Colville Tribes, Fish & Wildlife Department

2014 Okanogan Subbasin Steelhead Escapement and Spawning Distribution

Bonaparte Creek, 2014

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Executive Summary

OBMEP monitored adult Viable Salmonid Population (VSP) abundance attributes (McElhany et al. 2000) within the Okanogan River subbasin for summer steelhead (*Oncorhynchus mykiss*). Monitoring of adult spawners was conducted through redd surveys, underwater video counts, and Passive Integrated Transponder (PIT) tag detections. Figure ES1 summarizes the total summer steelhead spawning estimates in the Okanogan subbasin, from 2005 through 2014. Spawning estimates can be compared to 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).

Results from steelhead adult enumeration efforts in the Okanogan subbasin indicate that the number of spawning steelhead in the Okanogan River, both hatchery and naturally produced, has been increasing since data collection began in 2005. The slope of the trend line from 2005 to 2014 abundance estimates suggests that the number of naturally produced spawners increased at an average rate of 33 fish per year. From 2005 through 2014, the average total number of steelhead spawners in the Okanogan subbasin was 1,818 and the ten year average number of naturally produced spawning steelhead was 309. The proportion of natural origin spawners (pNOS) from 2005 through 2013 averaged 0.15, but the pNOS increased to 0.38 in 2014. Spawning occurred throughout the mainstem Okanogan River, although narrowly focused to distinct areas that contained suitable spawning substrates and water velocities. Steelhead spawning has been documented 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 largely influenced by stocking location because juvenile hatchery steelhead were scatter-planted in Omak Creek, Salmon Creek, and the Similkameen River acclimation site.

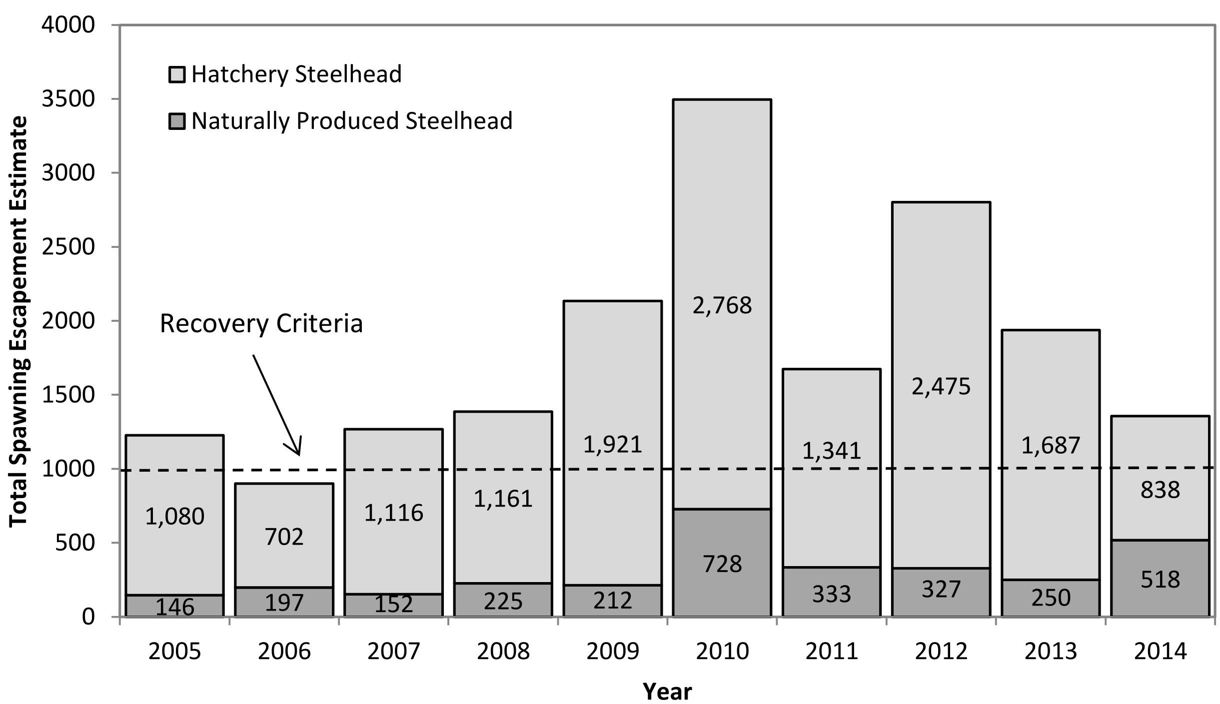

Figure ES1. Spawning estimates for the Okanogan subbasin from 2005 through 2014, as determined by OBMEP.

Steelhead redd surveys can provide a reasonable depiction of spawning distribution and an estimate of escapement on years when spring runoff occurs post-spawning. 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, modeling distribution and abundance of spawning on years with early runoff is less objective. 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 an Upper Columbia Basin-wide PIT tag interrogation systems (Project # 2010-034-00), coupled with the representative marking of returning adults at Priest Rapids Dam, allowed managers an additional means to estimate abundance on years with poor water visibility, to validate redd survey efficiency, and describe spatial distribution and upstream extent of spawning, where previously unknown. The Fish and Wildlife Program should consider continuing these efforts to allow managers to more accurately describe the spatial extent of spawning in tributaries, to 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, Entitat, 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. Since 2004, 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 these methods were later revised in 2007 (Arterburn et al. 2007). In addition to redd surveys, adult weir traps, Passive Integrated Transponder (PIT) tag arrays, and underwater video counting were combined 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 PIT tag arrays to enhance monitoring 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: www.colvilletribes.com/obmep.php.

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 downstream of anadromous fish migration barriers in the mainstem and all accessible tributaries of the Okanogan and Similkameen River drainages were conducted within the United States (Arterburn et al. 2007, Walsh and Long 2006). Adult weir traps, PIT tag arrays, and underwater video enumeration were used at locations where habitat was extensive or difficult for surveys to be performed on foot.

Summer steelhead were enumerated in all remaining spawning habitats 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. Designated mainstem and tributary redd survey reaches are listed in Table 1. 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 directly related to the EDT reach layer, used in habitat monitoring. 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' catarafts. Small tributaries were surveyed on foot, walking in an upstream direction, once per week during the steelhead spawning period.

Geographic position of redds were collected with a Trimble GeoXT™ GPS unit and downloaded into GPS Pathfinder® after each survey. The GIS data were reviewed and differentially corrected. To avoid recounting, redds were marked by flagging tied to bushes or trees adjacent to the area where they 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.

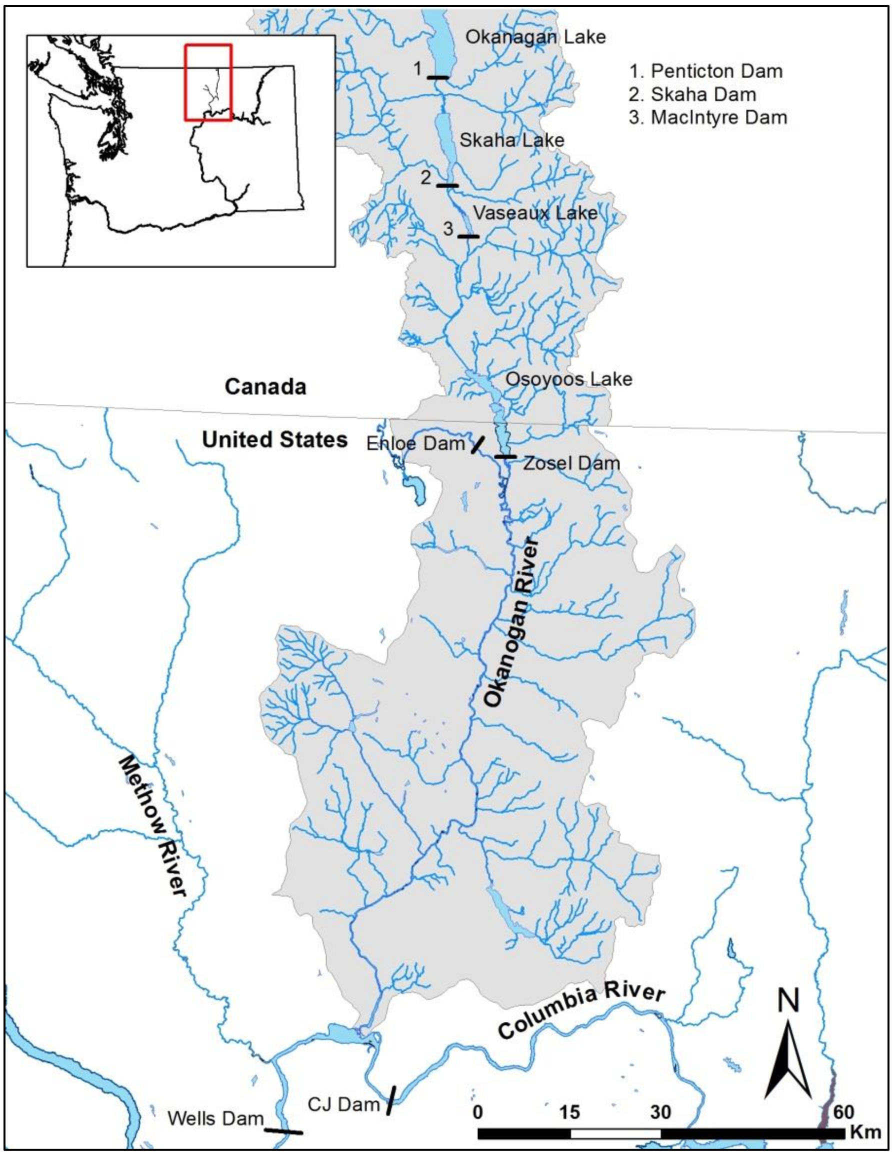

Figure 1. Study area, the Okanogan River subbasin in north-central Washington State and southern British Columbia.

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
Loup Loup Cr	Loup Loup Creek/Ok. R. confluence to Loup Loup Creek diversion (2.3)	2.3
Salmon Cr	Salmon Creek/Okanogan River confluence (0) to OID diversion (7.2)	7.2
Omak Cr	Omak Creek/Ok. R. Confluence (0) to Omak Creek trap site (1.5)	1.5
Wanacut Cr	Wanacut Creek/Okanogan River confluence (0) to the falls (2.5)	2.5
Johnson Cr	Johnson Cr./Ok. R. conf. (0) to PIT tag array above Hwy 97 (0.5)	0.5
Tunk Cr	Tunk Creek/Okanogan River confluence (0) to the falls (1)	1.0
Aeneas Cr	Aeneas Creek/Okanogan River confluence (0) to the barrier (0.4)	0.4
Bonaparte Cr	Bonaparte Creek/Ok. River confluence (0) to the falls (1.6)	1.6
Antoine Cr	Antoine Creek/Okanogan River confluence (0) to video weir (1.3)	1.3
Wildhorse Sp Cr	Wildhorse Spring Creek/Okanogan River Confluence to barrier (1.1)	1.1
Tonasket Cr	Tonasket Creek/Okanogan River confluence (0) to the falls (3.5)	3.5
Ninemile Cr	Ninemile Creek from Lake Osoyoos (0) to PIT tag array (0.7)	0.7
Foster Cr	Foster Creek/Columbia River confluence (0) to barrier (1.7)	1.7

2.1 Sex Ratio and Number of Fish Per Redd

OBMEP employed the method currently used by Washington Department of Fish and Wildlife in the Upper Columbia Basin to extrapolate escapement estimates from redd counts using the sex ratio fish collected randomly over the run at Wells Dam (Andrew Murdoch, WDFW, pers. comm.). A sample of 511 summer steelhead, including 201 males and 310 females, were sexed at Wells Dam during the 2013 upstream migration by WDFW personnel (Charles Frady, WDFW, pers. comm.). Adjusted proportionally for the run, the WDFW calculated a sex ratio of 0.648 males per female or 1.648 fish per redd (FPR). This value was used to expand redd counts on the mainstem Okanogan River into steelhead spawning estimates. All calculations using sex ratio multipliers assume that each female will produce only one redd.

2.2 PIT Tag Expansion Estimates

Permanent and temporary PIT tag arrays were operated near the mouth of all tributaries to the Okanogan River known to contain steelhead spawning, throughout the spring of 2014. The WDFW operates as the lead investigator on project number 2010-034-00 and the study is conducted in conjunction with the CCT. The CCT operates and maintains 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. Data analyses are currently in progress for the entire Upper Columbia for multiple years of the project, which will contain 95% confidence intervals. Final analyses will be reported under project number 2010-034-00.

Population estimates derived from PIT tag detections were calculated following Murdoch et al. 2011. In the 2013 migration year, a random representative sample of steelhead were captured at Priest Rapids Dam, two to three days per week over the course of the run, from July through November. A proportion of fish, approximately 14.5%, were tagged and released above Priest Rapids Dam (Ben Truscott, WDFW, pers. comm.). The mark-rate was used to expand the number of detections into escapement estimates for tributaries with PIT tag arrays. For example, if three hatchery and two natural origin steelhead were detected at a given creek, the escapement estimate would be 21 hatchery steelhead (21=3/0.145) and 14 natural origin steelhead (14=2/0.145), calculated from the mark-rate at Priest Rapids Dam. This method assumes that tagged fish are representative of unmarked fish. Based on the relatively few numbers of detections at many locations, particularly at smaller tributaries, escapement estimates derived from PIT tag detections may be variable and should be considered a general estimate. In addition to fish tagged at Priest Rapids, steelhead may have also received PIT tags at other locations (such as out-migrating juveniles, adults returning to Bonneville Dam, Wells Dam, among others); however, marking at those locations were not consistent across the run. Therefore, any extrapolations from PIT tag detections to an escapement estimate were derived only from the Priest Rapids release group. Detections of steelhead tagged at other locations may be mentioned anecdotally in this report.

2.3 Percent-Wild

Mainstem percent-wild.

A number of steelhead from the PRD mark-release group were detected only at OKL (lower Okanogan PIT array near Malott, WA). After factoring for antenna efficiency at upstream locations, it is likely that these fish may represent a mainstem-spawning component of the population. The percent-wild of these remaining fish was approximately 17%, which is markedly lower than the 42% total percent-wild for the subbasin as a whole. This is not surprising, because a large number of hatchery steelhead in the Okanogan are planted in the mainstem Similkameen River. The 17 percent-wild value was applied to all mainstem Okanogan River reaches to estimate the number of wild steelhead that spawned in mainstem habitats (further outlined in Table 5).

Tributary percent-wild.

A unique value for each subwatershed was calculated for the percent of natural origin steelhead spawning in tributaries to the Okanogan River. The estimated number of wild steelhead spawning in each tributary, as determined by the PRD mark-release group, was divided by the total number of steelhead spawning in that system. Each unique percent-wild number was then applied to the number of steelhead calculated from redd surveys in individual tributaries.

3.0 Results

In 2014, it was estimated that a total of 1,356 summer steelhead (838 hatchery origin and 518 natural origin) spawned in the Okanogan subbasin. A summary of the estimated number of adult steelhead spawners, distributed by mainstem survey reach and individual tributaries, are presented in Table 2. Detailed results for unique spawning reaches and tributaries are outlined in sections 3.1 to 3.3 of this document. Over the past 10 years, it was estimated that an average of 1,818 steelhead spawned in the Okanogan subbasin (Table 3). The 10 year average for natural origin steelhead was estimated to be 309.

Table 2. Estimated number of total and natural origin spawning steelhead for each sub-watershed or assessment unit in 2014. Estimates were based on a combination of redd counts, underwater video observations, and PIT tag detections.

Distribution of Steelhead Spawning in the Okanogan Subbasin, 2014

Category	Description/location	Estimated Total # Spawners	Estimated Total # Wild
WA Mainstem	Okanogan River 1	6	1
WA Mainstem	Okanogan River 2	24	4
WA Mainstem	Okanogan River 3	5	1
WA Mainstem	Okanogan River 4	20	3
WA Mainstem	Okanogan River 5	32	5
WA Mainstem	Okanogan River 6	9	1
WA Mainstem	Okanogan River 7	206	35
WA Mainstem	Similkameen River 1	70	12
WA Mainstem	Similkameen River 2	53	9
WA Tributary	Loup Loup Creek	35	27
WA Tributary	Salmon Creek	163	51
WA Tributary	Omak Creek	393	207
WA Tributary	Wanacut Creek	0	0
WA Tributary	Johnson Creek	57	19
WA Tributary	Tunk Creek	48	11
WA Tributary	Aeneas Creek	3	1
WA Tributary	Bonaparte Creek	135	71
WA Tributary	Antoine Creek	0	0
WA Tributary	Wild Horse Spring Creek	0	0
Zosel Dam	**Observed Passing Zosel Dam**	NA	NA
WA Tributary	Tonasket Creek	49	28
WA Tributary	Ninemile Creek	9	9
Subtotal	**Adult escapement into WA mainstem**	**425**	**71**
Subtotal	**Adult escapement into WA tributaries**	**892**	**424**
Subtotal	**Adult escapement into BC**	**39**	**23**
Grand total		**1,356**	**518**

Table 3. Estimated number of summer steelhead spawners in the Okanogan subbasin, 2005-2014.

Year	Hatchery Steelhead	Naturally Produced Steelhead	Total Steelhead
2005	1,080	146	1,226
2006	702	197	899
2007	1,116	152	1,268
2008	1,161	225	1,386
2009	1,921	212	2,133
2010	2,768	728	3,496
2011	1,341	333	1,674
2012	2,475	327	2,802
2013	1,687	250	1,937
2014	838	518	1,356
Average	1,509	309	1,818

3.1 Steelhead Spawning Estimates: Okanogan and Similkameen River Mainstem

Redd surveys were largely unsuccessful at documenting the spawning activity of steelhead in the Okanogan River mainstem reaches in the spring of 2014. Due to an early onset of runoff in the Okanogan and Similkameen Rivers, only one or two preliminary surveys could be completed on most mainstem reaches before conditions became unfavorable for visual surveys to occur. Flows remained high through the end of July, when spawning had long since concluded and steelhead redds were indistinguishable. However, three complete surveys were conducted in Okanogan River Reach 7 (Table 4), the reach where approximately 49% of the total mainstem spawning was documented occurring in previous years surveys.

Although redd surveys were unable to capture the complete spawning activity of summer steelhead in all mainstem reaches of the Okanogan River, an estimate of mainstem spawning for 2014 was calculated as follows. Assuming that the ratio of mainstem spawning remained comparable to previous years' surveys, spawner estimates for 2014 were calculated by combining data from previous years' redd distributions and the complete count of redds documented in Okanogan Reach 7. A total of 424 summer steelhead (352 hatchery and 72 natural origin) were estimated to have spawned in the mainstem Okanogan and Similkameen Rivers in the spring of 2014. The estimated number of steelhead spawning in each mainstem reach are provided in Table 5.

Table 4. Redd survey steelhead spawning estimates for mainstem reaches, 2014[a].

Redd Survey Reach	A. GPS'd Steelhead Redds	B. Total Steelhead Estimate (B=A*1.648)	C. Wild Steelhead Estimate (C=B*0.17)	D. Hatchery Steelhead Estimate (D=B-C)	Complete Redd Counts?
Okanogan River 1	0	0	0	0	No
Okanogan River 2	7	12	2	10	No
Okanogan River 3	0	0	0	0	No
Okanogan River 4	1	2	0	1	No
Okanogan River 5	2	3	1	3	No
Okanogan River 6	0	0	0	0	No
Okanogan River 7	125	206	35	171	Yes
Similkameen River 1	1	2	0	1	No
Similkameen River 2	9	15	3	12	No
Mainstem Total	145	239	41	198	No

[a] Observed redds were multiplied by the WDFW fish per redd value (1.648) for a total steelhead estimate. The total steelhead estimate was multiplied by the proportion of naturally produced steelhead from the PRD mark-release group (0.17) to calculate a mainstem wild steelhead estimate.
* Totals might not reconcile due to rounding.

Table 5. Modeled estimate of mainstem steelhead spawning, 2014.

Mainstem Survey Reach	E. Avg. Proportion of Mainstem Spawning by Reach (2005-2011)	F. 2014 Total Estimate (F=E*424[a])	G. 2014 Wild Steelhead (G=F*0.17)	H. 2014 Hatchery Steelhead (H=F-G)
Okanogan River 1	0.015	6	1	5
Okanogan River 2	0.055	24	4	20
Okanogan River 3	0.012	5	1	4
Okanogan River 4	0.047	20	3	17
Okanogan River 5	0.076	32	5	27
Okanogan River 6	0.020	9	1	7
Okanogan River 7	0.486	206[b]	35	171
Similkameen River 1	0.165	70	12	58
Similkameen River 2	0.124	53	9	44
Mainstem Total	1.000	424[a]	72	352

[a] The Okanogan mainstem spawning estimate of 424 (424=206[b]/0.486) was multiplied by the average proportion from previous spawning years in each mainstem reach. The total estimate was multiplied by the proportion of naturally produced steelhead from the PRD mark-release group (0.17) to calculate a mainstem wild steelhead estimate.
[b] Number of steelhead documented in Okanogan Reach 7, from Table 4.
* Totals might not reconcile due to rounding.

3.2 Steelhead Spawning Estimates: Tributaries to the Okanogan River

Tributary redd surveys were more successful at documenting locations of spawning steelhead when compared to the mainstem and surveys occurred weekly from March 17 through June 16, 2014. Redd survey efforts on tributaries to the Okanogan River were rarely limited by high or turbid water events from snow melt and precipitation and most tributaries were successfully surveyed across the entire spawning period. The upstream extent of each survey was limited by either a natural fish passage barrier, access to private land, or extensive reach length that would preclude walking surveys. Redd surveys documented 311 summer steelhead redds in tributaries to the Okanogan River. These redds were expanded to account for 513 steelhead, 273 hatchery and 239 natural origin steelhead (Table 6). A number of additional steelhead were documented passing beyond areas surveyed for redds by weir traps and underwater video. Detailed results are presented in the following sections for individual subwatersheds, and outline spatial and temporal distribution of redds, video observations, and weir counts.

In-stream PIT tag interrogation sites were installed and successfully operated on 12 tributaries to the Okanogan River. PIT tag detections in the spring of 2014 accounted for a total of 903 summer steelhead in tributaries, 476 hatchery and 428 of natural-origin. The number of tags detected at discrete locations and the expanded summer steelhead spawning estimates are presented in Table 7. In the following sections, a summary of spawning estimates for steelhead in tributaries to the Okanogan River are presented, comparing both redd survey and PIT tag expansion methods.

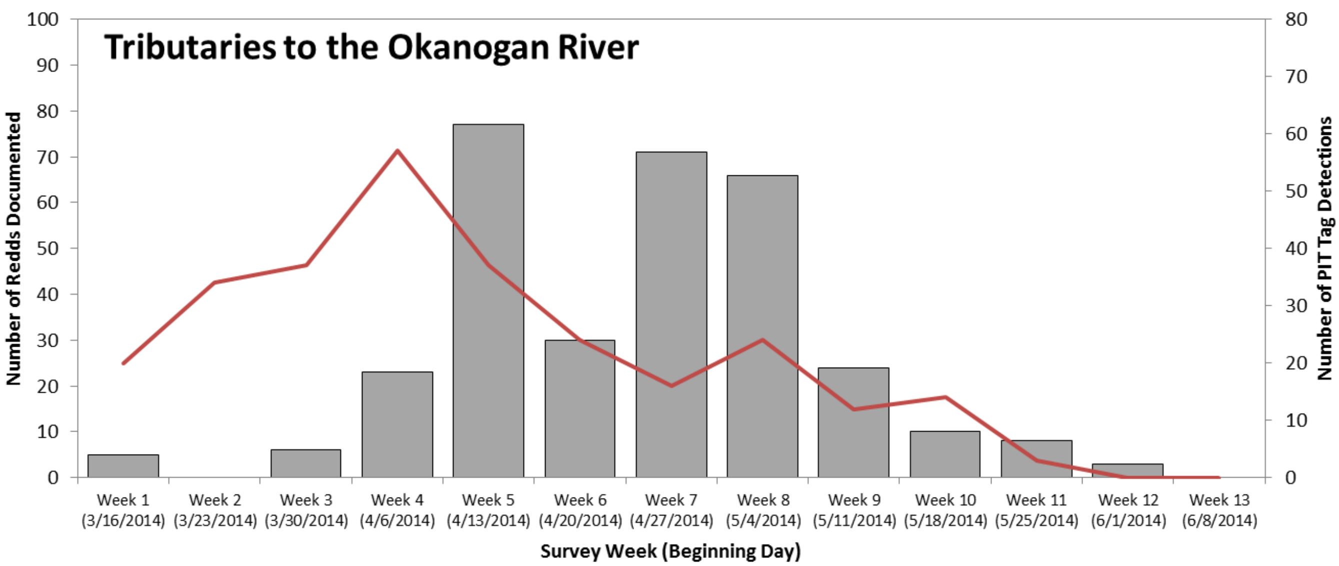

Figure 2. Number of steelhead redds (bar) documented by week in tributaries to the Okanogan River compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on interrogation sites and grouped by week.

Table 6. Redd survey and steelhead spawning estimates for tributary reaches, 2014.

Redd Survey Reach	I. GPS'd Steelhead Redds	J. Total Steelhead Estimate [a] (J=I*1.648)	K. Wild Steelhead Estimate [b] (K=J*%wild)	L. Hatchery Steelhead Estimate (L=J-K)	Complete Redd Counts?
Loup Loup Cr	21	35	27	7	Yes
Salmon Cr, below PIT tag array	0	0	0	0	Yes
Salmon Cr, above array/below diversion	61	101	15	86	Yes
Omak Cr, below weir trap	40	66	35	31	Yes
Wanacut Cr	0	0	0	0	Yes
Johnson Cr, below gabion weir	22	36	11	25	Yes
Tunk Cr	29	48	11	37	Yes
Aeneas Cr	2	3	0	3	Yes
Bonaparte Cr	82	135	71	64	No
Antoine Cr	0	0	0	0	Yes
Wildhorse Spring Cr	0	0	0	0	Yes
Tonasket Cr	53	87	50	37	Yes
Ninemile Cr, below PIT tag array	1	2	2	0	Yes
Tributary Total	311	513	221	292	

[a] Observed redds were multiplied by the WDFW fish per redd value (1.648) for a total steelhead estimate.
[b] The total estimate was multiplied by the proportion of naturally produced steelhead from the PRD mark-release group (Table 7) to calculate a tributary wild steelhead estimate.
* Totals might not reconcile due to rounding.
* Totals do not include weir or underwater video counts.

Table 7. PIT tag expansion estimates at detection sites in the Okanogan subbasin, 2014.

Creek (Interrogation Site)	M. PRD Wild PIT Tags	N. PRD Hatchery PIT Tags	O. Expanded Wild [a] (O=M/0.145)	P. Expanded Hatchery [a] (P=N/0.145)	Q. Expanded Total (Q=M+N)
Loup Loup Cr (LLC)	4	1	28	7	34
Salmon Cr (SA1)	7	14	48	97	145
Omak Cr (OMK)	30	27	207	186	393
Wanacut Cr (WAN)	0	0	0	0	0
Johnson Cr (JOH)	3	7	21	48	69
Tunk Cr (TNK)	2	7	14	48	62
Aeneas Cr (AEN)	0	0	0	0	0
Bonaparte Cr (BPC)	11	10	76	69	145
Antoine Cr (ANT)	0	0	0	0	0
Wildhorse Spring Cr (WHS)	0	0	0	0	0
Tonasket Cr (TON)	4	3	28	21	48
Ninemile Cr (NMC)	1	0	7	0	7
Total	62	69	428	476	903

[a] PIT tag detections in tributaries were divided by the proportion steelhead observed in the PRD mark group (0.145).
* Totals might not reconcile due to rounding.

3.2.1 Loup Loup Creek

Conditions in Loup Loup Creek remained favorable to conduct weekly redd surveys throughout the spring of 2014. Surveys were conducted weekly from March 9 through June 9 and a total of 21 redds were documented (Figures 3 and 4). An escapement estimate from redd surveys was calculated by expanding the observed redds by the FPR value of 1.648, which rendered a total spawning estimate of 35 steelhead in Loup Loup Creek.

Four natural origin and one hatchery PIT tagged steelhead from the PRD mark-release group were detected in Loup Loup Creek (site LLC) in the spring of 2014. These were expanded to 28 wild and 7 hatchery steelhead, for a total spawning estimate of 35 steelhead. The number of redds documented by survey week were compared to weekly unique PIT tag detections and are presented in Figure 3 below. Both survey methods provided very similar results.

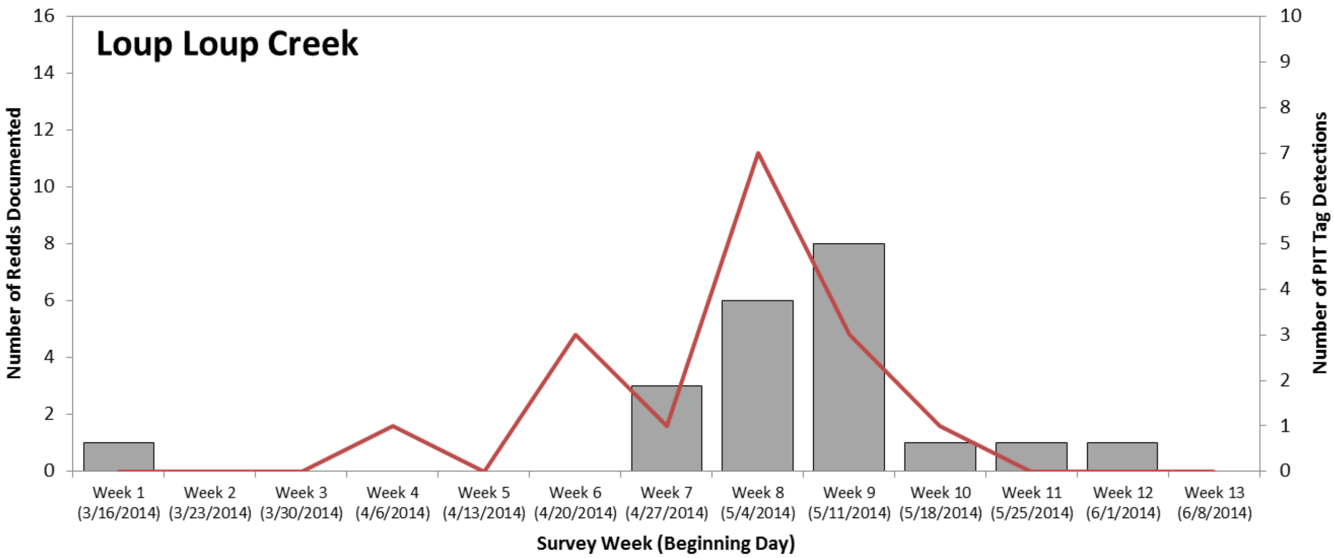

Figure 3. Number of steelhead redds documented by week in Loup Loup Creek (bar) compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on the interrogation site and grouped by week.

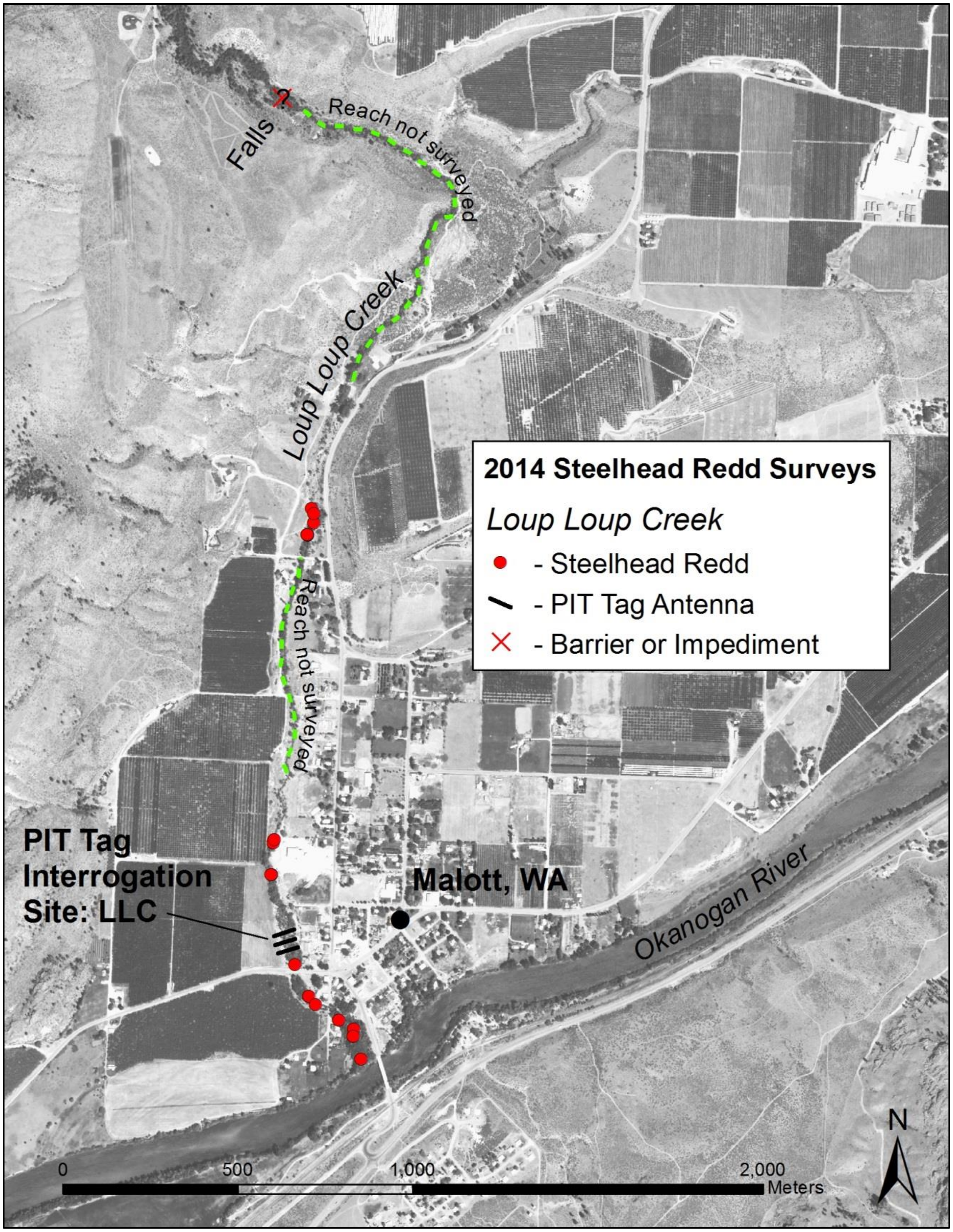

Figure 4. Spatial distribution of summer steelhead redds documented in Loup Loup Creek in 2014.

3.2.2 Salmon Creek

Salmon Creek was divided into three reaches, based on survey access points and an irrigation diversion site: (1) from the confluence with the Okanogan River to the PIT tag array located approximately 2.9 km upstream, (2) from the PIT tag array to the Okanogan Irrigation District (OID) diversion, and (3) from the OID diversion to Conconully dam. Redd surveys were conducted weekly from the confluence to the OID diversion. An underwater video system was operated at the OID diversion to monitor passage past that point. Zero redds were found below the PIT tag array, 61 redds were documented between the PIT tag array and the diversion (Figures 5 and 6), and 62 adult steelhead (36 adipose present and 26 hatchery origin) were counted passing the OID diversion. The combined redd survey and video count provided an estimate of 163 steelhead (51 wild, 112 hatchery) spawning in Salmon Creek in 2014.

In 2014, video technicians deployed two additional underwater cameras and one additional surveillance camera to monitor steelhead movement directly above and below the underwater video fish monitoring chute. These additional cameras allowed passage events of each steelhead to be further examined, including determination of potential fallback or double counting. Clear water conditions and stable flows contributed to improved accuracy of video counts and redd surveys in 2014, compared with previous years. Therefore, it is likely that the combined redd survey and underwater video estimate represent a realistic count of total spawning steelhead in Salmon Creek.

Seven natural origin and 14 hatchery origin PIT tagged steelhead from the PRD mark-release group were detected at PIT tag site SA1 during the spring of 2014. This led to an estimated 48 natural origin and 97 hatchery origin steelhead passing that point, for a combined estimate of 145 steelhead in Salmon Creek.

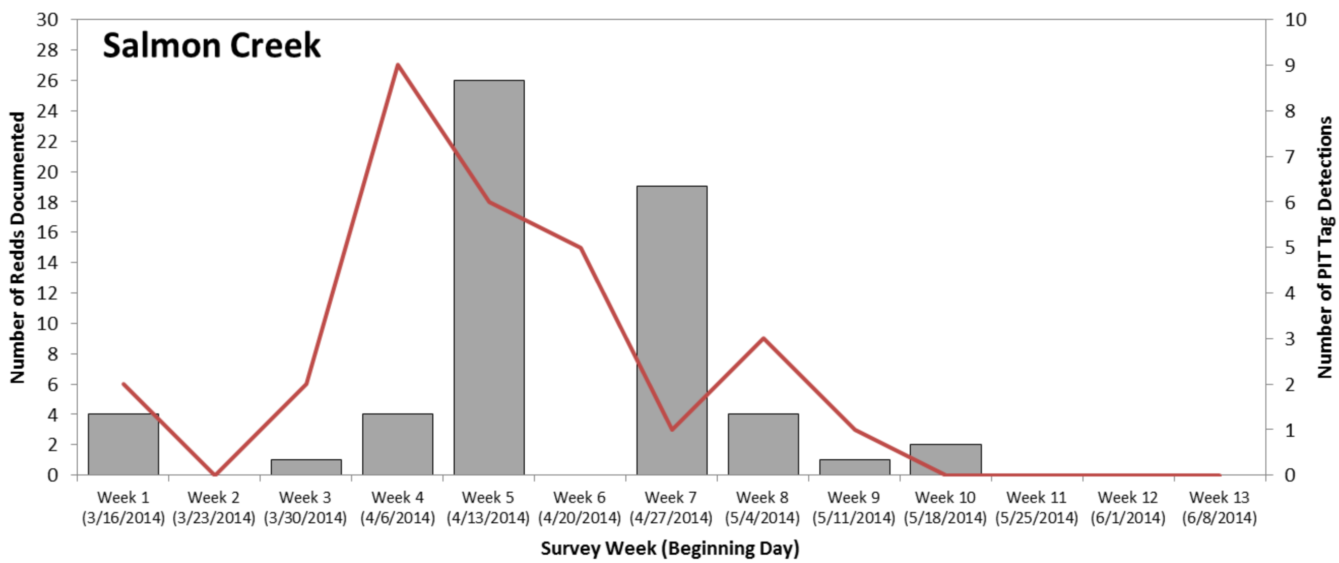

Figure 5. Number of steelhead redds documented by week in Salmon Creek (bar) compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on the interrogation site and grouped by week.

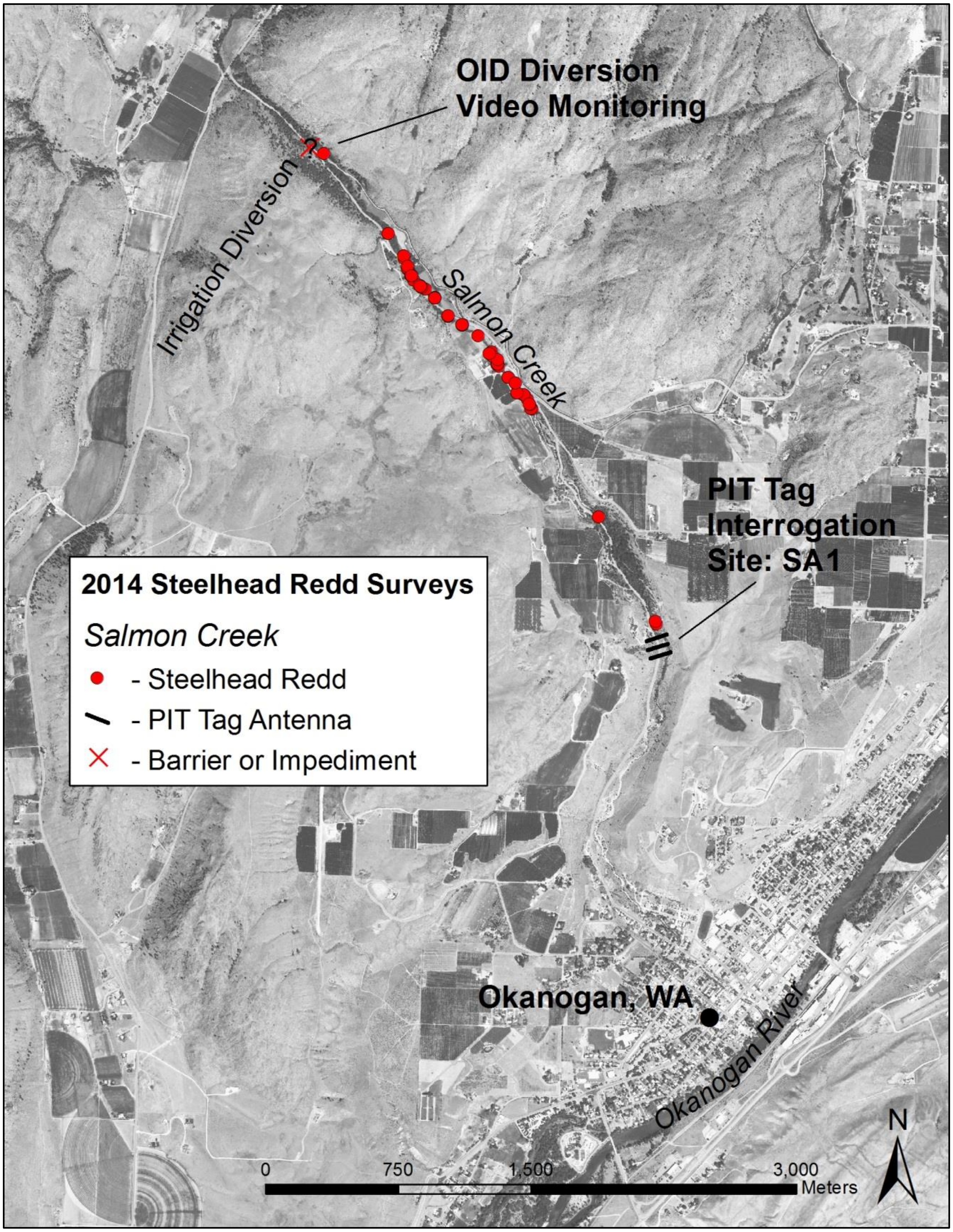

Figure 6. Spatial distribution of summer steelhead redds documented in Salmon Creek in 2014.

3.2.3 Omak Creek

Steelhead surveys on Omak Creek consisted of weekly redd surveys from the confluence of the Okanogan River up to an adult weir trap, located approximately 1.5 km upstream (Figure 8). Forty redds were documented below the adult weir trap in 2014, and when expanded by 1.648 FPR, an estimated 66 steelhead spawned between the mouth and the weir. The adult weir trap (operated by the Colville Tribes Broodstock Acclimation Program (BAM) with funding from Grant County PUD) captured and released 136 natural origin and 30 hatchery steelhead upstream (Wes Tibbits, CCT fisheries biologist, pers. com.). A number of additional hatchery steelhead were also denied upstream access and placed downstream of the weir upon capture. However, due to a number of fish passing the site without being captured, a Lincoln-Peterson calculation led to an estimated 196 steelhead spawning above the weir (Wes Tibbits, CCT fisheries biologist, pers. com.). A single redd survey during peak spawning was conducted between the weir and Mission Falls to characterize spatial distribution of spawning in that reach; the positions of 54 redds were recorded during that survey (Figure 8).

A permanent PIT tag array, site OMK, was operational throughout the spring of 2014 near the mouth of Omak Creek. Thirty natural origin and 27 hatchery origin steelhead from the PRD mark-release group were detected at this location. The expanded Omak Creek estimate from PRD PIT tag detections rendered 207 natural origin and 186 hatchery origin steelhead, for a total of 393 steelhead. Two additional temporary antennas were installed above and below Mission Falls in 2014 to examine potential passage after habitat modifications in previous years. All steelhead captured and placed upstream of the weir were implanted with a PIT tag, if not previously tagged. A total of 70 PIT tagged steelhead were detected at the base of the falls and 10 were detected above Mission Falls. These detections represent the first steelhead documented above this point, showing there is now access to the historical upstream reaches of Omak Creek. The habitat above Mission Falls represents an increase of approximately 81% for anadromous steelhead.

Due to an unknown number of steelhead passing the weir uncaptured, hatchery steelhead access being managed at the weir, and superimposition of redds downstream of the weir, it is likely that the PIT tag method better captured the total spawning estimate for Omak Creek in 2014.

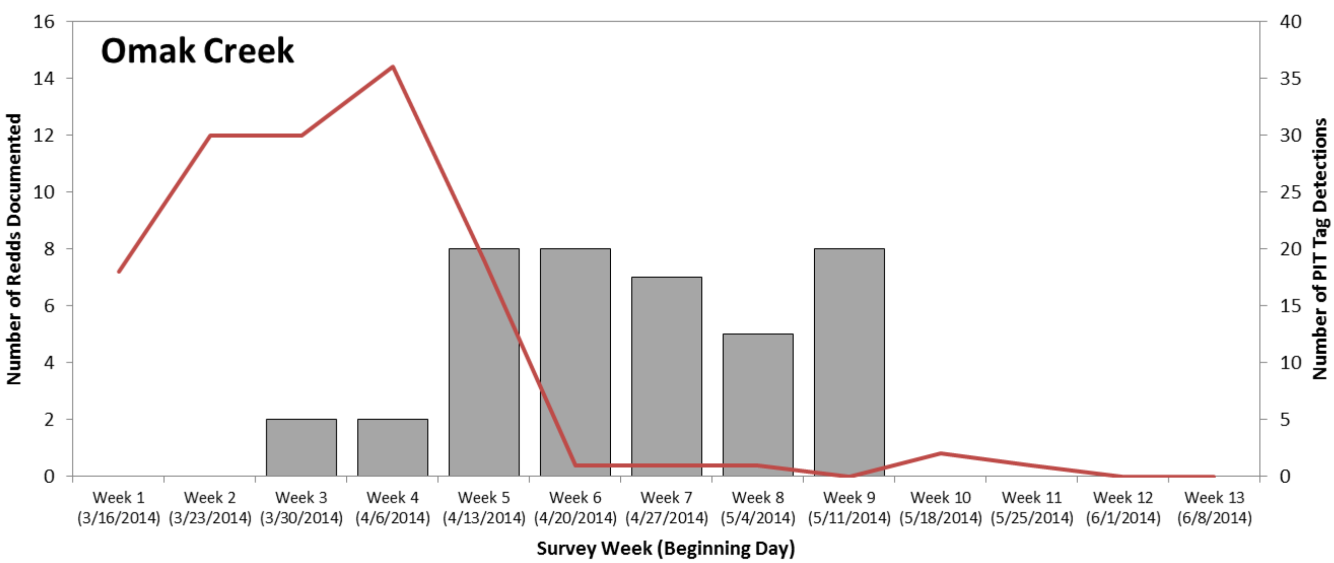

Figure 7. Number of steelhead redds documented by week in Omak Creek (bar) compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on the interrogation site and grouped by week.

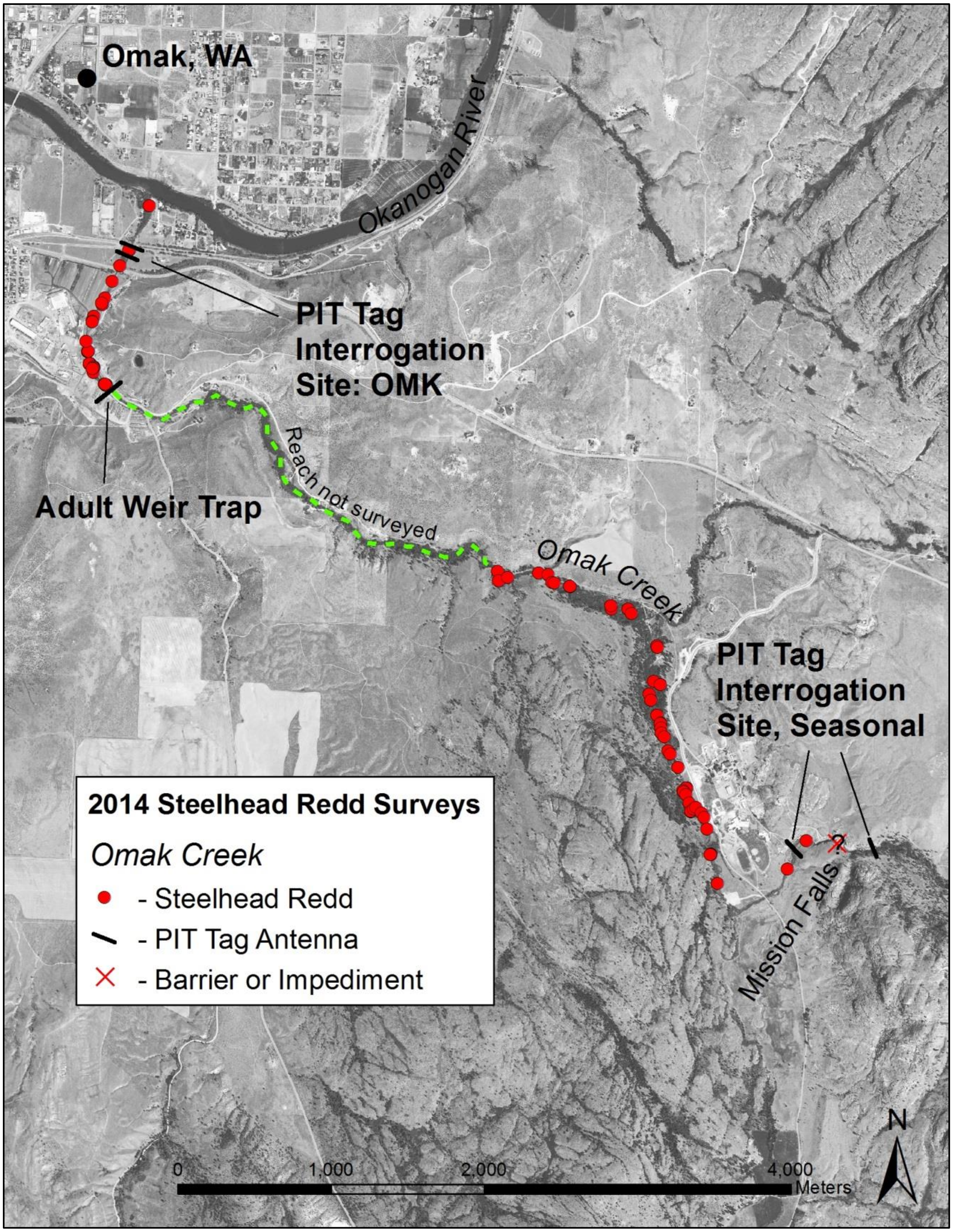

Figure 8. Spatial distribution of summer steelhead redds documented in Omak Creek in 2014.

3.2.4 Wanacut Creek

Due to the low snow pack in the lower elevations of the Okanogan subbasin, including Omak Mountain, Wanacut Creek only flowed intermittently during the spring of 2014. No redds were documented when water was present in the creek and zero PIT tagged steelhead were detected at the interrogation site near the mouth of the creek. It is likely that no steelhead utilized Wanacut Creek for spawning in 2014 due to extremely low water levels.

3.2.5 Johnson Creek

Redd surveys occurred weekly in Johnson Creek throughout the spring of 2014 due to clear water conditions and stable water flows. A total of 22 redds were documented between the mouth and the highway culvert representing 36 total steelhead, 5 naturally produced and 31 hatchery origin (Figures 9 and 10).

Ten PIT tags from the PRD mark-release group near the mouth of Johnson Creek, 3 of natural origin and 7 of hatchery origin. These tags were expanded to 21 natural origin and 48 hatchery, for a total of 69 steelhead. Although a total of 10 PIT tags were detected near the mouth of Johnson Creek, only 4 were detected upstream of the Highway 97 culvert and those 4 were also detected above the gabion weir structure (PRD tags: 2W/1H), suggesting that significant impediments exist for adult migration in this reach. Figure 11 show pictures of steelhead attempting to pass the gabion weir (braided metal wire backfilled with rock) and steelhead spawning below the highway 97 culvert.

PRD PIT tag detections above the gabion weir may account for 14 natural origin and 7 hatchery steelhead. The remainder below the HWY 97 culvert would render 7 natural origin and 41 hatchery steelhead (14.6% wild). Due to the documented redds, we chose to use the more conservative redd count of 5 wild and 31 hatchery steelhead below the gabion and 14 wild and 7 hatchery steelhead above the gabion weir. The total estimate of steelhead in Johnson Creek would be 19 natural origin and 38 hatchery, for a total of 57 steelhead.

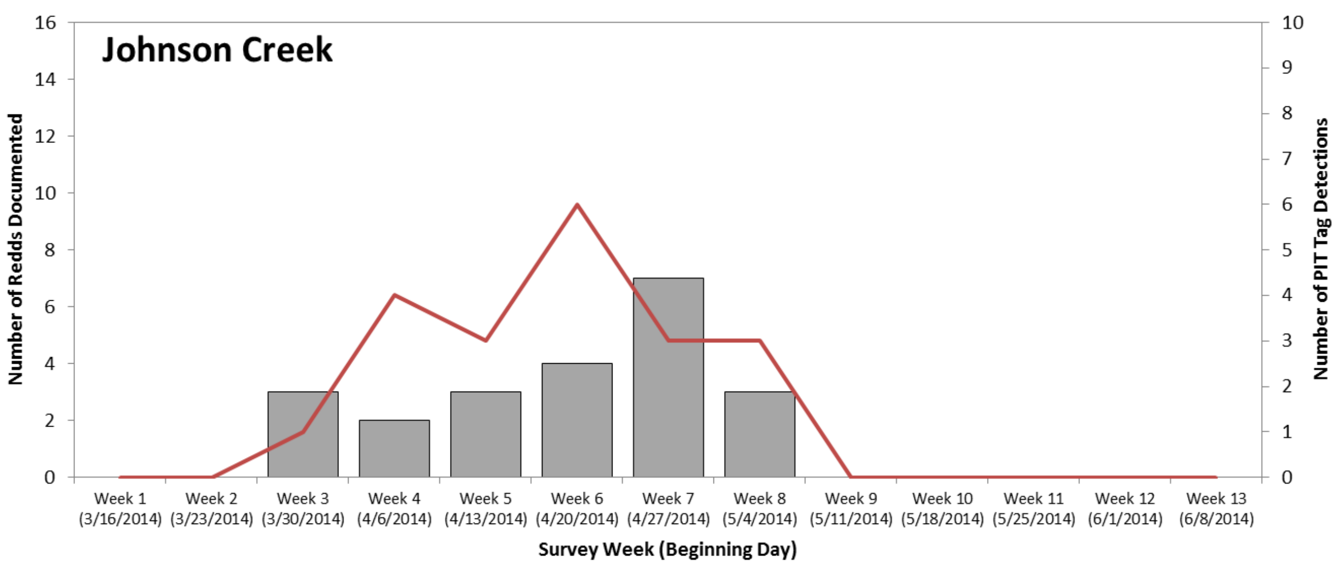

Figure 9. Number of steelhead redds documented by week in Johnson Creek (bar) compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on the interrogation site and grouped by week.

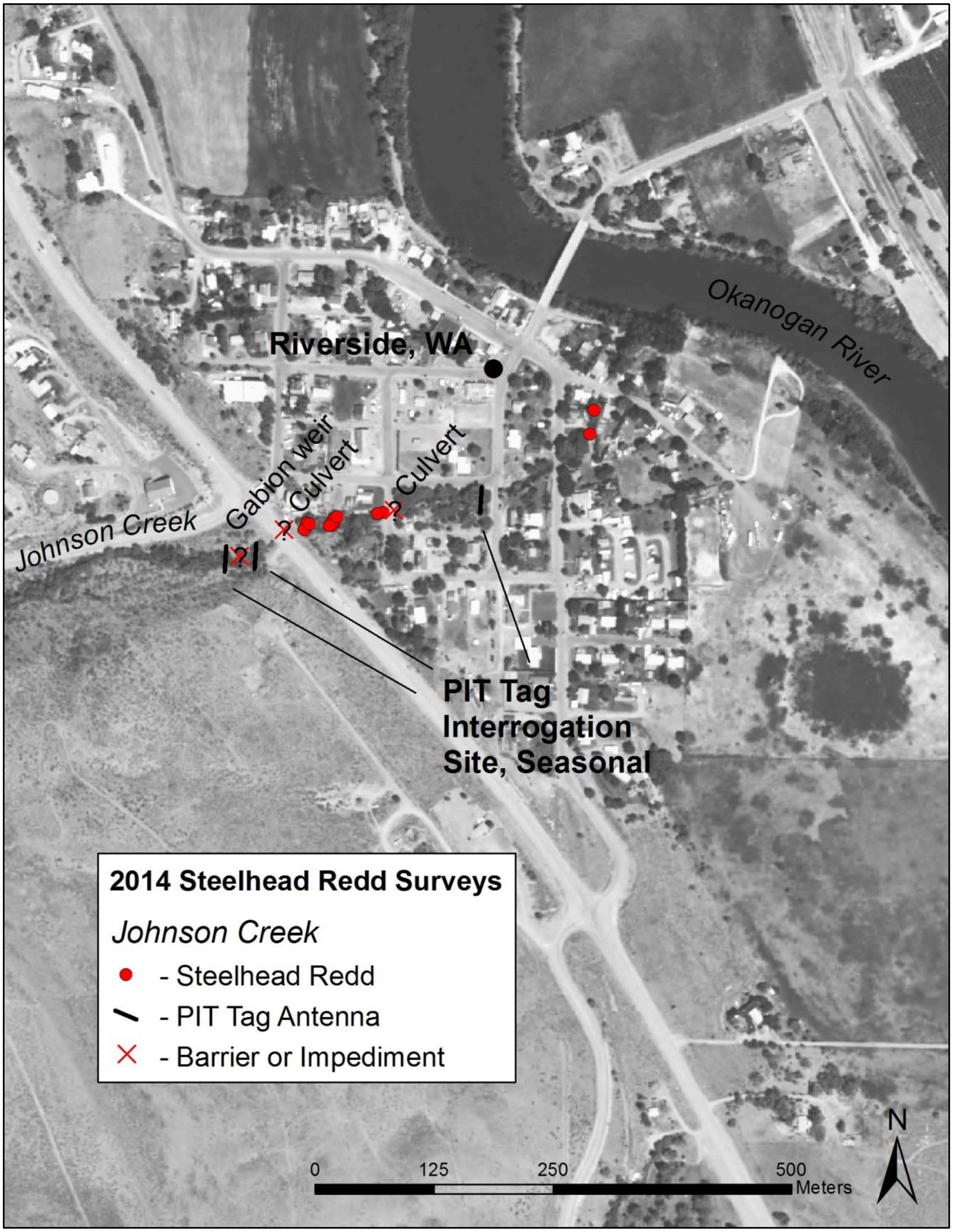

Figure 10. Spatial distribution of summer steelhead redds documented in Johnson Creek in 2014.

Figure 11. Steelhead in Johnson Creek, all panels. Left panels are still images from video, showing a pass through PIT tag antenna and steelhead attempting to pass the gabion weir upstream of HWY 97. Right panel shows a pair of steelhead spawning in the town of Riverside below HWY 97, multiple redds (approximately 5) can be seen in this picture.

3.2.6 Tunk Creek

Redd surveys were successfully conducted weekly in Tunk Creek, with one exception of turbid water on May 22, when no survey occurred due to low water visibility. A number of the new redds created that week were likely documented in the following survey week. A total of 29 redds were documented in 2014 (Figures 12 and 13), when expanded by 1.648 FPR, 48 steelhead were represented by redd surveys. The 48 total spawners were divided into 11 natural origin and 37 hatchery steelhead, determined by the percent-wild of PRD PIT tags.

Two wild and 7 hatchery steelhead from the PRD PIT tag mark-release group were detected in Tunk Creek during the spring of 2014. These detections were expanded to 14 natural origin and 48 hatchery steelhead, for a total of 62. Due to successful redd surveys, the redd expansion method was selected as the final estimate.

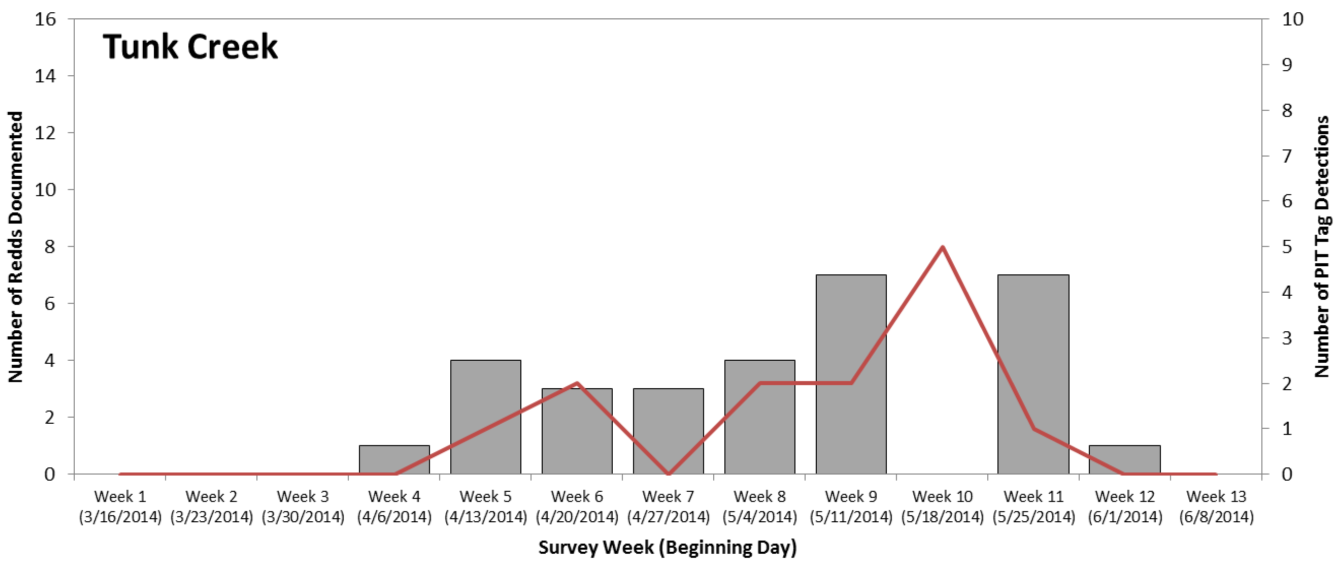

Figure 12. Number of steelhead redds documented by week in Tunk Creek (bar) compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on the interrogation site and grouped by week.

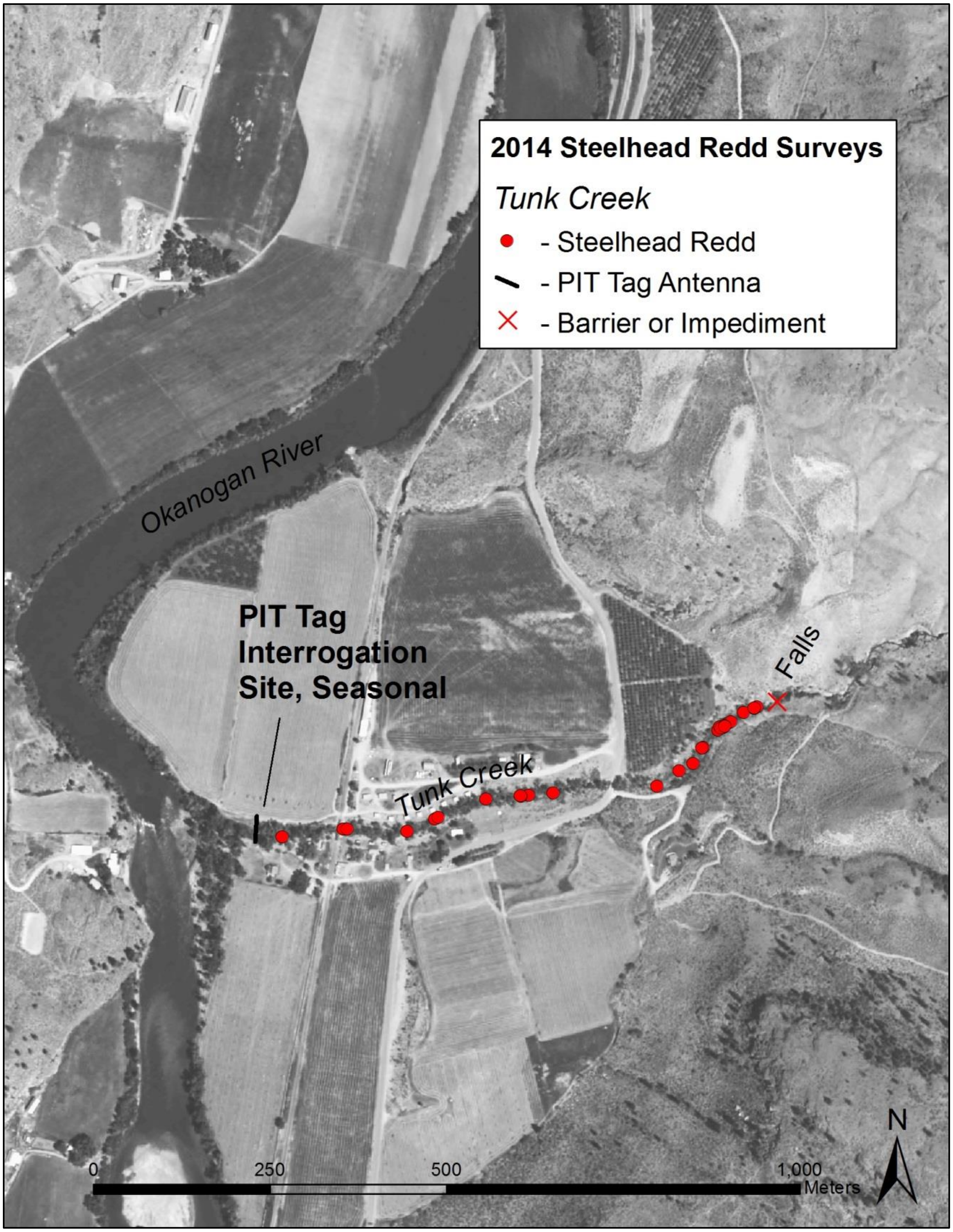

Figure 13. Spatial distribution of summer steelhead redds documented in Tunk Creek in 2014.

3.2.7 Aeneas Creek

Water conditions remained favorable to conduct spawning surveys in Aeneas Creek throughout the spring of 2014. Adult steelhead were documented in Aeneas Creek for the first time in 2014 after a project removed a series of large beaver dams filled with sediment. Although adult passage at the highway culvert has not been examined, the combination of steep gradient and a culvert likely presents a significant passage impediment beyond that point. A total of two redds were counted (Figures 14 and 15), which represented 3 steelhead spawners below the highway.

One PRD marked steelhead was detected in the creek, however, this fish was detected in Omak Creek after leaving Aeneas Creek. Zero PRD marked fish were apportioned to Aeneas Creek in 2014 for a PRD escapement estimate of zero steelhead. However, one hatchery and one wild steelhead marked at Wells Dam were detected in the creek. Shortly after those fish entered the creek, two adult steelhead were found predated on the stream bank during a redd survey; one was the wild Wells Dam PIT tagged fish (female) and the other did not have a PIT tag (male, adipose present, CWT in caudal peduncle). It is unknown if these fish completed spawning before they were predated, although two redds were found in the immediate vicinity. Due to two redds being located and adult steelhead being observed in the creek, a total of three steelhead spawners represent our best estimate for Aeneas Creek in 2014.

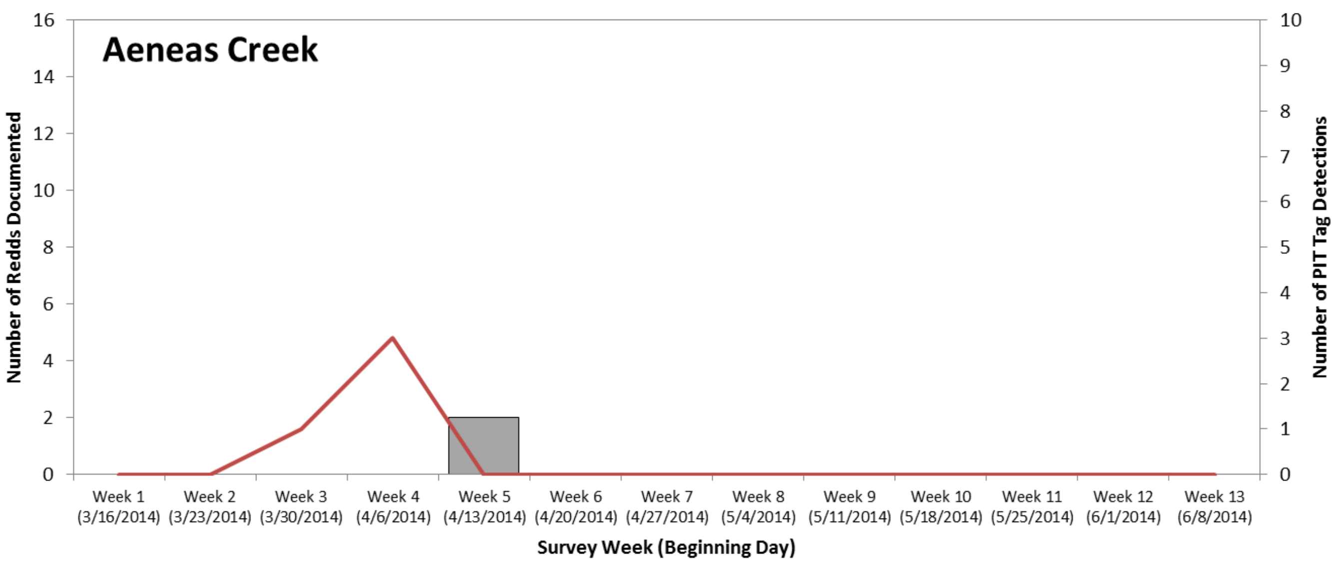

Figure 14. Number of steelhead redds documented by week in Aeneas Creek (bar) compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on the interrogation site and grouped by week.

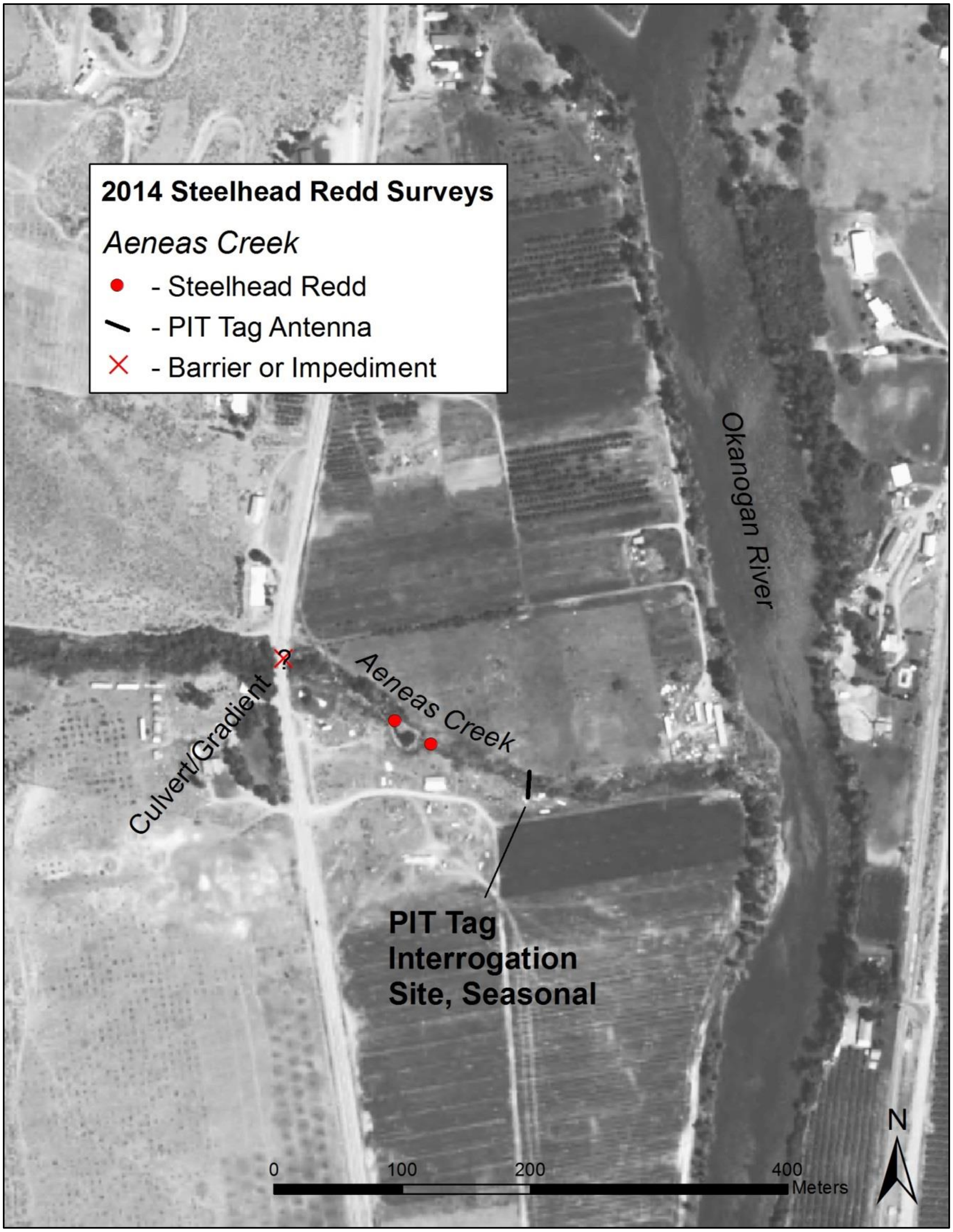

Figure 15. Spatial distribution of summer steelhead redds documented in Aeneas Creek in 2014.

3.2.8 Bonaparte Creek

Redd surveys were successfully completed on Bonaparte Creek throughout peak spawn timing. However, water conditions were turbid during the month of March and from May 15 through June; no redds were documented during those timeframes (Figures 16 and 17). A total of 82 redds were documented in Bonaparte Creek, which were expanded by 1.648 FPR to 135 steelhead. Although any redds created after mid-May were not counted, a number of redds created during March may have been counted during the early April redd survey.

Eleven natural origin and 10 hatchery PRD PIT tagged steelhead were detected at interrogation site BPC, near the mouth of the creek. These detections rendered a spawning estimate of 76 natural origin and 69 hatchery steelhead, for a total of 145 steelhead.

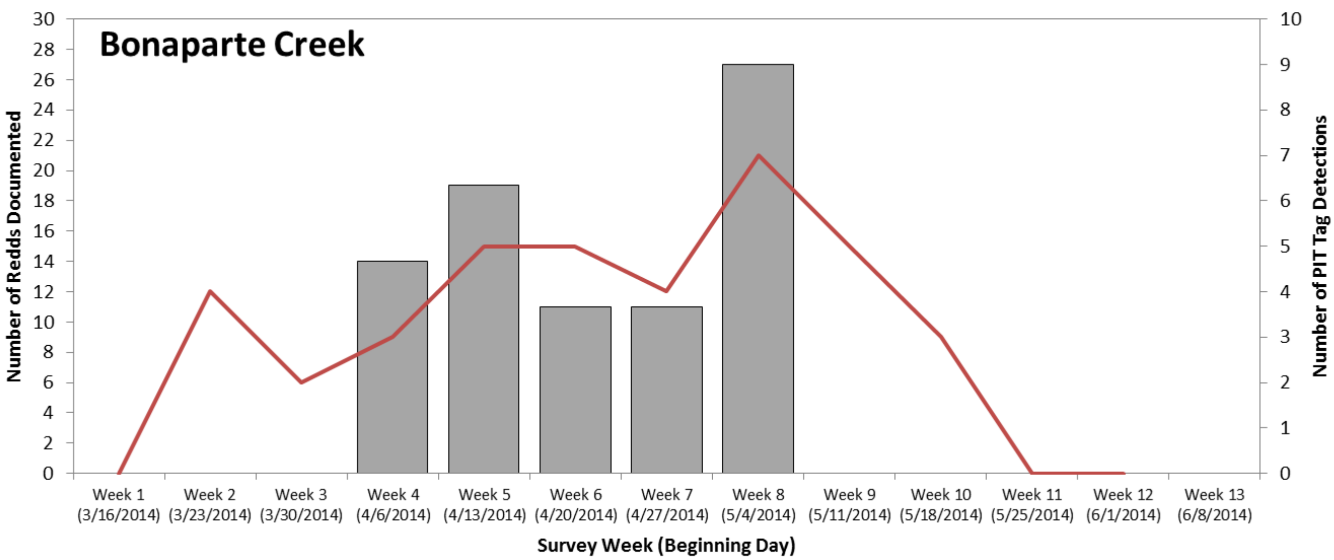

Figure 16. Number of steelhead redds documented by week in Bonaparte Creek (bar) compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on the interrogation site and grouped by week.

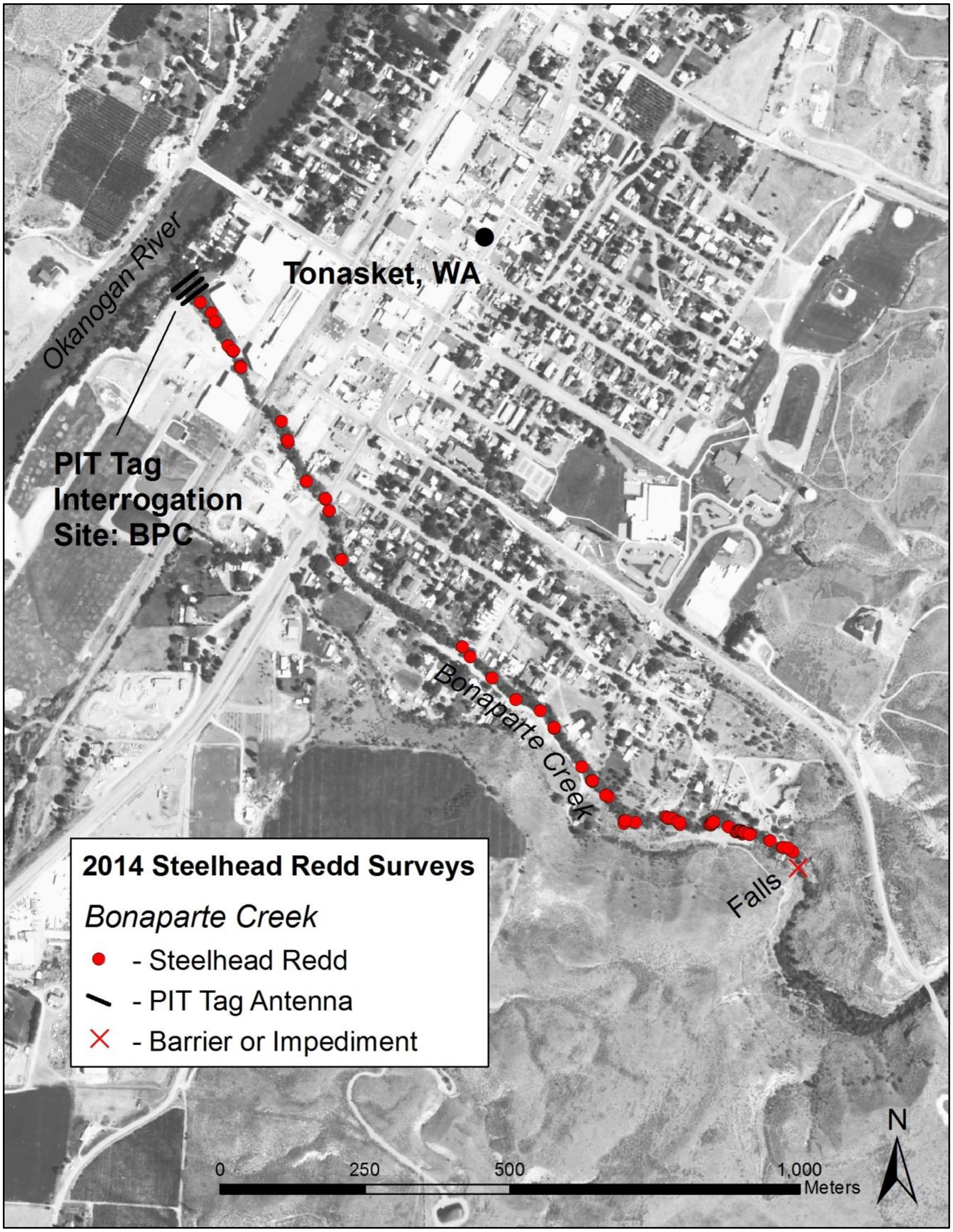

Figure 17. Spatial distribution of summer steelhead redds documented in Bonaparte Creek in 2014.

3.2.10 Antoine Creek

A small concrete dam was removed in the fall of 2013, which opened up an additional 11 km of habitat in upper Antoine Creek. A permanent PIT tag interrogation site was in operation near the mouth of Antoine Creek (site ANT) and a seasonal PIT tag antenna was installed above where the dam was removed to document potential passage above that point. Neither site detected a PIT tagged steelhead in the spring of 2014. Additionally, no redds were documented and no steelhead were observed passing through the underwater video site (Figure 18). While Antoine Creek appears to have sufficient habitat and juvenile O. *mykiss* are observed in the creek, utilization by adult steelhead has been minimal, as monitored by OBMEP from 2005-2014, potentially due to access related issues near the mouth of the creek. In previous years, and also in 2014, there was a ~ 6' cut bank falls near the confluence with the Okanogan River. Frequently, wood debris piles up in this slot and may inhibit adult upstream passage. In previous years, adults have been able to gain access after the Okanogan River stage height increases to a level that allows fish to jump this obstacle. Habitat programs should address access related issues at the mouth of the creek, now that sufficient habitat has been made available in the upper Antoine Creek watershed.

3.2.11 Wildhorse Spring Creek

In 2014, Wildhorse Spring Creek remained dry across the spawning period due to low snowpack and water availability in the lower elevations. Towards the end of May, a very small amount of water flowed down the creek, likely insufficient for adult passage. No redds were observed and no PIT tag detections were recorded (Figure 19).

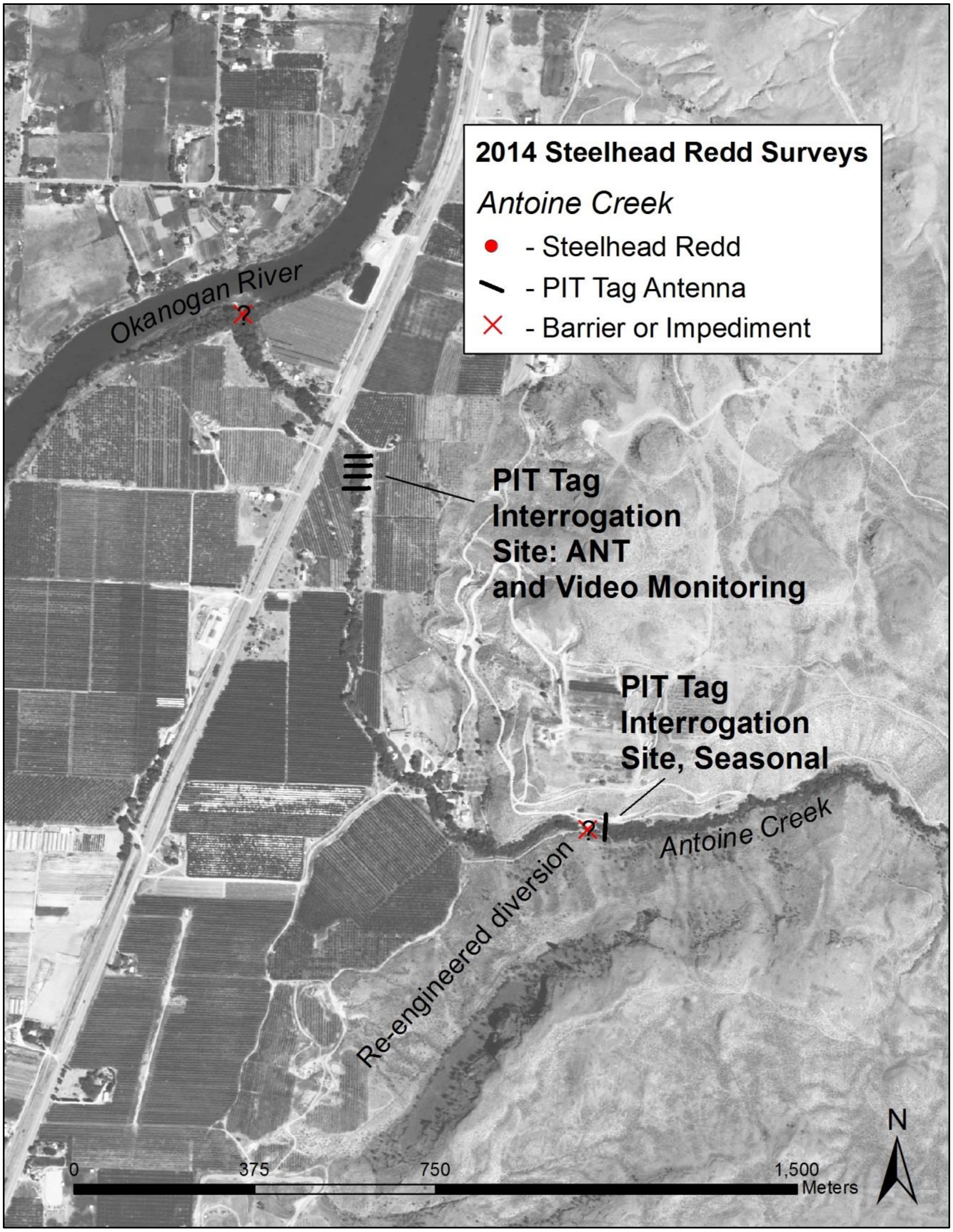

Figure 18. Spatial distribution of summer steelhead redds documented in Antoine Creek in 2014.

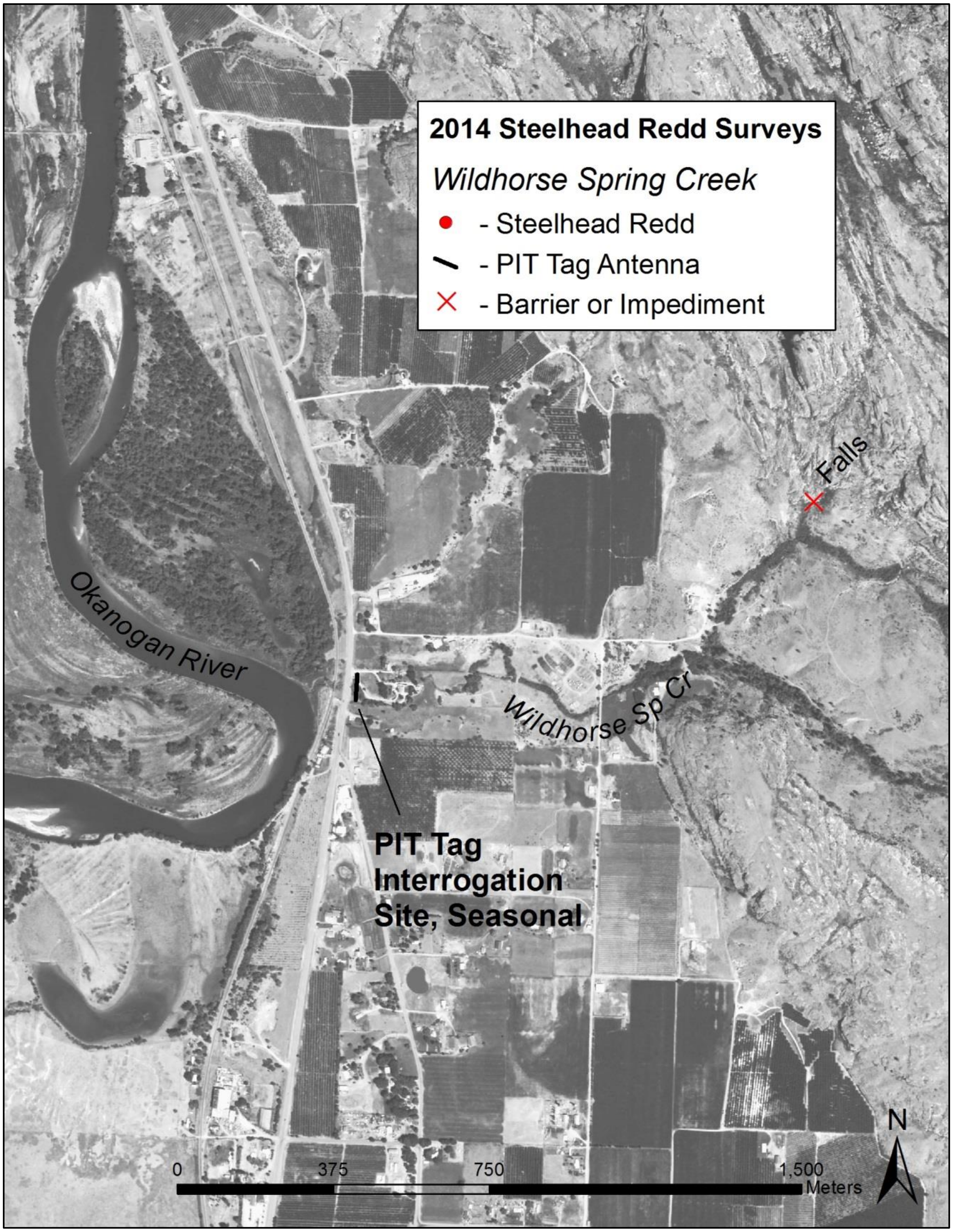

Figure 19. Spatial distribution of summer steelhead redds documented in Wildhorse Spring Creek in 2014.

3.2.12 Tonasket Creek

Redd surveys were successfully conducted weekly from March through mid-June on Tonasket Creek. A total of 53 redds were documented (Figures 20 and 21), rendering an expanded estimate of 87 steelhead, 50 natural and 37 hatchery origin.

Four natural origin and three hatchery PRD PIT tags were detected in the creek, for an estimated 28 natural origin and 21 hatchery, or 49 total steelhead. The lower reaches of Tonasket Creek dry up annually and a short canyon section below the anadromous barrier (falls) contains very little water in mid-summer. It is likely that the lower redds become desiccated and there is little remaining water for rearing in the upper reach, suggesting the large number of redds documented in that relatively short section may not produce many parr. Because of this, the more conservative estimate of 21 hatchery and 28 natural origin steelhead was selected.

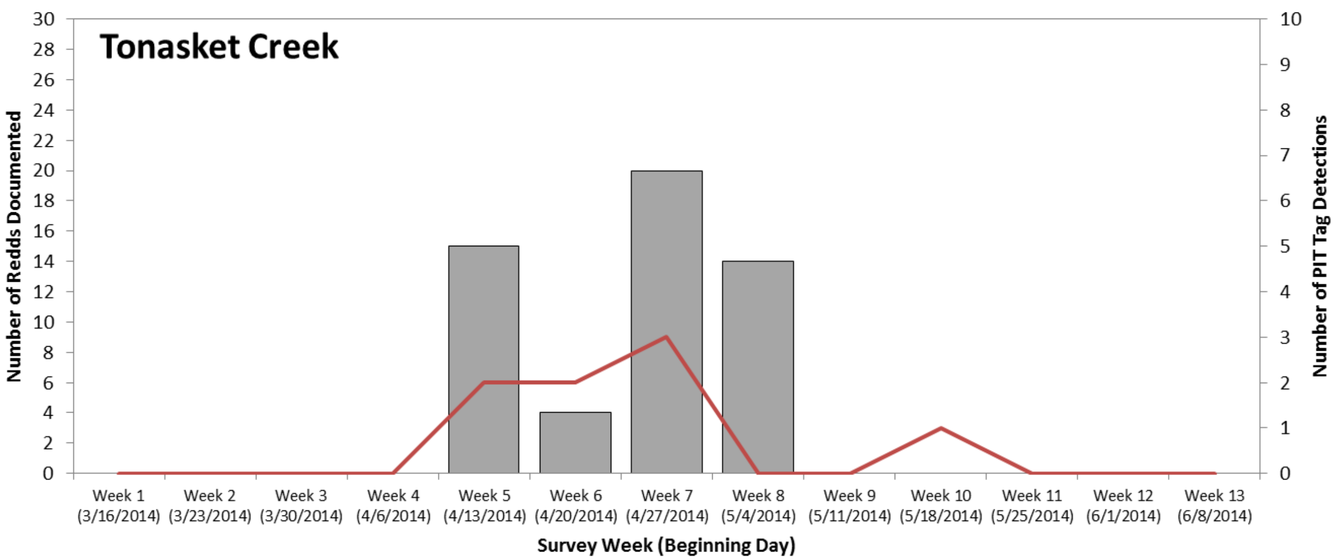

Figure 20. Number of steelhead redds documented by week in Tonasket Creek (bar) compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on the interrogation site and grouped by week.

3.2.13 Ninemile Creek

In Ninemile Creek, redd surveys were conducted from the mouth up to the PIT tag interrogation site (NMC), and tag detections were used to calculate escapement above that point. One redd was documented in the lower reaches in 2014 (Figure 22), for an estimated 2 steelhead spawning below the antenna.

One wild and zero hatchery PRD PIT tagged steelhead were detected on the permanent PIT tag array (NMC), which was operable throughout the season. This provided a total estimate of seven natural origin steelhead spawning above the PIT tag antenna. An additional temporary PIT tag antenna was operated in the upstream Eder Ranch, to examine spatial distribution of adult steelhead spawning in the creek. The one wild steelhead detected near the mouth was also detected at the upstream antenna. One additional unknown origin steelhead was also detected at both interrogation sites. The total upstream extent of spawning in Ninemile Creek remains unknown, but in 2015, the upper seasonal interrogation site will be moved further upstream to continue examining the extent of adult steelhead utilization in Ninemile Creek.

Figure 21. Spatial distribution of summer steelhead redds documented in Tonasket Creek in 2014.

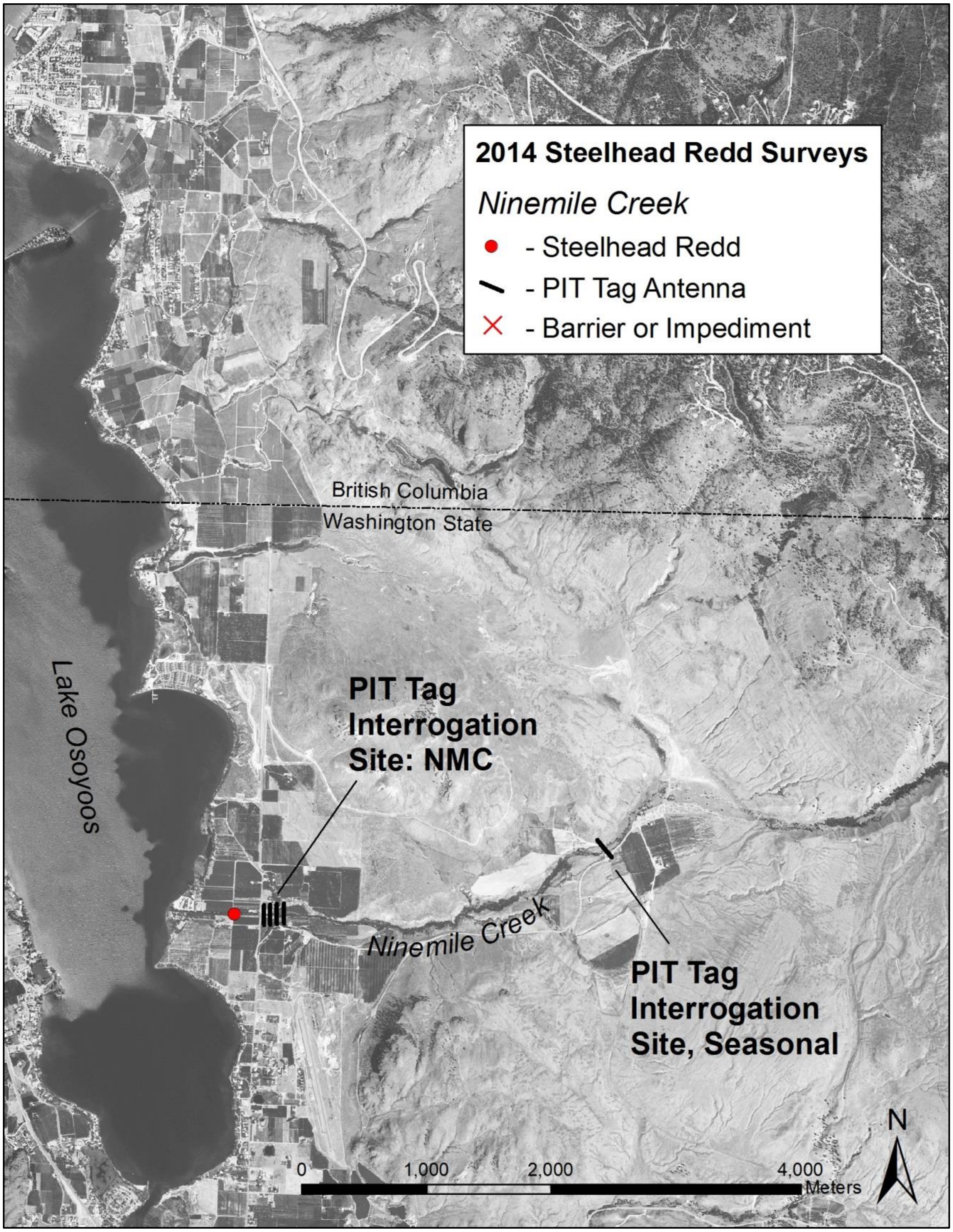

Figure 22. Spatial distribution of summer steelhead redds documented in Ninemile Creek in 2014.

3.3 Zosel Dam and Upstream Locations

Zosel Dam is located immediately above Okanogan River Reach 7, the largest steelhead spawning area in the Okanogan subbasin, at the downstream end of Osoyoos Lake. 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 7. Zosel Dam was constructed in its current state in 1987 with undershot spillways. When the spillway gates are raised to a height of more than 12 inches, fish may be able to through the spillways and bypass the fishway monitoring systems. In the spring of 2014, the spillway gates were opened earlier than in previous years to prepare for a large spring freshet (Figure 23). OBMEP staff were informed by the operators of the dam that the gates would likely not be lowered during the steelhead run. A decision was made not to deploy and operate the underwater video at Zosel Dam in order to focus staff hours to other projects. However, gates were lowered during from mid-March through April and a total of 47 unique PIT tagged steelhead were detected in the fishways, including 14 wild and 14 hatchery PRD marked fish. All spring-time steelhead PIT tag detections at the dam occurred between March 14 through April 25. The number of steelhead that passed Zosel Dam before mid-March and during the month of May remained unknown.

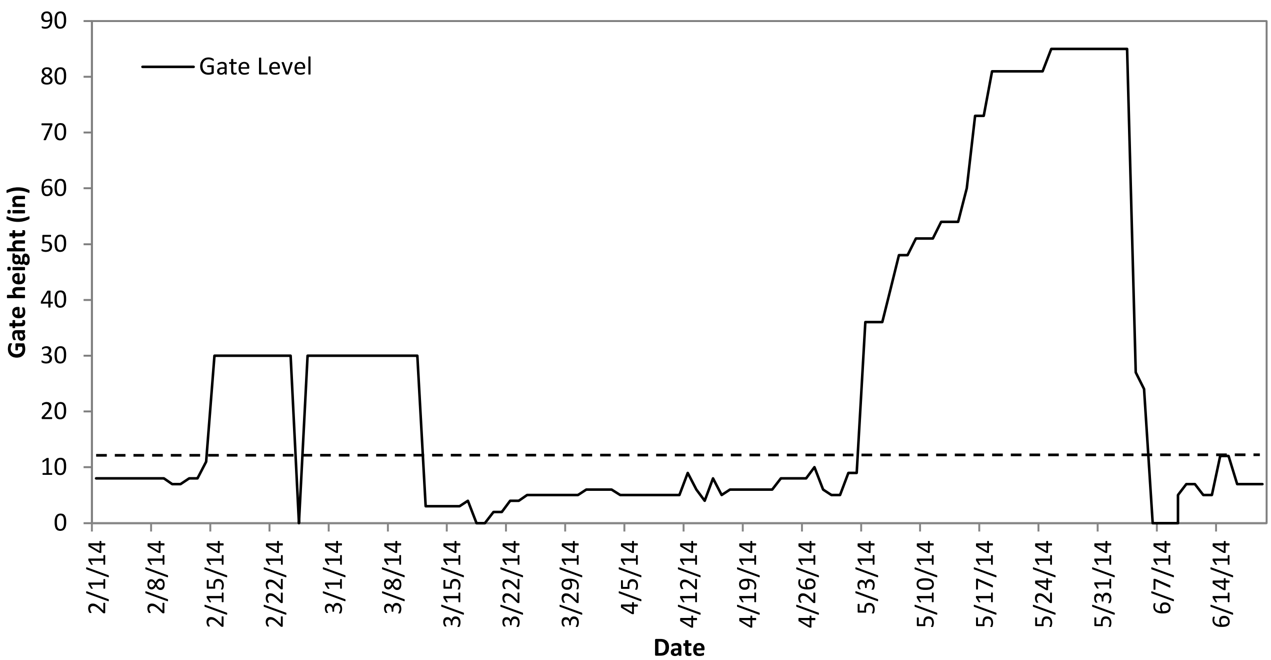

Figure 23. Gate levels at Zosel Dam in 2014. The dashed line represents 12 inches in gate height, above which point, fish may be able to pass underneath the spillway gates and bypass the fishway monitoring systems.

Above Zosel Dam are Tonasket and Ninemile Creeks in the Washington State portion of the subbasin, which both have PIT tag interrogation sites. Inkaneep Creek (no adult steelhead monitoring in 2014) and other small ephemeral streams also drain into Osoyoos Lake in the Canadian side of the border. It is unknown how many steelhead entered Inkaneep Creek in 2014, however, anadromous steelhead have been documented in that creek in previous years.

In the Canadian portion of the Okanagan subbasin above Lake Osoyoos (upstream of OKC at VDS3), steelhead have access up to the dam at the outlet of Okanagan Lake in Penticton, British Columbia. Three wild steelhead and two hatchery steelhead from the PRD mark-release group were detected at OKC, which represented approximately 21 wild steelhead 14 hatchery steelhead. In future years, as more PIT antennas become operable above OKC, it may be possible to develop a detection rate specific to steelhead at this detection site. However, if the number of steelhead were expanded by the 0.89 detection rate of OKC, developed for fall-migrating sockeye (Fryer et al. 2014), the total estimate of steelhead spawning above OKC would be 23 natural origin and 16 hatchery steelhead.

Between Lake Osoyoos and Okanagan Lake are thirteen Vertical Drop Structures, as well as two more lakes (Skaha Lake and Vaseux Lake), both with outlet dams. The outlet dam at Vaseux Lake (McIntyre Dam) was the upstream barrier for anadromous salmonids until 2009 and the outlet dam at Skaha Lake was still undergoing improvements for fish passage in 2014. In the summer of 2014, passage at Skaha dam was created, extending the upstream extent of anadromous fish to Okanagan Dam in Penticton, BC. The majority of the Canadian portion of the mainstem Okanagan River is characterized as being straightened and channelized. The main tributaries to the mainstem Okanagan River include Shingle Creek, Ellis Creek, McLean Creek, Shuttleworth Creek, Vaseux Creek and a number of small perennial streams.

3.4 Foster Creek (located outside the Okanogan subbasin)

Although Foster Creek is not located within the Okanogan subbasin, OBMEP installed a PIT tag antenna and conducted redd surveys every other week (shown as even weeks in Figure 24) in 2014 to further describe the spatial extent of Upper Columbia River steelhead above Wells Dam. Foster Creek was successfully surveyed across the entire 2014 spawning period, due to clear water and stable flows. A total of 11 steelhead redds were observed for an estimated total of 18 hatchery steelhead. All documented redds were below the Chief Joseph Dam outflow pipe (Figure 24), where water is bypassed from the Chief Joseph Dam forebay into the lower reaches of Foster Creek. No redds were documented in the upper reaches of Foster Creek in 2014, potentially due to low water levels in Foster Creek proper, above the outflow pipe.

The PIT tag antenna detected 0 wild and 2 hatchery PIT tagged steelhead from the PRD mark-release group, which led to an estimated 0 wild and 14 hatchery steelhead, for a total spawning estimate of 14.

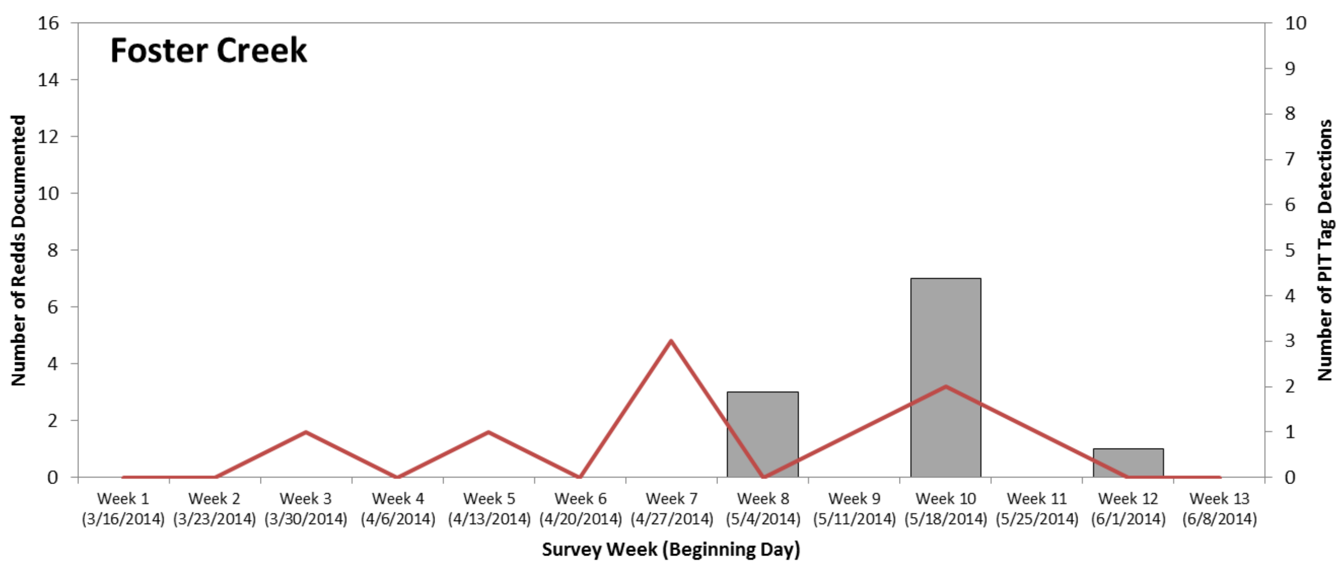

Figure 24. Number of steelhead redds documented in Foster Creek (bar) compared with PIT tag detections (line). PIT tag detections are presented by date of first detection of unique tag codes on the interrogation site and grouped by week.

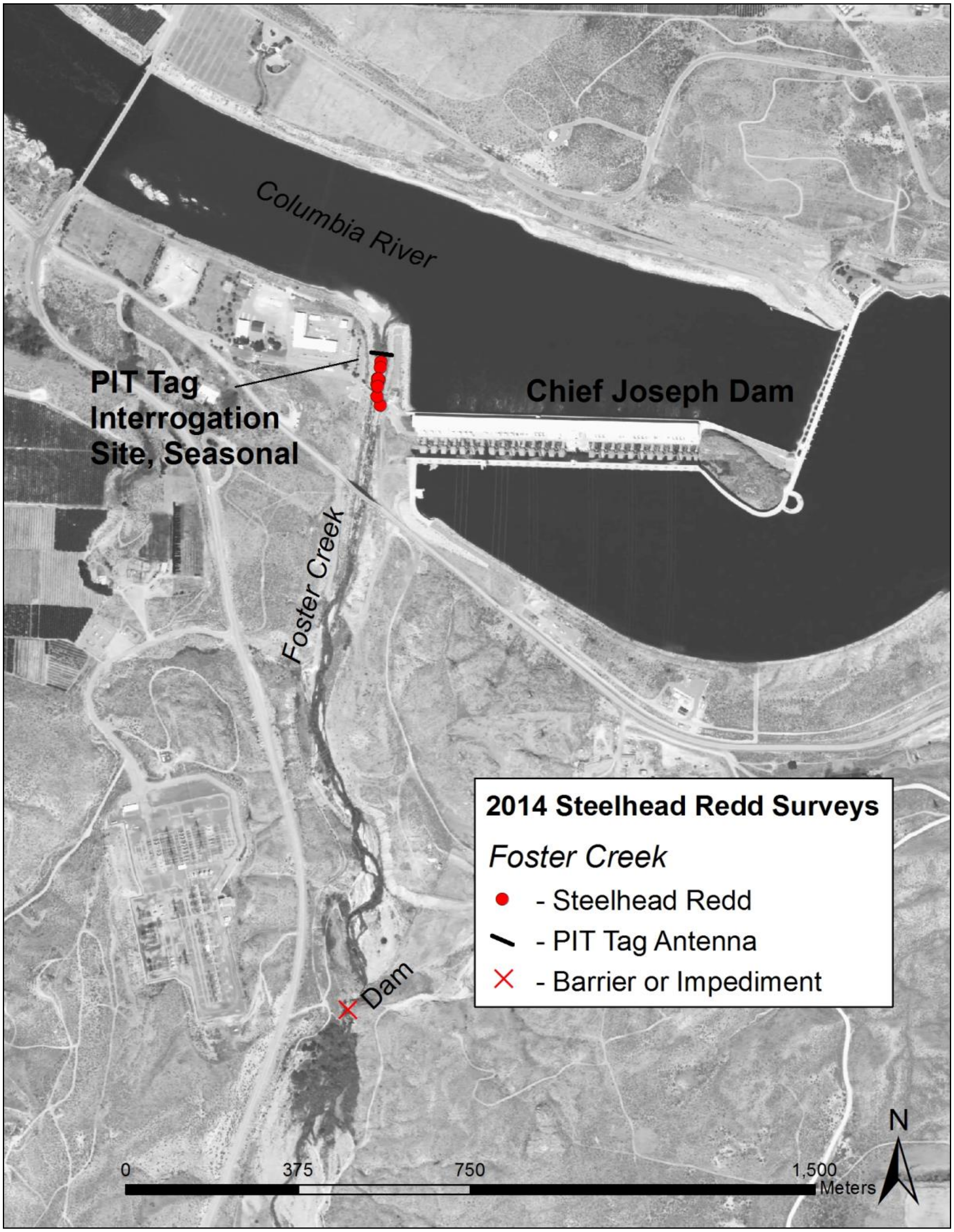

Figure 25. Spatial distribution of summer steelhead redds documented in Foster Creek in 2014.

4.0 Discussion

In the United States, summer steelhead are currently listed as “threatened” under the Endangered Species Act in the Upper Columbia River ESU (NMFS 2009). OBMEP monitored adult Viable Salmonid Population (VSP) abundance attributes (McElhany et al. 2000) within the subbasin for Okanogan River summer steelhead. Adult monitoring was conducted through redd surveys, underwater video counts, and PIT tag expansion estimates. A summary of spawning estimates in the Okanogan subbasin from 2005 through 2014, for both hatchery and naturally produced steelhead is presented in Figure 26. The average total number of steelhead spawners in the Okanogan subbasin was 1,818 and the ten year average number of naturally produced spawning steelhead was 309. The proportion of natural origin spawners (pNOS) from 2005 through 2013 averaged 0.15, but the pNOS increased to 0.38 in 2014.

Summer steelhead spawning estimates were compared with recovery goals outlined by the Upper Columbia Spring Chinook and Steelhead Recovery Plan (UCSRB 2007). The Upper Columbia Spring Chinook and Steelhead Recovery Plan stated 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).

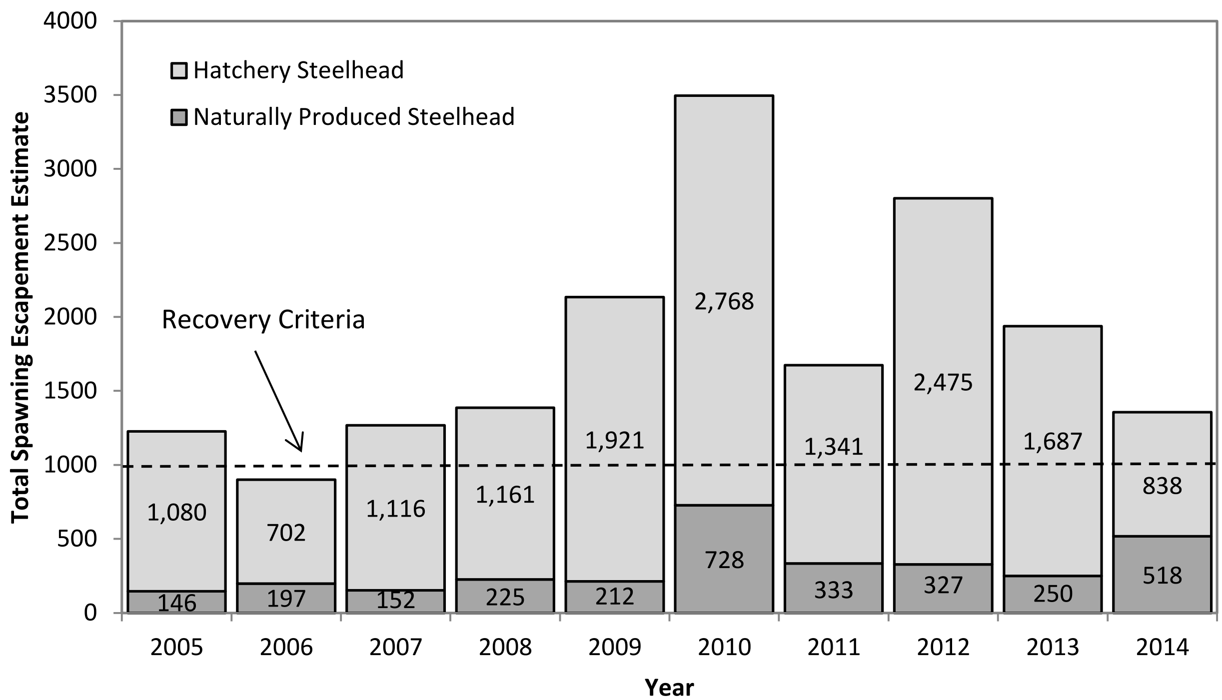

Figure 26. Spawning estimates for the Okanogan subbasin from 2005 through 2014, as determined by OBMEP.

Results from steelhead adult enumeration efforts indicate that the number of spawning steelhead in the Okanogan River subbasin, both hatchery and naturally produced, increased since data collection began in 2005. The slope of the 2005 through 2014 ten year trend line suggests that the number of total steelhead spawning in the Okanogan subbasin increased at an average rate of 111 fish per year and the number of naturally produced spawners increased at an average rate of 33 fish per year (Figure 27). Spawning occurs throughout the mainstem Okanogan River, although narrowly focused to distinct areas that contained suitable spawning substrates and water velocities. Steelhead spawning has been documented 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 largely influenced by stocking location because juvenile hatchery steelhead were scatter-planted in the Similkameen River, Omak Creek, and Salmon Creek.

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. Numerous methods have been described in the literature for analyzing complex fisheries data. When more years of data become available, additional detailed data analysis methods may be employed. 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.

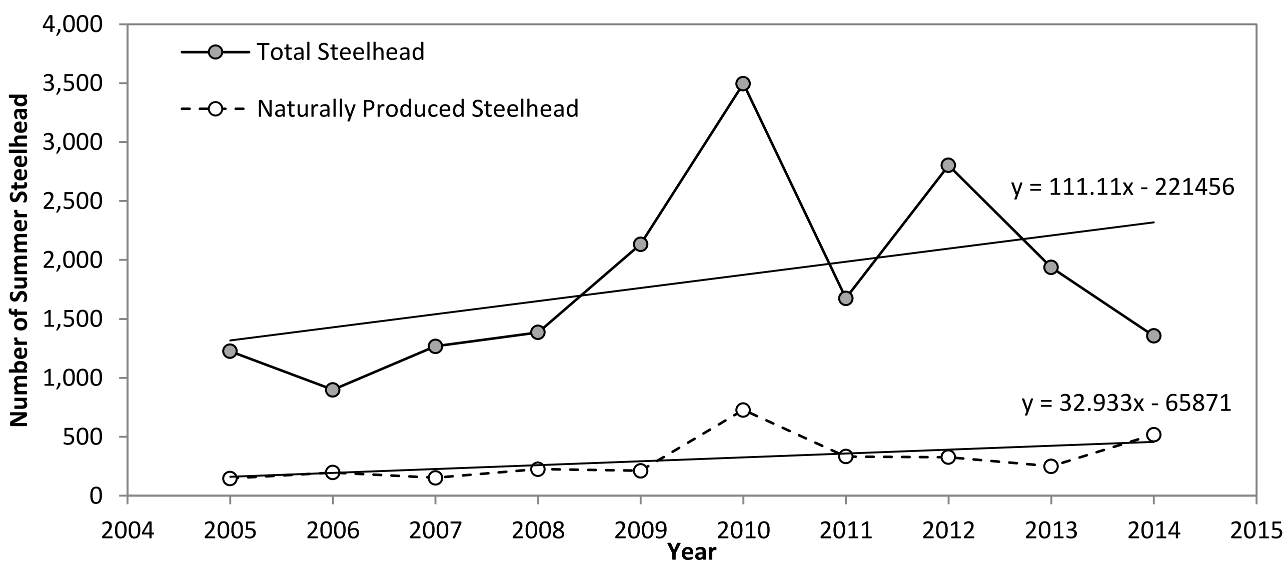

Figure 27. Trend in the estimated number of summer steelhead spawning in the Okanogan River subbasin, 2005 - 2014.

Annual variations of 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 smolts. 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 climate change. 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 (Figure 5). Habitat alterations at the mouths of key spawning tributaries may improve access, provided that sufficient discharge is available.

In 2010, 2011, and 2012, water availability in the Okanogan subbasin was above normal and subsequently, a larger proportion of steelhead spawned in tributaries than documented in previous years. Approximately 41% and 43% of steelhead were estimated to have spawned in tributaries to the Okanogan in 2010 and 2011, respectively (Figure 28). Because mainstem values were largely calculated and not directly counted for 2007, 2012, 2013, and 2014, no certain conclusions can be drawn for those survey years. Summer steelhead that spawn in tributary habitats of the Okanogan subbasin are more likely to find suitable environmental conditions and rearing habitats than those spawning in mainstem habitats. Therefore, the Fish and Wildlife Program should consider continuing restoration projects that address adequate flow in tributaries to the Okanogan River and providing access to additional kilometers of tributary streams.

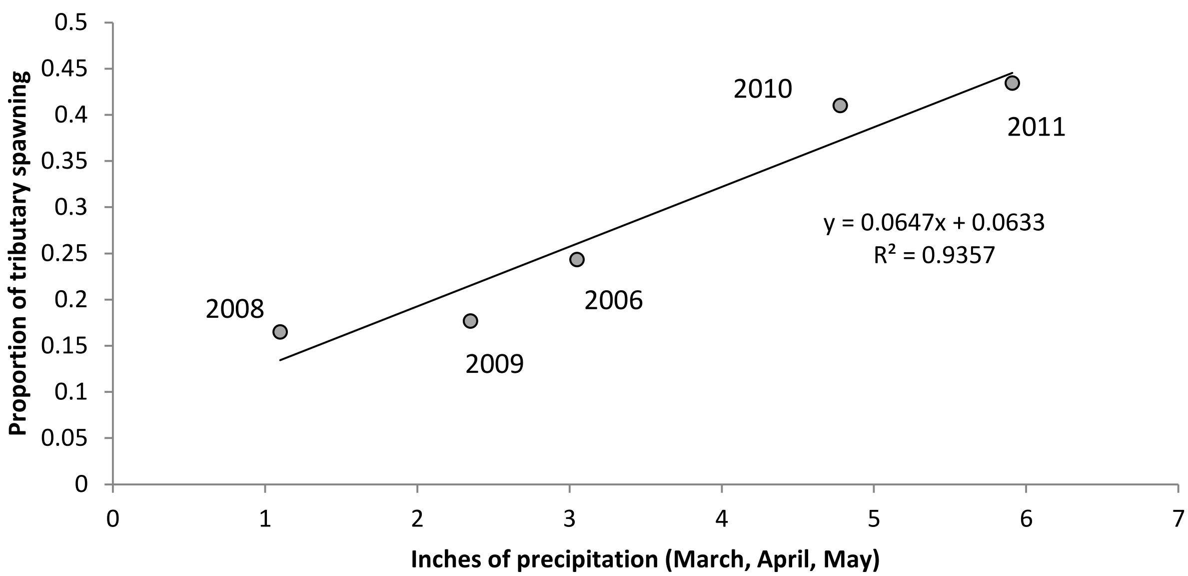

Figure 28. Correlation between precipitation occurring during March, April, and May and the proportion of summer steelhead spawning in tributaries to the Okanogan River in Washington State.

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