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2013 SURVEY FOR *POTAMOPYRGUS ANTIPODARUM* (NEW ZEALAND MUDSNAIL) WITHIN A FIVE-MILE RADIUS OF CAPITOL LAKE, THURSTON COUNTY, WASHINGTON.

Potamopyrgus antipodarum (Gray, 1843). Height 5.1 mm.
Specimen with perostracal fringes from Capitol Lake, Olympia, Washington.

Final Report
Contract #13-1018

Prepared for:
Washington Invasive Species Council,
Washington State Recreation and
Conservation Office, Olympia,
Washington

EDWARD J. JOHANNES
June 30, 2013

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DISCLAIMER

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“On a global basis…the two great destroyers of biodiversity are, first habitat destruction and, second, invasion by exotic species”

E. O. Wilson

INTRODUCTION

Background

During a bird-watching trip on October 22, 2009, Olympian resident Bert Bartleson (former president of the Pacific Northwest Shell Club), discovered the first evidence that *Potamopyrgus antipodarum* (Gray, 1843) (New Zealand mudsnail) (NZMS) had reached the Puget Sound Basin at Capitol Lake, Marathon Park, Olympia, Thurston County, Washington (Bartleson, 2010). He found 16 specimens of the NZMS inside a live *Anodonta* shell, which he showed to the author for confirmation on November 15th, 2009. The author contacted Kevin Aitkin at U. S. Fish & Wildlife Service (USFWS) on November 16th who subsequently contacted Washington State Department of Fish & Wildlife (WDFW) personnel. As a result, Washington State Department of General Administration (GA) closed Capitol Lake boat launches on November 24th, 2009 and signs were posted to inform the public of the introduction.

As a consequence of the find of NZMS in Capitol Lake, USFWS, WDFW, Washington Invasive Species Council (WISC; Washington State Recreation and Conservation Office), and GA, jointly came together to assess the situation and how to inform the public and other government agencies, conduct surveys to determine the extent of the introduction, and to research ways to contain or control the introduction.

History of Introduction

Potamopyrgus antipodarum has become a worldwide invasive species in fresh and brackish water habitats in Europe, Australia, Japan, and North America. In the U. S., Dwight Taylor first discovered NZMS in the middle Snake River, Idaho (Taylor, 1987). He recognized the population as being all female (parthenogenic) and guessed the snails were from New Zealand. Since he did not see the snails during a previous survey in the area (Taylor, 1985), he estimated that the introduction possibly occurred 2-3 years previous to his discovery at The Nature Conservancy's Thousand Springs Preserve. Since it's discovery over two decades ago, it has spread to 10 western states including Washington State at Long Beach in 2002 (Davidson *et al.*, 2008), Capitol Lake, Olympia in 2009 (Bartleson, 2010; Benson, 2010; Johannes, 2010b) and Lake Washington basin (Thornton Creek, Seattle; Kelsey Creek, Bellevue; and in Lake Washington at the mouth of Thornton Creek) in 2011 (USGS, 2011; PBBS, 2013; Olden & Twardochleb, 2011; Johannes, 2013). In addition it has been reported as far north as Port Alberni, Vancouver Island, British Columbia, Canada (Davidson *et al.*,

2008). A map in Anderson (2006) erroneously shows introductions of NZMS in south Puget Sound and eastern Washington. With the exception of Long Beach, there were no reports of additional sites in Washington previous to 2009 (Davidson *et al*., 2008; Benson, 2010).

Introductions in Capitol Lake

Even before the finding of the NZMS, introductions in Capitol Lake were one of the major concerns of the GA (CLAMP, 2002). There was at least 9 introduced species known which included Eurasian watermilfoil (*Myriophyllum spicatum*), purple loosestrife (*Lythrum salicaria*), American bullfrog (*Rana catesbeiana*), nutria (*Myocaster coypus*), common carp (*Cyprinus carpio*), brown bullhead (*Ameiurus nebulosus*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*) (Hayes *et al*., 2008). In addition, both the introduced Asian clam (*Corbicula fluminea* (Müller, 1774)) and Big-ear radix (*Radix auricularia* (Linnaeus, 1758)) were first reported in Capitol Lake in 2003 (Herrera, 2004). Both mollusks were also found in Capitol Lake in WDFW samples from 2009 and in Deixis samples from 2011 survey, neither species occurred in great numbers in the lake (Johannes, 2010b, 2011a). With the find of the NZMS, a total of three introduced mollusks were known to occur in Capitol Lake.

Previous surveys for *P. antipodarum* in Capitol Lake drainage

After the initial notification on November 16th, 2009, Will Morris (WDFW) collected snail samples on the next day from Marathon Park. WDFW identifies the snails as NZMS. On November 18th, Kevin Aitkin (USFWS) checked Tumwater Falls Park, Tumwater Historical Park, Capitol Lake at Interpretive Center, and Capitol Lake at Marathon Park. He only found NZMS at Marathon Park area of Capitol Lake. On November 24th, 2009, an initial survey by WDFW of Capitol Lake was conducted using wading method. WDFW personnel also surveyed the outflow of Black Lake Ditch and Percival Creek from the mouth upstream approximately 0.75 mile using snorkel method. Allen Pleus (WDFW) conducted searches on December 3rd, 2009 in the Deschutes River at 3 sites. None had NZMS present. On December 9th, 2009 five sites on Percival Creek were sampled and one additional site was surveyed in Capitol Lake at the North Basin boat launch. None of the Percival Creek sites had the New Zealand mudsnail, but the Capitol Lake boat launch site did. In 2010, NZMS was found at the junction between the north and middle basins of Capitol Lake (Allen Pleus, pers. comm). Surveys conducted in 2011 in Capitol Lake showed the NZMS had invaded all of the North Basin and most of the Middle Basin except in the extreme south end (Johannes, 2011a). It is unknown if it has invaded the South Basin of Capitol Lake. Surveys of West and East Bays of Budd Inlet did not turn up any

introductions of the NZMS (Johannes, 2011b).

PROJECT DESCRIPTION

In 2010 the WISC contracted with Deixis Consultants to conduct a more extensive New Zealand mudsnail survey than was undertaken previously. This survey was to determine if additional introductions of NZMS have occurred within a 5-mile radius of Capitol Lake (Johannes, 2010a). The scope, methods, and collection protocols for this survey were worked out with Wendy Brown (WISC). In partial fulfillment of contract 13-1018 with WISC, sites surveyed in 2010 were revisted in 2013 to look for the presence of the NSMS. Both survey years were conducted under the provisions of WDFW Scientific Collection Permits, No. 10-262 for 2010 and No. 12-263 for 2013, both issued to Edward J. Johannes, SeaTac, Washington.

Before fieldwork commenced in 2010, USGS 7.5' maps (Lacey, East Olympia, Maytown, Summit Lake, and Tumwater) were examined and a list of mapped water bodies within a 5-mile radius of Capitol Lake was compiled (**Appendix D**) and possible accesses noted. Because of the possibility of introductions of the NZMS by humans and or their pets, sites on water bodies with public access or possible public access (boat ramps, fishing access, parks, public trails, and road crossings or bridges) were chosen for sampling sites. Various sources were used to find public accesses including maps (USGS 7.5' maps, DeLorme Mapping's Washington Atlas and Gazetteer, and National Geographic TOPO!®) and the internet (sites accessed included Google Earth and those maintained by WDFW, Thurston County, cities of Olympia, Tumwater, and Lacey). Private lakes and streams running through private property were also sampled when permission could be obtained. Other sites not visited by humans for boating or fishing (*e.g.*, swamps or marshes) but which waterfowl, could visit, were also chosen. Though the possibility of the NZMS being introduced by waterfowl on their feet or feathers has not been documented locally, it could not be discounted. In 2010 field work was carried out for a total of 9 days in August on the 9th, 11th, 16th, 18th, 21st, 23rd, 25th, 27th and 30th and additional 2 days in September on the 1st and 11th. In 2013 field work was conducted on 1 day in May on the 23rd and 7 days in June on the 4th, 6th, 8th, 10th, 13th, 14th and 15th. Most samples were collected by one-person (Edward J. Johannes, Deixis Consultants) except when Bert Bartleson, Olympia joined the author in the field for 2 days in 2010 and 1 day in 2013. A total of 85 sites were collected in 2010 and 83 in 2013 (**Figure 1; Appendix A**). Three sites surveyed in 2010 were not resurveyed, 2 because landowners denied access (sites 30 and 49) and 1 (site 57) because of an extensive thick undergrowth of Himalayan blackberries prevented access. One site (86) was added to this survey near the mouth of Percival Creek with Capitol Lake. This site was collected previously in 2011 during another project (Johannes, 2011a). Most sites except 13 (sites 9, 11, 12, 16, 40, 41, 44, 45, 61, 63,

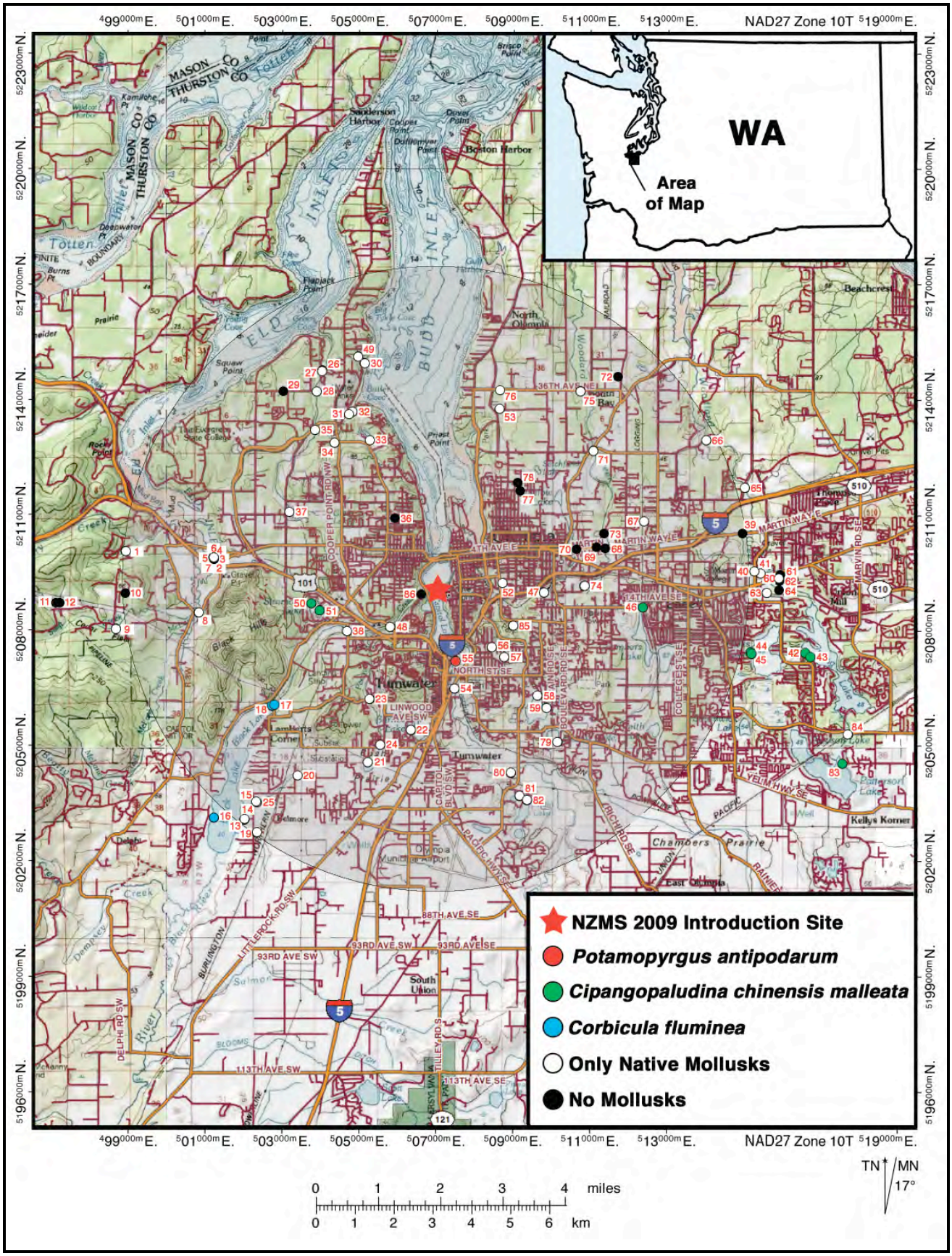

FIGURE 1. Map of Survey Area Showing Locations of Sites and Introduced Mollusks within a 5-mile Radius of Capitol Lake, Olympia, Thurston County, Washington. See **Appendix A** and **B** for details. Shaded region within a 5-mile radius of Capitol Lake. Map created with National Geographic TOPO!® ©2009.

64, 65, 83 and 84) were within a 5-mile radius of Capitol Lake (**Figure 1**). Most sites outside the 5-mile radius were within a mile beyond the boundary with 2 exceptions (sites 83, 84) that were almost 2 miles from the boundary. Despite being just outside the project area, it was felt that Hicks, Long and Pattison lakes should be surveyed as well.

Methods

Field Collections

Standard methods in malacology were used to implement the survey. Search methods varied according to substrate type and degree of aquatic macrophyte or plant cover. In general, all sites were spot-sampled to ensure completeness of coverage and sampling of major subhabitats. In coarse substrate areas with cobbles or boulders, a random sample of stones was removed and the mollusks were either hand collected or washed from them into a 7.5" X 13" tray and examined. Areas with mud, sand, or silt substrate were sampled by excavating small areas of bottom sediment to a depth of about 3 cm using a dip net with an 20 cm diameter and effective mesh size of 40 [Tyler equivalent 35 mesh: openings 0.425 mm]. The net was shaken just above the water surface to allow the sediment to fall through the net. Any organic debris that did not go through was carefully "floated" out of the net leaving the mollusks behind. Areas with rooted aquatic macrophyte vegetation were also sampled using the same size dip net. Vegetation was retrieved with the net and vigorously shaken to dislodge all mollusks into the net. Mollusks collected by dip net were dump into a 7.5" X 13" tray and then carefully examined. Areas with course substrates that could not be completely sieved through the net were also collected with the dip net or by hand and dumped into a 7.5" X 13" tray and carefully examined. At least a minimum of 10 subsamples was obtained from each sample site: the surface area represented at each was generally about 1 m^2. Regardless of origin, the collected material from each subsample was decanted into a labeled 16 oz. plastic container when mollusks were retained. The containers were placed into a cooler to keep the mollusks alive until they were transported to the lab. If samples contained large volumes of organic material, it was necessary to sieve them upon collection to ensure proper relaxation and preservation back at the lab. Each site required an average of 1 hour to sample. Notes on collection conditions, substrate, habitat, and associated flora and fauna were made at each site (see **Appendix A** for details).

Decontamination Procedures

Before leaving a site any mud or sediment adhering to the waders or rubber boots were removed, with a stiff bristled brush if necessary, into the stream just surveyed. Decontamination protocols as suggested by Hosea & Finlayson (2005) were followed. Based on their results Formula

409® disinfectant was determined to be the best compromise in regards to effectiveness in killing the NZMS versus the corrosive impact on waders or rubber boots and other equipment; cost, availability and toxicity to the user or environment. A Rubbermaid 10-gallon water cooler jug was used to contain a solution of 1:1 Formula 409® disinfectant with tap water where waders or rubber boots, collecting equipment and trays would be placed for 5 minutes after surveying a site. After being dipped into the 50% diluted Formula 409® solution they were rinsed in a water filled bucket covered with a lid to prevent spillage. This water was disposed of later down the sewer. After being decominated and before preceeding to the next site waders or rubber boots, collecting gear and trays were also visually examined for any adhering NZMS.

Laboratory Procedures

For samples, relaxation, fixation, and preservation using a succession of menthol, dilute formalin, and either 70% isopropyl or ethyl alcohol are routinely employed to preserve anatomical material (Frest & Johannes, 1992). In addition, a portion of samples with *Juga* and hydrobiids (*Flumincola*, *Pristinicola* and *Amnicola*) were preserved in 90% ethyl alcohol for DNA samples. Preserved samples were resieved if necessary in the laboratory to remove fine sediment and plant and animal detritus, and the full volume was examined. The whole sample was picked under a low-power binocular microscope. With many mollusk taxa (especially certain Physidae and Hydrobiidae), dissection, particularly of relaxed specimens, is necessary for proper identification. In regards to NZMS, relaxed specimens are not necessary for proper identification. No substantive identification problems were encountered with the material. Picked mollusks have been retained for further study.

Identifications Methods

The need for species-level identifications precluded the use of standard textbooks (*e.g.*, Pennak, 1989; Thorp & Covitch, 1991). Very few of the common species found here are mentioned in Pennak (1989). However, species-level manuals have long been available for many North American freshwater forms. Where possible, the standard references (*e.g.*, Burch, 1989 or its two predecessors Burch & Tottenham, 1980-Burch, 1982b-Burch, 1983 and Burch, 1982a for gastropods except for Physidae where Taylor (2003) was followed; Burch, 1972 and Clarke, 1973, 1981 for sphaeriids) were used. Deixis' rather extensive reference collection was also made use of. Common names, and species endings, are generally those of Turgeon *et al.* (1998) where possible. Higher taxonomic arrangement is that of Vaught (1989), except for that of the Sphaeriidae, which follows McMahon (*in* Thorp & Covich, 1991). Species definitions and ranges of Taylor (*e.g.*, as in Taylor, 1981, 2003) in preference to other sources for certain western North American forms were used.

Museum Collections

I have examined freshwater taxa in the major U. S. museums (*e.g.* Academy of Natural Sciences of Philadelphia (ANSP), University of Michigan Museum of Zoology (UMMZ), University of Colorado Museum of Natural History (UCM), Delaware Museum of Natural History (DMNH), Smithsonian Institution, National Museum of Natural History (NMNH), Burke Museum of Natural History and Culture, University of Washington (UWBM) and California Academy of Sciences (CAS)). Dr. Robert Hershler (NMNH) confirmed the identification of *Amnicola* n. sp. 1 (lake amnicola) in 2010.

RESULTS

A total of 83 sites were resurveyed during this project in which 65 (78%) had mollusks present (**Appendix A** and **C**). Fourteen lakes (25 sites), 3 marshes (3 sites), 4 ponds (4 sites), 2 springs (9 sites), 1 river (3 sites), and 21 creeks and tributaries (39 sites) were sampled. Three sites sampled in 2010 were not sampled this time and 1 additional site was sampled. A total of 33 (40%) sites had mollusks that should be considered Species of Special Concern (Frest & Johannes, 1995, 1999a, 2000, 2004, unpub.; WNHP, 2013) and cold-water species (see criteria in Frest & Johannes, 1992) (**Appendix C**). Introduced species were found at 12 sites (mostly in lakes, see below; **Appendix A** and **C**). Three taxa (NZMS, *Colligyrus* n. sp. 9 (coastal duskysnail) and *Anodonata oregonensis* (Lea, 1838) (Oregon floater)) not found in 2010 have been added to the faunal list (**Appendix C**).

New Zealand Mudsnail Found Within a 5-mile Radius of Capitol Lake and rate of movement

One new introduction of NZMS just upstream of Capitol Lake was found during this survey at

Figure 2. New NZMS introduction at site 55. Deschutes River at Tumwater Historical Park, Deschutes River, Thurston County, Tumwater.

site 55 in the Deschutes River, Tumwater Historical Park, Tumwater. NZMS was found to be in low numbers and has not reached the densities found in the nearby Capitol Lake. Of some significance, none were detected in the other tributaries of Capitol Lake (Percival Creek, Black Lake Drainage Ditch and Black Lake), which connect with the adjacent Chehalis River drainage.

Using the data from three sites where NZMS has been detected (2 in Capitol Lake (Marathon Park and Middle Basin) and 1 in the Deschutes River; **Tables 1** & **2**) gives us a rough baseline for determining the rate of the invasion of the NZMS in the Capitol Lake basin (**Table 3**). The variation in the rate of movement seen between the sites is interesting. The rate of movement of NZMS between Marathon Park and Middle Basin in Capitol Lake is 1.68 times as fast as seen between Middle Basin and Deschutes River at Tumwater Historical Park (**Table 3**). Possibly the current in the river versus

Table 1. The three NZMS localities in the Capitol Lake basin used to determine NZMS rate of movement.

LOCALITIES	DATE NZMS WAS DETECTED	Latitude (N)	Longitude (W)
Marathon Park (North Basin, Capitol Lake)[1]	10/22/2009	47.038	122.912
Middle Basin (Capitol Lake 3) [2]	06/20/2011	47.027	122.905
Deschutes River (Tumwater Historical Park)[3]	06/13/2013	47.020	122.903

1=Date and site from Bartleson (2010; pers. comm. 2009).
2=Site 3 in Johannes (2011a).
3=Site 55 herein.

Table 2. Distance and number of days of discovery of NZMS occurrence between 3 localities in the Capitol Lake basin. Upper triangle number of days between discoveries; lower triangle distance (m) between localities.

LOCALITIES[1]	Marathon Park	Middle Basin	Deschutes River
Marathon Park (North Basin, Capitol Lake)		607	1331
Middle Basin (Capitol Lake 3)	1316		725
Deschutes River (Tumwater Historical Park)	2254	938	

1=See Table 1 for explanation
Drainage distance between sites determined using National Geographic TOPO!® ©2009.

Table 3. Rate of movement of NZMS between 3 localities in the Capitol Lake basin. Upper triangle m/day; lower triangle m/year.

LOCALITIES[1]	Marathon Park	Middle Basin	Deschutes River
Marathon Park (North Basin, Capitol Lake)		2.17	1.69
Middle Basin (Capitol Lake 3)	792.1		1.29
Deschutes River (Tumwater Historical Park)	616.9	470.8	

1=See Table 1 for explanation

Table 4. Literature compliation from Kappes & Haase (2012) of active dispersal rates for NZMS.

PUBLISHED RATES	RATE (m/day)	SOURCE
288 cm/hr.	69.12	Sepulveda & Marczak (2012)
15 cm in 30 min.	7.2	Haynes *et al.* (1985)
51 cm in 5 hr.	2.4	Haynes *et al.* (1985)
120 cm in 24 hr.	1.2	Haynes *et al.* (1985)
0.44 m/15 min.	42.24	Ribi (1986)
1 m/hr.	24	Richards *et al.* (2001)
60 m over 3 months	0.66	Adam (1942)

the relatively still water in Capitol Lake has slowed the NZMS movement. Estimated rate of movement in **Table 3** is based on the assumption no transport of the NZMS by animals (fish, mammal or bird) has occurred between these sites and actual date the NZMS reached the site is not too many days different from the observed date.

Rates of NZMS movement cited in the literature have generally been much higher than that seen at Capitol Lake (**Table 4**). Comparisons of observed movements over a short time period versus longer time period reveal a bias toward higher estimated rate of movement for short observations. Short periods of observation may not take in account times when the NZMS would be not moving when it is resting, feeding, etc. Also random movement that could include movement toward the point of introduction could be missed during short observations. It seems reasonable based on the results

here (**Table 3**) and the results of the longest observation periods on **Table 4** that NZMS snail invasion rate probably ranges between 0.66-2.4 m/day.

Mollusks Found Within a 5-mile Radius of Capitol Lake

Though the main purpose of the survey was to find evidence of NZMS introductions outside of Capitol Lake, a secondary result was the first detailed survey of the freshwater mollusk fauna of the region around Capitol Lake. Not much was reported in the literature regarding freshwater mollusk occurrences in the Olympia area. Most previous surveys by malacologists either very briefly covered the region (Henderson, 1929, 1936) or were conducted in immediate adjacent areas such as the Olympic Peninsula or Cascades (Branson, 1977b, 1980; Branson & Barrett, 1981; Branson & Branson, 1984). Frest and Johannes (Deixis coll.) collected largely springs and streams, and very few lakes in Thurston County, mostly adjacent to the area of this survey. Thurston County recently conducted macroinvertebrate surveys and reported *Juga* from Black Lake ditch, Deschutes River, Green Cove, Little McAllister, Moxlie, Percival and Woodland creeks; *Fluminicola* from the Deschutes River (PSSB, 2013).

A total of 3 introduced species were found during this survey. The Asian clam *Corbicula fluminea* (Müller, 1774) (Asian clam) was found in Black Lake and at one of its outlets, Black Lake Ditch (dead only); *Potamopyrgus antipodarum* was found for the first time outside of Capitol Lake in the Deschutes River at Tumwater Historical Park; and *Cipangopaludina chinensis malleata* (Reeve, 1863) (Chinese mysterysnail)), another introduced species from Asia, was found in Long, Hicks, Chambers, Ken (Simmons) and Pattison lakes. Twelve sites have introduced species (**Figure 1**; **Appendix A** and **C**). Three introduced mollusks have been report previously in the area in Capitol Lake. Both *Corbicula fluminea* and *Radix auricularia* (Linnaeus, 1758) (Big-ear Radix) were found in 2003 and NZMS in 2009 in Capitol Lake (Herrara, 2004; Bartleson, 2010; Johannes, 2010b).

Twenty native freshwater mollusks were found (13 gastropods and 7 bivalves) with the addition of *Anodonta oregonensis* and *Colligyrus* n. sp. 9 to the faunal list during this survey. One land snail was also found during both survey years (*Oxyloma* sp.). A total of 6 species were found that should be considered Species of Special Concern (**Figure 3**; **Appendix C**). The total number of cold-water species found in the survey area was 7. All are considered Species of Special Concern except *Pisidium (N.) insigne* Gabb, 1868 (tiny peaclam). Below are entries for each species covering miscellaneous background information, habitat, distribution in the west, co-occurring mollusks, threats to Species of Concern, and site occurrence for species found during this survey. Also included is 1 entry for *Margaritifera falcate* (Gould, 1850) (western pearlshell) known to potentially occur in the

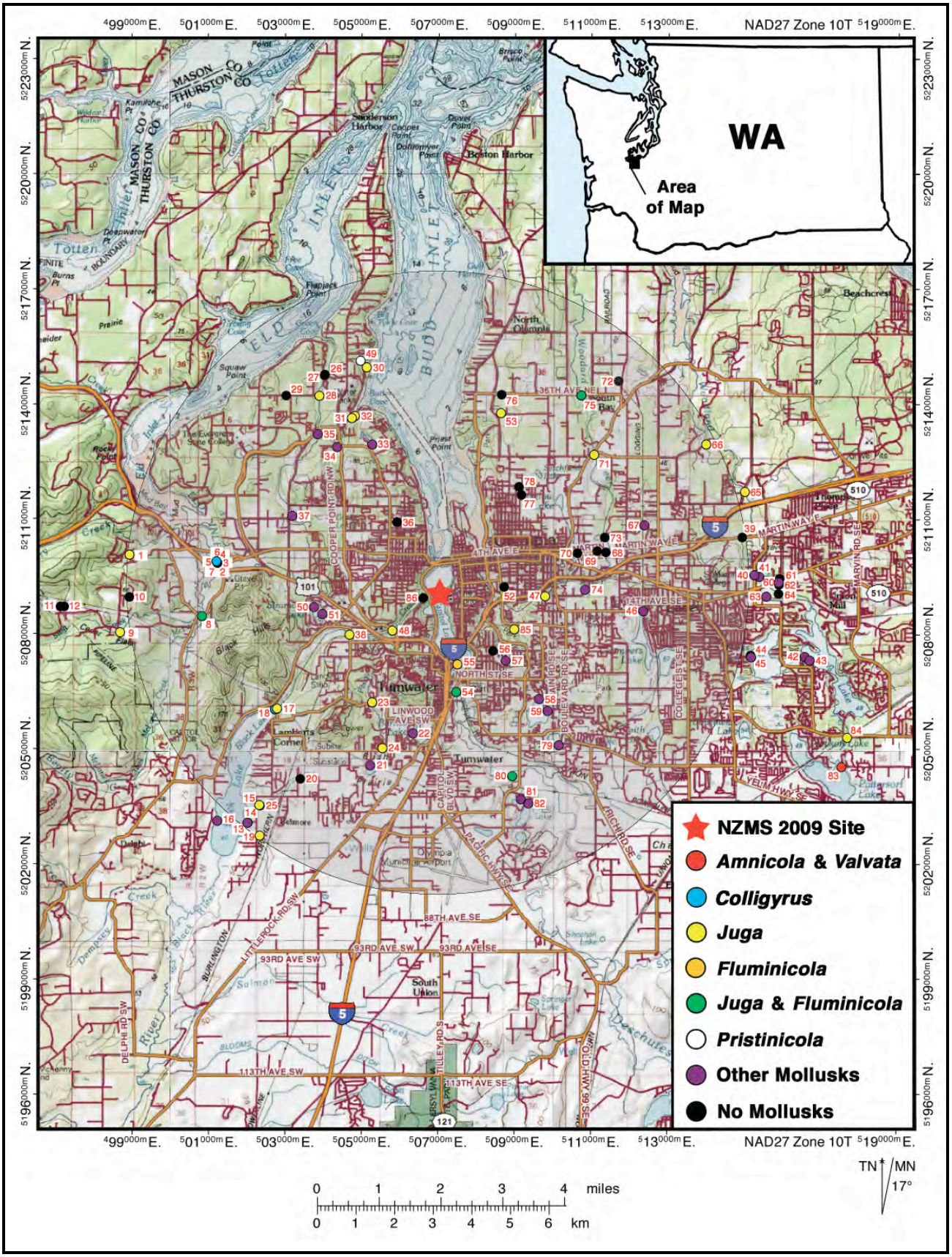

FIGURE 3. Map of Survey Area Showing Locations of Sensitive Native Mollusks within a 5-mile Radius of Capitol Lake, Olympia, Thurston County, Washington. See **Appendix A** and **B** for details. Shaded region within a 5-mile radius of Capitol Lake. Map created with National Geographic TOPO!® ©2009.

region surveyed but not found during this project (entry preceded by an asterisk). In addition, a figure of the shell (and for some the animal) for each introduced mollusk and gastropod Species of Concern (except for *Fluminicola* n. sp.) is included. The NZMS is placed as the first entry in **Introduced Mollusks** out of taxonomic order.

Introduced Mollusks

Family Hydrobiidae

***Potamopyrgus antipodarum* (Gray, 1853) (New Zealand mudsnail)**

The NZMS was first noticed in the Columbia in 1995, at Youngs Bay near Astoria, Oregon (Litton, 2000; Bersine *et al.*, 2008). Since then, it has been reported as far east as Cathlamet Bay, Oregon. Frest & Johannes (2004) extended the species range in the Columbia River eastward, to St. Helens, Oregon.

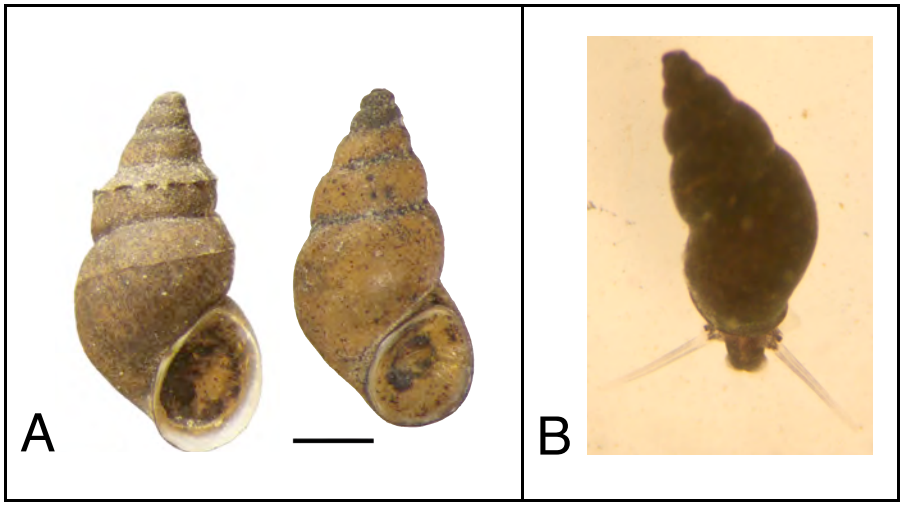

FIGURE 4. *Potamopyrgus antipodarum* from Capitol Lake, Thurston County. A. Shell with perostracal fringes on the left and smooth shell on right. Operculum present in both shells. **B.** Live snail. Measurement line= 1 mm.

Specimens at Frest & Johannes (2004) two non-estuary sites are as yet quite rare; but massive increases are likely, to judge by the species' history in the middle Snake River. It is expected that the Columbia will provide sufficient degraded habitat as to allow this taxon to become a true nuisance species. While Mackie (1999b) does not seem to regard this taxon as nuisance, except possibly to native mollusks, experiences in the middle Snake River (Bowler, 1991; Bowler & Frest, 1992; Frest & Johannes, 1992) suggest that it not only negatively impacts native mollusks but also can be both an aesthetic irritant and impediment to hydroelectric, trout rearing, and irrigation facilities.

Aside from impacts on native species (USFWS, 1995; Richards *et al.*, 2001: see also earlier references in Frest *et al.*, 2002), the species is a biofouler. At one Idaho Power hydroelectric facility, for example, it has proved necessary to operations to remove some 30 tons of organic detritus per day. Half of that by weight is NZMS.

The further spread of the NZMS has been a concern of Washington State legislature since 2008 (ANSC, 2007). In Capitol Lake it is estimated the population densities are 20,000 per square meter in limited areas of the North Basin (Allen Pleus, pers. comm., 2009). Based on the extent of the area invaded and population density of NZMS in Capitol Lake, introduction probably occurred in 2008 or 2009 (Johannes, 2010b).

This species is fairly pollution tolerant and known to occupy a variety of habitats from freshwater (rivers, creeks, lakes and springs) to brackish and occupy various substrates from mud to bedrock (pers. obs.).

Attenuate shell; adult height ca. 4-12 mm; adults with 7 to 8 whorls; color varies between gray and dark brown to light brown; aperture oval; some individuals have periostracal fringes. Operculum corneus; thin; paucispiral. Body has a dark mantle.

One introduction of NZMS outside of Capitol Lake was found at site 55 in the Deschutes River just upstream of where it enters Capitol Lake during this survey.

Family Viviparidae

Cipangopaludina chinensis malleata **(Reeve, 1863) (Chinese mysterysnail)**

Cipangopaludina chinensis malleata was not reported from this area before the 2010 survey. Found in 5 lakes, all but Ken (Simmons) Lake occur within 3 miles of the BNSF (formerly Northern Pacific Railroad) mainline, which runs through the area and cuts across Pattison Lake (see **Figure 1; Appendix B,** p. B3). It is possible this species was introduced as a food source by Chinese laborers working for the former Northern Pacific Railroad during construction of the railroad mainline in the 1870's. Hanna (1966) and Mackie (1999c) emphasize food usage as the rationale for introductions. However, the aquarium trade route is a very possible introduction route as well (this species is not mentioned in Mackie, 1999a, nor are apple snails [*Pomacea*]). The Chinese mysterysnail is raised specifically for this purpose in the middle Snake River region (Bowler & Frest, 1992) and has commonly been seen in pet stores throughout the U. S., as are apple snails, for at least 30 years. Boats were suggested as another possible route of introduction by a recent study (Havel, 2011). Field experiments under mesic conditions indicated that juveniles of this snail could survive exposure to air for at least 4 weeks. Survival rates were not affected as much by air temperature as it was by humidity. Results from this study suggest that *C. chinensis malleata* is highly resistant to air exposure

and could be readily transported by boats moving between lakes, particularly in a cool mesic environment, like that found in the Pacific Northwest.

It is primarily a detritivore; but has been observed feeding upon aquatic macrophytes as well; and in aquaria will feed upon a variety of plant and animal products. In the wild, it seems to be found most often in relatively quiet waters and on silt or mud substrates. It seems to be a poikilothermophile, with warm waters perhaps more conducive to survival, but not necessarily. Occurrences are quite scattered in the West so far. This taxon seems fairly pollution-tolerant as compared to many natives, and has been found in ditches and warm spring pools as well as streams, ponds, and lakes.

FIGURE 5. *Cipangopaludina chinensis malleata* shell from Pattison Lake, Thurston County. Measurement line= 1 cm.

In Washington also known to occur in Lake St. Clair and Lake Lawrence, Thurston County (Deixis coll., collected with B. Bartleson); Green Lake, Angel Lake, Lake Sawyer, Lake Meridian, Shadow Lake, Spring Lake, and Lake Fenwick, King County (Clench & Fuller, 1965; Hanna, 1966; Deixis coll.; Bartleson pers. comm., 2010); Lake Cascade, Moran State Park, Orcas Island, San Juan County (Branson, 1977a; Deixis coll.); Wildcat Lake, Kitsap County (NatureServ, 2010); Crocker Lake, Jefferson County (Bartleson pers. comm., 2010); Wiser, Bug, and Terrell lakes, Whatcom County (Deixis coll.); and one site in the Columbia River drainage, Longview drainage ditch, Solo Storage entrance, Cowlitz County (Frest & Johannes, 2004).

This species has been shown to be an intermediate host for human intestinal parasites (Chung & Jung, 1999). Smith (2000) has argued for placing this species under the genus *Bellamy*a. For the moment, kept under the genus *Cipangopaludina.*

During this survey *Cipangopaludina* was found at a total of 8 sites at Long Lake (42 & 43), Hicks Lake (44 & 45), Chambers Lake (46), Ken Lake (50 & 51), and Pattison Lake (83). One additional site for this taxon was found in 2013 at Long Lake (42) (**Appendix A** & **C**). Hicks, Long, and

Pattison lakes are all connected together by 2 intervening creeks, but *Cipangopaludina* was not found in the creek between Long and Pattison lakes nor was it found in the outlet creek for Long Lake.

Family Lymnaeidae

***Radix auricularia* (Linnaeus, 1758) (Big-ear Radix)**

This Euarasian aquarium species was first collected from the Great Lakes in 1901 (Mills *et al.,* 1993). This taxon is now widely introduced over the whole State and is similarly common elsewhere in the western U. S.

While most likely to be found in relatively quiet situations on soft substrates, often with common macrophytes, this taxon is effectively a poikilothermophile and has been noted from streams of all sizes, lakes, ponds, springs, spring runs, and spring pools. It appears most successful in warmer areas with little current and definite nutrient enrichment; and has even been seen occasionally in cattle troughs. While often an epiphyte scraper, then species is also believed to be able to survive on aquatic macrophytes.

FIGURE 6. *Radix auricularia* shell from a pond in Wyoming. Measurement line= 1 cm.

Note that Taylor (1981) has sometimes considered the species, at least in Alaska, native. However, its rapid spread in much of the western U. S. in recent years suggests that it was not recently present historically. Has been noted by Frest & Johannes at a number of sites elsewhere in the State, especially in eastern Washington. Capitol Lake is a perfect habitat for this introduced species but it has not become a major component of the benthic fauna of the lake (Johannes, 2010b). First reported in the lake in 2003 (Herrera, 2004).

Strangely, it was not found at any of the sites during the 2010 or 2013 surveyes outside of Capitol Lake.

Family Corbiculidae

***Corbicula fluminea* (Müller, 1774) (Asian clam)**

Corbiculids were native residents of North America for a considerable time before becoming extinct on the continent relatively recently (Taylor, 1988a, b). The first known introduction, in North America, occurred in the Columbia River and it has been known to be present there since perhaps 1937 (Burch, 1944; Counts, 1985). Since its introduction, it is now found in 38 states and the District of Columbia (Foster *et al.*, 2009). It can be a major biofouler of intakes (Isom, 1986; Isom *et al.*, 1986). Its method of dispersal in North America is not well understood. Unlike all freshwater native North American species, *Corbicula* has a free larva that may drift for days in a current (Taylor, 1987). This may help in the rapid spread of this species.

FIGURE 7. *Corbicula fluminea* from Shasta Lake at Centimudi Boat Ramp, Shasta County, California. View of left valve. Measurement line= 1 cm.

Corbicula is uncommon in more prisitine oligotrophic habitats and more common in somewhat disturbed settings, especially if waters are warm. The local example thrives best in flowing water, although slow flow situations can support dense populations.

Taxonomic status of *Corbicula* in North America is still somewhat cloudy, with claims for at least two taxa**.** More recently, morphological differences within the introduced populations have been ascribed to origin as separate clones of uncertain number, distribution, and status.

Despite the early introduction, *Corbicula* is only moderately successful as an invader in Washington and Oregon, especially as compared with, say, the Tennessee Valley. It is a pest species with considerable economic impact in the central and eastern states. In Capitol Lake, Olympia Washington it does not occur in great numbers (Johannes, 2010b) and was first reported in 2003 (Herrera, 2004). In Washington this species has also been found in the lower Columbia River, Black

Lake, Thurston County, Lake Washington, King County, and Angel Lake, SeaTac, King County (Counts, 1985; Frest & Johannes 2004, 2008; Johannes, 2013; Deixis unpub).

This species was found at one site (16) at Black Lake in 2010. It was mostly found as rare shell fragments (no live adults were seen), but one live juvenile was collected. During the 2013 survey it was found at Black Lake sites 16 and 18 and Black Lake Ditch site 17 as either shell fragments or complete adult dead shells (see **APPENDIX A**). It is a mystery as to why only dead specimens were found as the habitat for all 3 sites looked appropriate for this species. It is possible this species is extinct in Black Lake, but sampling sites collected at deeper depths in the lake may reveal live populations.

Native Mollusks

Family Valvatidae

***Valvata* n. sp. 2 (Washington valvata)**

A totally unexpected discovery found in Pattison Lake that was made during the last days of the 2010 survey. This rare species was first collected from Paradise Lake, King County, Washington by an early Seattle naturalist Walter Eyerdam in 1937 (USNM lot 18590), where it still occurs abundantly today. Pattison Lake is the southern most known occurrence for this species. This species was initially was thought to be disjunct populations of the Alaska occurring *Valvata mergella* Westerlund, 1883 (Johannes, 2010a). The subsequent discovery of the whereabouts of the type specimens of *mergella* at the Swedish Museum of Natural History and examinations of photographs of them have shown that the Paradise and Pattison lakes *Valvata* is a new species (Johannes, 2011c).

This taxon occurs in colder lakes and ponds at low to moderate elevations. Presence of oxygenated soft substrate and aquatic macrophyte beds seem to be desiderata. The Paradise Lake occurrence is with *Anodonta oregonensis*, *Planorbella subcrenatum*, *Menetus callioglyptus*, *Gyraulus parvus*, *Fossaria* sp., *Stagnicola* sp., *Musculium raymondi*, *Sphaerium patella*, *Pisidium variabile*, *Pisidium compressum*, and *Pisidium casertanum*. Also occurs with *Amnicola* n. sp. 1 (lake amnicola) at Pattison Lake (see below). This species seems to avoid near shore habitats in glacially formed lakes making collecting by waders difficult.

Shell depressed turbinate; adult diameter *ca.* 5-7 mm; even, pale green, including initial whorls; luster glossy; axial striae low, inconspicuous; aperture rounded, commonly slightly expanded terminally (see **Figure 2**). Operculum corneus; thin; circular in outline; multispiral. The relatively large size, light green (not blue-green or emerald green as in *V. virens*) shell, and expanded aperture are quite distinctive.

Using habitat requirements for both the *Amnicola* and *Valvata* and possible migration routes based on knowledge of Pleistocene geology of the region (see **Figure 13** in **Appendix F**), two additional glacial lakes (Ravensdale and Walsh) were found by the author in quick succession in 2012 to have *Valvata* n. sp. 2 present. These lakes occur in the glacially formed Covington Channel (Mullineaux, 1970) near Black Diamond, King County in an intermediate position between Paradise and Pattison lakes (**Figure 13**). The *Valvata* was found to be very rare in both these lakes. The best lake for this species continues to be Paradise with Pattison the second best.

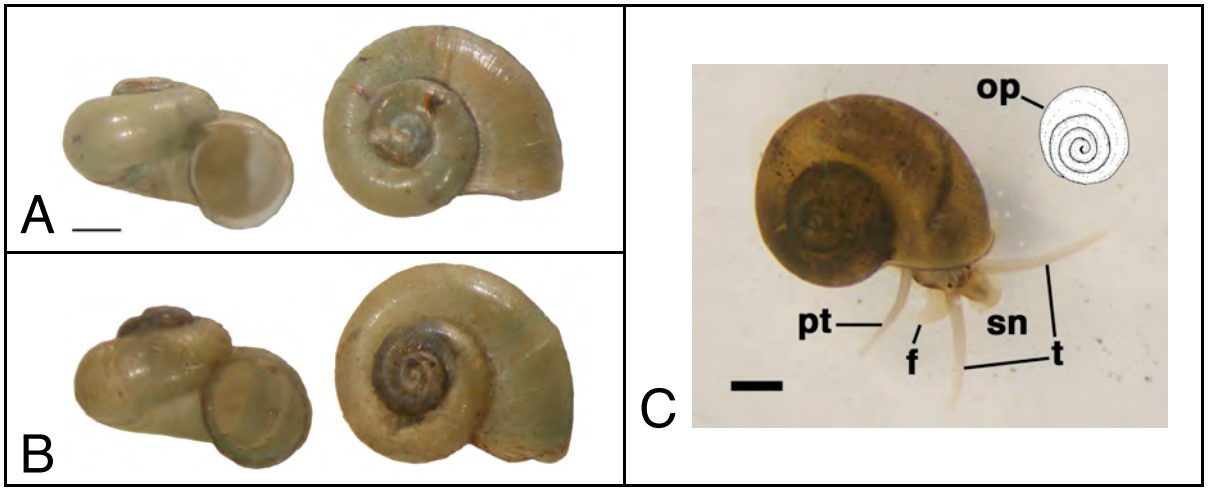

FIGURE 8. *Valvata* n. sp. 2. A. Shell from Paradise Lake, King County; **B.** Shell from Pattison Lake, Thurston County. **C.** Live animal from Pattison Lake, Thurston County. f=foot; op=operculum; pt=pallial tentacle; sn=snout; t=tentacles. Measurement lines= 1 mm.

Threats include human habitation and urbanization around kettle lakes; modification of native fish fauna and concomitant extinction of some or all native mollusks; ground water pollution; eutropification; irrigation usage of lakes; ground water pumping lowering lake levels. Most lakes in western Washington have been either rotenoned to modify the fish fauna or had herbicide applied to control introduced aquatic plants. Many western Washington lower elevation lakes are polluted due to human habitation and/or occurrence in the Olympia-Tacoma-Seattle urban corridor. Pattison Lake site is in a rapidly growing urban area within the City of Lacey. Frest & Johannes (unpub.) have found very few western Washington lower elevation lakes to retain the native mollusk fauna. Other *Valvata* species more common than *Valvata* n. sp. 2 are now rarely found in Washington lakes and streams and despite historic reports of occurrences in the Puget Sound basin, including within Seattle City limits and Lake Washington (Randolph, 1896; Dall, 1910; UWBM lot 4349), no other *Valvata* species have been found still surviving in this region (Deixis unpub.). The nearby introduction of the New Zealand mudsnail in Capitol Lake is another threat to this species. Recent survey of lakes near Pattison Lake (Offutt, Deep, and Lake St. Clair) has not resulted in additional sites for this species (Johannes, unpub.).

Found the following lots of *Valvata* n. sp. 2 from Paradise Lake at ANSP collection in the 1990's and at USNM collection in 2013 (ANSP 21695-6, collected by B. R. Bales on 17 Nov 1958; ANSP 177577, collected by W. J. Eyerdam on 7 May 1941; ANSP 177875-6, ibib., 19 Aug 1941; USNM 18590, ibib., 18 Oct 1937; USNM 742027, collector unknown, unknown date).

This species is currently not listed as a State Species of Concern in Washington but should have a State Status of S1 (critically imperiled) (WNHP, 2013).

Sufficient survey work has been done in recent years to indicate that this species should be Federal and State (Washington) Endangered. This species co-occurs with *Amnicola* n. sp. 1 (lake amnicola) (see below).

Found at site 83 near State public boat ramp, Pattison Lake in 2010 but not in found in the 2013 survey. Water levels were too high for waders to reach the deeper waters where this species occurs. Sites collected in 2012 where the railroad cuts across Pattison Lake did not have this species.

Family Amnicolidae

***Amnicola* n. sp. 1 (lake amnicola)**

Another totally unexpected find also discovered in Pattison Lake at the same site as *Valvata* n. sp. 2. This is a major range extension across the Cascades from the known distribution of this species, which has been found in eastern Washington at Spectacle Lake S. of Oroville, Curlew Lake near Republic and recently in Bonapart Lake west of Curlew Lake; and in Montana at McWenneger Slough, Flathead County, Ninepipe Reservoir, Lake County and Georgetown Lake, Deerlodge County (Prof. Royal B. Brunson, University of Montana, unpub. mollusk catalog; Deixis unpub.). Sites in Idaho have not been found as of yet. Mistakenly reported from Flathead Lake, Montana in Taylor (1985). Common name was formerly Washington duskysnail in Frest & Johannes (1995, 1999b, 2001b, unpub.).

Unlike the eastern U. S. *Amnicola limosa*, which occurs in streams as well, this species is apparently strictly a limnophile of which four Washington sites are in glacially formed lakes (Curlew, Spectacle, Bonapart and Pattison), with streams flowing in and out of them. Pattison Lake is part of a train of glacially formed lakes that include adjacent lakes to the south and north (Walsh *et al*., 2005). The sites in Montana do occur in lakes but do not fit the pattern seen in Washington. One site is found in a Flathead River oxbow lake (McWenneger Slough), which is eutrophic/mesotrophic but has high aquatic plant diversity (Flathead Lakers, 2002). The other two sites are found in reservoirs, one is Ninepipe Reservoir and the other is Georgetown Lake, the only site with this species outside of glaciated terrain. At first glance the Montana sites do not seem to match at all the formational history of the Washington sites. However, Ninepipe Reservoir has inundated several small glacially formed

lakes, any one of them could have had *Amnicola* present and McWenneger Slough is near other glacially formed lakes, none which have been investigated for this species. It is possible the Georgetown Lake *Amnicola* site is an introduction. Often this species is found among aquatic macrophyte beds, generally on soft but well-oxygenated substrate, *e.g.* marl or mud. Absent from dense macrophytes or in areas with anoxic sediments. Depth generally 2-6'+. This species grazes periphyton, apparently from macrophyte surfaces, but is also a detritivore.

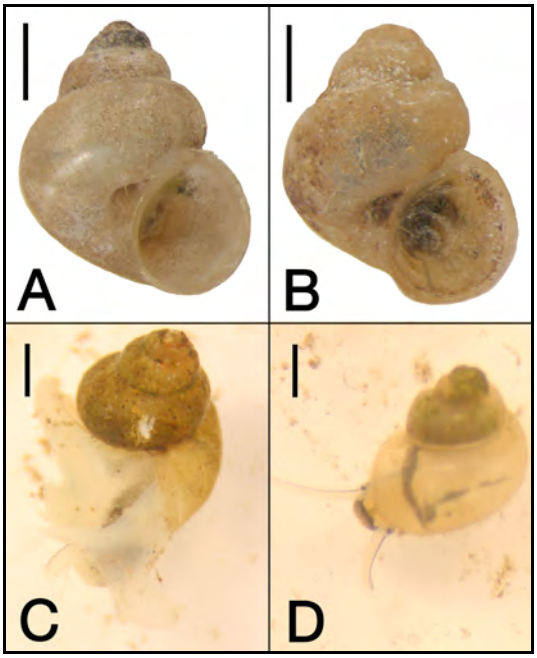

FIGURE 9. *Amnicola* n. sp. 1. A. Shell from Pattison Lake, Thurston County, Washington; **B.** Shell from McWenneger Slough, Flathead County, Montana. **C.** Relaxed specimen from Pattison Lake showing male anatomy. **D.** Live snail from Pattison Lake. Note characteristic dark pigment pattern on mantle seen throught the shell. Measurement lines= 1 mm.

Shell similar to that of *Amnicola limosa* (see Hershler & Thompson, 1988); height to 5.0 mm; ovate-conic, well-rounded whorls; comparatively thin; 4-5 whorls in adult; small umbilicus. Operculum corneus; paucispiral. Body similar to *Amnicola limosa*, but dark pigment on mantle concentrated in bar parallel to edge of pallial cavity, then in dark streak along intestine and digestive gland; no bar on outside cephalic tentacles, although a faint central band is sometimes present (see **Figure 3**). This taxon (live specimen from McWenneger Slough) is illustrated as *Amnicola limosa* in Taylor & Bright (1987).

This species is not found in strongly eutropified lakes. Lakes used as part of irrigation systems, with untreated sewage, or having other sources of nutrient enrichment, seem to lack the species. Many of the kettle lakes in the area of occurrence have heavily developed shorelines, including housing with inadequate provisions for sewage and nutrient runoff management. Siltation is also a

problem, exacerbated by logging, grazing, and residential development. Lakes with extensive herbicide treatment to kill out aquatic macrophytes or to stock game fish or modify the native fish fauna using rotenone also seem to lack this species. The great majority of northern Washington, Idaho, and northwestern Montana lakes have one or several of such problems including recent development of farmland as the areas population grows. Pattison Lake is in a rapidly growing urban area within the City of Lacey. The nearby introduction of the New Zealand mudsnail in Capitol Lake is another threat to this species. The introductions of *Bithynia tentaculata* (Linnaeus, 1758) (faucet snail) into McWennegar Slough and Geogetown Lake (Deixis coll.) and *Esox masquinongy* (Tiger muskies) into Curlew Lake in 1997 by WDFW to control populations of Squaw fish are additional threats to *Amnicola* n. sp. 1.

In addition to *Valvata* n. sp. 2, this species co-occurs with the Clinton Forest Plan ROD (Record of Decision) species *Colligyrus* (formerly *Lyogyrus*) n. sp. 2 (formerly Washington now masked duskysnail) at Curlew Lake (ROD, 1994; Frest & Johannes, 1993, 1999b). The lake amnicola should be considered a Species of Special Concern by the states of Washington, Montana and by the State of Idaho if found there and listed as Endangered by the State and Federal governments. Previously suggested by Frest & Johannes (1995) as a sensitive species in need of listing as Endangered.

Found only at one site (83) near a State public boat ramp in Pattison Lake during 2010 and during this survey. Sites collected in 2012 where the railroad cuts across Pattison Lake did not have this species.

Family Hydrobiidae

***Colligyrus* n. sp. 9 (coastal duskysnail)**

No other western U. S. hydrobiid looks like this minute species. The only other North American hydrobiid with similar shell shape is *Amnicola cora* Hubricht, reported from a cave in Arkansas; but the western form is not known to be stygian and has an even more strongly depressed shell and multispiral operculum and is not a Amnicolid. Originally placed under *Lyogyrus* (Frest & Johannes, 1999a, 2000, unpub.). Hershler (1999) erected *Colligyrus*, another genus for *Lyogyrus greggi* and a new taxon. This form may also belong to the same genus and is tentatively placed there.

Although Washington individuals seem to be smaller, more discoidal, and have a broader umbilicus, they are for the time being grouped with this taxon. It is not recommend to attempt to identify western *Colligyrus* species from shells only, even when they are described species, if they come from a region like this in which discovery of additional similar taxa is quite possible. Consultation with a specialist is *de rigueur* for this genus.

Oregon populations are small, depressed conic hydrobiid; shell off-white to clear, partly translucent; often partly covered by black organic coating; periostracum thin, gray to light tan; shell diameter to 2.4 mm at 3 3/4- 4.0 whorls; height to 2.3 mm; umbilicus broad, open, 1/4 to 1/5 full diameter; body largely colorless; with scattered melanin granules on cephalic tentacles, snout, neck, and sides; visceral coil pale gray to (commonly) black. Dorsal surface of cephalic tentacles often darker than undersides; sometimes weakly striped longitudinally; white triangular patches of pigment granules behind eye spots, displaced slightly toward snout. Operculum circular, very light amber to colorless peripherally, paucispiral with slightly excentric nucleus, with subcentral darker (orange to yellow-brown) thickening. Aperture nearly circular; about 1 mm in height; width nearly 1 mm; thin (not reinforced or expanded), barely adnate or barely detached; last 1/2 whorl commonly slightly detached, sometimes deflected; penial lobe and filament unpigmented; lobe originating near base; both relatively short (as commonly preserved).

Washington populations are similar. Shell strongly depressed to nearly discoidal: maximum diameter about 2.4 mm at 3 3/4 whorls; umbilicus width about 1/4-1/3 full diameter; visceral coil light gray to (rarely) black; head and tentacles light gray (a few melanin granules), often darkest and faintly striped on upper surfaces (see **Figure 4**); verge lobes unpigmented; to 2.3 mm height; 3-3 3/4 whorls. In life, white triangular patches behind eyes. Operculum circular, concave, light amber to nearly colorless except at nucleus (orange to amber), paucispiral with subcentral nucleus, with central darker thickening.

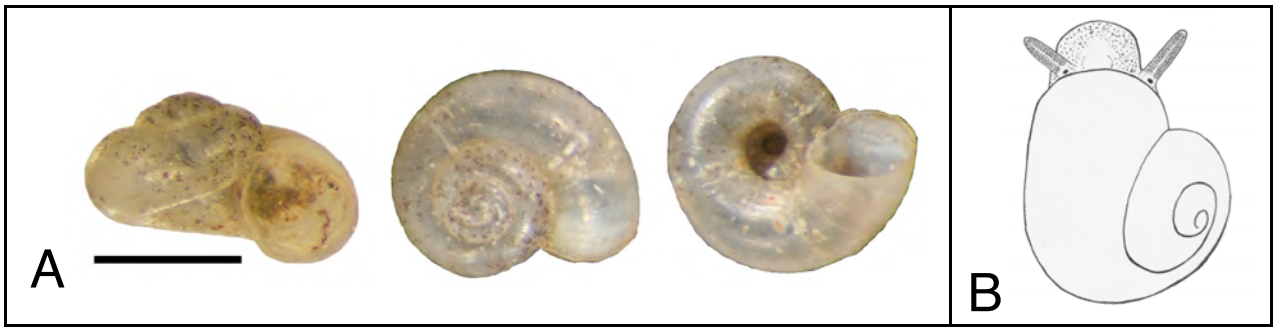

FIGURE 10. *Colligyrus* n. sp. 9 from Capitol State Forest, Black Hills, Thurston Co., Washington. **A.** Three views of shells. **B.** Drawing of preserved specimen. Measurement line= 1 mm.

Found in shallow, cool muddy seeps and spring runs; substrate generally mud; very limited patches of *Rorippa*; no noticeable epiphytic algae; common *Lysichitum* and wood fragments; often with *Hydrophyllum* spp. and *Chrysosplenium glechomaefolium*; infallen deciduous leaves; site often with *Acer macrophyllum* nearby and/or in *Alnus* stand; depth averaging less than 1". Snails found preferentially on infallen, waterlogged deciduous leaves and wood (*Alnus*, *Acer*).

Probably widespread in coastal western Oregon and Washington south of the Wisconsinan glacial border (roughly, the Chehalis River drainage and south). Southern terminus of range uncertain at this point. In Oregon currently found at 2 sites in Lane County and in Washington at 31 sites in Grays Harbor, Mason, and Thurston counties (Chehalis River drainage: North River and Black Hills (Capitol State Forest)). Despite searches, sites have not been found between the Oregon and Washington occurrences as of yet.

Threats include coastal development, in terms of housing; resort and beach projects; increasing human traffic in general; road building and maintenance, particularly of the coastal highway (US 101); clearing and logging in both coastal Washington and Oregon. Development from nearby Tumwater and Olympia, Washington; increasing human traffic in general; heavy recreational usage, road development, groundwater usage, spring development and logging of Capitol State Forest; clearing and logging throughout southwestern Washington and coastal western Oregon. Additional possible threat is from the New Zealand mudsnail, which is known to invade springs (Richards *et al*., 2001; pers. obs.).

Has no status at present; should minimally be considered a Species of Special Concern by appropriate State (Washington, Oregon) and federal wildlife and land management agencies. It is very likely that this species should be listed with both State and Federal authorities as Endangered.

This unusual species was missed during the 2010 survey but was found while resurveying site 6 at Allison Springs. Currently known to occur in about 31 sites in and around the Black Hills (Capitol Hills State Forest), just west of the area surveyed during this project, and at 2 sites in southwest Oregon. Occurs with *Pristinicola* at 1 site in Washington and 2 in Oregon.

***Pristinicola hemphilli* (Pilsbry, 1890) (pristine pyrg)**

Monotypic genus with scattered sites in part of the Columbia Basin (with a concentration of sites in the Columbia Gorge), including a few large tributaries; and south in the Willamette and the coastal drainages at least to southwestern Oregon; absent from most of northern Washington; interior Oregon except for the Blue Mountains (especially John Day River; but also Snake River) and Deschutes River drainage; and from all except western Idaho (not in the Snake system upstream of the Weiser area). Range recently pushed south to Del Norte, Humbolt, and Trinity counties, California in the Klamath and Smith River systems and north to King County, Washington into glaciated terrain (Deixis coll.).

Most sites for the pristine pyrg are small to medium pristine cold springs or spring-influenced creeks, often primarily in source areas. The crenicole habitat and groundwater preferences make this taxon easily subject to extirpation despite the relatively broad range (for a spring snail). In fact, several of the sites noted by Frest & Johannes (unpub.) since 1994 were extirpated by road building and

maintenance (Washington 14; I-84), grazing (Baker District BLM), dam construction and maintenance (Hells Canyon Dam, John Day Dam); and diversion and capping for campground, hatchery, stock, and domestic water supply (Columbia Gorge area). In the Columbia Basin part of the range, grazing is probably the biggest single problem. On the Westside (west Cascades and Coast ranges), logging and urbanization are the primary concerns. In some areas, nutrient-enriched groundwater is a problem also, *e.g.,* Grant County, Washington. In both areas, diversion, modification, or outright destruction of small springs is rampant.

See Hershler *et al.* (1994) for detailed anatomy and shell description and illustrations. The small, elongate, *Bythinella*-like conch is unique in western North America. Shell white, partly translucent, elongate pupiform: height generally 2-3 mm; whorls 5 1/2; flattened, gently convex (see **Figure 5**); sutures deeply impressed. Aperture reinforced slightly all around, orthocline; last whorl often slightly disjunct and reflected. Body almost pigmentless except for small eye spots.

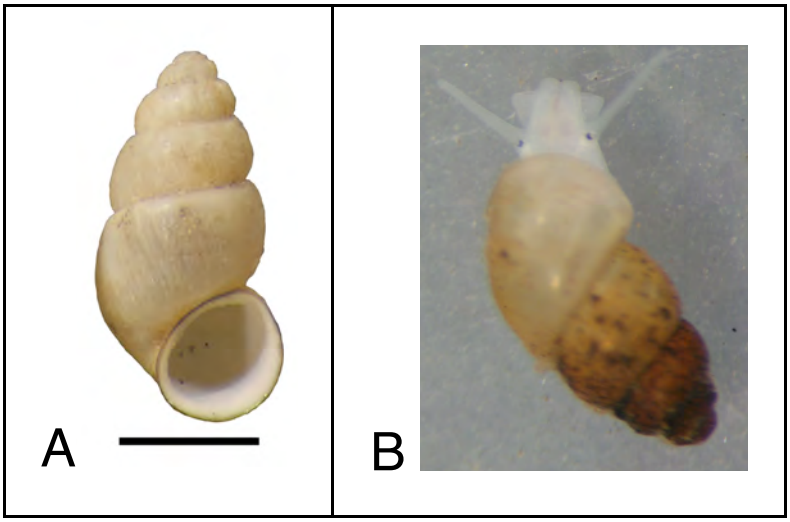

FIGURE 11. *Pristinicola hemphilli*. A. Shell from Rock Creek, Cedar River tributary, King County. **B.** Live snail from spring in City of Renton Springbrook Watershed, King County. Measurement line= 1 mm.

Pristinicola shows no close resemblances in morphology to any eastern North American forms. It is convergent in shell morphology on the European *Bithynella*; and perhaps even more strongly so on the pomatiopsinid tribe Erhaiini, which has a similar ecology (for most recent review, see Davis & Kang, 1995; see also Davis *et al*., 1992 & 1985). Often the land snail *Carychium occidentale* has been mistaken for *Pristinicola* (records in PBBS (2013) confirmed by Deixis; Burke, 2013). This land snail can often be found fallen into springs. It has similar shell shape, but has unlike *Pristinicola*, aperatural dentition or laemellae, no operculum and somewhat smaller shell. At present (Hershler *et al*., 1994), *Pristinicola* is classified as a lithoglyphinid hydrobiid; but this placement is dubious (Hershler, pers. comm. to T. Frest, 1998) though not revised by Hershler (1999), and possible relationship with the

aberrant pomatiopsid Erhaiini is suggested here, but needs confirmation. Note that such relationship would strengthen the importance of the Asian element in the western North American malacofauna, especially if such Japanese supposed hydrobiids as *Akiyoshia* prove to have pomatiopsinid relationships.

Within its range, the distribution of *Pristinicola* can be somewhat peculiarly sporadic in that it is frequently found just in a single spring in a nasmode (spring family) or in just one nasmode (often headwater) in a seemingly suitable spring-rich drainage. Primary fear for these animals is often modification or diversion of springs for various agricultural, industrial, and domestic needs. This is particularly apparent in rapidly expanding urban areas such as Seattle, King County and Olympia, Thurston County. In many such areas, large springs have become part of various cities' water supply (*e.g.*, in King County Springbrook Spring (City of Renton), Rock Creek, Cedar River tributary (City of Kent); and in Thurston County McCallister and Allison Springs (City of Olympia)). This often results in modifications to the source that extirpate the springsnails.

Springs and spring habitats have been increasingly impacted locally, to the point that most surviving springs in Puget Sound region show some human impacts. A complete census of the condition or biota of springs in Puget Sound region has never been undertaken. Information regarding the distribution and status of populations is limited. Additional surveys are needed to clarify the location and extent of populations and to identify conservation priorities for this species.

The pristine pyrg *Pristinicola hemphilli* has a State of Washington ranking of S2 (Imperiled (6 to 20 occurrences), very vulnerable to extirpation) or S3 (Rare or uncommon (21 to 100 occurrences) (WNHP, 2013). It is currently not listed as a State Species of Concern in Washington nor was it a candidate for Federal listing under the U. S. Endangered Species Act prior to a rule change in 1996 that dropped candidate species (USFWS, 1996). The pristine pyrg also has a global ranking of G3 (either very rare and local throughout its range or found locally in a restricted range (21 to 100 occurrences)). It is considered a Species of Concern (by states of Washington, Oregon, California and Idaho) because of its preference to inhabit springs and seeps that are very readily subject to modification and destruction from a variety of causes (Frest & Johannes, 1995, 2001b). Should be listed as Threatened by the federal and state governments.

This species was found at 1 spring site (49) during the 2010 survey but was not surveyed in 2013. Two other confirmed *Pristinicola* sites are known to occur in Thurston County (Deixis coll.). One of these 2 sites also has *Colligyrus* n. sp. 9 present, the only known Washington site where both species co-occur. All three Thurston County *Pristinicola* sites are in glaciated areas. Strangely, despite the fact that the nearby Capitol State Forest (Black Hills) was not glaciated (Bretz, 1913) and where the most *Colligyrus* n. sp. 9 sites are found, *Pristinicola* was not encountered in any of the numerous seeps and springs in that area.

Family Lithoglyphidae

***Fluminicola* n. sp. (no common name)**

About 7 undescribed taxa known over the state; range from common to highly restricted; see Frest & Johannes (1995, 2004, unpub.) and Hershler *et al.* (2007) for details. One taxon in this group was reported from Okanogan River by Frest & Johannes (1995); see also Neitzel & Frest (1993). *Fluminicola* is likely to be a large and complex genus when revision is completed (Hershler & Frest, 1996). The genus as now defined is likely not monophyletic and probably will roughly divided between large (largely stream dwellers) and small (<5 mm height; mostly spring dwellers) forms (Frest & Johanne, 1999a, 2000). Many are spring snails, but Washington undescribed *Fluminicola* are large and mostly amniphiles (Frest *et. al*., 2008). For DNA phylogeny see Hershler *et al.* (2007).

Fluminicola virens (Lea, 1838) (Olympia pebblesnail) does not occur in the Olympia area despite the common name. The common name is mysterious in origin, as the type locality is in Oregon and there is no reason to think Olympia, Washington *Fluminicola* are conspecific.

It has not been determined if more than one species of *Fluminicola* has been found during this survey and at present they are placed under one name.

Fluminicola has been reported previously from the Deschutes River (UMMZ 199466, Deschutes River, 11.0 mi. SE of Olympia, collected by B. E. Percival on 11/May/1958). *Fluminicola* was not found in Capitol Lake (Johannes, 2010b), but during 2010 and this survey it was found to occur at sites in McLane Creek (8), Deschutes River (54, 55 & 80) and uncommonly at Woodward Creek (75) (see **Figure 1** & **Appendix A**). It co-occurs with *Juga* in all three streams.

All *Fluminicola* spp. should be minimally considered Species of Concern by appropriate State of Washington and federal wildlife and land management agencies.

Family Semisulcospiridae

***Juga (Juga) silicula* (Gould, 1847) (glass juga)**

Of the three currently recognized extant subgenera, *Juga* (*Juga*) has the widest distribution. It ranges on the Pacific Coast from the extreme northern half of coastal Olympic Peninsula south and elsewhere from the southern terminus of Wisconsinan glaciation (approximately the Nisqually drainage, Puget Sound, Washington) to the Klamath and Smith rivers, Coast Range, California. Interior from the coast range, *Juga* occur from the American River drainage north in the Sierra Nevada to the Oregon border and north in the Cascades, mostly on the west side, to the Nisqually drainage, Washington. North of the Nisqually drainage there is recent find of a disjunct occurrence in a Green River tributary (Big Soos Creek drainage), King County. Both *Juga* (*J.*) *silicula silicula* and *Juga* (*J.*) n.

sp. occur there (Campbell *et al*., in press). Along the Columbia River and east side of the Cascade Range, Washington, *Juga* extend possibly as far as the Yakima River drainage (Henderson, 1929). It appears to be absent from both the mainstem Columbia and its tributaries to the north and east in Washington and British Columbia (despite doubtful reports in Clarke, 1981). The subgenus also appears to be absent from Idaho; Montana; Utah; and Wyoming, despite early reports such as Bland & Cooper (1861) and Ingersoll (1875). *Juga* (*Juga*) are largely absent from interior Oregon and interior Washington. Most *Juga* (*Juga*) species are amniphiles; but several are crenophile specialists. *Juga* is present in the northern and possibly central Sierra Nevada; but further study is required to place occurrences farther south than the American River.

Juga (*J.*) *silicula silicula* should be considered a Species of Special Concern because of its limited range in streams in Thurston, Pierce, and King counties which are very readily subject to modification and destruction from ongoing rapid urban growth. Information regarding the distribution and status of populations is limited. Recent DNA work on *Juga* in the Puget Sound region showed that a population sequence from Little Soos Creek matched topotypic *Juga* (*J.*) *silicula silicula* but the shells are conchologically similar to *J. (J.)* n. sp. from Jenkins Creek (both steams part of the Big Soos Creek system, Green River tributary) (Cambell, *et al.*, in press). *Juga* in Ravena Creek (also Big Soos Creek tributary) matched *silicula* DNA sequence and shell morphology (Campbell, *et al*., in press). The drainages in this region have undergone significant rearrangements as recently as within the past 6000-12000 years (Bretz, 1913; Dragovich *et al*., 1994) due to glacial outwash channels, sea level change, and eruptions of Mt. Rainier. Recent searches of the intervening creeks and rivers has not revealed the presence of *Juga*, but past drainage rearrangements could have allowed *J. silicula silicula* from the south end of Puget Sound to invade the range of a relict population represented by *J.* (*J.*) n. sp. (Campbell, *et al*., in press). Mitochondrial introgression is a possibility, but it will need further investigation.

FIGURE 12. *Juga* (*Juga*) *silicula* from McAllister Creek, Thurston County, Washington.
Measurement line= 2 mm.

This recent find shows that additional surveys to collect DNA and anatomical samples are needed to clarify the location and extent of populations of *silicula* and to identify conservation priorities for this and other *Juga* species.

This species prefers streams and rivers with relatively good water quality, though found very rarely in lakes (site 8). Not found in rivers with glaciers as sources containing glacial flour (*e.g.*, Nisqually and Green rivers), but can be found in their tributaries. Also not found in drainages impacted by recent (geologically speaking) mudflows (White, Puyallup and Carbon rivers).

For detailed anatomical description and illustrations see Strong & Frest (2007). Elongate *Juga* (*Juga*) with prominent plications on the uppermost couple of whorls (immediately past the nepionic) only; rather tall spire; very strongly convex-whorled; rather finely but strongly and evenly lirate (see **Figure 6**) and with at least one weak tan stripe on a yellow-tan background. Operculum ovate, corneous, dark reddish brown in color, with 3.5 whorls; paucispiral with eccentric nucleus of approximately 3 whorls. Head-foot dark gray to black in color, with lighter gray snout tip and pale foot sole.

The glassy juga has not been ranked by the State of Washington (WNHP, 2013) and is currently not listed as a State Species of Concern in Washington nor was it a candidate for federal listing under the U. S. Endangered Species Act prior to a rule change in 1996 that dropped candidate species (U. S. Fish and Wildlife Service 1996). It has a global rank of G3 (either very rare and local throughout its range or found locally in a restricted range (21 to 100 occurrences)).

Allen Pleus (WDFW) collected this species in Capitol Lake (Johannes, 2010b). *Juga* were also found in Percival Creek (Johannes, 2010a, b). *Juga* were reported from Black Lake (UMMZ 134051, collector and date unknown). Not found in the lake during this survey, but found in the outlet (Black Lake drainage ditch). It is possible the Moxlie Creek *Juga* (site 85) represents a new species, but until this is confirmed by anatomical and DNA analysis, this population is tentatively placed under *silicula*.

Of all the mollusks collected, this species was found at the most sites (29). Found at sites in McLane (8), Swift (9), Fish Pond (15 & 20), Percival (23, 24 & 48), Green Cove (27, 28 & 34), Indian (47), Ellis (53), Woodland (65 & 66), Woodward (71 & 75) and Moxlie (85) creeks; unnamed creeks flowing to Little Tykle (30) and Butler (31 & 32) coves; Pattison Lake outlet (84); tributaries of Perry Creek (1) and Black Lake (19); Deschutes River (54 & 80). *Juga* was found at 3 sites where it was not found during the 2010 survey (20, 27 & 34).

Occurrence of *Juga* in Hewitt Lake (79) may be result of the snails being transported with trout that were planted in the lake in 2010 and 2013. Only recent dead specimens were found during the 2 survey years. According to a local resident the trout are dumped less than a 100' from site 79. Hewitt Lake is a classic kettle lake with no outlet or drainages into the lake. It is not a typical habitat for *Juga*.

Potentially the NZMS could also be transported this way as well. **Appendix G** shows how numerous trout plantings are in lakes in the vicinity of Capitol Lake for a portion of 2013 conducted by the WDFW.

Family Lymnaeidae

***Fossaria (Fossaria) modicella* Say, 1825 (rock fossaria)**

This taxon seems to prefer cool but not very cold temperatures; it is common over the northern U. S. and found through Idaho generally. More of a lithophile than most other *Fossaria* species; often found in shallow to very shallow situations, such as smaller drainages, stream edges; and pond and lake edges. Though found in quite shallow situations, it is not normally emergent, like *F. parva*.

This species was found at only site 16.

Family Physidae

***Physella (Physella) gyrina* (Say, 1821) (tadpole physa)**

Physids are among the common snails in the Western U. S., as they are in the East as well. Taxonomy is badly in need of revision; and here Taylor (1981, 2003) and Burch (1989) are followed, both recognizing a small number of taxa in the West. Forms of *gyrina* are widespread in a variety of habitats in Western North America. Many literature reports are more likely ascribable to *Physella (Physella) propinqua*. This taxon seems to prefer small stream, pond, and lake habitats locally.

Found at sites 13, 14, 16, 17, 18, 22, 33, 37, 40, 41, 42, 43, 45, 50, 54, 57, 60, 63, 67, 72, 79, 81, 82, 83, and 84 during 2010 and this survey.

Family Planorbidae

***Gyraulus* (*Torquis*) *parvus* (Say, 1817) (ash gyro)**

One of the most common small freshwater taxa over most of North America; equally common over the State; often abundant when found. An epiphyte feeder, equally at home in warm to cold-water. This small snail usually occurs in areas with mud substrates, with or without emergent or aquatic vegetation, and can tolerate seasonal habitats as well as permanent. This seems to be one of the better examples of a eurythermic taxon. It is most often found in low to nil velocity situations, such as lakes, ponds, quieter stream portions, fens, marshes, and springs.

Found during 2010 and this survey at sites 16, 18, 40, 41, 45, 67, 79, 81, and 83.

***Menetus (Menetus) callioglyptus* Vanatta, 1894 (button sprite)**

Note that most sources regard this taxon as *Menetus opercularis* (Gould, 1847); but Taylor (1981) argues that that name applies mostly to snails from Mountain Lake, California that are now extinct. This is a widespread taxon in western Washington, northern Oregon, and northwestern California in a variety of habitats. It is usually uncommon in larger streams. Abundant in western and northern Washington and sporadic in southeast; usually termed *opercularis* but true *opercularis* rare in Washington. This taxon is found in a variety of habitats, mostly in shallow water, and including springs and lakes a well as streams. Substrate preference is similarly broad.

Found at sites and 2, 6, 16, 34, 42, 46, 49, 77 and 83 during 2010 and this survey.

***Planorbella (Pierosoma) subcrenatum* (Carpenter, 1857) (no common name)**

This is a very widespread western form occupying a position similar in ubiquity to that of the eastern form *P. trivolvis*. It lives in much of the U. S. from the Rocky Mountains to the Pacific Coast and in the western half of Canada. This taxon can tolerate a wide temperature range but is replaced by other forms in southern California and some of the Southwest. Found especially on aquatic macrophytes in areas with muddy substrates; most frequently in rather shallow water and in lower velocity settings, such as ponds, lakes, marshes, cut-offs, ditches, and sloughs (all permanent settings).

During 2010 and this survey found at sites 13, 14, 16, 17, 18, 33, 40, 43, 63, 79, 81, 82, 83, and 84.

Family Ancylidae

***Ferrissia californica* (Rowell, 1863) (fragile ancylid)**

Taylor (1981) believes that this name precedes *Ferrissia fragilis* for the common North American river limpet. This taxon is uncommon in the West and seems to prefer low-elevation, rather warm and eutrophic habitats, often with low flow (especially in lotic settings) or is found in similar lentic habitats, such as ponds and lakes. Note that another form often confused with this, *Ferrissia rivularis* (Say 1817) (creeping ancylid), is more often found in flowing habitats. For mainstream Columbia habitats the species term *fragilis* or *californica* are preferable of *rivularis*. This form may be present also in the Okanogan and Methow in rocky, swift-flow areas in some abundance. Found over the state but distribution sporadic.

Found at sites 55 and 83 during 2010 survey. Not found at site 55 during 2013.

Family Succineidae

***Oxyloma* sp. (no common name)**

A semiaquatic landsnail that can be found on emergent aquatic plants or even some distance from shore on water lily pads. Genus found throughout the U. S.

At sites 17, 81, 82, 83 where it was found crawling on water lily pads.

Family Unionidae

***Anodonta oregonensis* (Lea, 1838) (Oregon floater)**

The mussel termed the Oregon floater was first described from the lower Columbia River but appears currently uncommon to rare in it. Formerly rather widespread, it is found over much of Washington and Oregon, although seldom in large numbers. Along the Cascade axis, it seems to be replaced by *Anodonta kennerlyi*, and is more often found in streams than that largely lentic taxon. Not found in any of the sites outside of Capitol Lake. Only dead shells or fragments were found in Capitol Lake by WDFW samples in 2009 (Johannes, 2010b). However, Bert Bartleson found a live *Anodonta* (most likely *oregonensis*) in Capitol Lake (Bartleson, 2010).

Juvenile found at site 16 (Black Lake) during 2013.

****Margaritifera falcata* (Gould, 1850) (western pearlshell)**

Now sporadic over state; formerly ubiquitous west and common east. Many populations show little evidence of reproduction. This mussel generally uses salmon and trout as glochidial host species. As a result, now somewhat restricted, especially in interior Washington. Reported formerly from the Methow and Okanogan; but not recently found live in typical Okanogan habitats. Seldom seen in the mainstem Columbia currently. Much reduced in the Puget Sound region. Not found in many streams it was reported from historically (*e.g.*, ANSP 139180, Ravenna Creek [Lake Washington tributary, Seattle] collected by W. Eyerdam, 1925).

This taxon prefers fast water, cold and clean, and gravel, cobble, or boulder habitat and is seldom seen in lakes. May occur in streams of almost all sizes except the smallest. This taxon is usually seen as *Margaritifera falcata*; but Smith (2001) cites cogent reasons for separating *falcata* from other U. S. margaritiferids. However, will be kept under the genus *Margaritifera* here.

This species was collected from the Deschutes River (ANSP 26777, Deschutes R., 12 mi. SE of Olympia, collected by B. [E.] Percival on Aug/1958; UMMZ 198326, ibid.). Was not found at any of the sites collected from the Deschutes River during this survey.

Family Sphaeriidae

***Sphaerium patella* (Gould, 1850) (Rocky Mountain fingernailclam)**

Despite the common name, this sphaeriid is much more characteristic of the Cascade Range and Coast Range, where it occurs from extreme southern British Columbia to northern California. It is a cold-water species, often found in larger streams and bodies of water and quite abundant when found. Substrate rather variable; sometimes in areas with no macrophytes.

Found at site 21.

***Musculium raymondi* (Cooper, 1890) (western lake fingernailclam)**

Most often seen in the literature as *Musculium lacustre* (Müller 1774) (lake fingernailclam); Taylor (1981) argues that the western form is distinct. As this common name would suggest, this taxon is most often found in lentic habitats, or at least in low flow situations. *Lacustre* is a frequently seen taxon in eastern and central North America in warm-water, soft-sediment situations but *raymondi* is rather uncommon in the West (Frest & Johannes, 2001a). Here, it is often a lake form and occasionally an impoundment or reservoir (or similar habitat) form.

Occurs at sites 33, 45, 46, 67, 74, 81, 83, and 84.

***Musculium securis* (Prime, 1851) (pond fingernailclam)**

A filter feeder found in cool to warm water. Found over much of the U. S. (not as common in the west) and across southern Canada. Found to be abundant in permanent and impermanent waters, in variety of habitats.

Found at site 40.

***Pisidium* (*Cyclocalyx*) *casertanum* (Poli, 1791) (ubiquitous peaclam)**

As the common name implies, this is a very frequently encountered sphaeriid species, perhaps the most widespread native mollusk in the northern hemisphere. It is rapidly spreading currently south of the Equator a well. Very frequent in a wide variety of habitats in the West. For examples, see Frest & Johannes (2001a).

Found at sites 58 and 59.

***Pisidium* (*Cyclocalyx*) *variabile* Prime, 1852 (triangular peaclam)**

Found over much of the U. S. and Canada. Mostly a filter feeder that is equally at home in cold or warm water and noted from a variety of habitats.

Occurred at sites 40, 50 and 63.

***Pisidium* (*Neopisidium*) *insigne* Gabb, 1868 (tiny peaclam)**

Distribution sporadic over parts of southwestern and northeastern Canada and the western U. S. (mostly the northern states and down the Rocky Mountain chain to New Mexico); over the state in Idaho. A cold-water stenotherm, common mostly in permanent cold springs and cold seeps with slow flow. In some cold seeps and small spring runs may be the only sphaeriid present. Rather uncommon in Washington and scattered; Washington sites mostly south of the glacial margin.

Found at site 49 in 2010 and site 6 in 2013. Both are spring habitats.

CONCLUSIONS

The primary objective of this study was to survey as many of the mapped water bodies within a 5-mile radius of Capitol Lake as possible to determine if there is any additional NZMS introductions. The survey covered the most likely areas the NZMS could be introduced, such as parks, public boat ramps, and areas with public fishing accesses. In addition, several private lakes and marshes were also surveyed. The New Zealand mudsnail has been found at site 55 in the Deschutes River at Tumwater Historical Park. As this is just upstream of Capitol Lake this occurrence is not unexpected.

Though the primary objective was to survey for NZMS, the secondary result of the project was a detailed survey of the mollusk fauna within a 5-mile radius around Capitol Lake. The find of the rare *Aminicola* n. sp. 1 and *Valvata* n. sp. 2 in Pattison Lake within a relatively small area surveyed, indicates that our knowledge of freshwater mollusks of Washington State is still mostly incomplete and that detailed surveys are necessary to determine species occurrence and distribution, especially for rare species.

RECOMMENDATIONS

Surveys for NZMS should be done at least every two years or at most once a year and the number of sites and the area of coverage should be increased to include the lakes to the west, east

and south of Capitol Lake. A Statewide survey for NZMS should also be considered, which the recent finds of NZMS in the Lake Washington basin only emphasizes the need for such a survey.

Aminicola n. sp. 1, *Valvata* n. sp. 2*, Juga silicula*, *Colligyrus* n. sp. 9, and *Fluminicola* spp. should be considered Species of Special Concern by the State of Washington. Any management plans or development in or around Pattison Lake should not be undertaken without considering the impact to *Aminicola* n. sp. 1 and *Valvata* n. sp. 2. Before any application of herbicides or rotenone, surveys of Washington lakes should be conducted to determine if either of these species or other rare species are present.

ACKNOWLEDGEMENTS

I would like to thank the following land owners for generously allowing access on or through their properties: John Henkle, Deborah Reback-Cashman, Dennis Ellison, Jaclyn K. Reid, Lori Warren, Christopher Woodsum, John Gray, Sarah and Rick Knight, Ben Cushman, Vic and Liz Kaufman and Eric and Ruby Erickson. I would also like to thank Bill Buckles (Vice-President, Lakeside Estates at Tumwater Homeowners Association), Carol Gruen (Treasurer, Lakemoor Community Club), Streater Johnson (President, Holiday Hills Home Owners Association) and Kevin Humphries (Manager, Alderbrook Estate) for all generously giving their time to allow access. In addition I would liker to thank John Edwards (Public Works Department, City of Olympia) for granting access to Allison Springs. Thanks to Bert Bartleson (Olympia) for accompanying me into the field, and for introducing me to some of the landowners. Kevin Aitkin (USFWS) gave valuable suggestions on the draft report. I would like to especially thank Wendy Brown (WISC) for once again making sure the contract went smoothly.

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APPENDIX A: SITE DESCRIPTIONS.

UTM coordinates (based on NAD27 all in Zone 10) and elevation are derived from National Geographic TOPO!® ©2006. Geographic names, road names and numbers were confirmed using DeLorme Mapping's Washington Atlas and Gazetteer; USGS 7.5' series topographic maps; and from National Geographic TOPO!® ©2006. Site descriptions are a partial dump from Deixis MolluscDB™. For maps of the sites see **Appendix B** (map page number in brackets at the end of each site entry).

Site entry format:

Project site number; Deixis locality number [in brackets]; locality name; coordinates (UTM: legal); quadrangle (name and year); county; state; drainage; mountain range; valley; geographic description; elevation; depth; locality remarks; habitat description; collector remarks; date collected, and collectors.

Collector abbreviations as follows:

BB= Charles A. "Bert" Bartleson
EJ= Edward J. Johannes
TF= Terrence J. Frest

1. [6595] Unnamed Perry Creek tributary at SW 2nd Avenue crossing. Zone 10: 498,925E 5,210,066N. NE1/4 NW1/4 NE1/4 SE1/4 sec. 14, T18N R3W, Summit Lake 1981 quad., Thurston Co., Washington. Unnamed Cr.-Perry Cr., Black Hills. Unnamed S. Perry Creek tributary on S. side of SW 2nd Ave crossing, just W. of junction with Simpson Court. Elev. 98'. Depth 1-3". Small creek with mud-boulder substrate; no macrophytes. Very rare *Juga* hand collected. 8/9/2010 EJ! Depth 1-5". Habitat as before. *Juga* hand collected for DNA sample. 6/6/2013 EJ! [B8]

2. [6596] Allison Springs 3rd pool from north. Zone 10: 501,238E 5,209,816N. SW1/4 SE1/4 SW1/4 NE1/4 SW1/4 sec. 18, T18N R2W, Tumwater 1994 quad., Thurston Co., Washington. Allison Springs. Allison Springs 3rd spring pool from the north, S. side of Allison Springs Lane SW, E. of Mud Bay, City of Olympia Public Works Department. Elev. 31'. Depth 1-2'. Large dug out spring-fed pool with silt-cobble substrate; rare *Elodea* and *Rorippa* patches. Pool dammed by dirt berm. Spring heavily modified for use as a water supply source for City of Olympia. No longer used for that purpose. *Menetus* and sphaeriids only. No springsnails found. Dip net collected from substrate and macrophytes. Also collected off cobbles and wood. 8/9/2010 EJ! Depth 3-17". Habitat as before. Dip net collected from substrate and macrophytes. *Menetus* and sphaeriids not retained. 6/6/2013 EJ! [B8]

3. [6597] Allison Springs 2nd pool from north. Zone 10: 501,235E 5,209,843N. NW1/4 SE1/4 SW1/4 NE1/4 SW1/4 sec. 18, T18N R2W, Tumwater 1994 quad., Thurston Co., Washington. Allison Springs. Allison Springs 2nd spring pool from the north, N. side of Allison Springs Lane SW, E. of Mud Bay, City of Olympia Public Works Department. Elev. 35'. Depth 2-3'. Large dug out spring-fed pool with mud substrate; pool entirely covered by *Lemna minor*; edges with *Typha*. Pool dammed by dirt berm. Spring heavily modified for use as a water supply source for City of Olympia. No longer used for that purpose. Dip net collection attempted. No mollusks found. 8/9/2010 EJ! Depth 2-3'. Habitat modified. Pool no longer exists. Dip net collected stream where pool was. No mollusks found. 6/6/2013 EJ! [B8]

4. [6598] Allison Springs 1st pool from north. Zone 10: 501,214E 5,209,874N. NW1/4 SE1/4 SW1/4 NE1/4 SW1/4 sec. 18, T18N R2W, Tumwater 1994 quad., Thurston Co., Washington. Allison Springs. Allison Springs 1st spring pool from the north, N. side of Allison Springs Lane SW, E. of Mud Bay, City of Olympia Public Works Department. Elev. 22'. Depth 2-3'. Large dug out spring-fed pool with silt-cobble substrate; completely covered by *Lemna minor* on the surface. Pool dammed by dirt berm. Spring heavily modified for use as a water supply source for City of Olympia. No longer used for that purpose. Dip net collection attempted. No mollusks. 8/9/2010 EJ! Depth 2-3'. Habitat as before except no *Lemna minor*. Dip net collection attempted. No mollusks. 6/6/2013 EJ! [B8]

5. [6599] Allison Springs run of 1st and 2nd pools from north. Zone 10: 501,193E 5,209,874N. SE1/4 NW1/4 SW1/4 NE1/4 SW1/4 sec. 18, T18N R2W, Tumwater 1994 quad., Thurston Co., Washington. Allison Springs. Run of Allison Springs 1st and 2nd pools from the north, N. side of Allison Springs Lane SW, E. of Mud Bay, City of Olympia Public Works Department. Elev. 19'. Depth 2-4". Fairly large spring run with mud-cobble substrate; *Scirpus*. Springs heavily modified for use as a water supply source for City of Olympia. No longer used for that purpose. Examined cobbles and sticks; dip net substrate. No mollusks found. 8/9/2010 EJ! Depth 2-4". Habitat as before. Examined cobbles and sticks; dip net substrate. No mollusks found. 6/6/2013 EJ! [B8]

6. [6600] Allison Springs N.-most spring. Zone 10: 501,253E 5,209,914N. NE1/4 NE1/4 SW1/4 NE1/4 SW1/4 sec. 18, T18N R2W, Tumwater 1994 quad., Thurston Co., Washington. Allison Springs. Allison Springs north most spring, N. side of Allison Springs Lane SW, E. of Mud Bay, City of Olympia Public Works Department. Elev. 19'. Depth 0-2". Spring with mud-cobble substrate; no macrophytes. Spring source dug out. Springs heavily modified for use as a water supply source for City of Olympia. No longer used for that purpose. Examined rocks and wood. Dip net substrate. No mollusks present.

8/9/2010 EJ! Depth 0-2”. Habitat as before. Examined rocks and wood. *Colligyrus, Mentus* and sphaeriids collected by dip net or in a benthic sample. 6/6/2013 EJ! [B8]

7. [6601] Allison Springs run of 3rd pool from the north. Zone 10: 501,214E 5,209,812N. SE1/4 SW1/4 SW1/4 NE1/4 SW1/4 sec. 18, T18N R2W, Tumwater 1994 quad., Thurston Co., Washington. Allison Springs. Allison Springs north most spring, N. side of Allison Springs Lane SW, E. of Mud Bay, City of Olympia Public Works Department. Elev. 27'. Depth 2-5". Large spring run with silt-cobble substrate. Impacted by salt water incursion (marine algae present). Springs heavily modified for use as a water supply source for City of Olympia. No longer used for that purpose. Run is going through the 4th from N. pool shown on USGS 7.5' map. Dam removed and 4th pool is drained. Cobbles and wood examined. No mollusks. 8/9/2010 EJ! Depth 2-6”. Habitat as before. Dip net sampled. No mollusks. 6/6/2013 EJ! [B8]

8. [6602] McLane Creek south of Delphi Road SW bridge. Zone 10: 500,813E 5,208,454N. NE1/4 SW1/4 NW1/4 NW1/4 SW1/4 sec. 19, T18N R2W, Tumwater 1994 quad., Thurston Co., Washington. McLane Cr. McLane Creek on S. side of Delphi Road SW bridge, near junction with Mckenzie Road SW. Elev. 21'. Depth 1-14". Medium-sized creek with mud-cobble substrate; no macrophytes. *Juga* and *Flumincola* dip net collected. 8/9/2010 EJ! Depth 1-16”. Habitat as before. *Juga* and *Fluminicola* dip net collected for DNA sample. 6/6/2013 EJ! [B8]

9. [6603] Swift Creek on both sides of Cedar Flats Road SW. Zone 10: 498,681E 5,208,053N. SE1/4 NE1/4 NE1/4 SW1/4 SE1/4 sec. 23, T18N R3W, Summit Lake 1981 quad., Thurston Co., Washington. Swift Cr.-McLane Cr. McLane Creek on both sides of Cedar Flats Road SW bridge, near junction with Mckenzie Road SW. Elev. 203'. Depth 0-2". Medium-sized creek with sand to mostly cobble substrate; no macrophytes. Very rare *Juga* hand collected. 8/9/2010 EJ! Depth 3-15”. Habitat as before. *Juga* moderately common hand collected for DNA sample. 6/6/2013 EJ! [B8]

10. [6604] Unnamed Swift Creek tributary at Canning Court SW. Zone 10: 498,946E 5,208,996N. NE1/4 NE1/4 NW1/4 SE1/4 NE1/4 sec. 23, T18N R3W, Summit Lake 1981 quad., Thurston Co., Washington. Unnamed Cr.-Swift Cr.-McLane Cr. Unnamed tributary creek of Swift Creek at Canning Court SW crossing. Elev. 222'. Depth 0-2". Small creek with mud substrate; no macrophytes. Shown as a marsh on USGS 7.5' map. Channel has been dug which has drained the marsh. No mollusks. 8/9/2010 EJ! Depth 0-2”. Habitat as before. Dip net collection. No mollusks. 6/6/2013 EJ! [B8]

11. [3248] Swift Creek head spring. Zone 10: 497,110E 5,208,720N. SE1/4 SE1/4 NE1/4 SW1/4 NE1/4 sec. 22, T18N R3W, Summit Lake 1981 quad., Thurston Co., Washington. Swift Cr.-McLane Cr., Black Hills. Head spring of Swift Creek on S. side of power transmission lines right of way, 0.15 mi. N. on unnamed road off Cedar Flats Road, NW of Cedar Flats. Elev. 326'. Depth 4-8". Spring in bed of creek with sand and gravel; no macrophytes; but scattered bryophyte patches. No mollusks. 12/18/1997 TF, EJ! No mollusks. 8/9/2010 EJ! Depth 2-9”. No mollusks. 6/6/2013 EJ! [B8]

12. [6605] Swift Creek northwest of Cedar Flats. Zone 10: 497,240E 5,208,714N. Summit Lake 1981 quad., Thurston Co., Washington. Unnamed Cr.-Swift Cr.-McLane Cr. Unnamed tributary creek of Swift Creek at unnamed road crossing off Cedar Flats Road, S. side of power transmission lines right of way, NW of Cedar Flats. Elev. 319'. Depth 0-2". Small creek with mud-cobble substrate; no macrophytes. No mollusks. 8/9/2010 EJ! Depth 0-2”. Habitat as before. No mollusks. 6/6/2013 EJ! [B8]

13. [6606] East side of Black Lake on south side of public boat ramp. Zone 10: 501,996E 5,203,059N. Maytown 1973 quad., Thurston Co., Washington. Black Lk.-Black R.-Chehalis R. E. side of Black Lake on the S. side of Washington Department of Fish & Wildlife public boat ramp. Elev. 139'. Depth 5'. Large lake with mud bottom; thick bed of water lily and *Scirpus*. *Planorbella*, *Physella* and

sphaeriids dip net collected. 8/9/2010 EJ! Depth 4-5'. Habitat as before. *Planorbella*, *Physella* and sphaeriids dip net collected (not retained). 6/10/2013 EJ! [B7]

14. [6607] East side of Black Lake on north side of public boat ramp. Zone 10: 502,002E 5,203,090N. Maytown 1973 quad., Thurston Co., Washington. Black Lk.-Black R.-Chehalis R. E. side of Black Lake on N. side of Washington Department of Fish & Wildlife public boat ramp. Elev. 139'. Depth 3'. Large lake with mud bottom; water lily and *Scirpus*. *Physella* and *Planorbella* dip net collected. 8/9/2010 EJ! Depth 3-4'. Habitat as before. *Physella* and *Planorbella* dip net collected (not retained) 6/10/2013 EJ!
[B7]

15. [6608] Fish Pond Creek at Fairview Road SW. Zone 10: 502,292E 5,203,546N. Maytown 1973 quad., Thurston Co., Washington. Fish Pond Cr.-Black Lk.-Black R.-Chehalis R. Fish Pond Creek on E. side of Fairview Road SW bridge, Kennydell County Park. Elev. 153'. Depth 0-3". Small creek with silt-cobble substrate; *Cicuta*, grasses along banks. Unnamed on USGS 7.5' map. Abundant *Juga* hand collected off cobbles & dip net collected off overhanging vegetation. Very good water quality (spring influenced). 8/9/2010 EJ! Depth 0-4". Habitat as before. *Abundant Juga* dip net and hand collected off cobbles for DNA sample. 6/10/2013 EJ! [B7]

16. [6609] West side of Black Lake at 7020 Lakeside Street SW. Zone 10: 501,213E 5,203,150N. Maytown 1973 quad., Thurston Co., Washington. Black Lk.-Black R.-Chehalis R. W. side of Black Lake at dock of house at 7020 Lakeside St. SW. Elev. 139'. Depth 4-5'. Large lake with mud-silt bottom; *Elodea* abundant. *Planorbella*, *Physella* and shell fragments and 1 live juvenile *Corbicula* dip net collected. 8/11/2010 EJ! Depth 4-5'. Habitat as before. *Physella*, *Planorbella,* dead sphaeriids and shell fragments of *Corbicula* dip net collected (not retained). 1 juvenile *Anodonta* collected by dip net retained. 6/10/2013 EJ! [B7]

17. [6610] Black Lake Drainage Ditch at Black Lake Belmore Road SW. Zone 10: 502,768E 5,206,069N. Tumwater 1994 quad., Thurston Co., Washington. Black Lk. Drainage Ditch-Percival Cr.-Deschutes R. (Capitol Lk.). Black Lake Drainage Ditch on N. side of Black Lake Belmore Road SW bridge. Elev. 131'. Depth 5-20". Man-made creek with silt-cobble substrate; *Potamogeton*, abundant *Elodea* and water lily patches; very rare *Oenanthe*; green freshwater sponges on cobbles. *Planorbella*, *Physella, Succinea*, and *Juga* dip net collected. 8/11/2010 EJ! Depth 6-28". Habitat as before. Dead adult complete valves of *Corbicula*, *Physella* and *Juga* dip net collected. 6/10/2013 EJ! [B7]

18. [6611] Black Lake at Black Lake Drainage Ditch. Zone 10: 502,730E 5,206,037N. Tumwater 1994 quad., Thurston Co., Washington. Black Lk.-Black R.-Chehalis R. Black Lake Drainage Ditch on N. side of Black Lake Belmore Road SW bridge. Elev. 139'. Depth 3'. Large lake with silt-rock bottom; patches of *Elodea* and water lily. *Physella* and *Planorbella* dip net collected. 8/11/2010 EJ! Depth 4'. Habitat as before. *Physella* and *Planorbella* dip net collected (not retained). 6/10/2013 EJ! Depth 4-5'. Habitat as before. Fragments of *Corbicula* shells, *Physella* and *Helisoma* dip net collected (not retained). 6/10/2013 EJ! [B7]

19. [6612] Unnamed creek SW of Belmore at Fairview Road SW. Zone 10: 502,302E 5,202,718N. Maytown 1973 quad., Thurston Co., Washington. Unnamed Cr.-Black Lk.-Black R.-Chehalis R. Unnamed creek on E. side of Fairview Road SW crossing, just 0.18 mi. N. of 77th Ave SW junction, SW of Belmore. Elev. 159'. Depth 3-7". Small creek with mostly cobble substrate; mud in patches. Moderately common *Juga* hand collected from cobbles and dip net collected from mud substrate. 8/11/2010 EJ! Depth 3-8". Habitat as before. *Juga* dip net and hand collected from cobbles for DNA sample. 6/10/2013 EJ! [B7]

20. [6613] Fish Pond Creek at Belmore Road SW. Zone 10: 503,378E 5,204,212N. Tumwater 1994 quad., Thurston Co., Washington. Fish Pond Cr.-Black Lk.-Black R.-Chehalis R. Fish Pond Creek on E. side of Belmore Road SW, N. of Belmore, Tumwater. Elev. 164'. Depth 7". Small creek with deep mud substrate; *Lemna minor*, *Lysichiton americanum* and *Oenanthe samentosa*. Unnamed on USGS 7.5' map. No mollusks. 8/11/2010 EJ! Depth 8". Habitat as before. *Juga* dip net collected. 6/10/2013 EJ! [B7]

21. [6614] Trosper Lake on northwest side. Zone 10: 505,215E 5,204,576N. Maytown 1973 quad., Thurston Co., Washington. Trosper Lk.-Percival Cr.-Deschutes R. (Capitol Lk.). NW side of Trosper Lake under powerlines at Lakeside Estates at Tumwater Homeowners Association dock, Tumwater. Elev. 158'. Depth 6'. Small kettle lake with mud substrate; dense *Typha latifolia* along shoreline, water lily, *Elodea* and *Potamogeton*. Sphaeriids only collected from dock with dip net. 8/11/2010 EJ! Depth 6'. Habitat as before. Sphaeriids only collected from dock with dip net (not retained). 6/10/2013 EJ! [B7]

22. [6615] West side of Barnes Lake. Zone 10: 306,277E 5,205,355N. Tumwater 1994 quad., Thurston Co., Washington. Trosper Lk.-Percival Cr.-Deschutes R. (Capitol Lk.). W. side of Barnes Lake off Lake Park Drive SW, Tumwater. Elev. 161'. Depth 2'. Small shallow kettle lake with mud underlain by peat; *Nymphaea* and *Brasenia* abundant in patches. *Physella gyrina* only dip net collected. 8/11/2010 EJ! Depth 2'. Habitat as before. No mollusk found. 6/10/2013. EJ! [B7]

23. [6616] Percival Creek at Sapp Road. Zone 10: 505,274E 5,206,196N. Tumwater 1994 quad., Thurston Co., Washington. Percival Cr.-Deschutes R. (Capitol Lk.). Percival Creek on N. side of Sapp Road, Tumwater. Elev. 145'. Depth 1-2'. Small creek with mud-sand substrate; no macrophytes. *Juga* dip net collected. Found only common along steam edge. 8/11/2010 EJ! Depth 1-2'. Habitat as before. *Juga* dip net for DNA sample. Sphaeriid also collected. 6/10/2013 EJ! [B7]

24. [6617] Percival Creek at N. of 54th Ave SW. Zone 10: 505,558E 5,205,017N. Tumwater 1994 quad., Thurston Co., Washington. Percival Cr.-Deschutes R. (Capitol Lk.). Percival Creek N. of 54th Ave SW (Trosper Road SW) in Alderbrook Estate Mobil Home Park, Tumwater. Elev. 163'. Depth 0-10". Small creek with mud-sand substrate; *Nasturtium officinale*. Abundant *Juga* dip net collected. Good water quality. 8/11/2010 EJ! Depth 1-2'. Habitat as before. *Juga* dip net for DNA sample. 6/10/2013 EJ! [B7]

25. [6618] Spring west of Belmore. Zone 10: 502,296E 5,203,533N. Maytown 1973 quad., Thurston Co., Washington. Fish Pond Cr.-Black Lk.-Black R.-Chehalis R. Spring on S. side of Fish Pond Creek on E. side of Fairview Road SW bridge, W. of Belmore, Kennydell County Park. Elev. 153'. Depth 0-3". Small spring with mud substrate; *Lysichitom americanum*. Not shown on USGS 7.5' map. No mollusks. 8/9/2010 EJ! Depth 0-1". Habitat as before. No mollusks. 6/10/2013 EJ! [B7]

26. [6619] Springs at Green Cove Street NW. Zone 10: 504,013E 5,214,755N. Tumwater 1994 quad., Thurston Co., Washington. Green Cove Cr. Springs on N. side of Green Cove Creek on W. side of Green Cove Street NW, W. of Little Tykle Cove. Elev. 115'. Depth 0-0.5". Small springs and seeps with mud-cobble substrate; *Lysichitom americanum*. Not shown on USGS 7.5' map. No mollusks. Looked at leaves and cobbles. 8/16/2010 EJ! Depth 0-0.5". Habitat as before. No mollusks. 6/8/2013 EJ! [B9]

27. [6620] Green Cove Creek at Green Cove Street NW. Zone 10: 504,002E 5,214,749N. Tumwater 1994 quad., Thurston Co., Washington. Green Cove Cr. Green Cove Creek on W. side of Green Cove Street NW, W. of Little Tykle Cove. Elev. 112'. Depth 0-2". Small creek with cobble substrate; no macrophytes. No mollusks. 8/16/2010 EJ! Depth 0-6". Habitat as before. Moderately common *Juga* dip net and hand collected. 6/8/2013 EJ! [B9]

28. [6621] Green Cove Creek at 36th Ave NW. Zone 10: 503,872E 5,214,212N. Tumwater 1994 quad., Thurston Co., Washington. Green Cove Cr. Green Cove Creek on N. side of 36th Ave NW (Adams Road), W. of Butler Cove. Elev. 119'. Depth 0-4". Small creek with silt-cobble substrate; no macrophytes. Seep on E. bank of creek (no mollusks). *Juga* moderately abundant. Hand and dip net collected. 8/16/2010 EJ! Depth 2-4". Habitat as before. Somewhat abundant *Juga* dip net and hand collected. 6/8/2013 EJ! [B9]

29. [6622] Marsh east of Snyder Cove. Zone 10: 503,005E 5,214,227N. Tumwater 1994 quad., Thurston Co., Washington. Unnamed Marsh. Unnamed kettle marsh on N. side of 36th Ave NW (Adams Road), 0.1 rd. mi. W. of Cedrona Drive NW junction, E. of Snyder Cove. Elev. 154'. Depth 0-2'. Shallow kettle marsh with dense stands of *Typha latifolia*. No mollusks. 8/16/2010 EJ! Depth 0-3'. Habitat as before. No mollusks. 6/8/2013 EJ! [B9]

30. [6623] Little Tykle Cove creek. Zone 10: 505,109E 5,214,973N. Tumwater 1994 quad., Thurston Co., Washington. Unnamed Cr. Unnamed creek which flows to Little Tykle Cove, ca. 0.3 rd. mi. off Cooper Point Road on driveway. Elev. 17'. Depth 0-2'. Small spring influenced creek with silt-cobble substrate; no macrophytes. Very uncommon *Juga* hand collected. Cobbles washed into tray. 8/21/2010 EJ! Not recollected. [B9]

31. [6624] Butler Cove west creek. Zone 10: 504,719E 5,213,631N. Tumwater 1994 quad., Thurston Co., Washington. Unnamed Cr. W.-most unnamed creek which flows to Butler Cove along E. side of French Road NW at junction with Windolph Loop. Elev. 89'. Depth 0-2". Small creek with mud-cobble substrate; sporadic *Lysichiton americanum*. Creek not shown on USGS 7.5' map. Common *Juga* hand and dip net collected. 8/16/2010 EJ! Depth 0-2". Habitat as before. Common *Juga* not retained. 6/8/2013 EJ! [B9]

32. [6625] Butler Cove east creek. Zone 10: 504,790E 5,213,664N. Tumwater 1994 quad., Thurston Co., Washington. Unnamed Cr. E.-most unnamed creek which flows to Butler Cove, above (E. of) French Road NW near junction with Windolph Loop NW. Elev. 99'. Depth 0-3". Small creek with mud-cobble substrate; rare *Nasturtium*. Creek flows from unnamed lake. Uncommon *Juga* hand collected. 8/16/2010 EJ! Depth 0-2". Habitat as before. Common *Juga* mostly juveniles hand and dip net collected for DNA sample. 6/8/2013 EJ! [B9]

33. [6626] Pond S. of Butler Cove. Zone 10: 505,263E 5,212,963N. Tumwater 1994 quad., Thurston Co., Washington. Unnamed Cr. Pond at 2824 Division Street NW, S. of Butler Cove. Elev. 141'. Depth 4'. Small man made pond impounded by earthen dam. Mud substrate; *Elodea*, *Lemna* and *Typha*. *Planorbella*, *Physella* and sphaeriids dip net collected. 8/16/2010 EJ! Depth 4-5'. Habitat as before. *Planorbella*, *Gyraulus*, *Physella* and sphaeriids dip net collected (not retained). 6/8/2013 EJ! [B9]

34. [6627] Green Cove Creek tributary south of Butler Cove. Zone 10: 504,324E 5,212,876N. Tumwater 1994 quad., Thurston Co., Washington. Unnamed Cr.-Green Cove Cr. Unnamed Green Cove Creek tributary on S. side of 28th Ave NW, 0.1 rd. mi. W. of Cooper Point Road NW junction. Elev. 141'. Depth 1-2'. Ditched very small creek flowing through a marsh. Sphaeriids dip net collected. Not retained. 8/16/2010 EJ! Depth 4-6". Habitat as before. 2 *Juga*, *Menetus* and sphaeriids dip net collected. 6/8/2013 EJ! [B9]

35. [6628] Green Cove Creek at Kaiser Road NW. Zone 10: 503,829E 5,213,212N. Tumwater 1994 quad., Thurston Co., Washington. Green Cove Cr. Green Cove Creek on S. side of Kaiser Road NW, 0.4 rd. mi. W. of Cooper Point Road NW junction. Elev. 141'. Depth 1-10'. Small creek with mud substrate; *Oenanthe samentosa*. Sphaeriids only dip net collected. 8/16/2010 EJ! Depth 0-5". Habitat as before. Sphaeriids dip net collected. 6/8/2013 EJ! [B9]

36. [6629] Schneider Creek at Bowman Avenue NW. Zone 10: 505,895E 5,210,922N. Tumwater 1994 quad., Thurston Co., Washington. Schneider Cr. Schneider Creek at Bowman Avenue NW, Olympia. Elev. 180'. Depth 0'. Dry creek. No mollusks. 8/16/2010 EJ! Depth 0-1". Some water flowing. No mollusks. 6/8/2013 EJ! [B9]

37. [6630] Louise Lake off Kaiser Road NW. Zone 10: 503,173E 5,211,066N. Tumwater 1994 quad., Thurston Co., Washington. Louise Lk.-Green Cove Cr. Louise Lake off Kaiser Road NW, ca. 0.18 rd. mi. S. of 14th Ave NW, Olympia. Elev. 141'. Depth 3-4'. Kettle lake with mud-gravel substrate; *Scirpus*, water lily and *Elodea*. *Physella gyrina* dip net collected (not retained). 8/16/2010 EJ! Depth 3-4'. Habitat as before. *Gyraulus* dip net collected. 6/8/2013 EJ! [B9]

38. [6631] Black Lake Drainage Ditch above RW Johnson Road SW. Zone 10: 504,675E 5,207,993N. Tumwater 1994 quad., Thurston Co., Washington. Black Lk. Drainage Ditch-Percival Cr.-Deschutes R. (Capitol Lk.). Black Lake Drainage Ditch W. (above) RW Johnson Road SW. Elev. 124'. Depth 0-7". Medium-sized creek with silt-cobble substrate; patches of *Lemna minor*. Check dams (logs) below and above site. *Juga* hand collected off cobbles and dip net collected from grasses. 8/16/2010 EJ! Depth 2-7". Habitat as before. *Juga* hand collected off cobbles for DNA sample. 6/10/2013 EJ! [B7]

39. [6632] Woodland Creek at Martin Way E. Zone 10: 514,913E 5,210,541N. Lacey 1973 quad., Thurston Co., Washington. Woodland Cr. Woodland Creek on N. side of Martin Way E., Lacey. Elev. 89'. Depth 0". Dry creek. No mollusks. 8/18/2010 EJ! Depth 0.5". Nearly dry creek. No mollusks. 6/4/2013 EJ! [B4]

40. [6633] Lake Lois at Lake Lois Park. Zone 10: 515,203E 5,209,550N. Lacey 1973 quad., Thurston Co., Washington. Lake Lois-Woodland Cr. Lake Lois at City of Lacey Lake Lois Park off 7th Ave SE. Elev. 154'. Depth 4-5'. Kettle lake with mud underlain by peat; water lily, *Myriophyllum* and *Elodea*. *Planorbella*, *Physella* and sphaeriids dip net collected. 8/18/2010 EJ! Depth 1-3'. Habitat as before. Sphaeriids only dip net collected (not retained). 6/4/2013 EJ! [B4]

41. [6636] Lake Lois at Lake Lois Park Habitat Preserve. Zone 10: 515,383E 5,209,499N. Lacey 1973 quad., Thurston Co., Washington. Lake Lois-Woodland Cr. Lake Lois at City of Lacey Lake Lois Park Habitat Preserve E. of Carpenter Road SE, behind the Safeway Grocery Store. Elev. 157'. Depth 3'. Kettle lake with anoxic mud underlain by peat; *Myriophyllum*, *Potamogeton natans* and *Elodea*. Mollusk dip net collected. 8/18/2010 EJ! Depth 4'. Kettle lake with dense *Typha* stands and *Lemna minor* present. No mollusks. 6/4/2013 EJ! [B4]

42. [6637] W. side of Long Lake at Long Lake Park swimming area. Zone 10: 516,560E 5,207,427N. Lacey 1973 quad., Thurston Co., Washington. Long Lake-Woodland Cr.-Lake Lois-Woodland Cr. W. side of Long Lake at City of Lacey Long Lake Park swimming area, N. of Thurston County Fairground. Elev. 157'. Depth 4-5'. Large kettle lake with silt-gravel substrate; aquatic grasses. *Physella* dip net collected. 8/18/2010 EJ! Depth 2-3'. Habitat as before. *C. chinensis*, *Physella* and *Menetus* dip net collected (not retained). 6/4/2013 EJ! [B3]

43. [6638] W. side of Long Lake at Washington State boat ramp. Zone 10: 516,687E 5,207,335N. Lacey 1973 quad., Thurston Co., Washington. Long Lake-Woodland Cr.-Lake Lois-Woodland Cr. W. side of Long Lake at Washington Department of Fish & Wildlife boat ramp, E. of Thurston County Fairground. Elev. 157'. Depth 4'. Large kettle lake with silt-gravel substrate; algae. *Physella*, *Planorbella* and *Cipangopaludina* dip net collected. 8/18/2010 EJ! Depth 4-5'. Habitat as before. *Physella* and *C. chinensis* dip net collected (not retained). 6/4/2013 EJ! [B3]

44. [6639] Hicks Lake at N. side of Washington State boat ramp. Zone 10: 515,146E 5,207,454N. Lacey 1973 quad., Thurston Co., Washington. Hicks Lk.-Pattison Lk.-Long Lake-Woodland Cr.-Lake Lois-Woodland Cr. W. side of Hicks Lake on the N. side of Washington Department of Fish & Wildlife

boat ramp at terminus of Donegal Ct SE. Elev. 164'. Depth 4'. Large kettle lake with mud substrate; water lily and *Scripus* in patches. *Cipangopaludina* dip net collected. 8/18/2010 EJ! Depth 2-4'. *Potamogeton* and *Elodea* present. Sphaeriids and *C. chinensis* dip net collected (not retained). 6/4/2013 EJ! [B3]

45. [6640] Hicks Lake at N. side of Washington State boat ramp. Zone 10: 515,146E 5,207,423N. Lacey 1973 quad., Thurston Co., Washington. Hicks Lk.-Pattison Lk.-Long Lake-Woodland Cr.-Lake Lois-Woodland Cr. W. side of Hicks Lake on the S. side of Washington Department of Fish & Wildlife boat ramp at terminus of Donegal Ct SE. Elev. 164'. Depth 4'. Large kettle lake with mud substrate; patches of water lily and dense *Elodea*. Planorbids, *Physella*, *Cipangopaludina*, and Sphaeriids dip net collected. 8/18/2010 EJ! Depth 2-4'. Habitat as before. *Physella*, *Gyraulus* and *C. chinensis* dip net collected (not retained). 6/4/2013 EJ! [B3]

46. [6641] Chambers Lake at Thurston County boat ramp. Zone 10: 512,289E 5,208,625N. Lacey 1973 quad., Thurston Co., Washington. Chambers Lk.-Unnamed Cr.-Deschutes R. N. end of Chambers Lake at Thurston County boat ramp. Elev. 195'. Depth 3-4'. Large kettle lake with anoxic mud over peat substrate; water lily patches. Sphaeriids and *Cipangopaludina* dip net collected. 8/12/2010 EJ! Depth 3-4'. Habitat as before. *Planorbella*, sphaeriids and *C. chinensis* dip net collected (not retained). 6/13/2013 EJ! [B6]

47. [6642] Indian Creek at Frederick Street SE. Zone 10: 509,766E 5,208,993N. Lacey 1973 quad., Thurston Co., Washington. Indian Cr. Indian Creek on W. side of Frederick Street SE, Olympia. Elev. 109'. Depth 0-8". Small creek with silt-cobble substrate; wood debris. Common *Juga* and uncommon sphaeriids dip net collected. *Juga* hand collected off cobbles. *Juga* crawling out of water in splash zones. 8/18/2010 EJ! Depth 0-8". Habitat as before. *Juga* and sphaeriids dip net collected. 6/14/2013 EJ! [B6]

48. [6643] Percival Creek under Cooper Point Road bridge. Zone 10: 505,773E 5,208,103N. Tumwater 1994 quad., Thurston Co., Washington. Percival Cr.-Deschutes R. (Capitol Lk.). Percival Creek under Cooper Point Road bridge, City of Olympia Percival Creek Park. Elev. 121'. Depth 0-14". Medium-sized creek with silt-cobble substrate; no macrophytes. Common *Juga* hand and dip net collected. 8/21/2010 EJ! Depth 2-7". Habitat as before. *Juga* dip net collected (DNA sample). 6/10/2013 EJ! [B7]

49. [6644] Spring seeps W. of Little Tykle Cove. Zone 10: 504,935E 5,215,147N. Tumwater 1994 quad., Thurston Co., Washington. Percival Cr.-Deschutes R. (Capitol Lk.). Spring seeps on N. side of private drive to Little Tykle Cove, 0.2 rd. mi. off from Cooper Point Road NW. Elev. 103'. Depth 0-0.5". Cold spring seeps flowing down slope; mud-cobble substrate; *Oplopanax horridus* and *Lysichiton americanum*. Spring not shown on USGS 7.5' map. *Pristinicola* hand collected off sticks and leaves. 8/21/2010 EJ! Not recollected. [B9]

50. [6645] Ken Lake at Christopher Park. Zone 10: 503,976E 5,208,499N. Tumwater 1994 quad., Thurston Co., Washington. Ken Lk. E. side of Ken Lake at Christopher Park off Cedarbury Lane, Lakemoor Community Club. Elev. 144'. Depth 3-7'. Medium-sized kettle lake with mud-silt substrate; *Scirpus*, *Potamogeton*, *Myriophyllum*. Simmons Lake on USGS 7.5' map. Sphaeriids and *Cipangopaludina* dip net collected. Some samples collected from dock. 8/21/2010 EJ! Depth 4-5'. Habitat as before. *Physella*, sphaeriids and *C. chinensis* dip net collected (not retained). 6/8/2013 EJ! [B7]

51. [6646] Ken Lake at Westside Park. Zone 10: 503,692E 5,208,720N. Tumwater 1994 quad., Thurston Co., Washington. Ken Lk. W. side of Ken Lake at Westside Park off Camelot Park SW, Lakemoor Community Club. Elev. 144'. Depth 4-5'. Medium-sized kettle lake with mud-gravel substrate; Abundant *Myriophyllum*. Simmons Lake on USGS 7.5' map. *Cipangopaludina* dip net

collected. 8/21/2010 EJ! Depth 2-4'. Habitat as before. Sphaeriids and *C. chinensis* dip net collected (not retained). 6/8/2013 EJ! [B7]

52. [6647] Indian Creek at 12th Ave SW. Zone 10: 508,695E 5,209,209N. Tumwater 1994 quad., Thurston Co., Washington. Indian Cr. Indian Creek on S. side of 12th Ave SW, at a USGS gauging station, Olympia. Elev. 30'. Depth 9-16". Small creek with anoxic mud substrate; no macrophytes. Water quality and sedimentation problem. No mollusks. 8/21/2010 EJ! Depth 6-18". Habitat as before. Sphaeriids dip net collected (not retained). 6/14/2013 EJ! [B6]

53. [6648] Ellis Creek north of 33rd Ave NE. Zone 10: 508,656E 5,213,744N. Tumwater 1994 quad., Thurston Co., Washington. Ellis Cr. Ellis Creek E. of house at 1020 33rd Ave NE. Elev. 102'. Depth 0-3". Small creek with silt-cobble substrate; no macrophytes. Very uncommon *Juga* hand collected. 8/21/2010 EJ! Depth 6-9". Habitat as before. *Juga* dip net collected. 6/14/2013 EJ! [B6]

54. [6649] Deschutes River at bridge of Capitol Way. Zone 10: 508,656E 5,213,744N. Tumwater 1994 quad., Thurston Co., Washington. Deschutes R. Deschutes River under bridge of Capitol Way, Tumwater Falls Park, Olympia Tumwater Foundation. Elev. 88'. Depth 0-4'. River with silt-cobble substrate; *Elodea* in patches. *Fluminicola* and mostly immature *Juga* dip net collected. Also collected off cobbles. 8/23/2010 EJ! Depth 2'. Habitat as before. *Fluminicola, Juga, Physella* and sphaeriids dip net collected. 5/23/2013 EJ, BB! [B5]

55. [6650] Deschutes River at Tumwater Historical Park. Zone 10: 507,502E 5,207,214N. Tumwater 1994 quad., Thurston Co., Washington. Deschutes R. Deschutes River at S. end of Tumwater Historical Park. Elev. 4'. Depth 0-3'. River with mostly gravel-cobble substrate, patches of mud-silt substrate; *Elodea* in uncommon patches. Uncommon *Fluminicola* (juveniles) and *Ferrissia* on cobbles. 8/23/2010 EJ! Depth 0-3'. Habitat as before. Sphaeriids, rare *Potamopyrgus* and dead *Fluminicola* dip net collected. 6/13/2013 EJ! [B5]

56. [6651] Pond in Trillium Park. Zone 10: 508,415E 5,207,552N. Tumwater 1994 quad., Thurston Co., Washington. Unnamed Pond. Pond in N. end of City of Olympia Trillium Park. Elev. 164'. Depth 12". Mostly filled in kettle pond; peat substrate; no open water; *Trillium* abundant, patches of *Lysichiton americanum*, *Typha* along N. end of pond. No mollusks. 8/23/2010 EJ! Depth 1'. Habitat as before. Gyraulus dip net collected. 6/13/2013 EJ! [B5]

57. [6652] North side of Hazard Lake. Zone 10: 508,757E 5,207,308N. Tumwater 1994 quad., Thurston Co., Washington. Hazard Lk. N. side of Hazard Lake behind house at 3000 Monta Vista Street SE, Olympia. Elev. 164'. Depth 2-6'. Small kettle lake with mud over peat substrate; *Myriophyllum*, *Lemna*, algae, and water lily. *Physella* dip net collected, not retained. 8/23/2010 EJ! Not recollected. [B5]

58. [6653] Ward Lake at Holiday Hills Private Lake Park. Zone 10: 509,645E 5,206,315N. Lacy 1973 quad., Thurston Co., Washington. Ward Lk. N. end of Ward Lake at Holiday Hills Private Lake Park, off Lakewood Drive SE near intersection with Lakehurst Drive SE, Olympia. Elev. 133'. Depth 5-6'. Medium-sized kettle lake with mud-silt substrate; *Elodea*, water lily patches (white flowers) and minor amounts of *Scirpus*. Sphaeriids only dip net collected. 8/23/2010 EJ! Depth 5-6'. Habitat as before. Sphaeriids dip net collected. 6/13/2013 EJ! [B5]

59. [6654] Ward Lake at Washington Fish & Wildlife boat ramp. Zone 10: 509,797E 5,206,015N. Lacy 1973 quad., Thurston Co., Washington. Ward Lk. E. side of Ward Lake collected on N. side of Washington Fish & Wildlife boat ramp at the terminous of 42nd Ave SE. Elev. 135'. Depth 4-5'. Medium-sized kettle lake with mud substrate; *Elodea*, water lily patches (white flowers), dense beds of *Myriophyllum*, *Elodea* and *Scirpus* along shoreline. Sphaeriids only dip net collected. 8/23/2010 EJ! Depth 5-6'. Habitat as before. Sphaeriids dip net collected. 5/23/2013 EJ, BB! [B5]

60. [6655] Longs Pond behind Lacey Community Center. Zone 10: 515,838E 5,209,370N. Lacy 1973 quad., Thurston Co., Washington. Longs Pond-Woodland Cr.-Lois Lk.-Woodland Cr. Longs Pond behind Lacey Community Center, City of Lacey Woodland Creek Community Park. Elev. 154'. Depth 4-5'. Medium-sized kettle lake with mud-gravel substrate; 2 spp. of *Potamogeton*. Not named on USGS 7.5' map. *Physella* dip net collected. Not retained. 8/25/2010 EJ! Depth 2-3'. Habitat as before. No mollusks. 6/4/2013 EJ! [B4]

61. [6656] Longs Pond east of Lacey Senior Center. Zone 10: 515,887E 5,209,450N. Lacy 1973 quad., Thurston Co., Washington. Longs Pond-Woodland Cr.-Lois Lk.-Woodland Cr. Longs Pond E. of Lacey Senior Center, City of Lacey Woodland Creek Community Park. Elev. 154'. Depth 5'. Medium-sized kettle lake with mud-gravel substrate; no macrophytes. Not named on USGS 7.5' map. No mollusks. 8/25/2010 EJ! Depth 2-3'. Habitat as before. No mollusks. 6/4/2013 EJ! [B4]

62. [6657] Longs Pond south of Lacey Community Center. Zone 10: 515,887E 5,209,450N. Lacy 1973 quad., Thurston Co., Washington. Longs Pond-Woodland Cr.-Lois Lk.-Woodland Cr. Longs Pond S. of Lacey Community Center, City of Lacey Woodland Creek Community Park. Elev. 154'. Depth 5'. Medium-sized kettle lake with mud-gravel substrate; no macrophytes. Not named on USGS 7.5' map. No mollusks. 8/25/2010 EJ! Depth 2-3'. Habitat as before. No mollusks. 6/4/2013 EJ! [B4]

63. [6658] Southeast side of Goose Pond. Zone 10: 515,533E 5,208,993N. Lacy 1973 quad., Thurston Co., Washington. Goose Pond. Goose Pond on SE side, off of Lacey Woodland Trail (abandoned Burlington Northern Railroad grade), Lacey. Elev. 163'. Depth 3-5'. Kettle pond with mud-gravel substrate; water lily, *Potamogeton*, *Elodea*, and *Myriophyllum*. *Planorbella* dip net collected. 8/25/2010 EJ! Depth 2-3'. Habitat as before. *Physella, Planorbella, Gyraulus* and sphaeriids dip net collected (not retained). 6/4/2013 EJ! [B4]

64. [6659] Woodland Creek at Woodland Creek Community Park. Zone 10: 516,870E 5,209,063N. Lacey 1973 quad., Thurston Co., Washington. Woodland Cr.-Lk. Lois-Woodland Cr. Woodland Creek at City of Lacy Woodland Creek Community Park at bridge of walking path, E. of Goose Pond. Elev. 160'. Depth 2-5'. Creek with cobble substrate; *Lemna minor*. No mollusks. 8/25/2010 EJ! Depth 2-5'. Habitat as before. No mollusks. 6/4/2013 EJ! [B4]

65. [6660] Woodland Creek at Draham Road NE. Zone 10: 514,987E 5,211,731N. Lacey 1973 quad., Thurston Co., Washington. Woodland Cr. Woodland Creek at 1824 Draham Street NE, Lacey. Elev. 75'. Depth 12-20". Spring-influenced small creek with mud, sand, gravel substrate; *Oenanthe sarmentosa* along banks, *Lemna minor*, introduced grasses (Reed canary grass). Abundant *Juga* hand dip net collected. 8/25/2010 EJ! Depth 2'. Habitat as before. *Juga* dip net collected for DNA sample. 6/15/2013 EJ! [B4]

66. [6661] Woodland Creek at bridge of Pleasant Glade Road NE. Zone 10: 513,979E 5,212,950N. Lacey 1973 quad., Thurston Co., Washington. Woodland Cr. Woodland Creek on both sides of Pleasant Glade Road NE bridge, City of Lacey Pleasant Glade Park. Elev. 41'. Depth 0-3'. Creek with mostly sand substrate with patches of gravel; no macrophytes. USGS gauging station at bridge. Common *Juga* found in grasses and substrate. Dip net collected. 8/25/2010 EJ! Depth 2-3'. Habitat as before. *Juga* dip net collected for DNA sample. 6/15/2013 EJ! [B4]

67. [6662] Unnamed marsh east of Saint Peters Hospital. Zone 10: 512,343E 5,210,845N. Lacey 1973 quad., Thurston Co., Washington. Unnamed Marsh. Marsh E. of the terminus of Ensign Road NE, along E. side of Chehalis Western Trail, Olympia. Elev. 200'. Depth 0-2'. Large kettle marsh with mud substrate on peat; *Nuphar* in patches. Sphaeriids dip net collected. 8/25/2010 EJ! Depth 0-2'. Habitat as before. Mollusks dip net collected (not retained). 6/14/2013 EJ! [B6]

68. [6663] Woodward Creek at Martin Way E. Zone 10: 511,374E 5,210,142N. Lacey 1973 quad., Thurston Co., Washington. Woodward Cr. Woodward Creek on S. side of Martin Way E., Olympia. Elev. 162'. Depth 10-25". Creek with anoxic mud substrate; *Lemna* and *Typha*. No mollusks. 8/27/2010 EJ! Depth 9-20". Habitat as before. No mollusks. 6/14/2013 EJ! [B6]

69. [6664] Woodward Creek tributary at Martin Way E. Zone 10: 511,120E 5,210,173N. Lacey 1973 quad., Thurston Co., Washington. Unnamed Cr.-Woodward Cr. Woodward Creek tributary on S. side of Martin Way E., Olympia. Elev. 162'. Depth 0". Creek almost dry; mud substrate; thick *Typha* and *Lysichiton americanum*. No mollusks. 8/27/2010 EJ! Depth 0". Habitat as before. No mollusks. 6/14/2013 EJ! [B6]

70. [6665] Indian Creek at Martin Way E. Zone 10: 510,617E 5,210,119N. Lacey 1973 quad., Thurston Co., Washington. Indian Cr. Indian Creek on N. side of Martin Way E., behind TLC Veterinary Clinic, Olympia. Elev. 161'. Depth 0-6". Creek with silt substrate; no macrophytes. Creek dug out and channel straightened. No mollusks. 8/27/2010 EJ! Depth 0-6". Habitat as before. No mollusks. 6/14/2013 EJ! [B6]

71. [6666] Woodward Creek at S. Bay Road. Zone 10: 511,073E 5,212,673N. Lacey 1973 quad., Thurston Co., Washington. Woodward Cr. Woodward Creek at 2610 S. Bay Road NE, near junction with 26th Ave NE. Elev. 135'. Depth 6-19". Medium-sized creek with thick mud substrate; *Lemna* minor and grasses. Common *Juga* dip net collected. 8/27/2010 EJ! Depth 20". Habitat as before. *Juga* hand and dip net collected for DNA sample. 6/14/2013 EJ! [B6]

72. [6667] Marsh north of South Bay. Zone 10: 511,606E 5,214,602N. Lacey 1973 quad., Thurston Co., Washington. Woodward Cr. Marsh N. of of South Bay collected on N. side of Chehalis Western Trail (former Chehalis Western Railroad grade), off Shincke Road. Elev. 151'. Depth 3-5". Kettle marsh with mud bottom; *Typha*, *Potamogeton*, *Elodea*, and *Lysichiton americanum*. *Physella gyrina* dip net collected (not retained). 8/27/2010 EJ! Depth 2-6". Habitat as before. No mollusks. 6/14/2013 EJ! [B6]

73. [6668] Woodward Creek at Ensign Road. Zone 10: 511,333E 5,210,506N. Lacey 1973 quad., Thurston Co., Washington. Woodward Cr. Woodward Creek on SE side of Ensign Road NE, Olympia. Elev. 152'. Depth 5-20". Medium-sized creek with deep mud substrate; *Lemna minor* and grasses. No mollusks. 8/27/2010 EJ! Depth 0-20". Habitat as before. No mollusks. 6/14/2013 EJ! [B6]

74. [6669] D'Miller Lake. Zone 10: 510,816E 5,209,171N. Lacey 1973 quad., Thurston Co., Washington. D'Miller Lake. D'Miller Lake at 1415 Dayton SE. Elev. 163'. Depth 5'. Kettle pond with mud substrate; *Typha* abundant along shoreline, abundant *Brasenia* offshore. Unnamed pond on USGS 7.5 map. Sphaeriids only dip net collected. 8/30/2010 EJ! Depth 0-4'. Habitat as before. Sphaeriids dip net collected (not retained). 6/14/2013 EJ! [B6]

75. [6670] Woodward Creek at 36th Ave NE. Zone 10: 510,707E 5,214,220N. Lacey 1973 quad., Thurston Co., Washington. Woodward Cr. Woodward Creek on S. side of 36th Ave NE at USGS gauging station. Elev. 141'. Depth 5-14". Medium-sized creek with mud-gravel substrate; *Lemna minor* and grasses. Somewhat common *Juga* and very uncommon *Fluminicola* dip net collected. 8/30/2010 EJ! Depth 2-16". Habitat as before. *Juga* and *Fluminicola* dip net collected. 6/14/2013 EJ! [B6]

76. [6671] Ellis Creek at 36th Ave NE. Zone 10: 508,639E 5,214,227N. Tumwater 1994 quad., Thurston Co., Washington. Ellis Cr. Ellis Creek on S. side of 36th Ave NE. Elev. 108'. Depth 0-2". Small creek with mud-cobble substrate; *Lysichiton americanum*; water is tea colored from tannins. No mollusks. 8/30/2010 EJ! Depth 0-2". Habitat as before. Very rare *Juga* not retained. 6/14/2013 EJ! [B6]

77. [6672] Mission Creek at Ethridge Ave NE. Zone 10: 509,148E 5,211,616N. Tumwater 1994 quad., Thurston Co., Washington. Mission Cr. Mission Creek on S. side of Echridge Ave NE, Olympia. Elev. 162'. Depth 0-2". Small creek with mud-cobble substrate; *Lysichiton americanum*. Sphaeriids dip net collected. 8/30/2010 EJ! Depth 0-4". Habitat as before. Sphaeriids and *Menetus* dip net collected (not retained). 6/14/2013 EJ! [B6]

78. [6673] Mission Creek at Miller Ave NE. Zone 10: 509,092E 5,211,836N. Tumwater 1994 quad., Thurston Co., Washington. Mission Cr. Mission Creek on S. side of Miller Ave NE, Olympia. Elev. 161'. Depth 0-3". Small creek with mud-cobble substrate. No mollusks. 8/30/2010 EJ! Depth 0-5". Habitat as before. No mollusks. 6/14/2013 EJ! [B6]

79. [6674] Hewitt Lake on east side. Zone 10: 510,126E 5,205,100N. Lacey 1973 quad., Thurston Co., Washington. Hewitt Lk. Hewitt Lake at private beach behind house at 5021 Laura Street SE. Elev. 144'. Depth 3-5". Medium-sized kettle lake with mud-sand substrate; *Myriophyllum*, *Potamogeton* and some *Elodea*. *Planorbella*, sphaeriids, *Physella*, and 1 dead *Juga* dip net collected. Sediment had *Juga* operculums present. 9/1/2010 EJ, BB! Depth 3-5'. Habitat as before. Dead *Juga* and live *Physella* in shallow areas. Dip net collected. 5/23/2013 EJ, BB! [B5]

80. [6675] Deschutes River at Pioneer Park. Zone 10: 508,919E 5,204,302N. Maytown 1973 quad., Thurston Co., Washington. Deschutes R. Deschutes River at City of Tumwater Pioneer Park, 0.18 mi. downriver from Henderson Boulvard bridge. Elev. 114'. Depth 4'. Large river with mud-silt substrate. *Juga* and *Fluminicola* dip net collected. 9/1/2010 EJ, BB! Depth 1-4'. Habitat as before. *Fluminicola*, *Juga* and sphaeriids dip net collected. 5/23/2013 EJ, BB! [B5]

81. [6676] Susan Lake channel at 1633 Susan Court SE. Zone 10: 509,144E 5,203,680N. Maytown 1973 quad., Thurston Co., Washington. Susan Lk. Susan Lake channel behind house at 1633 Susan Court SE. Elev. 155'. Depth 2-5". Channel from lake; deep mud substrate; dense *Typha*. *Planorbella*, *Physella* and sphaeriids. 9/1/2010 EJ, BB! Depth 2-6". Habitat as before. *Planorbella*, *Physella* and sphaeriids dip net collected. 5/23/2013 EJ, BB! [B5]

82. [6677] Munn Lake at Public Fishing Access. Zone 10: 509,334E 5,203,621N. Maytown 1973 quad., Thurston Co., Washington. Munn Lk. N. end of Munn Lake at Washington State Public Boat Ramp. Elev. 147'. Depth 4'. Lake with mud substrate; *Typha* along shoreline, water lily in deeper water. *Planorbella* and sphaeriids dip net collected. 9/1/2010 EJ, BB! Habitat as before. *Planorbella* and sphaeriids dip net collected. 6/13/2013 EJ [B5]

83. [6678] Pattison Lake at public boat launch. Zone 10: 517,519E 5,204,528N. East Olympia 1973 quad., Thurston Co., Washington. Pattison Lk.-Long Lake-Woodland Cr.-Lake Lois-Woodland Cr. Pattison Lake on E. side on both sides of Washington Department of Fish & Wildlife boat ramp at terminus of Boat Launch Road SE, off Henslin Drive SE. Elev. 157'. Depth 3-5'. Also known under the names Patterson and Petterson Lake. Large kettle lake with mud-cobble substrate; *Myriophyllum*, dense *Scirpus* and *Typha*. *Planorbella*, *Cipangopaludina*, *Valvata*, *Physella*, sphaeriids, and *Amnicola* dip net collected. 9/1/2010 EJ, BB! *Amincola*, *Planorbella*, *Cipangopaludina*, and sphaeriids dip net collected. No *Valvata* seen. 9/11/2010 EJ, BB! Habitat as before. Mollusks as before except for *Valvata.* Dip net collected. 6/15/2013 EJ [B3]

84. [6679] Pattison Lake outlet at Mullen Road SE. Zone 10: 517,675E 5,205,342N. East Olympia 1973 quad., Thurston Co., Washington. Pattison Lk.-Unnamed Cr.-Long Lake-Woodland Cr.-Lake Lois-Woodland Cr. Pattison Lake outlet above Mullen Road SE under Union Pacific Railroad trestle, near Afflenbaugh Drive SE junction. Elev. 157'. Depth 15-50". Medium-sized creek with mud-cobble substrate; *Typha*, canary grass, *Lemna minor*, *Oenanthe* and *Elodea*. *Juga*, *Planorbella*, sphaeriids and *Physella*. 9/11/2010 EJ, BB! Depth 16-25". Habitat as before. *Juga*, *Planorbella*, sphaeriids and *Physella* dip net collected. 6/15/2013 EJ! [B3]

85. [6682] Moxlie Creek in Olympia Watershed Trail Park. Zone 10: 508,979E 5,208,088N. Tumwater 1994 quad., Thurston Co., Washington. Moxlie Cr. Moxile Creek in Olympia Watershed Trail Park, off G. Eldon Marshall Trail. Elev. 69'. Depth 2-14". Creek with silt-sand substrate; no macrophytes. Common *Juga* dip net and hand collected. 9/11/2010 EJ, BB! Depth 2-12”. Habitat as before. *Juga* dip net collected for DNA sample. 6/15/2013 EJ [B5]

86. [6761] Percival Creek above Percival Cove. Zone 10: 506,620E 5,208,933N. Tumwater 1994 quad. Thurston Co. Washington. Percival Cr.-Capitol Lk. Percival Creek above where empties into Percival Cove, W. of Deschutes Parkway SW, Olympia. Elev. 3'. Depth 0-10". Creek with silt-cobble substrate; no macrophytes. No mollusks found. 6/22/2011 EJ! Depth 8-15”. Habitat as before. No mollusks found. 6/13/2013 EJ! [B5]

APPENDIX B: SITE MAPS.

Maps of sites visited during this survey. Base maps from appropriate USGS 7.5' topographic series (1:24,000 quadrangles) derived from National Geographic TOPO!® ©2009. For locality details see **Appendix A**.

Site Dot Color Code Explanation (see also **Figure 2** for map legend):

Red Dot=*Potamopyrgus antipodarum*
Brown Dot=*Amnicola* and *Valvata*
Yellow Dot=*Juga*
Orange Dot=*Fluminicola*
Green Dot=*Juga* and *Fluminicola*
White Dot=*Pristinicola*
Purple Dot=Other mollusks
Black Dot=No mollusks present

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*Lacey, Maytown & Tumwater	54, 55, 56, 57, 58, 59, 79, 80, 81, 82, 85, 86	B5
*Lacey & Tumwater	46, 47, 52, 53, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78	B6
*Maytown & Tumwater	13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 38, 48, 50, 51	B7
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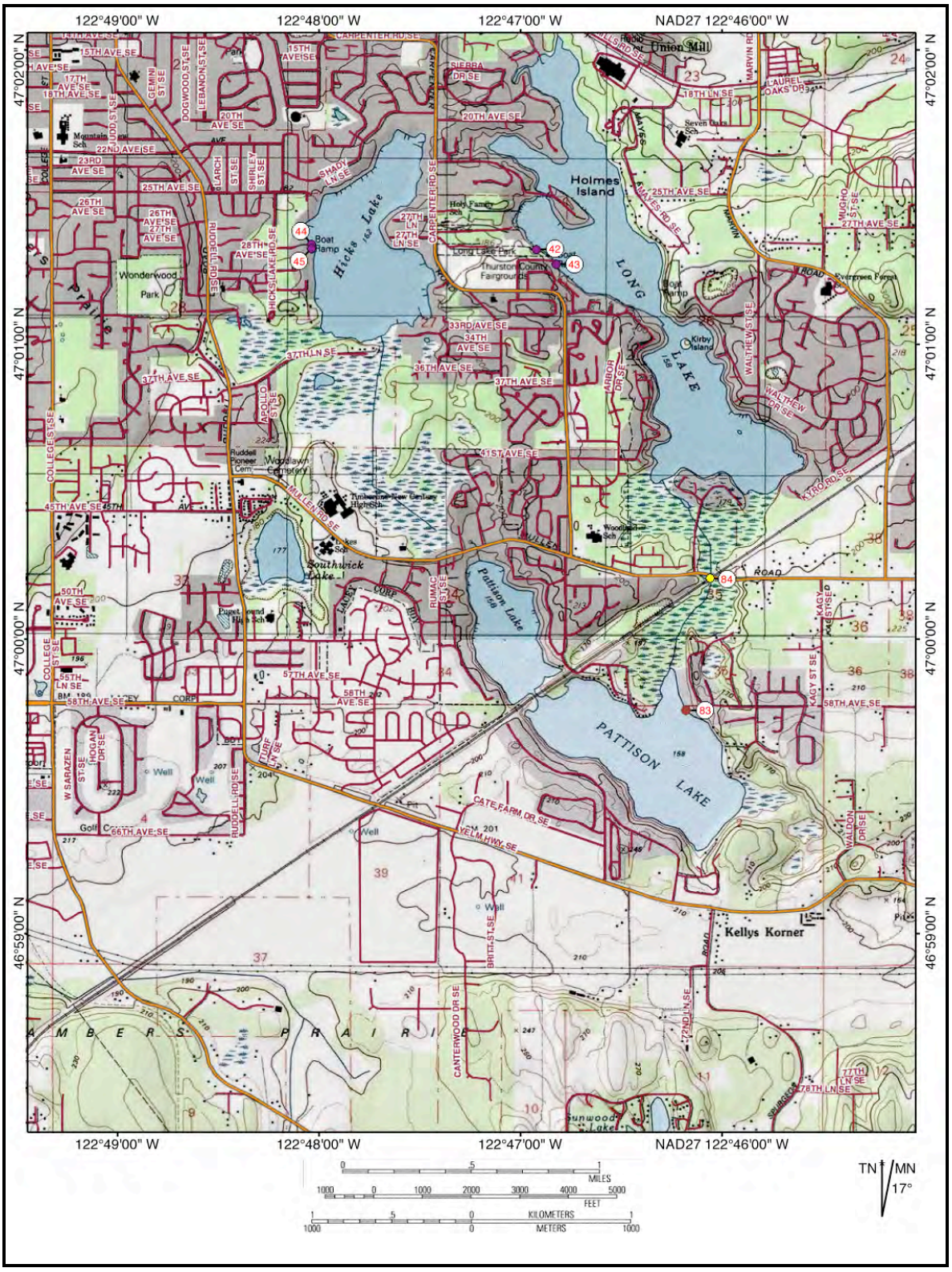
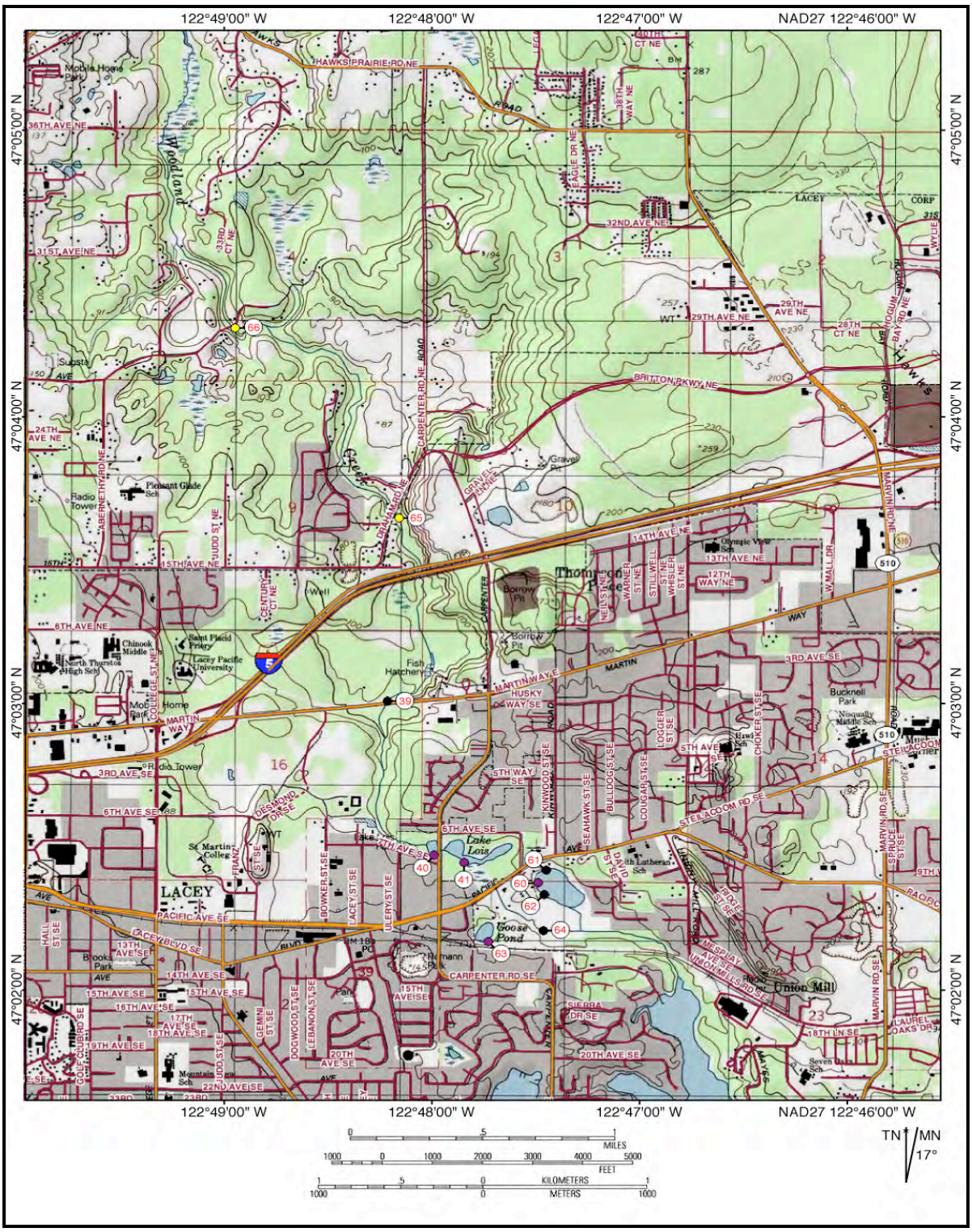
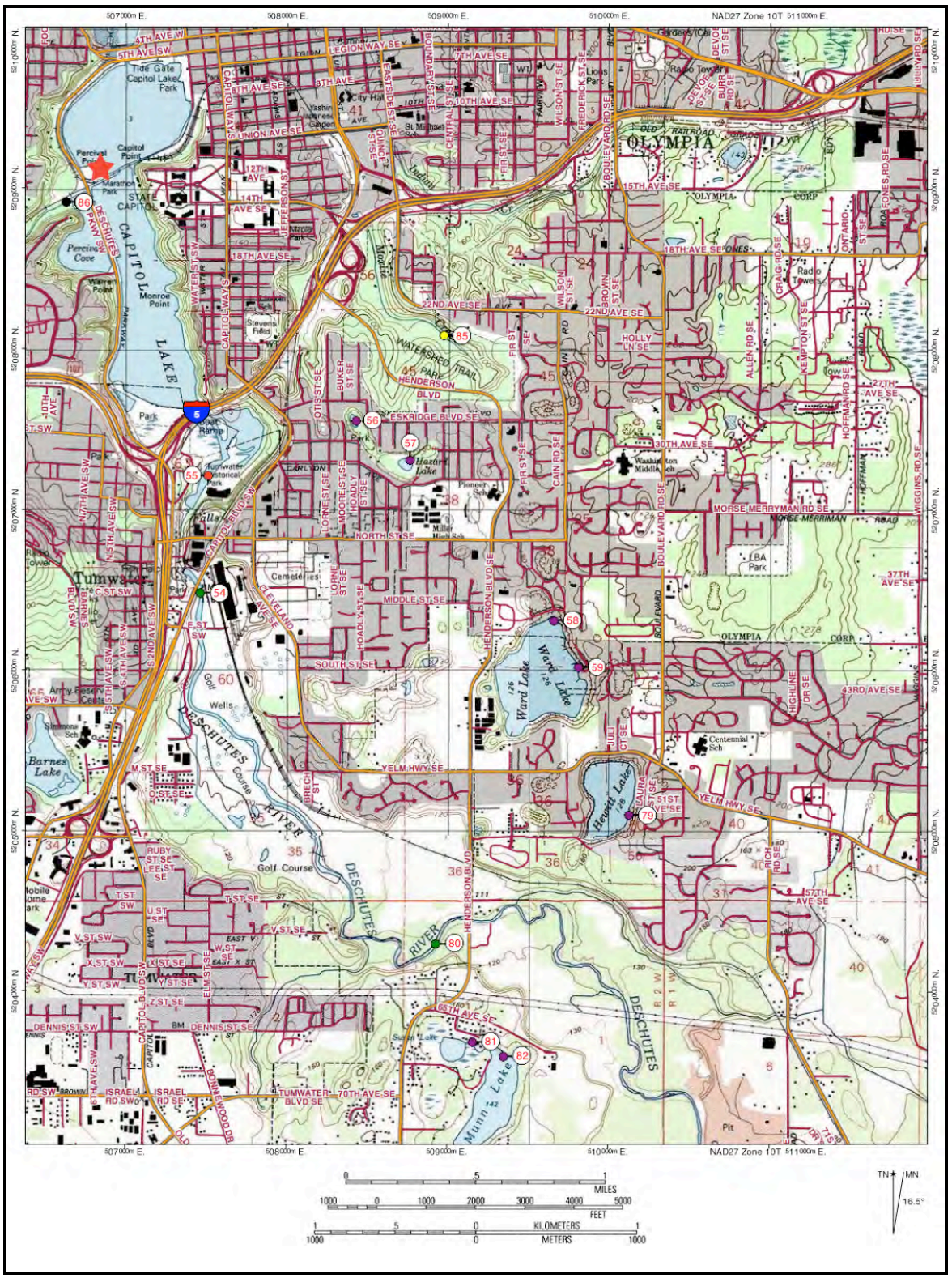
*Tumwater	26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 49	B9



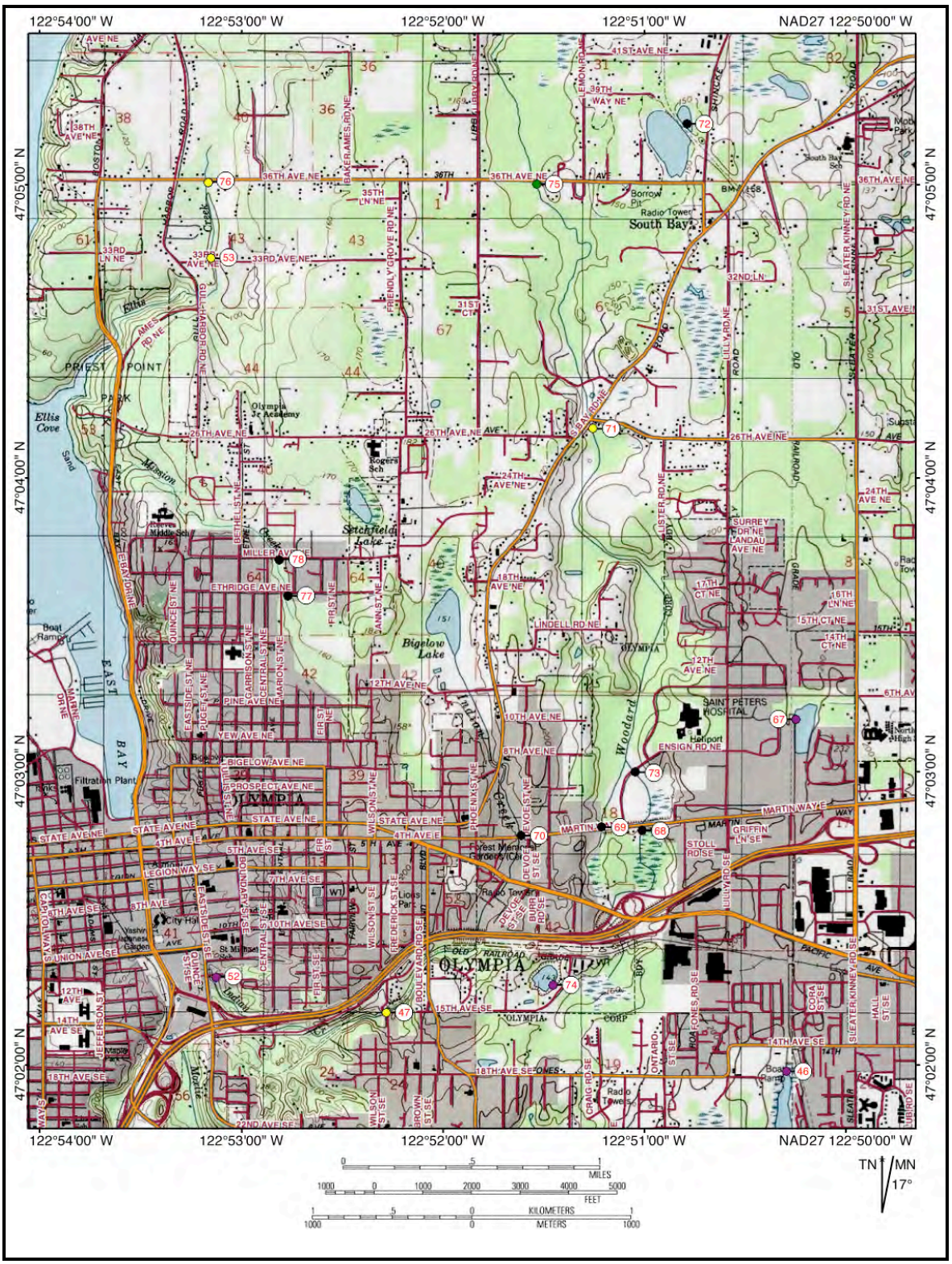
EAST OLYMPIA QUADRANGLE, THURSTON CO., WA.
SITE 83
LACEY QUADRANGLE, THURSTON CO., WA.
SITES 42, 43, 44, 45, 84



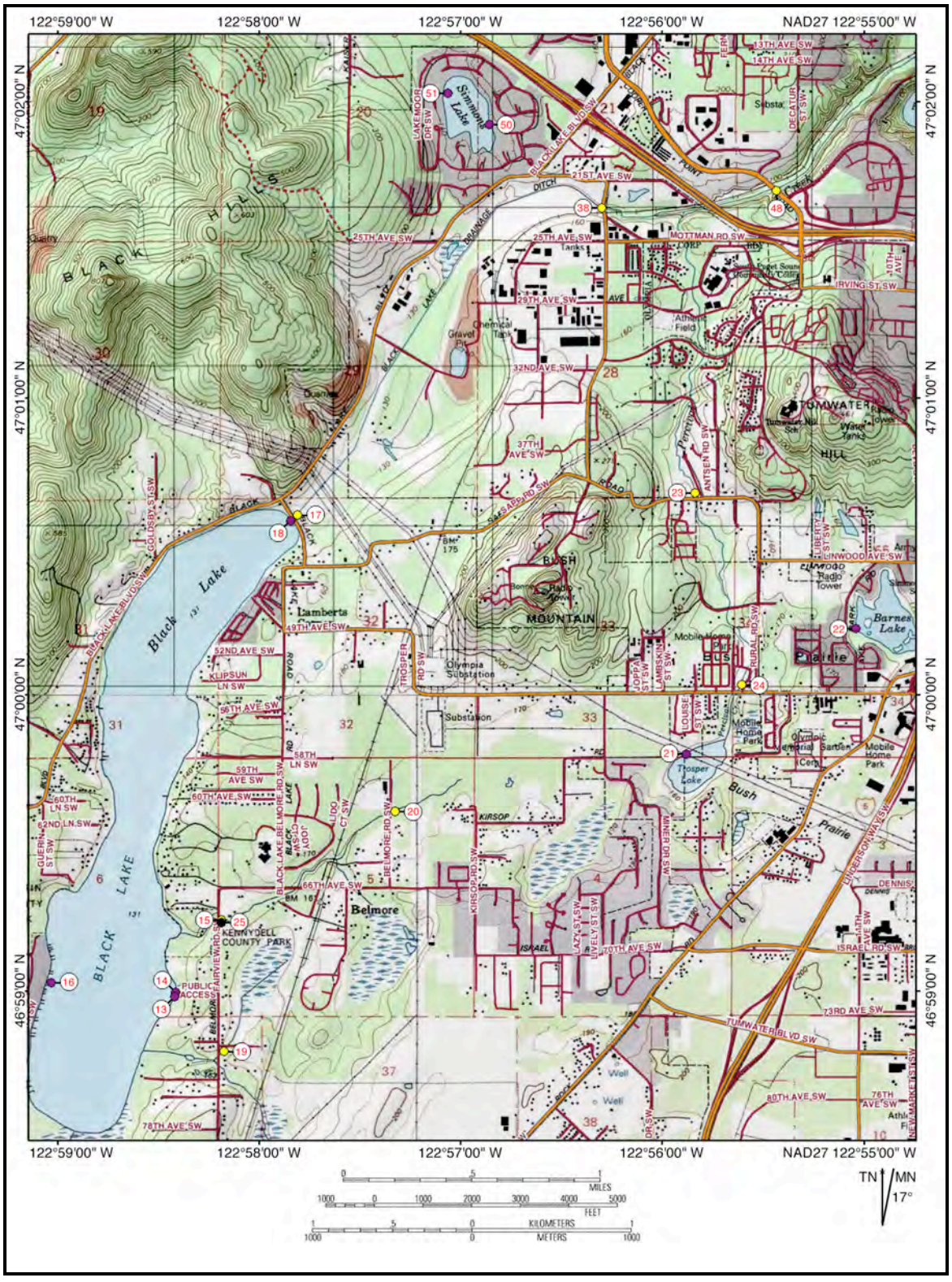
LACEY QUADRANGLE, THURSTON CO., WA.
SITES 39, 40, 41, 60, 61, 62, 63, 64, 65, 66



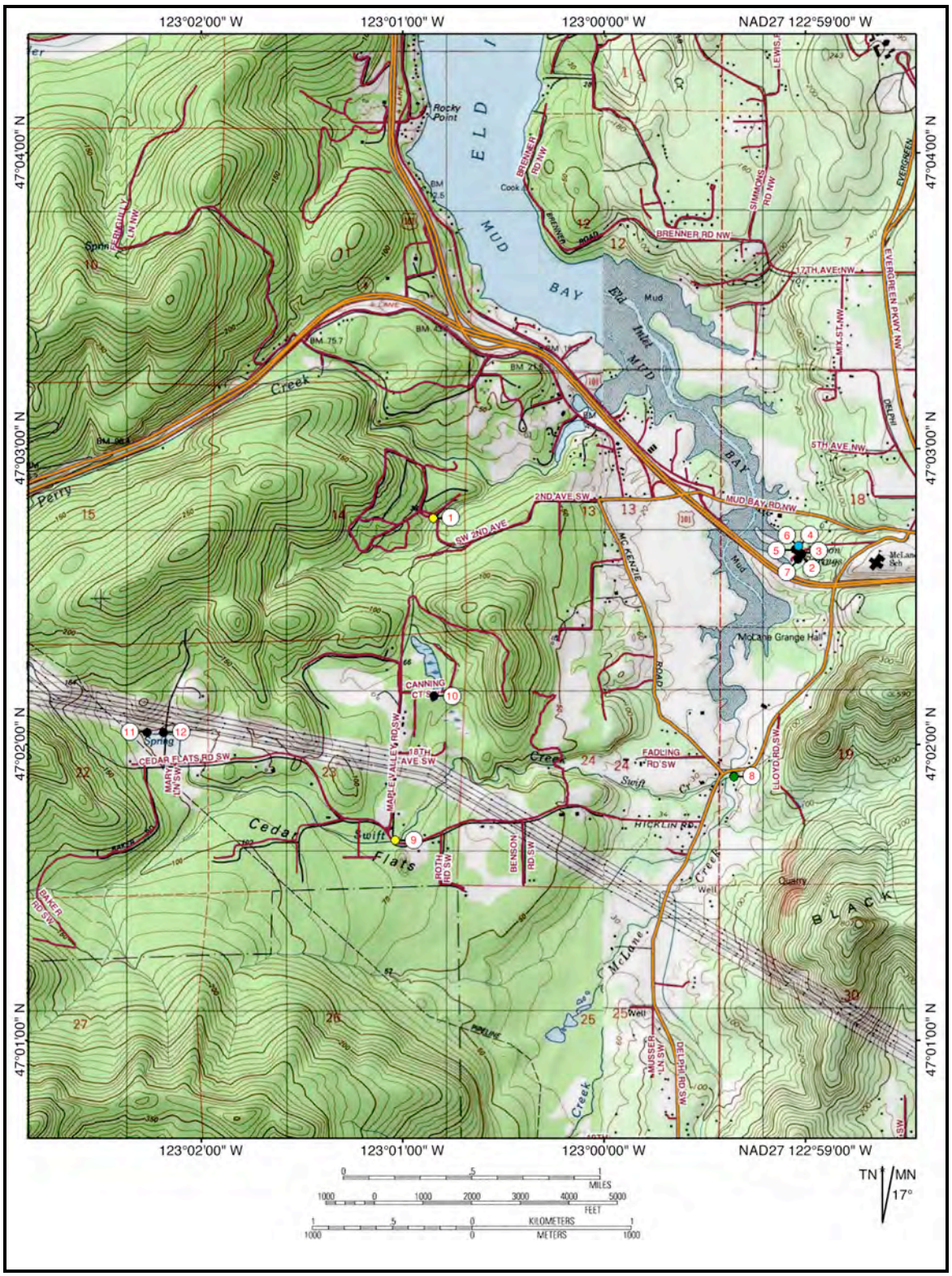
LACEY QUADRANGLE, THURSTON CO., WA.
SITES 58, 59, 79
MAYTOWN QUADRANGLE, THURSTON CO., WA.
SITES 80, 81, 82
TUMWATER QUADRANGLE, THURSTON CO., WA.
SITES 54, 55, 56, 57, 85, 86, red star (2009 NZMS site)



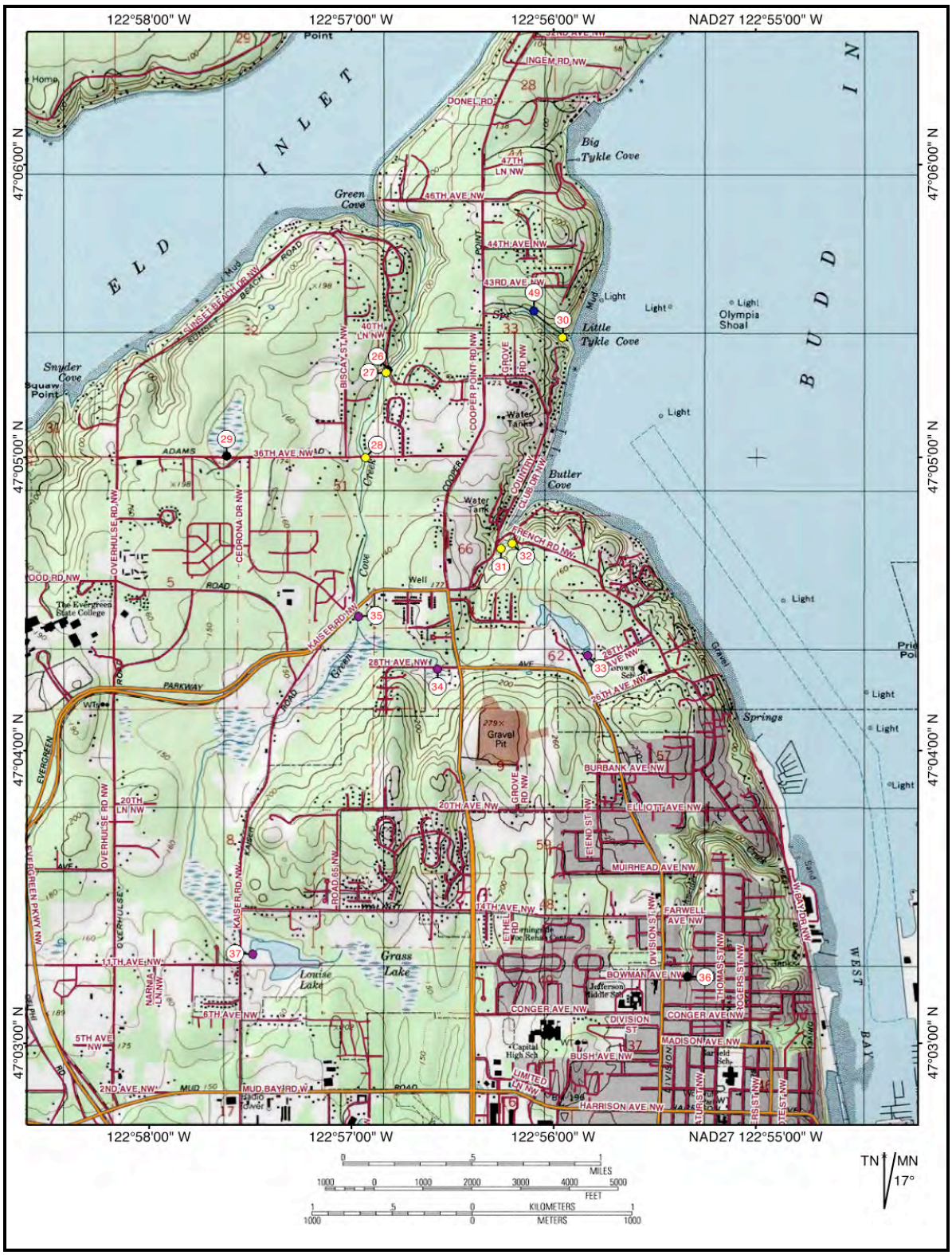
LACEY QUADRANGLE, THURSTON CO., WA.
SITES 46, 47, 67, 68, 69, 70, 71, 72, 73, 74, 75
TUMWATER QUADRANGLE, THURSTON CO., WA.
SITES 52, 53, 76, 77, 78



MAYTOWN QUADRANGLE, THURSTON CO., WA.
SITES 13, 14, 15, 16, 19, 20, 21, 25
TUMWATER QUADRANGLE, THURSTON CO., WA.
SITES 17, 18, 22, 23, 24, 38, 48, 50, 51



SUMMIT LAKE QUADRANGLE, THURSTON CO., WA.
SITES 1, 9, 10, 11, 12
TUMWATER QUADRANGLE, THURSTON CO., WA.
SITES 2, 3, 4, 5, 6, 7, 8



TUMWATER QUADRANGLE, THURSTON CO., WA.
SITES 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 49

APPENDIX C: SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE.

Mollusks faunal tables at collection sites visited during this survey. Sites with no mollusks are blacked out. For locality details see **Appendix A** and site maps see **Appendix B**.

Table Explanation:

*=introduced species
bold=Species Special of Concern (as defined in Frest & Johannes, 1993, 1995)
°=cold-water species (see criteria in Frest & Johannes, 1992)
O=dead only
\=site not visted

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE.

TAXON NAME	SITE (LOCALITY) NUMBERS											
	1 (6595)		2 (6596)		3 (6597)		4 (6598)		5 (6599)		6 (6600)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	-	-	-								-
**Cipangopaludina chinensis malleata*	-	-	-	-								-
°***Amnicola* n. sp. 1**	-	-	-	-								-
°***Fluminicola* n. sp.**	-	-	-	-								-
°***Colligyrus* n. sp. 9**	-	-	-	-								X
**Potamopyrgus antipodarum*	-	-	-	-								-
°***Pristinicola hemphilli***	-	-	-	-								-
°***Juga silicula***	X	X	-	-								-
Fossaria (F.) modicella	-	-	-	-								-
Physella (P.) gyrina	-	-	-	-								-
Gyraulus (T.) parvus	-	-	-	-								-
Menetus (M.) callioglyptus	-	-	X	X								X
Planorbella (P.) subcrenatum	-	-	-	-								-
Ferrissia californica	-	-	-	-								-
Oxyloma sp.	-	-	-	-								-
BIVALVES												
Anodonta oregonensis	-	-	-	-								-
Sphaerium patella	-	-	-	-								-
Musculium raymondi	-	-	-	-								-
Musculium securis	-	-	-	-								-
Pisidium (C.) casertanum	-	-	-	-								-
Pisidium (C.) variabile	-	-	-	-								-
°*Pisidium (N.) insigne*	-	-	-	-								X
Pisidium sp.	-	-	-	-								-
Sphaeriid indet.	-	-	-	-								-
**Corbicula fluminea*	-	-	-	-								-
SPECIES OF CONCERN	1	1	0	0	0	0	0	0	0	0	0	1
COLD-WATER SPECIES	1	1	0	0	0	0	0	0	0	0	0	2
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	0	0	0	0
SITE DIVERSITY BY YEAR	1	1	1	1	0	0	0	0	0	0	0	2
TOTAL SITE DIVERSITY (2010 & 2013)	1		1		0		0		0		3	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	7 (6601)		8 (6602)		9 (6603)		10 (6604)		11 (3248)		12 (6605)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**			-	-	-	-						
**Cipangopaludina chinensis malleata*			-	-	-	-						
°***Amnicola* n. sp. 1**			-	-	-	-						
°***Fluminicola* n. sp.**			X	X	-	-						
°***Colligyrus* n. sp. 9**			-	-	-	-						
***Potamopyrgus antipodarum*			-	-	-	-						
°***Pristinicola hemphilli***			-	-	-	-						
°***Juga silicula***			X	X	X	X						
Fossaria (F.) modicella			-	-	-	-						
Physella (P.) gyrina			-	-	-	-						
Gyraulus (T.) parvus			-	-	-	-						
Menetus (M.) callioglyptus			-	-	-	-						
Planorbella (P.) subcrenatum			-	-	-	-						
Ferrissia californica			-	-	-	-						
Oxyloma sp.			-	-	-	-						
BIVALVES												
Anodonta oregonensis			-	-	-	-						
Sphaerium patella			-	-	-	-						
Musculium raymondi			-	-	-	-						
Musculium securis			-	-	-	-						
Pisidium (C.) casertanum			-	-	-	-						
Pisidium (C.) variabile			-	-	-	-						
°*Pisidium (N.) insigne*			-	-	-	-						
Pisidium sp.			-	-	-	-						
Sphaeriid indet.			-	-	-	-						
**Corbicula fluminea*			-	-	-	-						
SPECIES OF CONCERN	0	0	2	2	1	1	0	0	0	0	0	0
COLD-WATER SPECIES	0	0	2	2	1	1	0	0	0	0	0	0
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL SITE DIVERSITY	0	0	2	2	1	1	0	0	0	0	0	0
TOTAL SITE DIVERSITY (2010 & 2013)	0		2		1		0		0		0	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	13 (6606)		14 (6607)		15 (6608)		16 (6609)		17 (6610)		18 (6611)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	-	-	-	-	-	-	-	-	-	-	-
**Cipangopaludina chinensis malleata*	-	-	-	-	-	-	-	-	-	-	-	-
°***Amnicola* n. sp. 1**	-	-	-	-	-	-	-	-	-	-	-	-
°***Fluminicola* n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-
°***Colligyrus* n. sp. 9**	-	-	-	-	-	-	-	-	-	-	-	-
**Potamopyrgus antipodarum*	-	-	-	-	-	-	-	-	-	-	-	-
°***Pristinicola hemphilli***	-	-	-	-	-	-	-	-	-	-	-	-
°***Juga silicula***	-	-	-	-	X	X	-	-	X	X	-	-
Fossaria (F.) modicella	-	-	-	-	-	-	X	-	-	-	-	-
Physella (P.) gyrina	X	X	X	X	-	-	X	X	X	X	X	X
Gyraulus (T.) parvus	-	-	-	-	-	-	X	-	-	-	X	-
Menetus (M.) callioglyptus	-	-	-		-	-	X	-	-	-	-	-
Planorbella (P.) subcrenatum	X	X	X	X	-	-	-	X	X	-	X	X
Ferrissia californica	-	-	-	-	-	-	-	-	-	-	-	-
Oxyloma sp.	-	-	-	-	-	-	-	-	X	X	-	-
BIVALVES												
Anodonta oregonensis	-	-	-	-	-	-	-	X	-	-	-	-
Sphaerium patella	-	-	-	-	-	-	-	-	-	-	-	-
Musculium raymondi	-	-	-	-	-	-	-	-	-	-	-	-
Musculium securis	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium (C.) casertanum	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium (C.) variabile	-	-	-	-	-	-	-	-	-	-	-	-
°*Pisidium (N.) insigne*	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium sp.	-	-	-	-	-	-	X	O	-	-	-	-
Sphaeriid indet.	X	-	-	-	-	-	-		-	-	-	-
**Corbicula fluminea*	-	-	-	-	-	-	X	O	-	O	-	O
SPECIES OF CONCERN	0	0	0	0	1	1	0	0	1	1	0	0
COLD-WATER SPECIES	0	0	0	0	1	1	0	0	1	1	0	0
INTRODUCED SPECIES	0	0	0	0	0	0	1	1	0	1	0	1
SITE DIVERSITY BY YEAR	3	2	2	2	1	1	6	2	4	4	3	2
TOTAL SITE DIVERSITY (2010 & 2013)	3		2		1		7		5		3	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	19 (6612)		20 (6613)		21 6614)		22 (6615)		23 (6616)		24 (6617)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	-		-	-	-	-		-	-	-	-
**Cipangopaludina chinensis malleata*	-	-		-	-	-	-		-	-	-	-
°***Amnicola* n. sp. 1**	-	-		-	-	-	-		-	-	-	-
°***Fluminicola* n. sp.**	-	-		-	-	-	-		-	-	-	-
°***Colligyrus* n. sp. 9**	-	-		-	-	-	-		-	-	-	-
**Potamopyrgus antipodarum*	-	-		-	-	-	-		-	-	-	-
°***Pristinicola hemphilli***	-	-		-	-	-	-		-	-	-	-
°***Juga silicula***	X	X		X	-	-	-		X	X	X	X
Fossaria (F.) modicella	-	-		-	-	-	-		-	-	-	-
Physella (P.) gyrina	-	-		-	-	-	X		-	-	-	-
Gyraulus (T.) parvus	-	-		-	-	-	-		-	-	-	-
Menetus (M.) callioglyptus	-	-		-	-	-	-		-	-	-	-
Planorbella (P.) subcrenatum	-	-		-	-	-	-		-	-	-	-
Ferrissia californica	-	-		-	-	-	-		-	-	-	-
Oxyloma sp.	-	-		-	-	-	-		-	-	-	-
BIVALVES												
Anodonta oregonensis	-	-		-	-	-	-		-	-	-	-
Sphaerium patella	-	-		-	X	X	-		-	-	-	-
Musculium raymondi	-	-		-	-	-	-		-	-	-	-
Musculium securis	-	-		-	-	-	-		-	X	-	-
Pisidium (C.) casertanum	-	-		-	-	-	-		-	-	-	-
Pisidium (C.) variabile	-	-		-	-	-	-		-	-	-	-
°*Pisidium (N.) insigne*	-	-		-	-	-	-		-	-	-	-
Pisidium sp.	-	-		-	-	-	-		-	-	-	-
Sphaeriid indet.	-	-		-	-	-	-		-	-	-	-
**Corbicula fluminea*	-	-		-	-	-	-		-	-	-	-
SPECIES OF CONCERN	1	1	0	1	0	0	0	0	1	1	1	1
COLD-WATER SPECIES	1	1	0	1	0	0	0	0	1	1	1	1
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	0	0	0	0
SITE DIVERSITY BY YEAR	1	1	0	1	1	1	1	0	1	2	1	1
TOTAL SITE DIVERSITY (2010 & 2013)	1		1		1		1		2		1	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	25 (6618)		26 (6619)		27 (6620)		28 (6621)		29 (6622)		30 (6623)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**						-	-	-			-	\
**Cipangopaludina chinensis malleata*						-	-	-			-	\
°***Amnicola* n. sp. 1**						-	-	-			-	\
°***Fluminicola* n. sp.**						-	-	-			-	\
°***Colligyrus* n. sp. 9**						-	-	-			-	\
**Potamopyrgus antipodarum*						-	-	-			-	\
°***Pristinicola hemphilli***						-	-	-			-	\
°***Juga silicula***						X	X	X			X	\
Fossaria (F.) modicella						-	-	-			-	\
Physella (P.) gyrina						-	-	-			-	\
Gyraulus (T.) parvus						-	-	-			-	\
Menetus (M.) callioglyptus						-	-	-			-	\
Planorbella (P.) subcrenatum						-	-	-			-	\
Ferrissia californica						-	-	-			-	\
Oxyloma sp.						-	-	-			-	\
BIVALVES-												
Anodonta oregonensis						-	-	-			-	\
Sphaerium patella						-	-	-			-	\
Musculium raymondi						-	-	-			-	\
Musculium securis						-	-	-			-	\
Pisidium (C.) casertanum						-	-	-			-	\
Pisidium (C.) variabile						-	-	-			-	\
°*Pisidium (N.) insigne*						-	-	-			-	\
Pisidium sp.						-	-	-			-	\
Sphaeriid indet.						-	-	-			-	\
**Corbicula fluminea*						-	-	-			-	\
SPECIES OF CONCERN	0	0	0	0	0	1	1	1	0	0	1	\
COLD-WATER SPECIES	0	0	0	0	0	1	1	1	0	0	1	\
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	0	0	0	\
SITE DIVERSITY BY YEAR	0	0	0	0	0	1	1	1	0	0	1	\
TOTAL SITE DIVERSITY (2010 & 2013)	0		0		1		1		0		1	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	31 (6624)		32 (6625)		33 (6626)		34 (6627)		35 (6628)		36 (6629)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	-	-	-	-	-	-	-	-	-		
**Cipangopaludina chinensis malleata*	-	-	-	-	-	-	-	-	-	-		
°***Amnicola* n. sp. 1**	-	-	-	-	-	-	-	-	-	-		
°***Fluminicola* n. sp.**	-	-	-	-	-	-	-	-	-	-		
°***Colligyrus* n. sp. 9**	-	-	-	-	-	-	-	-	-	-		
**Potamopyrgus antipodarum*	-	-	-	-	-	-	-	-	-	-		
°***Pristinicola hemphilli***	-	-	-	-	-	-	-	-	-	-		
°***Juga silicula***	X	X	X	X	-	-	-	X	-	-		
Fossaria (F.) modicella	-	-	-	-	-	-	-	-	-	-		
Physella (P.) gyrina	-	-	-	-	X	X	-	-	-	-		
Gyraulus (T.) parvus	-	-	-	-	-	X	-	-	-	-		
Menetus (M.) callioglyptus	-	-	-	-	-	-	-	X	-	-		
Planorbella (P.) subcrenatum	-	-	-	-	X	X	-	-	-	-		
Ferrissia californica	-	-	-	-	-	-	-	-	-	-		
Oxyloma sp.	-	-	-	-	-	-	-	-	-	-		
BIVALVES												
Anodonta oregonensis	-	-	-	-	-	-	-	-	-	-		
Sphaerium patella	-	-	-	-	-	-	-	-	-	-		
Musculium raymondi	-	-	-	-	X	X	-	-	-	-		
Musculium securis	-	-	-	-	-	-	-	-	-	-		
Pisidium (C.) casertanum	-	-	-	-	-	-	-	-	-	-		
Pisidium (C.) variabile	-	-	-	-	-	-	-	-	-	-		
°*Pisidium (N.) insigne*	-	-	-	-	-	-	-	-	-	-		
Pisidium sp.	-	-	-	-	-	-	-	-	-	-		
Sphaeriid indet.	-	-	-	-	-	-	X	X	X	X		
**Corbicula fluminea*	-	-	-	-	-	-	-	-	-	-		
SPECIES OF CONCERN	1	1	1	1	0	0	0	1	0	0	0	0
COLD-WATER SPECIES	1	1	1	1	0	0	0	1	0	0	0	0
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	0	0	0	0
SITE DIVERSITY BY YEAR	1	1	1	1	3	4	1?	3?	1?	1?	0	0
TOTAL SITE DIVERSITY (2010 & 2013)	1		1		4		3?		1?		0	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	37 (6630)		38 (6631)		39 (6632)		40 (6633)		41 (6636)		42 (6637)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	-	-	-			-	-	-		-	-
**Cipangopaludina chinensis malleata*	-	-	-	-			-	-	-		-	X
°***Amnicola* n. sp. 1**	-	-	-	-			-	-	-		-	-
°***Fluminicola* n. sp.**	-	-	-	-			-	-	-		-	-
°***Colligyrus* n. sp. 9**	-	-	-	-			-	-	-		-	-
**Potamopyrgus antipodarum*	-	-	-	-			-	-	-		-	-
°***Pristinicola hemphilli***	-	-	-	-			-	-	-		-	-
°***Juga silicula***	-	-	X	X			-	-	-		-	-
Fossaria (F.) modicella	-	-	-	-			-	-	-		-	-
Physella (P.) gyrina	X	-	-	-			X	-	X		X	X
Gyraulus (T.) parvus	-	X	-	-			X	-	X		-	-
Menetus (M.) callioglyptus	-	-	-	-			-	-	-		-	X
Planorbella (P.) subcrenatum	-	-	-	-			X	-	-		-	-
Ferrissia californica	-	-	-	-			-	-	-		-	-
Oxyloma sp.	-	-	-	-			-	-	-		-	-
Anodonta oregonensis	-	-	-	-			-	-	-		-	-
Sphaerium patella	-	-	-	-			-	-	-		-	-
Musculium raymondi	-	-	-	-			-	-	-		-	-
Musculium securis	-	-	-	-			X	X	-		-	-
Pisidium (C.) casertanum	-	-	-	-			-	-	-		-	-
Pisidium (C.) variabile	-	-	-	-			X	X	-		-	-
°*Pisidium (N.) insigne*	-	-	-	-			-	-	-		-	-
Pisidium sp.	-	-	-	-			-	-	-		-	-
Sphaeriid indet.	-	-	-	-			-	-	-		-	-
**Corbicula fluminea*	-	-	-	-			-	-	-		-	-
SPECIES OF CONCERN	0	0	1	1	0	0	0	0	0	0	0	0
COLD-WATER SPECIES	0	0	1	1	0	0	0	0	0	0	0	0
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	0	0	0	1
SITE DIVERSITY BY YEAR	1	1	1	1	0	0	5	2	2	0	1	3
TOTAL SITE DIVERSITY (2010 & 2013)	2		1		0		5		2		3	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	43 (6638)		44 (6649)		45 (6640)		46 (6641)		47 (6642)		48 (6643)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	-	-	-	-	-	-	-	-	-	-	-
**Cipangopaludina chinensis malleata*	X	X	X	X	X	X	X	X	-	-	-	-
°***Amnicola* n. sp. 1**	-	-	-	-	-	-	-	-	-	-	-	-
°***Fluminicola* n. sp.**	-	-	-	-	-	-	-	-	-	-	-	-
°***Colligyrus* n. sp. 9**	-	-	-	-	-	-	-	-	-	-	-	-
**Potamopyrgus antipodarum*	-	-	-	-	-	-	-	-	-	-	-	-
°***Pristinicola hemphilli***	-	-	-	-	-	-	-	-	-	-	-	-
°***Juga silicula***	-	-	-	-	-	-	-	-	X	X	X	X
Fossaria (F.) modicella	-	-	-	-	-	-	-	-	-	-	-	-
Physella (P.) gyrina	X	-	-	-	X	X	-	-	-	-	-	-
Gyraulus (T.) parvus	-	-	-	-	X	X	-	-	-	-	-	-
Menetus (M.) callioglyptus	-	-	-	-	-	-	-	X	-	-	-	-
Planorbella (P.) subcrenatum	X	X	-	-	-	-	-	-	-	-	-	-
Ferrissia californica	-	-	-	-	-	-	-	-	-	-	-	-
Oxyloma sp.	-	-	-	-	-	-	-	-	-	-	-	-
BIVALVES												
Anodonta oregonensis	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerium patella	-	-	-	-	-	-	-	-	-	-	-	-
Musculium raymondi	-	-	-	-	X	-	X	X	-	-	-	-
Musculium securis	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium (C.) casertanum	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium (C.) variabile	-	-	-	-	-	-	-	-	-	-	-	-
°*Pisidium (N.) insigne*	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium sp.	-	-	-	-	-	-	-	-	-	-	-	-
Sphaeriid indet.	-	-	-	X	-	-	-	-	-	X	-	-
**Corbicula fluminea*	-	-	-	-	-	-	-	-	-	-	-	-
SPECIES OF CONCERN	0	0	0	0	0	0	0	0	1	1	1	1
COLD-WATER SPECIES	0	0	0	0	0	0	0	0	1	1	1	1
INTRODUCED SPECIES	1	1	1	1	1	1	1	1	0	0	0	0
SITE DIVERSITY BY YEAR	3	2	1	2?	4	3	2	3	1	2	1	1
TOTAL SITE DIVERSITY (2010 & 2013)	3		2?		4		3		2		1	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	49 (6644)		50 (6645)		51 (6646)		52 (6647)		53 (6648)		54 (6649)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	\	-	-	-	-		-	-	-	-	-
**Cipangopaludina chinensis malleata*	-	\	X	X	X	X		-	-	-	-	-
°***Amnicola* n. sp. 1**	-	\	-	-	-	-		-	-	-	-	-
°***Fluminicola* n. sp.**	-	\	-	-	-	-		-	-	-	X	X
°***Colligyrus* n. sp. 9**	-	\	-	-	-	-		-	-	-	-	-
**Potamopyrgus antipodarum*	-	\	-	-	-	-		-	-	-	-	-
°***Pristinicola hemphilli***	X	\	-	-	-	-		-	-	-	-	-
°***Juga silicula***	-	\	-	-	-	-		-	X	X	X	X
Fossaria (F.) modicella	-	\	-	-	-	-		-	-	-	-	-
Physella (P.) gyrina	-	\	-	X	-	-		-	-	-	-	X
Gyraulus (T.) parvus	-	\	-	-	-	-		-	-	-	-	-
Menetus (M.) callioglyptus	X	\	-	-	-	-		-	-	-	-	-
Planorbella (P.) subcrenatum	-	\	-	-	-	-		-	-	-	-	-
Ferrissia californica	-	\	-	-	-	-		-	-	-	-	-
Oxyloma sp.	-	\	-	-	-	-		-	-	-	-	-
BIVALVES												
Anodonta oregonensis	-	-	-	-	-	-		-	-	-	-	-
Sphaerium patella	-	\	-	-	-	-		-	-	-	-	-
Musculium raymondi	-	\	-	-	-	-		-	-	-	-	-
Musculium securis	-	\	-	-	-	-		-	-	-	-	-
Pisidium (C.) casertanum	-	\	-	-	-	-		-	-	-	-	-
Pisidium (C.) variabile	-	\	X	-	-	-		-	-	-	-	-
°*Pisidium (N.) insigne*	X	\	-	-	-	-		-	-	-	-	-
Pisidium sp.	-	\	-	-	-	-		-	-	-	X	-
Sphaeriid indet.	-	\	X	X	-	X		X	-	-	-	X
**Corbicula fluminea*	-	\	-	-	-	-		-	-	-	-	-
SPECIES OF CONCERN	1	\	0	0	0	0	0	0	1	1	2	2
COLD-WATER SPECIES	2	\	0	0	0	0	0	0	1	1	2	2
INTRODUCED SPECIES	0	\	1	1	1	1	0	0	0	0	0	0
SITE DIVERSITY BY YEAR	3	\	2?	3?	1	2?	0	1?	1	1	3?	4?
TOTAL SITE DIVERSITY (2010 & 2013)	3		3?		2?		1?		1		4?	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	55 (6650)		56 (6651)		57 (6652)		58 (6653)		59 (6654)		60 (6655)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	-		-	-	\	-	-	-	-	-	-
**Cipangopaludina chinensis malleata*	-	-		-	-	\	-	-	-	-	-	-
°***Amnicola* n. sp. 1**	-	-		-	-	\	-	-	-	-	-	-
°***Fluminicola* n. sp.**	X	O		-	-	\	-	-	-	-	-	-
°***Colligyrus* n. sp. 9**	-	-		-	-	\	-	-	-	-	-	-
**Potamopyrgus antipodarum*	-	X		-	-	\	-	-	-	-	-	-
°***Pristinicola hemphilli***	-	-		-	-	\	-	-	-	-	-	-
°***Juga silicula***	-	-		-	-	\	-	-	-	-	-	-
Fossaria (F.) modicella	-	-		-	-	\	-	-	-	-	-	-
Physella (P.) gyrina	-	-		-	X	\	-	-	-	-	X	-
Gyraulus (T.) parvus	-	-		X	-	\	-	-	-	-	-	-
Menetus (M.) callioglyptus	-	-		-	-	\	-	-	-	-	-	-
Planorbella (P.) subcrenatum	-	-		-	-	\	-	-	-	-	-	-
Ferrissia californica	X	-		-	-	\	-	-	-	-	-	-
Oxyloma sp.	-	-		-	-	\	-	-	-	-	-	-
BIVALVES												
Anodonta oregonensis	-	-		-	-	-	-	-	-	-	-	-
Sphaerium patella	-	-		-	-	\	-	-	-	-	-	-
Musculium raymondi	-	-		-	-	\	-	-	-	-	-	-
Musculium securis	-	-		-	-	\	-	-	-	-	-	-
Pisidium (C.) casertanum	-	-		-	-	\	-	X	X	X	-	-
Pisidium (C.) variabile	-	-		-	-	\	-	-	-	-	-	-
°*Pisidium (N.) insigne*	-	-		-	-	\	-	-	-	-	-	-
Pisidium sp.	-	-		-	-	\	-	-	-	-	-	-
Sphaeriid indet.	-	X		-	-	\	X	-	-	-	-	-
**Corbicula fluminea*	-	-		-	-	\	-	-	-	-	-	-
SPECIES OF CONCERN	1	1	0	0	0	\	0	0	0	0	0	0
COLD-WATER SPECIES	1	1	0	0	0	\	0	0	0	0	0	0
INTRODUCED SPECIES	0	1	0	0	0	\	0	0	0	0	0	0
SITE DIVERSITY BY YEAR	2	3?	0	1	1	\	1?	1	1	1	1	0
TOTAL SITE DIVERSITY (2010 & 2013)	3?		1		1		1		1		1	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	61 (6656)		62 (6657)		63 (6658)		64 (6659)		65 (6660)		66 (6661)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**					-	-			-	-	-	-
**Cipangopaludina chinensis malleata*					-	-			-	-	-	-
°***Amnicola* n. sp. 1**					-	-			-	-	-	-
°***Fluminicola* n. sp.**					-	-			-	-	-	-
°***Colligyrus* n. sp. 9**					-	-			-	-	-	-
***Potamopyrgus antipodarum*					-	-			-	-	-	-
°***Pristinicola hemphilli***					-	-			-	-	-	-
°***Juga silicula***					-	-			X	X	X	X
Fossaria (F.) modicella					-	-			-	-	-	-
Physella (P.) gyrina					-	X			-	-	-	-
Gyraulus (T.) parvus					-	X			-	-	-	-
Menetus (M.) callioglyptus					-				-	-	-	-
Planorbella (P.) subcrenatum					X	X			-	-	-	-
Ferrissia californica					-	-			-	-	-	-
Oxyloma sp.					-	-			-	-	-	-
BIVALVES												
Anodonta oregonensis					-	-			-	-	-	-
Sphaerium patella					-	-			-	-	-	-
Musculium raymondi					-	-			-	-	-	-
Musculium securis					-	-			-	-	-	-
Pisidium (C.) casertanum					-	-			-	-	-	-
Pisidium (C.) variabile					X	X			-	-	-	-
°*Pisidium (N.) insigne*					-	-			-	-	-	-
Pisidium sp.					-	-			-	-	-	-
Sphaeriid indet.					-	-			-	-	-	-
**Corbicula fluminea*					-	-			-	-	-	-
SPECIES OF CONCERN	0	0	0	0	0	0	0	0	1	1	1	1
COLD-WATER SPECIES	0	0	0	0	0	0	0	0	1	1	1	1
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	0	0	0	0
SITE DIVERSITY BY YEAR	0	0	0	0	2	4	0	0	1	1	1	1
TOTAL SITE DIVERSITY (2010 & 2013)	0		0		4		0		1		1	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	67 (6662)		68 (6663)		69 (6664)		70 (6665)		71 (6666)		72 (6667)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	-							-	-	-	
**Cipangopaludina chinensis malleata*	-	-							-	-	-	
°***Amnicola* n. sp. 1**	-	-							-	-	-	
°***Fluminicola* n. sp.**	-	-							-	-	-	
°***Colligyrus* n. sp. 9**	-	-							-	-	-	
**Potamopyrgus antipodarum*	-	-							-	-	-	
°***Pristinicola hemphilli***	-	-							-	-	-	
°***Juga silicula***	-	-							X	X	-	
Fossaria (F.) modicella	-	-							-	-	-	
Physella (P.) gyrina	X	X							-	-	X	
Gyraulus (T.) parvus	X	-							-	-	-	
Menetus (M.) callioglyptus	-	-							-	-	-	
Planorbella (P.) subcrenatum	-	-							-	-	-	
Ferrissia californica	-	-							-	-	-	
Oxyloma sp.	-	-							-	-	-	
BIVALVES												
Anodonta oregonensis	-	-							-	-	-	
Sphaerium patella	-	-							-	-	-	
Musculium raymondi	X	X							-	-	-	
Musculium securis	-	-							-	-	-	
Pisidium (C.) casertanum	-	-							-	-	-	
Pisidium (C.) variabile	-	-							-	-	-	
°*Pisidium (N.) insigne*	-	-							-	-	-	
Pisidium sp.	-	-							-	-	-	
Sphaeriid indet.	-	-							-	-	-	
**Corbicula fluminea*	-	-							-	-	-	
SPECIES OF CONCERN	0	0	0	0	0	0	0	0	1	1	0	0
COLD-WATER SPECIES	0	0	0	0	0	0	0	0	1	1	0	0
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	0	0	0	0
SITE DIVERSITY BY YEAR	3	2	0	0	0	0	0	0	1	1	1	0
TOTAL SITE DIVERSITY (2010 & 2013)	3		0		0		0		1		1	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	73 (6668)		74 (6669)		75 (6670)		76 (6671)		77 (6672)		78 (6673)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**			-	-	-	-		-	-	-		
**Cipangopaludina chinensis malleata*			-	-	-	-		-	-	-		
°***Amnicola* n. sp. 1**			-	-	-	-		-	-	-		
°***Fluminicola* n. sp.**			-	-	X	X		-	-	-		
°***Colligyrus* n. sp. 9**			-	-	-	-		-	-	-		
***Potamopyrgus antipodarum**			-	-	-	-		-	-	-		
°***Pristinicola hemphilli***			-	-	-	-		-	-	-		
°***Juga silicula***			-	-	X	X		X	-	-		
Fossaria (F.) modicella			-	-	-	-		-	-	-		
Physella (P.) gyrina			-	-	-	-		-	-	-		
Gyraulus (T.) parvus			-	-	-	-		-	-	-		
Menetus (M.) callioglyptus			-	-	-	-		-	-	X		
Planorbella (P.) subcrenatum			-	-	-	-		-	-	-		
Ferrissia californica			-	-	-	-		-	-	-		
Oxyloma sp.			-	-	-	-		-	-	-		
BIVALVES												
Anodonta oregonensis			-	-	-	-		-	-	-		
Sphaerium patella			-	-	-	-		-	-	-		
Musculium raymondi			X	X	-	-		-	-	-		
Musculium securis			-	-	-	-		-	-	-		
Pisidium (C.) casertanum			-	-	-	-		-	-	-		
Pisidium (C.) variabile			-	-	-	-		-	-	-		
°*Pisidium (N.) insigne*			-	-	-	-		-	-	-		
Pisidium sp.			-	-	-	-		-	-	-		
Sphaeriid indet.			-	-	-	-		-	X	X		
**Corbicula fluminea*			-	-	-	-		-	-	-		
SPECIES OF CONCERN	0	0	0	0	2	2	0	1	0	0	0	0
COLD-WATER SPECIES	0	0	0	0	2	2	0	1	0	0	0	0
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	0	0	0	0
SITE DIVERSITY BY YEAR	0	0	1	1	2	2	0	1	1?	2?	0	0
TOTAL SITE DIVERSITY (2010 & 2013)	0		1		2		1		2?		0	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS											
	79 (6674)		80 (6675)		81 (6676)		82 (6677)		83 (6678)		84 (6679)	
	YEAR COLLECTED											
	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013	2010	2013
GASTROPODS												
°***Valvata* n. sp. 2**	-	-	-	-	-	-	-	-	X	-	-	-
**Cipangopaludina chinensis malleata*	-	-	-	-	-	-	-	-	X	X	-	-
°***Amnicola* n. sp. 1**	-	-	-	-	-	-	-	-	X	X	-	-
°***Fluminicola* n. sp.**	-	-	X	X	-	-	-	-	-	-	-	-
°***Colligyrus* n. sp. 9**	-	-	-	-	-	-	-	-	-	-	-	-
**Potamopyrgus antipodarum*	-	-	-	-	-	-	-	-	-	-	-	-
°***Pristinicola hemphilli***	-	-	-	-	-	-	-	-	-	-	-	-
°***Juga silicula***	O	O	X	X	-	-	-	-	-	-	X	X
Fossaria (F.) modicella	-	-	-	-	-	-	-	-	-	-	-	-
Physella (P.) gyrina	X	X	-	-	X	X	X	X	X	X	X	X
Gyraulus (T.) parvus	X	-	-	-	X	-	-	-	X	X	-	-
Menetus (M.) callioglyptus	-	-	-	-	-	-	-	-	X	X	-	-
Planorbella (P.) subcrenatum	X	-	-	-	X	X	X	X	X	X	X	X
Ferrissia californica	-	-	-	-	-	-	-	-	X	X	-	-
Oxyloma sp.	-	-	-	-	-	X	X	-	X	X	-	-
BIVALVES												
Anodonta oregonensis	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerium patella	-	-	-	-	-	-	-	-	-	-	-	-
Musculium raymondi	-	-	-	-	X	X	-	-	X	X	X	-
Musculium securis	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium (C.) casertanum	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium (C.) variabile	-	-	-	-	-	-	-	-	-	-	-	-
°*Pisidium (N.) insigne*	-	-	-	-	-	-	-	-	-	-	-	-
Pisidium sp.	X	X	-	-	-	-	-	-	-	-	X	-
Sphaeriid indet.	-	-	-	-	-	-	X	-	-	-	-	X
**Corbicula fluminea*	-	-	-	-	-	-	-	-	-	-	-	-
SPECIES OF CONCERN	1	1	2	2	0	0	0	0	2	1	1	1
COLD-WATER SPECIES	1	1	2	2	0	0	0	0	2	1	1	1
INTRODUCED SPECIES	0	0	0	0	0	0	0	0	1	1	0	0
SITE DIVERSITY BY YEAR	5?	3?	2	2	4	4	4?	2	10	9	5?	4?
TOTAL SITE DIVERSITY (2010 & 2013)	5?		2		5		4?		10		5?	

TABLE 1. SITE FAUNAL LISTS OF MOLLUSKS FOUND WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

TAXON NAME	SITE (LOCALITY) NUMBERS				TOTAL SITE OCCUR-ENCES (2010)	TOTAL SITE OCCUR-ENCES (2013)
	85 (6682)		86 (6761)			
	YEAR COLLECTED					
	2010	2013	2011	2013		
GASTROPODS						
°***Valvata* n. sp. 2**	-	-			1	1
**Cipangopaludina chinensis malleata*	-	-			7	8
°***Amnicola* n. sp. 1**	-	-			1	1
°***Fluminicola* n. sp.**	-	-			5	5
°***Colligyrus* n. sp. 9**	-	-			0	1
****Potamopyrgus antipodarum***	-	-			0	1
°***Pristinicola hemphilli***	-	-			1	1
°***Juga silicula***	X	X			25	29
Fossaria (F.) modicella	-	-			1	1
Physella (P.) gyrina	-	-			22	26
Gyraulus (T.) parvus	-	-			9	12
Menetus (M.) callioglyptus	-	-			4	9
Planorbella (P.) subcrenatum	-	-			13	13
Ferrissia californica	-	-			2	2
Oxyloma sp.	-	-			3	3
BIVALVES						
Anodonta oregonensis	-	-			0	1
Sphaerium patella	-	-			1	1
Musculium raymondi	-	-			8	8
Musculium securis	-	-			1	2
Pisidium (C.) casertanum	-	-			1	2
Pisidium (C.) variabile	-	-			3	3
°*Pisidium (N.) insigne*	-	-			1	2
Pisidium sp.	-	-			4	4
Sphaeriid indet.	-	-			6	14
****Corbicula fluminea***	-	-			1	3
SPECIES OF CONCERN	1	1	0	0	28	33
COLD-WATER SPECIES	1	1	0	0	28	33
INTRODUCED SPECIES	0	0	0	0	6	12
SITE DIVERSITY BY YEAR	1	1	0	0	59	57
TOTAL SITE DIVERSITY (2010 & 2013)	1		0		65	

APPENDIX D: LIST OF WATERBODIES SHOWN ON USGS 7.5' MAP WITHIN A 5-MILE RADIUS OF CAPITOL LAKE.

For localities collected during this survey see **Appendix A** and for site maps see **Appendix B.**

TABLE 2. WATERBODIES SHOWN ON USGS 7.5' MAP WITHIN A 5-MILE RADIUS OF CAPITOL LAKE.

WATERBODY	COMMENTS
NW Quarter	
Springs sec. 62, T18N R2W, W. side of West Bay	From driveway to houses off Crestline Blvd NW. Not sampled, could not obtain permission.
Green Cove Creek	Kaiser Rd NW (3 crossings), sampled only at N. crossing; sampled at 36th Ave NW and Green Cove St. NW crossings.
Source spring of unnamed cr. sec. 33, T18N R2W, W. side of West Bay above Little Tykle Cove	Spring along private driveway off Cooper Pt. Rd. NW. Spring destroyed. Sampled with owners permission.
Unnamed Cr. sec. 33, T18N R2W, W. side of West Bay above Little Tykle Cove	Creek along private driveway. Sampled with owners permission.
Unnamed cr. at Butler Cove	Sampled off French Rd. NW.
Unnamed trib. of Green Cove Cr.	Sampled at 28th Ave NW.
Unnamed Lake sec. 62, T18N, R2W	Off Division St NW. Private lake. Due to presences of livestock, sampled connecting pond S. of lake with owners permission
Louise Lake near Kaiser Rd. NW & 14th Ave NW intersection	Off Kaiser Rd. NW but access good by trail. Private lake.
Grass Lake near 14th Ave NW and Cooper Point Rd NW intersection	No road access. Public lake. Not sampled because of no access.
Simmons Lake E. of Lakemoor Dr. SW	Private lake. Access from two private beaches granted by homeowners association.
Allison Springs W. of Mclane School	Sampled off Allison Springs Lane NW. Access granted by City of Olympia Public Works Dept.
Unnamed lake at Canning Ct SW	Off Canning Ct SW
Schneider Creek W. of West Bay	Examined at Bowman Ave NW, cr. dry; access elsewhere to cr. could not be obtained.
Unnamed marsh sec. 32 T18N R2W; sampled off 36th Ave NW.	Sampled off 36th Ave NW.
Perry Cr lake sec 13, T18N R3W.	Perry Cr Rd SW. Private lake, permission not granted.
Unnamed trib. to Perry Cr.	Sampled off SW 2nd Ave.

TABLE 2. WATERBODIES SHOWN ON USGS 7.5' MAP WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

WATERBODY	COMMENTS
NE Quarter	
Marsh at North Olympia	Off 46th Ave NE, not sampled.
Ellis Creek	Boston Harbor Rd NW, no pull off, not sampled; Gull Harbor Rd NW, deep ravine, no easy access, not sampled; 33rd Ave NE, sampled from house on W. side of cr. with owners permission; sampled off 36th Ave NE on S. side.
Mission Creek SE of Ellis Cove	E Bay Dr NE, not sampled; Bethel St NE, not sampled; Miller Ave NE, sampled on S. side; Etheridge Ave NE, sampled on S. side.
Marsh N. of South Bay	Private marsh sampled off Chehalis Western Trail with owners permission.
Ponds E. of South Bay	Possibly 2 of 3 can be accessed from driveway off Sleater Kinney Rd NE; private; not sampled
Marsh S. of South Bay	W. side of Lily Rd NE, private, could not find access or permission
Woodard Creek	Martin Way E, sampled on S. side; Ensign Rd NE, sampled on S. side; not sampled at Lindell Rd NE; S. Bay Rd NE, sampled near house with owners permission; not sampled at 28th Ln NE; Sampled off 36th Ave NE at USGS gauging station.
Woodland Creek tributary	Jorgenson Rd NE, not sampled.
Woodland Creek (upper part only)	Sampled off Martin Way E; Carpenter Rd SE
Unnamed lake head of Woodard Creek	Sampled off Dayton St SE
Indian Creek	Frederick St SE, sampled on S. side; Wheeler Ave, not sampled; 12 Ave SW, sampled on S. side; Eastside St SE, not sampled; Boulevard Rd SE; Pacific Ave SE; Martin Way E, sampled on N. side; 8th Ave NE, not sampled; 12th Ave NE, not sampled.
Bigelow Lake (head of Indian Creek)	No road access. Private lake, permission denied
Setchfield Lake S. of Rogers School	No road access. Private lake. Not sampled
Unnamed marsh E. of St. Peters Hospital	Off Ensign Rd NE. Sampled off Chehalis Western Trail.
3 unnamed kettles lakes NE of Pleasant Glade School	1 from Palm Rd NE, unable to find permission for access. Not sampled.

TABLE 2. WATERBODIES SHOWN ON USGS 7.5' MAP WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

WATERBODY	COMMENTS
SE Quarter	
Moxlie Creek in Watershed Trail Park	Via trails. One site sampled
Hazard Lake	Hawthorn Pl. SE; collected from Monta Vista St. SE. Private lake.
Unnamed kettle pond NW of Hazard Lake in park	Trail to pond accessed off Hoadly St. SE. One site sampled.
Ward Lake	42nd Ave SE; Lakewood Dr SE, site access at private beach; also collected at State boat ramp
Hewitt Lake	Laura St SE, permission granted by homeowner, one site sampled.
Swan Lake	Susan Ct SE; could not find access or permission.
Munn Lake	State boat ramp (1 site sampled)
Trails End Lake	Trail's End Ln off 73rd Ave SE; private lake in summer camp, unable to find permission.
Unnamed Lake W. of Trails End Lake	73rd Ave SE; permission not granted.
Deschutes River downstream of Rich Rd SE crossing	Tumwater Falls Park (1 site); Pioneer Park (1 site); Tumwater Historical Park (1 site).
Chambers Lake	1 site collected at public boat ramp.
Unnamed creek draining from Chambers Lake	Not collected. Herman Rd SE; 40th Ave SE; Fuller Ln SE; Wilderness Drive SE; Donnelly Dr SE; Yelm Hwy SE; 57th Ave SE
Unnamed creek draining from Chambers Prairie	Rainier Rd SE; Rich Rd SE, not sampled
Smith Lake	Viewridge Dr SE. Private lake, could not find access.
Unnamed lake W. of Smith Lake	Rd off of Fuller Ln SE. Private lake, not sampled.
Unnamed lake S. of Smith Lake	Kinsale Ln SE; Prestwick Ln SE. Private lake which goes dry (Bartleson pers. comm., 2010), not sampled.
Unnamed pond E. of Smith Lake	Off Chehalis Western Trail, not sampled.
Southwick Lake	Crestwood Mobil Home Pk., no access to lake (fence).
Hicks Lake	37th Ln SE; 27th Ln; 27th Ln SE; Gwinn Ln SE off 25th Ave SE; Donegal Ct SE; Sampled from public boat ramp.
Unnamed lake N. of Hicks Lake	Shadywood Ct SE, not sampled.

TABLE 2. WATERBODIES SHOWN ON USGS 7.5' MAP WITHIN A 5-MILE RADIUS OF CAPITOL LAKE (cont.).

WATERBODY	COMMENTS
SW Quarter	
Barnes Lake	Sampled off Lake Park Dr SW.
Trosper Lake (source of Percival Creek)	Sampled with permission of homeowners association.
Percival Creek	54th Ave SW, sampled; 48th Ave SW, not sampled; Sapp Rd SW, sampled; Chapperel Dr SW not sampled; Somerset Hill Dr SW; S Puget Sound Community College; Mottman Rd SW; Cooper Point Rd SW, sampled.
Black Lake Ditch	Not sampled at 29th Ave SW; sampled at public access above RW Johnson Rd SW; sampled at bridge of Black Lake Belmore Rd SW
Black Lake	Kennydell Co. Pk (off Fairview Rd SW); Guerin Co. Pk (off Guerin St SW); Columbus Park (private)
McLane Creek	Delphi Rd SW (2 crossings; sampled at N. crossing at USGS gauging station); State Dept of Nat Res. maintains scenic walk upstream of Delphi Rd
Swift Creek	Delphi Rd SW; Cedar Flats Rd; Harmony Ln SW
Perry Creek (lower 0.25 mi. only)	Unnamed rd. adjacent to creek; could not get permission.
Marsh S. of Belmore	No road access
Marsh SW of Belmore	No road access
Unnamed cr. near Belmore	Belmore Rd SW; 66th Ave SW; Fairview Rd SW
Unnamed lake SE of Belmore	Rhondo St SW

APPENDIX E: MOLLUSKS AS BIOLOGICAL INDICATORS

INTRODUCTION

In many regards, mollusks are an especially practical group for use in assessing the general health of the aquatic ecosystem. They are present in some numbers in almost any environment. Certain species are eurytopic; however, many species are stenotopic and unusually sensitive to various kinds of disturbance or pollution. Most species respond quickly and obviously to disturbance. As almost all are relatively sessile and complete their life cycles in place, they are particularly convenient for site-specific assessments. Sampling procedures are relatively simple and can be readily quantified. As it happens, many of the Species of Special Concern would be readily useful indicator species (*e.g.*, the species of *Juga* and *Fluminicola*). Mollusk centers of diversity generally correlate well with those determined from other groups; examples are common from plants, fish, salamanders, and insects. Similarly, mollusk abundance tends to peak in particularly high diversity locales.

The presence of a number of local endemics makes mollusks of unusual biogeographic significance. As compared to insects, there are relatively few taxa, many are comparatively large, taxonomy and morphology are comparatively comprehensible and straightforward, and most can be easily identified. The shell of most is durable, making them both obvious and also quite likely to be preserved as fossils or subfossils. They are one-part animals, and most can be identified from the shell alone. The extensive fossil record of some provides a long-term background history unavailable with most groups. An extensive literature attempts to relate fossils to past and present climates, drainages, and large-scale geologic and ecological processes.

Most North American freshwater mollusk species are sensitive to pollution (Burch, 1989) regardless of source. Relatively few species tolerate warm waters, low dissolved oxygen, or major seasonal fluctuations. Certain pulmonates in the families Physidae, Lymnaeidae, and Planorbidae and some sphaeriid species are major exceptions. Most native Pacific Coast forms, however, are cold-water stenotherms. Such species prefer permanent clear and cold, unpolluted waters with dissolved oxygen (DO) levels near saturation. The cold-water forms are quite sensitive to hypoxic or anoxic conditions, in either the water column or substrate: again, certain lymnaeids and sphaeriids and a few unionaceans are the major exceptions. Very few clams or snails can tolerate algal blooms or dense macrophyte stands; they avoid or are excluded from areas with major diurnal DO fluctuations.

Substrate is a major factor influencing both diversity and abundance in freshwater mollusk communities (Harman, 1972). In the Pacific Northwest, the majority of short-range or endemic taxa are those preferring coarse substrate, such as gravel, boulders, or cobbles. A few of such taxa are limited to soft substrate (e.g., *Valvata*); but in these cases, mostly to oxygenated soft substrate, a habitat in short supply in polluted circumstances. A major feature of human-related activities in the Pacific Northwest is that nearly all lead to increased fine-particle runoff, inimical to the majority of native mollusks, which are perilithon grazers and lithophiles. Among such are dams and impoundments; grazing; logging; and road and domicile construction.

Given the foregoing, many Pacific Coast freshwater mollusk species can accurately be characterized overall as stenotopic (more specifically as cold-water stenotherms). These species in particular can be quite vulnerable to major disturbance events, due to certain features of their life history. Annual population turnover in most freshwater mollusk species is considerable, and many breed only once, generally in a well-defined and short season. In disturbed streams, mollusks may be disproportionately affected. This often makes them particularly effective bioindicators of pollution and other forms of environmental disturbance.

Generally, increase in siltation, decrease in flow, nutrient enrichment, pollution, dredging or other channel alterations, and damming or other flow impediments are likely to extirpate the more sensitive species. Most of the endemic or geographically restricted species discussed here prefer unpolluted, swift-flowing, clear, cold, well-oxygenated water. Level bottom and gravel-boulder substrate with relatively little rooted vegetation is also preferable for most. Families such as the Hydrobiidae (especially the Hydrobiinae, Amnicolinae, Nymphophylinae, and Lithoglyphinae), Pleuroceridae, and Lancidae are essentially restricted to such habitats. In some cases the reason is clearly physiological; the Lancidae, *e.g.*, lack lungs and gills. Sites with mobile substrate, seasonal siltation, warm water, glacial flour, or impoundments have low diversity and few if any endemics or sensitive species. Many of the described freshwater taxa are found mostly at low to middle elevations in streams and springs; there are a few lake endemics in this region. Destruction of springs by grazing, logging, and human exploitation (troughing or capping for stock use; diversion for human [water supply, fish hatcheries] or stock use) has already caused extensive extinction of species throughout western North America. In general, few of the cold-water species can live in impoundments; nor can they tolerate eutropification. As most are obligate perilithon grazers and require stable substrate, siltation (such as that resulting from clear-cutting) generally means loss of habitat and at least local extirpation. Many taxa respond negatively to increases in water temperature, such as caused by increased insolation from removal of vegetation. Many freshwater mollusk species face habitat loss or degradation from a combination of human actions operating simultaneously.

Freshwater mollusks are used extensively in the eastern and central parts of the U. S. as biological indicators and to monitor physical and chemical, as well as biotic changes of waters. Examples include Clarke (1979a, b) for freshwater gastropods. Bivalves have been used regularly to study uptake of various organic and inorganic pollutants, and are among the most sensitive organisms for such purposes; reviews include Fuller (1974), Imlay (1982) and McMahon (1991).

JUGA AS AN INDICATOR OF STREAM HEALTH

Juga can comprise more than 90% of the invertebrate biomass in some streams (Hawkins & Furnish, 1987), and similar dense occurrences may have been standard in undisturbed aquatic habitats in the region. As a result they can serve as a good biological indicator in the Pacific Northwest. They can be more widespread than “large” *Fluminicola* (also a good indicator genus), which generally occurs in rivers and large streams.

During 2010 and this survey, no quantative or water quality measurements were taken. As a result, only presence or absence of *Juga* and other mollusks, relative abundance of *Juga*, condition of the substrate (*e.g.*, anoxic vs. oxygenated mud), macrophyte community, density of algae, and visual water condition was used.

Below are stream observations and conditions using *Juga* as 1 indicator. Some changes noted this year vs. 2010 are the occurrence of *Juga* at sites in where it was not found previously (1 upper and lowest site in Green Cove Creek drainage; 1 upper site in Ellis Creek; and 1 upper site in Fish Pond Creek). This shows that *Juga* has the ability to rapidly reinvade habitat that was not available to it in the recent past or in stream stretches where it was swept out by a flood event.

STREAM CONDITIONS

Black Lake Drainage Ditch

Black Lake Drainage Ditch was built in 1922-23 by Thurston County to control flooding and regulate Black Lake level in conjunction with a bridge project at the north end of the lake. In 1952, the County deepened the Black Lake Drainage Ditch eight feet below bedrock. *Juga* was found to be common at both sites sampled in this man-made stream, one site near its origin at Black Lake and the other near its confluence with Percival Creek. *Juga* were not found in Black Lake near the mouth of Black Lake Drainage Ditch. Despite its inablility to live in Black Lake, *Juga* are able to survive in this large ditch (more like a creek) even though the source of the water is Black Lake. Has a very diverse macrophyte flora at the upper site including introduced species.

Black Lake east side tributary creek

One site was collected in this creek, which is almost as good as the *Juga* site on Fish Pond Creek. *Juga* moderately common.

Butler Cove unnamed creeks

Three sites were collected in this drainage. Common *Juga* was collected at site 31 from the west tributary creek and was uncommon at site 32 from the east tributary creek. Upper part of the east tributary has been made into an artificial lake and pond (site 33) that may impact water quality and temperature and may be a possible reason *Juga* is uncommon here. The east tributary is more incised and may be more prone to flooding than the west tributary. Substrate is also coarser in the east tributary than in the west.

Deschutes River

Three sites were collected in this drainage. Only the upper two sites had both common *Juga* and less common *Fluminicola* present, lower site had only very rare *Fluminicola* present. It is interesting to note that the stretch of river with very rare *Fluminicola* occurs below a fish hatchery and industrial facilities, which include a brewery.

Ellis Creek

Two sites were collected in this drainage. Creek mostly flows through a heavily wooded residential area. Very rare *Juga* were only found at the lower site (53). Lower site has good flow with excellent water quality, silt and cobble substrate and no macrophytes of any kind. Upper site (76) had no mollusks in 2010 but *Juga* is now somewhat commonly present in 2013. Water is tea colored because of the presence of tannins in 2010 but less

so in 2013. Beaver dam above the site in 2010 is no longer present. The lower part of Ellis Creek still has the best water quality.

Fish Pond Creek

A total of 3 sites were collected in this drainage. The 2 lower sites were found to have *Juga* present with none found in the upper most site in 2010. In 2013 all 3 sites were found to have *Juga* present. Very abundant *Juga* were collected at the downstream site (15). This was one of the best sites collected during this project. Creek has moderate velocity and excellent water quality (spring or ground water influence). This is much better than that seen in the upper drainage. Substrate mostly cobble with some silt. Upper part of the drainage at site 20 had no mollusks present in 2010 and just a few were collected in 2013. Flow was slow and substrate was deep mud that was somewhat anoxic in 2010. This creek is mostly flowing through wetland habitat in its upper part.

Indian Creek

A total of 3 sites were collected. Indian Creek had mollusks only in its middle reach at site 47. This section of the creek has moderate flow rate and silt-cobble substrate with abundant *Juga*. Well shaded by forests along both banks. Water quality looks good. Lower reach (site 52) is in an urban area of Olympia. This part of the creek has slow flow with poor water quality (scum floating on surface) and sedimentation problems. The upper reach at site 70 above Martin Way E. has been straightened (channelized) and creek is much smaller than at site 47. Flow is moderate. Source is Biglow Lake, which really is a marsh. Water quality improves (from groundwater) enough from source to the middle stretch of creek to supports *Juga*. Below this site water quality degrades again due to urbanization.

Green Cove Creek

A total of 5 sites were collected in this drainage, but *Juga* were found only at 1 site (28) at 36th Ave NW, about the middle part of the creeks drainage in 2010. No mollusks were found downstream and widespread and pollution tolerant mollusks were found upstream. In 2013 *Juga* was found at 1 upper drainage site (34) and 1 lower site (27) where they were not found in 2010. Below site 28 the gradient of the creek increases and it enters forested ravine which confines the creek until it reaches Green Cove. It is possible the creek becomes too flashy in its discharge downstream flushing *Juga* downstream to the cove. This may explain why *Juga* were not found at site 27 in 2010 but was relatively common there in 2013. Site 28 seems to have a stable cobble substrate while site 27 downstream of it seems to have less stable cobble substrate. Springs were noted near the sites 27 and 28. The sites upstream of sites 27 and 28 had mud substrate and flow was slow. Source is Louis Lake and Grass Lake. Lois Lake had only *Physella* present.

McLane Creek

One of 2 creeks found with both *Juga* and *Fluminicola* present during this survey. *Juga* were more common than *Fluminicola*. Medium-sized creek with mostly sand but ranged from silt to cobble substrate in

areas and water quality looked good. McLane Creek originates in the Black Hills. It is quite possible that both *Juga* and *Fluminicola* occur a fair distance upstream from the collecting site. Swift Creek (see below) is major tributary of this creek, which only had *Juga* present.

Mission Creek

Two sites were collected in the upper part of this drainage. No mollusks were found at either site despite relatively good water quality and stable cobble substrate. It is a mystery as to why *Juga* were not found in this drainage. Despite being in the City of Olympia, the source area is undeveloped and large part of the creek corridor is mostly in public (city) ownership and kept as a wooded park that is not developed. It is possible that *Juga* could occur in the lower part of this drainage. Despite being in an urban area, creek looks good despite the lack of *Juga*.

Moxlie Creek

Only 1 site was collected in this drainage. Excellent water quality due to heavy spring and groundwater influence. *Juga* was common in this creek. Substrate mostly sand. Coldest creek collected during this survey.

Percival Creek

Four sites were collected in this drainage. Source at Trosper Lake only had a depauperate mollusk fauna. All 3 creek sites had common to abundant *Juga* present and water quality looks good. This creek seemed to be in good condition.

Swift Creek

Only one site collected. *Juga* may be very uncommon due to an unstable substrate. Headwaters in the Black Hills.

Woodland Creek

A total of 15 sites were collected in this complex drainage (most from lakes). Five were collected from creeks. Source of creek is Hicks Lake, which is connected to Pattison, Long, and Lois lakes by intervening creeks. *Juga* occurs in the mid to lower reaches of Woodland Creek at Draham and Pleasant Glade roads and in the creek flowing between Pattison and Long lakes. The creek bed is dry roughly from below Lois Lake to just below Martin Way E where it reemerges as a large spring at a fish hatchery. Water quality looks good below the spring and *Juga* are common to abundant at the 2 downstream sites. The *Juga* site in the creek connecting Pattison and Long lakes looks similar to the upper *Juga* site in Black Lake Drainage Ditch.

Woodward Creek

A total of 5 sites were collected in this drainage. Southern part (upper drainage) of the creek above Martin Way and below flows through highly developed area and the habitat is essentially marshes and wetlands. Flow was slow, water quality poor and substrate was mostly anoxic muds. *Juga* were found downstream at S. Bay Road NE. Creek had mud substrate, which was not anoxic. Both *Fluminicola* and *Juga* were found even

further downstream at 36th Ave NE. Substrate was mud to gravel substrate (with mostly sand). Water quality looked good in this area. Upper reaches of this creek are in poor condition but it improves downstream.

LAKE DIVERSITY AND CONDITION

The mean is about 3 native mollusk species for the 13 lakes surveyed during this project. Pattison Lake has the most species present (N=8). This higher diversity indicates a relatively healthy lake, as does the presence of the two Sensitive Species (*Amnicola* n. sp. 1 and *Valvata* n. sp. 2). The lake with the next most species present is Black Lake (N=6). This lake is fed by subsurface springs and by creeks with *Juga* present. *Juga* are also present in the outlet drainages for Black Lake. The absence of *Juga* in the lake is puzzling. Both Hewitt Lake and Lake Loise have a total of 5 species present. The presence of *Juga* dead only in Hewitt Lake may be explaned by introduction with planted trout (see *Juga (Juga) silicula* entry under **Native Mollusks**). Since Hewitt Lake is in an enclosed basin with no outlet or inflowing stream, it is unlikely it would support *Juga*. Lake Loise has creeks both flowing into and out of it, which keeps water quality up. All other lakes sampled range from 3 to 0 species present.

APPENDIX F: DISTRIBUTION OF WASHINGTON MOLLUSKS AND PLEISTOCENE GLACIATION

"Earth and life evolve together"

Croizat, 1962, p. 707

BACKGROUND

Glaciation during the Wisconsinan in the Puget Sound basin pushed freshwater mollusks as far south as the Chehalis River drainage during the maximum extent of the Puget Lobe of the Cordilleran Ice Sheet (Bretz, 1910, 1913; Crandell, 1965; Thorson, 1980; **Figure 13**). This adjacent basin served as a glacial refugium not only for terrestrial and freshwater mollusks, but also for freshwater fishes (e.g., *Novumbra hubbsi*), crustaceans and other taxa; some are either glacial freshwater or glaciomarine relicts (Johannes, 2010a, 2011d; McPhail, 1967; McPhail & Lindsey, 1986; Mongillo & Hallock, 1999; Segerstrale, 1971; **Figure 13** herein). As a result of the glaciation in the Puget Sound region, molluscan diversity is not evenly distributed from south to north across the region. As latitude increases molluscan diversity and in particular narrow range endemics (NRE) decrease significantly. Genera that contain NRE's such as *Juga*, *Fluminicola*, and *Colligyrus* are found in the southern Puget Sound region but were not known much further north (Henderson, 1929, 1936; Branson, 1977b, 1980; Branson & Barrett, 1981). Stream surveys conducted by Deixis Consultants, King County and other local governmental agencies during the last decades have uncovered unexpected disjunct occurrences of *Juga* and *Pristinicola* in central eastern Puget Sound region (**Figure 13**). Further evidence of the poor knowledge of the freshwater mollusk fauna of the Puget Sound basin was recently demonstrated by the discovery of two glacial relict snail species, *Valvata* n. sp. 2 and *Amnicola* n. sp. 1 in Pattison Lake, Thurston County, during a survey for the New Zealand mudsnail in southern Puget Sound (Johannes, 2010a). Using habitat requirements for both species and possible migration routes based on knowledge of Pleistocene geology of the region, two additional glacial lakes were found in quick succession with *Valvata* n. sp. 2 present in 2012 near the Covington Channel midway between the two known localities for *Valvata* n. sp. 2 (**Figure 13**). With exception of Eyerdam, most of the earlier collectors of freshwater mollusks in the Puget Sound region missed the glacial relicts and disjunct distributions of *Juga* and *Pristinicola* (*e.g.*, Henderson, 1929, 1936; Branson, 1977b, 1980; Branson & Barrett, 1981).

GASTROPODS

Frest & Johannes (2001b) summarize confirmed occurrences of freshwater mollusk species in Washington. About 73 native gastropod taxa occur in the state, as well as about 6 introduced species. These are not evenly spread. About 56 gastropods are currently known from western Washington, essentially in the molluscan Oregonian Province; *i.e.*, from the Cascades crest west to the Coast. The remainder of the gastropods are eastern, with slightly over 50 native species. Most likely to overlap are some of the *Fossaria* and

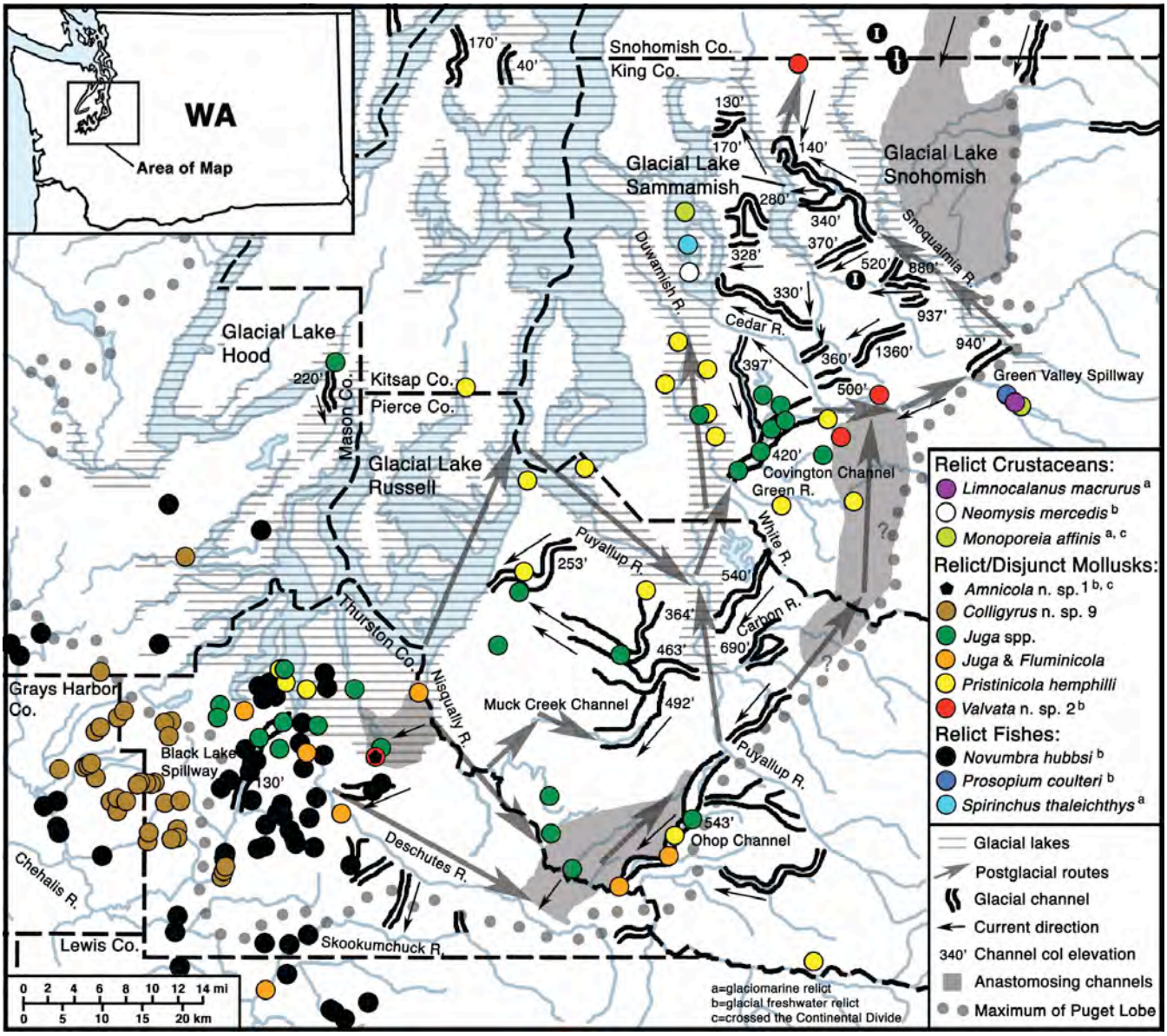


Figure 13. Potential Pleistocene migration paths of *Juga, Pristinicola* and *Valvata* in the Puget Sound Basin. *Juga*, *Fluminicola* and *Pristinicola* sites from verified locations collected by agencies of King, Pierce and Thurston counties (listed in PSSB, 2013); and (also including *Valvata* and *Amnicola*) sites collected by Deixis Consultants (Johannes, 2010a; unpub.). Sites for *N. hubbsi* from Mongillo & Hallock (1999), Trotter *et al.* (2000) and P. Trotter (pers. comm., 2010). Recent DNA results have proven that the eastern Puget Sound *N. hubbsi* sites are likely introductions (DeHaan *et al.*, 2012; black dots with white I). Other 2 relict fish distributions from Hallock & Mongillo (1998), McPhail (1967), McPhail & Lindsey (1986) and Wydoski & Whitney (2003). Relict crustacean distributions from Edmonds (1974), Kincaid (1953), Rickter (1959) and Segerstrale (1971). Dots may represent more than one site. Glacial Lake Russell shown at maximum extent of 160' stage modified from Bretz (1913). Glacial lakes, channels, channel col elevations and maximum of Puget Lobe based on Bretz (1910, 1913), Mackin (1941), Crandell (1968), Easterbrook (1992), Mullineaux (1970), Booth (1987, 1991, 1995), Booth & Minard (1992), Booth & Hallet (1993); examination of aerial images from Puget Sound LIDAR Consortium (PSLC, 2013); and USGS 7.5' geologic and topographic maps. Glaciomarine relicts are marine or brackish water species that have adapted to freshwater environments. Modified map from a poster presented by E. Johannes at the Olympic mudminnow workshop on Oct. 17th, 2012, Lacey, Washington.

Physella species. Unique to the Oregonian area of Washington are such taxa as *Valvata* n. sp. 2, *Colligyrus* n. sp. 9, *Colligyrus* n. sp. 1 (Columbia duskysnail), several *Fluminicola* species related to *Fluminicola virens*, and a few others. Unique to the eastern part of the state (Washingtonian Province) are such taxa as *Fluminicola fuscus* and several related taxa, *Fisherola nuttalli*, *Colligyrus* n. sp. 2 (masked duskysnail), *Valvata tricarinata*, and several others.

The area surveyed during this project is mostly in glaciated terrain just north and east of the margin of the Puget Lobe. Because of glaciation in the Puget Sound region by the Puget Lobe of the Cordilleran Ice Sheet, not all taxa are evenly distributed from north to south and the diversity of mollusks reflects this fact. Further north, mollusk diversity drops sharply, and several genera found in the Capitol Lake region such as *Juga*, *Fluminicola*, and *Pristinicola,* are not found in the north Puget Sound region. In particular, some taxa have not migrated back into the areas affected by Pleistocene glaciation or have marginally done so. Most of the range of *Juga* and *Pristinicola* are outside areas covered by Pleistocene continental glaciation. However, both *Juga and Pristinicola* ranges have recently been found to extend somewhat north in the eastern Puget Sound region well into glaciated terrain (**Figure 13**). This may have been the result, during the retreat of the Puget Lobe, of the unique geomorphology and history of the Puget Sound region, which led to the formation of large proglacial freshwater lakes (*e.g.*, Glacial Lake Russel) in the Puget Sound basin with spillover channels to the south (Bretz, 1910, 1913; **Figure 13**). In addition, a complex system of ice-marginal channels on the eastern side of the Puget Sound was cut along the front of the foothills of the Cascades from the Deschutes River in the south to as far north as the Nooksack River (Bretz, 1913; Mackin, 1941; Crandell, 1968; Mullineaux, 1970; Booth, 1987; Booth, 1990, 1991; Booth & Minard, 1992; Booth & Hallet, 1993; **Figure 13**). These ice-marginal channels cut across existing drainage divides. For a short time, the Deschutes River served as a drainage outlet for these ice-marginal channels (Bretz, 1913). Except for a few outlet channels in the northwest corner (Thorson, 1989), nothing like this exists on the west side of the Puget Sound. During the maximum extent of the Puget Lobe, mountain glaciers in the Cascades had already retreated up their valleys (Crandell, 1968). This left a narrow, north-south elongated ice-free corridor along the eastern margin of the Puget Lobe where the ice-marginal channels formed (Booth, 1987, 1991). This may have allowed a rapid migration of freshwater mollusks across drainage divides into newly formed drainages during the late Pleistocene retreat of the Puget Lobe. In the Capitol Lake area, *Juga* and *Flumincola* may have migrated from the Deschutes River into the proglacial lake in the Puget Sound basin, then into creeks with outlets only to the Puget Sound (*e.g.*, Green Cove, Woodward, Woodland, McLane, and Moxlie creeks). The Black Lake Drainage Ditch, Black Lake, and Black River are in a spillover channel which allowed the Puget Sound proglacial lakes to drain south into the Chehalis River drainage. This may have served as another possible migration route for *Juga* and *Fluminicola* from the Chehalis River into the Capitol Lake region drainages. *Pristinicola hemphilli,* and now recently *Amnicola* n. sp. 1, are known to occur in both of Washingtons' molluscan provinces across a major drainage divide which may indicate a pre-Cascade (Miocene or earlier) distribution. Parts of northern Washington, just at or below the Pleistocence glacially affected region, there occurs a peculiar molluscan distribution in which are found several Mississippi-drainage-related species such as *Valvata tricarinata* and *Amnicola* n. sp. 1 (a western endemic species of a mostly eastern U. S. genus). *Amnicola* n. sp. 1, *Valvata* n. sp. 2*,* and *Colligyrus* n. sp. 2 are glacial relicts and their ranges occur just within the edge of the Cordilleran Ice Sheet. It is a mystery where these species lived

during the Pleistocene glaciation, as the lakes they now occupy did not exist until the Cordilleran Ice Sheet receded to the north approximately 12,000 years ago or how they migrated to the newly formed habitats. None of these species have been found in lakes south of the glacial margin. The formation of numerous glacial lakes in the Capitol Lake region just inside the edge of the Puget Lobe was a fortuitous event that allowed the continued survival of *Amnicola* n. sp. 1 and *Valvata* n. sp. 2 after the ice receeded.

Unlike the Central and Midwest regions of the U.S., there are no usable Pleistocene fossil records available to reveal the history of freshwater mollusks in the Puget Sound basin (Taylor, 1985b). Current guesses of the postglacial migration history of both *Juga* and *Pristinicola* and other taxa shown in **Figure 13** are dependent on current distributions. A phylogenetic analysis of *Juga* and *Pristinicola* would further help in uncovering the postglacial history of freshwater mollusks in this region.

BIVALVES

Bivalve species have similar distributional peculiarities. There are about 30 native species, of which about 24 are sphaeriids or so-called fingernail clams, while about 6 are larger freshwater mussels (Frest & Johannes, 2001b).

Most of the fingernail clams are distributed across the state; but, in general, diversity increases from north to south along the Cascade Range axis. In the north several taxa especially adapted to cold waters are more prevalent, while some warm-adapted taxa appear to be absent. Sphaeriids seem to have increased their ranges more successfully than freshwater gastropods into glaciated areas; but there remain glacially-affected distributions. *Pisidium insigne*, for example, prefers cold springs and seeps but is essentially absent from northern Washington. *Sphaerium patella* seems to occur primarily on the flanks of the Cascades, but especially on the Oregonian side and only rarely near the Canadian border. *Pisidium punctatum* has been seen only in the Washingtonian area. As regards the larger freshwater mussels, only *Margaritifera falcata* seems well distributed originally over the state, but still sporadic on the east side. *Gonidea angulata* occurs mostly in the Washingtonian area and only sporadically south of the glacial margin in Oregonian western Washington. *Anodonta oregonensis* occurs on both sides of the Cascades but mostly south of the glacial margin; *Anodonta kennerlyi* occurs mostly along the eastern Cascades into Canada. *Anodonta californiensis* used to be rather ubiquitous in the Washingtonian Province and scattered on the west side of the Cascades (Oregonian Province) south of the glacial margin. There are literature reports of *Anodonta beringiana* in Washington; most of these appear inaccurate; but a few northwestern Washington sites could have been accurate historically.

Here again it is important to note the effects of both glaciation and late Cenozoic drainage history in determining mollusk distribution. Habitats north to south are currently essentially similar in the Oregonian and Washingtonian areas; and the two shares many: but mollusk distribution is not only related to current ecology and climate. A substantial portion of the State's mollusk diversity anywhere is relict or affected by major geologic events. Hence the pattern of species diversity in Washington is complex and not easily ascribable to a single set of factors.

APPENDIX G: CATCHABLE TROUT PLANT RECORDS FOR 2013 IN LAKES IN THE VICINITY OF CAPITOL LAKE

WATERBODY	DATE	SPECIES	NUMBER	FISH PER POUND	HATCHERY
Black Lake	May 21, 2013	Rainbow	2,688	2.1	Eells Springs
Black Lake	May 20, 2013	Rainbow	4,180	2.2	Eells Springs
Black Lake	May 15, 2013	Rainbow	3,960	2.2	Eells Springs
Black Lake	May 14, 2013	Rainbow	4,180	2.2	Eells Springs
Black Lake	May 10, 2013	Rainbow	760	2	Eells Springs
Black Lake	Mar 19, 2013	Rainbow	5,000	2.5	Puyallup Hatchery
Black Lake	Mar 18, 2013	Rainbow	13,000	2.5	Puyallup Hatchery
Black Lake	Mar 13, 2013	Rainbow	3,000	2.5	Puyallup Hatchery
Black Lake	Jan 07, 2013	Rainbow	2,500	2.5	Lakewood Hatchery
Black Lake	Jan 03, 2013	Rainbow	3,500	2.5	Lakewood Hatchery
Black Lake	Apr 23, 2013	Rainbow	6,800	2.5	Puyallup Hatchery
Hicks Lake	Apr 24, 2013	Rainbow	1,600	1	Puyallup Hatchery
Hicks Lake	Mar 25, 2013	Rainbow	6,675	2.5	Puyallup Hatchery
Pattison Lake	Apr 23, 2013	Rainbow	11,005	2.3	Eells Springs
Pattison Lake	Apr 18, 2013	Rainbow	4,393	2.3	Eells Springs
Pattison Lake	Apr 17, 2013	Rainbow	4,370	2.3	Eells Springs
Pattison Lake	Apr 15, 2013	Rainbow	4,655	2.45	Eells Springs
Pattison Lake	Apr 03, 2013	Rainbow	400	0.29	Eells Springs
Ward Lake	May 27, 2013	Rainbow	200	0.7	Trout Lodge Commercial
Ward Lake	Apr 24, 2013	Rainbow	670	1	Puyallup Hatchery
Ward Lake	Apr 24, 2013	Rainbow	2,800	2.5	Puyallup Hatchery
Ward Lake	Mar 25, 2013	Rainbow	2,775	2.5	Puyallup Hatchery
Hicks Lake	Mar 25, 2013	Rainbow	6,675	2.5	Puyallup Hatchery

Information obtained from Washington Department of Fish & Wildlife at: http://wdfw.wa.gov/fishing/plants/weekly/search.php?searchby=County&search=THURSTON&orderby=LakeStocked%20ASC,%20StockDate%20DESC (Accessed 25 June 2013).