**Survey of Columbia River Basin
Streams for Giant Columbia
River Spire Snail *Fluminicola
columbiana* and Great Columbia
River Limpet *Fisherola nuttalli***

D. A. Neitzel
T. J. Frest

October 1989

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute

DISCLAIMER

This program was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes **any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.** Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government of any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401. FTS 626-8401.

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

NTIS Price Codes, Microfiche A01

Printed Copy

<u>Pages</u>	<u>Price Codes</u>
001-025	A02
026-050	A03
051-075	A04
076-100	A05
101-125	A06
126-150	A07
151-175	A08
176-200	A09
201-225	A10
226-250	A11
251-275	A12
276-300	A13

SURVEY OF COLUMBIA RIVER BASIN STREAMS
FOR GIANT COLUMBIA RIVER SPIRE SNAIL
Fluminicola columbiana AND GREAT COLUMBIA
RIVER LIMPET *Fisherola nuttalli*

D. A. Neitzel
T. J. Frest^(a)

October 1989

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RL0 1830

Pacific Northwest Laboratory
Richland, Washington 99352

(a) University of Washington
Seattle, Washington

SUMMARY

Surveys have confirmed the survival of both the giant Columbia River spire snail *Fluminicola columbiana* and the great Columbia River limpet *Fisherola nuttalli* in the Hanford Reach of the Columbia River, Washington State, as well as other sites in Washington, Oregon, and Idaho. A review of historical collection records suggests that both species exist in still other sites of the Columbia River Basin. At present, there is insufficient information to allow adequate appraisal of either species relative to possible federal or state listing as endangered or threatened species.

The results of our studies suggest that additional undiscovered populations of both species exist. There is a relatively good chance that pristine habitat required by spire snails and limpets remains in 37 streams or portions of streams in Washington, Oregon, Idaho, and Montana (British Columbia was considered outside the project scope). For a thorough survey, visits to more than 600 sites will be required.

The giant Columbia River spire snail and the great Columbia River limpet are freshwater molluscs. The spire snail has a whorled shell and is about 0.4 in. high. Four to five whorls are typical of the species. They live on and under the rocks and vegetation in the slow to rapid currents of streams. The limpet has an acentric, conical shell as large as about 0.5 in. long, 0.4 in. wide, and 0.2 in. high. Its relatively large shell distinguishes it from other North American freshwater limpets. Limpets are distributed throughout the Columbia River and its tributaries, occurring on diatom-covered rocks in the main channels or fast-flowing water of streams.

Collections of both species have been limited during recent years. Spire snails were only collected at Hanford during the 1960s and 1970s. Limpet collections were limited to Hanford and one site in the Snake River, Idaho. Limited collections and impoundment of the Columbia River and its tributaries have led many wildlife managers to consider both species endangered or threatened. Because of the unknown status of these populations

and the impoundment of streams with limpet and spire snail habitat, both species are considered "candidates" for protection by the U.S. Fish and Wildlife Service.

ACKNOWLEDGMENTS

E. William Lusty and Alan J. Scott at the Pacific Northwest Laboratory, Richland, Washington, and Kirk Wright at the University of Washington, Seattle, Washington, provided the field support for field collections. Mr. Lusty prepared the field collection materials and transportation equipment. Susan A. Kreml edited the manuscript.

CONTENTS

SUMMARY.....	iii
ACKNOWLEDGMENTS.....	v
INTRODUCTION.....	1
METHODS.....	3
RESULTS.....	5
LITERATURE REVIEW OF PRE-1988 COLLECTIONS.....	5
1988 SURVEYS.....	12
Columbia River Collections	12
Deschutes River Collections	13
Okanogan River Collections.....	13
Other Collection Sites	13
DISCUSSION.....	21
UPDATE OF SPIRE SNAIL AND LIMPET COLLECTIONS.....	22
PROPOSED SURVEY SITES.....	22
SITE SELECTION STRATEGY.....	29
FUTURE PLANS.....	30
REFERENCES.....	33
APPENDIX - LATITUDE AND LONGITUDE FOR THE GIANT COLUMBIA RIVER SPIRE SNAIL <i>Fluminicola columbiana</i> AND THE GREAT COLUMBIA RIVER LIMPET <i>Fisherola nuttalli</i> SURVEY SITES PROPOSED FOR 1989 AND 1990	A.1

FIGURES

1	Pre-1987 Collection Sites for the Giant Columbia River Spire Snail <i>Fluminicola columbiana</i>	7
2	Pre-1987 Collection Sites for the Great Columbia River Limpet <i>Fisherola nuttalli</i>	11
3	1988 Collection Sites for the Giant Columbia River Spire Snail <i>Fluminicola columbiana</i>	16
4	1988 Collection Sites for the Great Columbia River Limpet <i>Fisherola nuttalli</i>	19
5	Columbia River Basin in the United States Showing Potential Streams or Drainages That May Have Extant Populations of the Giant Columbia River Spire Snail <i>Fluminicola columbiana</i> and the Great Columbia River Limpet <i>Fisherola nuttalli</i>	27

TABLES

1	Pre-1987 Collection Sites for the Giant Columbia River Spire Snail <i>Fluminicola columbiana</i>	6
2	Pre-1987 Collection Sites for the Great Columbia River Limpet <i>Fisherola nuttalli</i>	8
3	1988 Collection Sites for the Giant Columbia River Spire Snail <i>Fluminicola columbiana</i>	14
4	1988 Collection Sites for the Great Columbia River Limpet <i>Fisherola nuttalli</i>	17
5	Spire Snail <i>Fluminicola</i> spp. and Great Columbia River Limpet <i>Fisherola nuttalli</i> Collections from the Hanford Reach of the Columbia River, Washington	21
6	Ranked Listing of Collection Sites for the Giant Columbia River Spire Snail <i>Fluminicola columbiana</i> and the Great Columbia River Limpet <i>Fisherola nuttalli</i>	23
A.1	Latitude and Longitude of Proposed Collection Sites for the Giant Columbia River Spire Snail <i>Fluminicola columbiana</i> and the Great Columbia River Limpet <i>Fisherola nuttalli</i>	A.2

INTRODUCTION

Two aquatic invertebrate animals that occur in the Columbia River at the Hanford Site, the giant Columbia River spire snail *Fluminicola columbiana* and the great Columbia River limpet *Fisherola nuttalli*, are federally listed candidate species. As candidate species, the spire snail and limpet are not protected by law; however, the U.S. Fish and Wildlife Service (USFWS) monitors anthropogenic activities that may affect candidate species.

During the past 20 to 30 years, Hanford was the only known collection site for the spire snail and one of only two known collection sites for the limpet. Activities that affect the known habitat of candidate species can result in their listing as protected species, providing the USFWS with an administrative tool that allows for habitat protection. Thus, all U.S. Department of Energy-Richland Operations Office (DOE-RL) activities at Hanford that potentially affect the Columbia River are managed with the assessment of the spire snail and limpet in mind.

Assessment of the beneficial uses of the Columbia River at Hanford will be enhanced when the status of the spire snail and that of the limpet are known. Therefore, DOE-RL requested that the Pacific Northwest Laboratory (PNL) and the University of Washington conduct a survey of streams in the Columbia River Basin to determine the status of spire snail and limpet populations. This determination will be accomplished by 1) establishing locations of spire snail and limpet populations, 2) estimating the relative abundance of both species, and 3) evaluating potential threats to the habitat of known populations.

The initial scope of the project is to collect samples at Hanford where spire snails and limpets have been collected recently (Wolf 1976; Clarke 1976; Beak 1980; Page et al. 1982; Supply System 1985, 1986, 1987), and to collect samples from at least two locations within the historical range of the spire snails and limpets but outside the Hanford Reach of the Columbia River. Data from these collections will provide a measure of species status and preliminary information needed to determine whether or not the spire snail and limpet populations at Hanford are unique. We also present a study plan

defining a sampling program to fully document spire snail and limpet distribution over the expected historical ranges of these species.

This report describes the surveys that were conducted during 1988, the methods used for the surveys, and the survey results, and discusses the results. Additionally, we present the list of sites in the Columbia River Basin that should be surveyed during 1989 and 1990. The latitude and longitude of the survey sites that should be examined are listed in the Appendix.

METHODS

The collection methods included techniques that have been successful in past efforts to collect mollusks in the Columbia River Basin. Wire-basket benthos samplers (Mason et al. 1967; Jacobi 1971) were placed in streams in which we expected to find mollusks and were left to incubate for about 3 months. Before retrieving the baskets, we placed them into cloth bags. The bagged baskets were returned to the surface and tagged to identify sample location and sample date. Benthic organisms were removed from the rocks and baskets and washed into 600- μ m-mesh sieving buckets. The washed samples were preserved in 70% isopropyl alcohol. Additional surveys were accomplished by removing rocks from the stream and collecting snails and limpets from the rocks. These snails and limpets were placed in jars and preserved with alcohol.

Sample collections were scheduled for late summer and early fall. This schedule coincides with the more successful collections at Hanford (Wolf 1976; Clarke 1976; Beak 1980; Page et al. 1979, 1982; Supply System 1985, 1986, 1987).

Preserved spire snail and limpet samples were shipped to the Thomas Burke Memorial Washington State Museum at the University of Washington in Seattle, Washington. Individual specimens are being identified to species, if possible, and prepared for storage and placed in the archives at the Burke Museum. Samples will be maintained in perpetuity at the museum. Samples are assigned unique identification numbers in the Burke Museum system, providing an easy retrieval system for all samples.

During June 1988, we visited three sites: the mouth of the Okanogan River, near Bridgeport, Washington; the Columbia River near river mile (RM) 361; and the mouth of the Deschutes River near Biggs, Oregon. At each site we placed six basket samplers in the water. Collection at a Hanford site provided a positive control for the sampling techniques.

RESULTS

Visits to approximately one-third of the previously reported sites, and several sites not formerly recorded, have confirmed the survival of both the giant Columbia River spire snail and the great Columbia River limpet in the Hanford Reach, as well as in other Washington, Oregon, and Idaho sites outside Hanford. A review of the malacological literature and other mollusc collections suggests the possible presence of both species in still other sites of the Columbia River Basin.

LITERATURE REVIEW OF PRE-1988 COLLECTIONS

Pre-1987 collections of the giant Columbia River spire snail are from the Columbia and Payette rivers (Table 1; Figure 1). Columbia River sites extend from Portland, Oregon, upstream to the mouth of the Wenatchee River. Specific collection sites include Portland and The Dalles, Oregon; and Wallula, the Hanford Reach, and the mouth of the Wenatchee River, Washington. The Payette River site was upstream of Black Canyon in Idaho. All these sites, except the Hanford Reach, were surveyed before dam construction in the Pacific Northwest and are now within impoundments. Thus, eight of the nine sites (Table 1) may have been eliminated as viable habitat for spire snails.

Macroinvertebrate collections during the 1970s and 1980s documented the existence of spire snails throughout the Hanford Reach. Preliminary taxonomic work indicates there are four to six species of *Fluminicola*, including *F. columbiana*, at Hanford. Taxonomic examination of the samples from 1988 surveys will not be complete until 1989 or 1990.

Pre-1987 collections of the great Columbia River limpet are reported from the Columbia and Spokane rivers, Washington; Snake and Salmon rivers, Idaho; Deschutes River, Oregon; and Kootenai River, British Columbia (Table 2; Figure 2). Sites in the Columbia River extend from Portland, Oregon, to the Hanford Reach, Washington. All these sites, except the Hanford Reach, were surveyed before dam construction on the Columbia River. These sites are now

TABLE 1. Pre-1987 Collection Sites for the Giant Columbia River Spire Snail *Fluminicola columbiana*

State	River	Site Description ^(a)	Comments	Reference
Washington	Columbia	Wenatchee River, Chelan County	By P.B. Randolph, no date	Taylor 1982a
Washington	Columbia	Hanford Reach, Benton County	By A.H. Clarke during 1970s	Clarke 1976
Washington	Columbia	Hanford Reach, RM ^(b) 380; Benton County	1973-1974, sampling with rock-filled baskets	Wolf 1976
Washington	Columbia	Hanford Reach, RM 361; Benton County	1981-1982, grab samples and sampling with rock-filled baskets	Page et al. 1982
Washington	Columbia	Hanford Reach, RM 352; Benton County	1974-1986, sampling with rock-filled baskets	Page et al. 1979; Beak 1980; Supply System 1985, 1986, 1987
Washington	Columbia	Near Wallula, Walla Walla County	By H. Hemphill about 1889	Taylor 1982a
Oregon	Columbia	The Dalles, Wasco County	Old record, sampled during 1988 by T. Frest, population may be extinct	Taylor 1982a
Oregon	Columbia	Near Portland, Multnomah County	Old record; sampled during 1988 by T. Frest, population may be extinct	Taylor 1982a
Idaho	Payette	Upstream of Black Canyon Reservoir	By D.W. Taylor in 1950s population reported extinct by in Taylor in 1981	Taylor 1966, 1982a

(a) Sites listed from most upstream to most downstream for a given river.

(b) RM = river mile.

FIGURE 1. Pre-1987 Collection Sites (large dots) for the Giant Columbia River Spire Snail *Fluminicola columbiana*

TABLE 2. Pre-1987 Collection Sites for the Great Columbia River Limpet *Fisherola nuttalli*

State/ Province	River	Site Description(a)	Comments	Reference
Washington	Columbia	Hanford Reach, Benton County	1969-1970	Coutant and Becker 1970
Washington	Columbia	Hanford Reach, RM ^(b) 380; Benton County	1973-1974, sampling with rock-filled baskets	Wolf 1976
Washington	Columbia	Hanford Reach, RM 361; Benton County	1981-1982	Page et al. 1982
Washington	Columbia	Near Ringold, Benton County	1970s	Clarke 1976; Taylor 1985
Washington	Columbia	Hanford Reach, RM 352; Benton County	1974-1986	Page et al. 1979; Beak 1980; Supply System 1985, 1986, 1987
Washington	Columbia	Near Wallula, Benton County	No date	Taylor 1982b, 1985
Oregon	Columbia	Mouth of the Deschutes River, Wasco County	Old record; sampled by Frest during 1988; population may be extinct	Taylor 1982b, 1985
Oregon	Columbia	Near The Dalles, Wasco County	Old record; sampled by Frest during 1988; population may be extinct	Taylor 1982b, 1985
Oregon	Columbia	Near Portland, Multnomah County	Old record; sampled by Frest during 1988; population may be extinct	Taylor 1982b, 1985

TABLE 2. (contd)

State/ Province	River	Site Description(a)	Comments	Reference
Idaho	Snake	Near Rupert, Minidoka County	By F. Kenagy during 1913	Henderson and Daniels 1917; Taylor 1982b, 1985
Idaho	Snake	Lower Salmon Falls to Clover Creek, Elmore/ Gooding Counties	No date	Taylor 1982b, 1985
Idaho	Snake	Bancroft Springs, Gooding County	1980-1982	Taylor 1982b, 1985
Idaho	Snake	Near mouth of Clover Creek, Gooding County	1980-1982	Taylor 1982b, 1985
Idaho	Snake	Indian Cove Bridge	Shell only	Taylor 1975, 1985
Idaho	Snake	Near Lewiston, Nez Perce County	No date	Taylor 1982b, 1985
Idaho	Snake	Box Canyon Creek (Snake River tributary), Sculpin Pool, Gooding County	Shells only	Taylor 1982b, 1985
Idaho	Salmon	Idaho County	No date	Taylor 1982b
Washington	Spokane	Near Little Falls, Stevens County	No date	Taylor 1975
Washington	Spokane	Near Spokane, Spokane County	No date	Taylor 1975
Oregon	Deschutes	Near Sherars Bridge, Wasco County	No date	Taylor 1975, 1985

TABLE 2. (contd)

State/ Province	River	Site Description ^(a)	Comments	Reference
Oregon	Deschutes	Near Maupern, Wasco County	No date	Taylor 1975, 1985
Oregon	Deschutes	Near Grandview, Wasco County	No date	Taylor 1975
British Columbia	Kootenai	Kootenai	No date	Taylor 1975

(a) Sites listed from most upstream to most downstream for a given river.

(b) RM = river mile.

FIGURE 2. Pre-1987 Collection Sites (large dots) for the Great Columbia River Limpet *Fisherola nuttalli*

within impoundments that have eliminated most viable habitat for limpets. Most of the pre-1987 collection sites have been impounded or affected by irrigation withdrawals and pollutants. Limpets were collected at Hanford during the 1970s and 1980s.

1988 SURVEYS

Our primary collection sites for 1988 were the Columbia River at Hanford, RM 361; the Deschutes River, RM 0; and the Okanogan River, RM 0. Spire snails and limpets did not colonize on the basket samplers that we set. At Hanford, the baskets were vandalized. In the Deschutes and the Okanogan rivers, the bottom substrate probably does not support mollusk populations. The mouth of the Deschutes River has a sand bottom. The mouth of the Okanogan River is within the influence of the Wells Dam reservoir; the current is slow and the bottom is covered with sediment and debris. Spire snails and limpets are probably extinct in the mouths of the Deschutes and Okanogan rivers.

Grab samples were collected and inspected for spire snails at Hanford, and in the Deschutes, Okanogan, Methow, Wenatchee, Yakima, and Snake rivers. Spire snail and limpet samples were collected from the Columbia, Deschutes, Okanogan, Wenatchee, Methow, and Snake rivers. No spire snails or limpets were collected from the Yakima River. Both taxa are probably extinct in the Yakima River, at least downstream of Ellensburg, Washington.

Columbia River (Hanford) Collections

We collected both spire snails and limpets from the Hanford Reach during 1988 (Tables 3 and 4; Figures 3 and 4). Collections were taken near the 100-F Slough, RM 368. The samples were collected on October 1, 1988, about 10 to 30 ft from the shore from water about 3 ft deep. Average river flow for the day was about 55,000 cubic feet per second (cfs). This is a low flow; the administrative low flow is 36,000 cfs and the annual average flow is about 120,000 cfs. Thus, samples were collected in an area that is always wetted.

Deschutes River Collections

We collected spire snails and limpets from four location on the Deschutes River (Table 4; Figure 4): Sherer's Bridge, RM 42.6-42.8; Bull Run Canyon East; Harris Island South, RM 12.6-12.8; and RM 6.3-6.5. Limpets appeared to be plentiful in the "whitewater" areas. Spire snails were more easily collected in shallow water and near the shore. Most of the spire snails appear to be a species other than *Fluminicola columbiana*. A preliminary examination of the spire snails collected at Deschutes RM 42 indicated those samples may include *F. columbiana*.

Okanogan River Collections

We collected *Fluminicola columbiana* and *Fisherola nuttalli* from four sites in the Okanogan River (Tables 3 and 4; Figures 3 and 4): McAllister Rapids South, RM 44.5; northeast of Omak, RM 36.1-36.3; Rattlesnake Point, RM 14.2-14.5; and near Malott, RM 15.2-15.4. The spire snails were plentiful within 3 to 15 ft of the shore. At McAllister Rapids, most of the snails collected were in less than 5 in. of water. Very few (less than 50) limpets were collected from the Okanogan River.

Other Collection Sites

Spire snails and limpets were collected from six sites in the Methow, Wenatchee, and Snake rivers (Tables 3 and 4; Figures 3 and 4). The Wenatchee River sites are near Cashmere, Washington, at RM 11.5; the Monitor Bridge, at RM 7.2; and RM 5.5. The Methow River sites are RMs 4.0 and 5.7. There were no limpets in the Methow River. The Snake River site was near the Bliss Bridge, and both *Fluminicola columbiana* and limpets were prevalent in the Snake River.

TABLE 3. 1988 Collection Sites for the Giant Columbia River Spire Snail *Fluminicola columbiana*

State	River	Site Description ^(a)	Comments	Collector(s)
Washington	Okanogan	McAllister Rapids South, Okanogan County, RM ^(b) 44.51	1988 ^(c)	Neitzel
Washington	Okanogan	Northeast of Omak, RM 36.1-36.3; Okanogan County	1988	Frest and Wright
Washington	Okanogan	Near Malott, RM 15.2-15.4; Okanogan County	Sampled by K. Wright during 1987. 1988	Wright
Washington	Okanogan	Rattlesnake Point, RM 14.2-14.5; Okanogan County	1988	
Washington	Wenatchee	Near Cashmere, RM 11.5; Chelan County	1988	Frest and Wright
Washington	Wenatchee	Near Monitor Bridge, RM 7.2; Chelan County	1988	Frest and Wright
Washington	Wenatchee	Monitor County Park, RM 5.5; Chelan County	1988	Frest and Wright
Washington	Methow	Second bend, RM 4.0; Okanogan County	1988	Frest and Wright
Washington	Methow	Bridge two, RM 5.7; Okanogan County	1988	Frest and Wright

TABLE 3. (contd)

State	River	Site Description ^(a)	Comments	Collector(s)
Washington	Columbia	Hanford Reach, RM 368 Benton County	1988	Neitzel
Idaho	Snake	Near Bliss Bridge, Gooding County	1988	Frest

(a) Sites listed from most upstream to most downstream for a given river.

(b) RM = river mile.

(c) 1988 comment refers to collection discussed in this report.

FIGURE 3. 1988 Collection Sites (large dots) for the Giant Columbia River Spire Snail *Fluminicola columbiana*

TABLE 4. 1988 Collection Sites for the Great Columbia River Limpet *Fisherola nuttalli*

State	River	Site Description ^(a)	Comments	Collector(s)
Washington	Okanogan	McAllister Rapids South, RM ^(b) 44.5; Okanogan County	1988 ^(c)	Neitzel
Washington	Okanogan	Northeast of Omak, RM 36.1-36.3; Okanogan County	1988	Frest and Wright
Washington	Okanogan	Rattlesnake Point, RM 14.2-14.5; Okanogan County	1988	Frest and Wright
Washington	Okanogan	Near Malott, RM 15.2-15.4 Okanogan County	Sampled by K. Wright during 1987. 1988	Wright
Washington	Methow	Bridge two, RM 5.7; Okanogan County	1988	Frest and Wright
Washington	Methow	Second bend, RM 4.0; Okanogan County	1988	Frest and Wright
Washington	Columbia	Hanford Reach, RM 368; Benton County	1988	Neitzel
Oregon	Deschutes	Sherers Bridge South, RM 42.6-42.8; Wasco/Sherman Counties	1988	Frest and Wright
Oregon	Deschutes	Bull Run Canyon East, Wasco/Sherman Counties, SW1/4 NE1/4 SW1/4 sec. 30, T 1 S	1988	Frest, Wright, and Neitzel
Oregon	Deschutes	Harris Island South, RM 12.6-12.8	1988	Frest, Wright, and Neitzel

TABLE 4. (contd)

State	River	Site Description ^(a)	Comments	Collector(s)
Oregon	Deschutes	RM 6.3-6.5, Wasco/ Sherman Counties	1988	Frest, Wright, and Neitzel

(a) Sites listed from most upstream to most downstream for a given river.

(b) RM = river mile.

(c) 1988 comment refers to collection discussed in this report.

FIGURE 4. 1988 Collection Sites (large dots) for the Great Columbia River Limpet *Fisherola nuttalli*

DISCUSSION

The historical range of the limpet and spire snail includes almost the entire Columbia River Basin. However, malacologists and environmental managers assume the distribution of the spire snail is restricted to the Hanford Reach (Clarke 1976). The ranges of the two animals are very similar, with a probable 80% to 90% overlap. During the past 20 to 30 years, Hanford was the only known collection site for the spire snail and one of only two known collection sites for the limpet. Limpets were collected from 1980 through 1982 by Taylor (1982b) in Gooding County, Idaho (see Table 2). Much of this known or potential habitat for spire snails and limpets has been impounded since historical collections were made. Macroinvertebrate collection from 1969 through 1985 indicate spire snails and limpets still occur throughout the Hanford Reach of the Columbia River (Table 5).

TABLE 5. Spire Snail *Fluminicola* spp. and Great Columbia River Limpet *Fisherola nuttalli* Collections from the Hanford Reach of the Columbia River, Washington^(a)

Collection Site	River Mile	Collection Period	Number of Collections	Number of Snails Limpets	
100-F Area	368	1969-1970	9	0	(b)
HGP/ N Reactor	380	1973-1974	8	301	4
HGP/ WNP-1	380/ 352	1974	2	10	2
WNP-2	352	1974-1980	26	2712	258
Skagit/ Hanford	361	1981-1982	4	145	3

(a) Collection references: Wolf 1976; Coutant and Becker 1970; Page et al. 1979; Beak 1980.

(b) Coutant and Becker (1970) collected 23 samples, which contained 10 to 300 limpets, depending on abundance at the collection site.

UPDATE OF SPIRE SNAIL AND LIMPET COLLECTIONS

Our 1988 collections confirmed the presence of both the giant Columbia River spire snail and the great Columbia River limpet in the Hanford Reach, as well as in other Washington, Oregon, and Idaho sites outside Hanford. We collected spire snails and limpets at some of the proposed locations and at other sites during 1988. Additionally, we have a very large collection of spire snails and limpets from Hanford that were collected from 1985 through 1987 at RM 352. The Washington Public Power Supply System (Supply System) had several years' worth of samples that have been placed in the Burke Museum.

PROPOSED SURVEY SITES

We prepared a list of locations in the Columbia River Basin that should be surveyed before an appraisal is attempted of either species relative to possible federal or state listing as endangered or threatened. We ranked the list of locations and indicated the coordinates for each site for which we have maps.

Based on this information and some of the historical records, we have constructed a list of "all" the sites within the Columbia River Basin where we should look for limpets and spire snails. Site selection criteria for future surveys were based on known habitat (Taylor 1982a,b) and as modified by our field survey results in 1988. Abundance and occurrence within this historical range will provide the information needed to determine the level of protection for the animals.

A map survey of all streams within the suspected historical range of both taxa indicates that portions of 30 to 40 streams could harbor living populations of either or both species (Table 6; Figure 5). Most of the streams have never been surveyed for freshwater molluscs, and none has been adequately surveyed according to standards used in other portions of the United States for determining whether or not a mollusk should be protected. For most of the streams for which records are available, only single sites have been recently or historically sampled. The sole exception is Taylor's (1982a,b) work on a 24.5-mile stretch of the Snake River. Reevaluation of old records is long

TABLE 6. Ranked Listing of Collection Sites for the Giant Columbia River Spire Snail *Fluminicola columbiana* and the Great Columbia River Limpet *Fisherola nuttalli*

Rank	State	River	Site Description	Number of Sites
1	Washington	Wenatchee	Chelan County from Leavenworth to river mouth	11
2	Washington	Entiat	Chelan County from RM(a) 10.0 to river mouth	3
3	Washington	Okanogan	Okanogan County from RM 20.0 to river mouth	18
4	Washington	Methow	Okanogan County from RM 20.0 to river mouth	14
5	Washington	Nespelem	Okanogan County from RM 15.0 to river mouth	5
6	Washington	Sanpoil	Ferry County from RM 15.0 to river mouth	8
7	Washington	Colville	Stevens County from RM 15.0 to river mouth	3
8	Washington	Cowlitz	From Mayfield Lake to Castle Rock	5
9	Washington	Lewis	Cowlitz County from near Lake Merwin to river mouth	9
10	Washington	Wind	Skamania County from RM 15.0 to river mouth	6

TABLE 6. (contd)

Rank	State	River	Site Description	Number of Sites
11	Washington	White Salmon	Klickitat County from RM 10.0 to river mouth	4
12	Washington	Klickitat	Klickitat County from RM 20.0 to river mouth	15
13	Washington	Palouse	From RM 20.0 to river mouth	16
14	Washington/ Oregon	Grande Ronde	From RM 30.0 to river mouth	21
15	Washington	Walla Walla and Touchet	From Luckenbill Bridge to Lake Wallula	13
16	Washington	Tucannon	From Delaney to Powers	4
17	Oregon	Hood River	From Punchbowl Falls to river mouth	4
18	Oregon	Deschutes	From Warm Springs to river mouth	53
19	Oregon	Willamette	From RM 100.0 to river mouth	28
20	Oregon	John Day	From RM 40.0 to river mouth	10
21	Oregon	Umatilla	From RM 15.0 to river mouth	6

TABLE 6. (contd)

Rank	State	River	Site Description	Number of Sites
22	Washington	Columbia	Benton County from Priest Rapids to Richland (Hanford Reach)	21
23	Washington/ Oregon	Columbia	From Bonneville Dam to Skamokawa	22
24	Washington	Columbia	Tailrace of Bonneville, John Day, Dalles, McNary, Priest Rapids dams	9
25	Washington/ Idaho	Spokane	From Coeur d'Alene Lake to Spokane, and selected parts of the Coeur d'Alene, St. Joe, and St. Maries	34
26	Oregon	Malheur	Malheur County from RM 15.0 to river mouth	13
27	Oregon	Owyhee	Malheur County from Owyhee Dam to river mouth	6
28	Montana/ Idaho	Kootenai	From Libby, Montana, to Porthill, Idaho	21
29	Montana/ Idaho	Clark Fork	From Plains, Montana, to Clark Fork, Idaho	27
30	Idaho	Clearwater	Nez Perce County from east of Orofino to lower Selway and Lochsa rivers	30

TABLE 6. (contd)

Rank	State	River	Site Description	Number of Sites
31	Washington/ Idaho/ Oregon	Snake	From Hells Gate to Hells Canyon Dam, Idaho (Wiley Reach)	31
32	Idaho	Snake	From Minidoka Dam to Bruneau	51
33	Idaho	Snake	From above American Falls Reservoir to Ririe	38
34	Idaho	Salmon	From river mouth to Makay Bar, and from Challis to Lanz Rapids	78
35	Idaho	Weiser	From Weiser to Price Valley	11
36	Idaho	Payette	From Black Canyon Reservoir to river mouth, and from Black Canyon Reservoir to Forks	36
37	Idaho	Henrys Fork	From Last Chance to river mouth	27

(a) RM, river mile.

FIGURE 5. Columbia River Basin in the United States Showing Potential Streams or Drainages That May Have Extant Populations of the Giant Columbia River Spire Snail *Fluminicola columbiana* and the Great Columbia River Limpet *Fisherola nuttalli*. Sites are numbered from 1 to 37, indicating author's ranking.

overdue, as many of these are suspect and others are so vague as to be of extremely limited value [e.g., compare Taylor (1982a,b) with Burch and Tottenham (1980) and Burch (1982)].

The very large number of possible sites is daunting, but not unreasonable. As it is, the average spacing is approximately 5 miles, intervals far greater than that would be considered adequate in river surveys for molluscs in other regions. The lack of detailed systematic work on most western streams is noticeable for malacological surveys. Similarly, the usual museum surveys have not furnished much additional unpublished data. Museum records for eastern U.S. streams, which are often much more extensive than the published records, are important for assessing the status of a species being considered for protection. However, the total number of specimens of both taxa in museum collections is quite small.

We identified more than 600 sites, which we have ranked to indicate which sites we believe will provide the most information. During 1988, we tested some of the assumptions we used to rank the sites by sampling in some of the sites that are high in the ranking. Based on what we found in the Methow, Yakima, Wenatchee, and Snake rivers, collections from the highly ranked sites should provide good data for the resolution of the candidacy of the spire snails and limpets.

Both species were formerly regarded as especially typical of large-river habitats (e.g., the Columbia and Snake rivers). Information collected since 1980 necessitates modification of this view. For example, Taylor (1982a,b) reported the occurrence of *Fluminicola columbiana* in the Payette River above Black Canyon Reservoir. The Payette is only 200 to 300 ft wide at this point. Our new sites on the Wenatchee and Okanogan also fall into this category. Similarly, Taylor (1983) noted the presence of shells of recently dead *Fisherola nuttalli* in Box Canyon Creek, a small (less than 100 ft wide) spring-fed stream. We have likewise collected live specimens at two sites in the Methow River at points where it is also less than 300 ft wide. Evidently, stream size is not a limiting factor for either species, if the stream is relatively unpolluted, cold, and well oxygenated, with permanent flow and a cobble-boulder substrate; these conditions occur in rapids. Both species

occur together at some sites (e.g., Okanogan River, Methow River, Hanford Reach and possibly Snake River), and hence most sites selected have some possibility for both. Generally, *Fluminicola columbiana* appears to be more common immediately below and above areas with the maximum available flow velocity in which *Fisherola nuttalli* populations can be maintained.

SITE SELECTION STRATEGY

On the basis of the information from our literature review and our 1988 surveys of Columbia River Basin streams, we selected stream sites for future surveys. Actual site selection for future surveys will be determined by the preferred search strategy. Determination of this is complicated by the fact that no consensus exists as to how many sites, drainages, or individuals must be confirmed extant to determine endangered, threatened, or unprotected status. A reasonable and cost-effective strategy to establish the status of both subject species would include the following.

1. Survey the remaining sites in the historical range that have not yet been visited (~12 sites).
2. Select 2 sites each on the top 20 unexplored drainages within the potential range (about 40 sites): these should preferably be widely scattered to ensure the species is protected against potential natural or manmade catastrophes that could decimate major regions.
3. Survey a smaller drainage (perhaps the Okanogan or Deschutes River) more thoroughly to determine the total number of sites and estimated number of individuals possible in a single drainage. Such a survey should require visits to approximately 40 sites.

It is not possible to specify the total number of sites required for listing, delisting, or for qualification as a candidate species in such a manner as to satisfy all interested parties. Therefore, we suggest a more arbitrary but broadly acceptable definition of a "good faith" effort, to locate populations and to estimate the number of such populations. Demonstration of the survival of at least two populations in 20 separate drainages for each taxon should be adequate. In all likelihood, both taxa will be present in many of the drainages studied.

Unsurveyed drainages that are regarded as most likely to harbor one or both species are as follows:

Sanpoil River	Washington
Klickitat River	Washington
Columbia River	Washington, Oregon
Grande Ronde River	Washington, Oregon
Lower Snake River	Washington, Oregon, Idaho
John Day River	Oregon
Spokane River system	Washington, Idaho
Clearwater River	Idaho
Middle Snake River	Idaho
Upper Snake River	Idaho
Salmon River	Idaho
Payette River	Idaho
Henrys Fork River	Idaho
Kootenai River	Montana, Idaho

Several of the drainages listed include two or more additional, separately named tributaries also scheduled for at least spot survey. A ranked list of these streams and drainages is given in Table 6 and illustrated in Figure 5. The latitude and longitude for the collection sites are listed in the Appendix.

FUTURE PLANS

Surveying the remaining known sites would require about 16 visits. Adequate survey of the stream reaches from which old and recent records were derived (i.e., Wenatchee River, Okanogan River, Hanford Reach, lower Columbia River, Deschutes River, Spokane River, Kootenai River, upper Snake River, middle Snake River, Salmon River, and upper Payette River) would require about 150 to 200 sites. On the other hand, finding additional populations in a sizable number of streams would very likely result in removal of both species from candidate status for federal listing. It should be noted that site selection was done before the 1988 field season, with just a few of the most convenient sites selected for actual visits; of the sites sampled, all had at least one of the subject species, and several had both.

At present, only the sites studied in 1988 can be considered to be adequately explored. Taylor (1982a,b) sampled only with hand-grab samples. No population size data are available for any of Taylor's (1982a,b) sites. He estimated that "less than 1% of the potential habitat was sampled" and that further surveys are required.

Hand sampling is the most cost-efficient sampling alternative, and is necessary at each site to assess suitability for detailed sampling. Hand samples are also needed to estimate population size and recruitment, and in many cases are the only way to locate live specimens. The most efficient procedure is to conduct an initial sweep to choose final sites, hand-collect the shallows, and place rock baskets; this is followed later by a return sweep to retrieve baskets and to live-collect in deep water. Scuba diving is the preferred method in deep large streams, and can also be helpful in small ones. In some streams (e.g., some stretches of the Columbia and Snake rivers), dredging and/or the use of a grab sampler may be the only feasible alternatives.

REFERENCES

- Beak (Beak Consultants Incorporated). 1980. *Preoperational Environmental Monitoring Studies near WNP 1, 2 and 4, August 1978 through March 1980*. Prepared for the Washington Public Power Supply System, Richland, Washington by Beak Consultants Incorporated, Portland, Oregon.
- Burch, J. B. 1982. *North American Freshwater Snails: Identification Keys, Generic Synonymy, Supplemental Notes, Glossary, References, Index*. Society for Experimental and Descriptive Malacology, Ann Arbor, Michigan.
- Burch, J. B., and J. L. Tottenham. 1980. *North American Freshwater Snails: Species List, Ranges, and Illustrations*. Society for Experimental and Descriptive Malacology, Ann Arbor, Michigan.
- Clarke, A. H. 1976. "Endangered Freshwater Mollusks of Northwestern North America." *Bull. Am. Malacol. Union Inc.* 1976:18-19.
- Coutant, C. C., and C. D. Becker. 1970. *Growth of the Columbia River Limpet, Fisherola nuttalli (Haldeman), in Normal and Reactor-Warmed Water*. BNWL-1537, Pacific Northwest Laboratory, Richland, Washington.
- Henderson, J., and L. E. Daniels. 1917. "Hunting Mollusca in Utah and Idaho in 1916." *Proc. Acad. Nat. Sci. Phila.* 69:48-81.
- Jacobi, G. G. 1971. "A Quantitative Artificial Substrate Sampler for Benthic Macroinvertebrates." *Trans. Am. Fish. Soc.* 100:136-138.
- Mason, W. L., J. B. Anderson, and G. E. Morrison. 1967. "Limestone-Filled, Artificial Substrate Sampler-Float Unit for Collecting Macroinvertebrates in Large Streams." *Prog. Fish-Cult.* 29:74.
- Page, T. L., D. A. Neitzel, and R. W. Hanf. 1979. "Columbia River Benthic Macrofauna and Microflora near WNP 1, 2 and 4, from January through August 1978." In *Aquatic Ecological Studies near WNP 1, 2 and 4, January through August 1978. WPPSS Columbia River Ecology Studies, Vol. 6*. Prepared for the Washington Public Power Supply System by Battelle, Pacific Northwest Laboratories, Richland, Washington.
- Page, T. L., D. D. Dauble, and D. A. Neitzel. 1982. *Columbia River Aquatic Ecological Studies near the Skagit/Hanford Nuclear Project: Final Report*. Prepared for Northwest Energy Services Company, Kirkland, Washington, by Battelle, Pacific Northwest Laboratories, Richland, Washington.
- Supply System. 1985. *Operational Ecological Monitoring Program for Nuclear Plant 1985 Annual Report*. Washington Public Power Supply System, Richland, Washington.
- Supply System. 1986. *Operational Ecological Monitoring Program for Nuclear Plant 1986 Annual Report*. Washington Public Power Supply System, Richland, Washington.

Supply System. 1987. *Operational Ecological Monitoring Program for Nuclear Plant 1987 Annual Report*. Washington Public Power Supply System, Richland, Washington.

Taylor, D. W. 1966. "Summary of North American Blancan Nonmarine Mollusks." *Malacologia* 4:1-172.

Taylor, D. W. 1975. "Index and Bibliography of Late Cenozoic Freshwater Mollusca of Western North America." *Claude W. Hibbard Memorial Vol. 1*, Museum of Paleontology Papers on Paleontology, No. 10. 384 pp.

Taylor, D. W. 1982a. *Status Report on the Giant Columbia River Spire Snail in Southern Idaho*. Tomales Bay Marine Laboratory, Marshall, California.

Taylor, D. W. 1982b. *Status Report on the Great Columbia River Limpet in Southern Idaho*. Tomales Bay Marine Laboratory, Marshall, California.

Taylor, D. W. 1983. "Late Tertiary Mollusks from the Lower Colorado River Valley." *Univ. Mich. Mus. Paleontol. Contrib.* 26:289-298.

Taylor, D. W. 1985. "Evolution of Freshwater Drainages and Molluscs in Western North America." In *Late Cenozoic History of the Pacific Northwest: Interdisciplinary Studies on the Clarkia Fossil Beds of Northern Idaho*, eds. C. J. Smiley, A. E. Leviton, and M. Berson, pp. 265-309. American Association for the Advancement of Science, San Francisco, California.

Wolf, E. G. 1976. "Characterization of the Benthos Community." In *Final Report on Aquatic Ecological Studies Conducted at the Hanford Generating Project, 1973-1974*. WPPSS Columbia River Ecology Studies, Vol. 1. Prepared for the Washington Public Power Supply System with United Engineers and Constructors, Inc., by Battelle, Pacific Northwest Laboratories, Richland, Washington.

DISTRIBUTION

No. of
Copies

OFFSITE

2 DOE/Office of Scientific and Technical Information

5 T. J. Frest
Burke Museum DB-10
Division of Geology & Paleontology
University of Washington
Seattle, Washington 98195

J. S. Bader
District Park Manager
Deschutes Park District, Star Route
Wasco, Oregon 97065

L. Fujishin
3701 West 13th
The Dalles, Oregon 97058

ONSITE

DOE Richland Operations Office

M. W. Tiernan

31 Pacific Northwest Laboratory

C. S. Abernethy
C. D. Becker
D. D. Dauble
J. W. Falco
R. H. Gray
J. M. Hales
P. C. Hays
S. A. Kreml
E. W. Lusty
D. A. Neitzel (10)
W. T. Pennell
W. H. Rickard
L. E. Rogers
A. J. Scott
W. L. Templeton
R. E. Wildung
Publishing Coordination
Technical Report Files (5)

APPENDIX

LATITUDE AND LONGITUDE FOR THE GIANT COLUMBIA RIVER SPIRE SNAIL
Fluminicola columbiana AND THE GREAT COLUMBIA RIVER LIMPET *Fisherola*
nuttalli SURVEY SITES PROPOSED FOR 1989 AND 1990

LATITUDE AND LONGITUDE FOR THE GIANT COLUMBIA RIVER SPIRE SNAIL
Fluminicola columbiana AND THE GREAT COLUMBIA RIVER LIMPET *Fisherola*
nuttalli SURVEY SITES PROPOSED FOR 1989 AND 1990

Proposed survey sites for spire snails and limpets are listed by river system. In most cases, the proposed sites proceed downstream within the reach described by these sites. If major tributaries in a system are also surveyed, they are listed before the main system stream. Where possible, the most recent U.S. Geodesic Survey (USGS) 7.5' topographic map is used as a base. In a few cases, 15' maps only were available. In some instances, U.S. Forest Service forest survey 7.5' sheets or preliminary USGS 7.5' topographic maps were used to provide best available and most recent coverage.

TABLE A.1. Latitude and Longitude of Proposed Collection Sites for the Giant Columbia River Spire Snail *Fluminicola columbiana* and the Great Columbia River Limpet *Fisherola nuttalli*

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Wenatchee River						
1	120	42	22	47	35	11
2	120	39	34	47	35	31
3	120	37	3	47	35	0
4	120	35	13	47	34	6
5	120	34	14	47	32	47
6	120	31	23	47	31	60
7	120	29	19	47	31	39
8	120	25	29	47	30	4
9	120	24	38	47	29	8
10	120	22	12	47	28	26
11	120	20	5	47	27	31
Entiat River						
1	120	19	6	47	41	36
2	120	16	51	47	40	5
3	120	14	22	47	39	47
Okanagon River						
1	119	29	12	48	33	42
2	119	29	12	48	33	15
3	119	29	34	48	32	2
4	119	30	27	48	30	14
5	119	28	58	48	29	9
6	119	28	15	48	27	46
7	119	28	10	48	27	1
8	119	28	46	48	24	22
9	119	32	51	48	23	33
10	119	36	25	48	19	29
11	119	40	11	48	17	5
12	119	42	27	48	16	46
13	119	43	40	48	15	55
14	119	44	17	48	15	22
15	119	42	59	48	12	39
16	119	40	42	48	10	39
17	119	40	25	48	8	24
18	119	42	32	48	6	12
Methow River						
1	120	6	20	48	20	52
2	120	4	42	48	20	46
3	120	4	6	48	18	44
4	120	5	18	48	16	41
5	120	6	58	48	15	7
6	120	6	52	48	12	9

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Methow River (contd).						
7	120	4	41	48	9	59
8	120	3	22	48	9	4
9	120	1	4	48	8	14
10	120	1	13	48	6	3
11	120	0	52	48	5	5
12	119	58	1	48	4	36
13	119	57	0	48	4	3
14	119	56	30	48	3	21
Nespelem River						
1	118	56	16	48	16	16
2	118	58	58	48	14	30
3	118	58	2	48	11	38
4	119	0	14	48	7	60
5	119	1	28	48	7	38
Sanpoil River						
1	118	43	56	48	28	23
2	118	44	5	48	24	46
3	118	44	33	48	19	37
4	118	42	3	48	16	3
5	118	41	51	48	13	39
6	118	40	58	48	8	52
7	118	41	50	48	6	31
8	118	39	51	48	4	22
Colville River						
1	117	55	57	48	32	37
2	117	59	26	48	35	19
3	118	3	34	48	35	37
Cowlitz River						
1	122	53	16	46	23	52
2	122	55	50	46	24	23
3	122	55	46	46	22	57
4	122	55	56	46	22	5
5	122	55	28	46	20	9
Lewis River						
1	122	33	13	45	57	22
3	122	35	19	45	56	55
2	122	37	13	45	56	12

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Lewis River (contd).						
4	122	40	45	45	56	21
5	122	41	20	45	55	44
6	122	43	25	45	54	59
7	122	42	15	45	52	14
8	122	38	39	45	50	40
9	122	45	38	45	51	41
Wind River						
1	121	58	17	45.	51	56
2	121	56	24	45	50	18
3	121	54	34	45	48	30
4	121	50	7	45	45	32
5	121	48	5	45	44	15
6	121	47	29	45	43	43
White Salmon River						
1	121	30	32	45	52	15
2	121	28	48	45	48	59
3	121	32	5	45	45	56
4	121	31	1	45	44	52
Klickitat River						
1	121	7	59	45	59	35
2	121	6	57	45	56	10
3	121	6	44	45	55	22
4	121	6	49	45	53	29
5	121	7	35	45	56	2
6	121	4	45	45	51	33
7	121	4	41	45	49	58
8	121	6	17	45	49	24
9	121	8	40	45	49	13
10	121	10	13	45	48	36
11	121	12	21	45	46	53
12	121	12	30	45	45	30
13	121	13	36	45	44	27
14	121	15	17	45	43	0
15	121	16	32	45	42	17
Palouse River						
1	117	55	1	46	56	47
2	117	55	17	46	55	47
3	117	55	36	46	54	42
4	117	53	29	46	51	42

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Palouse River (contd).						
5	117	55	38	46	50	27
6	117	59	26	46	50	15
7	117	59	8	46	49	41
8	118	0	52	46	48	15
9	118	2	24	46	46	26
10	118	5	41	46	46	43
11	118	8	42	46	45	33
12	118	9	41	46	44	48
13	118	12	5	46	44	35
14	118	13	28	46	39	48
15	118	13	26	46	38	48
16	118	10	57	46	53	28
17	118	12	4	46	44	36
Grande Ronde River						
1	116	59	8	46	4	39
2	116	59	35	46	3	44
3	117	0	8	46	3	10
4	117	1	54	46	2	38
5	117	4	53	46	2	48
6	117	6	35	46	2	2
7	117	8	16	46	1	58
8	117	9	1	46	1	38
9	117	14	0	46	2	27
10	117	14	55	46	2	27
11	117	16	12	46	2	5
12	117	17	27	46	2	2
13	117	18	46	46	1	43
14	117	21	6	46	1	5
15	117	21	3	46	0	16
16	117	23	23	45	59	6
17	117	24	43	45	57	44
18	117	25	18	45	57	21
19	117	27	17	45	55	46
20	117	27	8	45	55	3
21	117	28	31	45	54	28
Walla Walla River						
1	118	34	29	46	13	23
2	118	38	1	46	11	53
3	118	38	7	46	10	50
4	118	38	39	46	9	29
5	118	39	20	46	7	40
6	118	39	21	46	6	29
7	118	39	55	46	3	26

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Walla Walla River (contd).						
8	118	40	6	46	1	46
9	118	43	41	46	1	41
10	118	45	48	46	2	17
11	118	46	56	46	4	22
12	118	48	59	46	4	14
13	118	50	17	46	4	30
Tucannon River						
1	118	1	28	46	30	11
2	118	6	10	46	30	37
3	118	7	32	46	30	59
4	118	9	31	46	32	33
Hood River						
1	121	37	43	45	36	17
2	121	35	6	45	38	42
3	121	32	38	45	39	19
4	121	30	19	45	40	59
Deschutes River						
1	121	21	28	44	0	40
2	121	20	8	44	6	25
3	121	18	47	44	5	33
4	121	19	25	44	8	28
5	121	14	48	44	14	28
6	121	14	18	44	18	46
7	121	17	15	44	21	36
8	121	15	13	44	19	39
9	121	17	33	44	29	34
10(b)	0	0	0	0	0	0
11(b)	0	0	0	0	0	0
12	121	13	46	44	41	45
13	121	14	45	44	43	36
14	121	11	30	44	47	9
15	121	4	36	44	50	20
16	121	5	41	44	48	57
17	121	2	52	44	52	25
18	121	3	31	44	53	40
19	121	4	50	44	55	2
20	121	4	46	44	55	58
21	121	4	23	44	56	55
22	121	4	36	44	57	49
23	121	4	47	44	58	4
24	121	3	40	44	58	29
25	121	2	53	45	0	22

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Deschutes River (contd).						
26	121	4	21	45	2	4
27	121	4	23	45	2	7
28	121	6	60	45	2	45
29	121	7	24	45	4	59
30	121	7	30	45	6	32
31	121	7	14	45	8	26
32	121	5	23	45	9	55
33	121	4	46	45	11	29
34	121	4	36	45	13	17
35	121	3	39	45	13	55
36	121	1	56	45	15	38
37	121	0	54	45	16	1
38	121	0	52	45	16	47
39	121	0	46	45	18	5
40	120	59	24	45	18	30
41	120	57	51	45	18	26
42	120	55	58	45	19	52
43	120	54	56	45	21	4
44	120	53	4	45	22	58
45	120	51	43	45	27	6
46	120	50	33	45	27	49
47	120	49	52	45	29	34
48	120	49	47	45	30	30
49	120	51	28	45	31	34
50	120	53	31	45	32	34
51	120	54	15	45	33	32
52	120	54	1	45	34	34
53	120	54	29	45	36	25
Willamette River						
1	123	13	43	44	31	24
2	123	14	57	44	33	58
3	123	14	19	44	34	46
4	123	10	43	44	36	52
5	123	9	15	44	38	16
6	123	6	7	44	40	28
7	123	8	31	44	43	12
8	123	7	36	44	47	7
9	123	9	25	44	51	45
10	123	7	39	44	53	17
11	123	5	20	44	55	53
12	123	4	12	45	1	25
13	123	2	40	45	5	15
14	123	0	13	45	6	31
15	123	1	31	45	8	35

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Willamette River (contd).						
16	123	2	48	45	12	49
17	122	58	31	45	16	22
18	122	56	24	45	16	3
19	122	53	24	45	15	23
20	122	49	58	45	16	18
21	122	45	58	45	17	33
22	122	42	5	45	17	49
23	122	40	25	45	17	21
24	122	37	47	45	20	44
25	122	49	31	45	38	52
26	122	51	13	45	39	49
27	122	51	54	45	41	27
28	122	52	3	45	42	46
John Day River						
1	120	30	37	45	22	55
2	120	29	43	45	26	46
3	120	28	8	45	28	35
4	120	24	27	45	28	13
5	120	22	49	45	29	46
6	120	21	26	45	31	51
7	120	22	49	45	32	46
8	120	23	54	45	34	9
9	120	24	34	45	35	26
10	120	28	54	45	44	12
Umatilla River						
1	119	12	35	45	51	36
2	119	19	6	45	47	32
3	119	20	24	45	48	45
4	119	19	50	45	50	9
5	119	18	57	45	51	59
6	119	19	27	45	54	8
Columbia River (Hanford Reach)						
1	119	53	33	46	37	54
2	119	46	22	46	43	57
3	119	50	55	46	43	27
4	119	40	49	46	38	52
5	119	43	52	46	38	25
6	119	32	11	46	42	31
7	119	36	46	46	38	54
8	119	34	7	46	40	59
9	119	29	31	46	42	50

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Columbia River (contd).						
10	119	27	29	46	40	30
11	119	24	51	46	38	4
12	119	22	28	46	35	12
13	119	19	47	46	34	4
14	119	15	42	46	30	38
15	119	15	12	46	29	15
16	119	15	17	46	25	52
17	119	15	36	46	22	49
18	119	15	11	46	20	59
19	119	14	54	46	19	17
20	119	15	37	46	16	39
21	119	14	21	46	15	44

Columbia River (near Portland, Oregon)

1	122	54	5	46	4	45
2	122	58	41	46	6	37
3	122	52	20	46	0	60
4	122	48	5	45	54	25
5	122	49	53	45	58	21
6	122	45	53	45	46	5
7	122	47	40	45	48	45
8	123	2	22	46	7	59
9	123	6	11	46	10	12
10	123	3	54	46	10	20
11	123	9	50	46	11	29
12	123	13	40	46	10	11
13	123	16	24	46	8	2
14	123	20	4	46	8	24
15	123	19	55	46	10	7
16	123	25	14	46	10	45
17	123	22	55	46	11	32
18	123	27	54	46	12	48
19	123	27	43	46	16	16
20	123	33	22	46	15	51
21	123	36	51	46	15	37
22	123	30	60	46	14	8

Columbia River (downstream of McNary, John Day, Dalles, Bonneville dams)

1	118	58	45	47	57	45
2	119	39	17	48	0	10
3	119	51	33	47	56	37
4	120	18	3	47	31	23
5	119	57	48	46	52	5
6	119	53	58	46	38	10
7	119	19	23	45	55	55

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Columbia River (contd).						
8	121	8	22	45	36	36
9	121	57	21	45	38	27
Spokane River						
1	117	57	38	47	49	48
2	117	55	4	47	49	44
3	117	51	1	47	50	20
4	117	14	0	47	41	30
5	117	11	33	47	40	19
6	117	4	22	47	41	22
7	117	2	36	47	41	55
8	117	0	13	47	41	36
9	117	10	48	47	40	19
10	117	9	11	47	40	42
11	116	14	18	47	36	40
12	116	10	30	47	39	13
13	116	8	48	47	39	40
14	116	30	55	47	31	27
15	116	29	18	47	32	11
16	116	25	42	47	32	32
17	116	19	58	47	33	4
18	116	15	33	47	33	14
19	116	10	29	47	32	55
20	116	29	28	47	10	32
21	116	25	25	47	8	14
22	116	33	4	47	12	18
23	116	37	8	47	13	40
24	116	35	58	47	15	43
25	116	32	32	47	18	28
26	116	17	1	47	19	19
27	116	15	28	47	16	58
28	116	20	50	47	18	58
29	116	23	34	47	19	27
30	116	28	3	47	20	26
31	116	31	20	47	20	32
32	116	35	35	47	19	50
33	116	40	8	47	20	51
34	116	11	50	47	37	23
Malheur River						
1	118	9	34	43	33	24
2	118	8	0	43	33	21
3	118	4	16	43	43	16
4	118	4	20	43	44	16
5	118	1	22	43	46	4

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Malheur River (contd).						
6	117	57	26	43	47	40
7	117	52	14	43	47	38
8	117	46	14	43	45	53
9	117	39	1	43	48	55
10	117	31	33	43	53	4
11	117	22	55	43	56	36
12	117	21	50	43	56	22
13	117	11	42	43	59	10
Owyhee River (lower reaches)						
1	117	14	46	43	39	9
2	117	12	30	43	40	43
3	117	10	15	43	44	16
4	117	8	49	43	45	26
5	117	4	31	43	46	38
6	117	2	60	43	47	4
Clark Fork River						
1	114	39	13	47	0	0
2	114	44	22	47	1	1
3	114	45	52	47	3	4
4	114	46	48	47	6	58
5	114	45	44	47	4	56
6	114	47	20	47	7	53
7	114	51	48	47	10	13
8	114	56	16	47	12	35
9	114	57	54	47	13	45
10	115	2	49	47	14	19
11	115	0	28	47	20	14
12	115	4	53	47	18	11
13	114	57	19	47	20	26
14	114	51	50	47	19	2
15	114	31	33	47	20	45
16	114	34	35	47	22	6
18	114	39	11	47	20	9
19	114	42	44	47	20	42
20	114	47	48	47	23	1
21	114	46	45	47	21	17
22	114	53	39	47	27	17
23	114	55	50	47	30	19
24	115	2	40	47	31	19
25	115	6	1	47	32	37
26	115	9	40	47	33	59
27	115	11	50	47	34	56

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Kootenai River						
1	115	19	6	48	24	20
2	115	20	22	48	21	53
3	115	25	49	48	22	21
4	115	28	40	48	25	4
5	115	36	56	48	25	44
6	115	39	33	48	26	40
7	115	47	52	48	26	50
8	115	52	3	48	26	59
9	115	55	10	48	29	43
10	115	57	12	48	31	57
11	115	58	34	48	34	2
12	116	2	55	48	36	59
13	116	13	42	48	42	22
14	116	22	13	48	42	16
15(b)	0	0	0	0	0	0
16(b)	0	0	0	0	0	0
17(b)	0	0	0	0	0	0
18(b)	0	0	0	0	0	0
19(b)	0	0	0	0	0	0
20(b)	0	0	0	0	0	0
21(b)	0	0	0	0	0	0
Clearwater River						
2	115	16	49	46	2	37
1	115	17	12	46	1	47
3	115	21	53	46	4	14
4	115	24	35	46	4	34
5	115	29	22	46	5	6
6	115	30	46	46	5	9
7	115	34	12	46	6	53
8	115	23	18	46	16	42
9	115	24	34	46	13	55
10	115	27	24	46	13	38
11	115	29	10	46	13	54
12	115	31	56	46	12	53
13	115	34	13	46	10	54
14	115	35	19	46	9	41
15	115	35	29	46	8	9
16	115	37	24	46	8	6
17	115	40	52	46	8	13
18	115	41	58	46	8	29
19	115	47	27	46	8	5
20	115	51	38	46	8	28
21	115	53	5	46	8	45
22	115	57	51	46	8	26

TABLE A.1. (contd)

Site Number ^(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Clearwater River (contd).						
23	116	1	3	46	11	54
24	116	1	48	46	14	23
25	116	3	18	46	15	13
26	116	6	58	46	17	24
27	116	8	11	46	19	27
28	116	9	47	46	21	43
29	116	12	13	46	25	7
30	116	13	42	46	27	39
Snake River (lower reaches)						
1	116	57	28	46	13	16
2	116	56	22	46	10	53
3	116	55	58	46	8	33
4	116	56	46	46	7	37
5	116	57	51	46	5	53
6	116	57	38	46	4	35
7	116	57	5	46	4	20
8	116	55	29	46	1	15
9	116	54	55	46	0	5
10	116	54	25	45	59	23
11	116	53	47	45	58	57
12	116	51	57	45	55	9
13	116	50	23	45	53	29
14	116	47	35	45	51	34
16	116	45	48	45	49	14
17	116	41	53	45	49	16
18	116	41	27	45	48	47
19	116	39	7	45	46	49
20	116	37	5	45	46	57
21	116	34	43	45	46	15
22	116	34	11	45	45	56
23	116	32	53	45	45	13
24	116	29	10	45	38	57
25	116	28	50	45	38	9
26	116	42	17	45	13	18
27	116	42	25	45	11	58
28	116	43	19	45	10	10
29	116	44	8	45	8	15
30	116	27	49	45	37	8
31	116	28	56	45	35	1
Snake River (middle reaches)						
1	115	12	18	43	0	6
2	115	10	2	42	59	33
3	115	10	35	42	57	53

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Snake River (contd).						
4	115	8	48	42	55	54
5	115	9	12	42	54	60
6	115	7	8	42	54	29
7	115	4	8	42	54	53
8	114	59	46	42	55	1
9	114	58	1	42	54	56
10	114	57	12	42	54	48
11	114	55	54	42	53	15
12	114	52	29	42	45	30
13	114	51	14	42	45	15
14	114	53	55	42	51	56
15	114	53	34	42	50	38
16	114	55	27	42	49	14
17	114	55	53	42	47	34
18	114	54	40	42	46	17
19	114	53	19	42	46	1
20	114	52	44	42	45	50
21	114	50	18	42	44	20
22	114	50	15	42	43	39
23	114	49	29	42	42	39
24	114	48	38	42	42	25
25	114	49	2	42	41	31
26	114	47	35	42	39	55
27	114	46	8	42	40	6
28	114	44	52	42	40	19
29	114	44	26	42	40	22
30	114	42	13	42	40	5
31	114	42	13	42	40	5
32	114	39	12	42	39	43
33	114	37	14	42	39	11
34	114	36	58	42	38	58
35	114	32	28	42	38	11
36	114	31	19	42	37	58
37	114	30	56	42	37	55
38	114	30	5	42	37	37
39	114	30	1	42	37	17
40	114	26	50	42	36	2
41	114	21	19	42	35	24
42	114	19	43	42	34	22
43	114	19	43	42	34	22
44	114	17	33	42	34	3
45	114	14	59	42	33	41
46	114	12	13	42	32	45
47	114	10	5	42	32	58
48	114	9	4	42	30	27

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Snake River (contd).						
49	114	7	51	42	29	52
50	114	4	2	42	31	3
51	114	4	2	42	31	3
Henry's Fork River						
1	111	56	40	43	46	57
2	111	53	47	43	49	36
3	111	50	49	43	53	14
4	111	47	41	43	54	57
5	111	46	14	43	55	38
6	111	42	55	43	57	0
7	111	37	29	43	58	59
8	111	34	52	47	2	20
10	111	33	47	47	2	2
9	111	31	49	47	3	17
11	111	30	1	47	4	17
12	111	29	50	47	4	38
13	111	26	47	47	6	42
14	111	24	58	47	5	54
16	111	21	60	47	5	54
15	111	19	56	47	6	39
17	111	17	45	44	9	8
19	111	19	31	44	11	26
18	111	19	7	44	10	36
20	111	25	37	44	12	59
21	111	26	53	44	20	46
22	111	26	43	44	19	17
23	111	26	18	44	18	22
24	111	23	45	44	21	55
25	111	24	22	44	21	25
26	111	26	18	44	17	23
27	111	27	0	44	15	51
Weiser River						
1	116	26	45	44	49	3
2	116	27	23	44	45	10
3	116	33	7	44	39	1
4	116	27	26	44	42	25
5	116	29	6	44	40	2
6	116	26	55	44	39	32
7	116	38	3	44	34	46
8	116	40	54	44	30	48
9	116	43	43	44	28	52
10	116	51	15	44	14	9
11	116	56	25	44	14	29

TABLE A.1. (contd).

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Snake River (upper reaches)						
1	112	37	30	47	1	22
2	112	35	48	47	2	39
3	112	31	56	47	6	1
4	112	30	46	47	6	53
5	112	29	31	43	8	25
6	112	30	17	43	7	46
7	112	28	14	43	9	20
8	112	24	43	43	10	34
9	112	23	18	43	11	9
10	112	19	25	43	13	46
11	112	18	60	43	14	33
12	112	17	53	43	16	5
13	112	13	1	43	17	46
14	112	13	56	43	16	41
15	112	10	40	43	18	45
16	112	9	39	43	22	13
17	112	9	31	43	20	26
18	112	8	34	43	24	45
19	112	9	39	43	22	49
20	112	5	11	43	27	28
21	112	5	45	43	26	23
22	112	5	56	43	25	20
23	112	7	16	43	24	48
24	112	4	10	43	27	49
25	112	3	12	43	32	31
26	112	3	4	43	35	9
27	112	3	10	43	35	26
28	112	4	18	43	40	28
29	112	4	27	43	39	26
30	112	4	58	43	43	22
31	112	6	46	43	44	32
32	112	3	1	43	46	13
33	112	0	52	43	45	38
34	111	58	41	43	45	16
35	111	55	21	43	46	11
36	111	51	58	43	43	48
Snake River (upper reaches continued)						
37	111	41	50	43	38	49
38	111	41	12	43	37	51
Salmon River						
1	114	11	12	44	35	24
2	114	8	18	44	37	50
3	114	4	2	44	39	46

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Salmon River (contd).						
4	114	1	39	44	42	4
5	113	59	42	44	45	29
6	113	51	56	44	52	23
7	114	0	14	44	48	30
8	113	59	16	44	49	30
9	113	58	26	44	52	0
10	113	58	10	44	53	7
11	113	57	21	44	54	14
12	113	57	39	44	56	12
13	113	56	50	44	57	21
14	113	56	25	44	59	42
15	113	55	2	45	1	13
16	113	53	30	45	5	0
17	113	54	31	45	9	26
18	113	53	18	45	13	51
19	113	53	59	45	15	37
20	113	53	20	45	17	24
21	113	54	4	45	18	35
22	113	55	24	45	20	3
23	113	57	8	45	21	51
24	113	57	52	45	23	23
25	114	7	54	45	23	31
26	114	2	22	45	23	13
27	114	11	18	45	24	1
28	114	17	9	45	21	49
29	114	22	48	45	19	11
30	114	26	33	45	19	7
31	114	30	52	45	19	41
32	114	30	22	45	18	28
33	114	36	40	45	18	3
34	114	34	39	45	18	1
35	114	37	15	45	18	36
36	114	39	31	45	20	19
37	114	40	25	45	21	24
38	114	40	54	45	21	57
39	114	42	21	45	23	1
40	116	47	51	45	51	19
41	116	43	57	45	54	18
42	116	49	36	45	56	23
43	116	43	34	45	58	37
44	116	44	41	45	57	45
45	116	39	27	45	59	30
46	116	41	59	45	59	44
47	116	37	28	46	2	12
48	116	38	31	46	0	46
49(b)	0	0	0	0	0	0
50(b)	0	0	0	0	0	0

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Salmon River (contd).						
51(b)	0	0	0	0	0	0
52	115	58	23	45	26	7
53	116	0	54	45	25	37
54	116	6	20	45	24	7
55	116	6	58	45	24	5
56	116	7	24	45	24	40
57	116	10	17	45	25	5
58	116	12	43	45	24	4
59	116	15	44	45	25	11
60	116	18	38	45	24	46
61	116	18	56	45	26	2
62	116	18	23	45	27	1
63	116	18	56	45	29	27
64	116	18	3	45	31	5
65	116	18	27	45	32	4
66	116	17	41	45	33	31
67	116	17	9	45	35	23
68	116	16	8	45	36	27
69	116	17	22	45	39	48
70	116	17	60	45	37	41
71	116	18	17	45	41	3
72	116	18	46	45	42	54
73	116	19	22	45	44	43
74	116	19	16	45	49	59
75	116	18	51	45	48	4
76	116	19	45	45	53	24
77	116	22	19	45	52	37
Payette River						
1	115	44	40	45	4	19
2	115	48	10	45	3	31
3	115	52	54	45	14	38
4	115	56	18	45	11	19
5	115	51	10	45	2	44
6	115	57	58	45	7	54
7	116	0	57	44	5	18
8	116	5	48	44	14	39
9	116	6	19	44	12	57
10	116	6	40	44	11	35
11	116	7	7	44	10	16
12	116	6	19	44	6	50
13	116	6	55	44	5	4
14	116	9	4	44	0	50
18	116	14	57	43	54	20
19	116	15	29	43	54	52

TABLE A.1. (contd)

Site Number(a)	Longitude			Latitude		
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds
Payette River (contd).						
20	116	19	20	43	55	53
21	116	26	26	43	55	51
22	116	26	26	43	55	15
23	116	26	59	43	54	29
24	116	28	15	43	53	29
25	116	34	29	43	52	56
26	116	35	13	43	53	43
31	116	46	4	43	58	38
32	116	47	27	43	59	29
33	116	50	21	44	0	58
17	116	11	53	43	54	18
15	116	10	55	43	59	14
16	116	11	32	43	56	32
27	116	37	9	43	53	50
28	116	38	18	43	54	27
29	116	42	28	43	56	36
30	116	42	49	43	57	15
34(b)	0	0	0	0	0	0
35(b)	0	0	0	0	0	0
36(b)	0	0	0	0	0	0

(a) Site number is author cross reference to project maps. Some numbers are out of sequence to match references.

(b) Map not available to determine latitude and longitude when appendix was printed.