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Technical Memorandum
Yule Creek Functional Assessment

Date: March 22, 2021

To: U.S. Army Corps of Engineers
Grand Junction Regulatory Office (Sacramento District)

From: Ecological Resource Consultants, Inc.

Project: **Yule Creek Functional Assessment, Yule Creek Mitigation, Marble, Gunnison County, CO (U.S. Army Corps of Engineers Project Number: SPK-2019-00889)**

On behalf of Greg Lewicki and Associates and Colorado Stone Quarries, Inc. (applicant), Ecological Resource Consultants, Inc. (ERC) has completed a Functional Assessment of Yule Creek using the Colorado Stream Quantification Tool (CSQT, Version 1.0, July 7, 2020). Per letter request dated February 18, 2021 (Request for Additional Information or RAI), the U.S. Army Corps of Engineers (Corps) is requiring a functional or condition assessment to be completed remotely, using the best available information and professional experience. During a project conference call on March 9, 2021, the Corps approved the use of the CSQT for this project. The CSQT model satisfies this requirement (Item #1 of the RAI), and this assessment addresses the functional impacts sustained by filling the western alignment of Yule Creek, provides a functional evaluation of the proposed eastern alignment Mitigation Plan (ERC 3-22-21) (Mitigation Plan), and is applicable for use for future post-construction assessments (e.g., Monitoring Plan) of Yule Creek.

The CSQT model is a spreadsheet-based estimator used to inform permitting and compensatory mitigation decisions within the Clean Water Act Section 404 program (CWA 404). The CSQT model utilizes Microsoft Excel worksheets to characterize and quantify stream ecosystem functions by assessing indicators that represent structural or compositional attributes of a stream and hydrologic processes. Parameters assessed with the model represent stream functional indicators that may be impacted by CWA 404 authorized projects and/or improvements made through restoration/mitigation activities. As such, the CSQT model was used to evaluate pre-impact (e.g., western alignment) conditions of Yule Creek as well as the post-impact (e.g., eastern alignment) mitigation scenario. The parameters assessed with the CSQT model are based on the Stream Functions Pyramid Framework (SFPF, Harman et al. 2021) which utilizes metrics within four functional categories to obtain condition scores and to estimate overall functional uplift in stream condition. The four functional categories are: hydrology and hydraulics, geomorphology, physicochemical, and biology. For Yule Creek, CSQT metrics within each category were estimated based on site knowledge, historical and current aerial photography and high-resolution drone imagery, and topographic mapping. The Corps pre-approved the use of the CSQT using modeled parameter data since field-based or empirical data could not be collected due to seasonal snowpack conditions.

Using the four SFPF categories, function based parameters and metrics were used to quantify stream condition for the western alignment and the proposed Mitigation Plan for the eastern alignment. The proposed Mitigation Plan has been contemporaneously submitted to the Corps under separate cover to

this Functional Assessment and CSQT summary. A numeric index is created by CSQT using available reference curves and site data based on the Yule Creek stream type. Yule Creek is characterized as a Rosgen Aa+ stream type (Rosgen 1996), which is very steep (>10%), well entrenched, has a low width/depth ratio, and is laterally contained by bedrock. The bedform of Yule Creek is composed of step/pool morphology with cascades, chutes, debris flows, and waterfalls. The Aa+ stream type of Yule Creek occurs in debris avalanche terrain, zones of deep deposition such as glacial tills, and bedrock landforms that are structurally controlled or influenced by faults, joints, or other structural contact zones. Yule Creek is a high energy, high gradient stream. Once the site information and reference stream reach information were selected (based on site knowledge and remote sensing data), data for each parameter and metric were inputted into the quantification tool. The function based parameters and metrics are listed by functional category, starting with Reach Hydrology and Hydraulics. Field values are derived for each metric, which represent function based parameters for each of the four SFPF functional categories. The table below provides a summary of metrics that were used for the Yule Creek CSQT model.

Table 1. Yule Creek CSQT Metrics (X = used in CSQT; NA = data not available or not applicable for Yule Creek stream type per CSQT manual).

Functional Category	Function Based Parameter	Metric	Yule Creek CSQT Use
Reach Hydrology & Hydraulics	Reach Runoff	Land Use Coefficient	X
		Concentrated Flow Points (#/1000 LF)	X
	Baseflow Dynamics	Average Velocity (fps)	NA
		Average Depth (ft)	X
	Floodplain Connectivity	Bank Height Ratio	X
		Entrenchment Ratio	X
		Percent Side Channels (%)	NA
Geomorphology	Large Woody Debris	LWD Index	NA
		No. of LWD Pieces/ 100 meters	X
	Lateral Migration	Greenline Stability Rating	NA
		Dominant BEHI/NBS	NA
		Percent Streambank Erosion (%)	X
		Percent Armoring (%)	NA
	Bed Form Diversity	Pool Spacing Ratio	NA
		Pool Depth Ratio	X
		Percent Riffle (%)	X
		Aggradation Ratio	NA
	Riparian Vegetation	Riparian Extent (%)	X
		Woody Vegetation Cover (%)	X
		Herbaceous Vegetation Cover (%)	NA
		Percent Native Cover (%)	X
Physicochemical	Temperature	Daily Maximum Temperature (^{o}C)	NA
		MWAT (^{o}C)	NA
	Dissolved Oxygen	Dissolved Oxygen Concentration (mg/L)	NA
	Nutrients	Chlorophyll α (mg/m2)	NA

Biology	Macroinvertebrates	CO MMI	NA
	Fish	Native Fish Species Richness (% of Expected)	NA
		SGCN Absent Score	NA
		Wild Trout Biomass (% Change)	NA

CSQT scores are averaged for each level of the stream function pyramid framework. Metrics are averaged to calculate parameter scores and parameter scores are then averaged to calculate category scores. All calculations are automated in the spreadsheet. The category scores are then weighted and summed to calculate overall scores. Categories are additive so a score of 1.0 is only feasible when parameters within all four categories area evaluated.

For the Yule Creek CSQT, parameters and metrics were assessed for the filled (impacted) channel (western alignment) as well as proposed Mitigation Plan (eastern alignment). Functional feet (FF) are calculated for each reach based on stream length and the existing (ECS) and proposed reach (PCS) condition scores. The change represented by the PCS or Mitigation Plan (ERC 2021) is the difference between the existing (pre-impact) and proposed (mitigation) overall scores. Functional lift is achieved when the PCS scores (mitigation) are greater than the baseline ECS (pre-impact) scores.

The Mitigation Plan was specifically developed to address non-functional and functional-at-risk CSQT metrics of the impacted channel (as well as to maintain existing functional metrics) and to replicate natural (unimpacted) reference conditions. The Mitigation Plan developed replicates a Rosgen Aa+ stream type with steep cascade-pool sequences, laterally constrained by rock, large woody debris and narrow woody dominated riparian/upland vegetation fringe among boulders, rubble and bedrock. Refer to **Photos 1-2** below for reference stream characteristics within undisturbed portions of Yule Creek.

Photo 1. View south of reference conditions of Yule Creek (Rosgen Aa+ stream) upstream of project reach showing large boulders and bedrock, and step-pool cascade sequence. Large woody debris present in photo center (Photo: 6/25/20).

Photo 2. View north of reference conditions of Yule Creek upstream of project reach, narrow (4-5 foot) riparian fringe present along left side of photo, bedrock and cascade present (Photo: 6/25/20).

Refer to **Photos 3-8** below for historic characteristics of the impacted western alignment of Yule Creek. Photos show poor channel morphology, significant erosion, very little riparian vegetation, debris/rubble within stream channel, and lack a natural cascade-pool sequence.

Photo 3. View north of the western alignment of Yule Creek (Photo: 8/30/18, pre-impact).

Photo 4. View south/southeast of the western alignment of Yule Creek (Photo: 8/30/18, pre-impact).

Photo 5. View south of the western alignment of Yule Creek (Photo: 9/18/18, pre-impact).

Photo 6. View west of the western alignment of Yule Creek (Photo: 8/30/18, pre-impact).

Photo 7. View north of the western alignment of Yule Creek (Photo: 7/12/16, pre-impact).

Photo 8. View south of the western alignment of Yule Creek (Photo: 7/12/16, pre-impact).

For Yule Creek, the overall results of the CSQT model (Quantification Tool) are summarized in **Tables 2** through **5** below. Based on the PCS condition (Mitigation Plan) scores, the proposed mitigation design for Yule Creek represents an uplift of 92.5 functional feet (FF). Implementation of the Mitigation Plan represents a functional increase over the ECS. The CSQT output worksheets are provided in **Attachment A** to this memo. Drone imagery, parameter calculations, and the impact analysis map from the Aquatic Resources Delineation (ERC 2020) are provided in **Attachment B** to this memo.

Table 2. Mitigation Summary

MITIGATION SUMMARY	
Perennial First Order Stream	
92.5	(FF) Lift

Table 3. Functional Change Summary

FUNCTIONAL CHANGE SUMMARY	
Change in Overall Condition	0.07
Existing Stream Length (ft)	1748
Proposed Stream Length (ft)	1689
Change in Stream Length (ft)	-59
Existing Functional Feet (FF)	713.2
Proposed Functional Feet (FF)	805.7
Proposed FF - Existing FF (ΔFF)	92.5
Yield (ΔFF/ Proposed LF)	0.05
ΔFF from Flow Alteration Module	
Total Proposed FF - Existing FF (ΔFF)	92.5

Table 4. Function Based Parameters Summary

FUNCTION BASED PARAMETERS SUMMARY			
Functional Category	**Function-Based Parameters**	**Existing Parameter**	**Proposed Parameter**
Reach Hydrology & Hydraulics	Reach Runoff	0.50	0.72
	Baseflow Dynamics	1.00	1.00
	Floodplain Connectivity	0.25	0.37
Geomorphology	Large Woody Debris	1.00	1.00
	Lateral Migration	1.00	1.00
	Bed Form Diversity	0.65	0.79
	Riparian Vegetation	0.49	0.76

Note: Red = Not Functioning, Yellow = Functioning At Risk, Green = Functioning

Table 5. Functional Category Report Card

FUNCTIONAL CATEGORY REPORT CARD				
Functional Category	**ECS**	**PCS**	**Change in Condition Scores**	**ΔFF**
Reach Hydrology & Hydraulics	0.58	0.70	0.12	50.5
Geomorphology	0.78	0.89	0.11	41.9

Attachment A:

- CSQT Microsoft Excel Workbook, worksheets include:
  - Project Assessment,
  - Catchment Assessment,
  - Quantification Tool; and
  - Yule Creek Field Values – this table provides the input parameters and metrics used for the CSQT modeling.

Attachment B:

- Drone imagery used for cascade-pool (channel morphology) estimates; and
- Aquatic Resources Delineation impact analysis map showing eastern and western alignments of Yule Creek.

ATTACHMENT A
CSQT WORKSHEETS

CSQT Version 1.0
Version Last Updated 7-Jul-20

Programmatic Goals

Select:

Voluntary Restoration or Enhancements

Reach Description

Reach ID:	Yule Creek Eastern Alignment, Pride of America Mine

Describe this reach:The approximately 123.6-acre survey area includes the area within the Pride of America mine permit boundary and is located south of the Town of Marble in Gunnison County, Colorado. Approximately 1,748 feet of Yule Creek, which flows north through the survey area, was diverted and impacted in 2018 (e.g., "eastern alignment") during the construction of a temporary mining road over the original stream channel (e.g., "western alignment"). Yule Creek is characterized as a Rosgen Aa+ stream type, which is very steep (>10%), well entrenched, has a low width/depth ratio, and is laterally contained by bedrock.

Lat:			
Long:			
Process Drivers Information:			
Geology	Source	**Erosion Resistance:**	High
	Bedrock		
Hydrology	Free Flowing	**Stream Power:**	Moderate
	Snow-dominated		
Biology		**Biotic Interaction:**	Low

Reference Stream Type:	A
Bed Material:	Bedrock
Existing Sinuosity:	1.1
Proposed Sinuosity:	1.1

The reference stream type is the stream type that should occur in a given landscape setting given the processes occurring at the watershed and reach scales. User should rely on process driver information and restoration end points to inform the reference stream type selection.

Restoration Approach

1) Expand on the programmatic goals of this project: The approach for the restoration (mitigation) Plan focused on natural channel design principles considering on site materials, conditions/constraints and reference conditions. Specific parameters targeted include floodplain connectivity, large woody debris, bed form diversity and riparian vegetation.

Restoration Potential: Full

2) Explain the restoration potential of this project based on the programmatic goals (based on catchment assessment form): The mitigation Plan for the eastern alignment will provide uplifts of ecological function by enhancing, restoring, preserving, protecting, or creating aquatic resources. Specifically, the Plan will restore lost function within the western (impacted) alignment of Yule Creek. Improvements will include re-establishing riparian (woody) vegetation, placement of Large Woody Debris (LWD), and re-establishing a natural cascade/pool sequence (these parameters are considered Not Functioning or Functioning At Risk within the western (impacted) alignment of Yule Creek). Existing functional parameters will be maintained.

3) Explain the goals and objectives for this project:

Goals: The overall goal of the project is to provide ecological uplift to the eastern alignment of Yule Creek by implementing the Plan.
Objectives:
1. Establish geomorphic characteristics appropriate of the stream type.
2. Minimize anthropogenic sources.

Insert Aerial Photo of Project Reach

Applicable Reach(es)*: Yule Creek, Marble, Gunnison County, Colorado

*If the Catchment Assessment form applies to multiple reaches within the project, the form only needs to be filled out once.
If the form is not filled out below, list the name of the workbook that contains the filled out form in the space above.

Date: 3/22/2021

Overall Watershed Condition	G	Describe how any Categories rated as Poor were considered in the selection of the restoration potential of the reach: Due to the high level of disturbance (e.g., marble quarry) adjacent to Yule Creek, catchment condition is rated as "poor". Overall watershed condition is "good".

CATCHMENT ASSESSMENT

Categories		Description of Catchment Condition			Rating (P/F/G)
		Poor	Fair	Good	
1	Impoundments	Project area located less than 1 mile upstream or downstream of an impoundment; or impoundments are less proximate, but have adverse effects within the project area.	Project area is located 1 mile or more upstream or downstream of an impoundment.	No impoundment upstream or downstream of project reach.	G
2	Flow Alteration	Substantial reduction or augmentation to one or more aspects of natural flow regime.	Moderate reduction or augmentation to one or more aspects of natural flow regime.	Little or no reduction or augmentation of natural flow regime.	G
3	Urbanization	Urban or rapidly urbanizing with ongoing or imminent large scale development.	Low density or rural communities or slow urban or suburban growth.	Predominantly natural land cover; or rural.	G
4	Fish Passage	Reach isolated by upstream and downstream anthropogenic barriers within 10 miles; or barriers otherwise severely affect fish populations within the project reach.	Reach isolated by upstream OR downstream anthropogenic barrier within 10 miles; or barriers otherwise have moderate effects on fish populations within the project reach.	No anthropogenic barriers within 10 miles upstream or downstream of the reach; or barriers otherwise have no effect on fish populations within a project reach.	F
5	Organism Recruitment	Channel immediately upstream or downstream of project reach (i.e., within 1 km or 0.62 mi) is concrete, piped, or hardened.	Channel immediately upstream or downstream of project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material that is highly embedded by fine sediment.	Channel immediately upstream or downstream of project reach (i.e., within 1 km or 0.62 mi) has native bed and bank material.	G
6	Colorado Integrated Report (305(b) and 303(d)) status	In Category 5 due to nonsupport of aquatic life uses OR in Category 4 and aquatic life impairment not actively being mitigated.	In Category 4 due to nonsupport of aquatic life uses and aquatic life impairment actively being mitigated.	In category 1, 2, or 3 or aquatic life uses not evaluated.	G
7	Development: Oil, Gas, Wind, Pipeline, Mining, Timber Harvest, Roads	High development in contributing watershed or some within 1 mile of project reach, or >1 mile but available information indicates high potential for impacts to project reach.	Moderate development or moderate potential for impacts and none within 1 mile of project reach.	No development or no potential for impacts.	P
8	CDPS Permits	CDPS permitted facilities comprise a high percentage of the baseflow in the project reach OR 1 or more facilities present within 2 miles upstream of project reach have a high potential to threaten aquatic life.	CDPS permitted facilities comprise a low to moderate percentage of the baseflow in the project reach AND no facilities are located within 2 miles upstream of project reach.	No CDPS permitted facilities upstream of the project reach.	G
9	Riparian Vegetation	Natural plant community is limited within the floodplain (~100 yr) and riparian corridor is absent for substantial portions of the contributing stream length.	Natural plant community occurs in portions of the floodplain (~100 yr) and moderate gaps in the riparian corridor vegetation occur in the contributing stream length.	Natural plant community extends throughout majority of floodplain (~100 yr) and riparian corridor is mostly contiguous along contributing stream length.	F
10	Sediment Supply	High anthropogenic-caused sediment supply from upstream bank erosion and surface runoff.	Moderate anthropogenic-caused sediment supply from upstream bank erosion and surface runoff.	Low anthropogenic-caused sediment supply. Upstream bank erosion and surface runoff is minimal.	F

Site Information and Reference Selection	
Project Name:	Yule Creek
Reach ID:	Eastern Alignment
Restoration Potential:	Full
Project Reach Stream Length - Existing (ft):	1748
Project Reach Stream Length - Proposed (ft):	1689
Drainage Area (sq.mi.):	9
Flow Permanence:	Perennial
Strahler Stream Order:	First
Ecoregion:	Mountains
Biotype:	2
Proposed Bankfull Width (ft):	20
Stream Slope (%):	10
River Basin:	Colorado
Stream Temperature:	CS-I
Reference Vegetation Cover:	Woody
Stream Productivity Class:	Moderate
Valley Type:	Bedrock
Reference Stream Type:	A
Sediment Regime:	Source

Notes
1. Users input values that are highlighted based on restoration potential
2. Users select values from a pull-down menu
3. Leave values blank for field values that were not measured and/or autopopulate.

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	Baseflow Dynamics	1.00	1.00
	Floodplain Connectivity	0.25	0.37
Geomorphology	Large Woody Debris	1.00	1.00
	Lateral Migration	1.00	1.00
	Bed Form Diversity	0.65	0.79
	Riparian Vegetation	0.49	0.76
Physicochemical	Temperature		
	Dissolved Oxygen		
	Nutrients		
Biology	Macroinvertebrates		
	Fish		

FUNCTIONAL CATEGORY REPORT CARD				
Functional Category	**ECS**	**PCS**	**Change in Condition Scores**	**ΔFF**
Reach Hydrology & Hydraulics	0.58	0.70	0.12	50.5
Geomorphology	0.78	0.89	0.11	41.9
Physicochemical				
Biology				

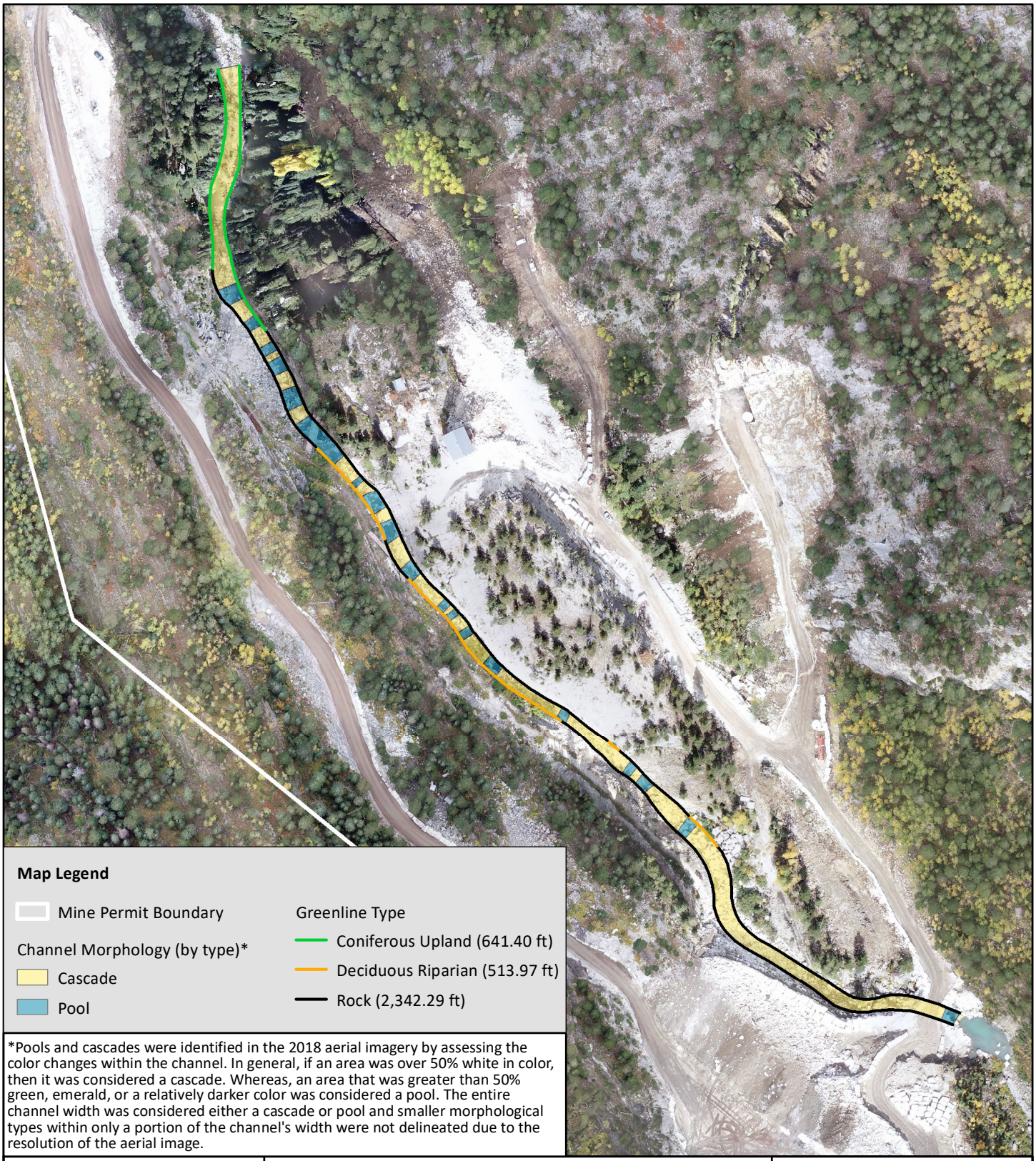
EXISTING CONDITION ASSESSMENT					Scoring		
Functional Category	**Function-Based Parameter**	**Metric**	**Field Value**	**Index Value**	**Parameter**	**Category**	**Category**
Reach Hydrology & Hydraulics	Reach Runoff	Land Use Coefficient Concentrated Flow Points (#/1000 LF)	55 5.7	1.00 0.00	0.50	0.58	Functioning At Risk
	Baseflow Dynamics	Average Velocity (fps) Average Depth (ft)	 2	-- 1.00	1.00		
	Floodplain Connectivity	Bank Height Ratio Entrenchment Ratio Percent Side Channels (%)	2 1.3	0.00 0.50	0.25		
Geomorphology	Large Woody Debris	LWD Index No. of LWD Pieces/ 100 meters	 30	 1.00	1.00	0.78	Functioning
	Lateral Migration	Greenline Stability Rating Dominant BEHI/NBS Percent Streambank Erosion (%) Percent Armoring (%)	 0	 1.00	1.00		
	Bed Form Diversity	Pool Spacing Ratio Pool Depth Ratio Percent Riffle (%) Aggradation Ratio	 1.5 78	 0.29 1.00	0.65		
	Riparian Vegetation	Riparian Extent (%) Woody Vegetation Cover (%) Herbaceous Vegetation Cover (%) Percent Native Cover (%)	15 40 100	0.07 0.40 1.00	0.49		
Physicochemical	Temperature	Daily Maximum Temperature (^{o}C) MWAT (^{o}C)					
	Dissolved Oxygen	Dissolved Oxygen Concentration (mg/L)					
	Nutrients	Chlorophyll α (mg/m2)					
Biology	Macroinvertebrates	CO MMI					
	Fish	Native Fish Species Richness (% of Expected) SGCN Absent Score Wild Trout Biomass (% Change)					

PROPOSED CONDITION ASSESSMENT					Scoring		
Functional Category	**Function-Based Parameter**	**Metric**	**Field Value**	**Index Value**	**Parameter**	**Category**	**Category**
Reach Hydrology & Hydraulics	Reach Runoff	Land Use Coefficient	55	1.00	0.72	0.70	Functioning
		Concentrated Flow Points (#/1000 LF)	1.8	0.44			
	Baseflow Dynamics	Average Velocity (fps)		--	1.00		
		Average Depth (ft)	2	1.00			
	Floodplain Connectivity	Bank Height Ratio	2	0.00	0.37		
		Entrenchment Ratio	1.5	0.74			
		Percent Side Channels (%)					
Geomorphology	Large Woody Debris	LWD Index			1.00	0.89	Functioning
		No. of LWD Pieces/ 100 meters	50	1.00			
	Lateral Migration	Greenline Stability Rating			1.00		
		Dominant BEHI/NBS					
		Percent Streambank Erosion (%)	0	1.00			
		Percent Armoring (%)					
	Bed Form Diversity	Pool Spacing Ratio			0.79		
		Pool Depth Ratio	2	0.58			
		Percent Riffle (%)	73	1.00			
		Aggradation Ratio					
	Riparian Vegetation	Riparian Extent (%)	75	0.56	0.76		
		Woody Vegetation Cover (%)	75	0.73			
		Herbaceous Vegetation Cover (%)					
		Percent Native Cover (%)	100	1.00			
Physicochemical	Temperature	Daily Maximum Temperature (^{o}C)					
		MWAT (^{o}C)					
	Dissolved Oxygen	Dissolved Oxygen Concentration (mg/L)					
	Nutrients	Chlorophyll α (mg/m2)					
Biology	Macroinvertebrates	CO MMI					
	Fish	Native Fish Species Richness (% of Expected)					
		SGCN Absent Score					
		Wild Trout Biomass (% Change)					

Metric	Explanation	Basis of Value	Source of Metric and Is it Calculable for Yule Creek based on site knowledge or available data?	Western Alignment Field Value (existing)	Mitigation Field Value (proposed)
Land Use Coefficient	An area weighted land use coefficient serves as an indicator of runoff potential from land uses draining into the project reach between the upstream and downstream end points. Higher values, nearer 100, indicate more runoff potential while lower values, nearer 0, indicate less runoff.	Table 10 of CSQT Manual	Yes, use default values from Table 10 of CSQT - 55 for vegetated forests	55	55
Concentrated Flow Points (#/1000 LF)	Concentrated flow points are defined as storm drains, outfalls or erosional features, such as swales, gullies or other channels that are created by anthropogenic impacts.	CFP / 1000 ft = $\frac{\#\ CFPs}{Proposed\ Reach\ length\ (ft)} * 1000\ ft$	Based on historical photographs, western alignment is estimated to contain 10 CFPs/1000'. Existing channel contains 3 total permitted discharge points.	5.7	1.8
Average Velocity (fps)	Average velocity is the baseflow discharge divided by the area wetted at the baseflow discharge for a cross-section. Velocity measurements may be collected in order to develop a stage-discharge relationship and can serve as a quality check for the calculated values within the reach.	$Velocity = Q_{baseflow} / A_{wetted}$	Baseflow data not available. Category is NA.	na	na
Average Depth (ft)	Average depth is the area wetted at the baseflow discharge divided by the wetted width of the cross-section. The average depth is calculated from three surveyed cross-sections. This metric uses cross-section geometry to determine the average cross-sectiondepth (d) at riffles within the reach for the baseflow discharge.	Mean depth $(d_{bkf}) = A_{wetted} / W_{wetted}$	Mean depth estimated at 2' based on site knowledge - surveyed cross - section data not available.	2	2
Bank Height Ratio	The bank height ratio (BHR) is a measure of channel incision and an indicator of whether flood flows can access and inundate the floodplain (Rosgen 2014). BHR is measured at riffles/cascades and calculated as the low bank height (LBH) divided by the bankfull riffle maximum depth (also referred to bankfull maximum depth; dmax). The low bank height is defined as the left or right streambank that has a lower elevation, indicating the minimum water depth necessary to inundate the floodplain.	$BHR_{weighted} = \frac{\sum_{i=1}^{n}(BHR_i * RL_i)}{\sum_{i=1}^{n} RL_i}$	LBH estimated at 4', bankfull cascade depth estimated at 2'. Therefore, BHR estimated to be 2.	2	2
Entrenchment Ratio	An entrenchment ratio characterizes the vertical containment of the river by evaluating the ratio of the flood-prone width to the bankfull channel width measured at a riffle cross-section (Rosgen 1996). This metric is described in detail by Rosgen (2014). The floodprone width is the cross-section width at a riffle feature perpendicular to the valley at an elevation of two times the bankfull riffle maximum depth.	$ER = \frac{Flood - Prone\ Width}{Bankfull\ Channel\ Width}$	100-yr floodprone width estimated to be 20' in western alignment and 30' in eastern alignment per the Plan, ER (western alignment) = 20/15 = 1.3, ER (eastern alignment per Mitigation Plan) = 30/15 = 1.5.	1.3	1.5
Percent Side Channels (%)	Side channels are small open water channels that are connected to the main channel at one or both ends. Floodplain channels can be included in this metric when one or both ends are connected to the main channel and the depth is at least one-half the bankfull riffle maximum depth.	$Field\ Value = 100 * \frac{\sum Side\ channel\ length\ (ft)}{Reach\ length\ (ft)}$	Based on historical and current photographs, as well as site knowledge, side channels are not present within the eastern and western alignment, therefore, this category is NA.	na	na
LWD Index	The Large Woody Debris Index (LWDI) is a dimensionless value based on rating the geomorphic significance of LWD pieces and dams within a 328-foot (100 meters) section of stream. This index was developed by the USDA Forest Service Rocky Mountain Research Station (Davis et al. 2001).	Identify the 328 feet (100 m) length of the project reach that contains the most LWD. Preferably this 328-foot reach is within the representative sub-reach. If the project reach is less than 328 feet, the LWDI should be determined using the entire reach length and the index value normalized to represent a value per 328 feet.	LWDI is based on emperical site data which are not available. Category is NA.	na	na
No. of LWD Pieces/ 100 meters	The LWD piece count metric is a count of the number of LWD pieces within a 328-foot (100 meters) section of stream.	Identify the 328 feet (100 m) length of the project reach that contains the most LWD. Preferably this 328-foot reach is within the representative sub-reach. If the project reach is less than 328 feet, count the number of pieces within the entire reach length and then normalize the value to represent a value per 328 feet.	Existing based on site knowledge/photos Proposed based on Mitigation Plan	30	50
Greenline Stability Rating	The greenline is a linear grouping of live perennial vascular plants on or near the water's edge. Greenline stability ratings (GSR) are calculated by multiplying the percent composition of each community type along the greenline by the stability class rating assigned to that type (per methods referenced below).	The Modified Winward Greenline Stability Rating procedures described in Riparian Area Management: Multiple Indicator Monitoring (MIM) of Stream Channels and Streamside Vegetation (USDOI 2011).	Not Applicable for this stream type. Must have perennial vascular plans that dominate bankfull perimeter.	na	na
Dominant BEHI/NBS	Near-bank Stress (NBS) is an estimate of shear stress exerted by flowing water on the stream banks. Together, BEHI and NBS are used to populate the Bank Assessment for Non-point source Consequences of Sediment (BANCS) model and produce cumulative estimates of stream bank erosion rates for surveyed reaches (Rosgen 2014).	Follow the guidance in Appendix D of the Function-Based Rapid Field Stream Assessment Methodology (Starr et al. 2015), or River Stability Field Guide, Second Edition (Rosgen 2014).Banks that are armored should not be assessed with the dominant BEHI/NBS metric.	Not applicable for highly armoured (i.e., bedrock dominated stream types).	na	na
Percent Streambank Erosion (%)	The percent streambank erosion is measured as the length of streambank that is actively eroding divided by the total length of bank (left and right) in the representative subreach.	$Percent\ Streambank\ Erosion = \frac{Length\ of\ eroding\ bank}{Total\ length\ of\ streambank_{sub-reach}} * 100$	Existing based on site knowledge/photos Proposed based on Mitigation Plan	0	0
Percent Armoring (%)	Bank armoring is defined as any rigid human-made stabilization practice that permanently prevents lateral migration processes. Examples of bank armoring include rip rap, gabion baskets, concrete, and other engineered materials.	$Percent\ Armoring = \frac{Length\ of\ armored\ bank}{Total\ length\ of\ streambank_{reach}} * 100$	Not applicable for bedrock dominated stream types.	na	na
Pool Spacing Ratio	The pool spacing ratio compares the stream length distance between sequential geomorphic pools to the bankfull width at a riffle (Rosgen 2014).	$Pool\ Spacing\ Ratio = \frac{Distance\ between\ sequential\ geomorphic\ pools}{Bankfull\ channel\ width}$	Index values not available for "Aa+" type streams.	na	na
Pool Depth Ratio	The pool depth ratio is a measure of pool quality, where deeper pools score higher than shallow pools. Pool depth ratio is calculated as the bankfull pool maximum depth divided by the bankfull mean depth. Pool depth represents the difference in elevation between the deepest point of each pool and the bankfull elevation.	$Pool\ Depth\ Ratio = \frac{D_{max\ pool}}{D_{mean\ riffle}}$	Estimated based on site knowledge/photos. Assume cascade = riffle. Estimated D(max) = 2'. Estimated D(mean cascade) = 2'. Pool= 3' (existing) and 4' (proposed)	1.5	2
Percent Riffle (%)	The percent riffle is the proportion of the representative sub-reach containing riffle and run features, as distinct from pool features. Riffle is defined in detail in the glossary, and generally refers to the plan form crossover section in between lateral scour pools in meandering channels and the cascade section of a mountain stream.	$\%\ Riffle = \frac{\sum(Riffle\ length_{sub-reach})}{Total\ length_{sub-reach}}$	Existing based on site knowledge/photos Proposed based on Mitigation Plan	78	73
Aggradation Ratio	Channel instability can result from excessive deposition that causes channel widening, lateral instability, and bed aggradation. Visual indicators of aggradation include midchannel bars and bank erosion within riffle sections, and the deposition of gravel on the floodplain. The aggradation ratio is measured as the bankfull channel width at the widest riffle within the representative sub-reach divided by the bankfull mean depth (width/depth ratio [W/D]). This ratio is then divided by a reference W/D. This metric is described as W/D ratio state by Rosgen (2014).	$Aggradation\ Ratio = \frac{W_{riffle}}{D_{mean\ riffle}} / Reference\ WDR$	Not applicable for highly armoured (i.e., bedrock dominated) stream types. Category is NA.	na	na
Riparian Extent (%)	The riparian extent metric describes the portion of the expected riparian area that currently contains riparian vegetation and is free from utility-related, urban, or otherwise soil disturbing land uses, fill, and development.	$Riparian\ Extent = \frac{Observed\ Riparian\ Area}{Expected\ Riparian\ Area} * 100$	Estimated based on site knowledge/photos, riparian extent calculated in GIS using percent of linear streambank occupied by riparian vegetation. Proposed based on Plan assuming 75% linear converage along bank and 5' wide riparian planting zone along each bank.	15	75
Woody Vegetation Cover (%)	The woody vegetation cover field value for the CSQT is the sum of absolute percent woody plant cover from shrub and tree species, averaged across all plots within the representative sub-reach.	$Woody\ vegetation\ cover = Woody_{Shrub\ Species\ Cover} + Woody_{Tree\ Species\ Cover}$	Estimated based on site knowledge/photos, woody vegetation (%) calculated in GIS using percent of linear streambank occupied by woody riparian vegetation. Proposed based on Plan assuming 75% linear converage along bank and 5' wide woody riparian planting zone along each bank.	40	75
Herbaceous Vegetation Cover (%)	The herbaceous vegetation cover field value for the CSQT is the sum of absolute percent herbaceous plant cover from herbaceous species averaged across all plots within the representative sub-reach.	$Herbaceous\ vegetation\ cover = Herbaceous_{\ Ground\ Cover}$	Not applicable for woody vegetation reference types.	na	na
Percent Native Cover (%)	Percent native cover metric is the relative cover of native species averaged across all plots within the representative sub-reach. Relative cover is the absolute cover of a species, or group of species, divided by the total coverage of all species, expressed as a percent.	$Percent\ Native\ Cover = \frac{Native\ Vegetation\ Cover}{Herb\ Vegetation\ Cover + Woody\ Vegetation\ Cover} * 100$	Estimated based on site knowledge/photos, proposed based on Mitigation Plan	100	100

Metric	Explanation	Basis of Value	Source of Metric and Is it Calculable for Yule Creek based on site knowledge or available data?	Western Alignment Field Value (existing)	Mitigation Field Value (proposed)
Daily Maximum Temperature (°C)	The daily maximum (DM) temperature is the highest two-hour average water temperature recorded during a given 24-hour period (5 CCR 1002-31).	Install continuous temperature gages following Best Practices for Continuous Monitoring of Temperature and Flow in Wadeable Streams (USEPA 2014) or USFS's Measuring Stream Temperature with Digital Data Loggers: A Field Guide (Dunham et al. 2005). Record data and perform any necessary maintenance throughout the summer season.	No physicochemical data available. Category is NA.	na	na
MWAT (°C)	The Maximum Weekly Average Temperature (MWAT) is the largest weekly average stream temperature in the period of interest (5 CCR 1002-31).	Install continuous temperature gages following Best Practices for Continuous Monitoring of Temperature and Flow in Wadeable Streams (USEPA 2014) or USFS's Measuring Stream Temperature with Digital Data Loggers: A Field Guide (Dunham et al. 2005). Record data and perform any necessary maintenance throughout the summer season.	No physicochemical data available.Category is NA.	na	na
Dissolved Oxygen Concentration (mg/L)	The DO parameter assesses in-stream DO to determine suitable water quality during summer. There is one metric included in the CSQT for this parameter, the DO concentration, measured in milligrams per liter (mg/L).	Measure DO concentration in accordance with the CDPHE or USEPA Standard Operating Procedures. Deploy continuous recording DO loggers. Refer to sensor instructions for deployment, calibration, and instrument cleaning instructions.	No physicochemical data available.Category is NA.	na	na
Chlorophyll α (mg/m2)	Chlorophyll α is the pigment that allows plants (including algae) to use sunlight to convert simple molecules into organic compounds via the process of photosynthesis. Chlorophyll α concentration is directly affected by the amount of nitrogen and phosphorus in the stream. Chlorophyll α data should be expressed as milligrams of chlorophyll α per square meter of sampled rock substrate (mg/m2).	Methods for collecting chlorophyll α are included in Appendix A to CSQT manual. Chlorophyll α sample collection and processing should be conducted according to the CDPHE Standard Operating Procedure procedures outlined in CDPHE (2015).	No physicochemical data available.Category is NA.	na	na
CO MMI	The CO MMI is a statewide regionally calibrated macroinvertebrate-based multimetric index. According to CDPHE (2017), "[w]ithin the benthic macroinvertebrate assemblage, metrics are selected that represent some measurable aspect of the community structure and function. These measurements are grouped into five metric categories: taxa richness, composition, pollution tolerance, functional feeding groups, and habit (mode of locomotion). Combining metrics from these categories into a multi-metric index transforms taxonomic identifications and individual counts into a unitless score that ranges from 0-100."	Methods for collecting, processing, and identifying macroinvertebrates are included in Appendix A of CSQT manual and are consistent with the benthic macroinvertebrate sampling, processing, and identification procedures outlined in Policy Statement 10-1 and its appendices (CDPHE 2017).	Macroinvertebrate data not available.Category is NA.	na	na
Native Fish Species Richness (% of Expected)	This metric documents the diversity of the native fish community in comparison to reference expectations. The deviation of the observed from the expected taxa, a ratio known as the O/E value, is a measure of compositional similarity expressed in units of taxa richness.	Record the number of native fish species on the Field Value Documentation form in Appendix B of CSQT manual. Include the list of species and names of any aquatic biologists consulted in developing the list in the reference column.	Fish data not available.Category is NA.	na	na
SGCN Absent Score	Species of Greatest Conservation Need (SGCN) are identified in the SWAP (2015) as those species whose conservation status warrants increased management attention and funding. SGCN are also considered in conservation, land use, and development planning in Colorado. SGCN species are classified into tiers; tier 1 species have the highest conservation need while tier 2 species have less of a conservation need than tier 1.	Prior to calculating this metric, users need to determine the expected fish community and observed fish community following the methods outlined in the previous section for Native Fish Species Richness. Follow Table 13 of CSQT manual.	Fish data not available.Category is NA.	na	na
Wild Trout Biomass (% Change)	This metric measures the increase in wild trout biomass following a restoration project relative to the change observed at a control site.	The proposed condition field value and field values for all subsequent monitoring events are calculated as the percent increase in biomass compared with pre-project biomass data, after correcting for natural variability using control site data.	Fish biomass data not available.Category is NA.	na	na

ATTACHMENT B
DRONE IMAGERY
AQUATIC RESOURCES IMPACT ANALYSIS



Map Legend

Mine Permit Boundary

Channel Morphology (by type)*

Cascade

Pool

Greenline Type

Coniferous Upland (641.40 ft)

Deciduous Riparian (513.97 ft)

Rock (2,342.29 ft)

*Pools and cascades were identified in the 2018 aerial imagery by assessing the color changes within the channel. In general, if an area was over 50% white in color, then it was considered a cascade. Whereas, an area that was greater than 50% green, emerald, or a relatively darker color was considered a pool. The entire channel width was considered either a cascade or pool and smaller morphological types within only a portion of the channel's width were not delineated due to the resolution of the aerial image.

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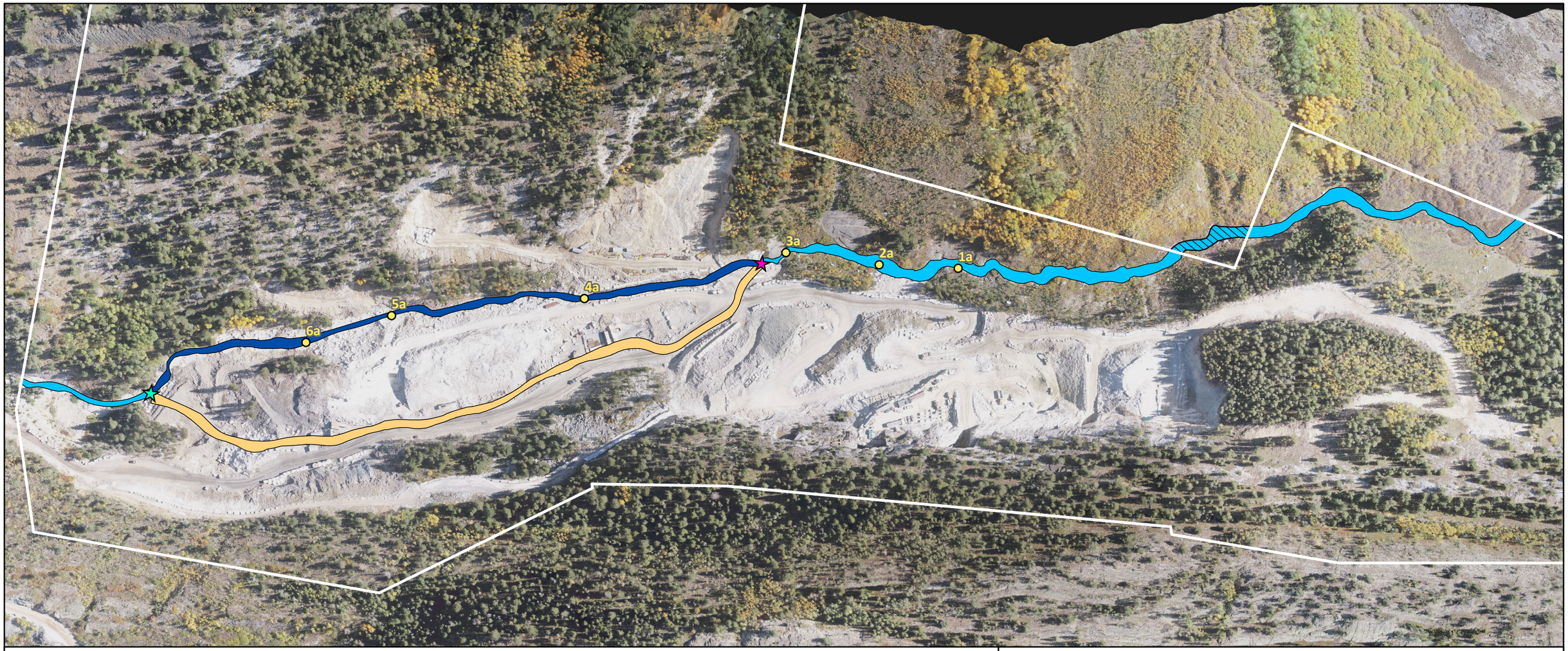
YULE CREEK - 2018

PRIDE OF AMERICA MINE
COLORADO STONE QUARRIES
MARBLE, GUNNISON COUNTY, COLORADO

N

0 100 200

Feet



NOTES:

1. THE SURVEY AREA IS LOCATED IN GUNNISON COUNTY, COLORADO SECTIONS 1 & 12, TOWNSHIP 12 SOUTH RANGE 88 WEST.

2. AQUATIC RESOURCE LOCATIONS WERE FIELD DELINEATED BY ERC ON JUNE 25, 2020, USING THE 1987 CORPS OF ENGINEERS WETLANDS DELINEATION MANUAL AND THE REGIONAL SUPPLEMENT TO THE CORPS OF ENGINEERS WETLAND DELINEATION MANUAL: WESTERN MOUNTAINS, VALLEYS, AND, COAST REGION (VERSION 2.0) (MAY 2010).

3. THESE AREAS HAVE BEEN FIELD DELINEATED AND MAPPED WITH HAND-HELD SUB-METER ACCURACY GLOBAL POSITIONING SYSTEM (GPS) EQUIPMENT (+/-2 FEET). ORDINARY HIGH WATER MARK (OHWM) BOUNDARIES AND AQUATIC RESOURCE MAPPING WERE PREPARED BY ERC USING GEOGRAPHIC INFORMATION SYSTEMS (GIS).

4. SATELLITE IMAGERY WAS BY DRONE, DATED 2020.

5. THE PROJECTED COORDINATE SYSTEM FOR THE AQUATIC RESOURCE DELINEATION MAPPING IS: NAD_1983_STATEPLANE_COLORADO_CENTRAL_FIPS_050_FEET.

Stream Segment Length and Area

Stream Segment	Linear Feet	Acreage
Yule Creek within Permit Boundary	2,272.50	1.22
Eastern Alignment Yule Creek	1,670.94	0.62
Western Alignment Yule Creek	1,748.87	0.83
TOTAL	**5,692.31**	**2.67**

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MAP LEGEND

- Mine Permit Boundary
- Wetland Determination Point
- Point of Diversion
- Approximate Point of Confluence
- Aquatic Resources A: Yule Creek (within permit boundary, 1.22 ac)
- Aquatic Resources B: Eastern Constructed Channel of Yule Creek (0.62 ac)
- Western Original Channel of Yule Creek (0.83 ac), Estimated
- Yule Creek (outside permit boundary)

AQUATIC RESOURCES DELINEATION MAP

PRIDE OF AMERICA MINE
COLORADO STONE QUARRIES
MARBLE, GUNNISON COUNTY, COLORADO

1 inch = 250 feet

0 125 250 500 Feet