ATTACHMENT 3

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# TECHNICAL MEMORANDUM

**To:** Sean VonRoenn
East Rio Blanco Metropolitan Parks and Recreation District
101 Ute Road
Meeker, Colorado 81641

**From:** David Bidelspach, P.E., and Noah Greenberg

**Date:** November 11, 2020

**Re:** **White River at Circle Park—Fluvial Assessment and Design Considerations (Revised Draft)**

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SWCA Environmental Consultants (SWCA) has prepared this memorandum to summarize the results of a fluvial geomorphological assessment and conceptual river improvement design for the White River at Circle Park in the Town of Meeker. This work was directed and supervised by David Bidelspach, P.E., of 5 Smooth Stones Restoration (5SSR), working as a subconsultant to SWCA.

## BACKGROUND AND OBJECTIVES

SWCA was engaged by the East Rio Blanco Metropolitan Parks and Recreation District (ERBM), with support from the Town of Meeker (Town), to develop a landscape design for Circle Park. The existing conditions at Circle Park include an approximately 290-linear-foot-long reach of instable river bank that consists of turf grass with incised banks that are prone to erosion. Preliminary observations of these banks indicated that the river bank instability is a result of a disequilibrium of the White River at this location—the channel is overly wide, resulting in deposition of sediment within the primary flow conveyance of the channel and displacement of erosive forces to the perimeter of the channel.

Because instable river banks will compromise the resilience of any landscape design for Circle Park, SWCA's scope of work includes a fluvial geomorphological assessment for this reach of the White River and development of a conceptual design to mitigate bank erosion and promote overall river health. It should be noted that additional engineering design and permitting will be required prior to the implementation of any in-channel improvements. The goal of the conceptual river improvement design is to provide ERBM and the Town with a recommended approach for mitigating bank instability and to facilitate development of a landscape design that is compatible (and hopefully synergistic) with the expected river improvements.

SWCA understands that the Town and ERBM goals and constraints for potential White River improvements at this location include the following:

- Ice dam formation and associated flooding is an ongoing issue along this reach of river, resulting in property damage.

- The river corridor includes other areas with instable banks that have the potential to damage property.
- While there is interest in promoting river health, there is not an appetite for projects that are focused on creating whitewater boating features (e.g., wave features).
- River improvements should be focused on achieving bank stability and healthy river function while minimizing construction impacts and costs.

Based on these goals and constraints, SWCA's assessment and design are focused on achieving the following objectives:

1. Using a combination of field and desktop methods, identify the river processes that are responsible for the existing bank instability.
2. Develop a river design that prioritizes the following attributes:
    a. Promotes stable channel conditions in the White River through Circle Park.
    b. Is compatible with Circle Park landscape design and intended uses.
    c. Has neutral or positive impacts on the 100-year flood elevation.
    d. Has neutral or positive impacts on the formation of ice dams and associated flooding.
    e. Uses bioengineering approaches to achieve the desired river condition with a minimal footprint.

The following sections of this memorandum provide additional details and considerations regarding this evaluation and design process.

## FLUVIAL ASSESSMENT

The fluvial assessment of the White River through Circle Park consisted of desktop and field studies conducted February through May 2020. Throughout the remainder of this memorandum, reference will be made to various river features that are depicted in Figure 1.

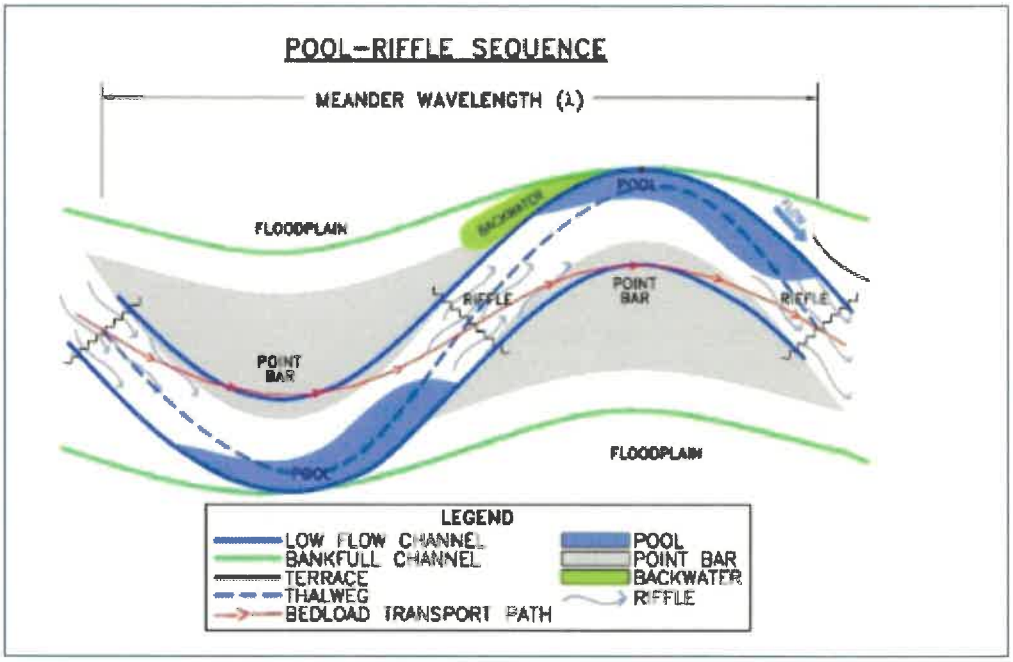


**Figure 1. Typical riffle-pool sequence with common feature terms.**

## Desktop Assessment

The desktop assessment included an evaluation of the White River hydrology and planar geomorphic characteristics (e.g., sinuosity, channel width, etc.). Notable observations include the following:

Conditions in Upstream/Downstream Reaches that Provide Typical Reference Conditions

- The White River below Meeker is a pool-riffle system with a relatively uniform bed slope of about 0.0048ft/ft.
- Based on the distance between fresh sandy depositional bars on Google Earth aerial photography, an approximately 600-foot spacing currently exists between pools in the river upstream and downstream.
- Downstream of 10th Street, the low flow channel has widths of roughly 75 feet, with bankfull widths of roughly 100 feet.
- Based on 2014 aerial photography, the channel has widened by a minimum of 13 feet to a maximum of 20 feet over 20 years, indicating approximately 1foot of bank erosion per year. Although not overly concerning, the channel should be stabilized from a park and fishery standpoint.

Conditions Observed in White River at/near Circle Park

- When compared with downstream reference reaches, the river channel appears over-widened:
    - At 3rd Street, the bankfull width is approximately 125 feet based on aerial photography.
    - At Town/Circle Park, the bankfull width appears to be about 105 feet, with a mid-channel bar downstream of 5th street.
- Based on initial assessment and not survey, the river's natural condition is presumed to consist of a channel width of approximately 90 feet but has been over-widened to 125 feet. The existing

pool-to-pool spacing is appropriate for the smaller widths observed downstream of the Town but is not consistent with the channel widths observed at Circle Park.

### Field Survey and Associated Assessment

The field survey and associated assessment included a focused topographic survey of the channel bottom and surrounding terrain, an analysis of the channel cross sectional area, calculation of channel width-to-depth ratios, and other field-based observations. Notable aspects of this evaluation, including methods and findings, include the following:

- Topographic field surveys were performed for:
  - Three channel cross sections (i.e., perpendicular to stream).
    - Two cross sections surveyed upstream of the Circle Park bridge.
    - One cross section surveyed downstream of the bridge closer to a run (transition from riffle before meeting a pool).
  - A 1,600-foot-long reach of the river beginning near 3rd Street and extending past Circle Park roughly 200 feet. Along this reach, the ground surface elevation of the thalweg (deepest parts of the river) was surveyed.
- Surveyed results show a pool-to-pool spacing of 460 to 630 feet, which was verified by aerial analysis.
- Cross section 2 (just upstream of the bridge) was the best riffle cross section identified. A clear bankfull stage could not be identified from this cross section because both banks had been manipulated. The other two channel cross sections showed bankfull cross-sectional areas of approximately 500 square feet.
  - The existing channel cross-sectional area (i.e., 500 square feet) provides a basis for design of a channel that will allow similar flow conveyance as is currently present.
- Current channel width-to-depth ratios on this reach range from 34 (near 3rd Street) to 38 (downstream of Circle Park).
  - Although smaller width-to-depth ratios would be preferred for this reach (e.g., a ratio of roughly 20), the transitions in the reach will not support smaller width-to-depth ratios.
- The overly wide channel is likely resulting in shallow water during winter months, which can result in adverse frazzle ice buildup.

## FLUVIAL DESIGN

SWCA developed a conceptual fluvial geomorphologic design for the White River at Circle Park that is consistent with the assessment findings and our understanding of the goals for this effort. For graphical representations of the conceptual channel design, please refer to the landscape design for Circle Park. The following summarizes key aspects of this design concept.

- The basis of design includes a targeted 450-square-foot design cross-sectional area (90% of the existing cross-sectional area). The design focus is on pool-to-pool spacing and promoting development of a narrower and steeper channel.
  - A 450-square-foot cross-sectional area represents a design discharge of 2,800 cubic feet per second (cfs) and a flood return interval of 1.6 years, which is generally consistent with a typical bankfull channel capacity of 1.5- to 2.0-year recurrence.

    - In-channel structures would be designed to handle a 100-year discharge and the corresponding shear force applied at bankfull discharge and to the 100-year discharge.

- To promote the concentration of low flows (and associated desirable sediment flushing, a two-stage channel is proposed:
    - An inner berm channel (a low flow channel), and
    - A bankfull channel (occupied only during high flow) that is stabilized using revegetation transplants.
- The establishment of two deep pools and narrow riffles with an inner berm bench for low flow, totaling approximately 800 feet in length, are to be excavated to promote bank stability and fish habitat enhancement. This approach will help mitigate conditions that lead to frazzle ice formation and will promote conditions that are favorable for shelf ice formation, preventing water from freezing along the channel bed.
- Two boulder J-hook structures are proposed just downstream of the Circle Park bridge. The J-hook structures will tie into the river bank and extend across the channel. Note that much of these structures will be below water or buried in the alluvial sediment. These structures will help to centralize flows coming out from the bridge and create beneficial scour holes downstream of the hooks. Bridge piers constrict the channel to be to about 90 feet wide.
    - The upper J-hook arm on the south riverbank (i.e., at Circle Park) will be situated with the American with Disabilities Act (ADA) access ramp.
- Toe wood structures are proposed in the banks for fishery habitat improvements and taking transplants from the existing bar to build up the banks.
- The design would lower the existing bed slightly, and a bed slope of approximately 0.005 feet/feet would be achieved at tie-in. The bankfull maximum riffle depth would also increase slightly allowing for sediment to move through the reach more efficiently.
    - This narrower and steeper channel would have more specific energy to clear ice through the area than is provided by the current channel configuration.
- A large mid-channel bar downstream of the bridge is to be cut out, and a pool is to be created in the area.
    - A secondary benefit of this is the potential to lower the 100-year base flood elevation by as much as 0.05 feet downstream of the 5th Street bridge at Circle Park.

Figure 2 shows the design channel cross section (green) and the existing channel cross section (red). The bankfull area differences are roughly balanced.

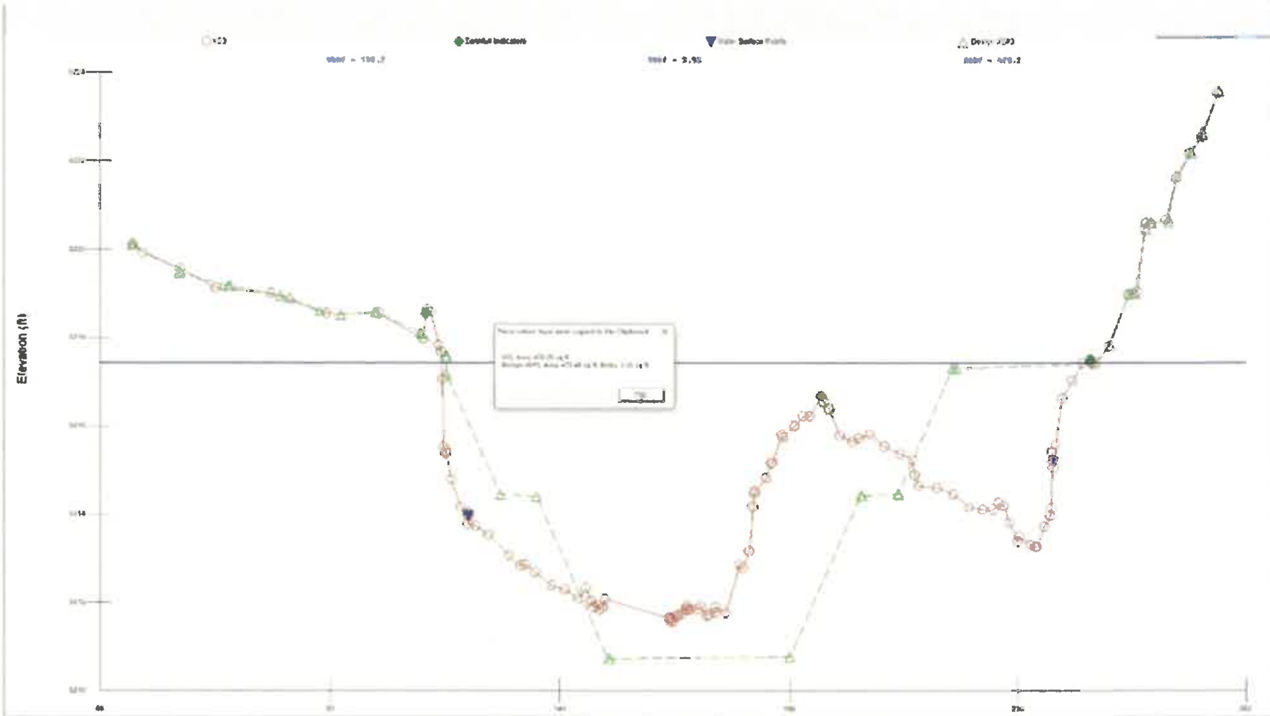


**Figure 2. Existing and design channel cross sections.**

## Bank Stabilization Alternative—Avoidance of In-Channel Structures

Following the July Town Board meeting, SWCA was asked to develop an alternative to in-channel work in the White River. An approach that would provide bank stabilization without in-channel structures could include installation of soil-lifts that consist of a bioengineered approach to stabilize the channel banks without modifying fluvial geomorphologic processes in the channel. Figure 3 provides a typical diagram for this bank stabilization approach.

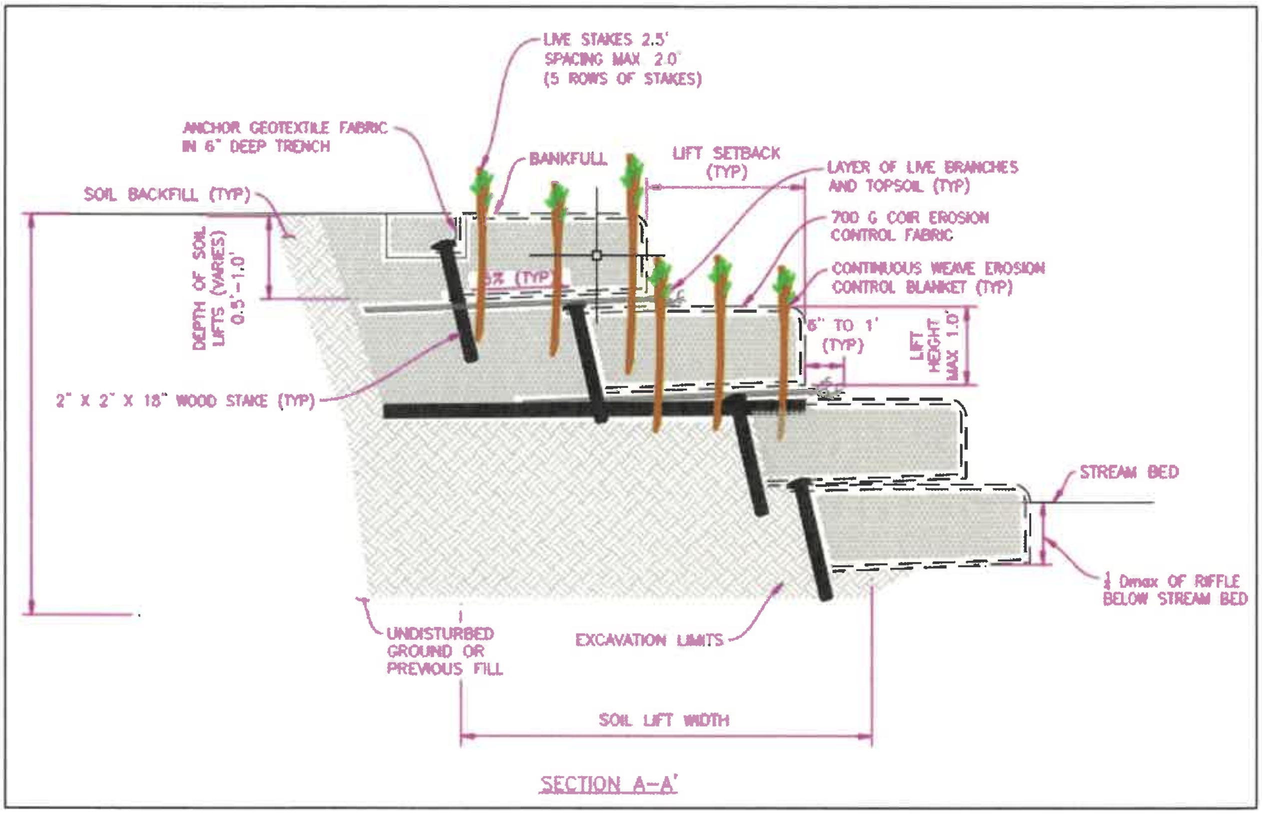


**Figure 3. Soil lift bank stabilization.**

Details Pertaining to Soil Lift Preparation and Installation

Soil lifts are constructed by placing soil on top of a portion of two horizontal geotextile fabrics. The reinforcement of the soil is provided by the outer geotextile fabric woven into a strong mesh of high tensile strength. After the soil is compacted, the remaining fabric is wrapped over the front and top of the soil mass and the lifts are staked in place and built on top of each other as shown in the diagram below. The lifts are about 1 foot thick. The live stakes from willows hold the soil lifts together. Furthermore, the soil lifts need to be lightly compacted and both neatly and tightly wrapped to prevent drag forces on loose fabric from high-flow events.

Recommended Changes from the Hydraulic Letter Soil Lift Detail at Town Park

SWCA reviewed the hydraulic analysis letter prepared by JVA Inc. (JVA) for Town Park and recommends considering changes as outlined below. For bank stabilization, JVA indicated that as the fabric wrapping the soil mass is permanent, there is low concern with needing vegetation establishment to help provide bank stabilization. The proposed change would include live willow stakes as the soil lifts are being put in place to help provide bank stabilization.

JVA also indicated the soil lifts will be set at a 1:1 slope, resulting in approximately 900 cubic yards of existing bank material removed for soil lift installation. The proposed change would be to have a side slope of 3:1 during installation, resulting in a safer, more sustainable river bank slope.

Costs per Linear Foot for Treatment Alternative

For a typical cross section at Circle Park (see Figure 4 below), the bank stabilization approach will require six soil lifts.

- The cost for this treatment is $25 per linear foot per lift (or a total of $150 per linear foot for the cross section depicted in Figure 4)
- The total length of the bank is 400 linear feet

The total estimated cost for installing bioengineering soil lifts at Circle Park is roughly $60,000, not including access ramps, fencing, permitting, or other appurtenant improvements.

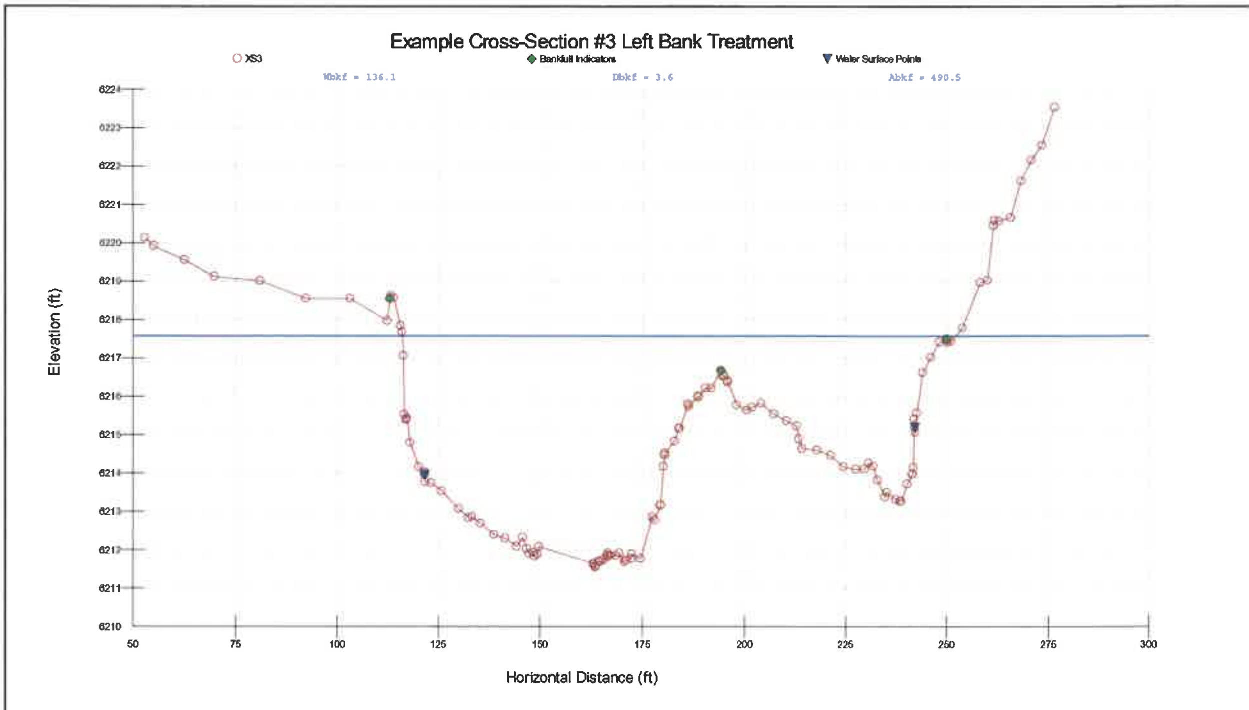


**Figure 4. Typical cross-section at Circle Park where soil lifts would be installed.**

Pros and Cons and Long-Term Stability of this Treatment Alternative

Pros associated with a soil-lift approach include likely lower cost (compared with channel work), easier permitting, and a lower risk of changing the floodplain (either favorably or adversely relative to other properties). In addition, the stair steps provide access and a good place for vegetation to establish.

Cons associated with a soil-lift approach include lower level of environmental enhancement, less resilience to flood damage, and less opportunity to mitigate the development of frazzle ice. Although long-term stability will be adequate on the southern left bank, as the mid-channel bar grows, faster water will be pushed toward both banks, and the potential for erosion and bank migration on the north bank will increase without the removal of the mid-channel bar.

An additional consideration is that there would be roughly 20 horizontal feet of park bank loss with the construction of 3:1 side slope because soil lifts cannot be used as fill in the active river channel. The soil-lift stabilization approach is expected to have an approximate life-span of 25 years, with maintenance expected following high-flow events and to manage vegetation.

Other Alternatives Considered

If the Town wanted to include toe boulders in combination with soil lifts, this approach would cost roughly $70,000 for Circle Park and would be more difficult to permit. Additionally, if erosion occurs behind a boulder toe, the boulders can encourage bank migration and instability.

SWCA also considered the potential to merely use riprap along this bank, with approximately 18- to 24-inch rock. This approach would not be visually appealing at the park and would require a minimum depth of 3 feet for stabilization. At a cost of roughly $125 per ton, a riprap stabilization approach would cost approximately $100,000 and be challenging from a Clean Water Act Section 404 permitting perspective.

# ICE JAM ANALYSIS AND CONSIDERATIONS

Ice jam formation is known to cause flooding issues in the White River in Rio Blanco County. Based on anecdotal observations shared with SWCA, ice jams form downstream (near Rangely) and move upstream to Meeker. In addition to these personal accounts of ice jam issues on this reach of the White River, the report *Ice Considerations in the Design of Modern In-Stream Structures* (Tuthill et al. 2006) evaluated the potential for stream structures to contribute to ice jam formation, including a case study of a recently constructed diversion weir on the White River which resulted in ice jam formation.

SWCA conducted an initial evaluation of the White River relative to the observed ice jams in the White River drainageway through the Town. For the purposes of this evaluation and relative to our conceptual river enhancement design, ice jam formations are a result of two processes: 1) frazil ice formation, and 2) frazil ice deposition and ice jam formation. Our observations regarding these processes and the proposed river enhancement design concept are summarized in the following sections.

## Frazil Ice Formation

The formation of frazil ice is a preliminary step in the development of an ice jam. This section provides a summary of existing and proposed design conditions relative to frazil ice formation. A report from the U.S. Bureau of Reclamation states that frazil ice formation is dependent on turbulence and suggests that frazil ice production is most evident in the vicinity of rapids (Hayes 1974. Rapids are places in the river where the bed slope is higher, causing significant rise in water velocity and turbulence. In pools, the bed slopes are flatter than in rapids and corresponding velocity is lower.

### *Existing Conditions*

SWCA observed that this reach of the White River, including upstream segments, has significantly wider channel areas with greater surface area to volume ratios, which can promote formation of frazil ice during winter weather. A published investigation evaluated frazil ice formation in riffle-pool sequences as a result of supercooling of turbulent open water (Tuthill 2008). These observations suggest that potential river enhancement designs should strive to reduce the surface area to volume ratio in the project reach at base flow conditions.

### *Proposed Conceptual Enhancement Design*

SWCA's proposed enhancement design, consisting of cross-channel J-hook weir structures, would result in a lower surface area to volume ratio under low- and baseflow conditions. This will be achieved by concentrating low flows into a central portion of the drainageway, thereby minimizing the amount of low-flow spreading that currently occurs.

SWCA's proposed enhancement design includes a typical drainageway cross sectional area of 500 square feet. At a design flow rate of 3,000 cfs, the resulting flow velocity in this reach will be 6 feet per second, significantly higher than the lower threshold for thermal ice growth. Furthermore, bankfull velocities through the channel in this area with the design are expected to be in the range of 4 to 5 feet per second, which is well above the threshold for thermal ice growth. During very low flow conditions, flow velocities below 1 foot per second may be observed, however these slow velocities will be mitigated using a low-flow inner-berm channel to increase low flow velocities. Of note is that the current low-flow channel width is about 4 times greater than the proposed low flow inner berm width.

## Frazil Ice Deposition and Ice Jam Formation

The frazil ice may travel long distances downstream in the water column until surface concentration exceeds conveyance capacity of the channel or channel obstructions are encountered (including sharp bends, channel constrictions, or human-made structures), whereupon frazil ice sheets will deposit to form an ice jam cover. The ice jam cover can spread out of riverbanks to flood fields and other property (Tuthill 2008). Additionally, the ice jam can travel great distances upstream from the origination.

### *Existing Conditions*

SWCA understands that ice jams are known to form downstream and then travel upriver to Meeker. Relative to ice jam formation downstream, it is unlikely that the proposed enhancement will have any effect (positive or negative) on formation frequency or duration. However, the construction of instream structures in the White River at Meeker does have the potential to promote or retard ice jam formation in this reach, to the extent that this is an issue (either presently or in the future). In particular, instream structures which create protuberances or shallow areas that are prone to frazil ice entrapment are discouraged. This concern is addressed by reviewed literature (Tuthill 2008; Tuthill et al. 2006) and is considered in SWCA's proposed design approach.

### *Proposed Conceptual Enhancement Design*

SWCA's proposed enhancement design includes construction of cross-channel J-hook weir structures that would have a thalweg invert that is flush with the upstream channel bottom. As a result, when water flows downstream it should not encounter protrusion of the cross-channel structure above the bed of the channel. Additionally, the proposed locations avoid sharp river bends and channel expansion and contraction ratios are kept to 10:1, both of which should help the design pass frazil ice.

## Frazil Ice Analysis Summary

In summary, SWCA expects to not have boulders with a high protrusion height above the channel bed, and the majority of the work is to be focused on modifying channel conditions for flows corresponding to bankfull and 2-year discharge. The corresponding modifications include producing a channel with a narrow width to depth ratio. The flows above the 5-year storm event are not expected to change significantly. As a result, ice formation would still be visible, but these conditions would not be worsened from SWCA's design. SWCA recommends that final design follow the preliminary guidance for river restoration structures provided by Tuthill (2008), namely focusing on providing critical water velocities and frazil ice passage. It should be noted that frazil ice formation and ice jam formation are subject to a wide range of variables, some of which may be outside the scope of our analysis or which are feasibly addressed by localized channel enhancement projects.

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