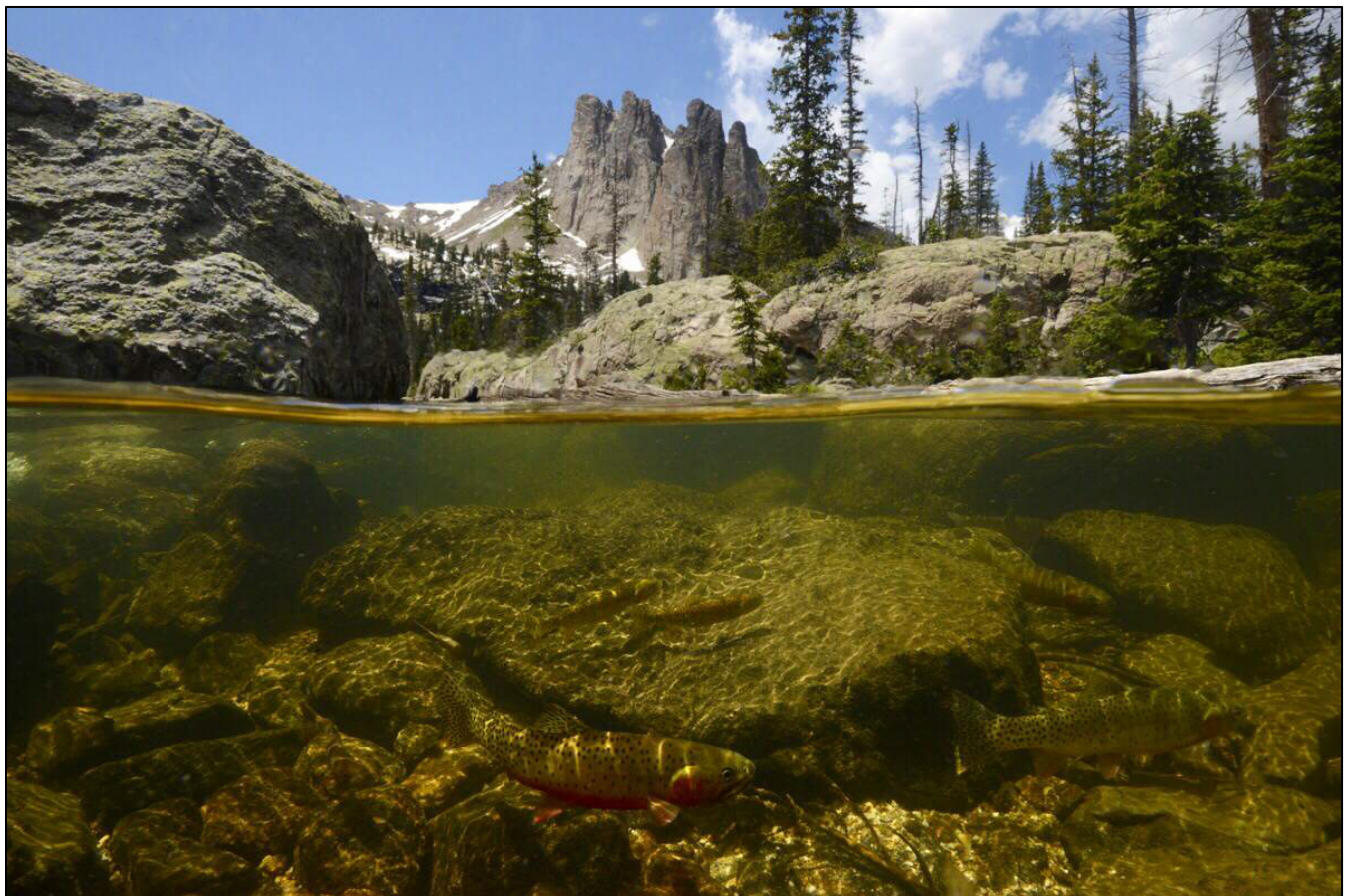




Evaluation of Waters for Native Cutthroat Trout Restoration in Rocky Mountain National Park

Natural Resource Report NPS/ROMO/NRR—2022/2364



ON THE COVER

With Ptarmigan Mountain looming in the background, blue lineage Colorado River cutthroat trout spawn in the outlet to Lake Nanita. (© MICHAEL FORSBERG)

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Natural Resource Report NPS/ROMO/NRR—2022/2364

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Abstract

The greenback cutthroat trout (*Oncorhynchus clarki stomias*) and the undescribed green lineage cutthroat trout (*O. clarki* ssp.) are the only cutthroat trout native to the waters of Rocky Mountain National Park (RMNP). In RMNP the greenback is native to the waters east of the Continental Divide (CD) and is listed as a federally threatened sub-species under the Endangered Species Act (ESA). There are only a few extant populations, none of which are within RMNP. The green lineage is taxonomically undescribed, native to the waters west of the CD in RMNP. Based on current understanding of cutthroat trout genetics, one population of green lineage fish resides within its historic drainage in RMNP and several more reside outside their historic range and east of the CD. This report compiles available data on parameters that affect the time and cost of conducting native cutthroat trout restoration and parameters that have been determined to be important for long-term persistence of cutthroat populations. It includes information on the existing habitat and populations, incorporates future projections (where available), applies accepted population conversion factors from brook trout to cutthroat (where available) and explores potential methods for conducting restoration projects (by chemical or mechanical means). It also proposes a prioritization scheme for native cutthroat restoration in RMNP at the individual project, sub-drainage and major drainage scales. The report is not a decision document but is intended to be used by managers as a reference and guide for native cutthroat restoration.

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Introduction

The greenback cutthroat trout (*Oncorhynchus clarki stomias*) and the undescribed green lineage of cutthroat trout (*O. clarki* ssp.) are the only cutthroat trout native to the waters of Rocky Mountain National Park (RMNP). In RMNP the greenback is native to the waters east of the Continental Divide (CD) and is listed as a federally threatened sub-species under the Endangered Species Act (ESA). There are only a few extant populations, none of which are within RMNP. The green lineage is taxonomically undescribed and is native to the waters west of the CD in RMNP. The green lineage is currently being evaluated as to whether it warrants listing under the ESA. Based on current understanding of cutthroat trout genetics, one population of green lineage fish resides within its historic drainage in RMNP, at Timber Creek/Lake, and several more reside outside their historic range, east of the CD.

Methods

This report compiles available data on parameters determined to be important for the long-term persistence of cutthroat trout and which may affect the time and cost of conducting a native cutthroat trout restoration project. It includes information on the existing habitat and populations, incorporates future projections (where available), applies accepted population conversion factors from brook trout to cutthroat (where available) and explores potential methods for conducting restoration projects (by chemical or mechanical means). The intent of this evaluation is to provide RMNP decision makers with the necessary information to identify the best areas and waters for cutthroat trout restoration.

Drainages which currently contain fish were analyzed from the most downstream barrier (complete or partial) within RMNP to the upper extent of fish. Ten parameters were selected for analysis based on their importance for the long-term persistence of cutthroat trout, ease of conducting a restoration project and the availability of data. These parameters include: presence of fish migration barriers, stream length, lake surface area, watershed area, current water temperature, future water temperature, number of fish present, current species of fish present, disease and access. Two scoring systems were devised; one to rank potential restoration projects based on the complexity of implementing them (Implementation Scoring) and one to rank the probability of long-term persistence of cutthroat trout (Persistence Scoring). Two scoring systems were deemed necessary because some of the parameters were in conflict with the two goals of this document: ease of conducting a project and long-term persistence of populations. For example, larger habitat segments are better for long-term persistence of cutthroat trout, but they are also more difficult to effectively remove all non-native fish and more costly.

Implementation Scoring parameters include: presence of fish migration barriers, stream length, lake surface area, watershed area, current species of fish present, disease and access. Persistence Scoring parameters include: presence of fish migration barriers, stream length, lake surface area, watershed area, current water temperature, future water temperature, number of fish present and access. Four of these parameters (presence of a fish migration barrier, number of fish that restoration projects waters could support and current and future water temperature) were identified as being more important in establishing long-term populations that could meet recovery goals. Therefore, these parameters were given greater weight in the scoring system. Data were compiled and summarized for each potential restoration project, sub-drainage and major drainage (Cache la Poudre, Big Thompson, St. Vrain, Colorado Headwaters, etc.) and scored using a point system for both scoring systems to prioritize waters for restoration.

Where possible the scoring mirrored the definitions and considerations for restoration areas and populations within the Greenback Cutthroat Trout Recovery Outline (Greenback Cutthroat Trout Recovery Team 2019), Colorado River Cutthroat Trout Conservation Strategy (CRCT Coordination Team 2006) and the Species Status Assessment Report for the Rio Grande Cutthroat Trout (USFWS 2014). Summarizing the data in this way will allow decision makers to weight the two scoring systems, Implementation and Persistence, based on which is more important at the time a decision on a project needs to be made. Total Persistence scores tend to be higher based on the higher number of

parameters, but this does not necessarily indicate higher priorities. The scoring is not intended to be something that is rigidly followed, but as a tool to make informed decisions. It will also allow decision makers to consider at which scale they would prefer to conduct restoration of cutthroat trout in RMNP (by individual project, sub-drainage, or major drainage). Restoration actions in the Cache la Poudre drainage have already been determined through the Long Draw Reservoir Special Use Authorization Record of Decision (NPS 2010); therefore, these lakes and streams are not separately scored here. We have included the Key Actions specified in the Record of Decision elsewhere in this document for easy reference and to provide a more complete picture of all waters in RMNP.

The boundaries of each potential restoration project were determined based on the location of known fish migration barriers, which are needed to exclude non-native fish species, and the appropriate size of habitat where the removal of non-native fish was deemed feasible. To break up projects into manageable pieces, where lakes are present, restoration projects were limited to one significant lake per project if barriers are present. Typically, projects only include multiple lakes when the additional lakes are small enough that they are not expected to add to the complexity of removal. The only exception to this was the Upper East Inlet, where three large lakes are in close proximity to each other with short, low-gradient stream reaches between lakes which do not contain barriers. Determination of sub-drainages was also based on the presence of barriers and consisted of two or more restoration projects which were connected to each other, typically tributary streams to major drainages and in a few cases portions of the major drainage themselves with single restoration project tributaries.

Additional parameters were considered, however sufficient data were not available to score all waters addressed in this report. If a particular parameter had substantial data gaps and suitable estimates could not be obtained it was not used for scoring restoration projects and instead was included in the report as additional information. These data gaps represent information that may be needed prior to making decisions on restoration. The substantive part of this report consists of tables summarizing the data with scoring and maps showing locations of the waters and important features, such as fish migration barriers.

Implementation Parameters Scored

Barriers

Fish migration barriers (waterfalls or cascades) are essential for a restoration project so that non-native fish are excluded from displacing or hybridizing with native cutthroat trout. The ideal situation is having a barrier which is both known to be effective at all flows and also excludes all fish from entering into the project area. A barrier that is partial (only excludes some fish species, sizes of fish or excludes fish during some flows but not all) would need to be improved. Improvement of a barrier would complicate a restoration project, particularly in wilderness, and increase the time and cost necessary to conduct the project.

Besides cutthroat trout, brook trout are the primary inhabitant of backcountry streams in RMNP. Kondratieff and Myrick (2006) determined waterfalls with a plunge pool depth of <10 cm and a vertical drop of >100 cm were the minimum necessary to prevent brook trout <30 cm in total length

from moving upstream. Since no brook trout >30 cm has been surveyed from a RMNP stream over the last 20 years these dimensions were used as a rough guide to determine whether a waterfall is a barrier. Since waterfalls and cascades, and their associated plunge pools, come in different dimensions and configurations, the primary determination as to whether a feature is a fish migration barrier is the species composition above and below the feature. For example, if brook trout are present below the feature and not above it will be considered a barrier.

Barrier Scoring:

- Partial barrier-needs improvement: 2 points
- Complete barrier: 4 points

Stream Length

Restoration projects with shorter stream reaches would be easier to conduct because the reduced habitat would make it more likely to effectively remove all non-native fish present. Smaller habitats would also lessen the cost of projects as less equipment, chemical, personnel would be needed to complete the chemical treatment. Less time would also be spent conducting pre-restoration data collection and planning.

Stream Length Scoring:

- <2.8 km: 2 points
- 2.8–9.65 km: 1 point
- ≥9.65 km: 0 points

Lake Surface Area

Restoration projects of smaller lakes would be easier to conduct because the reduced habitat make it more likely to effectively remove all non-native fish present. Smaller habitats would also lessen the cost of projects with less equipment, chemical and personnel needed to complete the chemical treatment. Less time would also be spent conducting pre-restoration data collection and planning.

Lake Surface Area Scoring:

- <1.3 hectare: 2 points
- 1.3–9 hectares: 1 point
- >9 hectares: 0 points

Watershed Area

Restoration projects of waters in smaller watersheds would be easier to conduct because the reduced habitat make it more likely to effectively remove all non-native fish present. Smaller habitats would also lessen the cost of projects with less equipment, chemical and personnel needed to complete the chemical treatment. Less time would also be spent conducting pre-restoration data collection and planning.

Watershed Scoring:

- $<14.7 \text{ km}^2$: 2 point
- $\geq 14.7 \text{ km}^2$: 1 point

Fish Species Present

The fish species and lineage (for cutthroat trout) were identified for each restoration project area. Lineages of cutthroat trout native to Colorado, outside their native range, will be evaluated for their conservation value and the need for translocation evaluated. The presence of non-native trout species and/or hybridized cutthroat trout species would make waters more desirable for restoration and thus result in higher scores. We set an 80% purity level for cutthroat trout to retain a conservative approach when evaluating removing existing cutthroat populations as measured by DNA analysis based on the most recent techniques. In the future this level may be adjusted once listing determinations are made for all the subspecies of cutthroat in Colorado, and levels of purity to count toward recovery are determined (generally $>90\%$).

Fish Species Present Scoring:

- Green lineage cutthroat trout west of the Continental Divide: 0 points
- Green lineage cutthroat trout $>80\%$ pure east of the Continental Divide: 1 point
- Blue lineage cutthroat trout $>80\%$ pure: 1 point
- Any non-native trout including hybrid cutthroat trout: 2 points

Disease

The presence of disease would complicate projects since waters would have to remain fishless for a period of time until the disease is no longer present. Salmonid whirling disease (WD) and bacterial kidney disease (BKD) have been detected within fish populations in RMNP. Waters where WD has been detected need to stay fishless for several years after fish are removed in order to eliminate the disease (Nehring et al. 2015). Limited research is available on the viability of the pathogen responsible for BKD within a water body once fish are removed, but one study indicates that it persists for less than 21 days (Austin and Rayment 1985).

Disease Scoring:

- WD present: 0 points
- Unknown or BKD present: 1 point
- No diseases present: 2 points

Access

The presence of fish and angling opportunities attracts anglers to wilderness waters. Restoration projects which are not in close proximity to roads or trails tend to increase resource damage in wilderness areas (e.g. social trails to lakes and trampled streamside vegetation). In addition, conducting restorations in wilderness areas increases the complexity of projects by requiring exemptions for stock use or permission to use helicopters to transport materials or conduct stocking.

Access Scoring:

- Established trail/road access greater than one mile of site: 0 points
- Established trail/road access within one mile of site: 1 point
- Direct established trail/road access to site: 2 points

Persistence Parameters Scored

Barriers

Barrier Scoring:

- Partial barrier-needs improvement: 2 points
- Complete barrier: 4 points

Stream Length

Longer stream reaches are more likely to provide the necessary habitat for all life stages of cutthroat trout, provide habitat complexity to survive stochastic events and can hold more fish than shorter reaches, all of which contribute to long-term persistence (Peterson et al. 2013, Roberts et al. 2013, USFWS 2014). Streams shorter than 2.8 km are unlikely to have enough habitat variability for a population to be able to survive stochastic events, while those ≥ 9.65 km have a higher probability of surviving extirpation due to stochastic events and small population size (USFWS 2014).

Stream Length Scoring:

- < 2.8 km: 0 points
- 2.8–9.65 km: 1 point
- ≥ 9.65 km: 2 points

Lake Surface Area

Larger lakes provide more habitat to hold higher numbers of fish and provide a greater variety of habitat for healthier populations and life history stages. They can also moderate and provide a range of water temperatures so fish can choose their preferred temperature. Five hundred fish is considered the minimum effective population size for cutthroat trout while populations containing greater than 2,500 are considered ideal for long-term persistence. Based on cutthroat trout population estimates in RMNP, a lake, on average, needs a minimum surface area of 1.3 hectares to support 500 fish and a surface area greater than nine hectares to support 2,500 fish.

Lake Surface Area Scoring:

- < 1.3 hectare: 0 points
- 1.3–9 hectares: 1 point
- > 9 hectares: 2 points

Watershed Area

Larger watersheds are expected to encompass low-elevation habitat that provides warmer summer temperatures and to have relatively wide stream channels of sufficient length to provide an adequate

number of deep pools (residual depth ≥ 30 cm). Harig and Fausch (2002) used a watershed area of 14.7 km^2 as coarse filter to determine an area that has a high probability of having high numbers of fish.

Watershed Scoring:

- $<14.7 \text{ km}^2$: 1 point
- $\geq 14.7 \text{ km}^2$: 2 points

Current Water Temperature

Water temperature affects most life processes of cutthroat trout, but in headwater streams its effect on reproduction and recruitment is one of the most important. Timing of spawning, egg incubation, and the abundance of prey after trout fry emerge are all temperature-dependent and temperatures must be warm enough for long enough on a regular basis to ensure recruitment and long-term persistence of populations.

Studies confirm the importance of warmer water temperatures for the persistence of cutthroat trout populations and set measurable metrics which can be compared to what is observed. Roberts et al. (2013) developed a metric called M30AT which is a measure of how well a stream can support cutthroat trout growth and recruitment. The M30AT is the mean of the average daily water temperature for the warmest 30 consecutive days in a year. An annual M30AT below 8°C indicates that there will not be recruitment, between 8 and 9°C there will be limited recruitment, and between 9.1 and 18°C is optimal for growth and recruitment of cutthroat trout.

Researchers at the U. S. Forest Service (USFS) Rocky Mountain Research Station Air, Water and Aquatic Environments Program in Boise, Idaho have developed spatial statistical models to predict historical and future stream temperatures (Isaak et al. 2016). This NorWeST Stream Temperature Project models mean August stream temperatures in one kilometer intervals. If historical data were available it was used to determine the current M30AT, if not the modeled NorWeST data was used. The following linear regression formula developed by Dr. James Roberts (Roberts, 2020, personal communication) was then used to convert NorWeST mean August temperatures to M30AT:

$$\text{M30AT} = 1.1054(\text{NorWeST Mean August Temperature}) - 0.7923$$

If multiple data points were available, they were averaged over the length of the stream that was evaluated.

Current M30AT Water Temperature Scoring:

- <8 no recruitment: 0 points
- $8-9$ low recruitment: 2 points
- $9.1-18$ optimal: 4 points
- $18.1-19.9$ declining growth: 2 points
- ≥ 20 low or no growth: 1 point

Future Water Temperature

To predict future suitability of RMNP waters for cutthroat trout growth and recruitment, modeled mean August temperatures from NorWeST were used at the 2080 time horizon (average of predicted temperatures between the years 2070 and 2099). NorWeST uses the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios A1B scenario in their models. This scenario describes a future world of very rapid economic growth, global population that peaks at mid-century and declines thereafter, the rapid introduction of new and more efficient technologies and a balance between fossil and non-fossil energy sources. Temperatures were averaged over the length of the stream that was evaluated. To utilize the Roberts et al. (2013) table for cutthroat trout growth and recruitment NorWeST data were converted to M30AT using the same linear regression conversion formula shown in the Current Water Temperature section.

Future M30AT Water Temperature Scoring:

- <8 no recruitment: 0 points
- 8–9 low recruitment: 2 points
- 9.1–18 optimal: 4 points
- 18.1–19.9 declining growth: 2 points
- ≥ 20 low or no growth: 1 point

Number of Fish Present

A minimum of 500 fish has long been held as a criterion for restoration to withstand the effects of low genetic diversity. More recently, an effective population size (number of fish breeding annually) has been suggested (Rieman and Allendorf 2001). With only 20% of the fish in cutthroat populations breeding annually, a population of 2,500 individuals are needed to prevent inbreeding and contain enough diversity for adaptation to changing environmental conditions and to survive stochastic events. Recently the Species Status Assessment for the Rio Grande Cutthroat Trout (USFWS 2014) provided guidance for evaluating the effective population size from poor to best; after being converted from effective population size to actual population size these numbers were followed.

Density estimates exist for almost all cutthroat trout populations within RMNP. These data, in conjunction with the length of the stream being evaluated, were used to estimate the number of fish in each reach. Many streams containing brook trout also have density data, however they have different life history strategies than cutthroat trout, and those estimates cannot be directly converted to estimate the number of cutthroat trout that would reside in that same section of stream following a restoration. Benjamin and Baxter (2012) found that brook trout had densities 1.5 times greater than cutthroat trout in allopatry based on a large data set from within the native range of inland cutthroat trout. This value was used to estimate the number of cutthroat trout that would reside in a stretch of stream which currently contains brook trout. If density data were not available for a stream reach or lake it was compared by stream size (judged by watershed area) or lake size of waters, with density data and assigned to the most appropriate score.

Potential Number of Cutthroat Trout Present Scoring:

- <250 fish: 1 point
- 250–1199 fish: 2 points
- 1200–2500 fish: 3 points
- >2500 fish: 4 points

Access

Populations which are further away from roads and established trails have far fewer visitors. Fewer anglers visiting an area decreases angler caused damage (to gills and mouth parts) and mortality of fish, the likelihood of the introduction of disease and invasive nuisance species, and likelihood of re-introduction of non-native trout species through illegal stocking.

Access Scoring:

- Established trail/road access greater than one mile from site: 2 points
- Established trail/road access within one mile of site: 1 point
- Direct established trail/road access to site: 0 points

Additional Information (not included in scoring systems due to limited data availability)

Stream Width

Wider streams provide more habitat for cutthroat trout, which results in more successful populations (Harig and Fausch 2002). In the scoring systems, watershed area was used as a surrogate for this parameter since that data was more readily available than stream widths.

Lake Volume

Lake volume is a better indicator of the amount of available habitat than lake surface area; however, there is a limited amount of lake depth data available. Where the mean depth of lakes is known, the volume has been calculated.

Number of Deep Pools

Pools deep enough to provide habitat after winter ice formation are necessary for cutthroat trout to survive through the winter. Research has observed that the number of deep pools (residual depths ≥ 30 cm) located within a stream reach was correlated with the successful establishment of cutthroat populations (Harig and Fausch 2002).

Biomass

Higher biomass indicates that waters have better habitat and environmental conditions, and thus can support more fish (Stoneman and Jones 2000; Harvey et al. 2005). Biomass estimates exist for almost all cutthroat trout populations within RMNP, however these data are not available for many non-native fish populations other than cutthroat trout. Estimates from waters currently containing non-native and hybrid cutthroat trout can be used to predict the biomass of native cutthroat trout in the same body of water following a restoration project. However, waters currently containing non-native

trout, primarily brook trout, cannot use pre-restoration biomass estimates to predict post-restoration biomass due to different species life history strategies and the lack of a conversion formula..

Number of Projects Upstream

Restoration projects will be scored and ranked based on the ten parameters previously described irrespective of their geographic location. In many cases a project with a higher score will be located downstream of one or more lower scoring projects. Projects cannot proceed until non-native fish are removed from projects upstream of them and have been converted to native fish species. The number of projects which are located upstream of each project will be included in the additional information section.

Results

A total of 52 potential cutthroat trout restoration project sites were identified, 34 east of the Continental Divide (CD) within the historic range of the greenback cutthroat trout and 18 west of the CD within the historic range of the green lineage of cutthroat trout (Tables 1 and 2). Data were compiled and scored for each scoring system using the previously stated criteria with a maximum score of 16 points for Implementation and 24 points for Persistence. Since projects cannot proceed until waters located upstream are fishless or already contain native cutthroat trout, rankings for projects/sub-drainages were grouped based on the number of projects/sub-drainages located upstream. Scoring for each individual restoration project and sub-drainage along with maps of each can be found in Appendix A.

If the strategy for cutthroat trout restoration is to establish populations within the best possible locations, then restoration should proceed on a project-by-project basis. For sites on the east side of the CD, at the headwaters of drainages, and without another restoration project upstream, Sky Pond, Lake Haiyaha and Black Lake scored the highest on the Implementation Scoring System (Table 1). Mirror Lake scored the highest on the Persistence Scoring System, followed by Ouzel Lake, Upper Hutcheson Lake, and Arrowhead Lake on the east side of the CD. West of the CD, Lake Nanita and Ten Lake Park scored the highest on the Implementation Scoring System and there was a four way tie between Lake Nanita, Pettingell Lake, Onahu Creek and Bench Lake for the highest score on the Persistence Scoring System (Table 2).

Table 1. Implementation and persistence scoring for individual restoration projects east of the Continental Divide within the historic range of the greenback cutthroat trout.

	Project Name	Sub-drainage	Drainage	Implementation	Persistence	# of Projects
				Score	Score	Upstream
12	Sky Pond	Icy Brook	Glacier	15	17	0
	Lake Haiyaha	none	Glacier	15	17	0
	Black Lake	Upper Glacier Creek	Glacier	15	14	0
	Dream Lake	none	Glacier	14	16	0
	Ypsilon Lake	Roaring River	Fall	14	16	0
	Bear Lake	none	Glacier	14	15	0
	Hunters Creek	none	North St. Vrain	14	15	0
	Upper Ouzel Creek*	Upper N. St. Vrain Creek	North St. Vrain	14	15	0
	Upper Hutcheson Lake	Cony Creek	North St. Vrain	13	19	0
	Box Lake	Upper N. St. Vrain Creek	North St. Vrain	13	18	0
	Thunder Lake	Upper N. St. Vrain Creek	North St. Vrain	13	17	0
	Odessa Lake	Fern Creek	Big Thompson	13	16	0
	Loomis Lake	Spruce Creek	Big Thompson	13	16	0
	Mirror Lake	none	Cache la Poudre	12	20	0
	Ouzel Lake	Upper N. St. Vrain Creek	North St. Vrain	12	19	0
	Sandbeach Lake	Upper N. St. Vrain Creek	North St. Vrain	12	18	0
	Lake Husted	Upper NF Big Thompson River	NF Big Thompson	12	17	0

* The Upper Ouzel Creek restoration project is a one kilometer section of stream located at the upstream extent of the Ouzel Lake restoration project. Since chemical reclamation is not currently approved in RMNP outside of the Cache la Poudre drainage it has been decided to conduct a restoration on this section of stream using mechanical removal (electrofishing) commencing in 2020. See the Mechanical Removal of Trout and Recommendations sections of this report for further information.

Table 1 (continued). Implementation and persistence scoring for individual restoration projects east of the Continental Divide within the historic range of the greenback cutthroat trout.

Project Name	Sub-drainage	Drainage	Implementation Score	Persistence Score	# of Projects Upstream
Lake Louise	Upper NF Big Thompson River	NF Big Thompson	12	17	0
Crystal Lake	Roaring River	Fall	12	16	0
West Creek	none	NF Big Thompson	12	16	0
Arrowhead Lake	Upper Big Thompson River	Big Thompson	11	19	0
Hidden Valley Creek	none	Fall	11	15	0
Mills Lake	Upper Glacier Creek	Glacier	15	15	1
Spruce Lake	Spruce Creek	Big Thompson	14	17	1
Fern Lake	Fern Creek	Big Thompson	13	18	1
Glass Lake	Icy Brook	Glacier	13	10	1
Middle-Hutcheson Lake	Cony Creek	North St. Vrain	12	17	1
Lawn Lake	Roaring River	Fall	12	17	1
Upper Big Thompson River	Upper Big Thompson River	Big Thompson	8	23	1
Lost Lake	Upper NF Big Thompson River	NF Big Thompson	12	19	2
Lower Hutcheson Lake	Cony Creek	North St. Vrain	12	17	2
Lower Roaring River	Roaring River	Fall	13	19	3
Pear Lake	Cony Creek	North St. Vrain	11	19	3
The Loch	Icy Brook	Glacier	12	19	4
Upper North St. Vrain Creek	Upper N St. Vrain Creek	North St. Vrain	10	18	8

* The Upper Ouzel Creek restoration project is a one kilometer section of stream located at the upstream extent of the Ouzel Lake restoration project. Since chemical reclamation is not currently approved in RMNP outside of the Cache la Poudre drainage it has been decided to conduct a restoration on this section of stream using mechanical removal (electrofishing) commencing in 2020. See the Mechanical Removal of Trout and Recommendations sections of this report for further information.

Table 2. Implementation and persistence scoring for individual restoration projects west of the Continental Divide within the historic range of the green lineage of cutthroat trout.

Project Name	Sub-drainage	Drainage	Implementation Score	Persistence Score	# of Projects Upstream
Lake Nanita	Upper North Inlet	North Inlet	13	19	0
Ten Lake Park	Paradise Creek	East Inlet	13	11	0
Bench Lake	Middle North Inlet	North Inlet	12	19	0
Onahu Creek	none	Upper Colorado	12	19	0
Haynach Lakes	none	Tonahutu	12	18	0
Pettingell Lake	Middle North Inlet	North Inlet	11	19	0
Timber Lake	Upper Colorado River	Upper Colorado	11	18	0
Adams Lake	Paradise Creek	East Inlet	11	17	0
Fifth Lake	Upper East Inlet	East Inlet	11	17	0
Columbine Creek	None	Lower Colorado	11	17	0
Upper East Inlet	Upper East Inlet	East Inlet	11	21	1
Upper North Inlet	Upper North Inlet	North Inlet	11	20	1
Upper Colorado River	Upper Colorado River	Upper Colorado	9	18	1
Upper Paradise Creek	Paradise Creek	East Inlet	11	21	2
Lower Paradise Creek	Paradise Creek	East Inlet	11	19	3
Middle North Inlet	Middle North Inlet	North Inlet	13	19	4
Lone Pine Lake	Lower East Inlet	East Inlet	13	17	6
Lower East Inlet	Lower East Inlet	East Inlet	14	19	7

If the strategy for cutthroat trout restoration is to create meta-populations consisting of several restoration projects, then restoration should proceed on a sub-drainage by sub-drainage basis. This will provide a greater variety of habitat and hold larger numbers of fish, which would be better for long-term persistence and survival from stochastic events. Nine sub-drainages were identified east of the CD and six were identified west of the CD (Tables 3 and 4). Data were compiled for each sub-drainage based on the data from each project within that sub-drainage. For the stream length, lake surface area and number of fish present parameters the data from each project was added together; for the water temperature parameters the data from each project was averaged; for the barrier and watershed parameters data from the most downstream location of the sub-drainage was used and for the fish species present, disease and access parameters the value from the lowest scoring project was used. For sub-drainages without a sub-drainage upstream of them, Upper Glacier Creek has the highest Implementation Score and Upper Big Thompson River followed, by the Roaring River had the highest Persistence Scores east of the CD (Table 3). West of the CD the Upper North Inlet and Upper East Inlet had the highest Implementation Scores and Paradise Creek followed by Upper East Inlet and Upper North Inlet had the highest Persistence Scores (Table 4).

If the strategy for cutthroat trout restoration is to create the largest meta-populations possible within RMNP then restoration should proceed on a drainage-by-drainage basis. Eleven major drainages were defined within RMNP, six east of the CD and five west of the CD (Tables 5 and 6). Data for each drainage were compiled based on the data from each restoration project located within that drainage using the same methods that were used for sub-drainages. The Cache la Poudre River (one restoration project included in this report with four planned restoration projects as part of the Long Draw Reservoir Special Use Authorization ROD) followed by Glacier Creek (eight restoration projects) had the highest Implementation Scores and the Big Thompson River (six restoration projects) followed by the North Fork Big Thompson River (four restoration projects) and Fall River (five restoration projects) had the highest Persistence Scores east of the CD (Table 5). West of the CD, Tonahutu Creek (one restoration project) had the highest Implementation Score, and the East Inlet had the highest Persistence Score (Table 6).

Table 3. Implementation and persistence scoring for individual sub-drainages east of the Continental Divide within the historic range of the greenback cutthroat trout.

Sub-drainage Name	Drainage	Implementation Score	Persistence Score	# of Restoration Projects	# of Sub-drainages Upstream
Upper Glacier Creek	Glacier	14	17	2	0
Spruce Creek	Big Thompson	13	17	2	0
Fern Creek	Big Thompson	12	19	2	0
Upper NF Big Thompson	NF Big Thompson	11	21	3	0
Cony Creek	North St. Vrain	10	21	4	0
Roaring River	Fall	9	22	4	0
Upper Big Thompson River	Big Thompson	7	24	2	0
Icy Brook	Glacier	9	21	3	1
Upper N. St. Vrain Creek	North St. Vrain	7	20	5	1

Table 4. Implementation and persistence scoring for individual sub-drainages west of the Continental Divide within the historic range of the green lineage of cutthroat trout.

Sub-drainage Name	Drainage	Implementation Score	Persistence Score	# of Restoration Projects	# of Sub-drainages Upstream
Upper North Inlet	North Inlet	10	21	2	0
Upper East Inlet	East Inlet	10	21	2	0
Paradise Creek	East Inlet	8	23	4	0
Upper Colorado River	Upper Colorado	6	19	2	0
Middle North Inlet	North Inlet	9	22	5	1
Lower East Inlet	East Inlet	12	20	8	2

Table 5. Implementation and persistence scoring for individual drainages east of the Continental Divide within the historic range of the greenback cutthroat trout.

Drainage	Implementation Score	Persistence Score	# of Restoration Projects
Cache la Poudre River	12	20	1
Glacier Creek	11	21	8
North Fork Big Thompson River	9	22	4
Fall River	8	22	5
Big Thompson River	7	24	6
North St. Vrain Creek	5	20	10

Table 6. Implementation and persistence scoring for individual drainages west of the Continental Divide within the historic range of the green lineage of cutthroat trout.

Drainage	Implementation Score	Persistence Score	# of Restoration Projects
Tonahutu Creek	12	18	1
Lower Colorado River	9	17	1
East Inlet	7	24	8
North Inlet	7	22	5
Upper Colorado River	6	19	3

Data Gaps

Although an abundance of data have been collected over the years, this exercise shows that more data are needed to successfully predict long-term persistence of cutthroat populations in RMNP. Four parameters were included in this report, but not scored, because there were insufficient data available to effectively score them. Data collection for these parameters; stream width, lake volume, number of deep pools and fish biomass, would more accurately quantify the amount and quality of available habitat and expected persistence of fish populations.

For parameters that were scored, the presence of disease was the parameter most in need of additional information. Several waters have not been tested; however, we anticipate that few wilderness waters would test positive for disease. Additionally, since disease can enter a system at any time, it is prudent to test for disease when a restoration project is closer to implementation (3–5 years out). Another parameter where the quality of data could be improved is the number of fish present for each project. The focus of the RMNP fisheries program is native fish and there are abundant survey data for these populations, however for some non-native fish populations survey

data do not exist or are sparse, especially for lakes. More detailed survey data would provide better estimates of how many fish a water can support.

Cache la Poudre Drainage

In the previous restoration project and sub-drainage tables little information was included regarding waters in the Cache la Poudre drainage. Actions in this drainage were determined through the Long Draw Reservoir Special Use Authorization planning process. In that plan five restoration projects were identified, including:

1. La Poudre Pass Creek above the reservoir, Neota Creek (USFS) and Long Draw Reservoir (USFS);
2. Hague Creek, Mummy Pass Creek, Hazeline Lake and Hazeline Creek;
3. Poudre Lake, Cache la Poudre River and Chapin Creek;
4. La Poudre Pass Creek below the reservoir, Willow Creek and Cache la Poudre (NPS and USFS); and
5. Mirror Lake and Cascade Creek.

The first four projects will be completed as mitigation for impacts associated with the operation of the expanded Long Draw Reservoir. The fifth project was included in the Long Draw planning process because it was planned in the same general area as the mitigation and including it provided a complete picture of the actions planned throughout the drainage. It is also specifically listed in this prioritization document because RMNP can choose whether or not to complete the project and decide how to prioritize it compared with other potential restoration projects throughout the park. Refer to the Long Draw Reservoir Special Use Authorization Final Environmental Impact Statement (USFS 2009) and Record of Decision (NPS 2010) regarding the details of these restoration projects.

Mechanical Removal of Trout

This report only considers waters which currently contain fish for restoration to native cutthroat trout. In order to convert waters to cutthroat trout the fish currently present must be removed through the use of piscicides (rotenone or antimycin) or by mechanical means (electrofishing or nets). The majority of successful fish removal projects within Colorado have used piscicides. Mechanical means have also been tried in other areas of the country, including several National Parks. In order to determine whether or not mechanical removal is a viable option for RMNP restorations, a literature search was undertaken to compile what is known about the success of and cost of these methods.

Meronek et al. (1996) conducted a review of all types of fish control projects and suggests that only 33–57% of mechanical removal projects were successful, depending on the method used. For this report literature on mechanical removal projects which specifically targeted trout in both lotic and lentic habitats and were upstream of fish migration barriers were considered. The summary of this literature can be found in Tables 7 and 8.

Table 7. Summary of trout eradication projects from streams using electrofishing.

Name of Stream	Location	Length (km)	Width (m)	Duration (years)	Annual Passes	Fish Eradicated	Reference
Taywa Creek	Great Smoky Mountains National Park	1.2	2.5	5	3	yes	Moore et al. 1986
Silers Creek	Great Smoky Mountains National Park	1.2	3.0	6	3	yes	Moore et al. 1986
Mannis Branch	Great Smoky Mountains National Park	0.9	3.1	2	6–12	yes	Kulp and Moore 2000
Lost Bottom Creek	Great Smoky Mountains National Park	3.8	–	8	3	yes	Kulp and Moore 2000
South Fork Baker Creek	Great Basin National Park	1.0	–	3	2–6	yes	Baker et al. 2008
Sun Creek	Crater Lake National Park	3.4	<2.0	6	2–9	yes	Buktenica et al 2013
Cottonwood Creek	Montana	3.0	2.4	4	1–5	yes	Shepard et al. 2014
Muskrat Creek	Montana	2.4	2.6	7	2–10	yes	Shepard et al. 2014
Staubach Creek	Montana	2.5	1.6	5	1–12	yes	Shepard et al. 2014
Whites Creek	Montana	2.9	2.0	8	1–3	yes	Shepard et al. 2014
Clearwater River	Banff National Park	4.5	4.8	5	4–5	yes	Pacas and Taylor 2015
Leconte Creek	Great Smoky Mountains National Park	2.7	5.6	2	3–12	yes	Kulp,2018,GRSM, pers. comm.
Anthony Creek	Great Smoky Mountains National Park	3.2	6.1	2	2–13	yes	Kulp,2018,GRSM, pers. comm
Ash Camp Creek	Great Smoky Mountains National Park	0.9	3.3	2	3	yes	Kulp,2018,GRSM, pers. comm
Winding Stair Branch	Great Smoky Mountains National Park	1.6	2.5	4	3–9	yes	Kulp,2018,GRSM, pers. comm

Table 7 (continued). Summary of trout eradication projects from streams using electrofishing.

Name of Stream	Location	Length (km)	Width (m)	Duration (years)	Annual Passes	Fish Eradicated	Reference
Beetree Creek	Great Smoky Mountains National Park	0.9	1.9	4	3	no	Moore et al. 1981
Mouse Creek	Great Smoky Mountains National Park	0.9	–	4	3	no	Moore et al. 1981
Sams Creek	Great Smoky Mountains National Park	1.2	5.0	4	3	no	Moore et al. 1981
Silers Creek	Great Smoky Mountains National Park	1.2	3.0	4	3	no	Moore et al. 1981
Taywa Creek	Great Smoky Mountains National Park	1.2	2.5	4	3	no	Moore et al. 1981
Nameless Creek	Wyoming	2.8	1.2	2	1–3	no	Thompson and Rahel 1996
Nylander Creek	Wyoming	1.3	1.6	2	1–4	no	Thompson and Rahel 1996
Irene Creek	Wyoming	3.6	1.6	2	1–5	no	Thompson and Rahel 1996
Pike's Fork	Idaho	4.5–7.8	2.8	3	1–4	no	Meyer et al. 2006
Bogard Spring Creek	California	2.8	1.2	3	3	no	Carmona-Catot et al. 2010
Coolridge Creek	Minnesota	1.6	3.1	3	2	no	Hoxmeier and Dieterman 2016

Table 8. Summary of trout eradication projects from lakes using gill netting. sl = shoreline length in meters, if = nets used only during ice free period, yr = nets used year round.

Name of Lake	Location	Surface Area (ha)	Max Depth (m)	Duration (years)	Number of Nets	Fish Eradicated	Reference
Maul Lake	California	1.6	6.0	3 if	3–6	yes	Knapp and Matthews 1998
Maul Lake	California	1.6	6.0	4 yr	3–6	yes	Knapp and Matthews 1998
Bighorn Lake	Banff National Park	2.1	9.2	5 yr	5–22	yes	Parker <i>et al.</i> 2001
Lakes 1–3	California	–	–	3 if	35	yes	Vredenburg 2004
Middle and Lower Devon	Banff National Park	23.1, 9.7	25.5, 6	5	10–40	yes	Pacas and Taylor 2015
Marmot Lake	California	3.1	7.8	4 yr	3–13	yes	Knapp <i>et al.</i> 2007
Cony Lake	California	1.5	3.2	3 yr	3–13	yes	Knapp <i>et al.</i> 2007
No Good Lake	California	1.2	5.0	3 yr	3–13	yes	Knapp <i>et al.</i> 2007
KP-1	Sequoia Kings Canyon National Parks	1552 sl	–	6 yr	–	yes	Chellman and Boiano 2016
KP-2	Sequoia Kings Canyon National Parks	283 sl	–	6 yr	–	yes	Chellman and Boiano 2016
PB-1	Sequoia Kings Canyon National Parks	759 sl	–	6 yr	–	yes	Chellman and Boiano 2016
SL-1	Sequoia Kings Canyon National Parks	416 sl	–	5 yr	–	yes	Chellman and Boiano 2016
SL-1	Sequoia Kings Canyon National Parks	433 sl	–	5 yr	–	yes	Chellman and Boiano 2016
SL-3	Sequoia Kings Canyon National Parks	762 sl	–	6 yr	–	yes	Chellman and Boiano 2016

Table 8 (continued). Summary of trout eradication projects from lakes using gill netting. sl = shoreline length in meters, if = nets used only during ice free period, yr = nets used year round.

Name of Lake	Location	Surface Area (ha)	Max Depth (m)	Duration (years)	Number of Nets	Fish Eradicated	Reference
UB-1	Sequoia Kings Canyon National Parks	646 sl	–	7 yr	–	yes	Chellman and Boiano 2016
UB-3	Sequoia Kings Canyon National Parks	717 sl	–	5 yr	–	yes	Chellman and Boiano 2016
UL-2	Sequoia Kings Canyon National Parks	579 sl	–	9 yr	–	yes	Chellman and Boiano 2016
UL-3	Sequoia Kings Canyon National Parks	293 sl	–	9 yr	–	yes	Chellman and Boiano 2016
UL-4	Sequoia Kings Canyon National Parks	549 sl	–	11 yr	–	yes	Chellman and Boiano 2016
UP-1	Sequoia Kings Canyon National Parks	1226 sl	–	4 yr	–	yes	Chellman and Boiano 2016
UP-2	Sequoia Kings Canyon National Parks	995 sl	–	4 yr	–	yes	Chellman and Boiano 2016
Lakes 4–5	California	–	–	3 if	35	no	Vredenburg 2004
Upper Leconte Lake	California	1.5	5.7	5 yr	3–13	no	Knapp <i>et al.</i> 2007
Lower Leconte Lake	California	0.5	1.5	5 yr	3–13	no	Knapp <i>et al.</i> 2007
Black Giant Lake	California	1.6	11.0	5 yr	3–13	no	Knapp <i>et al.</i> 2007
AB-1	Sequoia Kings Canyon National Parks	1076 sl	–	4 yr	12–29	no	Chellman and Boiano 2016
AB-2/3	Sequoia Kings Canyon National Parks	430 sl	–	4 yr	3–7	no	Chellman and Boiano 2016

Table 8 (continued). Summary of trout eradication projects from lakes using gill netting. sl = shoreline length in meters, if = nets used only during ice free period, yr = nets used year round.

Name of Lake	Location	Surface Area (ha)	Max Depth (m)	Duration (years)	Number of Nets	Fish Eradicated	Reference
AB-4	Sequoia Kings Canyon National Parks	1691 sl	–	4 yr	21–51	no	Chellman and Boiano 2016
SL-4	Sequoia Kings Canyon National Parks	1221 sl	–	12 yr	14–29	no	Chellman and Boiano 2016
SI-5	Sequoia Kings Canyon National Parks	124 sl	–	11 yr	2–3	no	Chellman and Boiano 2016
SL-8	Sequoia Kings Canyon National Parks	1490 sl	–	7 yr	14–29	no	Chellman and Boiano 2016
SL-9	Sequoia Kings Canyon National Parks	713 sl	–	7 yr	8–15	no	Chellman and Boiano 2016
SL-10	Sequoia Kings Canyon National Parks	134 sl	–	6 yr	2	no	Chellman and Boiano 2016
SL-11	Sequoia Kings Canyon National Parks	388 sl	–	4 yr	7–16	no	Chellman and Boiano 2016
UB-2	Sequoia Kings Canyon National Parks	357 sl	–	11 yr	7–13	no	Chellman and Boiano 2016

Lotic Habitats

In lotic habitats eradication of non-native trout using mechanical methods was only successful in small headwater streams that possess fish migration barriers, are less than six meters wide, are less than 5 km long, and relatively free of habitat complexity (deep pools, vegetation, undercut banks, large woody debris, beaver ponds and boulders/cobble) which lower capture efficiencies of target fish. Intensive electrofishing over multiple years was the method used in all successful projects. Successful eradication projects have been conducted in streams up to 6.1 km long and have taken between two and eight years and between eight and 33 electrofishing passes to complete (Table 7).

Based on the literature it appears that the best method to eradicate trout from streams using mechanical methods is very intensive electrofishing the first year which would consist of 3–4 removal efforts with each effort consisting of three passes through the entire length of the stream inhabited with the target trout species. Two to three of these efforts should be conducted prior to spawning of fall spawning fish, such as brook trout, and the last effort should be conducted just before the onset of winter when age 0 fish are larger and easier to capture. The first year is designed to eliminate adult fish, and thus reproduction, in the stream. Additional removal efforts are needed in subsequent years until all the immature fish are eliminated. It is best to concentrate these efforts over a shorter period of time to ensure complete removal prior to fish maturing and reproducing. Using this method, fish biologists in Great Smoky Mountains National Park have eradicated rainbow trout from several streams up to 3.2 km in length in two years (M. Kulp, 2018, personal communication), while another project in which they only conducted three passes annually took eight years to eradicate fish (Kulp and Moore 2000).

Failures of electrofishing removal projects can be attributed to habitat complexity and not exerting enough effort, i.e. not continuing the project for enough years and/or not putting enough effort into eliminating reproduction at the onset of the project. If reproduction is not eliminated, age 0 fish, the smallest and most difficult to capture, will continue to enter the system which will prevent eradication or prolong the time necessary to eradicate the stream.

In RMNP there are four streams or stream segments, Hunters, Upper Ouzel, Hidden Valley and Columbine Creeks, that do not contain lakes, are large enough to hold at least 250 cutthroat trout and meet the criteria described in the literature necessary for successful mechanical removal of trout.

Lentic Habitats

Successful projects to eradicate fish from lakes using mechanical methods involved intensive year-round gill netting for multiple years, as well as the elimination of fish within inlet and outlet streams. Effective gill netting can only occur in lakes with low habitat complexity (little vegetation, deadfall, large boulders/cobble substrates, extensive shallow areas where gill nets would not fish effectively, obstructions such as cliffs which would not allow for netting of sections of the lake) with short sections of stream inlets and outlets without complex habitat. Fish have been eradicated using gill nets from relatively large (surface area 23.1 ha) and deep (25.5 m maximum) lakes (Pacas and Taylor 2015). Currently the largest lake in RMNP which contains fish is Arrowhead Lake (surface area 14.1 ha) and the deepest is Crystal Lake (38.1 m maximum). Successful projects have averaged 5.4 years (range 3–11 years) to complete and utilized up to 50 gill nets in a single lake (Table 8). The most

common reason cited for the failure of projects is the inability to remove fish from adjacent stream reaches.

Based on the literature the best mechanical method for eradicating fish from lakes is to saturate the lakes with gill nets year round. It is also essential to intensively electrofish adjacent streams concurrent with the gill netting and before spawning takes place. It is also a good idea to electrofish the shoreline of lakes which are rocky or possess emergent vegetation to capture small fish which may hide in these locations. Most lakes in RMNP are within the parameters of successful fish removal projects in other locations, therefore, we do not list them separately here but can consider mechanical removal in lakes on a case by case basis.

Effort/Cost

For both lotic and lentic systems mechanical eradication of trout requires a great deal of cost and effort. For lotic habitats where authors provided their effort, an average of 1,462 (range 124–6,715) personnel hours were expended for successful projects. By comparison, only 573 (range 107–2,170) personnel hours were expended on average on unsuccessful projects. Where authors gave cost estimates for their project between \$3,036 and \$61,200 was spent. One project in Banff National Park in Canada cost CAD 325,000, however this project included 4.5 km of stream and two lakes (32.8 ha total) with half of the project cost being spent on helicopters, due to the remoteness of the project area (Pacas and Taylor 2015).

Only one author provided enough information to determine the effort in terms of man hours needed for their project in lentic habitats (Knapp and Matthews 1998). During their three year project they set and pulled their nets 18 times. Assuming a minimum two person crew and a ten hour day it took 360 hours to complete the eradication in the 1.6 ha lake. This project cost \$5,600, with \$1,000 going to the purchase of gill nets and the rest going toward salary and travel. After this project the California Department of Fish and Game inadvertently stocked rainbow trout back into the lake and the authors undertook another project to eradicate them. The removal of the rainbow trout took approximately 300 hours to complete.

Sequoia and Kings Canyon National Parks (SEKI) in California is expending a great deal of effort to remove trout from high mountain lakes to restore the mountain yellow-legged frog. From 2001 to 2015 removal efforts have been conducted on 23 lakes in seven basins within the park (Chellman and Boiano 2016). The effort relied exclusively on mechanical methods: gill nets in lakes and electrofishing in inlet / outlet streams. As of 2015 fish had successfully been eradicated from 13 of the 23 lakes, with removal efforts continuing in the remaining ten. On average it took 6.4 years (range 4–11 years) per lake to conduct these eradications. Of the lakes where eradication efforts are ongoing, the effort at one of the lakes has been going on for 12 years and, at two additional lakes, the effort has been going on for 11 years. Fish catch rates in all three of these lakes have been at zero at the end of several field seasons, however due to insufficient barriers fish have recolonized the lakes from adjacent streams.

An example of the effort that is going into the SEKI program comes from the summer of 2015 when a two person seasonal crew was hired and assigned to work in Sixty Lake Basin, the largest of the

basins where SEKI is conducting fish eradication, to maintain the nets in six lakes and an associated pond. Early in the season the crew retrieved 45 nets (301,322 net hours) that had been deployed in the lakes over the previous winter and over the course of the rest on the summer maintained 96 nets (208,474 net hours) through 998 net pulls (retrieval of the net, removal of fish and resetting the net). The crew also conducted electrofishing eradication on eight streams reaches adjacent to the lakes.

Effort and Cost Comparison Between Mechanical Removal and Piscicides

Biologists at Great Smoky Mountains National Park have successfully removed non-native rainbow trout from sections of five small streams using electrofishing to restore native brook trout (Moore et al. 2005). In order to continue their restoration program, they needed to eradicate fish from larger, more complex streams using piscicides. In 2002 they treated Sams Creek, a stream where electrofishing removals were unsuccessful, with the piscicide antimycin. Moore et al. (2005) conducted a time and cost comparison for native fish restoration projects where single annual electrofishing removals, multiple annual electrofishing removals and the use of antimycin, were employed to remove rainbow trout (Table 9). The cost and effort expended per kilometer of stream was much lower for the project using antimycin than it was for the mechanical removals using electrofishing.

Table 9. Time and cost comparison of native fish restoration techniques used in Great Smoky Mountains National Park since 1986. Note that all dollar amounts are represented in 2003 dollars (Adapted from Moore et al. 2005).

Eradication Method	Years to Completion	Total km	Average Cost per km	Hours per km
Single Annual Removals	5–7	5.8	\$31,055	1,498
Multiple Annual Removals	2	6.0	\$12,415–\$15,089	1,400
Antimycin	2	4.8	\$3,930	400

Biologists at Great Basin National Park successfully removed non-native trout from three stream reaches using three different techniques, electrofishing, the piscicide rotenone and the piscicide antimycin (Baker et al. 2008). An effort/cost comparison of the three projects shows that the rotenone project took about one tenth of the time and three tenths of the cost per kilometer to complete than the electrofishing project (Table 10). The effort for the antimycin project was similar to the electrofishing removal, but over twice as expensive. Costs for the antimycin project were higher than expected due to higher than ideal pH and temperatures causing rapid loss of toxicity which resulted in the necessity of using three times the amount of piscicide than was expected. In addition, the antimycin project was conducted over six days, compared to the two day rotenone treatment, which increased salary costs.

Biologists at Crater Lake National Park successfully eliminated non-native brook trout from 3.4 km of Sun Creek using electrofishing to restore native bull trout (Buktenica et al. 2013). This effort took 184 person days (approximately 1,840 hours) to complete over six years. To ensure that all brook

trout were eliminated they conducted an antimycin treatment on the same section of stream the year following the end of the electrofishing removals. This effort took 59 person days (approximately 590 hours) to complete in one year.

Table 10. Comparison of fish removal treatment costs used in Great Basin National Park. (Adapted from Baker et al. 2008).

Treatment	Years to Completion	Length Treated (km)	Hours	Hours/km	Total Cost	Cost/km
Electrofishing	4	1.0	288	288	\$3,0036	\$3,035
Rotenone	1	11.9	320	27	\$10,950	\$920
Antimycin	1	3.4	864	254	\$21,430	\$6,303

Summary of Mechanical Removal of Trout

Mechanical means such as electrofishing and netting have been shown to be a feasible option for removal of trout, however the waters in which it is attempted must contain low habitat complexity in order for projects to be successful. The effort and cost to remove trout by mechanical means is greater than using rotenone and the likelihood of success is less certain. However, effort and cost are not the only determinants in deciding which method to use. Other considerations such as, whether native species are in sympatry with the unwanted species which may prohibit certain techniques detrimental to the native species, wilderness minimum tool considerations, accessibility of the project area, effect of piscicides on non-target organisms, public concerns with piscicide use, ability to maintain visitor use, and availability of resources to complete the project must also be considered.

Recommendations

The intent of this document is to provide decision makers with necessary information to make informed decisions on how to proceed with native cutthroat trout restoration within RMNP. The authors would like to make the following recommendations on how they view restoration should initially proceed.

Currently there is only one known recruiting population of greenback cutthroat trout, which is located outside of RMNP and there are dozens of populations of the green lineage of cutthroat trout within its historic range. Initially, the restoration of the greenback should be given priority within RMNP. Dispensing piscicides, such as rotenone and antimycin, to remove non-native trout species outside the Cache la Poudre drainage has not been approved programmatically within RMNP. It is anticipated that approval would require the development of a programmatic Environmental Assessment (EA). The top priority for RMNP fisheries management is to implement the Long Draw Reservoir Special Use Authorization ROD (NPS 2010) and Settlement Agreement. This will create a greenback cutthroat trout meta-population including 33 miles of RMNP streams. As additional time and funding allow it is recommended that native cutthroat trout recovery efforts in RMNP proceed in four phases based on additional approval of the use of piscicides and the status of the greenback cutthroat trout throughout its entire range. The Recovery Outline for the Greenback Cutthroat Trout (Greenback Cutthroat Trout Recovery Team 2019) advocates that recovery populations for this subspecies be well distributed geographically. Almost all proposed restoration projects in the following recommendations are within the Big Thompson and North St Vrain drainages where no greenback are present.

Phase 1 – Restoration of greenback cutthroat trout through mechanical removal of non-native trout east of the Continental Divide (CD)

Until additional use of piscicides is approved, the only option outside the Cache la Poudre drainage is to remove non-native fish for native cutthroat trout restoration by mechanical means. Removing fish from lakes would require nets to be set in place continuously for several years. The sight of the nets and moribund fish in them would lessen visitor's wilderness experience-it is recommended that this not be undertaken. This leaves electrofishing of streams as the only means to mechanically remove non-native fish. In lotic habitats the eradication of non-native trout was only successful in small headwater streams that possess a fish migration barrier, are less than six meters wide, are less than 5 km long, and relatively free of habitat complexity. In RMNP there are four streams or stream segments that do not contain lakes and are large enough to hold at least 250 cutthroat trout that meet these criteria. Initial restoration should proceed in order at these streams until the additional use of piscicides is approved and at that time restoration should move to Phase 3.

Upper Ouzel Creek

This stream segment is a subset of the Ouzel Lake restoration project and is located upstream of a known fish migration barrier upstream of the lake. Its persistence score is 15 out of 24 with it losing points for stream length, surface area (no lakes present), watershed area, numbers of fish and access. It is approximately one kilometer long and has a small population of about 250 cutthroat trout.

Converting this stream segment to greenback would provide another population to secure the sub-species' long-term persistence. It is anticipated that this project will commence in 2020.

Hunters Creek

Hunters Creek's persistence score is 15 out of 24 with it losing points for stream length, surface area (no lakes present), watershed area, numbers of fish, current water temperature and access. While current water temperatures are less than ideal, it is predicted that future temperatures would be optimal for cutthroat trout in this creek. Survey data estimates that this creek can hold about 1,600 fish which is less than ideal for long-term persistence but it can still be a good population. Since it is located along a trail and is short in length it will be easier to complete. Currently a unique population of blue lineage cutthroat native to the Green River Drainage resides here. These fish may need to be relocated to their historic drainage which would complicate the project.

Hidden Valley Creek

Hidden Valley Creek's persistence score is 15 out of 24 with it losing points for barrier, stream length, surface area (no lakes present), watershed area, numbers of fish and access. Its short length and location along Trail Ridge Road will make completion easier. However, this project should be the last to be considered in Phase 1 due to two major shortcomings, the lack of a complete barrier and the presence of disease. A partial barrier exists where the creek crosses Fall River Road. It would take effort and money to plan, obtain compliance and modify the site to make it a complete barrier to fish passage. This creek has tested positive for BKD and salmonid whirling disease (WD). Once the barrier is complete and all fish are removed it will need to remain fishless for several years until the pathogens for these two diseases are no longer present. It is not recommended that this project be undertaken unless the previous two projects in this phase have been completed. If completed this creek would hold about 1,500 greenback cutthroat trout.

Phase 2 – Restoration of green lineage cutthroat trout through mechanical removal of non-native trout west of the Continental Divide (CD)

If all projects in Phase 1 are complete and piscicide use has not been approved for Phase 3 projects it is recommended that restoration of green lineage cutthroat trout through mechanical removal of non-native trout on the west side of the park commence.

Columbine Creek

Columbine Creek's persistence score is 17 out of 24 with it losing points for stream length, surface area (no lakes present), watershed area and numbers of fish. Currently the stream holds a cutthroat trout population of about 500 fish within a 1.25 km meadow upstream of a fish migration barrier. This project would be harder to complete than the others due to its inaccessibility.

Phase 3 – Restoration of greenback cutthroat trout on a project basis using piscicides east of the Continental Divide (CD)

When use of piscicides is approved the focus should move to conducting chemical treatments on projects with a low complexity of implementation. Initially conducting projects with high Implementation Scores where the likelihood for successfully eradicating non-native fish is highest would enable creation of greenback cutthroat trout populations in the shortest time and with the

lowest cost to secure the sub-species. It would also allow those who would be conducting the chemical treatments to gain experience on less complex projects. Initially, only projects at the headwaters of drainages where no projects are upstream should be considered for restoration. Once there are enough quality populations of greenback cutthroat trout throughout its historic range and the sub-species is considered secure, the focus of recovery within RMNP should shift to Phase 4. The first recommended project, Mirror Lake, has already been approved for the use of piscicides through the Long Draw Reservoir Special Use Authorization Final Environmental Impact Statement (USFS 2009) and Record of Decision (NPS 2010). The next three recommended projects on the list for this phase are the three highest ranked in terms of Implementation Score. The last two are recommended because they start to shift the focus from ease of implementation to long-term persistence (Phase 4). They have a relatively high Implementation Score and they also have a relatively high Persistence Score and are at the headwaters of sub-drainages with high Persistence Scores.

Mirror Lake

The Mirror Lake restoration project has the highest Persistence Score of any project east of the CD, with 20 out of 24 points. Its Implementation Score is relatively low, 12 out of 16 possible points, however it is at the top of the list for this phase because the use of piscicides has been approved for this project through the Long Draw Reservoir Special Use Authorization Final Environmental Impact Statement (USFS 2009) and Record of Decision (NPS 2010). This project loses points in Implementation Scoring for stream length, surface area, watershed area, and disease. It loses points in Persistence Scoring for stream length, surface area, and access. Once complete it is expected that this Mirror Lake and Cascade Creek would hold about 3,800 greenback cutthroat trout.

Sky Pond

Sky Pond is tied with two other projects, Black Lake and Lake Haiyaha, for highest Implementation Score, 15 out of 16 points, east of the CD and it is tied with Lake Haiyaha with a higher Persistence Score than Black Lake from this group of projects. Its persistence score is 17 out of 24 with it losing points for stream length, surface area, watershed area, numbers of fish and access. Once complete it is expected that this lake would hold about 1,500 greenback cutthroat trout. Sky Pond is at the headwaters of the Icy Brook sub-drainage which includes the Glass Lake and The Loch projects.

Lake Haiyaha

Lake Haiyaha's Persistence Score is 17 out of 24 points with it losing points for stream length, surface area, watershed area, numbers of fish and access. It is estimated that it will hold about 1,300 greenback cutthroat trout. One drawback to this project is that another restoration project cannot be completed downstream of it to create a meta-population due to the lack of a suitable barrier.

Black Lake

Black Lake's Persistence Score is 14 out of 24 points with it losing points for stream length, surface area, watershed area, current water temperatures, numbers of fish and access. While current water temperatures are less than ideal, it is predicted that future temperatures would be optimal for cutthroat trout in this lake. It is estimated that it will hold about 1,000 greenback cutthroat trout. Black Lake is at the headwaters of the Upper Glacier Creek sub-drainage which includes the Mills Lake project.

Upper Hutcheson Lake

Upper Hutcheson Lake's Implementation Score is slightly lower than the previous three projects, 13 out of 16 points, with the main difference being that it is over one mile from the closest trail and thus has a lower access score. Once complete Upper Hutcheson Lake would be considered an excellent greenback cutthroat trout population since it has the 2nd highest Persistence Score, 19 out of 24 points, of all projects at the headwaters of drainages and is part of the 3rd highest scoring sub-drainage (Cony Creek) in terms of Persistence. It loses points for stream length, surface area, watershed area and numbers of fish. It is estimated that it will hold about 1,700 greenback cutthroat trout. An additional benefit of this project is that it is geographically separated from the previous three in this Phase, which are in relatively close proximity. Projects in close proximity are more likely to be affected by a single stochastic event such as flood or wildfire.

Ypsilon Lake

Ypsilon Lake has the same Implementation Score as Upper Hutcheson Lake and a Persistence Score of 16 out of 24 points with it losing points for stream length, surface area, watershed area, numbers of fish and access. There are several projects with higher Persistence Scores; however, Ypsilon is at the headwaters of the Roaring River sub-drainage which has the 2nd highest Persistence Score. It is estimated that it will hold about 650 greenback cutthroat trout. It is also geographically separated from the other recommended projects in this phase.

Phase 4 – Restoration of greenback cutthroat trout on a sub-drainage basis using piscicides east of the Continental Divide (CD)

Once there are enough quality populations of greenback cutthroat trout throughout its native range, focus should shift from conducting restoration projects based in their low complexity of implementation to developing high quality meta-populations capable of long-term persistence. The groundwork for this shift was laid in the previous phase with conducting restoration projects at the headwaters of sub-drainages with the highest likelihood for long-term persistence of cutthroat trout. The Upper Big Thompson River sub-drainage has the highest Persistence Score in RMNP which is mostly based on the abundance of stream habitat (length and flow) it contains. While this amount of stream habitat is excellent for long-term persistence of cutthroat it would make it difficult to completely eradicate the fish in this sub-drainage and thus it is not part of these initial recommendations.

Roaring River

This sub-drainage contains the Ypsilon Lake, Crystal Lake, Lawn Lake and Lower Roaring River restoration projects. Its Persistence Score is 22 out of 24 points with it only losing points for access. This ranks it 2nd among RMNP sub-drainages. Once complete, it would provide an abundance of diversified habitat for greenback cutthroat trout in 12.8 km of stream and 21.4 hectares of lake. The main drawback for long-term persistence of this sub-drainage is its accessibility. There are maintained trails which go directly to all of the lakes and alongside most of the streams, and the lowest part of this sub-drainage is only a 1.5 mile hike from the trailhead in a popular section of the park. This access and popularity could increase angler-caused damage to fish, the likelihood of introduction of disease and invasive nuisance species, and likelihood of re-introduction of non-native trout species through illegal stocking.

Cony Creek

The Cony Creek sub-drainage contains the Upper Hutcheson Lake, Middle Hutcheson Lake, Lower Hutcheson Lake and Pear Lake restoration projects. Its Persistence Score is 21 out of 24 points with it losing points for stream length and access. This ranks it 3rd among RMNP sub-drainages. Once complete, it would provide an abundance of diversified habitat for greenback cutthroat trout in 9.1 km of stream and 12.4 hectares of lake. While the lower sections of this sub-drainage have access by the Pear Lake Trail there are no maintained trails to all three Hutcheson Lakes.

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Appendix A: Scoring of Individual Restoration Projects and Sub-drainages

Data were compiled and scored for each scoring system using the criteria described in the Methods section, with a maximum score of 16 points for Implementation and 24 points for Persistence. Scoring for each individual restoration project and sub-drainage, along with maps of each, can be found in Tables A-1 through A-184 and Figures A-1 through A-67.

Drainages East of the Continental Divide

Cache la Poudre River

Mirror Lake Restoration Project

Waters Included: Mirror Lake, Cascade Creek

Parameter Scoring

Table A-1. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	6.44	8.50	14.72	brook trout	BKD	yes	–
Score	4	1	1	1	2	1	2	12

Table A-2. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	6.44	8.50	14.72	11.40	11.65	>2500	yes	–
Score	4	1	1	2	4	4	4	0	20

Table A-3. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	2.1	1008	n/a	90.0	0

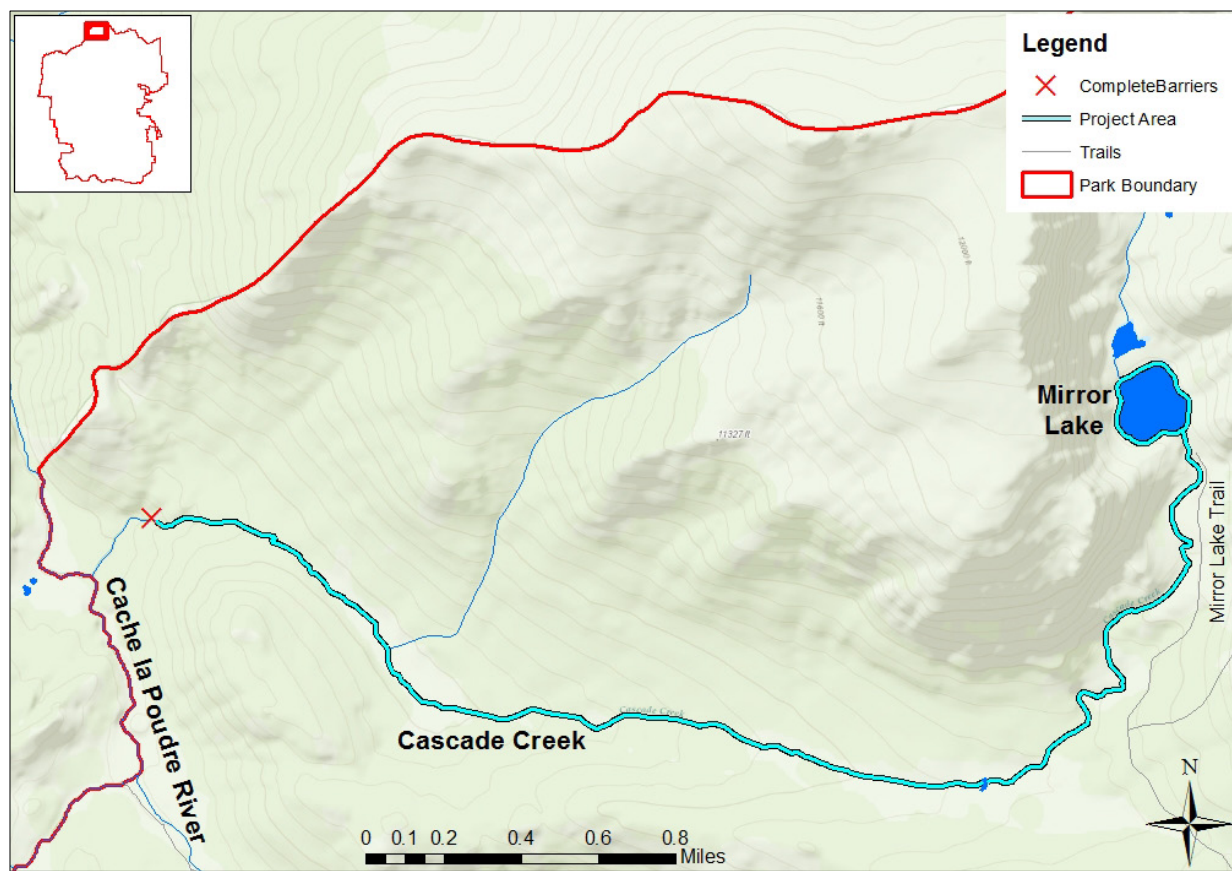


Figure A-1. Mirror Lake Restoration Project.

North Fork Big Thompson River

Lake Louise Restoration Project

Waters Included: Lake Louise, North Fork Big Thompson River

Parameter Scoring

Table A-4. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	1.28	2.59	8.12	green cutthroat	unknown	one mile	–
Score	4	2	1	2	1	1	1	12

Table A-5. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	1.28	2.59	8.12	10.79	11.05	250-1199	one mile	–
Score	4	0	1	1	4	4	2	1	17

Table A-6. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	18	101.0	0

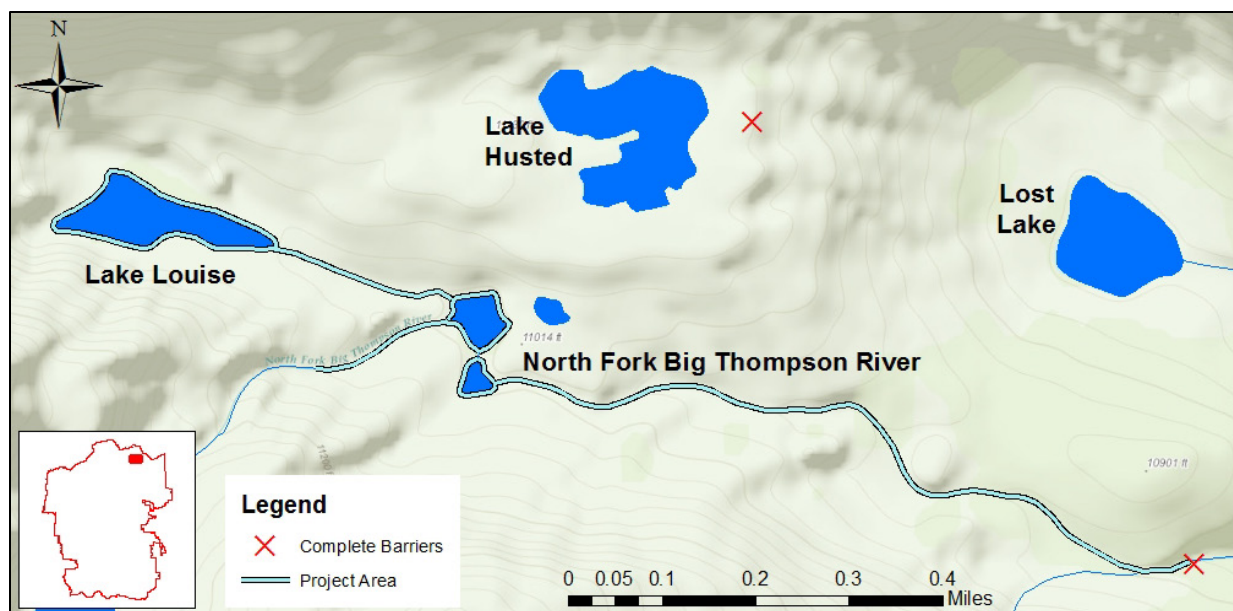


Figure A-2. Lake Louise Restoration Project.

Lake Husted Restoration Project

Waters Included: Lake Husted

Parameter Scoring

Table A-7. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.0	4.09	14.7	green cutthroat	unknown	one mile	–
Score	4	2	1	2	1	1	1	12

Table A-8. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.0	4.09	14.7	12.76	unknown	250–1199	one mile	–
Score	4	0	1	1	4	4	2	1	17

Table A-9. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	51	n/a	n/a	0

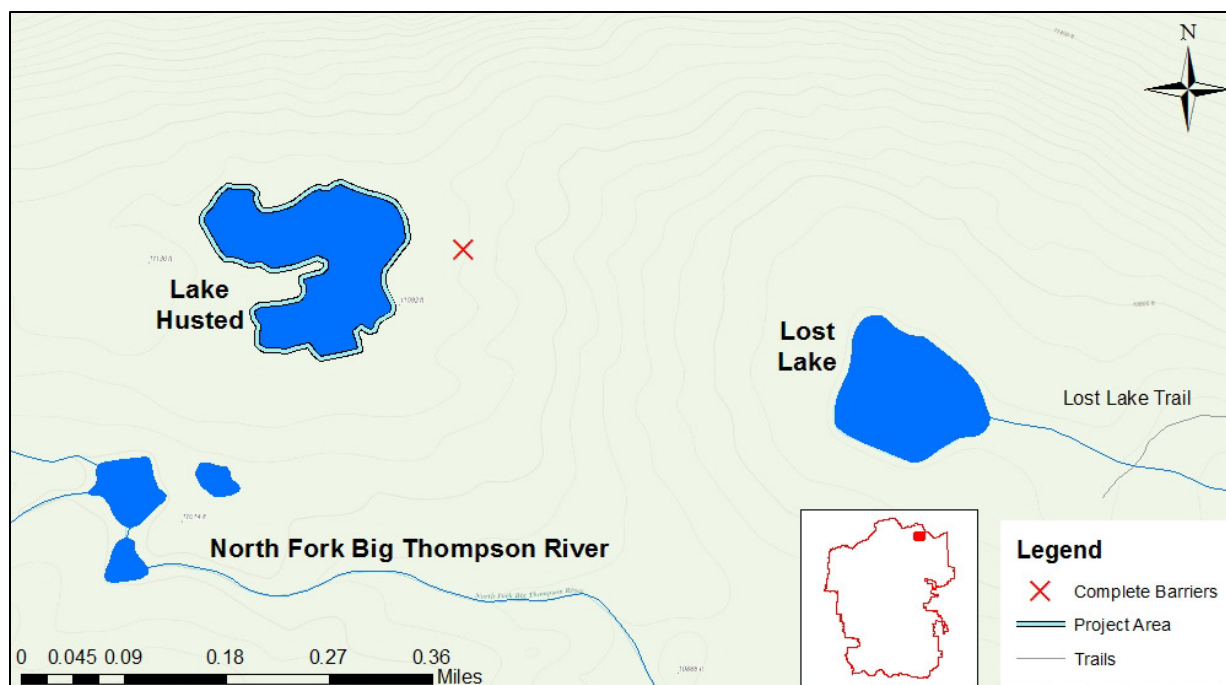


Figure A-3. Lake Husted Restoration Project.

Lost Lake Restoration Project

Waters Included: Lost Lake, North Fork Big Thompson River

Parameter Scoring

Table A-10. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	4.07	3.72	15.44	green cutthroat	none	yes	–
Score	4	1	1	1	1	2	2	12

Table A-11. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	4.07	3.72	15.44	11.90	10.77	1200–2500	yes	–
Score	4	1	1	2	4	4	3	0	19

Table A-12. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	2.7	n/a	n/a	62.0	2

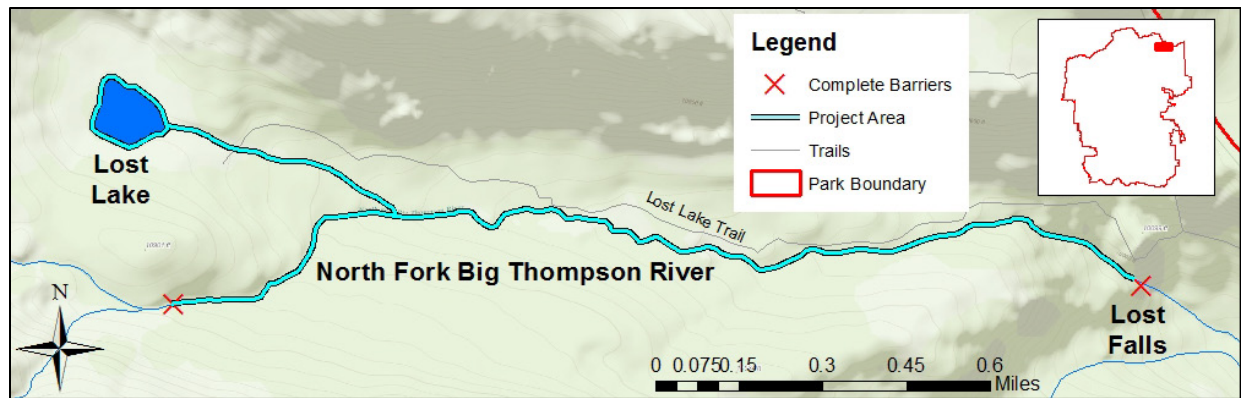


Figure A-4. Lost Lake Restoration Project.

West Creek Restoration Project

Waters Included: West Creek

Parameter Scoring

Table A-13. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	5.00	0.0	24.81	green cutthroat	none	one mile	–
Score	4	1	2	1	1	2	1	12

Table A-14. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	5.00	0.0	24.81	8.52	9.23	250–1199	one mile	–
Score	4	1	0	2	2	4	2	1	16

Table A-15. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	4.6	n/a	117	38	0

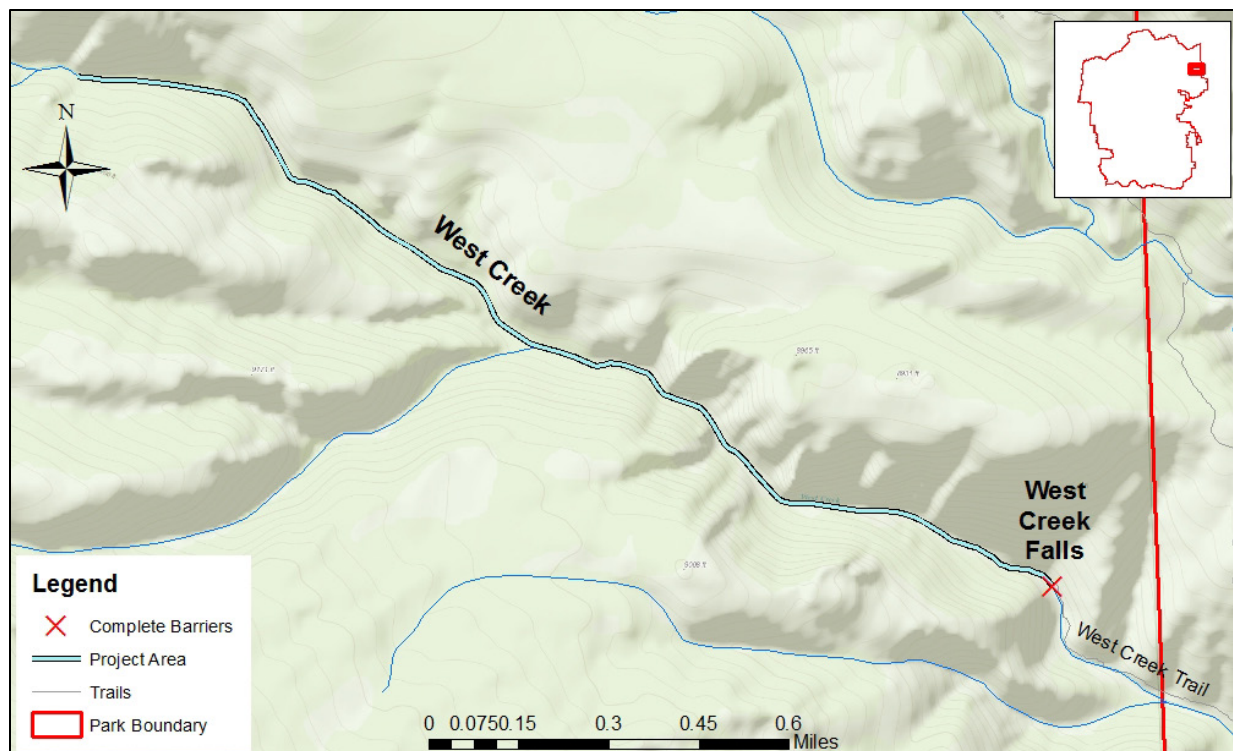


Figure A-5. West Creek Restoration Project.

Upper North Fork Big Thompson River Sub-drainage

Restoration Projects Included: Lake Louise, Lake Husted, Lost Lake

Parameter Scoring

Table A-16. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	5.35	10.40	15.44	green cutthroat	unknown	one mile	–
Score	4	1	0	2	1	1	2	11

Table A-17. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	5.35	10.40	15.44	11.82	10.91	>2500	yes	–
Score	4	1	2	2	4	4	4	0	21



Figure A-6. Upper North Fork Big Thompson River Sub-drainage.

Fall River

Crystal Lake Restoration Project

Waters Included: Crystal Lake, Roaring River

Parameter Scoring

Table A-18. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.44	10.04	1.04	green cutthroat	unknown	yes	–
Score	4	2	0	2	1	1	2	12

Table A-19. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.44	10.04	1.04	11.05	11.66	<250	yes	–
Score	4	0	2	1	4	4	1	0	16

Table A-20. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	2480	n/a	n/a	0

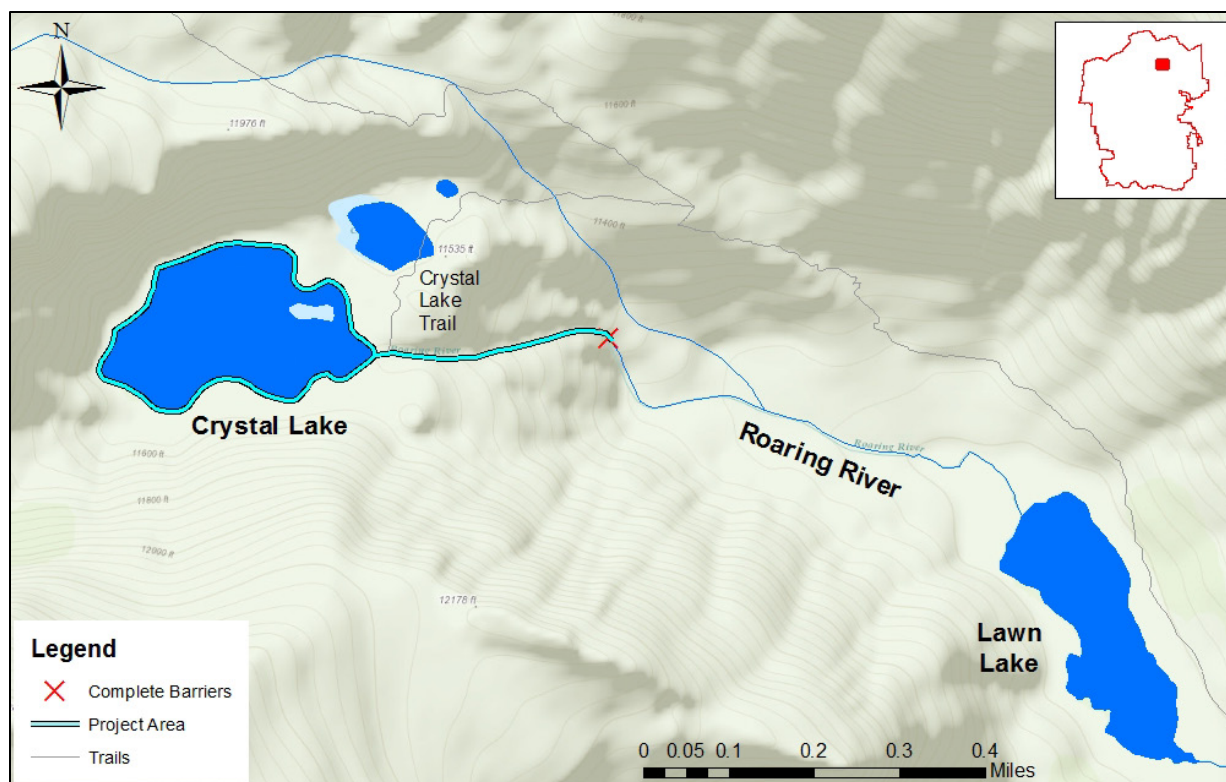


Figure A-7. Crystal Lake Restoration Project.

Lawn Lake Restoration Project

Waters Included: Lawn Lake, Roaring River

Parameter Scoring

Table 21. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	5.79	8.09	11.09	green cutthroat	unknown	yes	–
Score	4	1	1	2	1	1	2	12

Table 22. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	5.79	8.09	11.09	8.84	10.78	>2500	yes	–
Score	4	1	1	1	2	4	4	0	17

Table 23. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	4.6	n/a	21	72.0	1

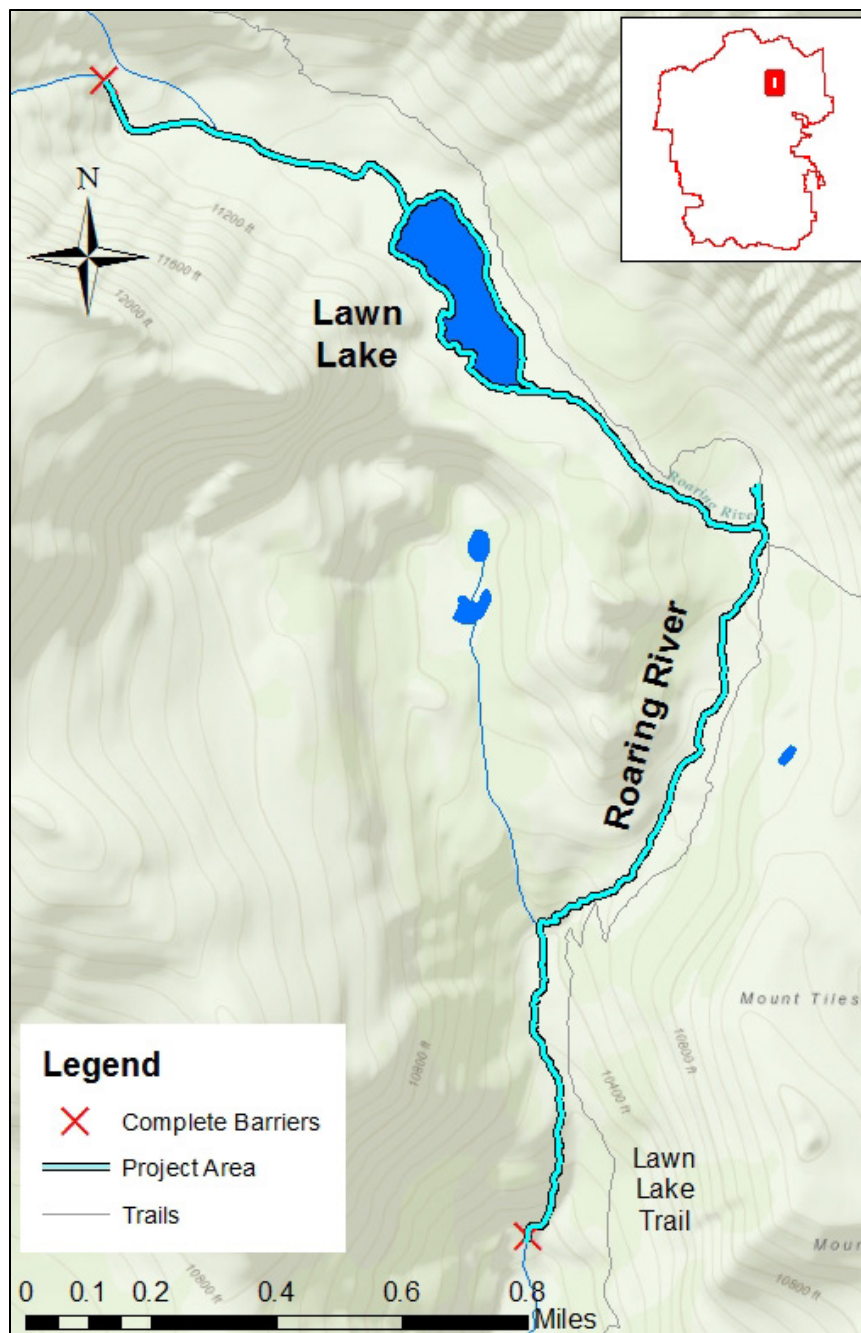


Figure A-8. Lawn Lake Restoration Project.

Ypsilon Lake Restoration Project

Waters Included: Ypsilon Lake, Ypsilon Creek

Parameter Scoring

Table A-24. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.11	2.99	3.38	blue cutthroat	none	yes	–
Score	4	2	1	2	1	2	2	14

Table A-25. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.11	2.99	3.38	12.02	12.23	250–1199	yes	–
Score	4	0	1	1	4	4	2	0	16

Table A-26. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	111	n/a	37.1	0

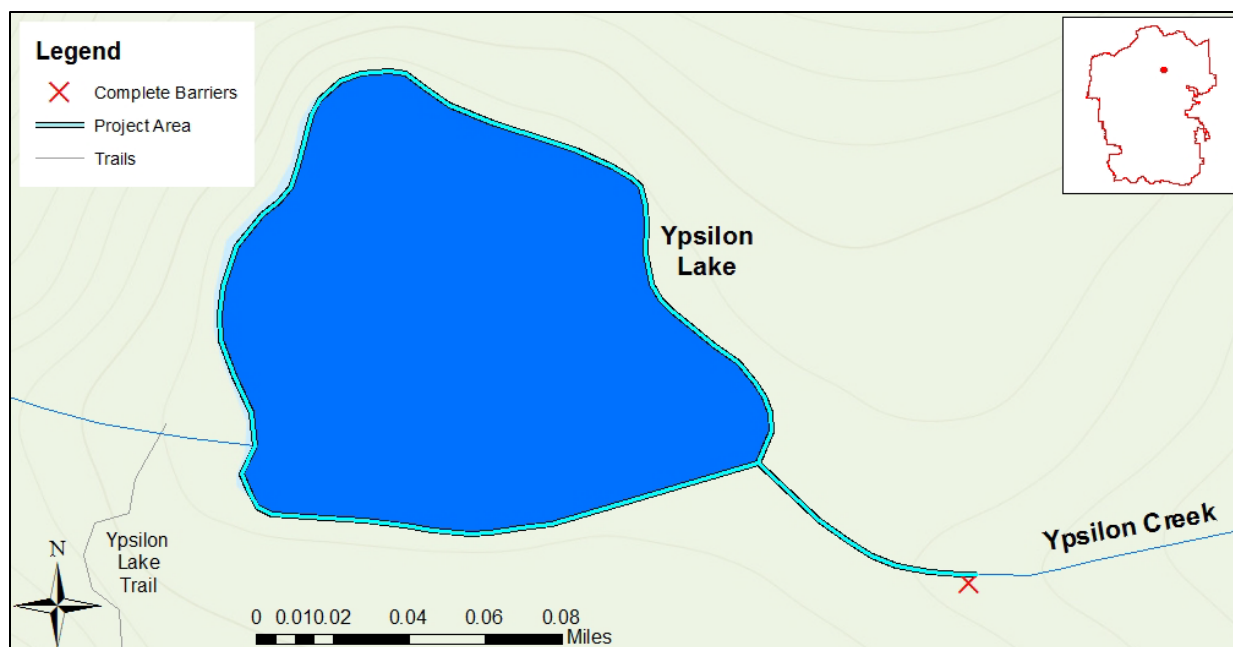


Figure A-9. Ypsilon Lake Restoration Project.

Lower Roaring River Restoration Project

Waters Included: Roaring River, Caddis Lake, Ypsilon Creek

Parameter Scoring

Table A-27. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	6.44	0.28	34.89	blue cutthroat	none	yes	–
Score	4	1	2	1	1	2	2	13

Table A-28. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	6.44	0.28	34.89	10.50	10.76	>2500	yes	–
Score	4	1	0	2	4	4	4	0	19

Table A-29. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg / ha)	# of Projects Upstream
Value	4.05	2.8	21	72.1	3

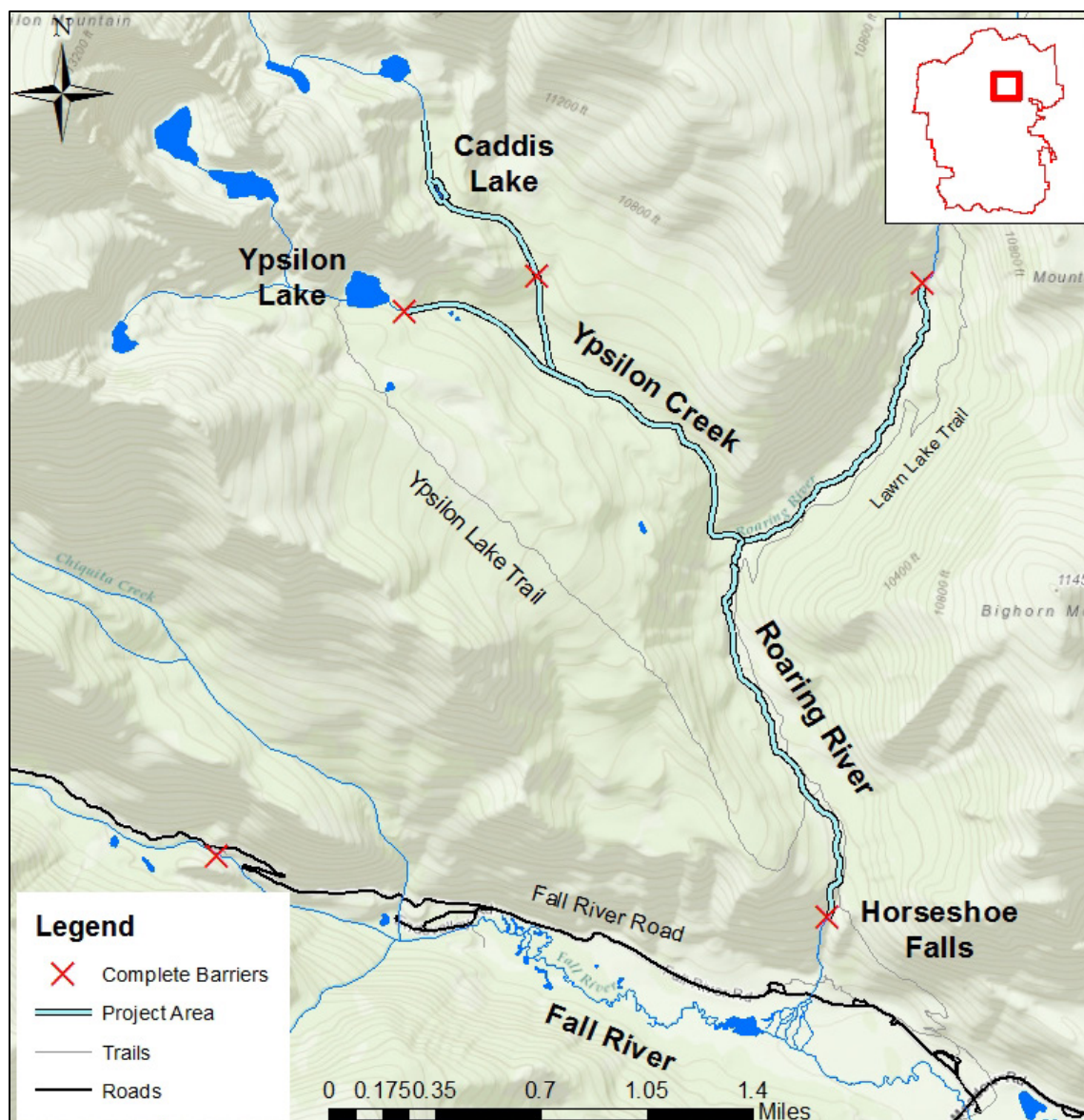


Figure A-10. Lower Roaring River Restoration Project.

Hidden Valley Creek Restoration Project
Waters Included: Hidden Valley Creek

Parameter Scoring

Table A-30. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	partial	2.90	0.0	10.15	brook trout	BKD & WD	yes	–
Score	2	1	2	2	2	0	2	11

Table A-31. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	partial	2.90	0.0	10.15	9.99	9.47	1200–2500	yes	–
Score	2	1	0	1	4	4	3	0	15

Table A-32. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	2.2	n/a	n/a	87.0	0

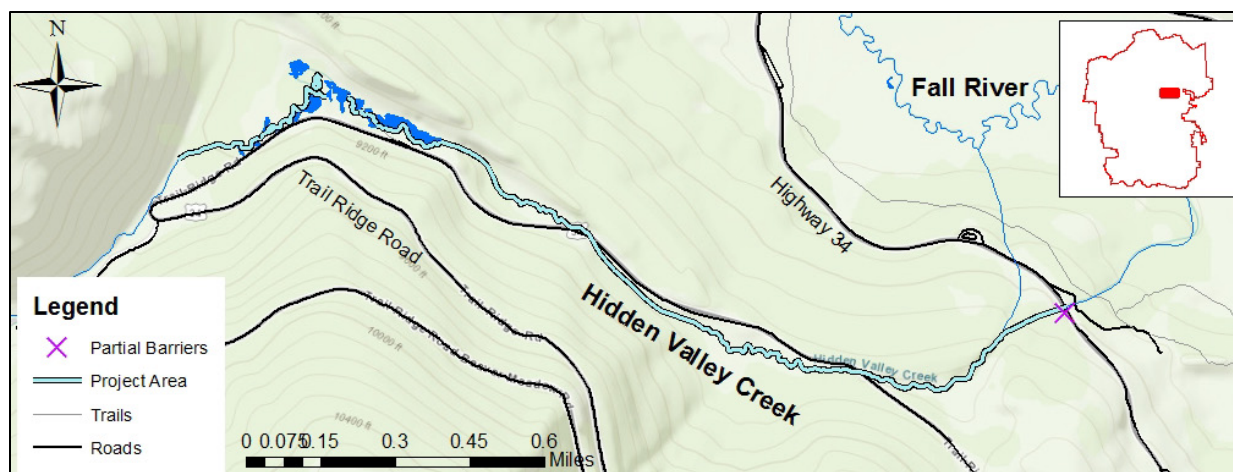


Figure A-11. Hidden Valley Creek Restoration Project.

Roaring River Sub-drainage

Restoration Projects Included: Crystal Lake, Lawn Lake, Ypsilon, Lower Roaring River

Parameter Scoring

Table A-33. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	12.78	21.40	34.89	blue/green cutthroat	unknown	yes	–
Score	4	0	0	1	1	1	2	9

Table A-34. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	12.78	21.40	34.89	10.60	11.36	>2500	yes	–
Score	4	2	2	2	4	4	4	0	22

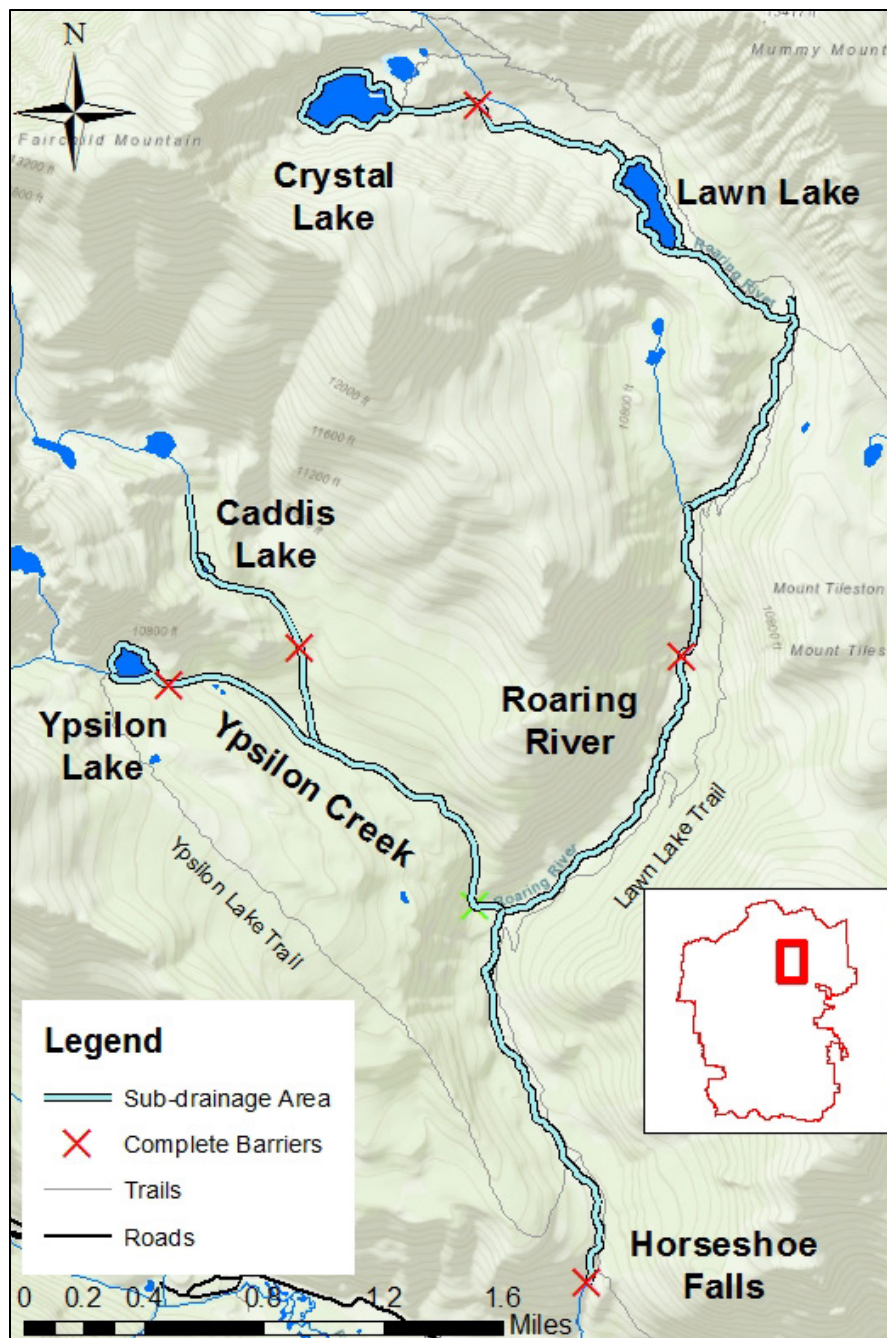


Figure A-12. Roaring River Sub-drainage.

Big Thompson River

Arrowhead Lake Restoration Project

Waters Included: Arrowhead Lake

Parameter Scoring

Table A-35. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.0	14.12	4.77	hybrid cutthroat	unknown	no	–
Score	4	2	0	2	2	1	0	11

Table A-36. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.0	14.12	4.77	9.42	10.21	250–1199	no	–
Score	4	0	2	1	4	4	2	2	19

Table A-37. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	0

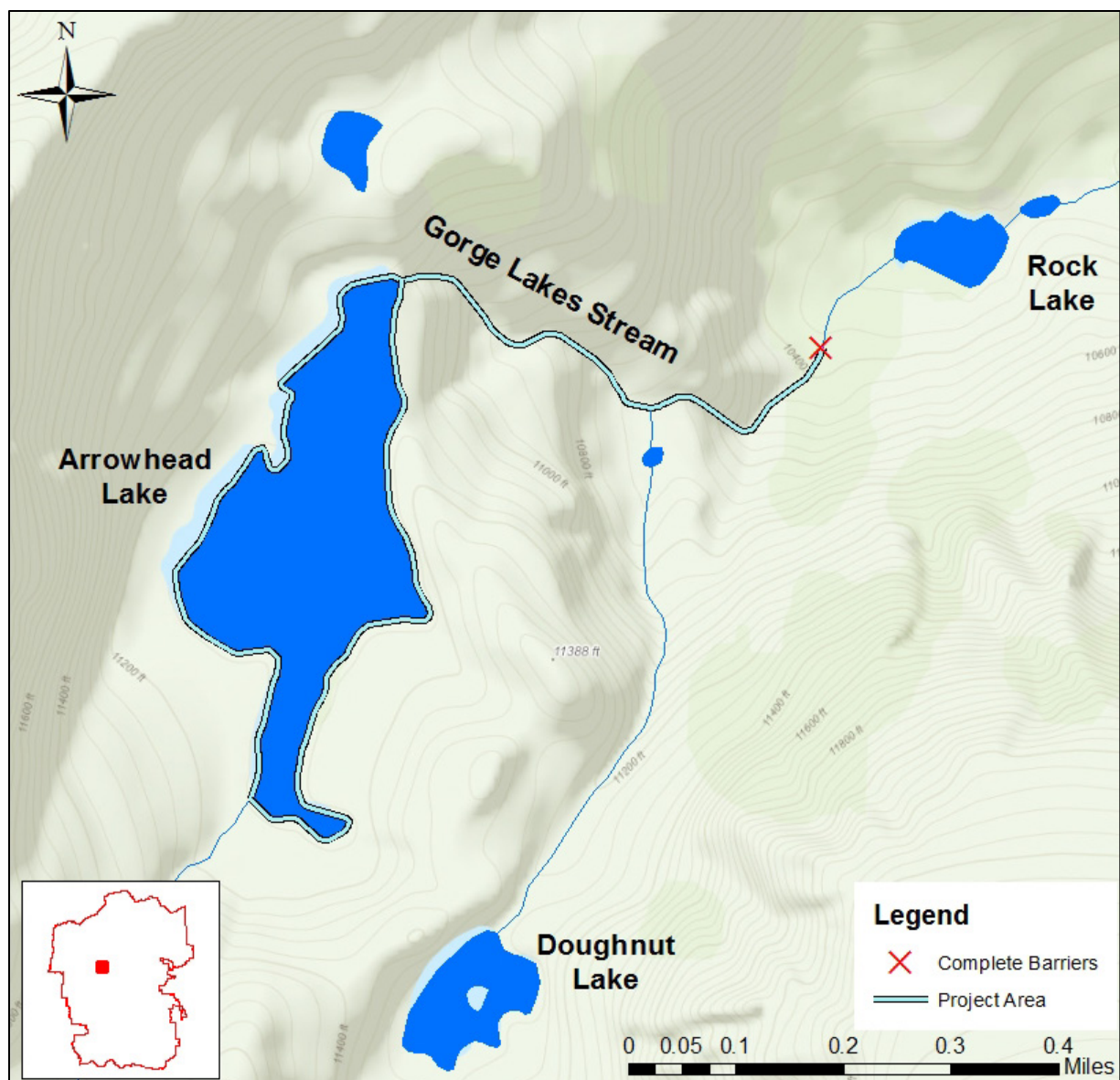


Figure A-13. Arrowhead Lake Restoration Project.

Upper Big Thompson River Restoration Project

Waters Included: Big Thompson River, Rock Lake, Little Rock Lake, Gorge Lakes Creek.

Parameter Scoring

Table A-38. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	15.13	2.51	64.07	blue / hybrid cutthroat	unknown	no	–
Score	4	0	1	1	1	1	0	8

Table A-39. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	15.13	2.51	64.07	10.34	11.94	>2500	no	–
Score	4	2	1	2	4	4	4	2	23

Table A-40. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	5.33	0.7	197	35.75	1

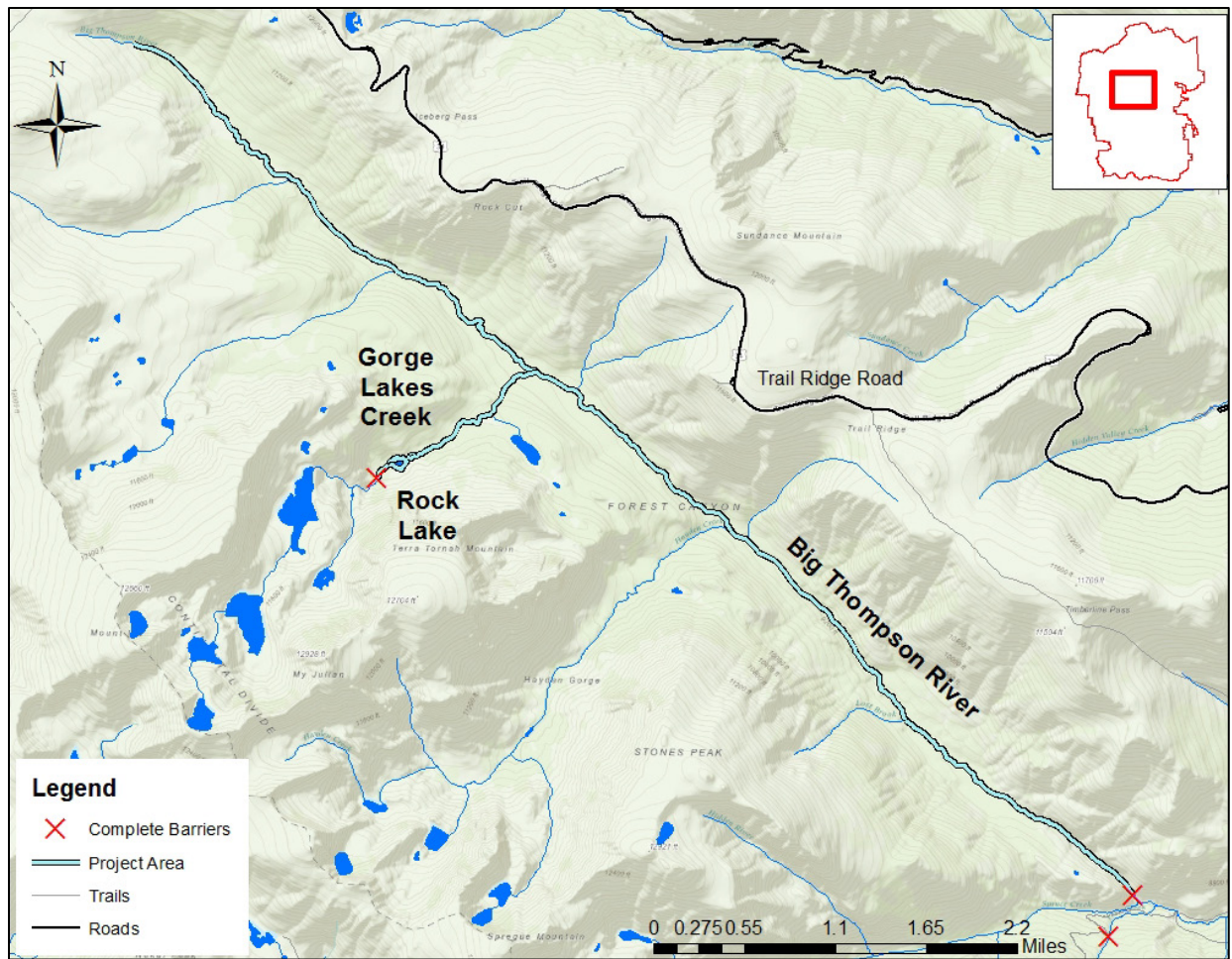


Figure A-14. Upper Big Thompson River Restoration Project.

Loomis Lake Restoration Project

Waters Include: Loomis Lake

Parameter Scoring

Table A-41. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.0	1.13	0.49	green cutthroat	unknown	one mile	–
Score	4	2	2	2	1	1	1	13

Table A-42. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.0	1.13	0.49	12.48	13.91	250–1199	one mile	–
Score	4	0	0	1	4	4	2	1	16

Table A-43. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	17.0	n/a	21.8	0

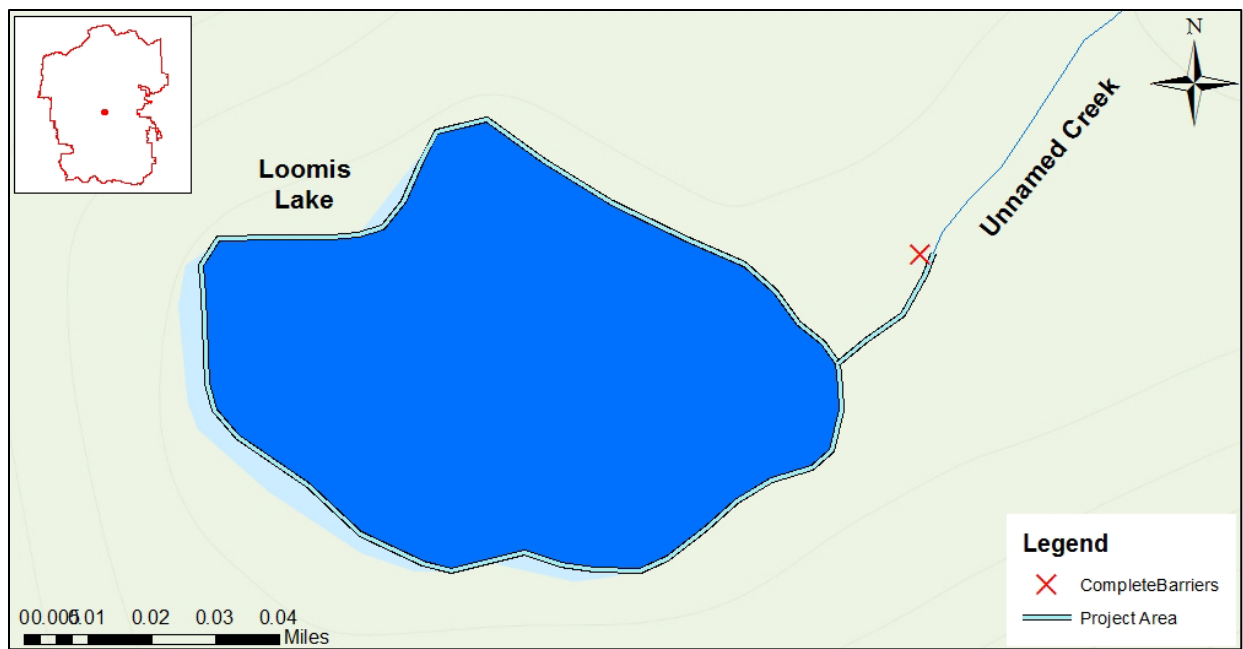


Figure A-15. Loomis Lake Restoration Project.

Spruce Lake Restoration Project

Waters Included: Spruce Lake, Primrose Lake, unnamed creek

Parameter Scoring

Table A-44. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.64	1.86	1.27	green cutthroat	none	yes	–
Score	4	2	1	2	1	2	2	14

Table A-45. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.64	1.86	1.27	15.79	14.46	1200–2500	yes	–
Score	4	0	1	1	4	4	3	0	17

Table A-46. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg / ha)	# of Projects Upstream
Value	n/a	13.0	n/a	152.5	1

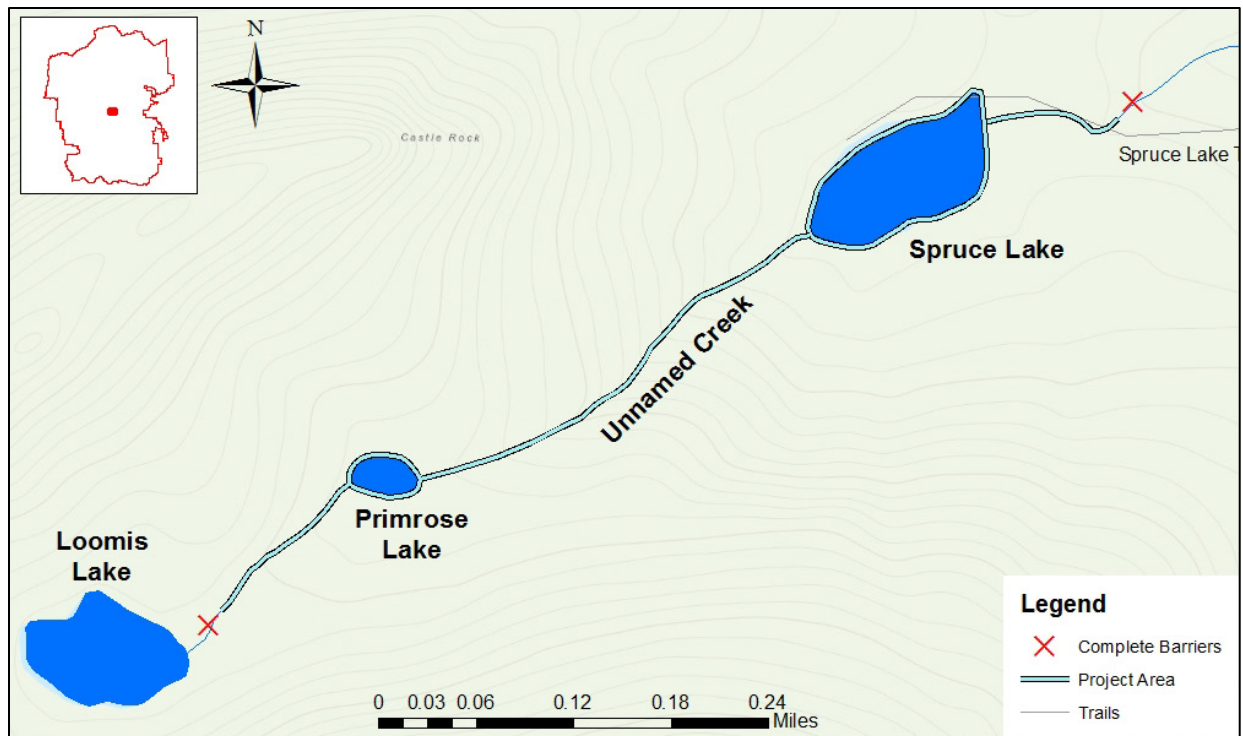


Figure A-16. Spruce Lake Restoration Project.

Odessa Lake Restoration Project

Waters Included: Odessa Lake, Fern Creek

Parameter Scoring

Table A-47. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	1.26	4.53	4.28	green cutthroat	unknown	yes	–
Score	4	2	1	2	1	1	2	13

Table A-48. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	1.26	4.53	4.28	10.40	12.13	250–1199	yes	–
Score	4	0	1	1	4	4	2	0	16

Table A-49. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	112	n/a	17.4	0

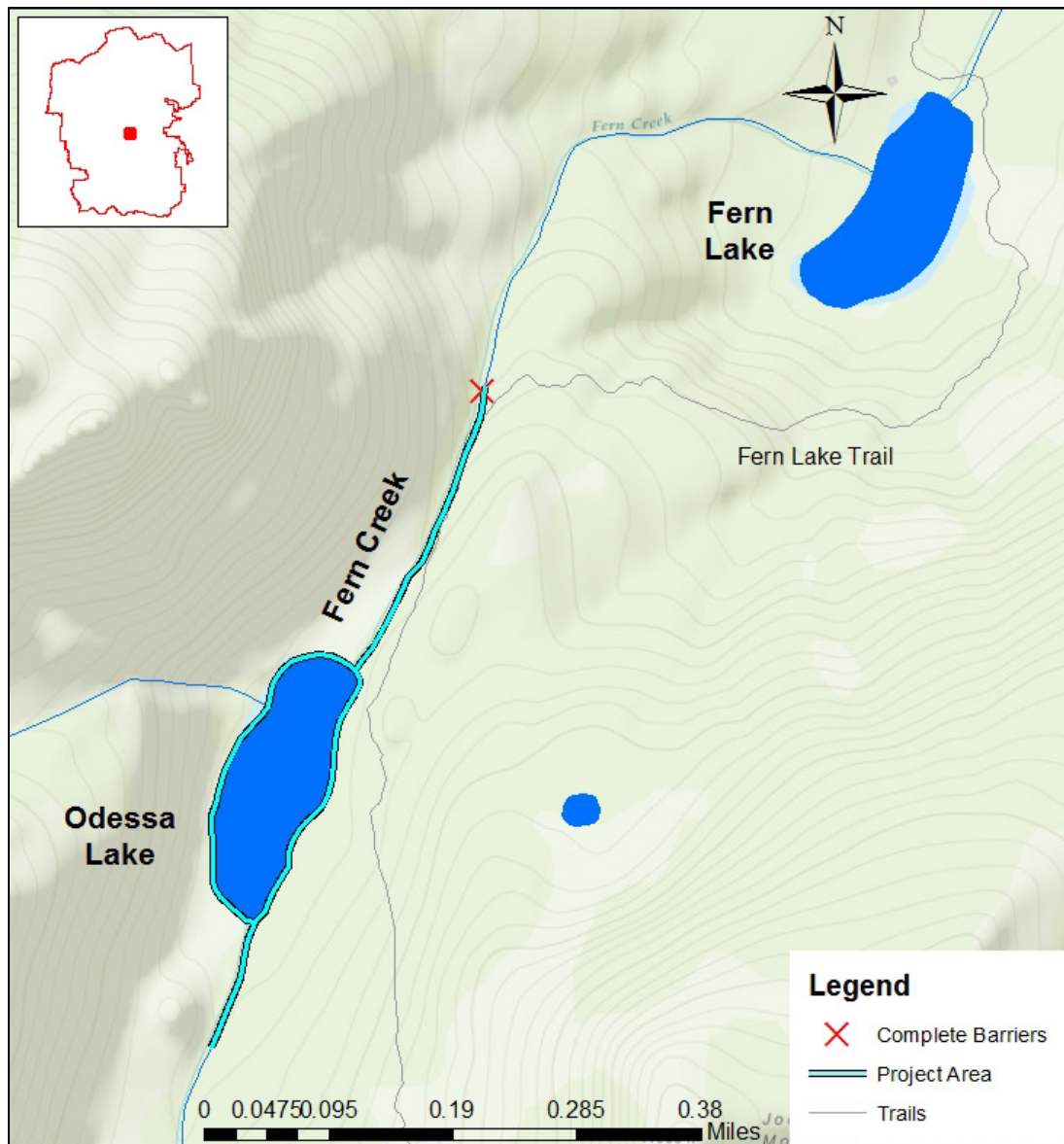


Figure A-17. Odessa Lake Restoration Project.

Fern Lake Restoration Project

Waters Included: Fern Lake, Fern Creek

Parameter Scoring

Table A-50. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	2.25	3.72	6.91	green cutthroat	unknown	yes	–
Score	4	2	1	2	1	1	2	13

Table A-51. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	2.25	3.72	6.91	12.92	12.67	>2500	yes	–
Score	4	0	1	1	4	4	4	0	18

Table A-52. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	4.6	92	56	68.6	1

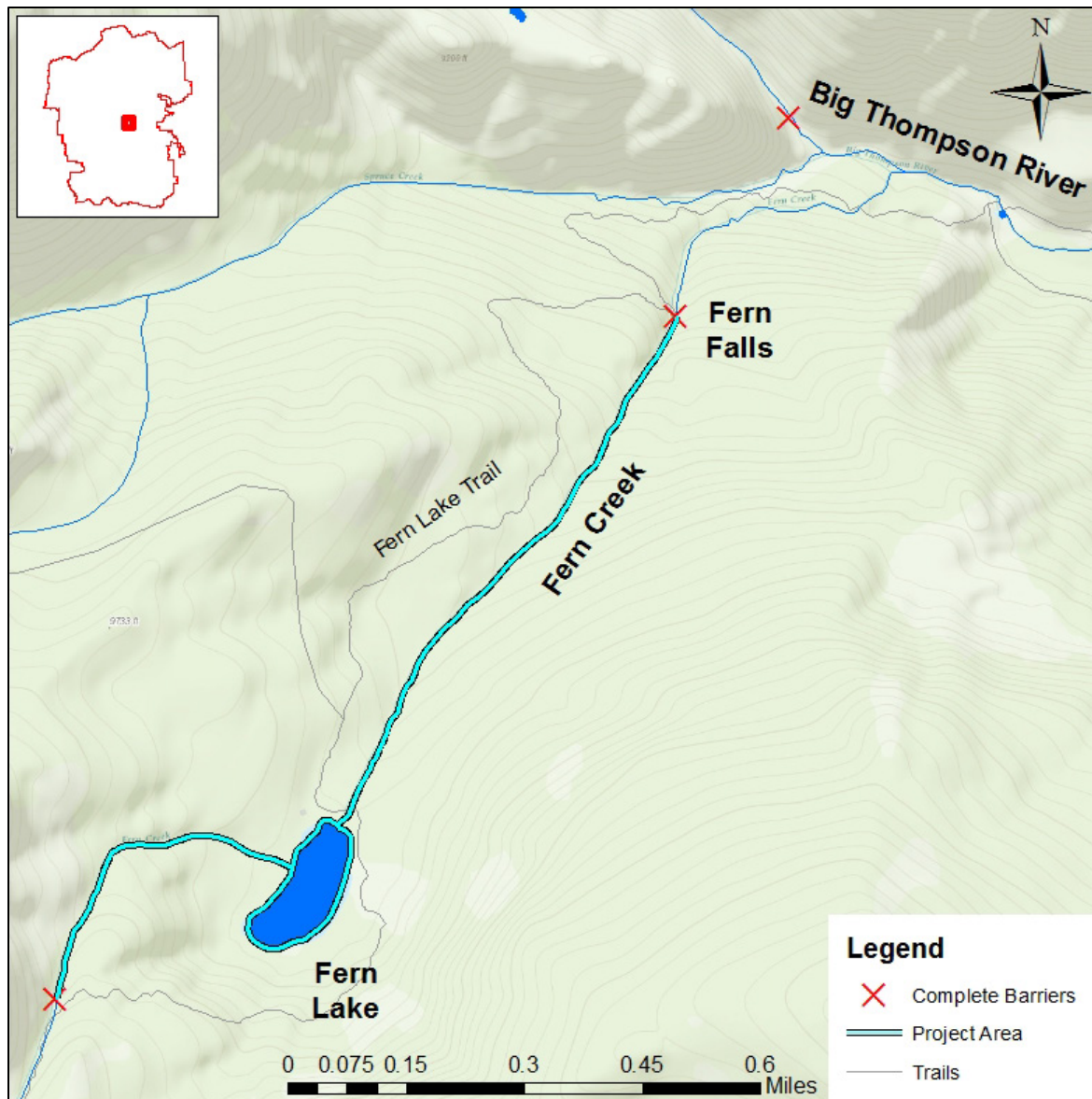


Figure A-18. Fern Lake Restoration Project.

Upper Big Thompson River Sub-drainage

Restoration Projects Included: Arrowhead Lake, Upper Big Thompson River

Parameter Scoring

Table A-53. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	15.1	16.63	64.07	blue / hybrid cutthroat	unknown	no	–
Score	4	0	0	1	1	1	0	7

Table A-54. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	15.1	16.63	64.07	9.88	11.08	>2500	yes	–
Score	4	2	2	2	4	4	4	2	24

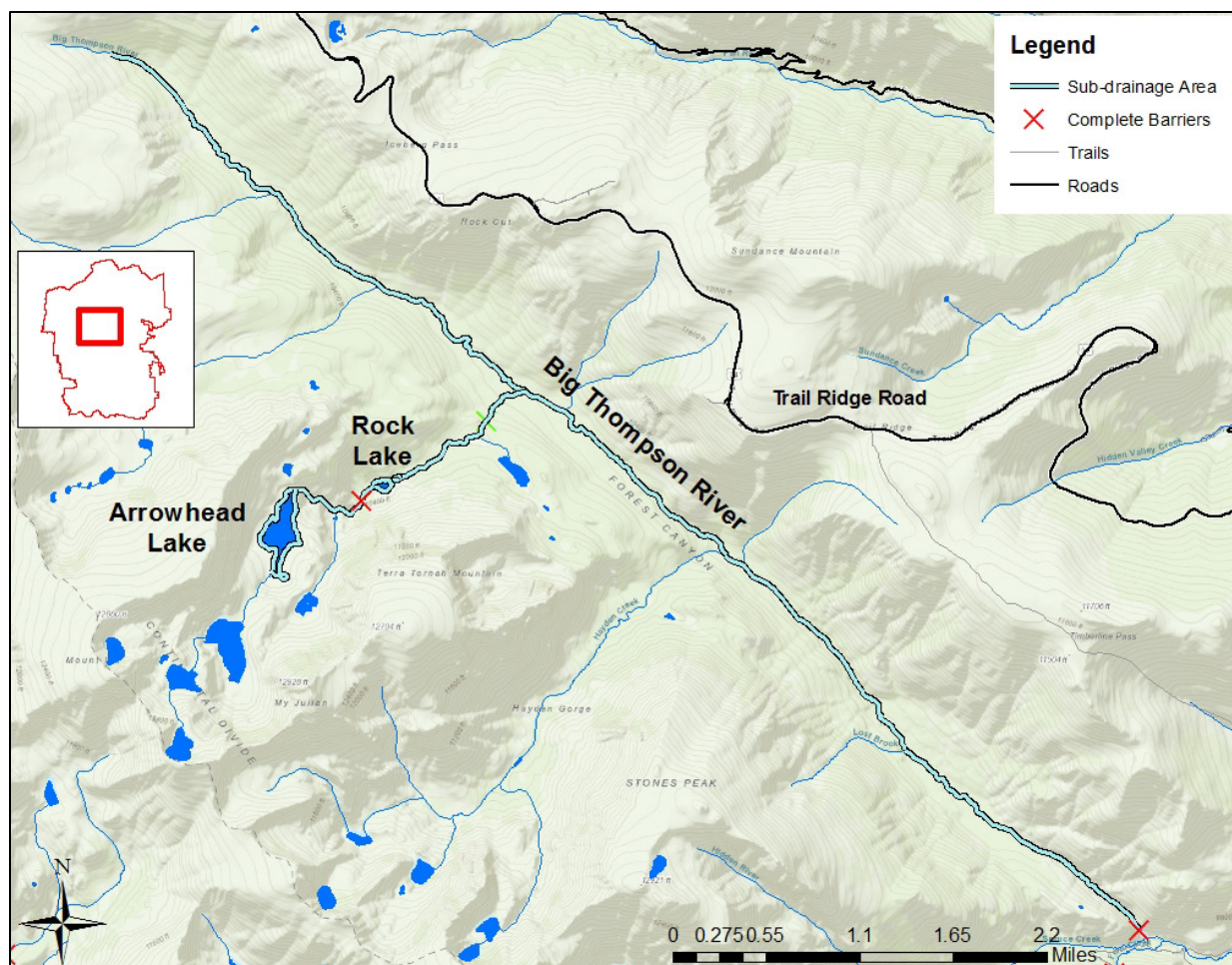


Figure A-19. Upper Big Thompson River Sub-drainage.

Spruce Creek Sub-drainage

Restoration Projects Included: Loomis Lake, Spruce Lake

Parameter Scoring

Table A-55. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.64	2.99	1.27	blue/hybrid cutthroat	unknown	yes	–
Score	4	2	1	2	1	1	2	13

Table A-56. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.64	2.99	1.27	14.13	14.19	1200–2500	yes	–
Score	4	0	1	1	4	4	3	0	17

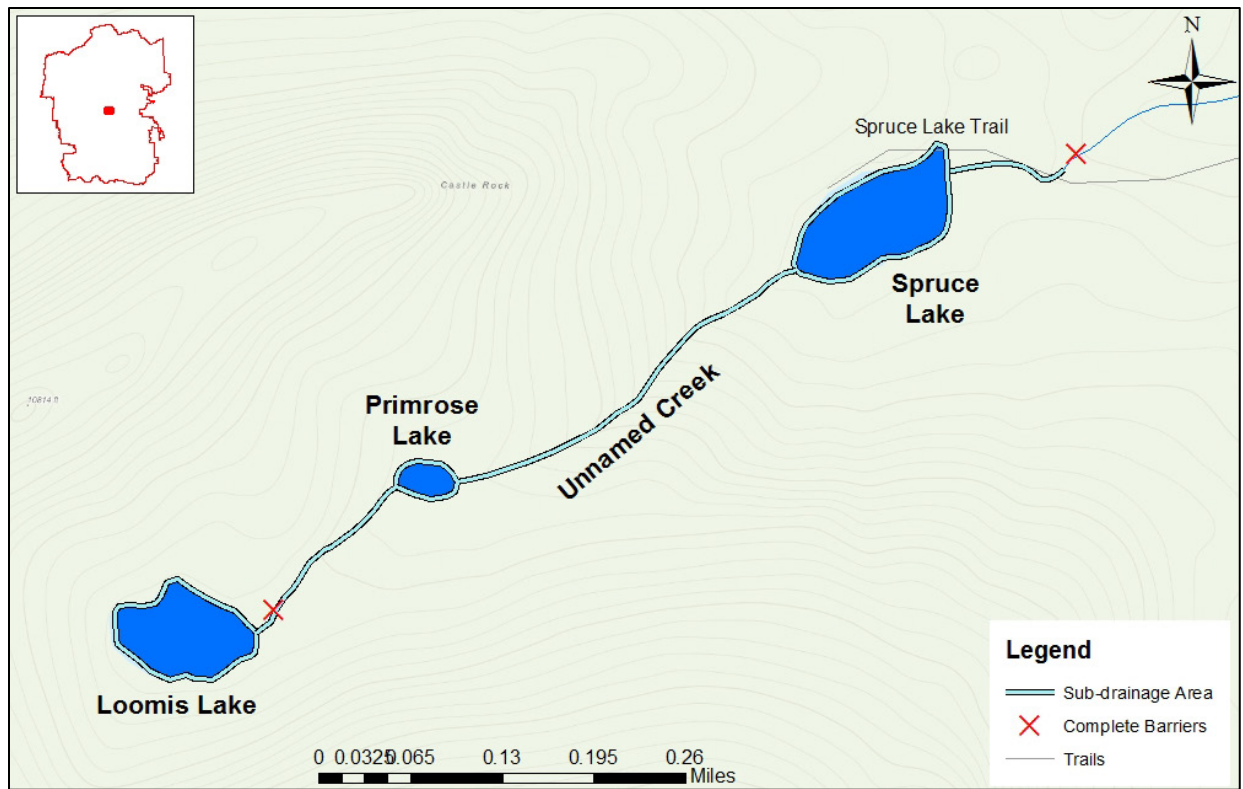


Figure A-20. Spruce Lake Sub-drainage.

Fern Creek Sub-drainage

Restoration Projects Included: Odessa Lake, Fern Lake

Parameter Scoring

Table A-57. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	3.51	8.25	6.91	green cutthroat	unknown	yes	–
Score	4	1	1	2	1	1	2	12

Table A-58. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	3.51	8.25	6.91	11.66	12.40	>2500	yes	–
Score	4	1	1	1	4	4	4	0	19

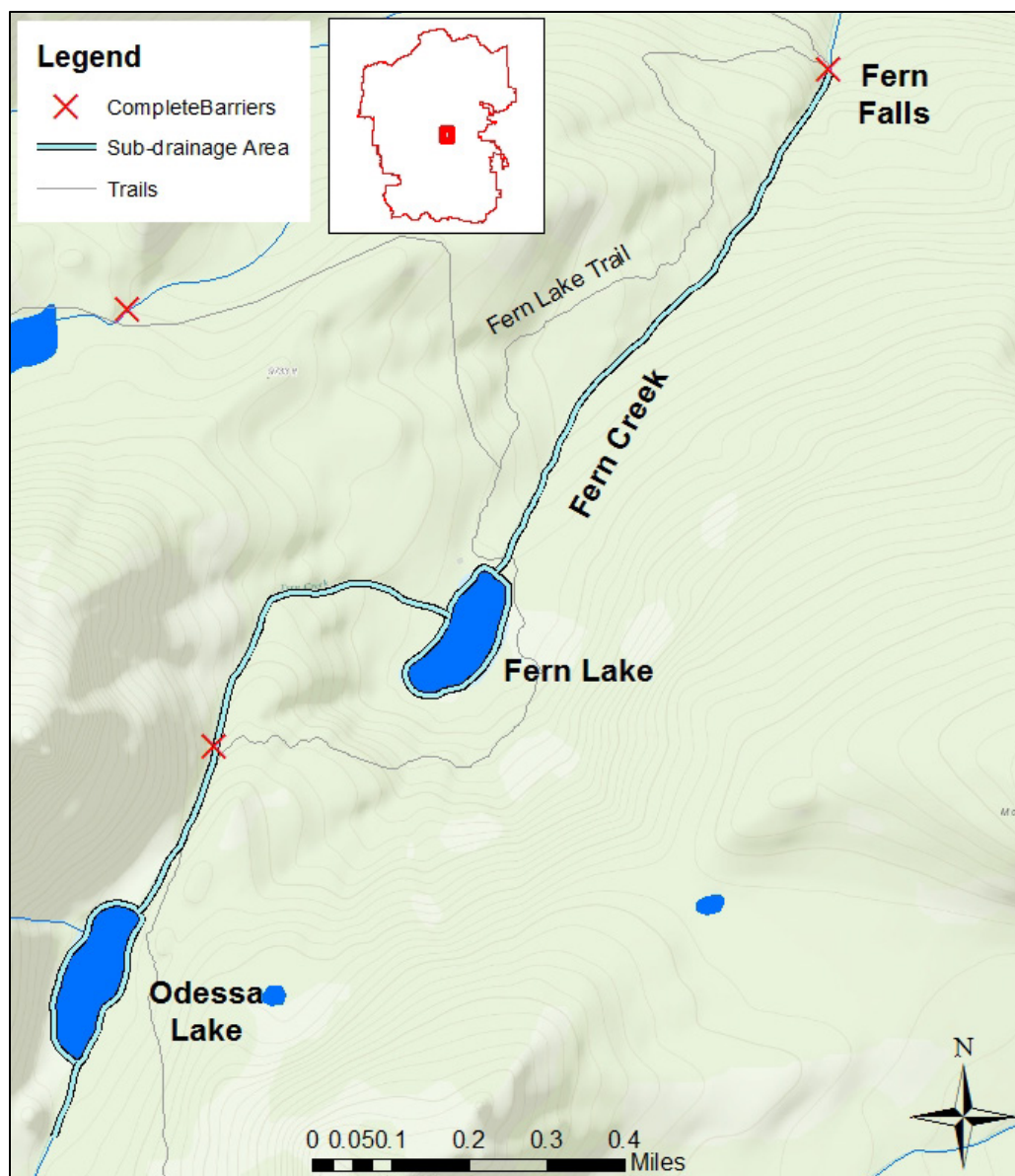


Figure A-21. Fern Creek Sub-drainage.

Glacier Creek**Black Lake Restoration Project**

Waters Included: Black Lake

*Parameter Scoring***Table A-59.** Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.0	3.72	5.39	brook trout	none	yes	–
Score	4	2	1	2	2	2	2	15

Table A-60. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.0	3.72	5.39	8.66	10.09	250–1199	yes	–
Score	4	0	1	1	2	4	2	0	14

Table A-61. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	0

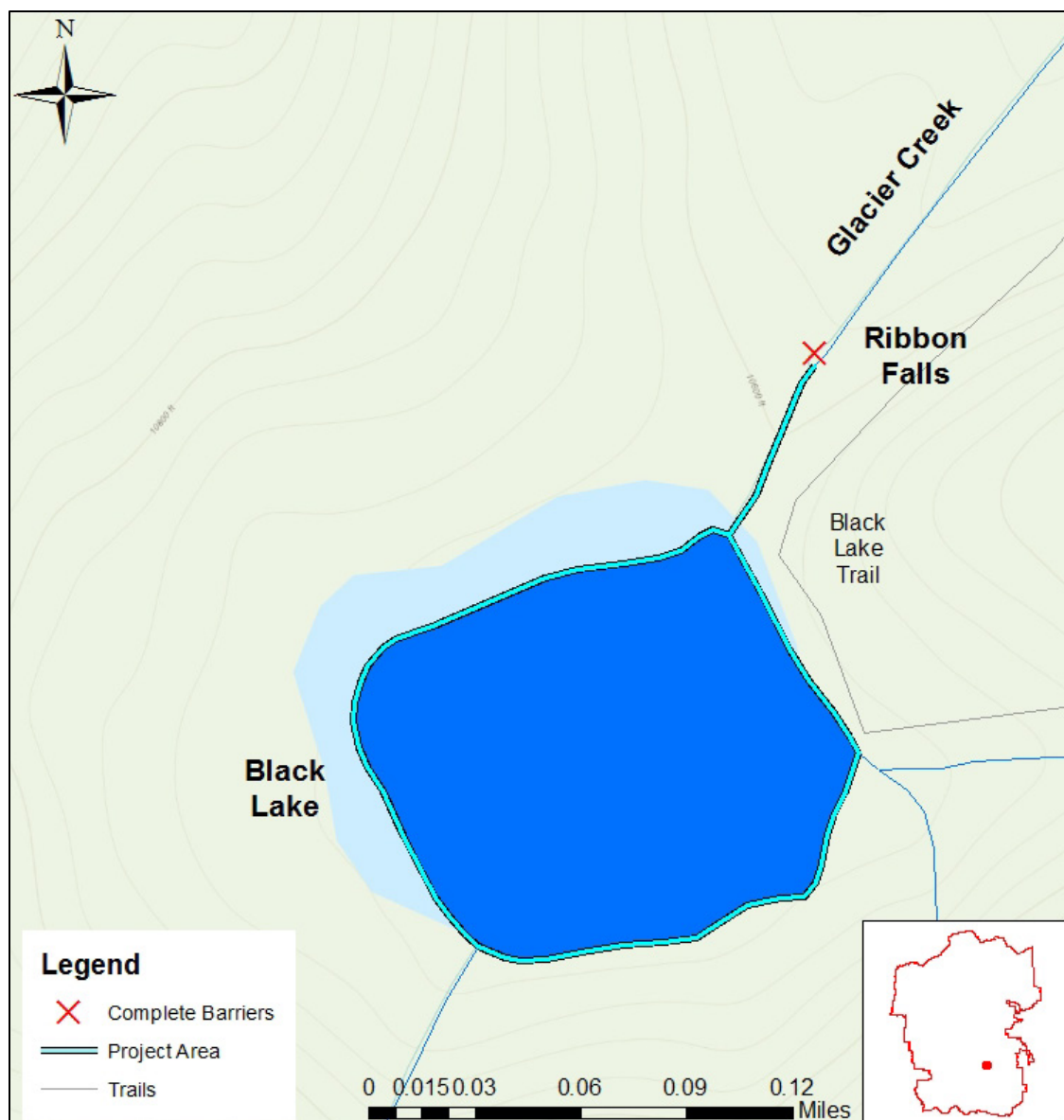


Figure A-22. Black Lake Restoration Project.

Mills Lake Restoration Project

Waters Included: Mills Lake, Jewell Lake, Glacier Creek

Parameter Scoring

Table A-62. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	2.57	8.17	12.20	hybrid cutthroat	none	yes	–
Score	4	2	1	2	2	2	2	15

Table A-63. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	2.57	8.17	12.20	8.76	10.69	1200–2500	yes	–
Score	4	0	1	1	2	4	3	0	15

Table A-64. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	121	n/a	n/a	1

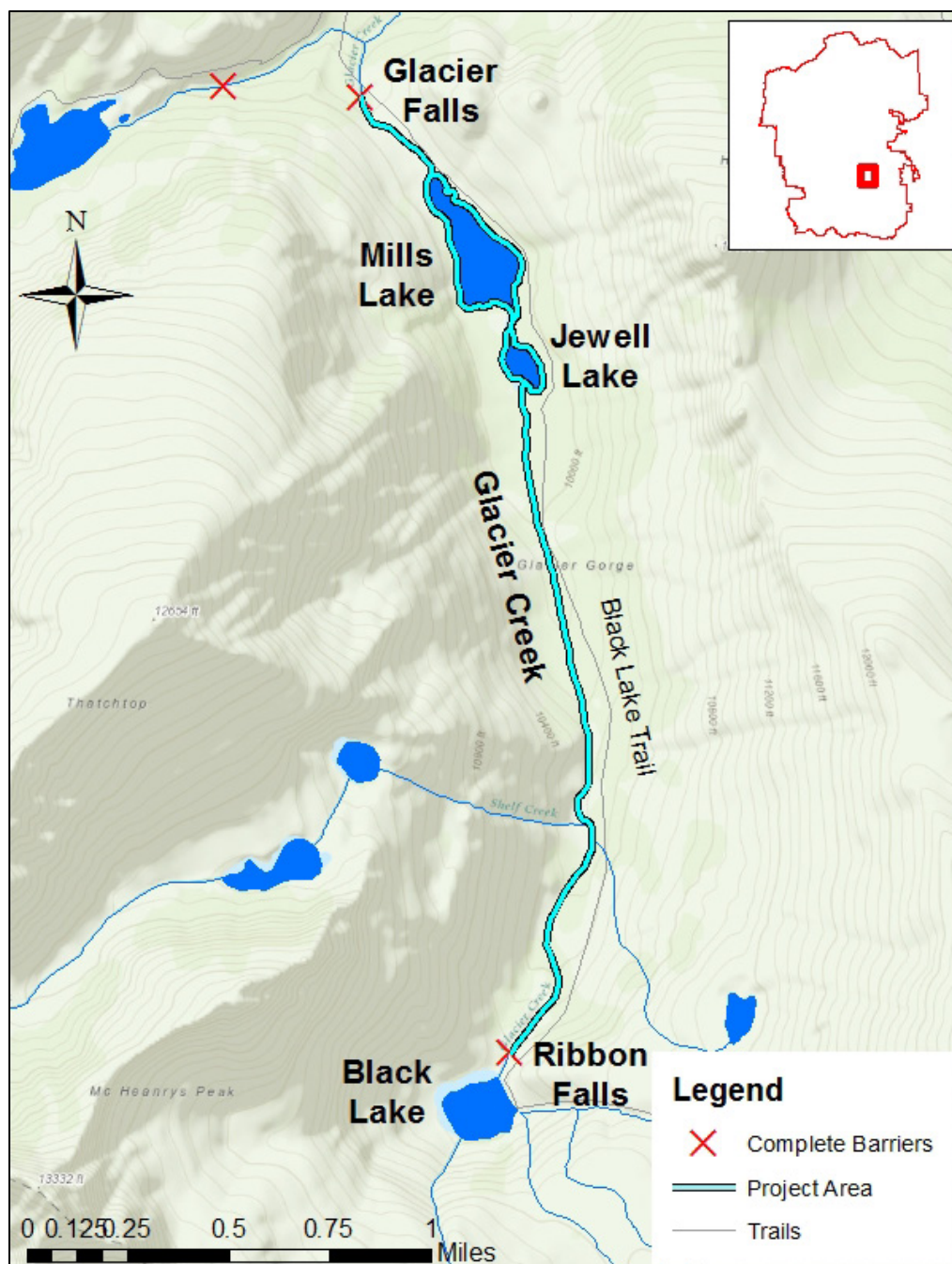


Figure A-23. Mills Lake Restoration Project.

Sky Pond Restoration Project

Waters Included: Sky Pond, Icy Brook

Parameter Scoring

Table A-65. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.16	4.53	2.31	brook trout	none	yes	–
Score	4	2	1	2	2	2	2	15

Table A-66. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.16	4.53	2.31	9.76	11.19	1200–2500	yes	–
Score	4	0	1	1	4	4	3	0	17

Table A-67. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	166	n/a	n/a	0

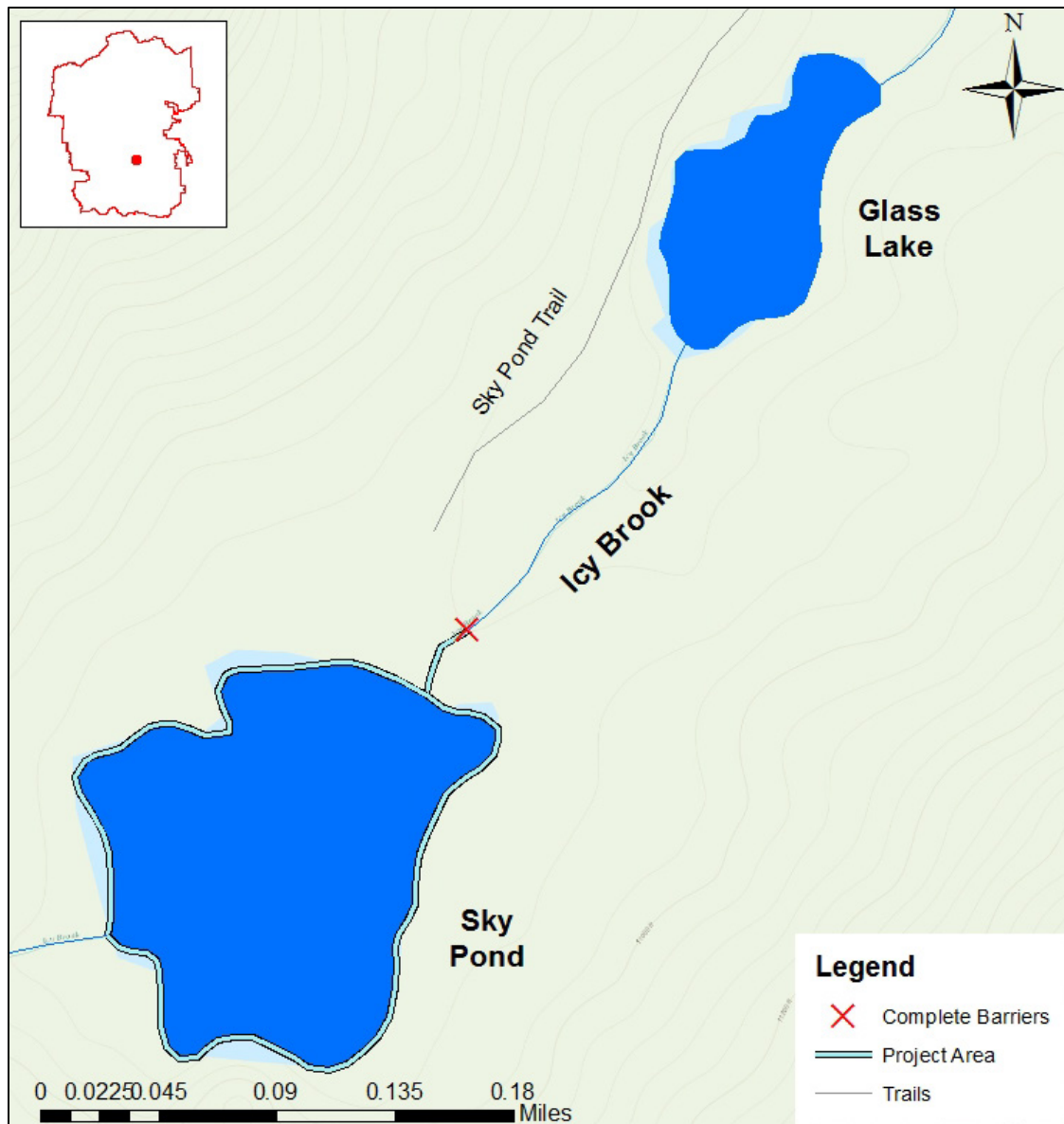


Figure A-24. Sky Pond Restoration Project.

Glass Lake Restoration Project

Waters Included: Glass Lake, Icy Brook

Parameter Scoring

Table A-68. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.48	1.86	2.82	blue cutthroat	unknown	yes	–
Score	4	2	1	2	1	1	2	13

Table A-69. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.48	1.86	2.82	8.10	7.61	250–1199	yes	–
Score	4	0	1	1	2	0	2	0	10

Table A-70. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	1

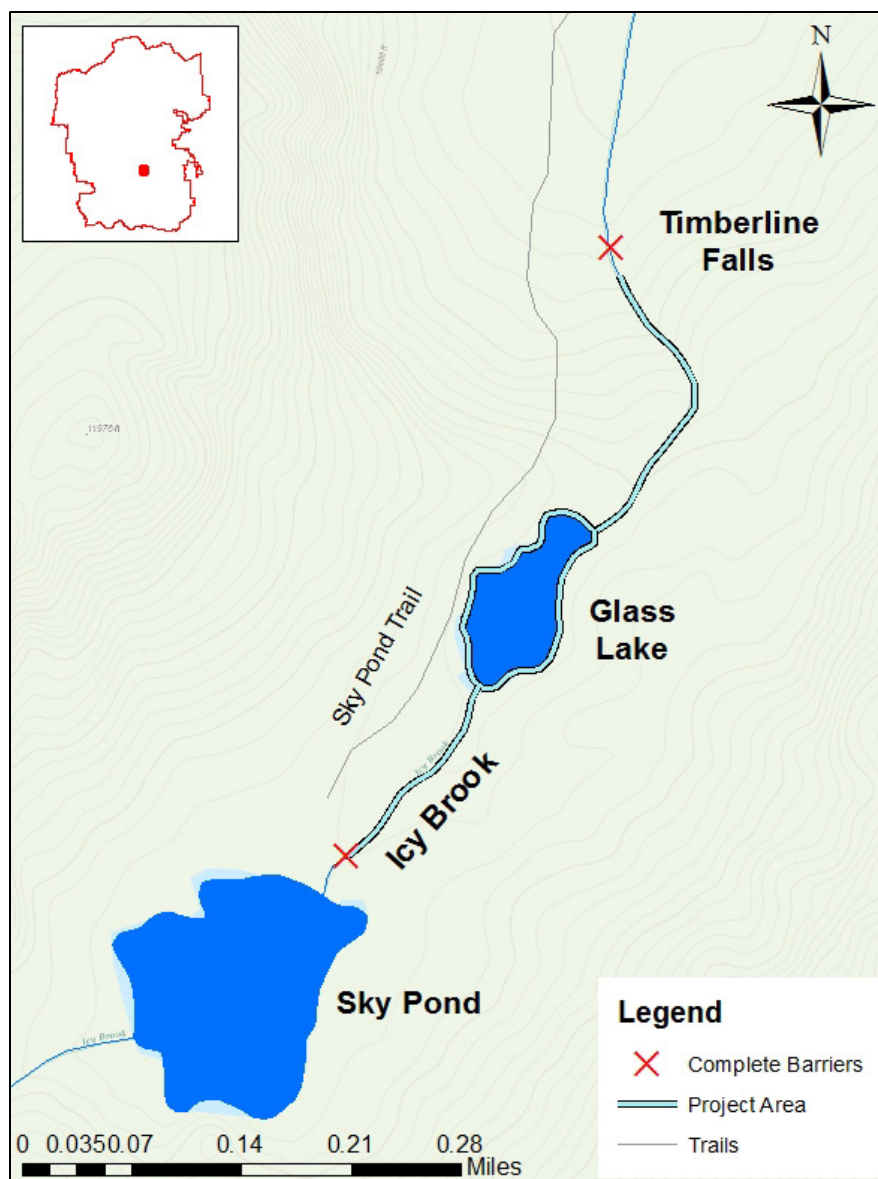


Figure A-25. Glass Lake Restoration Project.

The Loch Restoration Project

Waters Included: The Loch, Icy Brook

Parameter Scoring

Table A-71. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	3.22	5.95	20.23	blue cutthroat	none	yes	–
Score	4	1	1	1	1	2	2	12

Table A-72. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	3.22	5.95	20.23	9.98	9.42	1200–2500	yes	–
Score	4	1	1	2	4	4	3	0	19

Table A-73. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	72	n/a	n/a	4

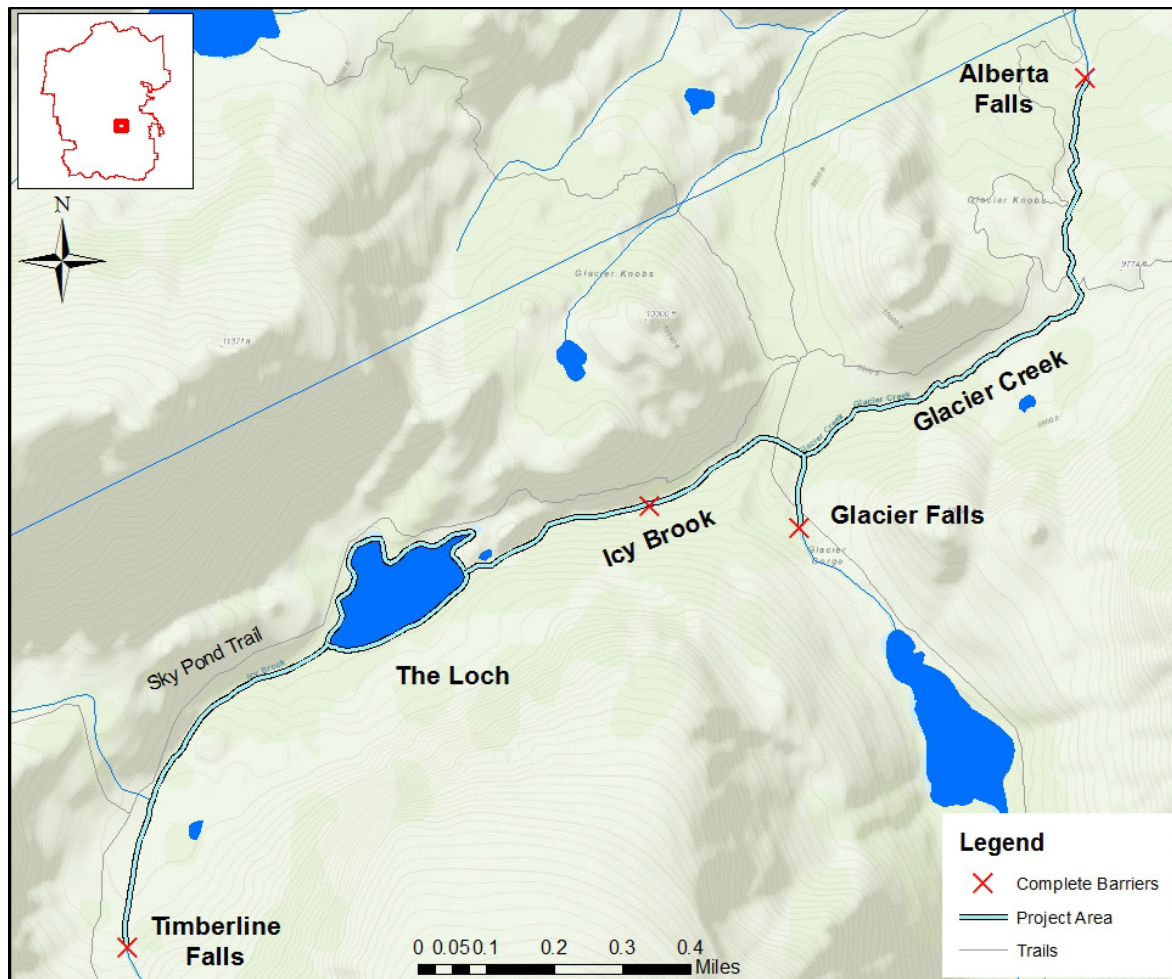


Figure A-26. The Loch Restoration Project.

Lake Haiyaha Restoration Project

Waters Included: Lake Haiyaha, Chaos Creek

Parameter Scoring

Table A-74. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.64	6.31	2.97	Yellowstone cutthroat	none	yes	–
Score	4	2	1	2	2	2	2	15

Table A-75. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.64	6.31	2.97	9.97	11.40	1200–2500	yes	–
Score	4	0	1	1	4	4	3	0	17

Table A-76. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	312	n/a	n/a	0

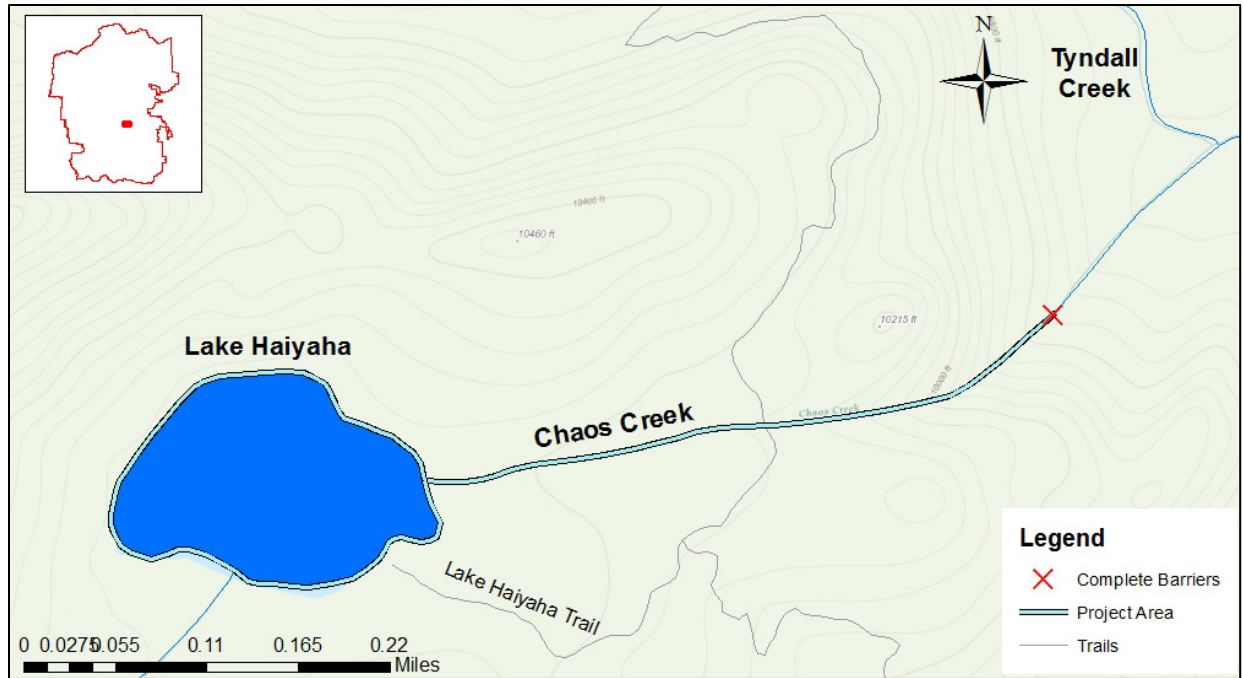


Figure A-27. Lake Haiyaha Restoration Project.

Dream Lake Restoration Project

Waters Included: Dream Lake, Tyndall Creek

Parameter Scoring

Table A-77. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.32	2.23	2.28	hybrid cutthroat	unknown	yes	–
Score	4	2	1	2	2	1	2	14

Table A-78. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.31	2.23	2.28	13.75	12.42	250–1199	yes	–
Score	4	0	1	1	4	4	2	0	16

Table A-79. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	na	n/a	28.0	0

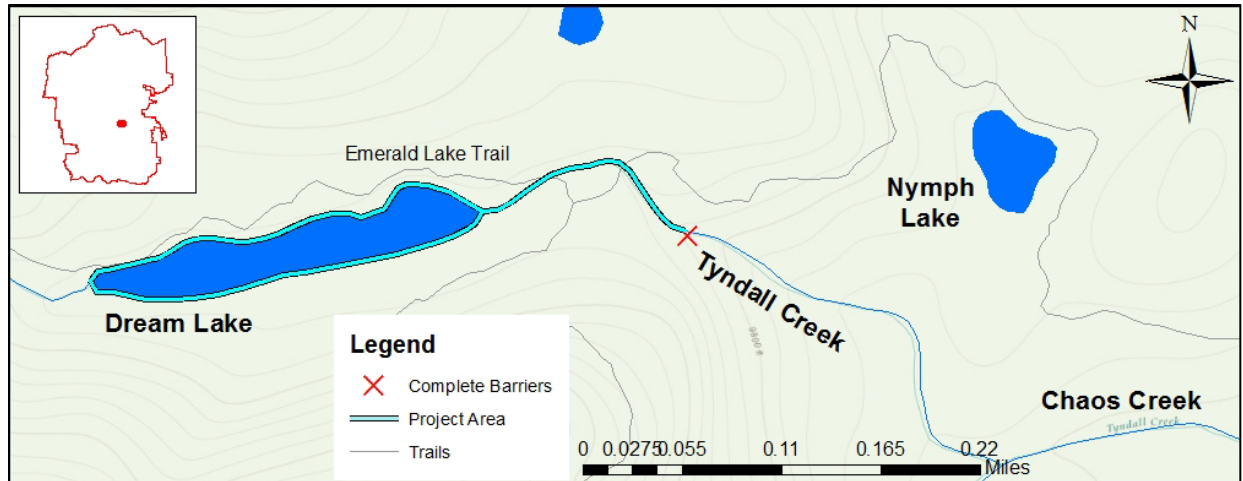


Figure A-28. Dream Lake Restoration Project.

Bear Lake Restoration Project

Waters Included: Bear Lake

Parameter Scoring

Table A-80. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.0	4.53	0.62	green cutthroat	none	yes	–
Score	4	2	1	2	1	2	2	14

Table A-81. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.0	4.53	0.62	9.80	10.01	<250	yes	–
Score	4	0	1	1	4	4	1	0	15

Table A-82. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	134	n/a	n/a	0

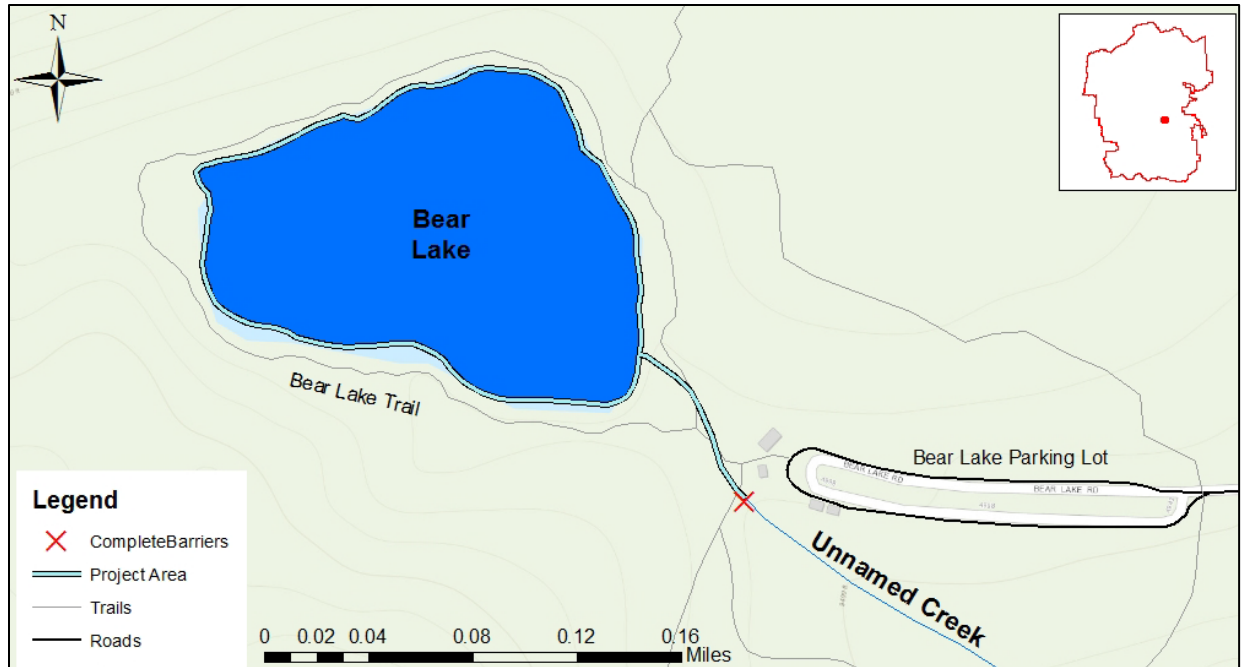


Figure A-29. Bear Lake Restoration Project.

Upper Glacier Creek Sub-drainage
 Restoration Projects Included: Black Lake, Mills Lake

Parameter Scoring

Table A-83. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	2.57	11.90	12.20	brook hybrid cutthroat	none	yes	–
Score	4	2	0	2	2	2	2	14

Table A-84. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	2.57	11.90	12.20	8.71	10.39	>2500	yes	–
Score	4	0	2	1	2	4	4	0	17

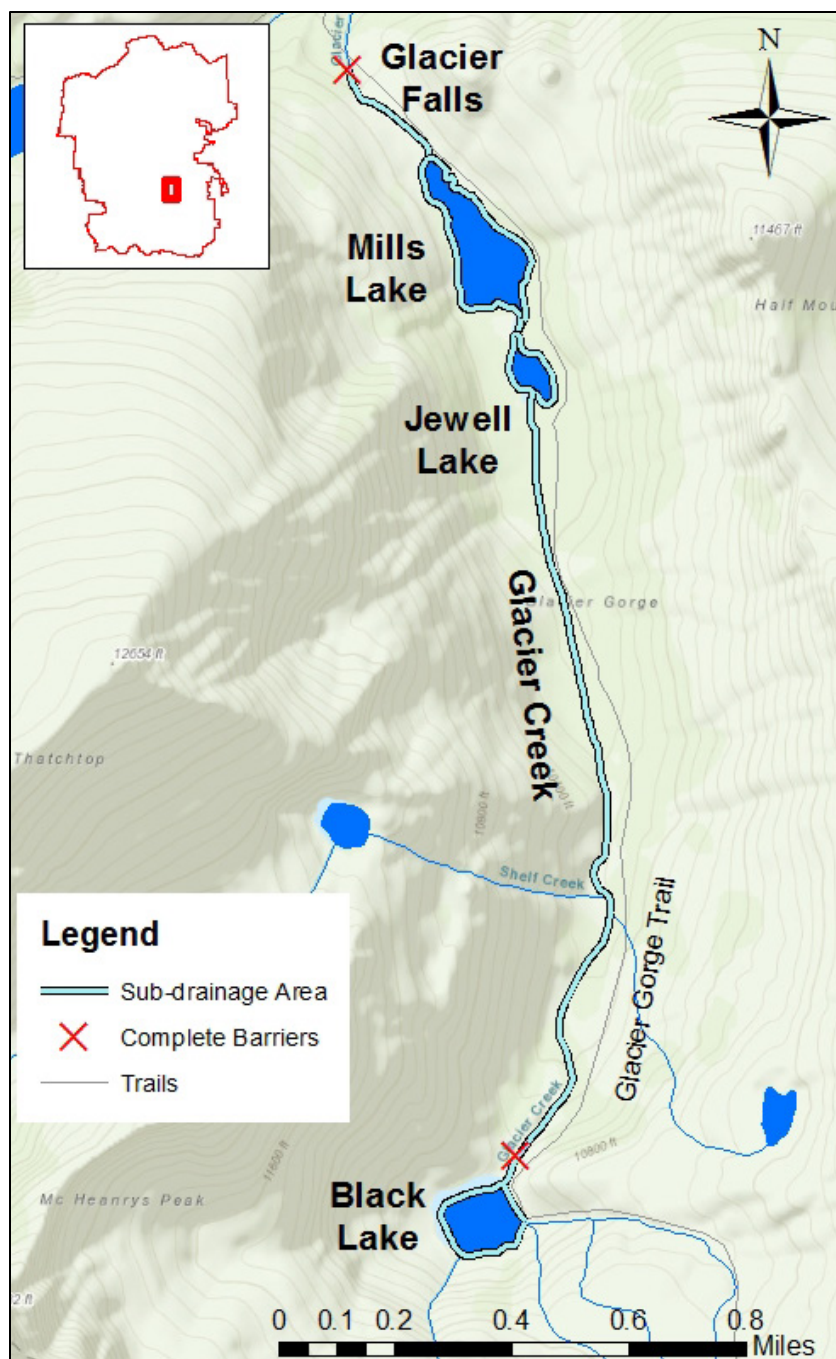


Figure A-30. Upper Glacier Creek Sub-drainage.

Icy Brook Sub-drainage

Restoration Projects Included: Sky Pond, Glass Lake, The Loch

Parameter Scoring

Figure A-85. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	3.86	12.34	20.23	blue cutthroat	unknown	yes	–
Score	4	1	0	1	0	1	2	9

Figure A-86. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	3.86	12.34	20.23	9.28	9.41	>2500	yes	–
Score	4	1	2	2	4	4	4	0	21

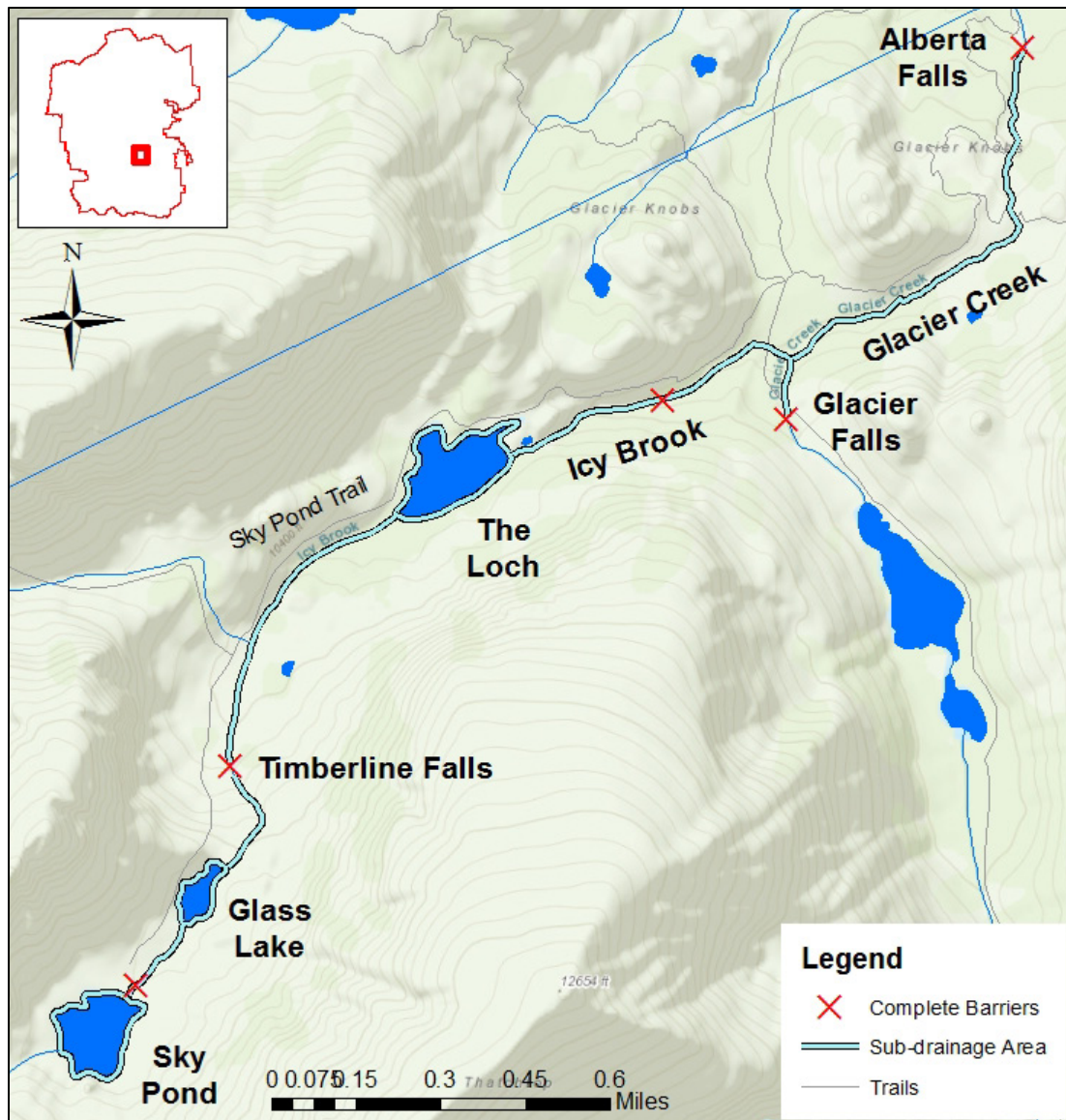


Figure A-31. Icy Brook Sub-drainage.

North St. Vrain Creek**Thunder Lake Restoration Project**

Waters Included: Thunder Lake, North St. Vrain Creek

*Parameter Scoring***Table A-87.** Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.50	6.68	4.57	blue cutthroat	unknown	yes	–
Score	4	2	1	2	1	1	2	13

Table A-88. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.50	6.68	4.57	10.81	12.24	1200–2500	yes	–
Score	4	0	1	1	4	4	3	0	17

Table A-89. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	0

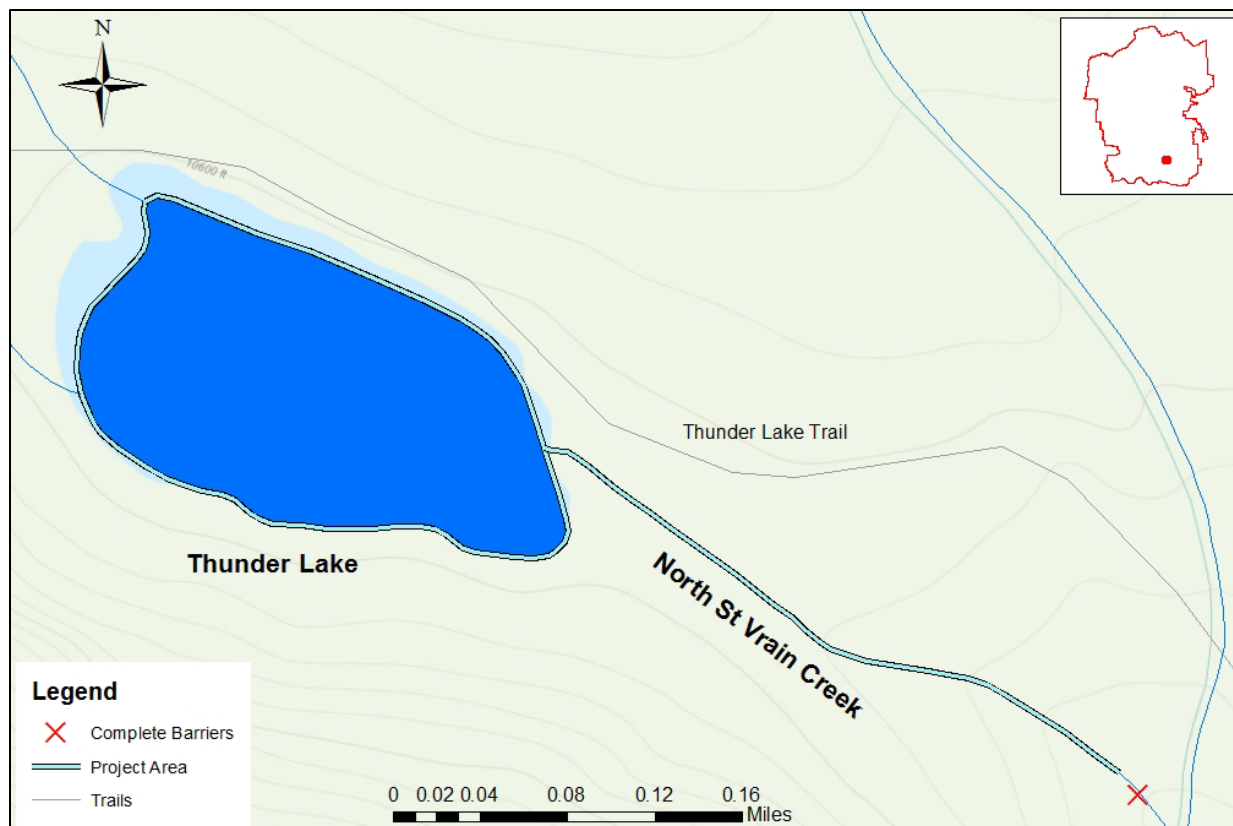


Figure A-32. Thunder Lake Restoration Project.

Box Lake Restoration Project

Waters Included: Box Lake, unnamed creek

Parameter Scoring

Table A-90. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.90	2.59	4.26	brook trout	unknown	one mile	–
Score	4	2	1	2	2	1	1	13

Table A-91. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.90	2.59	4.26	10.78	11.51	1200– 2500	one mile	–
Score	4	0	1	1	4	4	3	1	18

Table A-92. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	0

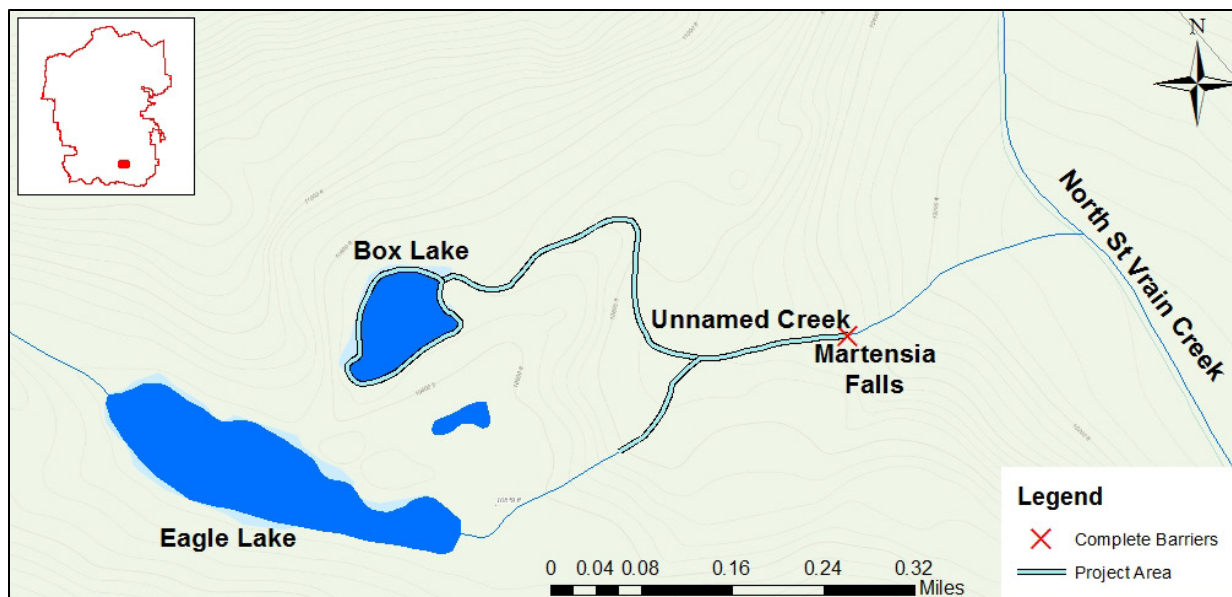


Figure A-33. Box Lake Restoration Project.

Ouzel Lake Restoration Project

Waters Included: Ouzel Lake, Ouzel Creek

Parameter Scoring

Table A-93. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	3.60	2.59	13.17	blue cutthroat/ brook trout	BKD	yes	–
Score	4	1	1	2	1	1	2	12

Table A-94. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	3.60	2.59	13.17	12.27	12.34	>2500	yes	–
Score	4	1	1	1	4	4	4	0	19

Table A-95. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	6.75	26	12	97.1	0

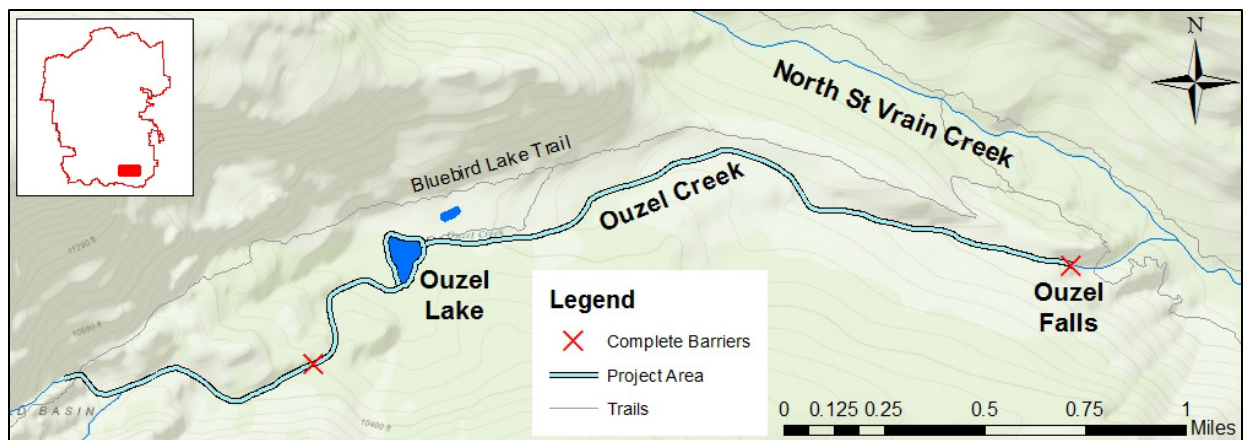


Figure A-34. Ouzel Lake Restoration Project.

Upper Hutcheson Lake Restoration Project

Waters Included: Upper Hutcheson Lake, Cony Creek

Parameter Scoring

Table A-96. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	1.61	2.99	3.12	hybrid cutthroat	none	no	–
Score	4	2	1	2	2	2	0	13

Table A-97. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	1.61	2.99	3.12	10.13	11.53	1200– 2500	no	–
Score	4	0	1	1	4	4	3	2	19

Table A-98. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	3.2	62.2	n/a	81.2	0

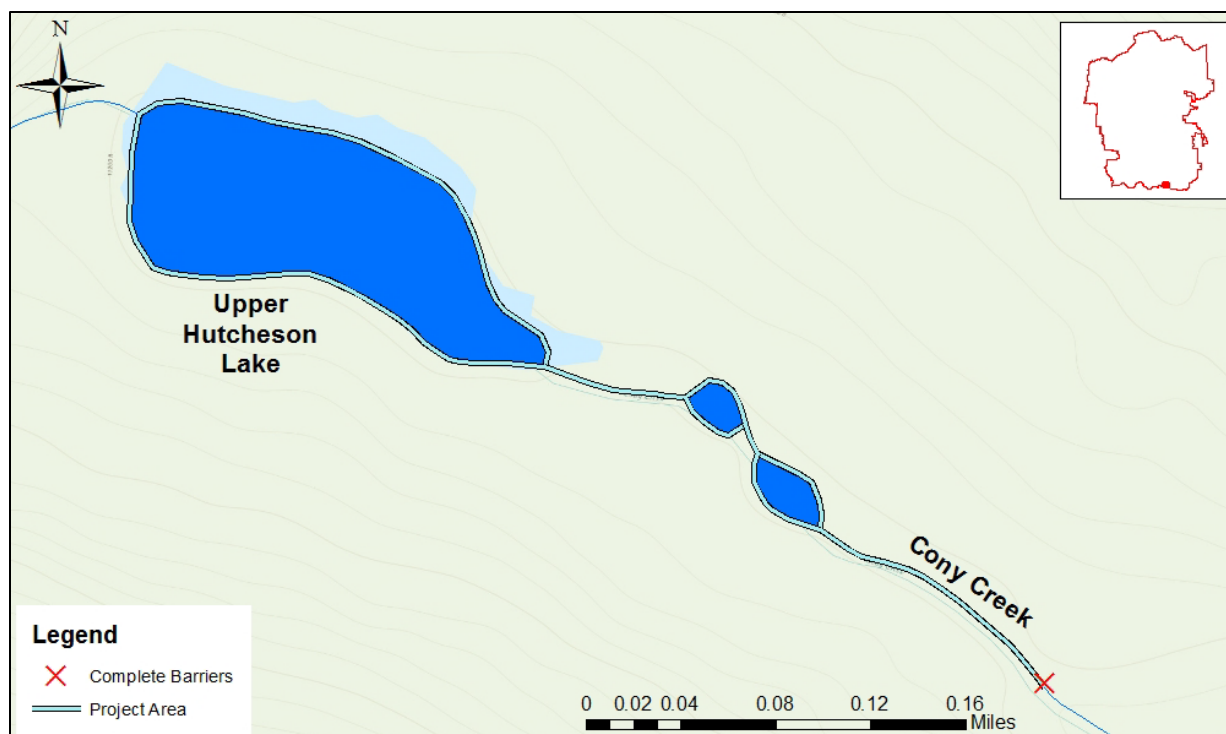


Figure A-35. Upper Hutcheson Lake Restoration Project.

Middle Hutcheson Lake Restoration Project

Waters Included: Middle Hutcheson Lake, Cony Creek

Parameter Scoring

Table A-99. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	1.40	1.01	3.56	green cutthroat	unknown	no	–
Score	4	2	2	2	1	1	0	12

Table A-100. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	1.40	1.01	3.56	10.34	11.65	250–1199	no	–
Score	4	0	0	1	4	4	2	2	17

Table A-101. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	1

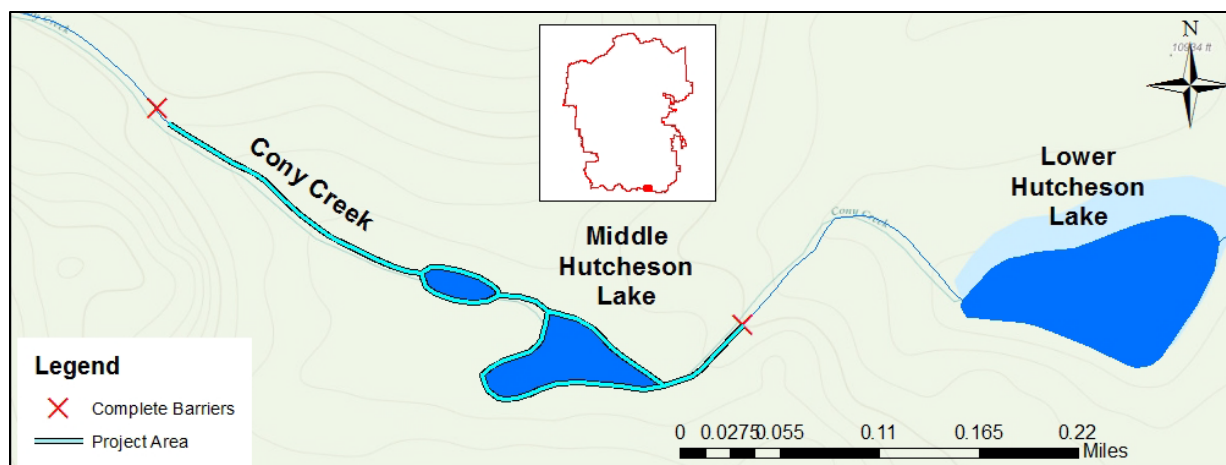


Figure A-36. Middle Hutcheson Lake Restoration Project.

Lower Hutcheson Lake Restoration Project

Waters Included: Lower Hutcheson Lake, Cony Creek

Parameter Scoring

Table A-102. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	1.40	1.74	4.60	green cutthroat	unknown	one mile	–
Score	4	2	1	2	1	1	1	12

Table A-103. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	1.40	1.74	4.60	11.71	11.62	250–1199	one mile	–
Score	4	0	1	1	4	4	2	1	17

Table A-104. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	4.0	45.5	n/a	45.0	2

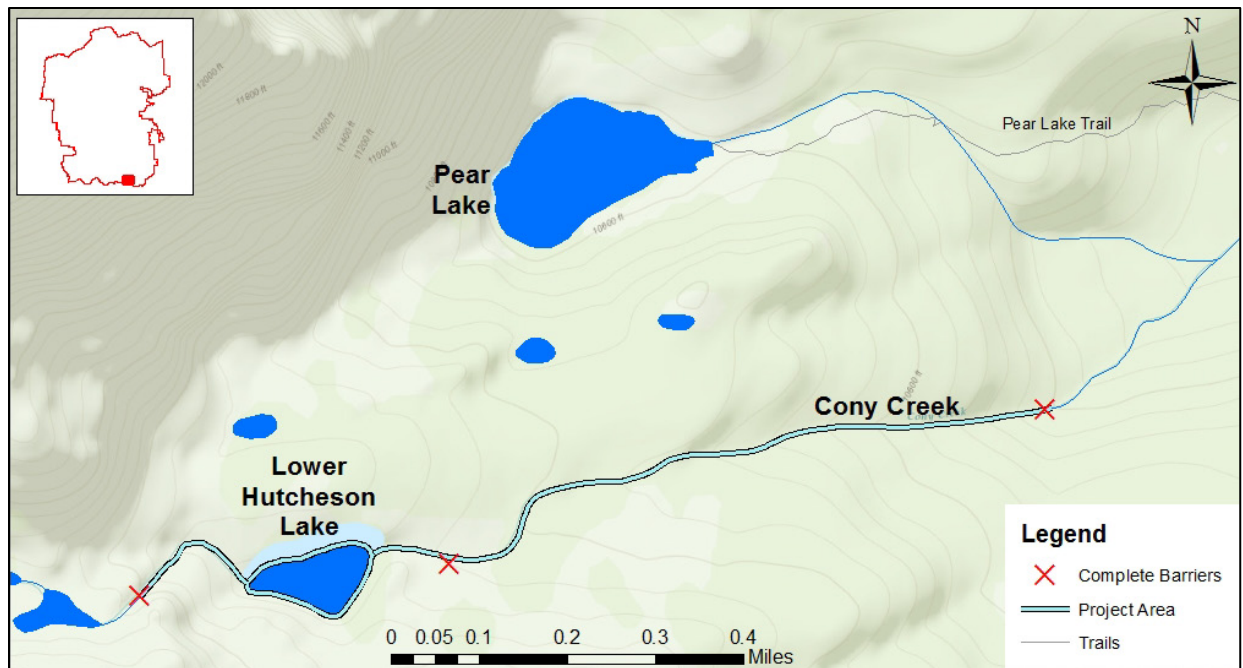


Figure A-37. Lower Hutcheson Lake Restoration Project.

Pear Lake Restoration Project

Waters Included: Pear Lake, Cony Creek

Parameter Scoring

Table A-105. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	4.73	6.68	18.42	green/ hybrid cutthroat	unknown	yes	–
Score	4	1	1	1	1	1	2	11

Table A-106. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	4.73	6.68	18.42	12.61	11.50	1200–2500	yes	–
Score	4	1	1	2	4	4	3	0	19

Table A-107. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	5.6	n/a	145	30.8	3

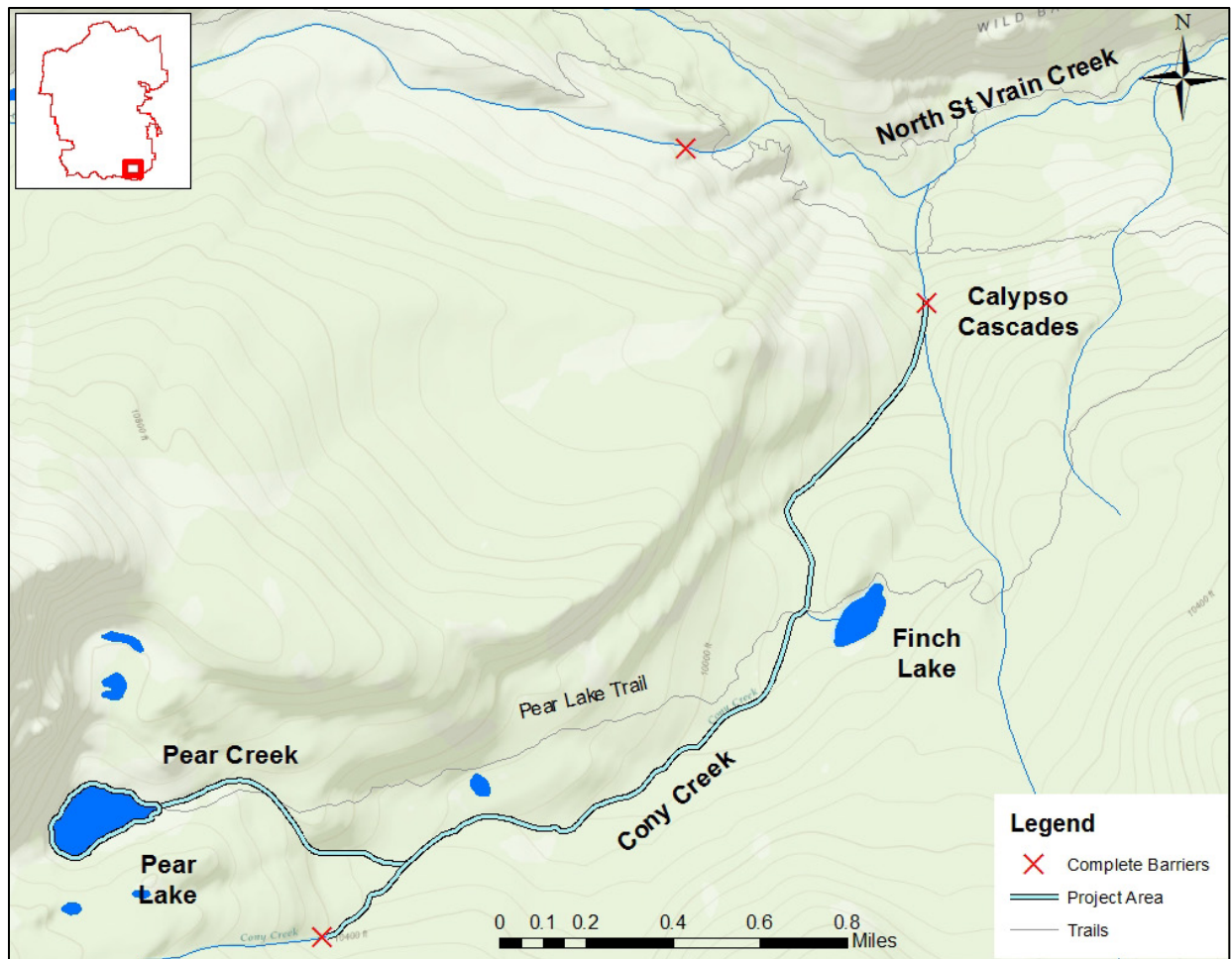


Figure A-38. Pear Lake Restoration Project.

Sandbeach Lake Restoration Project

Waters Included: Sandbeach Lake, Sandbeach Creek

Parameter Scoring

Table A-108. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	3.38	6.68	2.99	green cutthroat	unknown	yes	–
Score	4	1	1	2	1	1	2	12

Table A-109. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	3.38	6.68	2.99	13.61	13.40	1200–2500	yes	–
Score	4	1	1	1	4	4	3	0	18

Table A-110. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	2.0	n/a	n/a	47.0	0

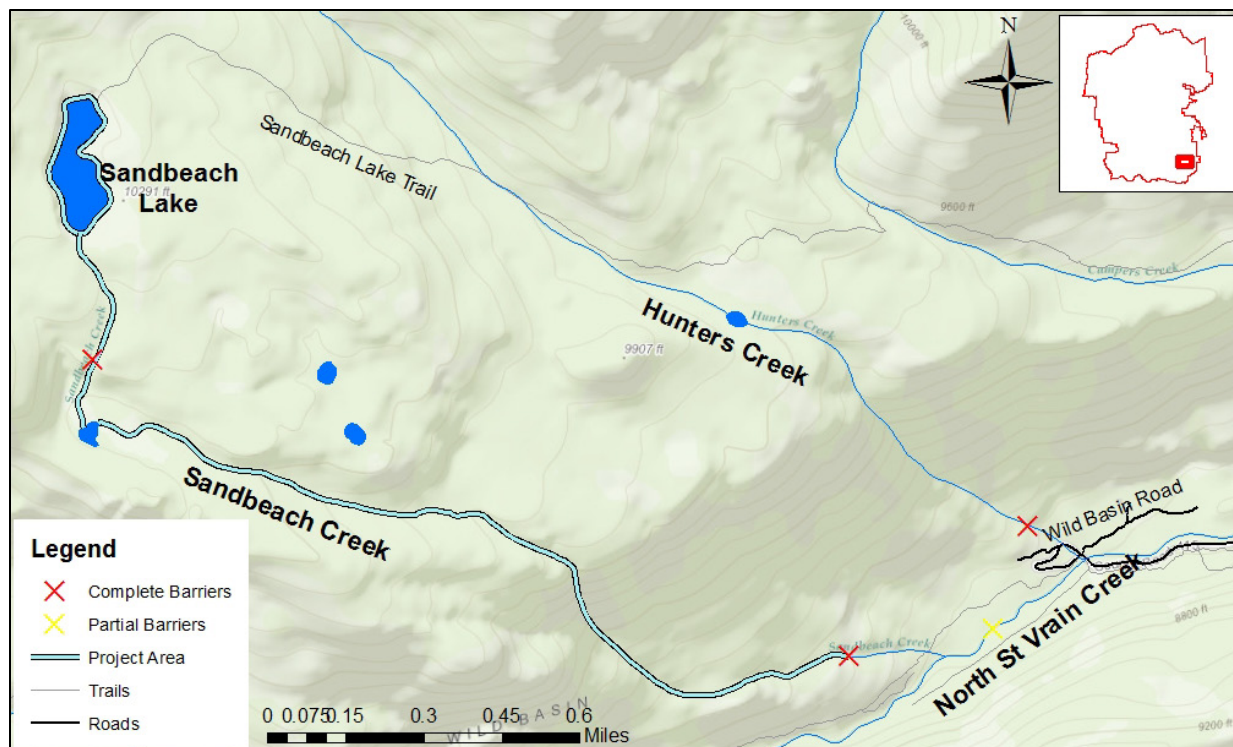


Figure A-39. Sandbeach Lake Restoration Project.

Upper North St. Vrain Creek Restoration Project

Waters Included: North St. Vrain Creek, Lion Lakes Stream, Ouzel Creek, Cony Creek, Sandbeach Creek

Parameter Scoring

Table A-111. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	partial	9.91	0.0	64.30	brook trout	unknown	yes	–
Score	2	0	2	1	2	1	2	10

Table A-112. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	partial	9.91	0.0	64.30	11.96	12.63	>2500	yes	–
Score	2	2	0	2	4	4	4	0	18

Table A-113. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	8

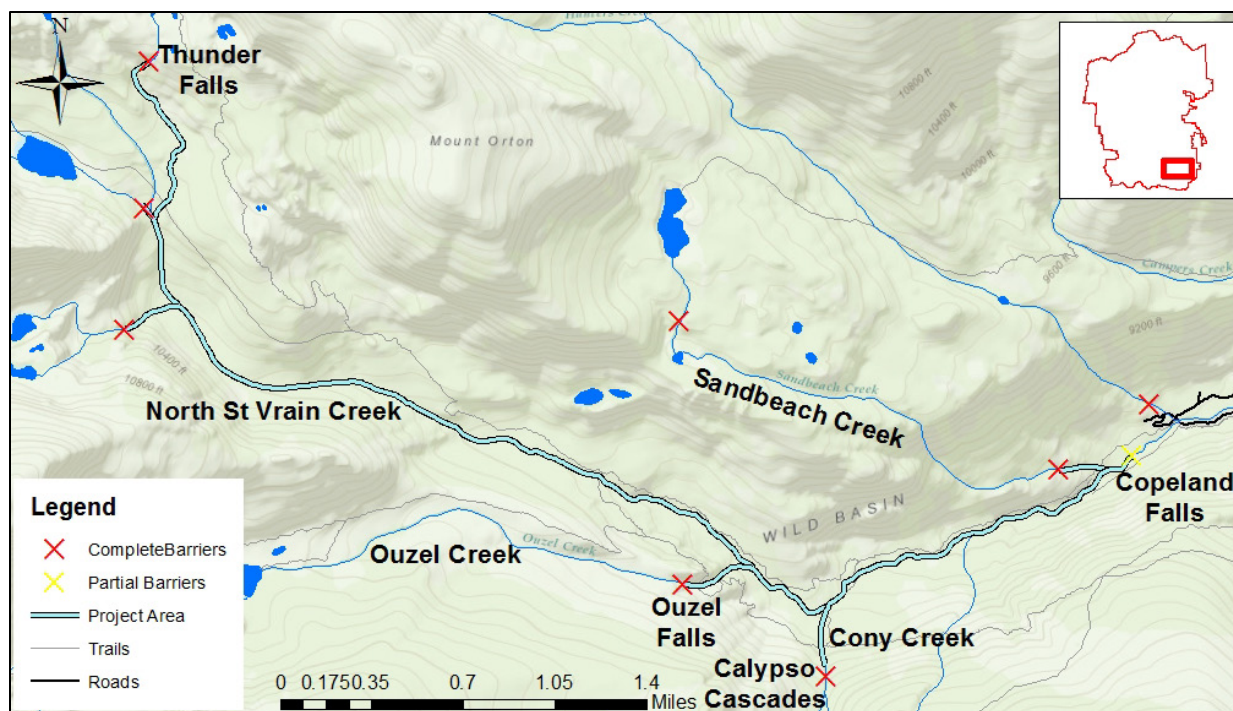


Figure A-40. Upper North St. Vrain Creek Restoration Project.

Hunters Creek Restoration Project

Waters Included: Hunters Creek

Parameter Scoring

Table A-114. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	2.90	0.0	11.52	blue cutthroat	none	yes	–
Score	4	1	2	2	1	2	2	14

Table A-115. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	2.90	0.0	11.52	8.89	9.85	1200–2500	yes	–
Score	4	1	0	1	2	4	3	0	15

Table A-116. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	3.1	n/a	n/a	55.0	0

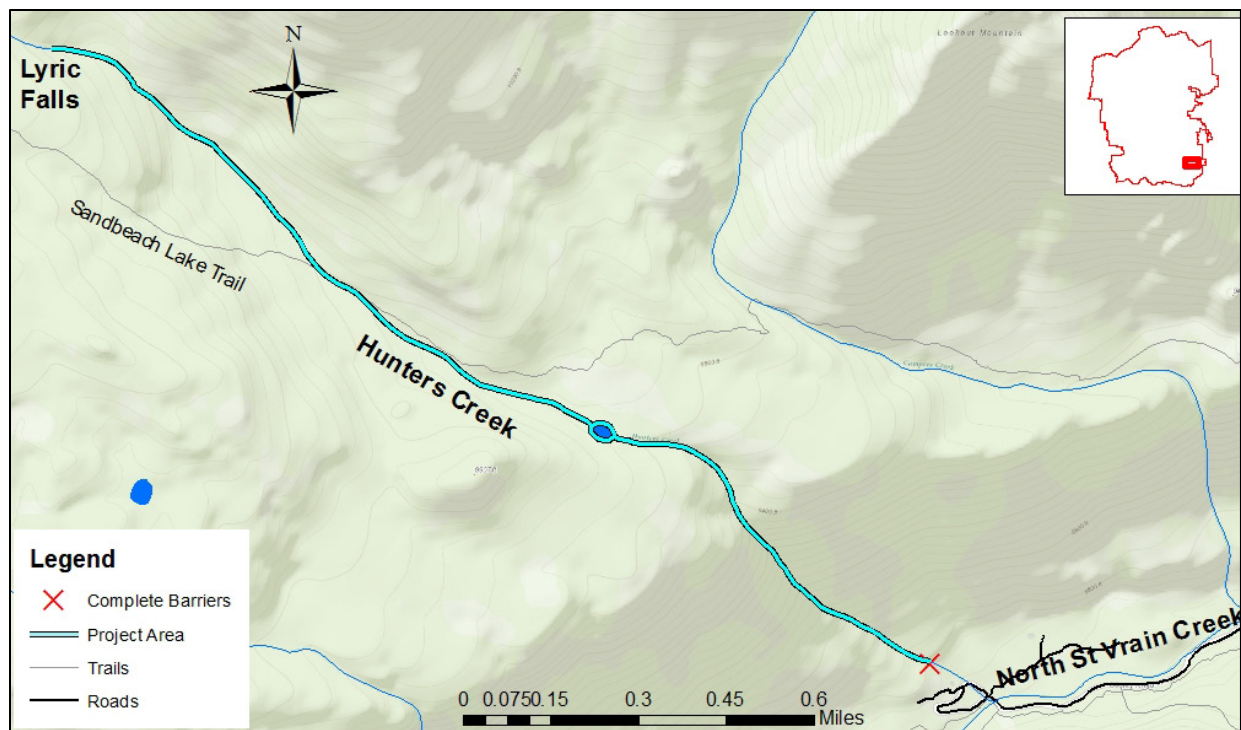


Figure A-41. Hunters Creek Restoration Project.

Cony Creek Sub-drainage

Restoration Projects Included: Upper Hutcheson Lake, Middle Hutcheson Lake, Lower Hutcheson Lake, Pear Lake

Parameter Scoring

Table A-117. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	9.14	12.42	18.42	green cutthroat	unknown	yes	–
Score	4	1	0	1	1	1	2	10

Table A-118. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	9.14	12.42	18.42	11.20	11.58	>2500	yes	–
Score	4	1	2	2	4	4	4	0	21

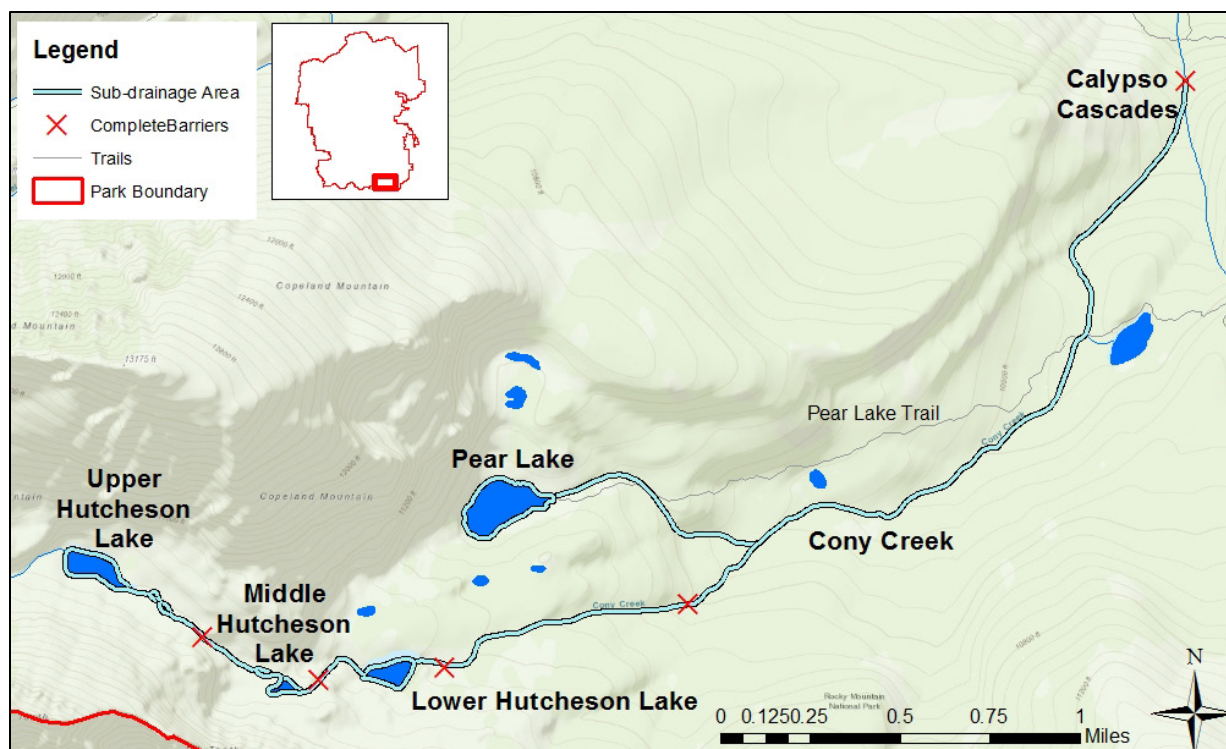


Figure A-42. Cony Creek Sub-drainage.

Upper North St. Vrain Creek Sub-drainage

Restoration Projects Included: Thunder Lake, Box Lake, Ouzel Lake, Sandbeach Lake, Upper North St. Vrain Creek

Parameter Scoring

Table A-119. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	partial	18.29	18.54	64.30	blue/green cutthroat	BKD	yes	–
Score	2	0	0	1	1	1	2	7

Table A-120. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	partial	18.29	18.54	64.30	11.89	12.42	>2500	yes	–
Score	2	2	2	2	4	4	4	0	20

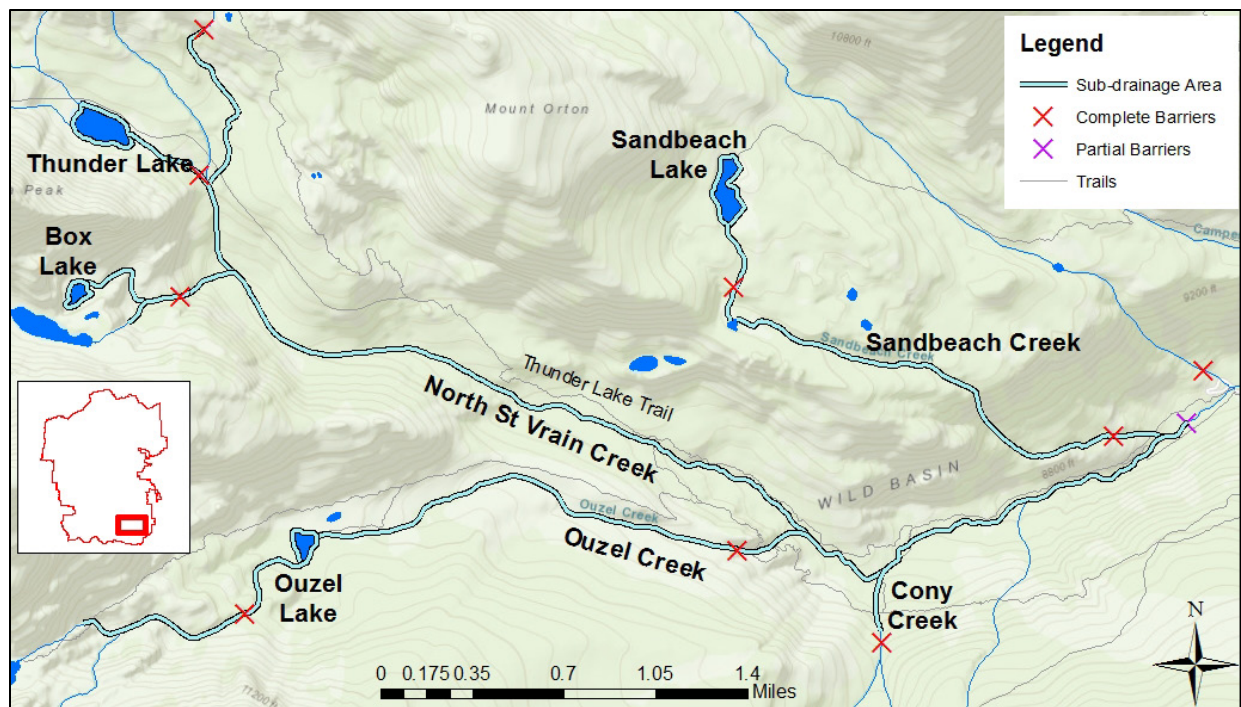


Figure A-43. Upper North St. Vrain Creek Sub-drainage.

Drainages West of the Continental Divide

Upper Colorado River

Timber Lake Restoration Project

Water Included: Timber Lake, Timber Creek

Parameter Scoring

Table A-121. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	4.18	4.09	10.14	green cutthroat	unknown	yes	–
Score	4	1	1	2	0	1	2	11

Table A-122. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	4.18	4.09	10.14	11.95	12.16	1200–2500	yes	–
Score	4	1	1	1	4	4	3	0	18

Table A-123. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	3.0	n/a	n/a	28.8	0

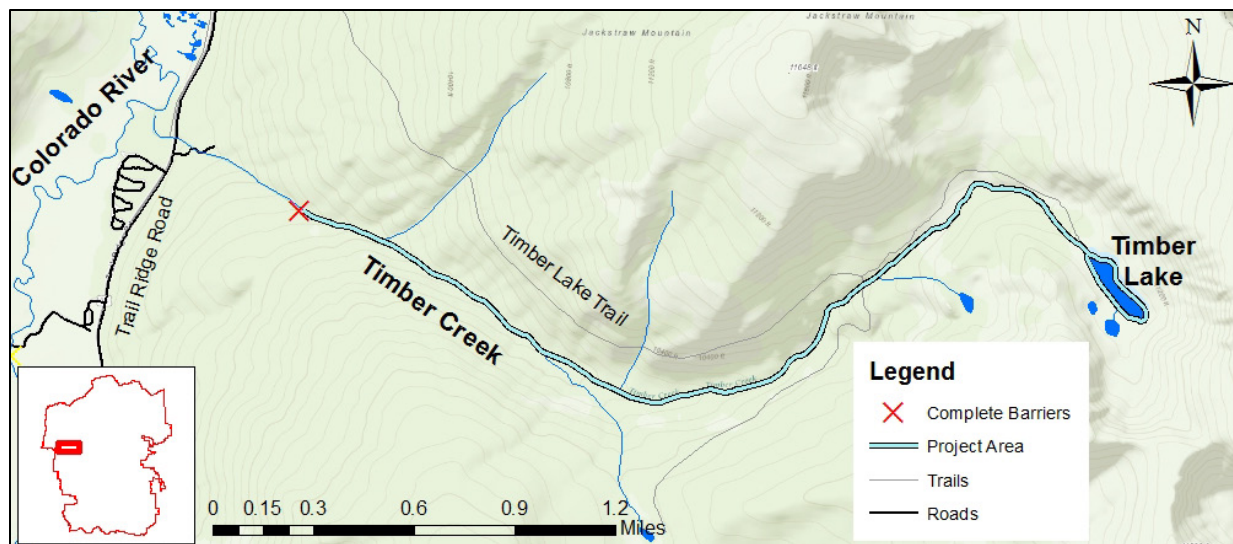


Figure A-44. Timber Lake Restoration Project.

Upper Colorado River Restoration Project

Waters Included: Colorado River, Beaver Creek, Timber Creek

Parameter Scoring

Table A-124. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	partial	22.92	0.0	96.78	brook/ brown trout	BKD/WD	yes	–
Score	2	0	2	1	2	0	2	9

Table A-125. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	partial	22.92	0.0	96.78	9.95	13.33	>2500	yes	–
Score	2	2	0	2	4	4	4	0	18

Table A-126. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	5.5	n/a	n/a	94.0	0

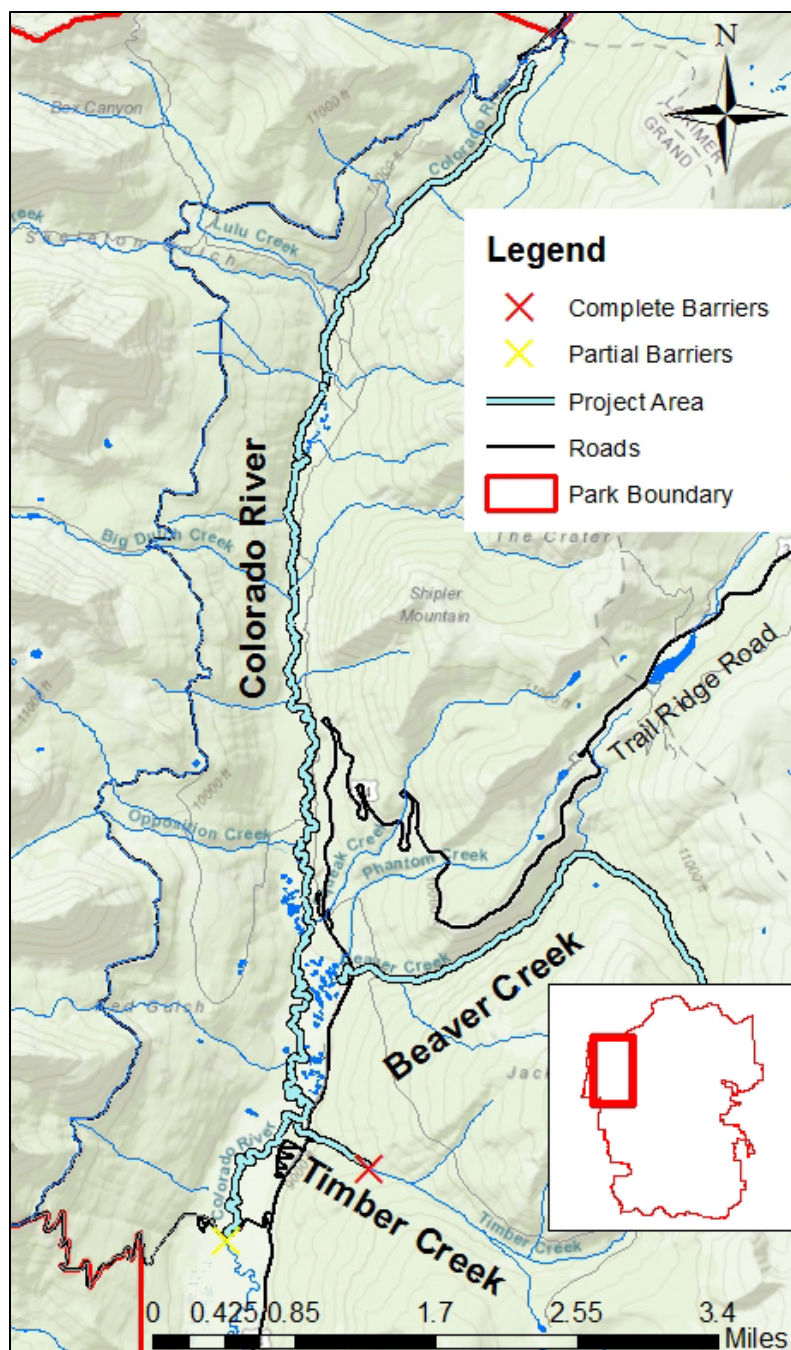


Figure A-45. Upper Colorado River Restoration Project.

Onahu Creek Restoration Project

Waters Include: Onahu Creek

Parameter Scoring

Table A-127. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	7.00	0.0	22.87	brook/ blue cutthroat	unknown	yes	–
Score	4	1	2	1	1	1	2	12

Table A-128. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	7.00	0.0	22.87	10.58	11.19	>2500	yes	–
Score	4	1	0	2	4	4	4	0	19

Table A-129. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	1.8	n/a	n/a	144.0	0

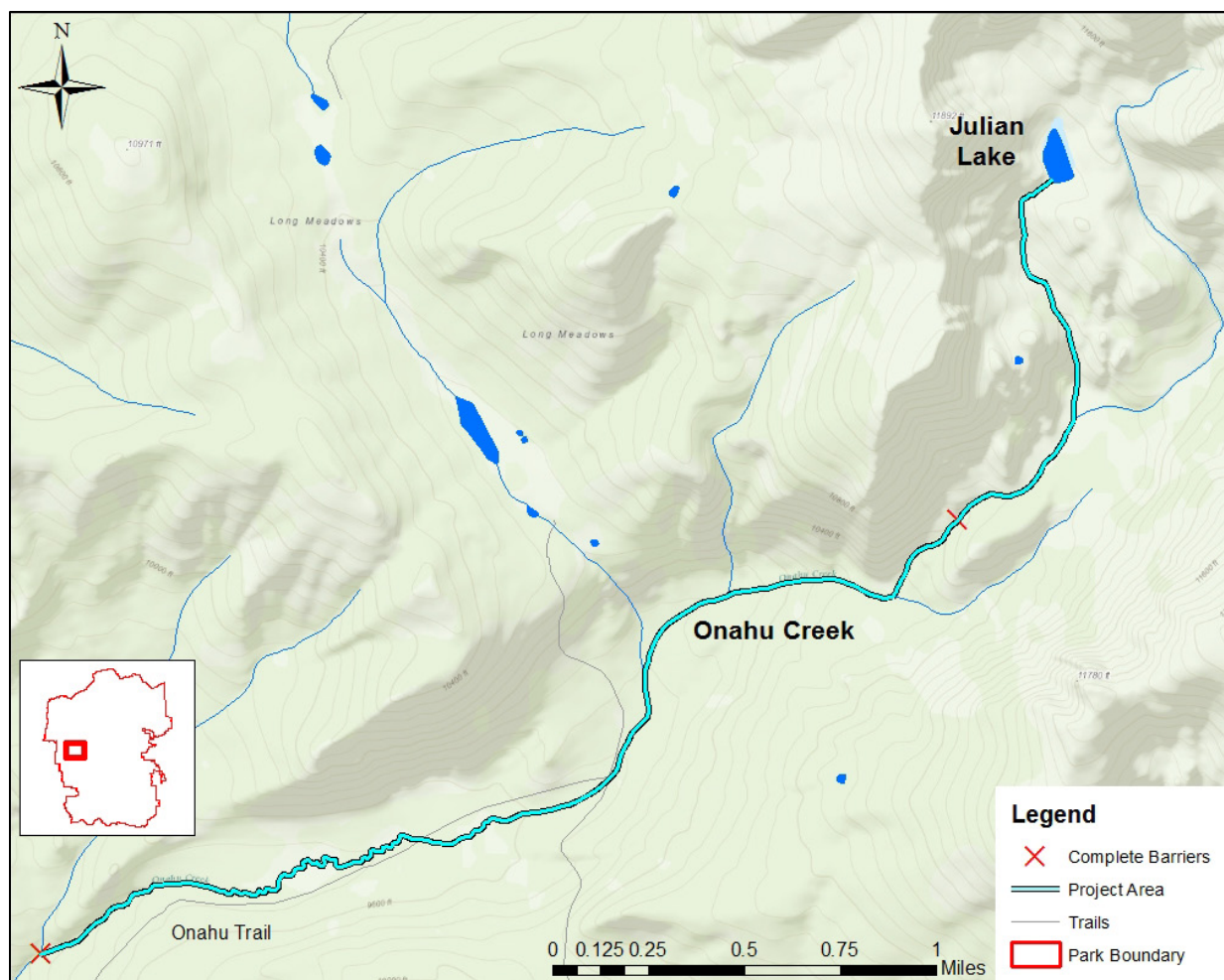


Figure A-46. Onahu Creek Restoration Project.

Upper Colorado River Sub-drainage

Restoration Projects Included: Timber Lake, Upper Colorado River

Parameter Scoring

Table A-130. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	partial	27.10	4.09	96.78	green cutthroat	BKD / WD	yes	–
Score	2	0	1	1	0	0	2	6

Table A-131. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	partial	27.10	4.09	96.78	11.88	12.75	>2500	yes	–
Score	2	2	1	2	4	4	4	0	19

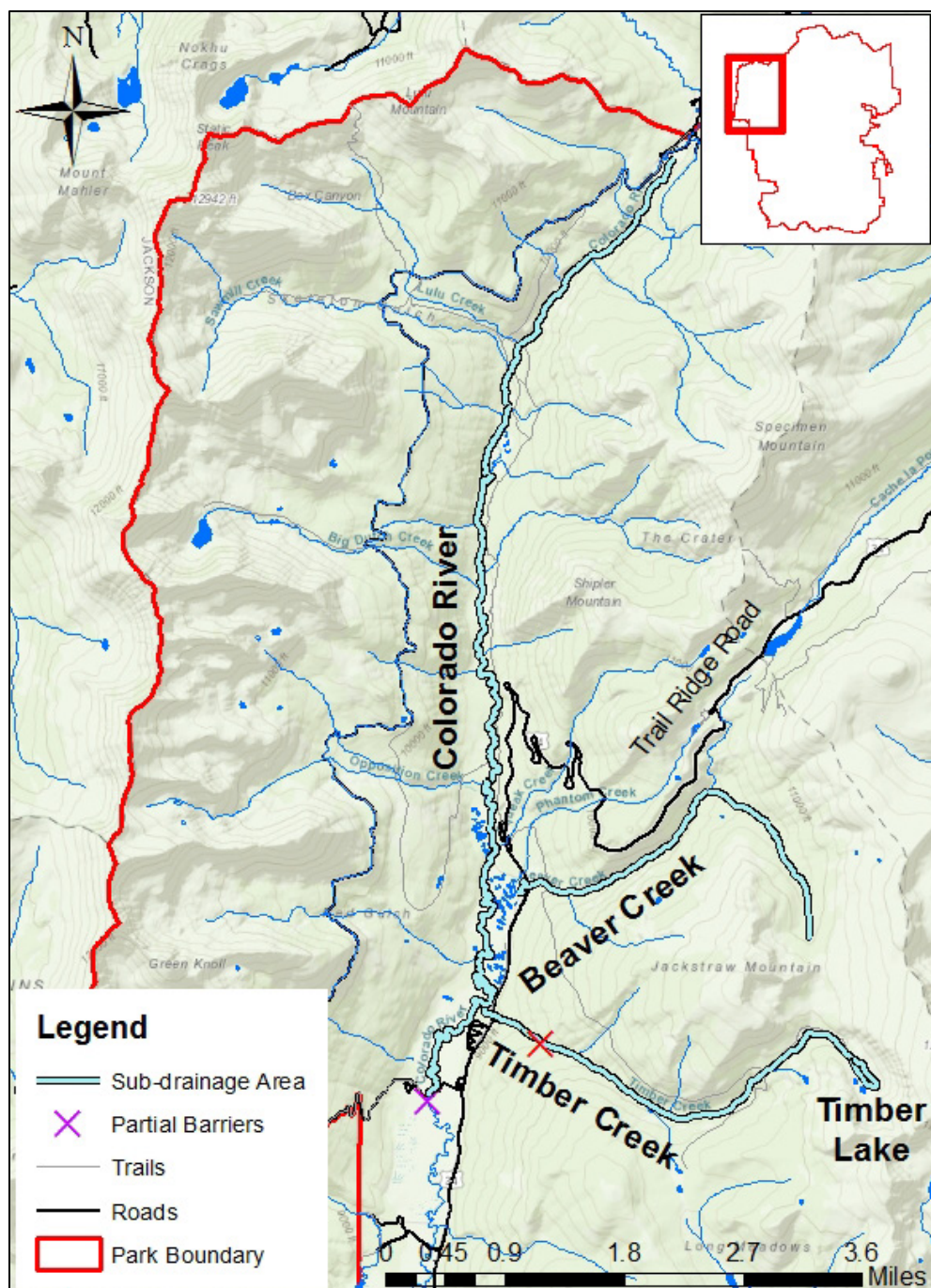


Figure A-47. Upper Colorado River Sub-drainage.

Tonahutu Creek

Haynach Lakes Restoration Project

Waters Included: Haynach Lakes, Tonahutu Creek

Parameter Scoring

Table A-132. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	4.66	2.59	16.55	Yellowstone cutthroat	BKD	yes	–
Score	4	1	1	1	2	1	2	12

Table A-133. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	4.66	2.59	16.55	10.10	11.00	250–1199	yes	–
Score	4	1	1	2	4	4	2	0	18

Table A-134. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	3.1	58	n/a	52.0	0

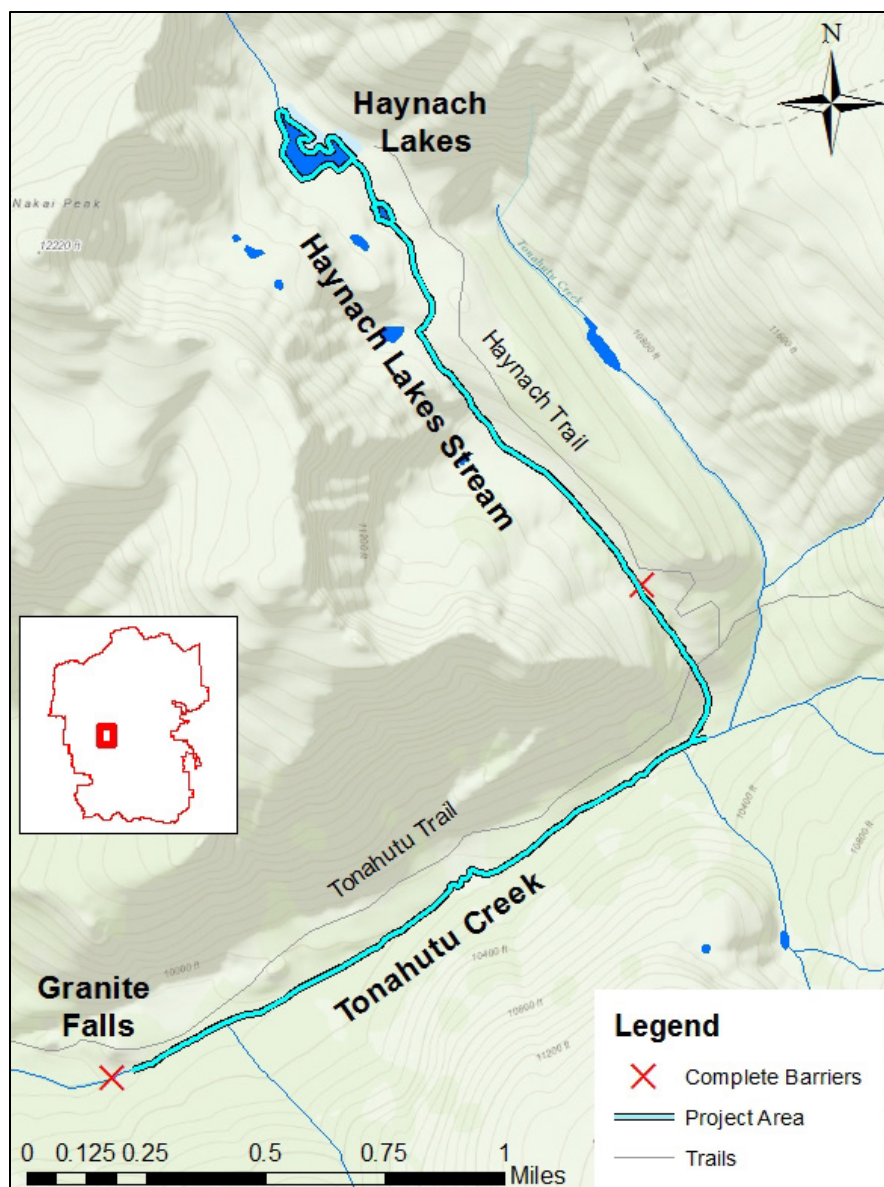


Figure A-48. Haynach Lakes Restoration Project.

North Inlet

Lake Nanita Restoration Project

Waters Included: Lake Nanita, unnamed creek

Parameter Scoring

Table A-135. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.24	13.76	3.13	blue cutthroat	none	yes	–
Score	4	2	0	2	1	2	2	13

Table A-136. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.24	13.76	3.13	13.78	13.97	>2500	yes	–
Score	4	0	2	1	4	4	4	0	19

Table A-137. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	70.4	0

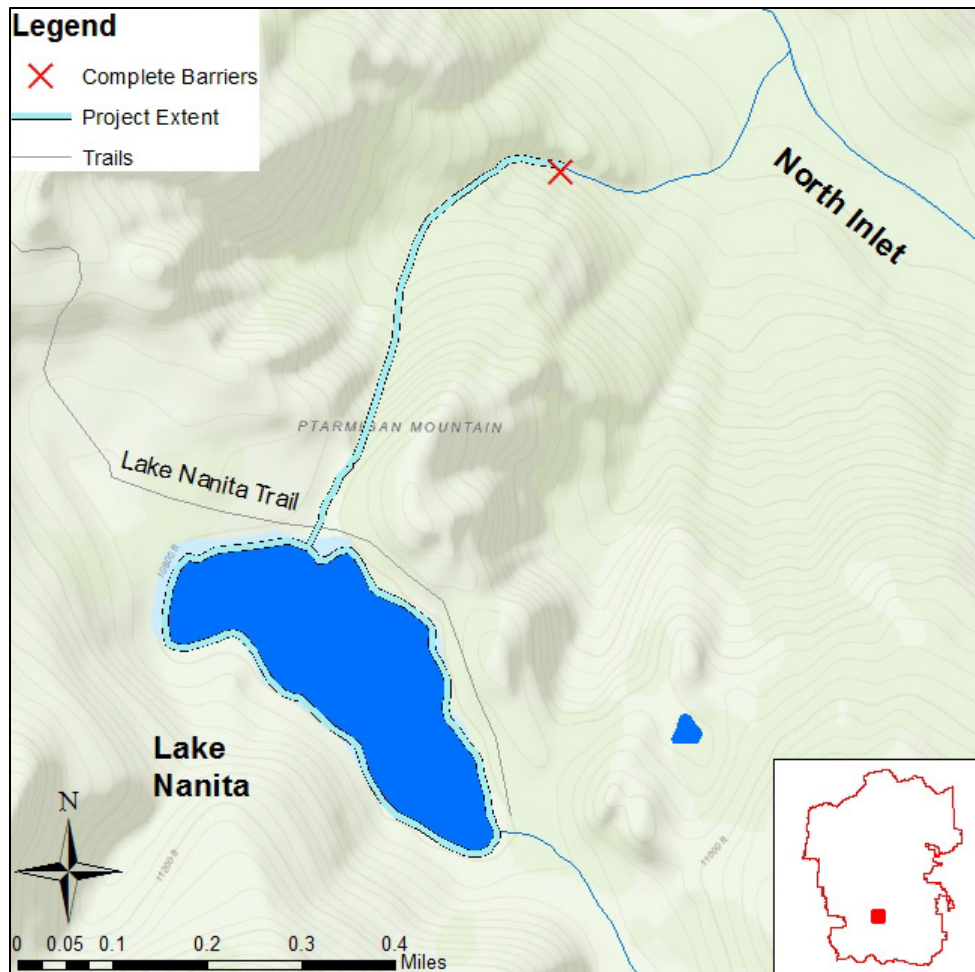


Figure A-49. Lake Nanita Restoration Project.

Upper North Inlet Restoration Project
Waters Included: North Inlet, Lake Solitude

Parameter Scoring

Table A-138. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	3.70	2.99	29.43	blue cutthroat	unknown	yes	–
Score	4	1	1	1	1	1	2	11

Table A-139. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	3.70	2.99	29.43	10.66	12.09	>2500	yes	–
Score	4	1	1	2	4	4	4	0	20

Table A-140. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	5.3	11	n/a	83.0	1

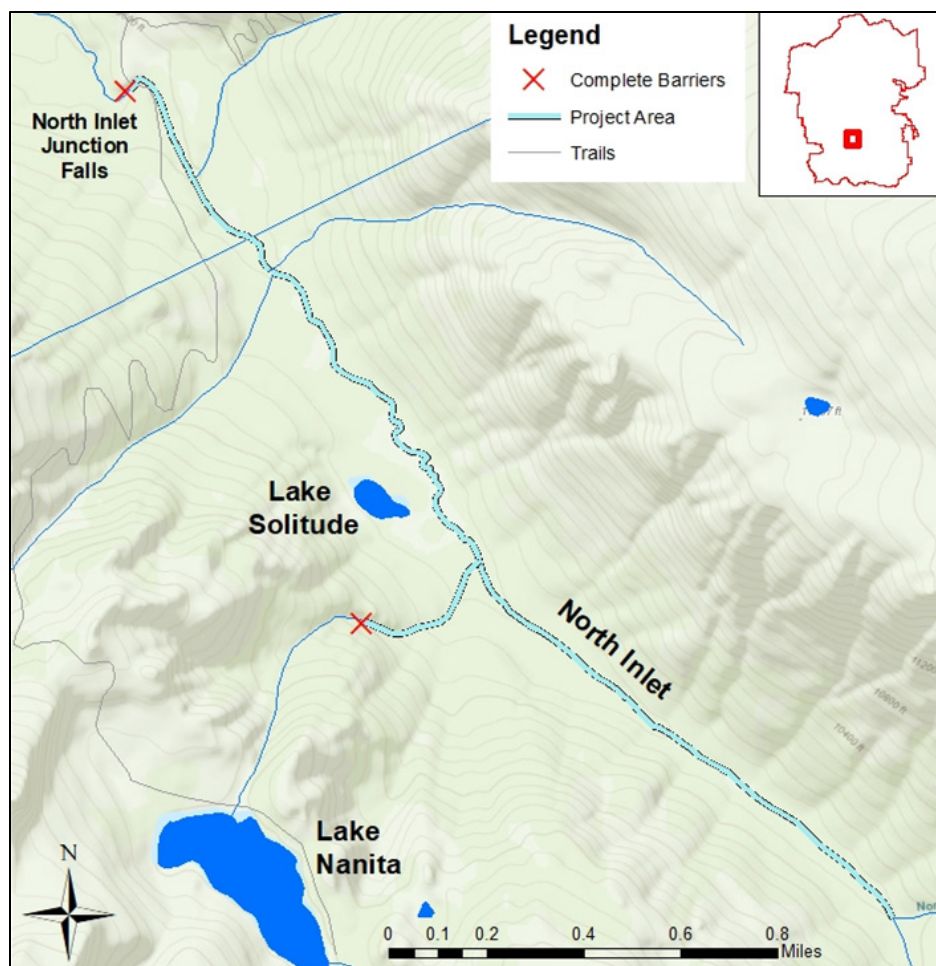


Figure A-50. Upper North Inlet Restoration Project.

Bench Lake Restoration Project

Waters Included: Bench Lake, Ptarmigan Creek

Parameter Scoring

Table A-141. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	1.93	2.59	9.74	blue cutthroat	none	no	–
Score	4	2	1	2	1	2	0	12

Table A-142. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	1.93	2.59	9.74	10.70	12.29	1200–2500	no	–
Score	4	0	1	1	4	4	3	2	19

Table A-143. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	3.4	19	n/a	138	0

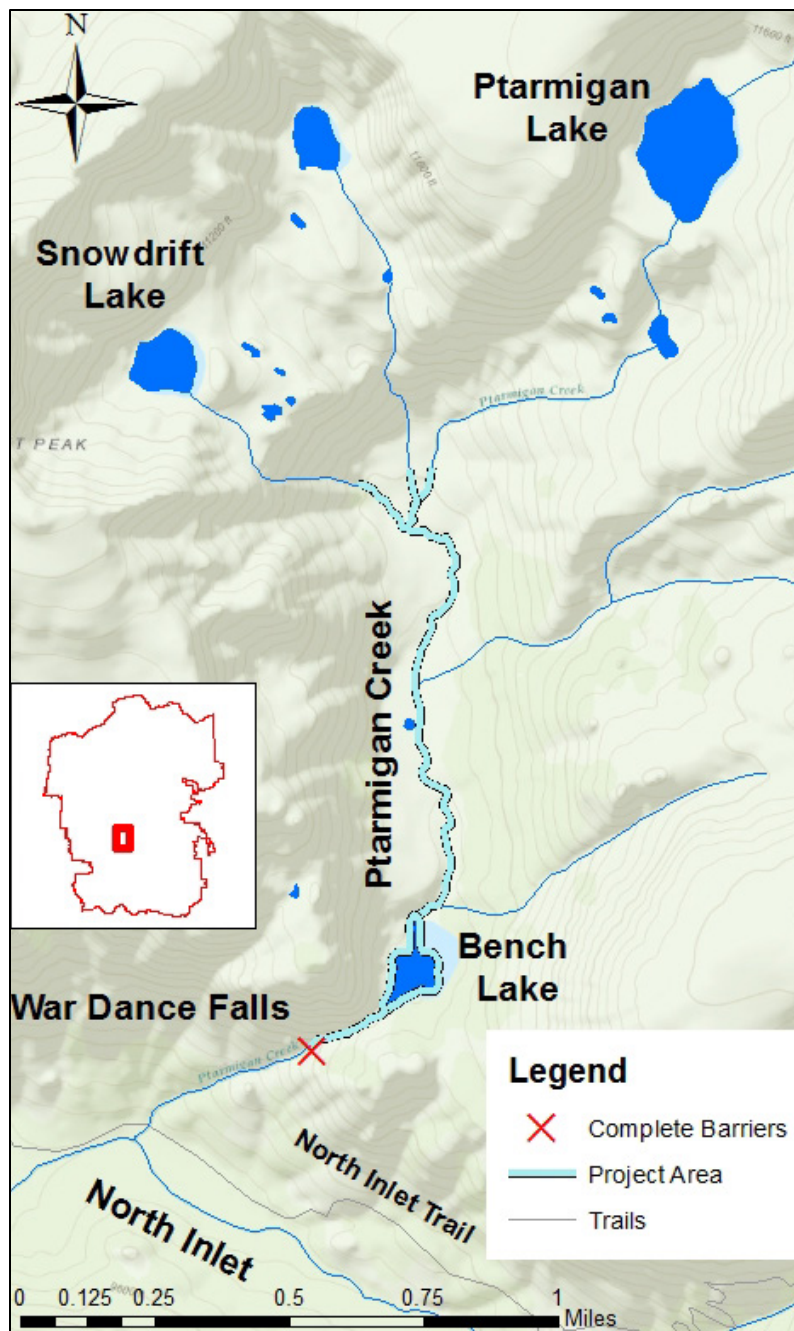


Figure A-51. Bench Lake Restoration Project

Pettingell Lake Restoration Project

Water Included: Pettingell Lake, unnamed creek

Parameter Scoring

Table A-144. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.80	4.09	1.58	blue cutthroat	unknown	no	–
Score	4	2	1	2	1	1	0	11

Table A-145. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.80	4.09	1.58	14.22	13.41	1200–2500	no	–
Score	4	0	1	1	4	4	3	2	19

Table A-146. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	143	n/a	n/a	0

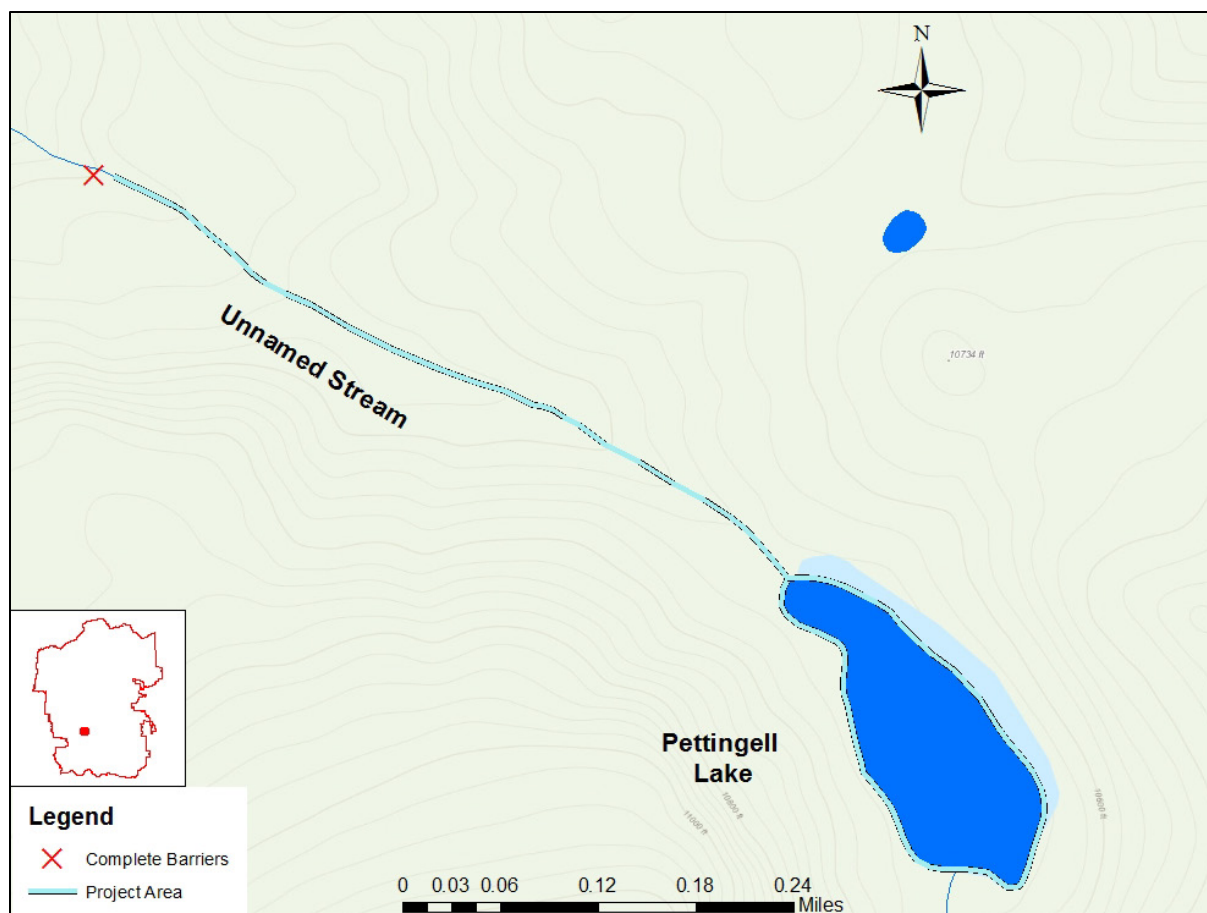


Figure A-52. Pettingell Lake Restoration Project.

Middle North Inlet Restoration Project

Waters Included: North Inlet, Ptarmigan Creek, unnamed creek

Parameter Scoring

Table A-147. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	6.44	0.0	60.14	brook trout	unknown	yes	–
Score	4	1	2	1	2	1	2	13

Table A-148. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	6.44	0.0	60.44	12.20	13.61	>2500	yes	–
Score	4	1	0	2	4	4	4	0	19

Table A-149. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	4

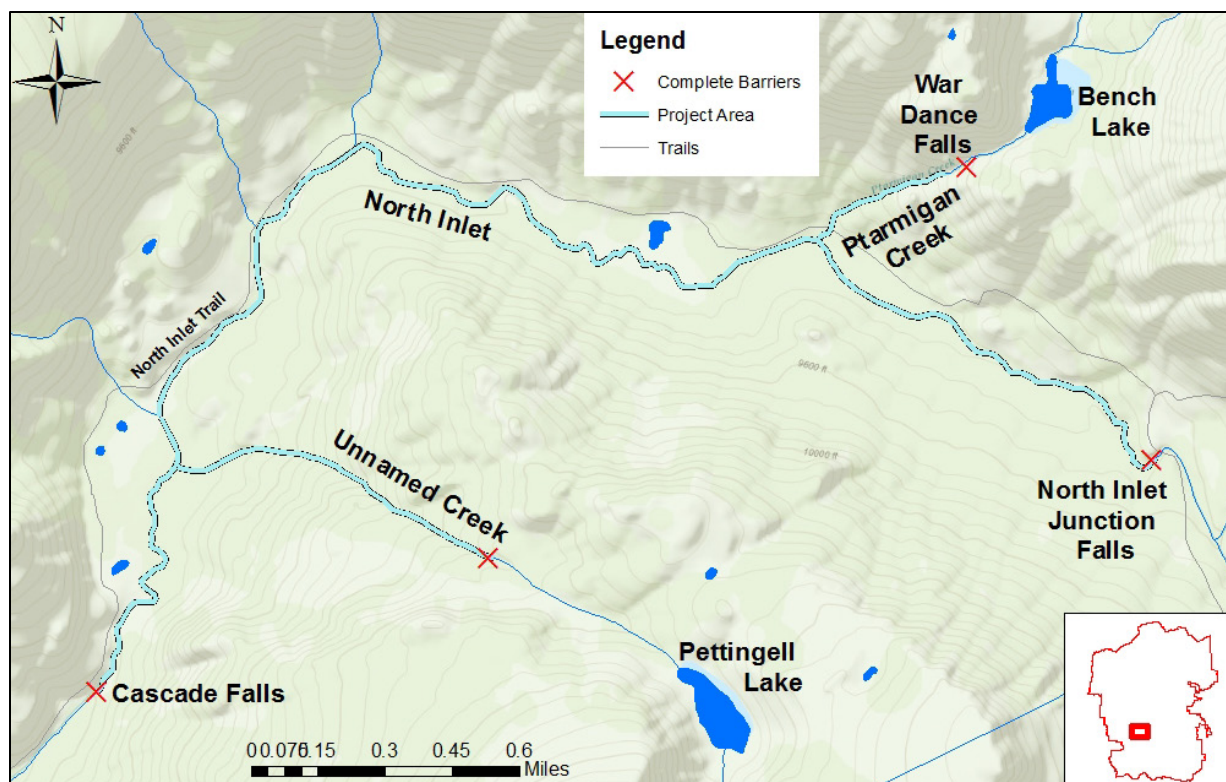


Figure A-53. Middle North Inlet Restoration Project.

Upper North Inlet Sub-drainage

Restoration Projects Included: Lake Nanita, Upper North Inlet

Parameter Scoring

Table A-150. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	3.94	16.75	29.43	blue cutthroat	unknown	yes	–
Score	4	1	0	1	1	1	2	10

Table A-151. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	3.94	16.75	29.43	12.22	13.03	>2500	yes	–
Score	4	1	2	2	4	4	4	0	21

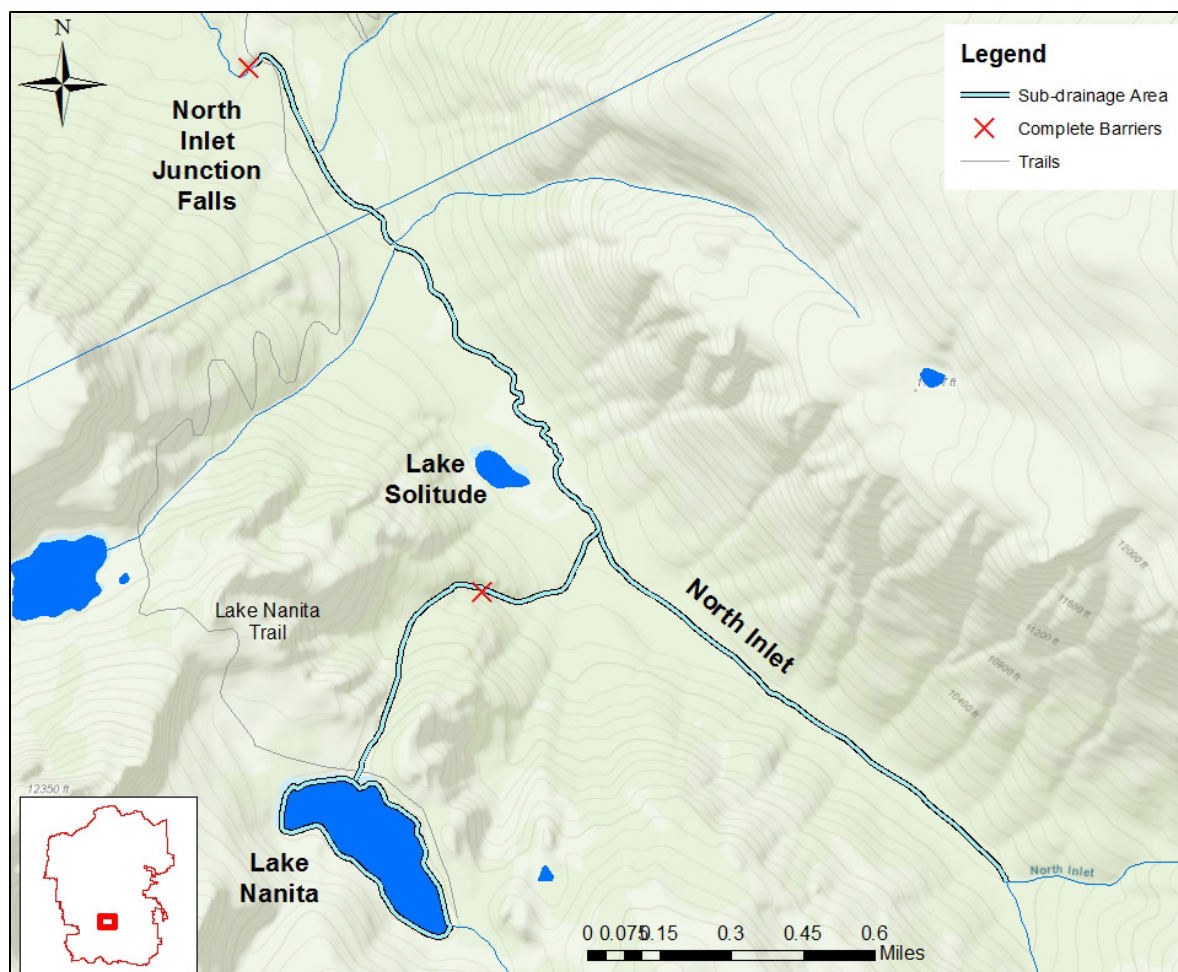


Figure A-54. Upper North Inlet Sub-drainage

Middle North Inlet Sub-drainage

Restoration Projects Included: Bench Lake, Pettingell Lake, Middle North Inlet

Parameter Scoring

Table A-152. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	9.17	6.68	60.14	blue cutthroat	unknown	no	–
Score	4	1	1	1	1	1	0	9

Table A-153. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	9.17	6.68	60.14	12.37	13.10	>2500	no	–
Score	4	1	1	2	4	4	4	2	22

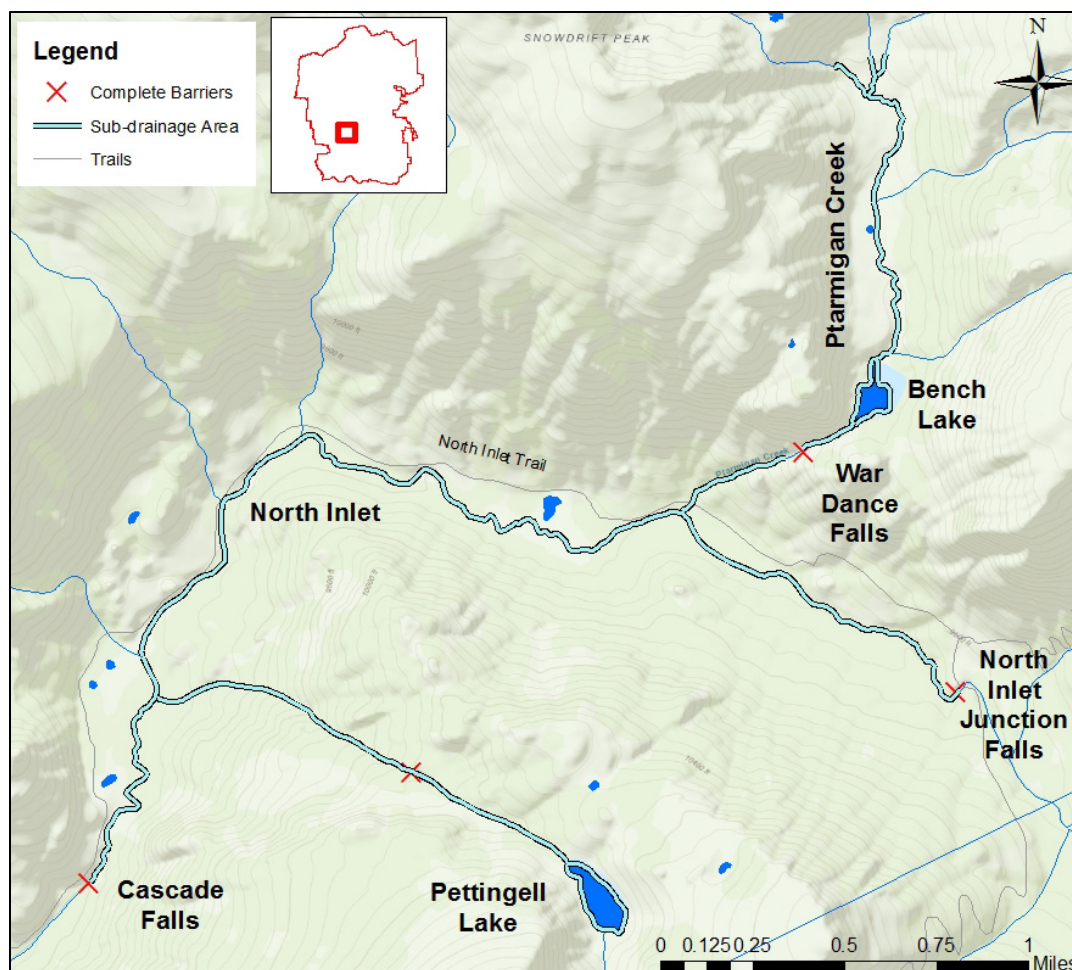


Figure A-55. Middle North Inlet Sub-drainage.

East Inlet

Fifth Lake Restoration Project

Waters Included: Fifth Lake, East Inlet

Parameter Scoring

Table A-154. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.16	2.99	2.03	blue cutthroat	unknown	no	–
Score	4	2	1	2	1	1	0	11

Table A-155. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.16	2.99	2.03	10.01	11.43	<250	no	–
Score	4	0	1	1	4	4	1	2	17

Table A-156. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	0

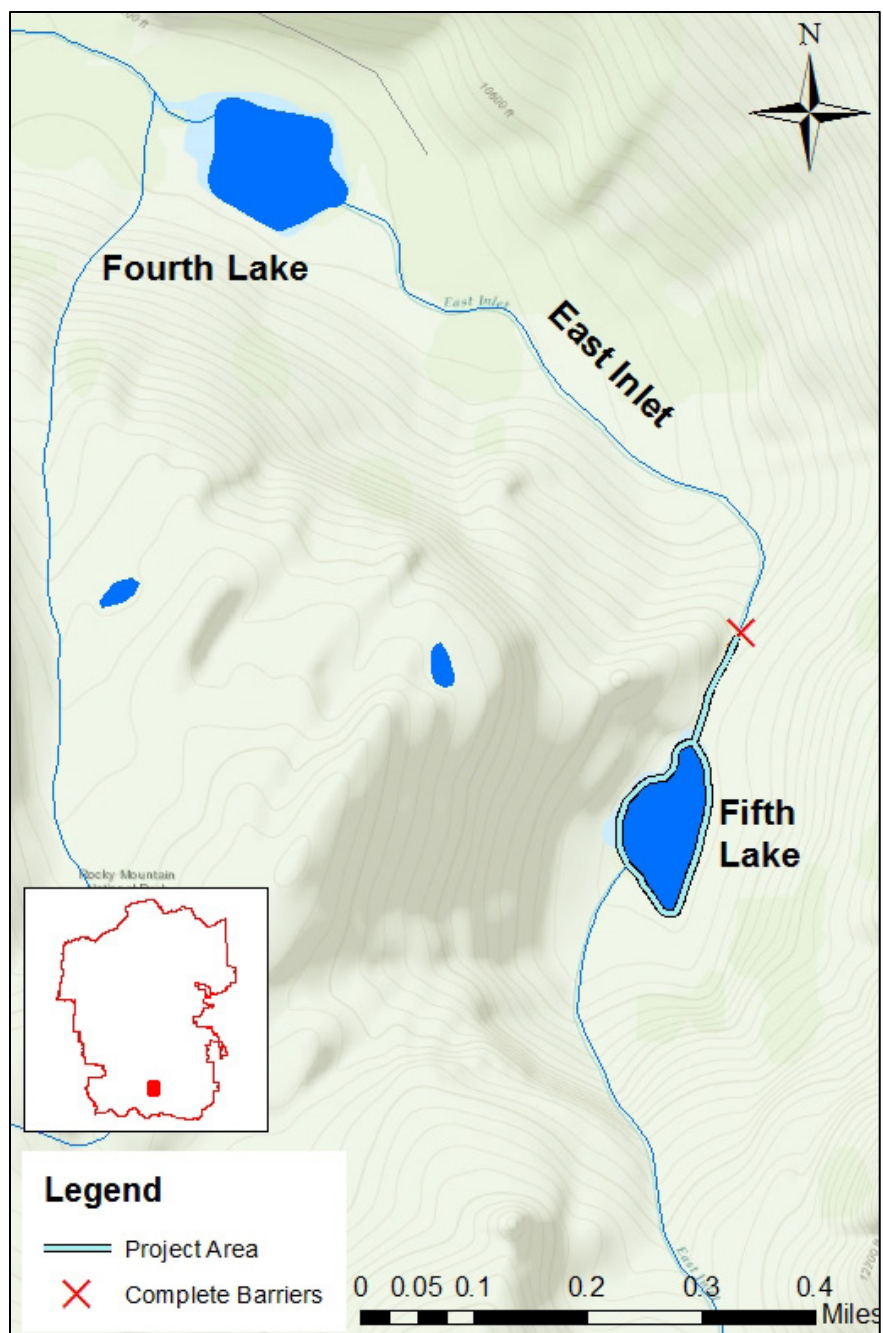


Figure A-56. Fifth Lake Restoration Project.

Upper East Inlet Restoration Project

Waters Included: East Inlet, Lake Verna, Spirit Lake, Fourth Lake

Parameter Scoring

Table A-157. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	3.30	23.84	15.02	brook trout	unknown	yes	–
Score	4	1	0	1	2	1	2	11

Table A-158. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	3.30	23.84	15.02	10.51	11.94	>2500	yes	–
Score	4	1	2	2	4	4	4	0	21

Table A-159. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	92 [^]	n/a	n/a	1

[^] Lake volume for Spirit Lake only. Does not include Lake Verna or Fourth Lake.

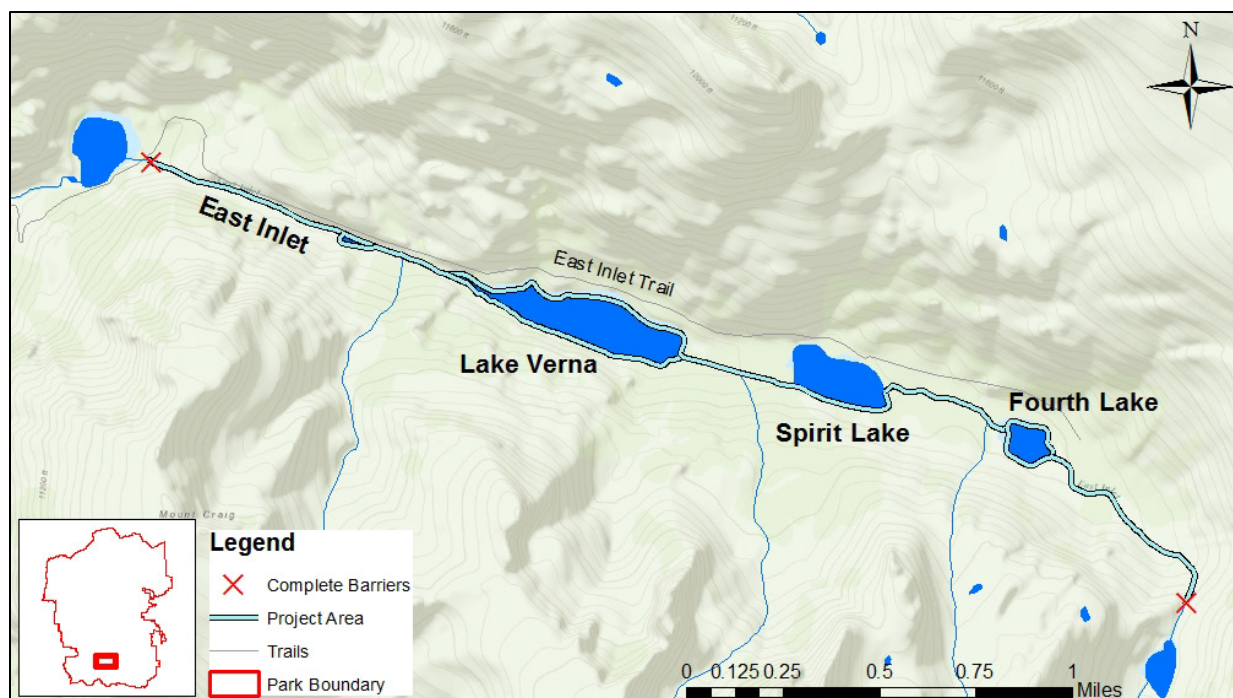


Figure A-57. Upper East Inlet Restoration Project.

Ten Lake Park Restoration Project

Waters Included: Ten Lake Park Lake

Parameter Scoring

Table A-160. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	0.0	4.94	<14.7	hybrid cutthroat	none	no	–
Score	4	2	1	2	2	2	0	13

Table A-161. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	0.0	4.94	<14.7	unknown	unknown	1200–2500	no	–
Score	4	0	1	1	0	0	3	2	11

Table A-162. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	0

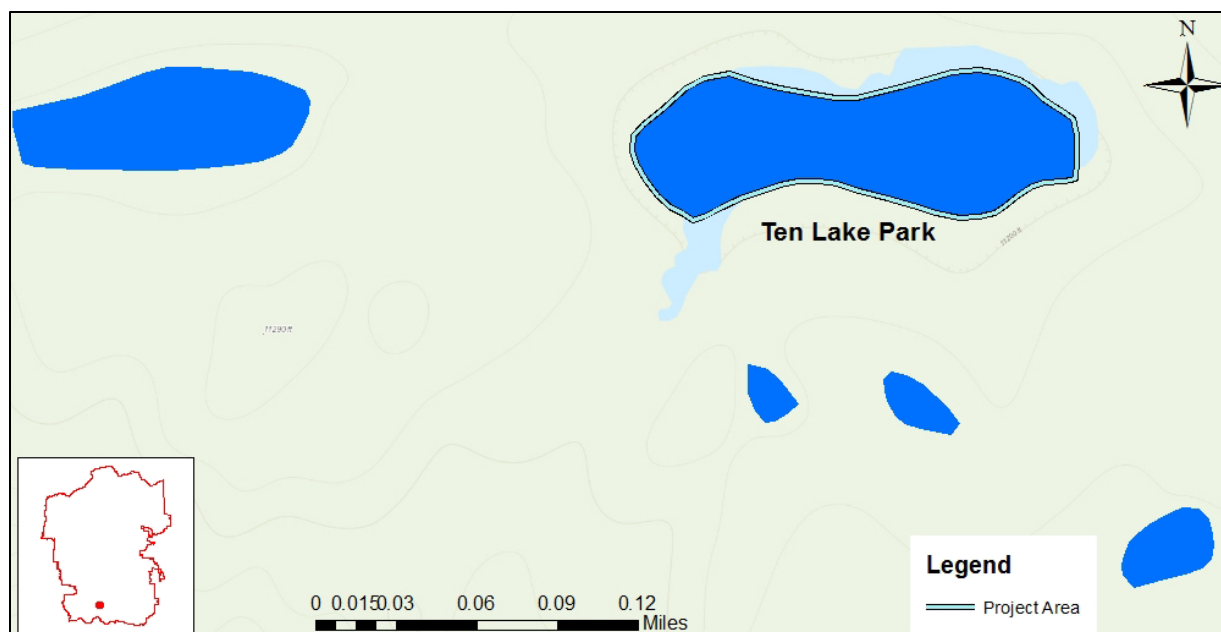


Figure A-58. Ten Lake Park Restoration Project.

Adams Lake Restoration Project

Waters Included: Adams Lake, unnamed creek

Parameter Scoring

Table A-163. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	1.80	1.86	1.96	blue cutthroat	unknown	no	–
Score	4	2	1	2	1	1	0	11

Table A-164. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	1.80	1.86	1.96	13.46	unknown	<250	no	–
Score	4	0	1	1	4	4	1	2	17

Table A-165. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	46	n/a	23.4	0

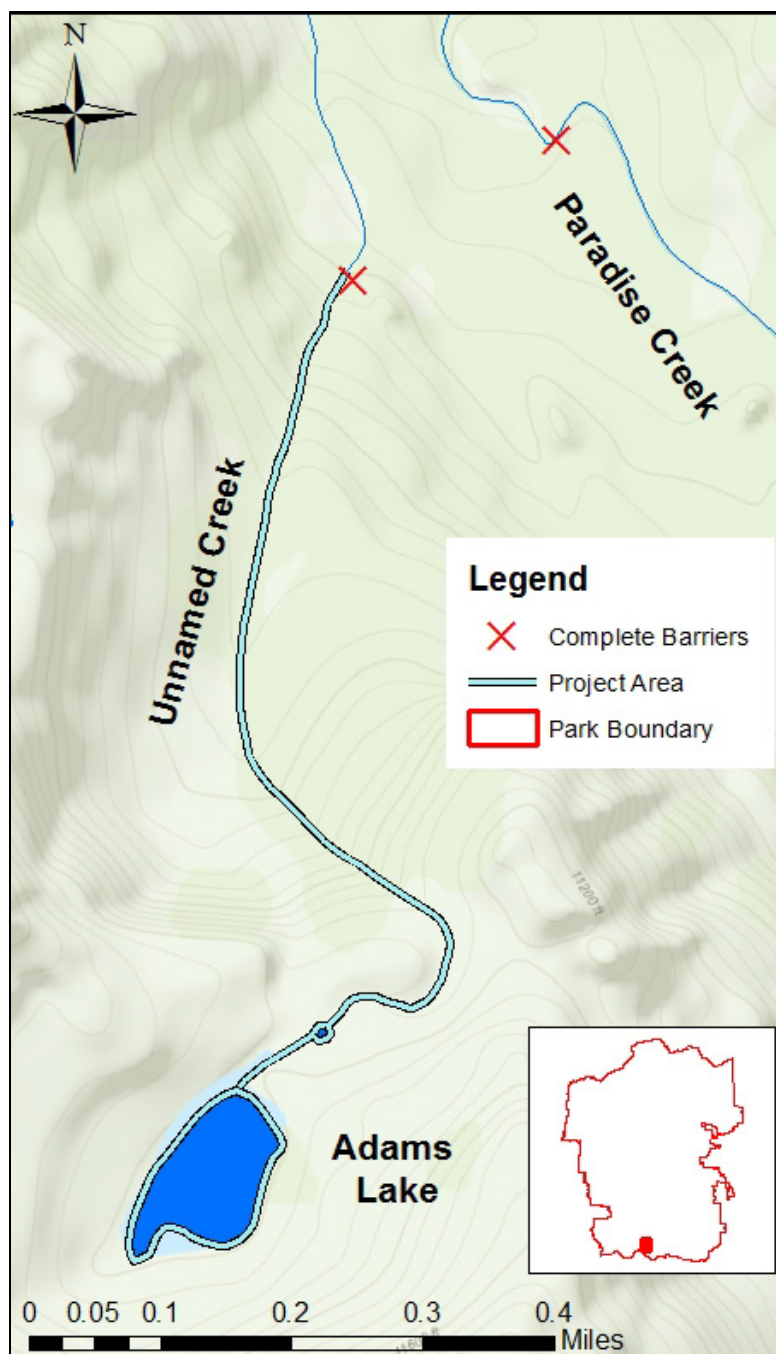


Figure A-59. Adams Lake Restoration Project.

Upper Paradise Creek Restoration Project
Waters Included: Paradise Creek

Parameter Scoring

Table A-166. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	6.12	0.0	22.82	hybrid/blue cutthroat	none	no	–
Score	4	1	2	1	1	2	0	11

Table A-167. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	6.12	0.0	22.82	11.16	12.05	>2500	no	–
Score	4	1	0	2	4	4	4	2	21

Table A-168. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	2

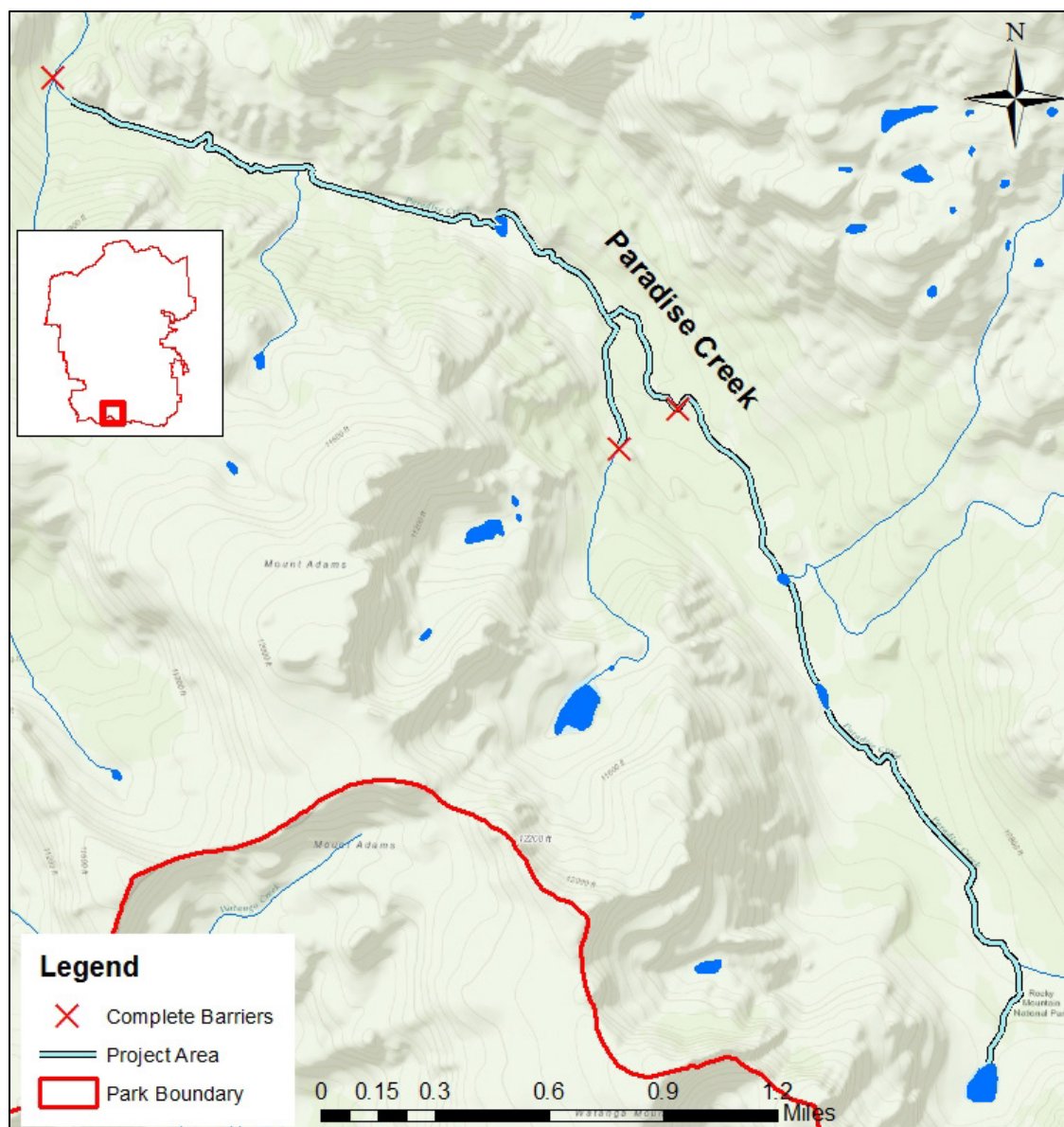


Figure A-60. Upper Paradise Creek Restoration Project.

Lower Paradise Creek Restoration Project

Waters Included: Paradise Creek

Parameter Scoring

Table A-167. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	1.93	0.0	29.31	blue cutthroat	unknown	no	–
Score	4	2	2	1	1	1	0	11

Table A-168. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	1.93	0.0	29.31	11.04	12.33	1200–2500	no	–
Score	4	0	0	2	4	4	3	2	19

Table A-169. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	47.0	3

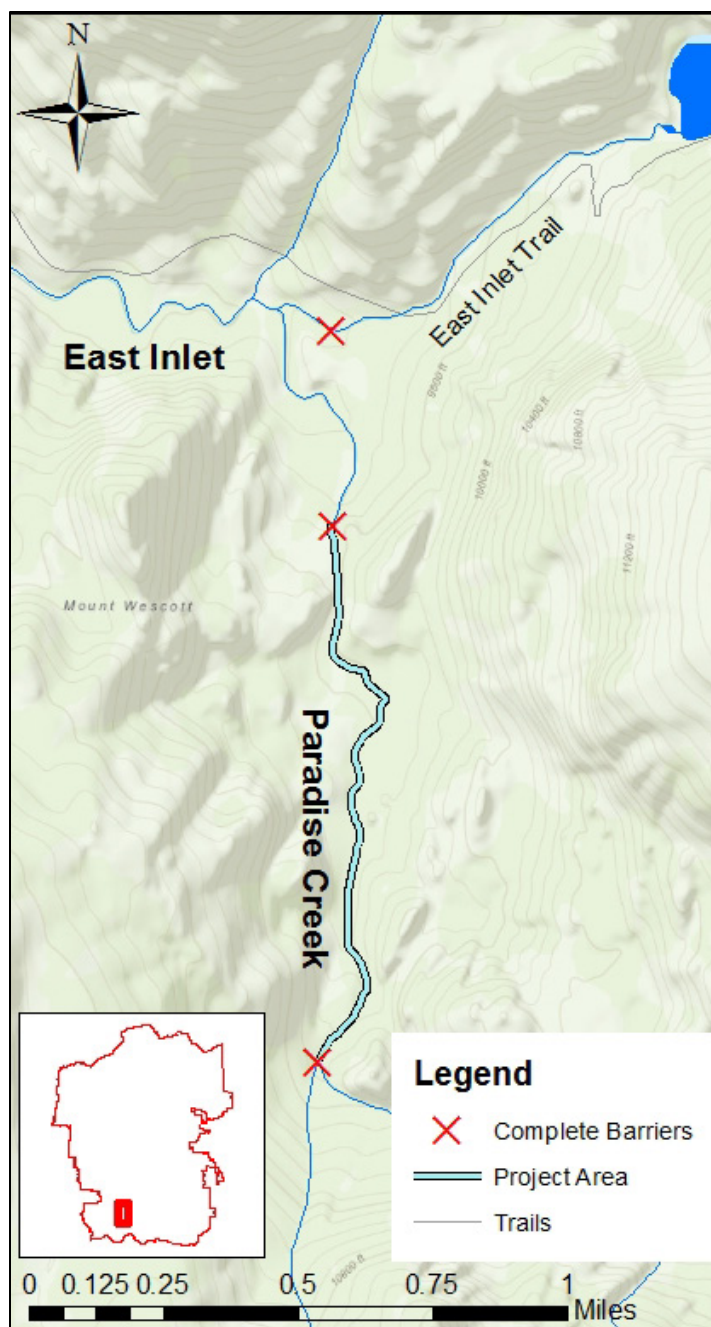


Figure A-61. Lower Paradise Creek Restoration Project.

Lone Pine Lake Restoration Project

Waters Included: Lone Pine Lake, East Inlet

Parameter Scoring

Table A-170. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	2.60	5.22	19.50	brook trout	unknown	yes	–
Score	4	2	1	1	2	1	2	13

Table A-171. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	2.60	5.22	19.50	14.24	13.10	250–1199	yes	–
Score	4	0	1	2	4	4	2	0	17

Table A-172. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	6

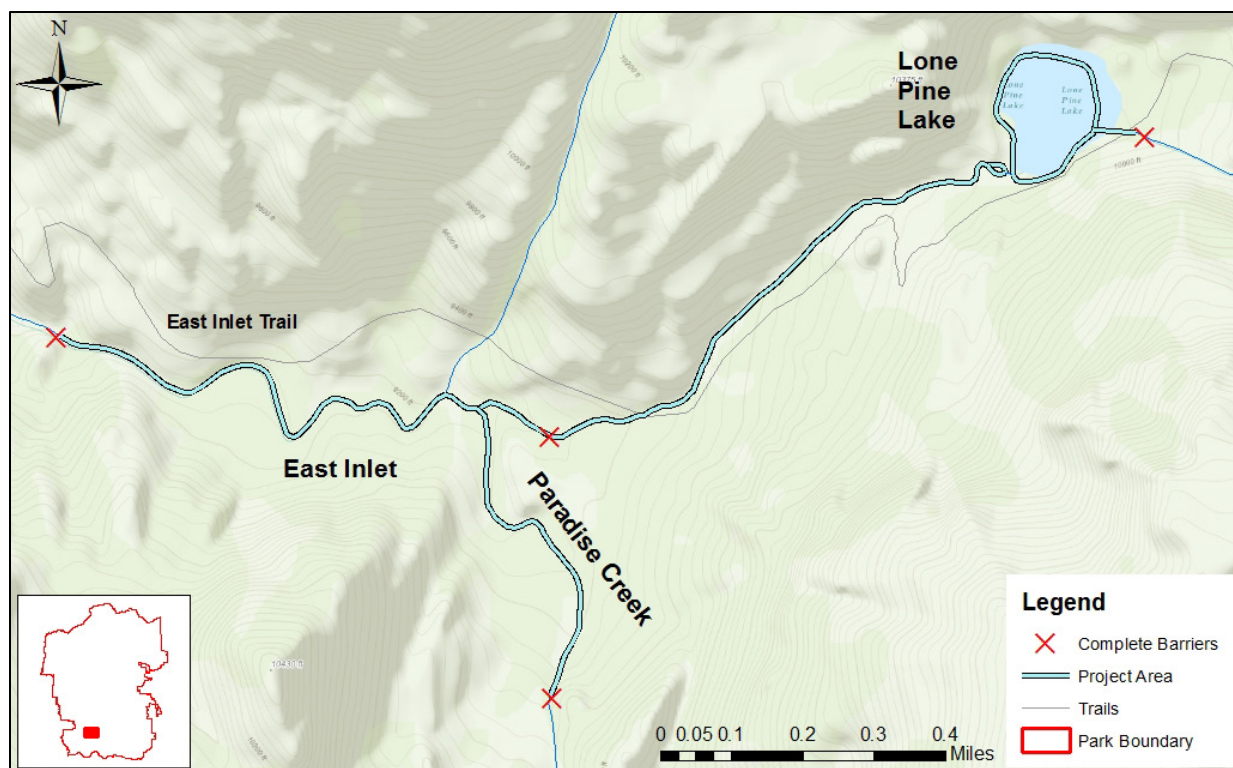


Figure A-62. Lone Pine Lake Restoration Project.

Lower East Inlet Restoration Project
Waters Included: East Inlet, Echo Creek

Parameter Scoring

Table A-173. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	5.95	0.0	70.39	brook trout	none	yes	–
Score	4	1	2	1	2	2	2	14

Table A-174. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	5.95	0.0	70.39	14.24	14.91	>2500	yes	–
Score	4	1	0	2	4	4	4	0	19

Table A-175. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	n/a	n/a	n/a	n/a	7

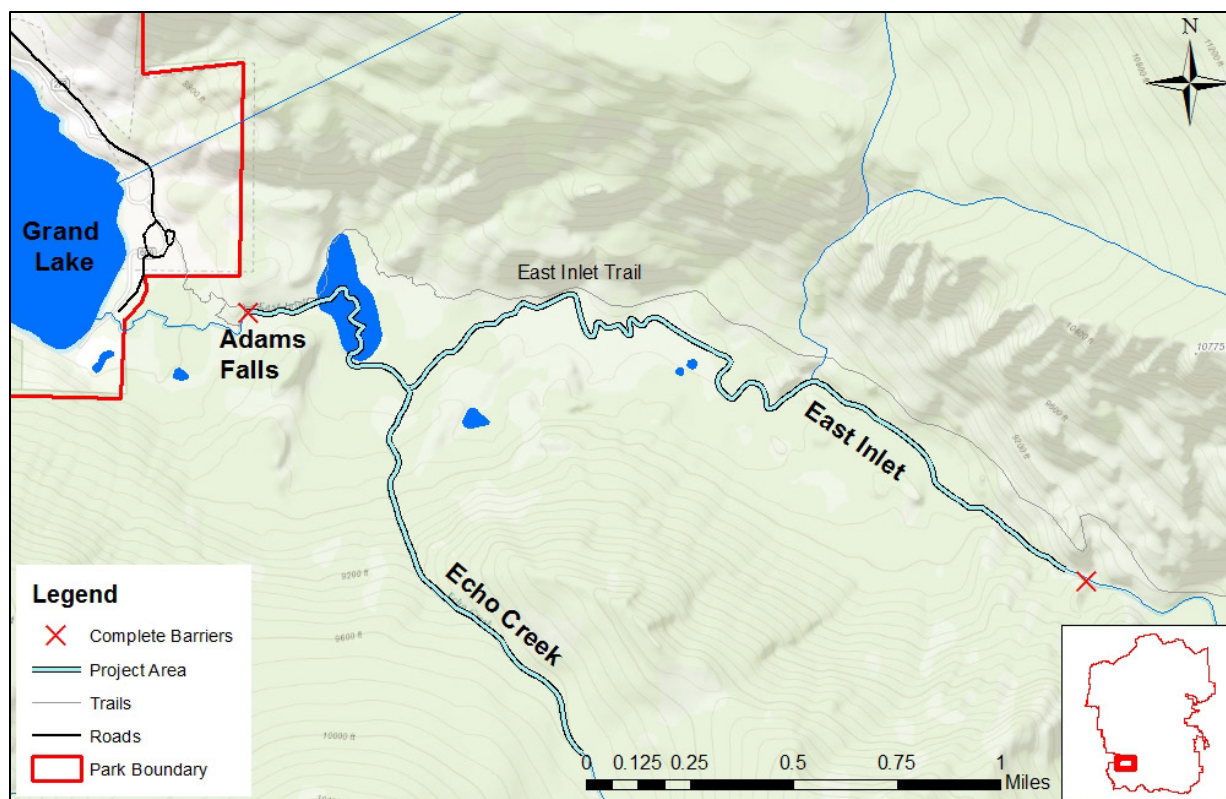


Figure A-63. Lower East Inlet Restoration Project.

Upper East Inlet Sub-drainage

Restoration Projects Included: Fifth Lake, Upper East Inlet

Parameter Scoring

Table A-176. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	3.46	26.83	15.02	blue cutthroat	unknown	yes	–
Score	4	1	0	1	1	1	2	10

Table A-177. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	3.46	26.83	15.02	10.26	11.69	>2500	yes	–
Score	4	1	2	2	4	4	4	0	21

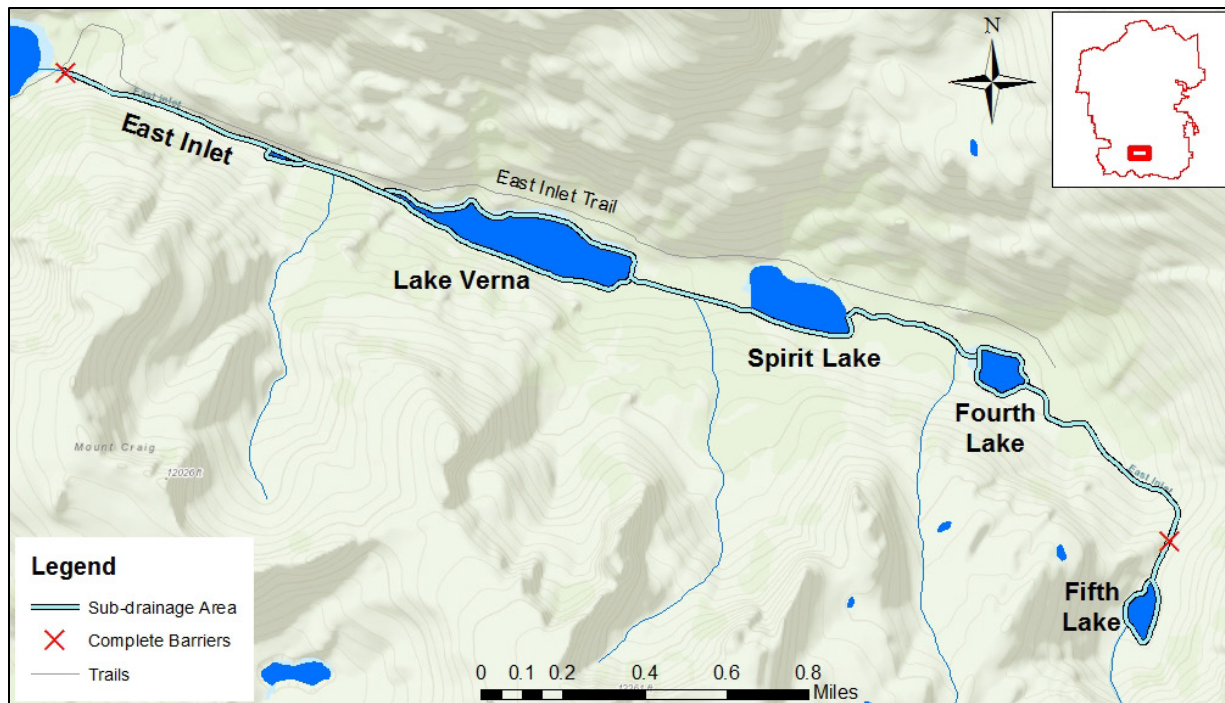


Figure A-64. Upper East Inlet Sub-drainage.

Paradise Creek Sub-drainage

Restoration Projects Included: Ten Lake Park, Adams Lake, Upper Paradise Creek, Lower Paradise Creek

Parameter Scoring

Table A-178. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	9.85	6.80	29.31	blue cutthroat	unknown	no	–
Score	4	0	1	1	1	1	0	8

Table A-179. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	9.85	6.80	29.31	11.89	12.19	>2500	no	–
Score	4	2	1	2	4	4	4	2	23

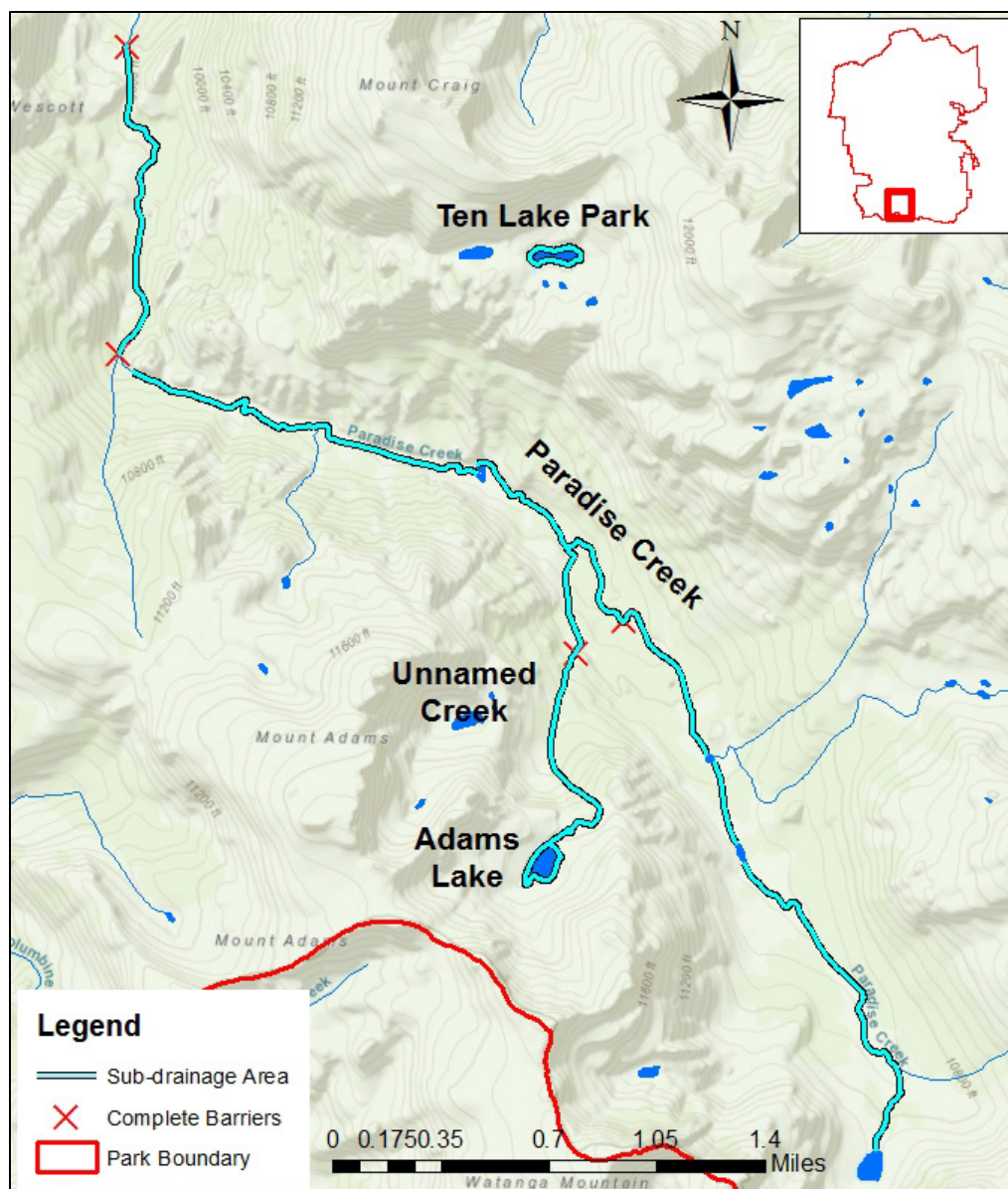


Figure A-65. Paradise Creek Sub-drainage.

Lower East Inlet Sub-drainage

Restoration Projects Included: Lone Pine Lake, Lower East Inlet

Parameter Scoring

Table A-180. Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	8.55	5.22	70.39	brook trout	unknown	yes	–
Score	4	1	1	1	2	1	2	12

Table A-181. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	8.55	5.22	70.39	12.29	14.01	>2500	no	–
Score	4	1	1	2	4	4	4	0	20

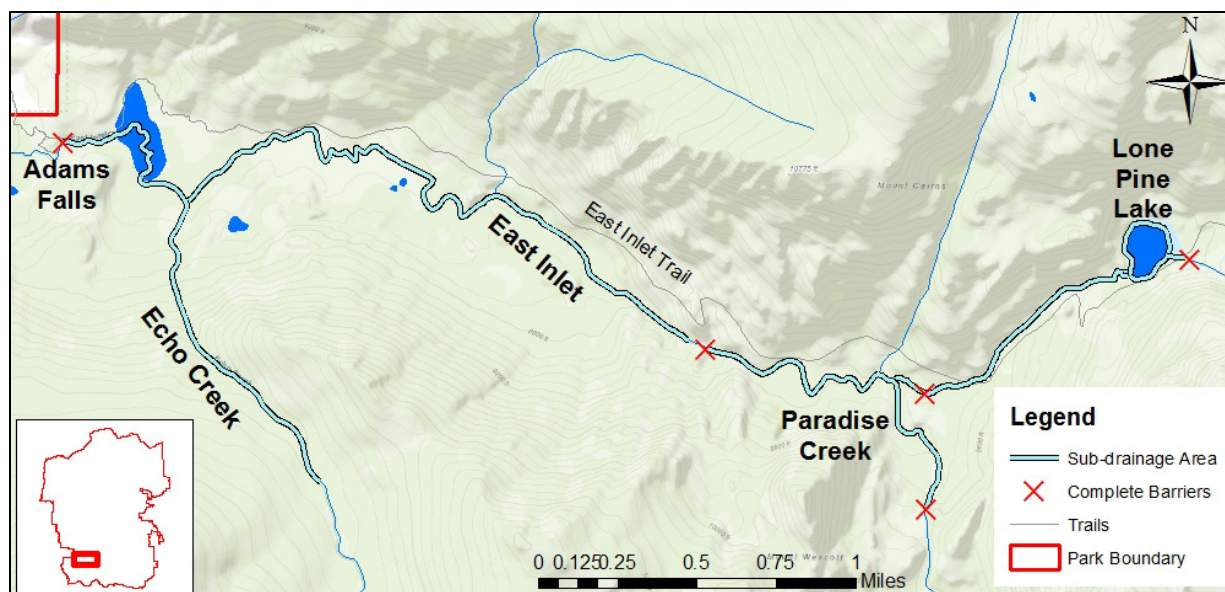


Figure A-66. Lower East Inlet Sub-drainage.

Lower Colorado River**Columbine Creek Restoration Project**

Waters Included: Columbine Creek

*Parameter Scoring***Table A-182.** Implementation Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Species Present	Disease	Access	Total
Value	complete	1.13	0.0	11.64	green cutthroat	unknown	no	–
Score	4	2	2	2	0	1	0	11

Table A-183. Persistence Scoring.

Type	Barrier	Stream Length (km)	Surface Area (ha)	Watershed Area (km ²)	Current Temperature (°C)	Future Temperature (°C)	# of fish	Access	Total
Value	complete	1.13	0.0	11.64	9.55	10.33	250–1199	no	–
Score	4	0	0	1	4	4	2	2	17

Table A-184. Additional Information.

Type	Stream Width (m)	Lake Volume (acre feet)	Number of Deep Pools	Biomass (kg/ha)	# of Projects Upstream
Value	3.6	n/a	n/a	22.0	0

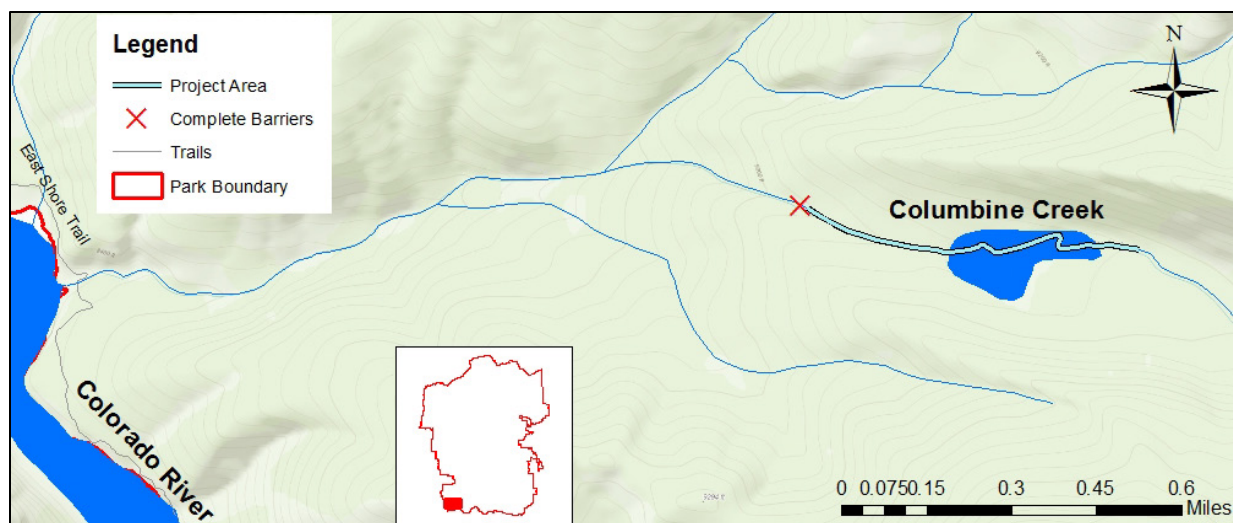


Figure A-67. Columbine Creek Restoration Project.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
U.S. Department of the Interior



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