U.S. Fish and Wildlife Service

Movement of bull trout in Mill Creek, Walla Walla County, Washington

2005-2012 Summary Report

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On the cover:
Upstream view of Mill Creek, a tributary of the Walla Walla River, showing stabilization weirs and levees within the Mill Creek Project. Photograph by Darren Gallion, USFWS.

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Introduction

In 1998, the Columbia River Distinct Population Segment of bull trout (*Salvelinus confluentus*) was listed as threatened under the Endangered Species Act due to the declining abundance, primarily brought on by anthropogenic factors (USDI 1998a). The U.S. Fish and Wildlife Service (USFWS) Bull Trout Draft Recovery Plan (USFWS 2002a) identifies four main objectives for recovery of the species: 1) Maintain current distribution of bull trout within core areas as described in recovery unit chapters and restore distribution where recommended in recovery unit chapters, 2) maintain stable or increasing trend in abundance of bull trout, 3) restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and 4) conserve genetic diversity and provide opportunity for genetic exchange. Research and monitoring of bull trout populations is required to assess the status of the species and recommend actions for recovery.

Beginning in 2002, the USFWS and Utah State University initiated a long term research project in the Walla Walla River Basin to address critical knowledge gaps concerning bull trout ecology (Budy et al. 2012). Since the beginning of this project, passive integrated transponder (PIT) technology has been one of the tools used to gather information. Detection arrays were first installed in the South Fork Walla Walla River during 2002, and eventually expanded downstream and into adjacent tributaries. In cooperation with the U.S. Forest Service (USFS) and Oregon Department of Fish and Wildlife (ODFW), USFWS began monitoring the Mill Creek bull trout local population with PIT tag detection arrays beginning in 2005.

The objectives of this monitoring effort were to 1) describe the migration timing of bull trout in Mill and Yellowhawk creeks, 2) describe how these fish used Mill and Yellowhawk creeks, 3) determine if there was a potential migration delay associated with the Mill Creek Project, and 4) describe the interaction with other Walla Walla Basin bull trout populations. The information in this report can serve as a pre-condition description of bull trout use and passage in Mill Creek prior to planned and recommended fish passage improvement projects (Burns et al. 2009, USFWS 2007, NMFS 2011). Additional monitoring activities in upper Mill Creek and the Walla Walla Basin have helped describe migratory behavior of Mill Creek bull trout. Throughout this monitoring effort, information on adult spring Chinook and steelhead migration in the basin was also collected and is summarized in Appendix A.

Study Area

Mill Creek originates in the Blue Mountains of southeastern Washington and flows through the City of Walla Walla before entering the Walla Walla River at rkm 54 (Figure 1). The upper watershed provides drinking water for the City of Walla Walla and remains protected from most human activities (USFWS 2002b). This area also serves as the main spawning area for resident and fluvial bull trout in the Mill Creek subbasin (Hemmingsen et al. 2001b). Human activities (e.g., agriculture, residential building, flood control structures) increase as Mill Creek approaches the City of Walla Walla and riparian areas and channel complexity become degraded.

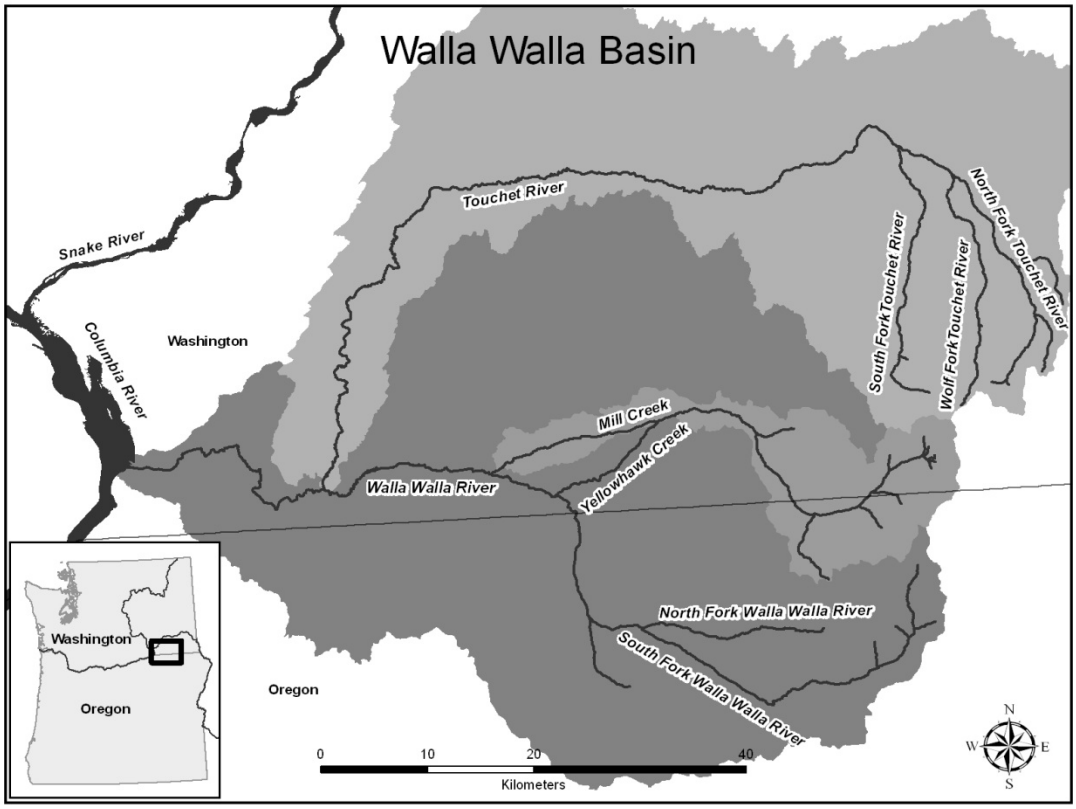

Figure 1. The Walla Walla Basin showing the Touchet River, Mill Creek, and Walla Walla River subbasins.

Beginning in the late 1930's, the COE created a series of dams, levees, weirs and concrete channels to protect the city of Walla Walla from high flow events (COE 2011). The USFWS monitoring efforts focused on bull trout use and movement near the upper 1.5 km of the Flood Control Project, which is referred to as the Mill Creek Project (Figure 2). The COE operates and maintains the Mill Creek Project for flood control and delivery of flows to satisfy water rights. The rest of the Flood Control Project, below the Mill Creek Division Dam (Figure 2), is managed by the local flood zone district. The Flood Control Project has succeeded in protecting the city since construction. However, fish passage needs were poorly understood or accounted for during project design. For example, the fish ladder at Bennington Lake Diversion Dam (Figure 2) was not installed until 1982, effectively blocking upstream fish passage for approximately four decades.

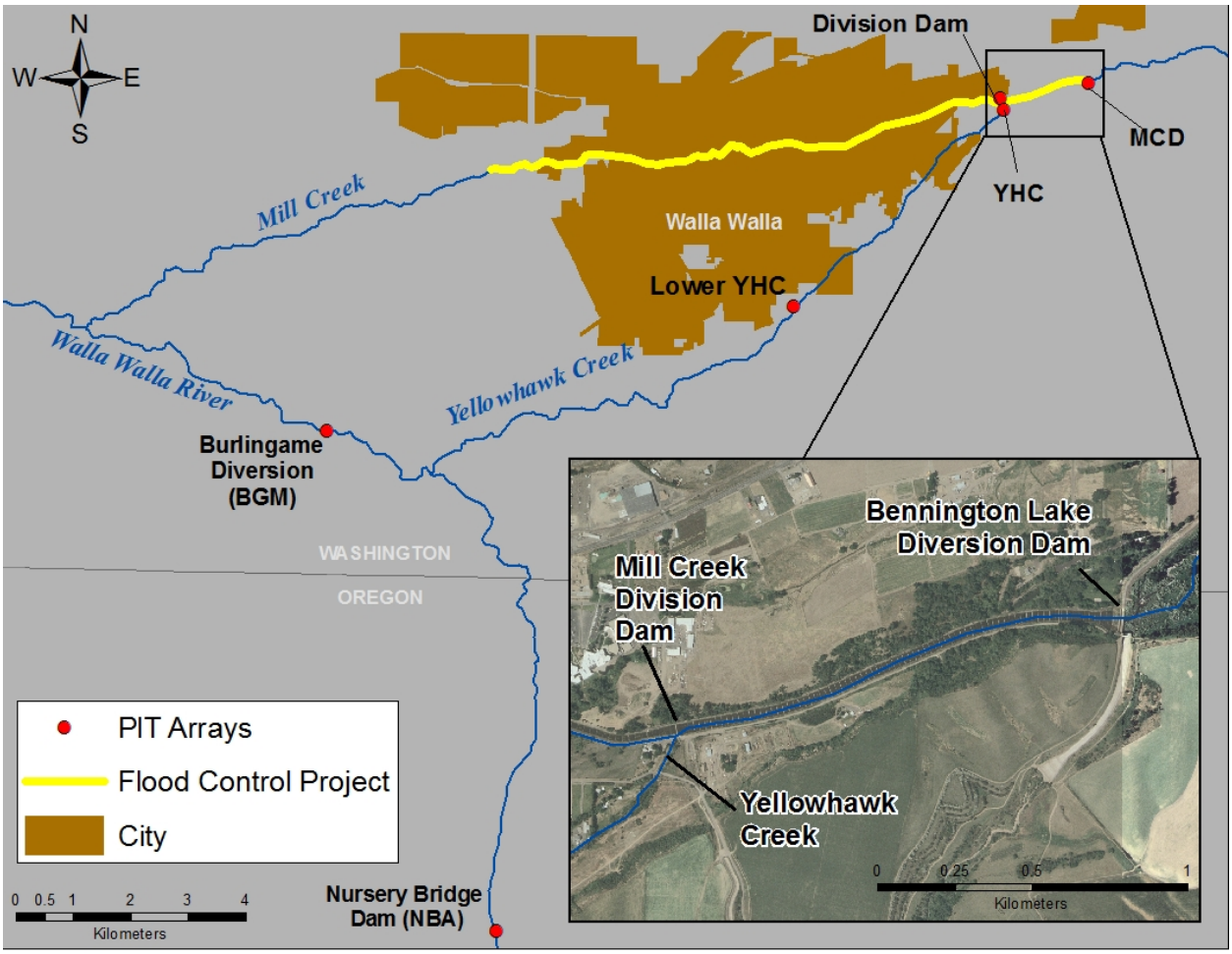

Figure 2. Locations of PIT arrays in relation to the Mill Creek Project (inset). MCD: Bennington Lake Diversion Dam PIT Array. Division Dam: Mill Creek Division Dam PIT Array. YHC: Yellowhawk Creek PIT Array. Lower YHC: Yellowhawk PIT Array at Walla Walla High School.

Bennington Lake Diversion Dam

Bennington Lake Diversion Dam (Figure 3) is located near the upper end (rkm 18.5) of the Mill Creek Project. The dam is a flood control structure that diverts water into Bennington Lake under flood conditions (flows >2500 cfs). Bennington Lake Diversion Dam has three routes of downstream fish passage; a fish ladder, low flow outlet (LFO), and spillway. Upstream fish passage is assumed to be possible only through the fish ladder since the spillway is impassable and a combination of high water velocity and head pressure at the radial gate in the LFO likely forms a barrier. The fish ladder is designed for flows up to 42 cfs. The LFO is opened when flows exceed 42 cfs and remain below approximately 400 cfs. When instream flows are between 400 – 2,500 cfs for extended periods, both the ladder and LFO are closed and all water passes over the spillway.

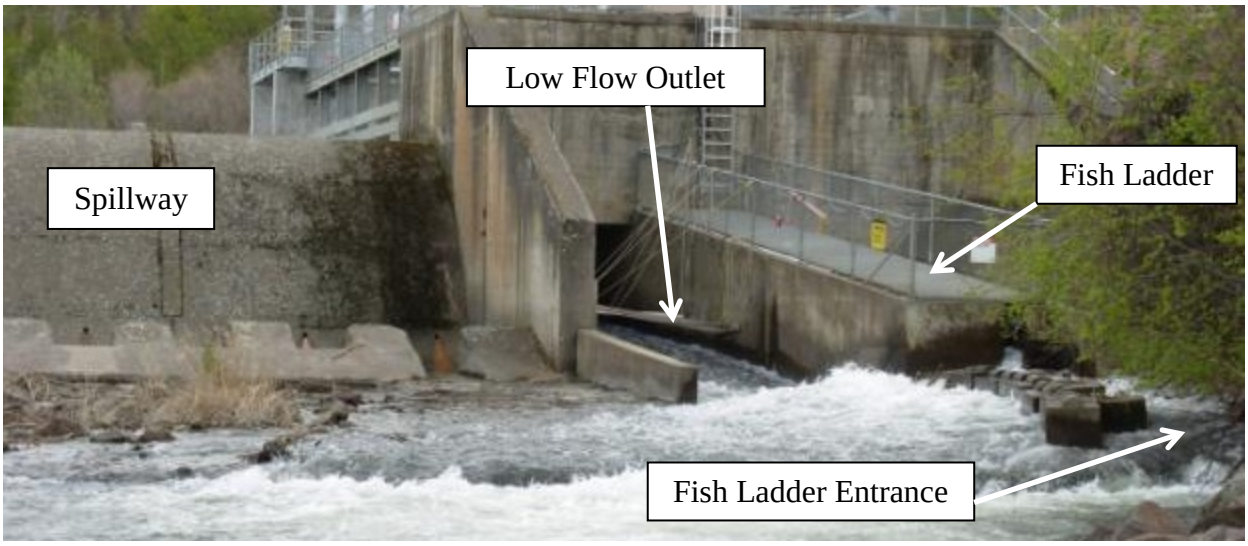

Figure 3. Downstream view of the south side of Bennington Lake Diversion Dam.

Mill Creek Division Dam

The Mill Creek Division Dam (Figure 4) is located downstream from Bennington Lake Diversion Dam and is part of the First Division Works that diverts water into Yellowhawk Creek at rkm 16.9. The Mill Creek Division Dam has two routes of passage; a fish ladder and spillway consisting of four arm gates. The gates are opened for spill when flows are predicted to remain above 400 cfs for extended periods. It is assumed that upstream passage is not possible when the gates are down and all upstream passage occurs through the fish ladder during non-spill operations (flows <400 cfs).

Figure 4. Downstream view of the Mill Creek Division Dam. Water is diverted into Yellowhawk Creek, right of picture (not shown).

Yellowhawk Creek

Yellowhawk Creek (Figure 5) is a distributary of Mill Creek that historically was operated to divert flows away from downtown Walla Walla during periods of flooding. Flows are

maintained through a radial gate at less than 70 cfs to prevent flooding of residential properties and to provide irrigation water (COE 2007). During low flow periods (summer and fall), a majority of Mill Creek instream flows are diverted down Yellowhawk Creek. Fish passage is provided by a needle slot gate adjacent to the radial gate; however fish can pass under the radial gate during suitable flows.

Figure 5. Downstream view of the headworks of Yellowhawk Creek with radial gate on right. Needle slot gate for fish passage is not visible under road way on left.

Methods

Bull trout have been PIT tagged in Mill Creek since 1998 (Hemmingsen et al. 2001b). Most bull trout have been tagged in the upper watershed by ODFW and USFS with supplemental tagging by the USFWS and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) near the middle and lower sections of Mill Creek (Table 1). Bull trout were captured in the upper basin using a screw trap (rkm 42) and upstream adult trap at the City of Walla Walla water intake dam (rkm 41). Several different PIT tag types (frequencies, sizes, models) were used based on the year of study and size of bull trout at capture. Sampling in the lower sections of Mill Creek consisted of primarily hook and line and screw trapping. Headwater PIT tagging was discontinued after 2010 and relatively few bull trout have been tagged in Mill Creek since then.

Table 1. Yearly number of bull trout PIT tagged by each agency and respective capture method in Mill Creek, a tributary of the Walla Walla River.

	USFS/ODFW		USFWS	CTUIR	
Year	Adult Trap[1]	Screw Trap[2]	Hook and Line[3]	Screw Trap[4]	**Total by Year**
1998	74	495	0	0	**569**
1999	147	179	0	0	**326**
2000	104	191	0	0	**295**
2001	52	49	0	0	**101**
2002	86	31	0	0	**117**
2003	67	0	0	0	**67**
2004	68	0	0	0	**68**
2005	93	526	0	0	**619**
2006	59	1188	0	3	**1250**
2007	43	1009	4	0	**1056**
2008	32	826	10	0	**868**
2009	29	310	23	1	**363**
2010	32	353*	12	3	**400**
2011	0	0	7	0	**7**
2012	0	0	6	0	**6**
Total by Agency	**886**	**5157**	**62**	**7**	**6112**

[1]Adult trap was operated on the upstream side of fish ladder at the city of Walla Walla water intake dam (rkm 41).
[2]Screw trap was operated above the city's intake dam (rkm 42).
[3]Hook and line sampling took place near the COE Mill Creek Project (rkm 18-21).
[4]CTUIR operated screw traps at rkm 22 and rkm 5.
*In addition to the upper screw trap, a second screw trap was operated in Mill Creek (rkm 22) and 45 bull trout were tagged at this site.

The number of detections of PIT tagged bull trout at any detection array is the result of two factors; first, the number of tagged fish that were released and second, the detection efficiency of the array. Detection efficiency is highly variable through the year and primarily changes with river flows. Since we did not attempt to estimate the efficiency of each array, we were not able to estimate the total number of PIT tagged bull trout that passed an array, or the total abundance of bull trout passing an array during any time period.

In general, detection efficiencies of the ladder antennas at MCD and the Division Dam were relatively high and operated almost continuously. Antennas in the LFO and Division Dam spillway were less efficient and operated more sporadically. Detection efficiency was high at the YHC arrays and they operated almost continuously. Long term monitoring allowed us to describe the general trends in migration and habitat use regardless of data gaps associated with array or antenna failure.

Each PIT detection array consisted of one or more antennas placed instream, a 1001A or 1001M transceiver (Destron-Fearing/Digital Angel) that reads and stores tag codes, and a computer to backup and upload data to the PIT Tag Information System (PTAGIS) database (http://www.ptagis.org). The PIT arrays were assigned codes in PTAGIS as follows. The array at Bennington Lake Diversion Dam is coded as MCD. The array at the Mill Creek Division Dam is also coded as MCD but can be differentiated by transceiver ID and antenna IDs starting with "A" (A1-A6) as opposed to the Bennington Lake Diversion Dam which is "0" (01-05). The

array in upper Yellowhawk Creek is coded as YHC with antenna ID A1. The lower YHC array is also coded as YHC, but its antenna ID is B1.

Bennington Lake Diversion Dam PIT Array (MCD)

The Bennington Lake Diversion Dam was monitored for tag detections within the fish ladder and the LFO. The ladder has two pass through antennas that were installed on February 25, 2005. Monitoring the LFO for PIT detections began in 2005, but none of the antenna designs were reliable due to high flows. An experimental flat plate antenna was mounted to the floor of the LFO on August 11, 2008 and proved to be the best design option. Two additional flat plate antennas were installed on February 18, 2009 to provide additional detection capabilities. High water velocities in the LFO may result in tagged fish passing downstream undetected even under relatively low flows. The spillway was not monitored for detections.

Mill Creek Division Dam PIT Array (Division Dam)

The Mill Creek Division Dam was monitored for tag detections with antennas in the fish ladder and spillway. The ladder has been monitored for tag detections since February 14, 2007 with a single pass through antenna. On November 20, 2008, a second antenna was installed to provide direction of fish movement. Flat plate antennas were mounted on the spillway on August 12, 2010, but soon started leaking and provided minimal detection capability. The spillway antennas were removed on May 15, 2012.

Yellowhawk Creek PIT Arrays (YHC)

Upper Yellowhawk Creek was monitored with a single pass through antenna that spanned the entire channel width. The YHC antenna was installed on December 12, 2006, approximately 50 meters downstream from the radial gate. The site was relocated immediately downstream of the Second Division Works (Garrison Creek diversion) on April 25, 2012 to make way for construction.

A second antenna was installed in Yellowhawk Creek on August 3, 2007. The antenna was located on the Walla Walla High School grounds at approximately the halfway point of the stream (rkm 4). The site was removed on March 27, 2012 due to minimal bull trout tagging in Mill Creek and the resulting lack of detections.

Bull Trout Migration Timing

Detections at the MCD array were used to describe bull trout migration timing in relation to the Mill Creek Project. Bull trout were considered adults if their fork length at tagging was $\geq$ 300 mm and evidence of a spawning migration could be established through tag detection histories. Bull trout were considered subadults if their fork length at tagging was < 300 mm and migration patterns showed a lack of a spawning migration, indicative of a subadult life history. The 300 mm limit between adults and subadults was based on the findings of Sankovich et al. (2003) and Howell and Sankovich (2012).

Bull Trout Use of Mill and Yellowhawk Creeks

Detection histories of adult and subadult bull trout passing upstream at MCD were analyzed to determine whether bull trout were migrating upstream out of lower Mill Creek (below Division Dam) or Yellowhawk Creek after overwintering or spring rearing. Detection data were analyzed from February 2007 (after Division Dam and YHC PIT arrays were installed) through 2012. Bull trout that did not have detections at Division Dam or YHC were considered to have resided within the Mill Creek Project between Bennington Lake Diversion Dam and the Division Dam. It is possible some bull trout may have passed upstream of the Division Dam undetected during spill operations and would be counted as overwintering within the Mill Creek Project.

Subadult bull trout detections were broken into spring and fall downstream migration groups. Spring migrants were characterized as fish that migrated from the headwaters during the spring to areas below Bennington Lake Diversion Dam and attempted to rear. Fall migrants were characterized as fish that migrated to areas below Bennington Lake Diversion Dam during the fall to overwinter. Both groups were then detected together during their upstream passage attempt.

Upstream Passage Delay at Bennington Lake Diversion Dam

Upstream passage delay was analyzed for adult and subadult bull trout at Bennington Lake Diversion Dam using detections at the fish ladder and LFO antennas. Since passage is not likely through the LFO, fish were considered delayed until they passed the upper antenna in the fish ladder. The number of attempts to pass the LFO was calculated by summing the number of times a fish tried to ascend the LFO as determined by tag detections. It is assumed that bull trout are not able to hold in the LFO and they must return below the antennas before attempting to re-ascend the LFO. It is also assumed detection efficiency is relatively good for PIT tagged individuals moving upstream in the LFO as the water velocities would slow them down, thus increasing the detection capability of the antennas. Duration of delay was determined by calculating the difference from the first detection at MCD to the last detection at the upper ladder antenna. It is possible that bull trout were delayed below the LFO and ladder antennas but were not detected, thus delay could not be quantified. Bull trout that passed from the lower ladder antenna to the upper ladder antenna were assumed to have passed the ladder. The upper ladder antenna is located on the second weir downstream from the ladder exit.

Dispersal of Bull Trout into the Mainstem Walla Walla River

The PTAGIS database was queried for detections and recaptures of bull trout that emigrated from Mill Creek and into the Walla Walla River or beyond. The mainstem Walla Walla River has several detection arrays both upstream and downstream of the confluence with Mill and Yellowhawk creeks. In addition, tagged bull trout have the potential to be detected at mainstem Columbia River hydroelectric projects and other instream arrays within the Columbia River Basin. The route of migration (i.e., lower Mill Creek or Yellowhawk Creek) was established by PIT detection histories.

Returns to Mill Creek from the Mainstem Walla Walla River

The PTAGIS database was queried for detections of bull trout that returned to Mill Creek from the mainstem Walla Walla River. Bull trout that were tagged, detected, or recaptured outside of

the Mill Creek sub-basin before a subsequent detection or recapture in Mill Creek would be considered returning fish. The route of immigration (i.e., lower Mill Creek or Yellowhawk Creek) was also determined from detection histories.

Results

Bull Trout Migration Timing

Adult bull trout typically begin moving upstream through the Mill Creek Project beginning in April to reach spawning grounds. Upstream movement peaks in May and June (Figure 6) and detections continue into July in some years. Upstream movement timing can be related to spring runoff flows for most years. Generally, in low runoff years (e.g., 2005, 2007), timing of upstream passage is earlier compared to that in high runoff years (e.g., 2008, 2011). Post-spawning bull trout return from the headwaters to downstream areas to overwinter, passing MCD starting in October and continuing into February (Figure 7). No post-spawn bull trout were detected passing downstream at MCD during 2005.

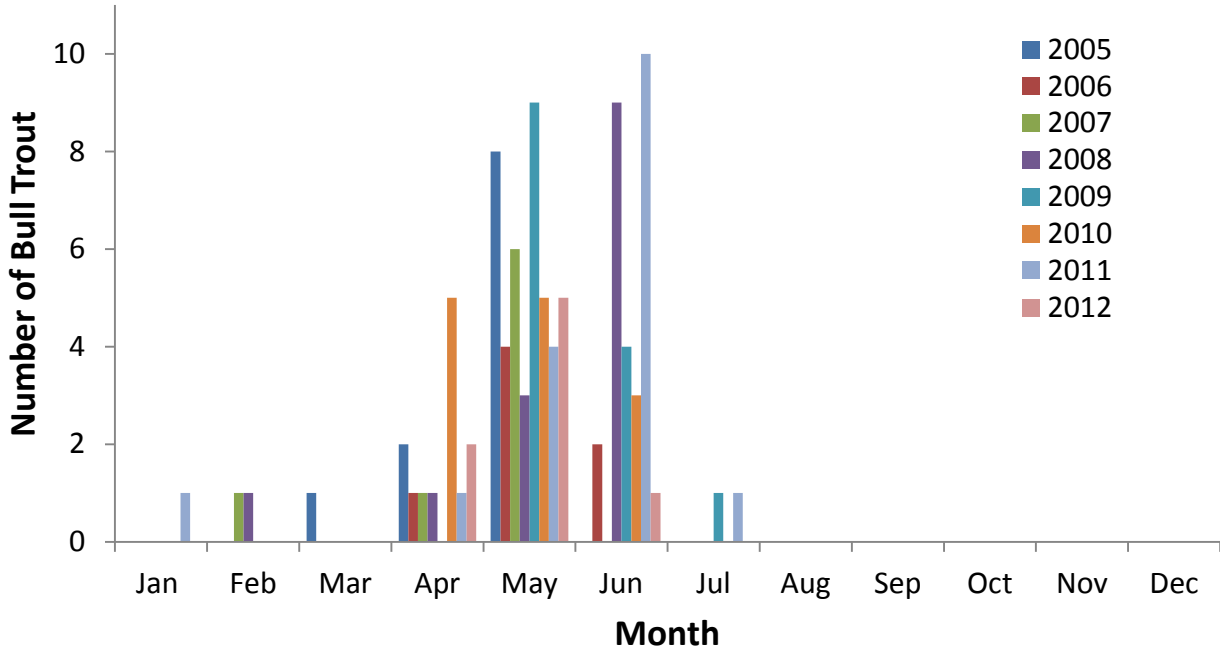

Figure 6. Upstream passage timing of PIT-tagged adult bull trout at Bennington Lake Diversion Dam (MCD) during 2005-2012.

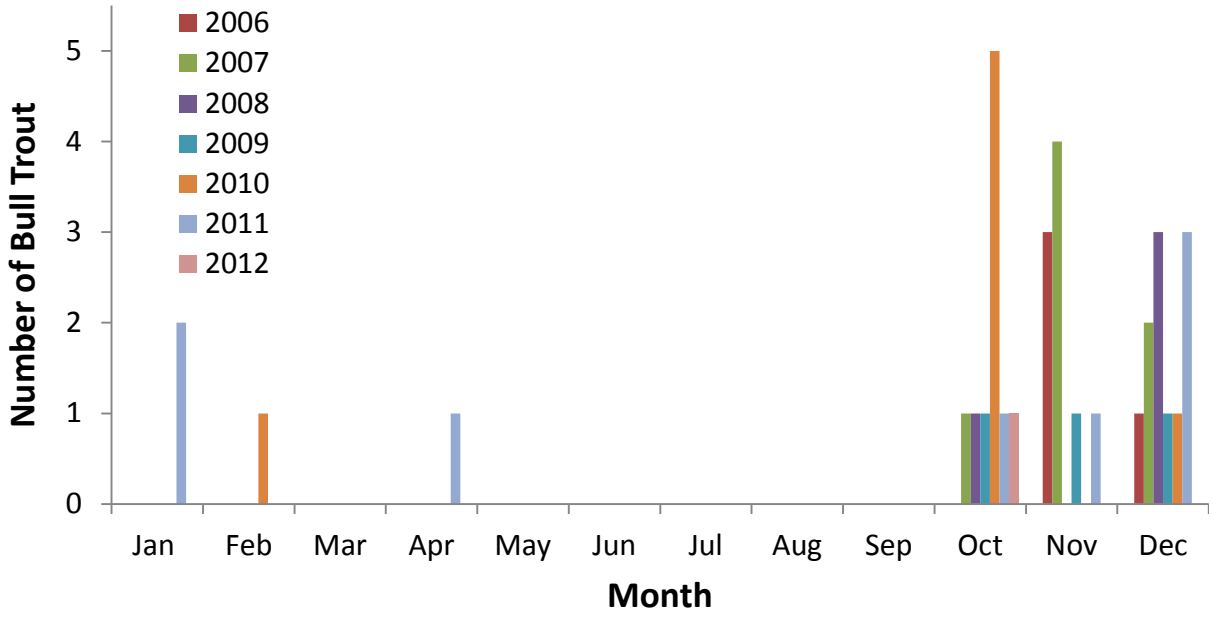

Figure 7. Downstream passage timing of PIT-tagged adult bull trout at Bennington Lake Diversion Dam (MCD) during 2006-2012.

Tagged subadult bull trout have been detected at the MCD array during all months with the exception of September (Figures 8 and 9). Tag detections are highest at MCD during late spring and early summer (May through July), and again during the fall (November). No upstream detections of subadult bull trout occurred in 2005 or 2012. No downstream detections of subadults occurred in 2011 or 2012.

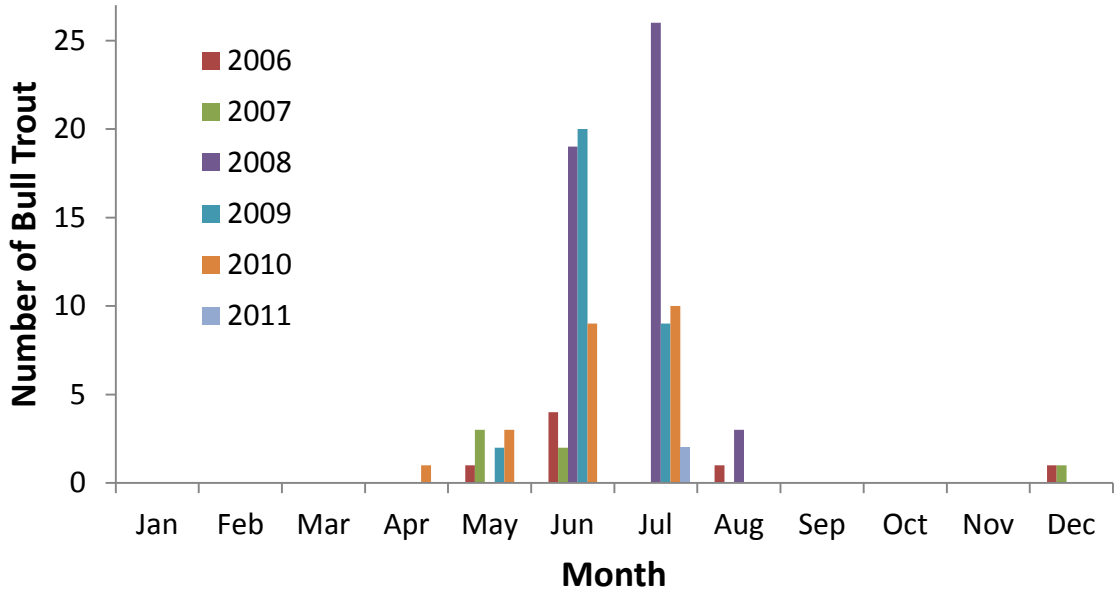

Figure 8. Upstream passage timing of PIT-tagged subadult bull trout at Bennington Lake Diversion Dam (MCD) during 2006-2011.

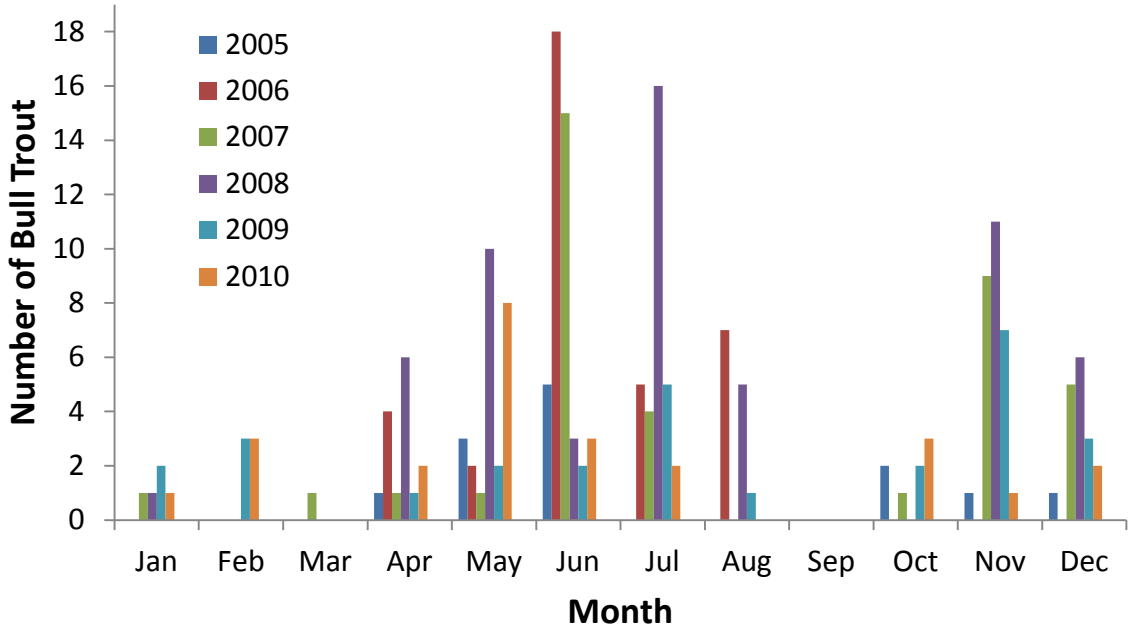

Figure 9. Downstream passage timing of PIT-tagged subadult bull trout at Bennington Lake Diversion Dam (MCD) during 2005-2010.

Bull Trout Use of Mill and Yellowhawk Creeks

There were 71 upstream detections of 46 individual adult bull trout at MCD from 2007 through 2012 (Table 2). Fifteen (33%) adults returned downstream to areas below MCD to overwinter in two or more years which increased the total number of upstream detections when these fish returned to spawn in subsequent years. Most (55%) adult bull trout overwintered within the Mill Creek Project. Adult bull trout were also detected using lower Mill Creek (below Division Dam) and Yellowhawk Creek for overwintering. A larger percentage of these fish overwintered in lower Mill Creek (38%) than Yellowhawk Creek (7%).

Subadult bull trout used rearing areas downstream from Bennington Lake Diversion Dam at different rates based on 74 detections of 72 individual fish. In addition, spring downstream migrants used rearing areas at different rates than fall downstream migrants (Table 2). The primary rearing area for spring migrants prior to moving back upstream in early summer was the Mill Creek Project, and Yellowhawk Creek was used at the lowest rate. This was similar to observations for adult bull trout. The primary rearing area for fall migrants prior to moving back upstream the following summer was Lower Mill Creek, and again, Yellowhawk Creek was used at the lowest rate. However sample size of fall migrants was low (n=10).

Table 2. Number of PIT detections for bull trout using Lower Mill Creek, Yellowhawk Creek and the Mill Creek Project. Percentages are reported in parentheses.

Life stage	Lower Mill Creek use	Yellowhawk Creek use	Mill Creek Project use	Total
Adult	27 (38)	5 (7)	39 (54.9)	71
Subadult				
Spring migrants	21 (32.8)	7 (10.9)	36 (56.3)	64
Fall migrants	5 (50)	2 (20)	3 (30)	10

Upstream Passage Delay at Bennington Lake Diversion Dam

A total of 183 bull trout detections were analyzed to determine potential upstream passage delay associated with the LFO (Table 3). Subadults were more likely to be delayed at the LFO than adults, although adults spent more time and attempts trying to pass. A small number of adult bull trout (n=2, 2.7%) were determined to have never successfully passed the structure and were never detected afterwards. Analysis of ladder detections showed most adult bull trout passed the dam once the ladder was found. Adults that attempted to pass via the LFO were delayed over 126 hours on average before finding the fish ladder (Table 4). Adults averaged less than 9 hours to pass from the lower ladder antenna to the upper ladder antenna. Total time to pass the Bennington Lake Diversion Dam averaged over two days with a maximum of almost 43.

Subadult bull trout behavior differed from adults in that many more fish wandered back and forth between the LFO and ladder with 30 (27.8%) never passing MCD (Table 3). Of the 30 subadults that failed to pass MCD, seven turned back downstream and into Yellowhawk (n=4) or lower Mill Creek (n=3). Only one subadult was determined to have oversummered below MCD, and survived into the next spring. The other 29 subadults were never detected again after their initial summer passage attempt and most likely perished within the Mill Creek Project. Subadults spent less time than adults trying to pass via the LFO, but took longer to pass upstream through the fish

ladder (Table 4). On average, subadults spent over three days trying to pass Bennington Lake Diversion Dam.

Table 3. Bull trout upstream passage delay associated with the low flow outlet (LFO) at Bennington Lake Diversion Dam.

Life stage	Total upstream detections	Number delayed at LFO (%)	Mean attempts	95% CI
Adult	75	26 (34.7)	7.6	±3.5
Subadult	108	55 (50.9)	6.6	±1.4

Table 4. Bull trout upstream passage delay at Bennington Lake Diversion Dam (BLDD).

	Adults		
	Time LFO to ladder hour:min (n=24)	Time in ladder hour:min (n=68)	Total delay at BLDD hour:min (n=68)
Min	2:05	0:10	0:10
Max	1025:08	191:15	1026:12
Average	126:38	8:44	53:18
	Subadults		
	(n=53)	(n=87)	(n=98)
Min	39:00	0:17	0:17
Max	546:59	956:22	976:46
Average	76:20	39:57	76:45

Dispersal of Bull Trout into the Mainstem Walla Walla River

Only one adult bull trout has been detected migrating into the mainstem Walla Walla River from Mill Creek since monitoring began in 2007 (Table 5). This fish was originally tagged in the Touchet River and the population of origin for this adult is unknown. After upstream spawning migrations in 2011 and 2012, this individual used Yellowhawk Creek during October to return to the mainstem Walla Walla River both years.

Table 5. Tagging, detection and recapture history for a Touchet River tagged bull trout (3D9.1C2CC95E46) that returned to Mill Creek.

Antenna ID	Observation date and time	Site	Movement notes
na	6/29/2010 12:00	Dayton adult trap (Touchet River)	Tagging location Fork length = 380 mm
A2	6/14/2011 23:08	Division Dam ladder	Upstream migration out of lower
A1	6/14/2011 23:08	Division Dam ladder	Mill Creek
03	6/16/2011 22:24	Diversion Dam ladder	
02	6/16/2011 23:43	Diversion Dam ladder	
03	8/1/2011 22:19	City of WW intake dam	
01	8/1/2011 22:32	City of WW intake dam	On spawning grounds
03	10/3/2011 20:50	City of WW intake dam	Beginning of downstream migration
02	10/15/2011 20:08	Diversion Dam ladder	
03	10/15/2011 20:10	Diversion Dam ladder	
A1	10/17/2011 17:57	Yellowhawk Creek (below headgate)	
B1	10/18/2011 06:30	Yellowhawk Creek (WA High)	
F1	10/18/2011 19:45	Burlingame Diversion (canal)	Mainstem Walla Walla River
F2	10/18/2011 19:45	Burlingame Diversion (canal)	(rkm 61)
FB	10/18/2011 22:56	Burlingame Diversion (bypass)	
na	11/22/2011 16:30	Lowden Diversion (rkm 51)	Hook and line recapture Fork length = 533 mm
A2	5/15/2012 00:12	Division Dam ladder	Upstream migration out of lower
A1	5/15/2012 00:13	Division Dam ladder	Mill Creek
04	5/22/2012 00:23	Diversion Dam (LFO)	Delay at Mill Creek Dam
03	5/24/2012 13:19	Diversion Dam ladder	(over 2 days)
02	5/24/2012 13:50	Diversion Dam ladder	
03	6/29/2012 22:05	City of WW intake dam	
03	7/4/2012 21:23	City of WW intake dam	
01	7/4/2012 21:40	City of WW intake dam	On spawning grounds
01	9/28/2012 20:00	City of WW intake dam	Beginning of downstream migration
03	9/28/2012 20:04	City of WW intake dam	
05	10/20/2012 02:26	Diversion Dam (LFO)	
A1	10/20/2012 04:29	Yellowhawk Creek (below headgate)	
F2	10/21/2012 04:15	Burlingame Diversion (canal)	Mainstem Walla Walla River
FB	10/21/2012 18:34	Burlingame Diversion (bypass)	(rkm 61)

Subadult bull trout tagged in Mill Creek were observed dispersing into the mainstem Walla Walla River. Since 2007, 34 subadults have been detected at mainstem Walla Walla River PIT tag detection arrays. Table 6 displays the migration route for the 34 fish. Subadults that had an unknown migration season or route are likely lower Mill Creek migrants. This assumption is based on the low probability of a tagged fish passing both YHC PIT arrays undetected and a higher probability of passing the Division Dam undetected during spill operations.

Table 6. Subadult bull trout dispersal route from Mill Creek into the mainstem Walla Walla River.

Migration season	Migration route		
	Yellowhawk Creek	Lower Mill Creek	Unknown
Fall	20	1	1
Spring	9	0	1
Unknown	0	0	2
Totals	29	1	4

Detections of Mill Creek subadults at mainstem Walla Walla River PIT arrays have shown that two subadults overwintered in the Walla Walla River and ascended the South Fork Walla Walla River as adults to presumably spawn the following spring. This is evidence of local population connectivity within the Walla Walla River core area. In total, eight Mill Creek bull trout have been detected at Nursery Bridge Dam (NBA, rkm 74) (Figure 2), upstream from the mouth of Yellowhawk Creek (rkm 64). In another example of connectivity, a Mill Creek tagged bull trout was recaptured in the Touchet River at the Dayton adult trap (rkm 86) approximately one year after entering the Walla Walla River. This individual migrated out of Yellowhawk Creek during late June 2008 and oversummered upstream of NBA. The following November, it migrated downstream to overwinter before ascending the Touchet River where it was recaptured in the spring of 2009. It is unknown if this fish spawned, however it displayed connectivity between the two core areas of the Walla Walla Basin. Seven Mill Creek bull trout were detected at the Oasis Road Bridge PIT array (ORB, rkm 10) in the lower Walla Walla River, indicating that they potentially entered the Columbia River. Of these seven bull trout, six were never detected again and one tag was recovered on Foundation Island, indicating that this fish was likely preyed on by a double crested cormorant during nesting season (Barrows et al. 2012b).

Returns to Mill Creek from the Mainstem Walla Walla River

Only one adult bull trout has been detected returning to Mill Creek after a known migration into the Walla Walla River. This is the same Touchet River tagged bull trout discussed in the previous section. This fish made two spawning migrations from the lower Walla Walla River into Mill Creek. Upstream migrations in 2011 and 2012 used the lower Mill Creek channel to reach spawning grounds. This fish migrated approximately 151 km from its initial tagging site in 2010, to the headwaters of Mill Creek to spawn.

No subadult bull trout from any origin have been detected returning to Mill Creek from the Walla Walla River. One subadult, tagged in the South Fork Walla Walla River, was detected migrating up Yellowhawk Creek during July 2011. This fish appears to have traveled to the upper YHC array, then back down again. It is unknown if this fish entered Mill Creek undetected and then moved back into Yellowhawk Creek. Another subadult tagged in the South Fork was detected twice at the middle YHC array during July 2009. There were no subsequent detections of these two subadults.

Conclusions

Bull Trout Migration Timing

Adult bull trout migration timing is usually related to spawning. For example, adult bull trout are either migrating upstream to spawning grounds during the spring and summer months or returning to overwintering areas in the fall and winter months. Detection data collected at the Mill Creek Project has repeatedly documented this behavior. Flows seem to impact the timing of upstream migration with higher flows delaying timing. The opposite may be true for downstream migration timing, as water withdrawal from Mill Creek may keep stream flows artificially low and impede bull trout movement, thus delaying timing. Caution should be used when determining in water work windows based on calendar date and not considering the specific river conditions present.

Subadult bull trout disperse from natal rearing areas throughout the year and some migrate downstream of MCD. The arrival of subadults to the Mill Creek Project peaks in spring and again in the fall. Subadults have been detected moving both upstream and downstream during the late spring and summer. The upstream movement of these fish may be an effort to escape low stream flows and the resulting high water temperatures that occur downstream from MCD. The reason for downstream detections during this time period is uncertain. It is possible that some subadults are unable to pass upstream through the ladder which forces them to search for more suitable conditions downstream. Downstream migration may also be to avoid predation. Although no tagged subadults have been detected at MCD during September, it is possible subadults are present throughout the year in areas near Bennington Lake Diversion Dam.

Bull Trout Use of Mill and Yellowhawk Creeks

Most adult bull trout that migrated below MCD were determined to have resided within the Mill Creek Project (55%). Numbers could be biased by missed detections at the Division Dam during spill operations, however most high flow events that trigger spill are relatively small in duration. Adults overwintered in higher numbers in lower Mill Creek when compared to Yellowhawk Creek. Of the bull trout overwintering in Yellowhawk Creek, only one was detected moving downstream past a second PIT tag array located approximately at the halfway point of the stream near Walla Walla High School. The lack of detections on the lower YHC array suggests that adult bull trout rarely use the lower half of Yellowhawk Creek for overwintering.

Subadult spring migrants resided within the Mill Creek Project at a higher rate than lower Mill Creek and Yellowhawk Creek. Fall migrants showed a different behavior than spring migrants in that they overwintered in lower Mill Creek at a higher rate than the Mill Creek Project although sample size was small and may have affected the results. Yellowhawk Creek was the least used for rearing by spring and fall subadult migrants.

Upstream Passage Delay at Bennington Lake Diversion Dam

The Bennington Lake Diversion Dam impedes the upstream passage of adult and subadult bull trout. The first mechanism of delay originates with flows from the LFO that attract upstream migrating bull trout, causing some fish to miss the entrance to the ladder. These fish expend valuable energy fighting the LFO and expose themselves to predation and injury. Secondly,

subadults seem to struggle passing upstream through the ladder based on ladder detections. This might explain behavior of subadults that repeatedly move between the LFO and ladder. At the onset of summer base flows, relatively high numbers of subadult bull trout have been observed below Bennington Lake Diversion Dam during sampling which is corroborated with detection data. Detection histories of subadults that fail to pass the dam suggest that few survive to adulthood. Bull trout concentrated below the dam have the potential to attract predators can be exposed to lethal water temperatures. In addition to attempted avian predation marks observed on bull trout, Caspian terns, herons, double crested cormorants, white pelicans, mergansers, kingfishers, mink and otter have been observed foraging near the Mill Creek Project. Further evidence of avian predation has also been documented as tags originally implanted into Mill Creek bull trout have been recovered on avian breeding colonies in the Columbia River upstream from the confluence of the Walla Walla (Barrows et al. 2012b). Since monitoring of the islands began around 2002, 16 PIT tags from Mill Creek tagged bull trout have been recovered. Recoveries have been predominately found at the double crested cormorant nesting site at Foundation Island (rkm 512) and American white pelican nesting site at Badger Island (rkm 518). There is also the potential for delay of upstream migrants during spill operations at Bennington Lake Diversion Dam. If spill were to occur during the adult upstream spawning migration, the fish ladder and LFO would be closed and passage would not be possible.

Dispersal of Bull trout into the Mainstem Walla Walla River

Since 2007, only one adult bull trout was detected migrating out of Mill Creek and into the mainstem Walla Walla River. This fish used Yellowhawk Creek to enter the lower Walla Walla River. During periods of low water in the summer and fall, Yellowhawk Creek is the probable route of downstream migration for bull trout as most flows from Mill Creek are diverted into Yellowhawk Creek and away from lower Mill Creek. No other Mill Creek origin adult bull trout have been detected at mainstem Walla Walla River PIT arrays. It is possible that tagged adults have entered the mainstem and were never detected or recaptured during sampling. Adults migrating out of lower Mill Creek have a 10 km section of the Walla Walla River to use between PIT detection arrays at Burlingame Diversion (rkm 61) and Lowden Diversion (rkm 51). An adult bull trout could exit Yellowhawk Creek and have a 13 km section of river to use between PIT detection arrays at Nursery Bridge Dam (rkm 74) and Burlingame (rkm 61), however few adults have been detected in Yellowhawk Creek and an adult migrating downstream out of Yellowhawk Creek would only need to travel three km downstream to reach the Burlingame Diversion array on the mainstem Walla Walla River. Another explanation is that most of the tagging in Mill Creek has taken place in the upper watershed. Anglin et al (2010a) indicated that the higher a bull trout is tagged in the system, the less likely that fish is going to undertake a long range migration into the lower parts of the basin. Thus, it is possible that few tagged adults are available in lower Mill Creek to provide observations showing migration into the mainstem Walla Walla River.

Subadult bull trout have been detected moving out of Mill Creek and dispersing throughout the Walla Walla Basin and likely into the Columbia River. A majority of these subadults migrated in the fall and used Yellowhawk Creek. Some spring out-migrants traveled upstream of NBA, likely to avoid unsuitable water temperatures that occur in the Walla Walla River downstream of Milton-Freewater, OR. Only two migrants were determined to have survived to adulthood and both made spawning migrations into the South Fork Walla Walla River. It is unclear why they

did not return to Mill Creek to spawn and this could be an indication of passage problems in lower Mill and Yellowhawk creeks. Genetic analysis has confirmed interbreeding between the Mill Creek and the South Fork local populations (Small et al. 2012). Based on the lack of detections of South Fork origin bull trout migrating into Mill Creek, and two Mill Creek origin bull trout making an upstream spawning migration into the South Fork Walla Walla River, it could be assumed that Mill Creek origin fish are likely contributing to the genetics of the South Fork local population.

Returns to Mill Creek from the Mainstem Walla Walla River

Only one bull trout has been detected migrating into Mill Creek from the Walla Walla River. This fish used the lower Mill Creek channel to migrate upstream and is the only bull trout to have been observed doing so during this study. Even though this fish was successful navigating the lower Mill Creek channel, the lack of observations of other adults completing this migration could suggest that most others fail. The lower Mill Creek channel has several passage concerns for bull trout, although this section is currently in the process of being remediated (Burns et al. 2009).

No subadult bull trout have been detected returning to Mill Creek after being detected entering the Walla Walla River. Two subadults ascended Yellowhawk Creek, which suggests that sufficient upstream passage conditions may exist at times in Yellowhawk Creek. These fish were never detected entering Mill Creek, and their timing in mid to late July suggests that they were seeking out thermal refuge which Mill Creek was probably unable to provide. Subadult bull trout that migrate into some sections of lower Mill Creek may become trapped below barriers. If these fish are unable to pass upstream when stream flows and water temperatures become unsuitable, they are likely lost to the population.

Genetic exchange between bull trout populations is identified in the Bull Trout Recovery Plan as an important recovery criterion. This study successfully documented local population connectivity and core area connectivity in the Walla Walla Basin suggesting that conditions are sometimes present for bull trout to perform these important biological processes. However, detection data also points to this process as a rare event. The failure to document South Fork Walla Walla origin fish contributing to the Mill Creek local population is concerning and might allude to passage concerns in lower Mill Creek. Additionally, the absence of Mill Creek tagged bull trout detected returning from the mainstem Walla Walla River is further evidence of potential barriers to migration and warrants further research.

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Appendix A: *Steelhead and Spring Chinook Salmon PIT Detections*

In addition to detections of bull trout, several adult steelhead and spring Chinook salmon have been detected at the Mill Creek Project PIT arrays. Returning adult salmon and steelhead were characterized by upstream detections at mainstem Columbia River hydroelectric projects such as Bonneville and McNary dams. Most fish were tagged as juveniles during outmigration to the ocean. However, some steelhead were tagged as adults at Bonneville and Lower Granite adult ladder traps. Individual detection histories of adults were analyzed to determine migration timing and routes, tagging origin, and potential delay at Mill Creek Project structures.

Steelhead PIT Detections

A total of 26 tagged adult steelhead have been detected at the MCD array from 2010 through 2012. No adult steelhead were detected prior to 2010 at any Mill Creek Project arrays. Upstream detections at MCD occurred in the months of March (n=6), April (n=17), and May (n=3) for all years. Of 26 adult steelhead detected at MCD, 13 were detected in the lower Walla Walla River at the Oasis Road Bridge PIT array (ORB, rkm 10) starting in late October and continuing into late April. Nineteen steelhead were PIT tagged as smolts in the Walla Walla Basin during their outmigration (Table A.1). Seven steelhead were PIT tagged as adults at Bonneville Dam and Lower Granite Dam. A single hatchery origin adult steelhead was detected at the Division Dam fish ladder in December 2012 but was not detected at MCD. The hatchery steelhead entered the Walla Walla in September 2012.

Table A. 1. PIT Tagging locations of adult steelhead detected at Bennington Lake Diversion Dam.

Return Year	PIT Tagging Site					Totals
	Lower Mill Creek	Lower Walla Walla River	Yellowhawk Creek	Bonneville Dam Adult Ladder	Lower Granite Dam Adult Ladder	
2010	0	3	0	0	1	4
2011	5	0	1	2	1	9
2012	7	3	0	2	1	13
Totals	12	6	1	4	3	26

Detection data were analyzed for returning Mill Creek adult steelhead to determine their migration route through the Mill Creek Project. Of the 27 adult steelhead (including a hatchery adult) that returned to the Mill Creek Project, only four (14.8%) used Yellowhawk Creek as an upstream migration route. The remaining 23 (85.2%) used the lower Mill Creek channel (below Division Dam) for upstream migration. Travel times were calculated for different sections of the migratory corridor (Table A.2). Generally, adult steelhead that were detected returning to the mouth of the Walla Walla River in the spring from March to April, migrated more rapidly than earlier returners in October through January. Although sample size was small (n=4), adult steelhead traveled from the YHC array to MCD relatively quickly when compared with fish that passed through the division ladder and traveled to MCD. Only two (7.7%) adult steelhead attempted to ascend the LFO before finding the fish ladder and successfully passing the structure, suggesting most adults are not delayed at Bennington Lake Diversion Dam (n=26). Median time to pass from the lower ladder antenna to the upper ladder antenna was just over 15 minutes, suggesting that once adults are in the ladder, they can pass relatively quickly.

Table A. 2. Travel times for adult PIT tagged steelhead returning to upper Mill Creek.

	ORB to Division Dam ladder (days) n=10	Division Dam ladder to MCD (hour:min) n=20	YHC to MCD (hour:min) n=4
Distance (km)	61.6	1.6	1.6
Minimum	9.75	4:29	9:17
Maximum	143.92	638:12	29:36
Mean	77.91	61:47	19:44

Detection data were also collected on post spawn adult steelhead (kelts) during downstream migration through the Mill Creek Project. Adult steelhead that passed upstream of MCD and then were detected moving downstream at a later date were assumed to have spawned and were considered kelts. A total of 10 kelts were detected migrating downstream during late March through early June. Eight of the 10 passed into YHC, one passed into lower Mill Creek through the Division Dam ladder, and one was detected passing downstream at MCD, but not detected again. One kelt of note was detected leaving Mill Creek via Yellowhawk Creek and was interrogated only 15 days later below Bonneville Dam in the upper Columbia River estuary (rkm 61-83) trawl PIT tag array.

Spring Chinook Salmon PIT Detections

A total of 20 adult spring Chinook salmon have been detected at the MCD PIT array from 2006 through 2012 (Figure A.1). No detections occurred during 2005, 2007 and 2008. One jack was detected returning in 2011 and is included as an adult for analysis.

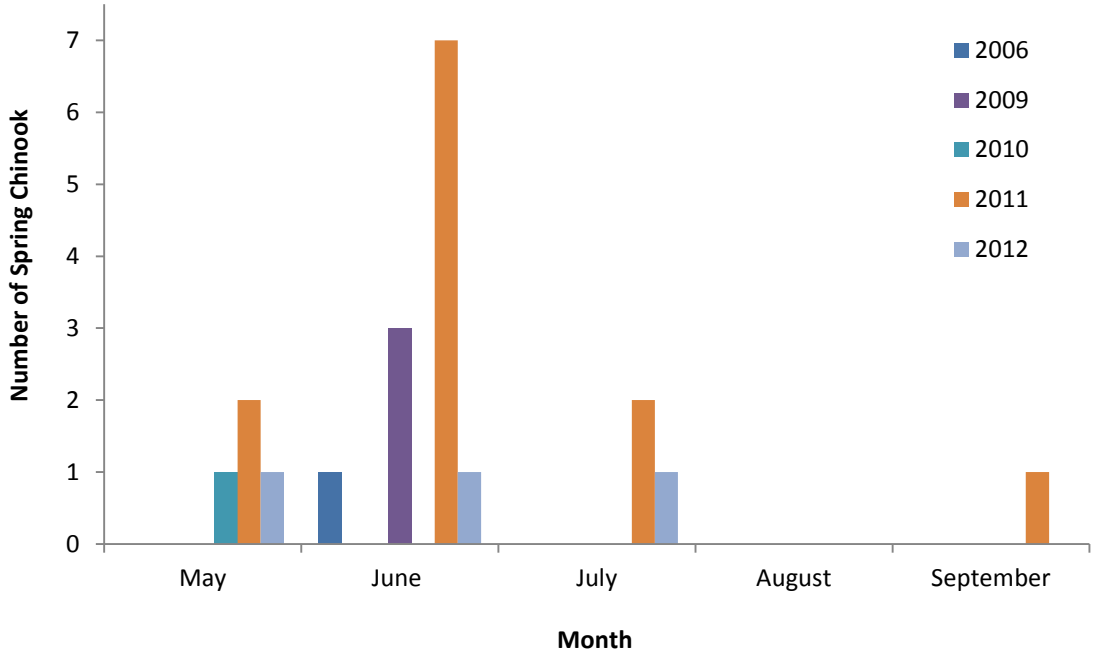

Figure A 1. Adult spring Chinook salmon PIT detections at Bennington Lake Diversion Dam fish ladder PIT array.

Of the 20 adult spring Chinook salmon interrogated at MCD, seven were detected entering the Walla Walla River in April and May at the ORB PIT array. All fish were tagged as juveniles and are assumed to have been naturally produced in upper Mill Creek (Table A.3). A smolt tagged at John Day Dam was also implanted with an acoustic tag by Pacific Northwest National Laboratory.

Table A. 3. Tagging locations of adult spring Chinook salmon detected at Bennington Lake Diversion Dam detection array.

Return year	PIT tagging site					
	Upper Mill Creek	Lower Mill Creek	Lower Walla Walla River	Yellowhawk Creek	John Day Dam	Totals
2006	1	0	0	0	0	1
2009	3	0	0	0	0	3
2010	0	0	0	0	1	1
2011	0	4	6	2	0	12
2012	0	3	0	0	0	3
Totals	4	7	6	2	1	20

Detection data were analyzed for returning Mill Creek adult spring Chinook salmon to determine their migration route to the Mill Creek Project. The migration route for the one returning spring Chinook salmon during 2006 was not discernible as the Division Dam ladder and Yellowhawk Creek arrays were not installed. Of the 19 remaining adult spring Chinook salmon, only three (15.8%) used Yellowhawk Creek to migrate to upper Mill Creek with the rest using the lower Mill Creek channel (below Division Dam). Travel times were calculated for different sections of the migratory corridor (Table A.4). Although the sample number is low (n=3), travel time from the YHC array to MCD is substantially greater than from Division Dam ladder to MCD. This suggests adult spring Chinook salmon may have trouble with upstream passage at the Yellowhawk Creek radial gate or adjacent needle slot gate. All three YHC passage events occurred in 2011, so passage may have been related to conditions present that year.

Table A. 4. Travel time for adult PIT tagged spring Chinook salmon returning to upper Mill Creek.

	ORB to Division Dam ladder (days) n=6	Division Dam ladder to MCD (hour:min) n=15	YHC to MCD (hour:min) n=3
Distance (km)	61.6	1.6	1.6
Minimum	4.86	4:05	69:07
Maximum	37.82	68:00	163:47
Mean	18.61	31:00	116:46

Spring Chinook salmon passage delay at Bennington Lake Diversion Dam was evaluated for adult returns from 2009 through 2012 (n=19). Adult Chinook salmon exhibited delay by trying

to ascend the LFO before finding the fish ladder and successfully passing the structure. Eleven (57.9%) adults tried to pass the LFO before finding the fish ladder (Table A.5). The remaining eight adults were not detected in the LFO and entered the ladder, presumably without delay. Median time to pass from the lower ladder antenna to the upper ladder antenna was seven minutes, suggesting that once adults are in the ladder, they can pass relatively quickly. One 2011 returning adult tried to pass Bennington Lake Diversion Dam via the LFO 16 times from June 26th through June 29th, and then was not detected again until September 18th, passing upstream through the fish ladder.

Table A. 5. Adult spring Chinook salmon passage delay at Bennington Lake Diversion Dam.

	Attempts to pass LFO n=11	Delay at LFO (days) n=11
Minimum	2	0.9
Maximum	42	84.0
Mean	17.6	18.6

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