

U.S. Fish and Wildlife Service

Seasonal Movements of Adult Fluvial Bull Trout and Redd Surveys in Icicle Creek 2010 Annual Report



Mark C. Nelson, Andy Johnsen, and R.D. Nelle

U.S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
Leavenworth, WA 98826

***On the cover:** Adult fluvial bull trout code 24 in Etienne Creek at rkm 5.6 on October 6, 2010.
USFWS photograph by Josh Pieratt.*

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Authored by

Mark C. Nelson
Andy Johnsen
R.D. Nelle

U.S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
7501 Icicle Road
Leavenworth, WA 98826

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Mark C. Nelson, Andy Johnsen, and R.D. Nelle

*U.S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
7501 Icicle Rd.
Leavenworth WA 98826*

Abstract- Relatively little is known about the life history, movement patterns, population numbers, and genetic diversity of the threatened bull trout *Salvelinus confluentus* in Icicle Creek. In 2007, the Mid-Columbia River Fishery Resource Office of the U.S. Fish and Wildlife Service began a telemetry study of adult fluvial bull trout to determine migration timing and distances, identify migration barriers and obstacles, document passage windows at natural and artificial obstacles, monitor seasonal movements, and locate spawning areas in Icicle Creek. The study was continued in 2010 when six adult bull trout radio-tagged in 2009 and three adult bull trout radio-tagged in 2010 were tracked. None of the three bull trout tagged during late summer in lower Icicle Creek in 2010 attempted to move upstream of Leavenworth NFH. None of the six bull trout tagged in 2009 returned to Icicle Creek in 2010. Instead, four of these bull trout migrated to spawning areas in different local populations, including one in Chiwaukum Creek, one in Nason Creek, one in Etienne Creek, and one in upper Entiat River. One bull trout shed its radio transmitter but its PIT tag was detected passing the fish ladder at Tumwater Dam as it migrated to the upper Wenatchee River. The remaining bull trout spent the summer in Tumwater Canyon downstream of Tumwater Dam. Upstream migration distances ranged from 30.8 to 122 km. During the fall, seven bull trout migrated downstream and four overwintered in the Columbia River while one overwintered in Tumwater Canyon. Downstream migration distances ranged from 17.6 to 118 km. One of the bull trout tagged in 2010 died and the other two apparently shed their radio transmitters. During spawning ground surveys in upper Icicle Creek, two bull trout redds were observed in French Creek. Tissue samples were taken from 17 subadult bull trout in 2010, including 10 captured in upper Icicle Creek and 7 in lower Icicle Creek. To date, tissue samples have been taken from over 90 bull trout in Icicle Creek and eventually a genetic analysis with comparison to the pending genetic baseline will provide additional insights into movements and population structure of bull trout in Icicle Creek. Future studies should focus on subadult bull trout including large scale genetic sampling and PIT tagging in tandem with tracking a small number of radio-tagged fish.

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Introduction

Bull trout *Salvelinus confluentus* in the Columbia River basin were listed as threatened in 1998 (USDOI 1998) and recovery planning focused on migratory populations (USFWS 2002a). Icicle Creek bull trout were initially identified as a resident population and were not included as a local population of the Upper Columbia Recovery Unit in the draft bull trout recovery plan (USFWS 2002b). The rugged canyon and boulder falls beginning at river kilometer 9.2¹ were considered a barrier to migratory fish (WDF 1938), but in autumn of 2002, migratory sized bull trout were observed immediately upstream of the boulder falls (USFWS 2004). Therefore, Icicle Creek bull trout were added as a local migratory population in a revised version of the draft bull trout recovery plan, and the potential use of Icicle Creek by migratory bull trout and their status and interaction with the resident component were identified as research needs (USFWS 2004).

The Upper Columbia Bull Trout Recovery Unit encompasses the Wenatchee, Entiat and Methow core areas (Figure 1). Icicle Creek bull trout are one of seven local migratory populations designated in the Wenatchee Core Area (USFWS 2004). The other local bull trout populations are located in Peshastin Creek (including Ingalls Creek), Chiwaukum Creek, Nason Creek (including Mill Creek), Chiwawa River (including Chikamin, Phelps, Rock, Alpine, Buck, and James creeks), White River (including Canyon and Panther creeks), and Little Wenatchee River (Figure 2).

During the recovery planning process it was determined that 50 pairs of spawning bull trout, or 50 redds, constituted the recovered abundance of Icicle Creek migratory bull trout (USFWS 2004). Spawning ground surveys to enumerate bull trout redds were not conducted in Icicle Creek until 2008, when 8 migratory-sized redds were found in French Creek, a tributary of upper Icicle Creek (Nelson et al. 2009). Although other spawning areas have not been delineated, the abundance of migratory adults in the Icicle Creek local population currently appears to be below recovery levels.

Little is known about the movements, migration timing, population numbers, and genetic diversity of migratory bull trout in Icicle Creek upstream of Leavenworth National Fish Hatchery (NFH). In 2007, the U.S. Fish and Wildlife Service (USFWS) Mid-Columbia River Fishery Resource Office (MCRFRO) developed a multiyear radio-telemetry study in Icicle Creek (Nelson et al. 2009). In 2008, three adult fluvial bull trout were radio-tagged and one (tagged in the upper river at Icicle Gorge at rkm 26.2) migrated to and spawned in French Creek (Nelson et al. 2009). In 2009, seven adult fluvial bull trout were radio-tagged in lower Icicle Creek, but none of these fish attempted to migrate upstream past Leavenworth NFH (Nelson et al. 2011). In 2010, the study was continued and this report details the results from February 4, 2010 to January 1, 2011.

The objectives of the study are to determine migration timing and distances, identify migration barriers and obstacles, document passage windows at natural and artificial obstacles, monitor seasonal movements, and locate spawning areas of adult migratory bull trout in Icicle Creek.

¹ Note that all river kilometer (rkm) designations in this report are approximate. See methods section.

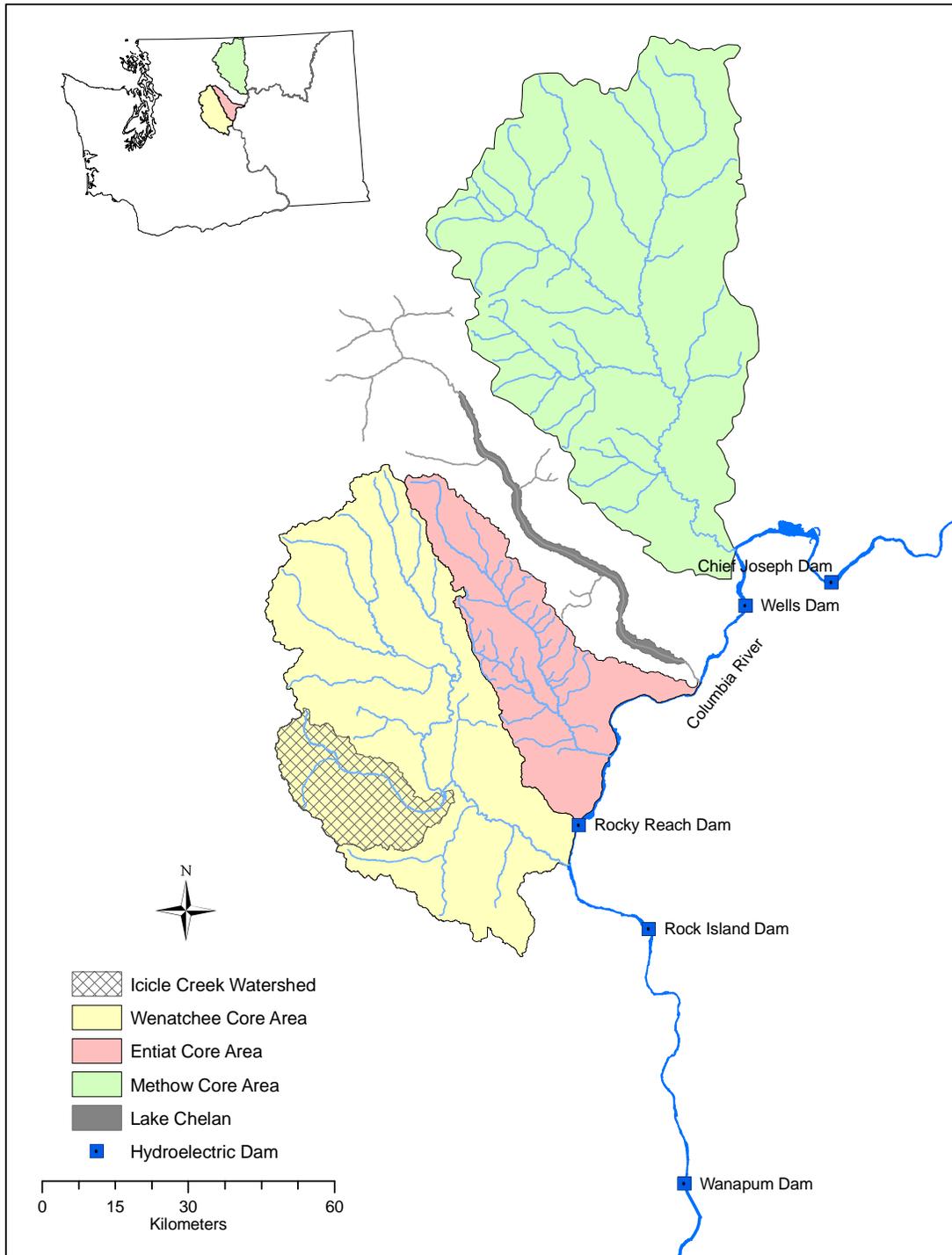


Figure 1. Map of the Upper Columbia Bull Trout Recovery Unit, showing the location of the Icicle Creek watershed within the Wenatchee Core Area.

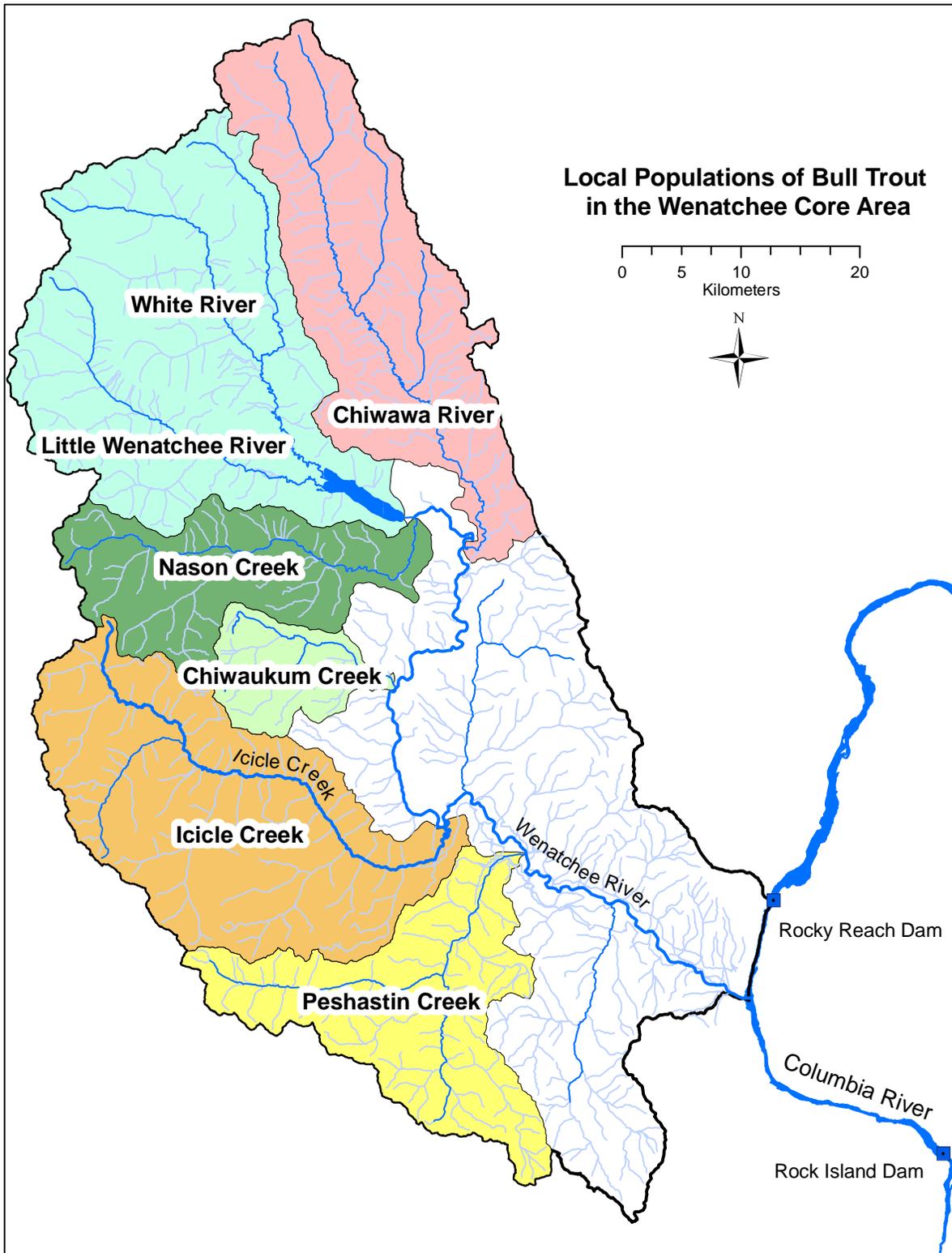


Figure 2. Map of the seven designated local populations of bull trout in the Wenatchee Core Area.

Study Area

Icicle Creek originates in Josephine Lake (elevation 1,427 m) near the crest of the Cascade Mountains in Chelan County of north-central Washington. It flows easterly for 51.2 rkm, drains a watershed area of 555 km², and enters the Wenatchee River at rkm 41.2 near the town of Leavenworth (Figure 3). Eighty-seven percent of the watershed is in public ownership (74% of which is in the Alpine Lakes Wilderness Area), and 13% is in private ownership (USFS 1995).

Icicle Creek is in a narrow, steep, and glaciated valley characterized by a cascading water course that plunges downstream in a series of cataracts, riffles, and rapids. Stream discharge has been recorded by the U.S. Geological Survey (USGS) Gage Station 12458000 at rkm 9.4 from 1936 to 1971 and from 1993 to the present. The average discharge for the period of record is 614 ft³/s and the minimum and maximum discharges are 44 ft³/s (November 30, 1936) and 19,800 ft³/s (November 29, 1995) (USGS 2010). Stream gradient is variable and ranges from 0.1 to 9% (Figure 4). Several natural and artificial obstructions to fish migrations occur in Icicle Creek. Among the many natural obstacles (Figure 4) are the boulder falls found both upstream of Snow Creek at rkm 9.2 and near Bridge Creek at rkm 14.3, the chute and flume falls at the Icicle Gorge (rkm 26.2), water falls at Rock Island Campground (rkm 29.1), and complex falls (step pool morphology over bedrock substrate) at rkm 34.3 and at French Creek (rkm 34.7). The high falls upstream of Leland Creek at rkm 46.8 are considered impassable to migrating fish (Bryant and Parkhurst 1950). Many of the tributaries, particularly the smaller ones, are inaccessible to migratory fish due to waterfalls and steep gradient (Mullan et al. 1992).

Artificial obstructions in Icicle Creek include structures associated with the operation of Leavenworth NFH (seasonal barrier (structure 5) at rkm 4.4, headgate (structure 2) at rkm 6.1, and intake diversion dam (structure 1) at rkm 7.2) and the Icicle-Peshastin Irrigation District (IPID) diversion dam at rkm 9.3 (Figure 5). Adaptive management of Leavenworth NFH attempts to balance hatchery operations, tribal and sport fisheries, and fish movements (USFWS 2006). Structure 5 is open except when it may be operated as a seasonal barrier during the hatchery's spring Chinook salmon brood stock collection period (May 15 – July 7). The headgate is open most of the year, but exceptions may occur during brood stock collection or when operated to control flooding and recharge groundwater wells. The Leavenworth NFH intake diversion dam, shared with the Cascade Orchards Irrigation Company, has a fish ladder which is typically in operation during the migration season. The IPID irrigation diversion dam, shared by the City of Leavenworth for municipal water intake, does not have a fish ladder.

The Icicle Creek watershed sustains the heaviest recreational use of any watershed within the Wenatchee River subbasin (USFS 1995). Recreational activities include kayaking, rock climbing, hiking, backpacking, bicycling, horse riding, hunting, fishing, bird watching, sightseeing, and camping. Six of the seven U.S. Forest Service (USFS) developed campgrounds are located in the riparian zone of Icicle Creek (Figure 6) and several primitive campsites are dispersed throughout the valley. The lower 32 kilometers of the river are accessible by road and the upper 19 km by trail. Forest Road 7600 closely parallels Icicle Creek for much of its route and in some locations prevents the stream from using its floodplain (USFS 1995). In 2008, a landslide near Doctor Creek (rkm 24.9) redirected Icicle Creek flows down the roadway and USFS closed FR7600 at rkm 23.5.

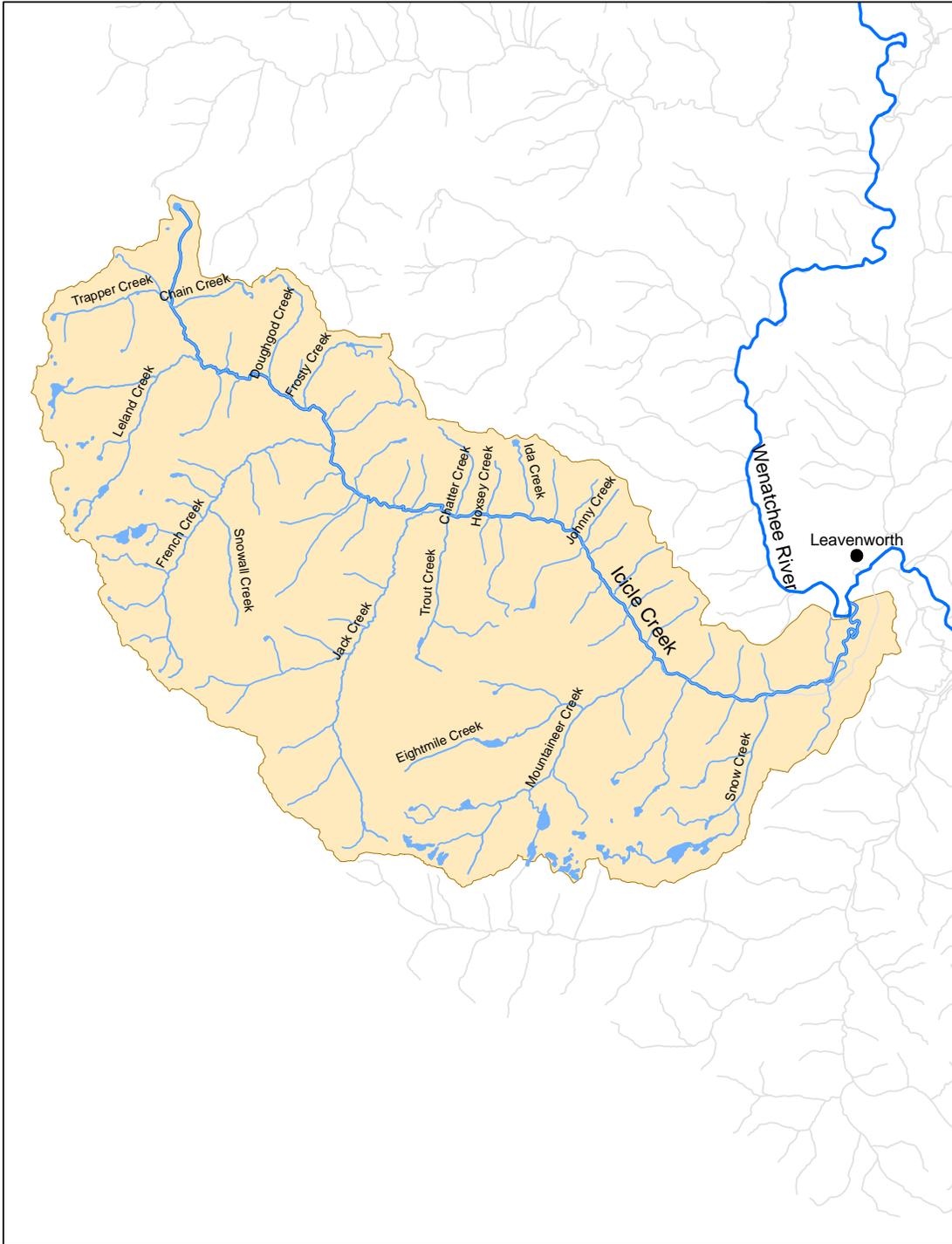


Figure 3. Map of the Icicle Creek watershed.

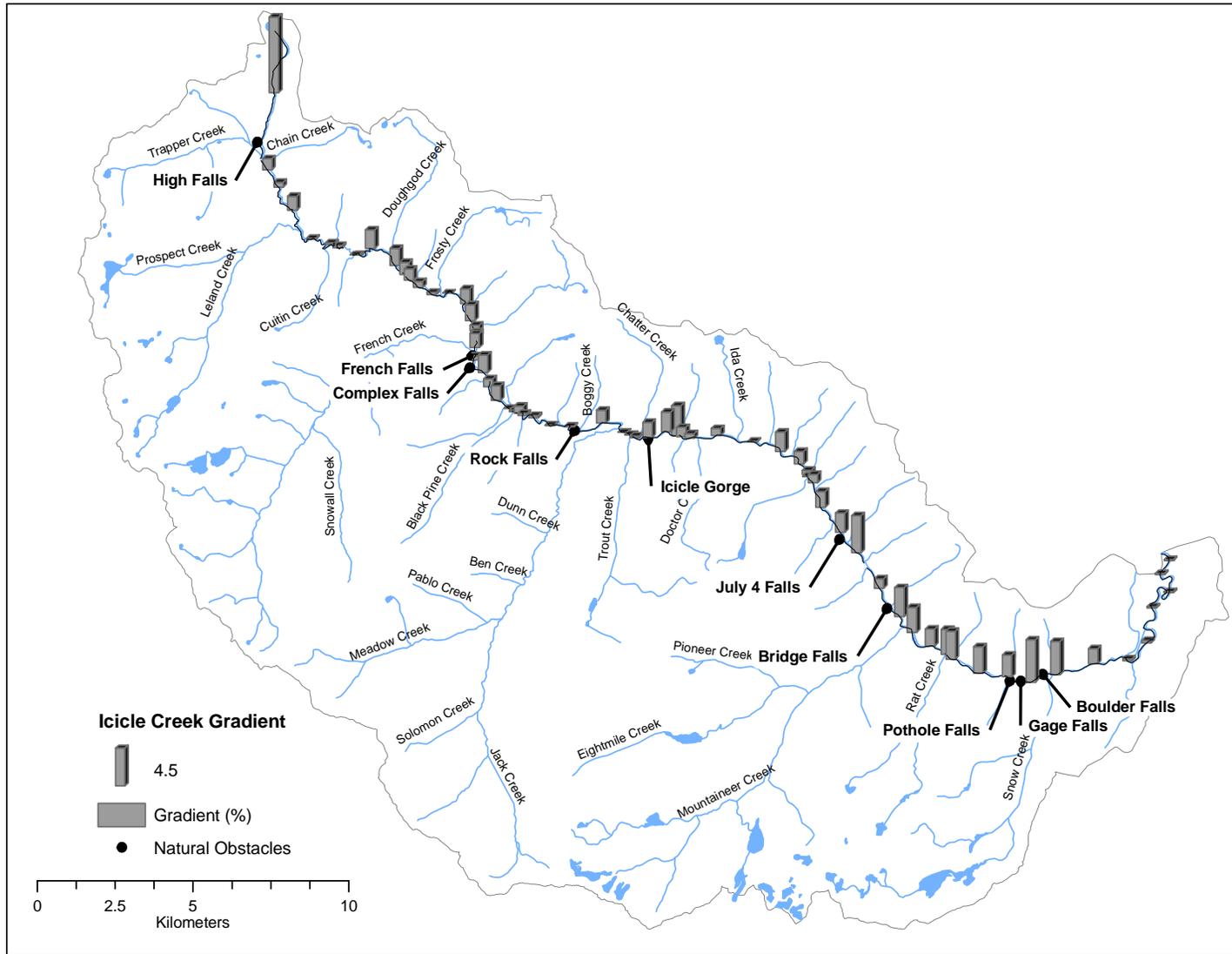


Figure 4. Map of Icicle Creek watershed, showing gradient (within stream segments as calculated in GIS) and locations of select natural obstacles.

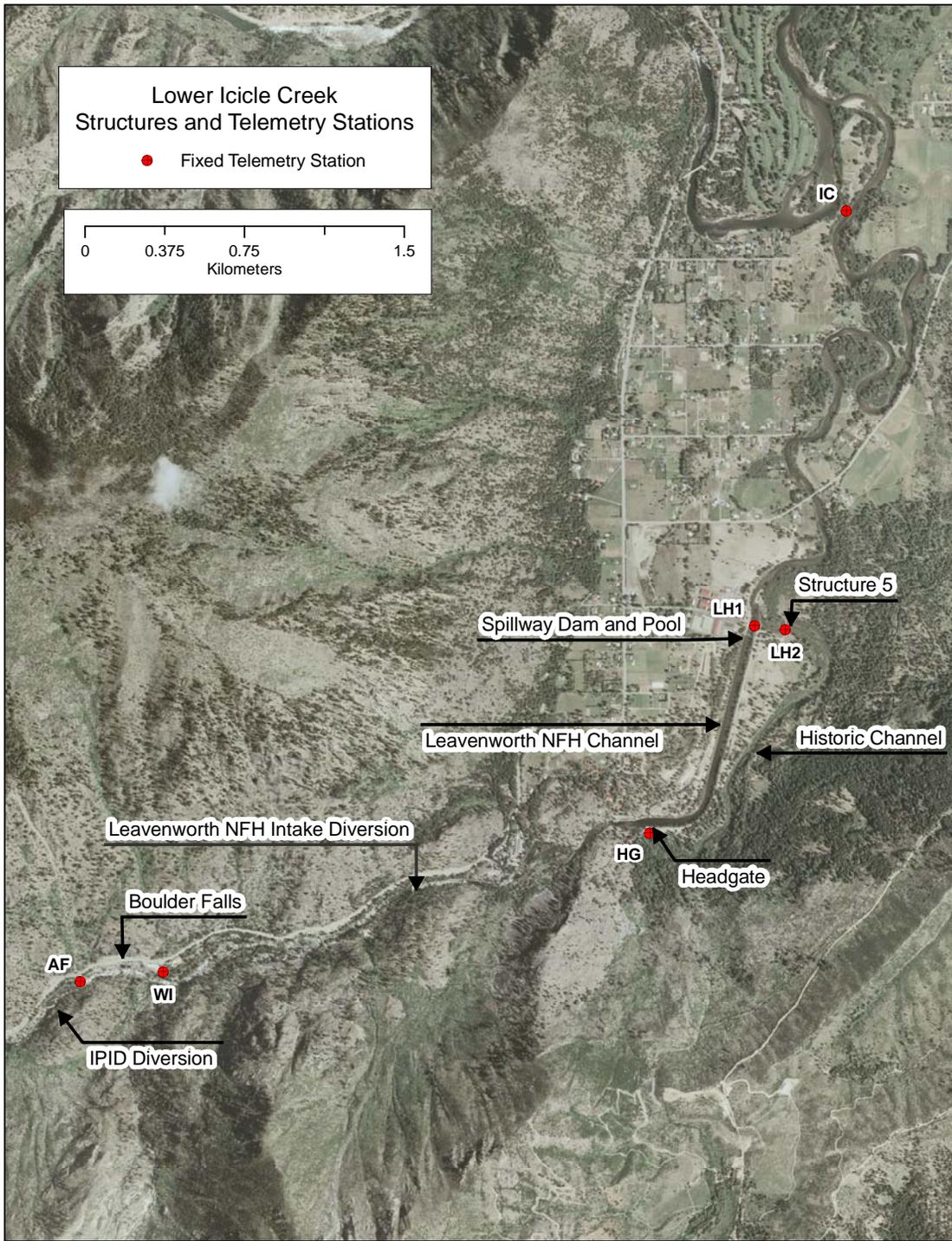


Figure 5. Aerial photograph of lower Icicle Creek, showing locations of natural and artificial obstacles and structures in the creek.

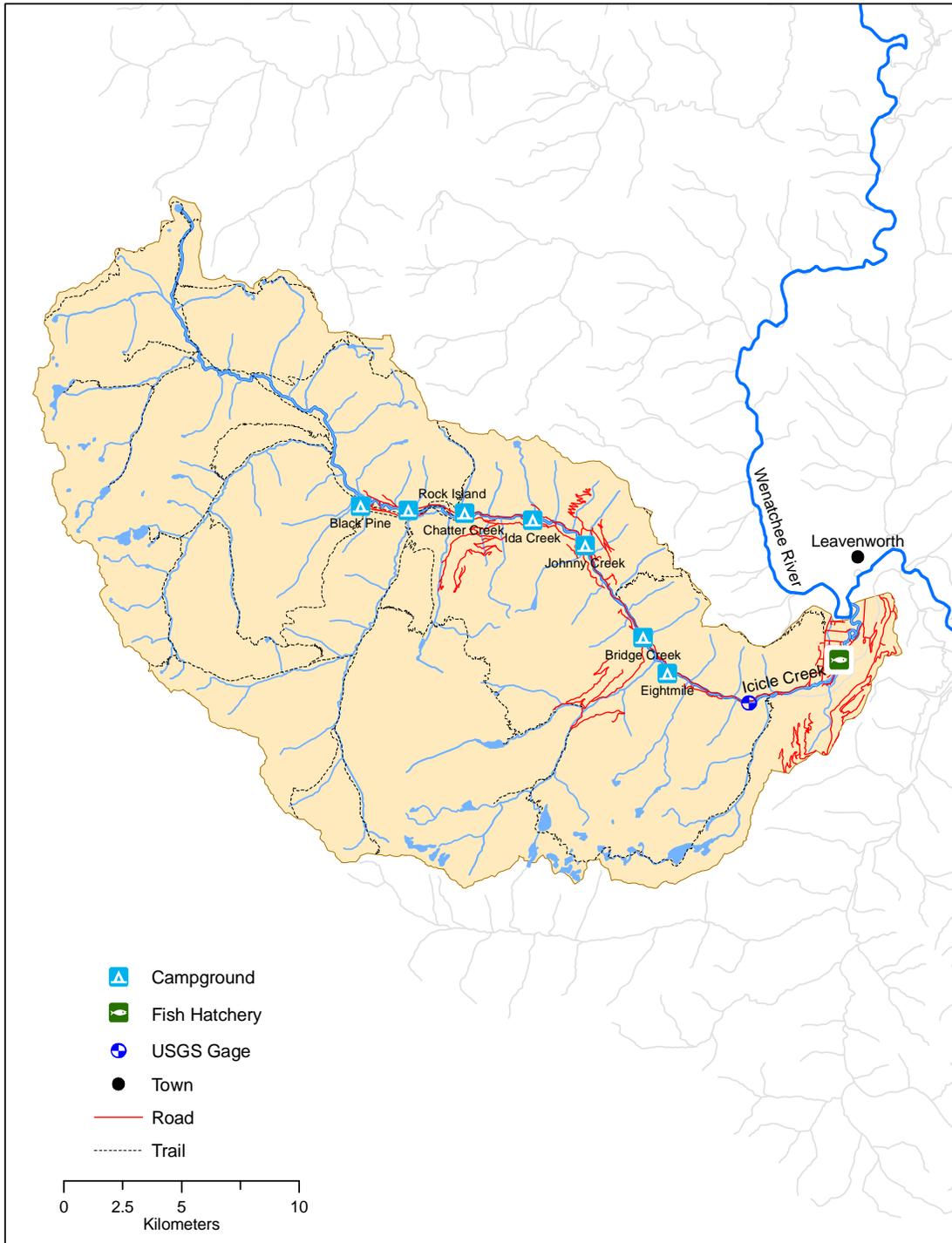


Figure 6. Locations of USFS campgrounds, Leavenworth NFH, USGS gage station, roads, and trails in the Icicle Creek watershed.

For descriptive purposes in this study, the boulder falls at approximately rkm 9.2 is considered the division between upper and lower Icicle Creek. Salmonines known to inhabit upper Icicle Creek are bull trout, brook trout *Salvelinus fontinalis*, hybrid bull trout x brook trout *S. confluentus x fontinalis*, westslope cutthroat trout *Oncorhynchus clarkii lewisi*, rainbow trout *O. mykiss*, and redband rainbow trout *O. mykiss gairdneri*. Salmonids found only in lower Icicle Creek include steelhead *O. mykiss*, spring and summer Chinook salmon *O. tshawytscha*, coho salmon *O. kisutch*, stray sockeye salmon *O. nerka*, and mountain whitefish *Prosopium williamsoni*. Non-salmonid species in Icicle Creek include northern pikeminnow *Ptychocheilus oregonensis*, longnose dace *Rhinichthys cataractae*, speckled dace *Rhinichthys osculus*, redband shiner *Richardsonius balteatus*, various sculpin species *Cottus* spp., and various sucker species *Catostomus* spp.

Methods

Capture

Bull trout were captured by angling with artificial lures and single barbless hooks and landed with a knotless hand net. Sub-adult or juvenile fluvial bull trout (generally < 450 mm; see Brown 1992) were measured (\pm 5 mm total length) and a genetic tissue sample was taken before release at the capture location. Bull trout only greater than 450 mm were selected for tagging in order to reduce potentially negative effects of the large transmitter in the body cavity of smaller fish (Chisholm and Hubert 1985, Paukert et al. 2001). Bull trout deemed suitable for radio-tagging were placed in perforated PVC tubes and tethered in a calm area of the river while the surgery field was prepared. Each capture site was geo-referenced using a hand held global positioning system (GPS) unit (GPSMap76, Garmin Corp.).

Radio transmitters and PIT tags

Radio tags implanted in the bull trout were Lotek Engineering model SR-M16-25 digitally-encoded radio transmitters using frequency 148.320 MHz. The radio tags contain a motion sensor, set to initiate a motionless code after 24 or 48 hours of inactivity. This model radio tag is 16 mm in diameter and 51 mm in length, weighs 17 g in air and has an expected battery life of 3 years at a 5 second burst rate. Each fish was also tagged with a passive integrated transponder (PIT) tag model TX1415 (3.4 x 23 mm) operating at 134.2 kHz.

Tag implantation procedure

Radio transmitters and PIT tags were surgically implanted in bull trout following the guidelines of Mulcahy (2003) and the methods described by Summerfelt and Smith (1990) and Ross and Kleiner (1982). All surgeries were performed when stream temperatures were less than 15°C.

Aseptic procedures were followed during surgery. This included triple wash and rinse of the surgeon's hands and arms with Purell® hand sanitizer (62% ethyl alcohol), use of sterile and doubled latex gloves, and an aseptic surgical field. Surgical instruments were steam sterilized using a pressure canner, and transmitters and PIT tags were gas sterilized by ethylene oxide. Seven sets of sterile surgical packs, each containing the necessary instruments and equipment for one implantation, were assembled and sterility was maintained by enclosing each pack in a series of waterproof zip lock type plastic bags. All surgeries were performed at the capture location.

Each fish was anesthetized for 8 – 10 minutes in a bath using a solution of 80 mg of tricaine methanesulfonate (MS-222) per L of H₂O and buffered with sodium bicarbonate to match the pH of the river water (Wedemeyer 1970). A battery operated bubbler was used to ensure the bull trout received adequate oxygen while in the anesthetic bath. Total length (\pm 1mm), weight (\pm 25g), and a genetic tissue sample were collected from each bull trout. While still in the bath, anesthetized bull trout were floated onto a foam surgical cradle designed to support the weight of the fish and prevent injury to the ribs and backbone during weighing and transport to and from the surgery table. The bull trout was oriented dorsal side down in the cradle while the gills were irrigated with a buffered solution of 40 mg of MS-222/L during surgery. The ventral body surface of the bull trout was rinsed of MS-222 with river water and a 40 mm incision was made immediately anterior to the pelvic girdle and approximately 10 mm lateral of the mid-ventral line.

A sterilized syringe was used to insert the PIT tag into the body cavity without contamination. A 1cc plastic tuberculin syringe was modified by removing and discarding the detachable needle and cutting the tip off. Since the PIT tag diameter matched the inside diameter of the syringe, it was placed inside the syringe and the plunger was used to insert the tag through the incision into the body cavity.

A modification of the shielded-needle method (Ross and Kleiner 1982) was used to insert the radio-tag and thread the antenna through the body wall of the bull trout. A hollow needle was constructed from a 14 gauge x 140 mm Radiopaque FEP I.V. catheter with the plastic tubing connector cut off. The shield was constructed from a plastic coffee straw with the ends rounded by a heat gun. Using the shielded hollow needle, the lateral body wall was punctured internally posterior to the incision. The shield was removed through the incision, the wire antenna end was threaded into the hollow needle and extended through the body wall, the needle was removed and the transmitter was inserted into the abdominal cavity. A sterile surgical drape was placed over the fish to reduce contamination of the suture material while the incision was closed in an interrupted pattern of 3 to 5 sutures tied with square surgeon knots. A FS-1 (24 mm) cutting needle and Ethicon™ absorbable ViaCryl 3-0 PDS II violet monofilament (Polydioxanone) suture material were used. Post surgery, tagged bull trout were allowed to recover from the anesthetic in a holding tube for at least 30 minutes and were released in an area of reduced water velocity and cover at the capture site, and if possible, monitored after release.

Monitoring of radio-tagged bull trout

Bull trout movements were recorded at fixed receiver telemetry stations and during mobile surveys. Telemetry receivers were programmed to also scan for radio-tagged bull trout from concurrent studies in the Upper Columbia Recovery Unit.

Fixed stations- Telemetry receivers (Lotek Wireless model SRX400 W7 or W31) equipped with antenna switching units (Lotek ASP-8 or Grant Engineering Hydra) and yagi-type antennas (Grant Engineering model 4LYVT) were used at fixed receiver telemetry stations. Solar panels (85 watt, Kyocera Solar, Inc.) equipped with charge controllers (SunSaver 10, Morningstar Corp.) were used to charge 12 V batteries at fixed stations. AC power was used to charge batteries connected to the receivers at six stations.

Fixed receiver telemetry stations were set up at key locations in Icicle Creek (Table 1, Figure 7). These locations, referenced by a two-letter code, were just upstream of the Icicle Creek confluence (IC) with the Wenatchee River, at the Leavenworth NFH spillway pool (LH), at the LNFH headgate (HG), at the City of Leavenworth water intake treatment building (WI) downstream of the boulder falls, and upstream above the boulder falls (AF). Two antennas were used at the LH station: LH1 monitored the Leavenworth NFH spillway pool and LH2 monitored structure 5 (see Figure 5).

Additional fixed receiver stations were located at other sites in the Wenatchee River basin (Table 2, Figure 7). On the Wenatchee River, the locations were Tumwater Dam (TUM), Dryden Dam (DD), and Wenatchee River County Park (WR). One station was on Chiwaukum Creek (CW) near the mouth and one station was on Peshastin Creek (PC) at the Yakama Nation Mid-Columbia Field Office.

Mobile surveys- Mobile telemetry surveys were conducted by foot and truck. For techniques used during in-stream foot surveys see Nelson (2004) and for truck surveys see Nelson (2006). Location coordinates were recorded with a GPS unit (GPSMap76, Garmin Corp.) or placed by hand on 1:24,000 USGS topographic maps. Data were recorded on daily tracking forms and in Rite-in-the-Rain field notebooks. GPS waypoints were downloaded into topographic mapping software (MapTech® Terrain Navigator 2002) and the marker files were exported into GIS (ESRI™ ArcGIS® v9.2) for creation of maps. The river mile (rm) of a location was determined in one of three ways: 1) interpolation from mile markers on USGS 1:24,000 topographic maps, 2) approximated using the linear distance tool in MapTech® Terrain Navigator, and 3) from established locations in an index (CBIACHS 1964). Therefore, the river mile designated at locations in this study may differ from those used in other documents or by other agencies. River miles were converted to river kilometers (rkm). Telemetry data were entered into a relational database (Microsoft Office Access) and paper copies archived at the Mid-Columbia River Fishery Resource Office.

Table 1. Fixed receiver telemetry stations operated during 2010 at locations on Icicle Creek.

Station	rkm	Dates operated	Notes
IC	0.8	1/1 – 12/31	At Two Rivers Farm
LH	4.3	1/1 – 12/31	At Leavenworth NFH: 2 antennas LH1 – spillway pool, LH2 – structure 5
HG	6.3	8/24-11/19	Mounted on LNFH headgate structure Monitored pool below headgate
WI	9.1	1/1 – 12/31	Downstream of boulder falls at City of Leavenworth water intake treatment facility
AF	9.3	1/1 – 12/31	Upstream of boulder falls at City of Leavenworth intake building

Table 2. Additional fixed receiver telemetry stations operated during 2010 at locations on the Wenatchee River, Chiwaukum Creek, and Peshastin Creek.

Station	rkm	Dates operated	Notes
CW	0.1	7/6 – 10/25	At mouth of Chiwaukum Creek also monitored Wenatchee R. (rkm 57.8)
TUM	52.6	1/1 – 12/31	At Tumwater Dam on Wenatchee River 1 ant. upstream; 1 ant. downstream
DD	28.3	1/1-12/31	At Dryden Dam on Wenatchee River 1 ant. upstream; 1 ant. downstream
WR	12.5	1/1 – 12/31	At Wenatchee River County Park on Wenatchee River
PC	3.4	1/1 – 12/31	At Yakama Nation Mid-Columbia Field Station on Peshastin Creek

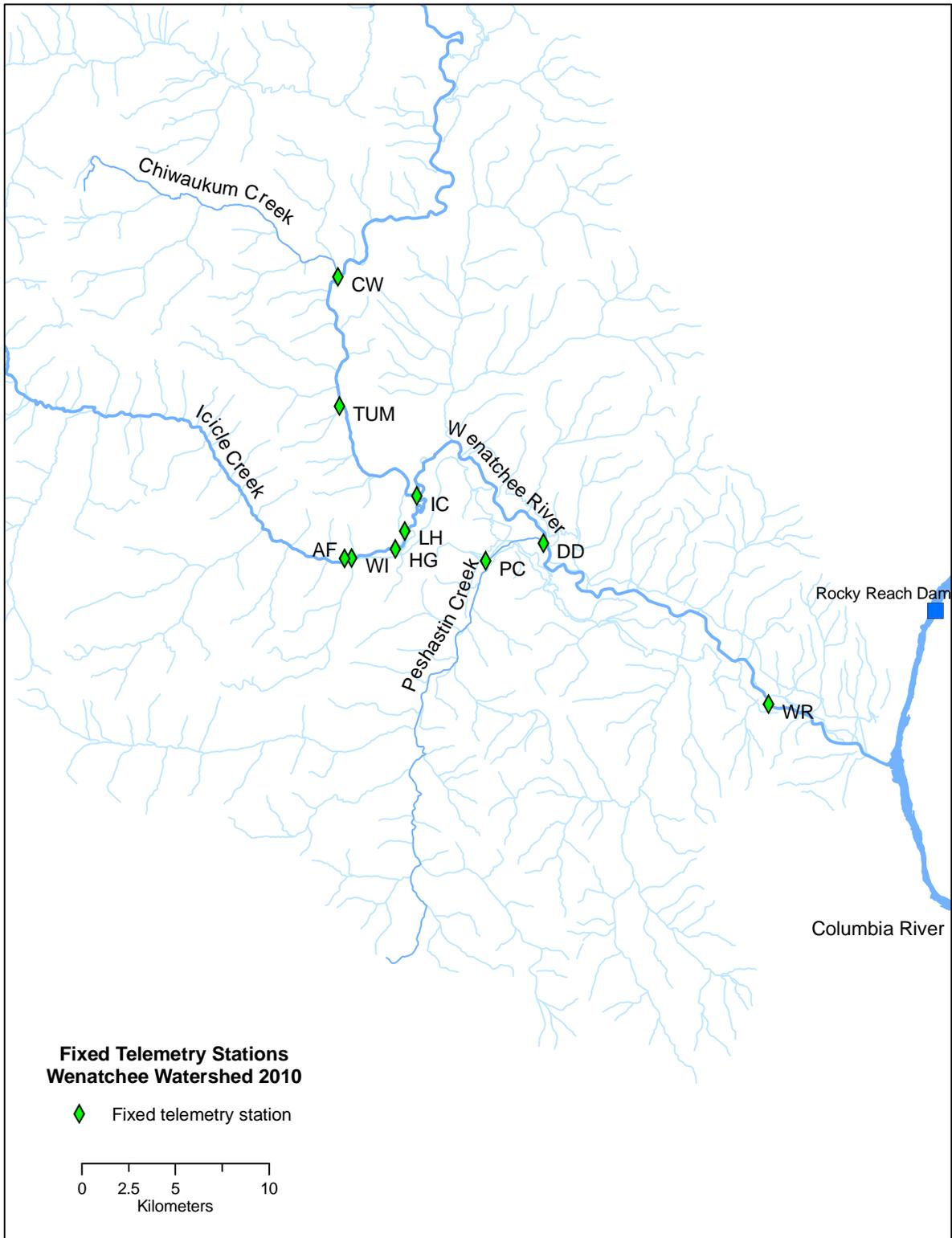


Figure 7. Map of the locations of fixed receiver telemetry stations in Icicle Creek, Wenatchee River, Chiwaukum Creek, and Peshastin Creek in 2010.

Spawning ground surveys

Spawning ground surveys were conducted by experienced observers in Icicle Creek (rkm 29.1 to 34.7) and French Creek (rkm 0.0 to 7.2). The surveys in French Creek were partitioned into three reaches based on hiking distance and recognizable tributaries as definition of the reach breaks: Reach A (rkm 0 to 3.2), Reach B (rkm 3.2 to 5.6) and Reach C (rkm 5.6 to 7.2). Redds were categorized as definite, probable, or possible, with only definite and probable redds included in the final count (Bonar et al. 1997). Redd dimensions were measured with a wading staff graduated in 0.05 m increments; locations were geo-referenced with GPS units (Rino530HCx®, Garmin Corp.), and waypoints downloaded onto a digital topographic map (MapTech® Terrain Navigator 2002). Redd area (m²) was approximated as length multiplied by width.

Discharge data

Discharge data were obtained from the USGS stream flow monitoring network for stations 12457000 Wenatchee River at Plain and 12458000 Icicle Creek above Snow Creek near Leavenworth (USGS 2010) and the Washington Department of Ecology (WDOE) stream flow monitoring network for station 45G060 Chiwaukum Creek near mouth (WDOE 2010).

Water temperature

The water temperature data in Icicle Creek were obtained from an ongoing USFWS temperature monitoring program (Hall and Kelly Ringel 2011). The water temperature data from the Wenatchee River at Tumwater Dam were recorded and provided by Washington Department of Fish and Wildlife (WDFW). Chiwaukum Creek water temperature data were recorded and provided by WDOE at station 45G060.

Bull trout counts at Tumwater Dam

Daily counts of bull trout passing Tumwater Dam were recorded and provided by WDFW. Daily counts of other salmonids at Tumwater Dam were downloaded from the Columbia River Data Access in Real Time website (DART 2010).

Results

Angling and capture of bull trout- Angling for bull trout occurred over two periods in Icicle Creek in 2010. Angling occurred in the historic channel of lower Icicle Creek (rkm 4.6 to 6.1) on 6 dates from June 23 to July 8 and no bull trout were caught during 16.5 angler hours. Angling resumed in late August when the Leavenworth NFH spillway pool (rkm 4.3) was fished on August 23 and the Leavenworth NFH headgate (rkm 6.1) on August 27. During 3 angler hours in the spillway pool, 8 bull trout were caught (cpue = 2.67 bull trout/hour), including 3 adults and 5 subadults (Table 3, Figure 8). During 1.5 angler hours at the headgate, 2 bull trout were captured (cpue = 1.33) and both were subadults (Table 3, Figure 8). The Boulder Falls area (rkm 9.2) was fished on August 27 and no bull trout were captured during 2.25 angler hours.

Several bull trout were observed in Icicle Gorge (rkm 26.2) during a snorkel survey conducted by the Wild Fish Conservancy on August 17. On August 24, we angled in the gorge and caught 10 bull trout during 5.5 angler hours (cpue = 1.82). Lengths of these bull trout ranged from 270 to 360 mm, indicating all were subadults (Table 3, Figure 8).

Tissue samples were collected from all captured bull trout, given a sample number, and archived for future genetic analyses (Table 3).

Table 3. Date, capture location, river kilometer (rkm), life stage, total length, and genetic sample number of all bull trout caught during angling in Icicle Creek during 2010.

Date	Location	Rkm	Life stage	Total Length (± 5 mm)	Sample #
8/23/2010	Spillway pool	4.3	Subadult	390	878-013
8/23/2010	Spillway pool	4.3	Subadult	370	878-014
8/23/2010	Spillway pool	4.3	Subadult	430	878-015
8/23/2010	Spillway pool	4.3	Adult (code 29)	580	878-016
8/23/2010	Spillway pool	4.3	Subadult	410	878-017
8/23/2010	Spillway pool	4.3	Subadult	280	878-018
8/23/2010	Spillway pool	4.3	Adult (code 27)	457	878-019
8/23/2010	Spillway pool	4.3	Adult (code 28)	530	878-020
8/24/2010	Icicle Gorge	26.2	Subadult	340	878-001
8/24/2010	Icicle Gorge	26.2	Subadult	325	878-002
8/24/2010	Icicle Gorge	26.2	Subadult	270	878-003
8/24/2010	Icicle Gorge	26.2	Subadult	320	878-004
8/24/2010	Icicle Gorge	26.2	Subadult	310	878-005
8/24/2010	Icicle Gorge	26.2	Subadult	340	878-006
8/24/2010	Icicle Gorge	26.2	Subadult	360	878-007
8/24/2010	Icicle Gorge	26.2	Subadult	330	878-008
8/24/2010	Icicle Gorge	26.2	Subadult	350	878-009
8/24/2010	Icicle Gorge	26.2	Subadult	360	878-010
8/27/2010	Headgate Pool	6.1	Subadult	220	878-011
8/27/2010	Headgate Pool	6.1	Subadult	250	878-012

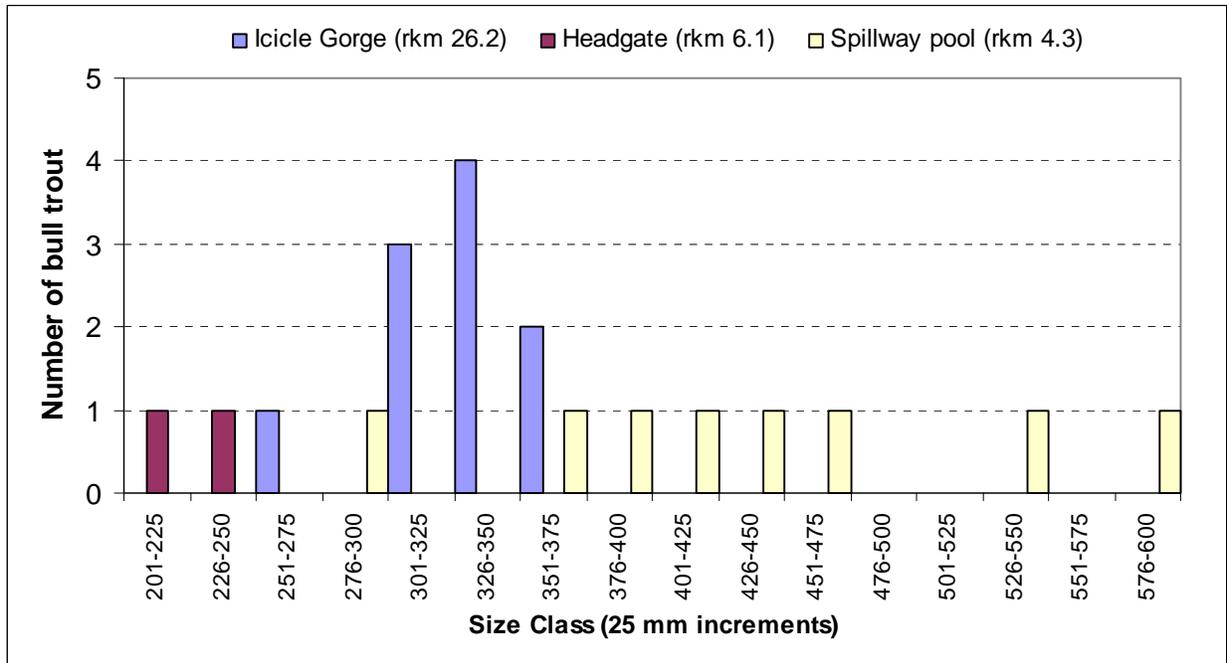


Figure 8. Number of bull trout in each size class (25mm increments) of bull trout caught in Icicle Creek during 2010.

Radio-tagging

Number tagged- The three adult bull trout caught in Icicle Creek at the Leavenworth NFH spillway pool (rkm 4.3) on August 23, 2010 were implanted with radio transmitters.

Morphometrics of tagged bull trout- Sizes of tagged adult bull trout ranged from 457 to 580 mm and weights ranged from 960 to 2260 g (Table 4, Figure 9).

Table 4. Radio transmitter code, capture location and rkm, weight, total length, and condition factor (K) of adult bull trout radio-tagged in lower Icicle Creek during 2010.

Code	Date	Location	Rkm	Weight (g)	Total length (mm)	K
27	08/23/10	Spillway Pool	4.3	960	457	1.01
28	08/23/10	Spillway Pool	4.3	1420	530	0.95
29	08/23/10	Spillway Pool	4.3	2260	580	1.16

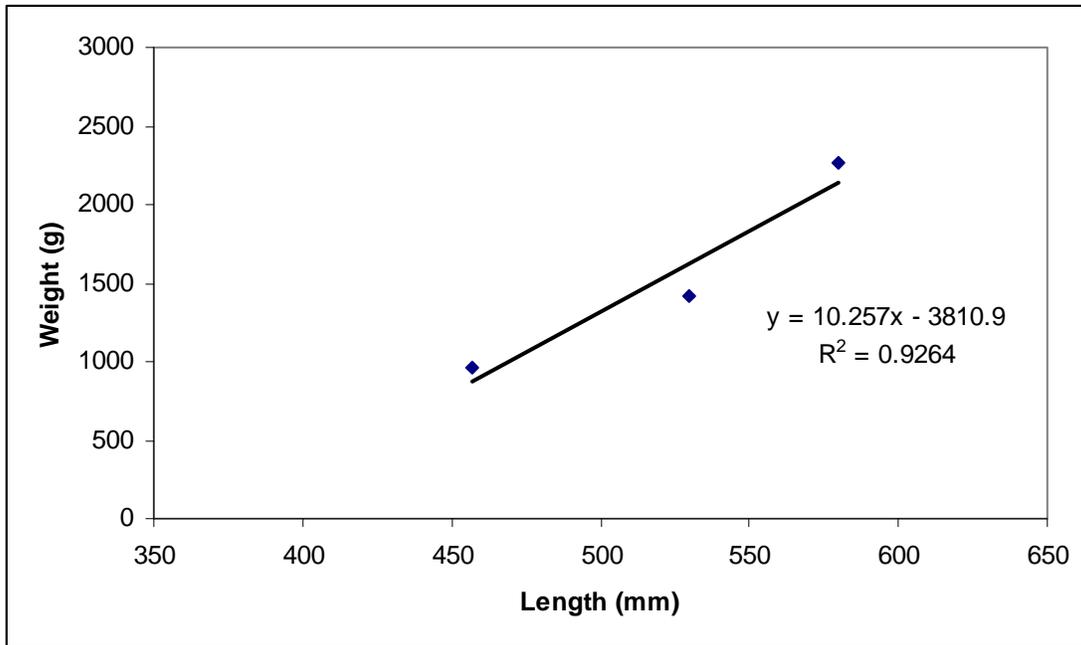


Figure 9. The weight versus length relationship for the three adult bull trout radio tagged in lower Icicle Creek during 2010.

Radio-tracking

Number of bull trout tracked- Six bull trout tagged in 2009 and three bull trout tagged in 2010 were radio-tracked during 2010.

Movements

None of the bull trout tagged in 2009 migrated back into Icicle Creek during 2010. Instead, four bull trout migrated to spawning areas in other local populations, including one each to Etienne Creek, Chiwaukum Creek, Nason Creek, and upper Entiat River (Figure 10). One bull trout moved to the middle Wenatchee River where it spent the summer. One bull trout shed its radio transmitter but the PIT tag was detected as the fish migrated upstream through Tumwater Dam. After exiting Icicle Creek, the three bull trout tagged in 2010 either shed their tags or died. The movements of individual bull trout are detailed in the following section and their detections at fixed telemetry stations are summarized in a later section.

Movements of individual bull trout

Code 24 (Figure 11)- Bull trout code 24 was tagged in lower Icicle Creek on July 20, 2009 (see Nelson et al. 2011 for details on its movements during 2009). After spending the winter of 2009/2010 in the Columbia River (rkm 750) it was the first tagged bull trout to migrate into the Wenatchee River in the spring. It entered the river before peak discharge and passed the WR station (rkm 12.5) on May 10, 2010 (Figure 12). It quickly moved upstream and passed Dryden Dam (rkm 28.3) on May 13. It remained upstream of Dryden Dam until after the highest peak discharge declined (Figure 12). Code 24 then entered Peshastin Creek and passed the PC station (rkm 3.4) on May 28 when discharge was 490 ft³/s and mean water temperature was 7.2 °C (Figure 13). Discharge increased to as high as 850 ft³/s while code 24 slowly migrated upstream in Peshastin Creek until June 29, when it was detected in the waterfall pool at the mouth of Etienne Creek at rkm 16.6 of Peshastin Creek (Figure 14).

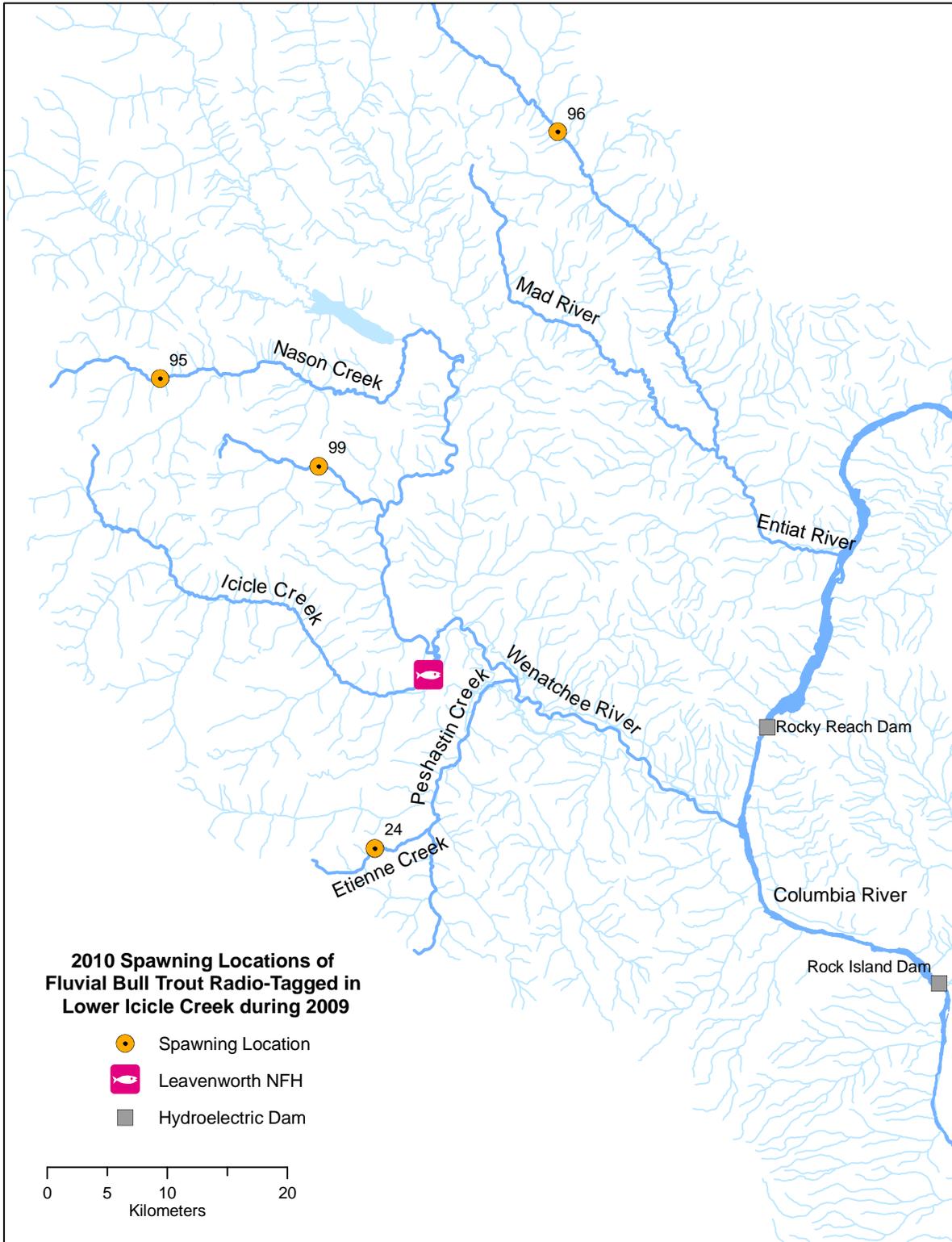


Figure 10. Map of 2010 spawning locations of adult fluvial bull trout that were radio-tagged in lower Icicle Creek during 2009.

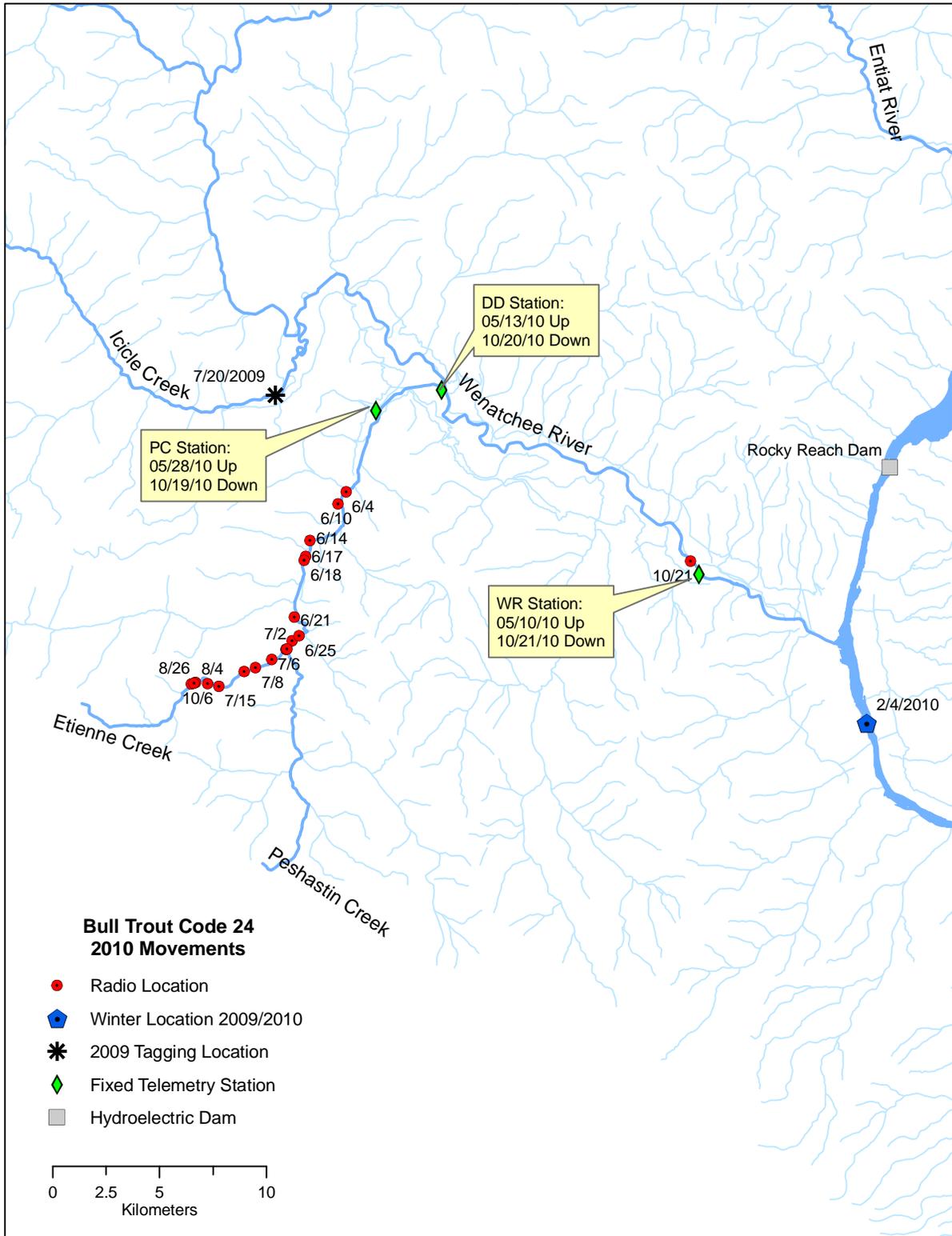


Figure 11. Map of the movements of fluvial bull trout code 24 during 2010.

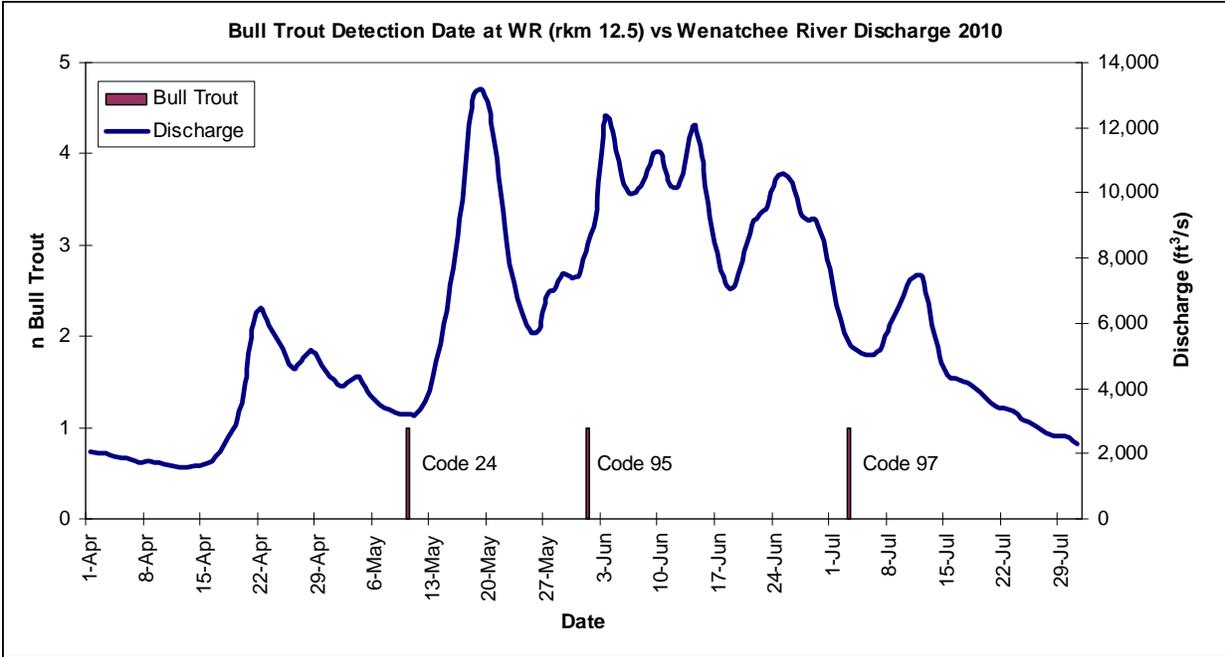


Figure 12. Wenatchee River discharge and dates that radio-tagged adult bull trout migrated upstream past the WR fixed telemetry station (rkm 12.5) during 2010.

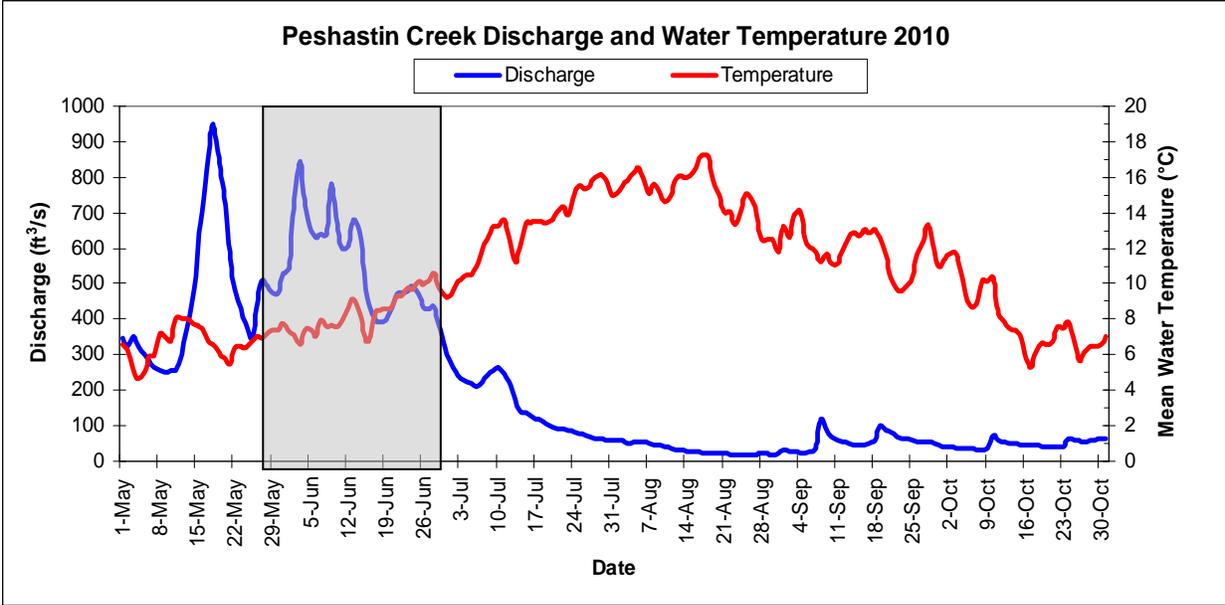


Figure 13. Peshastin Creek discharge and water temperature from May 1 to October 31, 2010 (gray shaded area represents time frame that bull trout code 24 migrated upstream in Peshastin Creek to Etienne Creek).



Figure 14. Waterfall and pool located at the mouth of Etienne Creek, June 29, 2010.

On July 6, code 24 was located in Etienne Creek at rkm 1. It slowly moved upstream until it encountered a boulder waterfall at rkm 5.6, which was apparently impassable due to the impediment height and shallow pool depth (Figure 15). It was detected just downstream of this location from August 4 until October 6. Three small incomplete redds or test digs were observed in the vicinity of the fish on October 6; these were unchanged on October 13, when code 24 had moved downstream and was detected in a boulder cascade area at rkm 4.9, and it is unknown if it successfully spawned. (However, two resident bull trout (250mm ♀ and 300mm ♂) were observed constructing a redd at rkm 5.3 on October 7 - the first documentation of bull trout actively spawning in Etienne Creek.) Code 24 continued downstream and was detected passing the PC station on October 19, the DD station on October 20, and the WR station on October 21. It entered the Columbia River but its winter location was not determined.

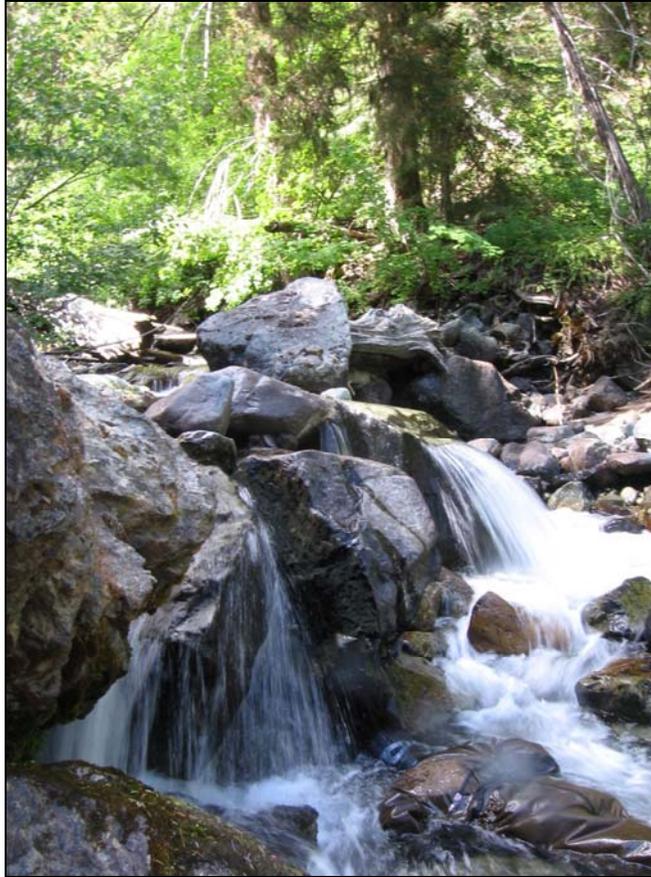


Figure 15. Waterfall impediment to further upstream movement of bull trout code 24 at rkm 5.6 of Etienne Creek, August 4, 2010.

Code 95 (Figure 16)- Bull trout code 95 was radio-tagged in lower Icicle Creek on August 11, 2009. It spent the winter of 2009/2010 in the Columbia River at rkm 758. In the spring it moved up the Wenatchee River after peak discharge and migrated past the WR station (rkm 12.5) on June 1 (Figure 12) and the DD station (rkm 28.3) on June 17, 2010. It was located downstream of Exit Drop Rapids at the mouth of Tumwater Canyon (rkm 44.3) on June 30 to July 4, when it paused its migration due to high discharge and turbulent whitewater conditions (Figures 17 and 18). Wenatchee River discharge declined from 6,500 ft³/s to 3,500 ft³/s and on July 6, code 95 was located upstream of the rapids (Figure 19). Code 95 continued its upstream migration and arrived at Tumwater Dam on July 8. It passed the dam on July 19 and continued upstream in the Wenatchee River past the CW station (at the mouth of Chiwaukum Creek at rkm 57.8) on July 21. It migrated to Nason Creek and was located at rkm 16 on August 4. It continued upstream and from August 16 to September 20, code 95 was located at rkm 31.5, where it was observed paired with an adult fluvial bull trout on spawning gravel on September 15. Rains increased discharge and turbidity immediately after this observation and a definite redd could not be confirmed at the site. However, this is the first observation of reproductive behavior of bull trout in Nason Creek downstream of Mill Creek. Code 95 moved downstream and on September 24 it was located in the vicinity of White Pine Creek (rkm 25.7). It migrated downstream past Tumwater Dam on October 4, past Dryden Dam on October 21, and exited the Wenatchee River after it passed the WR station on October 24. Its winter location in the Columbia River during 2010/2011 was not determined.

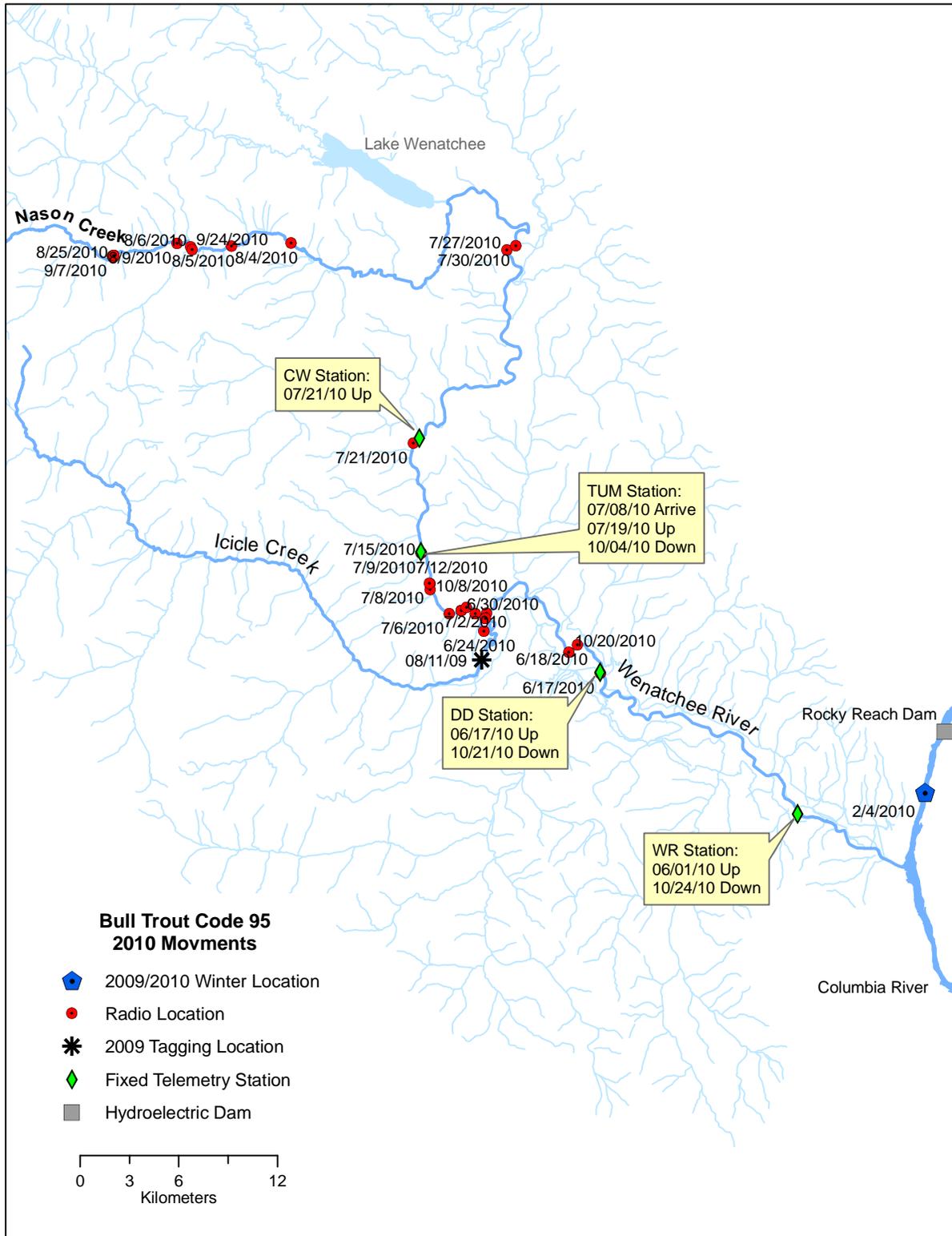


Figure 16. Map of the movements of fluvial bull trout code 95 during 2010.

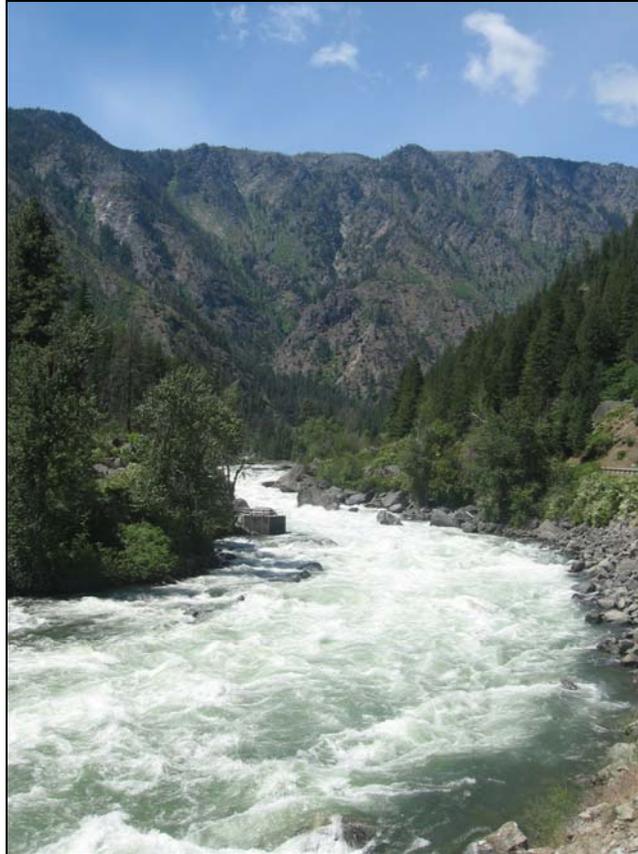


Figure 17. Exit Drop Rapids on Wenatchee River at mouth of Tumwater Canyon (rkm 44.3), June 29, 2010.



Figure 18. Close-up view of Exit Drop Rapids on Wenatchee River, showing turbulent white water conditions ($6500 \text{ ft}^3/\text{s}$) while two radio-tagged bull trout held downstream, June 30, 2010.

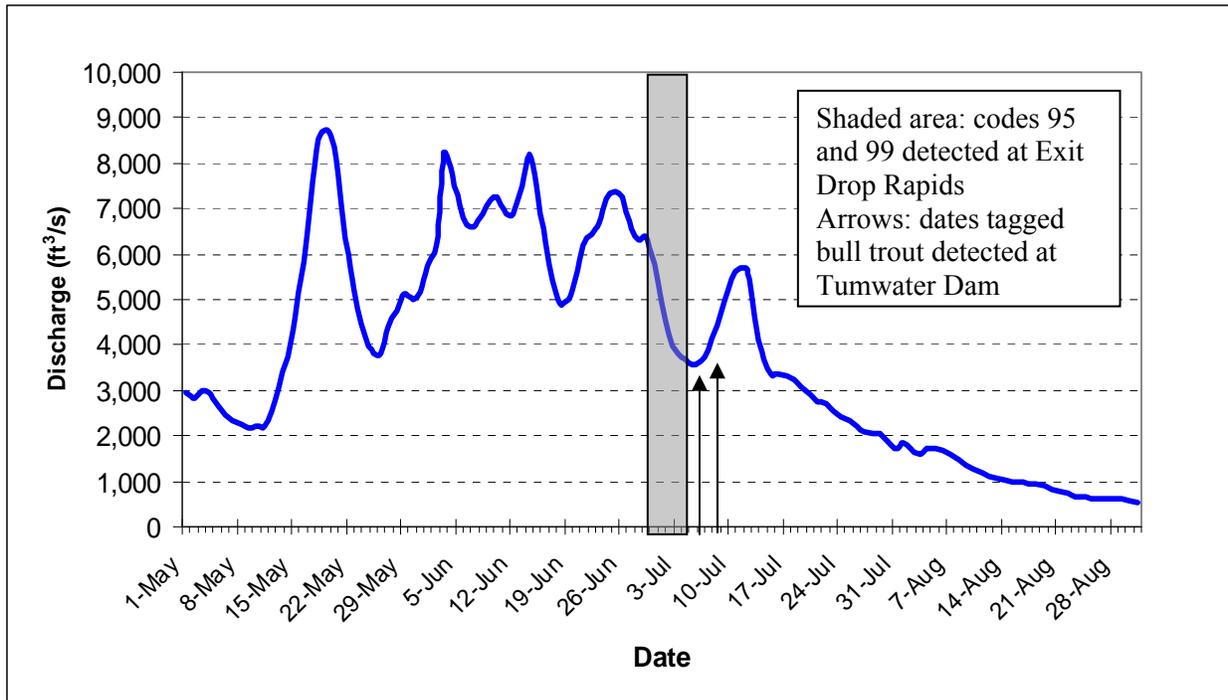


Figure 19. Wenatchee River discharge during the period that two radio-tagged bull trout were holding downstream until they passed Exit Drop Rapids (shaded area) and the dates they were detected at Tumwater Dam (arrows).

Code 96 (Figure 20)- Bull trout code 96 was radio-tagged in lower Icicle Creek on August 11, 2009 (see Nelson et al. 2011). It spent the winter of 2009/2010 at an unknown location in the Rock Island reservoir of the Columbia River. On June 9, 2010, it migrated upstream in the Columbia River and was detected by the PIT antenna in the fish ladder at Rocky Reach Dam (rkm 762.3). Code 96 migrated into the Entiat River and passed the EM station (rkm 0.4) on June 13. It was located near the station until late June before moving upstream on July 2. Code 96 migrated to the upper Entiat River and was detected in Box Canyon (rkm 46.7) from August 6 to August 28, when it jumped Fish Tail Falls and passed the BC station (rkm 47). On September 10, code 96 was detected at Entiat Falls (rkm 54.4) and was located on the spawning grounds until October 9, when it migrated downstream past the BC station. It moved downstream and passed the MD station (rkm 16.7) on October 15 and exited the Entiat River on November 4. Its winter location in the Columbia River was not determined in 2010/2011.

Code 97 (Figure 21)- Bull trout code 97 was radio-tagged in lower Icicle Creek on September 28, 2009 (see Nelson et al. 2011). It spent the winter of 2009/2010 at rkm 751 of the Columbia River, downstream of the Wenatchee River confluence. It migrated up the Wenatchee River and passed the WR station (rkm 12.5) on July 3. It slowly moved upstream and passed Dryden Dam (rkm 28.3) on July 27. It was detected by the TUM station at Tumwater Dam (rkm 52.6) on August 12 but did not pass the dam (see Tumwater Dam section below). It moved a short distance downriver and was located in the vicinity of rkm 49 of the Wenatchee River until

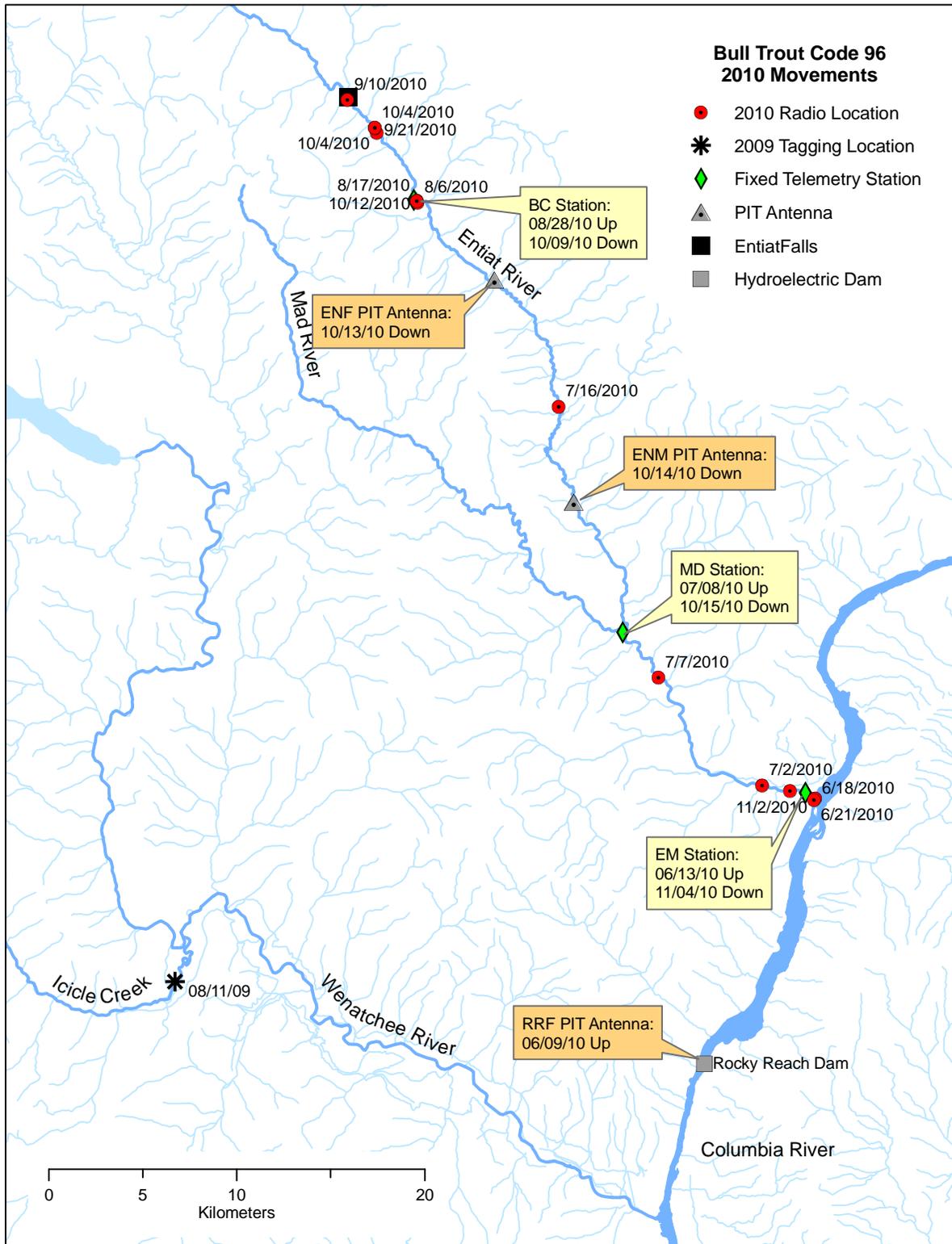


Figure 20. Map of the movements of fluvial bull trout code 96 during 2010.

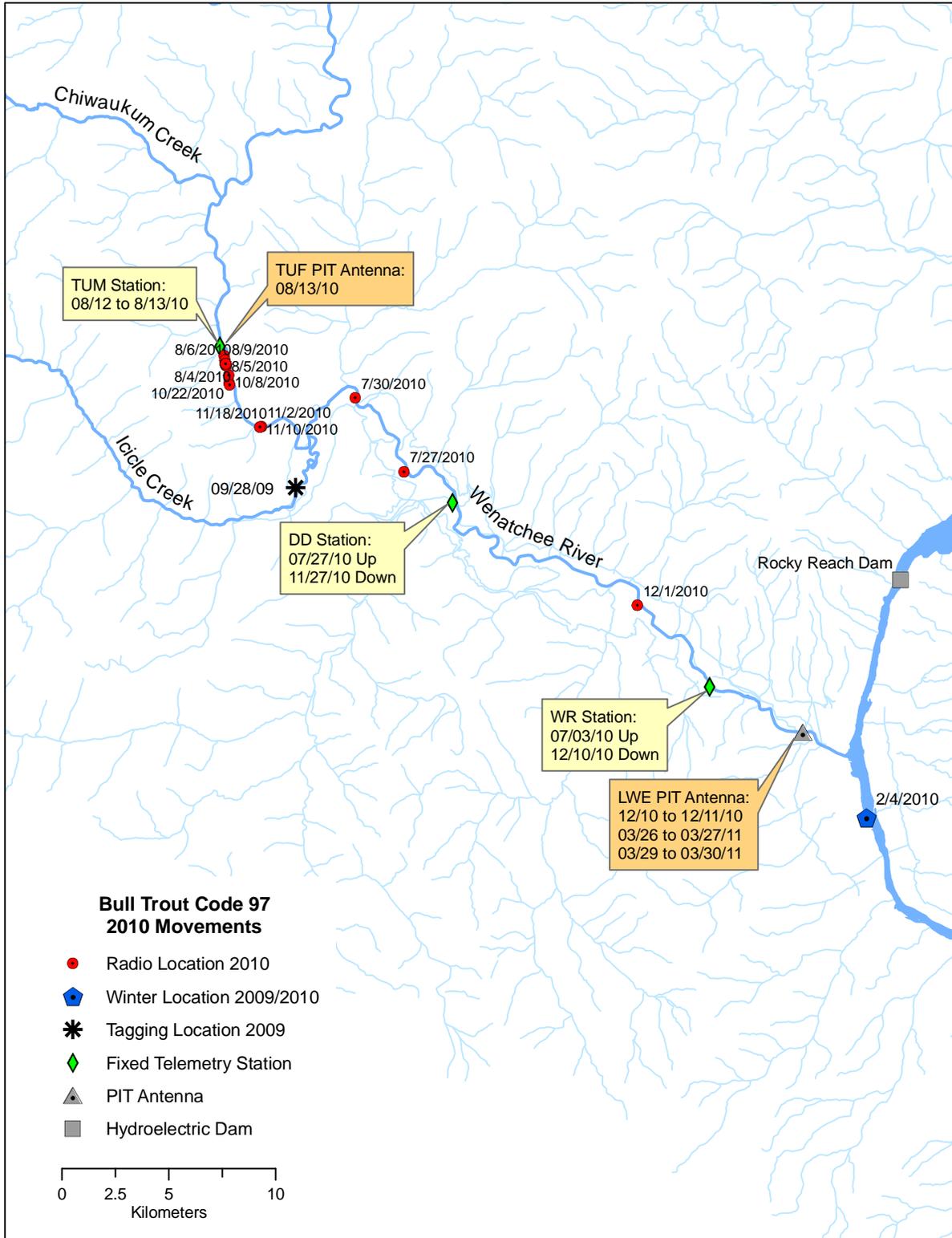


Figure 21. Map of the movements of fluvial bull trout code 97 during 2010.

October 22. It slowly moved downstream and passed Dryden Dam on November 27 and the WR station on December 10. In late March 2011, it was detected at the LWE PIT array (rkm 2), where 9170 PIT detections were tallied from March 26 – 30, perhaps indicating it was foraging in the area.

Code 98 (Figure 22)- Bull trout code 98 was tagged in lower Icicle Creek on September 25, 2009 (see Nelson et al. 2011). After exiting Icicle Creek in 2009, code 98 wintered in the Wenatchee River at rkm 42.3, upstream of the Icicle Creek confluence. It was located in this area until May 28, 2010 when the motionless signal was transmitted. On July 8, however, the PIT tag was detected by the PIT antenna in the fish ladder at Tumwater Dam, indicating that the transmitter was shed before the bull trout migrated upstream. The PIT tag of code 98 was not detected at any of the upper Wenatchee River PIT antennas, suggesting it migrated into Chiwaukum Creek. The PIT tag was not detected during the outmigration period, indicating the bull trout either overwintered upstream of a PIT array or that its PIT tag may have been shed during spawning.

Code 99 (Figure 23)- Bull trout code 99 was tagged in lower Icicle Creek on September 28, 2009 (see Nelson et al. 2011). During the winter of 2009/2010 it was located in the Wenatchee River at rkm 33.8. It was detected at this location until May 19, 2010 when it moved upstream. The detection distance for this bull trout was limited due to the broken transmitter antenna and the fish was not detected again until June 24, when it was located near the confluence of Icicle Creek. On June 30, code 99 was located downstream of Exit Drop Rapids at the mouth of Tumwater Canyon. As with code 95, the turbulent whitewater at high discharge (Figures 17 and 18) delayed its upstream migration until discharge dropped from 6500 to 3500 ft³/s (Figure 19). Code 96 was detected at Tumwater Dam on July 6 and passed the dam on July 8. It migrated into Chiwaukum Creek and passed the CW station (rkm 0.1) on July 12 when stream discharge was 250 ft³/s and the mean water temperature was 10.6 °C. It was located at rkm 6.8 in the spawning reach of Chiwaukum Creek during foot surveys on August 5 and September 2. Code 99 exited the creek on September 13 when stream discharge was 32 ft³/s and the mean water temperature was 10.4 °C. Code 99 was located in the Wenatchee River upstream of Tumwater Dam at several locations near rkm 51 during mobile surveys during fall. It never approached the dam but instead moved upstream to large pool at rkm 52.9, where it overwintered.

Code 27 (Figure 24)- Bull trout code 27 was tagged in the Leavenworth NFH spillway pool of lower Icicle Creek on August 23, 2010. It was detected in the spillway pool until August 27, when it moved downstream and exited Icicle Creek. It quickly moved downstream in the Wenatchee River and passed the DD station at Dryden Dam (rkm 28.3) on August 29 and the WR station (rkm 12.5) on August 31. Code 27 was detected in the Wenatchee River at rkm 7.7 on September 20. On September 24 it transmitted the inactive signal at this location, but on September 28 the inactive signal was detected further downstream at rkm 6.4 in a deep pool. The tag could not be recovered and the signal disappeared later in the fall. Although the fate of the bull trout could not be determined, circumstances suggest the transmitter may have malfunctioned.

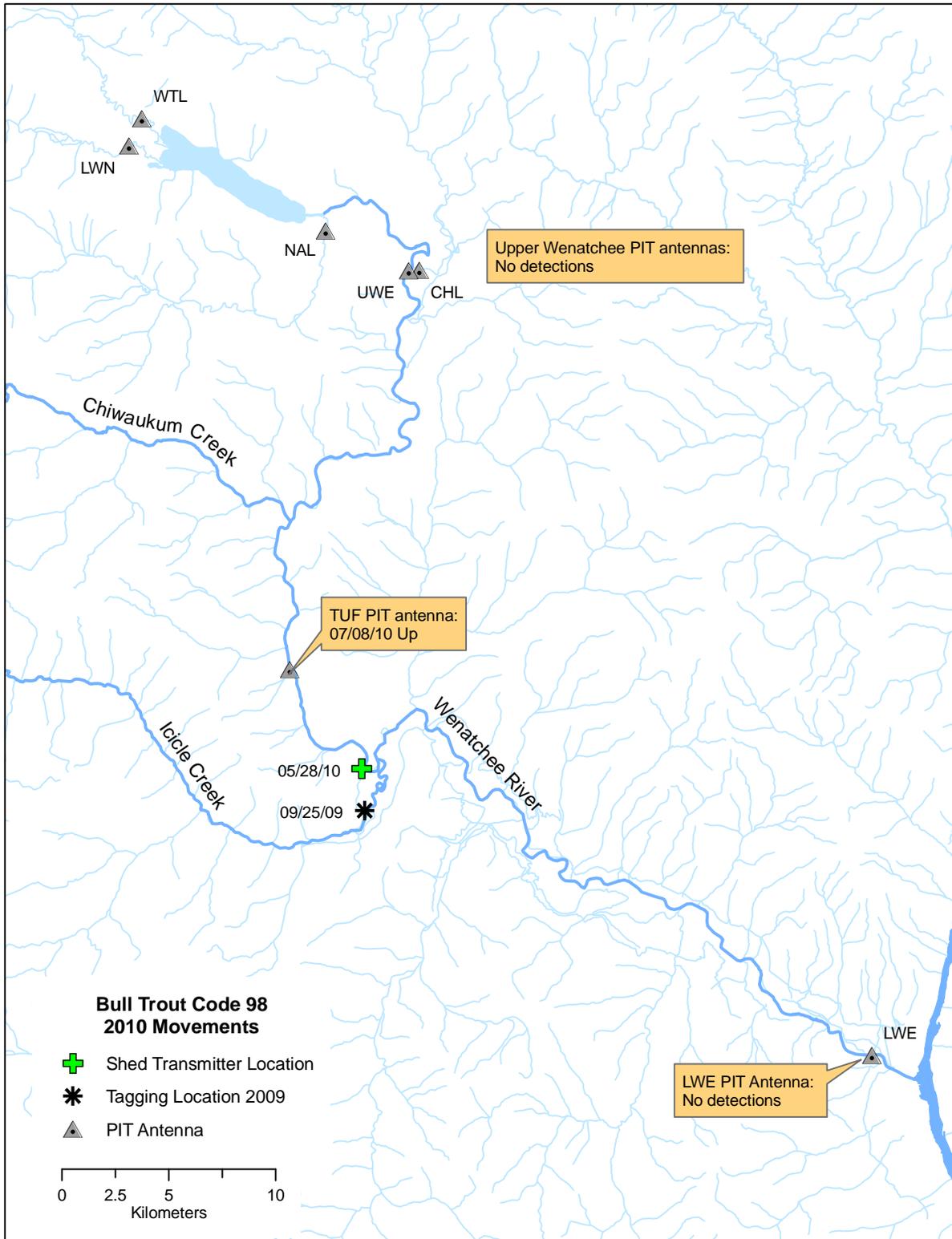


Figure 22. Map of the movements of fluvial bull trout code 98 during 2010.

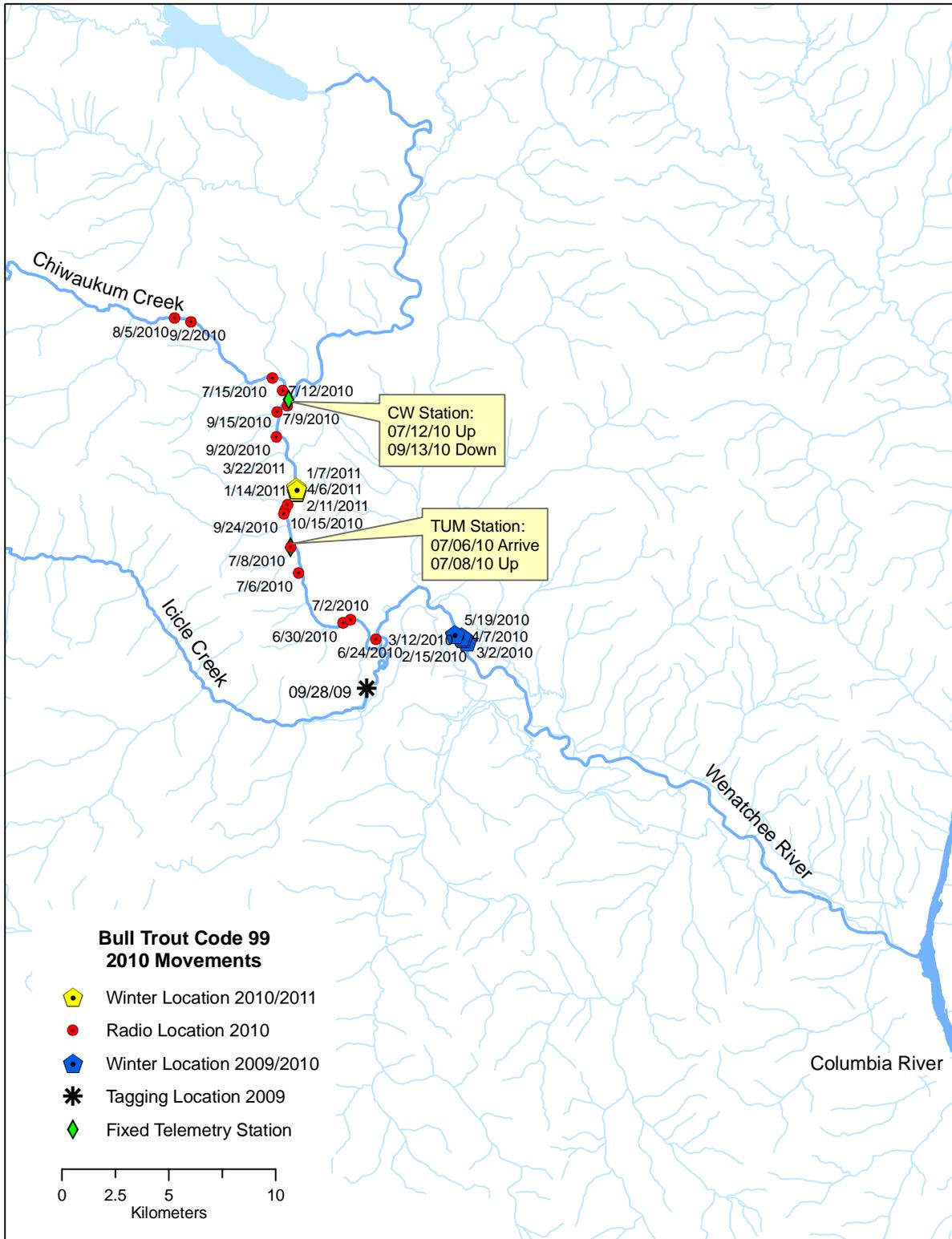


Figure 23. Map of the movements of fluvial bull trout code 99 during 2010.

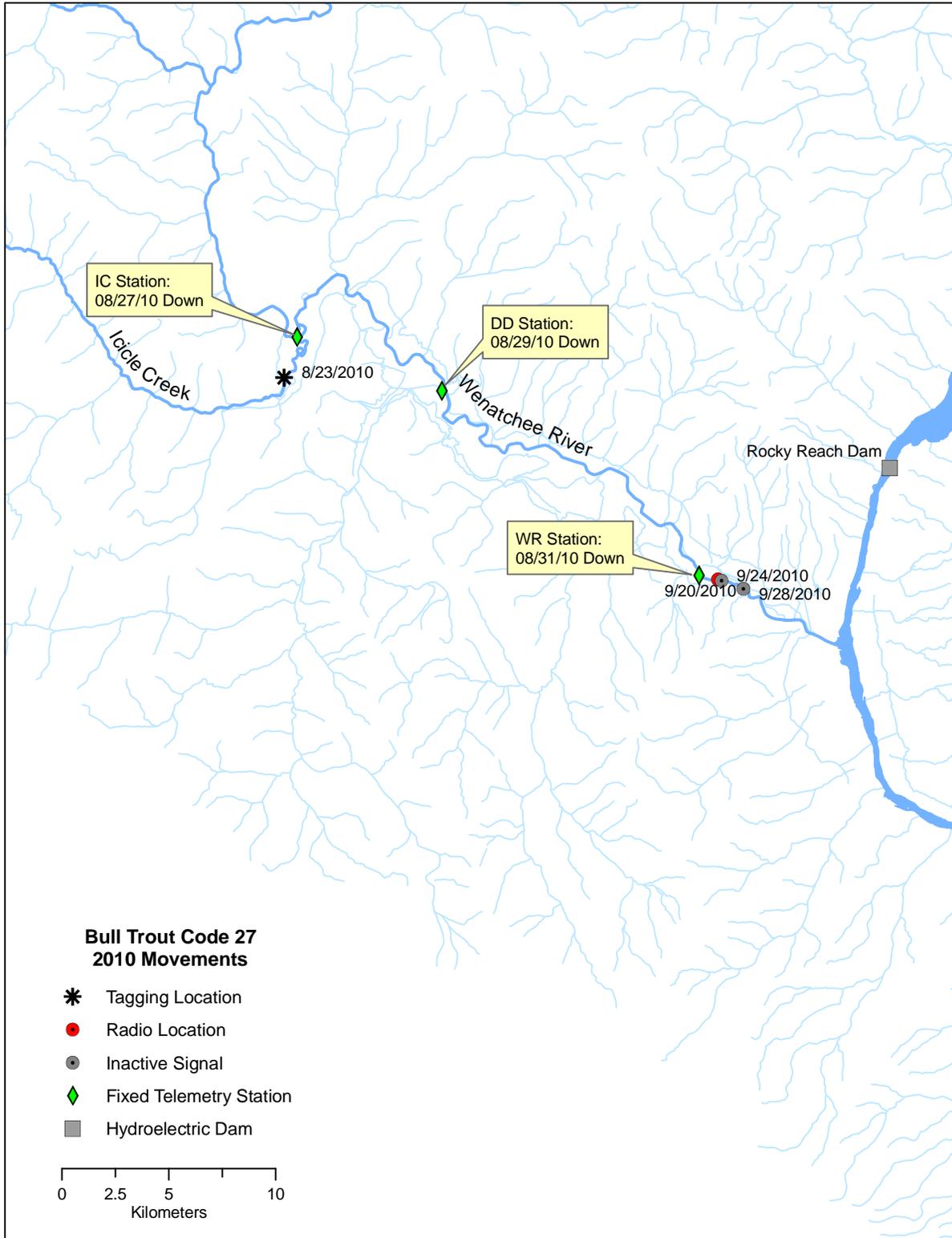


Figure 24. Map of the movements of fluvial bull trout code 27 during 2010.

Code 28 (Figure 25)- Bull trout code 28 was tagged in the Leavenworth NFH spillway pool of lower Icicle Creek (rkm 4.3) on August 23, 2010. It was detected in the spillway pool until it moved downstream and passed the IC station on September 3 as it exited Icicle Creek. On September 7, the motionless signal was transmitted at rkm 38.3 of the Wenatchee River. The carcass was recovered from under a boulder at 1 m water depth near the bank. It appeared the bull trout swam under the boulder and died. The autopsy revealed the fish was an immature male with undeveloped testes. There were no obvious signs of injury or marks on the body, but saprolegnia mold was present in small patches on the fins and incision area. The internal organs showed no obvious internal cuts or wounds from the implantation surgery and the stomach was empty. The cause of the death is unknown.

Code 29 (Figure 26)- Bull trout code 29 was tagged in the Leavenworth NFH spillway pool on August 23, 2010. It was detected in the spillway pool until it moved downstream and passed the IC station (rkm 0.8) on September 8 as it exited Icicle Creek. During a mobile survey on September 20 it was detected in the Wenatchee River at rkm 31.9. On September 24, the inactive signal was transmitted at rkm 31. On September 27, the transmitter was recovered from mid-channel where it was laying on sand substrate in a moderately fast run. Circumstances indicate the tag was shed but the fate of the bull trout is unknown.

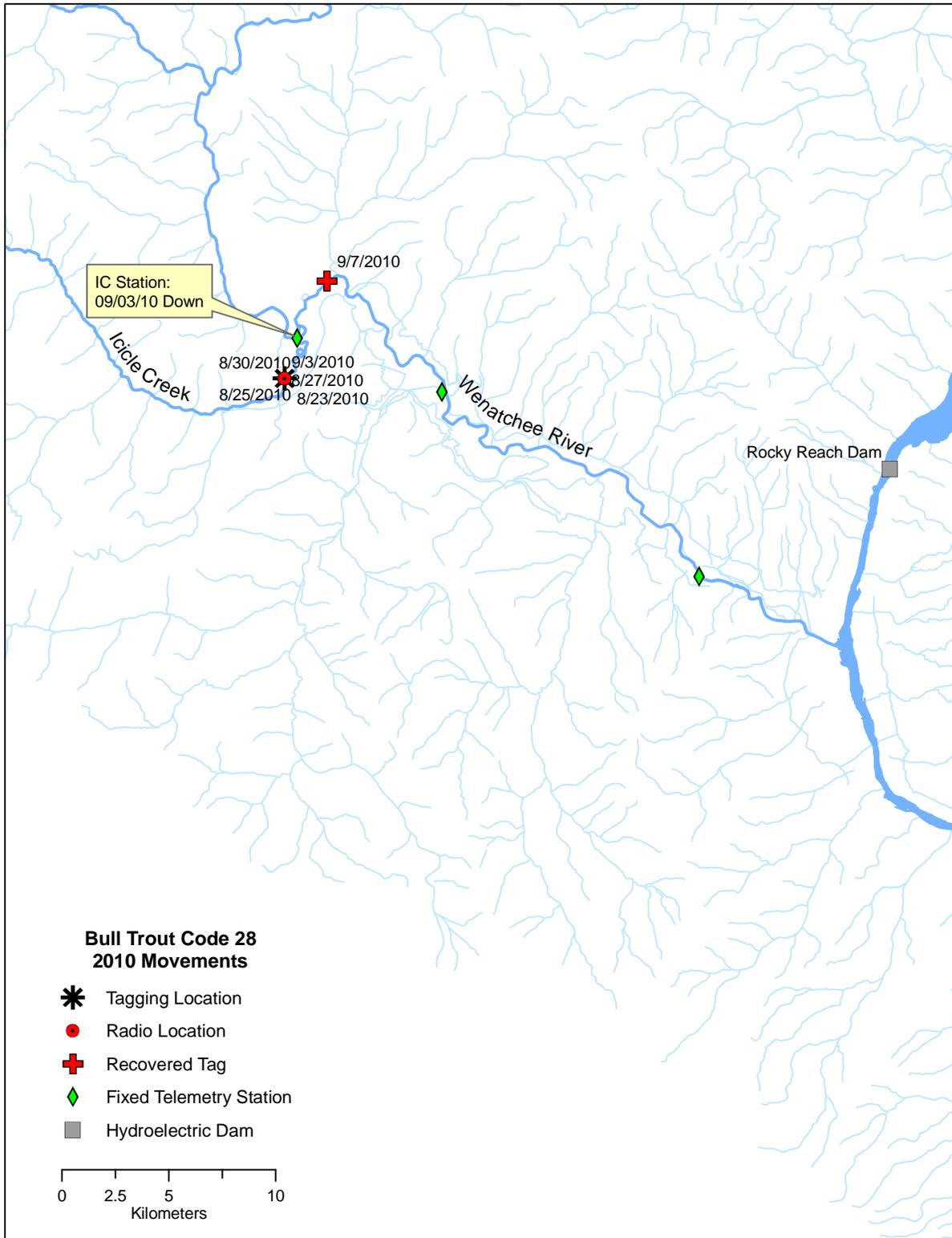


Figure 25. Map of the movements of fluvial bull trout code 28 during 2010.

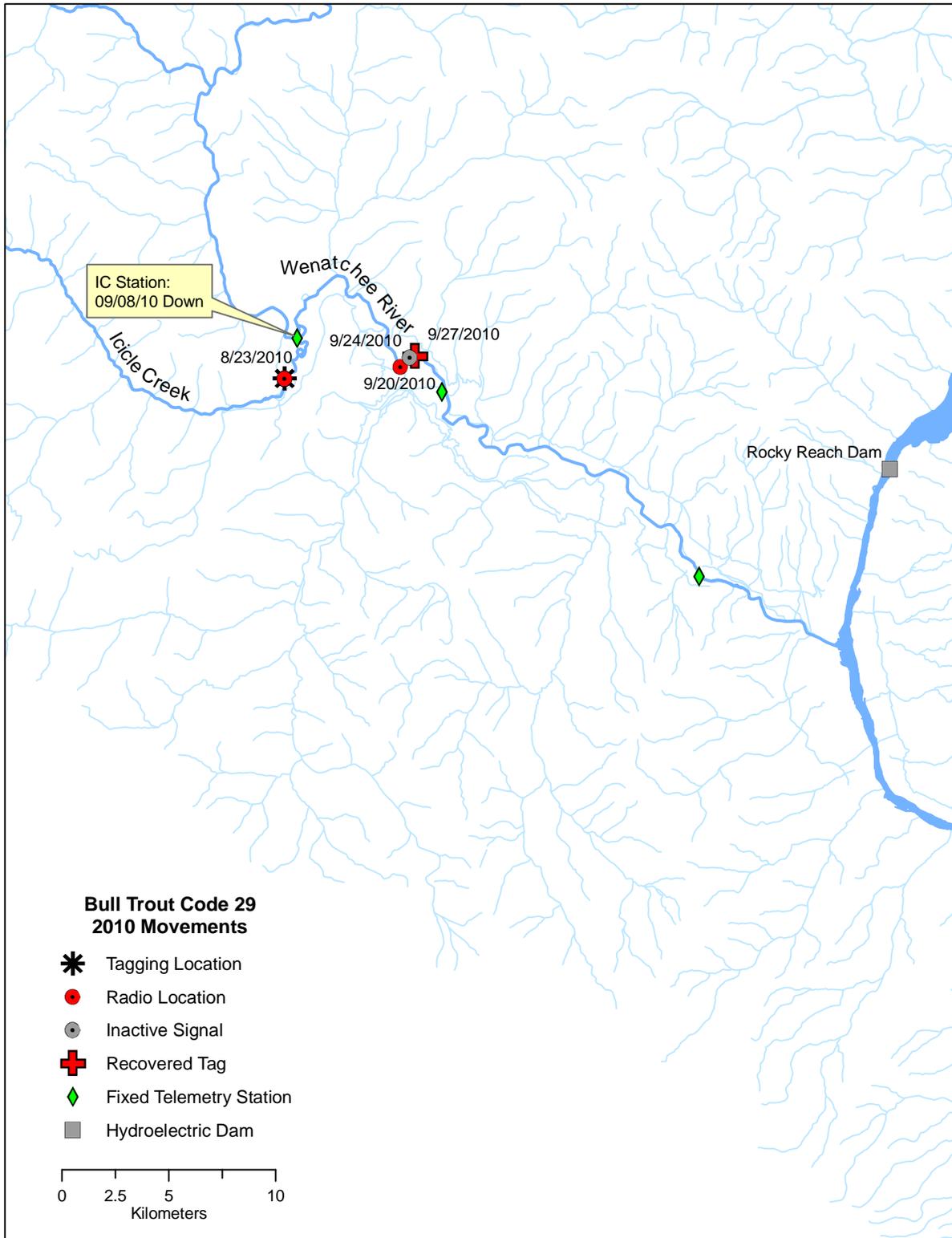


Figure 26. Map of the movements of fluvial bull trout code 29 during 2010.

Fixed Receiver Telemetry Stations

This section summarizes the detections of tagged bull trout at fixed receiver telemetry stations in the Wenatchee watershed during 2010.

WR station (rkm 12.5)- During the spring in-migration in the Wenatchee River, three bull trout were detected passing the WR station from May 10 to July 3, 2010 (Table 5). During the fall out-migration, four bull trout were detected moving downstream past the station from August 31 to December 10, 2010. All of the detections during the spring were during the day. Three of the four detections during the fall were at night.

Table 5. WR station data: Code, direction of travel, date, time, and diel period that radio-tagged adult fluvial bull trout were first detected at the fixed telemetry station on the lower Wenatchee River (rkm 12.5).

Code	Station	Direction	Date	Time	Diel Period
24	WR	Upstream	05/10/2010	10:20	Day
95	WR	Upstream	06/01/2010	07:55	Day
97	WR	Upstream	07/03/2010	15:18	Day
27	WR	Downstream	08/31/2010	19:34	Day
24	WR	Downstream	10/21/2010	18:49	Night
95	WR	Downstream	10/24/2010	04:35	Night
97	WR	Downstream	12/10/2010	00:55	Night

DD station (rkm 28.3)- During the spring in-migration, three bull trout were detected moving upstream in the Wenatchee River past this station at Dryden Dam from May 13 to July 27, 2010 (Table 6). During the fall out-migration, four bull trout were detected moving downstream from August 29 to November 27, 2010. Six of the seven detections were during the night.

Table 6. DD station data: Code, direction of travel, date, time, and diel period that radio-tagged adult fluvial bull trout were first detected at the fixed telemetry station at Dryden Dam on the Wenatchee River (rkm 28.3).

Code	Station	Direction	Date	Time	Diel Period
24	DD	Upstream	05/13/2010	04:33	Night
95	DD	Upstream	06/17/2010	23:49	Night
97	DD	Upstream	07/27/2010	02:04	Night
27	DD	Downstream	08/29/2010	15:27	Day
24	DD	Downstream	10/20/2010	19:31	Night
95	DD	Downstream	10/21/2010	02:49	Night
97	DD	Downstream	11/27/2010	03:30	Night

PC station (rkm 3.4)- One bull trout was detected passing this station on Peshastin Creek (Table 7). Code 24 was detected moving upstream in the spring on May 28 and downstream on October 19, 2010. Both detections were at night.

Table 7. PC station data: Code, direction of travel, date, time, and diel period that radio-tagged bull trout were first detected at the fixed telemetry station on lower Peshastin Creek (rkm 3.4).

Code	Station	Direction	Date	Time	Diel Period
24	PC	Upstream	05/28/2010	23:18	Night
24	PC	Downstream	10/19/2010	03:56	Night

IC station (rkm 0.8)- During the spring migration period in 2010, no bull trout were detected at this station near the mouth of Icicle Creek. Three bull trout tagged in lower Icicle Creek during 2010 were detected as they moved downstream and exited Icicle Creek after tagging (Table 8). All three detections were at night.

Table 8. IC station data: Code, direction of travel, date, time, and diel period that radio-tagged adult fluvial bull trout were first detected at the fixed telemetry station on lower Icicle Creek (rkm 0.8).

Code	Station	Direction	Date	Time	Diel Period
27	IC	Downstream	08/27/2010	21:33	Night
28	IC	Downstream	09/03/2010	20:44	Night
29	IC	Downstream	09/08/2010	20:25	Night

LH station (rkm 4.3)- The three bull trout radio-tagged in the spillway pool of Icicle Creek on August 23, 2010 were monitored by this station (Table 9). All detections were recorded on the LH1 antenna. None of the bull trout attempted to move upstream in Icicle Creek and therefore were not recorded on the LH2 antenna that monitored structure 5 at rkm 4.4. All three bull trout left the spillway pool during daylight hours.

Table 9. LH station data: Code, first date and last date of detection, time, and diel period of last detection of radio-tagged bull trout at the fixed telemetry station monitoring the LNFH spillway pool on Icicle Creek (rkm 4.3).

Code	Station	1 st Date	Last Date	Last Time	Diel Period
27	LH1	08/23/2010	08/27/2010	19:11	Day
28	LH1	08/23/2010	09/03/2010	16:53	Day
29	LH1	08/23/2010	09/07/2010	18:46	Day

TUM station (rkm 52.6)- Three radio-tagged bull trout were detected at this station at Tumwater Dam on the Wenatchee River and two of these moved upstream and passed the dam (Table 10). During the upstream migration, these two bull trout were first detected at the dam during the day while the fish that did not pass was first detected at night. Movements and passage rates at the dam are detailed in a following section on Tumwater Dam. During the downstream migration, only one bull trout passed the dam and that occurred during the night. One radio-tagged bull trout was not detected at the dam in the fall but instead overwintered in a reach 2 km upstream of the dam (see code 99 section).

Table 10. TUM station data: Code, direction of travel, date, time, and diel period that radio-tagged adult bull trout were first detected at the fixed telemetry station at Tumwater Dam on the Wenatchee River (rkm 52.6).

Code	Station	Direction	Date	Time	Diel Period
99	TUM	Upstream	07/06/2010	14:16	Day
95	TUM	Upstream	07/08/2010	17:25	Day
97	TUM	Did not pass	08/12/2010	20:31	Night
95	TUM	Downstream	10/04/2010	02:28	Night

CW station (rkm 0.1)- Two radio-tagged bull trout were detected by this station at the mouth of Chiwaukum Creek (Table 11). One bull trout migrated into Chiwaukum Creek and passed the station during the night. One bull trout continued upstream in the Wenatchee River and passed during the day. During the fall, only the bull trout migrating out of Chiwaukum Creek was detected and passed the station during the night.

Table 11. CW station data: Code, direction of travel, date, time, and diel period that radio-tagged adult fluvial bull trout were first detected at the fixed telemetry station at the mouth of Chiwaukum Creek (rkm 0.1).

Code	Station	Direction	Date	Time	Diel Period
99	CW	Upstream	07/12/2010	00:40	Night
95	CW	Upstream ¹	07/21/2010	13:44	Day
99	CW	Downstream	09/13/2010	23:38	Night

Note: 1- continued upstream in the Wenatchee River

Migrations between fixed stations

Migration rates during spring in-migration- The migration rates of tagged bull trout between stations ranged from 0.2 km/d to 5.7 km/d during the spring in-migration in 2010 (Table 12). The slow migration rate between Tumwater Dam and Chiwaukum Creek reflects the passage delay at the dam (see following section). The amount of time tagged bull trout spent traveling between stations ranged from 2.8 to 23.5 d (Table 13).

Table 12. Migration rates of radio-tagged bull trout between fixed telemetry stations in the Wenatchee River watershed during upstream migrations in 2010.

Code	WR - DD	DD - PC	DD - TUM	TUM - CW
24	5.7 km/d	0.2 km/d		
95	0.9 km/d		1.3 km/d	0.4 km/d
97	0.7 km/d		1.4 km/d	
99				0.9 km/d

Table 13. Number of days for radio-tagged bull trout to travel between fixed telemetry stations in the Wenatchee River watershed during upstream migrations in 2010.

Code	WR - DD	DD - PC	DD - TUM	TUM - CW
24	2.8 d	15.8 d		
95	16.7 d		18.6 d	12.9 d
97	23.5 d		16.8 d	
99				5.4 d

Migration rates during fall out-migration- During downstream migrations in the fall, migration rates of radio-tagged bull trout between stations ranged from 1.2 km/d to 35.5 km/d, with the highest rates occurring in lower Icicle Creek (Table 14). The amount of time tagged bull trout spent traveling between stations ranged from 0.1 d to 17 d (Table 15). During 2010, the three tagged bull trout that migrated into the Wenatchee River averaged 156.2 days (range 144.9 to 164.4 d) upstream of the WR station before returning to the Columbia River in the late fall.

Table 14. Migration rates of radio-tagged bull trout between fixed telemetry stations in the Wenatchee River watershed during downstream migrations in 2010.

Code	TUM - DD	LH - IC	IC - DD	PC - DD	DD - WR
24				2.4 km/d	16.3 km/d
95	1.4 km/d				5.1 km/d
97					1.2 km/d
27		35.5 km/d	7.8 km/d		7.3 km/d
28		21.8 km/d			
29		3.3 km/d			

Table 15. Number of days for radio-tagged bull trout to travel between fixed telemetry stations in the Wenatchee River watershed during downstream migrations in 2010.

Code	TUM - DD	LH - IC	IC - DD	PC - DD	DD - WR
24				1.7 d	1.0 d
95	17.0 d				3.1 d
97					12.9 d
27		0.1 d	1.7 d		2.2 d
28		0.2 d			
29		1.1 d			

Tumwater Dam

Four Icicle Creek-tagged bull trout were detected at Tumwater Dam in 2010, including one that had shed its radio transmitter and one that had shed its PIT tag (Table 16). It took 1.8 days for code 99 and 10.9 days for code 95 to pass the dam, but code 97 did not pass even though it was detected by the PIT antenna in the ladder. Code 95 shed its PIT tag so it is unknown how long it was at the dam before it was detected in the fishway or how many times it was in the ladder during its extended presence at Tumwater Dam. After arriving at the dam, it took 0.12 to 0.35 days before codes 99 and 97 were detected in the ladder at weir 15 (Table 16). PIT detections indicated code 99 moved in and out of the ladder at least three times before passing (Table 17). Code 97 moved up the ladder and spent a short time below the fish trap before it moved back downstream (Table 18). PIT detections indicated code 98 moved up and over the ladder very quickly (Table 19).

Table 16. Summary of radio- and PIT- detections of adult bull trout at Tumwater Dam during 2010.

Code	First detection telemetry	Last detection telemetry	Days at Dam	PIT detections	PIT et (days)	Time to detection in fishway (days)
95	7/8/10 17:25	7/19/10 15:35	10.92	shed	n/a	n/a
97	8/12/10 20:31	8/13/10 9:29	0.54	in & back out	0.06	0.35
99	7/6/10 14:16	7/8/10 10:27	1.84	in & out 3x; over	1.70	0.12
98	shed	n/a	n/a	in and over	0.01	n/a

Table 17. Details of PIT detections of bull trout code 99 in the fish ladder at Tumwater Dam during 2010.

Code	Type	Coil1	Weir	Direction	Observation date/time
99	OBS	A2	15	up	7/6/2010 17:06
99	OBS	A1	18	up	7/6/2010 17:14
99	OBS	A1	18	down	7/6/2010 18:04
99	OBS	A2	15	down	7/6/2010 18:08
99	OBS	A2	15	up	7/7/2010 19:11
99	OBS	A1	18	up	7/7/2010 19:24
99	OBS	A1	18	down	7/7/2010 19:43
99	OBS	A1	18	up	7/7/2010 19:51
99	OBS	A1	18	down	7/7/2010 20:33
99	OBS	A2	15	down	7/7/2010 20:37
99	OBS	A2	15	up	7/8/2010 8:28
99	OBS	A1	18	up	7/8/2010 8:44
99	OBS	A1	18	down	7/8/2010 9:35
99	OBS	A2	15	up	7/8/2010 9:42
99	OBS	A1	18	up	7/8/2010 10:00

Table 18. Details of PIT detections of bull trout code 97 in the fish ladder at Tumwater Dam during 2010.

Code	Type	Coil1	Weir	Direction	Observation date/time
97	OBS	A2	15	up	8/13/2010 5:02
97	OBS	A1	18	up	8/13/2010 5:33
97	OBS	A1	18	down	8/13/2010 6:29
97	OBS	A2	15	down	8/13/2010 6:32

Table 19. Details of PIT detections of bull trout code 98 in the fish ladder at Tumwater Dam during 2010.

Code	Type	Coil1	Weir	Direction	Observation date/time
98	OBS	A2	15	up	7/8/2010 10:40
98	OBS	A1	18	up	7/8/2010 10:56

During 2010, a total of 66 bull trout were counted by WDFW at Tumwater Dam. The majority of the bull trout were counted when Wenatchee River discharge was less than 3500 ft³/s at the Plain gage station (Figure 27).

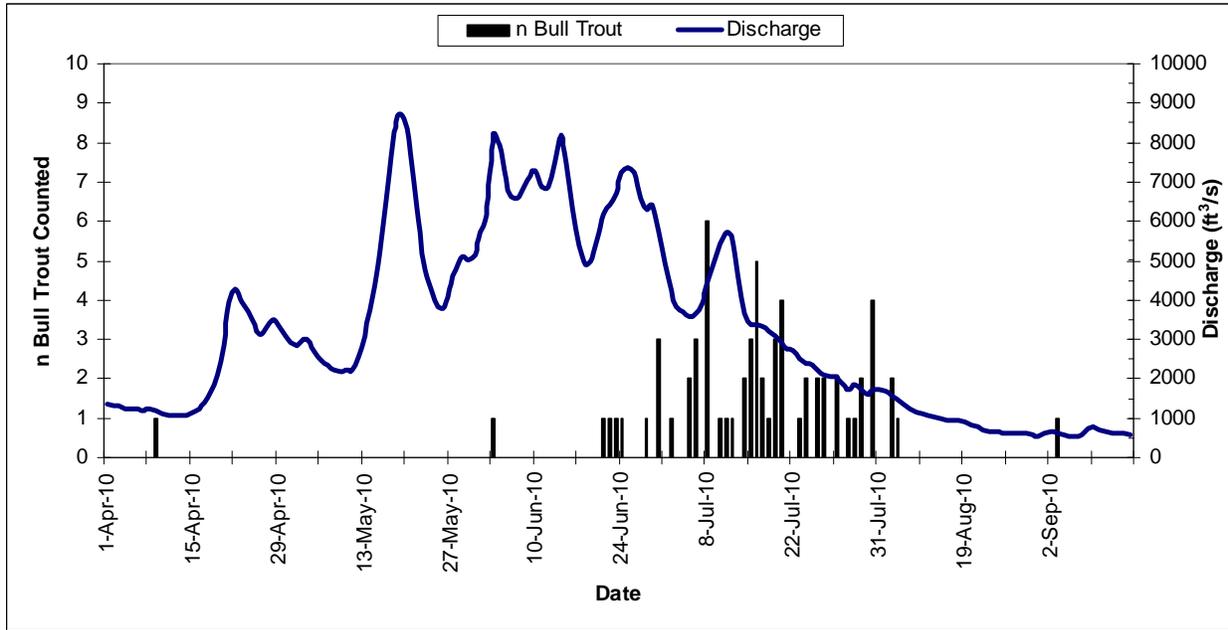


Figure 27. Wenatchee River discharge and dates bull trout were counted by WDFW at Tumwater Dam during 2010.

Winter locations

Four radio-tagged bull trout (codes 24, 95, 96, 97) over-wintered in the Columbia River during the winter of 2010/2011. Although the exact locations were not determined, examination of PIT interrogation site data in the spring indicated all four wintered in the Rock Island reservoir. Code 97 was detected at the lower Wenatchee River PIT array (rkm 2) during December and again in late March, suggesting it moved in and out of the lower Wenatchee River during the winter. One bull trout (code 99) wintered in Tumwater Canyon at rkm 52.9 of the Wenatchee River.

Migration distances

The upstream migration distances of tagged bull trout in 2010 ranged from 30.8 to 122 km and downstream migration distances ranged from 17.6 to more than 118 km (Table 20). Bull trout code 99 migrated the shortest distances and stayed in the Wenatchee River during the winters of 2009/2010 and 2010/2011.

Table 20. Migration distances (km) that 2009-tagged bull trout traveled during upstream and downstream migrations in the Wenatchee River and Entiat River watersheds during 2010.

Code	Upstream Migration		Downstream Migration	
	Start - Finish	km	Start - Finish	km
24	Col R – Etienne Cr	54.8	Etienne Cr – Col R	> 51
95	Col R – Nason Cr	122	Nason Cr – Col R	> 118
96	Col R – Entiat R	> 71	Entiat R – Col R	> 71
97	Col R – Wenatchee R	53.6	Wenatchee R – Col R	> 52
99	Wenatchee R – Chiwaukum Cr	30.8	Chiwaukum Cr – Wenatchee R	17.6

Spawning ground surveys

Icicle Creek (rkm 29.1 – 34.7)- Icicle Creek from Rock Island Campground to French Creek was surveyed on September 14 and October 14, 2010. No bull trout or redds were observed.

French Creek (rkm 0.0 – 7.2)- French Creek was surveyed three times in 2010 and a total of 2 bull trout redds were observed near rkm 5.6 (Table 21, Figure 28). Redd dimensions indicated one redd was migratory and the other resident (Table 22). No bull trout were observed in French Creek during any of the surveys in 2010.

Table 21. Summary of bull trout spawning ground surveys conducted by USFWS in the Icicle Creek watershed during 2010: Stream, dates of surveys, water temperatures, new redds, cumulative redds and number of bull trout observed.

Stream	Date	Water T (°C)	New Redds	Cumulative Redds	Bull trout
French	09/22/10	6	0	0	0
	10/07/10	5 - 6	2	2	0
	10/19/10	3 - 4	0	2	0
Icicle	09/14/10	9 - 10	0	0	0
	10/14/10	5	0	0	0

Table 22. Dimensions of bull trout redds observed in French Creek during 2010.

Redd	Length (m)	Width (m)	Depth of pit (m)	Depth at top of pit (m)	Redd area (m2)	Category
FC01	1.4	0.55	0.475	0.425	0.77	Probable
FC02	0.8	0.3	0.385	0.375	0.24	Probable

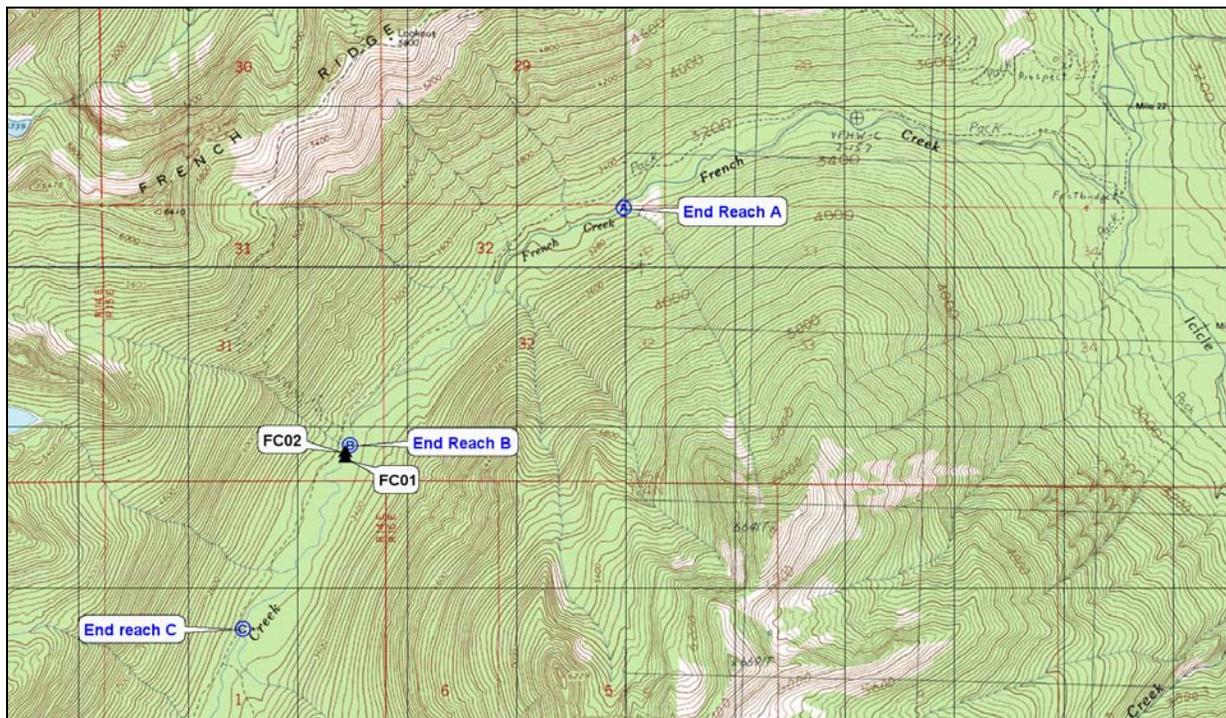


Figure 28. Map of the bull trout spawning ground survey reaches and locations of bull trout redds (black triangles) observed in French Creek during 2010.

Discussion

Movements of bull trout

The movements of tagged bull trout during 2010 provide additional documentation of the importance of lower Icicle Creek to fluvial bull trout from other local populations. To date, non-spawning adult bull trout that were radio-tagged in lower Icicle Creek migrated the following year to spawning grounds in Nason Creek, Chiwaukum Creek, Etienne Creek, and the Entiat River. Lower Icicle Creek is unique in the Upper Columbia Recovery Unit in providing foraging and refuge habitat for non-spawning bull trout from several widely separated local populations. No tagged bull trout have attempted to move upstream into upper Icicle Creek and it is still uncertain whether any of these fish are dispersers from the upper Icicle Creek population. Comparison of their genetic profiles to the pending genetic baseline of local populations should provide insights into dispersal and gene flow between local populations.

Most of the adult migratory bull trout observed in spawning aggregations on the Wenatchee-Okanogan National Forest range between 46 and 66 cm at five to nine years of age and the majority of first time female spawners are five to seven years old at approximately 51 cm long (Brown 1992, 1994). Ten bull trout were captured and several others were observed in Icicle Gorge during 2010 and all were smaller than 375 mm, indicating they were subadults. To date, this is the highest number of this age class of fluvial bull trout observed in upper Icicle Creek. Tissue samples were taken from the captured fish and will be compared to the genetic baseline to determine if they belong to the upper Icicle population or if they migrated from other areas. The landslide that diverted Icicle Creek into the forest upstream of Ida Creek in 2008 created diverse off-channel habitat and the high number of bull trout that were observed upstream may be a reflection of the additional high quality rearing habitat now available to bull trout in this reach. The number of subadults may also be due to the increased number of adult fluvial bull trout now able to migrate upstream to spawning areas due to the additional passage opportunities that have been provided in lower Icicle Creek.

As in previous years of the study, none of the tagged bull trout attempted to move upstream past Leavenworth NFH nor have any returned to Icicle Creek in the years after they were tagged. Therefore the passage windows are still not known at obstacles upstream of the hatchery and downstream of Icicle Gorge. No new information on the timing of migration into Icicle Creek has been gathered; thus the only information to date is from bull trout tagged outside of Icicle Creek (Nelson and Nelle 2008, Nelson et al. 2009), from angling (Nelson et al. 2011), or inferred from Tumwater Dam counts (Nelson 2008). Within the larger picture of fluvial bull trout migrations, however, additional information on patterns and timing of movements into and within the Wenatchee River has been documented.

Tumwater Dam

Fish trapping procedures were modified at Tumwater Dam in 2005 to allow complete trapping of spring Chinook salmon and steelhead for various fishery management studies by WDFW. Telemetry observations indicate these modifications impeded bull trout migrations at the dam (Nelson et al. 2011). During 2009 and 2010, radio-tagged bull trout took 1.84 to 22.79 d (mean = 11.85, n = 3) to pass Tumwater Dam while one bull trout stayed downstream of the dam after being detected by the telemetry station and the PIT array. In comparison, during an earlier

unpublished telemetry study conducted by USFWS from 2001 to 2004, radio-tagged bull trout took from 0.1 to 3.45 d (mean = 1.43, n = 6) to pass the dam and no fish stayed downstream (data from files, see Nelson et al. 2011). Bull trout from the 2001 – 2004 group spent significantly fewer days to pass than bull trout from the 2009 – 2010 group (Student's 2-sided t test; p = 0.037). Thus, it is reasonable to conclude that fish trapping procedures after 2004 were a factor in the delay rather than the physical structure of the fishway itself. A review of recent operations was conducted by WDFW and Chelan County PUD and changes in the trapping and handling procedures to improve passage times of salmonids were implemented in 2011 (J. Murauskas, CCPUD, pers. comm.).

In addition to the passage delay of adult fluvial bull trout there are other issues at Tumwater Dam deserving consideration. No sub-adult bull trout are observed passing upstream through the fishway or trapping facilities at Tumwater Dam (T. Maitland, WDFW, pers. comm.) but sub-adult bull trout have been observed in the tailrace of the dam and in Lake Jolanda (Hays 1981). Although it may be assumed that sub-adult bull trout only move downstream, they are known to move upstream elsewhere in the Wenatchee River, in the Entiat River, and in the fishways at Columbia River dams (MCRFRO data from files; S. Hemstrom, Chelan County PUD, pers. comm.). However, while Tumwater Dam may affect the movements of sub-adult bull trout, it is possible that hydrological barriers in Tumwater Canyon also affect their behavior. Other migratory fishes were historically counted in the old fishway at Tumwater Dam, including cutthroat trout, mountain whitefish, bridgelip sucker, largescale sucker, pikeminnow, and Pacific lamprey (WDF 1938) but apparently none are currently observed in the fish ladder. Thus, Tumwater Dam facilities or operations may be affecting the migrations of sub-adult bull trout as well as several fish species that are known to be important forage for bull trout (Beauchamp and Van Tassel 1999).

Recommendations for future study

New spawning areas of migratory bull trout were documented in the Wenatchee Core Area during 2010. Spawning ground surveys should be considered in Etienne Creek to help determine the contribution of the migratory life history to the Peshastin Creek local population. Spawning was also verified downstream of the current index reach in Nason Creek; thus past redd counts probably underrepresented the actual number of spawning adults in that local population. Expanded surveys should be conducted to determine the extent of the spawning area utilized by migratory bull trout in upper Nason Creek.

To date, tissue samples have been taken from over 90 bull trout in Icicle Creek and eventually a genetic analysis with comparison to the pending genetic baseline will provide additional insights into movements and population structure of bull trout in Icicle Creek. Future studies should focus on subadult bull trout including large scale genetic sampling and PIT tagging in tandem with tracking a small number of radio-tagged fish.

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U. S. Fish and Wildlife Service
Mid-Columbia River Fishery Resource Office
7501 Icicle Road
Leavenworth, WA



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