# Monitoring Riparian Forest Health in the Linley Valley

**Using a Proper Functioning Condition Assessment on Cottle Creek**

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**Prepared for: Nanaimo and Area Land Trust &**

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BRITISH COLUMBIA CONSERVATION FOUNDATION

CITY OF NANAIMO THE HARBOUR CITY

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# Acknowledgements

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The Linley Valley and Cottle Creek are within the traditional, ancestral and unceded territories of the Snuneymuxw First Nation. We recognize their enduring connection to this land and express our gratitude for their stewardship over generations.

# 1.0 Introduction

The Cottle Creek watershed in Nanaimo has been the subject of several citizen science monitoring studies focused on aquatic ecosystem health in a rapidly urbanizing area. Located in the Linley Valley, the watershed is unique within the city because 40% of its 4.86 km² area remains undeveloped and in a natural condition. This forested watershed provides an opportunity to monitor biotic variables, such as fish, and abiotic variables, such as stream hydrology and water quality, in the context of climate change and environmental resilience. In 2025, the Friends of Cottle Creek (FOCC), a local streamkeeper group, proposed a riparian field assessment to determine whether the area's riparian forests are maintaining properly functioning conditions that support long-term ecological sustainability.

To support this watershed health monitoring strategy, FOCC applied for funding from the City of Nanaimo's Community Environmental Sustainability Project to complete a field assessment with the following objectives:

- To assess if streamkeepers (with minimal training) can use the Province of BC's Forest and Range Evaluation Program (FREP) Riparian Management Routine Effectiveness Evaluation (RMREE) protocol, to determine the "functioning condition" of Cottle Creek, in four reaches below the lake.
- To determine if existing land use practices in Cottle Creek below the lake have altered the structure, or function of the riparian zone in a way that affects the properly functioning condition of the riparian zone and creek.
- To determine if the Proper Functioning Condition assessment process on Cottle Creek can provide useful metrics for the City of Nanaimo to use in assessing Healthy Watersheds as described in the Official Community Plan (OCP) Nanaimo Reminagined (City of Nanaimo, 2022; Ch.1.4)

# 2.0 Study Area and Background

Cottle Creek is located in the City of Nanaimo, lying between Departure Creek to the south and Walley Creek to the north (Figure 1). The creek is a 5.5 km long third order stream and is the primary watercourse in the Linley Valley. Its drainage area is 486 hectares, with 40% of its catchment being undeveloped second and third growth Coastal Douglas Fir forests. The dominant land tenures are owned by the City of Nanaimo (Linley Valley Cottle Lake Park and Lost Lake Park) and the Province of British Columbia (BC; DL 56).

Cottle Creek originates from a stormwater detention pond at 5740 Brookwood Drive. Flowing east, the creek receives additional flows in the winter months from three tributaries that join the drainage system at Cottle Lake. Below the lake, the creek flows 2.4 km in a natural forested valley that transitions into an urban development corridor from Nottingham to Stephenson Point Road area. The creek discharges into the ocean in Departure Bay, near the Pacific Biological Station at 3190 Hammond Bay Road.

Cottle Creek and Cottle Lake contain a population of resident Coastal Cutthroat Trout (*Oncorhynchus clarkii clarkii*).

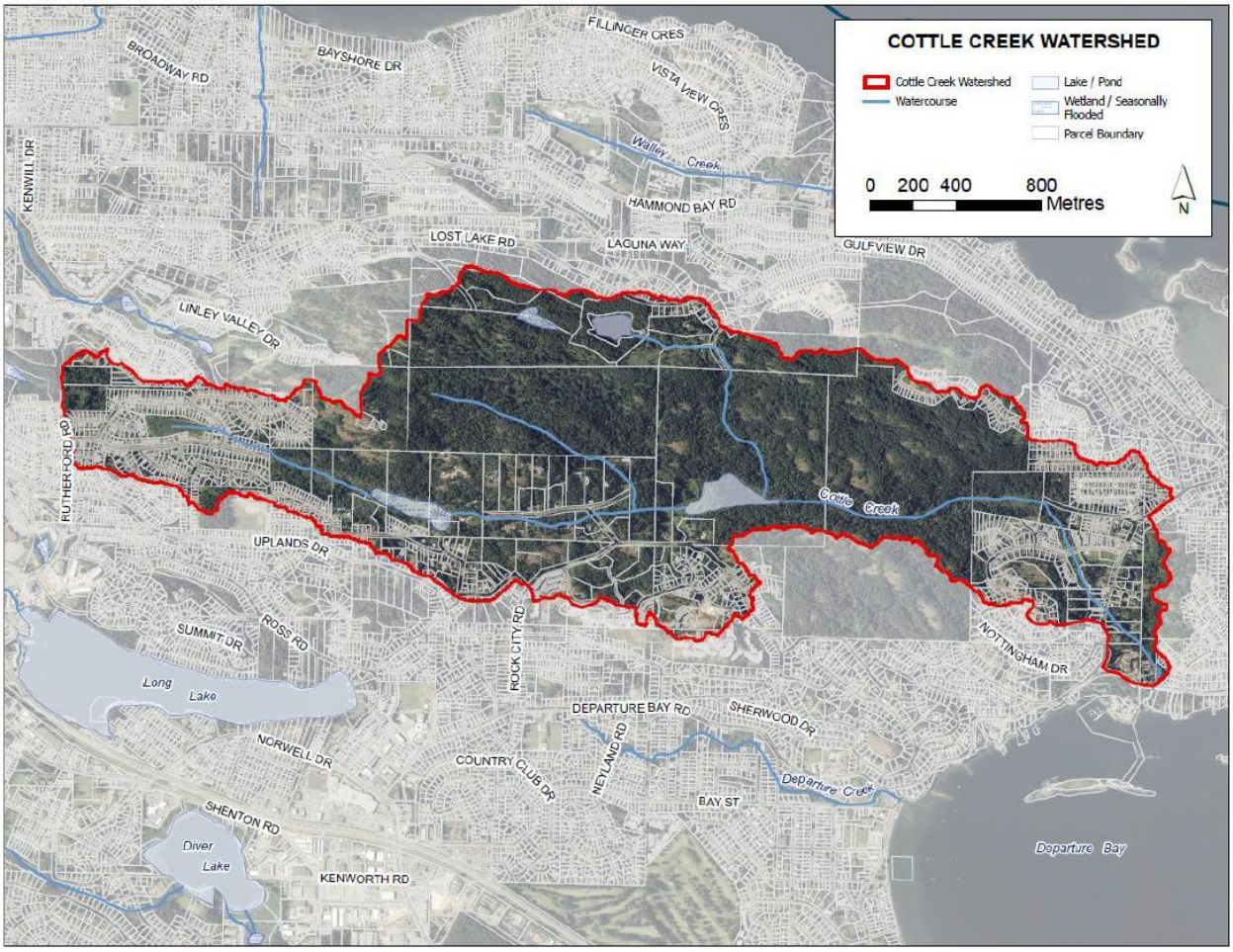


***Figure 1**. Overview map of the Cottle Creek Watershed. (City of Nanaimo, 2026)*

## 2.1 Developing a Watershed Health Monitoring Strategy

Beginning in the fall of 2024, the Friends of Cottle Creek have developed a monitoring strategy using "citizen science" to better understand the biotic and abiotic factors that influence ecological conditions in the watershed. This has included the following:

1. Stream flow monitoring,
2. Water quality monitoring,
3. Fish presence and distribution in the watershed,
4. Fish habitat assessment, and
5. Health of the Riparian Zone of lower Cottle Creek.

A brief description of each project is provided below:

### 2.1.1 Stream Flow Monitoring

FOCC volunteers have been monitoring stream discharge in Cottle Creek since September 2024 as part of Community Flow Monitoring Network (CFMN) (https://www.cfmnvi.com/). This project is a partnership between BCCF ARRC and the provincial Ministry of Environment and Parks that aids stewardship groups in the collection, verification, and analysis of flow data (https://aqrt.nrs.gov.bc.ca/Data). The prime objective for Cottle Creek is to better understand the hydrology of the watershed. A "rating curve" that defines the stage (water level) to discharge relationship has been developed for Cottle Creek, as well as an estimate of the mean annual discharge (MAD).

### 2.1.2 Water Quality Monitoring

The Departure Creek Streamkeepers have partnered with the RDN since 2012 to monitor a suite of surface water parameters at three locations on Cottle Creek (Province of BC EMS Sites E290473, E290475, E309186;). These data are used to assess trends in water quality in the region (Ecoscape Environmental, 2021).

### 2.1.3 Fish Presence & Distribution

In August 2024, NALT launched a Coastal Cutthroat Trout Assessment and Monitoring Project. The project is a collaborative, community-driven initiative aimed at generating essential long-term data on the presence and distribution of Coastal Cutthroat Trout in Nanaimo area streams and rivers (https://nalt.bc.ca/cutthroat-trout/). Using minnow traps on multiple occasions between 2024 and 2026 in Cottle Creek, the FOCC have gained a better understanding of fish distribution and habitat limitations in the watershed.

### 2.1.4 Fish Habitat Assessment

In the summer of 2025, the FOCC undertook an Urban Salmonid Habitat Program (USHP) survey to coincide with the low-flow period. This habitat assessment was limited to fish bearing waters from Landalt Rd to Stephenson Point Rd (Clark and Wightman, 2026). This data provided a measurement of available fish habitat in the creek at low summer flows.

### 2.1.5 Riparian Health – What is meant by the term "Proper Functioning Condition"?

Riparian areas are ecosystems. An ecosystem is a functional system that includes both biotic (e.g., plants and animals) and abiotic (e.g., soil and climate) factors. Organisms interact both with each other and with their environment. Every ecosystem is unique because the interactions of organisms and environment are unique.

A properly functioning riparian ecosystem along a creek acts as a critical interface between land and water, maintaining water quality, bank stability, and biodiversity. These areas are characterized by having adequate vegetation, landform, and woody debris to manage water energy and support diverse ecosystems. If a riparian area is not functioning properly, it may show symptoms such as:

- Incised or crumbling streambanks (vertical walls).
- Lack of native vegetation or dominance of shallow-rooted, non-native plants.
- Water that appears murky or has excessive algae growth.
- Decreased water levels or streams that dry up faster in the summer.

# 3.0 Methods and Materials

Riparian areas are complex, dynamic ecosystems incorporating biological, physical, and chemical processes. The proper functioning condition (PFC) assessment method was created by the Bureau of Land Management in the U.S. in 2002, to qualitatively evaluate the foundation of these processes—specifically the functionality of the physical processes occurring on a stream (USDI, Tech Circ 1737-15. 2015). Riparian areas are assessed as "properly functioning" when they can demonstrate the following:

- **Energy Dissipation:** They can handle high water flows by dissipating energy and reducing vertical/lateral erosion.
- **Sediment Capture:** They have the ability to catch sediment and build up floodplains.
- **Vegetation Health:** The plant community has good vigor and adequate diversity (species, age, and structure) to perform its functions.
- **Water Availability:** The vegetation and soil have capacity to store water for long periods.

A PFC quality assessment requires that an interdisciplinary team with expertise in these subjects assess the stream together. Based on this assessment, a stream reach is rated in one of three rating categories:

**Proper Functioning Condition (PFC)**: A lotic riparian area is "functioning properly," when adequate vegetation, landform, or woody material is present to:

- Dissipate stream energy associated with high waterflow, thereby reducing erosion and improving water quality.
- Capture sediment and aid floodplain development.
- Improve floodwater retention and ground-water recharge.
- Develop root masses that stabilize streambanks against erosion.
- Maintain channel characteristics.

A riparian area in PFC will, in turn, provide associated values, such as wildlife habitat or recreation opportunities.

**Functional – At Risk (FAR)**: These riparian areas are limited in the functional elements described above. Existing hydrologic, vegetative, or geomorphic attributes make them susceptible to impairment.

**Non-functional (NF)**: These riparian areas are not providing adequate vegetation, landform, or woody material to dissipate stream energy associated with moderately high flows, and thus are not reducing erosion, improving water quality, etc.

In British Columbia, the PFC methodology for rating riparian areas has been under development by the Ministry of Forests since 2009. Under the Forest and Range Evaluation Program, the Ministry staff and contractors have developed a *Protocol* for Riparian Management Routine Effectiveness Evaluation (Tripp et al., 2025).

The protocol for evaluating the condition of streams and riparian management areas has been developed into a handbook for use by anyone with a basic working knowledge of streams and riparian habitats. The handbook and the associated checklist are designed to guide the user as if they have a

professional background in the subject matter. For this reason, the FOCC decided to use this protocol for assessing the riparian areas of Cottle Creek.

The Province of BC's FREP RMREE protocol, supplementary field reference guide, and field data collection cards are available on the Government of BC's Forest and Range Evaluation webpage: https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/integrated-resource-monitoring/forest-range-evaluation-program/frep-monitoring-protocols/fish-riparian.

The surveyor team was composed of participants with varying backgrounds:

1) Team leader - BC Conservation Foundation biologist - trained in the field protocol by Ministry of Forests
2) 5 volunteers from the Friends of Cottle Creek:
    a. 3 people (ecology background),
    b. 2 people (generalists)
3) 1 academic – VIU Mount Arrowsmith Biosphere Research Institute staff member (ecology background)

Prior to initiating the field surveys, the team met to decide which sections of the creek should be assessed to ensure a proper reflection of riparian and creek channel conditions that exist in lower Cottle Creek. It was determined that reaches 2, 3, 4, and 5 were the best for comparison purposes. Field surveys were limited to four days to ensure there was enough time for reporting. Field surveys took place on September 11th and October 3rd, 2025 and April 24th and May 1st, 2026.

A representative "sub-sample" length was selected within each reach. Sample lengths were determined as described in the protocol by multiplying the average channel width by 30 (with a minimum of 100 m). Each surveyor was assigned three to four continuous indicators (e.g., lateral bars, pool length, windthrow), and these indicators were measured along the entirety of the sample length. All data was collected directly onto a printed paper field card. Continuous indicators were measured using various methods (eg. 30m measuring tape, or visual estimation). Once all continuous indicators were recorded, point indicators (e.g., benthic invertebrates, invasive plant cover, shade) were recorded at six riffle sites evenly distributed through the transect (e.g., in a 150 m transect, point indicators were measured approximately every 25 m). Point indicators were measured by visual estimation. Benthic invertebrates were collected by disturbing riffle substrate by hand with a 15 cm mesh sieve held immediately downstream.

The survey team then collectively answered the questions in the "other indicators to note" section and filled in the field data summary tables. Once all field data was collected, the totals, averages, and percentages for the continuous and point indicators were calculated and recorded on the field card. Using these summary statistics, the 15 questions with 'yes/no' responses were answered and a conclusion on functional condition was made. Causes of 'no' answers were then determined by consensus of the Survey Team and were recorded in the "Specific Causes of 'No' Answers" matrix provided in the field card (Appendix 1.0).

***Figure 2**. FREP RMREE Assessment crew (BCCF, FOCC, MABRRI) identifying and enumerating benthic macroinvertebrates at riffle sites on Cottle Creek.*

## 4.0 Results

Reach five received a PFC rating of 'Functioning, but at risk' (FAR) with three 'no' and twelve 'yes' answers (Table 1) and was the best rated reach in this assessment. Reaches two, three, and four all received ratings of 'Not properly functioning' (NF), with reaches two and four both receiving seven 'No' answers and reach three receiving the most (12) 'No' answers (Table 1).

Reach five received a FAR rating with the main reason for 'No' answers in the reach being natural impacts (Figure 5). The reach was found to be functioning in four of the five PFC categories, meaning the riparian zone was able to:

- Capture sediment and aid floodplain development.
- Improve floodwater retention and ground-water recharge.
- Develop root masses that stabilize streambanks against erosion.
- Maintain channel characteristics.

The reach received three 'No"' answers due to its inability to:

- Dissipate stream energy associated with high waterflow, thereby reducing erosion and improving water quality.

Reaches two and four were rated 'Not Functional' (NF). Both received seven 'No' and eight 'Yes' answers (Table 1), indicating they are impacted, but still contain some functional elements. Reach two 'No' answers were mainly caused by impacts of urbanization, while reach four 'No' answers were mainly caused by historical logging (Figure 5).

Reach three was rated as NF and had the most 'No' answers in the assessment. The main reasons for 'No' answers in this reach were historical agricultural land use impacts and the level of disturbance to

the creek channel by instream work by the City to repair infrastructure and remove sediment accumulations in the floodplain at Nottingham Drive (Figure 3).

The summary questions pertaining to channel morphology (Q4), benthic invertebrate diversity (Q9) and minimization of windthrow (Q10) received 'Yes' answers in all four assessed reaches (Table 2). A riffle-pool morphology was maintained in all assessed reaches of the creek, and despite high substrate embeddedness, a wide diversity of benthic invertebrates was found in riffle habitats of all assessed reaches.

The summary questions pertaining to habitat connectivity (Q5) and fine sediment introduction (Q8) received 'No' answers in all four assessed reaches (Table 2). Habitat connectivity in all assessed reaches of the creek is impacted by culverts impassable to fish, and summer low-flow conditions. Fine sediment introduction can be attributed to the erosion of unstable banks during high-flow periods.

***Figure 3.*** *Current riparian zone conditions in reach three of Cottle Creek upstream of Nottingham Drive.*

***Table 1.*** *Number of 'no' and 'yes' answers and subsequent 'Properly Functioning Condition' (PFC) rating of the four FREP RMREE evaluated reaches in Cottle Creek.*

| Reach | # of 'No' Answers | # of 'Yes' Answers | PFC Rating |
|---|---|---|---|
| 2 | 7 | 8 | Not Properly Functioning |
| 3 | 12 | 3 | Not Properly Functioning |
| 4 | 7 | 8 | Not Properly Functioning |
| 5 | 3 | 12 | Functioning But at Risk |

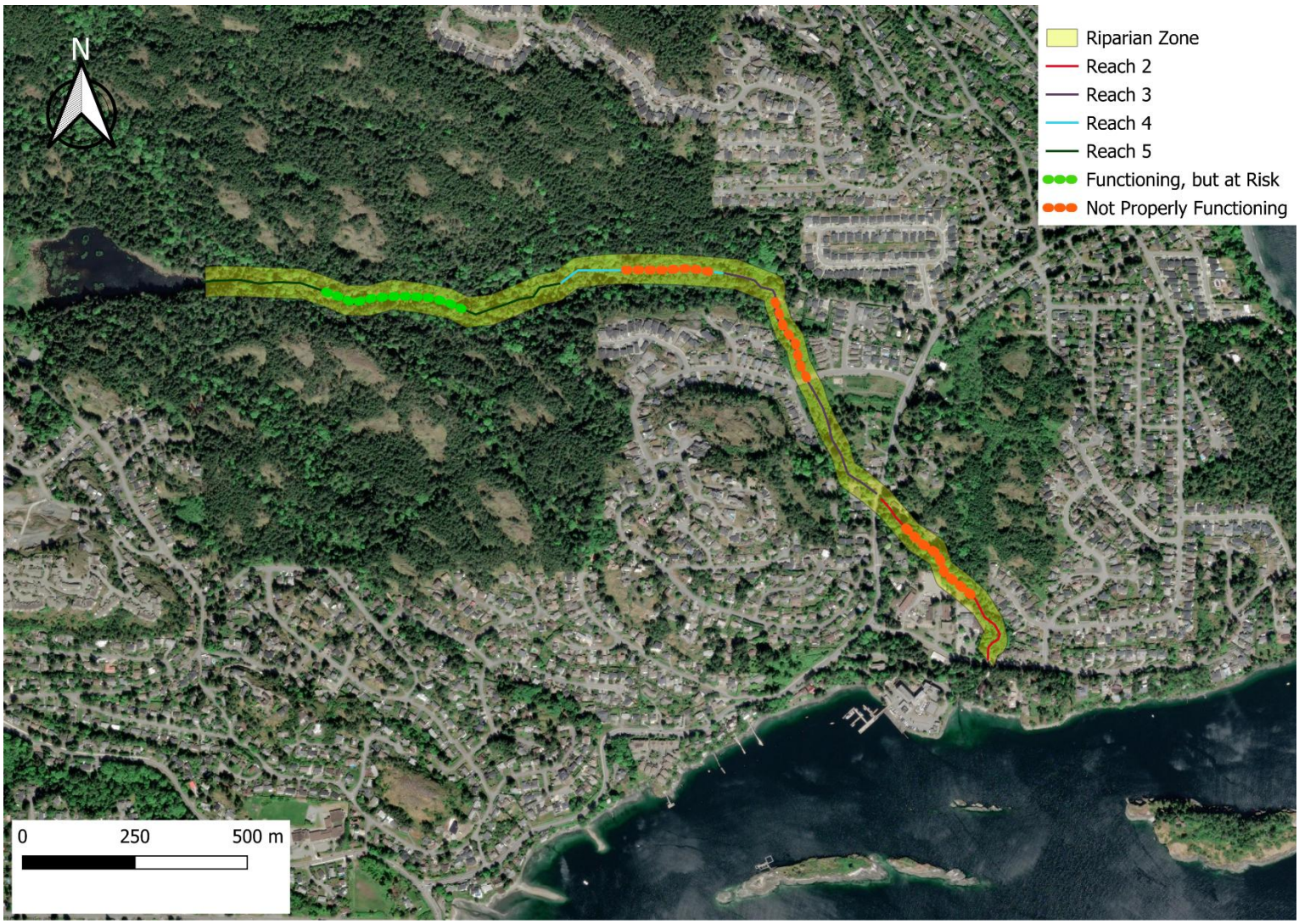


***Figure 4.*** *Map of Cottle Creek FREP RMREE assessed reaches and PFC scores. Dotted lines are the approximate areas surveyed within each reach.*

***Table 2****. Yes (Y) and no (N) answers to FREP RMREE summary questions (Q) for all evaluated reaches in Cottle Creek. Attributes that received a 'yes' answer in all assessed reaches are highlighted green and those that received all 'no' answers are highlighted red.*

| | | Reach 2 | Reach 3 | Reach 4 | Reach 5 |
|---|---|---|---|---|---|
| Q1 | Is the channel bed undisturbed? | N | N | Y | Y |
| Q2 | Are the channel banks intact? | Y | N | N | N |
| Q3 | Are channel LWD processes intact? | Y | N | N | Y |
| Q4 | Is channel morphology intact? | Y | Y | Y | Y |
| Q5 | Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris and sediments? | N | N | N | N |

| | | | | | |
|---|---|---|---|---|---|
| Q6 | Does the stream support a good diversity of fish cover attributes? | Y | N | Y | Y |
| Q7 | Does the amount of moss on substrates indicate a stable and productive system? | Y | N | N | Y |
| Q8 | Has the introduction of fine sediments been minimized? | N | N | N | N |
| Q9 | Does the stream support a diversity of aquatic invertebrates? | Y | Y | Y | Y |
| Q10 | Has the vegetation in the RMA been sufficiently protected from windthrow? | Y | Y | Y | Y |
| Q11 | Has the amount of bare erodible ground or soil compaction in the riparian area been minimized? | N | N | N | Y |
| Q12 | Has sufficient vegetation been retained to maintain an adequate root network or LWD supply? | N | N | N | Y |
| Q13 | Has sufficient vegetation been retained to provide shade and reduce bank microclimate change? | Y | N | Y | Y |
| Q14 | Has the number of disturbance-increaser plants, noxious weeds and/or invasive plant species present been limited to a satisfactory level? | N | N | Y | Y |
| Q15 | Is the riparian vegetation within the first 10 m from the edge of the stream generally characteristic of what the healthy unmanaged riparian plant community would normally be along the reach? | N | N | Y | Y |

The most common cause of ‘no’ answers was ‘other’ impacts (n = 25) which includes urbanization and historical agricultural impacts (Figure 5). Old logging was the cause of five ‘no’ answers. Both animal disturbance (inclusive of humans) and roads were the cause of seven ‘no’ answers, while natural impacts (e.g., floods or wind) were the cause of nine ‘no’ answers.

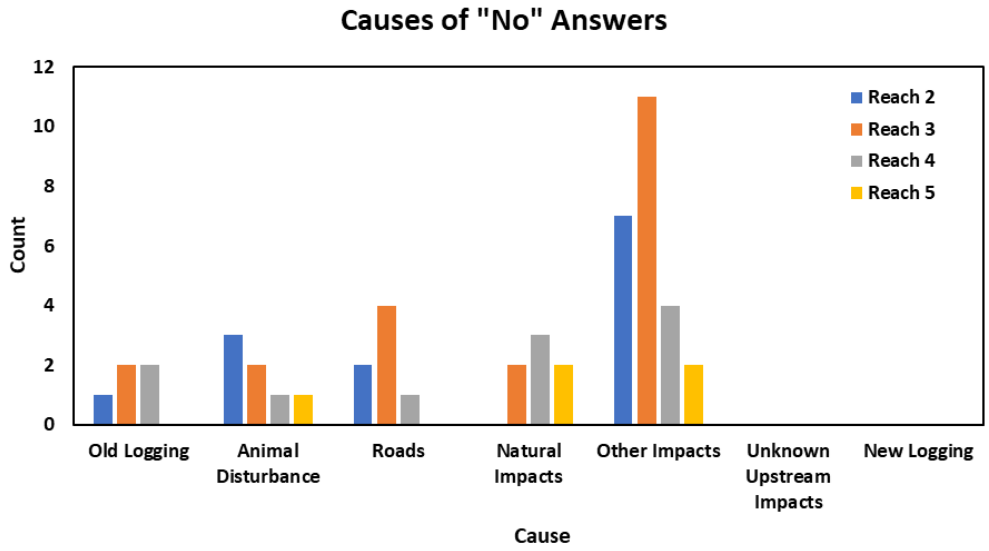


***Figure 5.*** *Causes of 'no' answers determined for all four FREP RMREE assessed reaches of Cottle Creek.*

# 5.0 Discussion

The main objective of this assessment was to rate the proper functioning condition (PFC) of Cottle Creek's riparian zone in four reaches below Cottle Lake using the Province of British Columbia's Forest and Range Evaluation Program (FREP) Riparian Management Routine Effectiveness Evaluation (RMREE) protocol. The project had two additional objectives: to determine whether a citizen science team with limited formal training could successfully use the protocol and generate accurate results, and if the PFC protocol could provide useful metrics for the City of Nanaimo to use in assessing watershed health. The results provide insight into the current condition of riparian habitats within the watershed, the influence of surrounding land-use on riparian function, and the potential value to the City of PFC assessments as indicators of watershed health.

## 5.1 Factors Affecting Cottle Creek Properly Functioning Condition

Three of the four assessed reaches in Cottle Creek received a PFC rating of 'not properly functioning' (NF), while Reach 5 received a rating of 'functioning, but at risk' (FAR). These ratings are not surprising when viewed in the context of the "stream health monitoring" data the FOCC have collected on the watershed to date.

Adapting the approach taken by Ghimire et al. (2025), the PFC results for Cottle Creek can be categorized into three attributes that influence watersheds: hydrology, geomorphology, and vegetation. The results of the Cottle Creek PFC assessment and the specific causes of 'no' answers can be more accurately discussed and understood in the context of these three categories.

### 5.1.1 Hydrology

The most significant issue impacting the proper functioning condition in the Cottle Creek watershed is the creek's flows during the summer and early fall months. Since September 2024, stream flows have been gauged in Cottle Creek (https://www.cfmnvi.com/) The data collected have developed a stage to discharge relationship for the creek, otherwise known as a "rating curve". This curve defines the relationship between water level and stream discharge. This monitoring has also facilitated an estimate

of the stream's mean annual discharge (MAD), of approximately 100 L/s, which is a critical hydrological measurement that provides an average of the stream's natural annual flow. MAD is also a useful measurement for understanding how the availability, quality, and quantity of aquatic habitat changes over time. The threshold for "fair spawning/rearing habitat" for fish in east coast Vancouver Island streams is 10 – 20% of MAD, with any flows below 5% MAD classified as "severely degraded spawning/rearing habitat" (Reid, Michalski & Reid, 1999).

### *Connectivity of Fish Habitat*

Lack of aquatic habitat connectivity in Cottle Creek can be largely attributed to low stream flows, especially during the summer low-flow period from April through October.

For three of the four reach assessments, Cottle Creek was below 10 % MAD, (Figure 6). At such low discharge, there is not enough water in the stream to maintain uninterrupted surface flows resulting in dry gravel bars. The severity and duration of the summer low-flow period (Figure 7) in Cottle Creek is the main cause of the lack of aquatic habitat connectivity observed in all reaches during this field assessment and remains a main limiting factor for productivity of aquatic life in the stream.

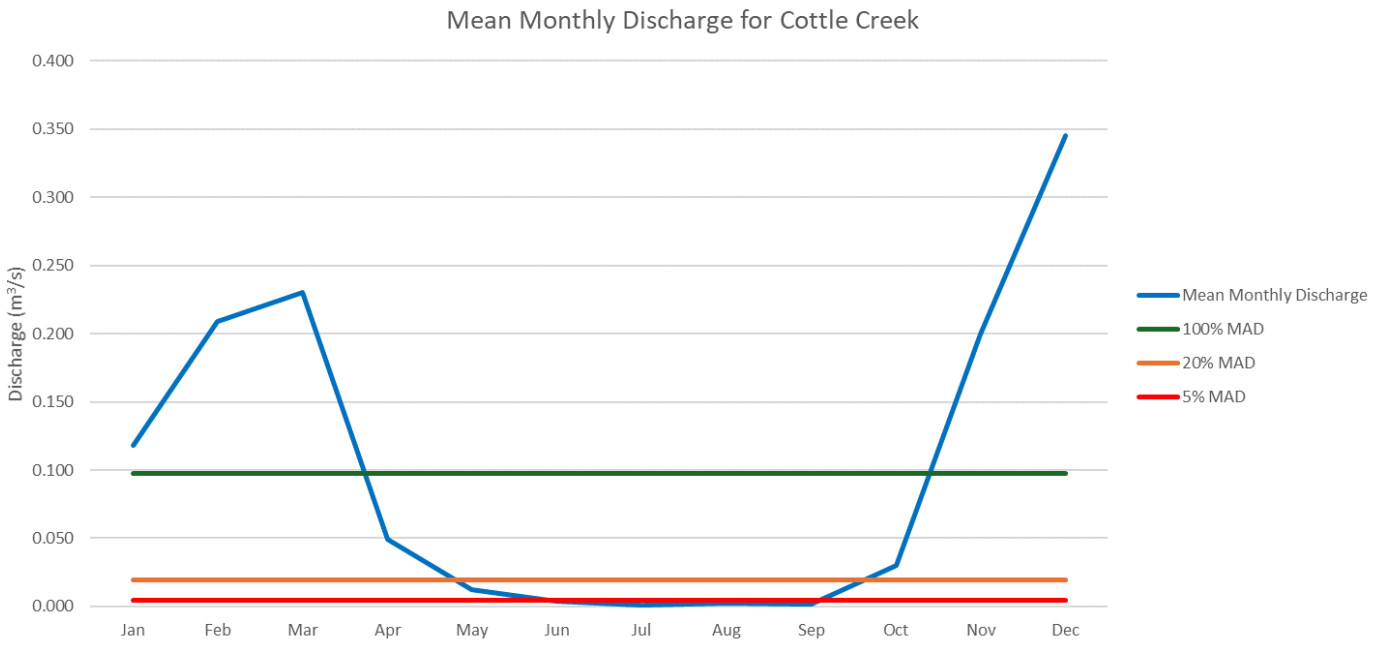


***Figure 6.*** *Annual Flows as shown in Mean monthly discharge ($m^3/s$) values recorded in Cottle Creek from 2024 through 2025*

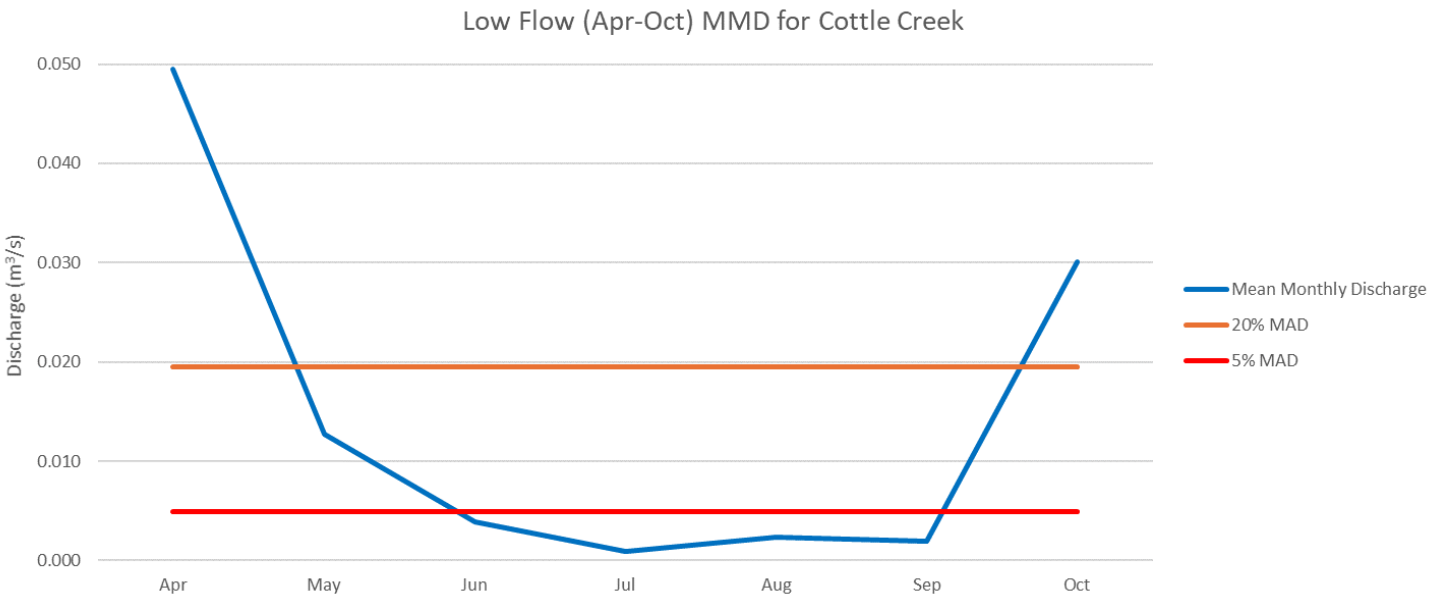


***Figure 7.*** *Mean monthly discharge (MMD; $m^3/s$) values recorded in Cottle Creek during low-flow period of April through October. (Courtesy of A. Wall, 2026).*

### *Channel Alterations*

In lower Cottle Creek where residential urban land use dominates (reaches 2 and 3), the abundance of linear road networks intersecting the creek corridor, has caused site disruptions that limit fish movement, constrict flow patterns, and cause sediment deposition in the channel.

A total of five culverts (four impassable to fish), an old concrete dam, stormwater headwalls and rip rap installed to protect streambanks from erosion are commonly found here (Figure 8).

***Figure 8.*** *The 200 Linley Road culvert is impassable to fish and large organic material (barrier between Reaches 3 and 4).*

Despite these intrusions at various points, Cottle Creek has an intact channel morphology (Table 2). All of Cottle Creek exhibits a riffle/pool morphology, with an average gradient of 1.7%.

Abundance and diversity of benthic invertebrates at riffle point sample sites exceeded the established thresholds of the PFC protocol in all reaches. Despite the high degree of substrate embeddedness observed, sufficient space and water quality existed at the time of this assessment to support a diverse array of aquatic invertebrates.

### 5.1.2 Geomorphology

#### *Erosion*

Multiple areas of channel downcutting and severe bank erosion were commonly observed in our survey (Figure 9). Channel bank erosion of mineral soil is a contributing factor to the sediments observed in the stream substrate. The majority of erosion-causing discharge occurs at streamflow levels above the mean annual discharge of 100 liters/second (Dumont, 2017). In a review of the hourly discharge on Cottle Creek from September 2024 to October 2025 we can see that discharges above the MAD are common for weeks at a time in the winter months (Figure 10).

***Figure 9**. Eroded bank and channel downcutting exposing the soil profile in Reach 3 of Cottle Creek.*

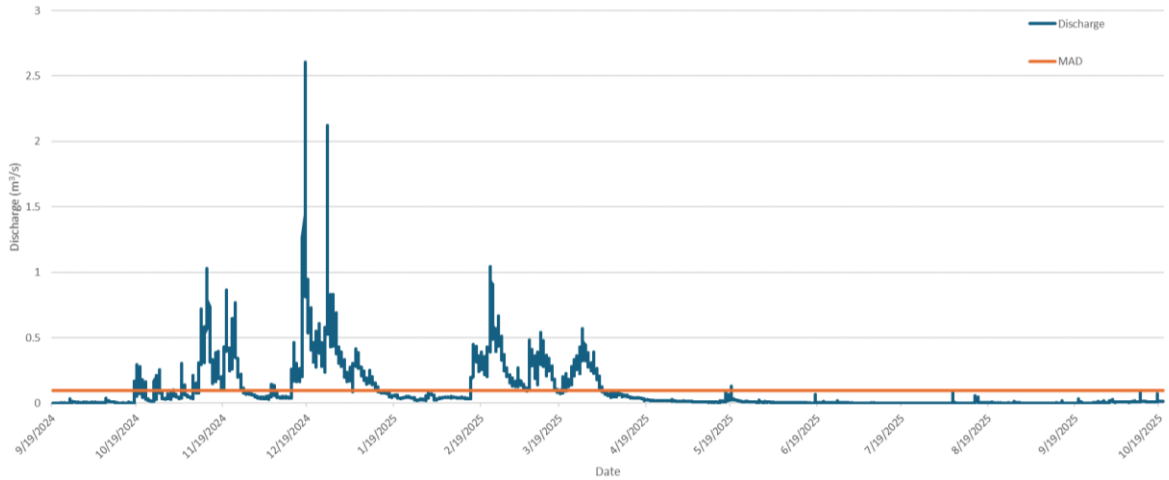


***Figure 10**. Hydrograph for Cottle Creek with hourly instantaneous discharge ($m^3/s$) values recorded from September 19, 2024 to October 19, 2025. The orange line represents the mean annual discharge (MAD) of approximately 0.100 $m^3/s$.*

### 5.1.3 Riparian Vegetation

The Linley Valley lies within the Coastal Douglas Fir Moist Maritime (CDFmm) biogeoclimatic zone of southeastern Vancouver Island, with climax forests containing mixed age stands of coastal Douglas fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), Arbutus (*arbutus menziesii*), red cedar (*Thuja plicata*),

and bigleaf maple (*Acer macrophylum*) trees (Meidinger & Pojar, 1991). This is one of the smallest and most at-risk zones in BC, as the majority of land use is taken up by urban and industrial development, with very few old growth patches remaining (Meidinger & Pojar, 1991). District Lot 56 within the Linley Valley is a protected parcel of CDFmm forest (BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 2018).

A recent report completed by McTavish Consulting for the Regional District of Nanaimo collated the current conditions of riparian cover for local watersheds like Cottle Creek. Current Riparian conditions within the RDN were spatially analyzed from existing datasets to create a comprehensive understanding of priority locations for potential restoration efforts (McTavish Consulting, 2022). The report provides a analysis of riparian vegetation at the watershed scale and useful mapping.

### *History of Disturbance*

Evidence of historical logging activity (100+ years ago) can be observed throughout the upper watershed (e.g., springboard cutouts on old growth stumps). Judging from the age and structure of what remains of the riparian forest in the valley, there were no efforts to protect streamside areas from logging impacts.

Reach 5 was used as a reference reach within the watershed, as the riparian zone was in a generally undisturbed condition. The reach appeared to have mostly recovered from, or been buffered from the direct effects of historical logging, likely due to running in a deep ravine that is unfavourable to human access. A vigorous understory dominated by salal (*Gaultheria shallon*) and sword fern (*Polystichum munitum*) now provide year-round shade and overhanging vegetation to the stream. A multi-layered canopy of coastal douglas fir, red cedar, and bigleaf maple trees (Figure 11) also provide year-round shade. LWD recruitment processes appeared intact in the reach, with multiple stable LWD structures observed. Invasive plant cover was minimal, except for individual English holly trees randomly distributed throughout the reach.

Riparian vegetation in reach 4 is in the early stages of forest succession. The canopy is dominated by mature pioneering tree species such as red alder (*Alnus rubra*) and bigleaf maple that are starting to self-thin. Many mature alders were found fallen in the riparian zone and into/across the stream. The lack of a mature forest canopy has interrupted LWD recruitment processes in the reach, as fallen red alders do not provide stable LWD structure to the stream as they decay rapidly compared to conifers (Naiman et al. 2002). Coniferous tree recruitment was observed below the well-established shrub layer of salmonberry (*Rubus spectabilis*), and Pacific ninebark (*Physocarpus capitatus*). Invasive plants including Himalayan blackberry (*Rubus armeniacus*), English holly (*Ilex aquifolium*), and spurge laurel (*Daphne laureola*) are distributed in patches along the reach, often most heavily associated with areas disturbed by human access.

The riparian forest in reaches 2 and 3 have been replaced with grass lawns, walking trails, and bank armouring (Figure 12). This has precluded the growth of native riparian vegetation along the banks of the creek. Invasive plant species such as Himalayan blackberry and English ivy (*Hedera helix*) have established in these disturbed areas, which has interrupted LWD recruitment, deep-rooted vegetation development, canopy shade, and overhanging bank vegetation for the stream.

***Figure 11**. Cottle Creek Reach 5 riparian vegetation structure and condition.*

***Figure 12**. Boulders used for bank armouring in Reach 2 of Cottle Creek within Stephenson Point Park.*

### *Recreational Trails*

Reaches two, four and five have walking trails through the riparian zone. Trail users and their pets have blazed informal side trails that access the creek from the designated trails. In these areas understory vegetation has been trampled and eroded to bare soil (Figure 13), and invasive plants were more common. This access has suppressed the establishment of native riparian understory vegetation, and provides a direct link for surface runoff to carry erodible soils into the stream.

***Figure 13**. Bare soil on stream banks in Reach 2 due to access from walking trails.*

## 5.2 Streamkeepers performing a PFC assessment

The FREP RMREE assessment protocol was intentionally designed by experts for use by anyone with a basic working knowledge of streams and riparian habitats (Tripp et al., 2025). The BC Ministry of Forests provides all the necessary resources for completing an assessment on the FREP webpage (Forest and Range Evaluation Program fish/riparian monitoring - Province of British Columbia), along with online training modules.

In this assessment, the team leader had previously received training in the protocol, but no other survey team members received training. All team members had access to the RMREE protocol, which explains in detail the 'how' and 'why' of all parameters assessed. A supplemental field guide (abbreviated version of the protocol) was used for reference on field days. To assess whether volunteer streamkeepers could use the protocol effectively, two of the survey team volunteers from the FOCC with different backgrounds provided feedback on their experience using the protocol. The survey questions and answers are below.

**Question 1**. Did you understand what was being asked of you while performing the assessment? (i.e., were team leader instructions along with the supplemental field guidebook sufficient?)

**Question 2**. Do you think the results (PFC scores) are correct?

Volunteer #1 – No formal scientific training:

1. *Yes, it was clear. The nuts-and-bolts descriptions were pretty easy to follow; it was helpful to get explanations from more experienced team members, of why the things being measured/ counted were important.*

   *I did also make some use of the protocol handbook (available online), which was helpful to gain a deeper understanding of the data being sought. However, it's not realistic for all team members to absorb all of the information in it.*

2. *I don't doubt that the results are correct, but I was surprised that they were as low as they were. It was a valuable learning experience for me as a volunteer streamkeeper, with no formal scientific training, to participate in the close, detailed observation of stream & riparian conditions.*

   *An important part of the exercise which I found to be challenging (and therefore also enlightening, because it provoked discussion) was after the field work, assessing how the documented conditions would compare to fully functioning conditions. It is hard for a less experienced person (who may actually never have seen undamaged stream ecosystems!) to recognize ecological damage that may be clear to others.*

Volunteer #2 – Professional biology background:

1. *"Yes, as I was assigned the task of enumerating/measuring "pool" habitats in the designated FREP sampling sections of each Reach (#2, 3, 4, 5), as well as describing the amount of in-stream (LWD, emergent vegetation) and over-stream (riparian vegetation) cover for each pool. This was very complementary to the earlier USHP inventory we competed in 2025 during the seasonal low flow period."*

2. "*Yes, with the biggest challenge being the initial selection of "representative" sampling sections in each reach. The FREP guidelines seem to be flexible to the point where individual sampling sections can be extended to better embrace the full diversity of riparian conditions on a Reach-specific basis. This became clearly evident in our Reach #2 sampling where we initially omitted some of the most impactful footprint effects of urbanization over the last several decades (i.e., old culverts, concrete sill, irrigation diversion dam). Our subsequent scoring needed to be adjusted to reflect these omissions, which resulted in a "not properly functioning" condition being assigned to the Reach in general.*

   *In looking at all 4 FREP Reach results, I think our final scores are representative of current conditions, with our highest-rated Reach #5 also ranked as the best remaining fish habitat in the watershed, downstream of Cottle Lake (Clark and Wightman, 2026)."*

From this volunteer feedback we can see that streamkeepers with differing backgrounds and limited training can feel comfortable using the FREP RMREE protocol. The detailed resources made available by the ministry of forests provide excellent background information to study before undertaking a field

evaluation, and concise reference materials are also available for use during field work. This makes the methodology robust enough to be used by those with minimal training. Having one team member trained and familiar with the protocol was valuable for making field days more efficient and for answering volunteer questions.

### 5.3 How the Cottle Creek PFC assessment relates to "Nanaimo Reimagined"

Healthy riparian areas play a key role in regulating microclimates and water quality, preventing riverbank erosion, promoting soil stability, supporting the aquatic and terrestrial food webs, and providing habitat for a wide range of aquatic, amphibious, and terrestrial organisms (Capon 2020). Streams and riparian areas are sensitive to climate and land-cover change.

As a result of climate change, the City of Nanaimo has been experiencing increases in air and water temperatures, prolonged drought periods, and increased frequency of high intensity rainfall events. In response, the City of Nanaimo has initiated efforts to prioritize the importance of riparian areas through the adoption of *City Plan Nanaimo Reimagined* (City of Nanaimo, 2022).

The use of the PFC assessment in this project was to assess the existing riparian conditions, to see if Cottle Creek can be identified as an example of what could be considered a "Healthy Watershed" within the City (i.e. OCP policy C1.4). The results also provide insights to the condition of urban tree canopy (i.e. OCP Policy C1.3) on both public and private lands within the Linley Valley. The results of the assessment show that Cottle Creek does not have a large "properly functioning" riparian area from the lake to the ocean. However, there is a reach that does reflect the important indicators of a healthy stream that was rated "functioning but at risk". Reach 5 provides a valuable understanding of what metrics of riparian conditions are necessary for a healthy watershed.

## 6.0 Conclusion

- During the summer of 2025 and spring of 2026, the Friends of Cottle Creek completed a survey of the Cottle Creek below Cottle Lake, to determine the properly functioning condition of the riparian zone.
- Using a methodology developed by the Province of BC, volunteers guided by a biologist trained in the procedure used the Riparian Management Routine Effectiveness Evaluation handbook to rate biophysical features along four sample reaches to determine whether they were "properly functioning".
- The survey found that none of the four reaches sampled were "properly functioning", despite a strict building setback of 30 meters.
- The survey concluded that reach five had the most robust riparian conditions in the watershed, however it was rated as "properly functioning but at risk".
- The poorest rated reach was reach three, where 12 essential riparian conditions were not functioning, despite efforts by the City (in the past 15 years) to protect this area from the impacts of development.
- The streamkeepers who participated in the survey found the methodology used in the project to be easy to follow (with guidance from a trainer) and provided results that were appropriate.
- The FREP RMREE "proper functioning condition" assessment could be used effectively by other streamkeeper groups, or by the City in the future to assist in rating the condition of riparian areas.

# 7.0 References


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# Appendix

## 1.0 FREP RMREE field card summary question results and causes for 'no' answers for all assessed reaches on Cottle Creek

| Summary | | Yes | No | NA |
|---|---|---|---|---|
| Question 1. | Is the channel bed undisturbed? | ☐ | ☒ | |
| Question 2. | Are the channel banks intact? | ☒ | ☐ | |
| Question 3. | Are channel LWD processes intact? | ☒ | ☐ | |
| Question 4. | Is the channel morphology intact? | ☒ | ☐ | ☐ |
| Question 5. | Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments? | ☐ | ☒ | |
| Question 6. | Does the stream support a good diversity of fish cover attributes? | ☒ | ☐ | ☐ |
| Question 7. | Does the amount of moss present on the substrates indicate a stable and productive system? | ☒ | ☐ | ☐ |
| Question 8. | Has the introduction of fine sediments been minimized? | ☐ | ☒ | ☐ |
| Question 9. | Does the stream support a diversity of aquatic invertebrates? | ☒ | ☐ | ☐ |
| Question 10. | Has the vegetation retained in the RMA been sufficiently protected from windthrow? | ☒ | ☐ | |
| Question 11. | Has the amount of bare erodible ground or soil compaction in the riparian area been minimized? | ☐ | ☒ | |
| Question 12. | Has sufficient vegetation been retained to maintain an adequate root network or LWD supply? | ☐ | ☒ | |
| Question 13. | Has sufficient vegetation been retained to provide shade and reduce bank microclimate change? | ☒ | ☐ | |
| Question 14. | Have the number of disturbance-increaser plants, noxious weeds and/or invasive plant species present been limited to a satisfactory level? | ☐ | ☒ | |
| Question 15. | Is the riparian vegetation within the first 10m from the edge of the stream generally characteristic of what the healthy unmanaged riparian plant community would normally be along the reach? | ☐ | ☒ | |

# of "Yes" answers: 8 + # of "No" answers: 7 + # of "NA" answers: 0 = Total # of answers: 15

Conclusion on Functioning Condition (check one):
- ☐ Properly Functioning (0-2 "No's")
- ☐ Functioning but at Risk (3-4 "No's")
- ☐ Functioning but at High Risk (5-6 "No's")
- ☒ Not Properly Functioning (>6 "No's")

List the questions that had a "No" answer below, and check what you believe was the main reason(s) for the problem. Up to two causes may be selected. A "No" answer due to natural causes would include any natural events such as insects, fires, floods, slides, diseases etc. that were clearly unrelated to man's activities in the stream or adjacent riparian area. Check Logging, Animals, Roads or Other Manmade if these factors directly or indirectly affected the stream or riparian area indicators. Check Unknown Upstream only if the "No" answer was the result of upstream disturbance that could not be identified.

| "No" answer questions | Causes of "No" Answers | | | | | | |
|---|---|---|---|---|---|---|---|
| | Current Logging | Old Logging | Animal Disturbance | Roads | Other Impacts | Natural Impacts | Unknown Upstream |
| 5 | ☐ | ☐ | ☐ | ☒ | ☒ | ☐ | ☐ |
| 8 | ☐ | ☐ | ☐ | ☒ | ☒ | ☐ | ☐ |
| 11 | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ |
| 12 | ☐ | ☒ | ☐ | ☐ | ☒ | ☐ | ☐ |
| 2/14/15 | ☐ | ☐ | ☒ | ☐ | ☒ | ☐ | ☐ |

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Specific Causes of "No" Answers and Proximity to Reach of Each Cause.
Check off each Question with a "No" answer, then beside each main specific cause that applies, record a 1 for within the reach, 2 for above the reach, and 3 for within and above the reach

| Cause of "No" Answers | 1 ☒ | 2 ☒ | 3 ☐ | 4 ☐ | 5 ☒ | 6 ☐ | 7 ☐ | 8 ☒ | 9 ☐ | 10 ☐ | 11 ☒ | 12 ☒ | 13 ☐ | 14 ☒ | 15 ☒ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OLD LOGGING | | | | | | | | | | | | | | | |
| Low retention | | | | | | | | | | | | 3 | | | |
| Forest structure issues | | | | | | | | | | | | 3 | | | |
| Other | | | | | | | | | | | | | | | |
| CURRENT LOGGING | | | | | | | | | | | | | | | |
| Low retention | | | | | | | | | | | | | | | |
| Falling and yarding | | | | | | | | | | | | | | | |
| Machine disturbance | | | | | | | | | | | | | | | |
| Windthrow | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Stream diversions | | | | | | | | | | | | | | | |
| Road or debris blockages | | | | | | | | | | | | | | | |
| Altered watershed hydrology | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| ROADS, TRAILS | | | | | | | | | | | | | | | |
| Encroachment on RMA | | | | | | | | | | | | | | | |
| Running surface erosion | | | | | | | | 1 | | | | | | | |
| Other ROW erosion | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Crossing structure | | | | | 3 | | | | | | | | | | |
| Ditch water delivery | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| ANIMAL DISTURBANCE | | | | | | | | | | | | | | | |
| Livestock | | | | | | | | | | | | | | | |
| Beavers | | | | | | | | | | | | | | | |
| Other ungulates | | | | | | | | | | | | | | | |
| Humans | | | | | | | | | | | | | | 1 | 1 |
| Other | | | | | | | | | | | | | | | |
| NATURAL IMPACTS | | | | | | | | | | | | | | | |
| High sediment levels | | | | | | | | | | | | | | | |
| Fire | | | | | | | | | | | | | | | |
| Insects | | | | | | | | | | | | | | | |
| Diseases | | | | | | | | | | | | | | | |
| Wind | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Floods | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| OTHER IMPACTS | | | | | | | | | | | | | | | |
| Non-logging roads, trails | | | | | | | | 1 | | | 3 | 3 | | | |
| Utility corridors | | | | | | | | | | | | | | | |
| Recreation | | | | | | | | | | | | | | | |
| Agriculture | | | | | | | | | | | | | | | |
| Mining | | | | | | | | | | | | | | | |
| Urban, industry | 1 | 1 | | | 3 | | | | | | | 1 | | 1 | 1 |
| Firewood cutting | | | | | | | | | | | | | | | |
| Silviculture treatments | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| UNKNOWN UPSTREAM | | | | | | | | | | | | | | | |

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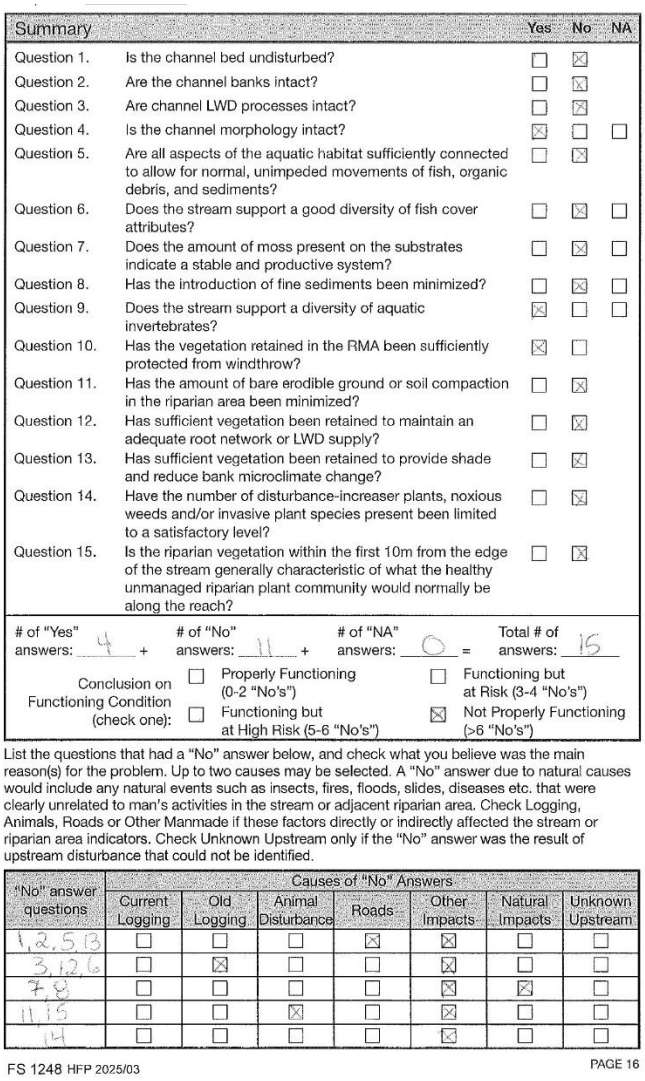
**Figure 1**. FREP RMREE summary questions, causes of 'no' answers and specific causes of 'no' answers from Reach 2 of Cottle Creek.



| Summary | | Yes | No | NA |
|---|---|---|---|---|
| Question 1. | Is the channel bed undisturbed? | ☐ | ☒ | |
| Question 2. | Are the channel banks intact? | ☐ | ☒ | |
| Question 3. | Are channel LWD processes intact? | ☐ | ☒ | |
| Question 4. | Is the channel morphology intact? | ☒ | ☐ | ☐ |
| Question 5. | Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments? | ☐ | ☒ | |
| Question 6. | Does the stream support a good diversity of fish cover attributes? | ☐ | ☒ | ☐ |
| Question 7. | Does the amount of moss present on the substrates indicate a stable and productive system? | ☐ | ☒ | ☐ |
| Question 8. | Has the introduction of fine sediments been minimized? | ☐ | ☒ | ☐ |
| Question 9. | Does the stream support a diversity of aquatic invertebrates? | ☒ | ☐ | ☐ |
| Question 10. | Has the vegetation retained in the RMA been sufficiently protected from windthrow? | ☒ | ☐ | |
| Question 11. | Has the amount of bare erodible ground or soil compaction in the riparian area been minimized? | ☐ | ☒ | |
| Question 12. | Has sufficient vegetation been retained to maintain an adequate root network or LWD supply? | ☐ | ☒ | |
| Question 13. | Has sufficient vegetation been retained to provide shade and reduce bank microclimate change? | ☐ | ☒ | |
| Question 14. | Have the number of disturbance-increaser plants, noxious weeds and/or invasive plant species present been limited to a satisfactory level? | ☐ | ☒ | |
| Question 15. | Is the riparian vegetation within the first 10m from the edge of the stream generally characteristic of what the healthy unmanaged riparian plant community would normally be along the reach? | ☐ | ☒ | |

# of "Yes" answers: 4 + # of "No" answers: 11 + # of "NA" answers: 0 = Total # of answers: 15

Conclusion on Functioning Condition (check one):
- ☐ Properly Functioning (0-2 "No's")
- ☐ Functioning but at Risk (3-4 "No's")
- ☐ Functioning but at High Risk (5-6 "No's")
- ☒ Not Properly Functioning (>6 "No's")

List the questions that had a "No" answer below, and check what you believe was the main reason(s) for the problem. Up to two causes may be selected. A "No" answer due to natural causes would include any natural events such as insects, fires, floods, slides, diseases etc. that were clearly unrelated to man's activities in the stream or adjacent riparian area. Check Logging, Animals, Roads or Other Manmade if these factors directly or indirectly affected the stream or riparian area indicators. Check Unknown Upstream only if the "No" answer was the result of upstream disturbance that could not be identified.

| "No" answer questions | Causes of "No" Answers | | | | | | |
|---|---|---|---|---|---|---|---|
| | Current Logging | Old Logging | Animal Disturbance | Roads | Other Impacts | Natural Impacts | Unknown Upstream |
| 1,2,5,13 | ☐ | ☐ | ☐ | ☒ | ☒ | ☐ | ☐ |
| 3,12,6 | ☐ | ☒ | ☐ | ☐ | ☒ | ☐ | ☐ |
| 7,8 | ☐ | ☐ | ☐ | ☐ | ☒ | ☒ | ☐ |
| 11,15 | ☐ | ☐ | ☒ | ☐ | ☒ | ☐ | ☐ |
| 14 | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ |

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Specific Causes of "No" Answers and Proximity to Reach of Each Cause.
Check off each Question with a "No" answer, then beside each main specific cause that applies, record a 1 for within the reach, 2 for above the reach, and 3 for within and above the reach.

| Cause of "No" Answers | 1 ☒ | 2 ☒ | 3 ☒ | 4 ☐ | 5 ☒ | 6 ☒ | 7 ☒ | 8 ☒ | 9 ☐ | 10 ☐ | 11 ☒ | 12 ☒ | 13 ☐ | 14 ☒ | 15 ☒ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OLD LOGGING | | | | | | | | | | | | | | | |
| Low retention | | | 3 | | | 1 | | | | | | 3 | | | |
| Forest structure issues | | | 3 | | | 1 | | 3 | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| CURRENT LOGGING | | | | | | | | | | | | | | | |
| Low retention | | | | | | | | | | | | | | | |
| Falling and yarding | | | | | | | | | | | | | | | |
| Machine disturbance | | | | | | | | | | | | | | | |
| Windthrow | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Stream diversions | | | | | | | | | | | | | | | |
| Road or debris blockages | | | | | | | | | | | | | | | |
| Altered watershed hydrology | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| ROADS, TRAILS | | | | | | | | | | | | | | | |
| Encroachment on RMA | | | | | | | | | | | | | | | |
| Running surface erosion | | | | | | | | | | | | | | | |
| Other ROW erosion | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Crossing structure | 1 | | | | 1 | | | | | | | | | | |
| Ditch water delivery | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| ANIMAL DISTURBANCE | | | | | | | | | | | | | | | |
| Livestock | | | | | | | | | | | | | | | |
| Beavers | | | | | | | | | | | | | | | |
| Other ungulates | | | | | | | | | | | | | | | |
| Humans | | | | | | | | | | | 1 | | | | 1 |
| Other | | | | | | | | | | | | | | | |
| NATURAL IMPACTS | | | | | | | | | | | | | | | |
| High sediment levels | | | | | | | 3 | 3 | | | | | | | |
| Fire | | | | | | | | | | | | | | | |
| Insects | | | | | | | | | | | | | | | |
| Diseases | | | | | | | | | | | | | | | |
| Wind | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | 3 | | | | | | | |
| Floods | | | | | | | 1 | 3 | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| OTHER IMPACTS | | | | | | | | | | | | | | | |
| Non-logging roads, trails | | | | | | | | | | | | | | | |
| Utility corridors | | | | | | | | | | | | | | | |
| Recreation | | | | | | | | | | | | | | | |
| Agriculture | | 1 | | | 1 | 1 | | | | | | 1 | | 1 | 1 |
| Mining | | | | | | | | | | | | | | | |
| Urban, industry | 1 | | | | | 1 | 1 | | | | 1 | 1 | | 1 | 1 |
| Firewood cutting | | | | | | | | | | | | | | | |
| Silviculture treatments | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| UNKNOWN UPSTREAM | | | | | | | | | | | | | | | |

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**Figure 2**. FREP RMREE summary questions, causes of 'no' answers and specific causes of 'no' answers from Reach 3 of Cottle Creek.

| Summary | | Yes | No | NA |
|---|---|---|---|---|
| Question 1. | Is the channel bed undisturbed? | ☒ | ☐ | |
| Question 2. | Are the channel banks intact? | ☐ | ☒ | |
| Question 3. | Are channel LWD processes intact? | ☐ | ☒ | |
| Question 4. | Is the channel morphology intact? | ☒ | ☐ | ☐ |
| Question 5. | Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments? | ☐ | ☒ | |
| Question 6. | Does the stream support a good diversity of fish cover attributes? | ☒ | ☐ | ☐ |
| Question 7. | Does the amount of moss present on the substrates indicate a stable and productive system? | ☐ | ☒ | ☐ |
| Question 8. | Has the introduction of fine sediments been minimized? | ☐ | ☒ | ☐ |
| Question 9. | Does the stream support a diversity of aquatic invertebrates? | ☒ | ☐ | ☐ |
| Question 10. | Has the vegetation retained in the RMA been sufficiently protected from windthrow? | ☒ | ☐ | |
| Question 11. | Has the amount of bare erodible ground or soil compaction in the riparian area been minimized? | ☐ | ☒ | |
| Question 12. | Has sufficient vegetation been retained to maintain an adequate root network or LWD supply? | ☐ | ☒ | |
| Question 13. | Has sufficient vegetation been retained to provide shade and reduce bank microclimate change? | ☒ | ☐ | |
| Question 14. | Have the number of disturbance-increaser plants, noxious weeds and/or invasive plant species present been limited to a satisfactory level? | ☒ | ☐ | |
| Question 15. | Is the riparian vegetation within the first 10m from the edge of the stream generally characteristic of what the healthy unmanaged riparian plant community would normally be along the reach? | ☒ | ☐ | |

# of "Yes" answers: 8 + # of "No" answers: 7 + # of "NA" answers: 0 = Total # of answers: 15

Conclusion on Functioning Condition (check one):
- ☐ Properly Functioning (0-2 "No's")
- ☐ Functioning but at Risk (3-4 "No's")
- ☐ Functioning but at High Risk (5-6 "No's")
- ☒ Not Properly Functioning (>6 "No's")

List the questions that had a "No" answer below, and check what you believe was the main reason(s) for the problem. Up to two causes may be selected. A "No" answer due to natural causes would include any natural events such as insects, fires, floods, slides, diseases etc. that were clearly unrelated to man's activities in the stream or adjacent riparian area. Check Logging, Animals, Roads or Other Manmade if these factors directly or indirectly affected the stream or riparian area indicators. Check Unknown Upstream only if the "No" answer was the result of upstream disturbance that could not be identified.

| "No" answer questions | Causes of "No" Answers: Current Logging | Old Logging | Animal Disturbance | Roads | Other Impacts | Natural Impacts | Unknown Upstream |
|---|---|---|---|---|---|---|---|
| 2, 3, 8 | ☐ | ☐ | ☐ | ☐ | ☒ | ☒ | ☐ |
| 3, 12 | ☐ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 4 | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ | ☐ |
| 5 | ☐ | ☐ | ☐ | ☒ | ☒ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

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Specific Causes of "No" Answers and Proximity to Reach of Each Cause.
Check off each Question with a "No" answer, then beside each main specific cause that applies, record a 1 for within the reach, 2 for above the reach, and 3 for within and above the reach.

| Cause of "No" Answers | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ☐ | ☒ | ☒ | ☐ | ☒ | ☐ | ☒ | ☒ | ☐ | ☐ | ☒ | ☒ | ☐ | ☐ | ☐ |
| OLD LOGGING | | | | | | | | | | | | | | | |
| Low retention | | | 3 | | | | | | | | | 3 | | | |
| Forest structure issues | | | 1 | | | | | | | | | 1 | | | |
| Other | | | | | | | | | | | | | | | |
| CURRENT LOGGING | | | | | | | | | | | | | | | |
| Low retention | | | | | | | | | | | | | | | |
| Falling and yarding | | | | | | | | | | | | | | | |
| Machine disturbance | | | | | | | | | | | | | | | |
| Windthrow | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Stream diversions | | | | | | | | | | | | | | | |
| Road or debris blockages | | | | | | | | | | | | | | | |
| Altered watershed hydrology | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| ROADS, TRAILS | | | | | | | | | | | | | | | |
| Encroachment on RMA | | | | | | | | | | | | | | | |
| Running surface erosion | | | | | | | | | | | | | | | |
| Other ROW erosion | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Crossing structure | | | | | 1 | | | | | | | | | | |
| Ditch water delivery | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| ANIMAL DISTURBANCE | | | | | | | | | | | | | | | |
| Livestock | | | | | | | | | | | | | | | |
| Beavers | | | | | | | | | | | | | | | |
| Other ungulates | | | | | | | | | | | | | | | |
| Humans | | | | | | | | | | | 3 | | | | |
| Other | | | | | | | | | | | | | | | |
| NATURAL IMPACTS | | | | | | | | | | | | | | | |
| High sediment levels | | | | | | | 3 | 3 | | | | | | | |
| Fire | | | | | | | | | | | | | | | |
| Insects | | | | | | | | | | | | | | | |
| Diseases | | | | | | | | | | | | | | | |
| Wind | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Floods | | 1 | | | | | 3 | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| OTHER IMPACTS | | | | | | | | | | | | | | | |
| Non-logging roads, trails | | 1 | | | | | | | | | | | | | |
| Utility corridors | | | | | | | | | | | | | | | |
| Recreation | | | | | | | 1 | 1 | | | | | | | |
| Agriculture | | | | | | | | | | | | | | | |
| Mining | | | | | | | | | | | | | | | |
| Urban, industry | | | | | | | | | | | | | | | |
| Firewood cutting | | | | | | | | | | | | | | | |
| Silviculture treatments | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| UNKNOWN UPSTREAM | | | | | | | | | | | | | | | |

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**Figure 3**. FREP RMREE summary questions, causes of 'no' answers and specific causes of 'no' answers from Reach 4 of Cottle Creek.

| Summary | | Yes | No | NA |
|---|---|---|---|---|
| Question 1. | Is the channel bed undisturbed? | ☒ | ☐ | |
| Question 2. | Are the channel banks intact? | ☐ | ☒ | |
| Question 3. | Are channel LWD processes intact? | ☒ | ☐ | |
| Question 4. | Is the channel morphology intact? | ☒ | ☐ | ☐ |
| Question 5. | Are all aspects of the aquatic habitat sufficiently connected to allow for normal, unimpeded movements of fish, organic debris, and sediments? | ☐ | ☒ | |
| Question 6. | Does the stream support a good diversity of fish cover attributes? | ☒ | ☐ | ☐ |
| Question 7. | Does the amount of moss present on the substrates indicate a stable and productive system? | ☒ | ☐ | ☐ |
| Question 8. | Has the introduction of fine sediments been minimized? | ☐ | ☒ | ☐ |
| Question 9. | Does the stream support a diversity of aquatic invertebrates? | ☒ | ☐ | ☐ |
| Question 10. | Has the vegetation retained in the RMA been sufficiently protected from windthrow? | ☒ | ☐ | |
| Question 11. | Has the amount of bare erodible ground or soil compaction in the riparian area been minimized? | ☒ | ☐ | |
| Question 12. | Has sufficient vegetation been retained to maintain an adequate root network or LWD supply? | ☒ | ☐ | |
| Question 13. | Has sufficient vegetation been retained to provide shade and reduce bank microclimate change? | ☒ | ☐ | |
| Question 14. | Have the number of disturbance-increaser plants, noxious weeds and/or invasive plant species present been limited to a satisfactory level? | ☒ | ☐ | |
| Question 15. | Is the riparian vegetation within the first 10m from the edge of the stream generally characteristic of what the healthy unmanaged riparian plant community would normally be along the reach? | ☒ | ☐ | |

# of "Yes" answers: 12 + # of "No" answers: 3 + # of "NA" answers: 0 = Total # of answers: 15

Conclusion on Functioning Condition (check one):
- ☐ Properly Functioning (0-2 "No's")
- ☒ Functioning but at Risk (3-4 "No's")
- ☐ Functioning but at High Risk (5-6 "No's")
- ☐ Not Properly Functioning (>6 "No's")

List the questions that had a "No" answer below, and check what you believe was the main reason(s) for the problem. Up to two causes may be selected. A "No" answer due to natural causes would include any natural events such as insects, fires, floods, slides, diseases etc. that were clearly unrelated to man's activities in the stream or adjacent riparian area. Check Logging, Animals, Roads or Other Manmade if these factors directly or indirectly affected the stream or riparian area indicators. Check Unknown Upstream only if the "No" answer was the result of upstream disturbance that could not be identified.

| "No" answer questions | Causes of "No" Answers: Current Logging | Old Logging | Animal Disturbance | Roads | Other Impacts | Natural Impacts | Unknown Upstream |
|---|---|---|---|---|---|---|---|
| 2 | ☐ | ☐ | ☐ | ☐ | ☒ | ☒ | ☐ |
| 5 | ☐ | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ |
| 8 | ☐ | ☐ | ☒ | ☐ | ☒ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

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| Specific Causes of "No" Answers and Proximity to Reach of Each Cause. Check off each Question with a "No" answer, then beside each main specific cause that applies, record a 1 for within the reach, 2 for above the reach, and 3 for within and above the reach. Cause of "No" Answers | 1 ☒ | 2 ☒ | 3 ☐ | 4 ☐ | 5 ☒ | 6 ☐ | 7 ☐ | 8 ☒ | 9 ☐ | 10 ☐ | 11 ☐ | 12 ☐ | 13 ☐ | 14 ☐ | 15 ☐ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OLD LOGGING | | | | | | | | | | | | | | | |
| Low retention | | | | | | | | | | | | | | | |
| Forest structure issues | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| CURRENT LOGGING | | | | | | | | | | | | | | | |
| Low retention | | | | | | | | | | | | | | | |
| Falling and yarding | | | | | | | | | | | | | | | |
| Machine disturbance | | | | | | | | | | | | | | | |
| Windthrow | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Stream diversions | | | | | | | | | | | | | | | |
| Road or debris blockages | | | | | | | | | | | | | | | |
| Altered watershed hydrology | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| ROADS, TRAILS | | | | | | | | | | | | | | | |
| Encroachment on RMA | | | | | | | | | | | | | | | |
| Running surface erosion | | | | | | | | | | | | | | | |
| Other ROW erosion | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Crossing structure | | | | | | | | | | | | | | | |
| Ditch water delivery | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| ANIMAL DISTURBANCE | | | | | | | | | | | | | | | |
| Livestock | | | | | | | | | | | | | | | |
| Beavers | | | | | | | | | | | | | | | |
| Other ungulates | | | | | | | | | | | | | | | |
| Humans | | | | | | | | 3 | | | | | | | |
| Other | | | | | | | | 3 | | | | | | | |
| NATURAL IMPACTS | | | | | | | | | | | | | | | |
| High sediment levels | | | | | 3 | | | | | | | | | | |
| Fire | | | | | | | | | | | | | | | |
| Insects | | | | | | | | | | | | | | | |
| Diseases | | | | | | | | | | | | | | | |
| Wind | | | | | | | | | | | | | | | |
| Mass wasting | | | | | | | | | | | | | | | |
| Floods | | 1 | | | | | | | | | | | | | |
| Other | | | | | 3 | | | | | | | | | | |
| OTHER IMPACTS | | | | | | | | | | | | | | | |
| Non-logging roads, trails | | | | | | | | | | | | | | | |
| Utility corridors | | | | | | | | | | | | | | | |
| Recreation | | | | | | | | | | | | | | | |
| Agriculture | | | | | | | | | | | | | | | |
| Mining | | | | | | | | | | | | | | | |
| Urban, industry | | 2 | | | | | | 2 | | | | | | | |
| Firewood cutting | | | | | | | | | | | | | | | |
| Silviculture treatments | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| UNKNOWN UPSTREAM | | | | | | | | | | | | | | | |

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**Figure 3**. FREP RMREE summary questions, causes of 'no' answers and specific causes of 'no' answers from Reach 5 of Cottle Creek.

## 2.0 Additional photographs from the field assessment


Streamkeeper at Wo