Colville Tribes, Fish & Wildlife Department

2019 Okanogan Subbasin Steelhead Spawning Abundance and Distribution

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Executive Summary

The Okanogan Basin Monitoring and Evaluation Program (OBMEP) monitored summer steelhead (*Oncorhynchus mykiss*) spawner abundance and distribution within the Okanogan River subbasin from 2005 through 2019. Monitoring has been conducted through a combination of redd surveys, underwater video counts, and Passive Integrated Transponder (PIT) tag detections. In 2019, it was estimated that 473 summer steelhead (306 hatchery origin and 167 natural-origin) spawned in the Okanogan subbasin, which was the second lowest total return since the monitoring project began in 2005. The lowest return occurred the previous year in 2018, with a total of 453 steelhead. Over the previous 14 years of monitoring (2005 through 2018), the average number of adult steelhead spawners in the Okanogan subbasin was 1,622 (geomean = 1,456). The average number of natural-origin spawning steelhead was 289 (geomean = 256). 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). Although the proportion of natural-origin steelhead spawning in the Okanogan River subbasin has slightly trended upward since data collection began in 2005, the minimum abundance threshold for ESA-recovery for natural origin spawners in the combined transboundary population was not reached.

The proportion of hatchery origin spawners (pHOS) from 2005 through 2013 averaged 0.85, but the average pHOS decreased to 0.72 from 2014 through 2019. The abundance of hatchery steelhead has been variable, ranging from a low of 306 in 2019 up to nearly 3,000 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 Creek, Salmon Creek, 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 (ID:192)
https://www.monitoringmethods.org/Protocol/Details/192
OBMEP - Adult Abundance - Adult Weir and Video Array (ID:6)
https://www.monitoringmethods.org/Protocol/Details/6
Estimate the abundance and origin of Upper Columbia steelhead (2010-034-00) v1.0 (ID:235)
https://www.monitoringmethods.org/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.

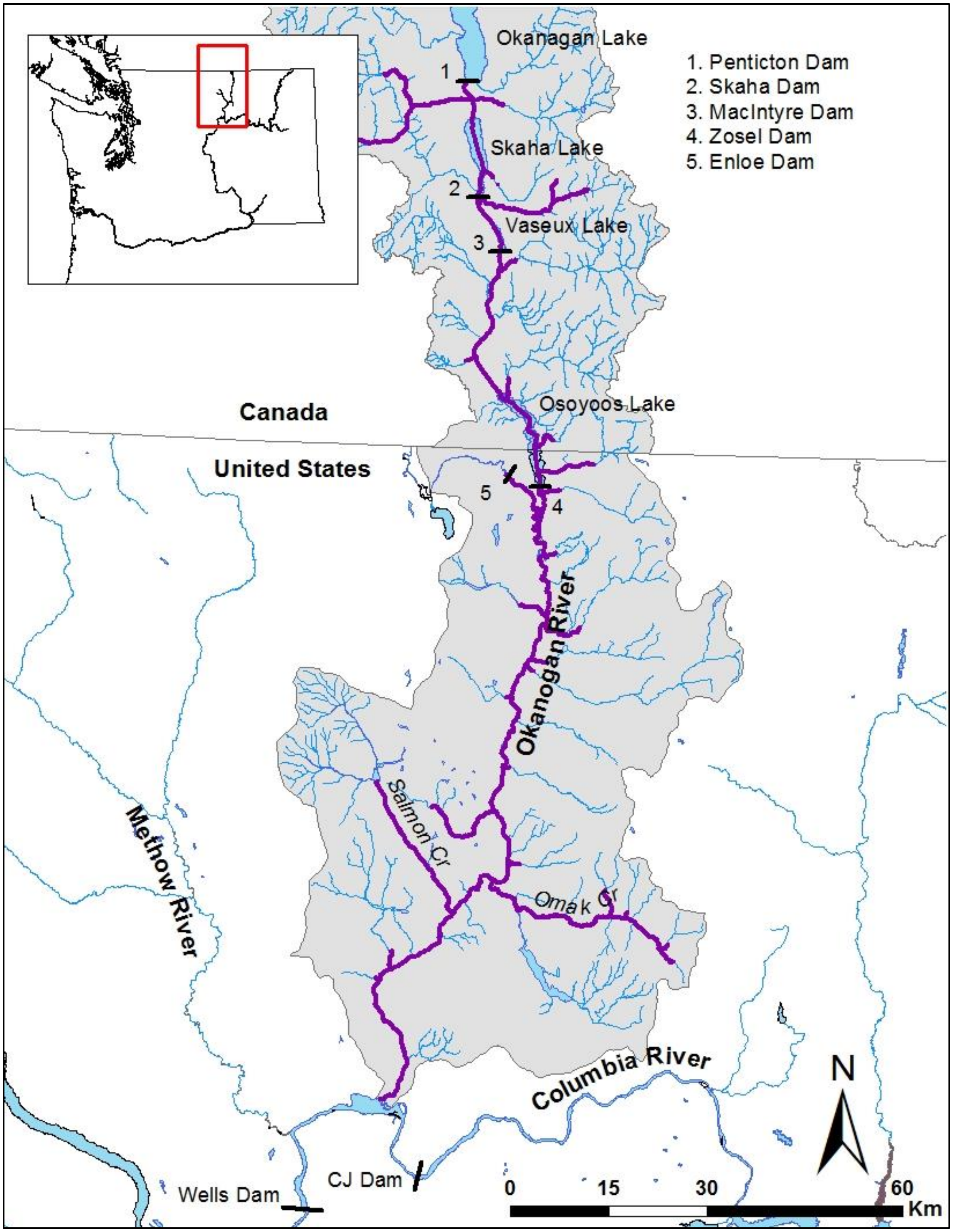

Figure 1. Study area, the Okanogan River subbasin in north-central Washington State and southern British Columbia.

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 during the 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.

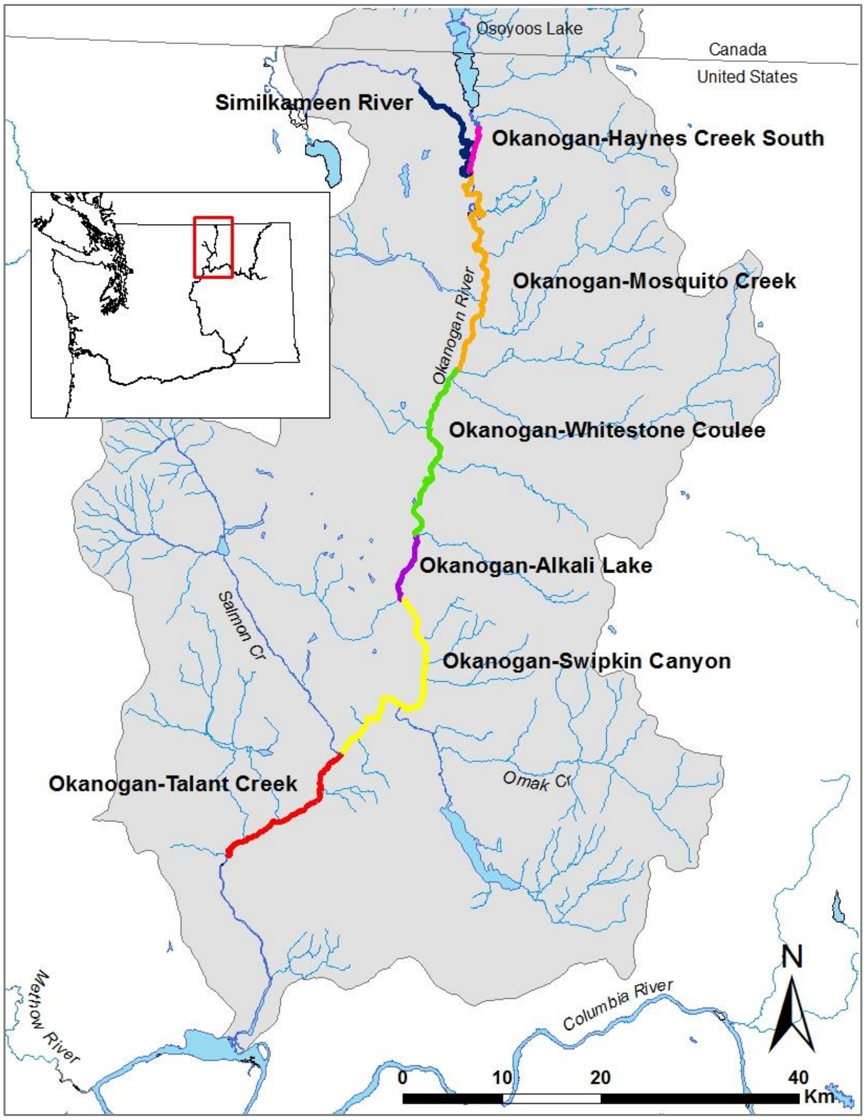

Figure 2. Mainstem Okanogan and Similkameen Rivers Hydraulic Unit Codes and diagnostic unit reaches.

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 967 summer steelhead, including 293 natural-origin and 674 hatchery fish were captured, marked, and sexed during the 2018 upstream migration by WDFW personnel (Ben Truscott, WDFW, pers. comm.). The proportion of female to male steelhead was similar for natural-origin (0.662:0.338) and hatchery fish (0.678:0.322), which rendered a combined average of 0.670:0.330. Rounded, that sex ratio of one female per 0.49 males or 1.49 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 2019, 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 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 2019 brood year, a representative sample of upstream migrating steelhead were captured at Priest Rapids Dam (PRD) from July through November, 2018. All fish were scanned for hatchery marks, sexed and marked with a PIT tag unless previously tagged. A portion of the total run, approximately 22.18% of hatchery and 22.18% of natural-origin steelhead, were included in this sample group (Ben Truscott, WDFW, pers. comm.). These mark-rates were used to expand the number of detections into escapement estimates for tributaries with PIT tag arrays. For example, if six hatchery and two natural-origin steelhead from the PRD sample group were detected at an instream PIT array in a given creek in the Okanogan subbasin, the escapement estimate would be 27 hatchery steelhead (27=6/0.2218) and 9 natural-origin steelhead (9=2/0.2218). 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 locations e.g., out-migrating juveniles, adults returning to Bonneville Dam, Wells Dam, among others. 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.

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 473 summer steelhead (306 hatchery origin and 167 natural origin) spawned in the Okanogan subbasin in 2019. That number is the second lowest total return since the monitoring project began in 2005 (Table 2). The lowest return occurred the previous year in 2018, with a total of 453 steelhead. Over the past 15 years of monitoring (2005 through 2019), the average number of adult steelhead spawners in the Okanogan subbasin was 1,545 (geomean = 1,351). The average number of natural-origin spawning steelhead was 289 (geomean = 282). Although the proportion of natural-origin steelhead spawning in the Okanogan River subbasin has slightly trended upward since data collection began in 2005 (Figure 3), the minimum abundance threshold for natural-origin spawners was not reached.

The proportion of hatchery origin spawners (pHOS) from 2005 through 2013 averaged 0.85, but the average pHOS decreased to 0.72 from 2014 through 2019. The abundance of hatchery steelhead has been variable, ranging from a low of 306 in 2019 up to nearly 3,000 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. Detailed 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, 2005–2019.

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
Average	1,545	1,256	289	282

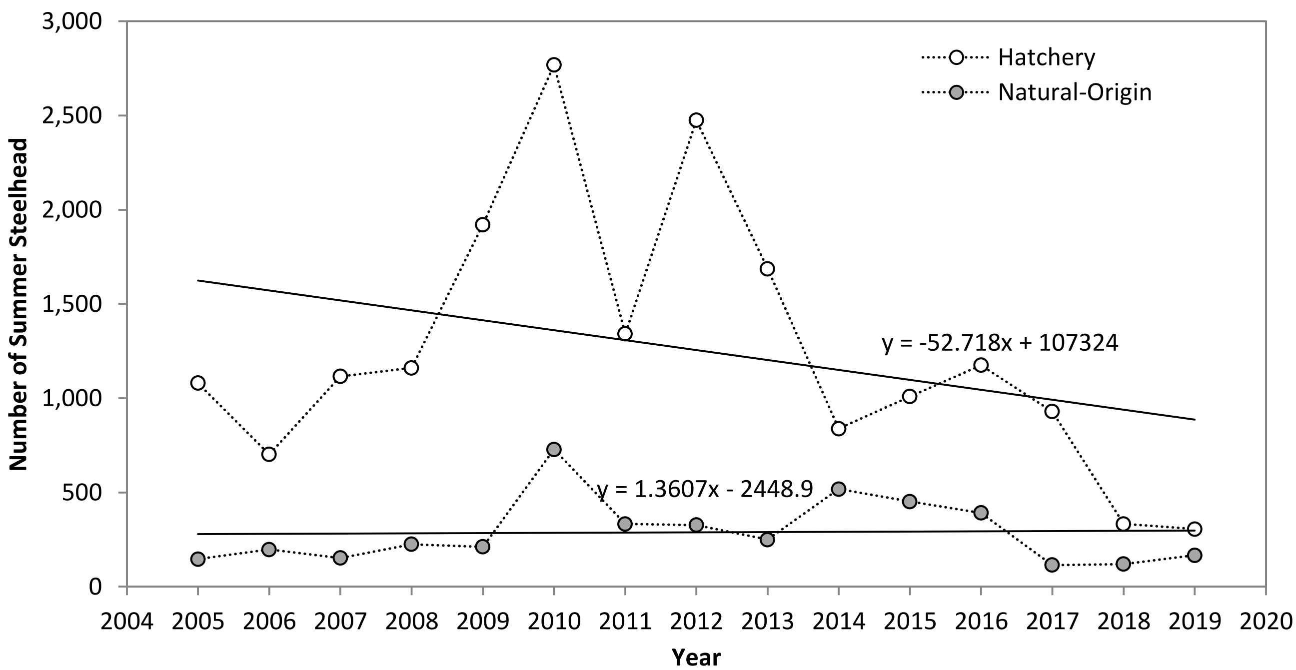

Figure 3. Trend in the estimated number of summer steelhead spawning in the Okanogan River subbasin, 2005–2019.

Table 3. Estimated number of hatchery and natural-origin steelhead spawning for each sub-watershed or assessment unit in 2019 compared with long-term averages.

Category	Location/HUC	2019 natural-origin spawner abundance	Average # of natural-origin spawners 2005–2019	2019 hatchery spawner abundance	Average # of hatchery spawners 2005–2019
WA Mainstem	Okanogan-Davis Canyon	0	*0*	0	*0*
WA Mainstem	Okanogan-Talant Creek	0	*1*	1	*11*
WA Mainstem	Okanogan-Swipkin Canyon	1	*5*	5	*48*
WA Mainstem	Okanogan-Alkali Lake	1	*3*	3	*28*
WA Mainstem	Okanogan-Whitestone Coulee	2	*6*	6	*60*
WA Mainstem	Okanogan-Mosquito Creek	0	*1*	2	*14*
WA Mainstem	Okanogan-Haynes Creek South	11	*40*	35	*346*
WA Mainstem	Similkameen River	7	*24*	21	*205*
WA Tributary	Loup Loup Creek	0	*10*	9	*34*
WA Tributary	Salmon Creek	27	*34*	3	*111*
WA Tributary	Omak Creek	37	*66*	131	*151*
WA Tributary	Wanacut Creek	0	*0*	0	*3*
WA Tributary	Johnson Creek	1	*6*	2	*21*
WA Tributary	Tunk Creek	9	*9*	18	*28*
WA Tributary	Aeneas Creek	0	*0*	5	*3*
WA Tributary	Bonaparte Creek	18	*29*	32	*61*
WA Tributary	Antoine Creek	9	*4*	0	*9*
WA Tributary	Wild Horse Spring Creek	0	*8*	0	*36*
WA Tributary	Tonasket Creek	5	*7*	18	*21*
WA Tributary	Ninemile Creek	14	*7*	0	*16*
Area	Washington State Mainstem	22	*80*	73	*712*
Area	Washington State Tributaries	120	*180*	218	*494*
Area	British Columbia	34	*25* [a]	23	*13* [a]

[a] Average from British Columbia only contain data from 2013-2019.

3.1 Steelhead Spawning Estimates: Okanogan and Similkameen River Mainstem

Compared with the extremely large runoff years in 2017 and 2018, the general runoff pattern for the mainstem Okanogan River in the spring of 2019 was generally below historical averages (Figure 4). However, low-elevation tributaries began their runoff cycle in late March and decreased visibility in the mainstem Okanogan to a point where mainstem redd surveys could not be effectively conducted. Discharge rates in the Similkameen River increased in mid-April and remained high through June, at which time spawning had long since concluded and steelhead redds were indistinguishable. For reference, locations of redds marked during previous years surveys (2005–2018) on the mainstem Okanogan and Similkameen Rivers are shown in Figures 5–11.

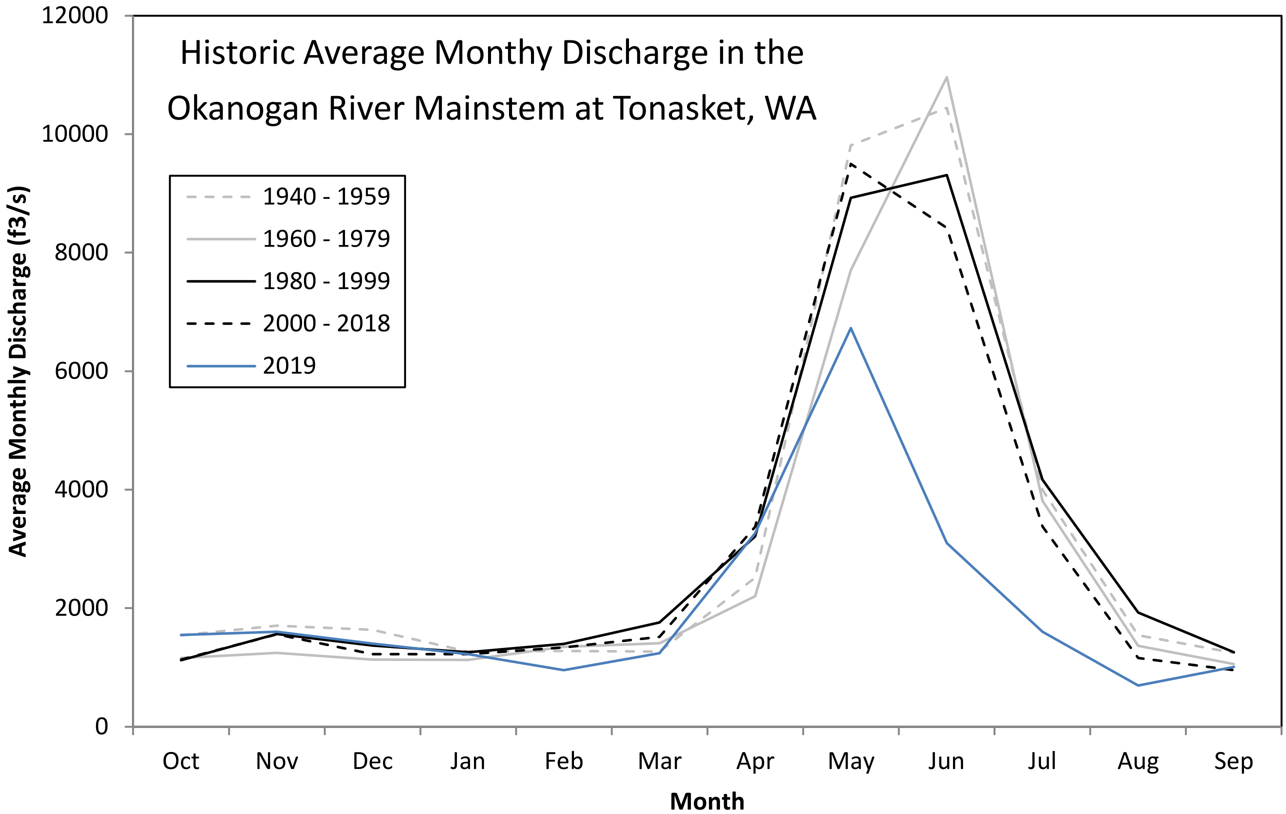

Figure 4. Average monthly discharge of the Okanogan River at Tonasket, WA (USGS Station 12445000, Okanogan River near Tonasket, WA).

Three passes of redd surveys were able to be completed on Okanogan River survey Reach O7, located immediately below Zosel dam. Surveys occurred on April 2 (1 redd), April 18 (12 redds), and May 2 (11 redds) (Figure 11). These 24 redds could be expanded by the fish per redd value of 1.49 to equal 36 fish. Only two surveys were able to be conducted on the lower Similkameen, on April 2 when one redd was found, and on April 18 when 11 redds were located (Figure 11). On April 19 through the end of the spring, water conditions were too turbid for visual redd surveys to occur.

Although redd surveys were unable to capture the complete distribution of spawning activity in 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 2019 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 rendered a total of 17 natural-origin and 52 hatchery steelhead. Additionally, another group of 5 natural-origin and 21 hatchery steelhead were last detected at Zosel Dam at the south end of Osoyoos Lake. These fish were not detected at any other upstream location, or any downstream subwatershed. Past surveys and video detections have shown that steelhead often ascend the Zosel Dam fishways (getting detected by the PIT tag interrogation antennas) and subsequently fall back to spawn in the heavily used Reach O7, just downstream of the dam. Therefore, we assume that these fish should be counted as mainstem spawners. Combining these two groups rendered 22 natural-origin and 73 hatchery steelhead that were estimated to have spawned in the mainstem Okanogan or Similkameen Rivers.

Because mainstem steelhead redd surveys were largely unsuccessful due to turbid water conditions, we estimated spatial distribution of steelhead spawning in 2019 based on prior 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 per survey reach, the total mainstem spawning estimates for natural-origin (22) and hatchery steelhead (73) 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 2019.

Mainstem Survey Reach	A. Avg. Proportion of Mainstem Spawning by Reach (2005-2011)	B. Natural-Origin Steelhead (B=A*22)	C. Hatchery Steelhead (C=A*73)	B. Total Estimate (D=A+B)
Okanogan River 1	0.015	0	1	1
Okanogan River 2	0.055	1	4	5
Okanogan River 3	0.012	0	1	1
Okanogan River 4	0.047	1	3	4
Okanogan River 5	0.076	2	6	8
Okanogan River 6	0.02	0	2	2
Okanogan River 7	0.486	11	35	46
Similkameen River 1	0.165	4	12	16
Similkameen River 2	0.124	3	9	12
Mainstem Total	1	22	73	95

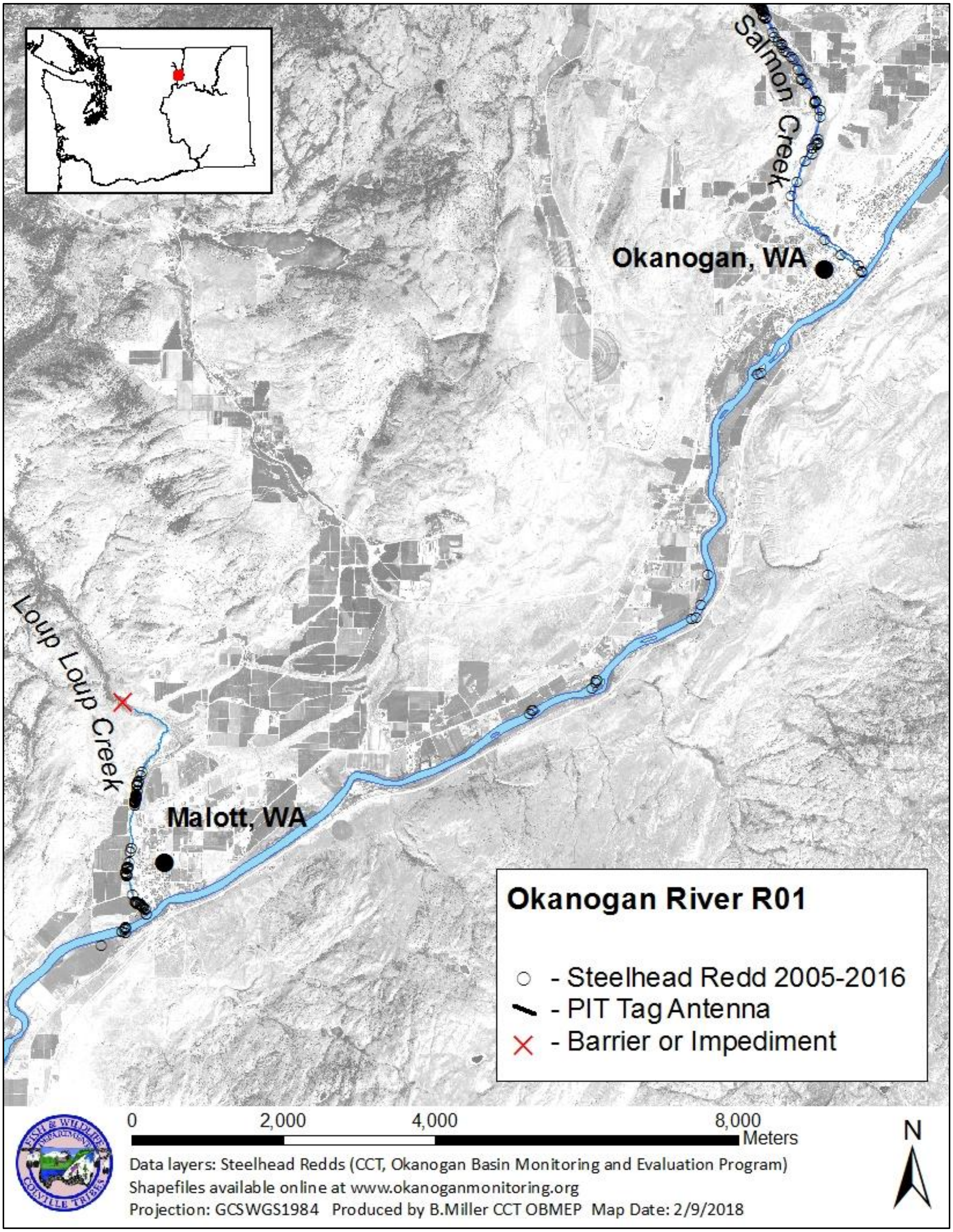

Figure 5. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO1, from Salmon Creek to Loup Loup Creek.

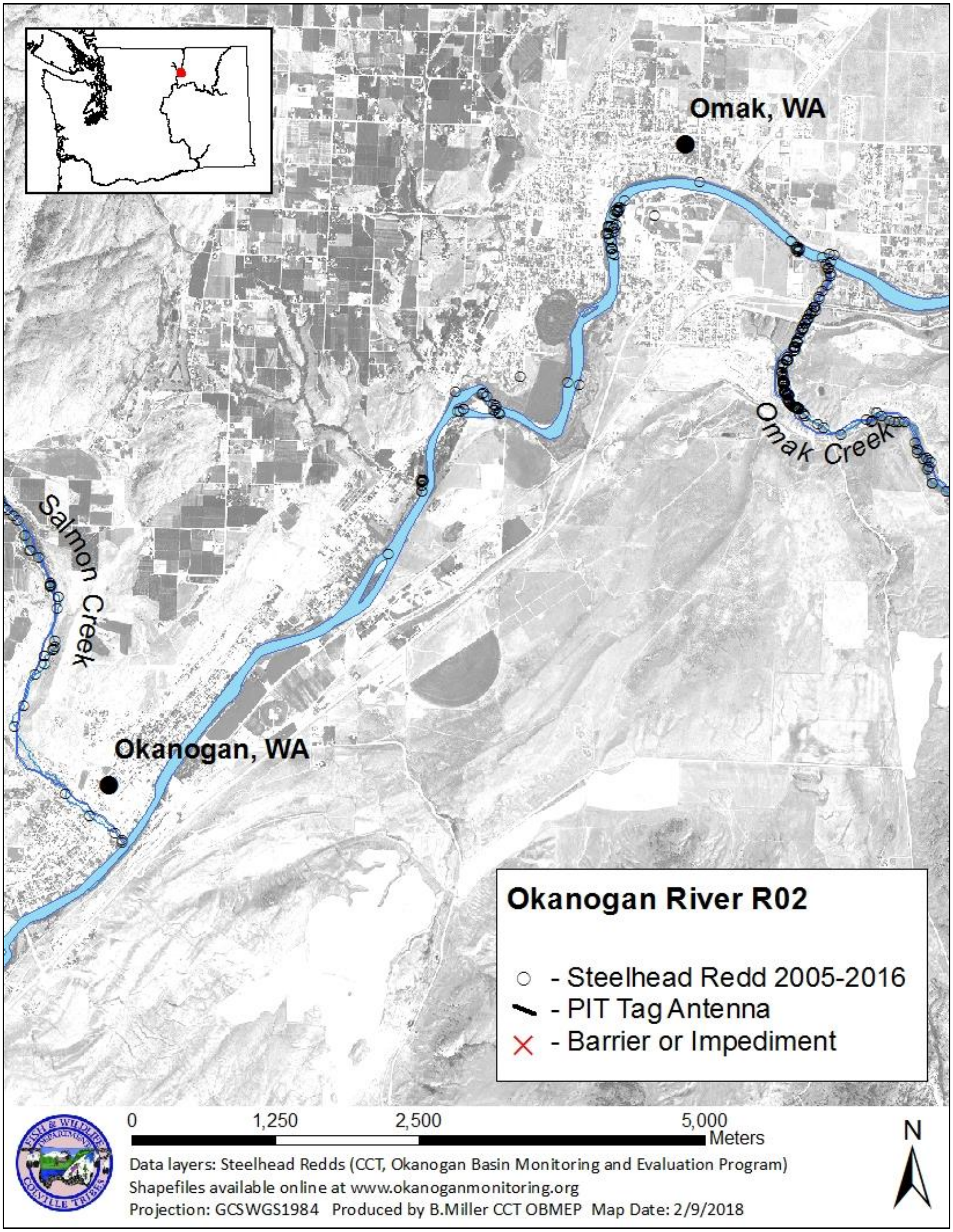

Figure 6. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO2, from Omak Creek to Salmon Creek.

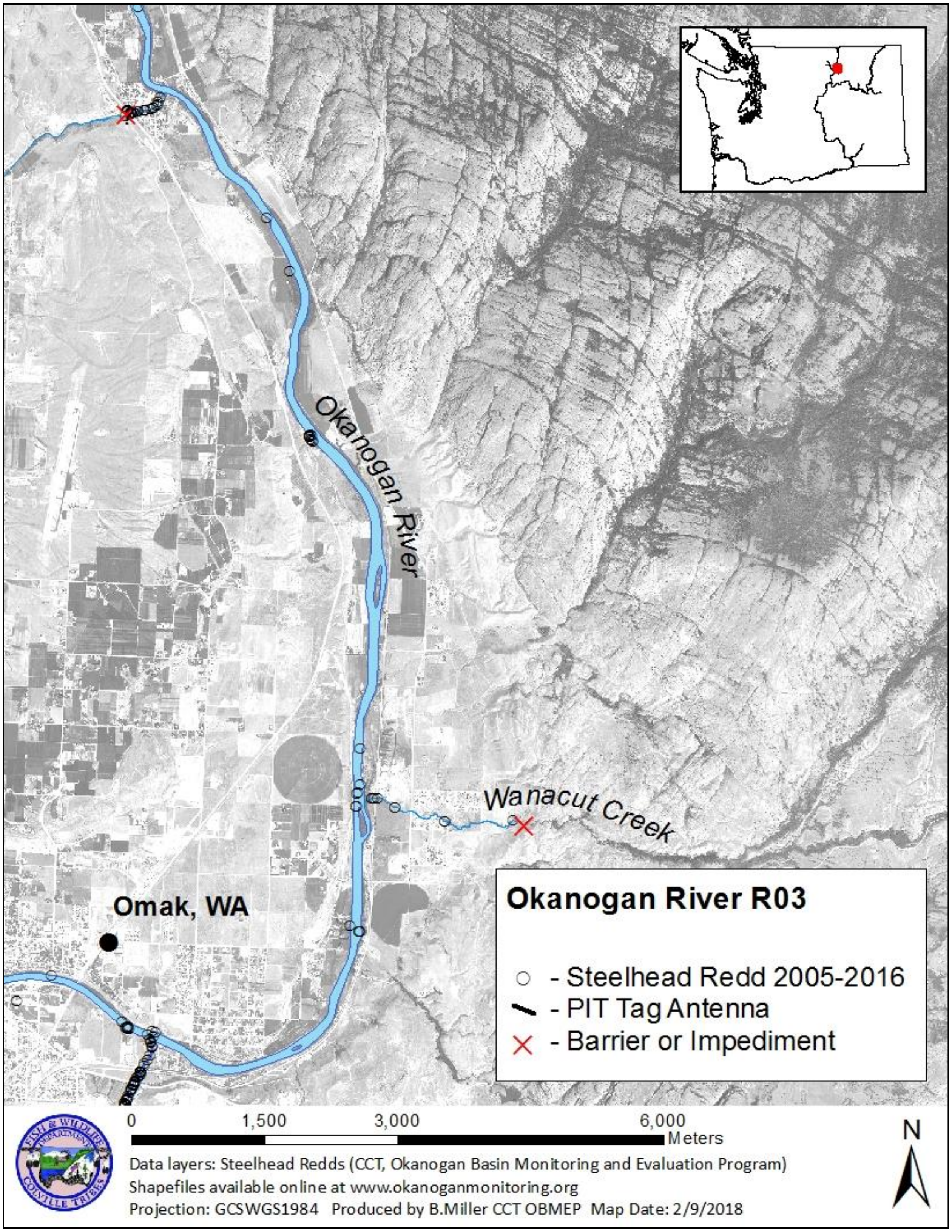

Figure 7. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO3, from Johnson Creek to Omak Creek.

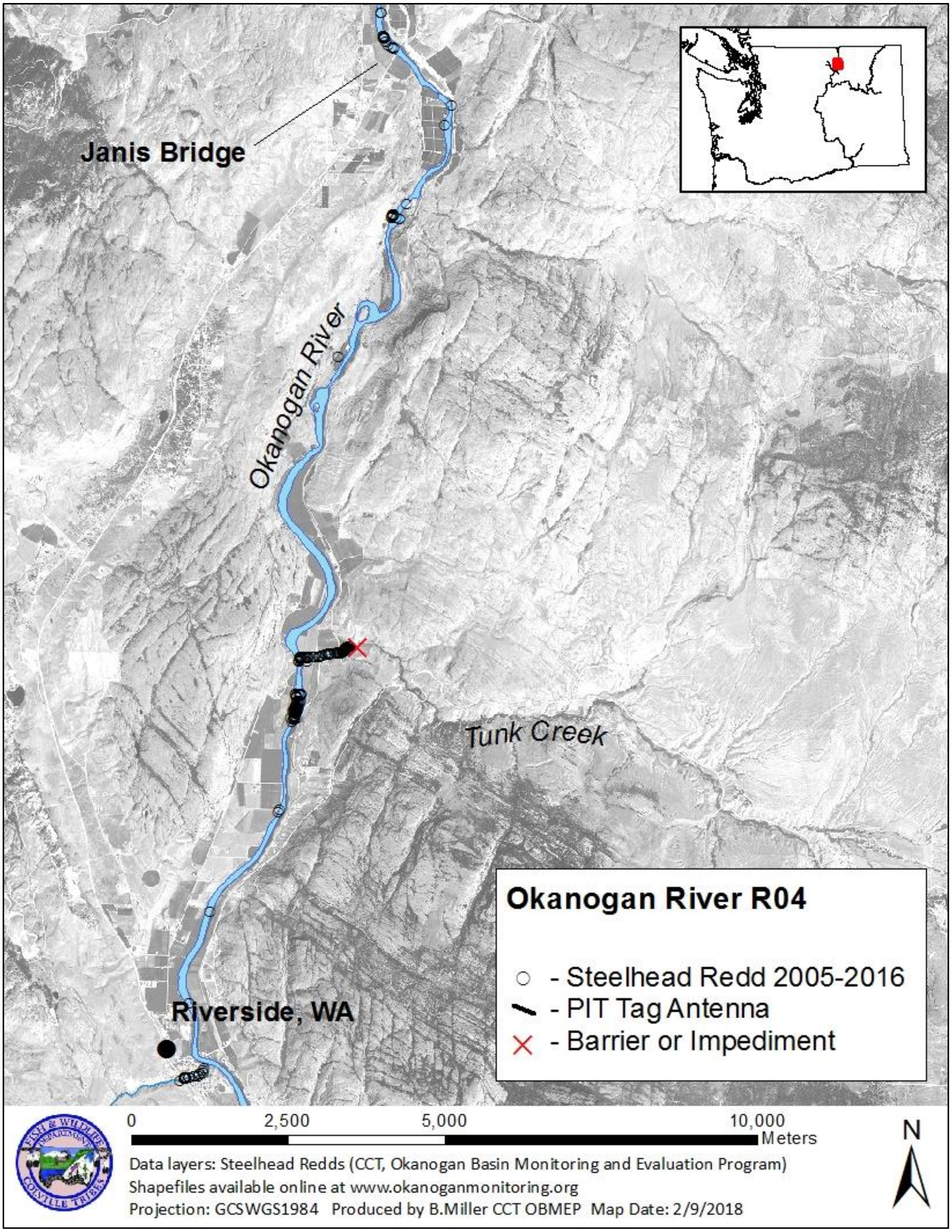

Figure 8. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO4, from Janis Bridge to Johnson Creek.

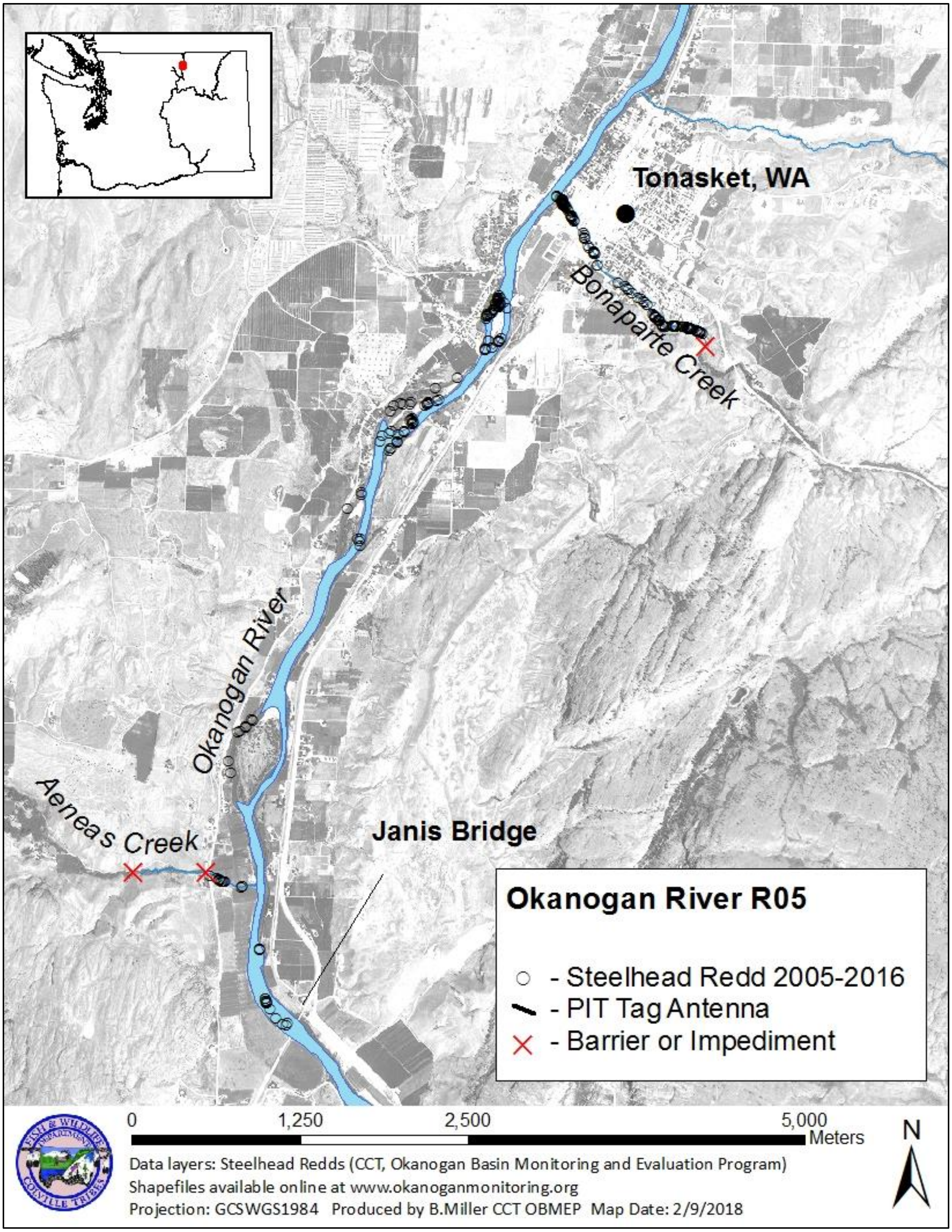

Figure 9. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO5, from the Tonasket boat launch to Janis Bridge.

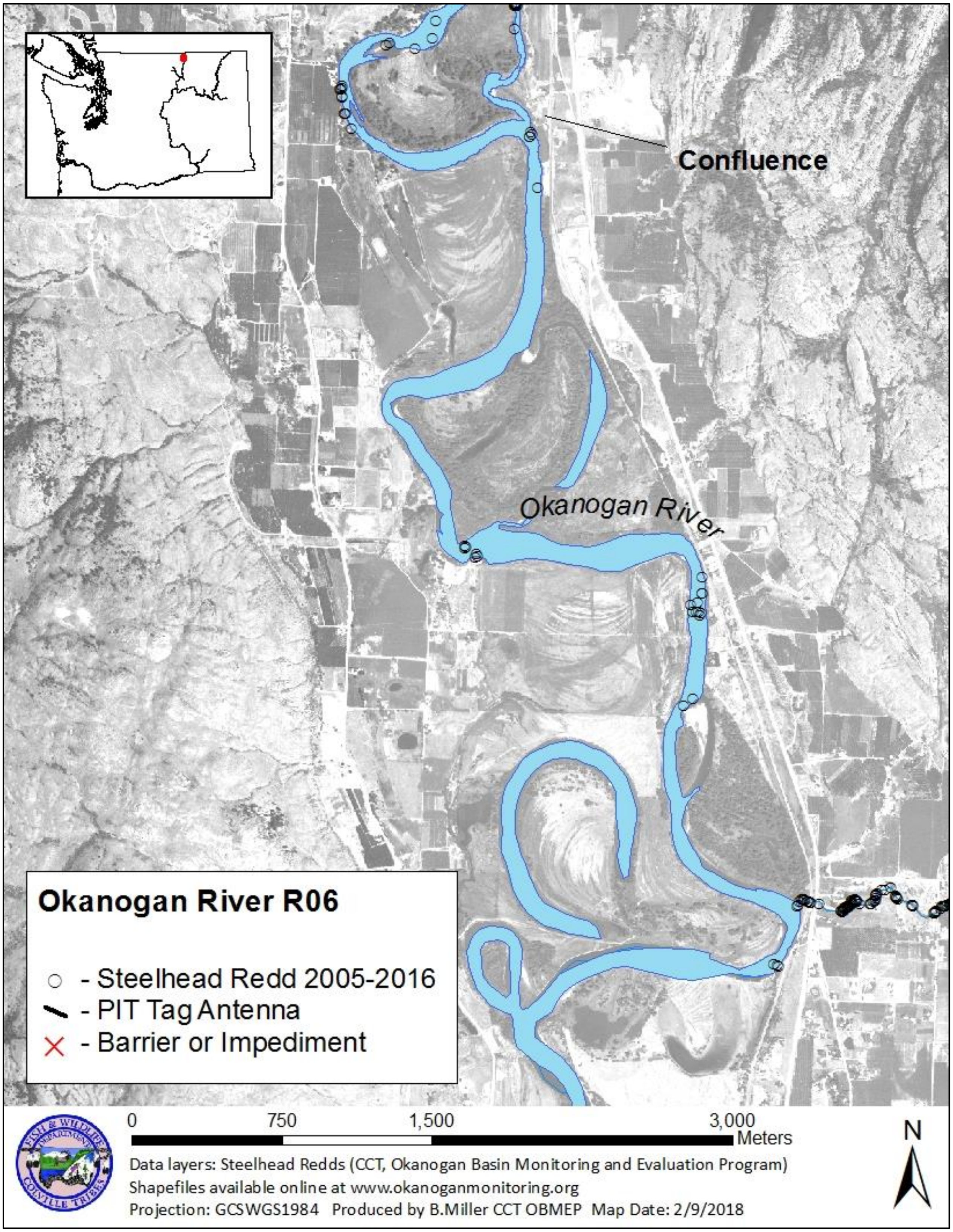

Figure 10. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO6, from the confluence of the Similkameen and Okanogan Rivers to Horseshoe Lake.

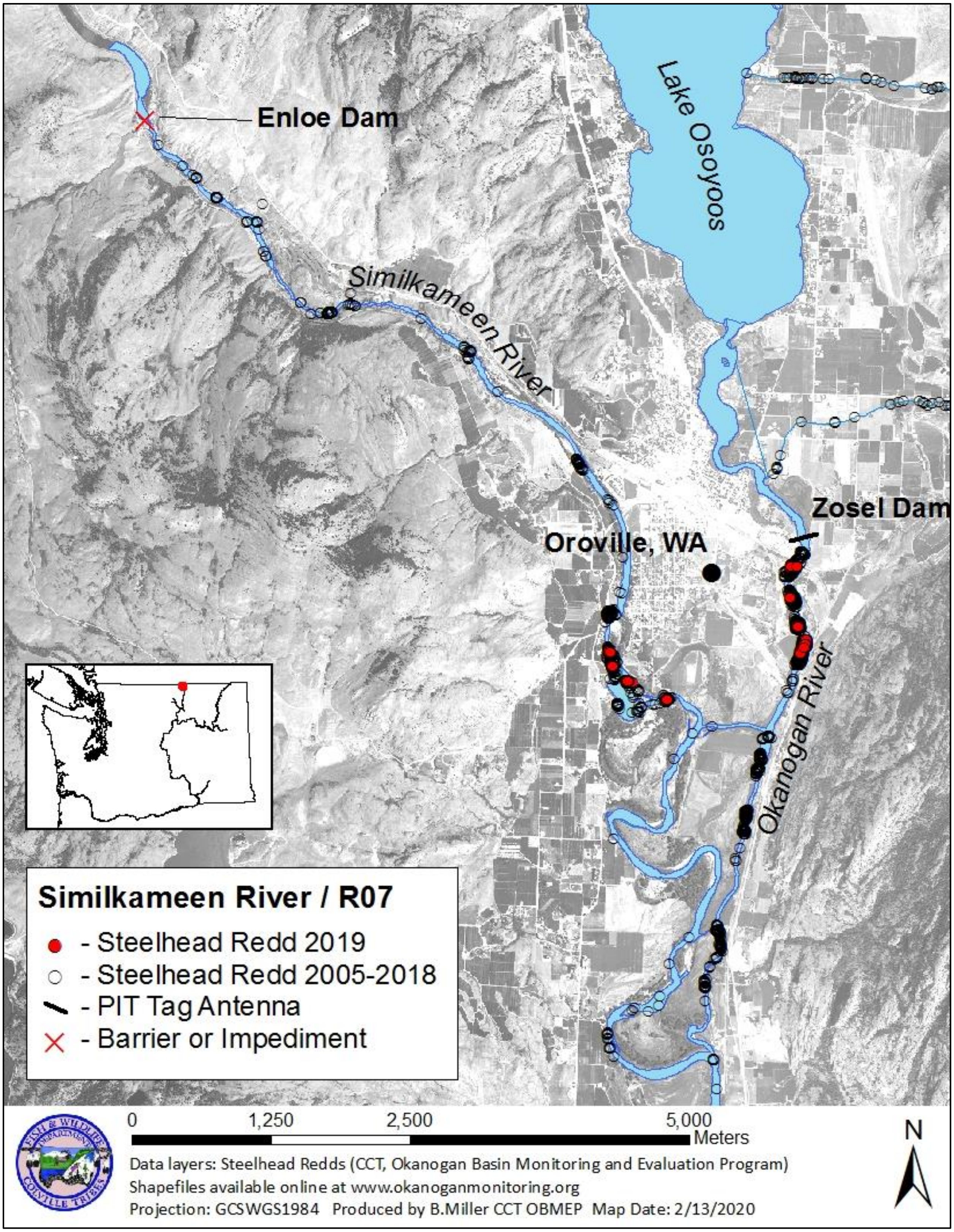

Figure 11. Spatial distribution of summer steelhead redds documented in the Similkameen River, from Enloe Dam to the confluence, and in Okanogan River survey reach RO7, from Zosel Dam to the confluence.

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 most tributaries (Figure 13 and 14). For reference, peak steelhead spawning typically occurs around April 15th. Because redd surveys in 2019 focused primarily on obtaining spatial distribution of spawning in each subwatershed, most subwatershed steelhead spawning estimates were determined from PIT tag detections under project #2010-034-00.

In the following sections, we present 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 2005–2019. GIS shapefiles of documented steelhead redds can be downloaded at: www.okanoganmonitoring.org

Figure 12. Redd surveys during 2018; clockwise from the top: Antoine, Wanacut, Upper Salmon, and Lower Salmon Creeks.

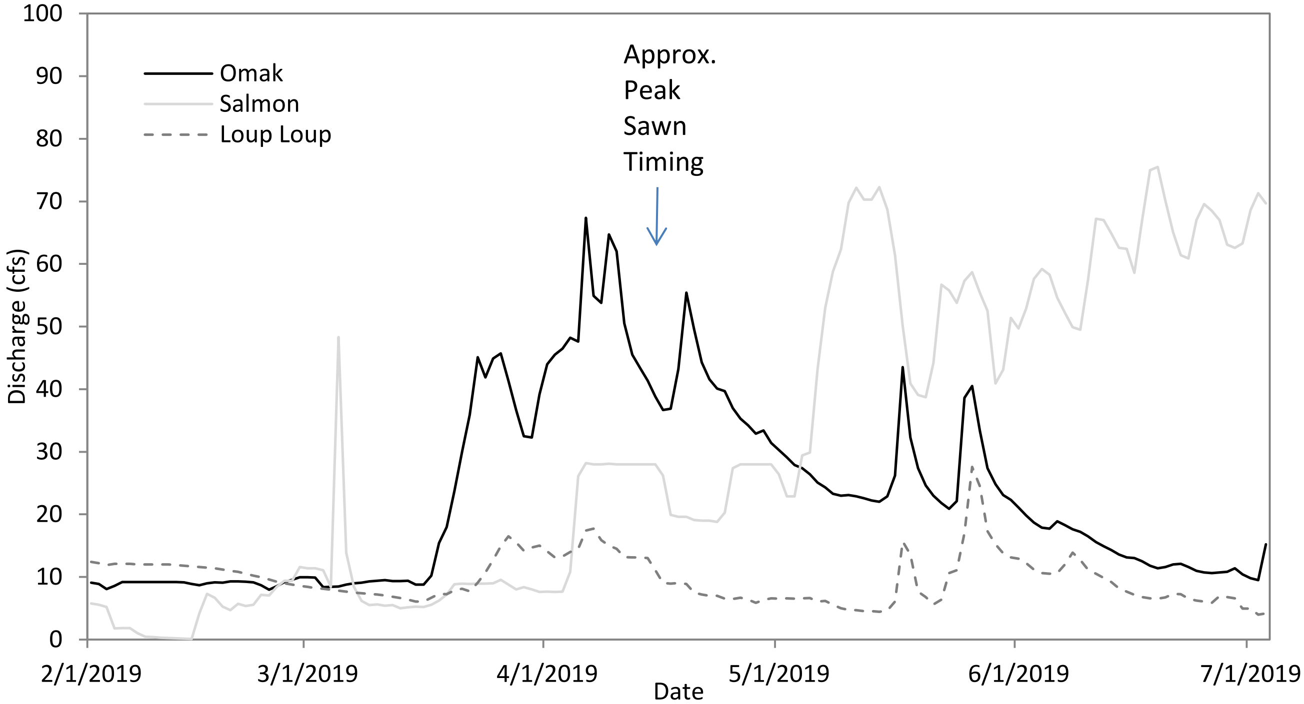

Figure 13. 2019 discharge in three tributaries in the southern Okanogan subbasin in Washington State.

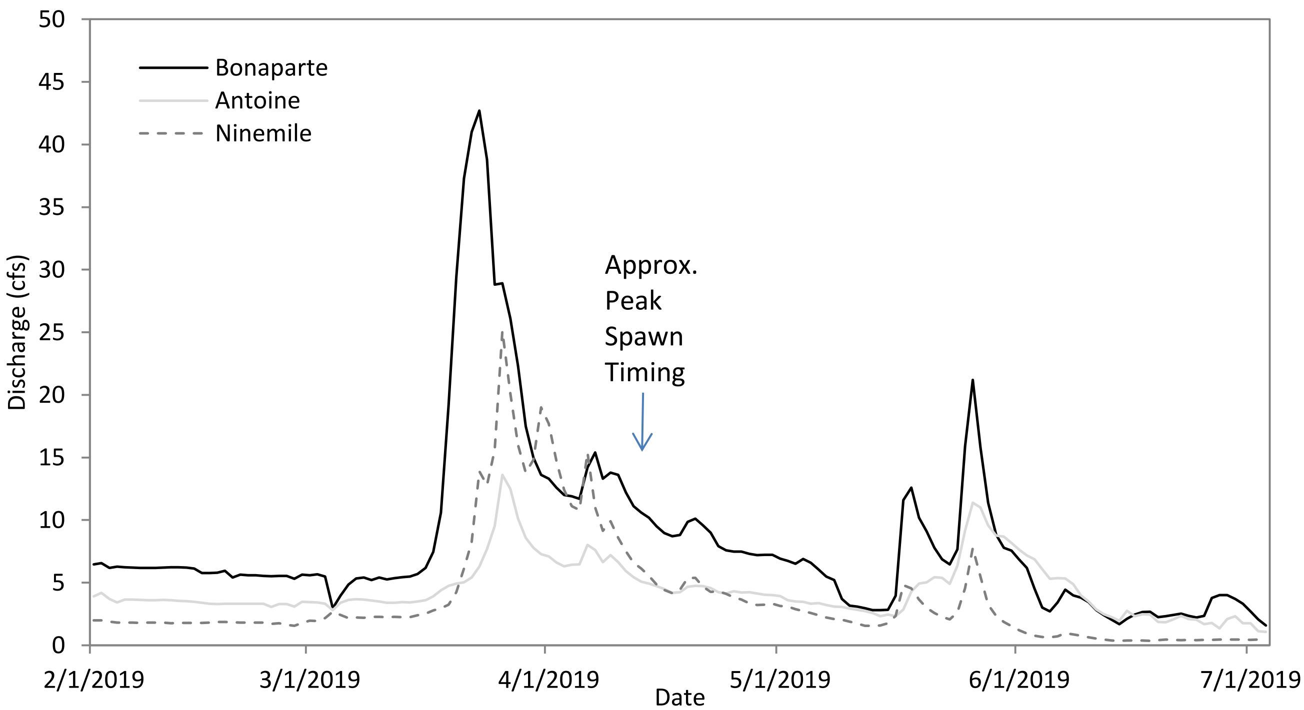

Figure 14. 2019 discharge in three tributaries in the northern Okanogan subbasin in Washington State.

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.

Conditions in Loup Loup Creek were unfavorable to conduct redd surveys throughout much of April 2019 due to turbid water. On May 9, a post-peak redd survey was conducted and a total of 6 redds were found (Figure 16). Those 6 redds were expanded by 1.49 FPR for a total spawning estimate of 9 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.

The instream PIT tag interrogation site LLC was operational throughout the spring of 2019. Although other PIT tagged steelhead entered the creek, most left and likely spawned in other subwatersheds. Only two hatchery PIT tags were left in the Loup Loup Creek bin, and when expanded by the mark rate of .2218, rendered 9 hatchery steelhead. This estimate was the same as the expanded redd counts. Trends in steelhead spawning escapement for Loup Loup Creek are included for reference in Figure 15.

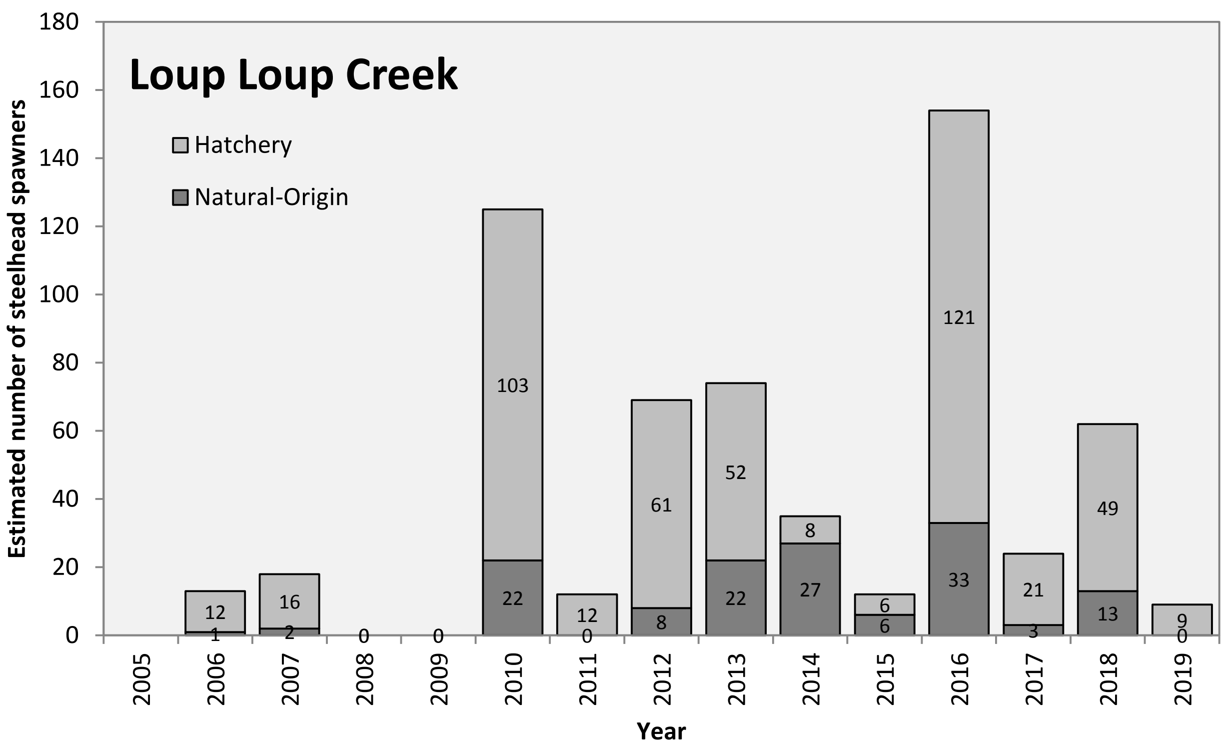

Figure 15. Trend in the number of steelhead spawners in Loup Loup Creek.

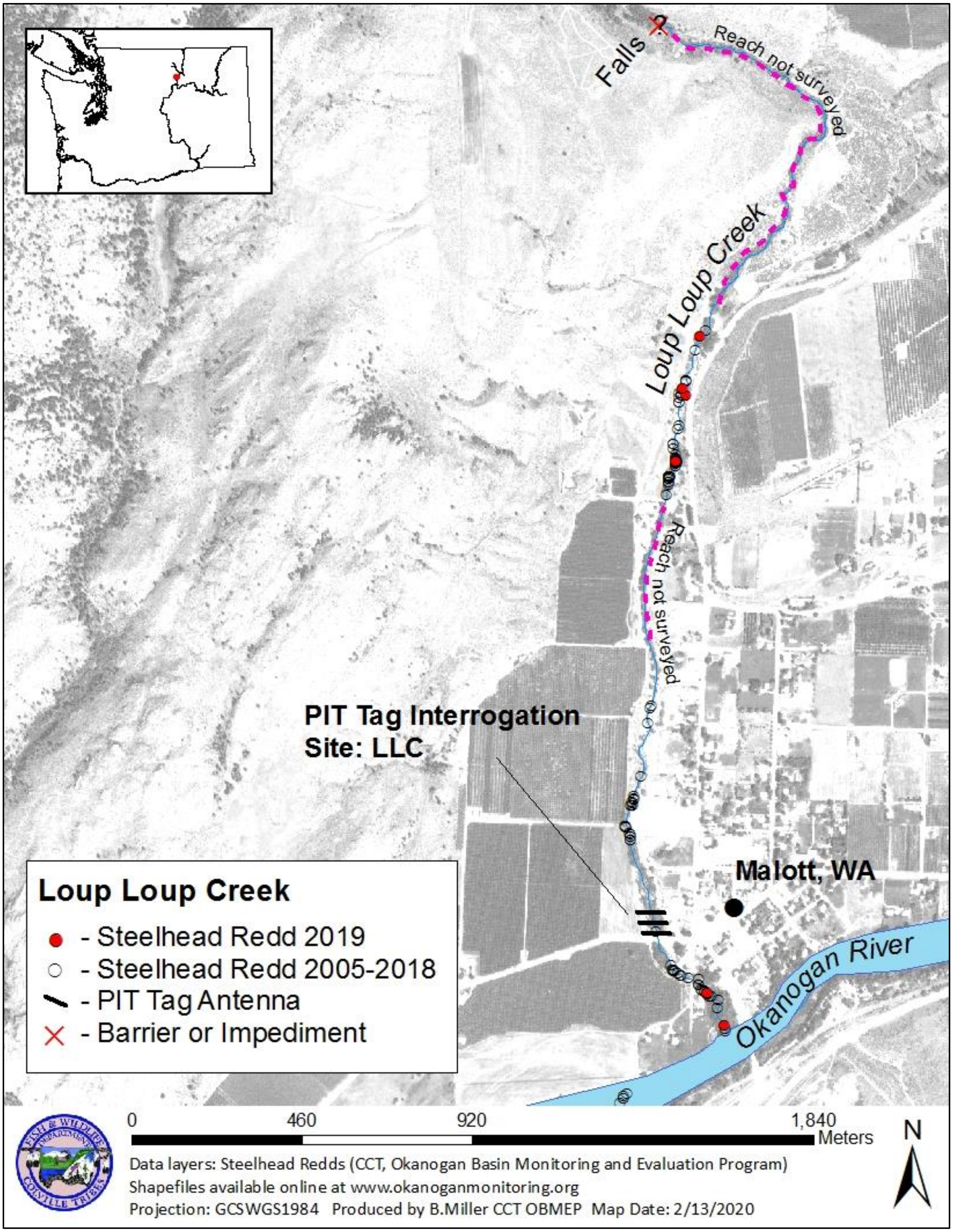

Figure 16. Spatial distribution of historical summer steelhead redds documented in Loup Loup Creek.

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.

Salmon Creek was surveyed three times from the confluence with the Okanogan River to the irrigation diversion. No redds were found on either April 4 or 24. On May 2, a total of 20 redds were documented (Figure 18). After that point, discharges became too high to perform walking surveys in the creek (Figure 13). When expanded by 1.49 fish per redd, the 20 redds rendered an estimate of 30 fish spawning in the reach below the diversion. Additionally, a large portion of upper Salmon Creek was surveyed from Conconully Dam down to the bridge near Happy Hill Road on May 1 and only two redds were documented (Figure 19). When expanded by 1.49 FPR, those two redds rendered three steelhead in this reach. A large section of the creek, from the irrigation diversion to the bridge near Happy Hill Road, has not been surveyed for steelhead spawning to date, mostly due to lack of staff hours. The combined number of spawning steelhead accounted for by redd surveys in Salmon Creek was 33.

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 2019 spawning season, all of the tags detected on the upstream site SA0 were detected on SA1, which rendered a detection efficiency estimate of 100% at the lower array. A total of 6 natural-origin and 0 hatchery steelhead from the PRD mark group were detected at SA1 and all subsequently on SA0. Those tags were expanded using the PRD mark rate, resulting in a spawning escapement estimate of 27 natural-origin and 0 hatchery steelhead in 2019. Additionally, three other hatchery steelhead tags not from the PRD group were also detected in the creek and were added in to the total estimate of 27 wild and 3 hatchery steelhead, or a total of 30 fish. 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 been declining in recent years, including the unexpectedly low estimate of 3 in 2019. 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 (22.18%) is included in the PRD mark group and interrogation site SA1 had a high detection efficiency in 2019 (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). Additionally, between 500 and 2,000 hatchery juveniles from the release groups are estimated to residualize in the creek as juveniles annually (OBMEP 2020a, Appendix B).

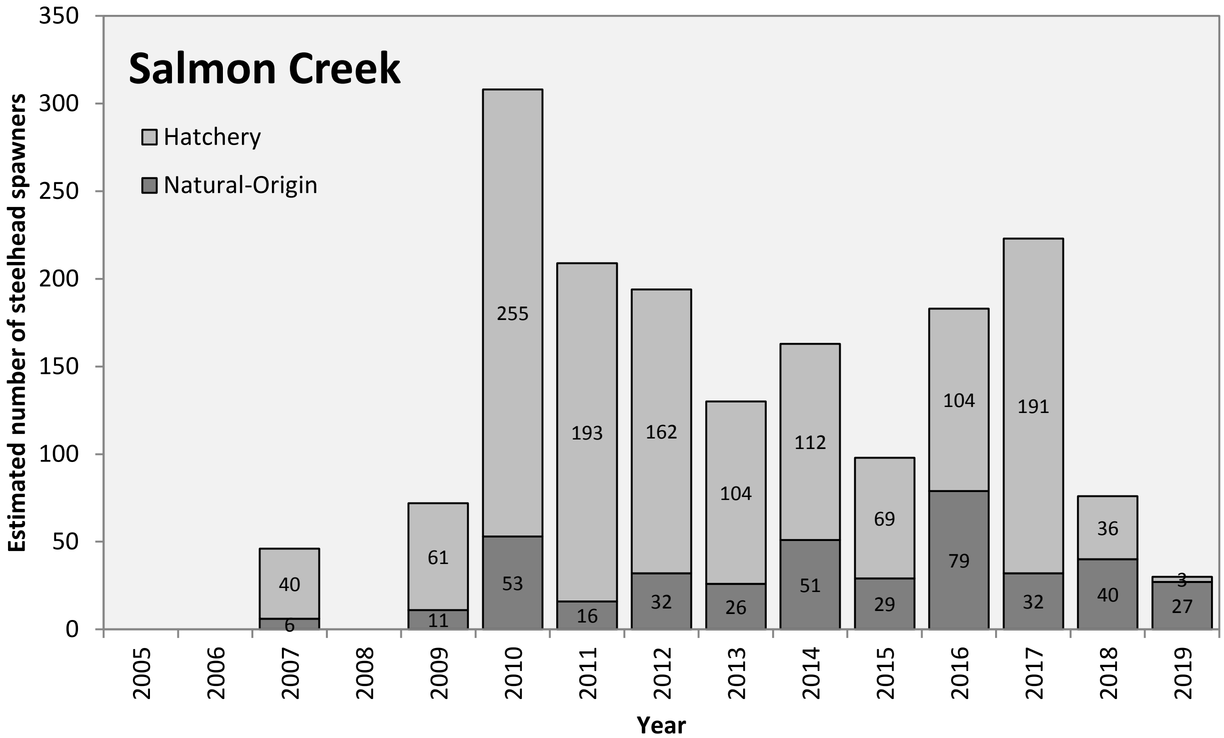

Figure 17. Trend in the number of steelhead spawners in Salmon Creek.

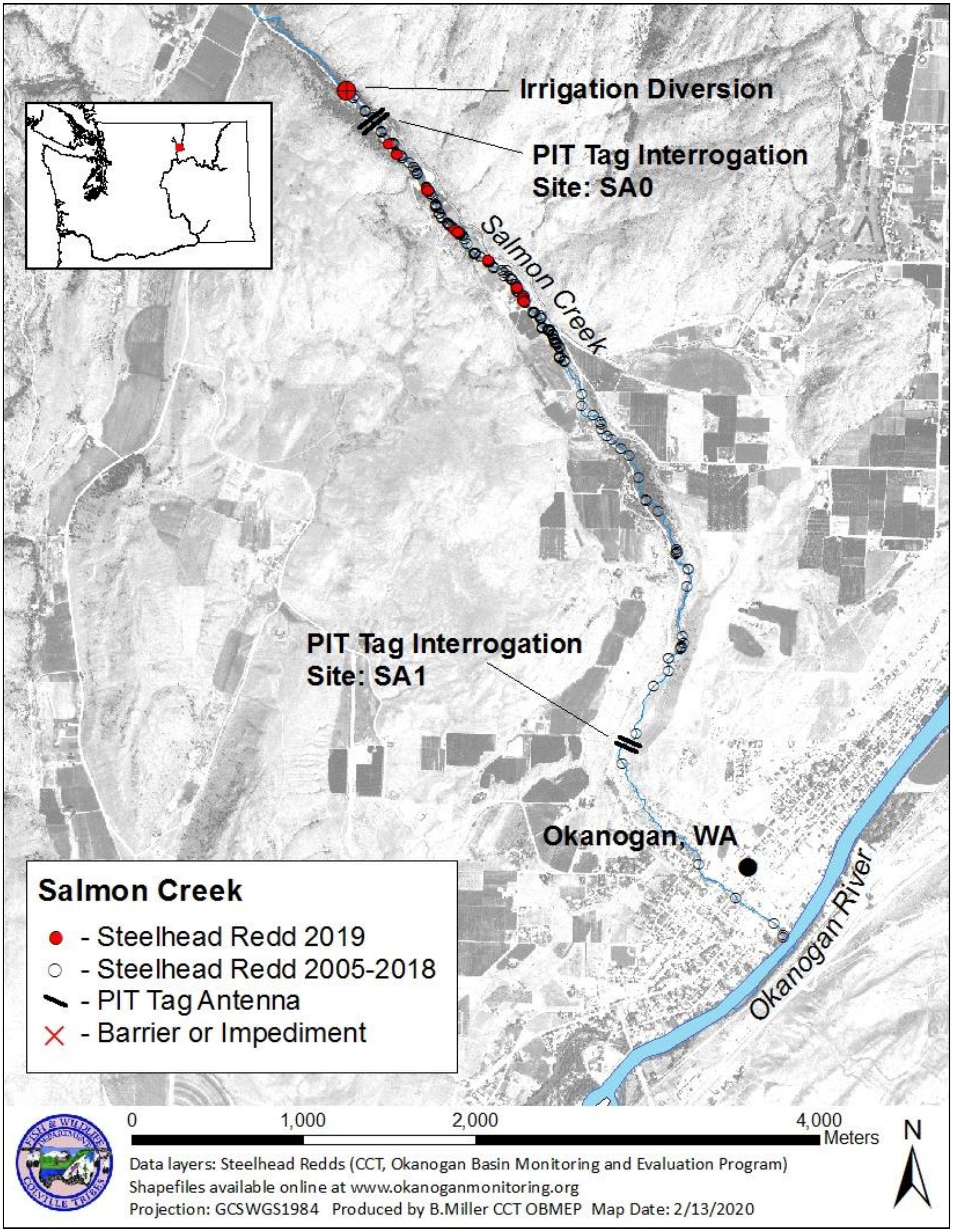

Figure 18. Spatial distribution of historical summer steelhead redds documented in lower Salmon Creek, from the confluence to the irrigation diversion.

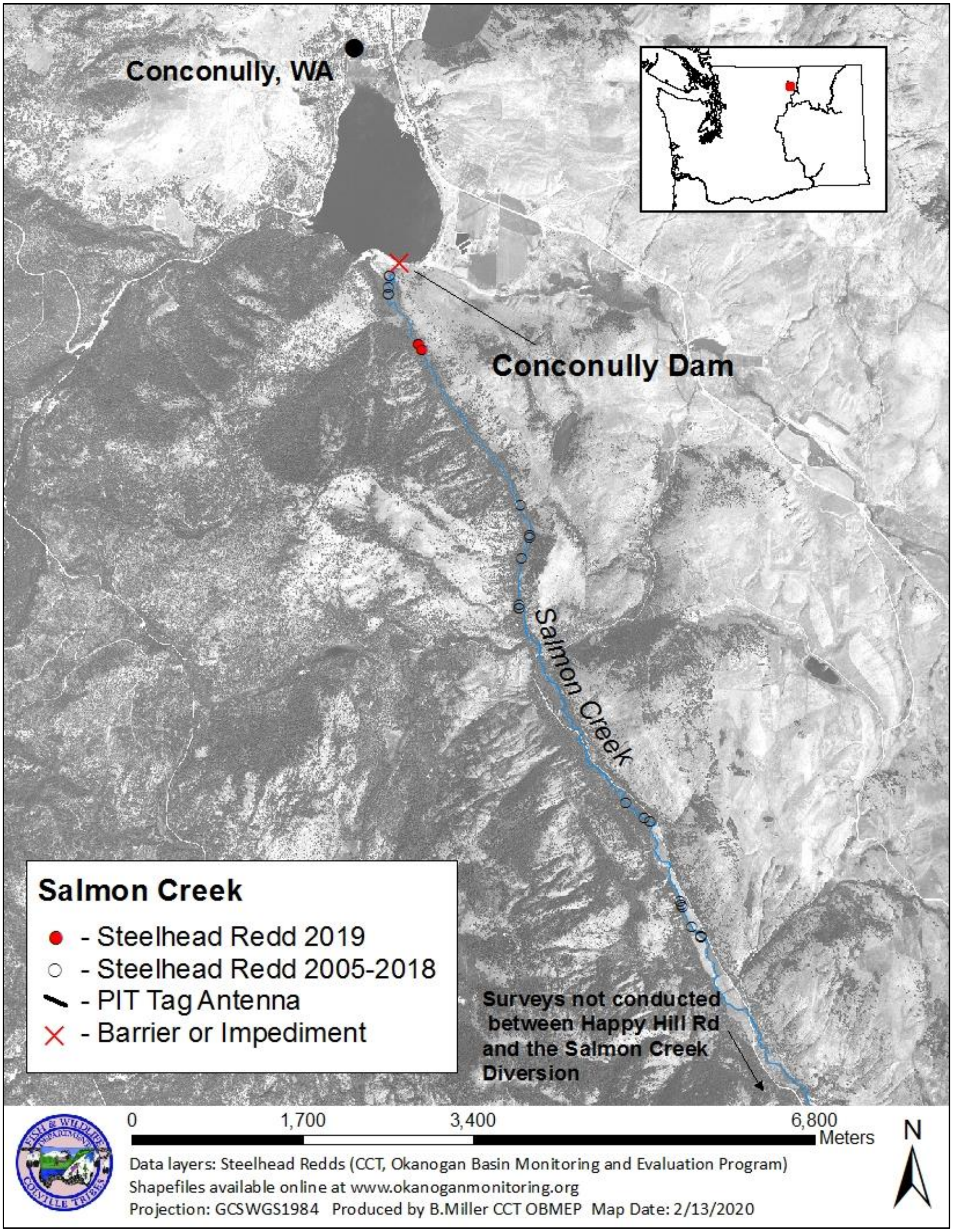

Figure 19. Spatial distribution of summer steelhead redds documented in upper Salmon Creek, below Conconully Dam.

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 began early in Omak Creek and lasted from mid-March through the beginning of May. Although water was elevated, two surveys occurred in April below the weir, on the 18th where five redds were found on April 23 when 10 more redds were located. When discharge rates receded, a third survey found an additional 27 redds, for a total of 42 redds documented below the weir (Figure 22). These redds were expanded by 1.49 fish per redd for an estimated 63 total steelhead spawning below the weir. A single pass redd survey occurred over a three day period on April 29 and 30, and May 4, from the weir trap to Mission Falls (Figure 22). A total of 36 redds were located, accounting for an estimated 54 spawning steelhead. 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 as follows. A total of 10 natural-origin and 29 hatchery steelhead were detected at OMK. We assume 100% detection efficiency at OMK in 2019 because all tags detected across the year at upstream OBF or OMF were detected previously at downstream OMK. Those tags were expanded by the mark rate of 0.2218 for a total number of 45 natural-origin and 131 hatchery steelhead entering the creek. A total of 8 wild fish were removed at the weir for broodstock, and 20 natural-origin and 41 hatchery steelhead were passed upstream of the weir. Those numbers were expanded by the weir efficiency of 0.9 (based on upstream tag detections at OBF and OMF) for a total spawning estimate above the weir of 22 natural-origin and 46 hatchery 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 15 natural-origin and 85 hatchery steelhead (Table 5).

Twenty PIT tagged steelhead were detected at OBF (at the base of Mission Falls) and five fish were detected above Mission Falls in 2019 (one of natural-origin and 4 hatchery steelhead). These tags were not expanded to unmarked fish because every adult steelhead passed upstream of the weir received a PIT tag. 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 20). 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. Stream discharge during passage events was generally 25-50 cfs. 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.

Table 5. Calculations used to estimate the number and distribution of spawning steelhead in Omak Creek in 2019.

Description (Variable)	Natural-origin	Hatchery
A. Total steelhead entering Omak Creek in 2019	45	131
B. Number of steelhead removed at weir	8	0
C. Number of steelhead passed upstream of weir	20	41
D. Estimated # steelhead spawning above weir (D = C/0.9)	22	46
E. Estimated # steelhead spawning below weir (E = A-B-D)	15	85
F. Number of steelhead above Mission Falls	1	4
G. Total estimated number of SH spawning 2019 (G = D+E)	37	131

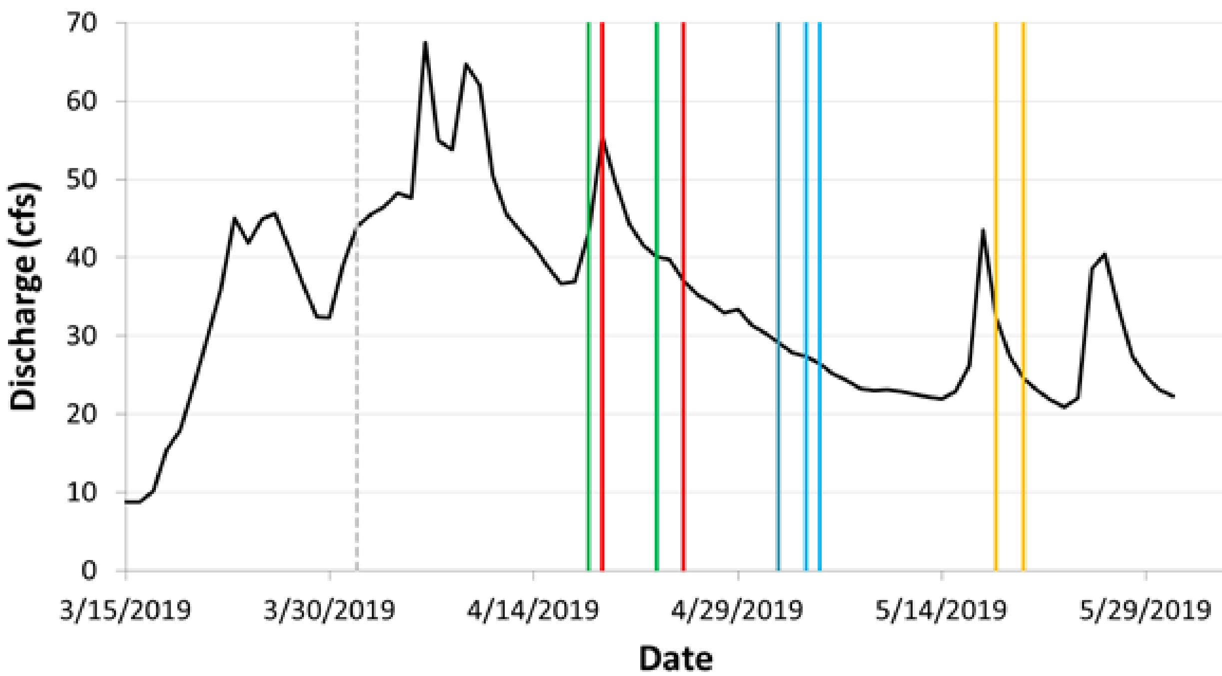

Figure 20. Timing of successful adult steelhead passage events at Mission Falls on Omak Creek. Dashed grey vertical line represents the date of first PIT tag detection below Mission Falls (OBF). Color coded lines are individual fish, with the first sequential color occurrence representing detection below the falls (OBF) and the second occurrence above the falls (OMF). One event occurred in a single day (dark blue line).

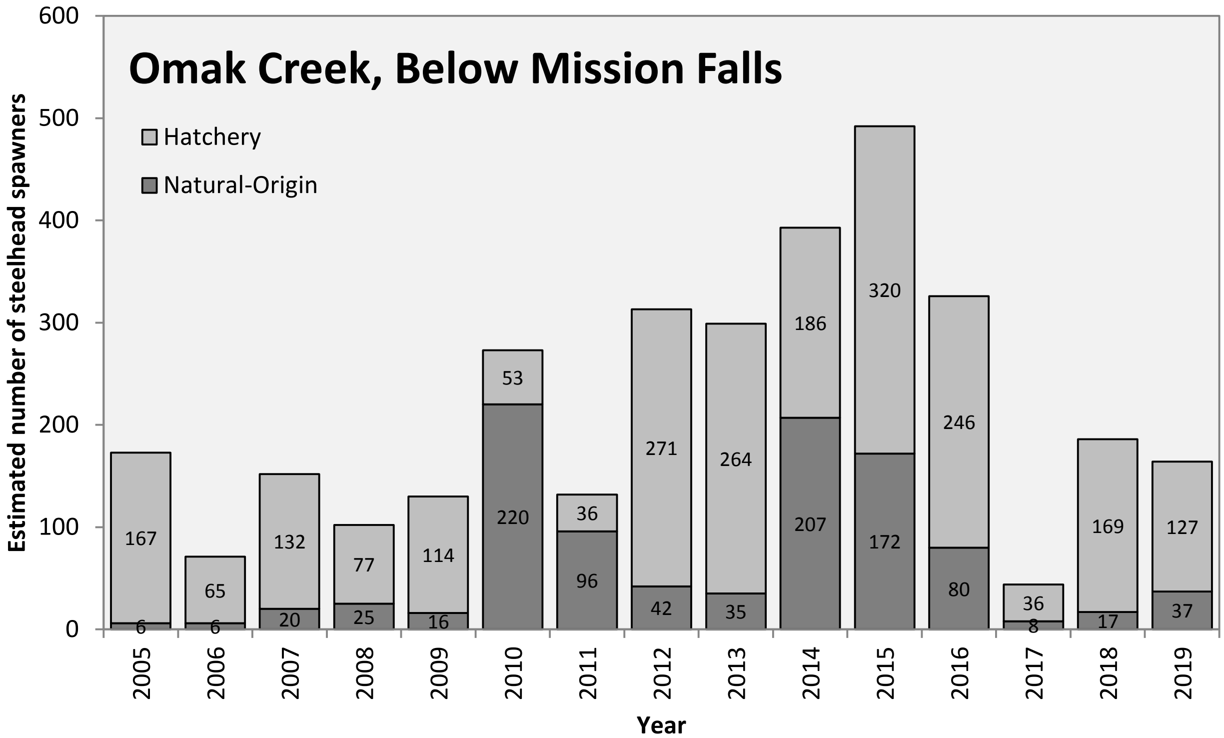

Figure 21. Trend in the number of steelhead spawners in Lower Omak Creek.

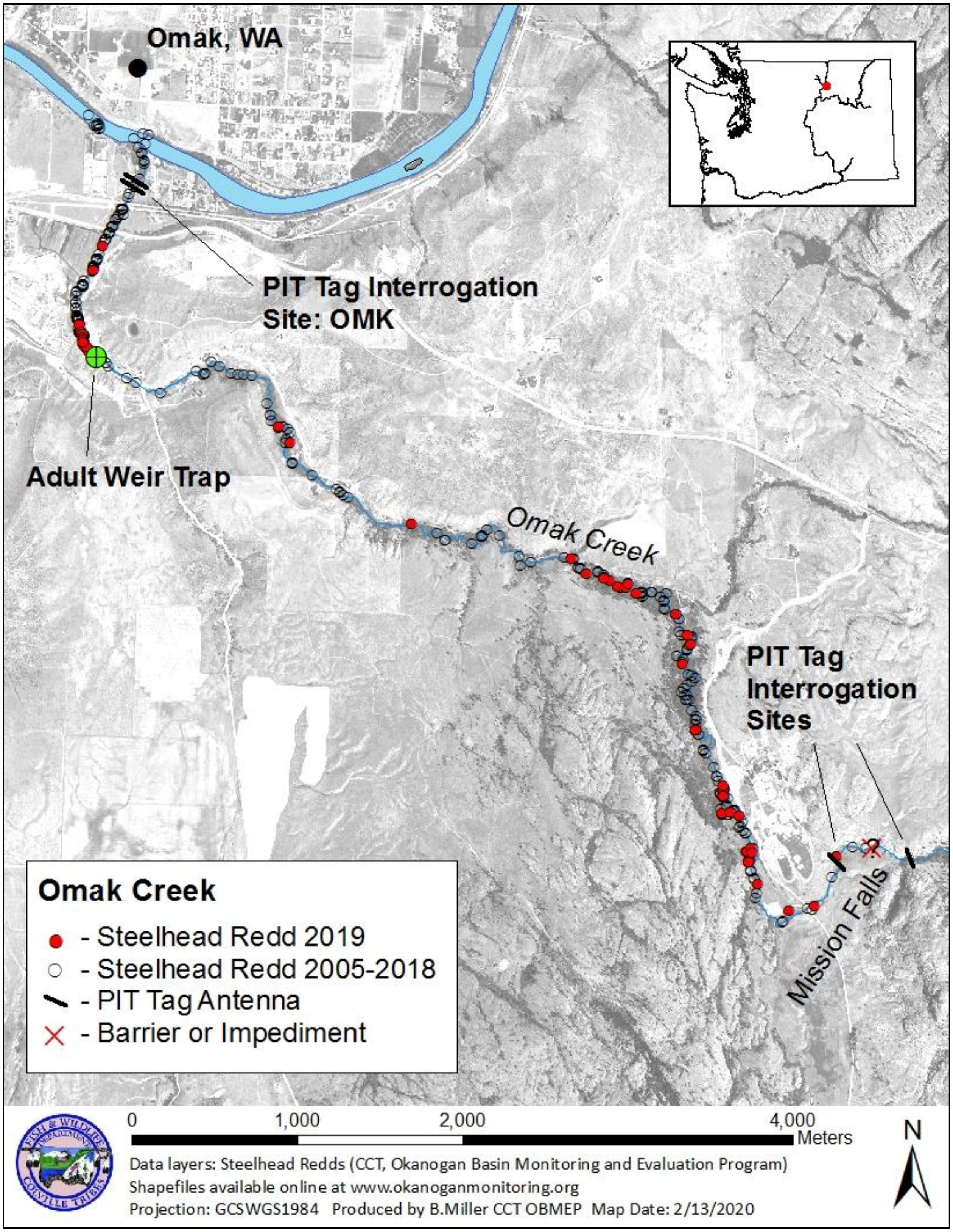

Figure 22. Spatial distribution of historical summer steelhead redds documented in Omak Creek, from the confluence to Mission Falls.

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.

Over the past 13 years of surveys conducted on Wanacut Creek (2007–2019), seven years had no steelhead spawning and the remaining 6 years had an average of 7 steelhead spawners. The maximum spawning estimate was 12 in 2012 (Figure 23).

Conditions in Wanacut Creek were favorable to conduct redd surveys throughout the spring of 2019, but no redds were found. The location of redds observed in previous years (2005–2016) are shown in Figure 24. Additionally, no PIT tags were detected on interrogation site WAN, also resulting in an estimated zero adult steelhead utilizing the creek for spawning in 2019. The lower portion of the creek was dry in early July.

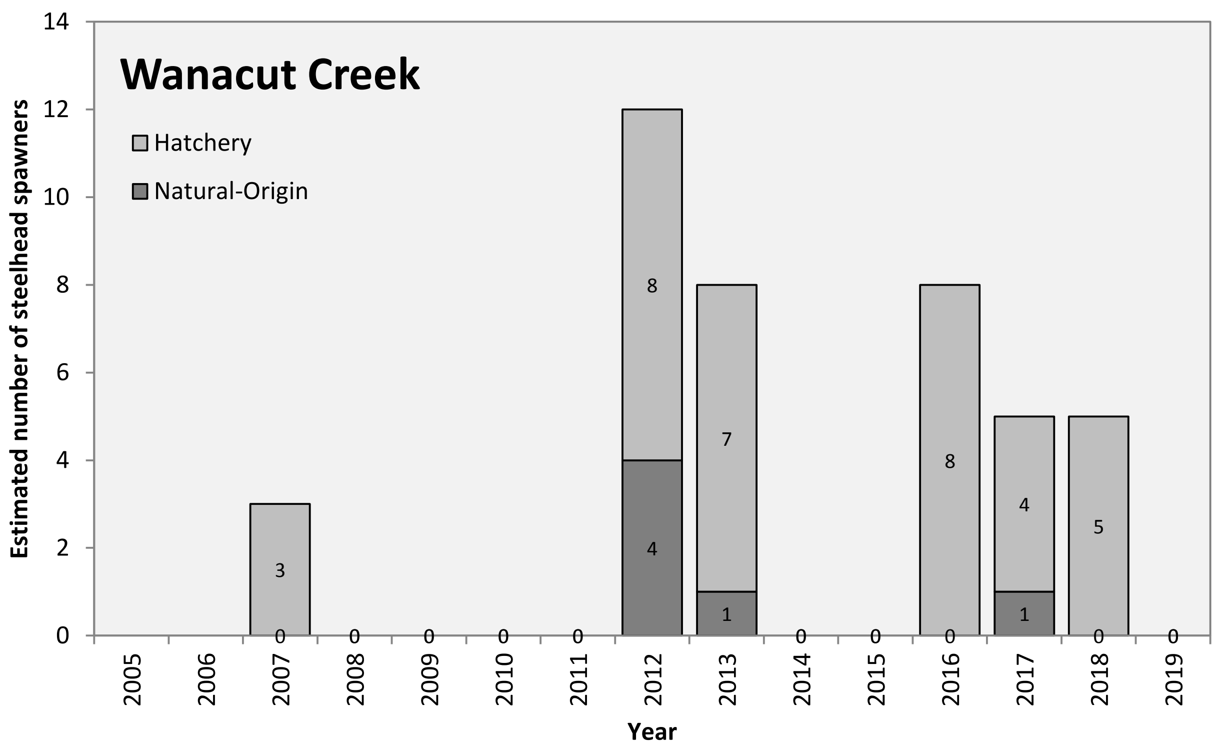

Figure 23. Trend in the number of steelhead spawners in Wanacut Creek.

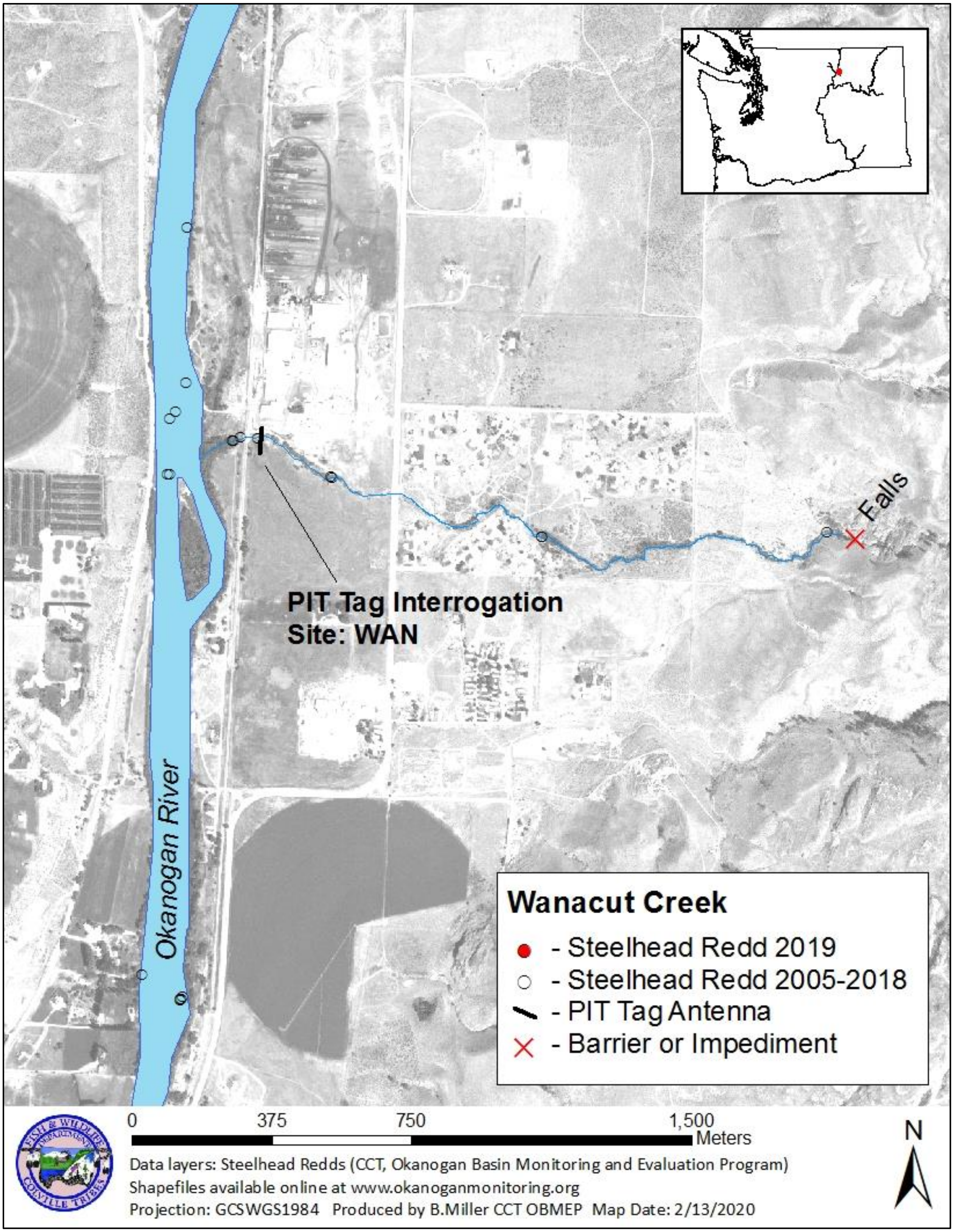

Figure 24. Spatial distribution of historical summer steelhead redds documented in Wanacut Creek.

3.2.5 Johnson Creek

Steelhead surveys have occurred in Johnson Creek since 2012. In 2019, only two redds were documented during the only survey conducted on April 25. Those two redds were expanded by 1.49 FPR for an estimated total of 3 steelhead spawning in the creek. The spatial distribution of steelhead spawning in lower Johnson Creek for 2019 and previous years are shown in Figure 26.

Two PIT tag arrays were operated in Johnson Creek in 2019. A permanent single pass-through antenna located near the mouth (JOH) and a single temporary antenna above the US 97 culvert. No steelhead from the PRD mark group were detected in Johnson Creek in 2019 and the total spawning escapement estimated from PIT tag detections alone would be 0. However, since 2 redds were found, we would revert to the redd survey spawning estimate of 3. Because the majority of fish in previous years were of hatchery-origin, and there was one PIT tagged natural-origin steelhead not from the PRD tag group detected in the creek, we divided the 3 total fish into 2 hatchery and 1 steelhead of natural-origin. For reference, trends in steelhead spawning escapement for Johnson Creek are included in Figure 25. No adult steelhead were detected above the highway culvert in 2019.

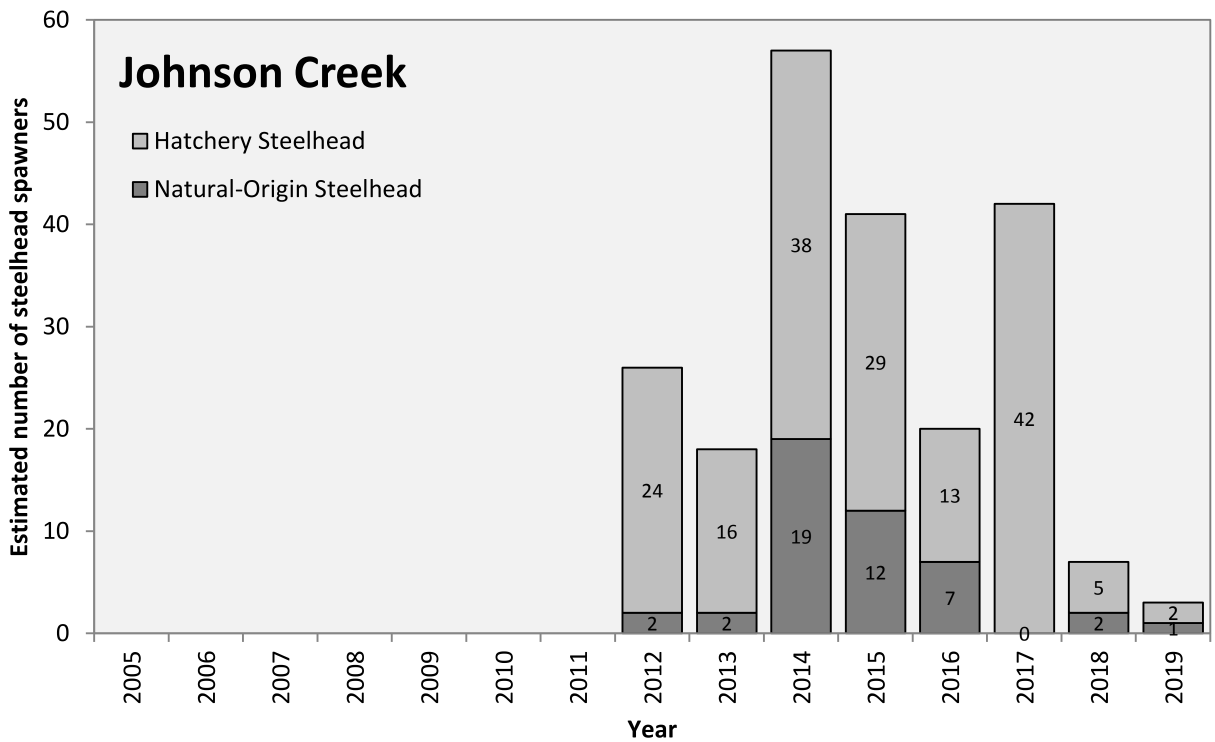

Figure 25. Trend in the number of steelhead spawners in Johnson Creek.

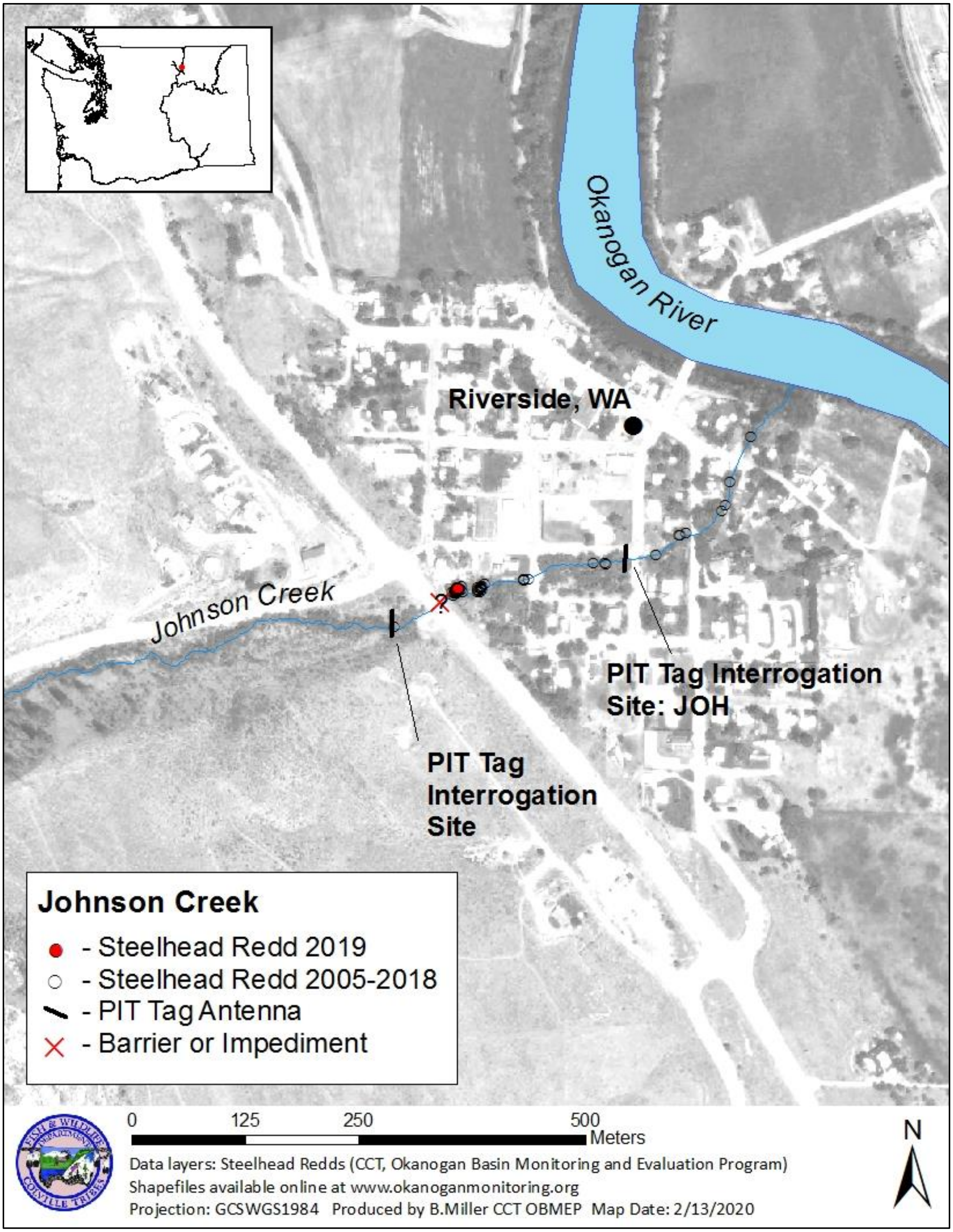

Figure 26. Spatial distribution of summer steelhead redds documented in Johnson Creek, from the confluence to the gabion weir.

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-over antenna is installed seasonally near the mouth of the creek.

Conditions in Tunk Creek were generally favorable to conduct redd surveys throughout the spring of 2019. Zero redds were found on April 2, eight redds on April 16, and nine on May 7. Twenty-five steelhead were estimated to have spawned in Tunk Creek, when expanded from the 17 total redds. The majority of steelhead spawning in Tunk Creek occurs in a relatively short reach just downstream of the falls (Figure 28).

In 2019, two natural- and four hatchery-origin steelhead from the PRD group were detected at site TNK. These fish were expanded by the mark rate to 9 natural- and 18 hatchery-origin, for a total of 27 steelhead, nearly identical to the redd survey-based spawning estimate.

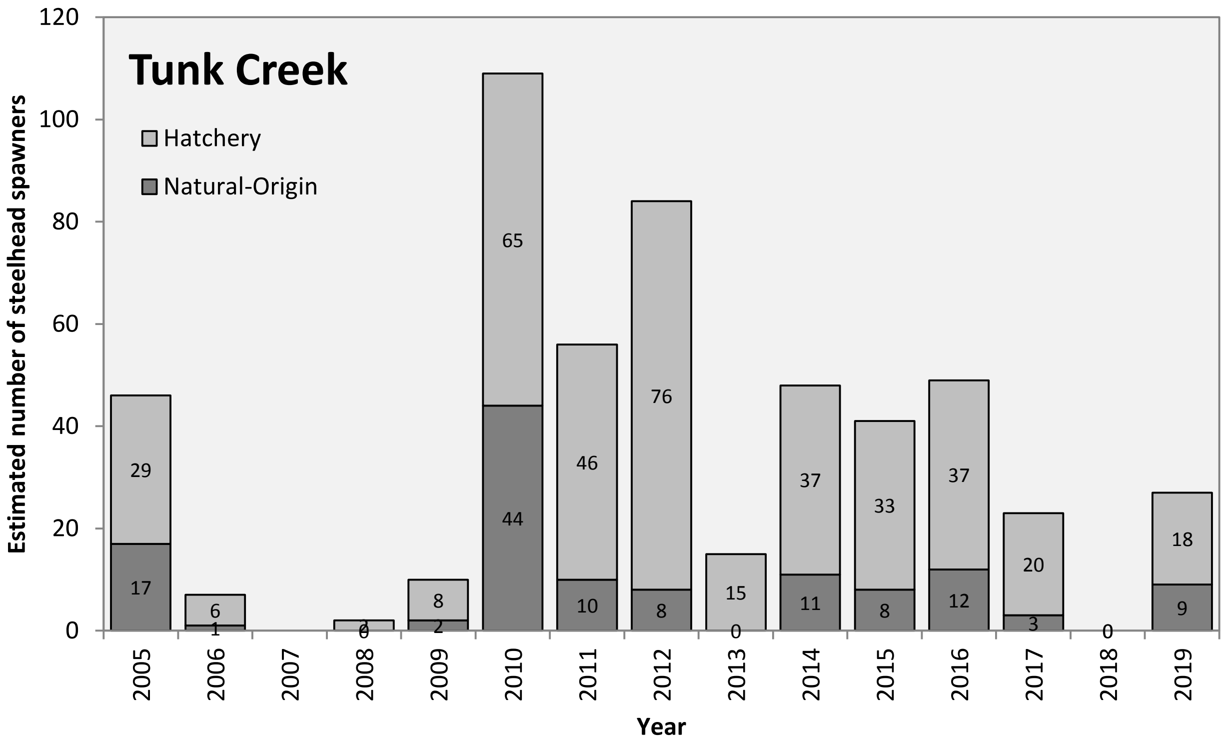

Figure 27. Trend in the number of steelhead spawners in Tunk Creek.

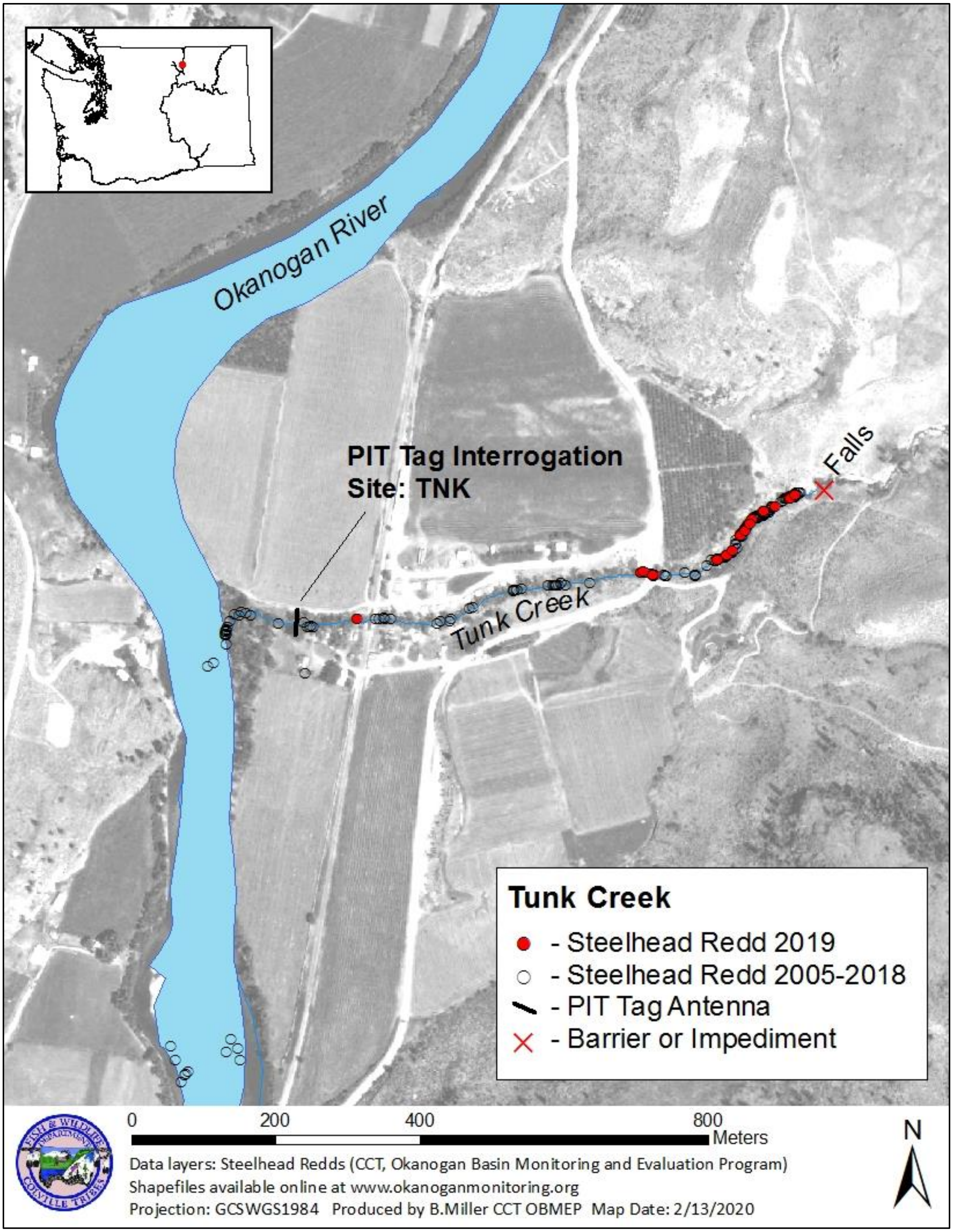

Figure 28. Spatial distribution of historical summer steelhead redds documented in Tunk Creek.

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 successfully conducted throughout the spring of 2019. Zero redds were found on April 2, 0 on April 16, 3 on April 22, and 0 on May 7, when only the previous 3 could be still seen. Three redds, expanded by 1.49 FPR equaled an estimated five steelhead spawning in Aeneas Creek in 2019.

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 2019, resulting a total spawning escapement estimate of zero steelhead. Because three redds were found, we defaulted to the redd survey-based estimate of 5 steelhead. We assumed that these fish were likely of hatchery-origin, based on historic hatchery/wild data from Aeneas Creek (Figure 29).

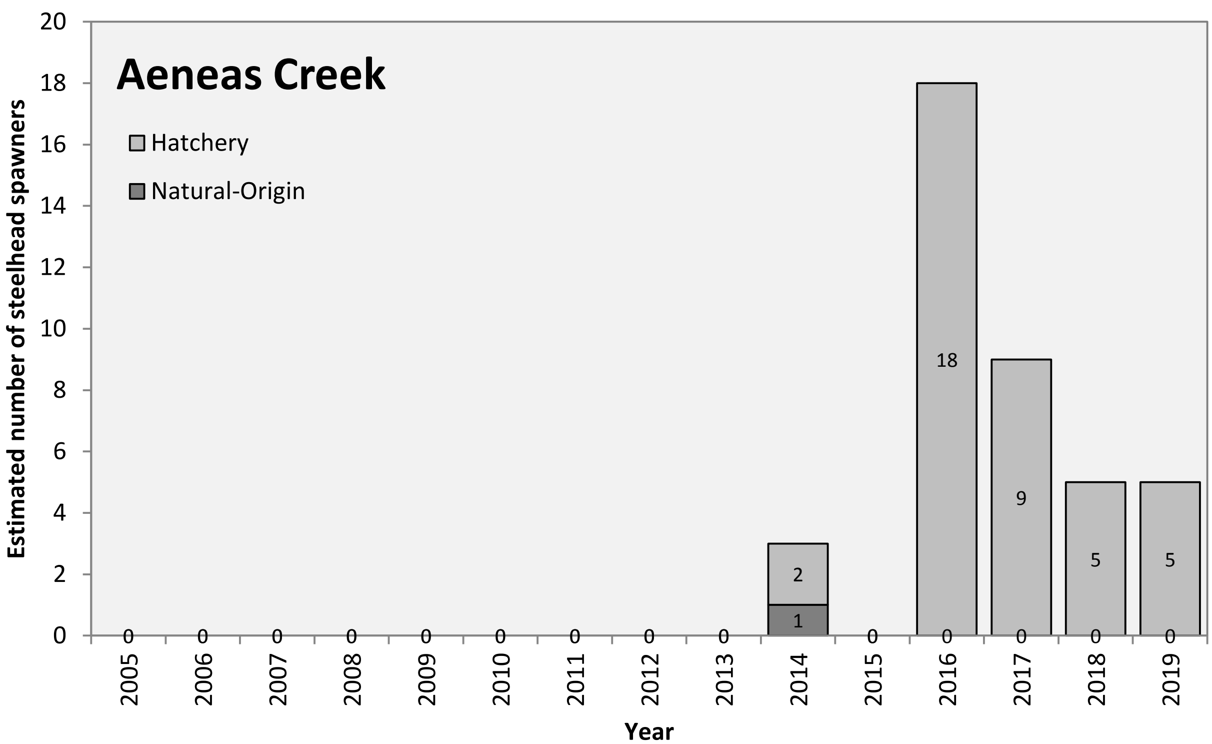

Figure 29. Trend in the number of steelhead spawners in Aeneas Creek.

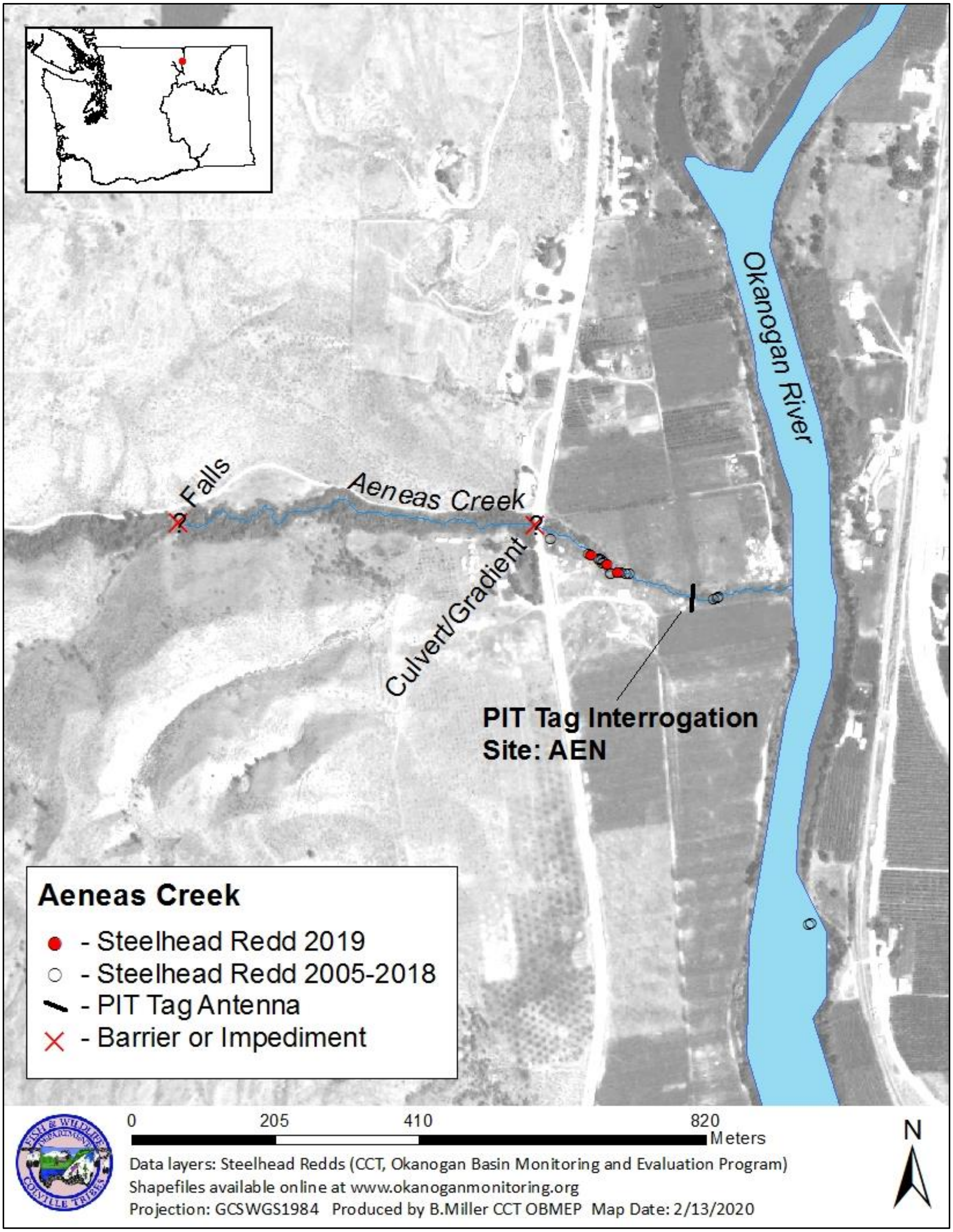

Figure 30. Spatial distribution of historical summer steelhead redds documented in Aeneas Creek.

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). Turbid water prevented visual spawning surveys from occurring until mid-April, when 11 redds were found on April 23.

A permanent PIT tag interrogation site (BPC) consisting of three pass-over PVC antennas arranged in three separate rows was located just upstream from the confluence with the Okanogan River. Based on tag detections from the PRD mark group (4 natural-origin, 7 hatchery), the estimated spawning escapement was 18 natural-origin and 32 hatchery steelhead in Bonaparte Creek in 2019. For reference, trends in steelhead spawning estimates for Bonaparte Creek are included in Figure 31.

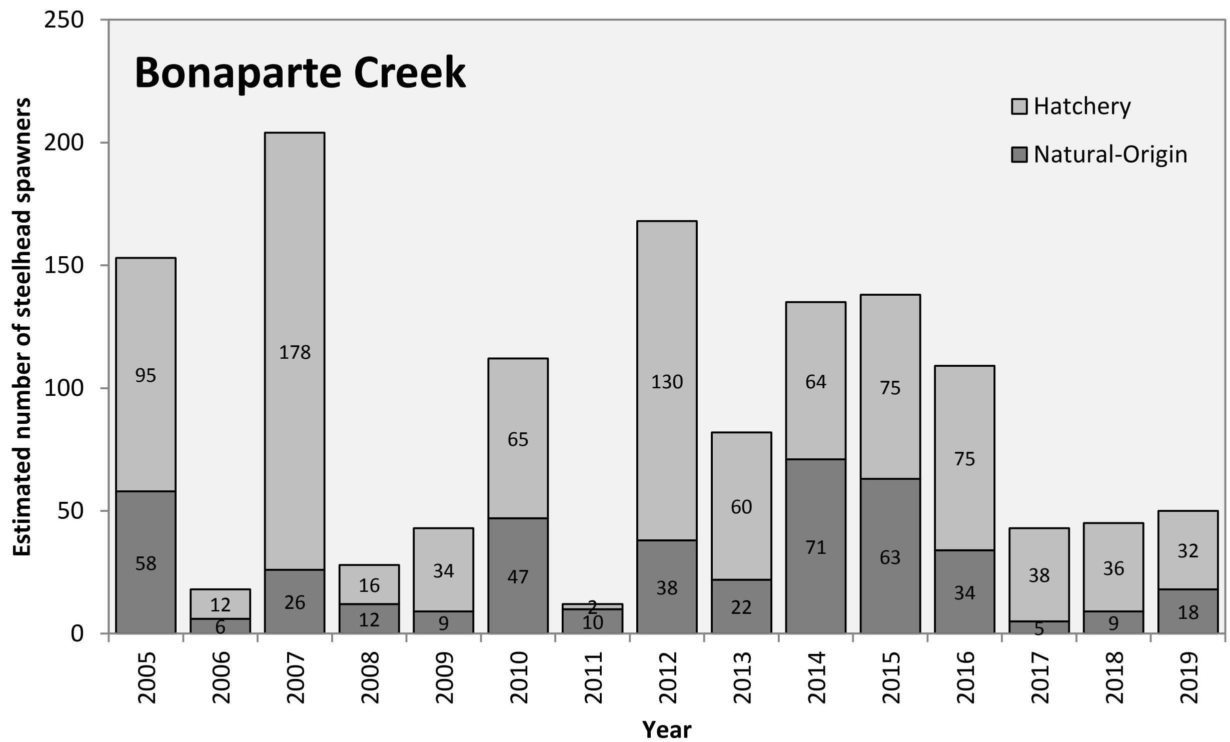

Figure 31. Trend in the number of steelhead spawners in Bonaparte Creek.

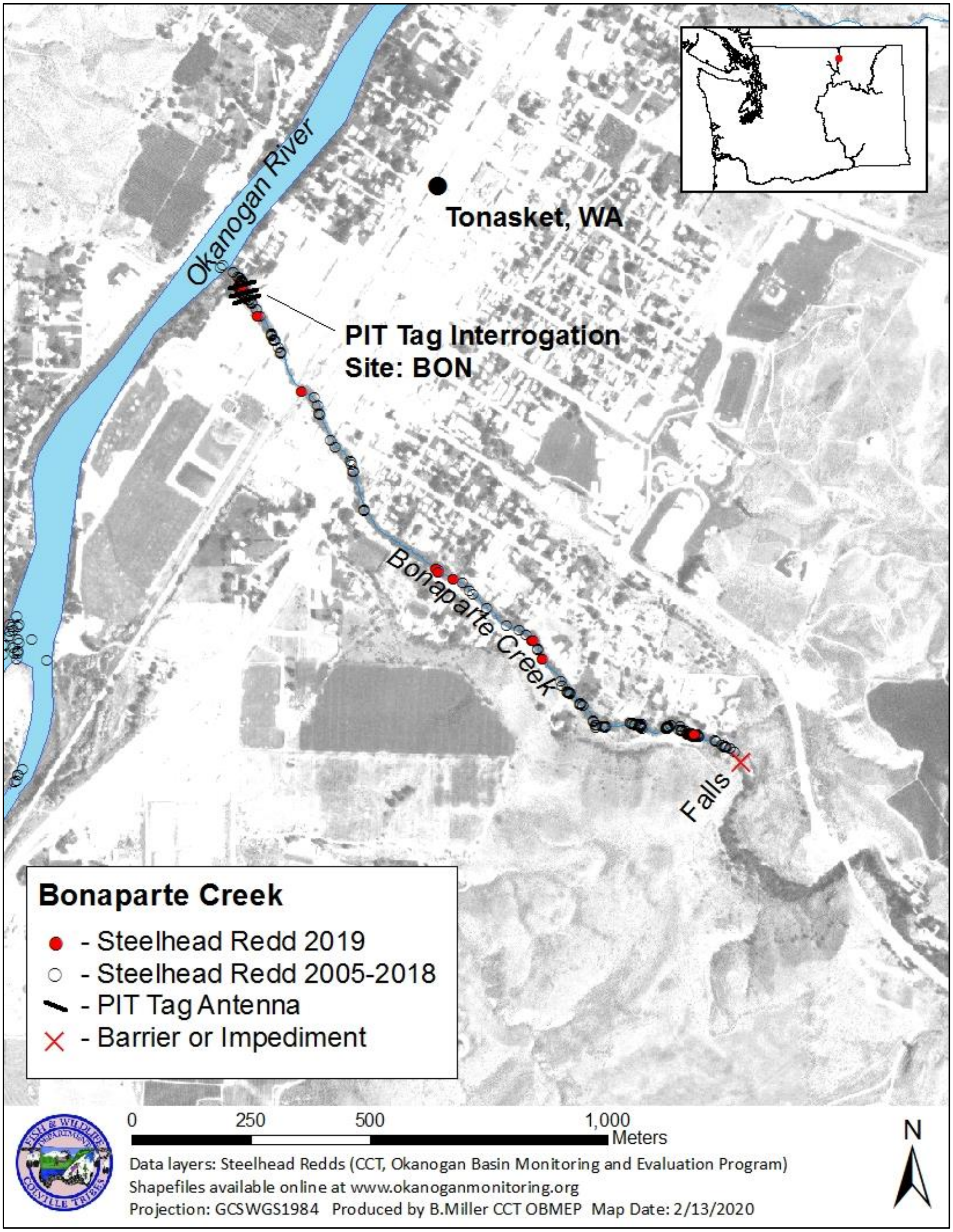

Figure 32. Spatial distribution of historic summer steelhead redds documented in Bonaparte Creek.

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 near the mouth of the creek. In part, this may be due to 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. Since increasing instream flows and removing access barriers, the number of steelhead utilizing Antoine Creek has increased over the past 4 years, compared with prior estimates (Figure 33).

Complete redd surveys occurred in Antoine Creek for the first time in 2018. On April 25th, 2018, surveyors walked upstream from the mouth of the creek through Antoine Valley Ranch and located 15 redds (Figure 34). In 2019, no redds were found in the lower section of the creek and surveys could not be conducted upstream due to lack of access. Two natural-origin and zero hatchery PIT tagged steelhead in the PRD mark group were detected on PIT tag interrogation site ANT in 2019. Those fish were expanded for a total spawning escapement estimate of 9 natural-origin and 0 hatchery steelhead.

A temporary PIT tag interrogation site operated on Antoine Valley Ranch for the first time in 2018 was not installed in 2019 due to lack of access. In 2018, an estimated 9 natural-origin and 9 hatchery fish passed this upper array, which along with the documented redds, was the first observation of adult steelhead this high in the Antoine Creek watershed. Although spatial distribution was unknown in 2019, positions of redds documented in previous years are shown in Figure 34.

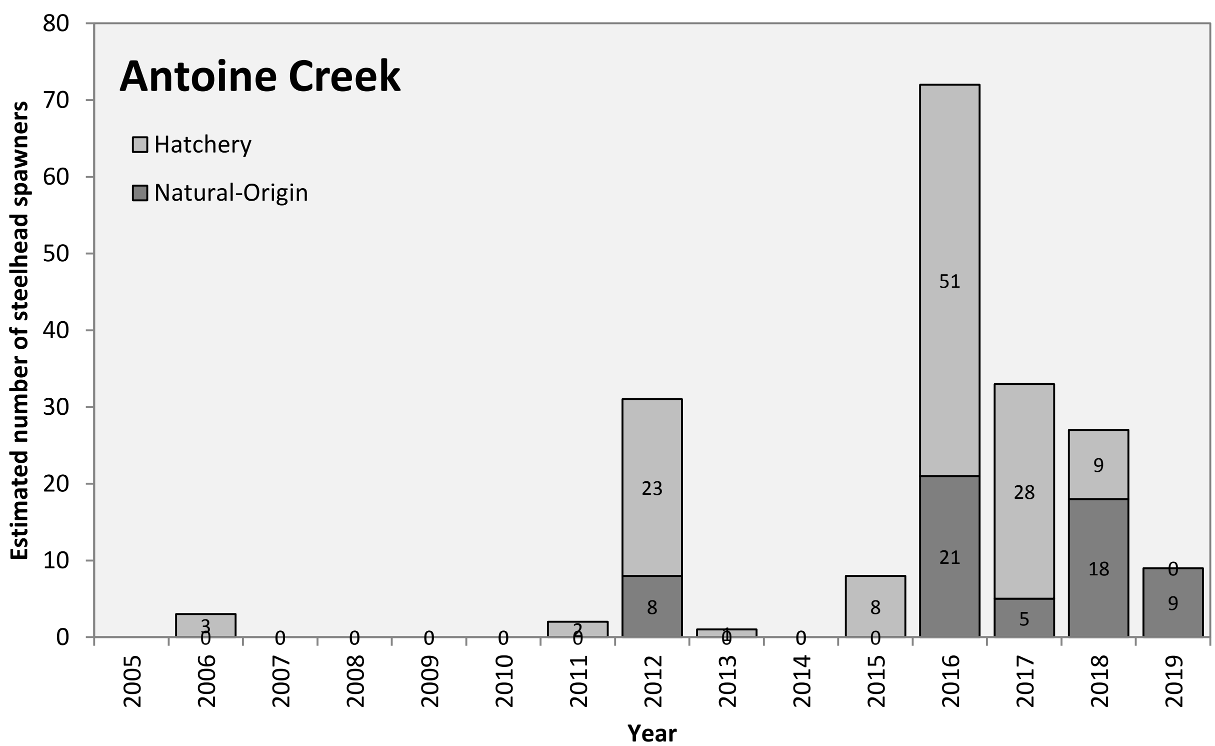

Figure 33. Trend in the number of steelhead spawners in Antoine Creek.

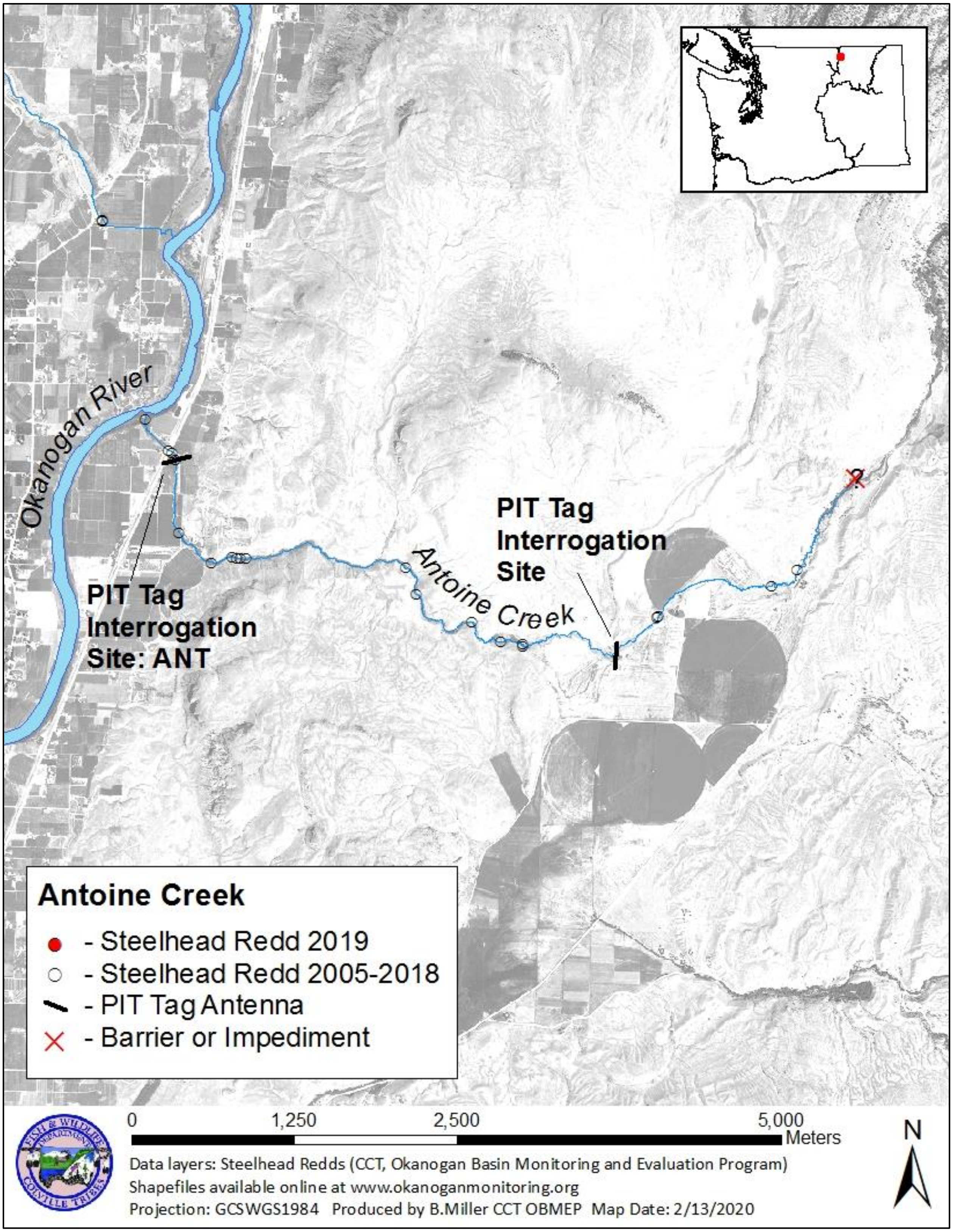

Figure 34. Spatial distribution of summer steelhead redds documented in Antoine Creek.

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 to allow for adult steelhead access, it is not uncommon for large numbers of fish to utilize this creek for spawning. Surveys have occurred over the previous 14 years (2006–2018). On five of the years (2008, 2009, 2014, 2015, 2018) zero steelhead were estimated to have entered the creek. In the remaining years, an annual average of 87 steelhead spawned in the creek (max=278 in 2012, Figure 35 and 36).

Although sufficient flow existed, no adult steelhead were detected on the PIT tag interrogation site in 2019. An adult steelhead weir trap was also operated in the lower portion of the creek, just above the PIT antenna, with no captures. Additionally, no redds were found below the trap and thus, no steelhead were estimated to have used Wildhorse Spring Creek for spawning in 2019.

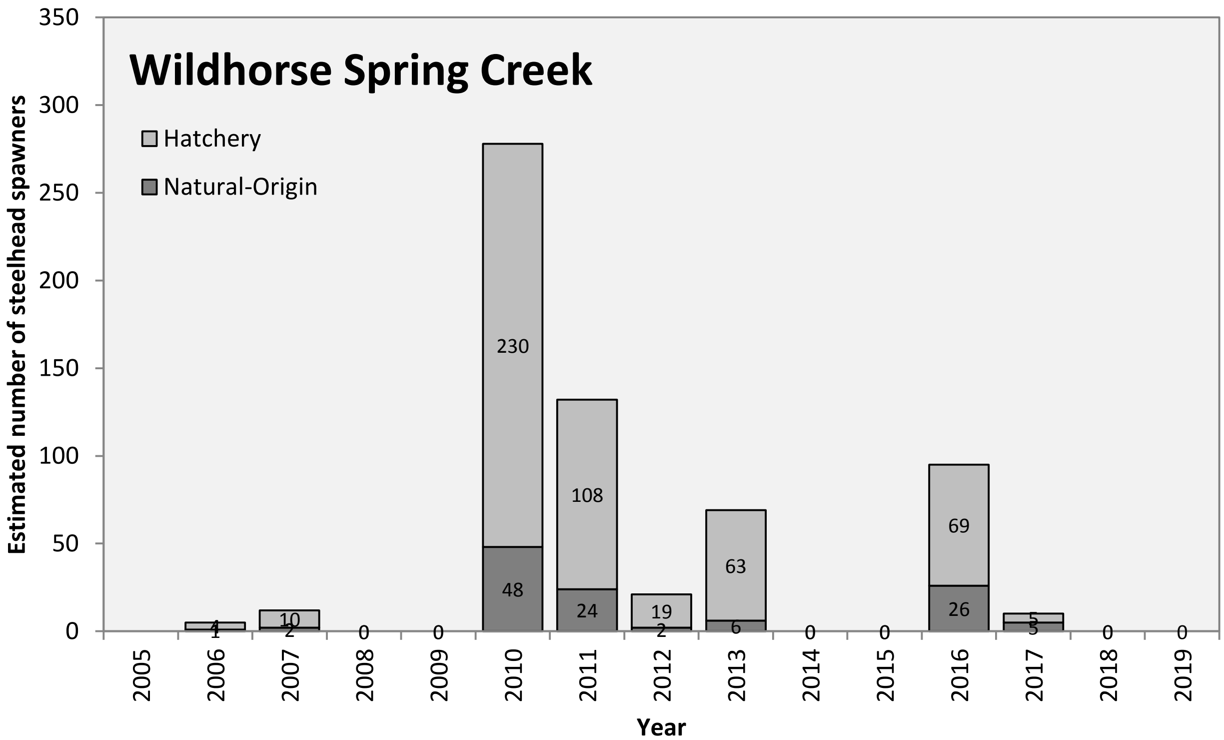

Figure 35. Trend in the number of steelhead spawners in Wildhorse Spring Creek.

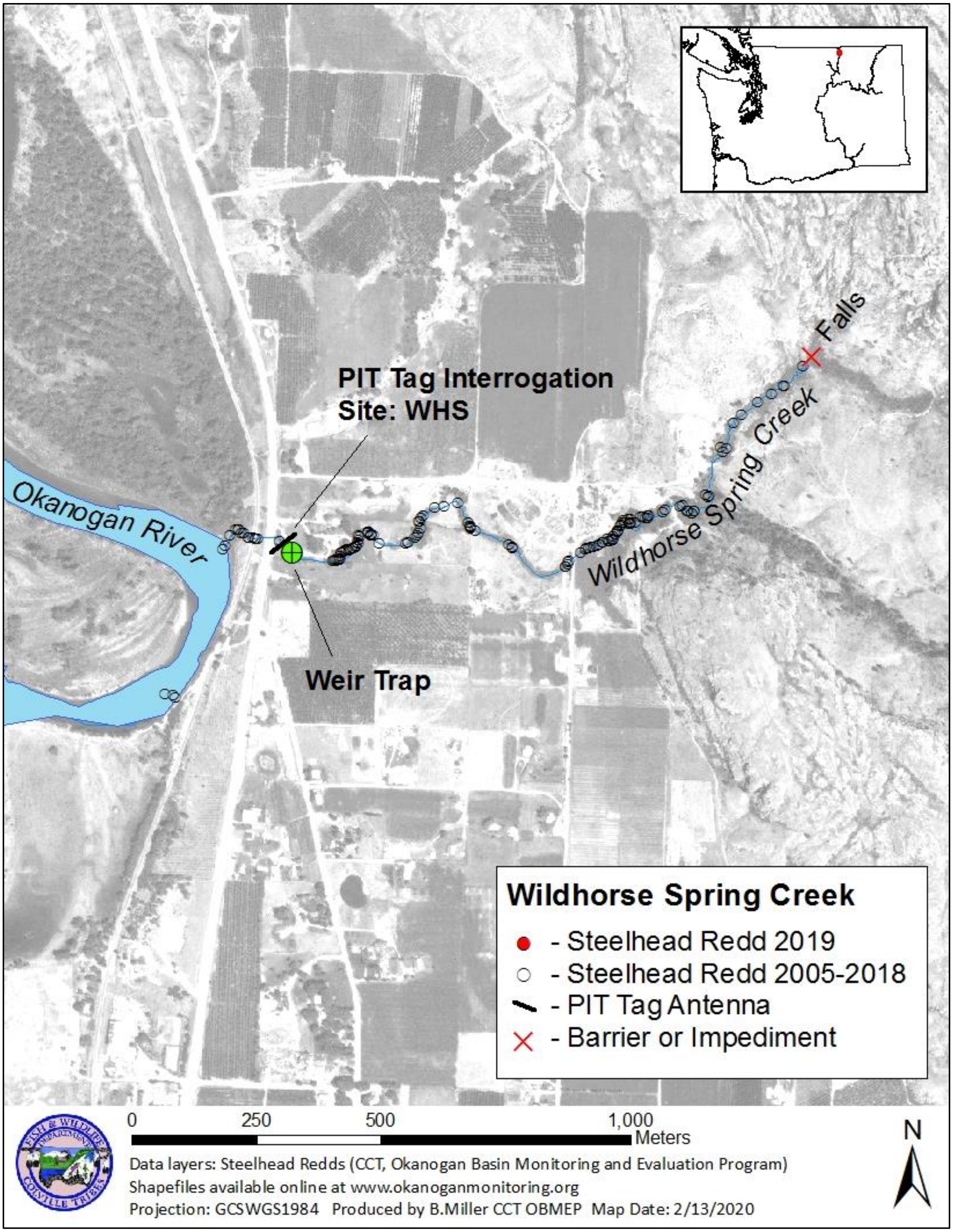

Figure 36. Spatial distribution of summer steelhead redds documented in Wildhorse Spring Creek.

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 redd survey occurred on April 3, no redds were found. Shortly after that date, flows appeared to be too low (<3cm) for adult steelhead to gain access across a broad alluvial fan at the mouth of the creek and no further walking surveys were conducted. However, based on PIT tag detections expanded from the PRD mark group, in 2019, an estimated 23 steelhead spawned in Tonasket Creek, 5 natural-origin and 18 hatchery steelhead. These fish were expanded from one natural-origin and 4 hatchery PRD tags. Apparently, adult steelhead were able to access the creek from mid-April through the end of the month across the extremely shallow alluvial fan. The lower portion of the creek was dry on June 19.

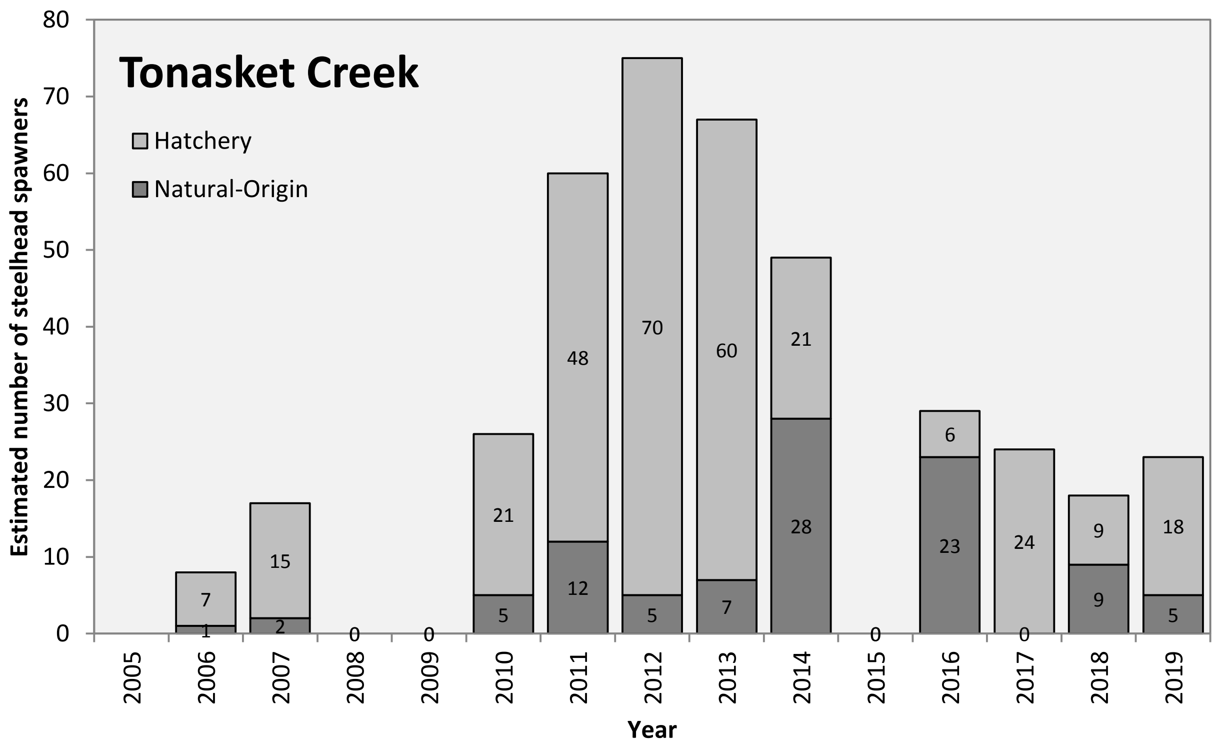

Figure 37. Trend in the number of steelhead spawners in Tonasket Creek.

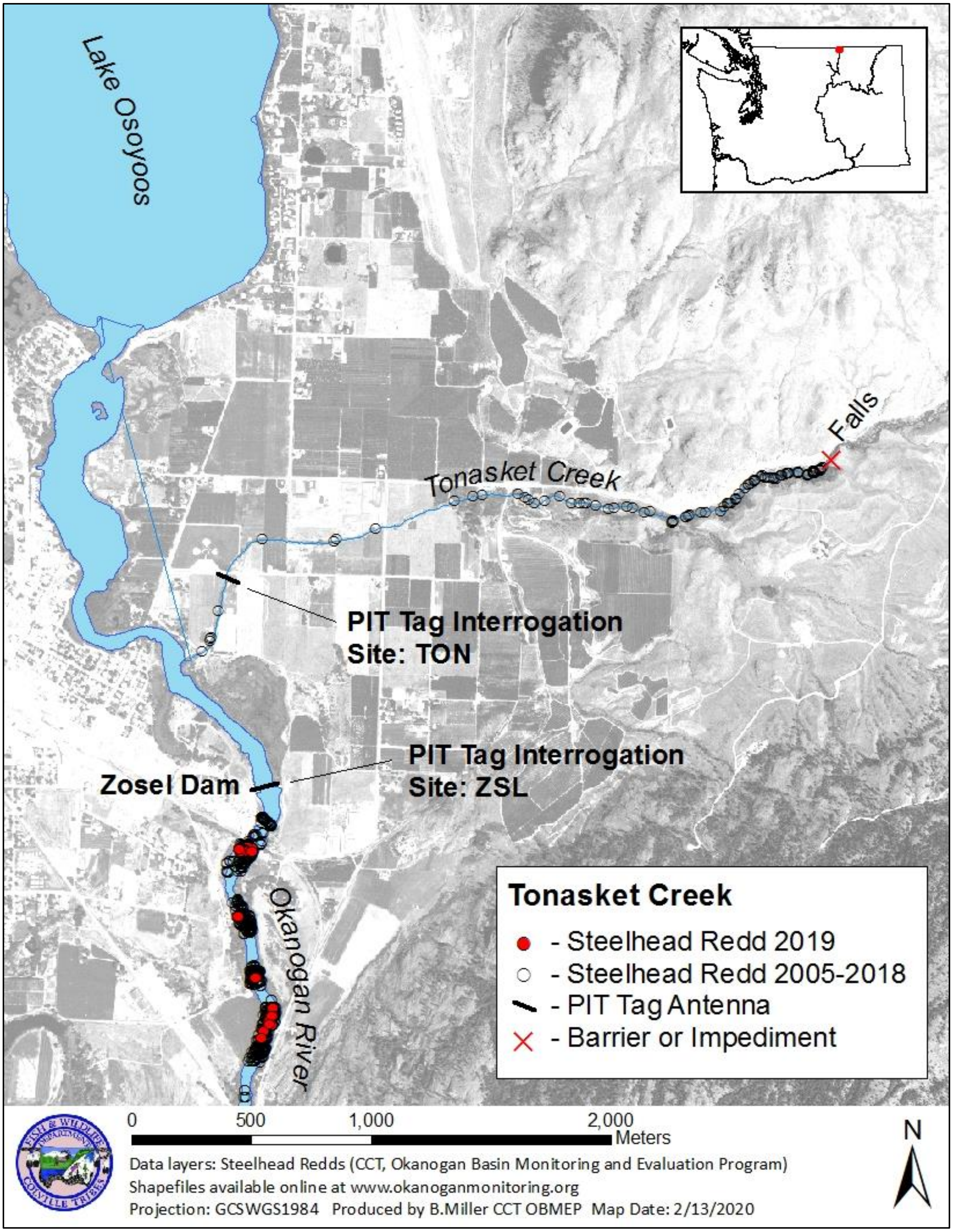

Figure 38. Spatial distribution of historic summer steelhead redds documented in Tonasket Creek.

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 reach. A permanent PIT tag detection site (NMC) consisting of three pass-through PVC antennas is located near the mouth of the creek. Based on PIT tag detections in 2019, an estimated 14 natural-origin and 0 hatchery steelhead spawned in Ninemile Creek. From 2005–2018, the average number of steelhead in Ninemile creek was 24 (max=77 in 2008, Figure 39). The lower portion of the creek below the PIT array was surveyed in 2019, but no redds were located. Steelhead redds marked in previous survey years are shown in Figure 40 for reference.

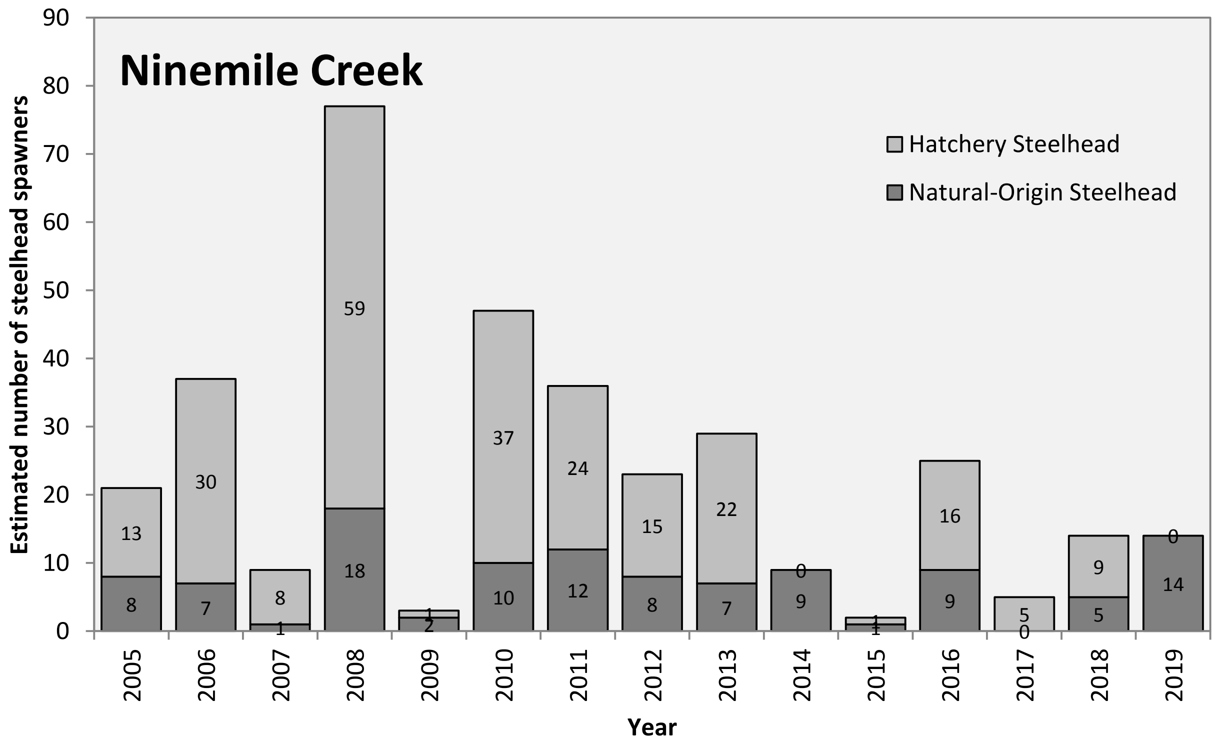

Figure 39. Trend in the number of steelhead spawners in Ninemile Creek.

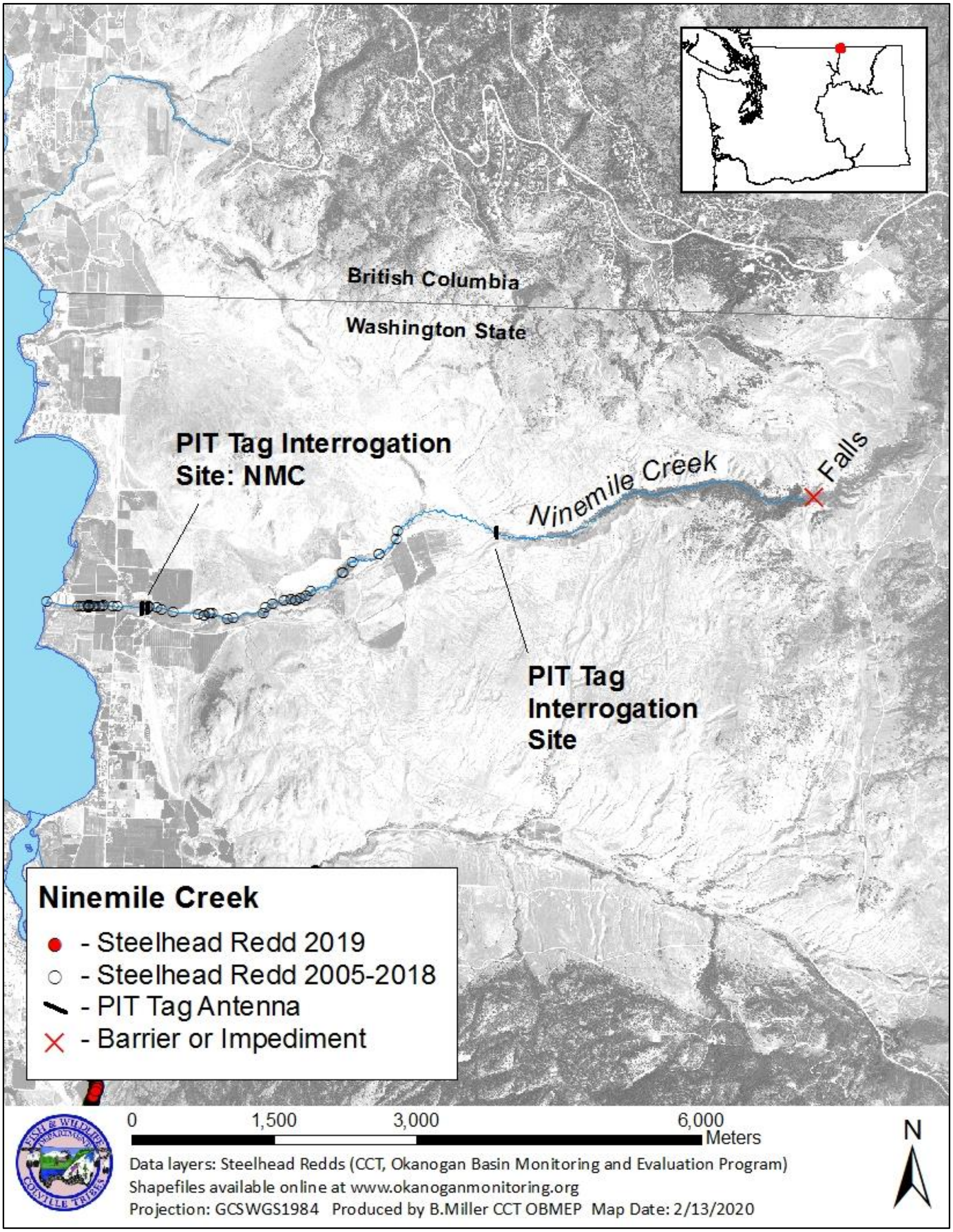

Figure 40. Spatial distribution of historic summer steelhead redds documented in Ninemile Creek.

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 a post-peak redd surveys in 2019 to further describe the spatial extent of Upper Columbia River steelhead above Wells Dam. During 2019, 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 May 16 from the mouth to Foster Creek Dam and a total of 24 redds were observed.

A total of 5 natural-origin and 10 hatchery PIT tagged steelhead from the PRD mark-group were detected at PIT tag interrogation site FST in 2019. Those tags were expanded to 23 natural-origin and 45 hatchery steelhead spawners. Spatial distribution of redds located during the 2019 survey and on previous years surveys are detailed on Figure 42.

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

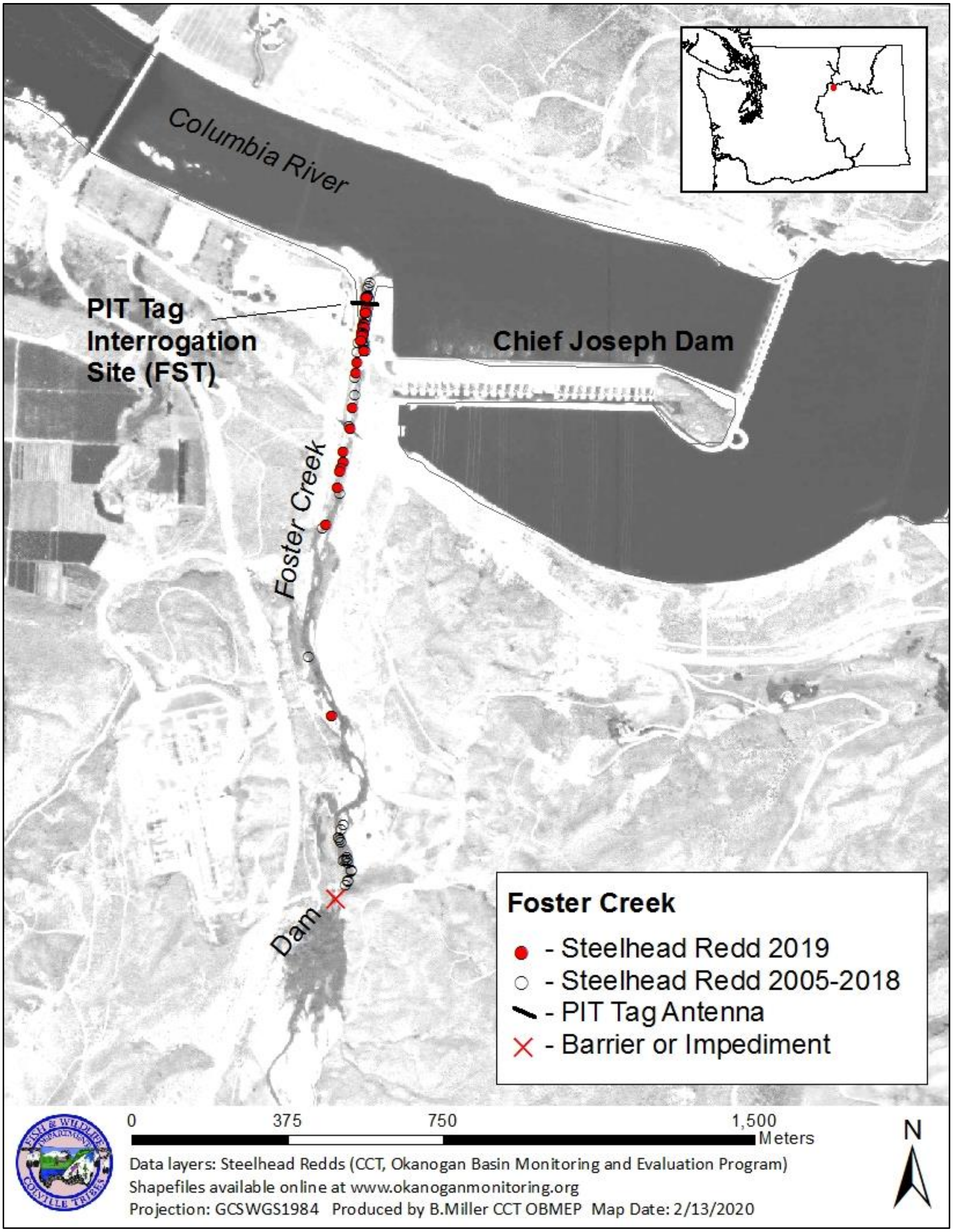

Figure 42. Spatial distribution of summer steelhead redds documented in Foster Creek.

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 and PIT tag array. 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 (akskʷəkʷant (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 akskʷəkʷant (Inkaneep Creek) in 2015. Approximately 5 km upstream of Lake Osoyoos, on the q̓awsitkʷ (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, nʕax̌ʷlqaxʷiya (Vaseux Creek), akɬxʷminaʔ (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 q̓awsitkʷ (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 q̓awsitkʷ (Okanagan River) is characterized as being straightened and channelized. The main British Columbia tributaries to the mainstem q̓awsitkʷ (Okanagan River) include akɬxʷminaʔ (Shingle Creek), Ellis Creek, McLean Creek, Shuttleworth Creek, nʕax̌ʷlqaxʷiya (Vaseux Creek), and a number of small perennial streams.

A total of 18 unique PIT tagged steelhead were detected on OKC from the fall of 2018 through the spring of 2019. 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. Two of those PIT tagged steelhead were detected at a newly installed array in the Penticton Channel, just dowstream of Okanagan Lake (current anadromous barrier). 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 0.2218. Four tagged steelhead were detected in nʕax̌ʷlqaxʷiya (Vaseux Creek), two of natural-origin and two hatchery steelhead. Those tags were expanded to 9 natural-origin and 9 hatchery steelhead. A total of seven PRD marked steelhead (5 natural, 3 hatchery) were only detected on OKC or in the Penticton Channel and those tags were expanded to 23 natural-origin and 14 hatchery steelhead. These fish likely spawned in the mainstem q̓awsitkʷ (Okanagan River), or potentially in another small stream that did not have a PIT antenna in operation, although would be considered rare. No tagged steelhead were detected in either Shuttleworth or akɬxʷminaʔ (Shingle) Creeks. Although no steelhead from the PRD mark group were detected in akskʷəkʷant (Inkaneep Creek), two natural-origin steelhead marked at other locations were detected, and added to the total spawning estimate of 34 natural-origin and 23 hatchery steelhead in British

Columbia in 2019 (Table 6). The average number of steelhead spawning in the British Columbia portion of the subbasin over the last seven years (2013-2019) was 25 natural-origin and 13 hatchery steelhead (Table 7).

Table 6. Brood-year 2019 steelhead detected on PIT tag sites in British Columbia.

Location	Status	Tag Group		
akskʷəkʷant (Inkaneep Creek)		PRD	Other	Total
	Natural-Origin	0	2	2
	Hatchery	0	0	0
	Total	0	2	2
nʕax̌ʷlqaxʷiya (Vaseux Creek)		PRD	Other	Total
	Natural-Origin	2	0	2
	Hatchery	2	0	2
	Total	4	0	4
Shuttleworth Cr		PRD	Other	Total
	Natural-Origin	0	0	0
	Hatchery	0	0	0
	Total	0	0	0
akłxʷminaʔ (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	1	1
	Hatchery	1	0	1
	Total	1	1	2
OKC Only		PRD	Other	Total
	Natural-Origin	4	1	5
	Hatchery	3	3	6
	Undetermined	0	1	1
	Total	7	5	12

Table 7. Estimated distribution of steelhead spawning in British Columbia based on expanded PIT tag detections.

Location	Status	2013	2014	2015	2016	2017	2018	2019	Mean
akskʷəkʷant (Inkaneep Creek)	Natural-Origin			1	0	0		2	1
akskʷəkʷant (Inkaneep Creek)	Hatchery			6	1	5		0	3
akskʷəkʷant (Inkaneep Creek)	Total			7	1	5		2	4
Shuttleworth Creek	Natural-Origin		0	0	0	0	0	0	0
Shuttleworth Creek	Hatchery		0	0	0	0	0	0	0
Shuttleworth Creek	Total		0	0	0	0	0	0	0
nʕax̌ʷlqaxʷiya (Vaseux Creek)	Natural-Origin						9	9	9
nʕax̌ʷlqaxʷiya (Vaseux Creek)	Hatchery						0	9	5
nʕax̌ʷlqaxʷiya (Vaseux Creek)	Total						0	18	9
akɬxʷminaʔ (Shingle Creek)	Natural-Origin			0	0	0	0	0	0
akɬxʷminaʔ (Shingle Creek)	Hatchery			0	0	0	0	0	0
akɬxʷminaʔ (Shingle Creek)	Total			0	0	0	0	0	0
Mainstem or Other	Natural-Origin	22	23	64	15	10	0	23	22
Mainstem or Other	Hatchery	2	16	20	14	5	0	14	10
Mainstem or Other	Total	24	39	84	29	15	0	37	33
Subtotal BC	Natural-Origin	22	23	65	15	10	9	34	25
Subtotal BC	Hatchery	2	16	26	15	10	0	23	13
Subtotal BC	Total	24	39	91	30	20	9	57	39

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 2019, an estimated 473 summer steelhead (306 hatchery origin and 167 natural origin) spawned in the Okanogan subbasin, which was the second lowest total return since the monitoring project began in 2005 (Figure 43). The lowest return occurred the previous year in 2018, with a total of 453 steelhead. Over the past 15 years of monitoring (2005 through 2019), the average number of adult steelhead spawners in the Okanogan subbasin was 1,545 (geomean = 1,351). The average number of natural-origin spawning steelhead was 289 (geomean = 282). Although the proportion of natural-origin steelhead spawning in the Okanogan River subbasin has slightly trended upward since data collection began in 2005, the 12-yr geomean abundance threshold for natural origin spawners (500) has not been reached.

Results from steelhead adult enumeration efforts indicate that the number of naturally produced spawning steelhead in the Okanogan River subbasin has generally increased since data collection began in 2005. 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.

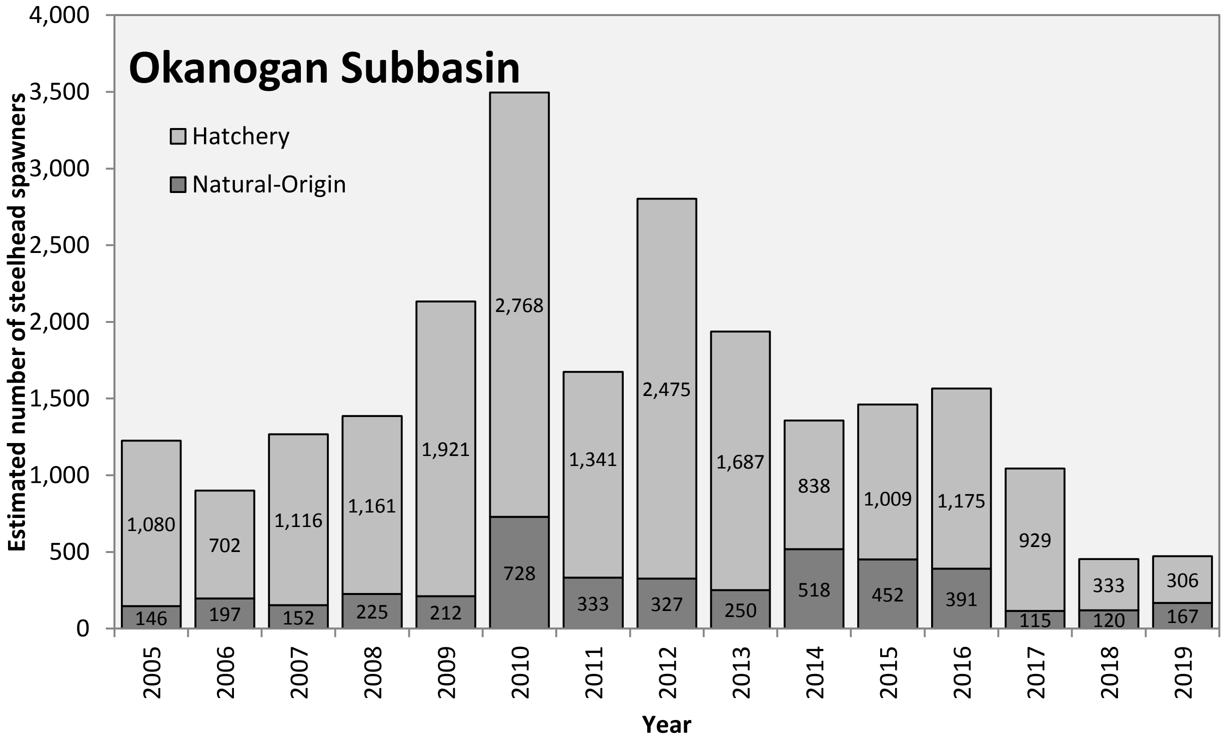

Figure 43. Estimated number of steelhead spawners in the Okanogan subbasin.

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.

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