Colville Tribes, Fish & Wildlife Department

2021 Okanogan Subbasin Steelhead Spawning Abundance and Distribution

Prepared for the Bonneville Power Administration,
Division of Fish and Wildlife, BPA Project # 2003-022-00

February 2022

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B.F. Miller, R.L. Johnson, M.L. Miller, R.S. Klett, and J.E. Arterburn
Colville Confederated Tribes**,** Omak**,** WA 98841

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Executive Summary

The Okanogan Basin Monitoring and Evaluation Program (OBMEP) has monitored summer steelhead (*Oncorhynchus mykiss*) spawner abundance and distribution within the Okanogan River subbasin from 2005 through 2021. Monitoring has been conducted through a combination of redd surveys, underwater video counts, and Passive Integrated Transponder (PIT) tag detections. In 2021, it was estimated that 710 summer steelhead (573 hatchery-origin and 137 natural-origin) spawned in the Okanogan subbasin. The total number of spawners to the subbasin reversed a generally declining trend that has continued since 2010. When specifically looking at natural-origin spawners, 2021 was the third lowest return on the period of record. The two lowest years occurred in 2017 and 2018, with 115 and 120 natural-origin spawners, respectively. Over the past 17 years of monitoring, the average number of adult steelhead spawners in the Okanogan subbasin was 1,427 (geomean = 1,206). The average number of natural-origin spawning steelhead was 278 (geomean = 241). Spawning estimates were also compared with recovery goals, as outlined by the Interior Columbia Basin Technical Recovery Team (ICBTRT). The Upper Columbia Spring Chinook and Steelhead Recovery Plan states that 500 naturally produced steelhead adults would meet the minimum abundance recovery criteria within the U.S. portion of the Okanogan subbasin; if the Canadian portion of the subbasin was included, minimum abundance recovery criteria would be 1,000 naturally produced adults (UCSRB 2007). The trend in the 12-year geomean of natural-origin steelhead spawning in the Okanogan River subbasin is fairly level and remains below the minimum abundance threshold for natural-origin spawners (500 in the US portion of the subbasin).

In the Okanogan subbasin, the proportion of hatchery origin spawners (pHOS) from 2005 through 2013 averaged 0.85, but the average pHOS decreased to 0.68 from 2014 through 2021. The lowest recorded pHOS was 0.31 in 2020. The abundance of hatchery steelhead has been variable, ranging from a low of 114 in 2020 up to 2,768 in 2010. Spawning occurred throughout the mainstem Okanogan River, but was concentrated in distinct areas that contained suitable water velocities and substrates. The highest concentration of steelhead spawning has been documented below Zosel Dam on the Okanogan River and in braided island sections of the lower Similkameen River. The release location of juvenile hatchery steelhead likely influences the spatial distribution of spawning adults. Hatchery releases occur in Omak, Salmon, Antoine and Aeneas Creeks and the Similkameen River.

On years when spring runoff takes place after peak spawning is completed, redd surveys can provide a reasonable depiction of steelhead spawning distribution and an estimate of escapement. Defining the physical location of redds informs managers about which, and to what extent, habitats are being used for spawning and allow for tracking of spatial status and trends through time. However, conducting redd surveys on years with early runoff is not always effective due to poor water clarity. Since OBMEP began collecting steelhead spawning data in 2005, the importance of not relying solely on redd surveys for abundance estimates has become evident. Implementation of Upper Columbia Basin-wide PIT tag interrogation systems (Project # 2010-034-00), coupled with the representative marking of returning adults at Priest Rapids Dam, provides managers an additional means to estimate abundance for years with poor survey conditions. Data from instream PIT arrays also helps validate redd survey efficiency, describes spatial distribution, timing of migration, and the extent of upstream spawning where previously unknown. These efforts allow managers to more accurately describe the spatial extent of spawning in tributaries, monitor effectiveness of barrier removal projects, and better define escapement estimates.

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1.0 Introduction

Within the Upper Columbia River Basin, the furthest upstream and northern-most extent of currently accessible anadromous habitat is found in the Okanogan River. Summer steelhead (*Oncorhynchus mykiss*) are listed as threatened in the Upper Columbia Evolutionarily Significant Unit (ESU) under the Endangered Species Act (ESA) (NMFS 2009). To recover this ESU requires that all four populations (Wenatchee, Entiat, Methow, and Okanogan) meet minimum adult abundance thresholds, have positive population growth rates, and each population must be widely distributed within respective basins (UCSRB 2007). Within the Okanogan River subbasin, the Okanogan Basin Monitoring and Evaluation Program (OBMEP) monitors adult abundance attributes. OBMEP developed protocols derived from the Upper Columbia Strategy (Hillman 2004) that called for a complete census of all spawning. Preliminary methodologies for implementing redd surveys were developed in 2005 and revised in 2007 (Arterburn et al. 2007). In addition to redd surveys, we used a combination of adult weir traps, Passive Integrated Transponder (PIT) tag arrays, and underwater video counting to improve escapement estimates and coordinate with other on-going data collection efforts. In cooperation with the Washington Department of Fish and Wildlife (WDFW), OBMEP expanded the use of instream PIT tag arrays to enhance the monitoring of adult summer steelhead use of small tributaries to the Okanogan River.

This document builds upon knowledge and information gained from preceding years' surveys. A literature review of historic spawning information related to the Okanogan River subbasin can be found in Arterburn et al. 2005. Previous years' data and reports can be accessed at:

https://www.okanoganmonitoring.org/Reports/SteelheadSpawningSurveys

2.0 Methods

OBMEP - Adult Abundance - Redd Surveys v1.0 (ID:192)
https://www.monitoringresources.org/Document/Protocol/Details/192
OBMEP - Adult Abundance - Adult Weir and Video Array (ID:6)
https://www.monitoringresources.org/Document/Protocol/Details/6
OBMEP – Adult Abundance – Analysis v1.0 (ID:2125)
https://www.monitoringresources.org/Document/Protocol/Details/2125
Upper Columbia River ESU Steelhead Stock Assessment (2010-034-00) v1.0 (ID:235)
https://www.monitoringresources.org/Document/Protocol/Details/235

The Okanogan River flows from the northern headwaters near Vernon, BC to the confluence with the Columbia River near Brewster, WA (Figure 1). Counts of summer steelhead spawning occurred downstream of anadromous fish migration barriers in the mainstem Okanogan River and its tributaries accessible to anadromous fish within the United States (Arterburn et al. 2007, Walsh and Long 2006) following the OBMEP redd survey protocol. The area of the Okanogan River downstream from Chiliwist Creek has very low gradient and is inundated by the Columbia River (Wells Pool/Lake Pateros). Consequently, this lower reach (~23 km) of the Okanogan River was excluded from surveys because it lacks appropriate velocity and substrate needed for summer steelhead to spawn. Mainstem and tributary redd survey reaches are listed in Table 1. Redd surveys were supplemented with adult weir traps, instream PIT tag arrays, and underwater video counts at locations where habitat was too extensive or when access could not be arranged with private landowners.

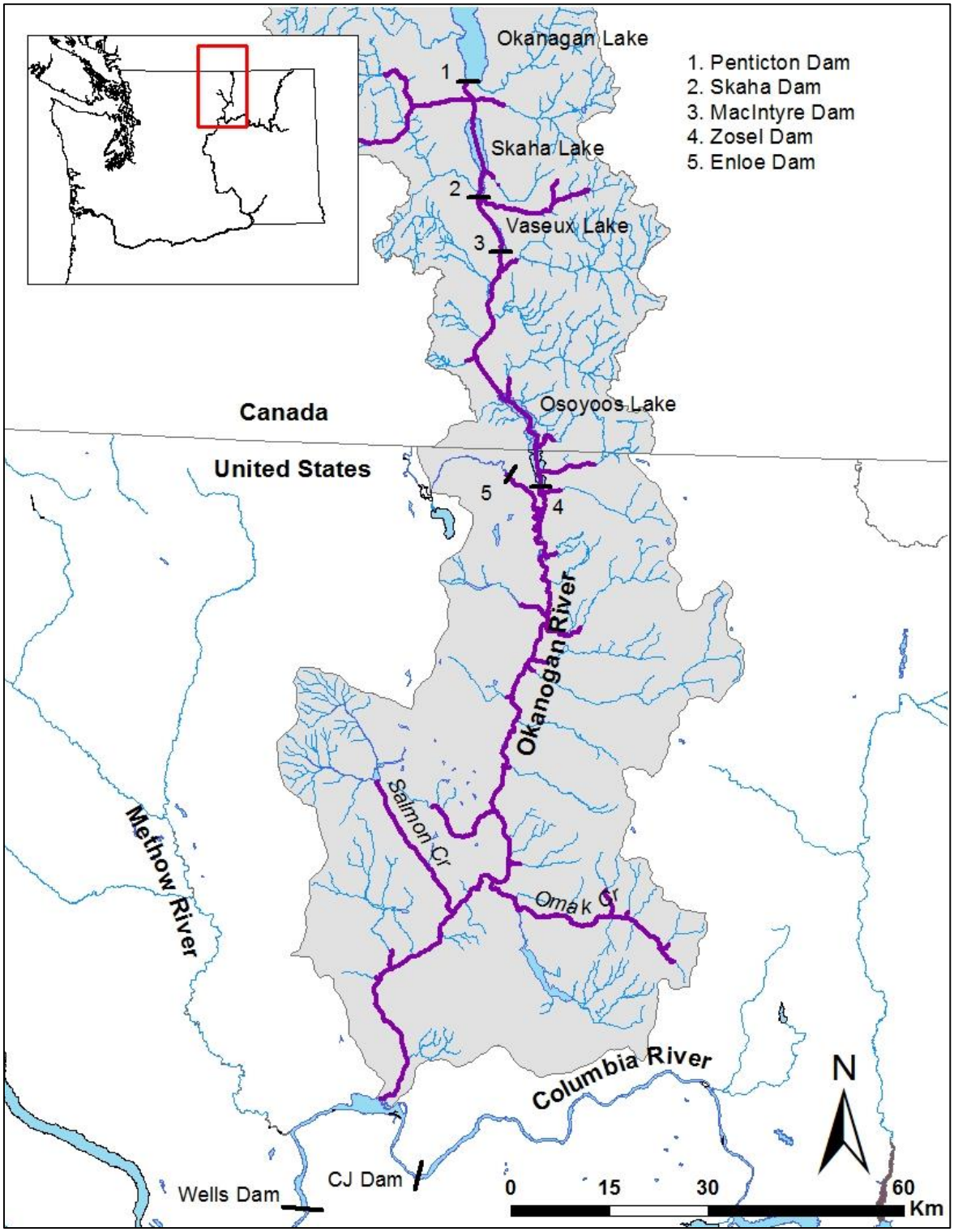

Figure 1. Study area, the Okanogan River subbasin in north-central Washington State and southern British Columbia. Stream segments shaded in purple represent habitat currently accessible to anadromous fish.

The Okanogan River was divided into seven survey reaches and the Similkameen River was surveyed as two reaches. Survey reaches were determined by access points along the river and outlined in Table 1. Discharge data, air and water temperature, and local knowledge of fish movements collected from previous years were used to determine when to begin surveys on the mainstem. Mainstem surveys were conducted from rafts and on foot in a downstream progression. All island sections or other mainstem areas that could not be floated due to limited access and/or obstacles (e.g. wood debris, braided channels, and diversions) were surveyed on foot. Raft surveys were conducted by a minimum of two people using 10 foot catarafts. Small tributaries were surveyed on foot, walking in an upstream direction, and are typically attempted three times to document spatial distribution of spawning across the entire steelhead spawning period.

Table 1. Okanogan subbasin steelhead redd survey reaches.

Redd Survey Reach	Location and Description	Reach Length (km)
Okanogan River 1	Okanogan River at Loup Loup Creek (26.7) to Salmon Creek (41.4)	14.7
Okanogan River 2	Okanogan River at Salmon Creek (41.4) to the office (52.3)	10.9
Okanogan River 3	Okanogan River at the office (52.3) to Riverside (66.1)	13.8
Okanogan River 4	Okanogan River at Riverside (66.1) to Janis Bridge (84.6)	18.5
Okanogan River 5	Okanogan River at Janis Bridge (84.6) to Tonasket Park (91.4)	6.8
Okanogan River 6	Ok. R. at Horseshoe Lake (112.4) to confluence with Similk. R. (119.5)	7.1
Okanogan River 7	Okanogan River at Similk. R. confluence (119.5) to Zosel Dam (127.0)	7.5
Similkameen River 1	Similkameen/Okanogan Confluence (0) to sewer plant (6.6)	6.6
Similkameen River 2	Similkameen from sewer plant (6.6) Enloe Dam (14.6)	8.0

Geographic position of redds were collected with a Trimble GeoXT™ GPS unit and downloaded into GPS Pathfinder® after each survey. Waypoints were reviewed and differentially corrected. To avoid recounting, flagging was tied to bushes or trees adjacent to the area where redds were observed. Individual flags were marked with the survey date, direction and distance from the redd(s), consecutive flag number, total number of redds represented by the flag, and surveyor initials. Incomplete redds or test pits were not flagged or counted.

Abundance of steelhead spawning within survey reaches were then converted to Hydrologic Unit Code (HUC), which adds to consistency within other approaches. HUCs also directly correspond to the Diagnostic Units (DU) used in habitat modeling within the mainstem Okanogan River (Figure 2). Each unique tributary to the Okanogan River also represent individual HUCs.

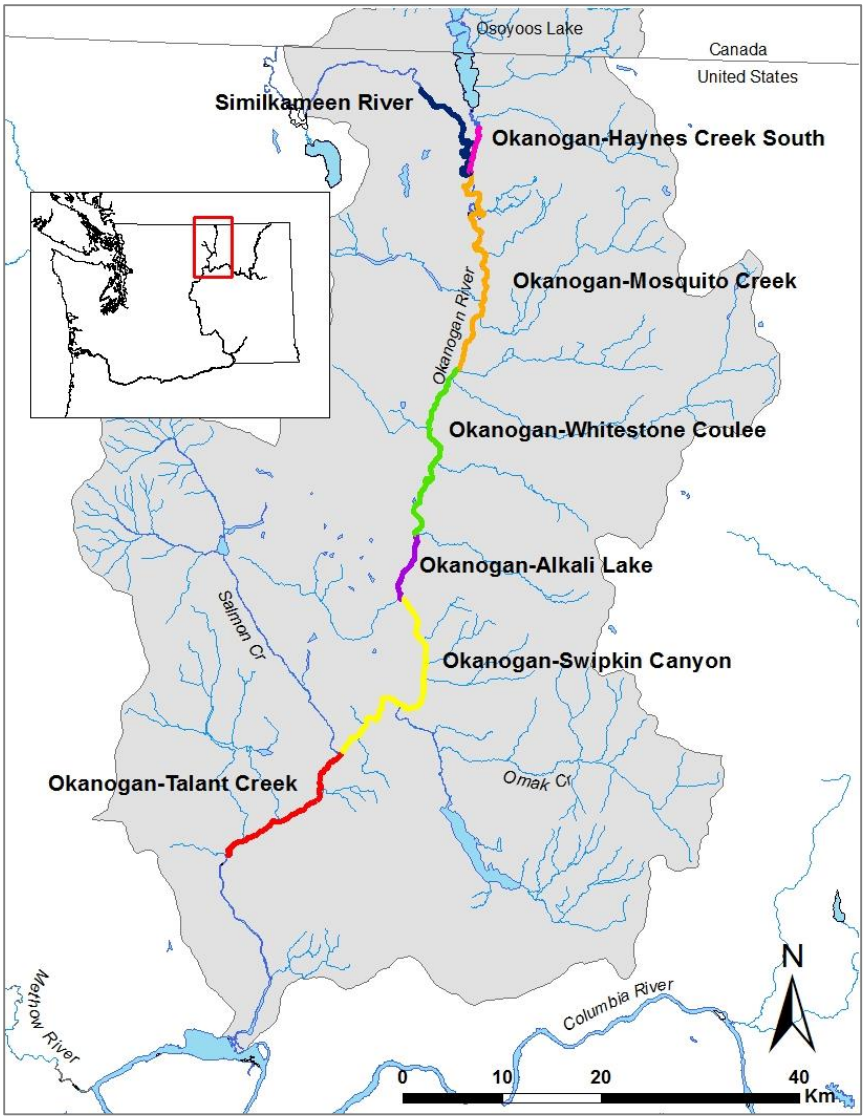

Figure 2. Mainstem Okanogan and Similkameen Rivers Hydraulic Unit Codes and diagnostic unit reaches.

2.1 Sex Ratio and Number of Fish Per Redd

OBMEP employed a method that has been used by the Washington Department of Fish and Wildlife (WDFW) in the Upper Columbia Basin to extrapolate escapement estimates from redd counts using the sex ratio of fish collected randomly throughout the run at Priest Rapids Dam. A sample of 878 summer steelhead, including 307 natural-origin and 571 hatchery fish were captured, marked, and sexed during the 2020 upstream migration by Chelan County Public Utility District (CCPUD) personnel (Catherine Willard, CCPUD, pers. comm.). The proportion of female to male steelhead was similar for natural-origin (0.694:0.306) and hatchery-origin (0.669:0.331). Since fish rear type is near impossible to discern during redd surveys, both origin-types were combined which rendered a 0.678:0.322 ratio. Rounded, that sex ratio of one female per 0.47 males or 1.47 fish per redd (FPR) was used to expand redd counts into steelhead spawning estimates for the subbasin. All calculations using sex ratio multipliers assume that each female will produce only one redd.

2.2 PIT Tag Expansion Estimates

Throughout the spring of 2021, permanent and seasonal PIT tag arrays were operated near the mouth of all tributaries to the Okanogan River known to contain steelhead spawning. The CCT works in conjunction with the WDFW (the lead investigator on project number 2010-034-00), to operate and maintain PIT tag detection sites in the Okanogan subbasin, along with data collection and management of those datasets. Any expanded PIT tag estimates presented in this document should be considered preliminary estimates as data analyses are currently in progress for the entire Upper Columbia for multiple years of the project. Final analyses of these data will be reported under BPA project number 2010-034-00.

Population estimates derived from PIT tag detections were calculated following the protocol developed by Murdoch et al. 2011. In the 2021 brood year, a representative sample of upstream migrating steelhead were captured at Priest Rapids Dam (PRD) from July through October, 2020. All fish were scanned for hatchery marks, sexed and marked with a PIT tag unless previously tagged. During this period approximately 13.9% of the total run was sampled, giving a tag rate of 0.139 for both natural- and hatchery-origin fish (Ben Truscott, WDFW, pers. comm.). These mark-rates were used to expand the number of PIT detections from the PRD mark-group on in-stream PIT arrays located near the mouth of creeks into escapement estimates. For example, if six hatchery-origin and two natural-origin steelhead from the PRD mark group were detected at the PIT array located at the mouth of a given tributary, the escapement estimate would be 43 hatchery-origin (6/0.139 = 43) and 14 natural-origin steelhead (2/0.139 = 14). This method assumes that marked fish are representative of unmarked fish. Given relatively few detections at many locations (particularly at smaller tributaries) escapement estimate confidence bounds derived from PIT tag detections may be quite wide. In addition to fish tagged at Priest Rapids, adult steelhead may have also received PIT tags at other times and locations e.g., as out-migrating juveniles, adults returning to Bonneville Dam, Wells Dam, etc. However, it is unknown how representative those fish are to the run at large. Therefore, only PIT tags from the PRD release group, project 2010-034-00, were used to estimate steelhead escapement. It is important to note that reported tag rates are preliminary. Recent questions about the validity of dam counts at certain locations have been expressed, and solutions to this issue are being addressed.

3.0 Okanogan Subbasin Summer Steelhead Spawning Estimates

Based on expanded redd counts and PIT tag detections from project 2010-034-00, it was estimated that 710 summer steelhead (573 hatchery-origin and 137 natural-origin) spawned in the Okanogan subbasin in 2021. The total number of spawners within the subbasin reversed a generally declining trend that has continued since 2010. When specifically looking at natural-origin spawners, 2021 was the third lowest return on the period of record. The two lowest years occurred in 2017 and 2018, with 115 and 120 natural-origin spawners, respectively. Over the past 17 years of monitoring, the average number of adult steelhead spawners in the Okanogan subbasin was 1,427 (geomean = 1,206). The average number of natural-origin spawning steelhead was 278 (geomean = 241). The number of natural-origin steelhead spawning in the Okanogan River subbasin has a fairly level trend and remains below the minimum abundance threshold for natural-origin spawners (500 in the US portion of the subbasin).

The proportion of hatchery origin spawners (pHOS) from 2005 through 2013 averaged 0.85, but the average pHOS decreased to 0.68 from 2014 through 2021. The lowest recorded pHOS was 0.31 in 2020. The abundance of hatchery steelhead has been variable, ranging from a low of 114 in 2020 up to 2,768 in 2010. A summary of the estimated number of adult steelhead spawners, distributed by mainstem survey reach and individual

tributaries, are presented in Table 3. Results for unique tributaries and mainstem reaches are further detailed in sections 3.1 to 3.3 of this document.

Table 2. Okanogan subbasin summer steelhead spawner abundance estimates, 2005–2020.

Year	Total	Hatchery Steelhead	Natural-Origin Steelhead	Natural-Origin 12-yr geomean
2005	1,226	1,080	146	
2006	899	702	197	
2007	1,268	1,116	152	
2008	1,386	1,161	225	
2009	2,133	1,921	212	
2010	3,496	2,768	728	
2011	1,674	1,341	333	
2012	2,802	2,475	327	
2013	1,937	1,687	250	
2014	1,356	838	518	
2015	1,461	1,009	452	
2016	1,566	1,175	391	292
2017	1,044	929	115	286
2018	453	333	120	274
2019	473	306	167	277
2020	374	114	260	280
2021	710	573	137	271
Average	1,427	1,149	278	278

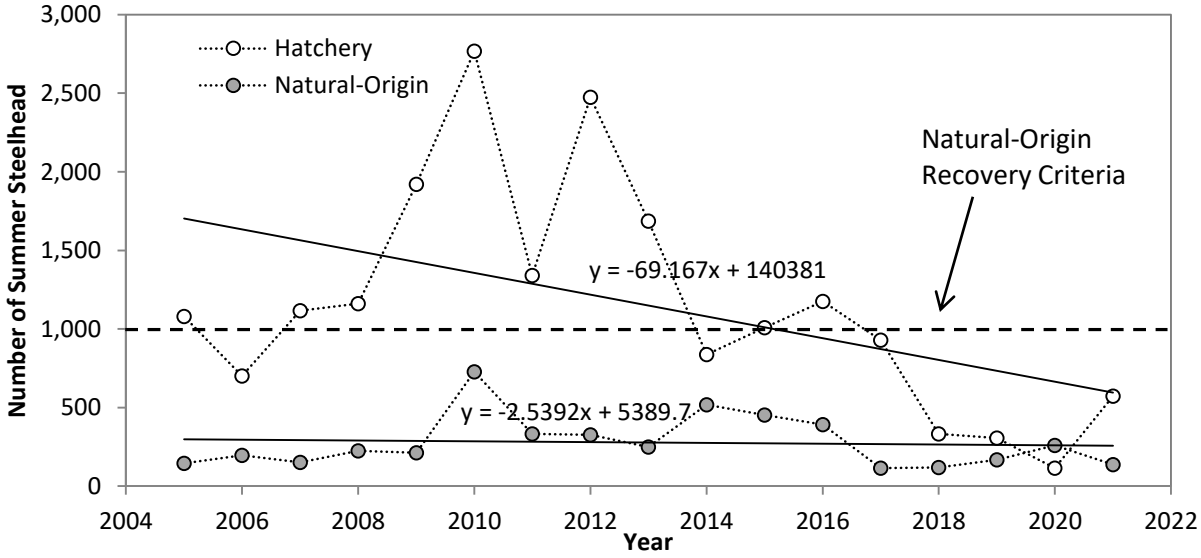

Figure 3. Trend in the estimated number of summer steelhead spawning in the Okanogan River subbasin, 2005–2021.

Table 3. Estimated number of hatchery and natural-origin steelhead spawning for each sub-watershed or assessment unit in 2021 compared with long-term averages.

Category	Location/HUC	2021 natural-origin spawner abundance	*Average # of natural-origin spawners 2005–2020*	2021 hatchery spawner abundance	*Average # of hatchery spawners 2005–2020*
WA Mainstem	Okanogan-Davis Canyon	0	*0*	0	*0*
WA Mainstem	Okanogan-Talant Creek	0	*1*	3	*10*
WA Mainstem	Okanogan-Swipkin Canyon	0	*5*	15	*46*
WA Mainstem	Okanogan-Alkali Lake	0	*3*	8	*27*
WA Mainstem	Okanogan-Whitestone Coulee	1	*6*	18	*56*
WA Mainstem	Okanogan-Mosquito Creek	0	*1*	4	*13*
WA Mainstem	Okanogan-Haynes Creek South	3	*37*	79	*325*
WA Mainstem	Similkameen River	2	*23*	62	*193*
WA Tributary	Loup Loup Creek	7	*10*	58	*32*
WA Tributary	Salmon Creek	38	*36*	8	*103*
WA Tributary	Omak Creek	36	*58*	113	*123*
WA Tributary	Wanacut Creek	0	*1*	2	*3*
WA Tributary	Johnson Creek	0	*5*	0	*19*
WA Tributary	Tunk Creek	14	*10*	50	*28*
WA Tributary	Aeneas Creek	0	*0*	9	*3*
WA Tributary	Bonaparte Creek	9	*28*	19	*57*
WA Tributary	Antoine Creek	12	*6*	37	*8*
WA Tributary	Wild Horse Spring Creek	0	*8*	43	*34*
WA Tributary	Tonasket Creek	14	*8*	29	*21*
WA Tributary	Ninemile Creek	0	*7*	7	*15*
Area	Washington State Mainstem	**6**	***76***	**189**	***670***
Area	Washington State Tributaries	**130**	***177***	**375**	***446***
Area	British Columbia	**1**	***25*** [a]	**9**	***12*** [a]

[a] Average from British Columbia only contain data from 2013-2020.

3.1 Steelhead Spawning Estimates: Okanogan and Similkameen River Mainstem

Compared with extremely large runoff years in 2017 and 2018, and a lower runoff year in 2019, the general discharge pattern for the mainstem Okanogan River in the spring of 2020 and 2021 was slightly above historical averages (Figure 4). One complete survey of all mainstem reaches was accomplished before discharge rates in the Similkameen River increased in mid-April and remained high through June. By that time, steelhead spawning had long since concluded and redds were indistinguishable. Locations of redds marked during 2021 and in previous years surveys (2005–2020) on the mainstem Okanogan and Similkameen Rivers are shown in Figures 5–11.

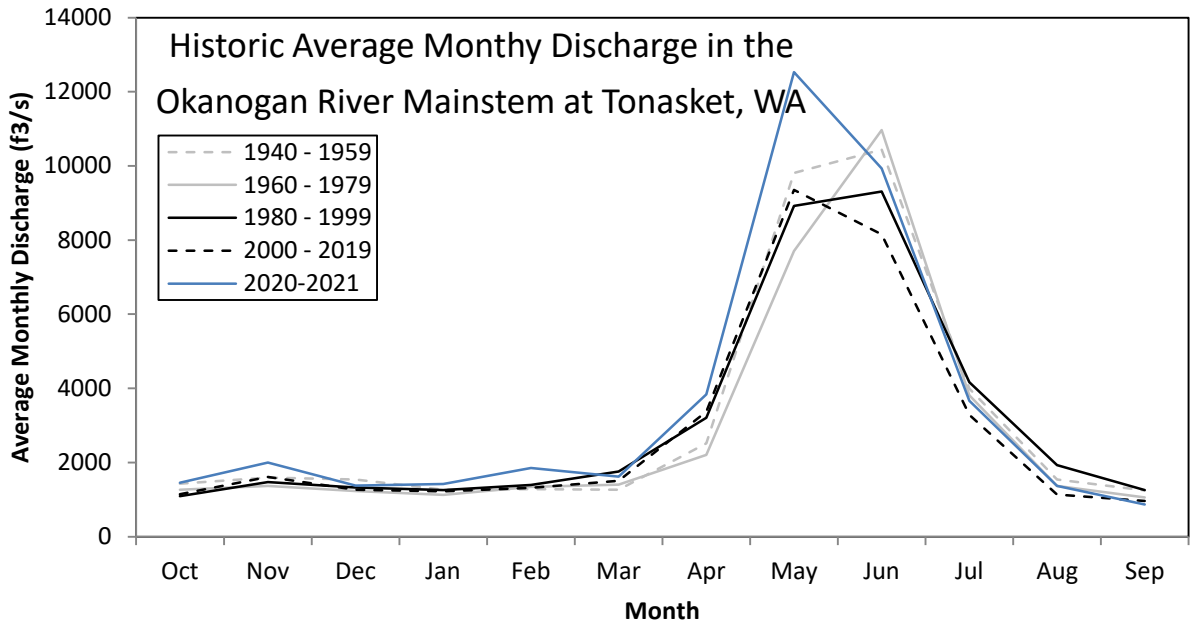

Figure 4. Average monthly discharge of the Okanogan River at Tonasket, WA (USGS Station 12445000, Okanogan River near Tonasket, WA).

One complete pass of redd surveys were completed on the Okanogan and Similkameen Rivers before runoff from the Similkameen created turbid water conditions (Figure 4). From dowstream to upstream survey reach, with dates and number of redds counted in parethenseis: Reach O1 (Apr 12, 0 redds), Reach O2 (Mar 23, 0 redds), Reach O3 (Mar 26, 0 redds), Reach O4 (Apr 5, 2 redds), Reach O5 (Mar 30, 0 redds), Reach O6 (Apr 6, 0 redds), Reach O7 (Apr 12, 37 redds), Reach S1 (Apr 6, 2 redds) and Reach S2 (Apr 8, 2 redds). After April 19, the Similkameen River runoff made mainstem conditions too turbid for further surveys to occur. Reach O7 began to back up with water (increased stage height), although water clearity remained acceptible for surveys to continue in that river segment. We used a jet boat sled to survey Reach O7 a second time on May 5 and marked an additional 19 redds. Surveyors were able to relocate ~80% of the redds marked on the first survey, so we were relatively confident in the counts. After this date, water temperatures increased and flow velocities decreased, therefore, it was unlikey further spawning occurred due to unfavorable spawning conditions. Expanding the total number of redds located in Reach O7 (56) by the 1.47 FPR value equaled a total spawning estimate of 82 fish in that reach.

Although redd surveys were unable to capture the complete distribution of spawning activity in the rest of the mainstem Okanogan and Similkameen Rivers, an estimate of mainstem spawning by reach was calculated as follows:

The total number of natural-origin and hatchery steelhead that spawned in the mainstem Okanogan River in 2021 can be estimated using the proportion of PRD marked fish only detected at the lower Okanogan River PIT array (OKL) i.e. entered the Okanogan River, but did not enter a tributary stream. This query rendered a total of 1 natural-origin and 20 hatchery steelhead tags. The detection efficiency of the OKL PIT tag interrogation site was 0.67 for the 2021 spawner year, calculated by examining all PIT tagged adult steelhead detected upstream of that location. Expanding the detected tags by the detection efficiency (0.67) and then by the PRD mark rate of

0.139 equaled a total estimated 11 natural-origin and 215 hatchery steelhead. The Colville Tribes Broodstock and Acclimation Monitoring program (BAM) used hook and line sampling to remove a total of 10 hatchery steelhead from the Similkameen, and 16 hatchery and five wild steelhead from the mainstem Okanogan. Removing these fish left six natural-origin and 189 hatchery steelhead, for a 3.1% natural-origin rate.

Applying the 3.1% natural-origin rate to the 82 fish that spawned in Reach O7 rendered an estimated 3 natural- and 79 hatchery-origin spawners in that reach. Subtracting those fish from the total mainstem spawners left 3 wild and 110 hatchery fish for the remaining mainstem reaches. We then estimated spatial distribution of steelhead spawning in 2021 based on previous years surveys when complete mainstem redd surveys occurred. Proportional distribution of spawning by survey reach is listed in Table 4 column A for the period of 2005–2011.

To estimate how many fish spawned in each survey reach, the remaining mainstem spawning estimates for natural-origin (3) and hatchery steelhead (110) were multiplied by the historical proportion of spawning recorded in each reach. This calculation assumes no change in the spatial distribution of spawning between the reference period (2005–2011) and in years when redd surveys could not be conducted due to turbid water conditions. Specific calculations are outlined below in Table 4.

Table 4. Modeled estimate of mainstem steelhead spawning in 2021.

Mainstem Survey Reach	A. Avg. Proportion of Mainstem Spawning by Reach (2005-2011)	B. Natural-Origin Steelhead (B=A*3)	C. Hatchery Steelhead (C=A*110)	D. Total Estimate (D=B+C)
Okanogan River 1	0.029	0	3	3
Okanogan River 2	0.107	0	12	12
Okanogan River 3	0.023	0	3	3
Okanogan River 4	0.091	0	10	10
Okanogan River 5	0.148	1	16	17
Okanogan River 6	0.039	0	4	4
Okanogan River 7	NA	NA	NA	NA
Similkameen River 1	0.321	1	35	36
Similkameen River 2	0.241	1	27	28
Mainstem Total [a]	1	3	110	113

[a] Does not include Okanogan River Reach O7, where physical redd surveys were conducted throughout the spawning season.

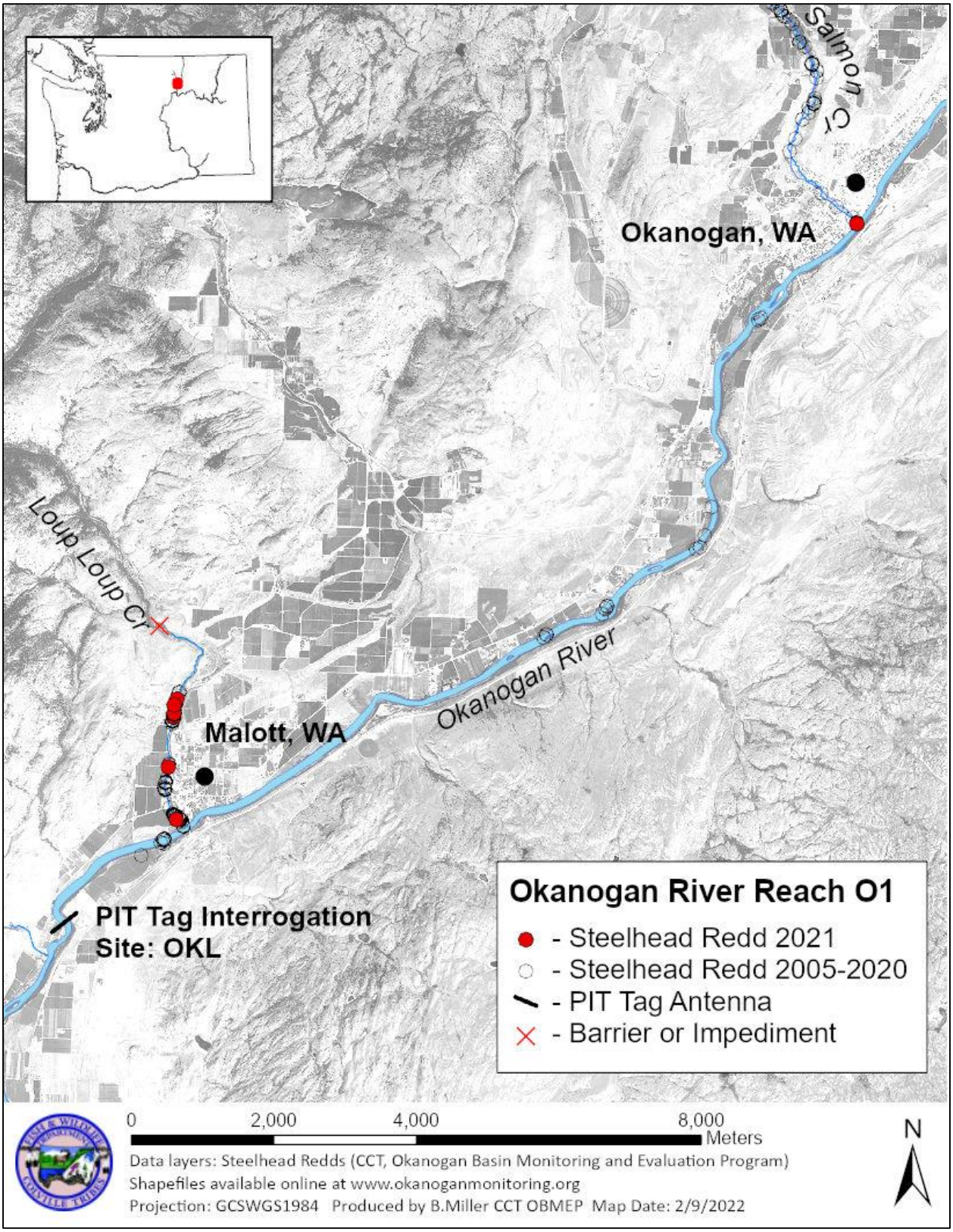

Figure 5. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO1, from Salmon Creek to the Okanogan River weir site, located immediately upstream of the OKL PIT tag interrogation site.

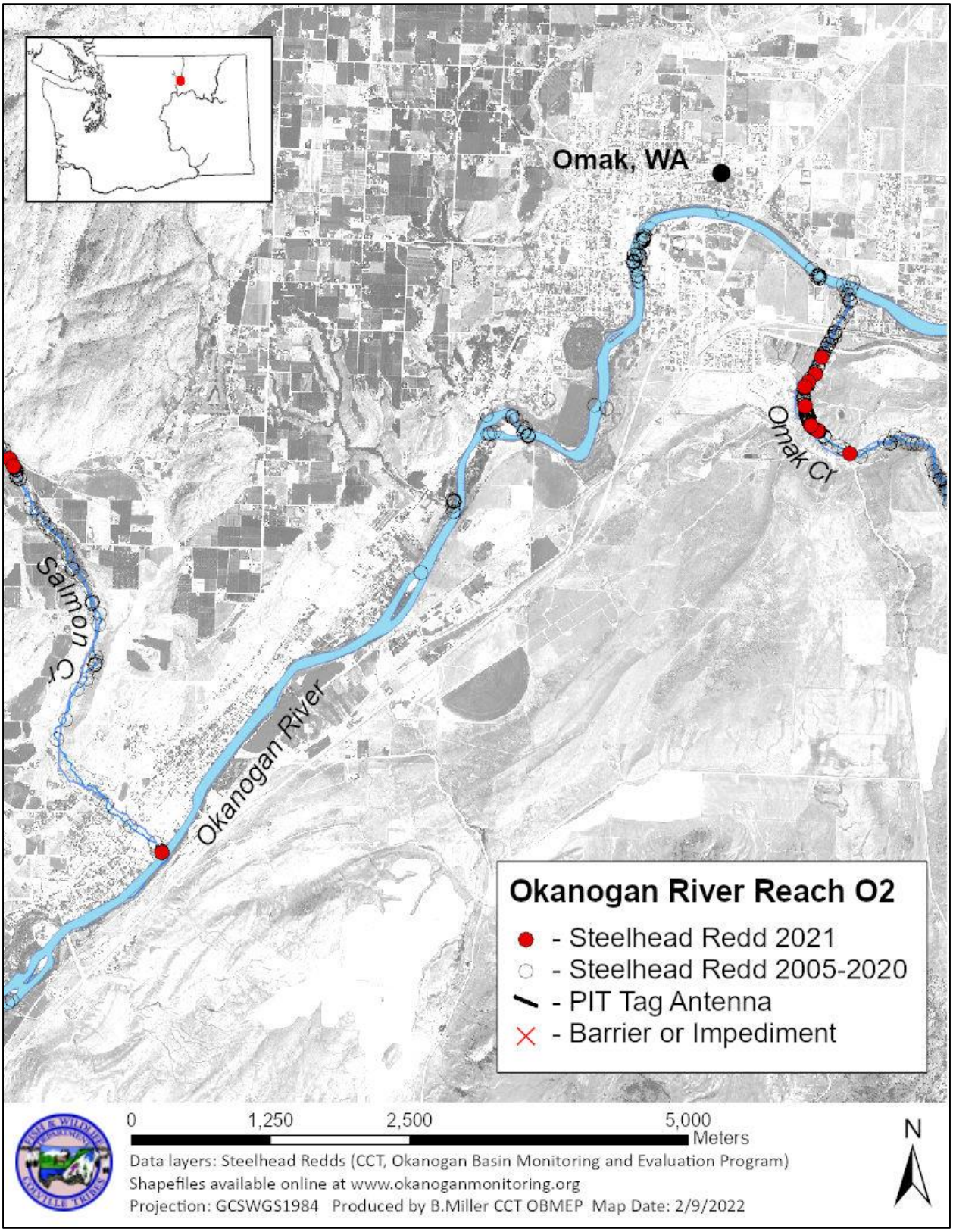

Figure 6. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO2, from Omak Creek to Salmon Creek.

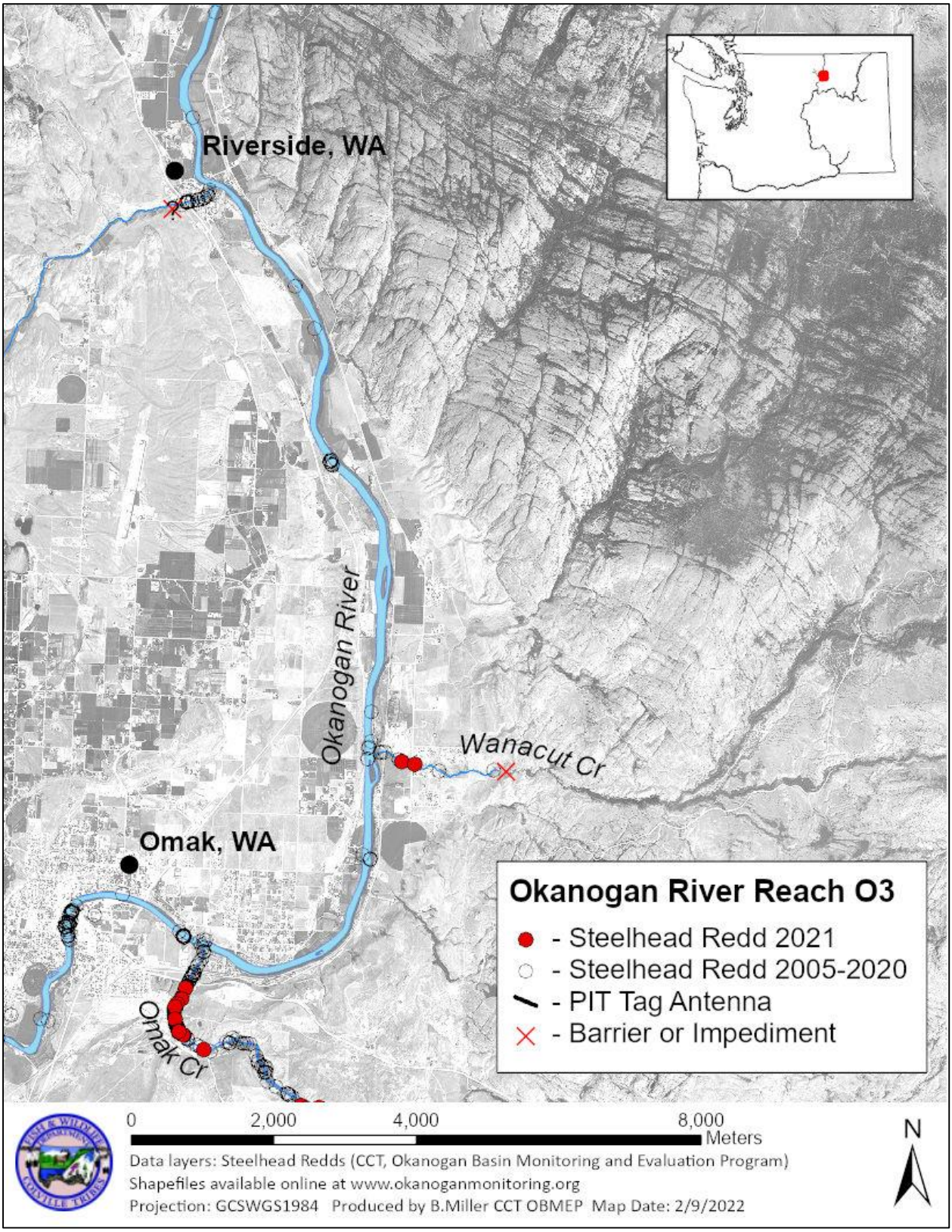

Figure 7. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO3, from Johnson Creek to Omak Creek.

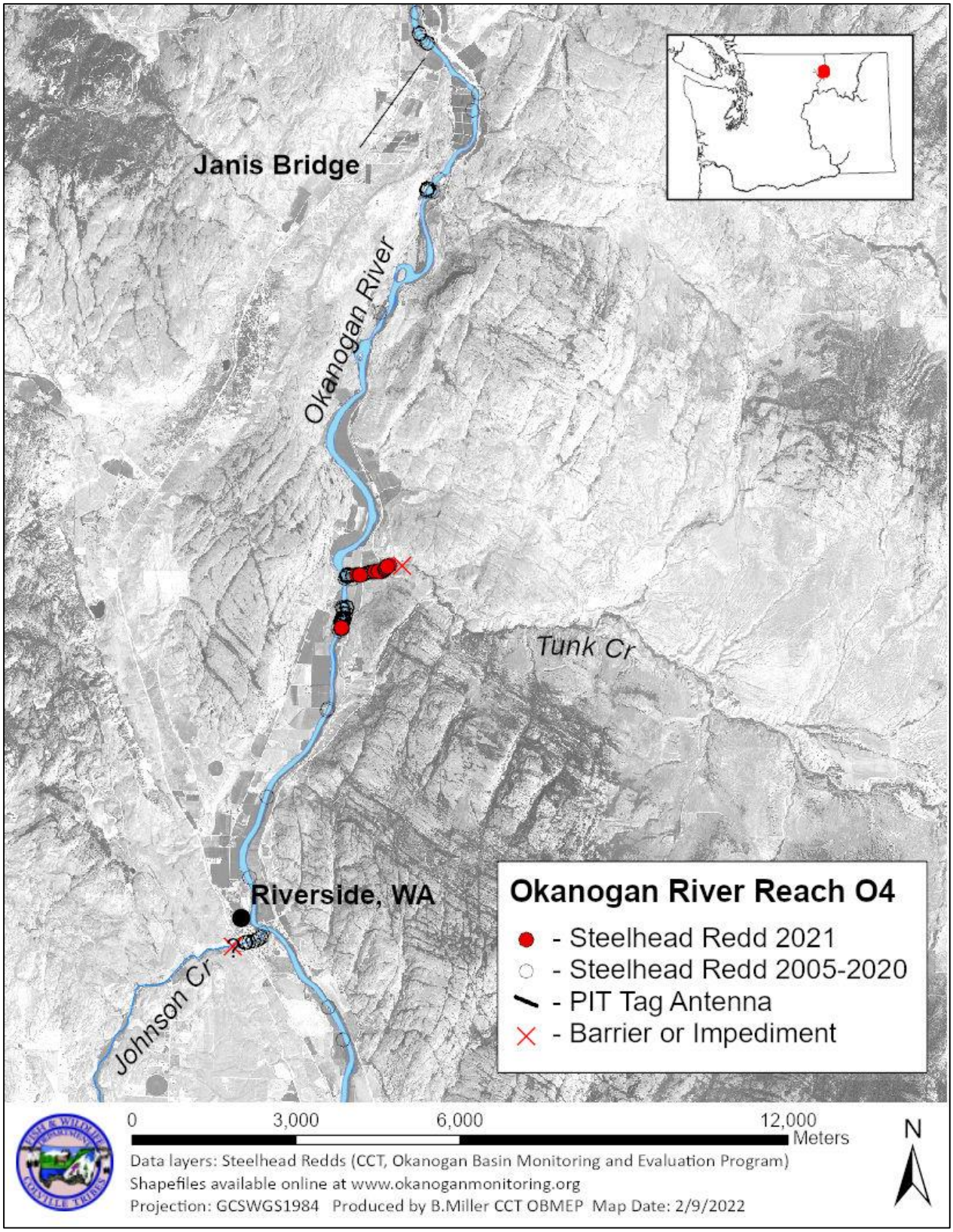

Figure 8. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO4, from Janis Bridge to Johnson Creek.

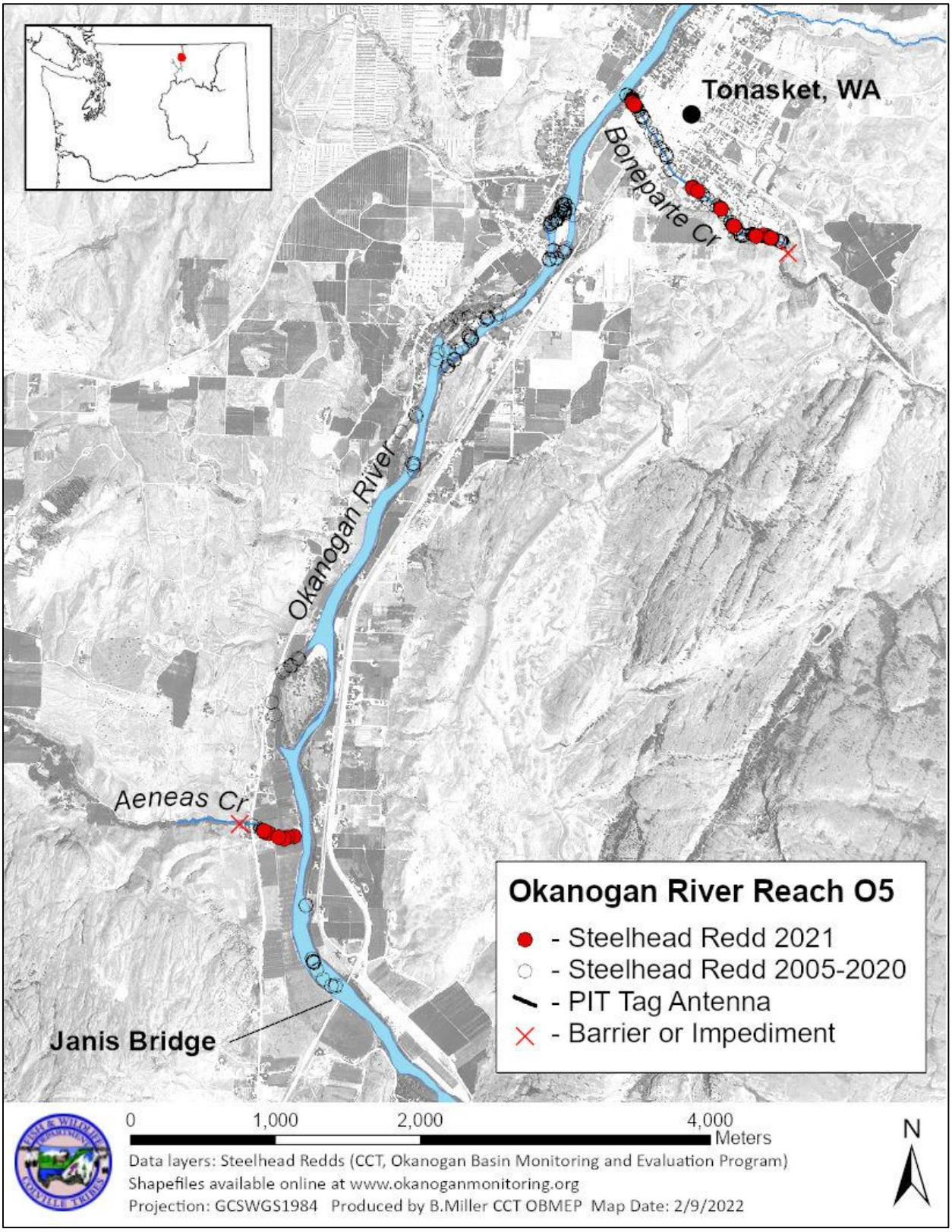

Figure 9. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO5, from the Tonasket boat launch to Janis Bridge.

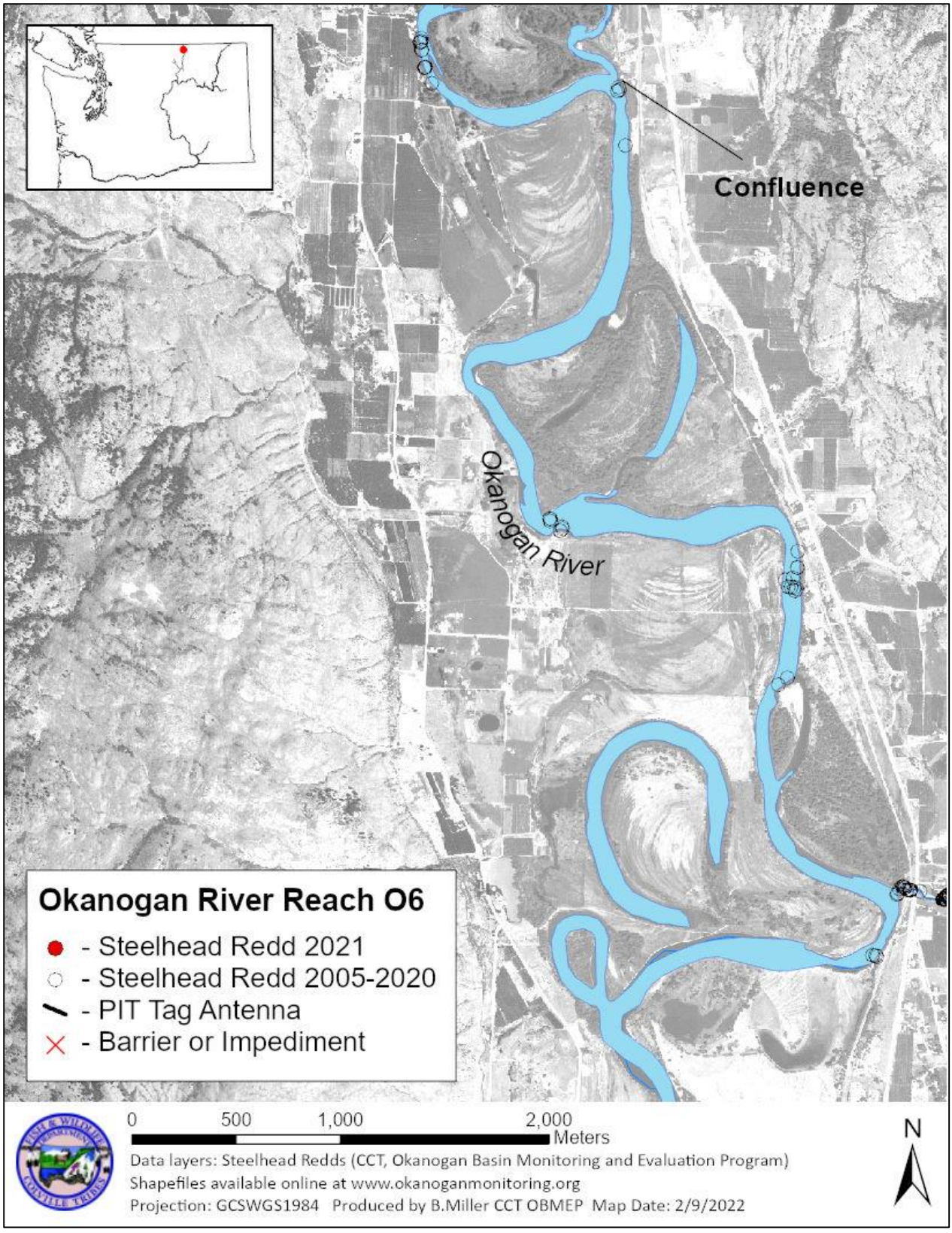

Figure 10. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO6, from the confluence of the Similkameen and Okanogan Rivers to Horseshoe Lake.

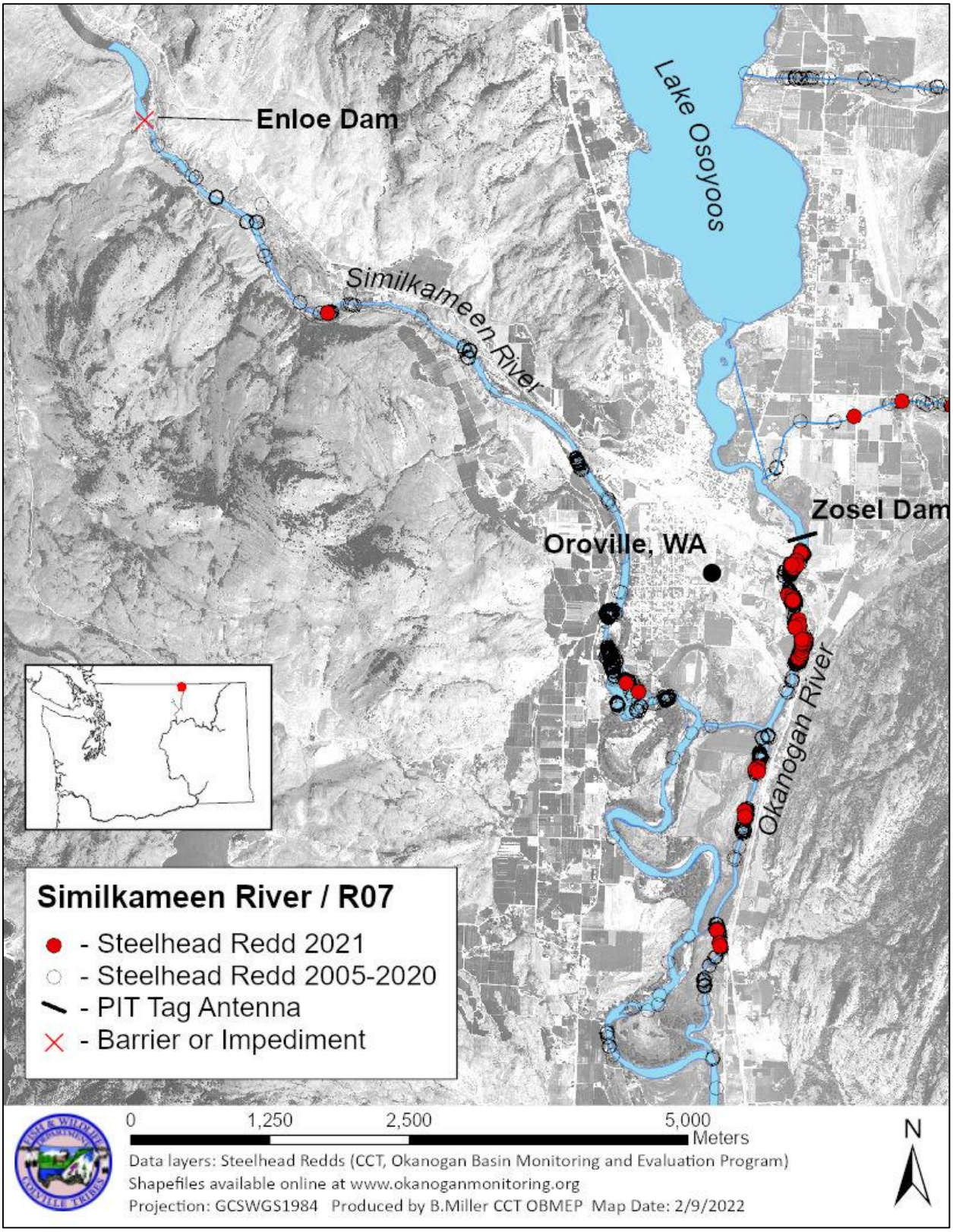

Figure 11. Spatial distribution of summer steelhead redds documented in the Similkameen River, from Enloe Dam to the confluence, and in Okanogan River survey reach RO7, from Zosel Dam to the confluence.

3.2 Steelhead Spawning Estimates: Tributaries to the Okanogan River

Tributary redd surveys were also occasionally affected by high flows and turbid water conditions (Figure 12) from an early runoff period, which began mid-March in Omak and Loup Loup Creeks and in mid-April in most other tributaries (Figure 13 and 14). For reference, peak steelhead spawning typically occurs around April 15th. Because some redd surveys in 2021 focused primarily on obtaining spatial distribution of spawning, many subwatershed steelhead spawning estimates were determined from PIT tag detections under project #2010-034-00. Others were determined from expanding redds by the number of fish per redd (1.47).

In the following sections, we outline methods and a summary of spawning estimates for steelhead in tributaries to the Okanogan River, along with spatial distribution information. Detailed maps are presented in the following sections for each tributary which outline distribution of historic observations from 2005–2021. GIS shapefiles of documented steelhead redds can be downloaded at: www.okanoganmonitoring.org

Figure 12. Staff performing steelhead redd surveys during spring 2021.

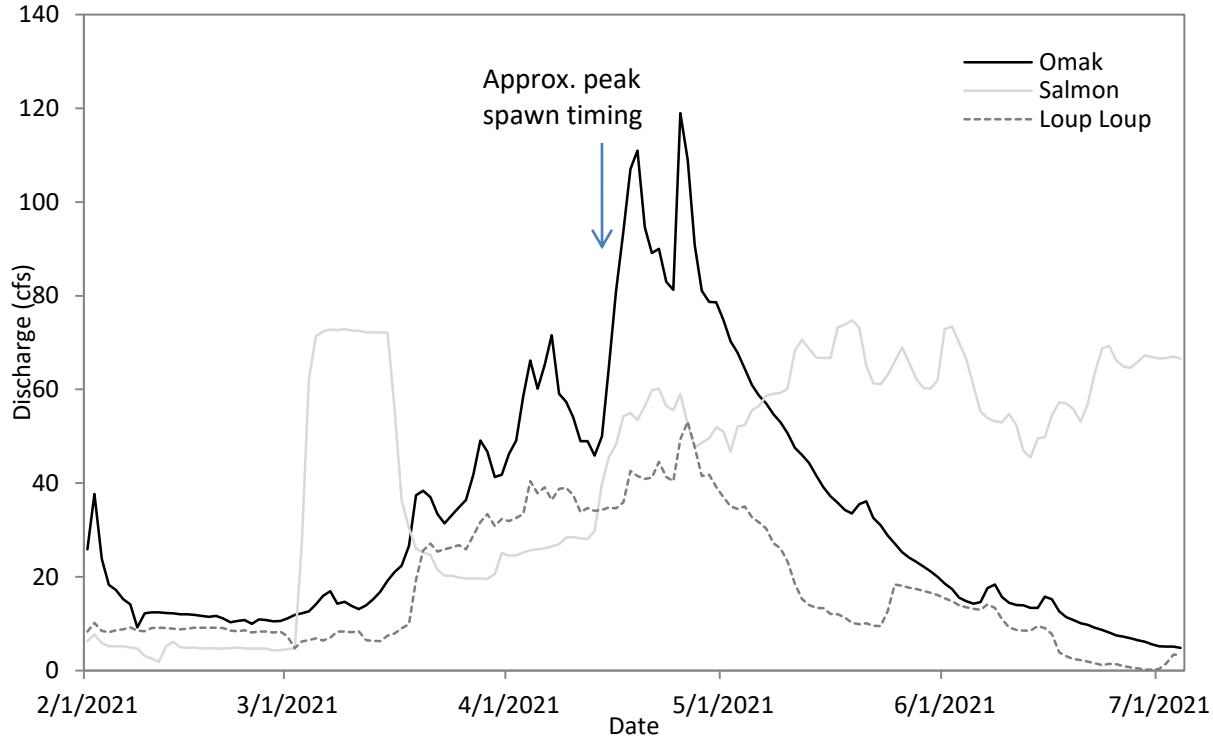

Figure 13. 2021 discharge in three tributaries in the southern Okanogan subbasin in Washington State.

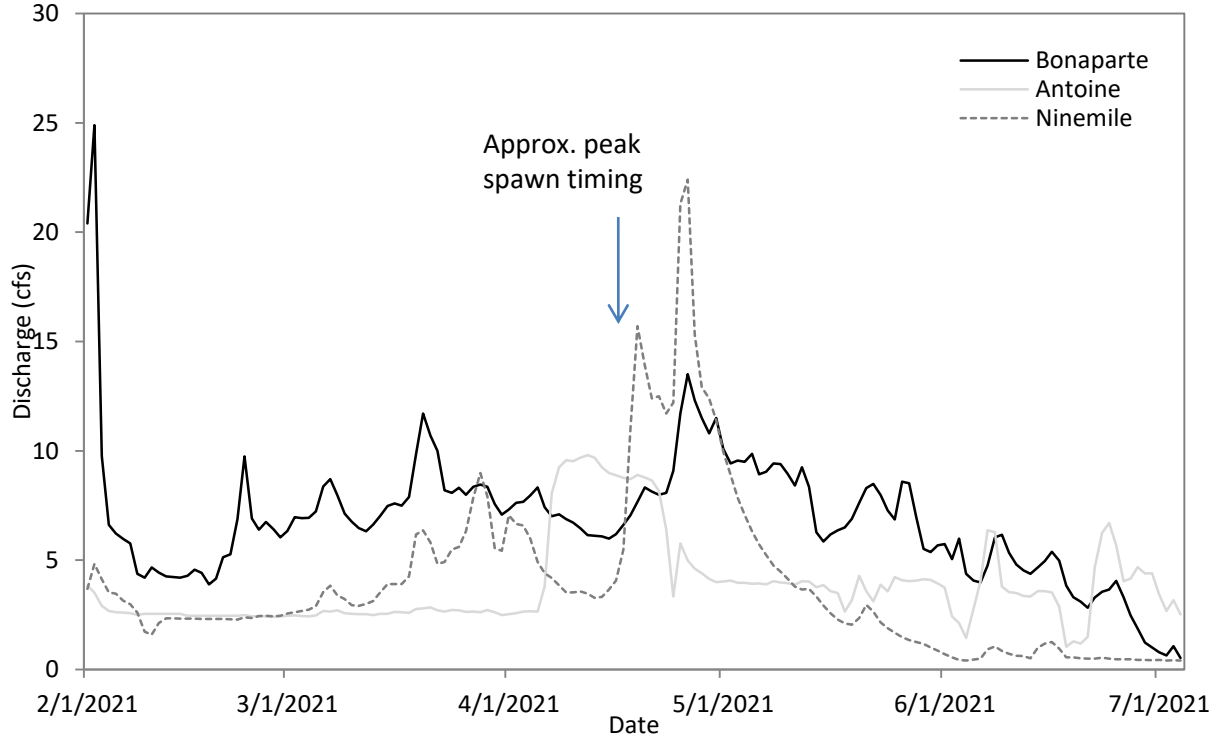

Figure 14. 2021 discharge in three tributaries in the northern Okanogan subbasin in Washington State.

3.2.1 Loup Loup Creek

Loup Loup Creek is a tributary that enters the Okanogan River at river kilometer (RKM) 24, in the town of Malott, WA. The lower sections of the creek frequently went dry during mid-summer, until 2010, when the point of diversion was transferred to the Okanogan River and the irrigation diversion on Loup Loup Creek was removed. PIT tag interrogation site LLC consists of three pass-over HDPE antennas configured in three separate rows near the mouth of the creek.

The instream PIT tag interrogation site LLC was operational throughout the spring of 2021 and detected eight hatchery and one natural origin steelhead from the Priest Rapids Dam (PRD) mark group. When those tags were expanded by the mark rate of .139, a total estimated 58 hatchery and 7 natural-origin steelhead likely spawned in Loup Loup Creek in 2021. Three PIT tags not from the PRD mark group were also detected in the creek, all of hatchery origin. Long term trends in steelhead spawning escapement for Loup Loup Creek are shown in Figure 15.

Conditions in Loup Loup Creek were unfavorable to conduct redd surveys throughout much of April 2021 due to increased discharge and turbid water (Figure 13). On May 6, a post-peak redd survey was conducted in which a total of 5 redds were found and a second survey was conducted on May 19 when an additional six redds were located (Figure 16). Those 11 redds were expanded by 1.47 FPR for a total spawning estimate of 16 steelhead. Observers noted that substrate in Loup Loup Creek had become embedded across much of the reach and most of the spawning gravels that existed in previous years were completely covered in sand. Due to the limited number of redd surveys conducted in 2021, we relied solely on PIT tag expansion for the spawner estimates.

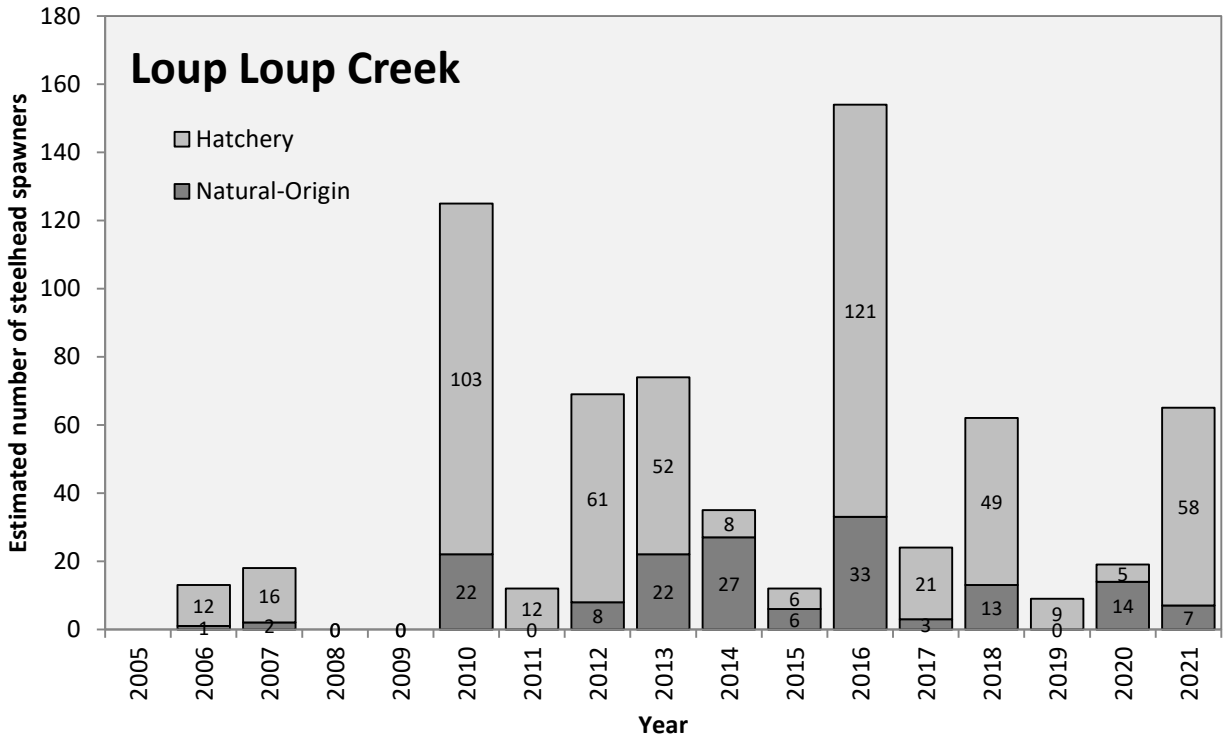

Figure 15. Trend in the number of steelhead spawners in Loup Loup Creek.

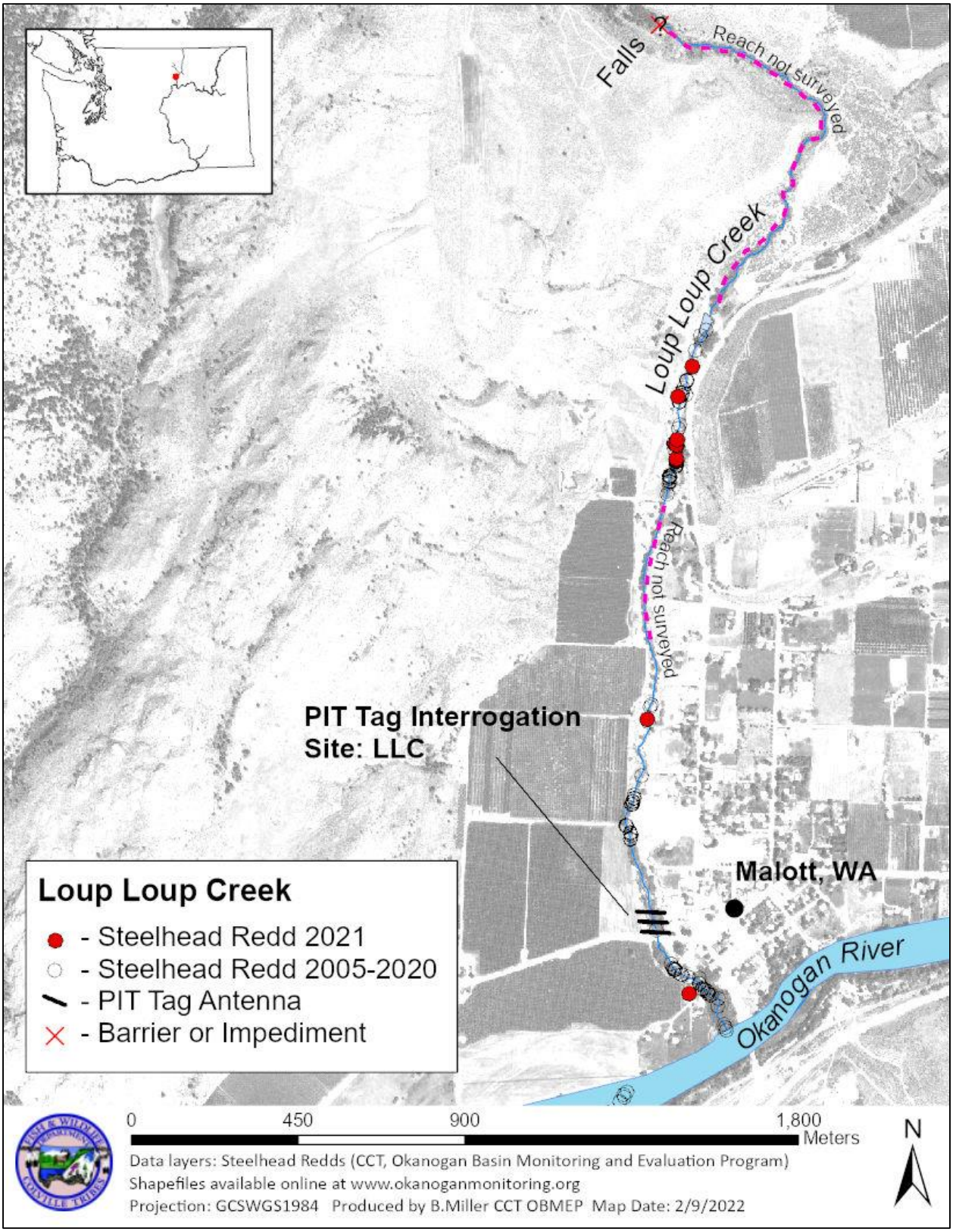

Figure 16. Spatial distribution of historical summer steelhead redds documented in Loup Loup Creek.

3.2.2 Salmon Creek

Salmon Creek is a highly managed medium sized tributary, which enters the Okanogan River at RKM 41.3 in the city of Okanogan, WA. Since the early 1900's, the majority of water from Salmon Creek had been diverted for irrigation usage. Resulting in a largely dry stream channel extended from the Okanogan Irrigation District (OID) diversion dam (7.2 km) to the confluence with the Okanogan River. Occasionally, uncontrolled spills occurred downstream of the OID diversion dam in high water years. These spills typically occurred in mid-May to June, which is after peak spawning for summer steelhead in the Okanogan basin. To provide sufficient water during the migration window of spring-spawning steelhead, the Colville Tribes purchased water from the OID and allowed it to flow down the channel to the Okanogan River. After several years of successful steelhead passage, the Tribes negotiated a long term water lease agreement with the OID. Since 2006, the long term water lease has provided seasonal water for returning adults and outmigrating juvenile salmonids. Further negotiations allowed for continuous flow, year-round since 2019.

A PIT tag interrogation site (SA1) is located 2.9 km upstream from the mouth of Salmon Creek. The instream array consisted of four pass-over HDPE antennas configured in two separate rows. A second PIT tag interrogation site (SA0) is located immediately downstream of the OID diversion dam and consists of five pass-over PVC antennas configured in two separate rows (Figure 18). During the 2021 spawning season, a total of 4 natural-origin and 1 hatchery PIT tagged steelhead from the PRD mark group were detected at the lower SA1 array. All of the tags detected on the upstream site SA0 (3 natural-, 1 hatchery-origin) were detected on SA1, which rendered a detection efficiency estimate of 100% at the downstream detection site. Assuming 100% detection efficiency, an expanded total estimate of 36 steelhead (29 natural-origin and 7 hatchery) spawned in Salmon Creek in 2021.

The lower portion of Salmon Creek was surveyed five times from the confluence with the Okanogan River to the irrigation diversion. The first survey was conducted over two days, March 25 and 31 and no redds were found. It was again surveyed on April 8, no redds were located. On April 27, two redds were found. Four new redds were found on May 13 and two additional were located on June 3 (Figure 18). When expanded by 1.47 fish per redd, the 8 redds rendered an estimate of 12 fish spawning in the reach below the diversion.

A one pass, post-peak redd survey was conducted from Conconully Dam downstream to the private property line above Happy Hill road. A total of 24 redds were located (Figure 19), rendering an estimated 35 fish spawning in that section of creek. Combining the total spawning estimates from the lower and upper spawning survey reaches would lead to a total of 46 steelhead. Multiplying that number by the proportion of wild PRD fish detected on SA1 (4/5=0.80) rendered 38 natural-origin and eight hatchery steelhead. This estimate was generally comparable to the 29 and 7, wild and hatchery estimate determined by PIT tag detections. Because the estimate from redd counts was larger, even with a large section of river not surveyed for redds above the diversion to above Happy Hill road, we defaulted to the redd survey based spawning estimate. For reference, trends in steelhead spawning escapement for Salmon Creek are included in Figure 18.

It is interesting that the number of hatchery steelhead spawners in Salmon Creek has generally been declining in recent years, including the unexpectedly low estimate of 3 in 2019, 14 in 2020 and 8 in 2021. Between 30,000 and 40,000 hatchery juvenile steelhead are released in the creek each year (Wes Tibbits, CCT, pers. comm.). It is certainly possible that spawning estimates could have been bias low due to error associated with small sample size and few detections. However, because a relatively large proportion of the total adult population (generally ~15-20%) is included in the PRD mark group and interrogation site SA1 had a high detection efficiency in 2019, 2020 and 2021 (all ~100%), it is unlikely that significant numbers of hatchery adults were unaccounted for. It is also possible that juvenile hatchery steelhead released in Salmon Creek are not returning to this stream,

potentially due to lack of imprinting or insufficient attractant flows in April (typically ~5cfs). Low smolt-to-adult return rates in recent years potentially contributes to the decline in hatchery return numbers, as well. Additionally, between 500 and 2,000 hatchery juveniles from the release groups are estimated to residualize in the creek annually (OBMEP 2022, Appendix B).

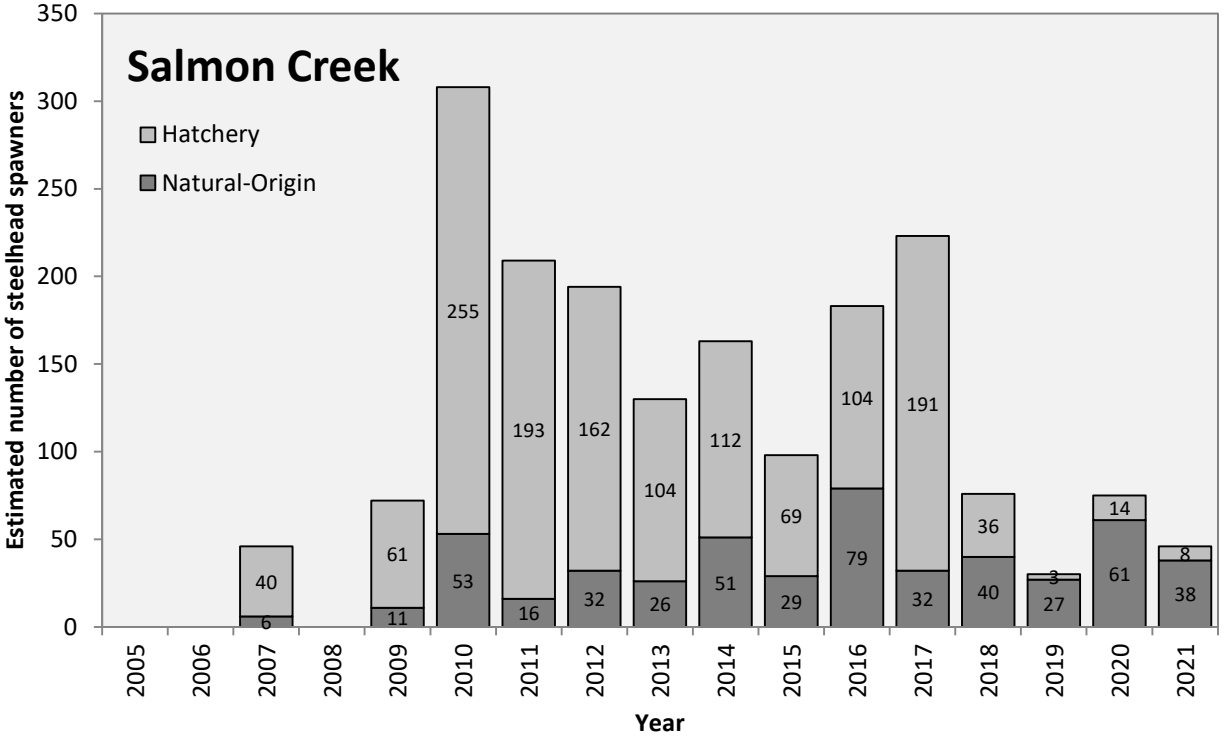

Figure 17. Trend in the number of steelhead spawners in Salmon Creek.

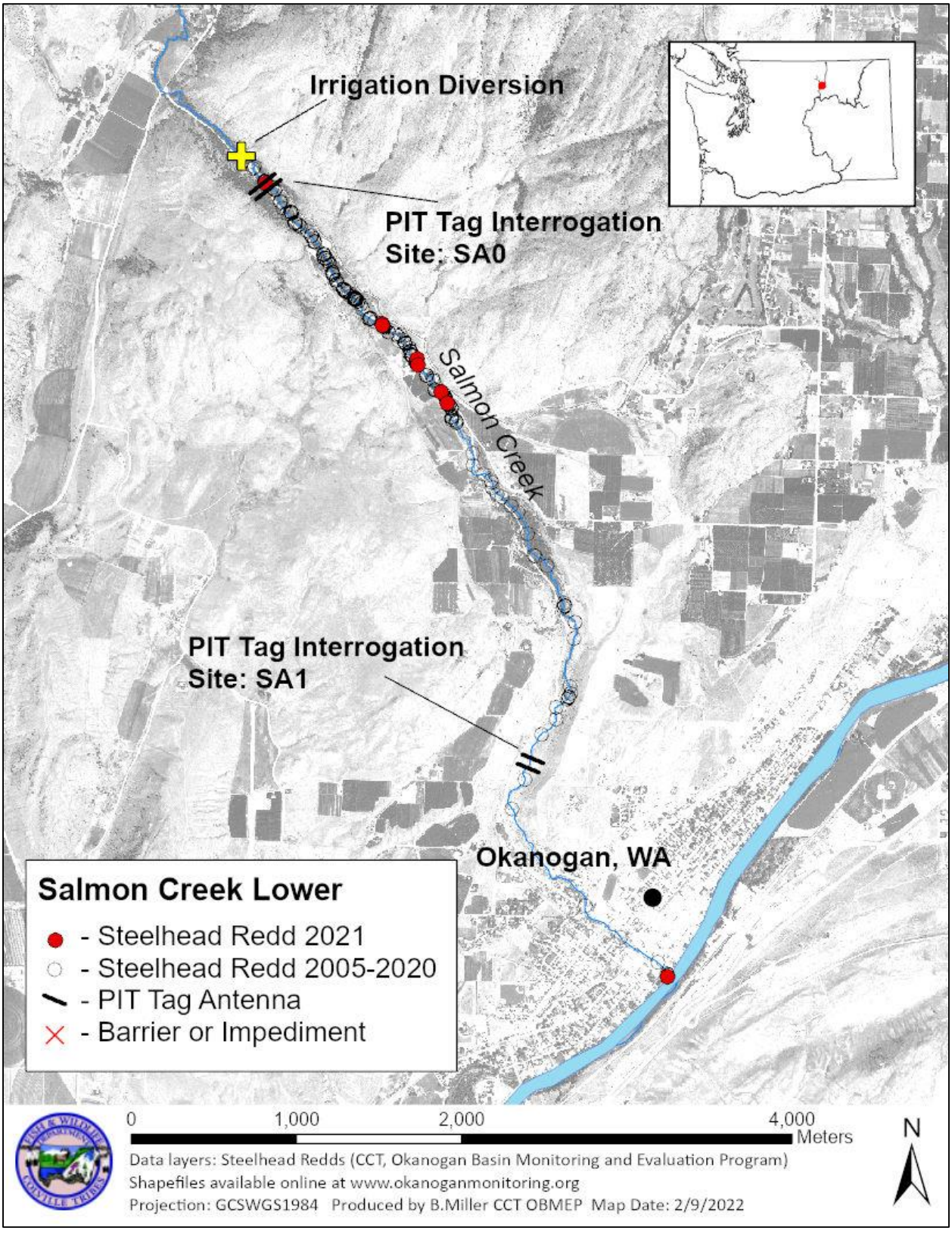

Figure 18. Spatial distribution of historical summer steelhead redds documented in lower Salmon Creek, from the confluence to the irrigation diversion.

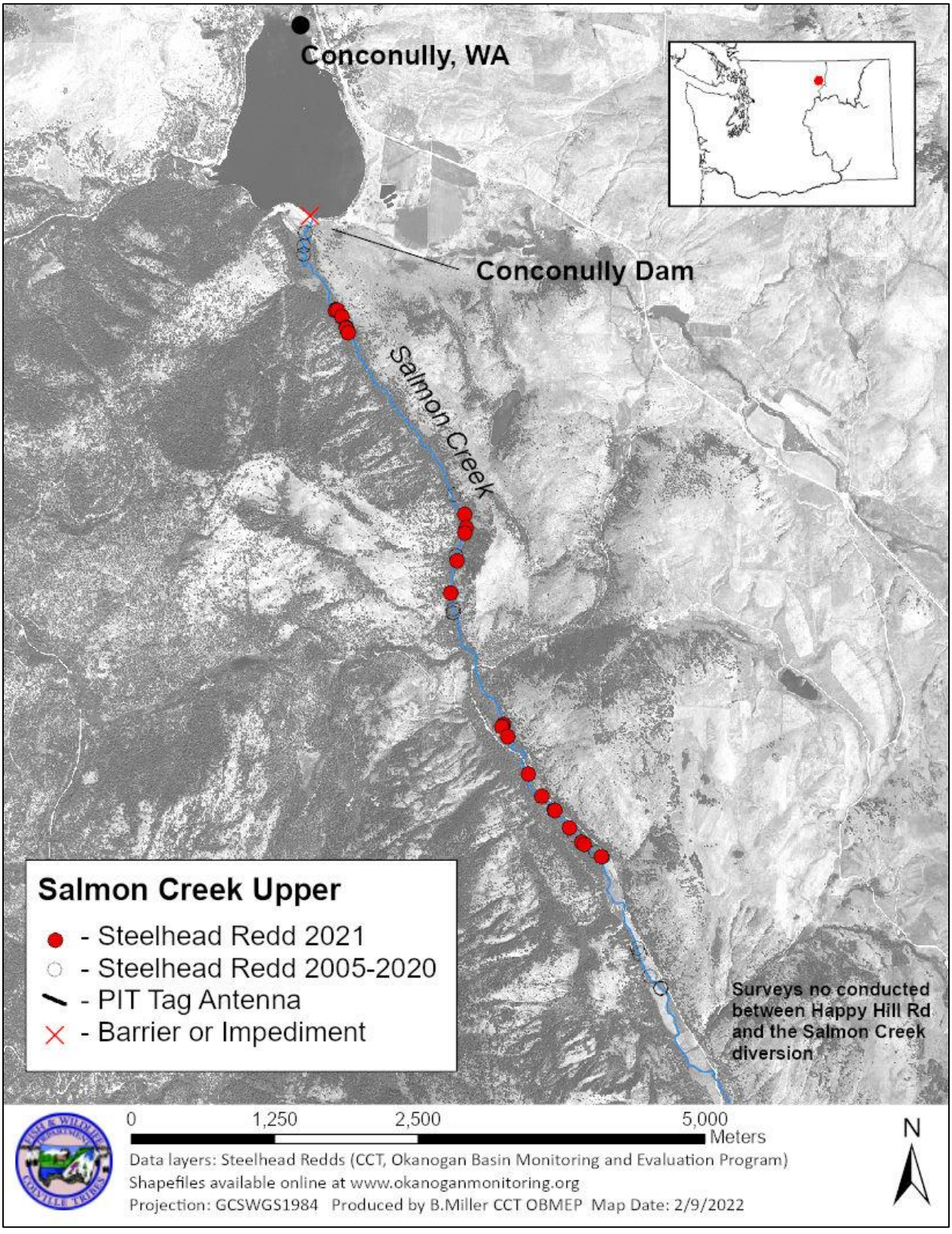

Figure 19. Spatial distribution of summer steelhead redds documented in upper Salmon Creek, below Conconully Dam.

3.2.3 Omak Creek

Omak Creek is characterized as a perennial, medium sized tributary that enters the Okanogan River at RKM 51.5, approximately 1.0 km upstream from the city of Omak, WA. Discharge rates in the creek generally range from a base flow of 2–4 cfs to over 150 cfs during peak runoff. During the base flow period, wetted widths range from approximately 2 to 8 m. A PIT tag interrogation site (OMK) consisted of four pass-over HDPE antennas configured in two separate rows located 0.24 km upstream from the confluence with the Okanogan River. Two additional PIT tag interrogation sites were also operated below (OBF) and above (OMF) Mission Falls to monitor passage rates. Each of these sites consisted of a two pass-over HDPE antennas configured in a single row.

Runoff in Omak Creek began in mid-March and lasted through the end of May (Figure 13). After the runoff period, a combination of redd surveys conducted during May 25, May 26 and June 10th covered the section of creek from the confluence with the Okanogan River to Mission Falls. A total of 15 redds were located below the adult weir trap and 33 redds were located from the weir trap to the falls (Figure 22). These redds were expanded by 1.47 fish per redd for an estimated 22 steelhead below the weir and 49 above the weir. This total of 71 fish accounted for by redd surveys was likely an underestimate due to missed redds during the high runoff period. Redd surveys have not been conducted above Mission Falls due to the very few numbers of fish ascending the falls to date and the significant number of stream kilometers above that point.

The total spawning estimate for Omak Creek was estimated based on PIT tag detections and fish handled at the adult weir trap. A total of 4 natural-origin and 12 hatchery steelhead were detected at OMK. We assumed a 72.7% detection efficiency at OMK in 2021 because 16 of the 22 PIT tagged fish detected at the weir or the upstream sites (OBF and OMF) were detected previously at downstream OMK. Those tags were expanded by the mark rate (0.139) and detection efficiency (0.727) for a total number of 40 natural-origin and 119 hatchery steelhead entering the creek. A total of 4 wild and 6 hatchery fish were removed at the weir for broodstock, and 17 natural-origin and 65 hatchery steelhead were passed upstream of the weir. To determine the efficiency of the adult weir trap in 2021, we looked at steelhead that were tagged prior to entering the creek and were detected at either OBF or OMF, both of which are located above the weir (12 total). Of those 12 fish, 11 were handled at the weir, rendering an estimated 0.92 efficiency across the season (0.92=11/12). The number of fish passed above the weir was expanded by the weir efficiency of 0.92, for a total spawning estimate above the weir of 19 natural and 71 hatchery-origin steelhead. The number of fish spawning below the weir would be the total number of fish entering the creek, minus the number removed at the weir and minus the expanded estimate passed above the weir, for a total of 17 natural-origin and 42 hatchery steelhead (Table 5).

Table 5. Calculations used to estimate the number and distribution of spawning steelhead in Omak Creek in 2021.

Description (Variable)	Natural-origin	Hatchery
A. Total steelhead entering Omak Creek in 2021	40	119
B. Number of steelhead broodstock removed at weir	4	6
C. Number of steelhead passed upstream of weir	17	65
D. Estimated # steelhead spawning above weir (D = C/0.92)	19	71
E. Estimated # steelhead spawning below weir (E = A-B-D)	17	42
F. Number of steelhead above Mission Falls (a subset of D)	2	1
G. Total estimated number of SH spawning 2021 (G = D+E)	36	113

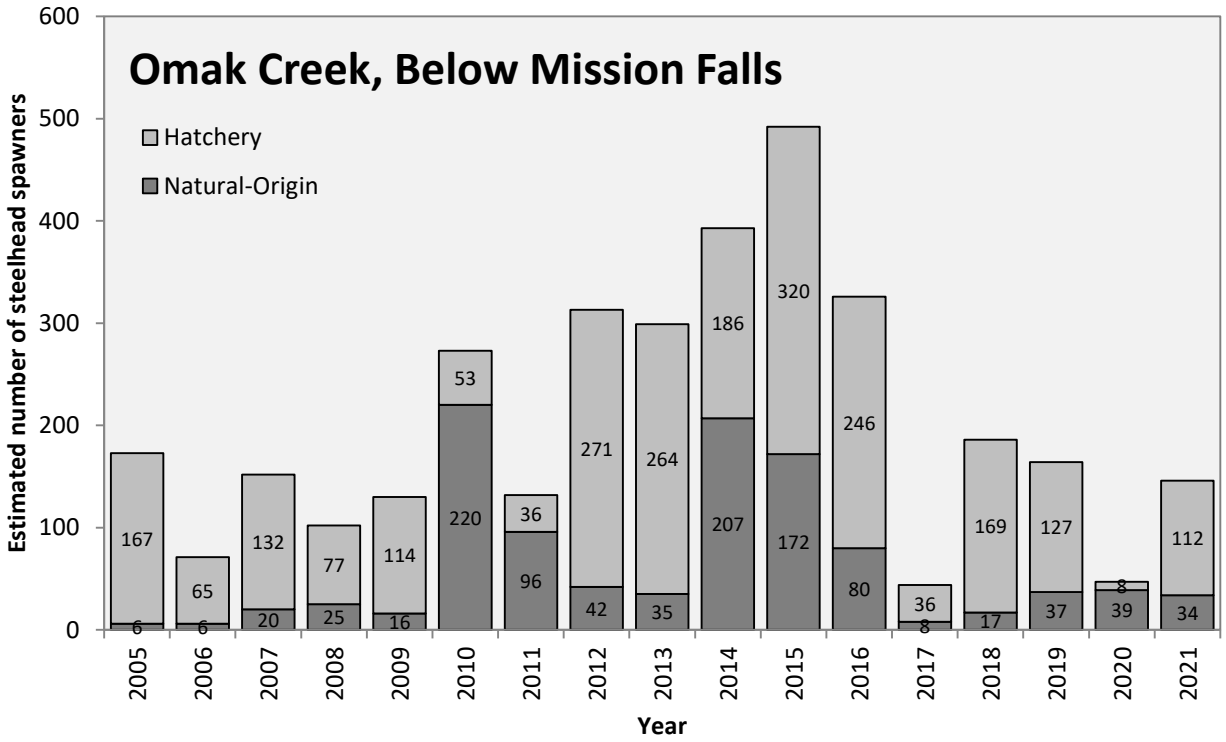

Figure 20. Trend in the number of steelhead spawners in Lower Omak Creek.

Passage through Mission Falls on Omak Creek

A total of fifty-five PIT tagged adult steelhead were detected at the OBF array located below Mission Falls. Every fish handled at the downstream weir received a PIT tag, thus expanding that detection count by the weir capture efficiency (0.92) gave a total estimated 60 steelhead that made it to the base of Mission Falls (13 natural- and 47 hatchery-origin). In 2021, three PIT tagged steelhead were detected above Mission Falls. One fish was detected below the falls on April 21 and above the falls on April 30, another below on April 22 and above on May 5, and the final fish was detected below the falls on May 12 and above on May 16 (Figure 21). The first fish appeared to ascend the falls outside the range that has been seen in previous years, at a minimum of at least 80 cfs. Prior to this fish, all adult steelhead that have been detected passing through the falls were generally confined between 25-50 cfs.

In 2020, nine PIT tagged steelhead were detected at OBF (at the base of Mission Falls) before equipment at the site was stolen in mid-April. However, a total of 14 fish were detected above Mission Falls in 2020 (13 of natural-origin and 1 hatchery steelhead). These tags were not expanded to unmarked fish because every adult steelhead that was handled and passed upstream of the weir received a PIT tag. Because the lower antenna OBF below the falls was stolen in 2020, the passage data and timing of fish detected on the bottom to the top of the falls were incomplete this year. Timing data from 2019 was more compete. Passage through Mission Falls was documented between April 18 and May 20, 2019. Steelhead were first detected at the base of the falls (OBF) on April 1, 2019 (dashed grey line, Figure 21). Passage time was between one and six days as calculated by the time elapsed between the last detection below the falls (OBF) and the first detection above the falls (OMF), a distance of approximately 1200 meters. The single day passage occurrence on 5/2/2019 was the only female in the group and was recaptured at the Omak Creek weir six days after last detection above Mission Falls.

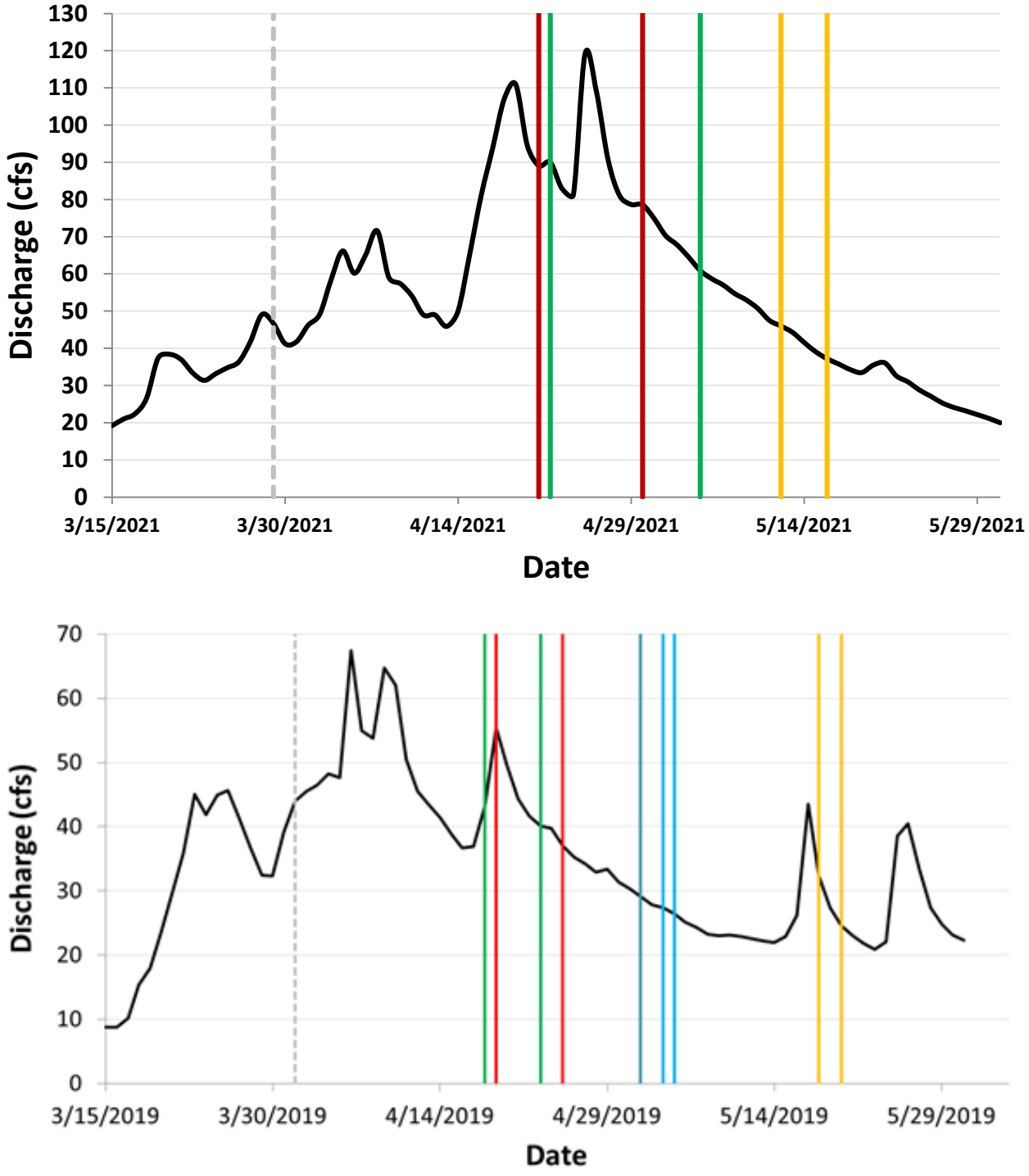

Figure 21. Timing of successful adult steelhead passage events at Mission Falls on Omak Creek 2021 (top) and 2019 (bottom). Dashed grey vertical line represents the date of first PIT tag detection below Mission Falls (OBF). Color coded lines are individual fish, with the first sequential color occurrence representing last detection below the falls (OBF) and the second occurrence is the first detection above the falls (OMF). One event occurred in a single day in 2019 (dark blue line).

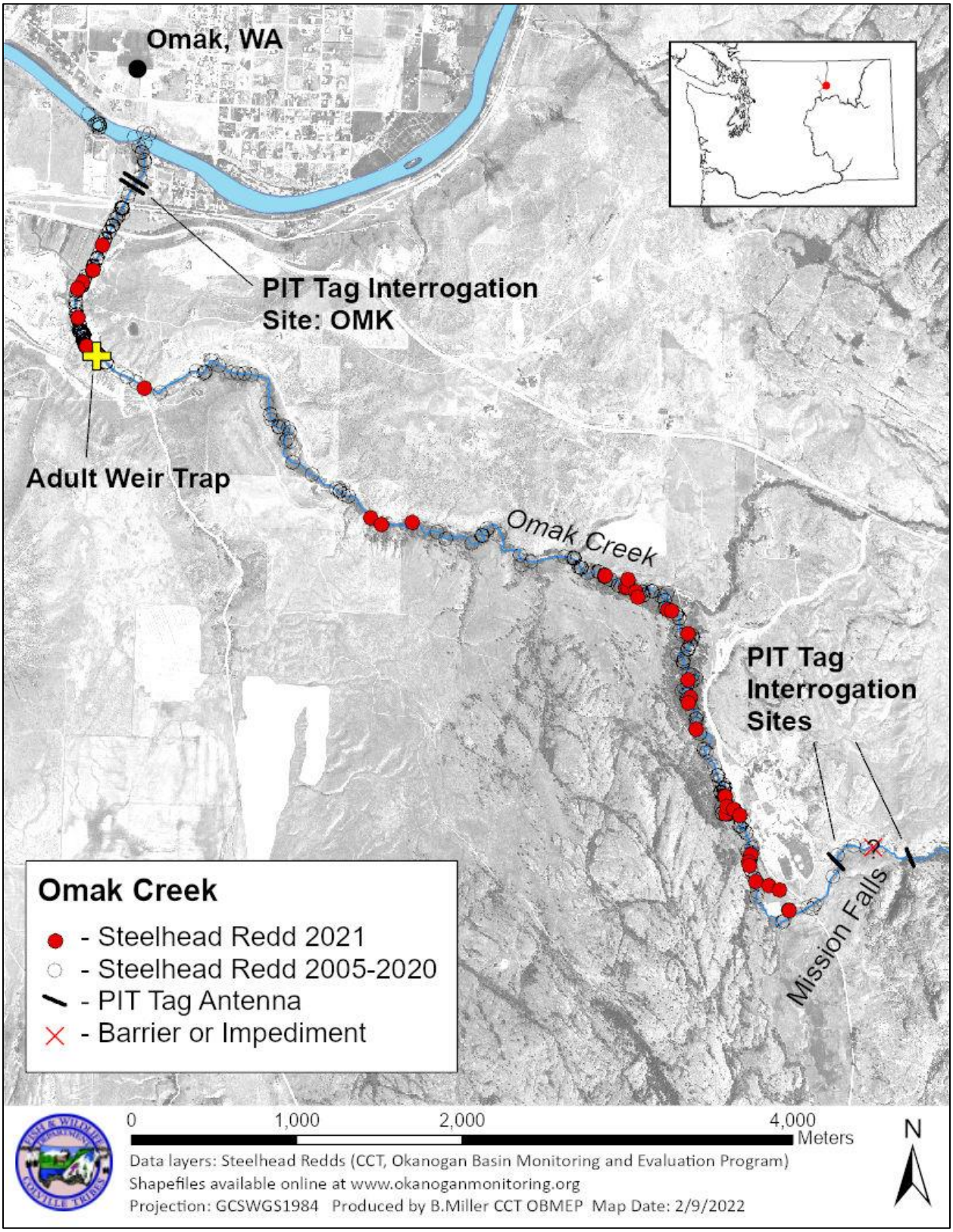

Figure 22. Spatial distribution of historical summer steelhead redds documented in Omak Creek, from the confluence to Mission Falls.

3.2.4 Wanacut Creek

Wanacut Creek is a small stream that joins the Okanogan River at approximately RKM 56, between Omak and Riverside, WA. The 51 km^2 Wanacut Creek drainage stems from Omak Mountain, located on the Colville Reservation. A large natural falls exists a short distance from the confluence with the Okanogan River and the creek frequently flows subsurface in the lower most reaches. A temporary PIT tag interrogation site (WAN) is operated seasonally near the mouth of the creek to record PIT tagged steelhead movements.

No PIT tagged steelhead were detected on interrogation site WAN, which would have resulted in a zero spawning estimate. Redd surveys were conducted on Wanacut Creek from the mouth to the upstream falls on Mar 24, Apr 21, May 5 and June 3. During all surveys, only one redd was found on May 5 (Figure 24). One redd expanded by the FPR rate of 1.47 rendered a rounded two steelhead spawners for the 2021 spawning year. In all previous years of data, the majority of steelhead spawning in Wanacut Creek has been of hatchery origin (0.80 across all years). Applying this rate to the 2021 fish would render both to be of hatchery-origin. The lower portion of the creek was dry in early July. The location of the redd observed in 2021 and in previous years (2005–2020) are shown in Figure 24. Over the previous 14 years of surveys conducted on Wanacut Creek (2007–2021), seven years had no steelhead spawning and the maximum spawning estimate was 12 in 2012 (Figure 23).

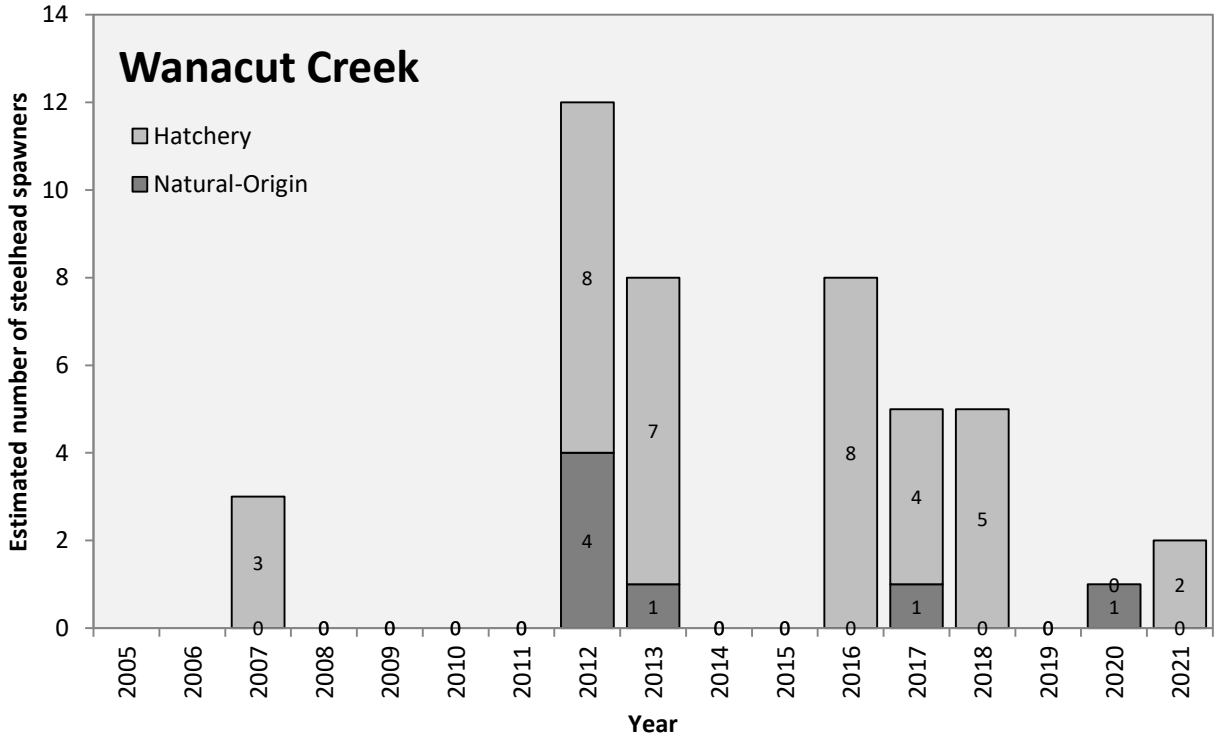

Figure 23. Trend in the number of steelhead spawners in Wanacut Creek.

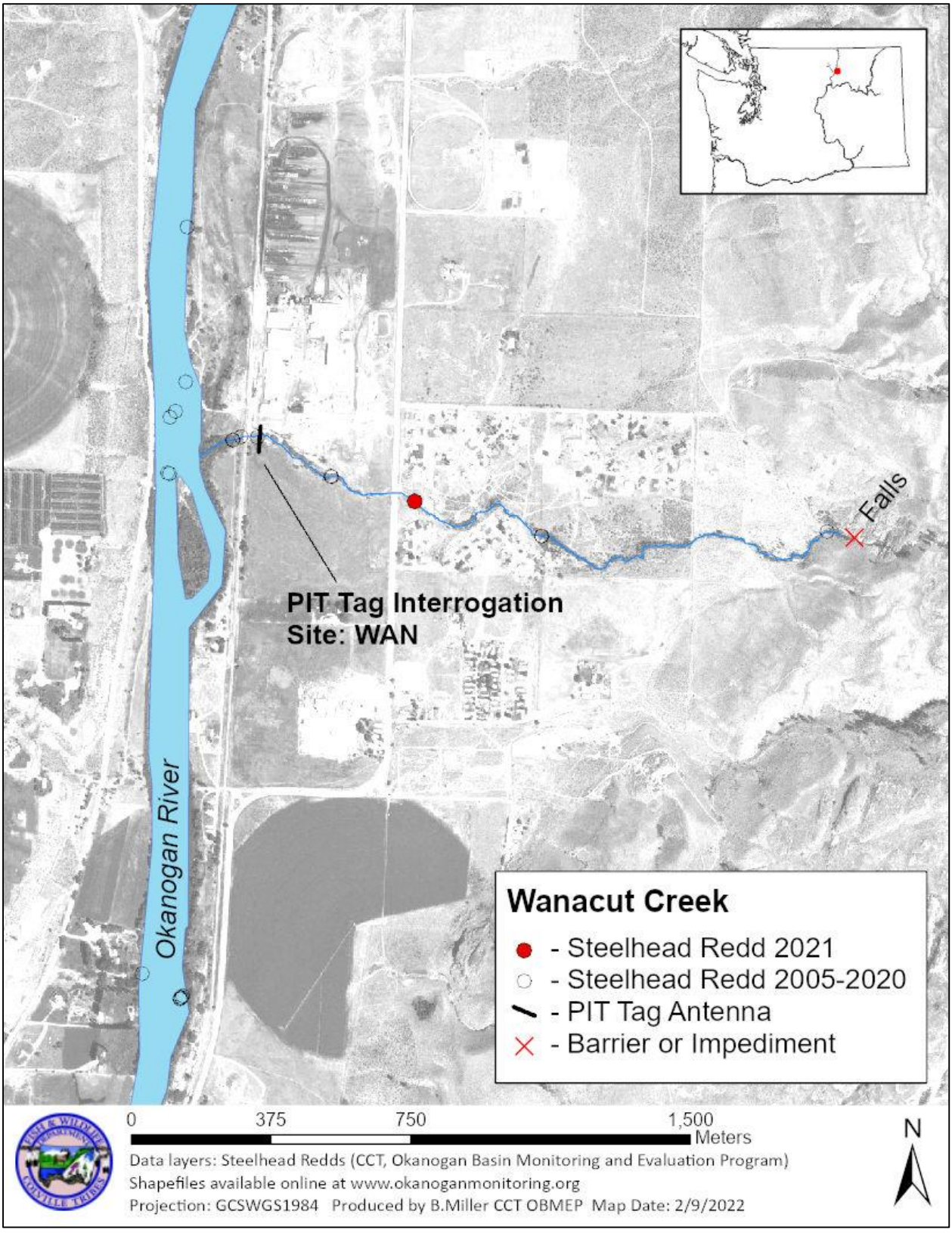

Figure 24. Spatial distribution of historical summer steelhead redds documented in Wanacut Creek.

3.2.5 Johnson Creek

Steelhead surveys have occurred in Johnson Creek since 2012 and two PIT tag arrays were again operated in the creek in 2021. A permanent single pass-through antenna located near the mouth (JOH) and a single temporary pass through antenna above the US 97 culvert. No PIT tagged steelhead were detected at either PIT tag interrogation site in Johnson Creek in 2021, which rendered a total spawning estimate of zero. Zero steelhead were also detected in 2020. For reference, trends in steelhead spawning escapement for Johnson Creek are included in Figure 25, which generally show a declining trend in steelhead spawners since data collection began in 2012. This trend from 2012 on- generally tracks the overall trend in total spawners in the subbasin as a whole (Figure 3).

Redd surveys on Johnson Creek were conducted on April 5, April 29 and May 30; no steelhead redds were found. The spatial distribution of steelhead spawning in lower Johnson Creek in previous years are shown in Figure 26.

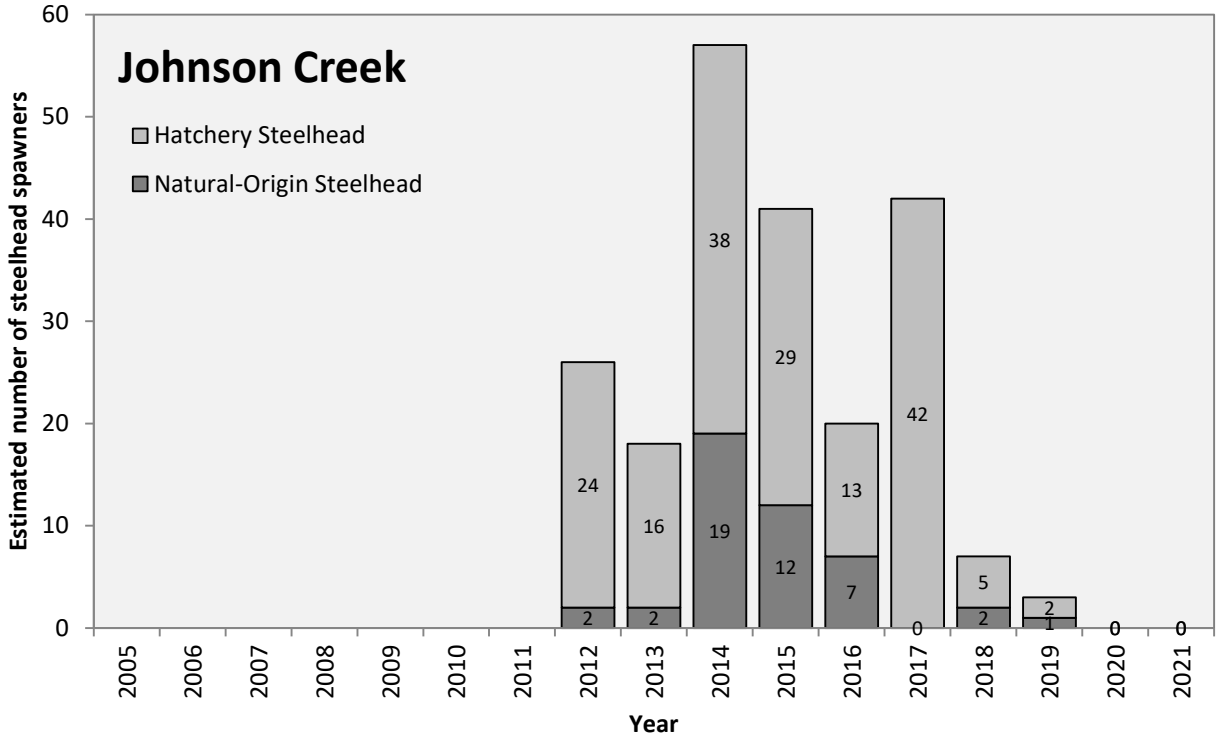

Figure 25. Trend in the number of steelhead spawners in Johnson Creek.

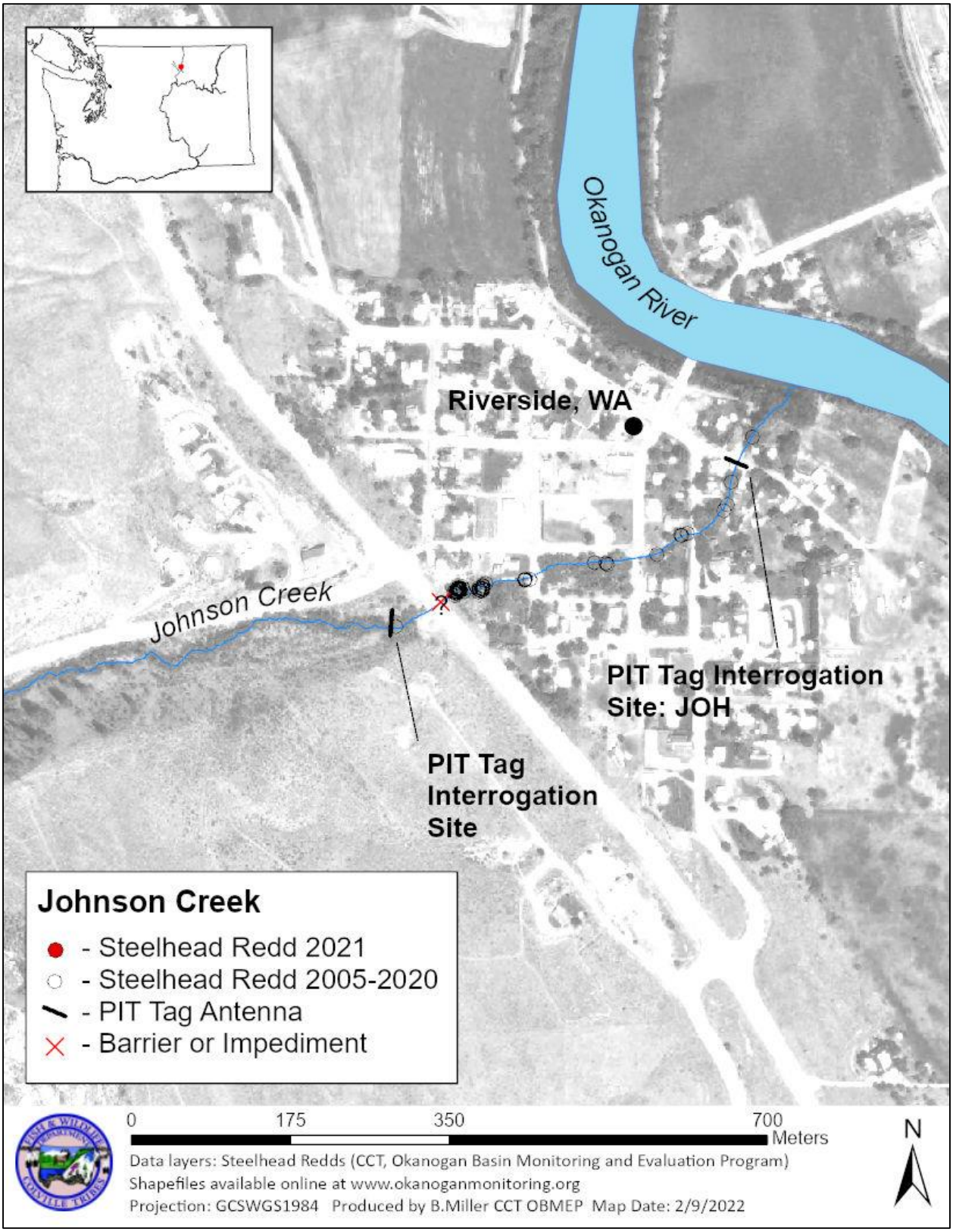

Figure 26. Spatial distribution of summer steelhead redds documented in Johnson Creek, from the confluence to the gabion weir.

3.2.6 Tunk Creek

Tunk Creek is a small tributary that joins the Okanogan River at RKM 72, upstream of Riverside, WA. Although the drainage area of Tunk Creek is approximately 186 km^2, only the lower 1.2 rkm are accessible to anadromous fish, due to a natural falls. The creek frequently flows subsurface in the lower reaches during mid-summer. A temporary PIT tag detection site (TNK) consisting of a single pass-through antenna is installed seasonally near the mouth of the creek.

Redd surveys in Tunk Creek were attempted from March through May. Conditions were generally unfavorable throughout the spring due to elevated flows and turbid water conditions. On April 12, water clairity improved slightly and a redd survey was attempted, which located eight redds. A final post peak survey was conducted at the end of the spawning season that marked an additional 14 redds for a total of 22. These redds, expanded by 1.47 FPR accounted for approximately 32 spawners. The majority of steelhead spawning in Tunk Creek occurs in a relatively short reach just downstream of the falls where superimposition is common (Figure 28), therefore, this count is likely an underestimate.

Through the spring of 2021, two natural- and seven hatchery-origin steelhead from the PRD group were detected at site TNK. These fish were expanded by the mark rate to 14 natural- and 50 hatchery-origin, for a total of 64 steelhead. The PIT tag expansion estimate was likely more reliable for a total spawner count due to surveyors likely missing redds due to superimposition, which is frequently observed in the region near the base of the falls (Figure 28).

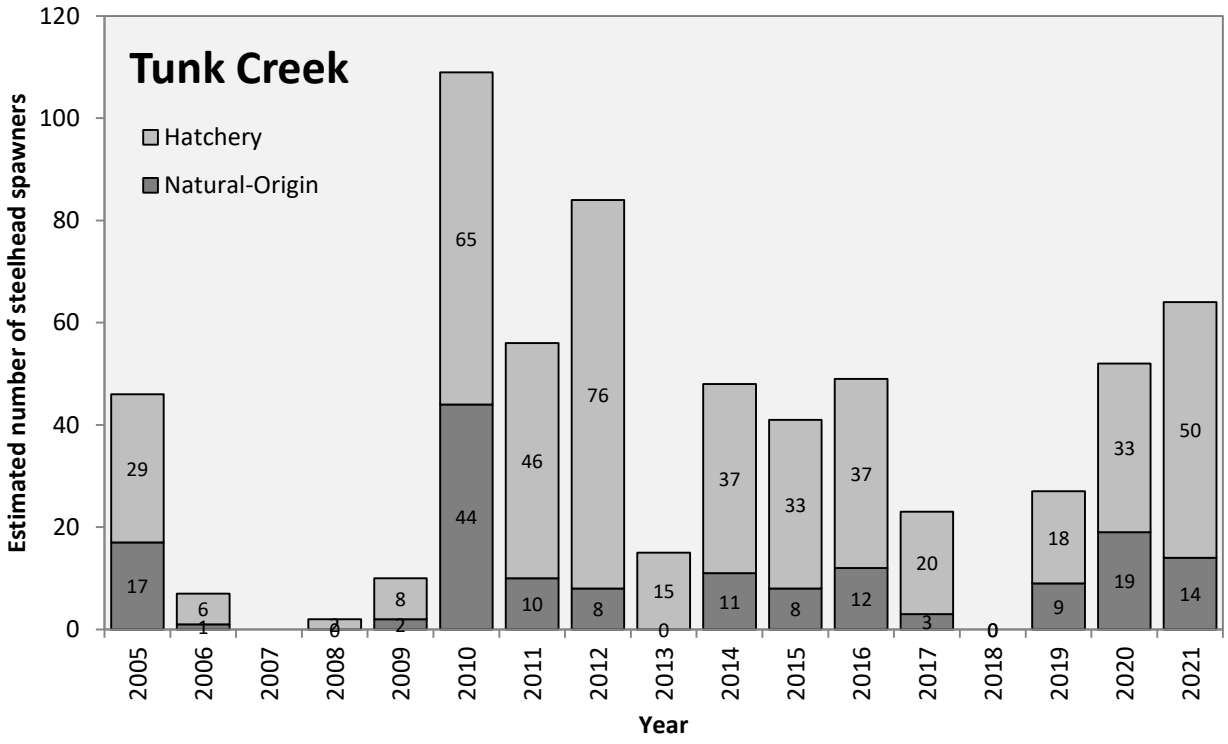

Figure 27. Trend in the number of steelhead spawners in Tunk Creek.

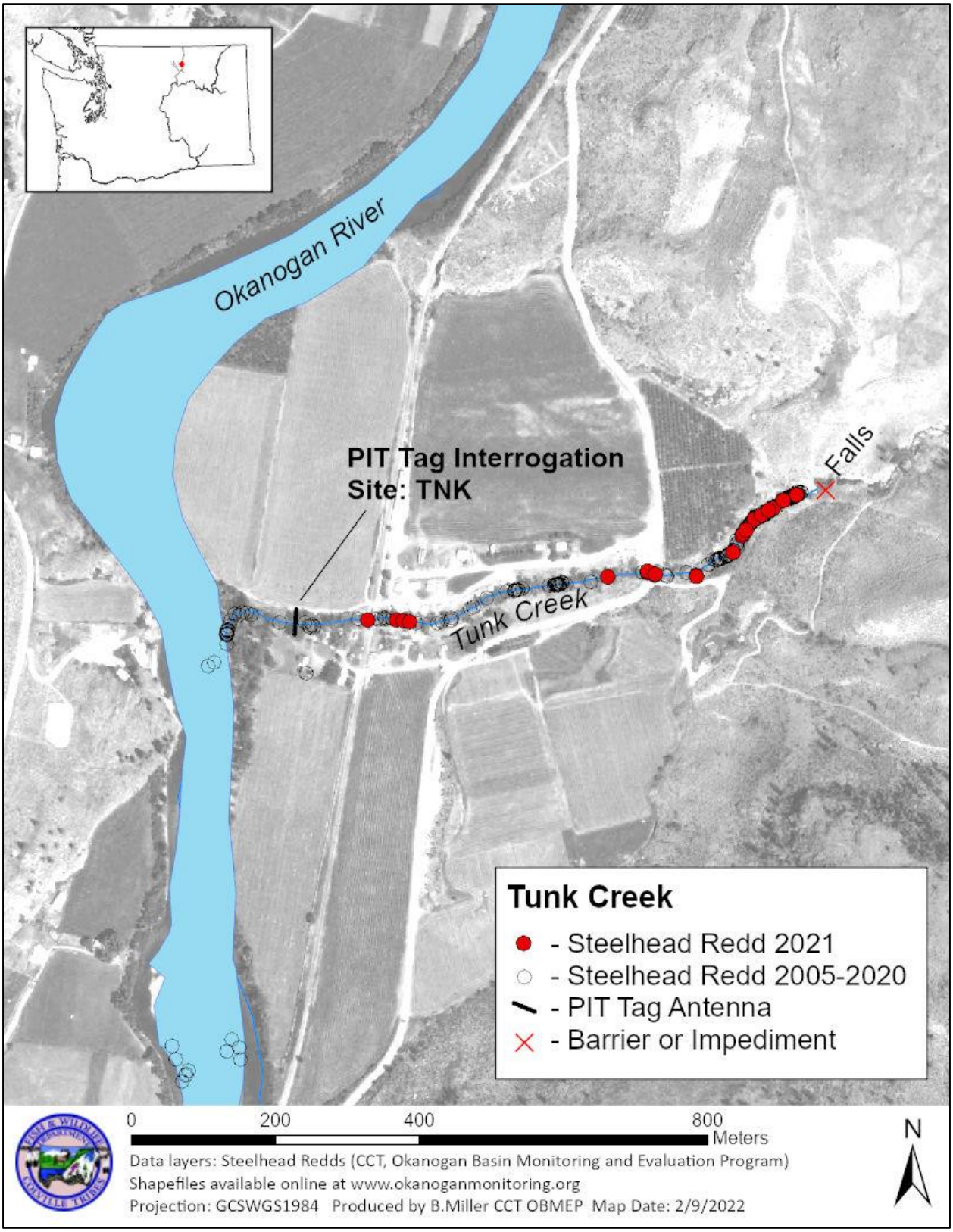

Figure 28. Spatial distribution of historical summer steelhead redds documented in Tunk Creek.

3.2.7 Aeneas Creek

Aeneas Creek is a small creek that enters the Okanogan River just south of the town of Tonasket, WA (RKM 85). The lower section of the creek was impounded with a series of very large beaver dams that were cemented in with calcified clay. In 2012, many of these structures were removed, allowing adult steelhead passage at the mouth of the creek. Although potential passage has not been studied at this location, the total habitat accessible to anadromous fish appears to be limited by a culvert and steep gradient (Figure 30). Redd surveys were conducted on April 1 (0 redds), April 22 (5 redds), May 3 (1 redd) and June 3 (0 redds), with a total of six redds counted throughout the season. The six redds, expanded by 1.47 FPR equaled an estimated nine steelhead spawning in Aeneas Creek in 2021.

A permanent PIT tag detection site (AEN) consisting of a single pass-through antenna operated near the mouth of the creek to document utilization of the creek by adult steelhead. No PIT tagged steelhead were detected in 2021, resulting a total spawning escapement estimate of zero steelhead. It is interesting to note that three of the redds were found below the PIT tag antenna, so it is possible that these fish may have not travel upstream through the antenna before spawning. Because six redds were found, we defaulted to the redd survey-based estimate of 9 steelhead. We assumed that these fish were likely of hatchery-origin based on historic hatchery/wild ratios from Aeneas Creek in previous years (Figure 29).

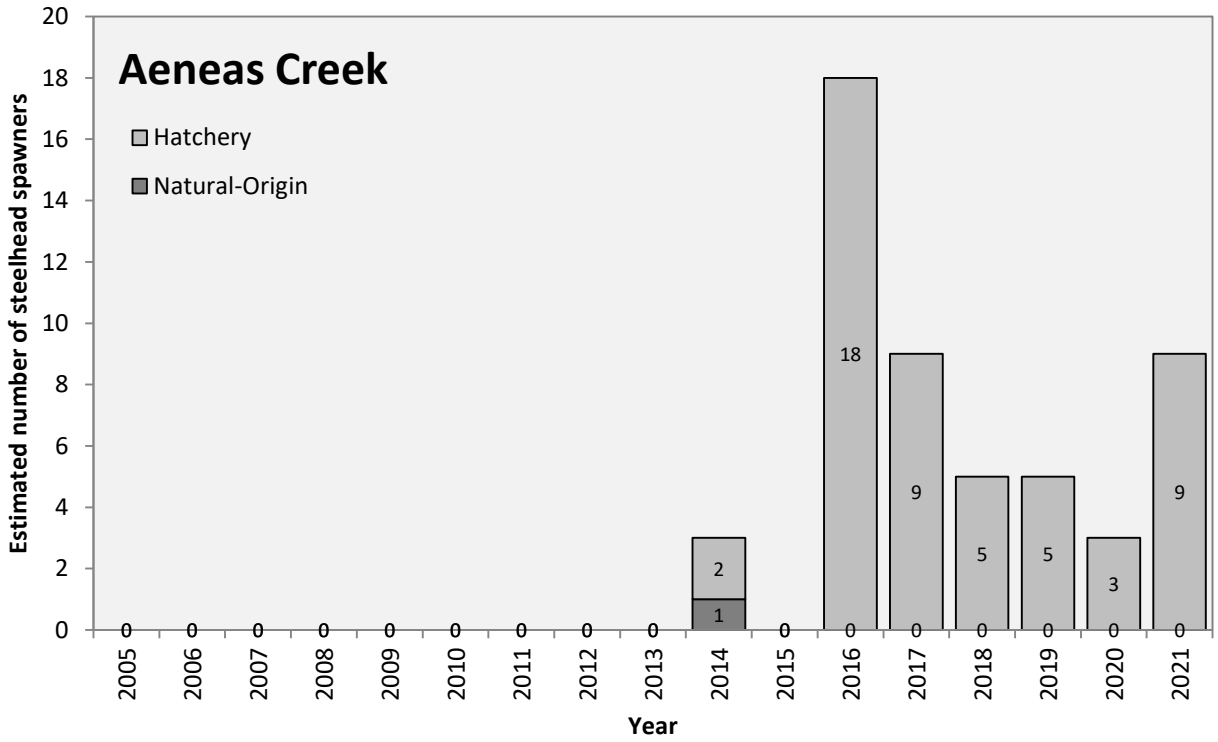

Figure 29. Trend in the number of steelhead spawners in Aeneas Creek.

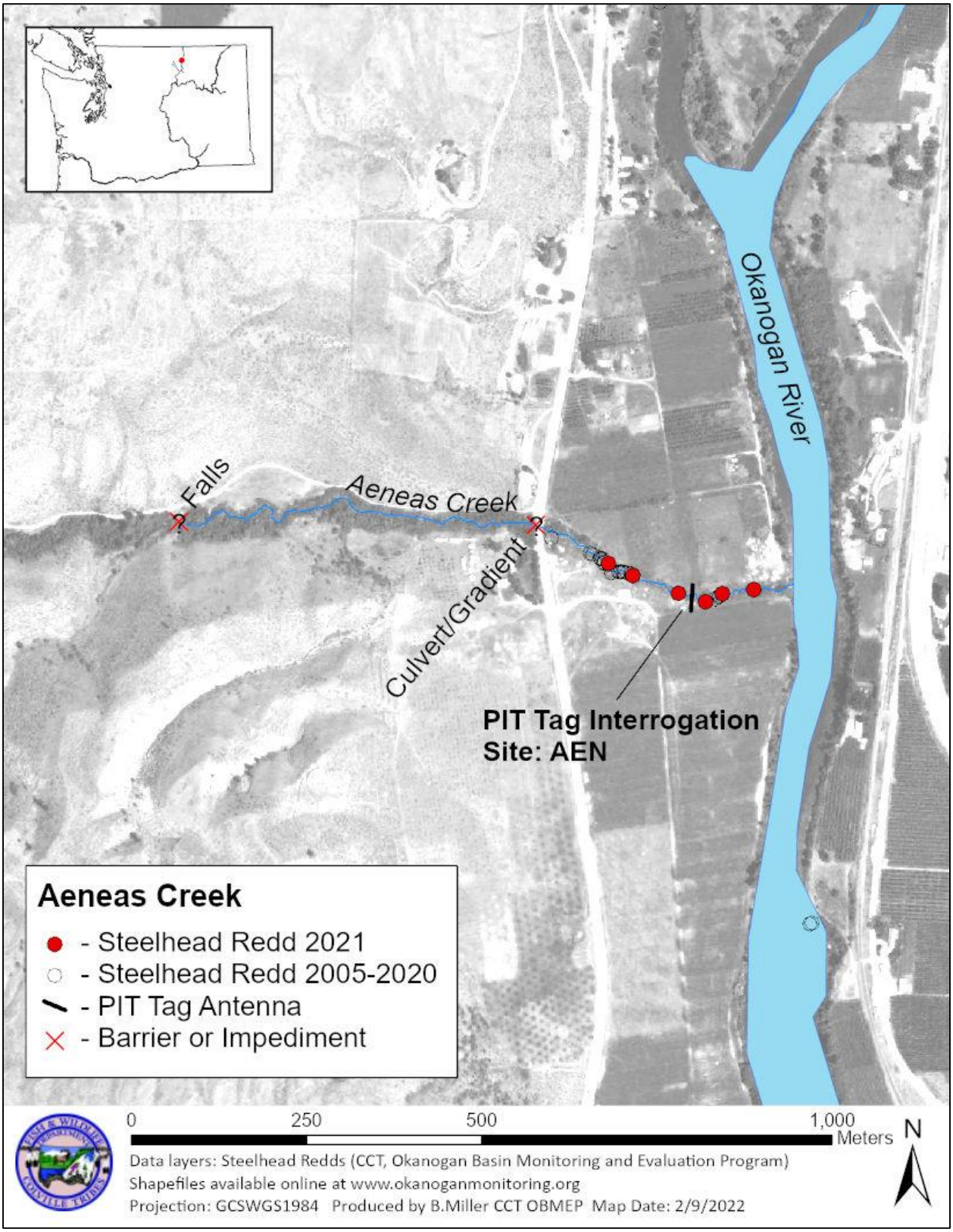

Figure 30. Spatial distribution of historical summer steelhead redds documented in Aeneas Creek.

3.2.8 Bonaparte Creek

Bonaparte Creek flows out of Bonaparte Lake, near Wauconda, WA, and enters the Okanogan River at RKM 91. The Bonaparte Creek watershed has a drainage area of 396 km^2; discharge ranges from 1 cfs during base flow conditions and usually reaches 20–40 cfs during runoff. During summer base flow, wetted widths range from 1.5 m to 3 m. Only 1.6 rkm of stream below a natural falls is accessible to anadromous fish (Figure 32).

A permanent PIT tag interrogation site (BPC) consisting of three pass-over HDPE antennas arranged in three separate rows was located just upstream from the confluence with the Okanogan River. Based on two natural-origin and one hatchery tag detections from the PRD mark group, the estimated spawning escapement was 14 natural-origin and seven hatchery steelhead in Bonaparte Creek in 2021. Three other hatchery steelhead not from the PRD mark group were also detected at BPC in the spring of 2021.

Redd surveys on Bonaparte Creek began on April 1 with no redds located. A second survey occurred on April 21 with 10 redds found. The water became turbid in the creek due to runoff through much of May (Figure 14). A final spawning survey occurred June 1 with nine new redds found. The total redd count (19), multiplied by the 1.47 FPR rate rendered a total of 28 spawners. To determine the proportion of wild and hatchery spawners, we took the total percent of wild and hatchery tags (33.33% wild) and multiplied that rate by the total number of spawners (28) for an estimated nine natural- and 18 hatchery-origin spawners. This ratio was generally supported by the number of wild/hatchery fish observed during redd surveys (based on presence of an adipose fin), which was one ad-present fish, four ad-clipped and two unknown. For reference, trends in steelhead spawning estimates for Bonaparte Creek are included in Figure 31. Distributions of redds found in the creek from current and previous years surveys (2005-2021) are shown in Figure 32.

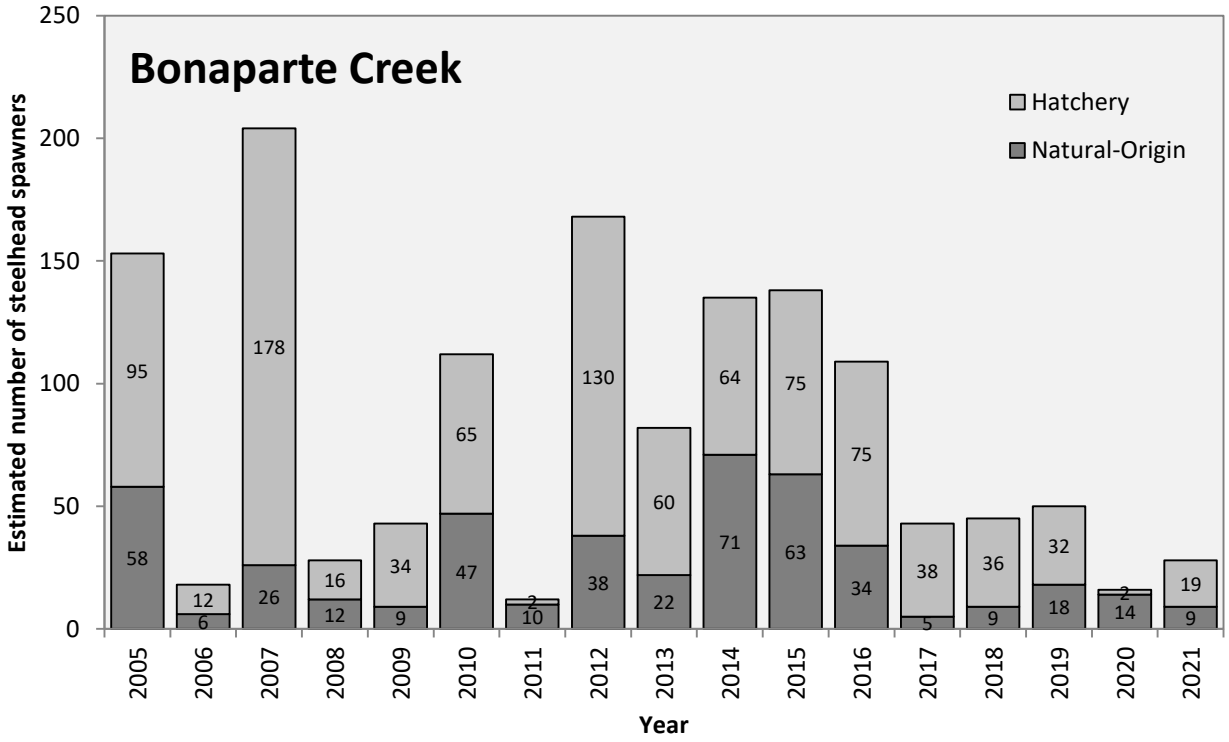

Figure 31. Trend in the number of steelhead spawners in Bonaparte Creek.

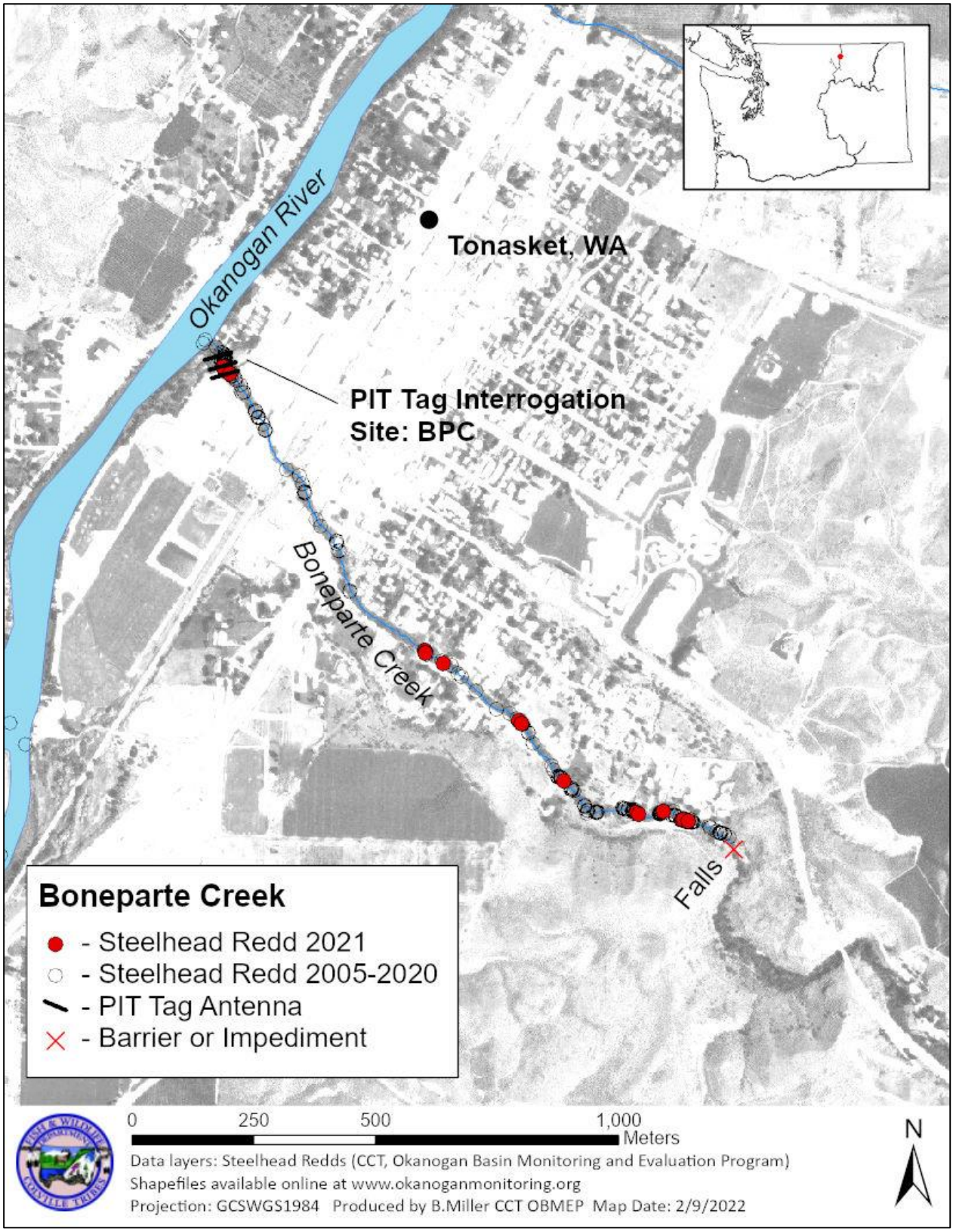

Figure 32. Spatial distribution of summer steelhead redds documented in Bonaparte Creek.

3.2.10 Antoine Creek

Steelhead surveys have occurred in the lower portion of Antoine Creek since 2006. The average number of estimated spawners is only five per year from 2006–2015. Utilization by adult steelhead had been relatively limited, potentially due to poor accessibility across the delta at the confluence with the Okanogan River. Additionally, access to Antoine Creek was at least partly impeded by an approximately 6-foot-high cut bank falls with a very shallow plunge pool near the confluence with the Okanogan River. Frequently, wood debris piled up in this slot and likely inhibited upstream passage. In late 2015, habitat modifications were completed near the mouth of Antoine Creek, designed to increase passage success for the 2016 spawning period (Keith Kistler, CCT, pers. comm.). Additionally, a small concrete dam was removed in Antoine Creek in the fall of 2013, which opened up an additional 11 rkm of habitat in the upper creek. In 2021, water was released from Fancher Reservoir in early April to act as an attractant flow and to facilitate adult steelhead passage into the creek (Figure 14). Since increasing instream flows and removing access barriers, the number of steelhead utilizing Antoine Creek has increased over the most recent six years, compared with prior estimates (Figure 33).

A series of three pass-through PIT tag antennas are operated near the mouth of Antoine Creek, just on the upstream side of the highway (PTAGIS site ANT). One natural-origin and three hatchery PIT tagged steelhead in the PRD mark group were detected on this site in 2021. Those fish were expanded for a total spawning escapement estimate of 7 natural-origin and 22 hatchery steelhead for a total of 29 fish. A temporary PIT tag interrogation site operated on Antoine Valley Ranch detected one PIT tagged natural-origin fish, which was also detected on downstream ANT site. Two additional hatchery steelhead were detected at the ANT array from outside of the PRD mark-group, with one of these being a successful kelt that likely spawned in the mainstem Okanogan the previous year.

In 2021, surveyors walked upstream from the mouth of the creek through Antoine Valley Ranch on a just post-peak survey on April 28 and at the end of the spawning season across two days (May 27 and June 14). On the first survey 28 redds were located and on the second set of surveys an additional five redds were found (Figure 34). These 33 redds expanded by 1.47 FPR rendered a total of 49 spawners. Due to the documented redds, we defaulted to the redd survey based estimate over the PIT tag expansion estimate. These fish were divided into 12 natural-origin and 37 hatchery spawners, based on the percent of wild tags detected on ANT (1/4=0.25). A picture of a redd located during surveys on lower Antoine Creek is seen on the cover of this report.

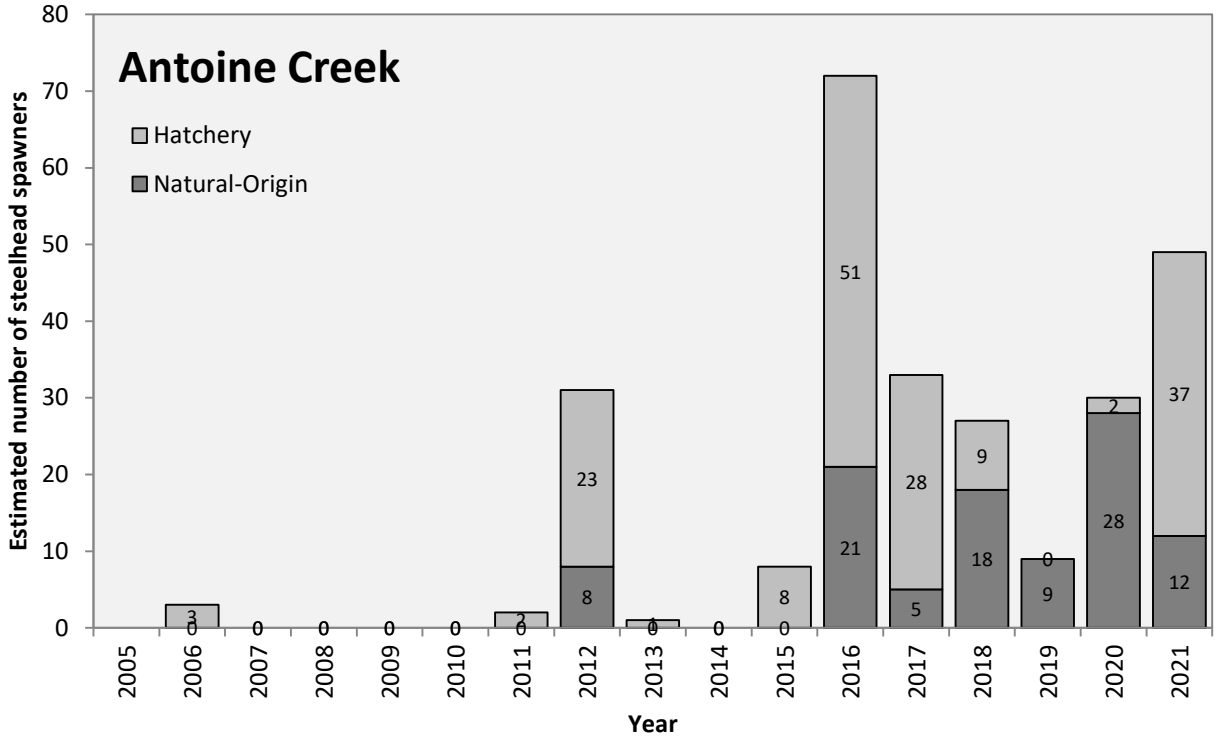

Figure 33. Trend in the number of steelhead spawners in Antoine Creek.

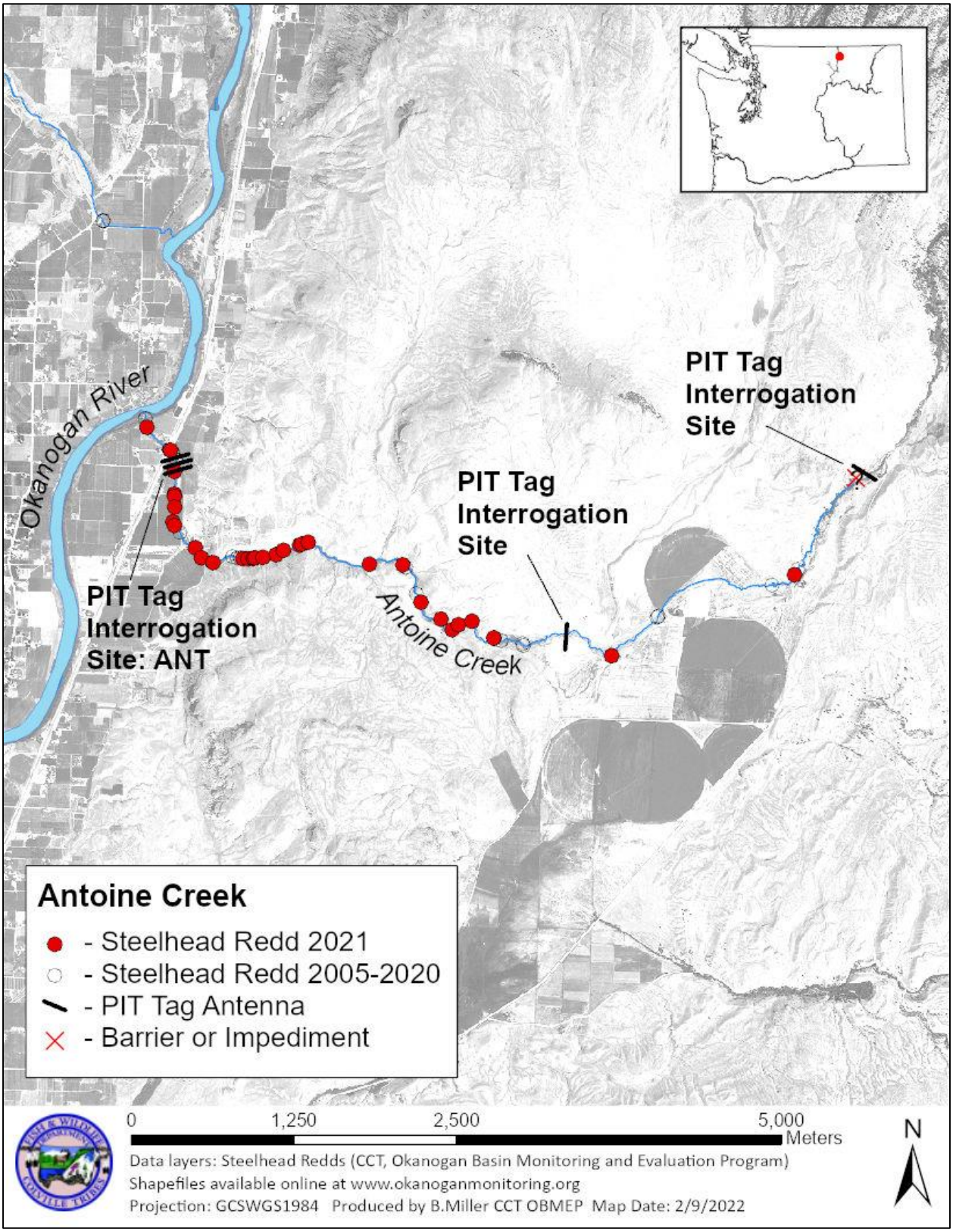

Figure 34. Spatial distribution of summer steelhead redds documented in Antoine Creek.

3.2.11 Wildhorse Spring Creek

Wildhorse Spring Creek is a fairly small watershed that flows off of the west side of Mt. Hull near Oroville, WA. Some years, there is not enough water depth for adult steelhead to access the creek. However, on years where sufficient water flows allow for adult steelhead access, it is not uncommon for relatively large numbers of fish to utilize this creek for spawning compared to its limited size. Surveys have occurred over the previous 16 years (2006–2021). On six of the years of record (2008, 2009, 2014, 2015, 2018, 2019) zero steelhead were estimated to have entered the creek.

Sufficient flow existed in 2021 to allow adult steelhead passage; zero natural-origin and six hatchery steelhead from the PRD mark group were detected on PIT tag detection site WHS, operated just above the highway culvert. The total spawning estimate for 2021 was 0 natural-origin and 43 hatchery steelhead, based upon PRD expansion rates. The Colville Tribes Broodstock Acclimation and Monitoring program (BAM) attempted to operate an adult steelhead weir trap in the lower portion of the creek, just above the PIT antenna with no captures, although the weir pickets were removed for much of the runoff. No redds were found below the trap/PIT tag interrogation site in 2021 and no redd surveys were attempted above the weir trap site due to lack of landowner permission.

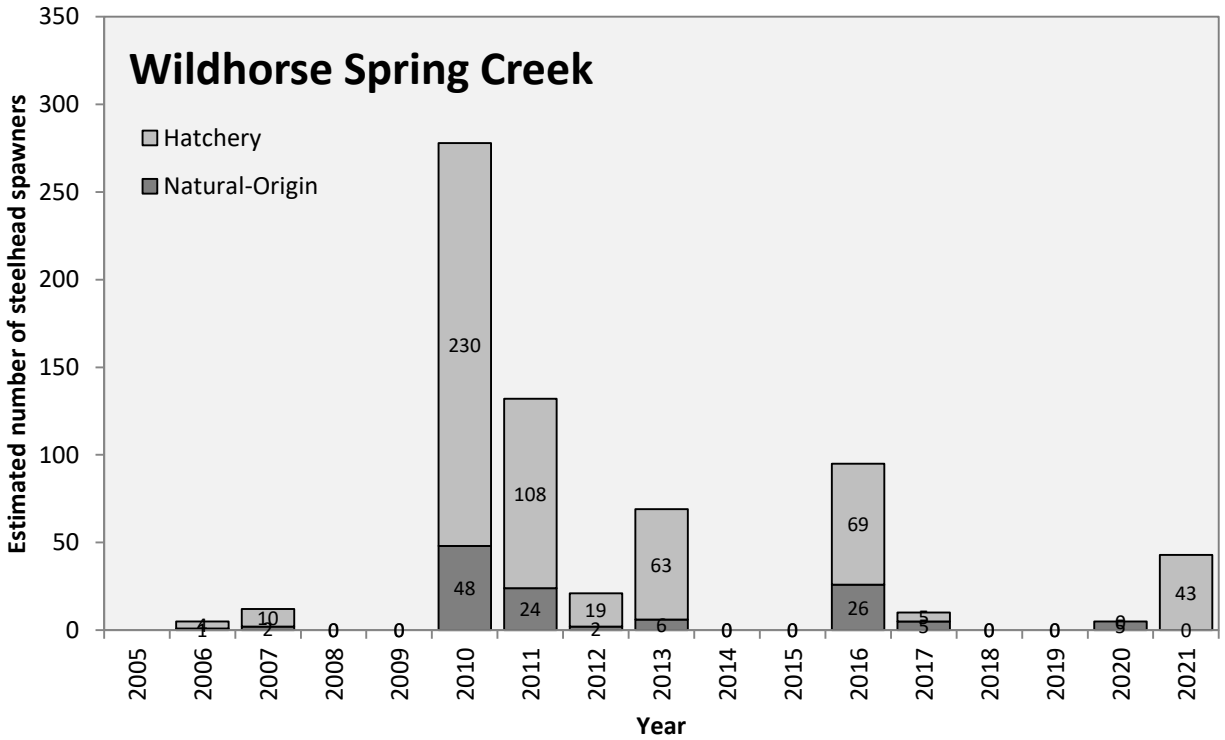

Figure 35. Trend in the number of steelhead spawners in Wildhorse Spring Creek.

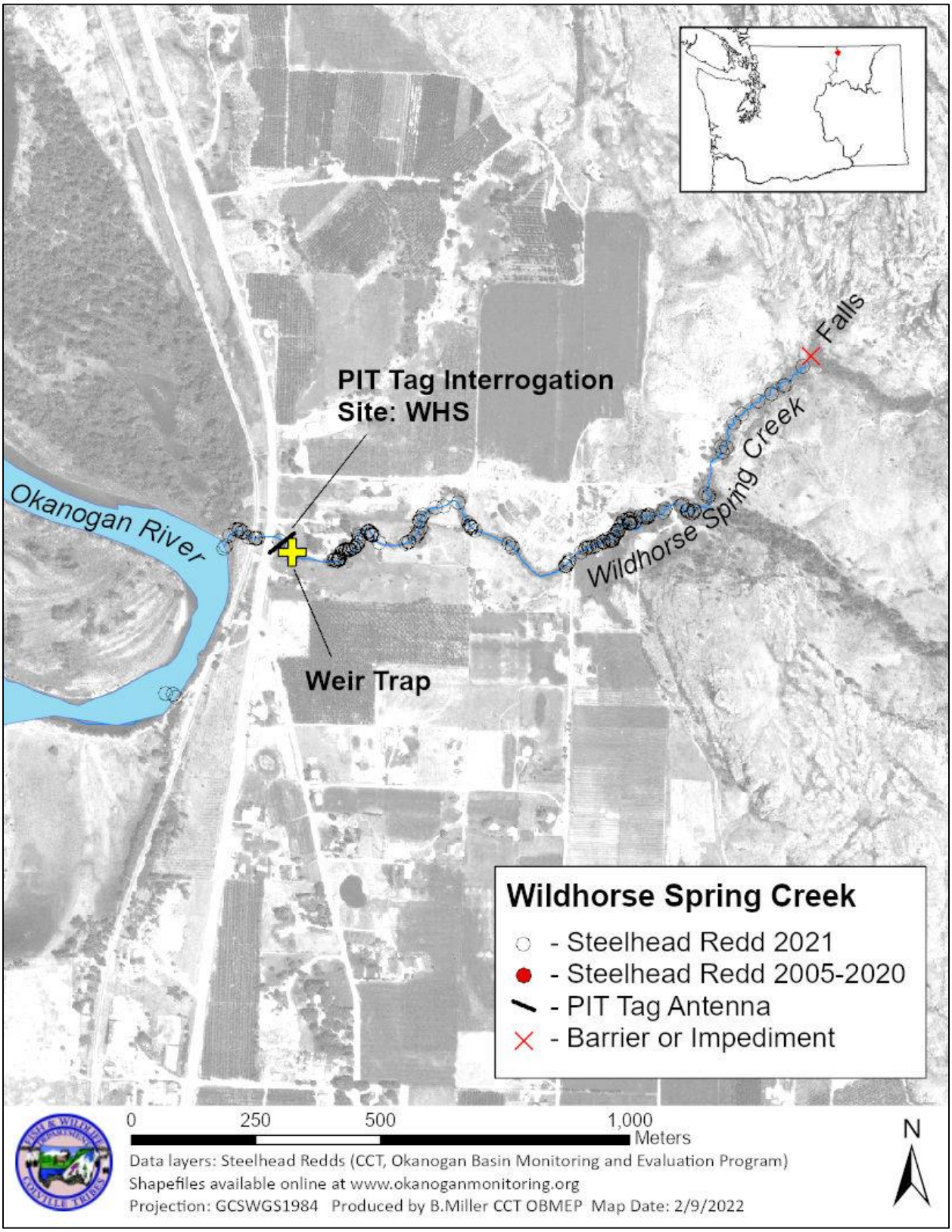

Figure 36. Spatial distribution of summer steelhead redds documented in Wildhorse Spring Creek.

3.2.12 Tonasket Creek

Tonasket Creek enters the Okanogan River at RKM 125, just upstream from Zosel Dam, at the tail end of Lake Osoyoos. The lower reach is known to go dry on an annual basis; however, there is typically some flow in the upper-most reach, below the natural falls (Figure 38). A seasonal PIT tag detection site (TON) consisting of a single pass-through antenna is operated near the confluence of the creek with the Okanogan River.

A total of two natural-origin and four hatchery steelhead from the PRD mark group were detected at site TON in 2021. This rendered a spawning estimate of 14 natural-origin and 29 hatchery steelhead spawners. Walking surveys occurred on April 5 and April 12. The creek was turbid due to runoff on Apr 26. The final survey was conducted on May 6 and nine redds were found. These nine redds were expanded by the FPR rate of 1.47 to equal an estimated 13 spawners. The surveys noted numerous fish at the upper falls and a lot of cleaned gravel. The redd count may have been an under count do to superimposition. Because of likely superimposition, the PIT tag value is the more accurate estimate for total spawners. The lower portion of the creek was dry by July.

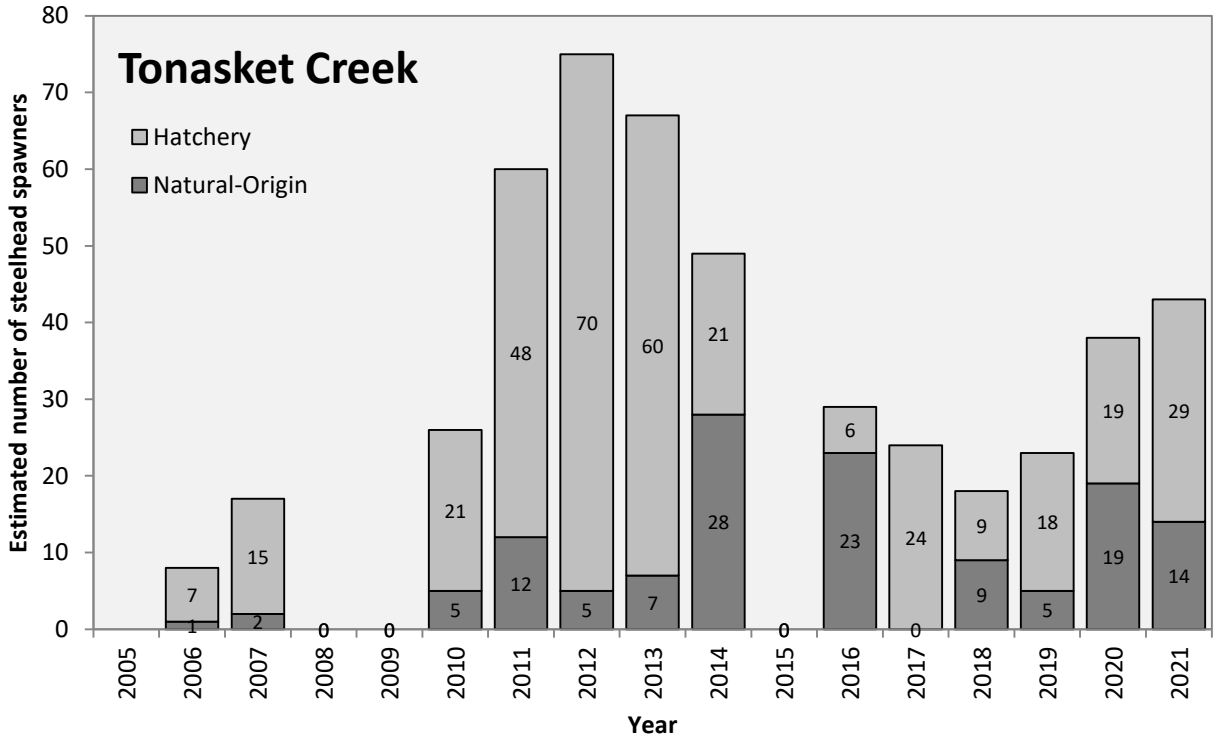

Figure 37. Trend in the number of steelhead spawners in Tonasket Creek.

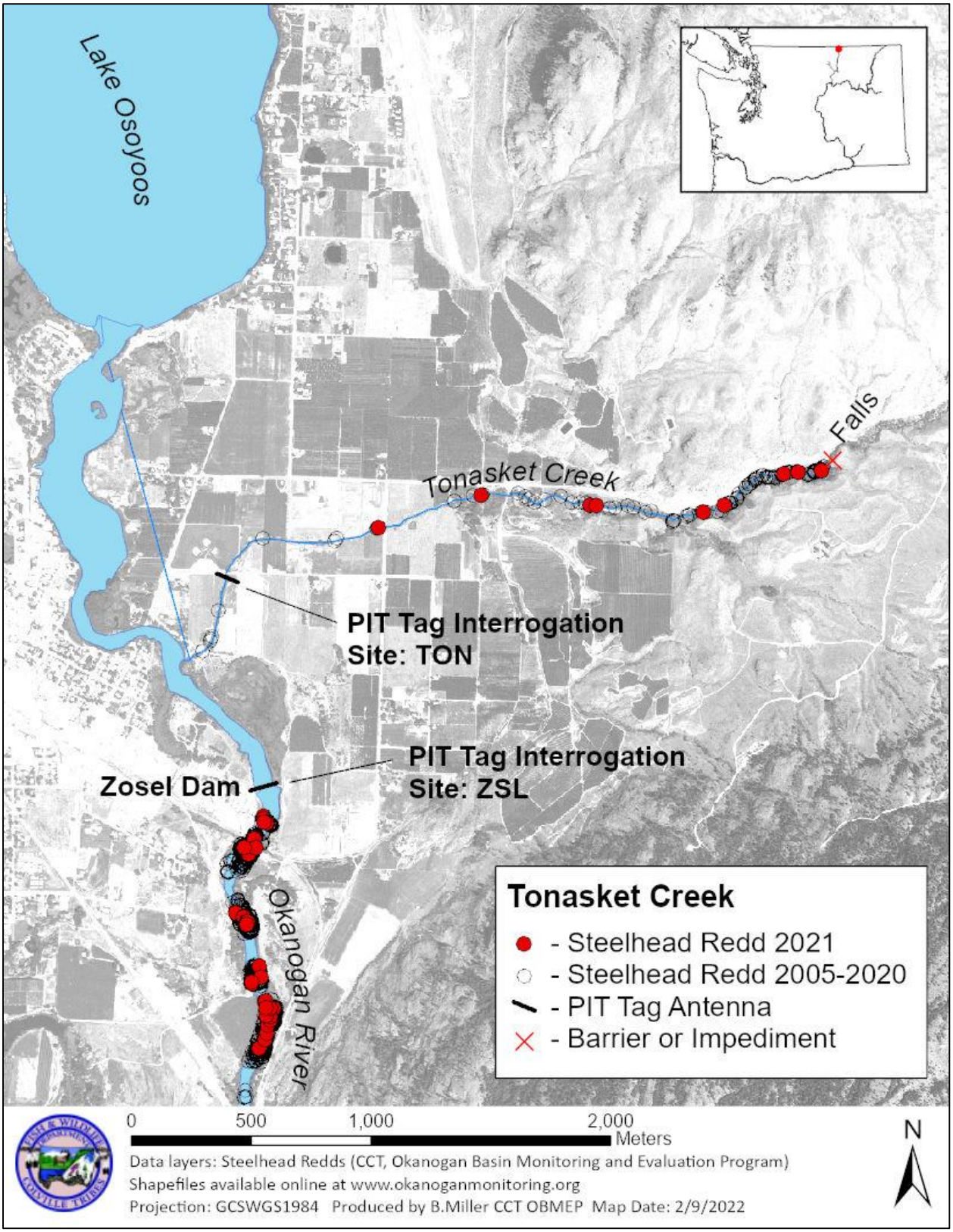

Figure 38. Spatial distribution of historic summer steelhead redds documented in Tonasket Creek.

3.2.13 Ninemile Creek

Ninemile Creek enters the eastside of Osoyoos Lake, just south of the British Columbia border. The creek is known to flow sub-surface annually in the middle reach during the summer, but surface flows are usually present in the upper and lower reaches. A permanent PIT tag interrogation site (NMC) consisting of three pass-through HDPE antennas is located near the mouth of the creek. Based on PIT tag detections in 2021, an estimated zero natural-origin (0 detections) and 7 hatchery steelhead (1 PRD detection) spawned in Ninemile Creek.

Walking surveys were conducted on lower Ninemile Creek, below the PIT tag interrogation site NMC, on April 1 (turbid water), April 6 (no redds found) and April 26 (turbid). A complete one pass survey was conducted on Ninemile Creek on May 18, from the mouth upstream through the WDFW Eder property, near the base of the upstream falls. A total of 21 redds were located (Figure 40). It is interesting to note that surveyors made comments in the recorded data that only four of the redds appeared to be large, potentially anadromous steelhead redds, and the remaining redds were small, likely resident trout redds. Expanding only the four large redds by the 1.47 FPR renders six spawners, which is similar to the PIT tag expansion estimate.

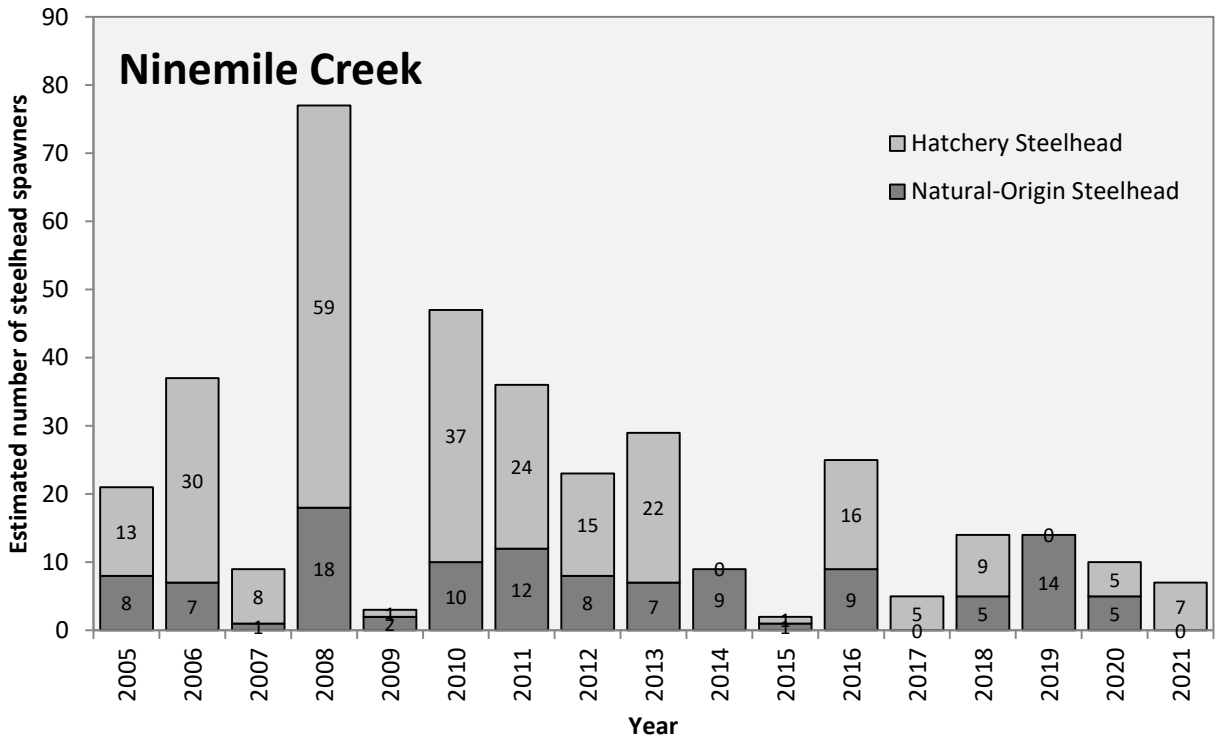

Figure 39. Trend in the number of steelhead spawners in Ninemile Creek.

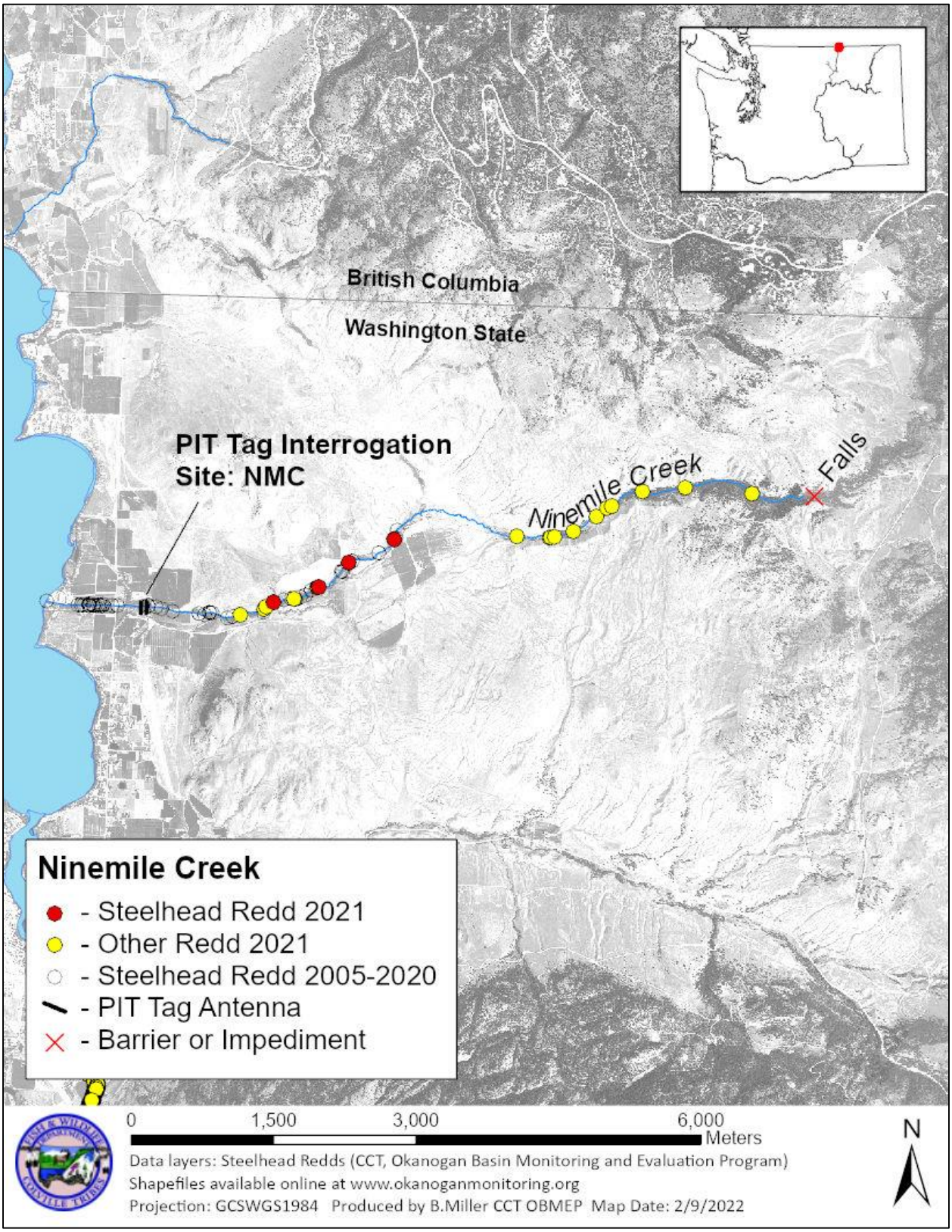

Figure 40. Spatial distribution of summer steelhead redds documented in Ninemile Creek.

3.2.14 Foster Creek (located outside the Okanogan subbasin)

Although Foster Creek is not located within the Okanogan subbasin, OBMEP operated a PIT tag detection site (FST) and conducted three redd surveys in 2021 to further describe the spatial extent of Upper Columbia River steelhead above Wells Dam. During 2021, sufficient water flowed down Foster Creek for adult steelhead to migrate into the upper reaches, past the dam outflow pipe. Foster Creek was surveyed on April 20 and one redd was located (one resident trout observed) and on May 12 where six new redds were found (two unknown-origin steelhead observed). An additional two redds were located on the final survey which occurred on May 25 (one ad-clipped, one ad-present steelhead observed. The redds were expanded by 1.47 fish-per-redd for a total estimate of 13 steelhead.

A total of one natural-origin and seven hatchery PIT tagged steelhead from the PRD mark-group were detected at PIT tag interrogation site FST in 2021. Those tags were expanded by the mark rate of 0.139 for a total spawning estimate of seven natural-origin and 50 hatchery steelhead. It is interesting to note the difference in the spawning estimate between the redd surveys and PIT tag expansion methods in 2021. Surveyors did note significant superimposition of redds in the lower portion of the creek, below the bridges. Additionally, notes from survey crews indicated significant deposition and increases of fine sediment in the area below the falls/upper dam, potentially stemming from fires in previous summers. This likely limited suitable spawning substrate in the upper reaches, concentrating fish in the lower creek. Spatial distribution of redds located during the 2021 survey and on previous years surveys are detailed on Figure 42.

Figure 41. Redd surveys conducted in Foster Creek in 2018.

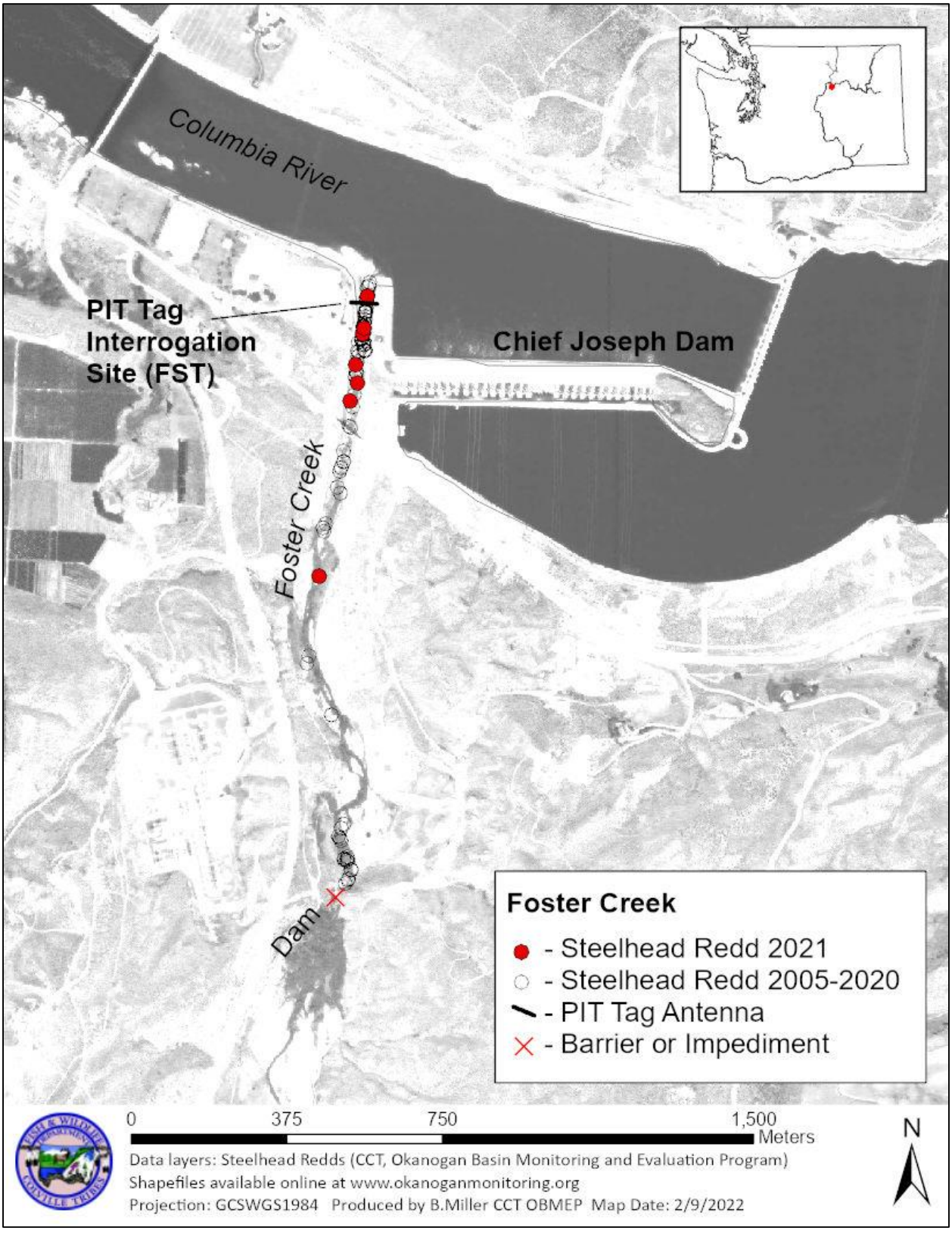

Figure 42. Spatial distribution of summer steelhead redds documented in Foster Creek.

3.3 Zosel Dam and Upstream Locations

Zosel Dam regulates Lake Osoyoos, which extends into the Canadian portion of the subbasin. A vertical-slot fishway provides upstream passage and is equipped with a PIT tag detection array (ZSL). Zosel Dam was constructed in its current state in 1987 with undershot spillways. When these spillway gates are raised to a height of more than 12 inches, fish may be able to ascend through the spillways and bypass the fishway where the PIT tag array is located. Underwater video enumeration of steelhead was discontinued at Zosel Dam in 2015 due to sufficient PIT tag detection sites upstream of that point. The fall back rate at Zosel Dam is currently unknown, but may be relatively large due to the heavily utilized spawning habitat available in Okanogan reach 07.

Three perennial tributaries flow into Lake Osoyoos, two on the Washington State side of the border (Ninemile and Tonasket creeks) and one in British Columbia (aksk^{w}ək^{w}ant (Inkaneep Creek)). Both Ninemile and Tonasket creeks have had PIT tag interrogation sites installed for a number of years; additionally, a permanent PIT tag interrogation site was installed in aksk^{w}ək^{w}ant (Inkaneep Creek) in 2015. Approximately 5 km upstream of Lake Osoyoos, on the ɑ̓awsitk^{w} (Okanagan River) mainstem, a permanent instream PIT array spans the entire channel (site OKC situated at Vertical Drop Structure 3) which has been in operation since 2010. Since all salmon migrating upstream of Lake Osoyoos must cross over OKC, it has been a pivotal detection site for enumerating adult salmon abundance and observing migration timing. PIT tag interrogation sites were also installed on three other British Columbia tributaries located further up the subbasin, nʕaǩ^{w}lqax^{w}iya (Vaseux Creek), akɬx^{w}minaʔ (Shingle) and Shuttleworth creeks.

Until 2009, the outlet dam of Vaseux Lake (McIntyre Dam) was the upstream migration barrier for anadromous salmonids. The dam was redesigned in 2009 and currently, the outlet dam of Okanagan Lake at Penticton, BC is the upstream barrier. A dam also exists at the outlet of Skaha Lake (Okanagan Falls, BC), which had a fish ladder installed in 2014. As well, 17 Vertical Drop Structures (VDS) currently exist along the ɑ̓awsitk^{w} (Okanagan River) mainstem, 13 between Oliver, BC and Lake Osoyoos, and four between Skaha Lake and Vaseux Lake. The majority of the Canadian portion of the mainstem ɑ̓awsitk^{w} (Okanagan River) is characterized as being straightened and channelized. The main British Columbia tributaries to the mainstem ɑ̓awsitk^{w} (Okanagan River) include akɬx^{w}minaʔ (Shingle Creek), Ellis Creek, McLean Creek, Shuttleworth Creek, nʕaǩ^{w}lqax^{w}iya (Vaseux Creek), and a number of other small perennial streams.

Total spawning estimates for steelhead in British Columbia were calculated the same as in the Washington portion of the subbasin, only using tags from the representitively marked Priest Rapids Dam sample group and expanded by the mark rate of 0.139. Within the entire Canadian Okanagan, only one tagged hatchery steelhead from the mark group was detected in nʕaǩ^{w}lqax^{w}iya (Vaseux Creek) (Table 6). That tag was expanded to a total of seven hatchery steelhead. Additionally, one natural-origin steelhead not from the mark group was also detected in nʕaǩ^{w}lqax^{w}iya (Vaseux Creek) and interestingly, this fish was a successful kelt that also spawned in the creek the previous year. Another two hatchery steelhead, also not included in the mark group, were only detected on the mainstem Penticton Channel interrogation site (Table 6). In the interest of best describing total spawning distribution of steelhead based on a very small sample size, we added these fish to those respective river segments (not expanding those tags). Any fish detected on OKC or Penticton Channel only likely spawned in the mainstem ɑ̓awsitk^{w} (Okanagan River), or potentially in another small stream that did not have a PIT antenna in operation, although would be considered more unusual. All adult steelhead detected on arrays upstream of that point were previously detected on OKC, so we assumed a 100% detection efficiency for this brood-year. No tagged steelhead were detected in in aksk^{w}ək^{w}ant (Inkaneep), Shuttleworth or akɬx^{w}minaʔ (Shingle) Creeks. The total spawning estimate in the British Columbia portion of the Okanagan subbasin for 2021 was one natural-

origin and ten hatchery steelhead (Table 7). The average number of steelhead spawning upstream of Lake Osoyoos over the last nine years (2013-2021) was 24 natural-origin and 12 hatchery steelhead.

Table 6. Brood-year 2021 steelhead detected on PIT tag sites in British Columbia.

Location	Status	Tag Group		
aksk^{w}ək^{w}ant (Inkaneep Creek)		PRD	Other	Total
	Natural-Origin	0	0	0
	Hatchery	0	0	0
	Total	0	0	0
nʕaǰ^{w}lqax^{w}iya (Vaseux Creek)		PRD	Other	Total
	Natural-Origin	0	1	1
	Hatchery	1	0	1
	Total	1	1	2
Shuttleworth Cr		PRD	Other	Total
	Natural-Origin	0	0	0
	Hatchery	0	0	0
	Total	0	0	0
akɬx^{w}minaʔ (Shingle Creek)		PRD	Other	Total
	Natural-Origin	0	0	0
	Hatchery	0	0	0
	Total	0	0	0
Pentincton Channel		PRD	Other	Total
	Natural-Origin	0	0	0
	Hatchery	0	2	2
	Total	0	2	2
OKC Only		PRD	Other	Total
	Natural-Origin	0	0	0
	Hatchery	0	0	0
	Undetermined	0	0	0
	Total	0	0	0

Table 7. Estimated distribution of steelhead spawning in British Columbia based on expanded PIT tag detections from the PRD mark group.

Location	Status	2013	2014	2015	2016	2017	2018	2019	2020	2021	Avg.
aksk^{w}ək^{w}ant (Inkaneep Creek)	Natural-Origin			1	0	0		2	0	0	1
aksk^{w}ək^{w}ant (Inkaneep Creek)	Hatchery			6	1	5		0	0	0	2
aksk^{w}ək^{w}ant (Inkaneep Creek)	Total			7	1	5		2	0	0	3
Shuttleworth Creek	Natural-Origin		0	0	0	0	0	0	0	0	0
Shuttleworth Creek	Hatchery		0	0	0	0	0	0	0	0	0
Shuttleworth Creek	Total		0	0	0	0	0	0	0	0	0
nʕax̌^{w}lqax^{w}iya (Vaseux Creek)	Natural-Origin						9	9	19	1	10
nʕax̌^{w}lqax^{w}iya (Vaseux Creek)	Hatchery						0	9	5	7	5
nʕax̌^{w}lqax^{w}iya (Vaseux Creek)	Total						9	18	24	8	15
akɬx^{w}minaʔ (Shingle Creek)	Natural-Origin			0	0	0	0	0	0	0	0
akɬx^{w}minaʔ (Shingle Creek)	Hatchery			0	0	0	0	0	0	0	0
akɬx^{w}minaʔ (Shingle Creek)	Total			0	0	0	0	0	0	0	0
Mainstem or Other	Natural-Origin	22	23	64	15	10	0	23	5	0	18
Mainstem or Other	Hatchery	2	16	20	14	5	0	14	0	2	8
Mainstem or Other	Total	24	39	84	29	15	0	37	5	2	26
Subtotal BC	Natural-Origin	22	23	65	15	10	9	34	24	1	23
Subtotal BC	Hatchery	2	16	26	15	10	0	23	5	9	12
Subtotal BC	Total	24	39	91	30	20	9	57	29	10	35

4.0 Discussion

OBMEP monitored adult Viable Salmonid Population (VSP) abundance attributes (McElhany et al. 2000) within the subbasin for Okanogan River summer steelhead. In 2021, it was estimated that 710 summer steelhead (573 hatchery-origin and 137 natural-origin) spawned in the Okanogan subbasin. The total number of spawners to the subbasin reversed a generally declining trend that has continued since 2010. When specifically looking at natural-origin spawners, 2021 was the third lowest return on the period of record. The two lowest years occurred in 2017 and 2018, with 115 and 120 natural-origin spawners, respectively. Over the past 17 years of monitoring, the average number of adult steelhead spawners in the Okanogan subbasin was 1,427 (geomean = 1,206). The average number of natural-origin spawning steelhead was 278 (geomean = 241). Results from steelhead adult enumeration efforts indicate that the number of naturally produced spawning steelhead in the Okanogan River subbasin has generally been level since data collection began in 2005. The trend of the 12-year geomean for natural-origin steelhead spawners is slightly negative at -3.43 (Figure 44).

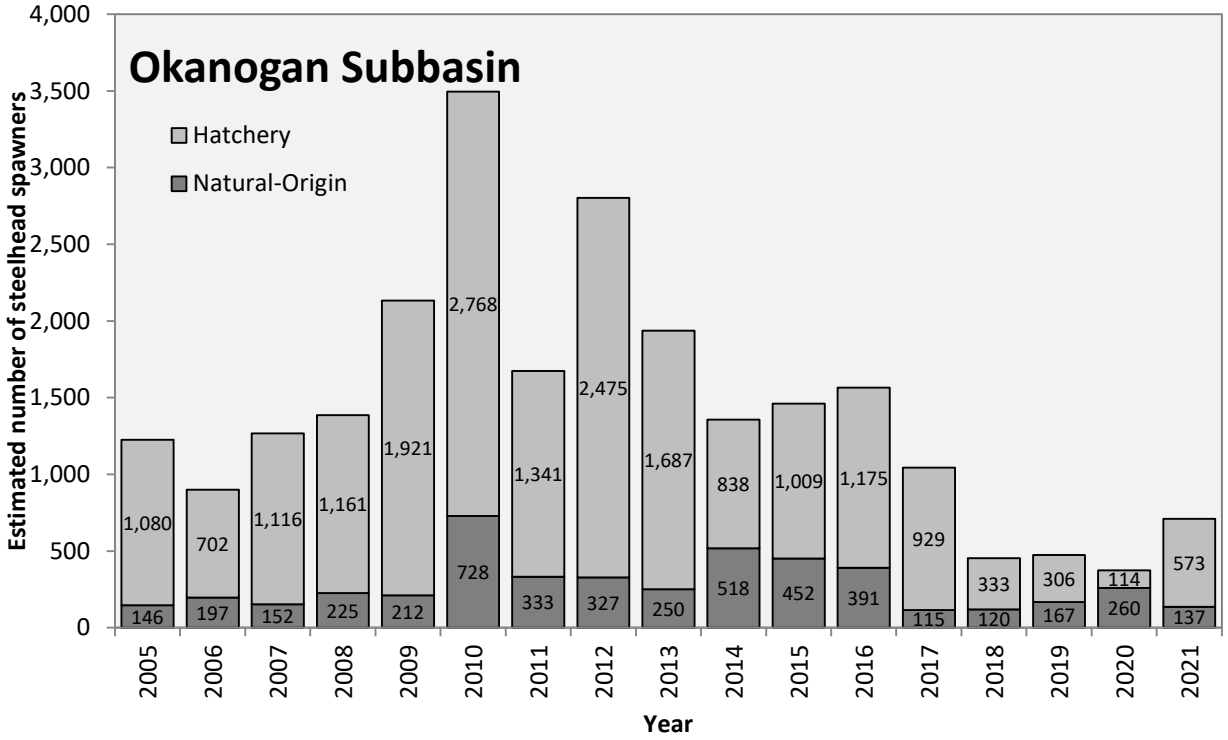

Figure 43. Estimated number of steelhead spawners in the Okanogan subbasin.

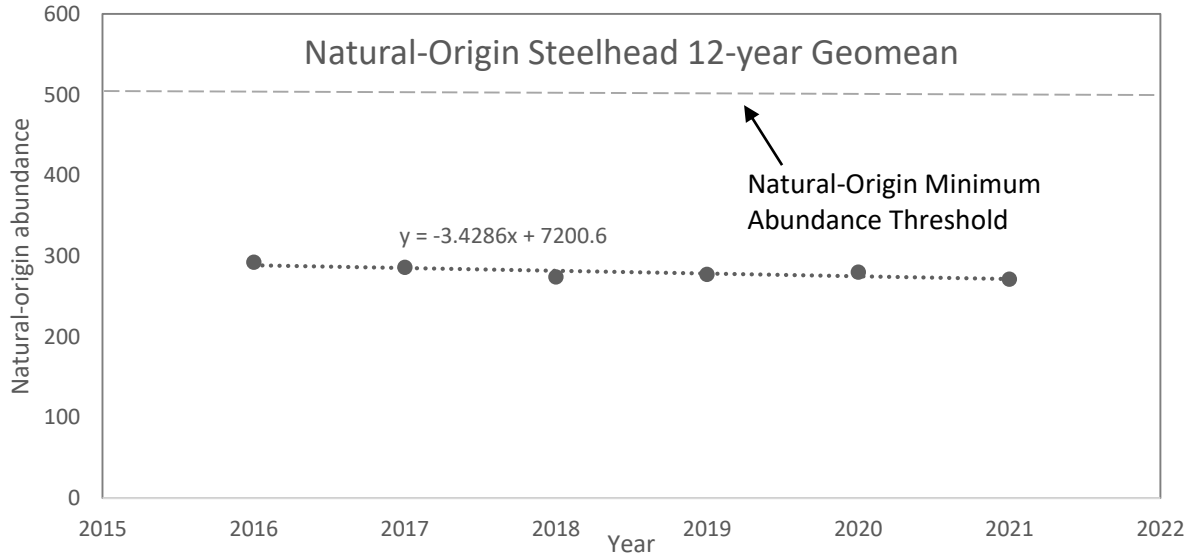

Figure 44. Twelve-year geomean for natural-origin summer steelhead spawners in the Okanogan River subbasin showing the trend (dotted line) and the ESA-recovery objective for the natural-origin minimum abundance thresholds (dashed line).

Spawning has been documented throughout the mainstem Okanogan River, although narrowly focused to distinct areas that contained suitable spawning substrates and water velocities. Steelhead spawning has been observed to be most heavily concentrated below Zosel Dam on the Okanogan River and in braided island sections of the lower Similkameen River. It is likely that distribution of spawning is influenced by stocking

location because juvenile hatchery steelhead have been released in the Similkameen River, Omak Creek, and Salmon Creek where large numbers of spawners have been consistently recorded.

Detailed percent-wild information has been provided annually and every attempt has been made to ensure that these estimates are as accurate as stated methods currently allow. However, these data should be used with caution, as it is difficult to define natal origin through visual observation alone (i.e. intact adipose fin) on redd surveys and underwater video. Values presented in this document represent our best estimate from available information, but the variability surrounding point estimates are currently undefined.

Large variations in estimates exist in many reaches from year to year, but often, these accurately reflect real-world situations rather than survey bias or calculation error. Small creeks may have extremely low flows for two years, blocking access with no spawning occurring, and then experience a large run of fish the following year when sufficient flows exist (e.g. Loup Loup Creek escapement of 0, 0, and 125 for 2008, 2009, and 2010, respectively). This irregular nature of small scale population data frequently results in data being scattered loosely around a linear trend line. We have made every effort to ensure that the reported values are as accurate as possible, including using multiple data collection methods for validation, comprehensive on-the-ground surveys, and best scientific judgment based on extensive local experience with the subbasin.

Annual variations in physical habitat and environmental factors can profoundly impact redd distributions in small tributaries to the Okanogan River. Changes in summer steelhead spawning distribution within tributaries appear to be driven by the following four factors: 1) discharge and elevation of the Okanogan River, 2) discharge of the tributary streams, 3) timing of runoff in relation to run timing of steelhead, and 4) stocking location of hatchery fish. The first three factors are largely based upon natural environmental conditions, which can be altered dramatically by such things as water releases from dams, irrigation withdrawals, and variations in climate. Years such as 2006, 2008, and 2009 clearly show how low tributary discharge can dramatically alter spawning location and reduce the available tributary habitat for steelhead to utilize.

The overall outcome of adult steelhead monitoring in the Okanogan subbasin is to guide natural resource managers' decisions to minimize threats to steelhead, choose restoration actions that will have the most positive impact, and set measurable steelhead enhancement objectives to coincide with fiscal investments over multiple jurisdictions. As monitoring efforts proceed, the Okanogan Basin Monitoring and Evaluation Program expects to continually deliver practical status and trend monitoring data and to make those data useful and readily available for use in more comprehensive, broad-scale analyses.

References

Arterburn, J.E., K. Kistler and R. Dasher 2005. 2005 Okanogan Basin Steelhead Spawning Ground Surveys. 2005 Report for Bonneville Power Administration project #200302200. Colville Confederated Tribes Fish and Wildlife Department. Nespelem, WA.

Arterburn, J.E., K. Kistler and C. Fisher 2007. Anadromous Fish Passage Barriers in the Okanogan Basin. Report# CCT/AF-2007-1 for the Colville Tribes. Colville Confederated Tribes Fish and Wildlife Department. Nespelem, WA.

Hillman, T. W. 2004. Monitoring strategy for the Upper Columbia Basin. Prepared for: Upper Columbia Regional Technical Team, Upper Columbia Salmon Recovery Board, Wenatchee, Washington.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionary significant unite. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-42, 156 p.

Murdoch, A. R., T. L. Miller, B. L. Truscott, C. Snow, C. Frady, K. Ryding, J. E. Arterburn, and D. Hathaway. 2011. Upper Columbia Spring Chinook Salmon and Steelhead Juvenile and Adult Abundance, Productivity, and Spatial Structure Monitoring. BPA Project # 2010-034-00. Washington Department of Fish and Wildlife, Olympia, WA.

NMFS (National Marine Fisheries Service). 2009. Listing Endangered and Threatened Species: Change in Status for the Upper Columbia River Steelhead Distinct Population Segment. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Federal Register, Volume 74, No. 162, pages 42605-42606. 50 CFR Part 223 Docket No. 0907291194–91213–01. RIN 0648–XQ71.

OBMEP. 2022. Okanogan Basin Monitoring and Evaluation Program, 2021 Annual Progress Report. Colville Confederated Tribes Fish and Wildlife Department, Nespelem, WA. Report submitted to the Bonneville Power Administration, Project No. 2003-022-00.

UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia Spring Chinook and Summer Steelhead Recovery Plan. https://www.ucsrb.org/mdocs-posts/00_upper-columbia-spring-chinook-salmon-and-steelhead-recovery-plan/

Walsh, M. and K. Long. 2006. Survey of barriers to anadromous fish migration in the Canadian Okanagan subbasin. Prepared by the Okanagan Nation Alliance Fisheries Department, Westbank, BC.