DUTCH CREEK WATERSHED LINEAR FEATURES CLASSIFICATION PROJECT

Submitted to:
Oldman Watershed Council

Submitted by:
Applied Aquatic Research Ltd.
Calgary, AB

October 2014
File: AAR14-105

EXECUTIVE SUMMARY

Applied Aquatic Research Ltd (AAR) was retained by the Oldman Watershed Council (OWC) to complete a detailed linear feature inventory in the Dutch Creek sub-watershed, AB. This is a pilot project to provide a field-based classification and assessment of linear disturbance. The results will be shared with the Government of Alberta, stakeholders and the public to inform planning for the reduction of linear feature disturbance impacts. The reproducibility of the field protocol was also assessed, and recommendations made for modifications that will improve future linear mapping projects in other watersheds in Alberta.

Four AAR field crew mapped linear features in the watershed in teams of two on off-road vehicles from September 16–23, 2014. A total of 640 GPS waypoints were collected, and 232 watercourse crossings and 164 km of linear features were mapped and classified according to the field assessment card established in conjunction with the OWC and stakeholders. Of the total Linear features that were surveyed, 74% are actively in use, and 65% of the total linear feature distance is used by off-road vehicles. The linear feature density is 1.09 km/km^2 in Dutch Creek. This density is classified as high pressure since Bull Trout populations have been shown to decline at density of 0.87 km/km^2 (Fiera, 2014). Furthermore, this density calculation is an underestimation because some linear features were not mapped due to safety and access concerns.

Almost 80% of watercourse crossings were unregulated fords. There is a high density of ford crossings on active features at the west end of the catchment, which overlaps with 70% of key Bull Trout spawning areas (redds) surveyed by Alberta Environment and Sustainable Resources Development (ESRD) in 2012. The western portion of the watershed is therefore of management concern as Bull Trout in Alberta are mainly distributed in headwater regions on the eastern slopes, and an increase in sedimentation from off-road vehicles may accelerate their population and distribution decline (Hurkett et al., 2013).

Most segments were classified as stable (compact), and the density of eroded features is 0.18 km/km^2. However, changes to road surfaces will inherently change the drainage patterns in the watershed, and for this reason, the overall high feature density makes Dutch Creek an area of management concern. Many eroded segments have a high density of unregulated ford crossings. About 37% of ford crossings in Dutch Creek have fine substrate, which is easily mobilized when disturbed. This is problematic as unregulated ford crossings can cause further erosion around banks, and the sedimentation will degrade Bull Trout spawning habitats downstream.

The field protocol is highly reproducible and can be used for other watersheds in Alberta. However, several key changes are recommended for future linear mapping work. This includes a more objective set of guidelines for determining the erosion status of linear features; a review of classification parameters; and a review and clarification of the terms ‘active’ and ‘enduring’. This will enable linear feature and watercourse crossing assessments to be more site specific and better catered to project goals.

ACKNOWLEDGEMENTS

Funding and support for this project provided by:

Alberta Conservation Association

RBC Blue Water Project™

Alberta Government

Roundtable on the Crown of the Continent

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1.0 INTRODUCTION

1.1 Scope of Work

The Oldman Watershed Council (OWC) is a designated Watershed Planning and Advisory Council under Alberta's Water for Life Strategy and is tasked with completing assessments of watershed health for a State of the Watershed report, and engaging the greater community in an Integrated Watershed Management Plan (IWMP) process. To address a key goal of the IWMP process, the OWC developed a Headwaters Action Plan that includes 'classification of linear features' as a key priority to address the management of linear disturbance and its impact on headwaters health. The purpose of the OWC Headwaters Linear Feature Classification project is to provide a field-based classification and assessment of linear disturbance in the Dutch Creek sub-watershed to help develop a protocol for completing similar assessments in other headwaters sub-watersheds.

Applied Aquatic Research (AAR) was retained by the OWC to complete a detailed inventory of all linear features within the Dutch Creek watershed, including roads and off-road vehicle (ORV) trails. This included the development and review of a field assessment protocol, and the ground-validation and spatial mapping of linear features. An assessment of the disturbance levels of each feature was also conducted, including the stability of the surface (rutting, erosion etc.), the condition of watercourse crossings, and the relationship between the state of the linear features and fish species at risk (including habitat/spawning areas). The results will be shared with the Government of Alberta, stakeholders and the public to inform planning for the reduction of linear feature disturbance impacts. This field program is also a pilot project for future linear feature mapping and classification projects in other Alberta watersheds. For this reason, AAR also undertook an assessment of the reproducibility of the field protocol for other watersheds in Alberta, including recommendations for modifying the field protocol for future use.

1.2 Study Area

The Dutch Creek Provincial Recreation Area is located on Range Road 35A off Forestry Trunk Road 40, approximately 52 km north from Coleman, AB (Figure 1). The watershed is approximately 150.1 km^2 in size with a perennial river that runs west to east through the valley. Aerial maps provided by Alberta Environment Resource Development (ESRD) show that the watershed is predominantly coniferous with some mixed broadleaf forest and grasslands at the southwest and east portions of the watershed, respectively. The provincial campground is located at the east entrance of the watershed, and random camping and off-road vehicles use occurs throughout the watershed. (Figure 2).

The Oldman River watershed has a drainage area of 26,700 km^2, and extends from the Canadian Rocky Mountains in the west to Grassy Lakes in the East (OWC, 2014). The Oldman River, with a total length of 362 km, joins the Bow River to form the South Saskatchewan River, which eventually drains into Hudson Bay (OWC, 2014). It is home to a wide variety of fish, such as Bull Trout, Westslope Cutthroat Trout, Brown Trout, Rainbow Trout, and Mountain Whitefish. Bull Trout are listed as threatened in Alberta, and Westslope Cutthroat Trout are listed as endangered in the federal *Species at Risk Act* (ESRD, 2014 and Government of Canada, 2014). Due to the ecological significance of Westslope Cutthroat Trout in Alberta, the species will be one of the primary focuses of the Alberta Conservation Association for the next several years, with specific focus on the upper Oldman headwaters region (Simmons, 2014 [pers. comm.]).

Dutch Creek is a sub-watershed of the Oldman headwaters region. The headwaters accounts for 24% of the total Oldman watershed area, and can deliver up to 90% of the Oldman River discharge (OWC, 2013). For this reason, land-use in the region can have a cumulative effect on the integrity and health of the entire watershed. As a result of high public use, the Oldman headwaters are an area of special management concern, and as a representative sub-watershed, the Dutch Creek Pilot Project was selected to help inform various management frameworks occurring in the headwaters region.

Historically the linear features in Dutch Creek were developed for: 1) access to logging sites, 2) oil exploration, 3) coal exploration, and 4) pipeline management. A small percentage of features were also developed for range management. As resource exploration dwindled in the area, the features were no longer used for their intended purposes, and there is now a legacy of access trails and roads that are regularly used by OHVs for hunting and other recreational use.

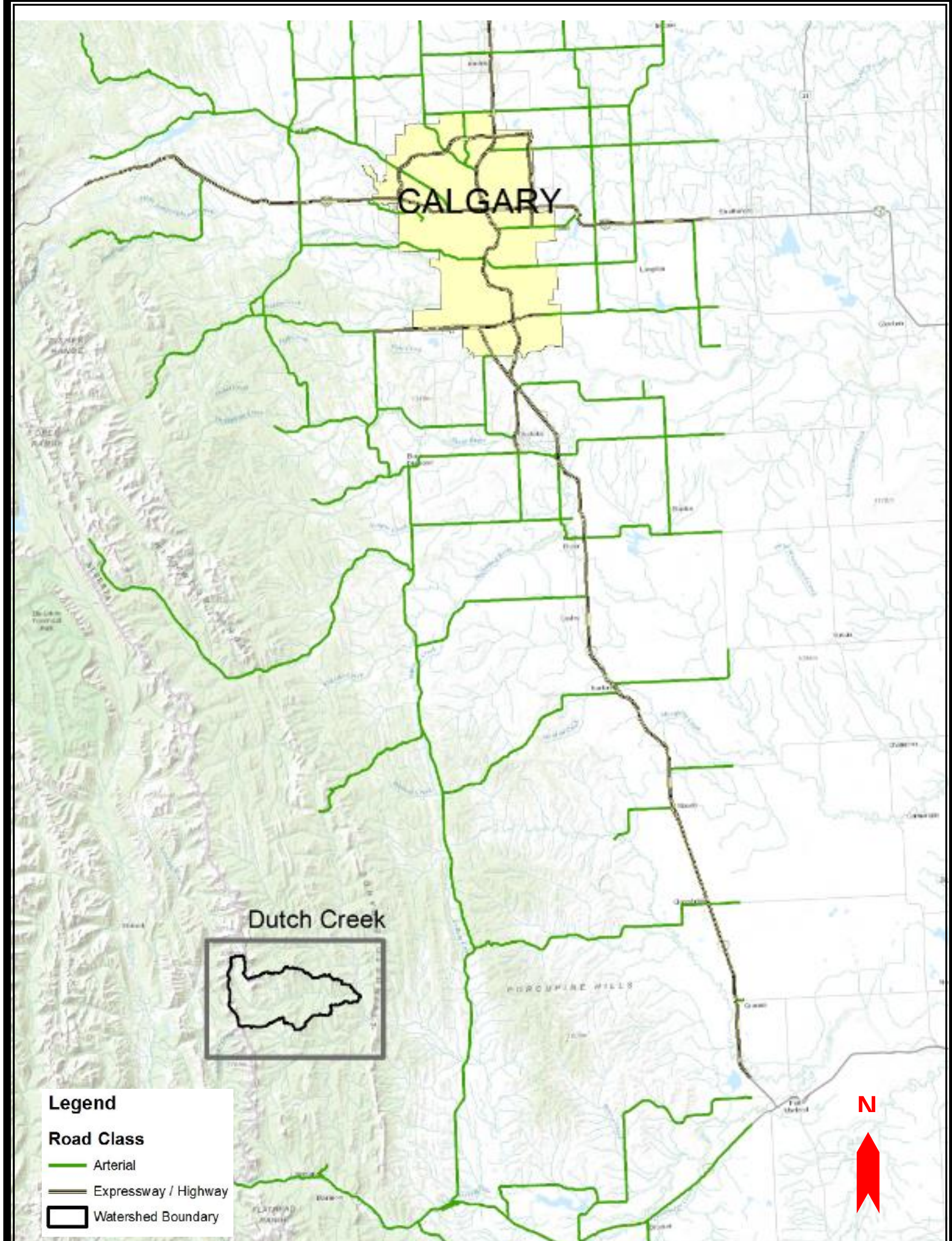

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Figure 1. Topographical map showing the location of the Dutch Creek watershed in southern Alberta.

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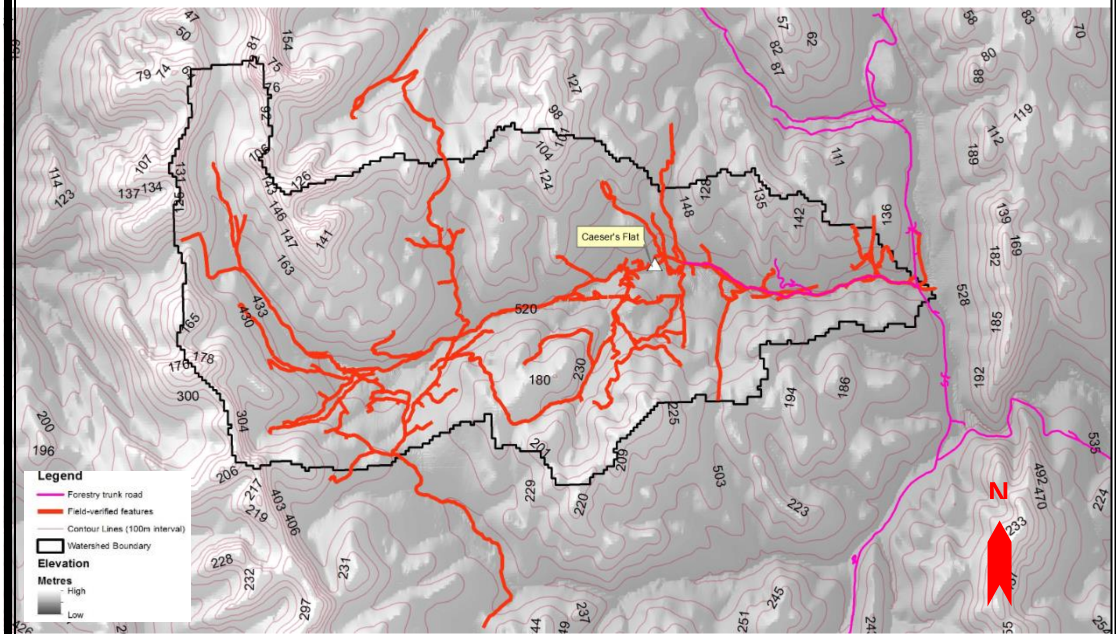

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Figure 2. Topographical map of the Dutch Creek watershed showing main access roads.

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2.0 METHODOLOGY

2.1 Pre-field Planning and Protocol Development

A comprehensive desktop assessment of the study site was conducted prior to the field program. This included a review of satellite maps of linear features, watershed vegetation, and watercourses provided by ESRD. A field assessment card was created to classify linear features and their characteristics (Appendix I). Parameters were determined in consultation with the OWC and stakeholders to ensure information required to properly assess the watershed health was included in the field program. A range of other watershed assessment protocols were consulted in the development of the field card, including an erosion model project prepared for the Washington Department of Natural Resources (Dubé et al., 2004); the Rocky Mountain Field Station Geomorphic Road Analysis and Inventory Package (GRAIP; Black et al., 2012); and the Alberta Watercourse Inspection Protocol (Government of Alberta, 2012). Aspects of these previous assessment protocols were incorporated and refined based on project goals and the location of the study site.

The two key linear types in the field assessment protocol are illustrated in Figure 3, and include:

1. *Linear Features*: This is a continuous trail or road from one junction or starting point to another junction or end point; and

2. *Linear Segments*: Each linear feature may be divided into a number of segments. A segment break occurs when there is either a change in use (e.g., a 4x4 road turns into a quad trail), or a change in the key characteristics of the trail, such as erosion condition, tread width, surface type, or vegetation cover.

In the field, each linear feature is numbered on the datasheet and corresponds with a GPS track file. If the physical characteristics are consistent throughout the linear feature, only the linear feature is identified; e.g., 'Feature 1'. If segments are identified by a change in physical characteristics, each segment is identified by a letter; e.g., 'Feature 2a', 'Feature 2b', etc.

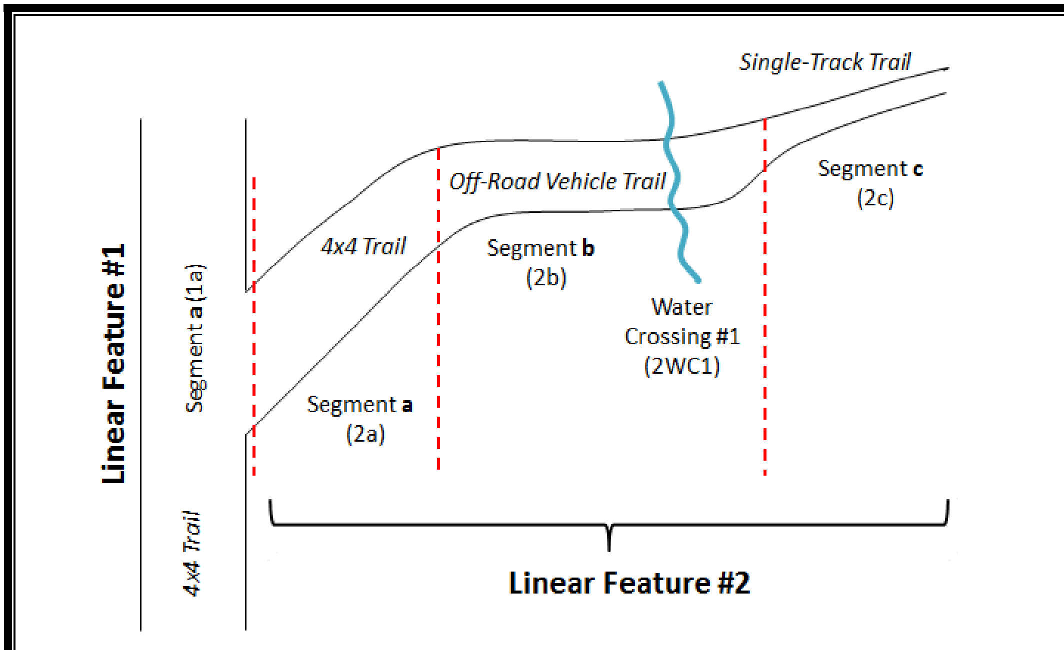

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Figure 3. Schematic diagram of the classification and labelling of linear features and segments.

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Feature and Segment Characteristics

The characteristics of each linear feature, including type code and status, are assessed using the field card. As shown in Figure 4, each segment (and single feature if no individual segments are identified) is also described by:

- surface type;
- tread width and depth;
- canopy cover; and
- erosion.

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DATE: September 20, 2014 CREW: KC and JW

Feature	Type Code	Status	Current Type Code*	Segment	Segment Slope	Surface Type	Tread Width	Avg Tread Depth	Vegeta-tion Cover	Canopy Closure	Erosion
#	1-8	A/E/R	1-8	(a–z)	F/M/S	AS/GR/DI	(m)	Nearest 5cm	Nearest 10%	Nearest 25%	R/S/E
1	1	A	--	a	F	GR	6	15	0	0	E
	2	A	--	b	S	DI	2	20	0	0	E
	3	A	--	c	F	DI	1	10	30	0	S
2	2	E	3	a	M	--	3	5	100	50	R

Dutch Creek Watershed Linear Features Classification Project

Figure 4. Field assessment card headers with sample assessment information.

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i. *Type Code:*

Type Code refers to the intended, or current use of the linear feature, determined in the field by parameters such as tread width and depth. Feature types include roads (highway and off-road vehicles), multi-use single track, horse trails, mountain bike trails, hiking trails, cattle or game trails, and 'other' features (Appendix I).

ii. *Status:*

Status refers to whether the linear feature is *active*, *enduring*, or *restored*. The following definitions were developed by ESRD to describe the status types:

- *Active*: A feature that remains actively used for its intended purpose.
- *Enduring*: A feature that has not been successfully reclaimed from an ecological function perspective either naturally or through active reclamation. These features may be permanent (being used for a purpose other than intended) or undergoing a process of reclamation. For example, a linear feature that has an existing reclamation certificate but is not representative of the adjacent native community is an enduring linear feature.
- *Restored*: Vegetation is representative of the adjacent native community, and the feature has thus been fully restored to its natural ecological function.

Features classified as enduring are assigned an initial type code to describe the original purpose of the feature (e.g., logging road), and a current type code to describe the current use of the feature (e.g., a logging road that is now a 4x4 road). Feature use (both current and historical) was detemined where possible by examining the characteristics of the surrounding environment (e.g., proximity to cut blocks), feature width, tread depth, and other qualtitative indications (e.g., tire marks, trackings) that demonstrated feature use.

iii. *Slope and surface type characteristics*

Segment Slope is defined as the average gradient over the whole segment and is separated into three categories: flat (F; <5%), moderate (M; 5–10%), and steep (S; >10%). Surface type refers to the ground coverage of the linear feature, and is classified as either ashphalt (AS), gravel (GR), or dirt (DI). In combination with tread width/depth and vegetation coverage (represented in precentage), the surface type can provide insight to the overall stability of the linear feature. The additional characteristic recorded is canopy cover, as this can also provide information about the frequency of use of each feature.

iv. *Erosion*

The erosion characteristics of each segment are notated as bedrock/vegetation (R), stable (S), or eroded (E). It is important to note that a surface with exposed bedrock could either have experienced severe erosion to bedrock, or could be in its natural condition. If bedrock is exposed as a result of erosion, the segments are classified as ‘E’.

Watercourses

Each watercourse crossing along a linear feature was assessed to determine the waterbody type, the crossing type, and the substrate in the case of fords. Bank shape and bank stability were also assessed at each crossing, as these parameters are important in determining the overall condition of the crossing and its impact on in-stream habitat.

The field card headings for watercourse crossings and some sample data are shown in Figure 5. Waterbody types are either large permanent (LP), small permanent (SP), intermittent (IN) or ephermeral draws (ED). Crossing types are categorized as bridges (BR), culverts (CU), fords (FO) or log bridges (LC). Crossing substrate is either bedrock (BE), cobble (CO), gravel (GR) or fines (FI). In each case, the dominant substrate is noted, and if there is an even representation of two or more substrate types, note of this is made on the field card. Bank shape is either sloping (S; 0–45^{o}), vertical (V; 45–90^{o}) or undercut (U; >90^{o}), and bank stability is rated as high, medium or low.

WATERCOURSE CROSSING						
Feature/ Segment	Crossing #	Waterbody Type	Crossing Type	Crossing Substrate*	Bank Shape	Bank Stability
#a-z	#	LP, SP, IN, ED	BR, CU, CF, FO, LC	BE, CO, GR, FI	S, V, U	H, M, L
1a	1	SP	FO	CO	U	M
1a	2	IN	FO	FI	S	L
1a	3	IN	FO	FI	S	L
1b	1	LP	BR	--	V	H

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Figure 5. Watercrossing field card with sample assessment information.

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2.2 Field Program

Four AAR field crew were deployed to Dutch Creek watershed from September 16–23, 2014. Fieldwork included mapping each feature and classifying each feature/segment using the field assessment card. On arrival, a site reconnaissance was conducted with all the field crew to establish the protocol to minimize data variation and error.

The field mapping was conducted by pairs travelling on ORVs, and linear features were mapped with a GPS into discrete segments. A waypoint was marked on the GPS at the beginning and end of each feature, and any visible change in the feature type or other characteristics were marked as a separate segment. The location of these segment changes were also marked on the GPS. Photos were taken at representative points along all linear features and segments.

The locations of watercourse crossing were marked as waypoints, and substrate and bank stability were assessed both upstream and downstream from the crossing. Points of interest and nodes were also mapped; notes and photos were taken at each point.

Points of Interest and Nodes

In addition to linear features and water crossings, “points of interest” such as cattle gates, old farmhouses, and other noticeable landmarks are recorded (Appendix I). An intersection of multiple linear features, such as campgrounds and parking lots, is classified as a “node”. The outer perimeter of these areas was tracked to determine their size. Each point of interest and node is photo-documented and referenced to a marked waypoint on the GPS. Multiple linear features in the node were not surveyed, but included in the 'node' designation.

2.3 Data Processing and Mapping

A Geographical Information System (GIS) was used to process all field data. Mapping included all field-verified and accessible linear features, associated watercourse crossings, as well as points of interest and the location of multiple trail intersections and nodes (e.g., campgrounds and parking lots). Detailed mapping of areas of erosion concern and fisheries information at watercourse crossings was completed to serve as a foundation for management priorities.

3.0 RESULTS AND DISCUSSION

3.1 Linear Feature Inventory

A total of 156 linear features, 205 segments, and 640 waypoints were collected during the Dutch Creek linear mapping program. The feature density, including linear features of all type codes, is 1.09 km/km^2. Bull Trout populations have been shown to decline at feature density of 0.87 km/km^2 (Fiera, 2014), therefore the feature density at Dutch Creek is classified as high pressure. This finding is not consistent with the results in the Fiera (2014) indicator project, where it reported low pressure density throughout the headwaters region. This is likely because of higher resolution of field data collected in this study. In Appendix II, Map 1 shows all field-verified linear features and their type codes. A total of 164 km of linear features was mapped, and the total mapped distance of each type code and their coverage (in percentage) is summarized in Table 1. ORV trails account for 65% of total linear feature distance, highway 4x4 vehicle roads (e.g., truck roads) account for 35% of mapped segments, and the remaining <1% are cattle and other trails (e.g., logging roads).

Plate 1 shows examples of active, enduring, and restored linear features, and the status of mapped linear features is shown in Map 2 (Appendix II). The intended and current use of each feature was identified where possible using knowledge of the surrounding environment and its characteristics. However, it was difficult to interpret the intended use of most linear features in the field without detailed background knowledge of the history of linear feature development in the watershed. Of the 205 classified segments, 74% are actively used, 18% are enduring, and 8% are fully restored such that the trail is representative of the adjacent native community. A small number of restored segments were identified due to the difficulty in distinguishing fully restored trails from their surroundings.

It is of note, that there was some discrepancies between the definition of active and enduring features presented above and the interpretation of these definitions by the field crew. For example, the field crew considered that if a feature was undergoing a process of reclamation and was no longer 'actively' used that it should be classified as enduring. This is not strictly correct according to the definition given by ESRD, which states that an enduring feature is one that "…may be permanent (being used for a purpose other than intended) or undergoing a process of reclamation." By this definition, a logging road that is now being used as a quad trail would be classified as enduring. However, the field crew considered these to be active; i.e., they are still actively used. We consider that this is an important result of the study in itself; i.e, there is some difficulty in interpreting these definitions for field use, and further explanation and training is required before field crews embark on a mapping project. The other point of confusion in relation to the active, enduring or reclaimed classification is that a reclaimed feature, by its definition, is one that is fully restored and the surface cover therefore has no satistically significant difference to the surrounding vegeation. By this definition, these features would no longer be identifiable on the ground, and can therefore not be mapped.

Table 1. The total distance and distance coverage of classified segments types.

Segment Use Type	Total Distance (km)	Total Distance Coverage (%)
Highway 4x4 Vehicle	57	35
Off-road Vehicle	106	65
Cattle/Game Trail	0.23	<1
Others (i.e., Logging road)	0.91	<1

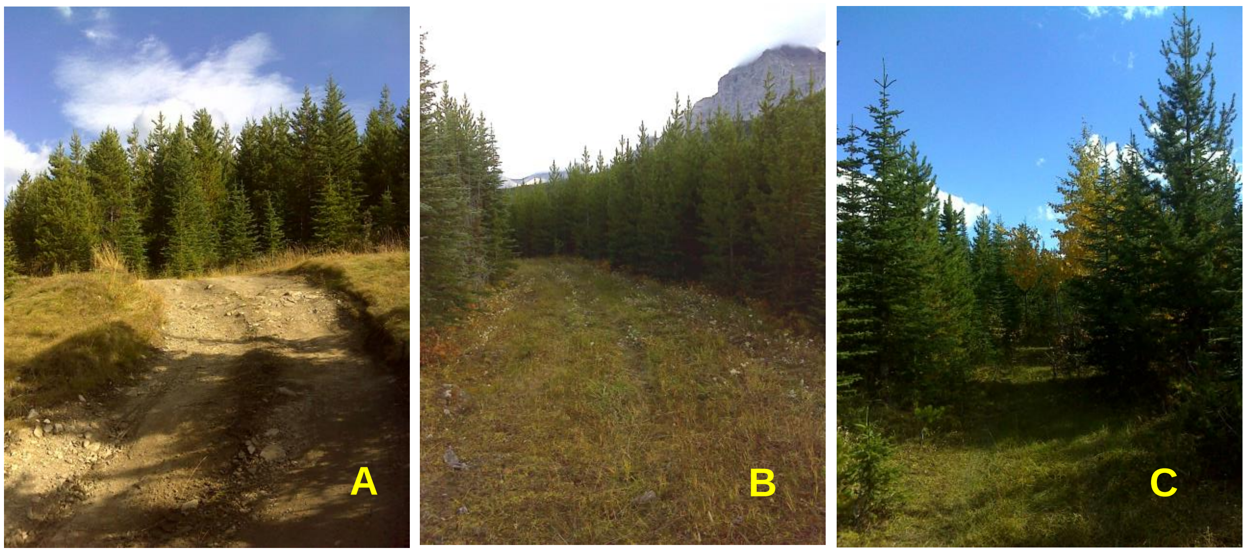

Plate 1. Examples of a) an active linear feature, b) an enduring feature, either abandoned or currently undergoing reclamation, and c) a feature undergoing restoration (please note that this was classified as restored in the field).

Comparison of satellite-derived and field-mapped linear features

Prior to the AAR field program, linear features in the watershed had been mapped by ESRD. These data were derived from satellite imagery, orthophotos, and LiDAR. A copy of the linear feature map provided by ESRD is included in Appendix II, and Maps 3 compare the ESRD mapped features with the field-verified results.

The overall watershed coverage of linear features identified in the field program was similar to the maps provided by ESRD. A total of 218 km of linear features were identified using source imagery compared with 164 km from our field mapping program. Many small linear features that branch off main trails on the ESRD maps were not identified verified in the field, but the key continuous features were comparable.

Some linear features were only partially mapped in the field due to time constraints, physical barriers (e.g., fences and log jams), and ground conditions (Map 3). Other features were not mapped because the feature was too steep or rutted for access. Walking these features is an option for future mapping projects, but this will require a significant amount of time, and a cost-benefit analysis should be undertaken to determine if it is feasible to map smaller features. It is also possible that satellite imagery provides spatial information that cannot be seen or interpreted on a smaller scale (i.e., on the ground). On the other hand, features identified from source imagery may also be artifacts from the mapping algorithm. However, any possible overestimation of the number of linear features from satellite data cannot be quantified because not all features were mapped in the field due to the reasons mentioned above.

There were also differences between feature classifications derived from satellite imagery and field-verified data. For example, a feature marked as a pipeline right-of-way on the ESRD maps was classified as an OHV in the field (Map 1). The discrepancy in this classification is because of scale differences between the shape recognition algorithm used by ESRD and our field program. Other limitations to the types of information that can be derived from source imagery include linear feature type codes, current status, and erosion condition. While the satellite map potentially provides more comprehensive spatial coverage of linear features at a catchment scale, it does not contain information regarding the current use of the individual features by the public. Because of this, field-based linear feature mapping provides more useful data and meaningful resolution of issues on the ground than satellite-derived mapping.

The shape recognition algorithm makes assumptions about a feature's characteristics that may not be uniform throughout the watershed. The majority of linear features identified from source imagery are cutline trails. In the algorithm, cutlines are defined as "a minor roadway, usually only a linear clearing, which may be surfaced with exposed soil, rock and/or low vegetation…" (Government of Alberta, 2013). These cutline trails were classified as ORV trails in the field, but data showed that low vegetation cover is not a consistent characteristic of ORV trails. ESRD's algorithm for delineating truck trails does not include slope as a factor, so truck trails on the source imagery maps may actually be ORV trails because of the feature's steepness.

A map of linear feature density developed from field data is included in Appendix II (Map 4), along with a copy of the linear density map from ESRD. The linear feature density was calculated using the same resolution as ESRD so the maps can be compared directly (raster output cell size was 100 m with 1 km radius). The scale for classification was created using natural breaks to reduce variance in the dataset while maximizing the class differences to locate areas of high linear feature density. The field-derived linear density map has more high density 'hot spots' compared with the ESRD map. ESRD identified 54 km of linear features that were not mapped in the field (Map 3, but these unverified linear features were concentrated in two locations, which suggests that satellite and field mapping for the remainder of the watershed is more comparable than in these specific areas.

In both field-verified and source imagery data, the linear density was highest along the main trails of the watershed. The linear feature density determined from source imagery and field data has a broadly similar pattern with some inconsistencies. Field data shows a high density area surrounding Caesar's Flat, located in the center-east of the watershed, which was not identified from source imagery by ESRD. The ERSD map also shows high linear-density areas at the center of the map, where the linear features were not verified in the field. Both methods confirmed a high linear density area in the southwest region of the watershed where there is active logging.

Both linear feature identification methods have limitations due to the nature of data processing, and the selection of methods should be based on available data, project goals, and budget. However, it is recommended that satellite imagery identification should always precede ground truthing, as it provides better site reconnaissance, and is more cost-effective. The desktop identification of linear features served well as a prerequisite for this project in providing base maps of linear feature spatial distribution and to help to strategize appropriately for the field program.

3.2 Erosion Condition of Linear Features

More than 70% of all mapped features are stable, but this includes trails that are heavily used but are subject to little erosion because they are so compacted. The density of eroded features (0.19 km/km^2) is considered negligible according to the Fiera (2014) classification system which has a threshold of 0.3 km/km^2. Though the eroded density is considered negligible, it is important to note that any changes to surface material on roads, stable or eroded, reduces the infiltration capacity of the ground and will inherently change the drainage and runoff patterns in the watershed. For this reason, overall feature density makes Dutch Creek an area of management concern and, after discussions with the OWC and stakeholders, the term ‘stable’ has been replaced by the term ‘compacted’.

The erosion status of linear features in Dutch Creek is shown in Map 5 (Appendix II), and examples of an eroded, vegetated, and compacted linear feature are shown in Plate 2. The total distance and percent coverage for stable, eroded and restored linear features are summarized in Table 2.

Table 2. The total distance and percent coverage of stable, eroded and restored mapped linear features.

Erosion Status	Total Distance (km)	Total Distance Coverage (%)
Compacted	120	73
Eroded	30.7	19
Vegetated/Bedrock	13.1	8

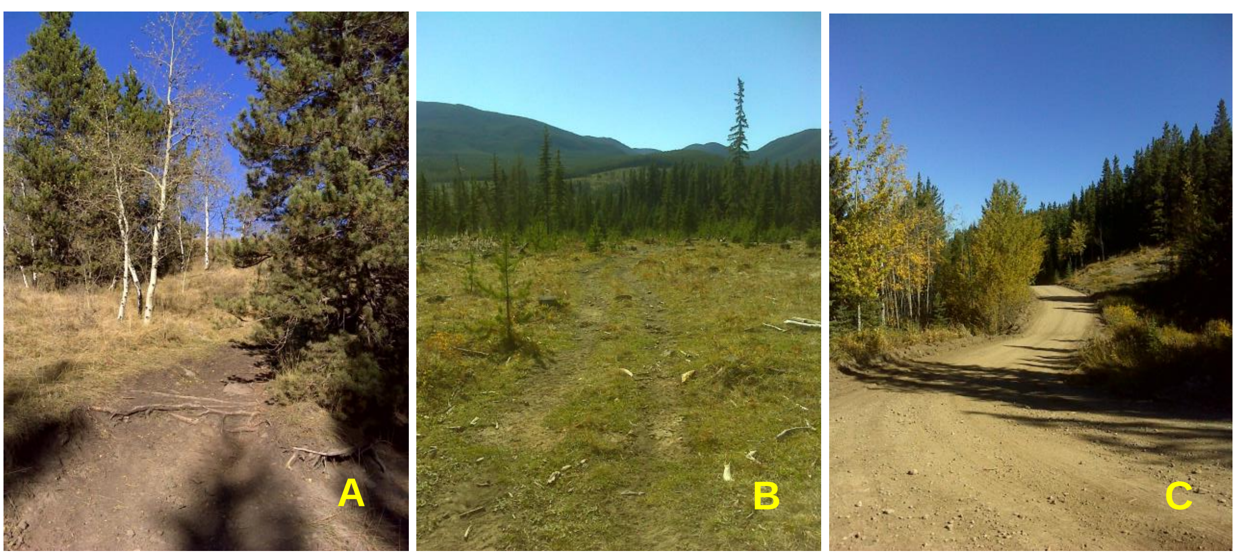

Plate 2. Example of a linear feature that is a) eroded, b) vegetated, and c) compacted.

As the majority of segments in Dutch Creek are classified for off-road vehicle use, it is important to pay particular attention to the erosion condition of these features. Figure 6 summarizes the erosion status of all mapped segments used for off-road vehicle use. 23% of all off-road use segments showed signs of erosion. Erosion was most prominent on steeper features, where deep trenches were carved out by water drainage (Plate 3). Heavy erosion was also observed at random camping sites along the main access roads as a result of truck and recreational vehicle use, and most quad trailers were found at lower elevations.

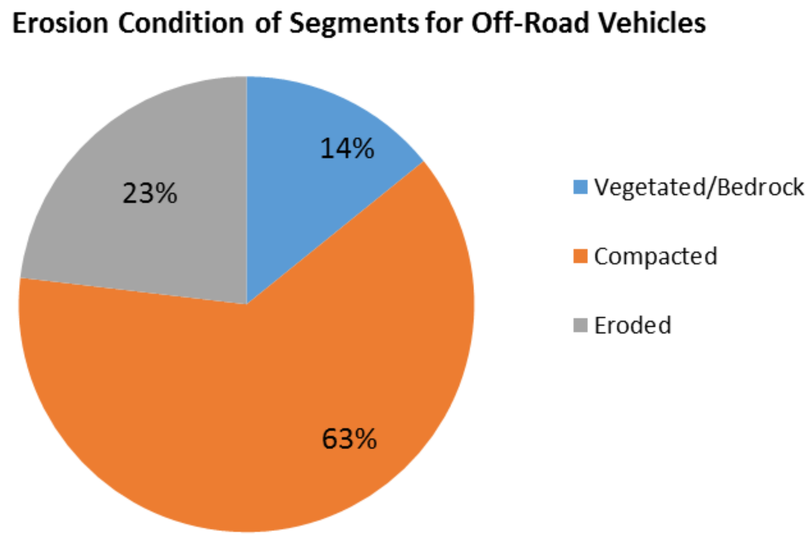

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Figure 6. The erosion status of segments for off-road vehicles use.

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Plate 3. Two photographic examples of ORV trails with deep ruts and erosion from water ponding and drainage.

3.3 Nodes

Map 5 (Appendix II) shows nodes and points of interest along with the erosion condition of linear features. The two labels became interchangeable in Dutch Creek because all the points of interest, such as undesignated campsites and areas of activities, were located in nodes. Points of interest include random campsites (defined as undesignated campsites with no amenities), cattle gates, and other noticeable landmarks. The cattle gates are all placed along the main road to deflect cattle away from traffic. The majority of the campgrounds and small random campsites are distributed along the main trail, where the road conditions are more compacted for easy RV access. Garbage and metal dump sites are found in close proximity to areas of high campground density, such as Caesar's Flat (Plate 4).

Caesar's Flat is an example of a node in Dutch Creek. It is popular for camping because it is large and flat, thus making it ideal for larger vehicles access (e.g., RVs, and truck trailers with ATVs). During the field program there was a large influx of visitors to Caesar's flat on the weekend, resulting in high use of trails and fords and increased litter near watercourses. As a result of high density camping at Caesar's Flat, many unregulated and short ORV trails originate in this area (Map 5). This is concerning as the quad trails around Caesar's Flat are heavily eroded from high traffic, and cross through watercourses that contain sensitive spawning habitat for Bull Trout (Map 6a).

Plate 4. RVs camping at Caesar’s Flat, which is a point of interest and a node.

3.4 Watercourse Crossings and Aquatic Resources

Approximately 232 watercourse crossings were identified and mapped (Map 6; Appendix II), and the crossing types are summarized in Figure 8. Almost 80% of the crossings in Dutch Creek are unregulated ford crossings, 16% are culverts, and bridges account for the remaining <10% of crossings. An example of an unregulated ford crossing is shown in Plate 5. It is common to see unregulated ford crossing(s) adjacent to bridges, which demonstrates that even if appropriate crossing structures are in place, ORVs are still fording the channel and causing unnecessary damage to the banks and riparian zone. Informal fords were also established at several locations alongside bridges that were washed out during the spring 2013 flood event.

Culverts are placed to provide drainage under and alongside high-traffic features that need to support larger vehicles (i.e., the main trail and logging roads). About 42% of culvert crossings are located in the southwest portion of the watershed where active logging occurs, while the remaining are distributed along the watershed’s main trail (Map 6). The number of culverts that are passable for fish was unknown and not assessed in our field program. A more detailed aquatic assessment is needed to determine the effects of culverts on aquatic habitat in Dutch Creek.

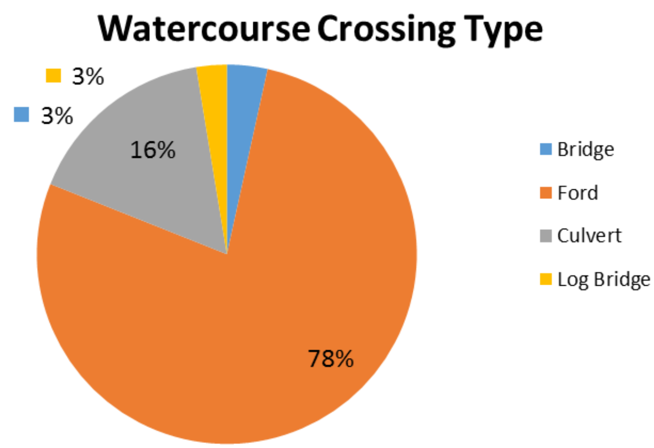

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	Figure 7. Watercourse crossing types in Dutch Creek.	
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Plate 5. Photograph of an unregulated ford crossing at a large permanent stream showing widened bank widths at the crossing.

The dominant substrates at ford crossings are fines (37%), cobble (35%), and gravel (28%). The high percentage of ford crossings with fine substrate is a concern, as finer sediments are more easily mobilized and transported downstream when disturbed. Fords with cobble substrate may previously had a higher proportion of fine substrate that has since been transported downstream from repeated crossings. The west end of the watershed has the highest density of ford crossings; the eroded quad trail located north from the main trail encompasses 12% of total ford crossings in the watershed (Map 6a). This is of management concern as fording across unprotected stream banks causes erosion and will subsequently widen the bank width at the crossing (Plate 5). This can lead to shallower flow for fish at the crossing and sediment release downstream. Field observation confirmed lesser fine sediments (“clean cobbles”) at ford crossings.

There are two fish species at risk in the Dutch Creek watershed: Bull Trout (which has been listed as threatened provincially) and Westslope Cutthroat Trout (listed as a species at risk federally). The majority of the Bull Trout population in Alberta is concentrated in the Oldman watershed headwater drainages (Hurkett et al., 2011), and yearly surveys since 2008 have shown Bull Trout spawning throughout the Dutch Creek sub-basin (Coombs, 2014 [pers. comm]). The headwater drainages of the Oldman River, including Dutch Creek, are also home to a genetically pure-strain Westslope Cutthroat Trout, which is of great conservation value (Coombs, 2014 [pers. comm.]), but detailed redd surveys have not been conducted in Dutch Creek to date.

A map of watercourse crossing locations and types in relation to Bull Trout spawning areas surveyed by ESRD in 2012 is shown in Map 6a (Appendix II). There is a high density of unregulated ford crossing in the west half of the watershed, which overlaps with 70% of redds surveyed in 2012 (Maps 6b and 6c). This is problematic because the decline in Bull Trout distribution and population has been accelerated by habitat degradation (Hurkett et al., 2011 and Government of Alberta, 2014).

Annual redd surveys in Dutch Creek (since 2008) show that Bull Trout spawning occurs in September (Hurkett et al., 2011), which coincides with the beginning of elk hunting season in Alberta. An increase in the number of hunters in the west end of the watershed to avoid heavy traffic along the main trail was noted during the field program. Increased sedimentation from unregulated fords, combined with the specific habitat preference and the non-repetitive spawning behaviour of Bull Trout (they tend to return to the same spawning areas), can produce damaging compound effects to their population and distribution in Dutch Creek.

3.5 Field Program Limitations

As noted in Section 3.1, some linear features were not captured by the 1-week field program. Game trails, for example, were not identified due to time constraints and access restrictions in heavily wooded areas. From a management perspective, game trails are not an erosion concern and have little influence in determining overall watershed health.

Some linear features were not identified (or fully mapped) due to ground conditions and physical barriers. The entrance of features that were not mapped in the field is shown in Map 3. Some features were too steep and/or rutted for access, other features were truncated by fences or bogs. Spring flooding in the area created log jams at some river crossings, wiped out several bridges, and steepened the bank gradient at several fords. Active logging blocked access to the southwest part of the watershed, and large woody debris from old logging activities also obstructed access to some cutblocks. The timing of the field program also coincided with the beginning of the hunting season and certain areas were not fully explored for safety reasons.

3.6 Recommendations for Future Field Programs

Overall Recommendations

The key area for improvement in future mapping projects is the erosion assessment of linear features. The current classification divides all segments to three categories: vegetated/bedrock, eroded, and stable (compacted). The latter two classifications are largely subjective, and an eroded feature can maintain a stable status, though it is heavily used and compacted. The term "compacted" should replace "stable" to avoid the implication that these features do not effect surface runoff and erosion in the watershed. The vegetated/bedrock category should be a surface type classification parameter because it contains little information about the overall stability of the linear feature. Vegetated linear features in the field can be stable from restored vegetation growth over time, or unstable if the feature is located in a low-lying wet area that is prone to erosion (Plate 6). This ambiguity also applies to bedrock linear features, as their stability largely depends on whether the surface type is scree.

Plate 6. Photographs of two linear features categorized as "vegetated" in the erosion assessment but have a very different erosion status.

The linear feature status classification also needs refinement. The definition discrepancy between the ESRD terminology and the field crew's interpretation needs further thought for practical field applications. To properly map features using the definitions provided by ESRD, a map of historical development of linear features would be required. A more precise classification indicating the different stages of reclamation should be implemented. A feature should only be classified as enduring if there is a change in type code from previous to current use, and features that are currently undergoing reclamation could be given a separate classification. By ESRD's definition, restored linear features have vegetation that is not statistically significant from their adjacent community because they have undergone full restoration to their natural ecological functions. By this definition, fully restored features cannot be classified as linear features because they are no longer identifiable. Therefore the classification “restored” should be omitted from the field card.

The layout of the field assessment card and reference notes was easy to navigate in the field, and the quality of the collected data is consistent. The classification parameters are easy to interpret in the field and very time-efficient. The classification parameters are also flexible and would be easily transferable to other watersheds in Alberta. However, it is recommended that the parameters be reviewed prior to other linear feature inventory projects to ensure the identification and assessment process are site-specific and suited to the project goals. A site reconnaissance is also highly recommended to help maintain consistency in the assessment process.

The season and weather are both important factors to consider when planning a linear feature inventory project. Game trails were not mapped in this project due to time constraints, and are not considered critical from a management perspective and in an overall erosion assessment of the watershed. Game trails are also easier to map during the winter when there is snow to mark trails. The field program for this project coincided with the beginning of hunting season and this created issues for crew safety. On the other hand, it also enabled the crew to make important observations about the use of camping nodes in high-use areas. Precipitation can also seriously affect the crew’s safety as it can alter road conditions, especially on steeper features.

Specific Recommendations for Dutch Creek

The overall goal of compiling a field-verified linear feature inventory at Dutch Creek has been achieved. However, there is scope for future work, and a vegetation survey and more detailed erosion assessment should be considered for areas with high linear feature density, such as Caesar’s Flat and along the main trail. This would provide more information to help strategize management priorities and reduce linear disturbance on headwater health.

Based on our observations of watercourse crossings and redd distribution in Dutch Creek, bridges are recommended as alternative crossing method to unregulated fords in the west half of the watershed to minimize sedimentation in water. Crossing restoration is recommended in areas where bridges were wiped out by floods in order to decommission fords that have been formed since that time. A more in-depth stream assessment in high-risk areas would help determine whether crossings at Dutch Creek pose a risk to aquatic habitat. Bull Trout redd information needs be updated when survey data becomes available to determine the effects of floods on their population and distribution.

4.0 CONCLUSION

The linear mapping pilot project in Dutch Creek has resulted in the mapping and classification of 164 km of linear features. Field data confirmed off-road vehicles as the dominant transport in the watershed, quad trails accounted for 65% of all linear features. Though most linear features were classified as stable, they should be considered of concern from an erosion perspective because the linear feature density (1.09 km/km^2) is rated as high pressure. A more detailed erosion assessment is recommended for specific areas in Dutch Creek with high linear feature density.

The field program has provided an important comparison with the ESRD source imagery method. Both methods yield similar linear feature density results, and confirm that linear density is highest along the main trail and at the active logging area in the southwest region of the watershed. Satellite mapping is a good precursor for the field program, but ground truthing is required to provide more meaningful surface characteristics and erosion concerns that cannot be detected with satellite imagery. Some modifications are recommended for the field assessment card for future linear feature inventory projects, but it is broadly transferable to linear mapping projects in other watersheds in western Canada.

New bridge installations and restoration of washed out bridges are recommended to minimize unregulated ford crossing in Dutch Creek, as the watershed is an important spawning corridor for Bull Trout and a genetically-pure strain of Westslope Cutthroat Trout. More detailed stream assessments in key hotspots are suggested to assess the impact of fords on aquatic habitat. Aquatic habitat information also needs to be re-evaluated when updated redd survey information becomes available to account for the effects of floods earlier this year.

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Personal Communications with Connie Simmons, Oldman Watershed Council. November 17, 2014.

6.0 CLOSURE

Please contact us with any questions or concerns regarding this report. We can be reached by telephone at (403) 294-0488 or by e-mail at kchin@appliedaquatic.com and ksinclair@appliedaquatic.com.

Sincerely,
Applied Aquatic Research Ltd.

Krystal Chin, MSc.
Hydrologist

Reviewed by:

Kate Sinclair, Ph.D.
Senior Hydrologist/Environmental Planner

APPENDIX I

FIELD DATA SHEET AND DATA SHEET REFERENCE NOTE

APPLIED AQUATIC RESEARCH LTD
1929 ï 10 Ave SW, Calgary AB (403) 294 0488

LINEAR FEATURE DATA SHEET

PROJECT:______________
DATE:__________________ **CREW:** ______________________

Feature	Type Code	Status	Current Type Code*	Segment	Segment Slope	Surface Type	Tread Width	Avg Tread Depth	Vegeta-tion Cover	Canopy Closure	Erosion
#	1-8	A/E/R	1-8	(a–z)	F/M/S	AS/GR/DI	(m)	Nearest 5cm	Nearest 10%	Nearest 25%	R/S/E

*Define current type code *only* if the status is identified as ñenduringò (E)

WATERCOURSE CROSSING						
Feature/ Segment	Crossing #	Waterbody Type	Crossing Type	Crossing Substrate*	Bank Shape	Bank Stability
#a-z	#	LP, SP, IN, ED	BR, CU, CF, FO, LC	BE, CO, GR, FI	S, V, U	H, M, L

*Define crossing substrate *only* if the crossing type is identified as ñfordò (FO)

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Point of Interest (e.g., Old farmhouse, farm gate, landmarks etc.)		
Waypoint ID	**Photo ID**	**Description**
Nodes (e.g., Parking lot, campground etc.) Track the perimeter of the node with GPS		
Trackfile ID	**Photo ID**	**Description**

Notes

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DATA SHEET REFERENCE NOTES

Type Codes

1. Road: Highway (4 x 4) vehicles
2. Road: Off-road vehicles
3. Multi-use single-track: Well-defined, wide path designed for foot traffic, bicycles and horses
4. Horse trail
5. Mountain bike trail
6. Hiking trail
7. Cattle or game trail
8. Other: Explanation in notes

Status

Active	A linear feature that remains actively used for its intended purpose.
Enduring	A linear feature that has not been successfully reclaimed from an ecological function perspective either naturally or through active reclamation. May be permanent (being used for a purpose other than intended) or undergoing a process of reclamation. For example, a linear feature that has an existing reclamation certificate but is not representative of the adjacent native community would be an enduring linear feature.
Restored	A linear feature that is restored such that vegetation within the feature is representative of the adjacent native community.

Segment Slope

Average the gradient over the whole **segment**. If segment is V shaped stream crossing, average both sides.

F	<5%, Flat or gently sloping road
M	5ï 10%, Moderate slope
S	>10%, Steep road

Surface Type

AS	Asphalt	
GR	Gravel	Little dust or fines on surface
DI	Dirt	Native dirt surface

Tread Width

Measure the width of feature from vegetated fringe on each side. When measuring a rutted track with a verge down the center, include verge in total.

Erosion

R	Rock/veg ï bedrock or vegetation
S	Surface appears stable, no signs of erosion
E	Surface shows signs of erosion

* If bedrock is exposed due to erosion, use classification ñEò

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WATERCOURSE CROSSINGS

Watercourse Type

LP	**Large Permanent**	Large Permanent Watercourse (channel development ï width more than 5.0 m)
SP	**Small Permanent**	Small Permanent Watercourse (channel development ï width up to 5.0 m)
IN	**Intermittent**	Intermittent Watercourse (channel development ï width up to 0.7 m)
ED	**Ephemeral Draw**	Ephemeral Draw (vegetated draw, no channel development; include when well defined and wet)

Crossing Type

BR	Bridge	Permanent Structure spanning watercourse bed and banks above the high water mark
CU	Culvert	Pipe or similar covered with fill to allow water flow under linear feature
CF	Constructed Ford	Cement pad or similar below water level, provides stable platform for vehicle crossing
FO	Ford	No change to watercourse
LC	Log bridge	Log(s) placed in or above watercourse to facilitate crossing

Crossing Substrate *(use only if crossing type is identified as "ford" [FO])*

BE	Bedrock
CO	Cobble
GR	Gravel
FI	Fine

Bank Shape

S	Sloping, 0 ï 45° (1:1 ratio)
V	Vertical, 45° ï 90°
U	Undercut, >90°

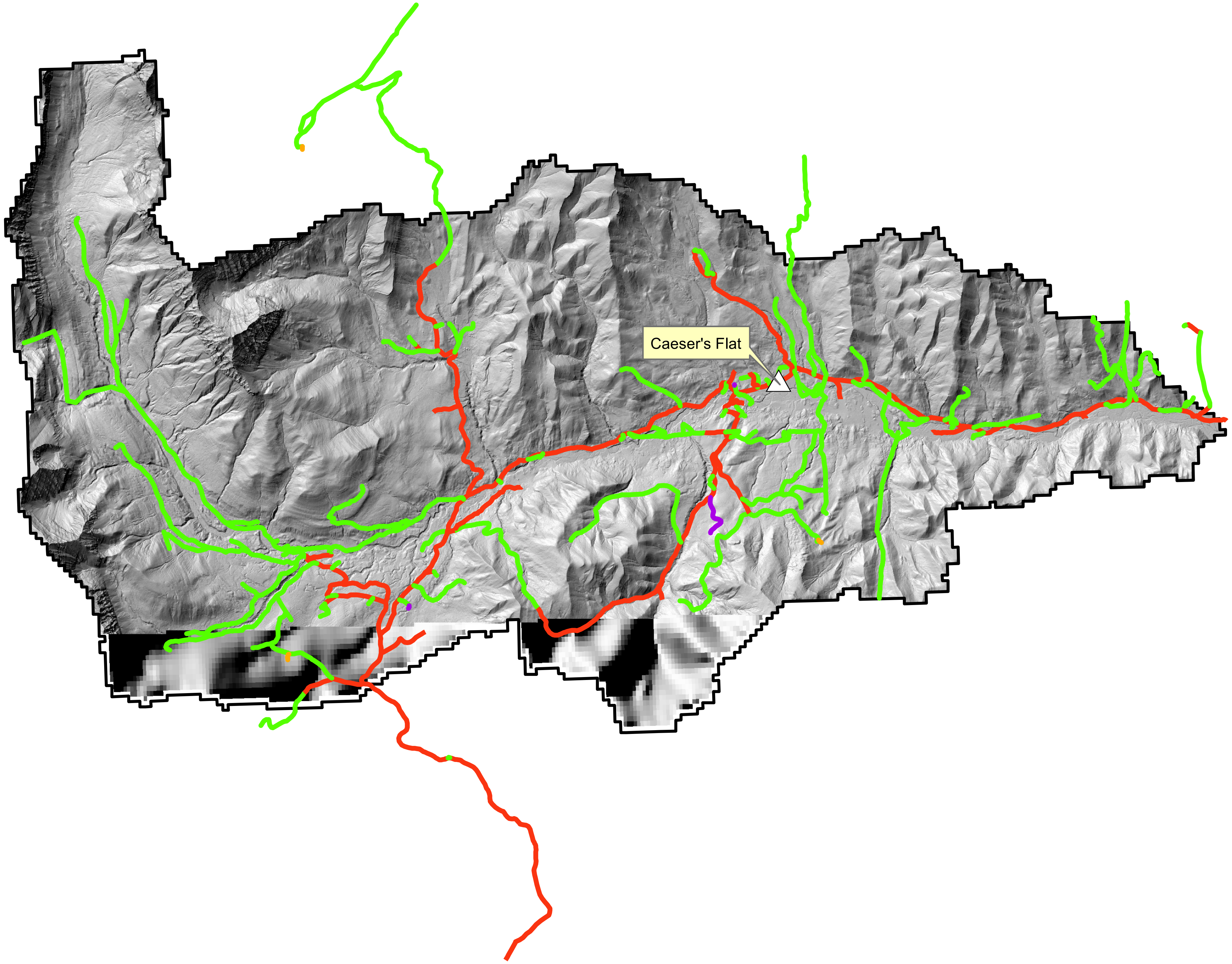
Bank Stability

H	Bank stable
M	Medium, no signs of sloughing, but potential exists
L	Visible sloughing or erosion

Naming Conventions

Feature	Numbered, 1ï xx
Segment	Lettered, aï z, aaï zz etc.
Watercourse Crossing	FeatureSegmentWC# (e.g., Feature 1, segment b, first crossing: 1bWC1)
Point of Interest	FeatureSegmentP# (e.g., Feature 1, segment b, first point of interest: 1bP1)
Node	FeatureSegmentN# (e.g., Feature 1, segment b, first node: 1bN1)
Photo	FeatureSegmentIN/OUT (e.g.,Feature 1, segment b, incoming: 1bUP)

APPENDIX II
MAPS



Legend

Type Code

- Highway (4 x 4) vehicles
- Off-road vehicles
- Cattle or game trail
- Others
- Watershed Boundary

10m Hillshade - from Lidar

Value

High : 254

Low : 0

N

APPLIED AQUATIC RESEARCH Ltd.

Map 1 - Dutch Creek Watershed - Linear Feature Type Code

Scale 1:80,000

0 2 4 Kilometres

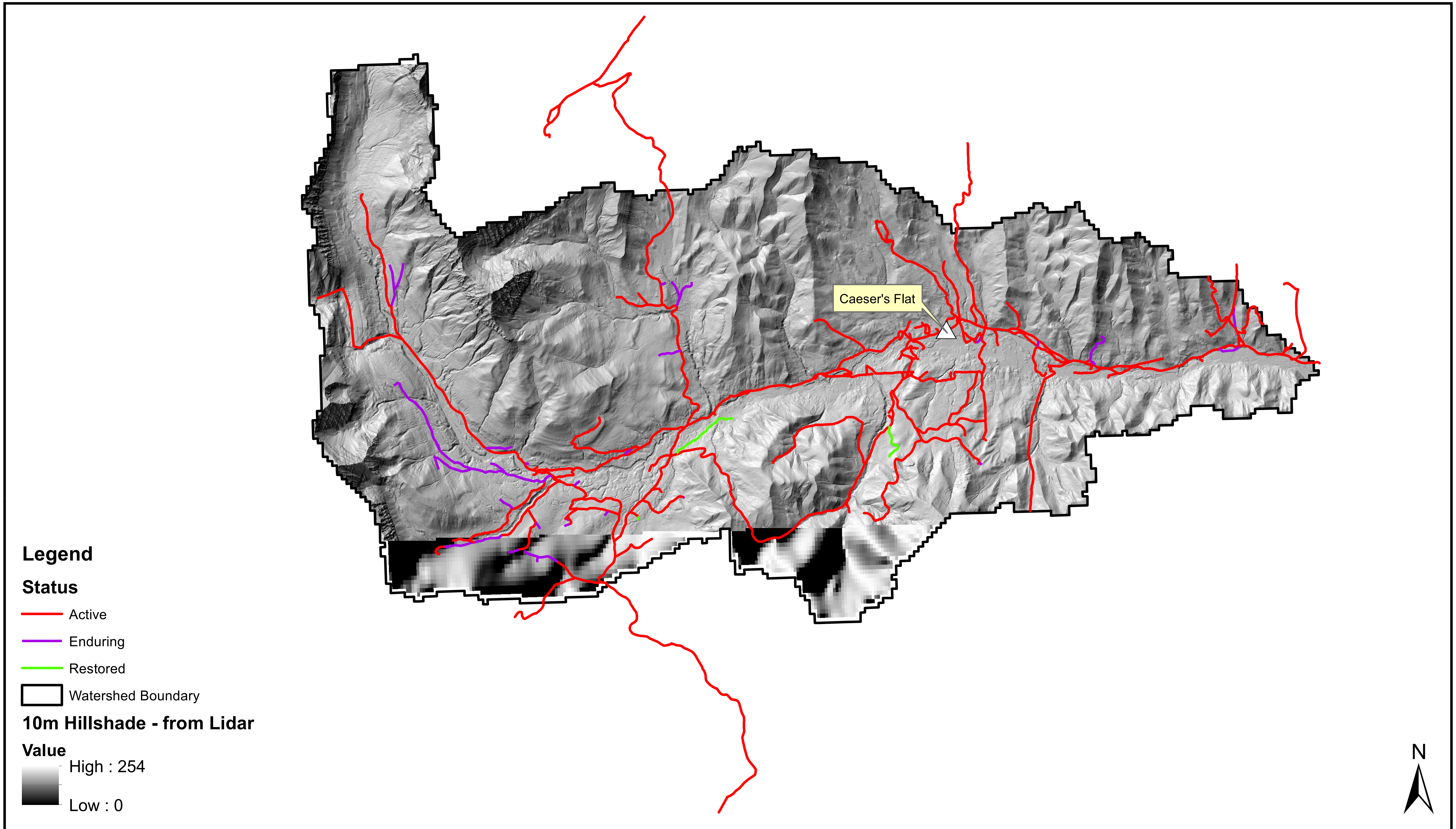
NAD_1983_UTM_Zone_11N

AAR14-105

October 2014

Map by S.B

Source: 10m Hillshade provided by ESRD 2014



Map 2 - Dutch Creek Watershed - Linear Feature Status

APPLIED AQUATIC RESEARCH Ltd.

Scale 1:80,000

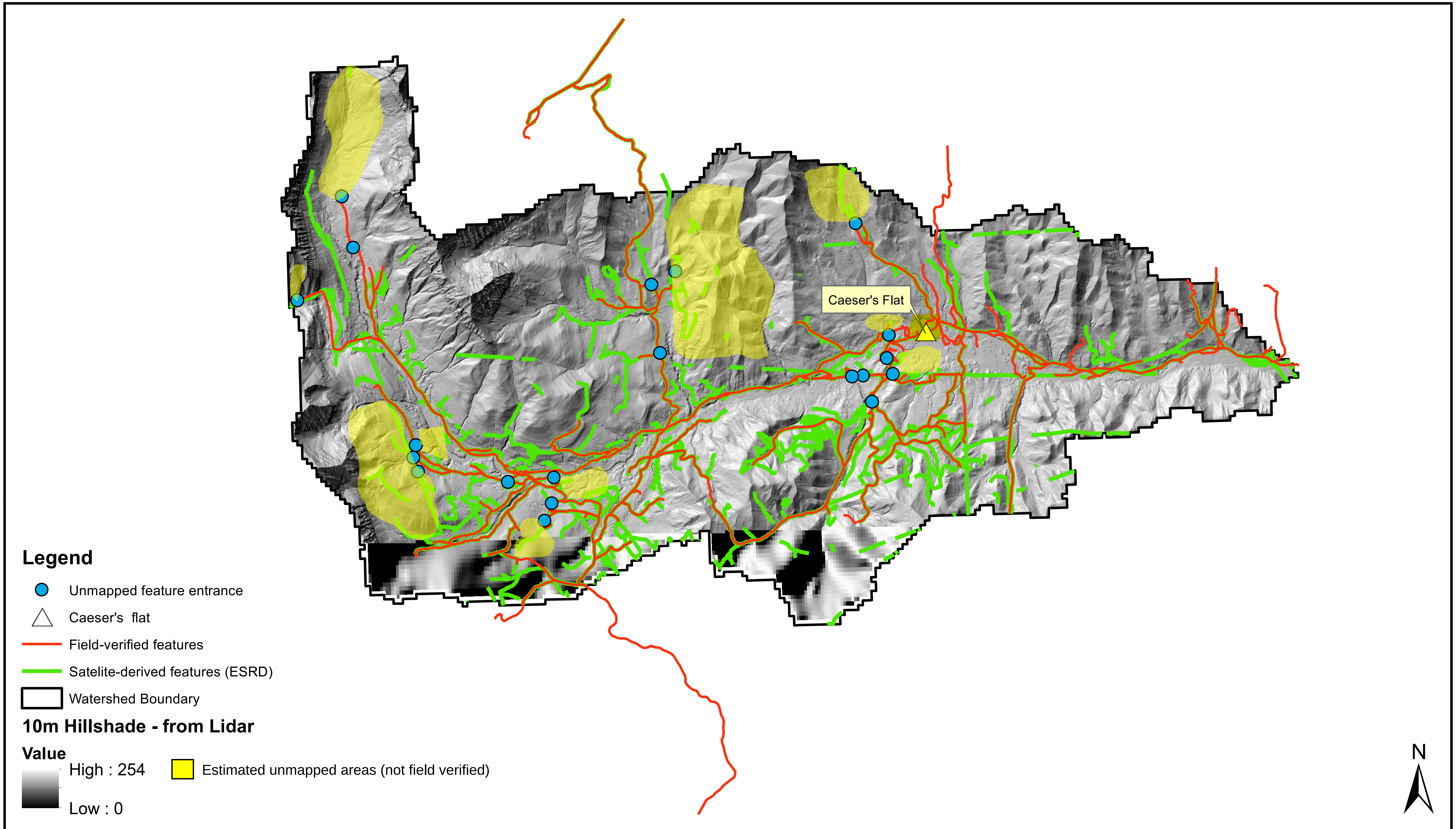
0 2 4 Kilometres

NAD_1983_UTM_Zone_11N

AAR14-105

October 2014 | **Map by S.B**

Source: 10m Hillshade provided by ESRD 2014



Map 3 - Dutch Creek Watershed - Comparison of Satellite-Derived and Field-Verified Linear Features

Scale 1:80,000

0 2 4 Kilometres

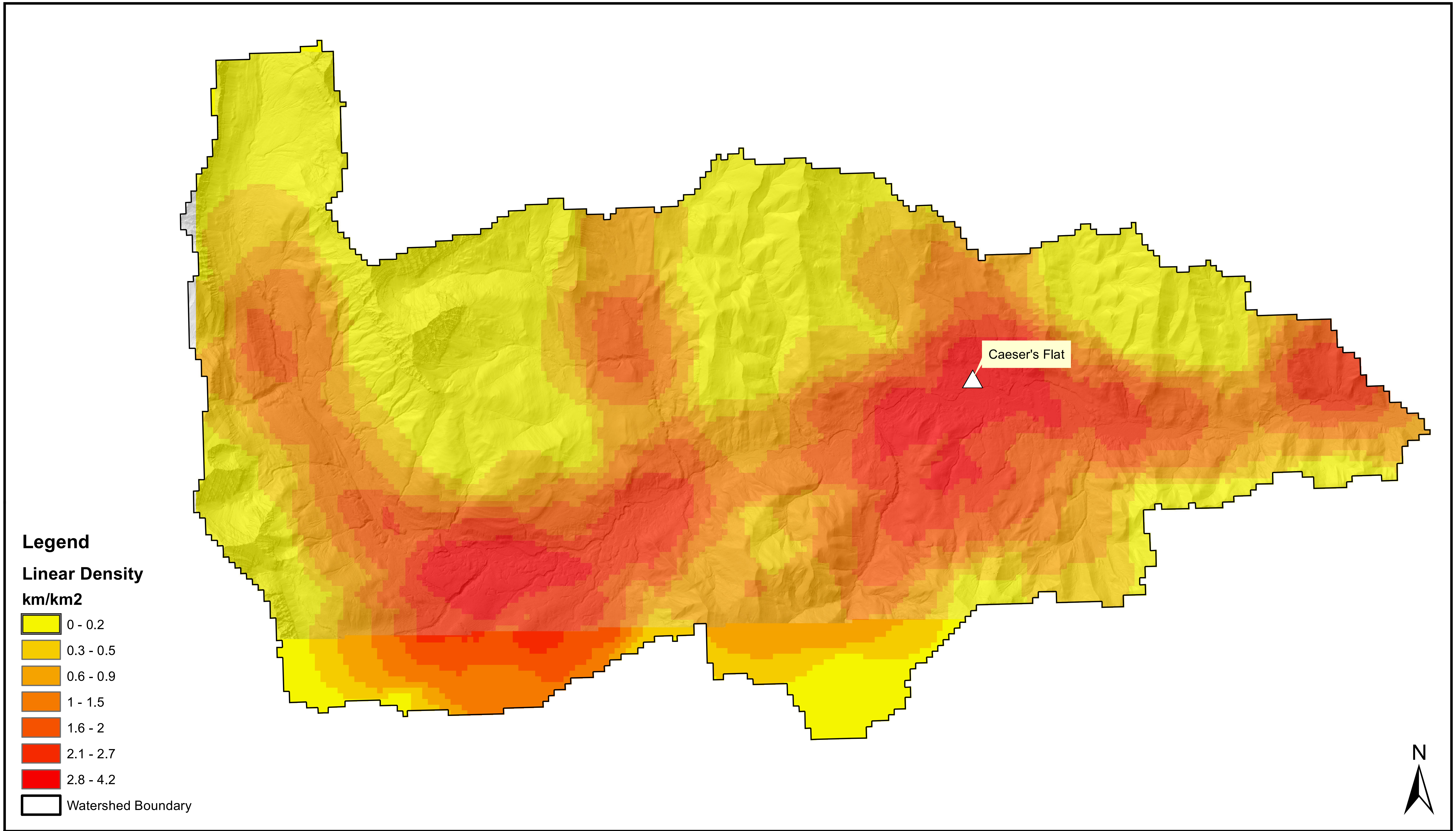
NAD_1983_UTM_Zone_11N

AAR14-105

October 2014

Map by S.B

Source:Satellite-derived linear feature provided by ESRD 2014
10m Hillshade provided by ESRD 2014



Map 4 - Dutch Creek Watershed - Linear Feature Density

Note: The output raster cell is100m with a 1km radius.

Scale 1:65,000

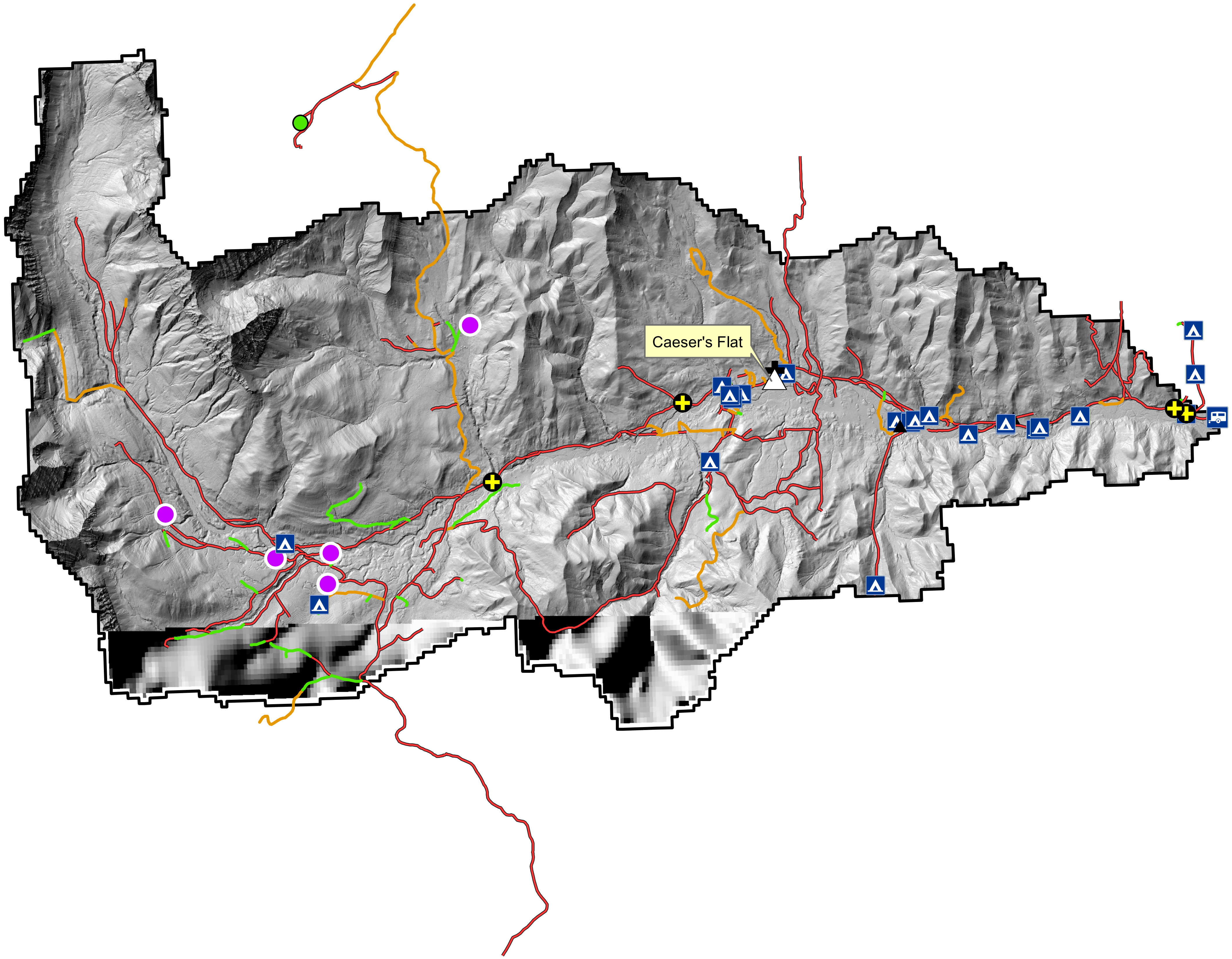
0 2 4 Kilometres

NAD_1983_UTM_Zone_11N

AAR14-105

October 2014

Map by S.B



Legend

- Provincial park campground
- Random campsite
- Cutblock access
- Dump
- Great Divide Trail Entrance
- Pipeline
- Texas Gate

Erosion Condition

- Bedrock/Veg
- Eroded
- Compacted
- Watershed Boundary

10m Hillshade - from Lidar

Value

High : 254

Low : 0

N

APPLIED AQUATIC RESEARCH Ltd.

Map 5 - Dutch Creek Watershed - Erosion Condition of Linear Features, Nodes, and Points of Interest

Scale 1:80,000

0 2 4 Kilometres

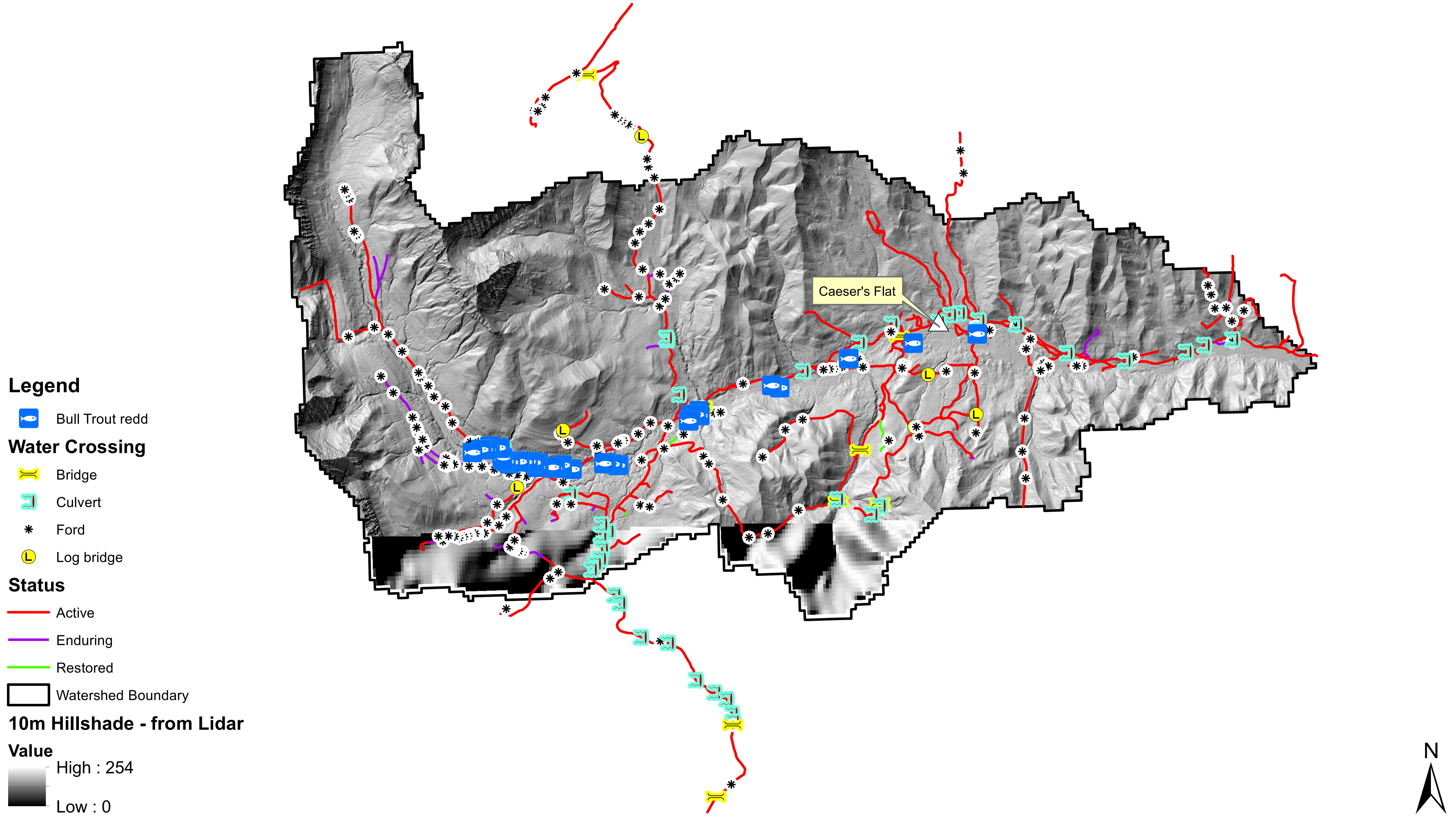
NAD_1983_UTM_Zone_11N

AAR14-105

October 2014

Map by S.B

Source: 10m Hillshade provided by ESRD 2014



Map 6a - Dutch Creek Watershed - Water Crossing Types and Bull Trout Redd

Scale 1:80,000

0 2 4 Kilometres

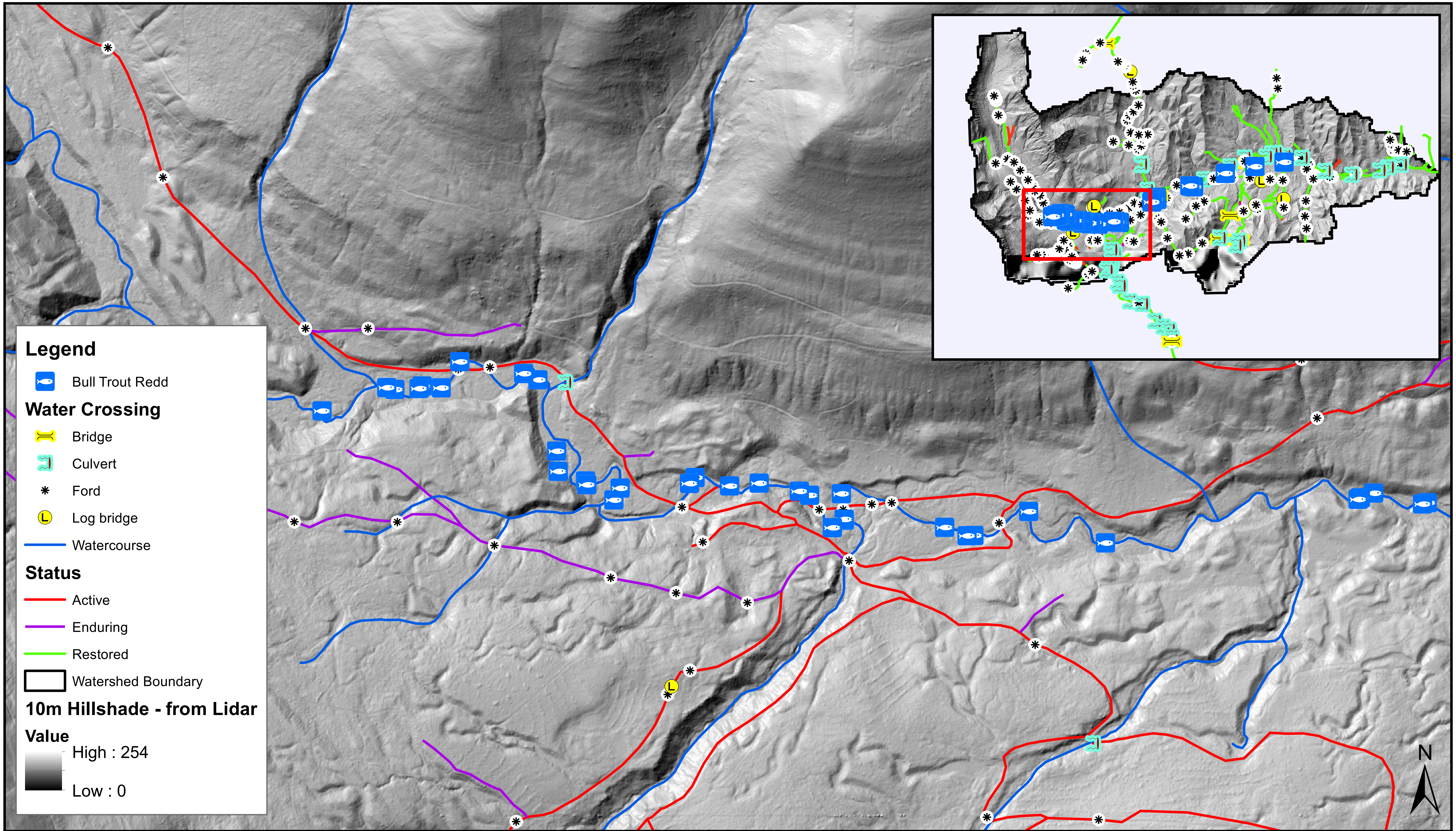
NAD_1983_UTM_Zone_11N

AAR14-105

October 2014

Map by S.B

Source: 2012 Bull Trout redd survey by ESRD (Coombs, 2014 [pers. comm])
10m Hillshade provided by ESRD 2014



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Map 6b - Dutch Creek Watershed - Sub Area of Management Concern

Scale 1:10,000

0 200 400 Metres

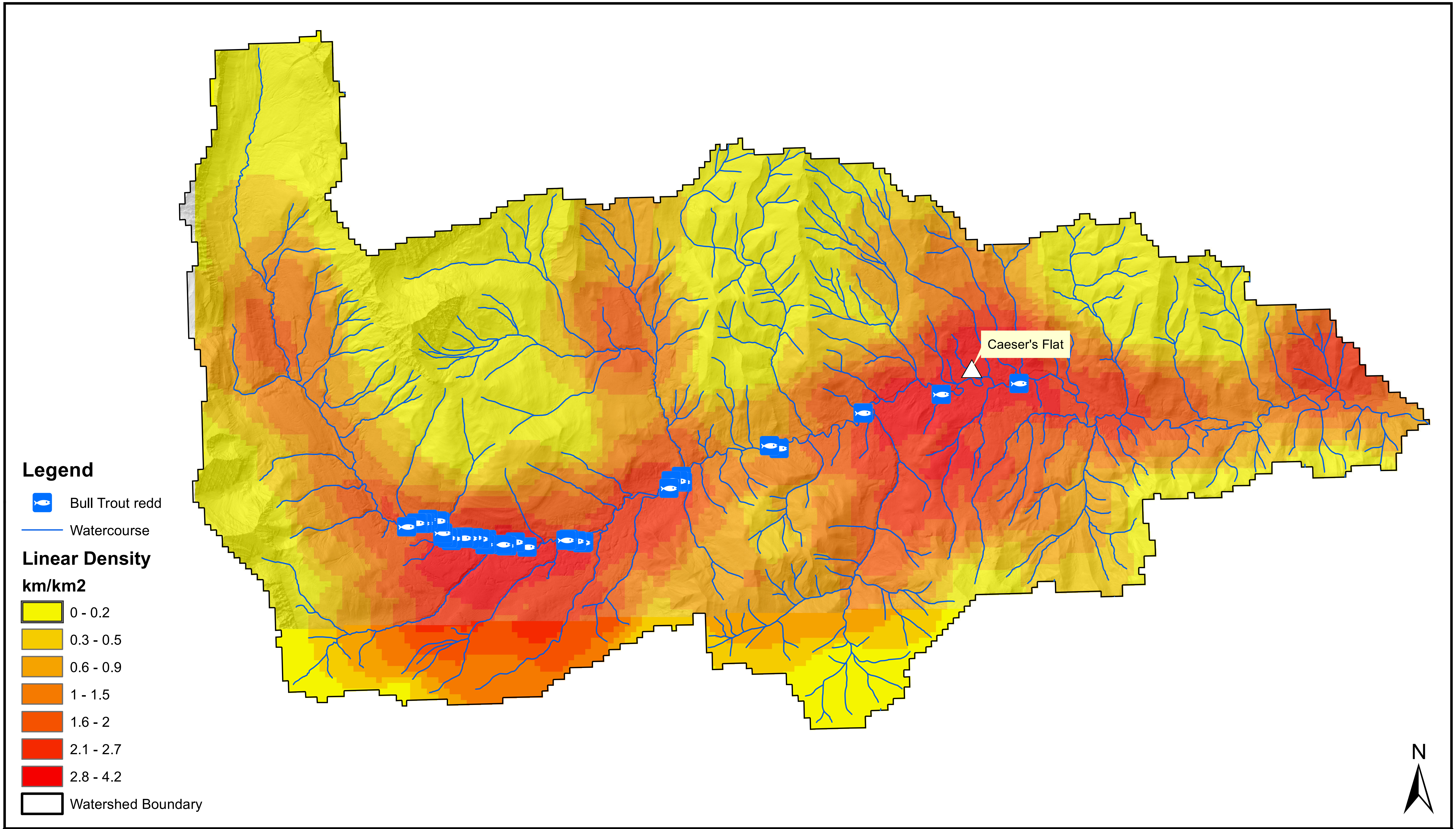
NAD_1983_UTM_Zone_11N

AAR14-105

October 2014

Map by S.B

Source: 2012 Bull Trout redd survey by ESRD (Coombs, 2014 [pers. comm])
10m Hillshade provided by ESRD 2014



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Map 6c - Dutch Creek Watershed - Linear Feature Density with Bull Trout Redd

Note: The output raster cell was 100m cell size with 1km radius

Scale 1:65,000

0 2 4 Kilometres

NAD_1983_UTM_Zone_11N

AAR14-105

October 2014

Map by S.B

Source: 2012 Bull Trout redd survey by ESRD (Coombs, 2014 [pers. comm])