950 West Bannock Street
Suite 350
Boise, ID 83702

T: 208.389.7700
F: 208.389.7750

2449 S. Vista Avenue
Suite B
Boise, ID 83705

T: 208-559-4615
Email: rob@rioase.com

Technical Memorandum

Prepared for: Midas Gold Idaho, Inc. (Midas Gold)

Project Title: Stibnite Gold Project

Technical Memorandum

Subject: Stream Functional Assessment Scoring Concerns Addressed: Stibnite Gold Project

Date: May 20, 2019

To: Dan Kline, Midas Gold Idaho, Inc.

From: Rio Applied Science and Engineering; Brown and Caldwell, Inc.

Copy to: Todd Glindeman, Brown and Caldwell, Inc. (for distribution)

Prepared by: Rob Richardson, Principal Geomorphologist (ID PGL-1245, Exp: 2/23/2020)

Paul M. Leonard, Senior Expert, Water Resources

Reviewed by: Jeff Fealko, Principal Engineer (ID PE- 12495, Exp: 6/30/2020)

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Introduction

In support of the Stibnite Gold Project (SGP) permitting effort, a Stream Functional Assessment (SFA) and associated SFA Ledger have been developed to evaluate baseline and proposed stream conditions. The SFA methodology was adapted from Watershed Condition Indicator (WCI) scoring and other elements as summarized in the U.S. Forest Service (USFS) Forest Land and Resource Management Plan (LRMP) for the Payette National Forest (USFS 2003), the SFA Report (Rio ASE 2019a), and associated SFA Ledger spreadsheet (Version 2/28/19). Following submittal of the February 28, 2019 version of the SFA Ledger, multiple meetings were held with the agencies to discuss the SFA Ledger development and initial results. During these meetings, several questions and concerns were raised by the agencies regarding the development of the SFA element scoring criteria. Many of these questions and concerns were addressed as part of the April 15, 2019 SFA Ledger Workshop, but several concerns remained. The purpose of this technical memorandum is to provide additional justification/rationale and/or to propose changes to the scoring criteria used within the SFA Ledger to address the remaining agency concerns regarding SFA scoring methodology.

During the April 15, 2019 SFA Workshop, the agencies expressed concerns regarding the following SFA scoring methodologies (including summary of agency concern):

- Standardized scoring metrics (not all elements are appropriate for all reaches)
- Scoring for diversions and lined channels (insufficient impact and/or excessive benefit in SFA)

Additionally, the agencies accepted the proposed SFA element scoring criteria for 10 of the 17 SFA elements except the following (including summary of agency concern):

- Fish Passage Barriers (reach ratings for activities not occurring within reach)
- Large Woody Debris (LWD; scoring for LWD recruitment)
- Pool Frequency (scoring threshold determination/justification)
- Pool Quality (scoring threshold determination/justification)
- Off-Channel Habitat (scoring for reaches that don't typically have off-channel habitat)
- Riparian Conservation Area (RCA) and Disturbance History (clarify definition, measurement, and scoring)

Provided below is a discussion with supporting documentation to address these remaining concerns of the agencies to gain consensus regarding SFA scoring methodology.

Section 1: Standardized Scoring Metrics

Table 1. Standard Scoring Metrics Summary

Agency Concern	The agencies have questioned the applicability of scoring several elements based on the relative appropriateness of a given element within a given reach.
Solution	No change to the SFA Ledger; provide additional justification/support; change nomenclature to reduce potential confusion.
Justification	Precedents from other existing and accepted SFA methods strongly support the use of standard/absolute evaluation criteria and performance thresholds.

Though the SFA was derived in part using many elements from the Watershed Condition Indicators (WCI) matrix, the applications and uses of the WCI elements as part of the this SFA are fundamentally different. As the name implies, WCIs were developed as a nationally consistent, science-based approach to classify the _condition_ of all National Forest System watersheds (Potyondy and Geier 2011). The WCI approach is based on the use of indicators (or measures) of the condition of ecosystem health at the watershed level. The WCI approach defines watershed condition relative to "potential natural condition." (Potyondy and Geier 2011). WCIs were developed to determine if conditions are in line with expectations, hence they are relative measures, not absolute.

In contrast, other approaches such as the Stream Function Assessment Method (SFAM) for Oregon (Nadeau et al. 2018a, 2018b) were developed primarily to provide a standardized assessment of *function*[1], not in a relative sense, but rather rating whether a function is present or not. A function can either be expressed or not expressed at a given site, while a value or a condition is the context of that function in the broader landscape (Nadeau et al. 2018b). This approach is based in similar concepts and underpinnings as outlined by Fischenich (2006), USEPA (2012), and Harman et al. (2012), all of which are cited in the development of the Scientific Rationale in Support of the Stream Function Assessment Method (Nadeau et al. 2018b). The approach of using functional assessment is needed to meet the requirements of the 2008 Final Compensatory Mitigation Rule (pursuant to Clean Water Act Section 404), which promotes the use of functional assessments to determine the appropriate amount of compensatory mitigation to replace the loss of functions due to unavoidable impacts to aquatic resources. Tools that have been developed along these lines–e.g., the SFA, SFAM, and the Function-Based Framework for Stream Assessment and Restoration Projects (Harman et al. 2012)–are designed with an emphasis on producing absolute measures of functional losses (debits) and gains through replacement or restoration (credits).

Therefore, in practical terms, any tool designed to measure functional losses and gains, especially in the context of project specific analysis, needs to use, to the greatest extent possible, a standardized index scale that can be used for all streams and for comparing losses and gains in function for characterizing existing function and function of proposed restoration. Quantification of functions facilitates the assessment of impacts associated with permitted actions as well as mitigation outcomes (USEPA 2012). Ultimately, the question is – Is a given function being provided at a site and is that level of function low (1), medium (2), or high (3)? This is important because restoration in some cases may not provide the exact replacement of a habitat type, but rather the creation of a different yet important habitat type that provides important functions not present or inherently expected to be present at an impacted site. It also can be used to establish that the function will be provided at a restoration site and, allowing for confirmation, that the function is provided (mitigation outcome).

The standardization rating function lies at the heart of the SFA approach and SFA Ledger for the SGP. Without standardized scoring of function, it would not be possible to accurately compare existing versus proposed conditions in a manner compatible with the requirements of the 2008 Final Compensatory Mitigation Rule. This conclusion was echoed in the Oregon SFAM where peer review "corroborated the identified critical need for standard performance indices and standardized thresholds to support meaningful SFAM outputs." (Nadeau 2018b).

The WCI scoring nomenclature includes the terms "appropriately" and "risk" when referring to functional conditions, but these words imply a relative evaluation-functioning appropriately or at risk relative to expectation and/or geomorphic condition/appropriateness. To reduce potential confusion surrounding the nomenclature as it pertains to standardized (versus relative) scoring, we propose changing the scoring nomenclature as follows for all SFA elements:

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[1] Function as used herein is defined as the processes that create and support an ecosystem, as defined by National Research Council (NRC) (2002), Fischenich (2006), Sandin and Solimini (2009), and Nadeau et al. (2018b).

Table 2. Proposed SFA Scoring Nomenclature

Existing Nomenclature	Proposed Nomenclature	SFA Score
Functioning Appropriately (FA)	High Function (Good)	3
Functioning at Risk (FR)	Moderate Function (Fair)	2
Functioning at Unacceptable Risk (UR)	Low Function (Poor)	1

Section 2: Scoring for Diversions

Table 3. Scoring for Diversions Summary

Agency Concern	SFA scoring methodology for proposed diversions does not sufficiently take into consideration the magnitude of anticipated impacts
Solution	Score the five specific habitat indicator elements (substrate embeddedness, large woody debris, pool frequency, pool quality, off-channel habitat) with a value of 0 as opposed to 1, 2, or 3
Justification	Proposed diversions are not intended to provide functional habitat, suggesting less than a "low function" score is warranted.

Several temporary stream channel diversions are proposed during the interim phase of the SGP. Most of these diversions are not intended to provide habitat or habitat function. Although some habitat may form and be utilized by aquatic organisms at times within the diversions, as is the case with the existing diversion of Meadow Creek around the Spent Ore Disposal Area, the diversions would be designed to resist habitat formation (i.e., pools and off-channel habitat) and maintained such that most other habitat elements that formed would be removed for safety and hydraulic efficiency (i.e. LWD and gravel deposition). It is difficult to quantify what limited habitat function may be afforded by the proposed diversions, and it is difficult to justify the function of that habitat given our interpretation of the intent of the five specific habitat indicator elements (substrate embeddedness, LWD, pool frequency, pool quality, off-channel habitat). For these reasons, we believe it is warranted to deviate from the standard SFA scoring of 1, 2, and 3, for diversions that are not intended to provide habitat to include an additional score of zero (0). We recognize that by and large, the lowest WCI score of "Low Function" (Score = 1) implies limited (not zero) function; therefore, when there is potentially zero (0) function, the score should be conservatively reduced to zero (0) for the five habitat elements. It is recommended that the SFA shall therefore conservatively assume zero (0) function for all five habitat elements within interim diversions that are not intended to provide habitat including:

- Meadow Creek diversion around the tailings storage facility (TSF) and Hangar development rock storage facility (DRSF)
- East Fork South Fork Salmon River through the tunnel fishway
- Fiddle Creek around the Fiddle DRSF
- West End Creek around the West End pit and DRSF

Section 3: Scoring for Lined Channels

Table 4. Scoring for Lined Channels Summary

Agency Concern	SFA reaches restored over the top of an impermeable liner appear to receive higher than expected scores considering association with underlying impacts including the tailings storage facility (TSF) and development rock storage facilities (DRSFs)
Solution	Include area of TSF, DRSF, mine pit highwall, and pit lakes as "disturbed" within the "Fully Restored" phase of SFA related to Watershed disturbance and Riparian Conservation Area (RCA) disturbance
Justification	Although the streams and floodplains will be restored, their association with human features such as an impermeable liner and underlying TSF/DRSF justify the classification of such areas as "disturbed" into perpetuity

Several of the proposed restoration reaches include the use of an impermeable stream liner to prevent excessive seepage loss and undesired contact with underlying materials (Rio ASE 2018 and Rio ASE 2019b). The stream liner is proposed to be buried at depth and covered with alluvium fill upon which the stream and floodplain would be constructed. Agency-hypothesized impacts associated with lining stream channels as proposed are centered primarily around reduced groundwater interaction and associated effects related to alterations in temperature, baseflow, and interaction with potential contaminants. These elements have been evaluated in detail for proposed conditions using calibrated models (BC 2018a; BC 2018c; BC 2019; SRK 2018), the results of which have been incorporated into the SFA Ledger.

Elements affected by the stream liner:

- Temperature – The reduced connection to groundwater is expected to affect stream temperature as shown by the detailed Stream and Pit Lake Network Temperature modeling (BC 2018a; BC 2019). These results are included in the SFA Ledger (Version 2/28/19).
- Chemical Contaminants – The proposed stream liner would separate the restored stream corridor from underlying materials affecting potential interaction with chemical contaminants as modeled by SRK (SRK 2018). Results are included in the SFA Ledger (Version 2/28/19).
- Change in Peak/Baseflow – Reduced connection to groundwater is expected to impact stream baseflows as shown by detailed hydrologic modeling summarized in the response to RFAI 88/88a (BC 2018b; BC 2018c). Results are included in the SFA Ledger (Version 2/28/19).

Most SFA elements are not expected to be impacted by use of stream liner as proposed, including:

- Fine Sediment – Small anticipated changes to baseflow are not expected to have a measurable effect on the generation or transport of sediment in lined reaches. As sediment transport is proportional to discharge, the majority of sediment transport would occur at higher flows (Barry et al 2008). Neither the channel nor floodplain will be confined laterally or vertically by the stream liner as proposed allowing a natural flux of sediment into and out of the designed reach.
- Physical Barriers – The liner will not generate a physical barrier to fish passage and is intended to ensure sufficient baseflow remains within lined reaches (as has been modeled – response to RFAI 88/88a: BC 2018b; BC 2018c) to maintain adequate flows for fish passage within those reaches where steep gradients do not otherwise create a barrier.
- Substrate Embeddedness – See explanation for Fine Sediment above.
- LWD– Wood is proposed to be placed during restoration to meet LWD requirements for the short term. See specific discussion regarding LWD Recruitment later in this technical memorandum (Section 5).
- Pool Frequency and Pool Quality – The depth of liner is defined in part by the maximum calculated scour depth of the proposed channel (Rio ASE 2019b), such that the liner would be positioned below the calculated maximum scour depth plus any additional armor layer, and therefore pools would form where geomorphically appropriate within the placed alluvium above the liner.

- Off-Channel Habitat – Neither the channel nor the floodplain will be excessively confined laterally or vertically by the stream liner as proposed. The Stream Design Report (Rio ASE 2019) provides explanation for the proposed geomorphically appropriate floodplain width and associated meander belt width for each lined reach.
- Width/Depth Ratio – The channel geometry (Rio ASE 2019b), including width/depth ratio, for restored channels is a derivative of the bankfull discharge, gradient, confinement, grain sizes, and in-stream structure, none of which would be impacted by a stream liner as proposed.
- Streambank Condition – The liner is proposed to be buried well beneath the entire channel and floodplain and therefore would not interact with the stream bank. The stream liner is not expected to interfere with the development and growth of riparian vegetation that would populate the stream bank (see Rio ASE 2019b, Tetra Tech 2019, and the LWD Recruitment discussion later in this technical memorandum – Section 5).
- Floodplain Connectivity – See explanation for Off-Channel Habitat above.
- Drainage Network Increase – The stream liner does not affect the location, length, or sinuosity of the restored streams as proposed (Rio ASE 2019b).
- Road Density – The stream liner is not associated with roads.

Two elements may be affected by the liner and a change to the SFA Ledger scoring is proposed:

- RCA Disturbance and Watershed Disturbance History – While it could be argued that the restoration of the streams and floodplains atop the TSF/DRSFs would eliminate the "disturbance" as defined by these elements, it could also be argued that the human alteration of the landscape (despite the restoration) represents a disturbance. To be conservative, we believe it is justifiable to include the entire TSF and DRSF areas as well as the pit lakes and associated highwalls (mining excavations) as part of the disturbance footprint during the "Fully Restored" project phase within the SFA Ledger. In this way, all else being equal, streams restored over a liner would receive less functional units than those not over a liner. Previous versions of the SFA Ledger (2/28/19) had considered these areas "restored" and therefore no longer disturbed.

Section 4: Fish Passage Barriers

Table 5. Fish Passage Barriers Summary

Agency Concern	1. Insufficient description and justification of existing barriers 2. SFA should not include natural barriers 3. SFA scoring for barrier impacts should not include reaches beyond the reach in which the barrier occurs
Solution	1. Greater description and justification of existing barriers provided in this memo 2. Removal of natural barriers from the SFA 3. Apply barrier impacts to all upstream fish-bearing reaches as opposed to all upstream reaches
Justification	1. N/A 2. Precedents established from other accepted evaluation methodologies which generally do not include natural barriers 3. Literature and professional judgment suggest fish passage barriers should only apply to reaches which fish can/could occupy

Following submittal of the February 28, 2019 version of the SFA Ledger, the agencies requested three items with respect to fish passage barriers: (1) improved documentation of existing barriers, (2) removal of natural barriers from the SFA, and (3) a change to the SFA scoring such that barrier scores should only apply to the reach in which the barrier occurs. Regarding Items 1 and 3, additional information about the evaluation of specific barriers within the SGP area and a summary of pertinent literature supporting the functions and values associated with barriers beyond the reach in which they occur will be provided soon in a subsequent technical memorandum currently in development.

Regarding Item 2, we propose modifying how fish passage barriers are applied within the SFA Ledger. In the February 28, 2019 version of the SFA Ledger, barriers were defined as both human-caused or natural and were evaluated as complete (UR = 1), partial (FR = 2), or none (FA = 3). The score associated with a given barrier was then applied to all upstream reaches. For the purpose of the SFA, we proposed refining the definition of passage barriers as follows:

- **Complete Barrier** (SFA score = 1): Natural or artificial stream condition that is impassable to fish. Complete passage barriers exclude fish entirely or from portions of a watershed and may isolate fish populations upstream of the barrier. Stream flows do not change hydraulic conditions sufficiently to create passable condition.
- **Partial Barrier** (SFA score = 2): Natural or artificial stream condition that may be impassable to some fish. A partial barrier may exclude only certain fish species or life stages at certain times of the year. Stream flows may change hydraulic conditions sufficiently to create passable conditions by some species.
- **No Barrier** (SFA score = 3): No impediment to fish passage.
- **Human-caused:** Obstruction to fish passage within a given reach that is primarily the result of human features and/or human-caused impacts. We propose changing the SFA Ledger to allow the flexibility of each user (i.e. each agency) to consider passage resulting from just human-caused barriers or both human-caused and natural barriers.
  - All of the existing streams within the SGP area have been at least partially impacted by humans whether it be due to roads in the watershed, historical land use, fire management, water diversion, power generation, physical alteration, etc. Every barrier identified within the SGP area has been classified as primarily “natural” or primarily “human-caused” based on the primary cause of the barrier. A detailed summary of each fish passage barrier classified within the SGP will be provided in a subsequent technical memorandum, which will soon be available to support the final scoring.

We also propose modifying the upstream extent to which a given barrier score is applied such that the SFA will score a reach with the appropriate value for a barrier in that reach, then extend that barrier score upstream to the next barrier or to the upstream extent of fish use, whichever occurs first. Upstream extent of fish use is defined by the upstream extent of the Ecosystem Sciences’ Occupancy Model (in progress) as 0.2 cubic feet per second summer flow or greater than 15 percent average slope for all upstream reaches.

Section 5: Large Woody Debris (LWD)

Table 6. Large Woody Debris Summary

Agency Concern	“Restored” and “Fully Restored” phases may over-predict LWD recruitment potential
Solution	Evaluate and revise planting plan to meet minimum tree density requirements identified in USFS LWD recruitment guidelines to provide for short- and long-term recruitment at the “Fully Restored” project phase.
Justification	Provide supporting documentation regarding proposal to plant trees on lined channel/floodplain reaches; follow USFS guidelines for performance requirements to achieve required recruitment potential adjacent restored stream corridors.

Recruitment of LWD is directly linked to riparian or adjacent upslope and/or upstream forest conditions (USFS 2006). The evaluation of future (proposed condition) LWD recruitment therefore depends on the proposed planting prescription and expected density of trees within the near-stream riparian floodplain at such future time as trees would be expected to reach a size class for which they would contribute to LWD recruitment to the streams.

The SGP stream design (Rio ASE 2019b) and Conceptual Mitigation Plan (Tetra Tech 2019) identify Engelmann spruce as the primary tree species utilized within the near-stream riparian floodplain which would be classified as potential vegetation group nine (PVG 9 – Hydric subalpine fir) (Nalder 2019). The USFS estimates 71-110 years for Engelman spruce to mature to a "medium" size class, defined as greater than or equal to 12-inch diameter at breast height (USFS 2006). Additionally, the USFS recommends 40 medium-size-class trees per acre are needed to provide 20 calculated recruitable trees within areas classified as PVG-9 (USFS 2006).

The SGP stream design (Rio ASE 2019b) prescribes Engelmann spruce container plantings on 8-foot centers within Zone 4 (above bankfull water surface elevation). The SGP wetland designs (Tetra Tech 2019) identify most of the proposed floodplain wetland area as palustrine emergent (PEM) for which the proposed planting plan does not prescribe Engelmann spruce or other tree plantings. Only a relatively small area of the proposed near-bank floodplain includes palustrine forested (PFO) wetland type for which the proposed planting plan does prescribe Engelmann spruce and lodgepole pine.

To clarify this inconsistency between the stream design and wetland design, Midas Gold proposes revising the wetland planting plan for those near-bank floodplain areas (within 100 feet of the stream) to include enough PFO wetlands to equal or exceed the tree density recommendations of the USFS (2006). This revision would ensure sufficient short- and long-term woody recruitment potential at the "Fully Restored" project phase on all restored streams with prescribed floodplain wetlands, but excluding the steep, rock-lined channels down the face of the Hangar, Fiddle, and West End DRSFs and the steep reach of Hennessy Creek where it cascades into the backfilled Yellow Pine pit DRSF.

Some concern has also been raised by the agencies that planting trees may not be appropriate or that planted trees may not survive in riparian areas associated with stream liners. As described in the stream design (Rio ASE 2019b), the impermeable stream liners are anticipated to be covered by 2.3- to 16-feet of alluvial fill material and soil (depending on the stream size and gradient – see RFAI 87; Rio ASE 2018), into which the proposed trees would be planted and subsequently grow. Research has shown that the risk of damage to subsurface impermeable liners as a result of tree root penetration is relatively low given adequate depth of cover over the liner (as proposed), and tree rooting depth will adjust to match site-specific soil conditions. See Attachment A of this technical memorandum for more specific details and references regarding tree rooting depth and risk of damage from tree roots to buried liners.

Section 6: Pool Frequency

Table 7. Pool Frequency Summary

Agency Concern	**Arbitrary divisions between functional scores (1, 2, or 3)**
Solution	**Revise and justify divisions in SFA Ledger using a large data set of undisturbed and minimally disturbed reference streams**
Justification	**Statistical analysis and precedent from existing/accepted SFA methods**

The February 28, 2019 version of the SFA Ledger utilized pool frequency criteria developed from Appendix B of the USFS LRMP (2003), which was derived from two sources:

- Overton et al. (1995) for bull trout including data from the Upper Salmon River basin in Idaho
- USFS (1994) for Chinook salmon and steelhead including data from Oregon, Washington, Idaho, and Alaska

As requested by the agencies, we have reviewed these source documents and have several concerns. Some of the Overton et al. (1995) data have very large standard deviations, such that one standard deviation from the average would result in negative values, and some sample sizes are so small that they may not provide an accurate representation of the pool frequency (e.g., only two observations for the 0- to 5-foot wetted width classification). Likewise, we have concerns with the USFS (1994) data. First, there is no statistical information reported with the summary conclusions in this report, so the standard error, standard deviation, or average condition are unknown and cannot be calculated. Second, the data only represent the frequency of pools greater than 1-meter residual depth rather than all pools. Third, the data were derived only from Rosgen Type-C, low-gradient channels, which do not adequately represent many of the conditions present or proposed within the SGP area.

We reviewed the literature for additional relevant classifications, and finding limited relevant literature, we then searched for more robust raw data sources. The Integrated Status and Effectiveness Monitoring Program (ISEMP) was created to support the Federal Columbia River Power System Biological Opinion. In 2011, ISEMP initiated the Columbia Habitat Monitoring Program (CHaMP) to further develop standardized fish and habitat monitoring. Data were collected for several years from 630 CHaMP sites spanning 26 watersheds in Oregon, Washington, and Idaho selected to represent a broad spectrum of habitat conditions. The CHaMP data include pool frequency along with many other stream criteria enabling refined queries based on the amount of human disturbance and the site locale as summarized in Attachment B of this technical memorandum. This robust dataset enabled a more detailed analysis and comparison with existing Overton et all (1995) and USFS (1994) data.

As stated in Appendix B of the LRMP (USFS 2003), the data tables derived from Overton et al. (1995) and USFS (1994) are to be used only if more relevant site-specific data are not available. The large CHaMP data set and the ability to query specific sites based on robust stream classification information, supports the selection of a dataset that is most representative of natural/reference conditions for streams similar to those at the SGP. Given the potential concerns with the Overton et al. (1995) and USFS (1994) data sources summarized above, and the availability of more relevant/robust data (CHaMP), we recommend that the CHaMP dataset for “undisturbed” and “low disturbance” sites be utilized for analysis of total pool frequency. Based on precedent (Nadeau et al 2018), we further recommend that the divisions between High, Moderate, and Low function use the 25th and 75th percentiles of the pool spacing data for each wetted width category (Table 8). Additional details regarding pool frequency data analysis are provided in Attachment B of this technical memorandum.

Table 8. Recommended Pool Frequency (pools/mile) Scoring Criteria for Various Channel Wetted Widths

Wetted Width (feet)			High Function (Good = 3)		Moderate Function (Fair = 2)			Low Function (Poor = 1)	
0	-	5	>	235	138	-	235	<	138
5	-	10	>	113	52	-	113	<	52
10	-	15	>	79	31	-	79	<	31
15	-	20	>	50	25	-	50	<	25
20	-	25	>	48	22	-	48	<	22
25	-	40	>	37	11	-	37	<	11
40	-	50	>	15	9	-	15	<	9
50	-	100	>	14	4	-	14	<	4

Note: Analysis of pool frequency data from Columbia Habitat Monitoring Program (CHaMP)

Section 7: Pool Quality

Table 9. Pool Quality Summary

Agency Concern	1. Arbitrary divisions between function scores (1, 2, or 3) 2. Concern for applicability of evaluating pool quality in small streams.
Solution	1. Revise and justify divisions using a large data set of undisturbed and minimally disturbed reference streams 2. No change to the SFA Ledger regarding applicability of evaluating pool quality in small streams; provide additional justification/support
Justification	1. Statistical analysis and precedent from existing/accepted SFA methods 2. Precedents from existing/accepted SFA methods strongly support the use of standard evaluation criteria and performance thresholds.

Pool Quality criteria developed by the USFS (2003) were qualitative–the criteria were many, few, or none. Within the SFA Ledger, Rio ASE quantified these values as a percentage of the optimal pool frequency, but the divisions between quantified ratings were based on professional judgement with little additional justification. As has been shown in other established stream functional analysis methods (Nadeau et al 2018), the statistical evaluation of a large dataset can be used as an effective and appropriate means of establishing divisions between functional ratings.

Rio ASE reviewed a summary of the US Fisheries Bureau studies completed in the 1940s to evaluate pools with residual depths greater than 1 meter (McIntosh et al 1994). We were able to determine that from the pools evaluated by the U.S. Fisheries Bureau, there were an average of 10.4 deep pools (greater than 1 meter deep) per mile. Following the standard method for establishing index thresholds from large datasets (Nadeau et al 2018), the threshold for “low” functioning was determined using the 25th percentile, and the threshold for “high” functioning was determined using the 75th percentile value (Table 10).

Table 10. Recommended Pool Quality Frequency (deep pools/mile) Scoring Criteria

High Function (Good = 3)	Moderate Function (Fair = 2)	Low Function (Poor = 1)
> 14.1	6.7 - 14.1	< 6.7

Note: Analysis of data summarized in Attachment B of this Technical Memorandum

As discussed at the beginning of this technical memorandum, we recommend that all stream reaches, regardless of size, should be evaluated for pool quality where there are data to support the evaluation (see discussion above).

Additional details regarding pool quality data analysis is provided in Attachment B of this technical memorandum.

Section 8: Off-Channel Habitat

Table 11. Off-Channel Habitat Summary

Agency Concern	Applicability of scoring off-channel habitat within reaches where off-channel habitat would not be expected or considered geomorphically appropriate
Solution	No change to the SFA Ledger; provide additional justification/support
Justification	Precedent from existing/accepted SFA methods strongly supports the use of standard evaluation criteria and performance thresholds.

During SFA workshops and meetings held following submittal of the SFA Ledger (2/28/19 Version), several agency representatives suggested that off-channel habitat should not be evaluated if off-channel features (such as side channels) were not appropriate for the watershed and/or associated geomorphic character. As discussed at the beginning of this technical memorandum, we recommend that all stream reaches, regardless of their geomorphic character, should be evaluated for off-channel habitat function where there are data to support the evaluation.

Section 9: RCA and Watershed Disturbance

Table 12. RCA and Watershed Disturbance Summary

Agency Concern	Unclear methodology
Solution	Refine methodology and provide improved explanation: • Refine timing of disturbance from reach-based to watershed-based. • Define disturbance as including only human-caused; remove equivalent clear-cut area (ECA) from definition. • Include area of TSF, DRSF, mine pit highwall, and pit lakes as “disturbed” within the “Fully Restored” phase of SFA.
Justification	• Disturbances are evaluated on a subwatershed-scale and therefore regardless of the timing for various reaches, the RCA and Watershed Disturbance scores should begin and end at the same time for all reaches within the same subwatershed. • The intent of the SFA is to evaluate the change in stream function from the project over time; therefore, only project-related disturbances should be evaluated. Natural disturbances are not expected to change as a result of the project and are difficult to predict in the future. • Reaches associated with human features such as TSF, DRSF, mine highwall, and pit lake justify the classification of such areas as “disturbed”

Rio ASE identified a discrepancy in the SFA timing as applied to the WCI (including RCA and Watershed Disturbance) that has been corrected and will be included in the forthcoming version of the SFA Ledger. The previous SFA Ledger (Version 2/28/19) applied a score for each WCI element based on the timing of the impact or restoration per reach. We believe it is more appropriate to apply the score based on the timing of the impact or restoration for all reaches within the evaluated subwatershed according to the earliest timing of the impact and after all restoration has been completed. This is a more conservative approach and will synchronize the timing of the impact and restoration scores for these elements within specified subwatersheds as reported in the SFA.

There was also stated to be lack of clarity regarding how the disturbance areas were mapped and therefore quantified per project phase. This apparently originated from language in the SFA Report (Rio ASE 2019a) defining disturbance as pertaining to human actions, and defining disturbance using the Equivalent Clear-cut Area (ECA) as recommended in USFS (2003). The ECA is a measure of area lacking tall trees which may result from many natural causes including fire, rock outcrop, open water, and different natural vegetation cover types (e.g. grass or scrub/shrub).

The intent of the SFA is to evaluate the change in stream function related to the proposed SGP, and should not include potential natural disturbances which, apart from being natural, are difficult to predict and quantify into the future. For this reason, we recommend defining disturbance as being directly related to human actions and eliminating the use of ECA terminology. Additionally, we propose classifying the TSF, all DRSFs, the remaining mining pit highwalls and pit lakes as “disturbed” even after restoration, given that these are human-constructed features and despite restoration of the streams and wetlands on their surfaces, the features are not natural and therefore should conservatively be considered “disturbed.”

Current assessment approach

- Baseline = Entire historical disturbance footprint = disturbed
- Interim = Entire proposed SGP footprint (maximum disturbance polygon) and roads = disturbed
- Restored = Same as Interim because vegetation has not yet grown back; therefore, the entire footprint is still directly related to human actions.
- Fully Restored = Only remaining roads = disturbed

Revised Assessment approach

- Same as current approach but change Fully Restored phase to reflect that the entire TSF and DRSF areas as well as the pit lakes and associated highwalls (mining excavations) would remain "disturbed" as well as any roads that are proposed to remain; all else is considered no longer disturbed.

Section 10: Next Steps

This technical memorandum provides additional explanation and proposed modifications to the SFA to bolster support for the SFA from the agencies. Listed below is a summary of the next steps associated with finalizing the SFA:

- Gain consensus on remaining WCI element scoring criteria (those listed above) based on additional justification and proposed changes summarized above
- Gain consensus on SFA application
  - Baseline condition scoring
  - Proposed conditions (interim, restored, fully restored) scoring
  - SFA calculations
  - Weights
- Make necessary adjustments to SFA Ledger
- Finalize SFA Ledger
- Revise and Finalize SFA Report to reflect all changes/modifications/additions/clarifications.

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Attachment A: Geosynthetic Liner Penetration by Woody Vegetation

TETRA TECH

Technical Memo

To: Dan Kline – Midas Gold Idaho, Inc.

From: Aaron English – Tetra Tech

Date: May 20, 2019

Re: **Geosynthetic Liner Penetration by Woody Vegetation**

This attachment provides an overview of the growth rates and rooting depth of lodgepole pine and Engelmann Spruce and the risk for the root systems of woody vegetation to penetrate geosynthetic liners. Some concern has been raised by the agencies that planting trees may not be appropriate or that planted trees may not survive in riparian areas associated with stream liners. However, research has shown that the risk of damage to subsurface impermeable liners as a result of tree root penetration is relatively low given adequate depth of cover over the liner.

Lodgepole Pine (*Pinus contorta* var. *latifolia*)

Growth Rate

The lodgepole pine grows to a height of 70–90' and an average diameter of 16 inches. It grows at a slow to medium rate, with annual height increases of anywhere from less than 12" to 24" per year. Application of nitrogen fertilizer may enhance growth. Height and diameter growth of lodgepole pine seedlings are higher following inoculation with ectomycorrhizae (Grossnickle, 1982).

Root Depths

Lodgepole pine develop a generally deep root system that is variable in form, depending primarily on soil type (Agee, 1993). A taproot is common, but so is profuse development of vertical sinkers from lateral roots (Koch, 1996). The taproot is dominant during seedling and sapling development, but gradually becomes less important as trees mature and develop lateral root systems. Sinker roots develop near the base of the laterals and provide the major support thereafter (Pfister and Daubenmire, 1975). Maximum rooting depth of lodgepole pine is approximately 11 feet (3.3 m) (Canadell and Ehleringer, 1996). However, growth rates and forms of growth might vary among species/subspecies and ecological setting.

Horton (1958) excavated 40 lodgepole pine in varied soils of Alberta Canada. His work extends over soils having a range of textures, moisture conditions, and fertilities. The adaptability of the lodgepole pine root system is clearly indicated. Three factors are considered predominant in modifying the genetic tendencies of lodgepole pine root systems: soil texture or structure, soil moisture, and soil fertility. These determine whether lateral or vertical root systems will be stunted, normal, or highly developed. Vertical development is particularly sensitive to these variables.

Lodgepole pine rooting habits have been described for Alberta by Horton (1958) and for northeastern Oregon by Bishop (1962). Regarding lateral rooting Horton concluded:

"*Most of the lateral roots are in the top few inches of soil. They will seek out areas free of root competition, but on a fully-stocked site the root systems of adjoining trees become interwoven, and natural grafts may occur. In wet and very dry conditions both rooting extent and amount of branching are much less than on the more productive sites. For the first 20 to 25 years, maximum lateral root length was found to be about the same as stem height in the open-grown conditions sampled*."

"*In general, rooting is extensive at first, attaining maximum areal coverage by 30 years, well before maximum stem height growth is reached; then, nearing maturity, as tree growth requirements increase, rooting becomes much more intensive and complex*."

Other studies of lodgepole pine show that trees may develop adventitious roots in response partial stem burial from flooding or other disturbance (Agee, 1988).

In conclusion, lodgepole pine can develop deeper roots (up to 11-feet) depending upon soil type. Vertical root development is most effected by soil texture or structure, soil moisture, and soil fertility. Ensuring sufficient soil depth and soil fertility should allow the use of lodgepole pine in the planting plans and the inevitable natural reestablishment of the species on reclaimed areas.

Engelmann Spruce (*Picea engelmannii*)

Growth Rate

Engelman Spruce grows to a height of 80-130 feet. It is a slow growing tree, with annual height increases of anywhere from 0.25 -0.5 inches a year. A 20 year old tree may only be 4-5-feet in height (Alexander and Sheppard, 1984) Engelmann spruce is a long-lived tree, maturing in about 300 years.

Root Depths

Engelmann spruce is considered to have a shallow root system. Under most growing conditions, roots of the Engelman spruce are in the first 12 to 18 inches of soil. But where spruce grows on deep, porous, well-drained soils, the lateral root system may penetrate to a depth of 8 feet or more (Alexander 1958, 1965).

In conclusion, Engelmann spruce typically have a shallow root system. However, Engelmann spruce can develop a deeper root system (up to 8-feet) if it is growing on deep, porous, well-drained soils. Insuring the tailings cap is designed to maintain moisture in the cap material where the root system of Engelmann spruce can draw from it, will be important to sustaining the typical shallow root system of this species.

Woody Vegetation Penetration of Geotextile Liners

Contrary to popular perception, the main orientation of a tree's root system is not vertical, but horizontal. Whereas the vertical depth of roots is commonly no more than about 3-6.5 feet, and is often less, the horizontal spread can be one to three times the tree height (Dobson and Moffat. 1995). This is especially the case for coniferous tree species in the mountains of central Idaho. Tree roots are highly sensitive to environmental condition and their downward penetration can be restricted by a number of soil factors including compaction, poor aeration and infertility (Dobson and Moffat. 1995). A detailed study of these factors indicates that the materials used for capping landfill sites, such as HDPE (high density polyethylene) and compacted clays, can provide an effective barrier to downward root growth (Dobson and Moffat. 1995).

In periods of dryness plant roots have an ability to deepen, penetrate even compact soils and potentially penetrate geotextiles used for GCLs (Sarsby and Meggyos, 2008). Roots can penetrate high-density sealing layers and to inhibit roots from penetrating the sealing layer, the cover layer should be carefully planned to reduce deep root growth. The most important factors seem to be nutrient supply in the upper part of the cover layer; hydraulic conductivity; thickness of the sealing layer is of less importance (Stoltz and Greger, 2006). If the cover layer contains sufficient nutrients for the plants, their roots have no need to grow deeper. Stoltz and Greger (2006) also found that the pH of the sealing layer may affect the root penetration; a too low or high pH reduces root growth.

Previous studies suggest that tree roots do not penetrate landfill liners (Gillman, 1989, Dobson and Moffat 1995, Robinson and Handel 1995, Handel et al. 1997, Hutchings et al. 2001). Moffate et all (2008) found that tree roots occasionally penetrated weaker areas of a mineral landfill liner when the soil layer over the cap was less than 3.2 feet. Other studies have indicated that the materials used for capping landfill sites, such as HDPE (high density polyethylene) and compacted clays, can provide an effective barrier to downward root growth (Holl and McStay 2014, Dobson and Moffat. 1995). Trees growing on landfill sites with a rootable soil depth of at least 4.5 feet should be at no greater risk of windthrow than most forest trees on undisturbed sites (Dobson and Moffat. 1995).

The above research on landfills suggests that woody plant roots rarely penetrate intact liners and that woody plant roots have a fairly flexible morphology allowing them to adjust to their immediate microenvironment (Handel et al. 1997) Woody plant roots should not penetrate intact liners as long as a sufficient soil layer over the liner for the type of woody vegetation planned is provided (Holl and McStay 2014).

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Attachment B: SFA Pool Frequency and Quality Analysis

Technical Memorandum

Rio ASE 2449 S. Vista Ave. Suite B, Boise, ID 83705 Telephone: 208-559-4615

TO: MIDAS GOLD IDAHO, INC.
FROM: RIO ASE
DATE: MAY 20, 2019
FILE: 023-090-001-05
SUBJECT: STIBNITE GOLD PROJECT – SFA POOL FREQUENCY AND QUALITY ANALYSIS

Detailed below is a description of recommended Stibnite Gold Project (SGP) Stream Functional Assessment (SFA) criteria along with supporting justification and rationale for pool frequency and pool quality.

Pool Frequency

ORIGINAL CRITERIA: USFS APPENDIX B (USFS 2003)

Pathways and WCIs	Functioning Appropriately	Functioning at Risk	Functioning at Unacceptable Risk
Habitat Access (continued)			
Pool Frequency and Quality: consider variations based on local biophysical elements i.e., vegetation habitat type/community type, ecological processes, stream channel width and type, landform etc., appropriate to the site.	Pools have good cover and cool water, and only minor reduction of pool volume by fine sediment. Large woody debris recruitment standards for functioning appropriately (above) are met and pool frequency in a reach closely approximates:[7], [13] **Steelhead and chinook:** Channel Width (ft.) No. Pools/Mile 0-5 184 5-10 96 10-15 70 15-20 56 20-25 47 25-50 26 50-75 23 75-100 18 **Bull Trout:** Wetted Width (ft.) No. Pools/Mile 0-5 39 5-10 60 0-15 48 15-20 39 20-30 23 30-35 18 35-40 10 40-65 9 65-100 4 Can use the formula: pools/mile = 5280/wetted channel width = # pools/mi # channel widths per pool	Pool frequency is similar to values in "functioning appropriately", but pools have inadequate cover/temperature,[6] and/or there has been a moderate reduction of pool volume by fine sediment. Large woody debris recruitment is inadequate to maintain pools over time.	Pool frequency is considerably lower than values desired for "functioning appropriately"; also cover/temperature is inadequate,[6] and there has been a major reduction of pool volume by fine sediment.

The USFS Appendix B criteria came from two sources depending on fish species – 1) bull trout or 2) Chinook salmon and steelhead. The bull trout criteria came from Overton et al (1995) and is based on data collected within the Salmon River basin in Idaho, which should include bull trout, Chinook salmon and steelhead habitat. The Chinook salmon and steelhead pool frequency data came from USFS (1994) and includes data from Oregon, Washington, Idaho and Alaska. As stated in the USFS Appendix B document these tables are only to be used if more relevant site-specific data are not available.

CURRENT CRITERIA (SFA LEDGER VERSION 2/28/19)

Rating	FA	FR	UR
Score	3	2	1
Pool Frequency Threshold Criteria	Optimal pool frequency (actual frequency ≥100% optimal)	Near Optimal Pool Frequency (frequency ≥67% - 100% optimal)	Much less than optimal pool frequency (frequency <67% optimal)

The current SFA criteria were modified from the original USFS Appendix B criteria. First, there was a need to quantify the divisions between Functioning Appropriately (FA), Functioning at Risk (FR), and Functioning at Unacceptable Risk (UR) rather than having qualitative divisions such as "considerably lower than," and "similar to." The simplest way to quantify these qualitative descriptions was by applying a percentage to the supplied pool frequency criteria, which was completed in order to establish the divisions outlined above. The other change to the USFS criteria was the removal of additional qualitative measures such as: cool water, cover, and large woody debris abundance and future recruitment. We interpreted these additional measures as contributing to pool quality not frequency, and these additional measures were already independently quantified within the SFA Ledger; therefore, the SFA metrics were only divided based on pool frequency.

Issue with Current Criteria:

The issue with the current criteria is that the divisions between FA, FR and UR (>100% of average, 100%-67%, and <67%) were set arbitrarily and a more scientific/ statistically correct method has been requested to justify the scoring divisions.

Agency and Services Recommended Alterations:

During an SFA workshop (4/15/19) the agencies and services (United States Forest Service, National Marine Fisheries Service, United States Fish and Wildlife Service, United States Environmental Protection Agency, and United States Army Corps of Engineers) recommended applying one standard deviation from the average for each division between FR and UR in the scoring criteria, or other comparably significant statistical division.

PROPOSED CRITERIA:

Attempt to Use Agency and Services Recommended Alterations

Rio ASE reviewed the original pool frequency data referenced in the USFS Appendix B document in an attempt to follow the recommended scoring criteria (using a standard deviation from average) or to better defend the existing divisions in the scoring criteria.

The pool frequency data associated with bull trout was based on the USFS User's Guide to Fish Habitat: Descriptions that Represent Natural Conditions in the Salmon River Basin, Idaho (Overton et al 1995). This report includes the average number of pools per mile, the standard error, and the number of observations for each channel width classification. In an attempt to apply one standard deviation from the average as the division between FR and UR, the calculated standard deviation for some of the wetted width categories exceeded the average pool frequency resulting in a negative or zero number of pools per mile. In addition, some of the sample sizes were so small that they did not provide an accurate representation of the specific wetted width size class (e.g. there were only two observations for the 0- to 5-foot wetted width classification).

The pool frequency data associated with Chinook salmon and steelhead came from inventory data from the USFS and Bureau of Fisheries in 116 watersheds in Oregon, Washington, Idaho and Alaska (USFS, 1994). There were three major issues associated with these data. 1) While the data presented in this document appeared to represent average pool density, the density was not defined as average, rather as a desired number of pools per mile based on channel wetted width. Associated with that, there was no statistical information available to derive a standard deviation or variation from the average. 2) The dataset did not represent total pool frequency, rather, it only represented the frequency of pools that are greater than 1 meter in residual depth (USFS, 1994). 3) This dataset only represented Rosgen C-type low-gradient channels and did not necessarily represent the range of conditions observed and proposed within the Stibnite Gold Project (SGP) area (USFS, 1994).

Research on Total Pools

Rio ASE evaluated available existing data summarizing undisturbed natural pool frequency and was unable to find published summaries of total pool frequency. There are historic data from some of the original US Fisheries Bureau work that summarized total pool frequency, but these data were not divided into wetted width size classes. In an effort to develop better information, Rio ASE obtained a large dataset consisting of completed Columbia Habitat Monitoring Program (CHaMP) for over 630 sites collected from 2011 through 2014. These data include pool frequency and wetted width among many other stream criteria. We queried the CHaMP data to analyze "All Sites," "Low and Undisturbed" sites, as well as only sites within the South Fork Salmon River basin (Figure 1 and Table 1).

As another comparison we also took the Salmon River pool frequency data (Overton et al 1995) and recalculated the data as an average number of wetted widths per pool (unitless dimension) for each size class and then combined all wetted width classes based on sample size to calculate the weighted average number of wetted widths per pool. This average number of wetted widths per pool was then converted back to number of pools per mile based on the specified wetted width groupings (Modified Overton Data). This creates a more robust data set (more sample sites) to develop an average unitless parameter scalable to different channel width classes. We compared these data to the various CHaMP data sets and all four of these analyses had similar distributions as seen in Figure 1 below.

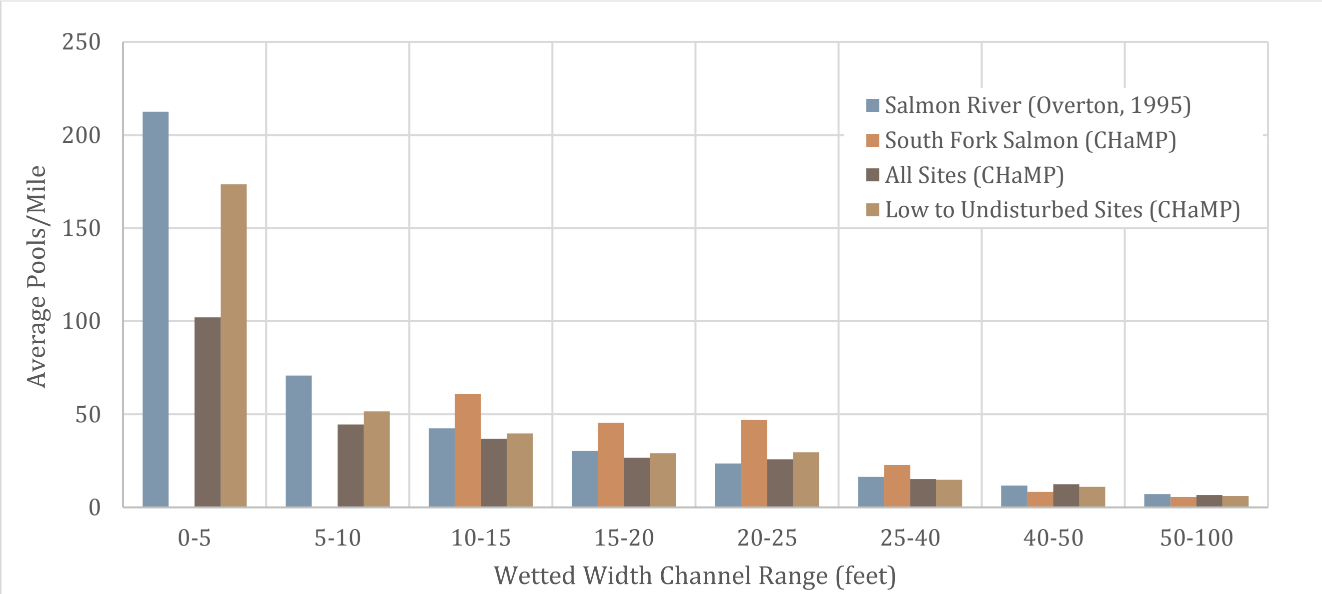

Figure 1. Pool frequency for various CHaMP datasets and USFS dataset (Overton, 1995) separated by various channel wetted width.

As summarized in Figure 1, the modified Overton (1995) and CHaMP data collectively illustrate a similar relationship between pool frequency and stream wetted width. The large CHaMP dataset and the ability to query specific sites based on robust stream classification information, supports the selection of a dataset that is most representative of natural/reference conditions for streams similar to those at the SGP. As summarized in Table 1, **we recommend that the CHaMP dataset for "undisturbed" and "low disturbance" sites be utilized for analysis of total pool frequency.**

Table 1. Summary of evaluated pool datasets and relevance to SGP area streams.

Dataset	SGP Relavance
Salmon River (Overton, 1995)	Includes data from 233 sites within the Salmon River watershed, but channel slope ranges are unknown
CHaMP (South Fork Salmon sites only)	Does not include sites with streams measuring less than 10-feet wetted width
CHaMP (all sites)	Includes many sites that may have been modified by human actions and therefore may not accurately represent natural and/or reference conditions
CHaMP (all "low" and "undisturbed" sites)	Includes 325 sites in the Pacific Northwest region that are minimally disturbed, with a wide range of wetted widths (0-100 feet) and with a wide range of channel slopes (0.0013 ft/ft to 0.0845 ft/ft) that typically fit within the SGP existing and proposed ranges

Statistical Classification

Review of other stream functional assessments completed as regulatory documents in other states suggests that the 25th and 75th percentiles are commonly used to divide between high, medium and low (Nadeau et al 2018). This assumption states that the lowest 25% of all sites are of poor condition and assumed to be functioning at an unacceptable risk level while the highest 25% of all sites are providing a high level of function are assumed to be functioning appropriately (Nadeau et al 2018). **It is recommended that the divisions between FA, FR, and UR use the 25th and 75th percentiles of the pool spacings data for each wetted width category.** The proposed recommendations would result in the scoring criteria for pool frequency identified in Table 2 below for all salmonid species. Pool frequency is driven by geomorphic characteristics such as slope, confinement, sediment size, large woody debris, and vegetative bank stability. These factors are present in a channel regardless of anticipated fish use, and while a specific species may prefer a certain pool frequency, the desire of that species does not drive the geomorphic character of the stream.

Table 2. Recommended pool frequency (pools/mile) scoring criteria for various channel wetted widths.

Wetted Width (feet)	Functioning Appropriately (FA)	Functioning at Risk (FR)	Functioning at Unacceptable Risk (UR)
0 - 5	> 235	138 - 235	< 138
5 - 10	> 113	52 - 113	< 52
10 - 15	> 79	31 - 79	< 31
15 - 20	> 50	25 - 50	< 25
20 - 25	> 48	22 - 48	< 22
25 - 40	> 37	11 - 37	< 11
40 - 50	> 15	9 - 15	< 9
50 - 100	> 14	4 - 14	< 4

Pool Quality

ORIGINAL CRITERIA: USFS APPENDIX B (USFS 2003)

Pathways and WCIs	Functioning Appropriately	Functioning at Risk	Functioning at Unacceptable Risk
Habitat Access (continued)			
Large Pools/Pool Quality (All Fish Species) In adult holding, juvenile rearing, and over wintering reaches where streams are 3.0 meters in wetted width at base flow.	Each reach has many large pools > 3.28 feet (1 meter deep).[6] Pools have good cover and cool water, and only minor reduction of pool volume by fine sediment.	Reaches have few large pools > 3.28 feet (>1 meter) present[6] or inadequate cover/temperature. Moderate reduction of pool volume by fine sediment.	Reaches have no deep pools > 3.28 feet (> 1 meter)[6] and inadequate cover/temperature. There is a major reduction of pool volume by fine sediment.

CURRENT CRITERIA:

Rating	FA	FR	UR
Score	3	2	1
Pool Quality Criteria	Reach has >25% of optimal pool frequency >1m deep	Reach has <25% but greater than 0% optimal pool frequency >1m deep	Reach has no deep pools (0% of optimal pool frequency >1m deep)

The current criteria were modified from the original USFS Appendix B criteria. First, all streams were assessed for pool quality regardless of wetted width. This is to maintain a standard/absolute measure between all analyzed reaches. Secondly, there was a need to quantify the breaks between FA, FR, and UR rather than having qualitative breaks such as "many large pools," and "few large pools." The other change was the removal of additional qualitative measures such as: cool water, cover, and pool volume reduction by fine sediment. While these additional qualitative measures assist in defining what makes a high-quality pool rather than just a deep pool they are already assessed elsewhere in the SFA – temperature, large woody debris, and fine sediment WCI elements.

Issue with Current Criteria:

There were two issues identified by the agencies and services. The first was the lack of scientific data to defend the quantified divisions in pool quality criteria. The scoring division of 25% was originally based on professional judgment with little literature justification. The second issue was that the original scoring criteria were identified as only applicable for streams over 3.0 meters in wetted width (USFS 2003), which excludes many of the stream reaches in the SGP area.

Agency and Services Recommended Alterations:

It was recommended by the agencies and services that a more scientific rationale be developed for the scoring criteria, or that the existing scoring criteria be better justified. It was also recommended by the agencies and services that streams smaller than 3 meters in wetted width not be evaluated for pool quality due to their inherent inability to scour deep, residual-depth pools.

PROPOSED CRITERIA:

Attempt to Use Agency and Services Recommended Alterations

Scoring all reaches in the same manner using a standardized/absolute metric whether an element can exist in a certain reach or not is paramount to a nonbiased evaluation of changes in conditions within a project area over time as discussed in the body of the parent document to this appendix (Stream Functional Assessment Scoring Concerns Addressed: Stibnite Gold Project Technical Memorandum). Therefore, it is recommended that all streams, regardless of size, should be evaluated for pool quality if there are data to support the evaluation. During background investigations into pool frequency discussed above, it was determined that the original pool frequencies for Chinook salmon and steelhead were based on historic pool data that only included pools with residual depths greater than 1 meter (USFS 1994). Within that dataset were many deep pools associated with channel wetted widths less than 3 meters, which ultimately removes the concern of applying this metric to small streams. Based on this information it is recommended that all stream reaches be analyzed with the same criteria regardless of wetted width size.

Research on Pool Quality

Rio ASE reviewed the US Fisheries Bureau studies that were completed in the 1940's to evaluate pools with residual depths greater than 1 meter (McIntosh 1994). This study summarized data from over 2,000 miles of streams and rivers, but typically only summarized deep pools without relation to channel width. One summarization of the data includes total pools and large pools within the upper Grande Ronde River basin in Oregon. On average, 60% of the total pools observed in 1941 were considered deep pools (> 1-meter residual depth) (McIntosh 1994). We are familiar with this basin and some of the smaller streams currently have zero deep pools, suggesting most of the pools documented were from larger streams. This information along with observations from other watersheds and basic hydraulic scour relationships (relationship between discharge, width, and potential scour depth – see scour calculations in the Stream Design Report section 3.3.6.2, Rio ASE 2019) suggest that small/narrow channels have less ability to develop and sustain deep pools so that the percentage of deep pools in a small/narrow channel should be less than the percentage of deep pools in a large/wide channel. **We recommend utilizing a standard deep pool density for all streams based on this geomorphic characteristic (rather than excluding small/narrow streams), and that the standard metric represent the average number of deep pools from the US Fisheries Bureau study equal to 10.4 deep pools/mile.** Comparing this average deep pool frequency to average total pool frequency (from low and undisturbed CHaMP sites – Figure 1) a trend results that as a channel becomes wider the percentage of pools qualifying as deep pools increases as seen in Figure 2.

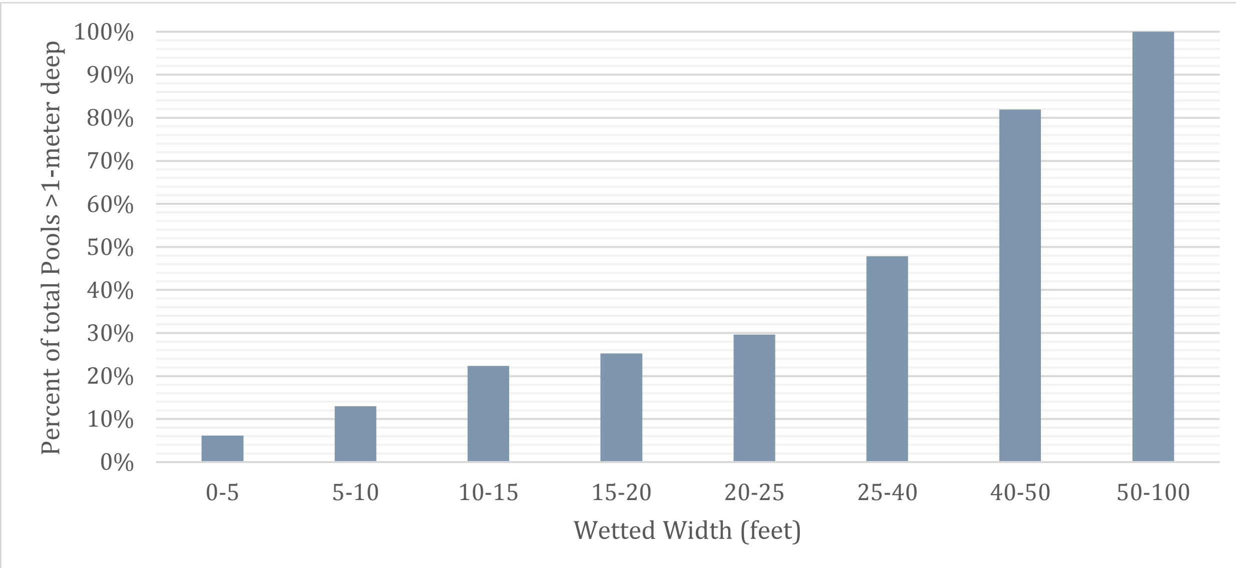

Figure 2. Example of percentage of total pools that are considered deep as derived from US Fisheries Bureau data (McIntosh 1994).

Statistical Classification

Plotting the cumulative distribution of deep pool frequency one can estimate the 25th and 75th percentiles for deep pool frequency. This analysis provides a similar quantifiable division in the scoring criteria as described in the pool frequency section above based on Nadeau et al 2018. The 25th percentile is 4.0 pools per mile while the 75th percentile is 14.6 pools per mile as seen in Table 3.

Table 3. Recommended pool quality frequency (deep pools/mile) scoring criteria.

Functioning Appropriately (FA)	Functioning at Risk (FR)	Functioning at Unacceptable Risk (UR)
> 14.6	4.0 - 14.6	< 4.0

References

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