# New Zealand Mudsnail Surveys at National Fish Hatcheries within the Lower Columbia River Basin 2011

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# Introduction

The New Zealand mudsnail (NZMS), *Potamopyrgus antipodarum* is an exotic aquatic snail species that has invaded brackish and freshwater habitats of Australia, Europe, Asia and North America. As its common name implies, this snail is native to New Zealand and may have been introduced globally through contaminated ballast water (Zaranko et al. 1997; Gangloff 1998) or the transport of live fish or eggs for the commercial aquaculture industry (Bowler 1991; Bowler and Frest 1992). In North America, the NZMS was first discovered in the middle Snake River (Idaho) in 1987 (Bowler 1991). Since this time, the NZMS has become established in ten Western states, five Great Lakes states and two Canadian provinces (British Columbia and Ontario) (Davidson et al. 2008; Benson 2011) (Figure 1).

The rapid spread of NZMS within the United States has been attributed to the snails biological and morphological traits. Adult NZMS typically range from 3-6 mm in length. In low densities, the small size of NZMS makes it difficult to detect thereby increasing the likelihood of unknowingly transporting and introducing the snail to new locations. In the United States, NZMS populations are comprised almost exclusively of self-cloning parthenogenetic females. The brood size of an individual female ranges from 20-120 embryos, each of which may mature to produce an average of 230 offspring per year (Alonso and Castro-Díez 2008; Cheng and LeClair 2011). Under favorable conditions, a single snail has the reproductive potential to establish a new population. In its non-native range, NZMS inhabit a wide range of aquatic ecosystems (e.g., estuaries, rivers, lakes and reservoirs), and tolerate broad range of aquatic conditions (e.g., temperature, salinity, turbidity, water velocity, productivity and substrate types) (see ANSTF 2007 and references therein). The broad environmental tolerances of the NZMS enable it to successfully colonize a wide array of aquatic habitats. New Zealand mudsnail have a rigid operculum that is used to seal off the shell opening making it relatively impervious to mild pollutants and highly resistant to desiccation (Richards et al. 2004; Schisler et al. 2008). Larger snail can survive up to 24 hours without water and for several weeks on damp surfaces (Cheng and LeClair 2011). This exceptional hardiness may provide ample time for the snail to be transferred from one water body to another. The shell wall of NZMS is very thick and is difficult for some species of fish to thoroughly digest. In some circumstances, the snail may pass through the digestive tract of fish unharmed (McCarter 1986; Vinson 2004; Bruce et al.

2009; Oplinger et al. 2010). Fish released from infested aquaculture facilities or rearing in infested rivers may increase the distribution of NZMS by transporting live snails in their stomachs to other locations (Vinson and Baker 2008; Bruce et al. 2009).

New Zealand mudsnail may be introduced to new locations through many natural and human-related processes. Within a watershed, snails may be transported on the fur or feathers of terrestrial wildlife, livestock and waterfowl or consumed and dispersed in the excrement of local fish species. New Zealand mudsnail may be scoured downstream by high water velocity, float passively on aquatic vegetation or move volitionally at a rate of up to 3 m /hour (Sepulveda and Marczak 2011). Long distance dispersal of NZMS has been attributed to ballast water discharge, the movement of commercial aquaculture products (i.e., fish, eggs, and ornamental plants), contaminated hatchery transplants or the translocation of recreational watercrafts, trailers and personal gear such as boots and waders.

In 2002, the NZMS was discovered at the first National Fish Hatchery in Hagerman Idaho (Hagerman National Fish Hatchery). Since this time they have been detected at a number of private, state and federal fish hatcheries and aquaculture facilities within the Western United States including: Arizona, California, Colorado, Idaho, Montana and Utah (Stockton 2011). New Zealand mudsnail are an issue of concern for federal fisheries managers because fish stocking and transfers of eggs or fish from contaminated hatcheries may introduce or spread NZMS to previously uninfested facilities or drainages (ANSTF 2007). Executive Order 13112 (USOFR 1999), prohibits federal agencies (except under certain conditions) from carrying out actions that are “likely to cause or promote the spread of invasive species”. In response, many federal fish hatcheries have developed regional Hazard Analysis and Critical Control Point (HACCP) Plans that are used as a risk assessment and management tool to prevent NZMS invasion, identify pathways of potential introduction or minimize impacts or spread of existing populations. These plans often call for regular visual inspections of hatchery facilities and grounds. Performing annual visual inspections of hatchery water intake and outflow structures may detect NZMS before they become established or are inadvertently spread to new areas.

The Columbia River Fisheries Program Office (CRFPO) has been intermittently monitoring for New Zealand mudsnails at lower Columbia River basin National Fish Hatcheries since 2006 (see Allard and Olhausen 2007a, 2007b; Hogle 2009). This report presents results of New Zealand

mudsnail surveys conducted by U.S. Fish and Wildlife Service (USFWS) CRFPO personnel in 2011.

## Methods

Six lower Columbia River Basin National Fish Hatcheries were surveyed for New Zealand mudsnail including: Carson, Eagle Creek, Little White Salmon, Spring Creek, Warm Springs and Willard National Fish Hatcheries (Figure 2). Surveys were conducted over a two week period from 6 October to 17 October, 2011. Prior to conducting the survey, hatchery managers and personnel were interviewed to identify areas where snails may access the facility as well as to determine if hatchery personnel had observed suspicious snails in head boxes or raceways. Sample sites identified during 2008 NZMS surveys were sampled again in 2011, as well as any new locations identified by hatchery personnel. All sample locations were georeferenced using a Trimble handheld global positioning system (GPS), and a photograph was taken to document current physical habitat conditions. One to two field personnel visually inspected up to a 50 meter portion of stream upstream and downstream of each survey location for approximately 15 minutes. Surface substrate was manually flipped over at random intervals, aquatic vegetation was sifted through by hand and surfaces of hatchery structures (i.e., pipes, intake/outflow grates, concrete walls, dam boards and log booms) were closely examined (visually and by hand) for the presence/absence of NZMS. In water depths greater than 0.6 m, substrate, aquatic vegetation and hatchery structures were visually inspected using an underwater viewing scope. If field personnel observed an aquatic snail closely resembling NZMS, the date and location of the snail was recorded and a specimen was collected and placed in an individual vial with 70% ethanol for preservation. Snail specimen were individually photographed and carefully examined under a dissecting microscope to determine if they were New Zealand mudsnail. Magnified photographs of specimen whose identification could not be positively determined were sent to Robyn Draheim with the Center for Lakes and Reservoirs for further examination.

# Results

A total of 35 sites were surveyed for NZMS at six lower Columbia River Basin National Fish Hatcheries (Table 1). Thirteen snail specimens were collected and taken back to the CRFPO laboratory for examination. Magnified photographs of four snail specimen were sent to Robyn Draheim for ID verification. No NZMS were observed during field surveys or examination of collected snail specimen.

**Carson NFH**

There were six sites surveyed for NZMS at Carson NFH in 2011 (Figure 3). Water inflow sites included the headwaters of Tyee Springs (hatchery source water), Tyee Springs road crossing culvert and primary hatchery inflow grate. Outflow sample sites included earthen pond, rearing pond and hatchery discharge water channels (i.e., raceway and adult fish ladder entrance). Two snail specimens were collected at the headwater of Tyee Springs for examination.

**Eagle Creek NFH**

There were five sites surveyed for NZMS at Eagle Creek NFH in 2011 (Figure 4). A single hatchery water intake grate and four outflow sites were inspected including the egg house drain, adult fish ladder, pollution abatement pond and upper raceway outflow. No snail samples were collected at Eagle Creek NFH.

**Little White Salmon NFH**

There were eight sites surveyed for NZMS at Little White Salmon NFH in 2011 (Figure 5). Water inflow sites included hillside, roadside and Baily springs as well as the primary hatchery inflow grate and microfilter house. Outflow sites included the pollution abatement pond, hatchery building and raceway outflow/fish ladder entrance. Two snail specimens were collected from hillside and roadside springs.

**Spring Creek NFH**

There were six sites surveyed for NZMS at Spring Creek NFH in 2011 (Figure 6). Water inflow sites included four hillside springs located on the north side of Washington State Highway 14. Outflow sites included the adult fish ladder entrance/raceway outflow on the Columbia River and pollution abatement pond channel. A single snail specimen was collected from hillside spring #1 (Figure 6).

**Willard NFH**

There were four sites surveyed for NZMS at Willard NFH in 2011 (Figure 7). A single hatchery water intake grate and three outflow sites were inspected including the pollution abatement pond, lower raceway outflow and the U.S. Geological Survey, Columbia River Research Laboratory circular tank outflow. No snail samples were collected at Willard NFH.

**Warm Springs NFH**

There were six sites surveyed for NZMS at Warm Springs NFH in 2011 (Figure 8). Inflow sites included the primary hatchery water intake grate and hatchery intake sump. Outflow sites included the adult holding pond outflow, hatchery raceway/fish ladder entrance, abatement pond discharge pipe and eastern perimeter of the pollution abatement pond. A total of eight snail specimens were collected from intake and outflow sites (Table 1).

## Discussion

To date, no NZMS have been found in the six Lower Columbia River Basin National Fish Hatcheries included in this survey. Although no NZMS were observed during 2011 surveys, a variety of native aquatic snails were found at a number of hatchery inflow and outflow sites (e.g., *Juga* sp. and *Pyrgulopsis* sp.). Unfortunately no historic data or current information exists regarding native aquatic snail fauna in these areas. The CRFPO is planning to conduct a baseline inventory of native freshwater snail species currently present at Lower Columbia River

Basin National Fish Hatcheries. Changes in snail fauna over time (i.e., decline in species richness or abundance) may indicate changes within the aquatic ecosystem (e.g., water quality, stream productivity, habitat availability) or the presence of an aquatic invader such as the New Zealand mudsnail.

In the Lower Columbia River, NZMS have been observed along the Oregon coast, Columbia River Estuary (including five peripheral bays) (Bersine et al. 2008), coastal lakes, coastal tributaries and in multiple locations along the lower Deschutes River (Benson 2011). The presence of NZMS in the Columbia River and relative close proximity of Warm Springs NFH to the Deschutes River should be cause for concern. Fish hatcheries may be more vulnerable to invasion because NZMS are known to thrive in the stable aquatic conditions of the hatchery environment (i.e., temperature, flow and nutrient load) (Bruce et al. 2009). Many Hatcheries are located on rivers that support popular sport fisheries or receive heavy recreational usage where NZMS may be introduced or transported by a multitude of pathways (e.g., boats, trailers, fishing gear, waders), and fish hatchery operations such as fish stocking and the transfer of live fish or eggs are a major vector of spread given the potential for NZMS to pass through the gut of fish alive and intact. Continuation of annual NZMS surveys at Lower Columbia Basin National Fish Hatcheries is important because early detection is critical to the prevention, control and management of the species and may significantly reduce the risk of spreading the snail to new areas.

## Acknowledgements

A big Thank You to Larry Zeigenfuss of Carson NFH; Larry Telles of Eagle Creek NFH; Jim Rockowski of Little White Salmon NFH; Mark Ahrens of Spring Creek NFH; Steve Wingert of Willard NFH and Roger Sorensen and Mary Bayer of Warm Springs NFH for taking time out of their schedule to provide suggestions for potential sample sites as well as giving tours of hatchery facilities. I would also like to thank Donna Allard and Doug Olson for their help with conducting the snail surveys, Robin Draheim for providing guidance and assistance with identification of snail specimen and Paul Heimowitz, Regional Aquatic Invasive Species Coordinator for financial support.

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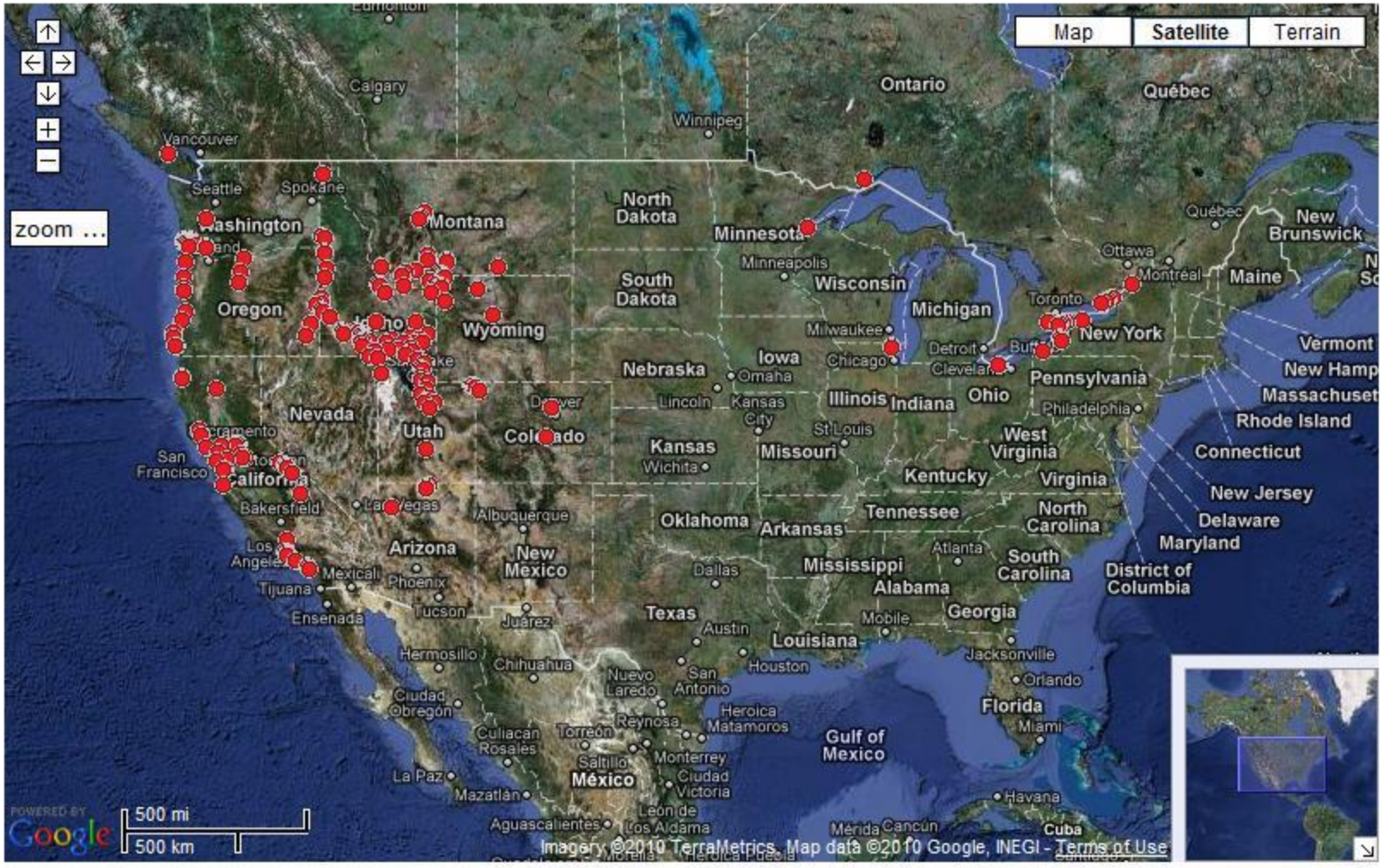


Figure 1. Map of New Zealand mudsnail sightings in the United States and Canada from 1987 through May 2010 (Benson, A. J. 2010).

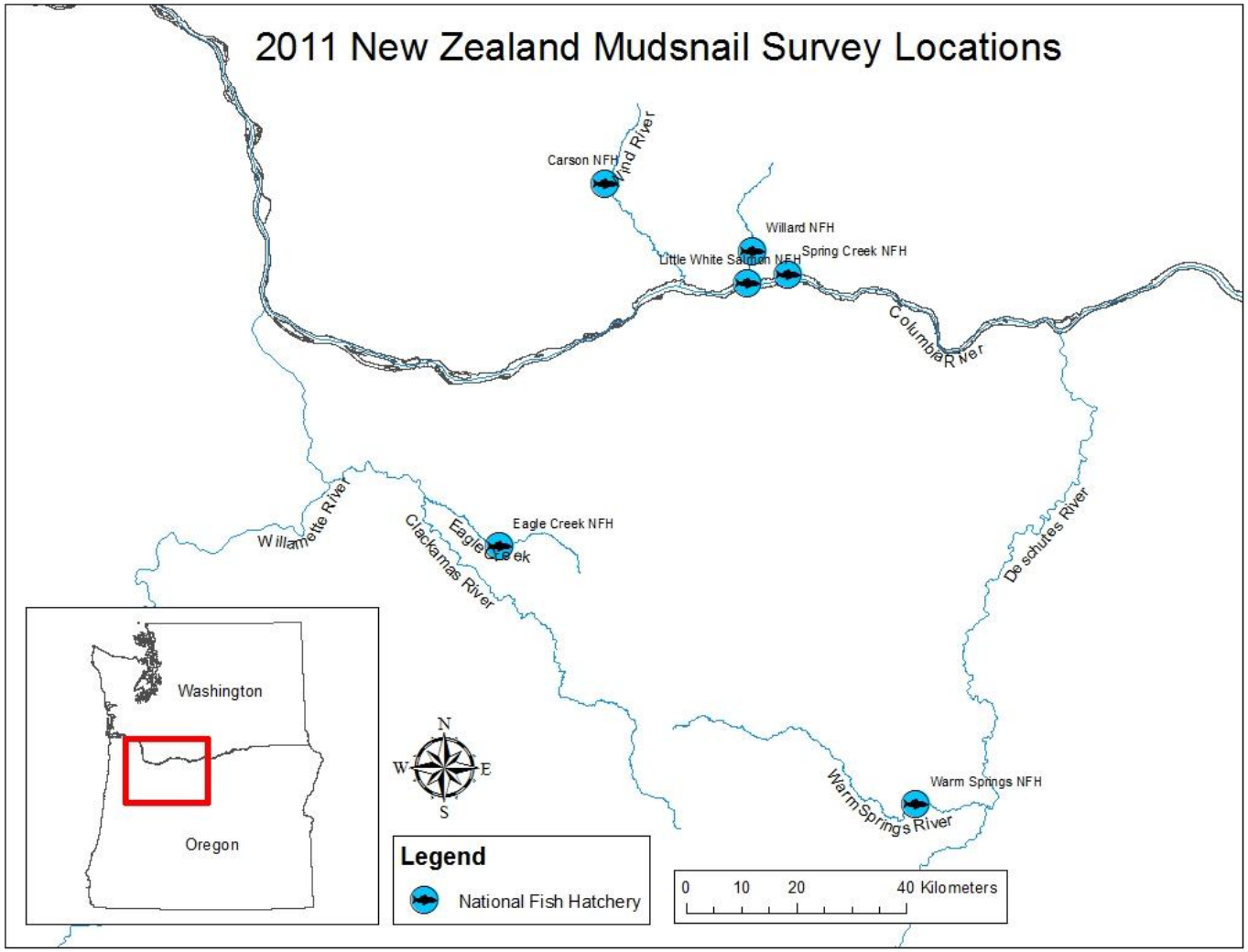


Figure 2. Map of USFWS Lower Columbia River basin National Fish Hatcheries surveyed for New Zealand mudsnail during 2011.

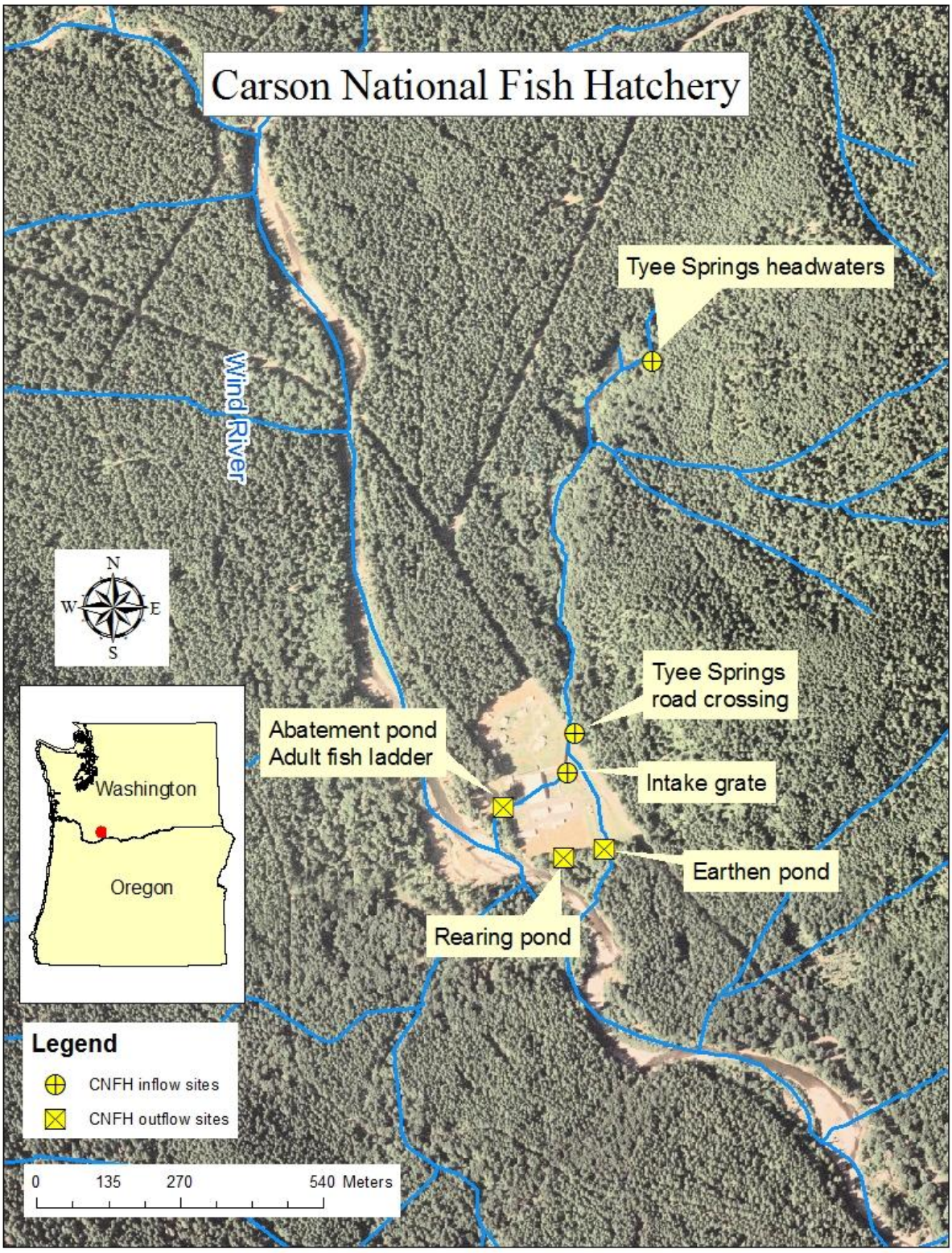


Figure 3. Carson NFH 2011 New Zealand mudsnail survey sample sites.

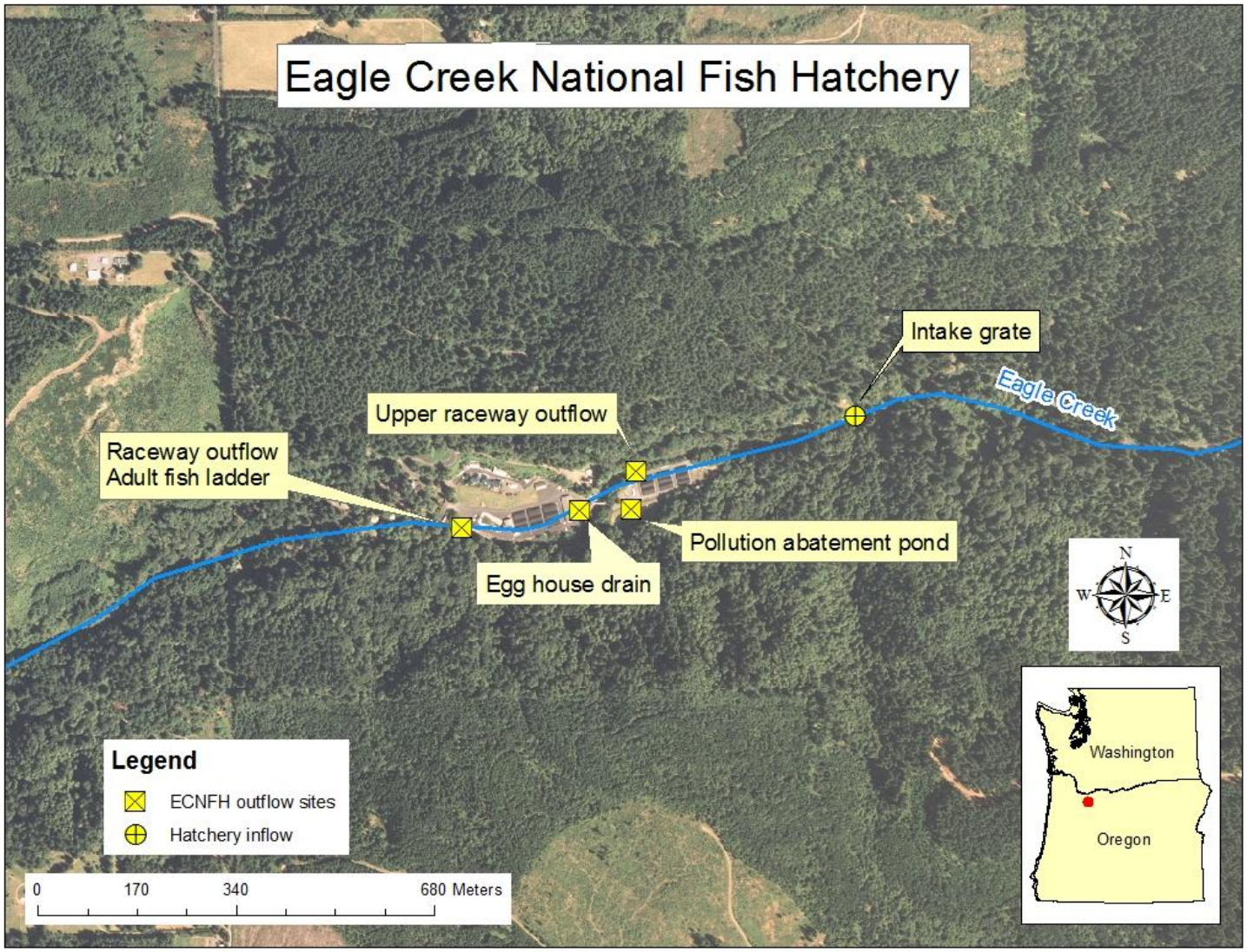


Figure 4. Eagle Creek NFH 2011 New Zealand mudsnail survey sample sites.

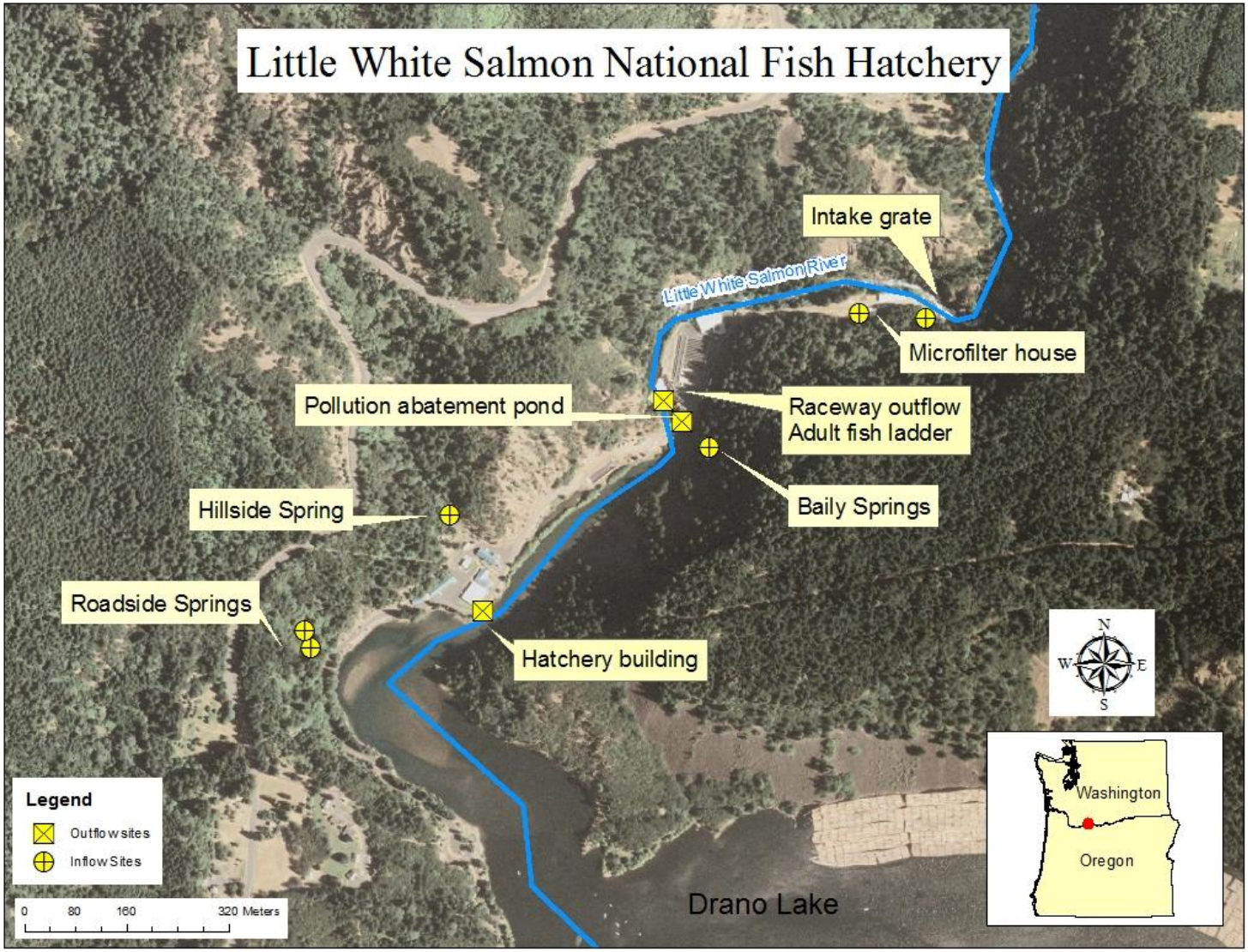


Figure 5. Little White Salmon NFH 2011 New Zealand mudsnail survey sample sites.

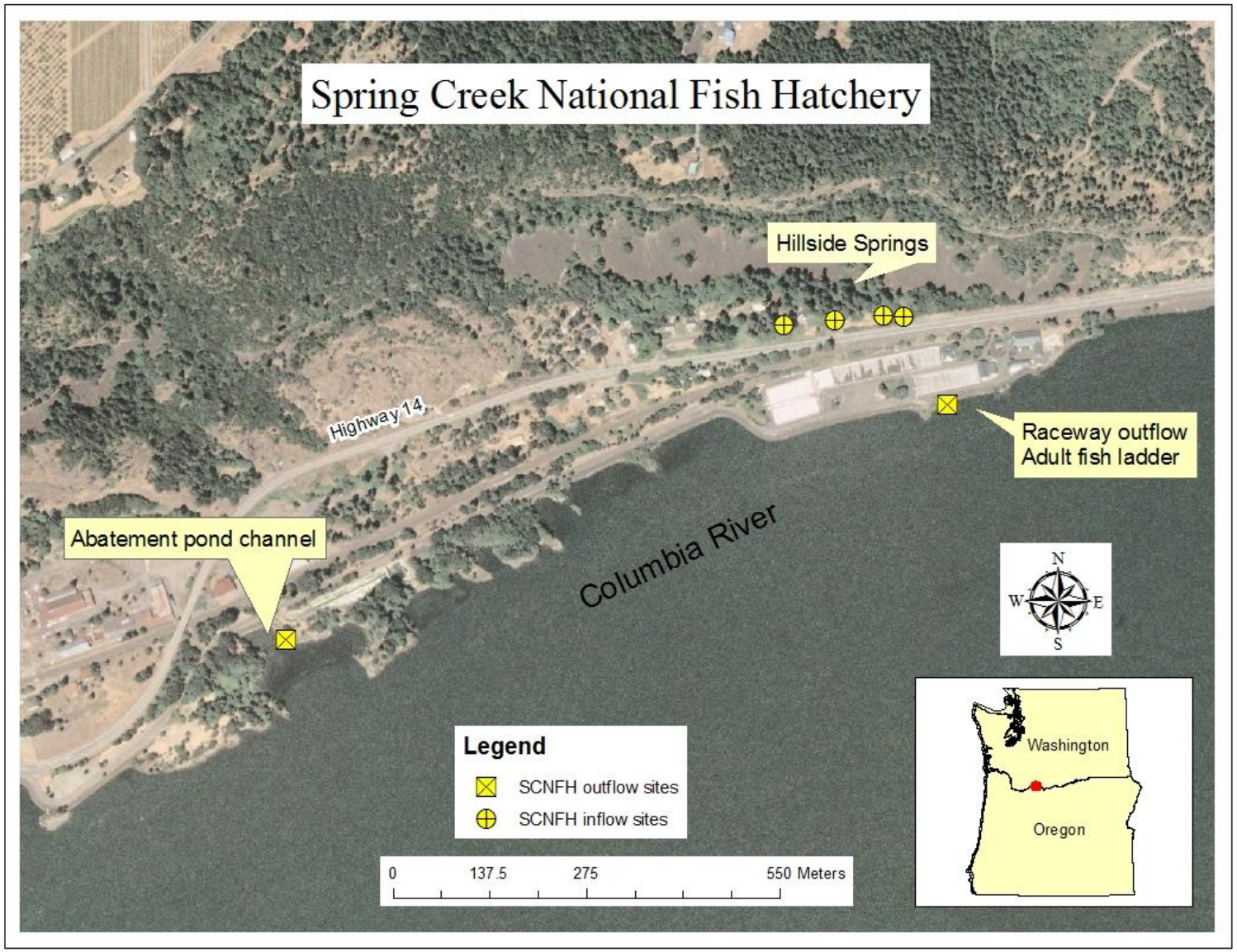


Figure 6. Spring Creek NFH 2011 New Zealand mudsnail survey sample sites.

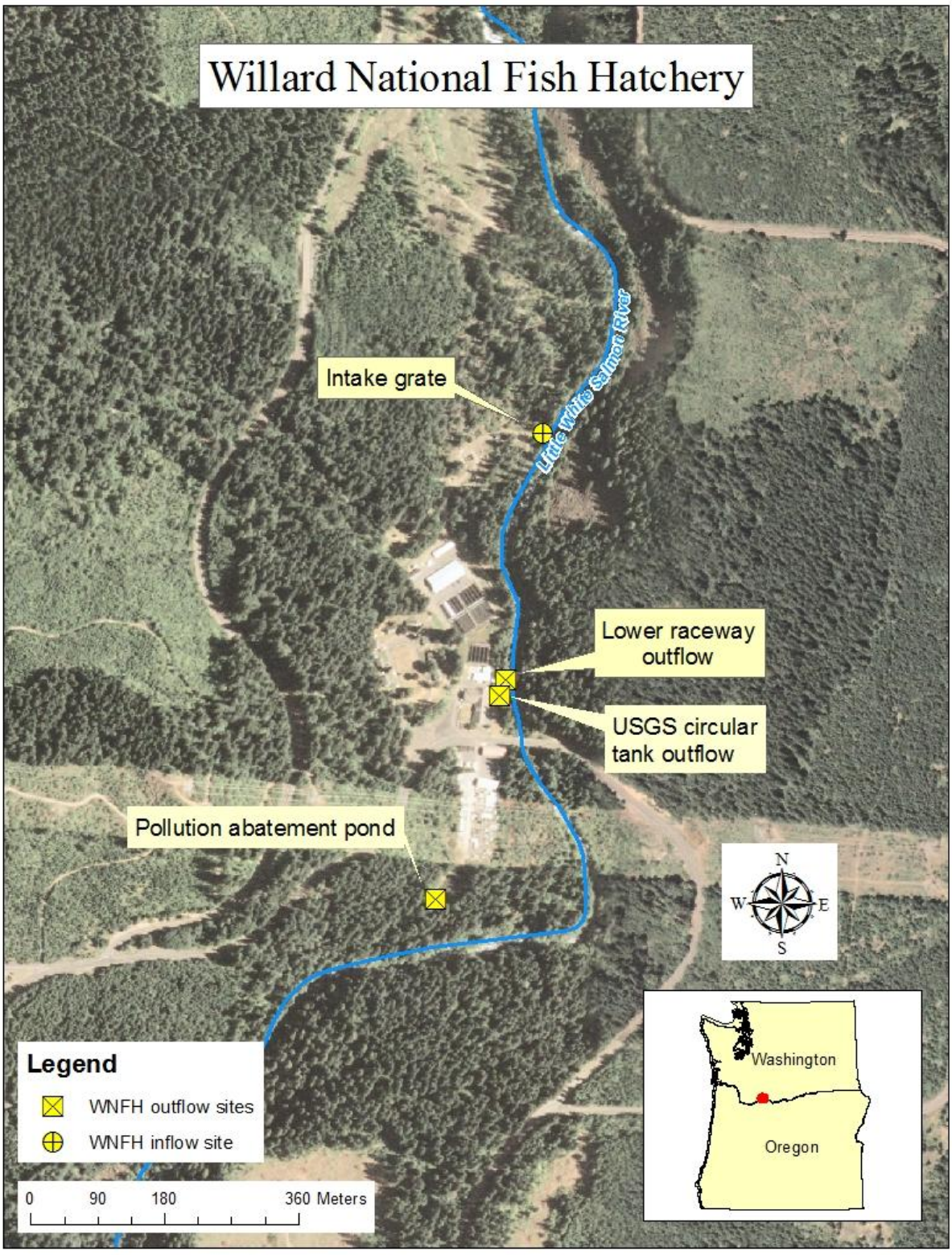


Figure 7. Willard NFH 2011 New Zealand mudsnail survey sample sites.


Figure 8. Warm Springs NFH 2011 New Zealand mudsnail survey sample sites.

Table 1. Results of 2011 New Zealand mudsnail surveys of Lower Columbia River Basin National Fish Hatcheries.

| Date | Time | National Fish Hatchery | Location | Specimens Collected | NZMS Found | GPS Coordinate System: UTM | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Zone | Datum | Northing | Easting |
| 10/6/2011 | 9:45 AM | Carson | **Outflow-** raceway outflow, adult fish ladder entrance | None | None | 10 | NAD 1983 (Conus) | 5079887.72 | 579566.79 |
| 10/6/2011 | 10:05 AM | Carson | **Outflow**- rearing pond outflow | None | None | 10 | NAD 1983 (Conus) | 5079793.16 | 579680.26 |
| 10/6/2011 | 10:23 AM | Carson | **Outflow**- earthen pond outflow | None | None | 10 | NAD 1983 (Conus) | 5079810.35 | 579755.90 |
| 10/6/2011 | 10:42 AM | Carson | **Inflow-** hatchery intake grate upstream of road crossing | None | None | 10 | NAD 1983 (Conus) | 5079956.49 | 579685.42 |
| 10/6/2011 | 11:00 AM | Carson | **Inflow**- downstream end of culvert road crossing | None | None | 10 | NAD 1983 (Conus) | 5080028.69 | 579699.17 |
| 10/6/2011 | 11:20 AM | Carson | **Inflow**- Tyee Springs headwaters | Sample 1,2 | None | 10 | NAD 1983 (Conus) | 5080730.12 | 579847.02 |
| 10/7/2011 | 10:48 AM | Eagle Creek | **Outflow**- raceway outflow, adult fish ladder entrance | None | None | 10 | NAD 1983 (Conus) | 5013908.07 | 562424.14 |
| 10/7/2011 | 11:10 AM | Eagle Creek | **Outflow**- egg house outflow | None | None | 10 | NAD 1983 (Conus) | 5013934.75 | 562629.41 |
| 10/7/2011 | 11:30 AM | Eagle Creek | **Outflow**- upper raceway outflow | None | None | 10 | NAD 1983 (Conus) | 5013936.81 | 562715.63 |
| 10/7/2011 | 11:48 AM | Eagle Creek | **Outflow**- pollution abatement pond | None | None | 10 | NAD 1983 (Conus) | 5014006.60 | 562723.84 |
| 10/7/2011 | 12:16 PM | Eagle Creek | **Inflow**- hatchery water intake grate | None | None | 10 | NAD 1983 (Conus) | 5014101.02 | 563099.48 |
| 10/6/2011 | 1:30 PM | Little White Salmon | **Inflow**- Hillside Springs | Sample 3 | None | 10 | NAD 1983 (Conus) | 5063841.55 | 605439.42 |
| 10/6/2011 | 1:47 PM | Little White Salmon | **Outflow-** hatchery building | None | None | 10 | NAD 1983 (Conus) | 5063689.47 | 605490.11 |
| 10/6/2011 | 2:10 PM | Little White Salmon | **Inflow-** Baily Springs | None | None | 10 | NAD 1983 (Conus) | 5063946.69 | 605846.84 |
| 10/6/2011 | 2:20 PM | Little White Salmon | **Outflow-** raceway outflow, adult fish ladder entrance | None | None | 10 | NAD 1983 (Conus) | 5064018.04 | 605775.50 |
| 10/6/2011 | 2:38 PM | Little White Salmon | **Outflow-** pollution abatement pond | None | None | 10 | NAD 1983 (Conus) | 5063984.24 | 605805.54 |
| 10/6/2011 | 2:57 PM | Little White Salmon | **Inflow-** hatchery water intake grate | None | None | 10 | NAD 1983 (Conus) | 5064147.59 | 606184.79 |
| 10/6/2011 | 3:15 PM | Little White Salmon | **Inflow-** micro-filter house | None | None | 10 | NAD 1983 (Conus) | 5064155.10 | 606081.53 |
| 10/6/2011 | 3:20 PM | Little White Salmon | **Inflow**- Roadside Springs | Sample 4 | None | 10 | NAD 1983 (Conus) | 5063633.15 | 605223.51 |
| 10/6/2011 | 4:00 PM | Spring Creek | **Outflow-** pollution abatement pond | None | None | 10 | NAD 1983 (Conus) | 5064464.42 | 612347.21 |
| 10/6/2011 | 4:18 PM | Spring Creek | **Outflow-** raceway outflow, adult fish ladder entrance | None | None | 10 | NAD 1983 (Conus) | 5064795.99 | 613286.11 |
| 10/6/2011 | 4:38 PM | Spring Creek | **Inflow-** hillside spring #1 | Sample 5 | None | 10 | NAD 1983 (Conus) | 5064912.53 | 613051.39 |
| 10/6/2011 | 4:55 PM | Spring Creek | **Inflow-** hillside spring #2 | None | None | 10 | NAD 1983 (Conus) | 5064917.46 | 613126.89 |
| 10/6/2011 | 5:12 PM | Spring Creek | **Inflow**- hillside spring #3 | None | None | 10 | NAD 1983 (Conus) | 5064925.67 | 613194.19 |
| 10/6/2011 | 5:28 PM | Spring Creek | **Inflow**- hillside spring #4 | None | None | 10 | NAD 1983 (Conus) | 5064924.02 | 613223.74 |
| 10/6/2011 | 12:00 PM | Willard | **Inflow-** hatchery water intake grate | None | None | 10 | NAD 1983 (Conus) | 5069171.79 | 606561.39 |
| 10/6/2011 | 12:17 PM | Willard | **Outflow-** lower raceway outflow | None | None | 10 | NAD 1983 (Conus) | 5068839.51 | 606509.70 |
| 10/6/2011 | 12:39 PM | Willard | **Outflow-** USGS circular tank outflow | None | None | 10 | NAD 1983 (Conus) | 5068818.59 | 606502.32 |
| 10/6/2011 | 12:55 PM | Willard | **Outflow-** pollution abatement pond | None | None | 10 | NAD 1983 (Conus) | 5068545.38 | 606414.94 |
| 10/17/2011 | 10:45 AM | Warm Springs | **Inflow-** hatchery intake sump | None | None | | | | |
| 10/17/2011 | 11:05 AM | Warm Springs | **Inflow-** hatchery water intake grate | Sample 6,7,8 | None | 10 | NAD 1983 (Conus) | 4968957.62 | 638644.45 |
| 10/17/2011 | 11:30 AM | Warm Springs | **Outflow-** adult holding pond outflow | Sample 9 | None | 10 | NAD 1983 (Conus) | 4968988.35 | 638658.23 |
| 10/17/2011 | 11:45 AM | Warm Springs | **Outflow-** raceway outflow, adult fish ladder entrance | Sample 10 | None | 10 | NAD 1983 (Conus) | 4968973.52 | 638652.93 |
| 10/17/2011 | 12:05 PM | Warm Springs | **Outflow**- abatement pond discharge pipe | Sample 11 | None | 10 | NAD 1983 (Conus) | 4969153.71 | 638752.56 |
| 10/17/2011 | 12:20 PM | Warm Springs | **Outflow**- Perimeter of pollution abatement pond | Sample 12,13 | None | 10 | NAD 1983 (Conus) | 4969124.03 | 638722.88 |