of the River Styles definition of Reach 16, summaries of recommendations made in the master plan, results of recent field assessments, and a summary of current recommendations for Reach 16. Preliminary channel dimension calculations are based on the effective discharge presented above.

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Table 4. Subreach summary or Reach 16.

Reach 16 Subreach	Description	DS Station	US Station	Reach Slope (%)	Sinuosity	Approx. Valley Width (ft)
1	Confined valley, steeper gradient	0	1800	4.0	1.00	40
2	Confined valley, lower gradient	1800	2450	3.0	1.05	90
3	Confined valley, steeper gradient	2450	2775	4.3	1.04	60
4	Pocket Floodplain, steeper gradient	2775	3375	3.6	1.04	150
5	Pocket Floodplain, lower gradient	3375	3750	2.2	1.10	150
6	Confined valley, lower gradient	3750	4350	3.4	1.03	60
7	Confined valley, steeper gradient	4350	4975	4.1	1.03	40
8	Pocket Floodplain, steeper gradient	4975	5894	4.5	1.05	120
9	Pocket Floodplain, lower gradient	5894	7075	2.8	1.00	100

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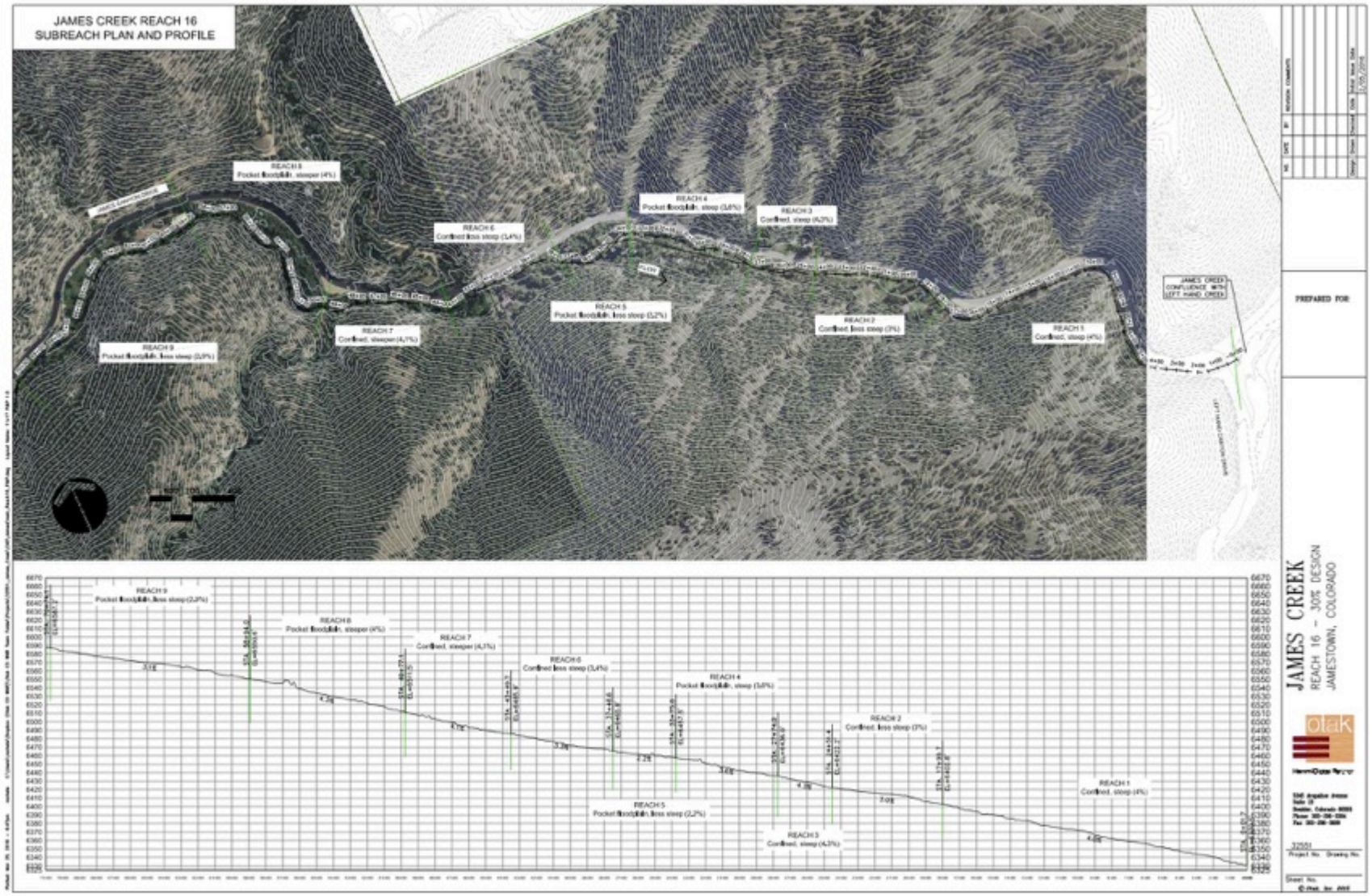

Figure 5. Subreach spatial extents.

2.4 Review of the Master Plan

For the Master Plan, watershed geomorphology was assessed using the River Styles Framework. The River Styles developed for the plan and the creek process diagrams offer insights into the restoration potential of Reach 16.

The process diagram (Figure 6 below), shows Reach 16 in relation to Reaches 17 through 20. Reach 16 is located in the canyon landscape unit characterized by relatively steeper gradients and confined channels. Reach 16 sits at the furthest downstream end of James Creek and is partly confined, relative to the rest of the reach. Given the steep gradient and confinement, Reach 16 exhibits relatively high unit stream power values (stream power per channel width), suggesting a significant capacity to shape the floodplain and valley.

Reach 16 was characterized using the River Styles Framework as a Bedrock-controlled with Floodplain Pockets River Style (Figure 6, Figure 7). Reaches of this type are tightly controlled in planform and profile by tight valley walls and bedrock outcrops, tending to exhibit straight, step-pool channel morphologies. The significance of the term 'pocket' refers to where breaks in the valley occur, reducing the valley confinement. These locations act as energy dissipaters, having shallower relative gradients, and small but functional floodplains that store sediment and debris at higher flows. With regard to sediment, this reach is primarily a transport reach with deposition zones in the floodplain pockets. The valley width is generally defined as 150 feet and channel with is approximately 30 feet. The channel planform for this river style is generally single thread and straight (i.e., ratio of channel length per unit valley length < 1.2), but floodplain pockets likely contain overflow, secondary, and chute channels. The bed morphology is generally step-pool with sections of pool-riffle at lower gradient pockets.

The Left Hand Creek watershed is debris flow dominated, meaning that debris flows have the most significant impact on channel configuration. Numerous debris flow channels line the slopes above the project reach, delivering high sediment loads to the channel during significant storm events. The floodplain pocket areas provide opportunities to moderate the transport of the sediment to downstream areas, reducing the overall impact of floods.

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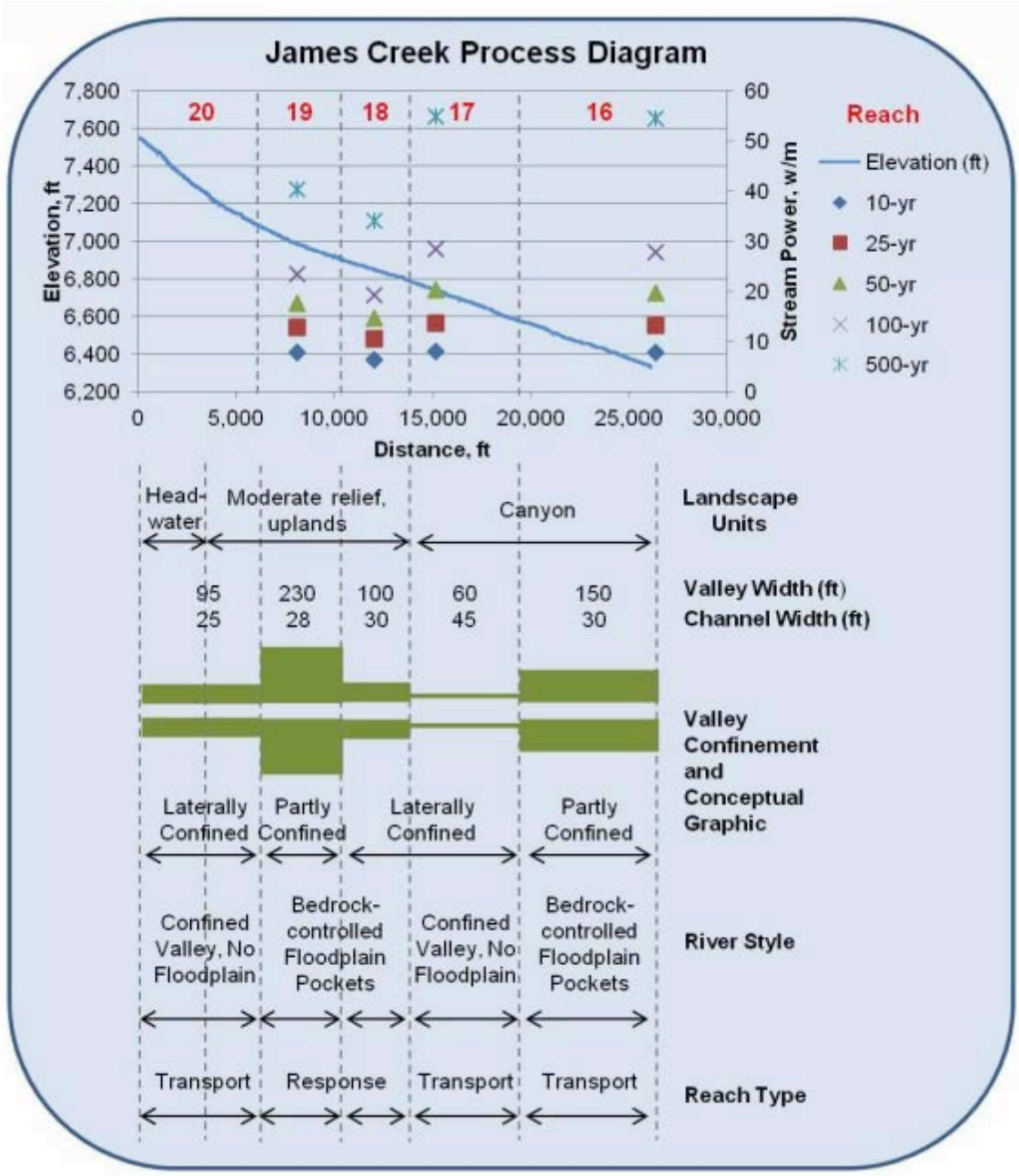

Figure 6. James Creek Process Diagram (Master Plan).

Figure 6 illustrates the controls on the downstream pattern of channel development for James Creek. Moving downstream, channel widths gradually increase along James Creek, with the exception of Reach 17. In Reach 17, a confined valley, no floodplain River Style, the channel has widened considerably. This behavior is a response to the flood and a direct result of the confined nature of the reach. Without floodplain areas in which to dispense energy, the flow condensed, destroying the channel and flushing much of the alluvium (and road surface) downstream. This is contrast to Reach 16 which saw accumulations of sediment in localized floodplain pockets (note the increase in valley width) as the

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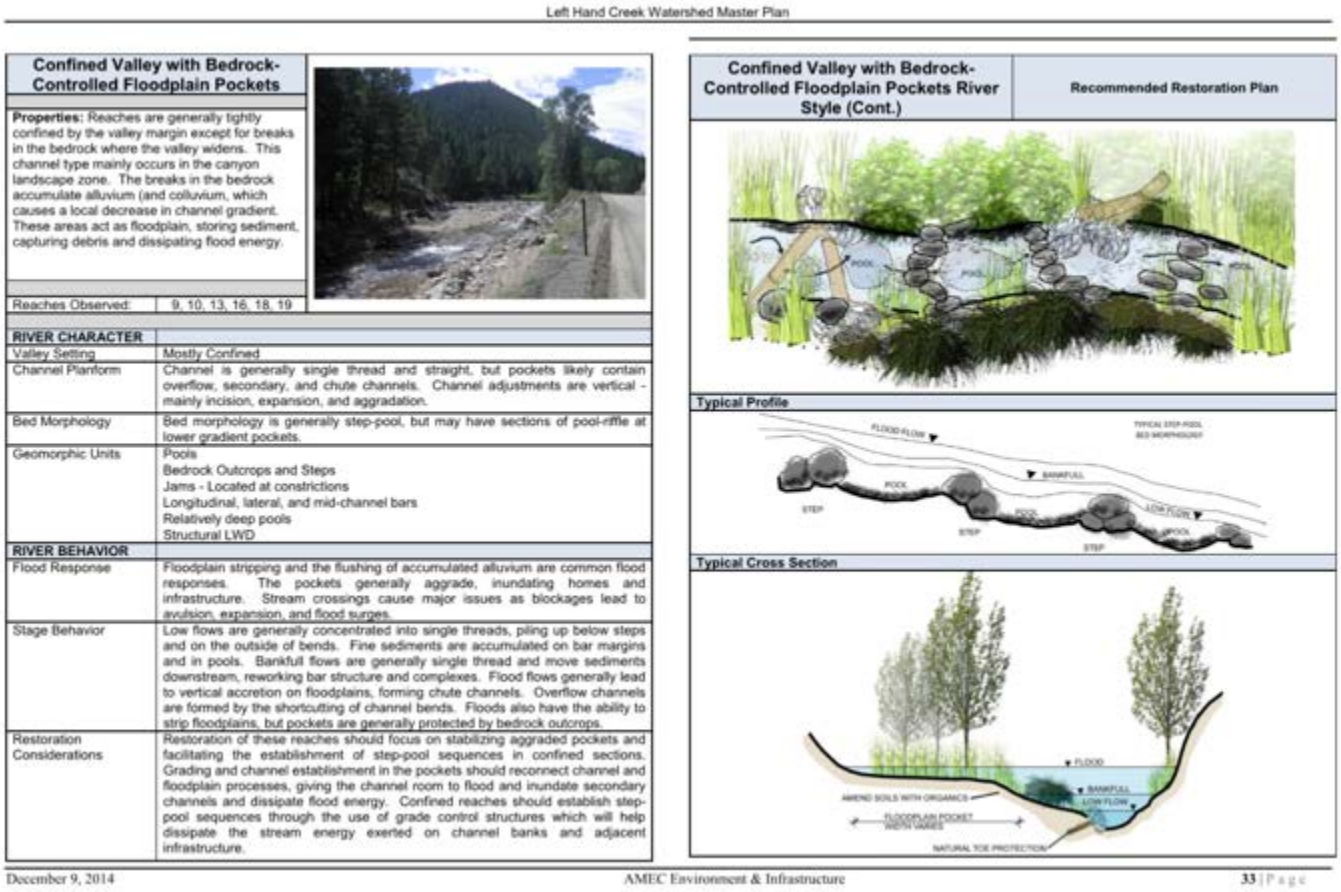
sediment stripped from Reach 17 was trapped behind bedrock and debris in Reach 16. This storage is a key function and primary goal of this restoration project. Note that the highest calculated gross stream power values also occur in this reach.



Left Hand Creek Watershed Master Plan

Confined Valley with Bedrock-Controlled Floodplain Pockets	
Properties: Reaches are generally tightly confined by the valley margin except for breaks in the bedrock where the valley widens. This channel type mainly occurs in the canyon landscape zone. The breaks in the bedrock accumulate alluvium (and colluvium, which causes a local decrease in channel gradient. These areas act as floodplain, storing sediment, capturing debris and dissipating flood energy.	
Reaches Observed:	9, 10, 13, 16, 18, 19
RIVER CHARACTER	
Valley Setting	Mostly Confined
Channel Planform	Channel is generally single thread and straight, but pockets likely contain overflow, secondary, and chute channels. Channel adjustments are vertical - mainly incision, expansion, and aggradation.
Bed Morphology	Bed morphology is generally step-pool, but may have sections of pool-riffle at lower gradient pockets.
Geomorphic Units	Pools Bedrock Outcrops and Steps Jams - Located at constrictions Longitudinal, lateral, and mid-channel bars Relatively deep pools Structural LWD
RIVER BEHAVIOR	
Flood Response	Floodplain stripping and the flushing of accumulated alluvium are common flood responses. The pockets generally aggrade, inundating homes and infrastructure. Stream crossings cause major issues as blockages lead to avulsion, expansion, and flood surges.
Stage Behavior	Low flows are generally concentrated into single threads, piling up below steps and on the outside of bends. Fine sediments are accumulated on bar margins and in pools. Bankfull flows are generally single thread and move sediments downstream, reworking bar structure and complexes. Flood flows generally lead to vertical accretion on floodplains, forming chute channels. Overflow channels are formed by the shortcutting of channel bends. Floods also have the ability to strip floodplains, but pockets are generally protected by bedrock outcrops.
Restoration Considerations	Restoration of these reaches should focus on stabilizing aggraded pockets and facilitating the establishment of step-pool sequences in confined sections. Grading and channel establishment in the pockets should reconnect channel and floodplain processes, giving the channel room to flood and inundate secondary channels and dissipate flood energy. Confined reaches should establish step-pool sequences through the use of grade control structures which will help dissipate the stream energy exerted on channel banks and adjacent infrastructure.

Confined Valley with Bedrock-Controlled Floodplain Pockets River Style (Cont.)	Recommended Restoration Plan

Typical Profile

Typical Cross Section

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Figure 7. River Styles definition for Reach 16 from the master plan.

2.5 Master Plan Recommendations

The master plan was developed so that every foot of stream in the planning area would have some level of recommendation or guidance on how to rehabilitate the channel. Identified projects have graphic examples and brief descriptions of that project's primary needs. Those areas not covered by a defined project then default to the recommendations provided in the definition of that particular reach's River Style. While the recommendations are mainly general in nature, they provide a solid geomorphic foundation upon which to build more focused and detailed concepts.

Recommendations in the master plan for the Confined Valley with Bedrock-Controlled Floodplain Pocket River Style are shown in Figure 7 above and include the following elements, which apply to all of Reach 16:

- Stabilizing accumulations of sediment in aggraded pockets;

- Re-establishing channel and floodplain connections by giving the channel room to flood, inundate secondary channels and dissipate flood energy; and
- Establishing step-pool sequences through the use of grade control structures, which will help dissipate the stream energy exerted on channel banks and adjacent infrastructure.

Flood resiliency strategies are also provided, at the concept level, for areas adjacent to the road. The key point (illustrated in Figure 8 below) is to move the asset protection as close to the road as possible and reconfigure the available space to maximize river function. Treatments depicted in these concepts (e.g., multi-stage channel, offset asset protection, revegetation, and wood loading) will be evaluated for use in subsequent design phases.

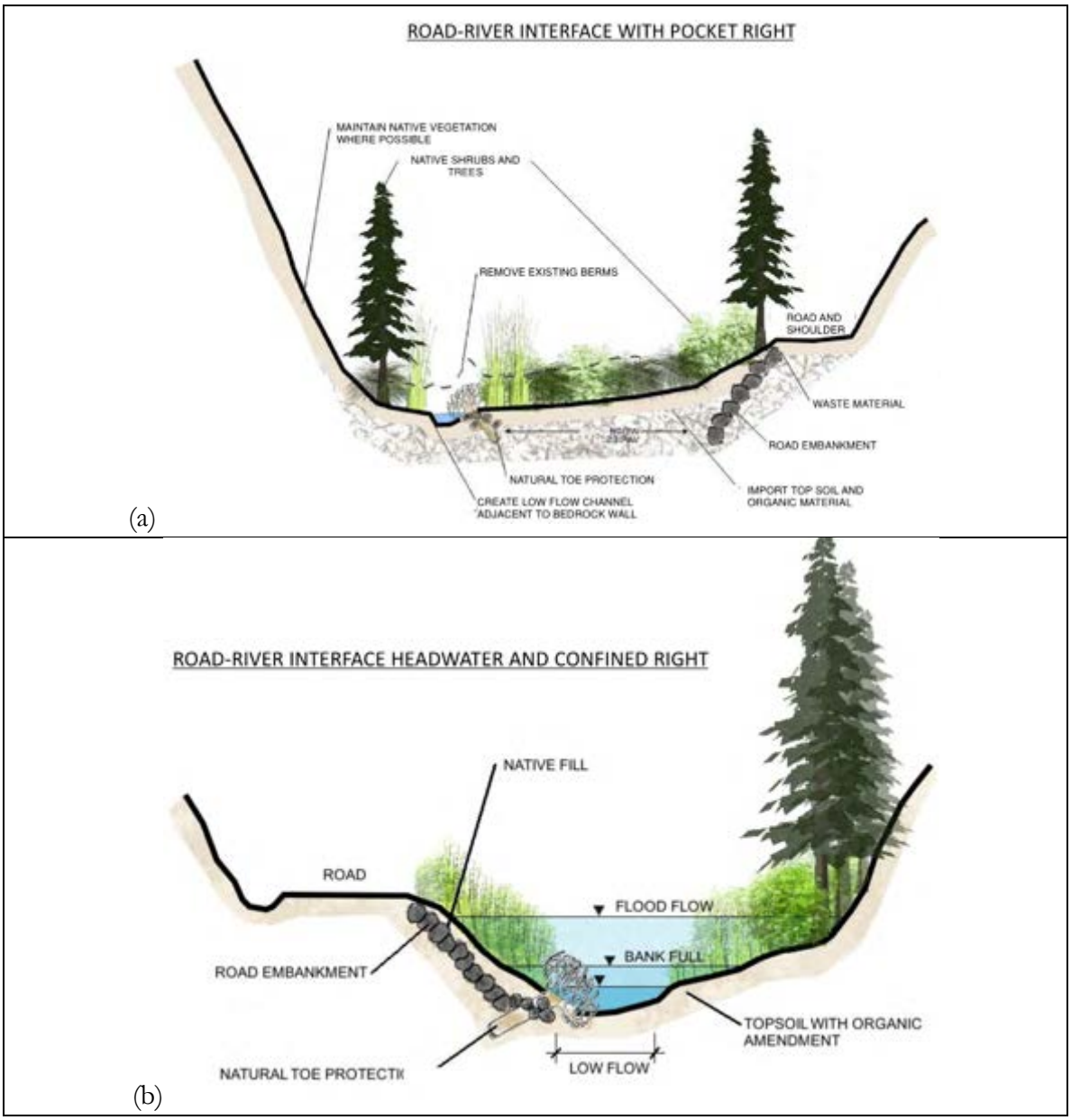

Figure 8. Flood resilient road-river interface strategies for (a) sections of channel located in pockets and (b) in tightly confined sections.

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For the master plan, Reach 16 was further divided into two projects, identified as 16_1 and 16_2. The needs identified for projects 16_1 and 16_2 are similar and include:

- Stabilizing the mobile sediments by grading functional floodplain
- Reconfiguring the channel in locations where berms have the channel perched above the floodplain;
- Removing the emergency berms;
- Installing hillside drainage controls;
- Providing additional conveyance capacity
- Reconfiguring the floodplain at 639 James Canyon Drive as the house appears to be vulnerable; and,
- Coordinating revegetation efforts in these locations with the landowners.

The team determined that all of these recommendations made in the watershed plan remain relevant and can be built upon for this focused study.

2.5.1 Design Recommendations for sub-reaches of Reach 16

In order to facilitate the design for this project, the general recommendations have been translated to each subreach as follows:

Subreach 1 (18+00 to 0+00)
Subreach 1 is highly confined by both the valley and the road, with bedrock controls. Recommendations for this reach are those provided for the River Style (Figure 7), along with the road-river interface for a confined reach depicted in (b) of Figure 8 above.

Subreach 2 (18+00 to 24+50)
Subreach 2 is confined by the valley and the road. Recommendations for this reach are those provided for the River Style (Figure 7), along with the road-river interface for a confined reach depicted in (b) of Figure 8 above.

Subreach 3 (24+50 to 27+75)
Subreach 3 is confined by the valley and the road. Specific recommendations for this reach are channel realignment in a split flow area, which also flows through Subreach 4. General recommendations for this reach are those provided for the River Style (Figure 7), along with the road-river interface for a confined reach depicted in (b) of Figure 8Figure 8 above.

Subreach 4 (27+75 to 33+75)
Subreach 4 is a floodplain pocket with substantial sediment aggradation. It is confined by the valley wall and road. Specific recommendations in Subreach 4 include channel and floodplain regrading, channel realignment in a split flow area (see Subreach 3), and potential acquisition of a residential property at 639 James Canyon Drive. General recommendations for this reach are those provided for the River Style, along with the road-river interface for a confined reach with a pocket floodplain depicted in (a) of Figure

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8 above. Additionally, sheet S-7 from the master plan mapbook depicts a conceptual cross section for the potential buyout property located in Subreach 4 (Figure 9).

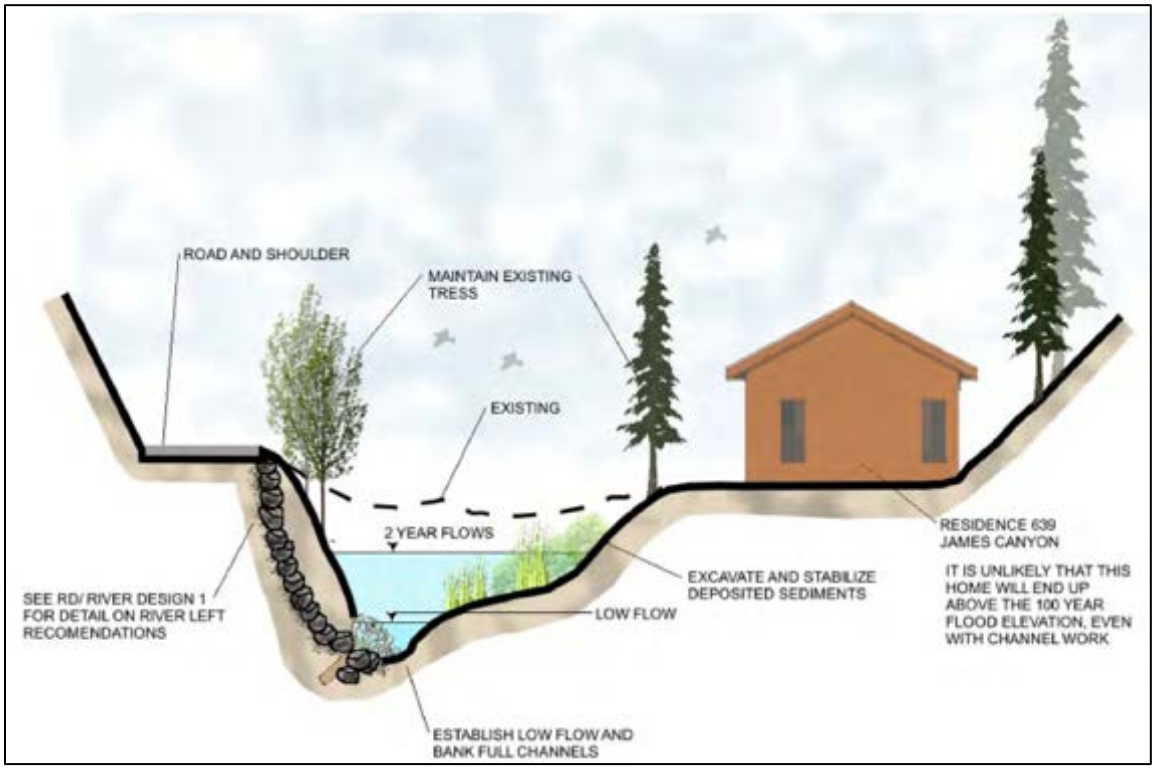

Figure 9. Concept graphic provided for the property at 639 James Canyon Drive.

The important points in Figure 9 include excavating the channel to remove the considerable aggradation, off-setting the road protection, providing a bench to the largest extent possible and revegetating with native grasses. If the home becomes part of the buyout program, the need to lower the channel decreases.

Subreach 5 (33+75 to 37+50)
Subreach 5 is a floodplain pocket with substantial sediment aggradation. It is confined by the valley wall and road. Specific masterplan recommendations in Subreach 5 include channel realignment, grading a high flow channel and habitat features. General recommendations for this reach are those provided for the River Style, along with the road-river interface for a confined reach with a pocket floodplain depicted in (a) of Figure 8 above.

Subreach 6 (37+50 to 43+50)
Subreach 6 is confined by the valley and the road. Specific masterplan recommendations in Subreach 6 include natural toe protection along approximately 200 feet of the left bank and approximately 600 feet of the right bank. General recommendations for this reach are those provided for the River Style, along with the road-river interface for a confined reach depicted in (b) of Figure 8 above.

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Subreach 7 (43+50 to 49+75)
Subreach 7 is highly confined by both the valley and the road. Recommendations for this reach are those provided for the River Style, along with the road-river interface for a confined reach depicted in (b) of Figure 8 above.

Subreach 8 (49+75 to 58+95)
Subreach 8 is a floodplain pocket with substantial sediment aggradation. It's confined by the valley wall and road. Specific recommendations are floodplain regrading and creek realignment to remove the berm confining the channel to bedrock on the right valley wall. General recommendations for this reach are those provided for the River Style, along with the road-river interface depicted in Figure 10 below.

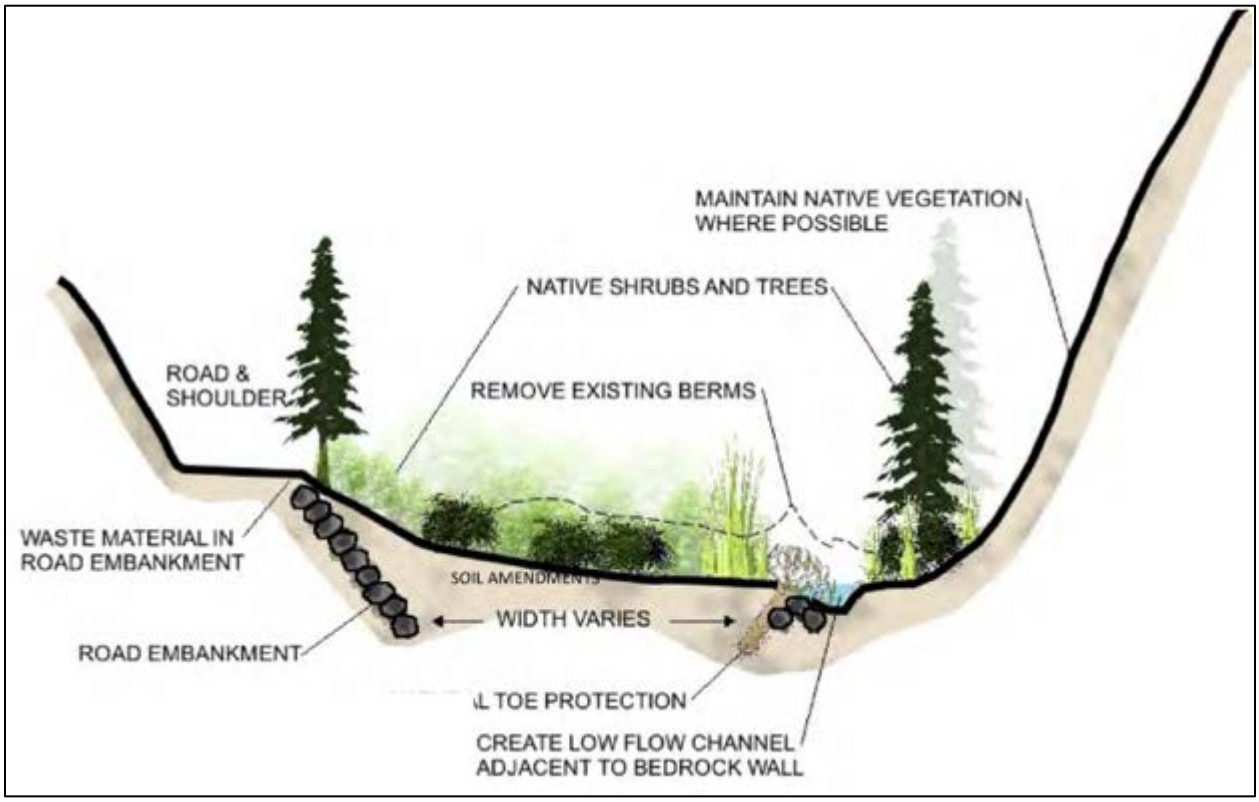

Figure 10. Concept graphic provided for the properties at 768 and 1029 James Canyon Drive.

The important points in Figure 10 include excavating the channel to remove the considerable aggradation, removing the existing berm that confines that channel to the valley wall, off-setting the road protection, providing a bench to the largest extent possible and revegetating with native grasses, trees and shrubs.

Subreach 9 (58+95 to 70+75)
Subreach 9 is a floodplain pocket with substantial sediment aggradation. It's confined by the valley wall and road. Specific masterplan recommendations are floodplain regrading and creek realignment along the downstream section to remove the berm confining the channel to bedrock on the right valley wall.

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General recommendations for this reach are those provided for the River Style, along with the road-river interface depicted in Figure 10 above.

2.5.2 Specific Site Assessment for Sub-reaches

Subreach 1 (18+00 to 0+00)
The Subreach 1 corridor (Figure 11) is a confined valley with bedrock on the valley right. Steps are beginning to form in the cobble-boulder substrate and the reach is relatively well vegetated with pockets that could benefit from willow plantings. A section (Figure 12) of ~4' high vertical cut banks was noted on the left for approximately 20 feet between 15+50 and 13+50. Due to the prevalence of large caliber material and a natural trajectory toward a relatively straight step-pool channel, this reach is expected to be largely self-healing. Earthwork here is not a priority.

Figure 11. Subreach 1 Site Photo 1.

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Figure 12. Subreach 1 Photo 1.

Subreach 2 (18+00 to 24+50)

The Subreach 2 (Figure 13) corridor is a moderately confined valley with bedrock on the valley right. Steps are beginning to form in the cobble-boulder substrate and there is decent vegetation cover on both sides of the channel. A roughly 250' stretch from 20+50 to 18+00 is messy, with fines, debris and large wood. While this reach is in relatively good condition, there are some opportunities to increase the channel and floodplain roughness and stabilize sections of actively-eroding bank. Through the property at 379 James Canyon Drive, the channel is fairly devoid of bedforms and could benefit from structure in the form of steps, pools, and rootwads.

Figure 13. Subreach 2 Photo 1.

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Subreach 3 (24+50 to 27+75)

The Subreach 3 (Figure 14, Figure 15) corridor is a confined valley with bedrock on the valley right. Steps are beginning to form in the cobble-boulder substrate and the reach is relatively well vegetated. A relatively small debris pile is noted near 25+50 and 25+00. There is a section of split flow that stretches upstream into Subreach 4. The split flow in this section offers channel complexity, energy dissipation and opportunity to increase the vegetation in the reach. The dry channel will be maintained as an overflow, but possibly requires an increase in roughness to slow velocities.

Figure 14. Subreach 3 Photo 1.

Figure 15. Subreach 3 Photo 2.

Subreach 4 (27+75 to 33+75)

The Subreach 4 (Figure 16) corridor is a pocket floodplain that extends upstream to Subreach 5. Substantial debris piles are located in the pocket floodplain and a residence on valley right is proposed for acquisition from the master plan. The pocket has severely aggraded, as result of the extensive

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floodplain roughness (i.e. tree density). The current channel configuration is bounded by massive accumulations of fine sediments that will readily mobilize in future flood events. Due to this lack of cohesion, the channel is likely to laterally migrate through the pocket causing further instabilities that may impact the properties below. The current channel is entrenched and the alignment is pushed to the left side of the valley by debris piles. Small steps are forming in the channel, which is composed of cobble, boulders and sand. A scour channel is located to the right near the residence that has been proposed for acquisition.

Figure 16. Subreach 4 Photo 1.

A log jam (Figure 17) is in located in the current channel adjacent to the residence at 639 James Canyon Drive. The jam looks stable, but the configuration may direct higher flows towards the road embankment or cause backwater to move towards the residence. Road protection is needed if the log jam remains, and it is unclear if that would be sufficient to limit damage to the road without further assessment.

Figure 17. Subreach 4 Photo 2.

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Subreach 5 (33+75 to 37+50)
The Subreach 5 (Figure 18) corridor is a pocket floodplain that extends downstream to Subreach 4. The pocket floodplain has large debris piles and multiple flow paths. The current channel alignment is primarily confined on valley right by large debris piles that are noted as sandy cobble. A debris dam was used during the flood to direct flow to the valley right, which caused some bank erosion and instability. The old flow path could be used as a high flow channel if the dam is removed and a culvert is under the residential access road. If debris in this reach is not removed it will likely be mobilized downstream. Some trees remain in the floodplain but there's little to no understory vegetation.

Figure 18. Subreach 5 Photo 1.

Subreach 6 (37+50 to 43+50)
The Subreach 6 (Figure 19) corridor is a moderately confined valley with bedrock on the far right valley margin. A new boulder toe was placed on the left and right banks since the master plan, probably in part utilizing the boulders that were located in the channel. The channel is primarily cobble and gravel where the new boulder toe was placed. No steps have formed here and grade control is necessary. Steps have begun to form upstream of the boulder toe.

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Figure 19. Subreach 6 Photo 1.

A new residential access bridge (Figure 20) was installed at approximately 40+50. The remnants of an old bridge (Figure 20) destroyed in the flood are located in the channel just downstream of the new bridge at 40+00. The bridge debris needs to be removed.

Figure 20. Subreach 6 Photo 2.

Subreach 7 (43+50 to 49+75)
The Subreach 7 (Figure 21) corridor is a confined valley with bedrock on the valley right. Steps are beginning to form in the cobble-boulder substrate and the reach is relatively well vegetated. Exposed bedrock was also noted in a part of the channel. Due to the prevalence of large caliber material and a natural trajectory toward a relatively straight step-pool channel, this reach is expected to be largely self-healing. Earthwork here is not a priority.

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Figure 21. Subreach 7 Photo 1.

Subreach 8 (49+75 to 58+95)
The Subreach 8 (Figure 22) corridor is a pocket floodplain that extends upstream to Subreach 9. Subreach 8 aggraded and has substantial debris piles from the flood. The channel is composed primarily of cobble and gravel, while the floodplain is sand with gravel and cobble. The channel is confined by a berm to the valley right against bedrock wall (Figure 23). Approximately 600' of channel from 56+00 to 49+75 is perched above the floodplain with a separate lower flow path located on valley right (Figure 24). The separate flow path was noted as having stagnant water with high metals content. Loose steps have begun to form in the perched channel.

Restoration opportunities exist to realign the channel or allow it to breach the berm, grade the floodplain, and remove debris (Figure 25, Figure 26) as necessary. Potential breach locations were noted at approximately 58+50 and 54+50. Revegetation is recommended for stability and there will be some potential existing tree removal for accessibility downstream.

Figure 22. Subreach 8 Photo 1.

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Figure 23. Subreach 8 Photo 2.

Figure 24. Subreach 8 Photo 3.

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Figure 25. Subreach 8 Photo 4 .

Figure 26. Subreach 8 Photo 5.

Subreach 9 (58+95 to 70+75)
The Subreach 9 (Figure 27, Figure 28, Figure 29) corridor is a pocket floodplain that extends downstream to Subreach 8. The floodplain has aggraded and has some large debris piles. The floodplain is sand with gravel, cobble and some boulders (Figure 30). The channel substrate and bedforms have not been accessible here due to snow and ice. The channel is confined by a berm to the valley right against bedrock wall.

Two small structures in the floodplain are still present after the flood (65+50 to 65+00). Some new willow establishment was noted on valley left in the same area. Tall, actively eroding, vertical banks are present from 70+50 to 67+00 on the right bank and could benefit from realigning the creek away from the valley right where the channel is below a debris pile.

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Restoration needs for Subreach 9 are to grade the berm back, realign the channel, and remove debris piles as necessary. Revegetation is necessary to stabilize the floodplain.

Figure 27. Subreach 9 Photo 1.

Figure 28. Subreach 9 Photo 2.

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Figure 29. Subreach 9 Photo 3.

Figure 30. Subreach 9 Photo 4.

2.6 Preliminary Channel Design

This analysis provides the Lynker team with the most useful information for geomorphic design basis, enabling us to assess whether or not various design ideas and concepts brought forward at this stage in the project are plausible, and to then begin refinement of these to ensure all subreach design concepts ideas can interconnect in a plausible manner, i.e. the conceived designs for subreaches can fit together and work as an integrated reach system.

Based on the geormorphology discussed above, primary rehabilitation strategies for the project reach include the establishment of effective bedforms, asset protection and the restoration of floodplain connectivity in 'pocket' areas. The goal is to jump start the channel's evolution and ability to absorb future disturbance events. As outlined in the master plan, the primary function of Reach 16, classified as Confined Valley with Bedrock-Controlled floodplain Pockets, is to maximize the potential for the pockets to moderate the transport of sediment, runoff, and debris. Primary strategies for accomplishing this goal include:

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1. Establishing effecting bedforms that moderate sediment loads;
2. Determining an equilibrium slope to minimize changes in bed elevation;
3. Preserving the existing alignment and flood/scour channels as overflow channels that will accumulate sediment over time;
4. Increasing channel and floodplain complexity through the use of benches and large wood to promote sediment storage and habitat development; and
5. Using offset asset protection to maximize room for the river.

Due to the amount of channel adjustment observed in the study area, and presence of much sediment, our approach does not include locking the channel in any particular location. Assets are few in the project reach and will be protected with offset protection. The larger benefit to downstream assets will come in the form of sediment and runoff moderation. Therefore, the design will progress to allow the channel to evolve (i.e., move) through the pocket reaches.

The preliminary channel design characterizes the planform and cross section parameters for each reach that would evolve in James Creek Reach 16 given sufficient time to naturally rebuild. The design parameters are a basis for further design and planning, and not intended to layout construction level detail for any given area.

2.6.1 Design Process

The design process follows an analytical approach driven by the valley slope, width, and grain size distribution identified for each reach. These parameters clarify the appropriate channel and planform type in a reach. As channels steepen they tend towards the formation of step-pools, which release their energy vertically, as compared to lower gradient pool-riffle channels that release energy horizontally. Unlike lower gradient pool-riffle reaches which form primarily in response to an effective discharge, step-pool reaches are a product of the lower frequency, higher magnitude events which was defined as the 25-year return period flow for step-pool dimensions (Thomas, 2000) and the 10-year return period flow for channel stability (Bathurst 1987; Costa, 1983). The nine subreaches in Reach 16 have valley slopes between 5% and 2%, and therefore vary between relatively straight step-pool channels to hybrid channel forms that are between straight step-pool and meandering pool-riffle channels.

For each subreach, average channel dimensions (appropriate for pool-riffle channels) and step-pool channel dimensions are calculated. Both dimension types are not appropriate for each subreach, and the appropriate channel type as determined in the geomorphic investigation (together with engineering judgment) guides what dimensions to use.

The U.S. Forest Service provides a useful guideline for projects of this nature, and includes recommendations on data collection, analysis, and implementation for designs on Forest Service Lands. The Lynker team uses this general guide in conjunction with our collective experience, and in the context of the specific scope for this project, to direct key design activities. The guidelines include (see page 78 for greater detail):

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- Longitudinal profile with bedform spacing
- Cross-sections and planform to direct reconstruction
- Design documents with stationing and design elevations ("Descriptions of bedform features must indicate the design scour depths being sought based on some natural reference condition to determine the configuration of pools. For example, pools formed at bends will have a different configuration than pools formed below steps. Such details should be outlined and specified in the design.")
- Appropriate sediment gradations which are similar in shape and angularity to those found naturally in the channel
- Stream gradient will fit in the field between designed and naturally-encountered hydraulic controls
- Bankfull width and height for various bedforms, riffle-pool spacing and geometry, typical wood placement configuration
- Use of survey equipment to set bedform elevations and other dimensions
- As-built documentation of implemented design
- Walk-though with key landowners with sufficient time to make modifications
- BMPs to protect water quality

2.6.2 Average Channel Dimensions

Average channel dimensions are calculated by first determining the appropriate bankfull channel with based on hydraulic geometry equations. Two sets of equations were compared for hydraulic geometry: Andrews (1984) and Thorne et al. (1998). Equations suggested by Thorne, et al. (1998) result in more variable channel widths given the absence or presence of vegetation. After comparison with Thorne et al. (1998) equations, the results given by the Andrews (1984) were used to define the bankfull channel width for all subreaches. Given the current condition of the creek and potential condition after construction, a wider bankfull channel width was considered to be a more conservative design and more appropriate for accommodating the estimated mobile sediment load both in the main reach and in the sub-reaches above. This also allows for channel narrowing as vegetation increases over time, and a wider and less erosive channel initially.

Next the stable channel slope is determined based on incipient motion for the median particle size (D_{50}) under the bankfull flow (Q_{BF}). Median particle sizes (Table 5) were chosen based on two pebble counts in Reach 16 (Table 6) for this assessment and previous pebble counts at similar locations on James Creek. Note that until recently, access to pebble counting and other investigations of channel sediment (armoring, using photo-sieving etc.) have been limited. Now that snow has receded we will conduct more assessments as necessary to refine our understanding of current channel bed and bank conditions and update design calculations using this data.

Table 5. Design grainsize for each subreach.

Parameter	Subreach								
	1	2	3	4	5	6	7	8	9
Existing Median Grain Size D_{50}, (ft)	0.298	0.298	0.298	0.253	0.253	0.253	0.253	0.202	0.202
Existing 84th-Percentile Grain Size $D_{84\ (ft)}$, (ft)	0.576	0.576	0.576	0.400	0.400	0.400	0.400	0.391	0.391

Table 6. Pebble count results from Reach 16 assessment (March 2016).

Grainsize (mm)	Harm Property (Subreach 9)	Ansbaugh Property (Subreach 4)
D_{16}	29.8	48.9
D_{50}	61.5	77.1
D_{84}	119.3	122.0
D_{max}	362.0	260.0

The channel depth and bottom width are calculated to accommodate the bankfull flow based on manning's equation assuming a trapezoidal channel. Further design will include 1D hydraulic modeling to refine channel dimensions. Manning's equation is also used to calculate the flows accommodated when flow just reaches the floodplain extents and when flow over the floodplain is 1.25' deep.

2.6.3 Step-pool Channel Dimensions

Typical step-pool parameters are calculated based on the valley slope and desired step height. Step heights of 1ft-1.5ft were chosen to accommodate fish passage, match existing steps noted in the creek, and to reflect variability in the valley slopes between subreaches.

Regression equations for typical step-pool dimensions were developed by Thomas et al. (2000) based on measurements in Colorado streams. The equations determine the approximate distance between steps, pool length, pool depth, pool width and minimum grain size for the step. The step is approximated as a broad crested weir and its width is calculated with a broad crested weir equation assuming approximately 1.25 feet of flow over the weir.

Finally, an appropriate runout length and slope are chosen to match the step-pool slope to the overall reach valley slope. These values are guided by the approximate distance between steps and the stable slope calculated for the median particle in the average channel dimensions. The runout width and depth are assumed to be the bankfull width and depth calculated for the average channel dimensions.

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The channel height over the weir is calculated to accommodate the bankfull flow. The channel is assumed to be trapezoidal and flow to be critical over the wier. The channel depth through the pool will vary. These values are summarized for each subreach below.

2.6.4 Preliminary Channel Dimensions

The preliminary channel dimensions are summarized for each subreach below and include the cross-section dimensions and longitudinal dimensions for a step-pool channel. Channel bedform pattern, or type, is primarily a function of channel slope, but also depends on other variables such as confinement. Preliminary target channel types are provided for each subreach and based on a combination of data sources, including the River Styles definition, channel confinement and sinuosity, observations of existing bedforms from the field assessment, the presence of bedrock, channel slopes, and the presence or absence of larger caliber material. While the majority of the reach is step-pool, the pocket areas have a shallower gradient and less confinement resulting in a transitional channel type consisting of roughened sections and steps. The design team recognizes that left to evolve naturally, the pocket areas would likely contain significant wood loading, resulting in a complex system of channels, or 'leaky' river (e.g., Wohl and Beckman, 2014).

Subreach 1 (18+00 to 0+00)
Data Review and Field Assessment Summary
The master plan recommends protecting the road while establishing step-pool sequences. This reach was confirmed in our field assessments as being largely self-healing, but could benefit from some localized revegetation, which will increase the habitat potential and provide erosion protection.

Opportunities and Constraints
Subreach 1 is not easily accessible and contains a mix of private and USFS land. Lefthand Canyon Dr. Bridge is at the downstream end of Subreach 1. The road design included grade control structures to lower the channel profile upstream of Lefthand Canyon Dr. Bridge and reduce bridge overtopping.

Preliminary Design Results
Subreach 1 is highly confined by the valley and road, and has a steeper gradient (4%). The target geomorphic channel type is step-pool with little to no sinuosity. Following the design approach described above, the preliminary channel dimensions are shown in the Table 7.

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Table 7. Subreach 1 preliminary channel design.

Parameter	Symbol	Value	Units
Average Channel Design			
Reach Slope	S_R	0.040	ft/ft
Design Gradient of Channel	S_A	0.029	ft/ft
Width - Channel Bed	W_{bed}	19	ft
Width - Bankfull (Chosen)	W_{BF}	23	ft
Channel depth	h_c	1.0	ft
Design Pool-Riffle Sinuosity	ω	1.4	ft/ft
Boulder Weir and Pool Design			
Step Drop Height	h_d	1.25	ft
Weir Width	$W_{w,top}$	19.0	ft
Weir Length	L_w	3.4	ft
Weir Boulder Size (Minimum)	$D_{W,min}$	1.7	ft
Weir channel depth	h_{wc}	1.2	ft
Pool Width	$W_{p,top(max)}$	22.8	ft
Pool Scour Depth	h_p	1.9	ft
Pool Length	L_p	21.7	ft
Runout Slope	S_R	0.015	ft/ft
Runout Length	L_R	10	ft

Subreach 2 (18+00 to 24+50)

Data Review and Field Assessment Summary

The master plan recommends protecting the road while establishing step-pool sequences. This reach was confirmed in the field assessment as being largely self-healing, but could benefit from some localized revegetation, which will increase the habitat potential and provide erosion protection.

Opportunities and Constraints

Subreach 2 is composed of private landowners with adjacent USFS property, and there is access from an existing residential road in the subreach.

Preliminary Design Results

Subreach 2 is confined by the valley and road and has a lower gradient (3%). The target geomorphic channel type is step-pool/transition with combination steps and riffles. The design channel planform has little to no sinuosity. Following the design approach described above, the preliminary channel dimensions are shown in the Table 8.

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Table 8. Subreach 2 preliminary channel design.

Parameter	Symbol	Value	Units
Average Channel Design			
Reach Slope	S_R	0.030	ft/ft
Design Gradient of Channel	S_A	0.029	ft/ft
Width - Channel Bed	W_{bed}	19	ft
Width - Bankfull (Chosen)	W_{BF}	23	ft
Channel depth	h_c	1.0	ft
Design Pool-Riffle Sinuosity	ω	1.1	ft/ft
Boulder Weir and Pool Design			
Step Drop Height	h_d	1.25	ft
Weir Width	$W_{w,top}$	19.0	ft
Weir Length	L_w	2.9	ft
Weir Boulder Size (Minimum)	$D_{W,min}$	1.4	ft
Weir channel depth	h_{wc}	1.2	ft
Pool Width	$W_{p,top(max)}$	22.8	ft
Pool Scour Depth	h_p	1.8	ft
Pool Length	L_p	19.9	ft
Runout Slope	S_R	0.015	ft/ft
Runout Length	L_R	36	ft

Subreach 3 (24+50 to 27+75)

Data Review and Field Assessment Summary

The master plan recommends channel realignment of the split flow location in Subreach 3 and 4, and protecting the road while establishing step-pool sequences. Field observations found the current alignment adequate and high flow channel sufficiently stable. Floodplain grading per master plan recommendations is still beneficial to control debris piles. Floodplain revegetation would improve this reach by increasing the habitat potential and providing erosion protection.

Opportunities and Constraints

Subreach 3 is composed of private landowners with adjacent USFS property, and there is access from the existing residential access road in Subreach 5.

Preliminary Design Results

Subreach 3 is confined by the valley and road, and has a steeper gradient (4.3%). The target geomorphic channel type is step-pool with little to no sinuosity. Following the design approach described above, the preliminary channel dimensions are shown in the Table 9.

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Table 9. Subreach 3 preliminary channel design.

Parameter	Symbol	Value	Units
Average Channel Design			
Reach Slope	S_R	0.043	ft/ft
Design Gradient of Channel	S_A	0.029	ft/ft
Width - Channel Bed	W_{bed}	19	ft
Width - Bankfull (Chosen)	W_{BF}	23	ft
Channel depth	h_c	1.0	ft
Design Pool-Riffle Sinuosity	ω	1.5	ft/ft
Boulder Weir and Pool Design			
Step Drop Height	h_d	1.50	ft
Weir Width	$W_{w,top}$	19.0	ft
Weir Length	L_w	3.5	ft
Weir Boulder Size (Minimum)	$D_{W,min}$	1.8	ft
Weir channel depth	h_{wc}	1.2	ft
Pool Width	$W_{p,top(max)}$	22.8	ft
Pool Scour Depth	h_p	2.3	ft
Pool Length	L_p	23.1	ft
Runout Slope	S_R	0.015	ft/ft
Runout Length	L_R	12	ft

Subreach 4 (27+75 to 33+75)

Data Review and Field Assessment Summary

The master plan recommends channel realignment downstream of the log jam and residence where split flow occurs, potentially acquiring the existing residential property, and protecting the road while establishing step-pool sequences. Field assessment of Subreach 4 confirmed the need for large scale regrading and debris removal in the floodplain and potential acquisition of the residence located in the floodplain at 639 James Canyon Drive. A primary design goal will be to encourage depositional behavior and energy dissipation through the creation of roughness, overflow channels, and floodplain connection.

If the residence is acquired and removed there will be more flexibility in how floodplain regrading occurs. There is a large wood jam adjacent with the residence, which could cause backwatering in the high flows. If the residence is occupied, high flow locations will have to be controlled to limit damage to the property. If the residence is removed the floodplain can be graded to allow flow across the full valley. Embankment protection is necessary at the log jam to limit damage to the road, since high flows over the jam could be directed towards to embankment. More analysis will be conducted in the design to evaluate if it is appropriate to leave the log jam in place.

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Opportunities and Constraints

Subreach 4 contains a mix of private and USFS land. There is access to Subreach 4 from the existing residential access road in Subreach 5. Private residents in Subreaches 4, 5 and 6 are in the midst of litigation. Part of dispute concerns the bridge rubble located in Subreach 6. The resident in the floodplain is interested in acquisition.

Preliminary Design Results

Subreach 4 is a pocket floodplain, moderately confined by the valley and road, with a moderate gradient (3.6%). The target geomorphic channel type is step-pool/transition with combination steps and riffles. The target design channel planform has little to no sinuosity. Following the design approach described above, the preliminary channel dimensions are shown in the Table 10.

Table 10. Subreach 4 preliminary channel design.

Parameter	Symbol	Value	Units
Average Channel Design			
Reach Slope	S_R	0.036	ft/ft
Design Gradient of Channel	S_A	0.023	ft/ft
Width - Channel Bed	W_{bed}	18	ft
Width - Bankfull (Chosen)	W_{BF}	23	ft
Channel depth	h_c	1.1	ft
Design Pool-Riffle Sinuosity	ω	1.6	ft/ft
Boulder Weir and Pool Design			
Step Drop Height	h_d	1.25	ft
Weir Width	$W_{w,top}$	19.0	ft
Weir Length	L_w	3.2	ft
Weir Boulder Size (Minimum)	$D_{W,min}$	1.6	ft
Weir channel depth	h_{wc}	1.2	ft
Pool Width	$W_{p,top(max)}$	22.8	ft
Pool Scour Depth	h_p	1.9	ft
Pool Length	L_p	20.9	ft
Runout Slope	S_R	0.015	ft/ft
Runout Length	L_R	18	ft

Subreach 5 (33+75 to 37+50)

Data Review and Field Assessment Summary

The master plan recommends channel realignment, and protecting the road while establishing step-pool sequences. Field assessment of Subreach 5 confirmed the need for large scale regrading of the floodplain, however it is recommended that the current channel not be realigned to the pre-flood alignment as initially recommended in the master plan. Instead the pre-flood alignment will be regraded as a high flow channel, which will require a culvert placement through the residential access road and

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removing the debris dam placed to control the flow path. Debris piles should be regraded or removed as necessary to reconnect the active channel to the floodplain. Floodplain revegetation would significantly improve stability and habitat in this reach. Floodplain reconnection and roughness elements will help to dissipate flood energy and store sediment.

Opportunities and Constraints

Subreach 5 is primarily on private property and also includes some USFS land. There is access to Subreach 5 from the existing residential access road downstream of the debris dam. Substrate above the residential access road is sandy and could easily be mobilized and plug a new culvert. Private residents in Subreaches 4, 5 and 6 are in the midst of litigation. Part of the dispute concerns the bridge rubble located in Subreach 6.

Preliminary Design Results

Subreach 5 is a pocket floodplain, moderately confined by the valley and road, with a lower gradient (2.2%). The target geomorphic channel type is transition with riffles. The target design channel planform has little to no sinuosity. Following the design approach described above, the preliminary channel dimensions are shown in the Table 11.

Table 11. Subreach 5 preliminary channel design.

Parameter	Symbol	Value	Units
Average Channel Design			
Reach Slope	S_R	0.022	ft/ft
Design Gradient of Channel	S_A	0.023	ft/ft
Width - Channel Bed	W_{bed}	18	ft
Width - Bankfull (Chosen)	W_{BF}	23	ft
Channel depth	h_c	1.1	ft
Design Pool-Riffle Sinuosity	ω	1.1	ft/ft
Boulder Weir and Pool Design			
Step Drop Height	h_d	1.00	ft
Weir Width	$W_{w,top}$	19.0	ft
Weir Length	L_w	2.4	ft
Weir Boulder Size (Minimum)	$D_{W,min}$	1.2	ft
Weir channel depth	h_{wc}	1.2	ft
Pool Width	$W_{p,top(max)}$	22.8	ft
Pool Scour Depth	h_p	1.4	ft
Pool Length	L_p	17.5	ft
Runout Slope	S_R	0.010	ft/ft
Runout Length	L_R	45	ft

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Subreach 6 (37+50 to 43+50)

Data Review and Field Assessment Summary

The field assessment found changed conditions in the Subreach 6 confined valley, which require an updated approach from the master plan. The master plan recommended placing natural toe protection on the right and left banks, and establishing step-pool sequences. Since the master plan, a boulder toe was added in this area on both banks, but the boulders and larger cobbles are now absent from the channel, having been piled on the banks by the landowner. The reach is largely bedrock-controlled, but grade control can be added to this reach if modeling suggests velocities are excessive.

Opportunities and Constraints

Subreach 6 contains a mix of private and USFS land. Access to Subreach 6 would need to be either through the residential property across landscaping or from downstream through the pocket floodplain, which could damage existing vegetation or steps which have formed as grade control. Private residents in Subreaches 4, 5 and 6 are in the midst of litigation. Part of dispute concerns the bridge rubble located in Subreach 6. The resident at 725 James Canyon Drive constructed a new access bridge (Figure 31), and would like assistance covering the riprap embankment at the new access bridge.

Figure 31. Subreach 6 new residential access bridge.

Preliminary Design Results

Subreach 6 is confined by the valley and road, with a moderate gradient (3.3%). The target geomorphic channel type is step-pool/transition with combination steps and riffles. The target design channel planform has little to no sinuosity. Following the design approach described above, the preliminary channel dimensions are shown in the Table 12.

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Table 12. Subreach 6 preliminary channel design.

Parameter	Symbol	Value	Units
Average Channel Design			
Reach Slope	S_R	0.033	ft/ft
Design Gradient of Channel	S_A	0.023	ft/ft
Width - Channel Bed	W_{bed}	18	ft
Width - Bankfull (Chosen)	W_{BF}	23	ft
Channel depth	h_c	1.1	ft
Design Pool-Riffle Sinuosity	ω	1.5	ft/ft
Boulder Weir and Pool Design			
Step Drop Height	h_d	1.00	ft
Weir Width	$W_{w,top}$	19.0	ft
Weir Length	L_w	3.0	ft
Weir Boulder Size (Minimum)	$D_{W,min}$	1.5	ft
Weir channel depth	h_{wc}	1.2	ft
Pool Width	$W_{p,top(max)}$	22.8	ft
Pool Scour Depth	h_p	1.5	ft
Pool Length	L_p	19.2	ft
Runout Slope	S_R	0.015	ft/ft
Runout Length	L_R	15	ft

Subreach 7 (43+50 to 49+75)

Data Review and Field Assessment Summary

The master plan recommends protecting the road while establishing step-pool sequences. Subreach 7 was confirmed in the field assessment as being largely self-healing, but could benefit from some localized revegetation, which will increase the habitat potential and provide erosion protection. Since steps are forming in reach, accessing the stream could cause more damage than good, and there are no assets to protect, no grading is proposed for subreach 7. Dimension calculations are provided in the event new information changes the decision to leave subreach 7 alone.

Opportunities and Constraints

Subreach 7 contains a mix of private and USFS land and has considerable access challenges.

Preliminary Design Results

Subreach 7 is highly confined by the valley and road, with a steeper gradient (4.0%). The target geomorphic channel type is step-pool with little to no sinuosity. Following the design approach described above, the preliminary channel dimensions are shown in the Table 13.

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Table 13. Subreach 7 preliminary channel design.

Parameter	Symbol	Value	Units
Average Channel Design			
Reach Slope	S_R	0.040	ft/ft
Design Gradient of Channel	S_A	0.023	ft/ft
Width - Channel Bed	W_{bed}	18	ft
Width - Bankfull (Chosen)	W_{BF}	23	ft
Channel depth	h_c	1.1	ft
Design Pool-Riffle Sinuosity	ω	1.8	ft/ft
Boulder Weir and Pool Design			
Step Drop Height	h_d	1.25	ft
Weir Width	$W_{w,top}$	19.0	ft
Weir Length	L_w	3.3	ft
Weir Boulder Size (Minimum)	$D_{W,min}$	1.6	ft
Weir channel depth	h_{wc}	1.2	ft
Pool Width	$W_{p,top(max)}$	22.8	ft
Pool Scour Depth	h_p	1.9	ft
Pool Length	L_p	21.3	ft
Runout Slope	S_R	0.015	ft/ft
Runout Length	L_R	9	ft

Subreach 8 (49+75 to 58+95)

Data Review and Field Assessment Summary

The master plan recommends floodplain regrading and creek realignment to remove the berm confining the channel to bedrock on the right valley wall, as well as protecting the road while establishing step-pool sequences. The field assessment confirmed the general plan of re-grading the floodplain and realigning the channel in Subreach 8. The field assessment revealed more complex conditions at the downstream end of the floodplain pocket (56+00 to 49+75). The current channel alignment is perched above the other inactive flow paths. A prominent debris flow path runs adjacent to the home on the north side of the road.

Restoration opportunities for Subreach 8 are to allow the current channel to breach the berm confining it to its current alignment or to realign the channel to the central inactive flow path. Grade control structures and debris pile removal are recommended to stabilize the area. Floodplain revegetation is necessary to create stable conditions in the reach. Stabilization of the debris flow path may require a coordinated solution between the road and river projects.

Opportunities and Constraints

Subreach 8 contains a mix of private and USFS land, and there is equipment access through a roughly graded road off of James Canyon Drive in Subreach 8. It may be difficult to access some downstream

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parts of the pocket floodplain without disturbing existing trees. The private resident wants to develop a low-impact organic farm in the floodplain.

Preliminary Design Results

Subreach 8 is a pocket floodplain, moderately confined by the valley and road, with a steeper gradient (4.5%). The design channel type is step-pool with low sinuosity. Following the design approach described above, the preliminary channel dimensions are shown in the Table 14.

Table 14. Subreach 8 preliminary channel design.

Parameter	Symbol	Value	Units
Average Channel Design			
Reach Slope	S_R	0.045	ft/ft
Design Gradient of Channel	S_A	0.017	ft/ft
Width - Channel Bed	W_{bed}	18	ft
Width - Bankfull (Chosen)	W_{BF}	23	ft
Channel depth	h_c	1.3	ft
Design Pool-Riffle Sinuosity	ω	2.8	ft/ft
Boulder Weir and Pool Design			
Step Drop Height	h_d	1.25	ft
Weir Width	$W_{w,top}$	19.0	ft
Weir Length	L_w	3.5	ft
Weir Boulder Size (Minimum)	$D_{W,min}$	1.8	ft
Weir channel depth	h_{wc}	1.2	ft
Pool Width	$W_{p,top(max)}$	22.8	ft
Pool Scour Depth	h_p	1.9	ft
Pool Length	L_p	22.2	ft
Runout Slope	S_R	0.015	ft/ft
Runout Length	L_R	3	ft

Subreach 9 (58+95 to 70+75)

Data Review and Field Assessment Summary

The master plan recommends floodplain regrading and creek realignment to remove the berm confining the channel to bedrock on the right valley wall, as well as protecting the road while establishing step-pool sequences. The field assessment confirmed the general plan of regrading the floodplain and realigning the channel in the Subreach 9 corridor. The field assessment noted tall vertical banks that are actively eroding at the upstream end of Subreach 9, which weren't a part of the master plan in this area. Realigning the channel and local floodplain regrading is still appropriate to address the eroding banks. Grade control, in the form of hardened riffles or roughened channels, may be necessary to add stability to the realigned channel. Floodplain revegetation and roughness elements would significantly improve reach stability and habitat potential.

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Large-scale debris removal may not be necessary to achieve stable conditions, and more analysis is needed here. The berm could simply be graded into the floodplain, with targeted debris removal just for larger piles.

Opportunities and Constraints

Subreach 9 is owned by one private property owner with USFS land adjacent. There is equipment access through a roughly graded road off of James Canyon Dr. in Subreach 8. Two small structures are located in the floodplain but don't appear to have any active use. The private resident wants to farm in the floodplain.

Preliminary Design Results

Subreach 9 is a pocket floodplain, moderately confined by the valley and road, with a lower gradient (2.9%). The design channel type is step-pool/transition with combination steps and riffles. The target design channel planform has moderate sinuosity. Following the design approach described above, the preliminary channel dimensions are shown in the Table 15.

Table 15. Subreach 9 preliminary channel design.

Parameter	Symbol	Value	Units
Average Channel Design			
Reach Slope	S_R	0.029	ft/ft
Design Gradient of Channel	S_A	0.017	ft/ft
Width - Channel Bed	W_{bed}	18	ft
Width - Bankfull (Chosen)	W_{BF}	23	ft
Channel depth	h_c	1.3	ft
Design Pool-Riffle Sinuosity	ω	1.7	ft/ft
Boulder Weir and Pool Design			
Step Drop Height	h_d	1.00	ft
Weir Width	$W_{w,top}$	19.0	ft
Weir Length	L_w	2.8	ft
Weir Boulder Size (Minimum)	$D_{W,min}$	1.4	ft
Weir channel depth	h_{wc}	1.2	ft
Pool Width	$W_{p,top(max)}$	22.8	ft
Pool Scour Depth	h_p	1.4	ft
Pool Length	L_p	18.5	ft
Runout Slope	S_R	0.010	ft/ft
Runout Length	L_R	20	ft

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3 Ecological Basis of Design

3.1 Introduction

Purpose

The purpose of this section is to document project goals, describe the ecological characteristics and conditions, and establish a basis of design for James Creek Reach 16 (Site) in accordance with Community Development Block Grant – Disaster Recovery (CDBG-DR) 30% Guidelines for Plan Development. The specific resources and issues of concern addressed in this section include:

- Federal and State Listed Candidate, Threatened and Endangered Species;
- Wildlife Species of Concern (including Raptors);
- Fisheries and Fish Passage
- Wetland and Riparian Areas
- Native Plant Communities;
- Soils;
- Hydrology; and
- Noxious Weeds.

3.1.1 Site Location and Study Area

Reach 16 of James Creek begins at the intersection of Lefthand Canyon Drive and extends upstream along James Canyon Drive for approximately 7,000 feet (1.3 miles). The upstream extent of Reach 16 is at an elevation of approximately 6600'. The lower extent is at 6300'. The creek falls approximately 300 vertical feet over 7,000 horizontal feet at a 4% slope. For the purpose of this memo, the Site is defined as the area contained within the 100-year floodplain, including any aquatic, wetland, riparian or adjacent upland areas. A secondary study area consisting of 1/3- mile buffer on either side of the creek center line has been established to capture geographic information pertaining to birds and raptors protected under the Migratory Bird Treaty Act (MBTA) and Bald and Golden Eagle Protection Act (BGEPA). Refer to Figure 32 - Site Location and Study Area - below.

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Figure 32. Site location and study area.

3.1.2 Physiography

Reach 16 of James Creek is located in EPA Level IV Ecoregion 21c of the Southern Rockies. Ecoregion 21c is characterized as having Crystalline Mid-Elevation Forests found mostly in the 7000 to 9000 feet elevation range on crystalline and metamorphic substrates. Most of the region occurs in the eastern half of the Southern Rockies (21). Natural vegetation includes aspen, ponderosa pine, Douglas-fir, and areas of lodgepole pine and limber pine. A diverse understory of shrubs, grasses, and wildflowers occurs. The variety of food sources supports a diversity of bird and mammal species. Forest stands have become denser in many areas due to decades of fire suppression. Land use includes wildlife habitat, livestock grazing, logging, mineral extraction, and recreation, with increasing residential subdivisions (Chapman, 2006).

From an elevational and plant community perspective, Reach 16 lies within an ecotone between the Plains (3,500 – 6,500 feet) and Foothills (6,500 – 8,000 feet) vegetation zones. Vegetation found on the hillslopes of Montane Zone (8,000 - 10,000 feet) also affects the riparian plant community found on the valley floor (CNAP, 1988).

3.2 Existing Conditions Assessment

3.2.1 Data Collection and Desktop Assessment

Available resources and literature were reviewed to gather background information on the environmental setting of the Study Area. Several organizations, agencies, and databases were consulted, including:

- United States Fish and Wildlife Services (USFWS) Information for Planning and Conservation (IPaC), Colorado Parks and Wildlife (CPW) and Boulder County (BOCO) regarding Federal, State and County Listed Candidate, Threatened and Endangered Species;
- CPW regarding appropriate construction windows for sensitive species.
- Colorado Oil and Gas Conservation Commission (COGCC) Web GIS and CPW regarding migratory bird and raptor/eagle nests;
- USFWS National Wetland Inventory (NWI) regarding wetland and riparian habitat;
- Lefthand Watershed Oversight Group (LWOG) data regarding water quality sources/concerns;
- United States Department of Agriculture (USDA) Web Soil Survey regarding soil types and characteristics;
- Colorado Natural Heritage Program (CNHP) Colorado Wetland Inventory Mapping Tool regarding the location and classification of wetlands and riparian areas in Colorado.
- Colorado Native Plant Society (CNPS) regarding native plant communities, associations and profiles;
- United States Geological Survey (USGS) topography maps;
- Google Earth current and historic aerial photography;
- Field guides on local flora and fauna
- Geographic Information System (GIS) data provided by LWOG and allied Team Members, including reach limits, parcel boundaries, road work boundaries, LIDAR topography;
- Lefthand Creek Watershed Master Plan; and
- Relevant and applicable assessment, permit, agency documents and data provide by BOCO Team members, including:
    - Pinyon Environmental, Inc., Threatened and Endangered Species Clearance Request for Boulder County Flood Responses, James Canyon Road Repairs, Boulder County, Colorado.
    - CPW and USFS fishery habitat goals;
    - Programmatic Environmental Impact Statements (EIS);
    - Programmatic Biological Assessment (BA);
    - Lefthand Watershed Oversight Group (LWOG) Status Report on Water Quality Monitoring;
    - University of Colorado at Boulder (CU), An Investigation of Metal Concentrations in Waste Rock Piles, Stream Water, Benthic Macroinvertebrates, and Stream Bed Sediments to Assess Long-term Impacts of Intermittent Precipitation Events in the Lefthand Creek Watershed, Northwestern Boulder County, CO.

3.2.2 Field Reconnaissance Surveys

Following the collection and review of background information, Ecos conducted field reconnaissance of the Study Area on February 22, 2016 and March 9, 2016. The purpose of the onsite assessment was to:

- compare background information with present-day conditions
- confirm the presence/absence and approximate extent/location of Federal and State Listed Candidate, Threatened and Endangered Species and Wildlife Species of Concern (including Raptors)
- document the existing conditions of wetland, riparian and upland plant communities
- identify and inventory a reference reach or reference patch of riparian habitat that may serve as basis for design and development of target plant community

- identify potential sources of native plant materials
- confirm the presence/absence of noxious or invasive weeds
- assess existing soil conditions, type, texture and amendment needs
- identify existing fishery habitat conditions and any existing obstructions to fish passage
- identify areas of opportunity along the riparian corridor for native vegetation, terrestrial and fishery habitat restoration
- mark-up base maps to illustrate the approximate extent/location of any confirmed resources and habitat restoration opportunities
- take representative photographs to assist in describing and documenting the Site conditions and affected environment

3.3 Summary of Findings

3.3.1 Federal Listed Candidate, Threatened and Endangered Species

The species below (Table 16) are federally listed as candidate, threatened or endangered by the USFWS (USFWS, 2016) and CNHP (CNHP, 2014) that may or could potentially be affected by activities in the project area. Based on this data and habitat requirements of each species, Ecos has provided professional opinion regarding the probability that these species may occur within the Study Area.

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Table 16. Federal protected species potentially impacted by the project.

Species	Status	Habitat Requirements and Presence	Probability of Impact by Project
FISH			
Greenback Cutthroat Trout (*Oncorhynchus clarki stomias)*	Threatened	This species inhabits cold water streams and cold water lakes with adequate stream spawning habitat present during spring. In general, trout require different habitat types for different life stages. Juveniles need protective cover and low velocity flow, as in side channels and small tributaries; spawning (riffles with clean gravels); over-winter habitat (deep water with low velocity flow and protective cover). Adults need a juxtaposition of slow water areas for resting and fast water areas for feeding, with protective cover from boulders, logs, overhanging vegetation or undercut banks. Both water quality and quantity are important. Greenbacks, like other cutthroat trout, generally require clear, cold, well-oxygenated water.	None. Lack of fish passage from diversions and presence of predator species makes greenback cutthroat presence unlikely in this reach. Ben Swigle of CPW indicated that the cutthroat trout lineage present in James Creek are not is considered a special status or federally listed species (personal communication with Rollin Daggett of the AECOM Team, January 19, 2016).
Pallid sturgeon (*Scaphirhynchus albus*)	Endangered	Listed for Weld County because water-related activities/use in the South Platte River Basin may affect the species in Nebraska.	None. The species occurs in Nebraska, and this proposed project will not deplete flows to the Platte basin.
BIRDS			
Least tern (*Sternula antillarum*)	Endangered	Listed for Weld County because water-related activities/use in the South Platte River Basin may affect the species in Nebraska.	None. The species occurs in Nebraska, and this proposed project will not deplete flows to the Platte basin.
Mexican spotted owl (*Strix occidentalis lucida*)	Threatened	Mature, old-growth forests of white pine, Douglas fir, and ponderosa pine; steep slopes and canyons with rocky cliffs.	None. Suitable forest/canyonhabitat does not exist on the Site.

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Species	Status	Habitat Requirements and Presence	Probability of Impact by Project
Piping plover (*Charadrius melodus*)	Threatened	Listed for Weld County because water-related activities/use in the South Platte River Basin may affect the species in Nebraska.	None. The species occurs in Nebraska, and this proposed project will not deplete flows to the Platte basin.
Whooping crane (*Grus americana*)	Endangered	Listed for Weld County because water-related activities/use in the South Platte River Basin may affect the species in Nebraska.	None. The species occurs in Nebraska, and this proposed project will not deplete flows to the Platte basin.
MAMMALS			
Canada Lynx (Lynx canadensis)	Threatened	Lynx habitat can generally be described as moist boreal forests that have cold, snowy winters and a high-density snowshoe hare prey base. The predominant vegetation of boreal forest is conifer trees, primarily species of spruce (Picea spp.) and fir (Abies spp.). In mountainous areas of the contiguous United States, the boreal forests that lynx use are characterized by scattered moist forest types with high hare densities in a matrix of other habitats (e.g., hardwoods, dry forest, non-forest) with low hare densities. In these areas, lynx incorporate the matrix habitat (non-boreal forest habitat elements) into their home ranges and use it for traveling between patches of boreal forest that support high hare densities where most foraging occurs.	None. None expected here because of lack of suitable forest habitat, development, and low elevation.

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Species	Status	Habitat Requirements and Presence	Probability of Impact by Project
Preble's meadow jumping mouse (*Zapus hudsonius preblei*)	Threatened	Inhabits well-developed riparian habitat with adjacent, relatively undisturbed grassland communities, and a nearby water source. Well-developed riparian habitat includes a dense combination of grasses, forbs and shrubs; a taller shrub and tree canopy may be present. Has been found to regularly use uplands at least as far out as 100 meters beyond the 100-year floodplain.	None. Suitable habitat does not exist on the Site. The closest known occupied habitat is 7.3 miles to the south in Sunshine Canyon, a tributary to Boulder Creek. The Project will improve habitat for PMJM by reducing erosion and sedimentation of streambanks and riparian area.
PLANTS			
Colorado butterfly plant (*Gaura neomexicana var. coloradensis*)	Threatened	Occurs on sub-irrigated, alluvial (stream deposited) soils on level or slightly sloping floodplains and drainage bottoms at elevations of 5,000–6,400 feet. Requires early-to mid-succession riparian habitat. Colonies are often found in low depressions or along bends in wide, active, meandering stream channels a short distance upslope of the actual channel. Only known population in Colorado is near the City of Westminster.	None. Suitable habitat does not occur on the Site. The Project is located above the 5000-6400' elevation range where the butterfly plant occurs.
Ute ladies'-tresses orchid (*Spiranthes diluvialis*)	Threatened	Primarily occurs along seasonally flooded river terraces, sub-irrigated or spring-fed abandoned stream channels or valleys, and lakeshores at elevations between 4300-6850 feet. May also occur along irrigation canals, berms, levees, irrigated meadows, excavated gravel pits, roadside borrow pits, reservoirs, and other human-modified wetlands.	None. Suitable habitat does not occur on the Site due to flood-related habitat disturbance. The Project will improve habitat by reducing erosion and sedimentation of streambanks and riparian area, and debris removal.

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Species	Status	Habitat Requirements and Presence	Probability of Impact by Project
Western prairie fringed orchid (*Platanthera praeclara*)	Threatened	Occurs in tallgrass prairie in Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and Oklahoma. Upstream depletions to the Platte River system in Colorado and Wyoming may affect the species in Nebraska.	None. The species occurs in Nebraska, and this proposed project will not deplete flows to the Platte basin.

3.3.2 NRCS North Counties EWP Phase 2 Biological Assessment

The species listed above were also reviewed by the NRCS in their North Counties EWP Phase 2 Biological Assessment (NRCS, 2015) and they concur with ecos findings. The NRCS BA also addresses some species that are not included in the table above, as they have received USFWS Block Clearance, their range does not overlap the Site, or suitable habitat conditions are not present at the Site to support them:

- Black-footed ferret (*Mustela nigripes*) Endangered – The Site is located in foothills riparian habitat, which not suited to ferrets or their prey species. Furthermore, the USFWS Block-cleared Areas for Black-footed Ferret Surveys in Colorado (USFWS, 2009) list Boulder County as an area in which this species does not occur.
- Arapahoe snowfly (*Arsapnia arapahoe*) Candidate – The Site is not located in the stream reaches where this species is found. It has only been found in two small tributaries (Elkhorn Creek and Young Gulch) of the Cache la Poudre River in the Front Range of the Rocky Mountains of Colorado.
- North Park phacelia (*Phacelia formosula*) Endangered – This species is not found in Boulder County where the Site is located. North park phacelia is found only in North Park of northern Colorado's Jackson County.

3.3.3 Site Assessment Observations:

None of the above federally listed species or their habitat was observed during the site inspection.

3.3.4 State Listed Species of Concern or Sensitivity

The Colorado Natural Heritage Program (CNHP) is a non-profit organization that tracks and ranks Colorado's rare and imperiled species and habitats, and provides information and expertise on these topics to promote the conservation of Colorado's valuable biological resources. Statewide Elements by Quad map data was accessed to show which species or natural communities are currently, potentially or historically located in an area. Due to the sensitive nature of these data, actual species and natural community locations have been generalized to 7.5 minute USGS quadrangles. The following species have been listed by CNHP in the Boulder 7.5 minute quadrant (Table 17). Federal and State status and Rank definitions are provided below (CNHP. 2016c).

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Table 17. CNHP State listed species of concern or sensitivity in Boulder (See Key below).

Common Name:	*Scientific Name:*	Federal Status	State Status	Global Imperilment Rank	State Imperilment Rank
MAMMALS:					
Black-necked Stilt	*Himantopus mexicanus*	-	-	G5	S3B
Fringed Myotis	*Myotis thysanodes*	-	-	G4	S3
Pale Lump-nosed Bat	*Corynorhinus townsendii pallescens*	-	SC	G3G4T3T4	S2
Black-tailed Prairie Dog	*Cynomys ludovicianus*	-	SC	G4	S3
Preble's Meadow Jumping Mouse	*Zapus hudsonius preblei*	LT	ST	G5T2	S1
Wolverine	*Gulo gulo*	-	SE	G4	S1
BIRDS:					
American White Pelican	*Pelecanus erythrorhynchos*	-	-	G4	S1B
FISH:					
Northern Redbelly Dace	*Phoxinus eos*	-	SE		
INSECTS:					
Mottled Duskywing	*Erynnis martialis*	-	-	G3	S2S3
Ottoe Skipper	*Hesperia ottoe*	-	-	G3G4	S2
Crossline Skipper	Polites origenes	-	-	G4G5	S3
Arogos Skipper	*Atrytone arogos*	-	-	G3	S2
Two-spotted Skipper	*Euphyes bimacula*	-	-	G4	S2
Dusted Skipper	*Atrytonopsis hianna*	-	-	G4G5	S2
Schryver's Elfin	*Callophrys mossii schryveri*	-	-	G4T4	S2S3
Yellow Dotted Alpine	*Erebia pawlowskii*	-	-	G5	S3
Painted Damsel	*Hesperagrion heterodoxum*	-	-	G5	S1
NATURAL COMMUNITIES:					

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Foothills Ponderosa Pine Savannas	*Pinus ponderosa / Leucopoa kingii Woodland*	-	-	G3	S3
Lower Montane Forests	*Pseudotsuga menziesii / Jamesia americana Forest*	-	-	G3G4	S1
Montane Riparian Forest	*Populus angustifolia / Betula occidentalis Woodland*	-	-	G3	S3
Foothills Ponderosa Pine Scrub Woodlands	*Pinus ponderosa / Cercocarpus montanus / Andropogon gerardii Wooded Herbaceous Vegetation*	-	-	G2	S2
Great Plains Mixed Grass Prairie	*Hesperostipa comata Colorado Front Range Herbaceous Vegetation*	-	-	G1G2	S2
Great Plains Mixed Grass Prairie	*Hesperostipa neomexicana Herbaceous Vegetation*	-	-	G3	S2
VASCULAR PLANTS:					
Larimer Aletes	*Aletes humilis*	-	-	G2G3	S2S3
Slimleaf Milkweed	*Asclepias stenophylla*	-	-	G4G5	S2
Bell's Twinpod	*Physaria bellii*	-	-	G2G3	S2S3
Front Range Milkvetch	*Astragalus sparsiflorus*	-	-	G2	S2
Wavy-leaf Stickleaf	*Nuttallia sinuata*	-	-	G3	S3
Colorado Butterfly Plant	*Oenothera coloradensis ssp. coloradensis*	LT	-	G3T2	S1
Prairie Violet	*Viola pedatifida*	-	-	G5	S2
Sweetflag	*Acorus calamus*	-	-	G4	S1
Rocky Mountain Sedge	*Carex saximontana*	-	-	G5	S1
Ute Ladies'-tresses orchid	*Spiranthes diluvialis*	LT	-	G2G3	S2
Water-thread Pondweed	*Potamogeton diversifolius*	-	-	G5	S1

3.4 Key to Status Designations

U.S. Endangered Species Act Status

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The federal legal status of the species as assigned by the U.S. Fish and Wildlife Service (USFWS). Blank values indicate no state legal status per USFWS.

Domain values for U.S. Endangered Species Act Status:

- C - ESA Candidate
- LE - Listed Endangered
- LE, LT - Listed as Endangered in a portion of the species' range and listed as Threatened in the rest of the species' range
- LT - Listed Threatened
- PT - Proposed Threatened
- LE-PDL - Listed Endangered, proposed delisting
- LE, XN - All of the species' infraspecific taxa worldwide are listed as Endangered or as a nonessential experimental population

3.4.1 State Protection Status (CDOW)

The state legal status of vertebrate or invertebrate species as assigned by the Colorado Division of Wildlife (CDOW). Blank values indicate no state legal status per CDOW.

Domain Values for State Protection Status are:

- E - State endangered; elements of native wildlife whose prospects for survival or recruitment within this state are in jeopardy
- T - State threatened; elements that are not in immediate jeopardy of extinction, but are vulnerable due to small numbers, restricted throughout its range, or experiencing low recruitment or survival
- SC- Special concern

3.4.2 Global Imperilment Rank

The global element rank that best characterizes the relative rarity or endangerment of the element worldwide. Factors other than the number of occurrences may be considered when assigning a global rank. Global ranks are derived primarily by staff at the Central Heritage Conservation Science Department, unless CNHP has lead responsibility for that element.

Domain values for Global Imperilment Rank are:

- G1 - Globally critically imperiled; typically 5 or fewer occurrences
- G2 - Globally imperiled; typically 6 to 20 occurrences
- G3 - Globally vulnerable; typically 21 to 100 occurrences
- G4 - Globally apparently secure; usually > 100 occurrences
- G5 - Globally demonstrably secure although it may be rare in parts of its range
- G#G# - A range between two of the numeric ranks; indicates uncertainty about the rarity f the element
- G? - Unranked; element is not yet ranked globally
- GU - Unrankable; not enough information is known
- GH - Historically known with hopes of rediscovery
- GX - Extinct; unlikely to be rediscovered
- T# - Rank applies to a subspecies or variety

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- Q - Taxonomic status is questionable
- C - Element is extant only in captivation or cultivation
- GNR – Not ranked globally

3.4.3 State Imperilment Rank

The state element rank that best characterizes the relative rarity or endangerment of the element statewide. Factors other than the number of occurrences may be considered when assigning a state rank. State ranks are derived by CNHP staff.

Domain values for State Imperilment Rank are:
S1 - State critically imperiled; typically 5 or fewer occurrences
S2 - State imperiled; typically 6 to 20 occurrences
S3 - State vulnerable; typically 21 to 100 occurrences
S4 - State apparently secure; usually > 100 occurrences
S5 - State demonstrably secure
S#S# - A range between two of the numeric ranks; indicates uncertainty about the rarity of the element
S? - Unranked; element is not yet ranked in the state
SU - Unrankable; not enough information is known
SH - Historically known with hopes of rediscovery
SX - Extinct; unlikely to be rediscovered
SE - An exotic established in the state; native to a nearby region
SA - Accidental; includes species (usually birds or butterflies) recorded once or twice or only at very great intervals, hundreds or thousands of miles outside their usual range
B - Rank refers to the breeding population of the element
N - Rank refers to the nonbreeding population of the element
C - Element is extant only in captivation or cultivation
SNR – Not ranked in the state

3.4.4 Site Assessment Observations:

None of the above listed species or their habitat was observed during the site inspection.

3.4.5 Common Species

The Colorado Parks and Wildlife (CPW) provides species activity data, including overall range, winter range, winter concentration, summer range, summer concentration, and resident populations (CPW, 2016). The following species have been listed by CPW as potentially occurring within the Study Area:

Mammals:

- Mule deer
- Preble's meadow jumping mouse
- River otter
- Abert's squirrel
- Black bear
- Moose
- Mountain lion
- Elk

Birds:

- Wild turkey

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Reptiles:

- Bullsnake
- Garter
- Hernandez short-horned lizard
- Lined snake
- Milk snake
- North American racer
- Ornate box turtle
- Painted turtle
- Plains black-headed snake
- Plains garter
- Praire 64lizard
- Plateau fence lizard
- Praire rattlesnake
- Western rattlesnake
- Six-lined racerunner
- Snapping turtle
- Terrestrial garter snake

3.4.6 Site Assessment Observations

None of the above listed species or their habitat was observed during the site inspection.

3.4.7 Migratory Birds (including Raptors)

The following species of migratory birds (Table 18) are listed by the USFWS as birds of conservation concern (FWS, 2016a). These birds, and all other migratory birds, but for a few, are protected under the Migratory Bird Treaty Act (MBTA) or Bald and Golden Eagle Protection Act (BGEPA) and could potentially be affected by activities in this project area:

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Table 18. Migratory birds.

Common Name:	*Scientific Name:*	Season:
American Bittern	*Botaurus lentiginosus*	Breeding
Bald Eagle	*Haliaeetus leucocephalus*	Year-round
Black Rosy-finch	*Leucosticte atrata*	Year-round
Black Swift	*Cypseloides niger*	Breeding
Brewer's Sparrow	*Spizella breweri*	Breeding
Brown-capped Rosy-finch	*Leucosticte australis*	Wintering
Burrowing Owl	*Athene cunicularia*	Breeding
Cassin's Finch	*Carpodacus cassinii*	Year-round
Dickcissel	*Spiza americana*	Breeding
Ferruginous Hawk	*Buteo regalis*	Year-round
Flammulated Owl	*Otus flammeolus*	Breeding
Golden Eagle	*Aquila chrysaetos*	Year-round
Lewis's Woodpecker	*Melanerpes lewis*	Breeding
Loggerhead Shrike	*Lanius ludovicianus*	Breeding
Long-billed Curlew	*Numenius americanus*	Breeding
Mountain Plover	*Charadrius montanus*	Breeding
Peregrine Falcon	*Falco peregrinus*	Breeding
Prairie Falcon	*Falco mexicanus*	Year-round
Sage Thrasher	*Oreoscoptes montanus*	Breeding
Short-eared Owl	*Asio flammeus*	Wintering
Swainson's Hawk	*Buteo swainsoni*	Breeding
Veery	*Catharus fuscescens*	Breeding
Virginia's Warbler	*Vermivora virginiae*	Breeding
Western Grebe	*Aechmophorus occidentalis*	Breeding
Williamson's Sapsucker	*Sphyrapicus thyroideus*	Breeding
Willow Flycatcher	*Empidonax traillii*	Breeding

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3.4.8 Site Assessment Observations

None of the above listed species or their habitat was observed during the site inspection, but could be seasonally present in the Study Area and should be assessed immediately prior to construction.

3.5 Fisheries and Fish Passage

3.5.1 Federal and State Listed Candidate, Threatened and Endangered Fish Species

None of the candidate, threatened and endangered fish species listed in the Summary of Findings above are known to occur in Reach 16 of James Creek, as the majority are plains fishes and the remainder are fish species endemic to the Platte River basin in Nebraska. Ben Swigle of CPW (Aquatic Biologist, Platte Basin Area 2- Fort Collins/Boulder) also confirmed that there are no known threatened and endangered fish species present in James Creek. Ben also stated that occasional cutthroat trout are present in the creek from CPW aerial stocking of lakes within the drainage upstream, but given that they are a greenback species that is not genetically pure, they are not special status or federally listed (personal communication with Rollin Daggett of the AECOM Team, January 19, 2016).

3.5.2 Left Hand Creek Master Watershed Plan

The Left Hand Creek Master Watershed Plan (Watershed Plan) (AMEC, et al. 2014) presents an assessment of Reach 16 of James Creek based on the SVAP results (Table 10, page 48) which includes pool presence, barriers to fish movement, and fish and aquatic invertebrate habitat complexity. Reach 16 is displayed as the lowest end of the “poor” rating (i.e., 3.0) for the few number of pools present, “excellent” (i.e., no barriers) for barriers to movement, and “fair” for fish and aquatic invertebrate habitat. Ecos generally agrees with most of these ratings, however our fishery habitat assessment has identified **13 barriers** that would impede movement through Reach 16, and likely drop the SVAP rating for this category to “fair”.

Table 10 of the Watershed Plan also categorizes Riparian Quantity, Riparian Quality, Canopy Cover and Vegetative Composition. Riparian quantity is listed as “fair”, riparian quality as “poor”, canopy cover as “severely degraded” and vegetative composition as “fair”. Ecos is also in general agreement with these ratings. A description of the specific elements evaluated as part of the SVAP2 protocol is presented in Table 16 *SVAP2 Ecologic Stream Assessment – Ecosystem Elements* in Appendix B of the Watershed Plan.

Table 11 of the Watershed Plan recommends, “Addition of riparian vegetation near-channel and create more planform complexity (pools)” for Reach 16. Section 5.3.3 of the Plan further recommends: “Increasing channel complexity and riparian vegetation throughout each reach will increase ecosystem value…”, “Large wood and the establishment of step-pool sequences will help dissipate stream energy and provide habitat.”, and “Additionally, in-stream structures and/or crossings should be evaluated for potential impedance to aquatic organism passage.” Appendix A - Project Prioritization of the Watershed Plan further details the recommended Ecosystem Risk Improvements to include, “Add woody material, increase number and depth of pools, increase channel complexity.” Ecos is in general agreement with all of these recommendations.

3.5.3 Trout Unlimited Fishery Observations

Rob McCormack with the Boulder Flycasters Chapter of Trout Unlimited provided the following data in an email to Glenn Patterson on November 23, 205, and classified it as “anecdotal fisherman details”:

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- "The upper reaches of the creek were dominated with small brook trout, the average size was around 5 inches and up to 12 inches. Brook trout were very abundant. The mid and lower reaches (from Lee Hill Rd downstream) contained mostly browns and the odd rainbow, average fish were around 6 inches and upper limits were 15 inches. I understand there may be a few cutthroat in the very high reaches. For those who fished it, Left Hand was a consistent brook trout fishery close to town and fish were occasionally harvested."
- "Brook trout in the upper reaches and brown trout in the lower reaches is consistent with the makeup of other similar healthy waterways."
- "Trout need cold oxygenated water, clean water, food to eat, places to hide from predators, and clean gravel to lay their eggs. Both brown and brook trout are fairly adaptable as long as there is food and oxygenated/ cold water. Brown trout are much more adaptable to higher temperatures and low oxygen and as such can survive in the lower reaches on the plains."

3.5.4 Fishery Habitat Assessment

A fishery habitat assessment for Reach 16 was conducted on March 9, 2016. The purpose of the onsite assessment was to:

- identify existing fishery habitat conditions and any existing obstructions to fish passage
- identify areas of opportunity for fishery habitat restoration
- mark-up the base maps to illustrate the approximate extent/location of any confirmed resources and habitat restoration opportunities
- take representative photographs to assist in describing and documenting the Site conditions

Reach 16 indicates obvious impacts from the 2013 floods along the floodplain, streambanks and within the channel, however fishery habitat in the majority of the reach has begun to reestablish with remarkable resiliency. For the most part, riffles dominate the reach, and are sporadically interrupted by short glides. Natural step-pool sequences have been almost completely obliterated by the floods. However, one unique, bedrock driven step-pool sequence was still present upstream of the Matzuk family Bed & Breakfast at approximately River Station 47+00 (725 James Canyon Drive). Significant pool habitat was relatively absent, with the exception of numerous, small pocket pools situated downstream of bedrock outcrops, boulders, large cobble and logs. A few large pools had formed downstream of very large boulders, bedrock outcrops, and as plunge pools below fish barriers (noted below). Flow diversity was lacking, with the exception of the aforementioned structures creating pocket pools and larger pools. Some of the point bar structure has begun to re-establish, however features such as mid-channel bars and other cross-channel structure was absent with the exception of a few naturally formed features in the downstream, narrow portion of the reach. Overhead cover is moderate to minimal in the lower, narrow portion of the reach and is comprised of steep valley walls on the south side of the canyon with little to no riparian vegetation along the highway (left/north bank). Further upstream, large evergreen trees are present and provide some shading of the channel, but the mid-story overhead cover that fish depend upon to avoid predation is primarily absent. Instream cover is comprised of pocket pools and larger pools, however undercut banks, concave bend pools, large woody debris and deeper plunge pools are absent.

13 barriers to fish movement were noted, which we define as greater than 12 to 18 inches in height above the water surface elevation. Most of the barriers in the upper, wider portion of the reach were comprised of natural wood and debris; and the barriers in the lower portion of the reach were

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comprised of boulders and cobble that were likely rearranged by the flood flows. Two of the barriers (#5 and #9) would be passable under higher flow conditions. Several shallow riffles are present that provide poor habitat and would be marginally passable during low water. The remaining 11 barriers noted would benefit from adding boulders below the impediment or reconstruction to create step-pools for better passage and pool habitat. A reworking of the existing impediments, addition of pocket pools or creation of roughened riffles, or pocket pools by adding "boulder lunkers" will depend on the proposed creek realignment

A Fish Passage Assessment Map is provided in the appendix that shows the location of the above-mentioned fish habitat impediments.

3.6 Wetlands and Riparian Areas

3.6.1 Wetlands

Ecos review of the National Wetland Inventory (NWI), Wetlands Mapper (FWS 2014c) indicate that there are no wetlands present within the Study Area. The on-site assessment confirms this finding. However, due to the age of the NWI data, it is probable that wetlands did actually exist on the fringes of the creek and alluvial floodplain pockets, but were eroded or buried by sediment during the 2013 flood.

3.6.2 Riparian Plant Communities

Reference Patch Vegetation

Viable reference reaches or sites in which to evaluate and base target plant communities are scarce in the watersheds of the northern Front Range because of the severity of damage caused by the 2013 rain/flood event. Most vegetation, except for well rooted trees and shrubs was washed away. However, small patches of intact riparian habitat remain as reference sites in which to inventory pre-flood vegetation and base restoration target species. One such patch was found on James Creek at River Station 46+50, at the Matzuk family Bed & Breakfast approximately 0.8-mile upstream from the intersection of Lefthand Canyon Drive. This small, north facing patch exhibited the greatest richness of species in the Reach, including:

Scientific Name:	Common Name:
Alnus incana	thinleaf alder
*Bromus spp.**	Brome spp.
*Dactylis glomerata**	orchardgrass
Elymus canadensis	Canada wildrye
Juniperus communis	common juniper
Physocarpus monogynus	mountain ninebark
Picea pungens	Colorado blue spruce
Pinus ponderosa	ponderosa pine
Populus angustifolia	narrowleaf cottonwood
Prunus americana	American plum
Pseudotsuga menziesii	Douglas fir
Rosa woodsii	Wood's rose

Note: Asterisk (*) indicates plants that could not be identified with certainty because of the time year, missing flowers, seed heads and other plant parts.

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3.6.3 Other Observed Vegetation

Additional species observed within the Reach 16 or reported to exist by landowners, include the following:

Scientific Name:	Common Name:
*Agropyron cristatum**	crested wheatgrass
*Agrostis spp. / Poa spp.**	Redtop spp./ bluegrass spp.
Betula occidentalis	water birch
Carex nebrascensis	Nebraska sedge
Juncus balticus	Baltic rush
*Phleum pratense**	timothy
Populus tremuloides	quaking aspen
Salix exigua	sandbar willow
*Salix fragilis**	crack willow
Salix monticola	mountain willow

Asterisk (*) indicates non-native or introduced species.

3.6.4 Potential Vegetation

Literature on native plant communities likely to occur within the Lefthand and James Creek watershed was assessed to determine potential or confirm species within the Reach. Colorado Natural Heritage Program (CNHP) Colorado Wetland Inventory Mapping Tool displays wetland mapping produced by National Wetlands Inventory and riparian mapping produced by Colorado Parks and Wildlife (CPW), including the location and classification of wetlands in Colorado (CNHP, 2106). CNHP identifies 4 major riparian plant communities (Figure 33) within the Reach, including:

- Shrub-Willow
- Evergreen-General
- Herbaceous – Sedges, Rushes and Mesic Grasses (Moist Soils)
- Deciduous - Aspen

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Figure 33. CNHP wetland and riparian habitat.

CNHP wetland and riparian data is consistent with CNAP Native Plant Revegetation Guide plant community classifications, which locate the Reach within the Rocky Mountain Region Upland Douglas-fir Forest and Riparian Foothills and Canyons. The CNHP Field Guide to Wetland and Riparian Plant Associates also indicates that the plant communities in the Reach are most closely associated with Narrowleaf cottonwood/Douglas-fir Woodlands within Group B, Mixed Coniferous and Deciduous Forests and Woodlands; and Narrowleaf cottonwood/Sandbar Willow Woodland within Group C, Deciduous Dominated Forests and Woodlands.

In Group B, narrowleaf cottonwood is co-dominant with Douglas-fir in narrow canyons bottoms and v-shaped valleys along the Front Range where a northern, protected aspect creates cool micro-climates. This association grows in wash bottoms and on immediate streambanks, cobble bars and terraces. Stream channels are usually steep and narrow with streambeds of bedrock, sand or silt. Soils are derived from alluvial and colluvial deposits and are fairly shallow, 10-30 thick. The soils become skeletal with depth. Surface layers are sandy loams, clay loams, and loams. Subsurface layers are sandy loams with 10-30% cobbles and gravels. Organic matter from accumulated litter is concentrated in the upper layers. This plant association dominated by an overstory of Douglas-fir and cottonwood is late successional/seral stage and is uncommon. Shrub cover is typically low and herbaceous undergrowth can be sparse due to heavy shade and dry soil conditions. Other plants typically present include Rocky Mountain juniper, Rocky Mountain maple, sandbar willow, river birch, shining willow, western white clematis, and wax currant (CNHP, 2003). In Group C, narrowleaf cottonwood is very commonly associated with sandbar willow and occupies point bars, gravel bars, benches and low areas that are frequently flooded.

This association is usually well within the active channel and immediate floodplain of the stream and does not occur more than 3-6 feet above the ordinary high water mark (OHWM). Stream channels are

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wide and slightly to moderately sinuous. Soils are skeletal (40% gravel and 10-20% cobbles) and shallow, 15 in deep, with sands, sandy loams, sandy clay loams, or silty clays over course alluvial material. This plant association is an early, successional stage characterized by open to dense stands of young cottonwood trees, saplings and seedlings of the same height as sandbar willow. Older trees may be present along with ponderosa pine, blue spruce, thinleaf alder, and other willows, including shining, strapleaf, Drummond and Bebb willow (CNHP, 2003).

The following is a characterization and list of target species for restoration of riparian habitat including wetland and upland species outlined in the literature that are appropriate for use in restoring the narrow valleys and broader floodplain pockets along James Creek.

3.6.5 Douglas Fir Forest (Upland Plant Community)

Forests dominated by Douglas fir (Doug fir) are found from 6,000 to 9,500 feet. In the foothills, Douglas fir forests are confined to rocky soils on cool north-facing slopes and in shaded canyons. In northern Colorado, Doug-fir may occur in pure stands or share the canopy with ponderosa pine, Rocky Mountain juniper, or Englemann spruce. Because dense forests often permit only diffuse light to reach the forest floor, understory vegetation is often sparse and consists of scatters shade-tolerant shrubs, grasses and forbs (CNAP, 1998). The following is a list of target species for upland and streamside areas that are shaded and/or north facing:

Scientific Name:	Common Name:
Grasses:	
Bromopsis porteri	nodding brome
Carex geyeri	elk sedge
Festuca arizonica	Arizona fescue
Koeleria macrantha	prairie junegrass
Leucopoa kingii	spike fescue
Muhlenbergia montana	mountain muhly
Poa nervosa	Wheeler bluegrass
Forbs:	
Antennaria rosea	rosy pussytoes
Arnica cordifolia	heartleaf arnica
Artemisia franserioides	ragweed sagebrush
Campanula rotundifolia	bluebell bellflower
Cerastium strictum	mouseears chickweed
Geranium viscosissimum	sticky geranium
Mertensia lanceolata	prairie bluebells
Potentilla concinna	red cinquefoil
Senecio eremophilus var. kingii	King's groundsel
Solidago spathulata var. neomexicana	New Mexico goldenrod

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Trees and Shrubs:

Acer glabrum	Rocky Mountain maple
Amelanchier alnifolia	Saskatoon serviceberry
Arctostaphylos uva-ursi	Kinnikinnick
Jamesia americana	Cliffbush
Juniperus communis	common juniper
Juniperus scopulorum	Rocky Mountain juniper
Mahonia repens	Oregon grape
Paxistima myrsinites	boxleaf myrtle
Physocarpus monogynus	mountain ninebark
Pinus ponderosa	ponderosa pine
Pseudotsuga menziesii	Douglas fir
Ribes cereum	wax currant
Rosa woodsii	Wood's rose
Rubus deliciosus	delicious raspberry
Rubus idaeusgray	leaf red raspberry
Symphoricarpos rotundifolius	roundleaf snowberry

3.6.6 Cottonwood – Willow Forest and Shrubland (Riparian Plant Community)

In the foothills, streams tend to be narrower with swifter flowing water. Water levels in these streams may fluctuate widely during the year, from several feet above the stream bottom during spring and after thunderstorms to a small trickle or even no water in the fall. Foothills riparian areas often have dense shrub layers composed of willows, currants, plums, chokecherries and hawthorn. Riparian areas often include a mosaic of vegetation types, with wetlands at stream edges, in backwater areas, and upland and transitional vegetation communities interspersed with wetland and riparian vegetation. Along foothills streams, narrowleaf cottonwood replaces the plains cottonwood found at lower elevations. Thinleaf alder, river birch, and blue spruce (mostly in southern Colorado) mix with the cottonwoods in the valleys along streams. Shrubs such as sandbar and other willows, red-osier dogwood, and twinberry grow along the cool, moist creek banks. (CNAP, 1998). The following is a list of target species for wetland and riparian areas along the stream channel and open, exposed floodplain areas:

Scientific Name:	Common Name:
Grasses:	
Glyceria grandis	American mannagrass
Glyceria striata	fowl mannagrass
Juncus arcticus	arctic rush
Juncus confusus	Colorado rush
Pascopyron smithii	western wheatgrass
Poa palustris	fowl bluegrass
Stipa viridula	green needlegrass

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Forbs:

Apocynum cannabinum	Indian hemp
Clematis ligusticifolia	western white clematis
Cyclachaena xanthifolia	marsh-elder
Equisetum arvense	field horsetail
Glycyrrhiza lepidota	wild licorice
Heracleum sphondylium	cow-parsnip
Hydrophyllum fendleri	Fendler's waterleaf
Hypericum formosum	St. Johnswort
Iris missouriensis	Rocky Mountain iris
Juncus arcticus	arctic rush
Maianthemum stellatum	starry false Solomon's seal
Mentha arvensis	wild mint
Mertensia ciliata	mountain bluebells
Monarda fistulosa	wildbergamot beebalm
Potentilla rivalis	brook cinquefoil
Solidago canadensis	Canada goldenrod
Vicia americana	American vetch

Trees and Shrubs:

Acer glabrum	Rocky Mountain maple
Acer negundo	box-elder
Alnus incana	thinleaf alder
Betula occidentalis	water birch
Crataegus rivularis	river hawthorn
Picea pungens	Colorado blue spruce
Populus angustifolia	narrowleaf cottonwood
Populus deltoides	plains cottonwood
Populus tremuloides	quaking aspen
Prunus americana	American plum
Prunus virginiana	black chokecherry
Pseudotsuga menziesii	Douglas-fir
Ribes aureum	golden currant
Ribes cereum	wax currant
Rosa woodsii	Woods' rose
Rubacer parviflorum	Thimbleberry
Salix amygdaloides	peachleaf willow
Salix bebbiana	Bebb willow
Salix drummondiana	Drummond's willow
Salix geyeriana	Geyer's willow
Salix irrorata	bluestem willow
Salix lucida	shining willow
Salix monticola	mountain willow
Swida sericea	red-osier dogwood

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The Colorado Native Plant Society (CNPS) makes plant inventories from field trips available to the public. No such data is available for the Lefthand or James Creek watersheds.

3.6.7 Potential Sources of Native Plant Materials

Due to the devastation of the flood, very little existing vegetation, especially shrubs, grasses and grass-like wetlands plants are present to provide a source of plant materials (seed, roots, cuttings or transplants) for revegetating the corridor without doing more harm. What vegetation that remains should be left in place to the maximum extent possible depending on creek realignment and landowner desires.

3.7 Noxious Weeds

The Department of Agriculture (CDA) maintains a prioritized list of noxious weed covered under the Colorado Noxious Weed Act (CNWA). Each noxious weed is required to be eradicated, contained or controlled. Weeds on the CDA list fall within the following categories (CDA, 2016).

List A species are invasive weeds that are either not known to occur in Colorado or are of very limited distribution and are required to be eradicated (completely eliminated).

List B species are invasive weeds with populations of varying distribution and densities within the state. The level of mandated control is based on local conditions. These weeds may require eradication within certain areas of the state.

List C species are widespread and common within the state. They may pose a risk to agricultural lands and may be required to be controlled.

Watch list species are plants known to be invasive in areas near Colorado but are not know to occur here or whose distribution is not yet fully understood.

The following noxious weeds were observed within the Site:

- Common mullein (*Verbascum thapsus*) – List C

The lack of readily observable weeds is likely due to sand, gravel, and cobble (alluvium), which is deficient in organic matter and nutrients that support weeds and early successional plants. Although not observed directly, landowners report the following listed weeds are present in the area:

- Cypress spurge (*Euphorbia cyparissias*) – A List
- Bull thistle (*Cirsium vulgare*) – List B
- Canada thistle (*Cirsium arvense*) – List B

Other weeds that do not appear on the list that were observed on Site include:

- Prickly lettuce (*Lactuca serriola*)

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3.8 Soils

Natural Resource Conservation Service (NRCS) Web Soil Survey (NRCS, 2016) (Figure 34 below) indicates soils within the valley floor consist of Pachic Argiustolls-Aquic Argiudolls complex, 0 to 15 percent slopes (Map Unit # 5101A) as shown below. Soils within this unit have the following characteristics:

Map Unit Setting

- *National map unit symbol:* tqlg
- *Elevation:* 5,800 to 8,530 feet
- *Mean annual precipitation:* 16 to 30 inches
- *Mean annual air temperature:* 39 to 46 degrees F
- *Frost-free period:* 50 to 80 days
- *Farmland classification:* Not prime farmland

Map Unit Composition

- *Pachic argiustolls and similar soils:* 55 percent
- *Aquic argiudolls and similar soils:* 30 percent
- *Estimates are based on observations, descriptions, and transects of the map unit.*

Description of Pachic Argiustolls

Setting

- *Landform:* Stream terraces
- *Parent material:* Alluvium derived from igneous, metamorphic and sedimentary rock

Typical profile

- *A1 - 0 to 10 inches:* gravelly loam
- *A2 - 10 to 21 inches:* gravelly loam
- *Bt1 - 21 to 31 inches:* gravelly sandy clay loam
- *Bt2 - 31 to 42 inches:* gravelly sandy clay loam
- *BCt - 42 to 60 inches:* very gravelly sandy clay loam

Properties and qualities

- *Slope:* 0 to 15 percent
- *Depth to restrictive feature:* More than 80 inches
- *Natural drainage class:* Well drained
- *Runoff class:* Medium
- *Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)
- *Depth to water table:* More than 80 inches
- *Frequency of flooding:* None
- *Frequency of ponding:* None
- *Available water storage in profile:* Moderate (about 6.8 inches)

Interpretive groups

- *Land capability classification (irrigated):* None specified
- *Hydrologic Soil Group:* C
  Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
- *Other vegetative classification:* Arizona fescue - mountain muhly (FEAR2-MUMO) (G1902), Needleandthread - mountain muhly (HESPE11-MUMO) (G3106)

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Description of Aquic Argiudolls

Setting

- *Landform:* Drainageways, alluvial flats
- *Parent material:* Alluvium derived from igneous, metamorphic and sedimentary rock

Typical profile

- *A - 0 to 8 inches:* gravelly loam
- *Btg1 - 8 to 15 inches:* gravelly sandy clay loam
- *Btg2 - 15 to 23 inches:* very gravelly sandy clay loam
- *Cg - 23 to 28 inches:* very gravelly sandy loam
- *Cr - 28 to 38 inches:* bedrock

Properties and qualities

- *Slope:* 0 to 10 percent
- *Percent of area covered with surface fragments:* 0.0 percent
- *Depth to restrictive feature:* 20 to 60 inches to paralithic bedrock
- *Natural drainage class:* Very poorly drained
- *Runoff class:* Low
- *Capacity of the most limiting layer to transmit water (Ksat):* Moderately high (0.20 to 0.60 in/hr)
- *Depth to water table:* About 6 to 12 inches
- *Frequency of flooding:* Occasional
- *Frequency of ponding:* None
- *Available water storage in profile:* Low (about 3.0 inches)

Range and Forest Vegetation Composition listed for this soil unit includes,

- common juniper
- currant
- ponderosa pine
- rush
- sedge
- silverweed cinquefoil
- Woods' rose
- Arizona fescue
- mountain muhly
- needle and thread

Consistent with the (NRCS) Web Soil Survey data, alluvial sand, gravel, cobble and exposed bedrock was observed within the Reach. In wide floodplain pockets, much of the alluvium has been manipulated with machinery and berms created to hold the creek in place against the valley wall. In some locations the channel is higher than the adjacent floodplain. A lens of alluvium has deposited or piled up on the pre-flood ground surface along the flanks of the floodplain. Large angular boulders (natural and imported) large cobble and loose alluvium define the narrow, confined portions of the Reach. Organic and mineral soils are essentially non-existent. The lack of organic soils that have are capable of retaining soil moisture and nutrients is a major constraint to establishing and long-term support of upland or wetland herbaceous plant life.

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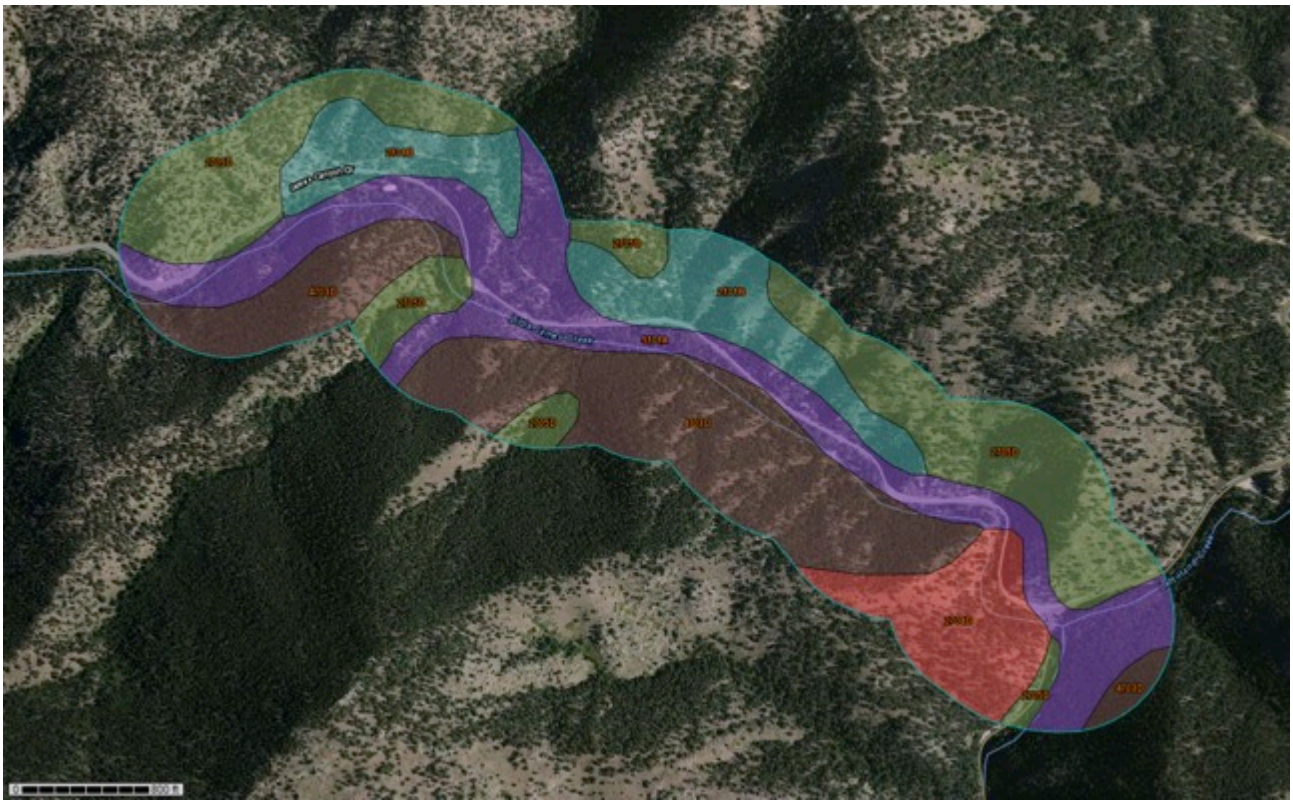

Tables — Map Unit Name — Summary By Map Unit

Summary by Map Unit — Arapaho-Roosevelt National Forest Area, Colorado, Parts of Boulder, Clear Creek, Gilpin, Grand, Park and Larimer Counties (CO645)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
2101B	Pachic Argiustolls, 5 to 25 percent slopes	Pachic Argiustolls, 5 to 25 percent slopes	35.9	14.2%
2704D	Typic Haplustolls-Cathedral family-Rock outcrop complex, 40 to 150 percent slopes	Typic Haplustolls-Cathedral family-Rock outcrop complex, 40 to 150 percent slopes	20.8	8.2%
2705D	Ratake-Cathedral families-Rock outcrop complex, 40 to 150 percent slopes	Ratake-Cathedral families-Rock outcrop complex, 40 to 150 percent slopes	69.7	27.5%
4703D	Bullwark-Catamount families-Rock outcrop complex, 40 to 150 percent slopes	Bullwark-Catamount families-Rock outcrop complex, 40 to 150 percent slopes	68.0	26.8%
5101A	Pachic Argiustolls-Aquic Argiudolls complex, 0 to 15 percent slopes	Pachic Argiustolls-Aquic Argiudolls complex, 0 to 15 percent slopes	59.1	23.3%
Totals for Area of Interest			**253.4**	**100.0%**

Figure 34. Natural Resource Conservation Service (NRCS) Web Soil Survey (NRCS, 2016).

3.9 ECOLOGICAL BASIS OF DESIGN

3.9.1 Project Goals:

Based upon review of available data, the James Creek Watershed Master Plan, and on-site observation, the Lynker Team proposed the following revegetation and habitat development goals:

- Re-establishment of the significantly degraded/absent wetland, riparian and upland tree and shrub plant community to promote natural ecologic succession, habitat development for terrestrial wildlife

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- Re-establishment of the significantly degraded/absent wetland, riparian and upland tree and shrub plant community to re-introduce organic matter and woody material into the stream system to provide shade, overhead cover, and serve as the basis for the aquatic food chain (i.e., to introduce terrestrial insects into the stream and accelerate growth in the aquatic insect population, both of which support the fishery)
- Restore and enhance instream fishery habitat to support a viable population of native and sport fish that ensures fish passage
- Create floodplain roughness to capture and retain woody debris, leaf litter, and sediment to initiate the process of accumulation of organic matter, soil building and nutrient cycling
- Select a diverse palette of regionally appropriate native riparian and wetland vegetation to restore and increase species richness
- Maximize the use of on-site material to promote cost savings and project sustainability
- Utilize transplanted or live woody material (where available) to accelerate plant community development that is “ecotypic” of the watershed
- Re-establish geomorphic conditions that support the establishment and regeneration of wetland and riparian plant community
- Maximize the use of native vegetation and natural materials for streambank and soil/slope stabilization (i.e., soil bioengineering)
- Maximize the use of native wetland vegetation to provide natural treatment of tributary contaminants that affect water quality (i.e., natural treatment systems)

3.9.2 Proposed Plant Communities

The non-invasive, native plant communities inventoried within the Reach, as well as the potential vegetation listed by the CNHP, CNAP, and NRCS data form the basis of design of the proposed plant community. Please refer to the species listed above for those riparian and upland/transitional plants that are appropriate for restoring the James Creek corridor.

3.9.3 Existing Vegetation and Revegetation Plans

But for a few surviving patches, understory vegetation is absent from the Reach as a result of flood scour. Periodic individual and small clusters of older pine, cottonwood, crack willow, alder, and smaller willow are present along the Reach. Mapping of the remaining existing vegetation will be performed as the 30% planting plan is developed. Gross-level planting plans cross-referenced with plant schedules that define the species, aerial cover percentages, and quantities of plant and seed material to be interplanted/inter-seeded with the existing vegetation will be provided as the design progresses and will be used as a basis to establish estimated revegetation costs. Location of each individual plant on paper is not a wise use of project funding. As the design moves in to subsequent construction/installation phases, it is recommended that specific location of proposed plant materials should be guided in the field depending on the species, preferred life zone, macro- and micro-topographic features, and channel alignment.

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3.9.4 USFS Vegetation and Revegetation Data and Recommendations

Christopher Carroll of the USFS (Boulder Ranger District Fisheries Biologist and ARP Forest/Grassland Watershed Crew Lead) provided *APPENDIX A – Stream Restoration Design Criteria* that he stated will be part of the USFS NEPA decision on stream restoration activities. This information was transmitted in his email comments regarding the Reach 18 Memo (personal communication with Jesse Olson et al, March 23, 2016). Appendix A contains a specific sub-section regarding *BOTANY/WEEDS*, which is copied herein:

1. Prior to ground disturbance associated with project activities, known weed infestations may be treated to minimize risk of future spread.
2. Prior to entering the project area, equipment would be cleaned to minimize risk of noxious weed introduction and spread. This applies to all contract and Forest Service equipment used off road for this project (not including service trucks or other vehicles that remain on roadways). Equipment would be free of mud, dirt, plant parts, seeds, or other debris that could contain or hold seeds or propagative plant parts. Equipment would be considered free of soil and other debris when a visual inspection does not disclose such material. Equipment would be re-cleaned whenever equipment leaves and re-enters project site. Disassembly of equipment components or specialized tools is not required.
3. If recommended by a Forest weeds/botany staff, weed concerns will be addressed in project implementation plans during the project planning phase.
4. On a case-by-case basis and prior to project implementation, surveys may be required for areas that contain habitat for Threatened and Endangered (TE) plant species as well as medium- to high-quality habitat for Sensitive plant species. If found prior to or during project implementation, TE plants would be managed per the programmatic agreement with USFWS. Impacts to sensitive species would be mitigated to avoid a loss of viability on the planning unit.
5. Plantings will use site-suitable native species. Whenever feasible, seedings will use site-suitable native species.
6. For site revegetation, tier to the Forest Revegetation Policy and minimize potential for weed introduction. Use wood straw for mulch where feasible, instead of agricultural straw. All areas requiring seeding will be accomplished with seed approved by the Forest Botanist or USFS botany representative. Mulch or erosion control methods (blankets) may be required on steep slopes to reduce erosion prior to vegetation becoming established. Government furnished seed may be used.

3.9.5 Landowner/Stakeholder Input

The incorporation of landowner desires and needs in a basis of design are critical and essential in the development of an acceptable revegetation plan since they are the ultimate stakeholders and are vested in overseeing the short- and long-term care and maintenance of their property. The following landowners (listed in order from upstream to down) that live on the creek and will be directly affected by the Project were interviewed during the design process (March 17, 2016):

- Harms, Eric and Amber
- Matzuk, Mike and Tana
- Webb, Jeff and Jennifer
- Matlin, Mark
- Williams, Donna and Christina
- Klein, Matt

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The following are some general desires of landowners interviewed during the design process, followed by specific requests:

General Desires and Agreeable Design Features

The above landowners were in favor and excited about restoring a natural channel, floodplain, and natural plant communities within the floodplain as well as reestablishing a viable fishery. All land owners were very disappointed with the loss of older trees from the flood event and are anxious to see restoration and the next steps towards healing the landscape and resources. None of the landowners disagreed with planting a diversity of species, various age classes or a high density of cottonwood, willow alder, pine, grasses or other wetlands plants. All landowners did not want to see artificial looking instream boulder features or drop structures or urban-looking walls (boulder or concrete) to define the creek as was installed in Jamestown.

Several landowners had specific requests and to not locate vegetation in areas where future access to their land will be required. Specific requests are as follows:

- The **Harms** requested that a clear access road (i.e., a natural surface path) be incorporated in to the channel and revegetation plan that leads from the existing access upstream to existing "spring house" where they want to cultivate a small plot of land and produce food. The spring house has a domestic water right that will be useful for irrigation and farming endeavors. The harms would like the flow from the spring house to be rerouted more directly to the creek instead of running parallel with the road. A great deal of run-off is discharged through culverts under James Canyon Road and dumps (from an elevated position) into the floodplain providing an opportunity and hydrology to develop a wetland swale. Harms requested that the concrete slab located within the floodplain that was previously slated to be the foundation of their house/cabin be removed.
- The **Matzuks** requested a list of appropriate native plants that they could install in the creek-side landscape that they have built. They have already planned to install Colorado blue spruce and red-twig dogwood and are looking for other options. They are fine with a full range of native plants to be installed in upstream and downstream areas that are still in disrepair including the rock-lined bank opposite of their home. They were completely amenable to installing fish habitat structures in the creek, including exposing the bedrock features under their new bridge. They were completely in favor of revegetation efforts of the rock blanket on the north bank facing their home.
- The **Webbs** would like to see a flat picnic/seating area reestablished on a low bench near the upstream extent of their property on the south bank where the channel currently bends away from the road. The Webbs plan to reuse the remnant bridge once the regulatory conditions allow. The Webbs were completely ok with removing dead or fallen pine trees and using them for root wads and stream habitat on their property.
- The **Matlins** mentioned that a flat seating area existed in the location of the current split flow channel prior to the flood. That was used for seating and campfires. They requested an accessible flat spot, preferably on the north side of the creek be rebuilt. Mark was not enthusiastic about leaving the split-flow channel near the road, but understood that leaving it or some version of a split flow improves their safety and protects their structures. Building a flat spot on the south side of the creek was discussed as an option. The Matlins also had a small bridge to a natural surface footpath on the south side of the creek that led up to the Matlin/Ansbaugh property. They would like to see conditions/land on the south side of the

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creek rebuilt/provided to accommodate private trail access. The Matlins also requested that the heavy rock and debris be removed to make their creek area walkable/accessible.

- The **Williams** requested that a an accessible, shady flat spot by the creek be provided for a seating area; and that the drainage/culvert system on the north side of the road be fixed by CDOT/Boulder County Transportation to prevent water from being directed and running in the front door of the house.
- The **Kleins** want to fill/reclaim lost land below their cobble/boulder retaining wall. Matt was very disappointed with the loss of very old pine trees and is ok with restoring all types of native vegetation along the creek, including willows for to improve instream fish habitat. The fishery is the reason the Kleins bought the property and are reporting catching 12-inch brook and brown trout post-flood. Kleins are amenable to removing material from the floodplain to improve capacity and habitat conditions. Kleins do need flat, drivable access along the lower terrace. Matt was amenable to removing crack willow once other trees and shrubs had matured (a long term management issues). Matt sees bird life in the valley, but has not directly observed any nests, particularly raptor nests.

3.10 Proposed Growth Media

3.10.1 Imported/Amended Soil

As discussed in the Soil section above, organic/mineral soils are absent in the Reach. The importation of soil and/or soil amendment is one option to develop a growth media in which to establish, develop, and kick-start an understory of herbaceous vegetation. Import of adequate quantities of reasonably balanced soil from the Front Range that exhibits good characteristics will be difficult, costly and increase the carbon footprint of the restoration project. Good soil characteristics include:

- Sandy clay loam, silty clay loam or clay loam
- High organic content
- Moderate pH between 6.0 and 7.5
- Low salt
- Low lime
- Balanced and adequate macro-nutrients (Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulfur)
- Balanced and adequate micro-nutrients (Chlorine, Iron, Boron, Manganese, Zinc, Copper, Molybdenum and Nickel)

Table 19 provides the minimum concentrations required for growth, and may vary somewhat from species to species.

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Table 19. Essential elements for plant growth.

Typical concentrations sufficient for plant growth. After E. Epstein. 1965. "Mineral metabolism" pp. 438-466. in: Plant Biochemistry (J.Bonner and J.E. Varner, eds.) Academic Press, London.				
Element	**Symbol**	**mg/kg**	**percent**	**Relative number of atoms**
Nitrogen	N	15,000	1.5	1,000,000
Potassium	K	10,000	1.0	250,000
Calcium	Ca	5,000	0.5	125,000
Magnesium	Mg	2,000	0.2	80,000
Phosphorus	P	2,000	0.2	60,000
Sulfur	S	1,000	0.1	30,000
Chlorine	Cl	100	--	3,000
Iron	Fe	100	--	2,000
Boron	B	20	--	2,000
Manganese	Mn	50	--	1,000
Zinc	Zn	20	--	300
Copper	Cu	6	--	100
Molybdenum	Mo	0.1	--	1
Nickel	Ni	0.1	--	1

Please note that concentrations, whether in mg/kg (=ppm, parts per million) or Percent (%), are always based on the weight of dry matter, instead of the fresh weight. Fresh weight includes both the weight of the dry matter and the weight of the water in the tissue. Since the percentage of water can vary greatly, by convention, all concentrations of elements are based on dry matter weights.

Somewhat arbitrarily, a dividing line is drawn between those nutrients required in greater quantities, **macronutrients**, and those elements required in smaller quantities, **micronutrients**. This division does not mean that one nutrient element is more important than another, just that they are required in different quantities and concentrations. On the table above, the dividing line is typically drawn between S and Cl, meaning that:

Inadequate soils, whether on-site or imported require amendment with nutrients and particularly organic matter to retain soil moisture and improve fertility, oxygenation, and soil biota. Nutrient deficiencies vary depending on the source of the imported soil, which can be determined by obtaining a soil nutrient analysis from the soil provider. Colorado soils are typically low in organic matter. Organic amendments, comes in various forms and quality. Recommended organics and soil activators, include:

- Class 1, low salt aged compost applied at an optimal rate of 200 cubic yards/ acre
- Granular humates applied at an optimal rate of 250 lbs/acre
- Endo mychorrizae applied at an optimal rate of 20 lbs/acre

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- Organic, slow release fertilizer applied at a rate of 1500 lbs/acre

Note: Soluble fertilizer is not recommended for soils placed in active stream channels or waterbodies or highly permeable substrates such sand or gravel.

3.10.2 Natural Soil Development Processes

Flooding is a natural process that periodically washes away the organic/mineral soil and decomposing biomatter, leaving exposed alluvium. Cottonwood and willow naturally regenerate in nutrient poor alluvium. As such, an alternative to importing soil and/or soil amendments is to increase floodplain roughness by actively planting and increasing the density of cottonwood and willow to build soil naturally over time. As the plant material drops leaf litter and fine woody debris from season to season, and course and fine woody debris drifts over the floodplain and catches in the vegetation, the leaf litter will eventually build up and break down to create soil, which will eventually support the germination and succession of herbaceous grasses and forbs. Although all plants benefit from having soil and the regeneration process is sped up by having soil, wetland plants are adapted to establish and survive in nutrient poor soil/alluvial conditions. Seeding and active planting of wetland plants in addition to woody plants is also a viable strategy to help build soil and restore the riparian/wetland corridor.

Upland grasses, however are less tolerant and less successful without soil and soil moisture holding capacity. Therefore, as a basis of design a combination of organic soil import and/or amendment should be considered for upland and transitional areas and natural soil development process in lowland areas. The costs of implementing these strategies will be explored during the design process.

3.10.3 Proposed Fishery and Fish Passage

James Creek is historically dominated by trout, but other native, non-game species are likely present. Therefore, ecos recommends that the basis of fishery design for the Lynker Team target salmonids and accommodate other native non-game species to the extent possible. This basis allows for a full range of instream and streamside habitat features, but specifically limits the height of drop structure to 12-inches or less above the water surface elevation at low-flow.

3.10.4 General Requirements for Optimal Trout Habitat

To provide a context for understanding the current and potential future condition of James Creek, the following section describes trout habitat requirements:

Optimal trout habitat is generally characterized by:

- clear, cool water
- a relatively stable water flow and temperature regime
- a relatively silt-free rocky substrate in riffle-run areas
- diverse instream cover and flow diversity
- adequate pools and holding water, including a low-flow channel
- Appropriate riffle pool sequence/spacing
- well-vegetated streambanks and adequate overhead cover
- Course Woody Debris (CWD)
- Backwater/nursery habitat for young fish rearing and refuge

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- Fish passage
- Absence of laminar flow (i.e., flow that occurs in pipes or culverts)

3.10.5 Water Temperature

Water temperature is the single most limiting factor surrounding fisheries productivity and sustainability. Water temperature has a direct correlation to water quality, as cool waters hold more dissolved oxygen (DO); and a stable temperature regime assists in maintaining a stable pH. These parameters are critical for spawning, egg development, maturation of fry, juvenile growth, distribution, and survival. Water temperature may be affected by a variety of natural factors including climate, riparian cover, flows, geomorphic features, as well as human impacts. A proper assemblage of natural, physical attributes (e.g., adequate overhead cover for shade, adequate riffle habitat for oxygenation, concentration and depth of flows) can assist in regulating water temperature.

Water temperatures in Colorado streams usually follow a regular pattern. Most waters reach their peak temperature in late July or early August as air temperatures climb and stream flows recede. This period is relatively free from the cooling influences of snowmelt runoff and fall weather. After the first part of August, stream temperatures often decrease, even though the weather may still be hot and dry. This trend reflects the shorter days and cooler nights of the approaching fall season.

3.10.6 Water Flow

There is a definite relationship between the annual flow regime and the quality of trout habitat. Flow rates and depths affect all life stages, including the upstream migration of adults, survival of eggs, and the emergence and viability of fry. The most critical period is typically during base flow (i.e., lowest flows of late summer through winter). Adequate low-flow channel (thalweg) definition and holding water (pools) must be present to allow passage/migration; sustain the fishery during base flow conditions; and provide critical, over-winter refuge. Man-made structures that may impede fish passage must be considered along with flow regime. Dams and irrigation diversions may not be designed to allow fish passage at some (or all) flow stages; and as such can isolate a stream reach and interrupt the life cycle of the fishery.

3.10.7 Gravel

Trout require coarse sediment (gravel) for several stages in their life cycle. Gravel is used in spawning, as habitat for recently emerged fry, and as a substrate for macro-invertebrate prey for juveniles. Sediment deposition degrades available habitat for fish and invertebrates and can facilitate habitat for tubifex worms (the intermediate host for whirling disease). Sedimentation rates vary between and within watersheds and are determined by geology, soils, streambank stability, vegetation patterns, and particularly by land use.

3.10.8 In-stream Cover

In-stream cover is recognized as one of the essential components of trout streams. While specific habitat requirements differ throughout the trout life cycle, a diversity of instream habitat types is required for all stages. Streams composed of a variety of habitats, such as pools, riffles, and flat water, provide productive spawning and rearing habitat. Habitat complexity also creates productive invertebrate habitat by providing nutrients, trapping nutrient inputs, and providing suitable substrates. Instream structural elements are required to create diverse microhabitats and maintain hydrologic and

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geomorphic complexity. Large and small woody debris, root wads, undercut banks, boulders, aquatic vegetation, and bedrock ledges provide shelter from predators, territorial niches, foraging areas, and resting habitat. These structural elements also create heterogeneous stream flow, increased pool development, and enhanced gravel retention.

3.10.9 Vegetated Streambanks and Overhead Cover

Development and maintenance of habitat diversity and in-stream structural elements requires mature streamside vegetation. Overhead cover from trees and shrubs is important in maintaining shade for stream temperature control; and providing terrestrial carbon and insect sources to the stream ecosystem for food chain support.

3.10.10 Spawning Habitat

The spawning habitat requirements of trout are based on substrate, water temperature and stream gradient. Rainbow, brown, brook and cutthroat require a streambed of clean, silt-free, well-aerated substrate for spawning. The preferred substrate is gravel and can vary based on the size of the reproducing fish. Although brook trout and brown trout are primarily stream spawners, they can spawn in lakes/ponds with adequate circulation and suitable spawning substrate. Spawning behavior of different trout species is dependent on seasonal influences associated with climactic change; as the water temperature usually provides the catalyst that initiates spawning behavior. Rainbow and cutthroat species generally spawn in the spring months, whereas, brown and brook trout spawn in the fall months. Areas of flowing, oxygenated water and groundwater upwelling appear to be highly preferred. These areas are typically located in streams at the head of a riffle or at the tailout of a pool; and in ponds they may occur at the inlets, outlets, and over springs. Typically, trout will spawn in areas displaying a 2% to 5% fall. Gradients less than 2% do not provide flows necessary to remove the finer sediments. Additionally, areas lacking fall will often not provide the oxygenation needed for developing embryos. Adequate water flow/upwelling appear to override substrate size as the site selection factor.

3.10.11 CPW Fishery Habitat Data and Recommendations

Ben Swigle of CPW provided a 1994 fishery sampling data that indicates that brook, brown, rainbow (all non-native), and occasional cutthroat trout are present within James Creek (personal email communication with Rollin Daggett of the AECOM Team, January 19, 2016). Ben specifically recommended the following fishery habitat design guidance: “Natural channel design (multistage) with incorporated woody debris. Pool spacing at approximately 5-7 stream widths. If weirs are used interstitial space must be maintained. All rip-rap must be angular and backfilled with 12" of topsoil, grouting of any structure is not advised. I would suggest using reference reaches upstream that were not damaged for stream slope and grading. Make certain you have a low flow channel” (personal communication with Rollin Daggett of the AECOM Team, January 19, 2016).

3.10.12 USFS Fishery Habitat Data and Recommendations

Christopher Carroll of the USFS (Boulder Ranger District Fisheries Biologist and ARP Forest/Grassland Watershed Crew Lead) said that a fish survey was conducted in James Creek in September 2015, and one fish species, brown trout, was collected. Forest Service Management Indicator Species (MIS) include brook and brown trout. A habitat survey also was conducted in James Creek in September 2015. Chris indicated that large woody debris is limited in the stream. He recommended that woody debris should

be added as part of the stream restoration work. (Personal email communication with Rollin Daggett of the AECOM Team, February 8, 2016).

Chris also provided *APPENDIX A – Stream Restoration Design Criteria* that he stated will be part of the USFS NEPA decision on stream restoration activities. This information was transmitted in his email comments regarding the Reach 18 Memo (personal communication with Jesse Olson et al, March 23, 2016). Appendix A contains a specific sub-section regarding *FISHERIES/HYDROLOGY*, which is copied herein:

7. Consult hydrologist/fish biologist prior to maintenance or construction activities for project-appropriate BMPs. Implement appropriate Best Management Practices (BMP's). See FS-990a, National Best Management Practices for Water Quality Management of National Forest System Lands-Volume 1, National Core BMP Technical Guide, Road Management Activities.
8. Prior to any construction work in or adjacent to stream channels or in-stream work, mud must be removed entirely from all off-road equipment (including both FS and contract equipment) and equipment decontaminated with extremely hot water, or a disinfectant or bleach.
9. For work that occurs adjacent to a stream channel or other water body (e.g. pond, wetland), or crosses a floodplain or riparian area and that may have measureable impact to streams or riparian areas (e.g. culvert replacement, work outside the existing road prism), consult a hydrologist, fish biologist and/or geomorphologist during design and through implementation. The Forest Service must approve designs for proponent-based proposals.
10. Design and construction of streams shall incorporate the following characteristics:
    a. Channel Form and Geometry - Dimensions (length, width, depth, and gradient), spacing, and boundary characteristics shall be appropriate for the site
    b. Access to floodplains – Construct stream banks and floodplains such that waters access the floodplain at discharges above bankfull discharge
    c. Large wood and rock – Replace or add large wood and rocks within the channel and floodplain to increase complexity, improve habitat, and provide energy dissipation
    d. Riparian area revegetation – Revegetate streambanks and riparian areas with appropriate woody and herbaceous vegetation.

Chris also provided a comprehensive list of USFS floodplain and stream channel design elements in his February 22, 2016 email to Rollin Daggett (and again in his 3/23/16 email to Jesse Olson referenced above) entitled *Data and Analysis to Support an informed Geomorphic floodplain and stream channel design*. This design information has been forwarded to the Lynker Team and is included herein:

3.10.13 Data and Analysis to Support an informed Geomorphic floodplain and stream channel design

The following list of design elements and features are needed to properly design the stream and floodplain features on National Forest System Lands (concise list of guidelines above in Section). These design elements require surveying to determine current conditions following road reconstruction as well as to establish the planform geometry, bedform elevations, and valley/channel cross-sectional profiles of the river.

1. Provide longitudinal profile with the spacing of bedforms (pools, cascades, riffles, ribs, etc.) for existing conditions (post-road construction) and the planned changes to that longitudinal profile (the design longit. Profile). An As-built longitudinal profile will be provided once all stream reconstruction has been completed.
2. Provide cross-sections and a planform to serve as a baseline to direct stream channel and floodplain reconstruction activities. This includes existing conditions following road-

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reconstruction, but proceeding stream/floodplain reconstruction as well as the planned changes to the planform and valley/bankfull cross-sectional profiles.

3. Prepare design documents (conceptual, preliminary, and final) to show station numbers for a linear frame of reference and key elevations of hydraulic controls. This applies to longitudinal profiles, cross-sections, and planform design documents. Descriptions of bedform features must indicate the design scour depths being sought based on some natural reference condition to determine the configuration of pools. For example, pools formed at bends will have a different configuration than pools formed below steps. Such details should be outlined and specified in the design.
4. Use appropriate composition, shape, size, and distribution of streambed and floodplain material. All streambed material will be similar in shape / angularity as those found in the natural stream channel, as designated in the specifications, or from a local fluvial source, provided that the appropriate particle distribution is represented. Adequate size, distribution of particle sizes, and sorting of streambed materials should vary based on stream slope as determined through local stream reference conditions and the following bed class specification.
5. Based on design elevations of key bedform features, stream gradient will be shown on design documents and fit in the field between the designed and naturally-encountered hydraulic controls
6. Specify prescriptions for:
    a. bankfull widths and bankfull heights for various channel bedforms at and between hydraulic controls. Provide typical cross-sections that are planned for various bedforms.
    b. riffle-pool sequencing, including, the configuration of riffles or geometry of steps that will maintain pool scour.
    c. placement/embedding of large wood along floodplain areas, within streambanks, and along channel margins. Provide typicals for wood placement configuration on floodplains and engineered log jams embedded into streambanks/channel margins.
7. Use survey equipment to set and establish bedform elevations, approximate planform layout, stream channel dimensions, and floodplain elevations, slopes, and widths.
8. Provide Documentation (As-Built) of the Implemented Design
9. Upon completion of the Design Plans, facilitate a walk through in the field with key landowners, providing sufficient time to make modifications to the plans, should they be required.
10. Provide sufficient BMPs to protect water quality and currently intact riparian and stream resources, including but not limited to:
    a. Diversion of flows away from channel and streambank excavation;
    b. Other sediment controls, timing of stream work;
    c. An oil spill containment kit is required on each job site when working in and around the stream.

Christopher Carroll of the USFS also stated, “I think the designs we would look to incorporate into the project would all look to benefit both sport fish and native non-game species to the extent possible.” (Personal email communication with Jesse Olson, February 23, 2016).

3.10.14 CPW Construction Windows for Sensitive Species and Trout

Ben Swigle of CPW was asked via email to identify construction windows to avoid impacts on special status species and trout species (e.g., spawning periods). Ben replied, “Brook/Brown October 1-November 15, Rainbow/Cutthroat March 15 - June 15 (I will not apply restrictions to your permitting

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based on spawning trout, populations near the headwaters are intact and lower sections will repopulate quickly)" (personal communication with Rollin Daggett of the AECOM Team, January 19, 2016).

3.10.15 USFS Wildlife Data and Recommendations

Christopher Carroll of the USFS (Boulder Ranger District Fisheries Biologist and ARP Forest/Grassland Watershed Crew Lead) provided – *Stream Restoration Design Criteria* that he stated will be part of the USFS NEPA decision on stream restoration activities. This information was transmitted in his email comments regarding the Reach 18 Memo (personal communication with Jesse Olson et al, March 23, 2016). This contains a specific sub-section regarding *WILDLIFE*, which is copied herein:
The following wildlife design criteria are primarily intended to be applied in flood repair project areas that are within areas of Preble's mouse habitat (i.e. project areas below 7,600 feet elevation adjacent to intermittent and perennial streams). However, limiting habitat disturbance in other upland and riparian areas to the greatest extent possible is also desirable for general wildlife habitat.

1. Avoid permanent impacts to riparian and adjacent upland habitats where possible. Otherwise, minimize temporary impacts to these habitats to the greatest extent possible. For work within Preble's habitat, permanent and temporary impacts to these habitats will be tracked and reported to the USFWS, as part of ESA Section 7 consultation practices. Measures to achieve this include the following:
    - Minimize the amount of concrete, riprap, bridge footings, and other "hard" impermeable engineering features with the stream channel and riparian or adjacent upland habitats.
    - Minimize the number and footprint of access routes, staging areas, and work areas and locate access routes, staging areas, and work areas within previously disturbed or modified non-habitat areas, when possible.
    - To the extent practicable, limit disturbing (e.g. crushing, trampling) or removing (e.g. cutting, clearing) all vegetation, such as willows, trees, shrubs, and grasses within riparian and adjacent upland habitats. Minimize the use of heavy machinery and use smaller equipment when possible.
    - For project activities that require substantial disturbance of residual upland and riparian habitat, especially within Preble's mouse habitat, install limits of work fencing (e.g. orange barrier netting or silt fencing), signage, or other markers to delineate access routes and the project area from habitats, and to indicate no-entry zones.
2. For projects within Preble's mouse habitat, written explanation or a preconstruction briefing for onsite personnel would occur to explain the importance of limits of work and other conservation measures.
3. USFWS would be contacted as soon as possible by telephone at (303) 236-4773 if a Preble's mouse is found alive, dead, injured, or hibernating within the project area.
4. For projects within Preble's mouse habitat, the acres or square feet of riparian and upland habitats that are temporarily or permanently affected (see definitions below) by the repair activities would be tracked for reporting to USFWS (see USFWS table for example). Work in areas that have been scoured down to rock debris (i.e. no vegetation remaining) do not need to be tracked as 'habitat affected' because they are not currently suitable habitat due to absence of any vegetation.
    a. Temporary impacts are when native vegetation and habitats are expected to reestablish following rehabilitation (e.g. access route that is rehabilitated with native seeds and plants).

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   b. Permanent impacts are when riparian or upland habitats will not return as a result of project activities (e.g. road surface, concrete footings).
5. For compliance with the Platte River Recovery Implementation Program (PRRIP) and reporting requirements to USFWS, if water uses for a project are expected to exceed 0.1 acre-foot, track the volumes of any water from onsite sources stored or used for dust abatement, soil compaction, concrete mixing, or other activities.
6. Where possible, locate, store, stage, and refuel equipment a minimum of 100 feet outside of riparian habitats.
7. Operate equipment from previously disturbed or modified roadbeds or road shoulders above riparian habitats.
8. Stockpile topsoil and debris outside of residual riparian vegetation and the riparian corridor, unless approved by the District Ranger, and protect from stream flows or runoff.
9. For projects within Preble's mouse habitat and during the Preble's active season (May 1 through November 1), work only during daylight hours to avoid disrupting Preble's nocturnal activities.
10. Sources for logs and root wads for instream or floodplain structures will be coordinated with a FS wildlife biologist and identified prior to project implementation.
11. Harvest of willow and cottonwood cuttings from FS lands for project site plantings will adhere to ARP guidelines and direction. For projects proposed and implemented by external partners where willow and/or cottonwood cuttings are requested from FS lands, ARP harvest/cutting permits must be obtained prior to project implementation.
12. Promptly remove waste to minimize site disturbance and avoid attracting predators.

3.10.16 Recommended Conservation Measures

These measures are desirable for minimizing impacts from project activities and to hasten restoration and recovery of damaged riparian and adjacent upland habitats from flood impacts and from emergency flood response activity impacts. They are recommended particularly for project activities within Preble's mouse habitat, but also would be beneficial for any project in and adjacent to streams and riparian areas.

13. Where feasible and appropriate, use bioengineering techniques to stabilize stream banks.
14. Develop and implement a habitat restoration plan that addresses site preparation, planting techniques, control of non-native weeds, native seed mixtures, and post-construction monitoring.
15. To minimize soil compaction, temporarily line access routes with geotextiles or other materials, especially, in wet, unstable soils to protect roots and the seed bank.
16. Within Preble's mouse habitat, upon project completion, revegetate all disturbed areas with native shrubs, trees, and grasses.
    a. Rip compacted access routes prior to replanting with native vegetation
    b. Fill and reseed with weed-free material and native seed mixtures
    c. Consult the Service before finalizing a seed and plant list
17. Where appropriate, bury riprap, then plant with native riparian vegetation.
18. Rehabilitate adjacent habitats impacted by floodwaters to restore connectivity and prevent future impacts from erosion or sedimentation.
19. Consider monitoring the revegetated areas for success. The NRCS can help establish success criteria during the consultation process.

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It is essential that the final surface elevation of the floodplain and low benches/point bars be within 2 to 4 feet of the base-flow water surface elevation (BFWSEL), the natural elevation were cottonwood/willow habitat is supported by sub-surface alluvial interflow. Low-lying areas that hold surface water that range between -0.5 below to 2 feet above the BFWSEL are ideal for the establishment of herbaceous wetlands.

4 Environmental Considerations

4.1 Environmental Permits

Lynker team currently compiling list of required permits.

4.2 Cost Estimate and Materials

Lynker will furnish a cost estimate in the final design. We recommend that LWOG does not share the cost estimate with potential contractors. The cost estimate is a target price subject to numerous variables. Actual bids from contractors or the participant's actual costs may vary by plus or minus 20% or more. Some of the variables that affect construction costs include market conditions, unforeseen site conditions, weather, equipment maintenance costs, energy costs, fluctuating material prices (rock, soil, plants etc), and the number of available contractors.

5 Performance/Construction Time

Lynker will provide an estimate of construction time for this project in the final design. Work will ideally be done during low flow conditions in the summer or fall. The estimate will include mobilization time, an allowance for delivery of materials, assumed weather days, and demobilization period.

6 Additional Landowner Concerns

James Creek Reach 16; March 17, 2016 – Landowner visit notes:

General Concerns Reach wide: USFS OHV trails and access, how the buyout property (Ansbaugh) will be utilized.

Eric Harms/Amber Hill
(Amber is a wildlife artist, both will be in Beijing March 25-April 4)
Goals: Hobby Farm, Greenhouse, Chickens, Permaculture, Bees, and Wildlife

Notes: Importance of bringing topsoil back (from photos at least 3-6 ft + of sediment accumulation)
In the process with Boulder County in building 600 ft2 back from losses on site.
Keep access road at current location and along current road to the west up to spring house.
Open to meandering stream configuration but has several buildings on property (Figure 35, Figure 36, Figure 37)**Error! Reference source not found.**.
Sent several documents and photos (above)

1. Greenhouse mockup

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2. Master Survey
3. ILC and Topo survey (two documents)
4. Project Survey with Building Labels
5. Photos of 3 locations below (2 with before and after)

Figure 35. Building F before and after

Figure 36. Building B before and after

Figure 37. Building D (pre-flood)

Matlin/Williams (Mark and Donna, daughter Christine):

(Matlin/Williams both concerned with AECOMs placement of the culvert)

Goals: Restore safe access to the creek, large cobbles are hard to walk on currently there are two channels 1 high flow and the main channel. Talked about a bridge crossing or grading on the side channel if kept such that the channel side slopes wouldn't be severe.

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Lots of debris (metal, cobbles) still on site some ½ buried.

There used to be a footpath/go-cart trail to through the jointly owned Matlin/Ansbaugh to Ansbaugh property.

Klein (Matt):

Goals: Fish habitat and access.

Notes: Fish have come back and is currently catching fish in the lower portion of his property, Needs to keep trailer path thought floodplain area of his property (currently existing). He hasn't observed any nesting birds recently.

Webb (Jennifer and John?)

Goals: reconfigure stream alignment.

Notes: Large berm built post flood is eroding ROB of property (their favorite spot) just downstream of the failing bridge. Plan to build adjacent to Matzuk's current house. Downstream they are very open to realignment of creek and removal of current "berm".

Matzuk (Tana and Michael)

Goals: Wanted to get vegetation plants and trees back in the ground in the next month or two.

Notes: Very confined channel through the property. Focus on revegetation instead of realignment.

Concerns: USFS OHV trails and access, how the buyout property (Ansbaugh) will be utilized.

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7 References

Design references, programs, and criteria include the following:

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8 Appendix: Comments in response to review of DRAFT Basis of Design for Restoration of James Creek between Jamestown and the Left Hand Creek Confluence, Boulder County

General Comments on Reach 16 Basis of Design

In general, the structural recommendations and revegetation recommendations can be combined into holistic recommendations and interventions that are composed of rocks, wood, and plants (i.e. bio stabilization). Please refer to the biostabilization manual for some of the available options: http://coloradoewp.com/document/living-streambanks-manual-bioengineering-treatments-Colorado-streams.

Response: The revegetation plans were built around an understanding of the key objectives and how the channel grading will accomplish those objectives such that planted material will have the best chance to access sustaining hydrology. Our intent was not to present complete plans, only enough information to receive buy-in that the direction is agreeable to the larger project team. Our hope is that this approach helps to maximize limited budget.

• Please use care throughout document to differentiate between excessive sediment and trash "debris" intended for removal versus large wood materials (LWM) intended for reuse.

Response: Following the nomenclature suggested for use in Wohl et al., 2016, we will change all references of LWD to LW (Large Wood) when referring to downed wood greater than 10cm in diameter and 1m in length.

Wohl, Ellen, Brian P. Bledsoe, Kurt D. Fausch, Natalie Kramer, Kevin R. Bestgen, and Michael N. Gooseff, 2016. Management of Large Wood in Streams: An Overview and Proposed Framework for Hazard Evaluation. Journal of the American Water Resources Association (JAWRA) 52(2): 315-335.

• Figure numbers are frequently incorrect - recommend reviewing document to ensure figures and tables are correctly labeled and referenced.

Response: Have edited document to improve this.

• Consider using large wood in constructed jams that mimic areas where wood would naturally attenuate.

Response: see plans and reference and details beyond typical rootwads.

• The U.S. Forest Service has excellent recommendations which we fully support, but we also suggest that the design team consult the Engineering Guidance provided by the NRCS and CWCB http://coloradoewp.com/document/emergency-watershed-protection-ewp-program-2013-colorado-flood-recovery-phase-2-project which references the CDBG- DR 30% design guidelines as appendix A2 as these two programs are funding the design and construction and itis these requirements that must be met in this design process.

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Response: The design team has consulted the NRCS engineering guidance manual. Is there a specific item we are lacking within these guidelines or is this a reference to include a citation for the NRCS guidance document?

• Please provide detailed written explanations on how the design features achieve the goals outlined in the DSR and the overall goals and objectives of the project.

Response: We have augmented the report to improve this.

• The Basis of Design provides a great deal of information, but little synthesis. Please explicitly state how the information provided in the Basis of Design is used to form and support the design and selected design criteria. Recommend using appendices to keep data details separate from main points and concepts.

Response: We have augmented the report to improve this.

• Recommend combining section 2.5.1 and 2.5.2 into one In order to improve readability and consolidate recommendations.

Response: Lynker have edited these sections to improve readability.

• Page 23 subreach 3 - Are avulsions acceptable into the overflow channels and are assets within their vicinity adequately protected? Consider whether installing plugs at upstream end of overflow channels using boulders/wood or a combination to control at which flows they are engaged is necessary.

Response: Sediment storage zone flow into the overflow channels can be controlled and is not designed to be a static system. There a few assets at risk in the vicinity. Reach 16 has several floodplain pockets, or areas where a decrease in local valley confinement (and thus channel gradient) facilitate the storage of sediment and development of floodplain (refer to the Left Hand Creek Watershed Master Plan for more information). These critical pocket areas work to dissipate flood energy and store transport sediment, debris, and LW. Our intent with the overflows is to reset the pocket so it once again provides this service for the folks located downstream. The overflow channels will help restore this function by spreading flow and providing floodplain access. With very few assets adjacent to the river, our approach is to put less emphasis on channel location and more emphasis on channel function. Therefore, the location of the channel is not critical and should be able to move around the pocket in order to provide critical watershed functions. We will use boulders and logs to initially enforce channel splitting and do recommend harder protection closer to the road. Our approach has been approved by the larger team.

• Page 25 subreach 4 -Please clarify what is meant by the term "scour channel"

Response: “Scour channel” refers to a channel formed by the flood, and may be a secondary or tertiary channel that will often not be inundated except under high flow conditions.

• Page 25 subreach 4 - What specific impacts are threatening properties below?

Response: Sediment mobilization. Further undermining of road/bridges.

• Page 33 - second paragraph - please provide a reference for the US Forest Service guide

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Response: Reference now included.

• Page 34 - Tables 5 and 6 - tables switch units from "ft" to "mm" which could unintentionally cause some confusion.

Response: Changed units in Table.

• Page 34 as noted for Reach 17 and 21, the recommended vertical drop in structures is no more than 0.5 to 1.0 foot. Please also refer to the CPW guidance for additional recommendations: https://coloradoewp.com/document/post-flood-recovery-assessment -and-stream-restoration-guidelines-Colorado-front-range.

Response: Understood. We are referring to natural drops in a steep mountain stream that often measure more than one foot. Structures will be field fit into multiple cascade type structures. Limiting drop structure to 1 foot may be a limiting factor and is not what is naturally forming now. Drops shown in channel profile refer to what is needed to achieve a theoretically stable slope, given our sediment gradations. These structures will be field fit to provide stepped passage, with no individual step larger than one foot. We are aware of the sensitivity around how the Jamestown features were constructed.

• Page 35 - section 2.6.3 Field fitting may require spacing changes of structures. Recommend noting in the text that it may be necessary to field fit the structures. It is unlikely that they will end up being evenly spaced or highly symmetrical.

Response: Ok noted, it is not our intent to have the structures evenly spaced or symmetrical

• Page 35 - Preliminary design results indicate "little to no sinuosity" but the "design pool riffle sinuosity" of the subreaches seems to be between 1.4·1.6 indicating a moderate sinuosity. (subreach 8 says sinuosity of 2.8 which is very high and may not be stable).

Response: We acknowledge the inconsistency and are working those issues out as we fine-tune the grading.

• Page 62 -Figure 33 may be improved with addition of a legend.

Response: Legend included.

General Comments on Reach 16 Plan and Profile Detail Sheets

• The contours on sheets 3-5 do not line up with the proposed overflow channels nor the grading for the benches, which is shown only by the shaded polygons.

Response: Overflow channels will not be added to 30% design and will be field engineered based on site conditions and field engineering judgement. We will define a relative elevation with which to engage the 2 year or effective (151 cfs) flows to define the overflow channel elevation.

• The contour lines as they grade back away from the channel would benefit from refinement throughout the plan set-they currently show ditches running back away from the channel at each pool location.

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Response: Contour lines have been refined.

• Check "Target Equilibrium Slopes" for consistency and against the proposed bedforms. For example, sheet S shows a 0.1% difference between a riffle-pool and step-pool bedform; sheet 3 shows a riffle-pool with a target slope of 3.1% but in sheet S this is considered a step-pool bedform slope. We understand there are not hard-set slope transitions for bedforms, however, if within this project one reach is different from another in its slope-bedform relationship, please provide the rationale for that design decision.

Response: As noted, slope ranges are not bedform mutually-exclusive – meaning that the slope transition between bedform channel types is not a hard line. Channel confinement, available sediment caliber, and other variables also influence bedform pattern.

• Clarify "subreach 1 no grading proposed"" and describe if this is commensurate with the DSR's requirements and the landowner desires.

Response: This does correspond with stakeholder needs, and LWOG direction that restoration work should be conducted only when it is sensible to do so. While the DSR report does note some scouring in this reach, there is more potential for the channel to adjust naturally than with restoration efforts, most of which have greater potential to cause damage simply because of the challenge gaining access to most of this reach.

• Please clarify if the sediment or debris in "no-work subreaches" could pose hazards to upstream or downstream properties if no work is done.

Response: A preliminary assessment of risk was a deciding factor on whether or not to perform work in each reach. There is some risk in doing work, and some in not doing work. In no work sub-reaches the design team believes there to be lower risk but recognizes the river needs to transport sediment to be stable.

- Please provide north and flow direction arrows as well as a sheet location key for both the plan and profile and planting sheets.

Response: North arrow and flow direction added

Specific Comments on Reach 16 Plan and Profile, Details

• Detail Sheet 1: Root wad plan view: drawing is not reflective of notes (Overlap rootwad by 1'; no overlap shown, please specify 1' overlap dimension).

Response: Notation has been removed.

• Detail Sheet 1: check availability of 20-30" DBH trees for this project.

Response: Number and type of structure trees will need determined closer to project construction.

• Detail Sheet 1: Please clarify the use and function of the rip-rapped banks surrounding the rootwads*

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Response: Riprap is used around the rootwads to help prevent fluvial and rill/gully erosion. Because the soil is the ballast holding the log in place, the longevity of the structure is maximized when it has the adequate ballast. Often times, flow will increase in the gap between the roots and the bank, accelerating the removal of the ballast material. The riprap approach is the most conservative approach, but other options for reducing eroding potential include soil lifts and reveg with blanket and matting.

• Detail Sheet 2: Clarify "more alluvium" note in the setback riprap drawing.

Response: Detail note has been modified to say Native Alluvium.

• Detail Sheet 2: Recommend specifying more than 6" of topsoil if container plants are being used over the setback riprap.

Response: Ok, will note if using container plants to use more than 6” or topsoil.

• Detail Sheet 2: Step-Pool: please clarify design details, in particular, the dimensions of the step or drop.

Response: note will be added to detail.

• DetailSheet 2: Typical stream cross section: clarify details and check for consistency with Sheet 1 of the Planting Plan, specifically with regard to the bankfull depth and bankfull width.

Response: The typical stream cross section shows a multi-stage (compound) channel showing key dimensions that are adjusted for each subreach (details in Tables included for each subreach). A table defining the dimensions for each subreach has been added to the planset.

• Detail Sheet 2: Provide detail on the slope and catch of the Boulder Toe Protection. Also, is it possible to include vegetation, as appropriate, in this feature? Perhaps add willows into boulder toe or create a brush layer (see Biostabilization Manual for additional considerations).

Response: Will provide detail on slope and catch of BTP. And will investigate using Brush layer in conjunction with BTP as referenced in Biostabilization manual.

Detail Sheet 3: Standardize hardened riffle/engineered riffle across plan sets

Response: Coordination with AECOM required and the purpose/function of their riffle is not certain. We included the hardened riffle to function as point specific grade control and not a feature to be re-worked/mobilized during effective (i.e., bankfull) flows.

• Detail Sheet 3: Call out a D50 and minimum depth of keyed in riffle crest.

Response: need to calculate

• Detail Sheet 3: Consider dropping riffle to existing grade to avoid possible increases in the BFE

Response: Detail modified to align with proposed grade

• Detail Sheet 3: Please indicate the elevation where the rock transitions to native soil in cross section B-B.

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Response: Added detail to B-B

Specific Comments on Reach 16 Planting Plan (ECOS)

• Page Dl: Grasses and Forbs refers to the seed schedule. However, no forbs are included in the seeding mix on seed schedule sheet. Clarify if this is intentional, as the mix is called out for both "grasses and forbs". Please include forbs at a percentage that can compete and establish in the presence of the called out grasses. For questions or suggestions, please refer to the vegetation matrix at: https://coloradoewp.com/document/pl ant-restoration-matrix

Response: Reference to forbs in the Typical Riparian Plant Community Cross-section had been removed for the reasons discussed above.

• Sheets 1 and 3: provide detail/explanation for Lower Riparian-Toe Treatment.

Response: The Lynker/ecos team has developed a typical wrapped soil lift detail for the final 30% design submittal for those portions of the project that are confined/steep yet require a toe treatment. These areas are identified on the Lynker/ecos plans and plant schedules as Lower Riparian – Toe Treatment (Zone 2).

• Page 1: Species under FACU-FAC: many of these species are unavailable.

Response: Ecos is not sure how a categorical statement about the availability of plants on the market can be made at this point in time, considering that a contract grow arrangement can be made to supply this project. Other comments on plant availability and contract grow are provided above.

• Page 1: Please clarify what species is meant by "delicious raspberry"

Response: Scientific names for all species is provided in the plant and seed schedules, including delicious raspberry.

• Page 1: Species under FAC-FACW: more diversity and alternative species are requested and needed considering the limitations of the plants on the market.

Response: The native species on the plant lists are the major dominant and associative plants for watershed. These are the staple species that are known to work and have been commonly available in the market. There are some species such as cottonwood and sandbar willow that the dominant species for which no substitution should be made. Adding in additional, lesser known diversity species is counter to the comments about availability. Ecos basis of design report thoroughly documents potential species. Those species that were determined to be the best and most hardy were placed on the plant schedules.

• Page 1: FACW-OBL: we have concerns about the availability of these species, if these species are unavailable, please provide back-up species.

Response: Once a plant order is ready to be made, substitutions or the interchange plants on the plant schedules can be made. Additionally, a contract grow arrangement can satisfy concerns about availability. Notes on which species can be swapped out have been added to the plant schedules.

• Page 1: OBL: elk sedge is upland species and small-wing sedge is a FACU species.

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Response: Elk sedge has been removed from the plant schedules.

• Page 1: Review bankfull depth, and the transitional elevations between zones. Check for consistency with Detail Sheet 2 of the Plan and Profile, specifically with regard to the bankfull depth and bankfull width.

Response: Ecos used the latest, available stream cross-section provided by Otak to develop the Typical Riparian Plant Community Cross-section, including development of planting zone guidelines relative to sustaining water surface elevation. Plant zonation is based on base-flow water surface elevation not bank full. Zonation and elevations provided on the planting cross-section are guidelines. Species will overlap in transitional areas. Precise location of plants must be made in the field.

• Page 1: Note 1: We recommend zone-specific seeding plans to avoid wasted seed.

Response: Seed is inexpensive. It is also not a best practice to locate niche specific seed. If the hydrology or micro-habitat is not favorable then nothing will grow. It's better to hedge your bets and use a broad spectrum mix to ensure that something grows based on the actual hydrology, soil moisture and micro conditions. There are few wetland species in the seed mix that would escalate the expense of the seed mix. To accommodate the concern for wasting seed, ecos dropped the number of seeds per square foot from 150 to 100 in the latest plans provide to Lynker on 6/22/16. Note, that the ecos seed mixes are consistent with the AECOM seed mixes which specify 150 seed per square foot.

• Page 1: Note 3: Please clarify intent of this note.

Response: This note was provided to indicate that upland and wetland plants may be found across the entire floodplain. For instance Baltic rush or sandbar willow, although are technically considered OBL and FACW wetland plants, they are often found in upland areas. Conversely, UPL or FAC plants like snowberry and narrowleaf cottonwood can be found in wetland areas.

• Page 1: Allocate the seed mix and seed specifications by planning zones and hydrologic characteristics shown on the planting plan (Zone, 2, 3,1).

Response: Allocation of seed by zone has been addressed in the comments above.

• Page2: No planting schedule provided, please include percentages, sizes, spacing, installation methods, timing windows and planting depths.

Response: Plant and seed schedules were provided, but may have been accidentally not provided during the submittal. Revised Plant and Seed Schedules are attached to the final delivery.

• Page 2: Review the above specified planting depths with the soil callouts on the structural design sheets.

Response: Comments on plant zonation, not planting depth are provided by Ecos in a separate attachment.

• Page2: There are several species that are listed in bold text in the list? Is there significance assigned to this?

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Response: Bold text indicates species that are dominant by percentage.

• Page2: Can the companion crop be eliminated if the seeding is timed for ideal germination?

Response: Companion crop can be eliminated if seeding is timed correctly. However, a sterile companion crop does no harm and actually provides other benefits besides immediate cover, including additional root holding capacity, additional organic matter, and competition with weeds.

• Page 3: Allocate these by planning zones and hydrologic characteristics shown on the planting plan (Zone, 2, 3,1).

Response: The comment about "Page 3: Allocate these by planning zones…" is unclear. It is assumed this pertains to seed zones which are addressed in the above comments.

Additional Comments

• Recommend coordinating with the Boulder County Team to standardize design details across the James Creek reaches.

• We appreciate the use of setback riprap.

• We appreciate the use of split flow jam features and look forward to monitoring how they perform. It should be noted that with the sediment loads in the creeks, it is possible that one of the flow paths may trap sediment and aggrade but that this shouldn't be considered a failure of the design or construction unless otherwise observed.

Response: Thank you: a key aspect of the design is the inclusion of the overflows to store sediment and restore the function of the floodplain pocket.

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TECH MEMO

June 30, 2016

RE: FINAL JAMES CREEK DESIGN COMMENTS

Ecosystem Services, LLC (ecos) reviewed the draft 60% revegetation plans for James Creek Reach 17 and 21 prepared by the AECOM team and provided additional follow-up comments and clarification on approach for the draft 30% revegetation plans for Reach 16 prepared by the Lynker Team to help bring these two sets of plans in to sync moving forward. Initial comments were provided to Lynker on June 10. Additional comments and edits (shown in red type) were provided to Lynker on June 15. On June 22nd, ecos provided final 30% planting plans to Lynker just prior to receiving DOLA comments. In response to the Design Review for James Creek Reach 16 Memo provided by DOLA, ecos is providing the following additional responses (in blue type) as well as revised planting plans.

1. Plant size and form: The Lynker/ecos revegetation plans and schedules call for smaller and more material in order to improve availability, feasibility of meeting the timeline of the project, and spreading project plant material costs over a broader area. Larger material will increase cost, may not be available in timely manner, and will not go as far with the project dollars. Additionally, until plant material has established it will be susceptible to washout should high, scouring flows occur. If lost, the larger plant material would cost more to replace and install.

2. Plant density: Converting the AECOM plants per acre, the proposed density is ~6' on center (o.c.) in Zones A and B (Channel Edge and Lower Riparian) and ~13' o.c. in Zone C (Upper Riparian). Lynker/ecos plans call for 1' o.c. in Zone 1 (Wetland Zone), 3' o.c. in Zone 2 (Lower Riparian), 6' o.c. in Zone 3 (Upper Riparian). Lynker/ecos density recognizes that some plant material may be lost to attrition, competition, and other environmental factors including variations in micro-topography and soil moisture. Ecos suggests that AECOM increase density to match the Lynker/ecos density.

3. Plant Cover: In Zones 1 and 2 (Wetland and Lower Riparian) the Lynker/ecos team proposes 100% absolute cover of shrubs. Some herbaceous cover is also expected in Zones 1 and 2 until such time as the shrubs fill in. Pockets of herbaceous plants are also expected if/when some shrubs do not survive. In Zone 3 (Upper Riparian) the Lynker/ecos team proposes 40% absolute cover of trees and shrubs and 100% herbaceous cover in the understory. Some bare pockets/patches should be expected. For consideration, should the AECOM and Lynker target plant cover percentage be made consistent across all reaches?

4. Plant acquisition and availability: The question came about as to whether or not the species and quantities of seed and plants on the plant schedules would be available in a timely manner. The decision was made to create a substitution list for species that were unavailable once the plant acquisition phase of the project is initiated. Lynker/ecos has included numerous species in the plant schedules to add diversity which the AECOM plans do not include. Lynker/ecos plans to use these "diversity species" as the substitute/back-up list to compensate for any plants that may not be found once nursery suppliers are contacted. Other species such as willow and cottonwood are core species for which there are no substitutes. Lynker/ecos will call out the differences between substitute species and core species by zone.

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Some species included for diversity and wildlife habitat may drop off the list completely as a result of not being available or those that will be too slow to be grown by a nursery in time for the planting.

It is our understanding that volunteer labor to harvest or install plants cannot be used under these grants.

5. Off-site plant collection and harvesting: It has been suggested that the teams collect and harvest plants to obtain the species and quantities outlined on the plant schedules. Plant collection and harvesting of plant material in the species and quantities needed will be a logistical and timing challenge, as well as cost prohibitive. Additionally, identification of sites and collection of species from Boulder County open space or private lands to meet the project requirements will be a timing issue, and may produce questionable/ inconsistent quality of plant material. It should be noted that volunteer labor cannot be used due to grant limitations and Davis Bacon wage requirements. The Otak/ecos team tried to get Wildland Restoration Volunteers involved with the St. Vrain restoration project in Lyons and were blocked by grant funding restrictions. As such, Lynker/ecos suggests that nursery grown material (available now or under a contract grow) is the most feasible and consistent source. If open space lands or private lands are made available to the nurseries to collect, that may be a viable option to control quality.

6. On-site transplanting: The Lynker/ecos team recommends that native plants that are currently present on-site that will otherwise be destroyed during grading operations should be transplanted under the direction of the supervising ecologist in the field.

7. Plant species and diversity: The Lynker/ecos team suggests that container stock should be added to the AECOM plant schedules to simplify and make plant orders consistent across all reaches.

8. Seed species – The AECOM and Lynker/ecos seed mixes will be synchronized so that the species proposed are consistent across all reaches. Due to availability and potential to introduce the wrong species or sub-species Wheeler bluegrass will be deleted as per Boulder County request. Boulder County suggested prairie cordgrass in Reach 16 only, but not in higher/upstream reaches. Due to expense and to make the seed mixes consistent, the Lynker/ecos team recommend removing this species from the list.

9. Seeding locations – The cost of seed is marginal compared to other major project components (i.e., earthwork, rock work, etc.). Acknowledging the merit of separating the seed mixes between wetland and upland to avoid placing expensive wetland seed in uplands and upland seed in wetlands, it will be important to have some upland species in the wetland seed mix and wetland species in the upland mix in order to ensure a diverse cross-section/ broad-spectrum of species are available for germination depending on soil moisture (xeric, mesic, hydric), texture, and micro-variations on topography. There is not a significant number of wetland species in the single Lynker/ecos mix currently proposed. We maintain that the use of 1 mix throughout the floodplain is a conservative (and industry standard) approach that will yield best results given variable site conditions in the floodplain. Wetland diversity will come from the planting of herbaceous plugs. A separate mix, without wetland species, is appropriate for purely upland areas/road side-slopes.

10. Upland Seeding – It is unclear if the stream restoration plans are to include seeding of steep, road-side slopes associated with the highway improvements. If so, was it contemplated that only those sections related to the proposed improvements/wall/revetments should be addressed or the entire length of each reach.

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Herbaceous cover on the road side-slopes following emergency seeding could use some enhancement. The Lynker/ecos team suggests reseeding and hydromulching thee entire length of each project reach. Any comments/clarifications from the entire team are welcome on this topic.

11. Temporary irrigation: None is proposed. The cost of installing a temporary system or hand watering will exceed the cost of the plant material and project budget. Difficult terrain and the propensity/risk of an irrigation system to be washed out are high. After initial watering at installation, stream hydrology and precipitation should be considered as the source of sustaining water. Lynker/ecos team plant density (as discussed above) accounts for some mortality. Wetland (Zone 1) will be within 1' of sustaining water/capillary fringe. Lower riparian/willow (Zone 2) will be within 2' of sustaining water/ capillary fringe. Upper riparian/cottonwood (Zone 3) will be within 2-4' of sustaining water/ capillary fringe. To ameliorate or mitigate for the lack of a temporary irrigation system, as the construction/planting implementation schedule and access and logistics dictate, the Lynker/ecos team recommends that planting should start in the Zone 3 and work downward to Zone 2 and then Zone 1 as run-off recedes to take advantage of higher ground water/subsurface interflow. Excluding true upland vegetation, upper riparian vegetation can also be deep planted (depending on the height of above ground plant parts) to insert the root ball in closer proximity to the subsurface interflow/capillary fringe. Upper plant heights of the riparian vegetation (out of the tubes) is expected to be 1.5 to 2.0 feet. Deep planting will allow this material to be inserted approx. 1' closer to the water table.

12. Weed management: Numerous weeds (noxious and otherwise) are present, including but not limited to spurge and thistle. Many more are likely to emerge as the soil/alluvium is graded and exposed. The Lynker/ecos team recommends not using forbs at this time as these species will not survive broadleaf chemical controls. For this reason, ecos has not included forbs in the seed mix and has removed reference to them in the typical riparian plant community cross-section. Mechanical controls or hand-pulling are not feasible due to the scale of the project and are ineffective on some weeds. Forbs could be inter-seeded later within the grasses once the weeds are under control.

13. Toe Treatment – Prior to the DOLA comments, the Lynker/ecos team has developed a typical wrapped soil lift detail for the final 30% design submittal for those portions of the project that are confined/steep yet require a toe treatment. These areas are identified on the Lynker/ecos plans and plant schedules as Lower Riparian – Toe Treatment (Zone 2).

14. Soil development – The Lynker/ecos strategy for soil development is outlined in the basis of design report. In summary, in order to avoid costly import of soil placed in the floodplain that could be lost via the next flood, we are recommending soil development via natural processes kick-started with compost and other amendments. This strategy includes roughening the floodplain with variable micro-topography and a high density of vegetation that provides sites for fine and course woody debris, sediment and leaf litter to drop, decompose, and bio-accumulate organic matter/carbon over time. Imported soil is also likely to import weeds and other inappropriate species. Suitable soils with appropriate composition/texture are also not likely to be obtainable in sufficient quantities and will be very costly to import. It is also likely that imported soil would have to be amended. Weed free soil is not a reality in the market place.

15. Compost and amendments – The Lynker/ecos team suggests utilizing Class 1 compost (100 CY/AC minimum), and also adding in straw (2000 LBS/AC minimum) for more carbon and to improve soil moisture;

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as well as mychorrizae (20 LBS/AC minimum), and humate (250 LBS/AC minimum) supplements to further activate the soil. Exact specifications and application rates will be developed in subsequent design phases for Reach 16. Depending on the results of soil testing, the amended soil may also need to be supplemented with macro- and micro-nutrients. The Lynker/ecos team provided a chart in our basis of design report to help compare deficient soil with an optimal soil.

16. Plans, Details, Notes and Specifications – If selected as an EWP subcontractor in subsequent phases, the Lynker/ecos team will further manage, develop plans, details, notes and specifications to take the 30% design to a design-build level. Although out of scope and not required as part of the 30% Design Guidelines, ecos has provided performance notes and requirements (Sheets N1 – N3).

Response to DOLA Comments:

- Reference to forbs in the Typical Riparian Plant Community Cross-section had been removed for the reasons discussed above.
- An explanation regarding Lower Riparian Toe Treatment is provided above.
- Ecos is not sure how a categorical statement about the availability of plants on the market can be made at this point in time, considering that a contract grow arrangement can be made to supply this project. Other comments on plant availability and contract grow are provided above.
- Scientific names for all species is provided in the plant and seed schedules, including delicious raspberry.
- The native species on the plant lists are the major dominant and associative plants for watershed. These are the staple species that are known to work and have been commonly available in the market. There are some species such as cottonwood and sandbar willow that the dominant species for which no substitution should be made. Adding in additional, lesser known diversity species is counter to the comments about availability. Ecos basis of design report thoroughly documents potential species. Those species that were determined to be the best and most hardy were placed on the plant schedules.
- Once a plant order is ready to be made, substitutions or the interchange plants on the plant schedules can be made. Additionally, a contract grow arrangement can satisfy concerns about availability. Notes on which species can be swapped out have been added to the plant schedules.
- Elk sedge has been removed from the plant schedules.
- Ecos used the latest, available stream cross-section provided by Otak to develop the Typical Riparian Plant Community Cross-section, including development of planting zone guidelines relative to sustaining water surface elevation. Plant zonation is based on base-flow water surface elevation not bank full. Zonation and elevations provided on the planting cross-section are guidelines. Species will overlap in transitional areas. Precise location of plants must be made in the field.
- Seed is inexpensive. It is also not a best practice to locate niche specific seed. If the hydrology or micro-habitat is not favorable then nothing will grow. It's better to hedge your bets and use a broad spectrum mix to ensure that something grows based on the actual hydrology, soil moisture and micro conditions. There are few wetland species in the seed mix that would escalate the expense of the seed mix. To accommodate the concern for wasting seed, ecos dropped the number of seeds per square foot from 150 to 100 in the latest plans provide to Lynker on 6/22/16. Note, that the ecos seed mixes are consistent with the AECOM seed mixes which specify 150 seed per square foot.
- Note 3 on Sheet D1, Typical Riparian Plant Community Cross-section has been modified as follows: 3. Upland species may be found and located in wetland areas, and conversely wetland species in upland areas depending

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on field conditions established during grading operations. Plant zonation shown is a general guideline. Transition or extension of species between zones may vary depending on actual field conditions, slope, hydrology, micro-habitat, soil texture and moisture conditions. The ecologist overseeing planting operations must make discretionary calls on plant locations considering that overflow swales include Zone 1(A) wetland plant materials that may extend up into Zone 2(B). Zone 2(B) plant materials may extend down into Zone 1(A). Zone 3(C) plants may extend in to zone 2(B).

This note was provided to indicate that upland and wetland plants may be found across the entire floodplain. For instance Baltic rush or sandbar willow, although are technically considered OBL and FACW wetland plants, they are often found in upland areas. Conversely, UPL or FAC plants like snowberry and narrowleaf cottonwood can be found in wetland areas.

A revised Sheet D1, Typical Riparian Plant Community Cross-section is attached.

- Allocation of seed by zone has been addressed in the comments above.
- Plant and seed schedules were provided, but may have been accidentally not provided during the submittal. Revised Plant and Seed Schedules are attached.
- Comments on plant zonation, not planting depth are provided above.
- Bold text indicates species that are dominant by percentage.
- Companion crop can be eliminated if seeding is timed correctly. However, a sterile companion crop does no harm and actually provides other benefits besides immediate cover, including additional root holding capacity, additional organic matter, and competition with weeds.
- The comment about "Page 3: Allocate these by planning zones..." is unclear. It is assumed this pertains to seed zones which are addressed in the above comments.

Ecos has provide the attached revised planting plan, details, notes and schedules to this memo in accordance with the 30 % Design Guidelines thereby finalizing the 30% planting plans for Reach 16.

Ecosystem Services, LLC

Jon Dauzvardis, P.W.S.
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