



Entiat Subbasin Lamprey Monitoring Report, 2016



[Cover Photo: Overview of an Entiat River side channel (river km 46.5) where potential Western Brook Larvae (59-70 mm) were found in August, 2016]

Project No. 2008-470-00

Report was completed under BPA Contract No. 56662 REL 100

Report covers work performed from: May 2016 – December 2016

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Report Created: March, 2016

This report was funded in part by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

ABSTRACT

Pacific Lamprey is an invaluable cultural and ecological species that is declining in abundance and distribution throughout their range, including the Entiat Subbasin. In an effort to monitor, manage and restore the species, the Yakama Nation Pacific Lamprey Program (YNPLP) has led electrofishing surveys for larval Pacific Lamprey throughout the Entiat Subbasin since 2012. This report highlights our 2016 electrofishing efforts in the Entiat Subbasin.

A total of eight sites (three index sites and five exploratory sites) were surveyed within the Entiat River. One additional site, river km 10.1, was visited (not electrofished) in order to better understand the distribution of available Type I and Type II habitat in the lower reach of the Entiat River. No electrofishing surveys were conducted in the Mad River, as there seems to be limited habitat for larval lamprey within the system.

Pacific Lamprey was found at all three of the index sites (100%), and at two out of the five exploratory sites (40%). Lamprey (n=6) with Western Brook Lamprey tail characteristics (43-70 mm) were discovered at an exploratory site at river km 46.5, and we are awaiting genetic analysis to confirm their species. Lamprey were not found at river km 47.2 (3.2 river km downstream of Box Canyon at river km 50.4). No macrophthalmia (eyed Pacific Lamprey) were found during our surveys.

In Type I habitat, lamprey densities were highest at river km 30.4 (76.0 #/m²), although densities near the river mouth (river km 1.1) were also high (59.0 #/m²). The lowest density was river km 46.5 (1.5 #/m²), where potential Western Brook Lamprey were found. The estimated number of lamprey and estimated biomass (g) within the 50 m reach were highest near the mouth at river km 1.1 (58,958 and 12,676 g, respectfully). The mouth also had the highest area of available habitat (1,000 m² in 50 m). At the index sites, estimated numbers of lamprey followed a decreasing trend from downstream to upstream (58,958, 20,032, and 1,396 at river km 1.1, 30.4 and 40.2, respectively).

A rapid drop in water level was noted in a side channel at river km 1.1 near the mouth of the Entiat River, and no lamprey were found during an exploratory electrofishing survey in this side channel. The fluctuating water level is likely due to water control at Rocky Reach Dam. The water level in the side channel was observed to drop approximately 30 cm in two hours, or a rate of 15 cm per hour. The absence of lamprey could potentially be explained by a lack of attraction by larval lamprey to occupy recently dewatered fine sediment and/or because larval lamprey in this habitat simply cannot survive.

At river km 12.8 (0.5 km north of the intersection of Crum Canyon Road off of Entiat River Road), there is a man-made side channel which leads to an irrigation pump with no return flow to the river. Larval lamprey will continue to move “downstream”, or towards the irrigation pump, with no way back to the river. An estimated 7,726 larval lamprey reside in this side channel.

Action needs to take place immediately to save the entrained lamprey. One recommendation is to salvage as many of the entrained lamprey as possible through electrofishing (and return them to the river). Alternatively, a connecting channel to the main river could be created near the downstream end of the side channel so entrained lamprey have an opportunity to return back to the river. Also, the screen on the pump needs to be replaced, as it has many small holes where larval lamprey could easily pass through.

A total of 85 larval lamprey genetic samples were collected from the Entiat River (34, 35, and 6 at river km 1.1, 40.2 and 46.5, respectively). The goals of these genetic samples are to 1) estimate the number of effective spawners by analyzing samples from the upper and lower reaches of the Entiat and 2) identify to species potential Western Brook Lamprey captured at river km 46.5.

METHODS

Site Choice and Field Survey

Throughout the Yakama Nation Ceded Lands, the YNPLP (Yakama Nation Pacific Lamprey Project) has conducted surveys for larval lampreys (beginning in 2009). Index sites, or long-term repeat monitoring sites, have been established throughout the Ceded Lands. The index sites are spatially distributed within watersheds with the potential to hold Pacific Lamprey. The primary goal of these index sites is to monitor the status and trend of Pacific Lamprey in the lower, middle, and upper reaches of interest watersheds. In addition to the index sites, exploratory sites are established each year to further our knowledge on Pacific Lamprey distribution and habitat availability within each watershed.

For all site types, survey sites were chosen based on aerial images from Google Earth and GIS software and site visits. Sites that had higher chances of being a Type I habitat [such as visibly recognizable areas on aerial image with slow water, shallow channel margin with dark tints (usually indicating fine sediment), backwater eddies, confluence of side channels, behind island bars, and tail end of deposition bars, etc.] were given priority. We determined that targeting the preferred habitat more effectually will provide us with a better framework for evaluating presence/absence, distribution, and relative abundance. Further, due to restricted survey time, the ease of access to a survey site (e.g. sites with public road access, short hikes, or near bridges, or private properties who permit access to the rivers/streams) was a critical issue and strongly considered when choosing sites. By prioritizing accessibility, more ground could be covered throughout the expansive area of interest. Chosen habitat sites were ultimately spatially distributed throughout individual watersheds.

Surveys were focused on Type I (preferred) and/or Type II (acceptable) habitat to provide optimal opportunity to capture the largest number of larval lamprey. Type I habitat primarily consists of fine sand, silt and/or clay and is absent of coarse substrate (gravel/cobble/boulder/bedrock). Type II habitat is coarse shifting sand or other fine substrate mixed with coarse substrate. Type III (unsuitable) habitat consists of no fine sediments and was not surveyed. Type I and II habitat is generally found in backwater areas, point bars, mainstem channel margins, and side channels.

Site surveys were categorized as “Full”, “Short” or “Visit”. During a full survey, both Type I and Type II habitat were surveyed. At short surveys only Type I habitat (or Type II habitat, in the case of no Type I habitat available) was surveyed. At visited sites, no electrofishing occurred, and were primarily designed to further assess available lamprey habitat in different reaches of a river/stream. In general, a full survey was performed at each index site (to gain the most knowledge possible). A short survey (in general) was conducted at exploratory sites, designed to focus on the best habitat and get a quick assessment of lampreys at the site (habitat availability, density, and presence/absence).

At each electrofished site (index or exploratory), a 50 m reach was measured out which encompassed the most accessible and abundant Type I and Type II larval lamprey habitat. The total area (m²) of Type I and Type II larval lamprey habitat was estimated within the 50 m reach. Electrofishing surveys were conducted separately over Type I and Type II habitat, and covered representative areas of each habitat type. At full survey sites, a minimum area of Type I and Type II habitat was surveyed (10 m² and 5 m², respectively). At short survey sites, a minimum area of 5 m² of either habitat type was surveyed. Sediment type (sand, silt or clay) was recorded for the specific area (1 m²) where the most lampreys were observed. The sediment depth (cm), water depth (cm), and plot temperature (°C) were also recorded at this location. If no fish were observed, plot temperature was taken where the best available habitat was observed. Thalweg temperature was also recorded to represent the main channel temperature.

Electrofishing surveys were conducted with an AbP-2 Backpack Electrofisher (ETS Electrofishing Systems Inc., Madison, WI), specially designed for the sampling of larval lampreys, was used to survey available (wetted) larval habitat, using standard survey methods (slow tickle pulse of 3 pulses/sec and fast stunning pulse of 30 pulses/sec, 25% duty cycle, 3:1 burst pulse train, and 125 volts). Another person, equipped with a fine-mesh hand net was also present to help capture any electrofished larvae.

Captured lampreys were separated by habitat type, and tallied by life stage and identified to species (if of identifiable length > 50 mm). For each group of captured lampreys, 15 representative lengths were taken (+/- 1 mm). Four of these lampreys were measured to the nearest 0.01 gram (length and weight was taken on the largest, smallest and two medium sized larvae relative to the site). The combined weights of all captured lampreys were also measured (nearest 0.01 g). Missed larvae were also counted and tallied.

Genetic samples were collected from Pacific Lamprey (> 50 mm) with scissors or 2 mm whole punch (top or bottom of the caudal fin). Lampreys less than 50 mm were generally collected as whole samples (by placement on a genetic sheet or preservation in 70% Ethanol), but efforts were made to take genetic clips from larger unidentifiable larvae (> 35mm) rather than whole samples. Samples were primarily collected in areas where adult Pacific Lamprey translocation efforts are ongoing, or where the distribution of Pacific Lamprey is uncertain.

Analysis

Captured and missed larvae were tallied together and added to the number captured, to determine the total number of observed lampreys from electrofishing for each habitat type. If the number of captured lampreys was less than half of the observed total, the number of captured lampreys was doubled, and used as the final observed total. If the number of captured lampreys was equal to or more than half, the recorded observed number was used as the final observed total (represented by “observed total” in the following report).

In many cases, survey visibility was less than ideal, and many lampreys went unseen. To account for unseen lamprey, the total number of lampreys observed (final observed total) was adjusted (increased) based on the following 1-5 visibility scale: (1) poor (60%), (2) fair (70%) , (3) good (80%), (4) very good (90%) and (5) excellent (100%). For each survey, the total number of observed lampreys was increased (by the percentage listed above) based on the survey's visibility rank. Survey densities ($\#/m^2$) were calculated using the adjusted observed number of lampreys.

To calculate the number of lampreys within each 50 m reach, survey densities were extrapolated over their respective habitat type (estimated area within the 50 m reach) to arrive at the total number of lampreys for each habitat type. The estimated number from both habitat types was then summed together for an estimated total number of lampreys by site. The number of Pacific Lamprey within a 50 m reach was calculated from the Pacific Lamprey ratio (from identified lampreys) multiplied by the total number of lampreys estimated to reside within the reach.

A condition factor for each site was calculated by averaging the condition factor for each of the fish measured by both length and weight. The average weight of the captured lamprey (total weight g/# weighed) was calculated for each site. In the event, that not all of the captured lampreys were weighed together, the average capture weight was multiplied by the total number of captured lampreys.

To arrive at an estimated biomass within a 50 m reach, the electrofishing density (by mass) was calculated separately for captured and missed lampreys. The biomass densities for captured and missed lampreys was summed together to get the total biomass density for the survey. The estimated final biomass density was then extrapolated over the respective habitat type. The estimated biomass for each habitat type was then summed together to arrive at a total site biomass (g).

RESULTS

A total of eight electrofishing surveys were conducted at spatially distributed sites between river km 1.1 and 47.2 (2.9 river km downstream of Box Canyon). Three index sites were surveyed and six surveys were conducted at exploratory sites (Map 1). Full surveys occurred at four sites and short surveys occurred at four sites. One site (river km 10.1) was visited, and not surveyed, to better understand the distribution of larval lamprey habitat in the lower reach of the Entiat River. Flow conditions were near the 58 year average according to the USGS flow station in Ardenvoir, WA, ~ river km 30.3 (Figure 1).

Lamprey (n=6) with Western Brook Lamprey tail characteristics (43-70 mm) were discovered at an exploratory site at river km 46.5, and we are awaiting genetic analysis to confirm their species (Photo 1). Lamprey were not found at river km 47.2 (3.2 river km downstream of Box Canyon at river km 50.4). No macrophthalmia (eyed Pacific Lamprey) were found during our surveys.



Photo 1. Overview of a likely Western Brook Lamprey ~ 70 mm in total length captured in the Entiat River at river km 46.5 (left) and close-up of the same lamprey's tail (right). Species identification was based on tail characteristics, and genetic samples are awaiting analysis to confirm species.

Water levels appear to fluctuate quickly near the mouth of the Entiat River. A rapid drop in water level was noted in a side channel at river km 1.1 (Photo 2). No lamprey were found during an exploratory electrofishing survey in this side channel. The fluctuating water level is likely due to water control at Rocky Reach Dam. The water level in the side channel was observed to drop approximately 30 cm in two hours, or a rate of 15 cm per hour. The absence of lamprey could potentially be explained by a lack of attraction by larval lamprey to occupy recently dewatered fine sediment and/or because larval lamprey in this habitat simply cannot survive.

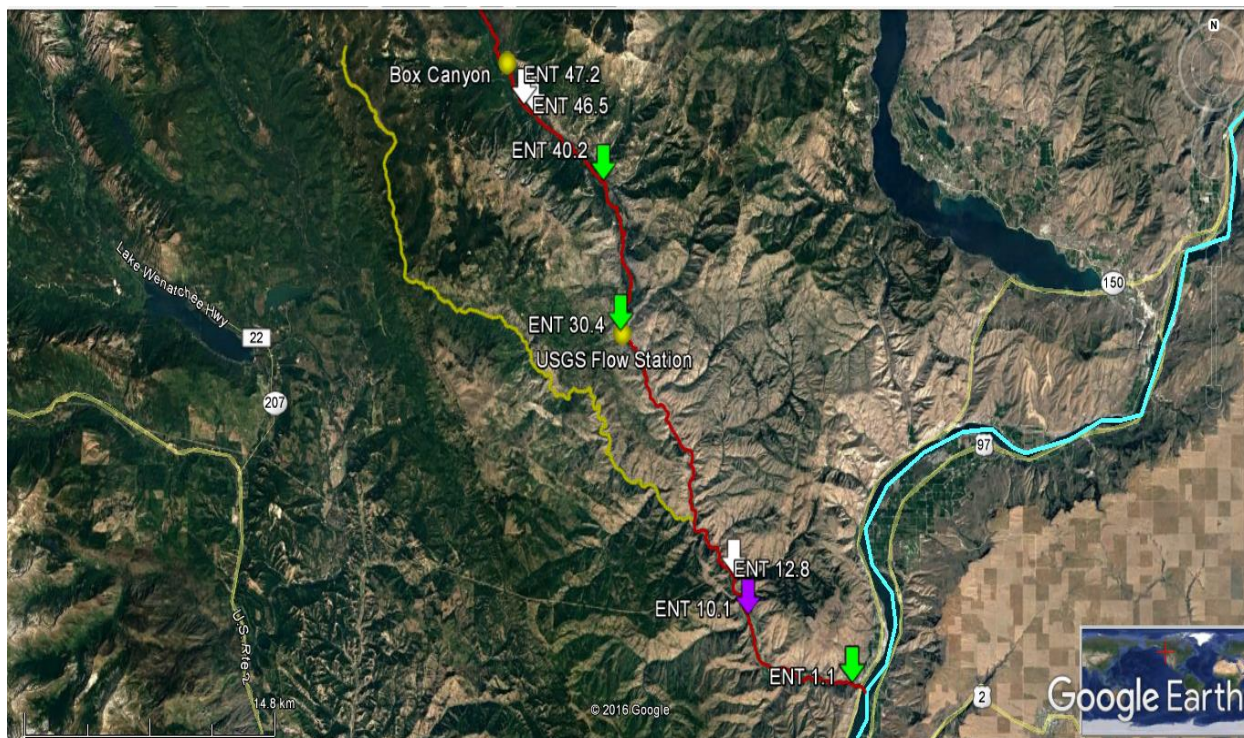


Photo 2. Side channel at river km 1.1 where no lamprey were found in August, 2016. The photo on the left was taken at 9:00 am and the photo on the right was taken at 9:50 am on August 10, 2016.

At river km 12.8 (0.5 km north of the intersection of Crum Canyon Road off of Entiat River Road), there is a man-made side channel which leads to an irrigation pump with no return flow to the river (Photo 3). Larval lamprey will continue to move “downstream”, or towards the irrigation pump, with no way back to the river. An estimated 7,726 larval lamprey reside in this side channel. Action needs to take place immediately to save the entrained lamprey. One recommendation is to salvage as many of the entrained lamprey as possible through electrofishing (and return them to the river). Alternatively, a connecting channel to the main river could be created near the downstream end of the side channel so entrained lamprey have an opportunity to return back to the river. Also, the screen on the pump needs to be replaced, as it has many small holes where larval lamprey could easily pass through.



Photo 3. Upstream view of the manmade side channel at river km 12.8 (left) and downstream view towards the irrigation pump (right).



Map 1. Overview of all surveyed sites in the Entiat River (red line) in August, 2016, displaying index sites (green arrows), exploratory sites (white arrows) where electrofishing occurred, and exploratory sites with no electrofishing (purple arrows). The locations of the USGS Flow Station (near Ardenvoir, WA) and Box Canyon (rkm 50.4) are also shown (yellow circles).

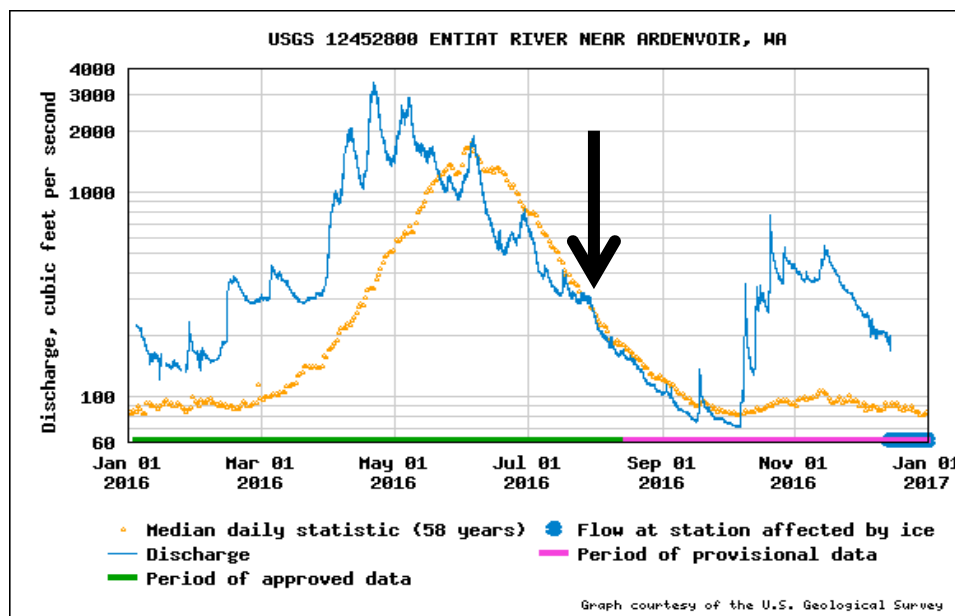


Figure 1. Discharge (cubic feet per second indicated by the narrow blue line) of the Entiat River near Ardenvoir, WA; black arrow indicates YN survey period (August 10 and 11, 2016).

Index Sites – Entiat River Mainstem

- Type I habitat was present at all of the surveyed index sites. Type I habitat was most abundant at the mouth (1000 m²) in a 50 m reach (100% of the available habitat was Type I habitat). Further upstream, the ratio of Type I habitat (to all available habitat types) was much lower (19%, 20%).
- Pacific Lamprey was present at all index sites (100%). In Type I habitat, lamprey densities were highest at river km 30.4 (76.0 #/m²), although densities near the river mouth (river km 1.1) were also high (59.0 #/m²).
- At the index sites, estimated numbers of lamprey followed a decreasing trend from downstream to upstream (58,958, 20,032, 1,396 at river km 1.1, 30.4 and 40.2, respectively).

Table 1. Larval lamprey habitat details from index sites surveyed in the Entiat River. Under “Survey Type”, a “Full” survey indicates that both Type I and Type II habitat were electrofished (when available). The percent of larval habitat shown is the ratio between available Type I and Type II habitat, and excludes Type III (unusable) habitat within the 50 m survey reach. Under “Type I Habitat Type”, “Edge” indicates that the primary survey location (for Type I habitat) was on the edge of the main channel; “Side Chan.” indicates this occurred in a side channel. Plot temp was taken where the most lampreys were found, and thalweg temp was taken in the main channel flow.

Site Type	Stream	River KM	Date	Survey Type	% Type I in 50 m	% Type II in 50 m	Type I Habitat Type	Primary Fine Sediment (Type I)	Primary Fine Sediment (Type II)	Plot Temp °C (Best)	Thalweg Temp °C
Index	Entiat	1.1	8/10/16	Full	100%	0%	Edge	Sand	-	16.8	15.7
Index	Entiat	30.4	8/10/16	Full	19%	81%	Edge	Sand	Course	17.8	17.6
Index	Entiat	40.2	8/10/16	Full	20%	80%	Side Chan.	Sand	Sand	15.8	15.7

Table 2. Survey details, separated by habitat type, for Entiat River index sites surveyed in in August, 2016. The total number of lampreys observed was adjusted (increased) based on the following 1-5 visibility scale (with estimated % visibility in parenthesis): (1) poor (60%), (2) fair (70%), (3) good (80%), (4) very good (90%) and (5) excellent (100%). Survey densities (#/m²) were calculated using the adjusted observed number of lampreys. The summary rows are a sum of presented values, except for e-fish density which is a mean of presented values.

Site Type	Stream	River KM	Habitat Type Surveyed	Shock Time (sec)	Shock Area (m2)	# Captured	# Observed	Survey Visibility (1-5)	Total # Observed (Adjusted)	E-Fish Density (#/m2)
Index	Entiat	1.1	Type I	647	12	144	566	3	707.5	59.0
Index	Entiat	30.4	Type I	458	12.5	184	736	3	920	73.6
Index	Entiat	40.2	Type I	837	16.5	161	461	5	461	27.9
Index	Entiat	1.1	Type II	0	-	-	-	-	-	-
Index	Entiat	30.4	Type II	442	8	16	32	5	32	4.0
Index	Entiat	40.2	Type II	493	9	5	10	5	10	1.1
Site Summary		1.1		647	12	144	566		708	59.0
		30.4	-	900	21	200	768	-	952	38.8
		40.2		1330	26	166	471		471	14.5
Habitat Summary		-	Type I	1942	41	489	1763	-	2089	53.5
			Type II	935	17	21	42		42	2.6

Table 3. Measurement details of captured lampreys, separated by habitat type, for Entiat River index sites surveyed in August, 2016 (sites without lamprey are excluded). The summary rows are a sum of presented values, except for mean weight, mean length and mean condition factor, which are a mean of presented values, and min and max length, which are the lowest and highest value, respectively.

Site Type	Stream	River KM	Habitat Type Surveyed	# Weighed	Total Weight of Captured (g)	Mean Weight of Captured (g)	Min. Length (mm)	Max. Length (mm)	Mean Length (mm)	Mean Condition Factor
Index	Entiat	1.1	Type I	144	56.82	0.39	17	120	65	0.704
Index	Entiat	30.4	Type I	184	81.22	0.44	29	132	77	0.772
Index	Entiat	40.2	Type I	161	62.74	0.39	36	137	82	0.806
Index	Entiat	1.1	Type II	-	-	-	-	-	-	-
Index	Entiat	30.4	Type II	16	22.53	1.41	38	136	102	0.757
Index	Entiat	40.2	Type II	5	0.62	0.12	31	66	44	0.883
Site Summary		1.1		144	56.82	0.39	17	120	65	0.704
		30.4	-	200	103.75	0.92	29	136	90	0.765
		40.2		166	63.36	0.26	31	137	63	0.844
Habitat Summary		-	Type I	489	201	0.41	17	137	75	0.760
			Type II	21	23	0.77	31	136	73	0.820

Table 4. Lamprey identification details, separated by habitat type, for Entiat River index sites surveyed in August, 2016. The summary rows are a sum of presented values except for % values, which are a weighted average.

Site Type	Stream	River KM	Habitat Type	# Identified	# of Pacific	# of Western Brook	% Pacific	% Western Brook	% of Cap. Identified
Index	Entiat	1.1	Type I	49	49	0	100%	0%	34%
Index	Entiat	30.4	Type I	13	13	0	100%	0%	7%
Index	Entiat	40.2	Type I	11	11	0	100%	0%	7%
Index	Entiat	1.1	Type II	-	0	0	-	-	-
Index	Entiat	30.4	Type II	13	13	0	100%	0%	81%
Index	Entiat	40.2	Type II	1	1	0	100%	0%	20%
Site Summary		1.1		49	49	0	100%	0%	34%
		30.4	-	26	26	0	100%	0%	13%
		40.2		12	12	0	100%	0%	7%
Habitat Summary		-	Type I	73	73	0	100%	0%	15%
			Type II	14	14	0	100%	0%	67%

Table 5. Lamprey population and biomass estimates within a 50 m reach, separated by habitat type, for Entiat River index sites surveyed in August, 2016. “Estimated # of Pacific Lamprey” is calculated based on the identified ratio of Pacific Lamprey (to Western Brook Lamprey) generally > 50 mm in length. Summary rows are a sum of presented values, except for e-fish density and mean weight of captured, which are a mean of presented values.

Site Type	Stream	River KM	Habitat Type	50 m	E-Fish	Estimated # in 50 m	Estimated # of Pacific Lamprey in 50 m	Mean Weight of Cap. (g)	Estimated Mass Density (g/m ²)	Estimated Mass (g) in 50 m
				Habitat Area (m ²)	Density (#/m ²)					
Index	Entiat	1.1	Type I	1000	59.0	58958	58958	0.39	12.68	12676
Index	Entiat	30.4	Type I	220	73.6	16192	16192	0.44	17.64	3880
Index	Entiat	40.2	Type I	43	27.9	1201	1201	0.39	6.84	294
Index	Entiat	1.1	Type II	0	-	-	-	-	-	-
Index	Entiat	30.4	Type II	960	4.0	3840	3840	1.41	4.02	3862
Index	Entiat	40.2	Type II	175	1.1	194	194	0.12	0.10	17
Site Summary		1.1		1000	59.0	58958	58958	0.39	12.68	12676
		30.4	-	1180	38.8	20032	20032	0.92	10.83	7742
		40.2		218	14.5	1396	1396	0.26	3.47	311
Habitat Summary		-	Type I	1263	53.5	76352	76352	0.41	12.38	16850
		-	Type II	1135	2.6	80386	80386	0.77	2.06	3880

Additional Index Site Observations:

- **River km 1.1** – This site is located near the river mouth, accessed from a public access area off of Entiat River Road. The survey took place at the mouth of a side channel. Type I habitat spans most of the wide channel. The survey was limited to the shallow water along the edge of the main channel, and did not include Type I habitat that was present in the side channel.
- **River km 30.4** – This site is located approximately 50 m upstream of the private crossing bridge at the Stormy Lodge. Type I habitat is limited to the channel margins. However, on the right bank, there is a small side channel (divided from the mainstem by a sediment bar) that has abundant Type I habitat. Type II habitat is most prevalent, spanning most of the channel width in the deeper waters. The survey was focused on the right bank, although the left bank was briefly included in the survey. The owners of the Stormy Lodge were very welcoming and supported our surveys (they had never seen a lamprey before!).
- **River km 40.2** – This site is located on private property (accessed with permission) from upstream of a private bridge 10.2 river km downstream of Box Canyon (river km 50.4). There is a small side channel (right bank of the main channel) that branches off of the main river at this site. Also connecting to this smaller side channel, is a larger side channel (the inlet of which is much further upstream). The larger side channel has a beaver dam at the mouth. The survey took the confluence of the large side channel where it meets the small side channel. There was abundant Type I habitat along the banks, though the deeper water held mostly Type II habitat.

Exploratory Sites – Entiat River

- Pacific Lamprey were present at two of the five exploratory sites surveyed (40%). Potential Western Brook Lamprey were discovered at river km 46.5 (pending genetic confirmation). No lamprey were found at river km 47.2 (3.2 river km downstream of Box Canyon, river km 50.4).
- The majority of survey locations were in side channels.
- No available habitat was observed at river km 10.1.
- Density of lamprey were highest at river km 12.8 (57.8 #/m²), and the lowest density was at river km 46.5 (1.5 #/m²).
- The estimated number of lamprey at river km 12.8 (a dead-end side channel that leads to an irrigation pump), was 7,726.

Table 6. Larval lamprey habitat details from the exploratory site surveyed in the Entiat River in August, 2016. Under “Survey Type”, a “Short” survey indicates that either Type I or Type II habitat was electrofished. The percent of larval habitat shown is the ratio between available Type I and Type II habitat, and excludes Type III (unusable) habitat within the 50 m survey reach. Under “Type I Habitat Type”, “Edge” indicates that the primary survey location (for Type I habitat) was on the edge of the main channel; “Side Chan.” indicates this occurred in a side channel. Plot temp was taken where the most lampreys were found, and thalweg temp was taken in the main channel.

Site Type	Stream	River KM	Date	Survey Type	% Type I in 50 m	% Type II in 50 m	Type I Habitat Type	Primary Fine Sediment (Type I)	Primary Fine Sediment (Type II)	Plot Temp °C (Best)	Thalweg Temp °C
Expl.	Entiat	1.1*	8/10/16	Short	94%	6%	Side Chan.	Silt	Silt	18.1	18.1
Expl.	Entiat	10.1	8/10/16	Visit	0%	0%	Main	-	-	-	-
Expl.	Entiat	12.8	8/11/16	Full	68%	32%	Side Chan.	Silt	Silt	18.2	16.6
Expl.	Entiat	40.2*	8/10/16	Short	100%	0%	Side Chan.	Sand	Sand	-	-
Expl.	Entiat	46.5	8/11/16	Short	77%	23%	Side Chan.	Silt	Sand	11.8	11.5
Expl.	Entiat	47.2	8/11/16	Short	33%	67%	Side Chan.	Sand	Course	-	11.7

Table 7. Survey details, separated by habitat type, for the Entiat River exploratory sites surveyed in August, 2016. The total number of lampreys observed was adjusted (increased) based on the following 1-5 visibility scale (with estimated % visibility in parenthesis): (1) poor (60%), (2) fair (70%), (3) good (80%), (4) very good (90%) and (5) excellent (90%). Survey densities (#/m²) were calculated using the adjusted observed number of lampreys. The summary rows are a sum of presented values, except for e-fish density which is a mean of presented values. Electrofishing details, separated by habitat type, for Entiat River Exploratory Sites surveyed in August, 2016. *Surveys conducted at river km 1.1 and 40.2 in addition to index site survey.

Site Type	Stream	River KM	Habitat Type Surveyed	Shock Time (sec)	Shock Area (m2)	# Captured	# Observed	Survey Visibility (1-5)	Total # Observed (Adjusted)	E-Fish Density (#/m2)
Expl.	Entiat	1.1*	Type I	600	11	0	0	5	0	0.0
Expl.	Entiat	12.8	Type I	570	10	132	462	3	578	57.8
Expl.	Entiat	40.2*	Type I	209	5	0	80	5	80	16.0
Expl.	Entiat	46.5	Type I	406	8	6	12	5	12	1.5
Expl.	Entiat	47.2	Type I	329	6	0	-	5	-	-
Expl.	Entiat	1.1*	Type II	-	-	-	-	-	-	-
Expl.	Entiat	12.8	Type II	330	7	27	67	5	67	9.6
Expl.	Entiat	40.2*	Type II	-	-	-	-	-	-	-
Expl.	Entiat	46.5	Type II	-	-	-	-	-	-	-
Expl.	Entiat	47.2	Type II	-	-	-	-	-	-	-
Site Summary		1.1*		600	11	0	0		0	0.0
		12.8		900	17	159	529		645	33.7
		40.2*	-	209	5	0	80	-	80	16.0
		46.5		406	8	6	12		12	1.5
		47.2		329	6	0	0		0	-
Habitat Summary		-	Type I	2114	40	138	554	-	670	18.8
			Type II	330	7	27	67		67	9.6

Table 8. Measurement details of captured lampreys, separated by habitat type, for the Entiat River exploratory sites surveyed in August, 2016 (sites without lamprey are excluded). The summary rows are a sum of presented values, except for mean weight, mean length and mean condition factor, which are a mean of presented values, and min and max length, which are the lowest and highest value, respectively. *Surveys conducted at river km 1.1 and 40.2 in addition to index site survey.

Site Type	Stream	River KM	Habitat Type Surveyed	# Weighed	Total Weight of Captured (g)	Mean Weight of Captured (g)	Min. Length (mm)	Max. Length (mm)	Mean Length (mm)	Mean Condition Factor
Expl.	Entiat	12.8	Type I	132	50.86	0.39	43	112	67	0.883
Expl.	Entiat	40.2*	Type I	0	-	-	-	-	-	-
Expl.	Entiat	46.5	Type I	0	-	-	43	70	60	-
Expl.	Entiat	12.8	Type II	27	13.81	0.51	36	100	66	0.701
Expl.	Entiat	40.2*	Type II	-	-	-	-	-	-	-
Expl.	Entiat	46.5	Type II	-	-	-	-	-	-	-
Mean		12.8				0.41			67	0.805
		40.2*		-		-	-		-	-
		46.5				-			60	-
Total		12.8		159	64.67					
		40.2*	-	-	-			-		
		46.5		0	-					

Table 9. Lamprey identification details, separated by habitat type, for the Entiat River exploratory site surveyed in August, 2016. The summary rows are a sum of presented values, and percentage values are calculated from the summed values. *Surveys conducted at river km 40.2 in addition to index site survey.

Site Type	Stream	River KM	Habitat Type	# Identified	# of Pacific	# of Western Brook	% Pacific	% Western Brook	% of Cap. Identified
Expl.	Entiat	12.8	Type I	12	12	0	100%	0%	9%
Expl.	Entiat	40.2*	Type I	0	-	-	-	-	-
Expl.	Entiat	46.5	Type I	5	0	5	0%	100%	83%
Expl.	Entiat	12.8	Type II	20	20	0	100%	0%	74%
Expl.	Entiat	40.2*	Type II	0	-	-	-	-	-
Expl.	Entiat	46.5	Type II	0	-	-	-	-	-
Total		12.8		32	32	0	100%	0%	20%
		40.2*	-	0	-	-	-	-	-
		46.5		5	0	5	0%	100%	83%

Table 10. Lamprey population and biomass estimates, separated by habitat type, for Entiat River Exploratory Sites surveyed in August, 2016. *Survey conducted at 40.2 in addition to index site survey. Estimated mass density used from 40.2 index site survey results. *Surveys conducted at river km 40.2 in addition to index site survey.

Site Type	River Stream	KM	Habitat Type Surveyed	50 m Type I Area (m2)	50 m Type II Area (m2)	Habitat Type Surveyed	E-Fish Density (#/m2)	Estimated # in 50 m	Estimated # of Pacific Lamprey in 50 m	Mean Weight of Cap. (g)	Estimated Mass Density (g/m2)	Estimated Mass (g) in 50 m
Expl.	Entiat	12.8	Type I	124		Type I	57.8	7161	7161	0.39	12.44	1542.9
Expl.	Entiat	40.2*	Type I	400	-	Type I	16.0	6400	6400	-	6.84	2735.6
Expl.	Entiat	46.5	Type I	100		Type I	1.5	150	0	-	-	-
Expl.	Entiat	12.8	Type II		59	Type II	9.57	565	565	0.51	3.23	190.3
Expl.	Entiat	40.2*	Type II	-	0	Type II	-	-	-	-	-	-
Expl.	Entiat	46.5	Type II		30	Type II	-	-	-	-	-	-
Total		12.8						7726	7726			1733.2
		40.2	-	713		-		6400	6400	-		2735.6
		46.5						150	0			-

Additional Exploratory Site Observations

- **River km 1.1*** - This site is located at river km 1.1 (same access point as the index site at this river km). The water level in the side channel was observed to drop approximately 30 cm over two hours (15 cm per hour). There was abundant larval habitat throughout the side channel, with patchy areas of Type II habitat in the main channel. The electrofishing survey was conducted when most of the larval habitat was still wetted (not knowing the water level would drop).
- **River km 10.1** – This site is located at the bridge of Roaring Creek Road where it crosses the Entiat River. No available habitat was observed upstream or downstream of the bridge. The goal of this site was to find
- **River km 12.8** – This site is located 0.5 km north of the intersection of Crum Canyon Road, off of. At this site, large amounts of fine sediment are collected within a man-made side channel. The side channel does not connect back to the river, leading to an irrigation pump. The irrigation pump has many holes in the screen intake (where larval lamprey can easily enter). The goal of this site was to establish an index site (for long term monitoring) in the lower/middle reach of the Entiat River (where larval habitat is limited). This site is not a natural side channel and will not be used as an index site.
- **River km 40.2*** - This site is located in the large side channel (upstream of the beaver dam) at the index site also present at this site. There is a large expanse of Type I habitat upstream of the beaver dam (spanning the entire width of the side channel; ~ 10 m wide). The goal of this site was to expand our knowledge of lampreys within this large side channel, as well as potentially move our index site into this area with more abundant Type I habitat compared to the current index site at this location.
- **River km 46.5** – This site is located 3.9 river km downstream of Box Canyon in a side channel on the right bank of the river. Type I habitat is present (primarily 2-3 cm silt on top of coarse sand). We surveyed throughout the side channel, but lampreys were found in the deeper water area near the mouth of the side channel (mostly deeper silt).
- **River km 47.2** – This site is located 3.2 river km downstream of Box Canyon. This site was in a small side channel primarily consisting of coarse sediments.

Genetic Samples – Entiat River

Table 11. Summary of lamprey genetic samples collected from the Entiat River in August, 2016.

Collection Date	River KM	# of Pacific Samples (Larvae)	# of Pacific Samples (Macro.)	# of Western Brook Samples	# Unknown Species Samples (< 50 mm)	Collection Purpose
08/10/16	1.1	37	0	0	7	Contributing Adult Analysis
08/10/16	40.2	35	0	0	0	Contributing Adult Analysis
08/11/16	46.5	0	0	5	1	Species Confirmation
Total	-	72	0	5	8	-

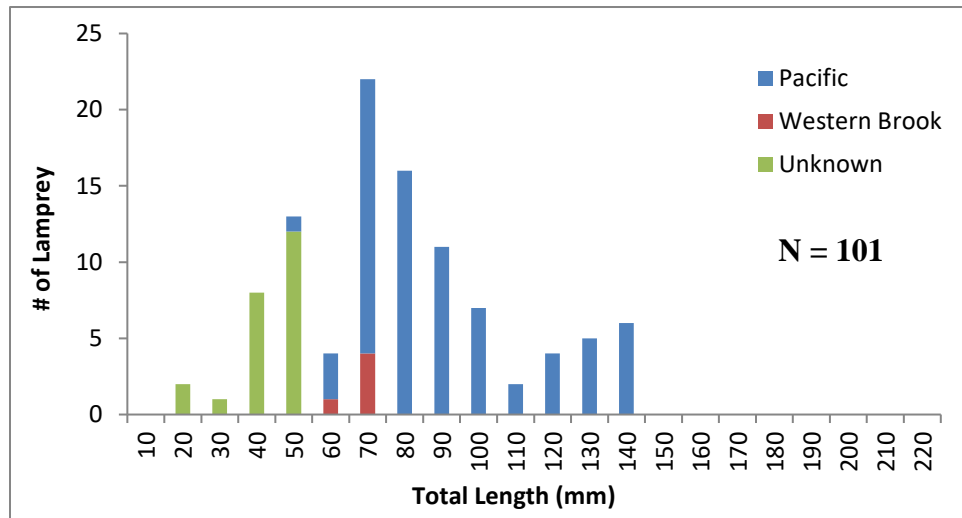
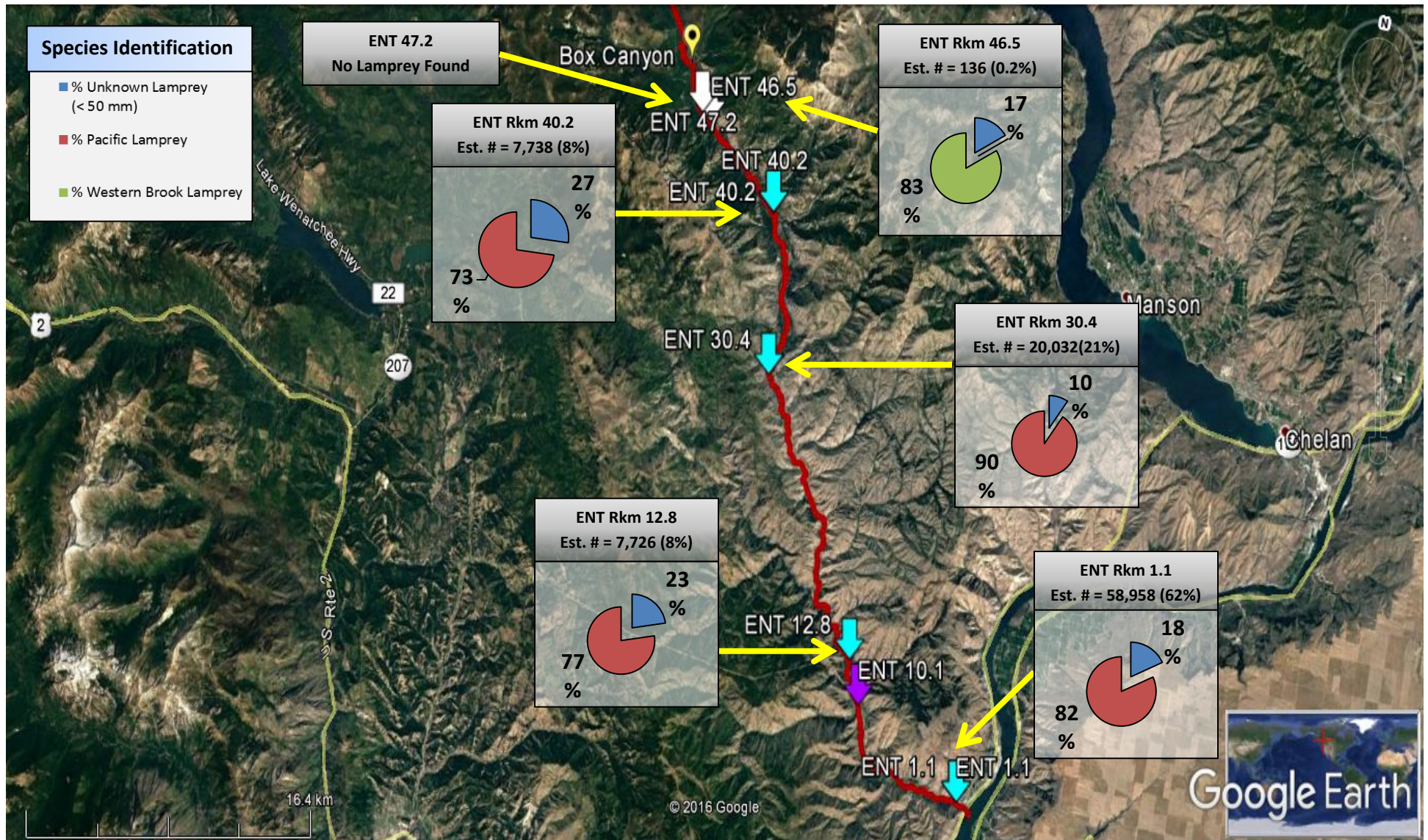
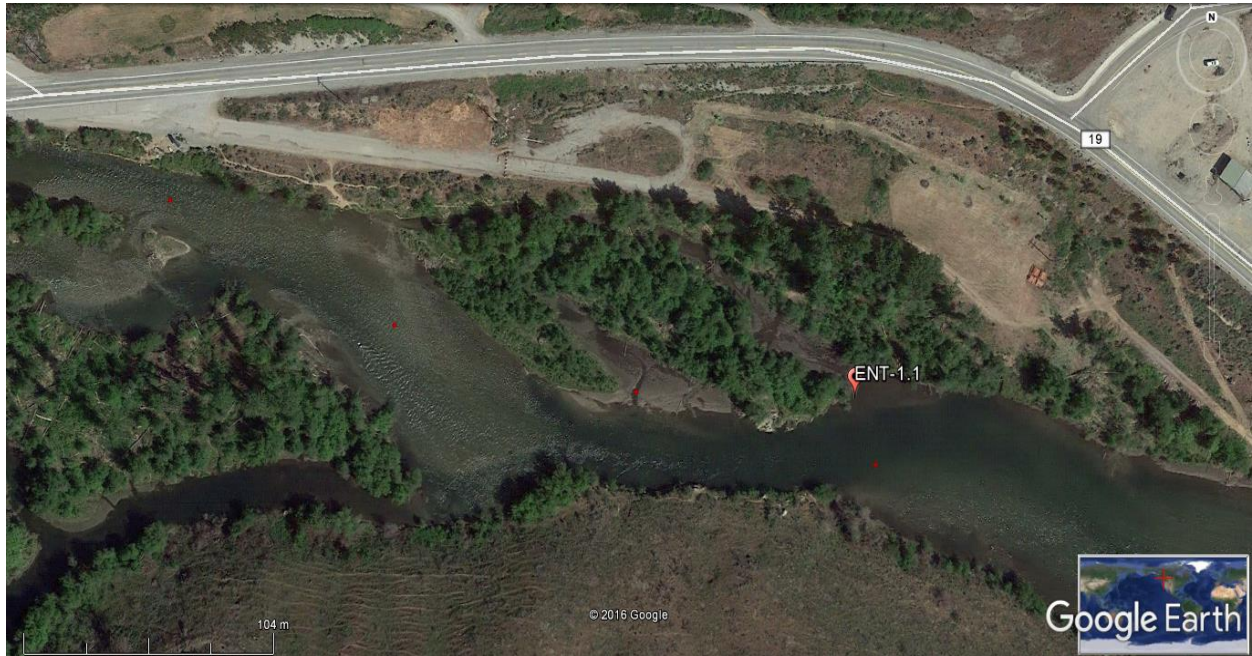


Figure 2. Histogram of all measured lampreys captured during electrofishing surveys, separated by species (“PA”= Pacific Lamprey (blue), “UN”=Unknown Lamprey <50 mm (green), “WB” Western Brook Lamprey (Red), in the Entiat River in August, 2016).



Map 2. Displayed is the distribution of Pacific Lamprey (red), Western Brook Lamprey (green) and Unknown Lamprey <50 mm (blue) in the Entiat River from August, 2016 electrofishing surveys. Ratio of unknown lampreys is based on captured and measured data only. Also shown is the estimated number of lampreys at each surveyed site. Estimated numbers of lampreys shown include both short and full surveys (river km 1.1 and 40.2). Full surveys are labeled by the blue arrows, short surveys by the white arrows and visit only sites by the purple arrow. Note no lampreys were found at river km 40.2. Box Canyon is located at river km 50.1 (yellow balloon).

APPENDIX: Additional Site Maps and Photos



Map A1. Site map of Entiat index site at river km 1.1 (surveyed in August, 2016); red balloon indicates presence of Pacific Lamprey.



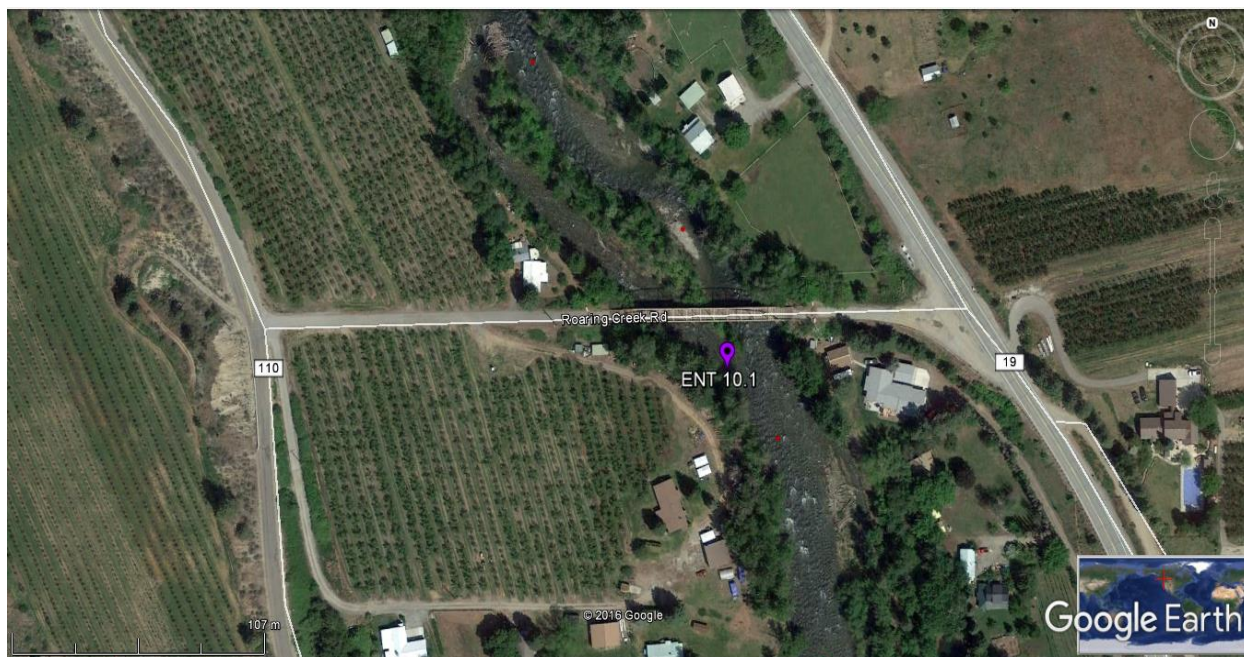
Photo A1. Entiat River index site at river km 1.1; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of silt/sand (right) from 2016 survey.



Map A2. Site map of Entiat exploratory site at river km 1.1 (surveyed in August, 2016); red balloon indicates presence of Pacific Lamprey. White balloon indicates no lampreys were found at this site. * This site is outside of the established index site area. The small red dots indicate stream distance of 100 m.



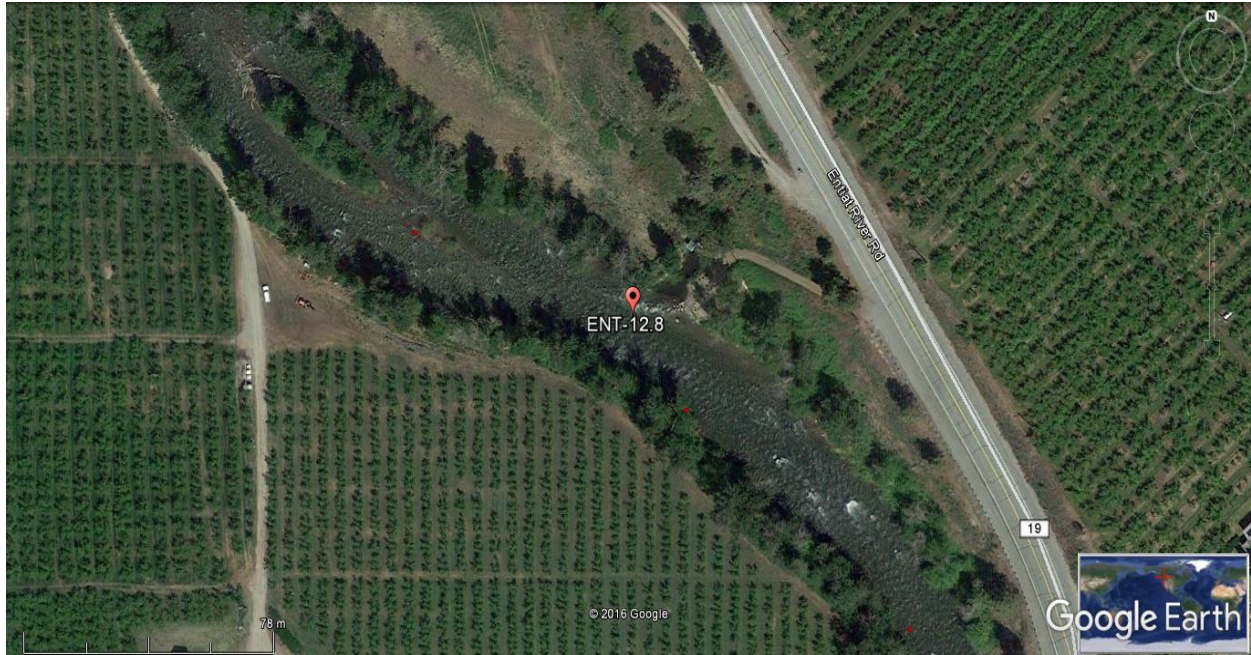
Photo A2. Entiat River exploratory site at river km 1.1; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of sand/silt (right) from 2016 survey.



Map A3. Site map of Entiat exploratory site at river km 10.1 (surveyed in August, 2016); purple balloon indicates no electrofishing survey occurred at this site. The small red dots indicate stream distance of 100 m.



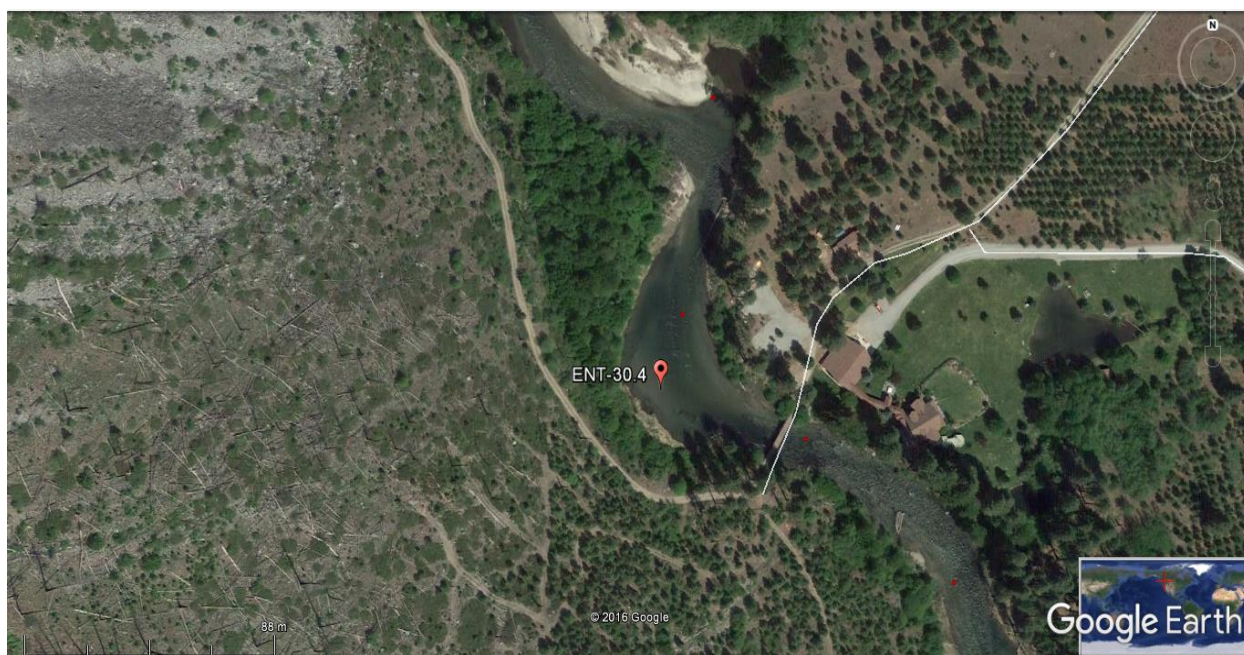
Photo A3. Entiat River index site at river km 10.1; overview of Type III habitat facing upstream (left) and Type III habitat downstream (right) from 2016 survey. No electrofishing occurred at this location.



Map A4. Site map of Entiat exploratory site at river km 12.8 (surveyed in August, 2016); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.



Photo A4. Entiat River index site at river km 12.8; overview of Type I habitat leading to irrigation pump (left) and close-up of best Type I habitat sediment composed of silt/sand (right) from 2016 survey.



Map A5. Site map of Entiat index site at river km 30.4 (surveyed in August, 2016); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.



Photo A1. Entiat River index site at river km 30.4; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of silt/sand (right) from 2016 survey.



Map A6. Site map of Entiat exploratory site at river km 40.2 (surveyed in August, 2016); red balloon indicates presence of Pacific Lamprey. The small red dots indicate stream distance of 100 m.



Photo A1. Entiat River index site at river km 1.1; overview of Type I habitat (left) and close-up of best Type I habitat sediment composed of sand/silt (right) from 2016 survey.



Map A7. Site map of Entiat exploratory site at river km 40.2 (surveyed in August, 2016); yellow balloon indicates presence of lamprey of unknown species. * This site is outside of the established index site area. All observed lampreys were missed at this site. The small red dots indicate stream distance of 100 m.



Photo A1. Entiat River index site at river km 40.2; overview of Type I habitat located upstream of a beaver dam at the mouth of a side channel. * This site is outside of the established index site area.



Map A8. Site map of Entiat exploratory site at river km 46.5 (surveyed in August, 2016); yellow balloon indicates the presence of lamprey of unknown species (<50 mm). However, Western Brook Lamprey was present at this site (pending genetic confirmation). The small red dots indicate stream distance of 100 m.



Photo A8. Entiat River index site at river km 46.5; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of sand/coarse (right) from 2016 survey.



Map A9. Site map of Entiat exploratory site at river km 47.2 (surveyed in August, 2016); white balloon indicates no lamprey found at this site. The small red dots indicate stream distance of 100 m.



Photo A9. Entiat River index site at river km 47.2; overview of Type I habitat (left) and close-up of best Type I/Type II habitat sediment composed of silt/coarse (right) from 2016 survey.