OSWB 2018 Grant Application Form
Grant Cycle 31-8 – Application Due Date: December 15, 2017

Project title: Willamette River Aquatic Weed Management, Phase 5

County or counties project is located in: Benton County, Linn County

Type of Organization: A grant applicant must be a **legal entity** identified below and have a FEIN number. A state or federal agency may apply for funding only as a co-applicant with an eligible entity.

- ☒ Cooperative Weed Management Area
- ☐ Not-For-Profit Organization
- ☐ Watershed Council
- ☐ Local or tribal government
- ☐ Soil & Water Conservation District
- ☐ Institution for Higher Education
- ☐ Individual (not eligible for indirect or administrative costs)

OSWB dollars requested: $ 19,232 **Total cost of project: $** 42,851

Name of Applicant or Organization: Benton County Cooperative Weed Management Area

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Project Manager for Applicant or Organization: Benton Soil and Water Conservation District

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Payee for Organization: Benton Soil and Water Conservation District

Contact: Holly Crosson **email:** hcrosson@bentonswcd.org

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Project Information

1.Weed Species: (List all state listed noxious weeds pertaining to this project. Use common name plus genus and species. If your project has more weeds than the allowable space please duplicate this table on a separate sheet and attach to this application)

*Habitat	**Method of treatment	*Weed species	Net/treatment acres	Gross/survey acres	Herbicide(s)	Define the timing of treatment
Wetland	*Bio-Control*	*Purple loosestrife, Lythrum salicaria*	*1*	*13*	*N/A*	*Late June*
Instream (Lake)	Herbicide	Yellow floating heart (*Nymphoides peltata*)	0.5	16.5	Imazamox, Triclopyr	June/July, and Sept./Oct
Instream (River side-channels)	Herbicide	Uruguayan primrose-willow (*Ludwigia hexapetala*)	5	12	Glyphosate	June/July, and Sept./Oct
Instream (River side-channels)	Herbicide	Parrot feather (*Myriophyllum aquaticum*)	<1 acre	10.5	Imazamox	June/July, and Sept./Oct
Instream	Manual	Uruguayan primrose-willow (*Ludwigia hexapetala*)	<1 acre	5	N/A	May through September
Instream	Manual	Yellow floating heart (*Nymphoides peltata*)	< 1 acre	5	N/A	May through September

*Choose the primary habitat where the weed exists – Upland, Riparian, Wetland, Instream, Estuary. It is recognized that some projects have mixed habitat types, chose only one habitat per weed per line. Habitats are described within the instructions. Use only state listed noxious weeds as described within the Instructions Exhibit B.**see question 5. below for treatment type

Total estimated project acreage: net: 8.5 gross: 49
(see appendix c with Instructions for understanding calculation of your total project net/gross project acreage)

2. Project location: (directions to the site)

Horseshoe Lake, Benton County (*Nymphoides peltata* site): From Hwy 20, head north onto NW N. Albany Rd, right onto NW Quarry Rd, left onto NW Cacade Heights Dr, and right onto NW Horseshoe Lake Cir. Parking area is on the right. Landowner permission required to park and walk down to lake.

Collins Bay (*Ludwigia hexapetala* site – 10.5 acre site): Heading east on Hwy 20, take the first right after intersection of HWY 20 & Independence Hwy, onto private road. Park at bridge and walk along ag field edge towards Willamette River. For both sites, call Benton SWCD to get landowner permission before entering private land.

Wapato Cove (*Ludwigia hexapetala* site – 1.5 acre site): On the mainstem Willamette River downstream from Corvallis, 1 mile downstream from Tripp Greenway Island on river right. Accesible by boat, or by vehicle with landowner permission. From Hwy 34 head north on Riverside Dr. Turn left on Stellmacher Dr. and follow to river. Private road, need permission to enter.

Several small patches of Ludwigia and yellow-floating heart will be hand pulled on the Willametter River between Corvallis and Albany.

Latitude: (Horseshoe Lake Site: W -123.112806), (Collins Bay Site: W - 123.173201), (Wapato Cove Site: W - 123.1756) Longitude: (Horseshoe Lake Site: N 44.660760), (Collins Bay Site: N 44.634964) (Wapato Cove Site: N 44.6192) (at least one lat/long reading is mandatory)

3. Does this project exist within a designated weed control district?
(Refer to ORS 569.360)

☐Yes ☒No If Yes, provide district name:

4. Is this part of an established Cooperative Weed Management Area? ☒ Yes ☐No If Yes provide name: Benton County Cooperative Weed Management Area

****5. Identify your integrated pest management methods:** (all activities must be directly related to the proposed project)**:**

☒Assessment/Management Plan Development
☐Biological control
☒Education and outreach
☒Herbicide control
☒Manual control
☐Mechanical control
☒Monitoring
☒Prevention
☒Restoration
☐Other – Explain:
☒Survey – Describe the method of survey planned: Survey Ludwigia and yellow floating heart populations by boat using GPS. The use of GPS technologies and Fulcrum software will allow us to quickly map aquatic invasive data along the river during surveys and share the data with other practitioners through shared databases including Weed Mapper, Oregon Invasives Hotline, iMapInvasives, and the Willamette Aquatic Invasive Network's (WAIN) shared database.

6. Have you consulted with ODA staff? ☒Yes ☐No

If yes who? Glenn Miller

7. Is this a landowner reimbursement (cost share) project? ☐Yes ☒ No
Remember to attach a list of landowners with acreage by weed species. Updated landowner lists are required with your progress reporting.

8. Project summary: In 200 words – give a statement about your overall project. Provide a summary in 200 words (1000 characters) or less describing what the project will accomplish and what problems will be addressed. The information you provide will be used for project review, OWEB reporting purposes and will be displayed to the general public.

The Willamette River Aquatic Weed Management Phase 5 (WRAWMP) is the continuation of a project started by Benton County Cooperative Weed Management Area in 2014 with Oregon State Weed Board funding. The focus of the project is the control of Uruguayan primrose-willow (*Ludwigia hexapetala*) and yellow floating heart (*Nymphoides peltata*): two aggressive, invasive aquatic plants that pose a threat to fish and wildlife habitat in fresh water systems. N. peltata is an A-listed Oregon State Noxious Weed. We also propose to control parrot feather (*Myriophyllum aquaticum*) in a limited area at one select site, Collins Bay, following four years of Ludwigia treatments at this priority area where parrot feather is starting to try and come into the site.

The project area spans the reach of the Willamette from Corvallis to Albany, and covers about 15 river miles. WRAWMP consists of three main components:

1. Management of aquatic weed species:

a. A-rated *Nymphoides peltata* at Horseshoe Lake, North Albany.

b. B-rated *Ludwigia hexapetala* at Collins Bay and other river inlets (e.g., Wapato Cove).

c. B-rated *Myriophyllum aquaticum* in a limited area of one select site, Collins Bay, following four years of Ludwigia treatments at this priority site.

d. Restoration of areas following years of Ludwigia treatments (e.g., Collins Bay)

e. Volunteer weed pulls for small patches of Ludwigia and yellow floating heart on the mainstem Willamette River.

2. Targeted practitioner outreach about aquatic invasive plant species and lessons learned about treatment methods and distribution of the Aquatic Weeds Guide for Benton County.

3. Monitoring at project sites before and after treatments.

9. What are you proposing to do? Give an overview of the project (1,300 words which is approximately 8,000 characters) This should include: is this an extension of a previously funded project if so, include details of past treatments such as successes and failures • estimated acreage for treatment • method of control • restoration component • how this project relates to other projects within the area. It is important to be concise and keep this to the 1,300-word limit.

Was this project previously funded by OSWB? ☒Yes ☐No

If yes what year(s) and provide the grant number? 2014 (2014-27-400), 2015 (2015-28-501), 2016 (2016-29-601), 2017 (2017-30-701)

Proposal details:

The Willamette River Aquatic Weed Management Phase 5 (WRAWMP) is the continuation of an existing project to control key invasive aquatic plants to prevent further spread and reinfestation, restore habitat, monitor treatment efficacy, and perform outreach on the Willamette River. For this project the Benton County CWMA proposes the following activities:

1. Management of Aquatic Weed Species:

One goal of this project component is to increase the quantity and quality of open water habitat in the Willamette River system through control of invasive aquatic weeds. Specifically, we will continue to reduce the ecological impacts of Ludwigia on the river system through control treatments and the reduction of its spread at specific priority sites, as well as promote native plant recovery through restoration plantings.

Another component of this project is to conduct a follow-up treatment and eventually eradicate yellow floating heart from Horseshoe Lake, the first reported population of this species in Benton County.

We will also reduce the ecological impacts of yellow floating heart on the river system. In the summers of 2016 and 2017 we saw the first observed yellow floating heart occurrences along the mainstem of the Willamette river in the Corvallis to Albany reach (at a side channel at Lower Kiger and Tripp Island). Our volunteer groups hand pulled the two small populations. Along the Corvallis to Albany reach of the river each summer, we will continue to monitor locations of previous small new occurrences of yellow floating heart and Ludwigia. We will also continue to survey the reach each summer for new occurrrences of these species, and hand pull new small populations of these species during volunteer paddle and pull events.

We will also control parrot feather in a limited area at one select site, Collins Bay, following four years of Ludwigia treatments at this priority area where parrot feather is starting to try and come into the site.

a. *Nymphoides peltata*:

Horseshoe Lake: One component of this project is the continued control of A-rated *N. peltata* at Horseshoe Lake, North Albany. (**Appendix A: Map and Photos of Yellow Floating Heart Treatment Area at Horseshoe Lake, Benton County**). This population was treated during summer, 2014, 2015, 2016, and 2017 with OSWB funds.

Between 2014 through 2016 we used a glyphosate treatment method to try and treat the population of yellow floating heart at Horseshoe Lake. Unfortunately, the glyphosate treatment method was not as effective as we had hoped. It may have been the glyphosate treatments were only able to produce a top burn of the yellow floating heart plants, where the root system remained and was able to reproduce for the next season. There is likely also an existing yellow floating heart seed bank at the site which contributes to the conintued plant growth.

In 2016/2017 we consulted with Glenn Miller of ODA as well as other partners and research scientists (i.e., Dr. Mark Systma, Director of the Center for Lakes and Reservoirs and Co-Director of the Aquatic Bioinvasion Research and Policy Institute; Dr. Michael Netherland, U.S. Army Engineer Research and Development Center, University of Florida Center for Aquatic and Invasive Plants) to explore additional options for treatment of *N. peltata* that have been successful for other organizations. We also continue to meet with landowners surrounding Horseshoe Lake to discuss possible alternative treatment options and their potential irrigation and water needs/restrictions.

In 2017 we tried a new treatment method based on methods used by scientists in Indiana who have successfully eliminated yellow floating heart populations from ponds after regular treatments over the last four to seven years. In 2017 at Horseshoe Lake we used aquatic label Imazamox (Clearcast) (1 quart per acre) with 0.5-2% surfactant (Agridex) and indicator dye for a July treatment of the plants, with our contractor checking the site in August to see if any areas were missed as part of the 2017 initial treatment. We checked the site in September and October 2017 to look for yellow floating heart regrowth, but did not observe it. If we had observed regrowth, we would have conducted a second round of treatment using aquatic label Triclopyr (Renovate), following the protocol recommended by the experts we consulted.

We propose to use this same treatment method in 2018. We are cautiously optomistic about the treatment method and are looking forward to checking the status of the yellow floating heart at the site in early summer of 2018.

Concurrent with our proposed treatment regimen for *N. peltata*, the Homeowners Association on the lake will have their detention pond, which drains into the lake, inspected for *N. peltata*, and treated by a contracted professional if any plants are found.

The focus of this project is to significantly reduce, and eventually eradicate, *N. peltata* from Horseshoe Lake and to prevent its spread to the nearby Willamette

River. This population was the first observed site in Benton County, making it a prime candidate for targeted removal.

River Mainstem: In the summers of 2016 and 2017 we saw the first occurrences of *N. peltata* on the mainstem of the Willamette river in the Corvallis to Albany reach (at Lower Kiger side channel and Tripp Island). At Tripp Island the population was found by one of our volunteers (!) who recognized the plant from our discussion about it the morning of the volunteer event, using our Water Weed Guide for Benton County. Our volunteer groups hand pulled both occurrences of yellow floating heart in the mainstem of the Corvallis to Albany reach of the river. We will continue to visit these areas to pull any new plants, as well as survey for this species along other areas of the Corvallis to Albany reach and hand pull any new small populations we observe. New observations will be GPS'd and included in a shared mapping database.

b. *Ludwigia hexapetala*:

Collins Bay: We propose to continue control of B-rated *L. hexapetala* at Collins Bay, a side- channel inlet of the Willamette River. This site was treated in summer 2014, 2015, 2016, and 2017 for Ludwigia by professional contractors (see **Appendix B: Map of Ludwigia and Yellow Floating Heart Treatment Areas along River; Appendix C: Maps and Pictures of Collins Bay - Before and After Ludwigia Treatments**). For treatments in 2018 at Collins Bay, we will be requesting a reduced amount of OSWB grant funds, as we will be able to use some Oregon Watershed Enhancement Board Willamette Strategic Implementation Plan (WSIP) grant funds to help pay for treatment at this site in 2018.

Collins Bay is a river inlet connected to the mainstem of the Willamette River, the entirety of which is infested with Ludwigia (see **Appendix B: Map of Ludwigia and Yellow Floating Heart Treatment Areas along River; Appendix C: Maps and Pictures of Collins Bay - Before and After Ludwigia Treatments**). This population was identified and mapped during an assessment of the floodplain along the Willamette River from Corvallis to Albany completed in 2013. In the final report based on this assessment, Ludwigia is identified as a priority for removal from the Willamette River system. Collins Bay is recommended for restoration due to the rarity of open marshland on the mainstem of the river, which is vital habitat for birds, fish, pond turtles, river otters and many other species. (Carex Working Group Sept. 2013). Ludwigia is also identified as a priority for management in the Five-Year Action Plan for the Willamette Mainstem Cooperative, a group of landowners, natural resource specialists, and other stakeholders who are working to promote, facilitate, and foster long-term stewardship of Willamete River natural resources. (WMC 5-Yr Plan 2014 with updates).

Based on results from previous treatments, we are getting good success in treating Ludwigia in the northern half of Collins Bay; however, it is taking longer to treat the southern half of Collins Bay (see **Appendix C: Maps and Pictures of Collins Bay - Before and After Ludwigia Treatments)**. This may be because the northern half of the site appears to be deeper and has more flow throughout the year, while the south side is shallower with more extensive mudflats. Results from USGS and PSU's monitoring efforts in 2017 will provide more information related to habitat conditions at this site.

Treatments at Collins Bay will consist of herbicide application to thick mats of Ludwigia in open water and the shoreline. To minimize impacts to aquatic non-target plants, backpack sprayers will be used to treat infestations around native plant communities. Contracted applicators will be familiar with native species, and trained in techniques for selective application in aquatic ecosystems. An herbicide mixture of 3% aquatic label glyphosate, 1-2% surfactant (Agridex), and indicator dye will be used. Applications will take place in early summer (June/July), when about half of the plants have flowered, but seed capsules have not yet matured. A follow-up application will take place about six to eight weeks later (September).

In 2017, because of high water levels into summer, the Ludwigia plants did not start coming up until July and our first heribicde application across the site was conducted in July 2017. We were able to conduct a second application on the south end of the site (which is shallower than north end) in early September; however, we were not able to conduct a second application on the north end of the site because of the depth of this side of the site and the high water levels maintained by the U.S. Army Corps of Engineers throughout September and October in 2017. During these months some Ludwigia was lying just underneath the surface of the water on the north end, but were not exposed. In 2018 we intend to conduct two applications on both sides of the site, water levels permitting.

<u>Wapato Cove</u>: This 1.5 acre site, referred to as Wapato Cove, is a river inlet between Corvallis and Albany, which for the purpose of this application is called Wapato Cove (**Appendix B: Map of Ludwigia and Yellow Floating Heart Treatment Areas along River; Appendix D: Wapato Cove Photos**). It has been identified during numerous river surveys and by Benton SWCD and the Willamette Aquatic Invasive Network as a priority for control based on its location directly on the river, presence of a significant native species (wapato), and the threat of spread of *L. hexapetala* to downstream locations.

This site had Ludwigia control treatments conducted for the first time in 2017. At this site we are using an integrated technique of chemical control (e.g., using hoses and backpack sprayer in areas with medium to dense stands of Ludwigia) and some manual control (e.g., contractors or volunteers in areas with sparser amounts of Ludwigia and dense numbers of native wapato plants). Photos in **Appendix D: Wapato Cove Photos** show examples of some of these treatment areas. This site is a highly visable site with easy public access from the river. Successful Ludwigia control treatments at this site, while also limiting impacts to the extensive native wapato stands at the site, will be extremely helpful with public outreach efforts related to Ludwigia control treatments. This site is one that is included in our on the river outreach and education events and the public is very intersted in learning more about.

Treatment at this site must work around water needs of a nearby landowner that has a water intake at the downstream end of the site to use for his mint oil processing. We aim to chemically treat the site at least two times each year, but this may not always be possible due to water needs by this landowner. This was the case in 2017. We will continue to work with the nearby landowner to work around their needs but try and find times where we could chemically treat this site two times each year.

Treatments at Wapato Cove will consist of herbicide application to thick mats of Ludwigia in open water and the shoreline. To minimize impacts to aquatic non-target plants, backpack sprayers will be used to treat infestations around native plant communities. In dense stand of wapato plants at Wapato Cove, with sparse Ludwigia, Ludwigia will be manually removed by volunteers or contractors. Contracted applicators will be familiar with native species, and trained in techniques for selective application in aquatic ecosystems. An herbicide mixture of 3% aquatic label glyphosate, 1-2% surfactant (Agridex), and indicator dye will be used. Applications will take place in early summer (June/July), when about half of the plants have flowered, but seed capsules have not yet matured. A follow-up application will take place about six to eight weeks later (September).

For treatments in 2018 at Wapato Cove, we will be requesting a reduced amount of OSWB grant funds, as we will be able to use some Oregon Watershed Enhancement Board Willamette Strategic Implementation Plan (WSIP) grant funds to help pay for treatments at this site in 2018.

<u>River Mainstem</u>: As part of on the paddle and pull events Ludwigia will be hand-pulled by volunteers on the Corvallis to Albany stretch of Willamette River. Sites that have had hand pulling of small populations of Ludwigia in previous years will be revisited during 2018 river surveys and volunteer river weed pull events to check for re-occurrence of Ludwigia and yellow floating heart. New occurrences of Ludwigia and yellow floating heart will also be surveyed for as part of paddle and pull events and new small populations will be hand pulled.

Volunteer hand pull events (using ODA OSWB funds) have been very successful in finding and removing new small populations of Ludwigia along the river. (**Appendix E: Pictures of Aquatic Weed Outreach and Education Events, Weed Pulls, and Monitoring**). For example, in 2016 we hand-pulled Ludwigia at a number of locations along the mainstem, including gravel beds, small unnamed backwater areas, the outlet of East Channel Willamette River, and at the native mussel beds. In 2017 Ludwigia re-growth was not observed at these locations. This was likely a result of the previous hand pulling instances coupled with the high water levels of the river this past year.

At Lower Kiger side channel, hand pulling of new small populations of Ludwigia has occurred for the past several years (as part of volunteer paddle and pull events using ODA OSWB funds). An area of large Ludwigia growth (not previously handpulled) at Lower Kiger side channel was treated for the first time in 2016 (with OWEB WSIP funds) and was treated again in 2017 (with OWEB WSIP funds) (**Appendix E: Pictures of Aquatic Weed Outreach and Education Events, Weed Pulls, and Monitoring**). The coupling of targeted herbicide application with hand pulling of small populations is showing great success in an area that also has good water depth and likely receives strong flows during winter, which likely helps flush out the area.

Scatter Bar Pond: We are not requesting 2018 ODA OSWB funds for control treatments of Ludwigia at Scatter Bar Pond. We will instead be asking for an extension of our 2017 ODA OSWB grant funds (2017-29-601) for treatments at this site in 2018.

Scatter Bar Pond is owned by Greenbelt Land Trust, a partner on the project. In coordination with Greenbelt Land Trust, we had intended to begin the first year of Ludwigia control treatments at Scatter Bar Pond summer 2017. As we were about to begin treatments in July 2017, we realized an adjacent landowner actually owned a few small feet of the pond (**Appendix F: Scatter Bar Pond at Horseshoe Lake, Linn County**). Greenbelt Land Trust and Benton SWCD are currently coordinating with the adjacent landowner about 2018 treatments at the site.

We feel the additional time for outreach is worth the effort. Greenbelt Land Trust has recently applied for OWEB Focused Investment Partnership (FIP) grant funds for longer term habitat restoration activities at Scatter Bar Pond, including invasive control treatments in riparian areas and native riparian plantings, and continued Ludwigia control treatments after the initial year of ODA OSWB grant funds have been expended. By spending the time now to create a friendly and considerate relationship with the landowner, we will help make things easier for conducting habitat restoration activities at Scatter Bar Pond in the long term.

c. *Myriophyllum spicatum*:

We propose to control parrot feather (*Myriophyllum aquaticum*) in a limited area at one select site, Collins Bay, where parrot feather is starting to establish at the site.

Following years of Ludwigia treatments at this priority site, we first observed parrot feather at this site in the summer of 2017 (**Appendix C: Maps and Pictures of Collins Bay: Before and After Ludwigia Treatments**). We began pulling of two patches of parrot feather at Collins Bay in September 2017 and disposed of the materials offsite in September 2017 (using non-ODA grant funds); however, the patches were determined to be too large for hand pulling.

In 2017 we consulted with Glenn Miller (ODA), Andrew Riggs and Sunny Simpkins (Multnomah County Drainage District), and Alex Staunch (Mosaic Ecology an contractor for the Drainage District) about potential herbicide control treatment options for parrot feather. In areas with irrigation restrictions the Drainage District is using 1.5% imazamox (Clearcast) with 1% Syltac as the surfactant.

Mosaic Ecology also shared that in low to moderate cover areas and where they are restrictions in herbicide products, they have handpulled parrot feather as well. Although handpulling is quite labor intensive (and sometimes gross), these areas have responded well. For example one ditch experienced 60 hours of handpulling in 2016, but in 2017 that same area utilized a total of 12 man-hours. Other factors may have influenced this of course, but there may be hope for smaller patches.

Mosaic Ecology also shared that the literature has supported an early summer spray, or when the plants are emerging and actively growing, as this has to do with the emergent surface area.

For parrot feather control treatments at Collins Bay we propose to conduct herbicide application to areas of parrotfeather in open water. To minimize impacts to aquatic non-target plants, backpack sprayers will be used to treat infestations around native plant communities. Contracted applicators will be familiar with native species, and trained in techniques for selective application in aquatic ecosystems. An herbicide mixture of 1.5% imazamox (Clearcast) with 1-2% surfactant (e.g., Syltac or Agridex), and indicator dye will be used. (We will be doing some more research and reaching out to colleagues about Syltac and it's use and restrictions before choosing the surfactant). Applications will take place in early summer (June/July), when the plants are emerging and actively growing. A follow up application would then occur in late summer or early fall to account for missed individuals or populations that were previously underwater. Applications would be timed to occur concurrently with Ludwigia control treatment herbicide applications in order to efficiently use labor hours and crew time and travel time to and from the site.

d. Additional restoration plantings at Collins Bay:

Four seasons of treatments at Collins Bay have led to a reduction in Ludwigia cover, with some areas having greatly reduced plant cover to no plant cover (**Appendix C: Maps and Pictures of Collins Bay - Before and After Ludwigia Treatments**). In Fall 2016, we collected native wapato (*Sagittaria latifolia*) tubers and added approximately 500 of them to Collins Bay (0.07 acre; **Appendix G: Collins Bay Restoration Areas Map and Photos**). However, because of the early October 2016 rains and quick flooding of the river, we were only able to add the tubers to already flooded areas. While we added the tubers to an area that had limited to no plant cover, there was low success and this is likely because the tubers could only be added at the water level and not individually gently pushed into the soil. Tubers may have also been predated by fish, beavers, or nutria using the area, or pushed out of the side channel during winter storms.

For our ODA OSWB 2017 grant application, we did not request grant funds for restoration. However, under separate grant funds (Meyer Memorial Trust) we collected wapato tubers again this fall and planted them at Collins Bay, along with native aquatic seed (0.33 acre; **Appendix E: Pictures of Aquatic Weed Outreach and Education Events, Weed Pulls, and Monitoring**; **Appendix G: Collins Bay Restoration Areas Map and Photos**). Over 1500 wapato tubers were collected and shared between Benton SWCD, City of Eugene,and the Confederated Tribes of Siletz Indians.

Marvin Gilmour, a local farmer and wetland restoration practitioner, continues to generously donate his labor and his staff's labor and time to help with harvesting and collection of wapato tubers using traditional agricultural methods. Benton SWCD volunteers also helped with tuber collection. Donated native plant materials include: tubers/bulbs (wapato) and native seed (e.g., wapato, common spikerush [*Eleocharis palustris*], soft rush [*Juncus effusus*], spike bent grass [*Agrostis exarata*], American slough grass [*Beckmannia syzigachne*], slender rush [*Juncus tenuis*], and slough sedge [*Carex obnupta*]).

Lauri Holts from the City of Eugene also joined the Fall 2017 wapato collection day at Marvin's property. Students from the Jane Goodall Middle School in Salem then planted the wapato tubers (>500) at Eugene's Golden Gardens ponds where the City has conducted control treatments for Ludwigia for a number of years (**Appendix E: Pictures of Aquatic Weed Outreach and Education Events, Weed Pulls, and Monitoring)**.

Wapato tubers from the collection day were also donated to the Confederated Tribes of Siletz. They will be working to grow them out at their Fish Hatchery site for use at their habitat restoration sites.

Benton SWCD has also begun coordinating with scientists from PSU's Center for Lakes and Reservoirs about potential appropriate native aquatic plants and seeds to be used at Collins Bay. PSU's vegetation sampling conducted this year will help inform a longer term habitat enhancement plan at the site.

Sites where native plant materials have been added will be monitored using photo points and GPS mapping, as well as presence-absence surveys of plant species.

We are not requesting 2018 ODA OSWB grant funds for restoration. However, under separate grant funds (Meyer Memorial Trust) we plan to collect wapato tubers again in Fall 2018 and plant them at additional areas of Collins Bay, along with native aquatic seed, as these plant materials are available. We are also beginning to explore other options for potential sources of native aquatic plant materials.

e. Volunteer weed pulls:

In 2018, Benton SWCD, in partnership with Willamette Riverkeeper, will host at least two volunteer weed pulls at locations where volunteers previously pulled Ludwigia and yellow floating heart between Corvallis and Albany, as well as any additional small populations we find during river surveys. One objective of these volunteer events is to increase community awareness about the connection between river health and aquatic invasives. Another objective is to remove target invasives from the river in areas where they are just getting established (satellite populations) before these smaller populations become more significant. Ludwigia and yellow floating heart will be manually harvested and secured in heavy duty plastic bags on individual watercrafts. The bags will be sealed and properly disposed of at the end of each pull event. To determine effectiveness of hand pulling, volunteer pull sites will be monitored at least once each year following weed pulls. The sites will be monitored using photo points and GPS mapping. Willamette Riverkeeper will provide boats and assist with coordination, safety, and labor.

2. Targeted outreach consisting of one workshop:

Benton SWCD, in partnership with Willamette Riverkeeper and Integrated Resource Management, will host at least one workshop on the Willamette River, targeted for restoration practitioners and for members of the Willamette Aquatic Invasives Network (WAIN). This field based workshop will focus on sharing management techniques and lessons learned after several years of control treatments of Ludwigia and yellow floating heart. Potential sites for the field trip may include: Collins Bay, Wapato Cove, Lower Kiger Side Channel, Horseshoe Lake (in Benton County), or Bower's Rock State Park.

Benton SWCD will also help with the Eugene area workshop targeted for the community and hosted by the City of Eugene and Willamette Riverkeeper. (Benton SWCD's assistance with the Eugene based workshop will be funded through Meyer Memorial Trust grant funds, included as match in the City of Eugene's 2018 ODA OSWB grant application.) The Eugene workshop targeted for the community will contain information on native and invasive aquatic plant identification, and appropriate response and reporting techniques for priority aquatic weed species.

During the workshops we will distribute the Aquatic Weed Guide for Benton County, developed during the first phase of this project (Benton County Water Weed Guide, BSWCD 2014). Willamette Riverkeeper and Portland State University Center for Lakes and Reservoirs will assist with the workshop.

3. Monitoring:

<u>Photo Monitoring</u>

Monitoring will consist of strategic photo-points throughout the areas of infestation and GIS mapping of the pre- and post-treatment extent at each site. Photos have been regularly recorded for each photo monitoring location before and after treatments (see attached photos in **Appendices**). Photo points were established at Collins Bay and pictures have been collected throughout the Ludwigia growing season for the past four years. Photos have been collected at Horseshoe Lake (Benton County) before and after treatments of yellow floating heart for the past four years. Photo points have also been established at Wapato Cove.

We also regularly take photos of hand pull sites (e.g., Lower Kiger Side Channel) during volunteer events to help with monitoring of hand pull efforts from year to year.

Monitoring will also include pre- and post-treatment surveys of native plant species and documentation of perceptible changes in plant species density.

Water Quality and Vegetation Monitoring

In 2015 and 2016, we began density mapping of Ludwigia on several project sites pre- and post-treatments and water quality monitoring through collection of baseline and post-treatment data. The purpose of monitoring is to track changes to water quality parameters as the Ludwigia is removed from each site. The following parameters were collected at each site in 2015 and 2016: dissolved oxygen (DO), temperature, specific conductivity (an indicator of nutrient load), and pH. The most noteworthy findings from the monitoring efforts in 2015 and 2016 include:

- Ludwigia infested areas possessed lower dissolved oxygen than open water environments. Heavy Ludwigia infestations can reduce DO concentrations to levels that would be expected to result in acute mortality to salmonids, non-salmonids, and aquatic invertebrates.

- Areas previously inhabited by Ludwigia did not immediately see a rise in DO in the year following initial efforts.

- A “DO crash” related to herbicide treatment of Ludwigia was not observed in the second year (2016) of monitoring.

- Drought conditions of 2015 likely contributed to the expansion of Ludwigia within open water environments and increased mortality along population fringes.

- Large floating mats of Ludwigia appear to be a major source of Ludwigia regrowth.

- Native plants such as *Sparganium* spp. and *Sagittaria* spp. were observed naturally colonizing areas previously occupied by high Ludwigia cover.

Reports summarizing 2015 and 2016 monitoring efforts are available in **Appendix H: 2015 Water Quality and Ludwigia Monitoring Report** and **Appendix I: 2016 Water Quality and Ludwigia Monitoring Report**.

In 2017, a unique opportunity came about to partner with U.S. Geological Survey (USGS), Portland State University (PSU), Oregon Parks and Recreation Department (OPRD), and Willamette Riverkeeper on a regional monitoring effort to learn more about the impacts of Ludwigia and other aquatic invasive species. This monitoring effort includes two sites in the Willamette Mainstem Cooperative project area (Collins Bay and Scatter Bar Pond; monitoring conducted under ODA OSWB grant funds and USGS Cooperative Water Program funds) and Willamette Mission State Park (monitoring conducted separately under OWEB FIP grant funds and USGS Cooperative Water Program funds). Both Collins Bay and Scatter Bar Pond were included in 2015 and 2016 monitoring efforts, and this collaborative opportunity with USGS and PSU allows for more rigorous scientific monitoring at these two sites in 2017.

For 2017 monitoring efforts, USGS and PSU conducted three surveys each at Scatter Bar Pond and Collins Bay: (1) before glyphosate treatments (surveys conducted July 2017), (2) after first round of glyphosate applications (surveys conducted September 2017), and (3) after second round of glyphosate applications and after plant senescence (surveys to be conducted October/November 2017).

USGS collected high-frequency water-quality data using a calibrated and GPS enabled Yellow Springs Instruments (YSI) EXO2 sonde to characterize water temperature, dissolved oxygen, pH, conductance, turbidity, and plant pigments (total chlorophyll and phycocyanin) in these two waterbodies. Water quality surveys have been timed to be conducted outside of plant sampling (since plant biomass sampling will stir up sediments). From this data, USGS will produce color maps for each water body portraying the water quality parameters results.

For each survey, PSU assessed the aquatic plant community at 60 random points at both Collins Bay and Scatter Bar Pond. As a result of this assessment, PSU will be able to create a database that includes:

- the percent coverage of floating or emergent aquatic plants by species at each site

- a semi-quantitative assessment of submerged plant abundance at each site

- percent composition of submerged plants by species at each site

- depth at each site for 60 sites per waterbody on three occasions

PSU will also create an archived voucher collection of each aquatic plant encountered and maps estimating coverage by species for each sampling event.

USGS and PSU are in the process of analyzing the data from summer and fall 2017 surveys and anticipate results will be available this spring for sharing with partners.

The monitoring proposal is included as **Appendix J: 2017 Monitoring Proposal with USGS and PSU**.

Volunteers from PSU and OSU were instrumental in assisting with data collection this summer and fall. The survey events have given local students the opportunity to interact with and learn from research scientists actively working in fields of interest to the students.

Data collection related to water quality and vegetation sampling at Collins Bay and Scatter Bar Pond will also contribute to the creation of an even larger dataset including multiple geographic areas (e.g., Willamette Mission State Park). The results of the research will result in a peer reviewed published paper to be shared with peers and stakeholders. Assessing the impacts of Ludwigia control on the aquatic plant community and water quality is an important component in the management of the Willamette River system.

USGS and PSU are in the process of analyzing 2017 field collection data and plan to have results available sometime in spring 2018. Once preliminary data is available from 2017 monitoring activities at Collins Bay, Scatter Bar Pond, and from Willamette Mission State Park (where even more rigorous monitoring activities are being conducted through an OWEB FIP Monitoring grant), partners will be able to re-assess next steps for water quality and vegetation monitoring activities related to Ludwigia along the Willamette River. Because scientifically rigorous monitoring is labor and time intensive, and monitoring funds are limited, we want to make sure we continue to be strategic about proposed monitoring activities.

Therefore, we are not requesting 2018 ODA OSWB grant funds for water quality and vegetation monitoring activities. Additional funding sources for potential future monitoring activities will also be needed as monitoring activities are labor and time intensive. For example, for 2017 montioring surveys, two days were needed for each vegetation sampling survey event (instead of the one day for each sampling event included in our ODA proposal) to survey both Collins Bay and Scatter Bar Pond. PSU and Benton SWCD used other match funds to help with the additional survey days that were needed. To continue scientifically rigorous monitoring, continued additional sources of funds (e.g., USGS Cooperative Water Program, OWEB Monitoring grants) will likely be needed, and are limited.

10. Using a bulleted list: Explain the project goals and objectives.
(See Instructions section for specific guidance on goals and objectives)

- The primary goal of this project is to increase the quantity and quality of open aquatic habitat in the Willamette River system through control of invasive aquatic weeds. Specifically, we will continue to reduce the ecological impacts of Ludwigia on the river system through the reduction of the downstream spread of the species through plant fragmentation. We will also promote native plant recovery through restoration plantings following treatments. Sites targeted for control include Collins Bay, Wapato Cove, the side channel of Lower Kiger (weed pull events), Tripp Island (weed pull events), and new, small populations of Ludwigia between Corvallis and Albany. We will reduce the populations of Ludwigia in the river using integrated techniques at strategic sites. Treatment methods include hand pulling and herbicide application using updated techniques and equipment (Inteli-spray system with tractor, boat, and hose & reel).

- Another goal of this project is to continue to control and eventually eradicate yellow floating heart at Horseshoe Lake, the first observed population in Benton County. We will also reduce the ecological impacts of yellow floating heart on the river system. In the summers of 2016 and 2017 we saw the first observed yellow floating heart occurrences along the mainstem of the Willamette river in the Corvallis to Albany reach (at a side channel at Lower Kiger and at Tripp Island). Our volunteer groups hand pulled the small populations. We will continue to visit these areas to pull any new plants, as well as survey for this species along the river and hand pull any small populations we observe.

- Another objective of this project is to continue to monitor site changes in response to treatments. We will use photo-point monitoring techniques. These techniques will allow us to track changes in post-treatment distribution and abundance of Ludwigia and yellow floating heart, native plant distribution, and non-target impacts.

- Another goal of this project to reach at least 50 people through education and outreach activities including presentations, workshops and volunteer weed pulls. We will provide information on aquatic weed identification and proper early detection and rapid response techniques. Through volunteer weed pulls, Ludwigia and yellow floating heart will be removed from areas where it is just becoming established before it forms significant populations.

- Another objective of this project is to share treatment methodology and results with other land managers and practitioners. Benton SWCD, in partnership with Willamette Riverkeeper and Integrated Resource Management, will host a workshop on the Willamette River targeted for restoration practitioners and for members of the Willamette Aquatic Invasives Network (WAIN). This field based workshop will focus on sharing management techniques and lessons learned after several years of control treatments of Ludwigia and yellow floating heart.

We will also use GPS technology and Fulcrum software to quickly map aquatic invasive data along the river during surveys and share the data with other practitioners through a shared WAIN database. All survey data collected for this project will also be entered into WeedMapper and WAIN's shared database to track treatments and map noxious weed populations. Control techniques and efficacy of treatments will continue to be recorded and shared through meetings, presentations, and workshops. Recent examples of where we have highlighted the work and shared lessons learned include presentations at the Fall 2017 Oregon Lakes Association Conference and the Fall 2017 Willamette Aquatic Invasives Network meeting.

• Another goal of the project is to continue restoration at Collins Bay. After the first several years of Ludwigia treatments, portions of Collins Bay were ready for replanting with native vegetation. Based on native plants found on site, some of the native species best suited for Collins Bay include wapato, softstem bulrush, common spikerush, and soft rush, broadfruit bur-reed (*Sparganium eurycarpum*), and yellow pond lily (*Nuphar polysepala*). We have begun adding donated native wapato tubers and native aquatic seed to the site (**Appendix G: Collins Bay Restoration Areas Map and Photos**). In 2016 and 2017 we did not have access to broadfruit bur-reed or yellow pond lily stock; however, we will be trying to access some of this seed for future planting seasons. Access to native aquatic riverine weltand plant material is extremely limited.

• Another objective of the project is to continue the development of a long-term management plan for priority sites within the Corvallis to Albany reach of the Willamette River, including Collins Bay and Wapato Cove. This plan will include clear goals and objectives for the sites and will integrate work already accomplished with future restoration needs. The plan will also include a timeline for achieving restoration goals, and the associated actions needed to accomplish these goals. These sites will also be included as part of a larger plan for invasives management on the Willamette River, which is being developed by WAIN.

• Another objective of the project is the strategic control of parrot feather at priority sites where Ludwigia has been treated for several years and where parrot feather is a new invader and is at low enough levels where it can still be managed for the overall health and function of the restoration site. Collins Bay is an example of such a priority site, where we observed parrot feather for the first time establishing in 2017. We want to treat this population before before it forms significant populations at this site.

11. Is the project part of an existing weed management plan?
☒Yes ☐No (if yes, provide the plan name, author & date published)
This project fits within the goals and management principles outlined in the Benton County CWMA Five-year Management Plan. Specifically, "projects [should be] designed using an ecosystem management approach based on an understanding of weed biology, weed ecology, and landscape level processes." (Benton County CWMA, 2012; pp. 2-4).

The control of Ludwigia on the Willamette River is listed as a priority in the Willamette Mainstem Cooperative 5-Year Action Plan. The first goal of this plan is to work with willing landowners to protect high quality and unique habitats through management and control of high priority invasive plant species, including water primrose (*Ludwigia* spp.) (WMC 5-Yr Plan, 2014 with yearly updates).

Control of Ludwigia is also recommended in the "Willamette Mainstem Vegetative Habitat Survey and Assessment Final Report." This report was prepared by Carex Working Group based on invasive plant and habitat assessment and survey work completed in 2012 & 2013 on approximately 2,500 acres of riparian habitat on the Willamette River from Corvallis to Albany. This document was reviewed by the WMC steering committee members, and staff of Oregon Watershed Enhancement Board and Meyer Memorial Trust (Carex Working Group, Sept. 2013). The abridged version of this report can by found on the WMC webpage on the Benton SWCD website: https://www.bentonswcd.org/assets/Willamette-Mainstem-Assessment-Final-Report-Abridged.pdf

12. Are there additional partners? ☒Yes ☐No
Who are the additional partners and what are their roles and responsibilities?
Additional partners include Benton Soil and Water Conservation District (BSWCD), Willamette Riverkeeper (WRK), Portland State University Center for Lakes and Reservoirs (PSU), Oregon Department of Agriculture (ODA), private landowners within the project area including the Horseshoe Lake Neighborhood Association (HLNA), the Willamette Mainstem Cooperative (WMC), Integrated Resource Management, and Willamette Aquatic Invasives Network (WAIN).

Glenn Miller, Integrated Weed Management Specialist with ODA, will continue to provide in-kind support in the form of professional advice, site visits, and consultation on weed control activities. ODA provided photos and GIS shapefiles from aerial surveys for Ludwigia in the Willamette River system conducted during summer 2014. Further survey work is planned, as feasible. This data has helped to assess the extent of Ludwigia populations in the Willamette River system, and is being utilized in the formation of a management plan for this plant (currently being developed by the Willamette Aquatic Invasives Network).

WRK staff will continue to work with Benton SWCD to organize at least three river events, including one aquatic invasive workshop and two volunteer weed pulls. WRK will provide in-kind funding in the form of equipment use (boats, vans, and trailers). Grant funds are requested in this grant proposal for WRK staff time and mileage, which will be disbursed under paid contract.

Integrated Resource Management will continue to conduct aquatic weed control treatments for the project. They will also help lead discussions for the field based workshop targeted for restoration practitioners and for members of WAIN focused on sharing management techniques and lessons learned related to control treatments of Ludwigia and yellow floating heart. Integrated Resource Management has been treating noxious aquatic weeds at all of the potential sites for the field trip: Collins Bay, Wapato Cove, Lower Kiger Side Channel, Horseshoe Lake (in Benton County), or Bower’s Rock

State Park. Grant funds are requested in this grant proposal for Integrated Resource Management, which will be disbursed under paid contract.

Staff from PSU Center for Lakes and Reservoirs will continue to participate, as they have for our previous workshops and volunteer events, by offering expertise on aquatic invasives, presentations, and sharing outreach materials.

Private landowners at Horseshoe Lake and Collins Bay will be partners in this project through site monitoring, regular contact with Benton SWCD, and outreach to neighbors in the area. The Horseshoe Lake Neighborhood Association will continue to monitor and treat yellow floating heart as necessary in a detention pond that drains into the lake. Benton SWCD will continue to provide informational handouts about the project and weeds of concern to interested landowners.

Marvin Gilmour, a local farmer, has offered to provide native plant materials including seeds (e.g., common rush, wapato) and wapato bulbs for restoration plantings at Collins Bay. Other private landowners will contine to allow access to their properties for treatment of target invasive species.

Both WMC and WAIN focus on management of invasive species on the mainstem of the Willamette River. The WMC is a group of landowners, organizations, volunteers, and other interested parties working towards shared long-term stewardship of Willamette River resources with a focus on the Corvallis to Albany river reach. The Willamette Aquatic Invasives Network, comprised of over 50 participating organizations (local, state, and federal), fosters collaboration to share information, expertise, technologies, scientific data, and best management practices and to develop strategies to protect aquatic resources and restore aquatic and riparian habitat in the Willamette River Basin (Cascade Pacific RC&D, WAIN webpage, 2015). WRAWMP (this project) has benefited from the work and expertise of members of WAIN and the WMC. The BC CWMA will continue to coordinate and work with these groups to share information and lessons learned in the management of Ludwigia.

13. Which elements of the project will OSWB funds be used for? Be specific to activity and specific timing of the activity.
The Benton County CWMA is requesting OSWB funds for the following elements of this proposed project:

1. Salary and Wages:

Funding for Benton SWCD staff will be used for these tasks: project coordination and management (on-going), administration and oversight of all grant activities (on-going), coordination and facilitation of education and outreach activities (April-September 2018), and information sharing and reporting (on-going).

2. Contracted Services:

Survey (May-September 2018) and monitoring (May-October 2018) to determine previous treatment effectiveness and post-treatment of yellow floating heart on 0.5 acres of Horseshoe Lake as needed. Treatments will take place in June or July (at first sign of leaf emergence and prior to flower formation), with a second treatment taking place in August or September (as soon as regrowth is observed). Monitoring will take place before and after treatments and as needed.

Survey and monitoring of Collins Bay and Wapato Cove to determine treatment effectiveness and other site changes, continue treatment of Ludwigia at both sites, and conducted strategic treatment of parrot feather at Collins Bay. Concurrent with survey and monitoring, treatment will occur between June-July depending on conditions, and consist of application of herbicide. Secondary control treatments will occur between Aug.-Sept. to spray remaining plants. Monitoring will take place before and after treatments and as needed.

Funding is requested for education and outreach including one aquatic weed training targeted for restoration practitioners and for members of the Willamette Aquatic Invasives Network.These activities will be led by Benton SWCD staff in partnership with Willamette Riverkeeper and Integrated Resource Management. The workshop will be held in late spring or early summer 2018. OSWB funds will pay for a portion of Benton SWCD, Willamette Riverkeeper, and Integrated Resource Management (Matt Mellenthin) time to coordinate these workshops.

OSWB funds are requested for coordination of at least two days of volunteer Ludwigia hand-pull activities on the Willamette from Corvallis to Albany and one aquatic weed work shop for restoration practitioners. This effort will be led by Benton SWCD and Willamette Riverkeeper. Funds will cover Benton SWCD and Willamette Riverkeeper staff time for the coordination of these activities. The first weed pull event will take place in early summer (June), and will be followed-up with a pull later in the season (August). Much of the Benton SWCD staff time will be in-kind matching services.

Monitoring of project sites will include pre- and post-treatment photo points and aerial imagery mapping (using ODA survey images and Google Earth).

14. How does this project relate to other projects (BLM, USFS or local projects) completed or planned? Is the project related to work funded in part with another grant from OWEB (i.e. restoration, land acquisition, or technical assistance)? List the OWEB grant number and briefly describe the relationship to this proposal.

The Willamette River Aquatic Weed Management Phase 5 (WRAWMP) fits within the mission and guiding principles of the Willamette Mainstem Cooperative (WMC), a group of landowners, organizations, and volunteers who work together to improve stewardship of natural resources across all landownerships on the mainstem, with a focus area of Corvallis to Albany (WMC Programmatic Bylaws, 2015). Ludwigia is listed as a priority species for control in the Willamette River in the WMC 5-Year Action Plan (WMC 5-Yr

Plan, 2014; pg. 8). Capacity funding for the WMC is funded by Meyer Memorial Trust, through the Willamette River Initiative program, with Benton SWCD providing leadership and fiscal management.

The Ludwigia sites proposed for treatment in this application were identified and mapped during a landscape scale invasive plant assessment of the floodplain along the Willamette River from Corvallis to Albany. The survey was conducted for the Willamette Mainstem Cooperative by Carex Working Group (CWG). In the final report submitted by CWG, Ludwigia was identified as a priority for removal from the Willamette River system, and specifically Collins Bay, due to the rarity of open marshland habitat on the Willamette (Carex Working Group, Sept. 2013). At the time of the CWG survey and report, yellow floating heart was not yet a known issue in the Corvallis to Albany reach of the river.

Benton SWCD has a Five Year Strategic Plan (2015-2020). One of the goals of the Strategic Plan is to deliver programs that inspire stewardship. To fulfill this goal, Benton SWCD coordinates the WMC, which entails management and implementation of several projects that focus on control of Ludwigia and yellow floating heart on the Willamette River. WRAWMP is one such project, funded through the ODA-OSWB. Another WMC project is funded through the Oregon Watershed Enhancement Board (OWEB) Strategic Investment Partnership (SIP) and Bonneville Power Administraiton (BPA). This four-year project includes the treatment of over four miles of side-channel/slough habitat and over 50 acres of floodplain habitat and gravel ponds heavily infested with Ludwigia. This project is located across the river from Wapato Cove, and less than 0.5 miles upstream from Collins Bay (**Appendix B: Map of Ludwigia and Yellow Floating Heart Treatment Areas along River,** see areas "Stewart Slough, "Asbahr Lake", "Lower Kiger Ponds").

Ludwigia is currently being controlled at several other locations on the Willamette River. One of the larger projects is being implemented by City of Eugene, which has been working on *Ludwigia hexapetala* control since 2011 at the Delta Ponds Natural Area. The City of Eugene developed the Invasive *Ludwigia hexapetala* Management Plan for the Delta Ponds Natural Area. Delta Ponds Natural Area is a series of gravel extraction ponds recently reconnected to the Willamette River. This 5-year plan outlines the systematic treatment of *Ludwigia hexapetala* in the Delta Ponds integrating manual and herbicide control methods. WRAWMP proposes to apply successfully implemented techniques for Ludwigia control, as outlined in the Management Plan by the City of Eugene.

The Delta Ponds Natural Area is located upstream from the WRAWMP project area. The WRAWMP project manager has consulted with several experts working on the Delta Ponds Invasive Ludwigia Control Project. Individuals consulted include: Lauri Holts, Resources Coordinator with the City of Eugene; Dr. Brenda Grewell, Delta Ponds project consultant and ecologist with USDA-Agricultural Research Service Exotic & Invasive Weeds Research Unit; Glenn Miller, Integrated Weed Management Specialist with the Oregon Department of Agriculture; Mark Systma, Associate Vice President for

Research, Research & Strategic Partnerships at Portland State University; and Matthew Mellenthin, Delta Ponds Ludwigia control contractor with Integrated Resource Management (also current control contractor for WRAWMP).

The City of Eugene, in coordination with Willamette Riverkeeper and the River Guardians program, is planning a 2018 outreach aquatic weed workshop for community members at the Delta Ponds Natural Area.The workshop will contain information on native and invasive aquatic plant identification, and appropriate response and reporting techniques for priority aquatic weed species. Benton SWCD will help with the workshop (using Meyer Memorial Trust grant funds, not included as match in this grant application, but provided as match in the City of Eugene's ODA OSWB grant application). Benton SWCD will also provide copies of the Aquatic Weed Guides for Benton County for the event:
https://www.bentonswcd.org/assets/BSWCDAquaticWeedGuidebklt15.pdf.

The City of Eugene is also planning two 2018 weed paddle and pull events with volunteers at Delta Ponds, which they have been doing for the past several years. Through these volunteer weed pulls, Ludwigia is removed from areas where it is just becoming established before it forms significant populations.

It is our understanding the City of Eugene, in coordination with McKenzie River Trust and Willamette Riverkeeper, is treating a patch of yellow floating heart near the McKenzie-Willamette in Lane County.

Calapooia Watershed Council in collaboration OPRD began control treatments of *Ludwigia hexapetala* in 2017 from the side-channel system running through Bowers Rock State Park. This work is being funded through an OWEB - FIP grant, Meyer Memorial Trust funding, and potentially ODA OSWB grant funds. This treatment work is being done prior to side-channel reconnection construction also being proposed on this site in the coming years (**Appendix B: Map of Ludwigia and Yellow Floating Heart Treatment Areas along River**).

OPRD and WRK will be collaborating to remove *Ludwigia hexapetala* from 95 acres of aquatic habitat at OPRD's Willamette Mission State Park. Willamette Riverkeeper, OPRD, the U.S. Geological Survey, Portland State University, and Benton SWCD are currently collaborating to conduct baseline monitoring of Ludwigia at the Park to learn more about the impacts of Ludwigia and other aquatic invasive species on the off channel habitat . This data will provide a basis for understanding complex interactions between aquatic plants, algal communities, water-quality conditions, and channel morphology during the post-treatment period. The project will also provide critical data for assessing pre and post treatment conditions, so that effects of Ludwigia treatment on plant cover, water quality, and bed substrate can be assessed.The pre-treatment monitoring work at Willamette Mission is being supported by a new OWEB-FIP monitoring grant,and post-treatment monitoring will be covered under a future OWEB proposal. Results from the Willamette Mission State Park monitoring effort, will be combined with data collection related to water quality and vegetation sampling at Collins

Bay and Scatter Bar Pond to create an even larger dataset including multiple geographic areas. The results of this research will result in a peer reviewed published paper to be shared with peers and stakeholders.

The Long Tom Watershed Council is currently working with the OSWB to remove Ludwigia from a number of locations on the Long Tom River and Amazon Creek subbasin, upstream of the WRAWMP project area. They started work in summer 2015, with follow up treatments in 2016 and 2017, and treatments proposed for 2018. They are also treating a patch of yellow floating heart on the historic confluence of the Long Tom River with the Willamette River.

ODA has been conducting control treatments for yellow floating heart at approximately River Mile 145/146 near OPRD's Sam Daws/Buckskin site, at the southeast end of Benton/Linn counties.

In 2017 Willamette Riverkeeper volunteers, who learned about yellow floating heart during previous volunteer weed pull events funded by ODA OSWB on the Corvallis to Albany reach(!), discovered an extensive population of yellow floating heart in the Upper Willamette. It is our understanding Willamette Riverkeeper and other WAIN members will be applying for 2018 ODA OSWB grant funds to begin treatments of this source population of yellow floating heart.

The WRAWMP project manager has consulted with several experts working on yellow floating heart, as well as other floating heart species such as crested floating heart (*Nymphoides cristata*). Individuals consulted include: Glenn Miller, Integrated Weed Management Specialist with the Oregon Department of Agriculture; Mark Systma, Associate Vice President for Research, Research & Strategic Partnerships at Portland State University and Dr. Michael Netherland, U.S. Army Engineer Research and Development Center.

The WRAWMP project manager has consulted with several experts working on parrot feather. Individuals consulted include: Glenn Miller (Oregon Department of Agriculture), Andrew Riggs and Sunny Simpkins (Multnomah County Drainage District), and Alex Staunch (Mosaic Ecology).

In summers 2015 and 2016, Willamete Riverkeeper, in partnership with Willamette Aquatic Invasive Network partners, conducted a survey of the Willamete River from north of Eugene to Salem to map high priority aquatic invasive species, including Ludwigia and yellow floating heart, on the river. Portland State University conducted similar surveys on the river around the Portland area in 2015. ODA conducted aerial surveys of the upper Willamette to map Ludwigia in 2014, and plans to continue mapping, as feasible. The data sets from these surveys have been entered into various databases and have been shared with the appropriate partners, who are using this information to develop plans, set priorities, and apply for funding to strategically manage this species. Benton SWCD is one of the groups who has partipated in these surveys,and additional surveys in 2017, and is currently utilizing the resulting data.

Benton SWCD will also be participating on the subcommittee for the strategic action plan being developed by WAIN (and led by Willamette River Keeper and OPRD) to prioritize invasive species treatments along the Willamette River.

15. How does this project fit into the statewide and/or local weed management objectives? Identify the county weed listing priority if known.
• Objective One: Leadership and Organization - Strategy One: Provide consistent statewide and local leadership and organization.

The Benton County CWMA provides local leadership and organization to groups, agencies, and landowners related to invasive plant issues around the county. The Benton County CWMA Management Plan outlines management principles for CWMA activities that align with this project such as; "projects are designed using an ecosystem management approach based on an understanding of weed biology, weed ecology, and landscape level processes." (Benton County CWMA 2012).

The BC CWMA is coordinated by Benton Soil and Water Conservation District. Benton SWCD's current Executive Director has over 30 years of experience managing aquatic invasive species programs and is committed to dedicating the resources necessary to address long-term management needs of this program (WRAWMP) in Benton County (within budget restraints). This will increase the likelihood of long-term success.

• Objective Two: Cooperative Partnerships - Strategy Two: Develop and expand partnerships.

The Benton County CWMA is made up of a broad partnership of agencies, organizations, and landowners. Benton SWCD provides fiscal oversight and coordination of the Benton County CWMA. Benton SWCD has a strong history of developing partnerships and collaborating with other agencies, organizations, and landowners to complete projects and develop programs for the stewardship of natural resources. Another partnership that will be involved in the planning and implementation of this project is the Willamette Mainstem Cooperative, which is supported by a group of stakeholders who represent local agencies and landowners, and is facilitated by Benton SWCD.

For this project Benton County CWMA and Benton SWCD will work with Willamette Riverkeeper, and other partners to implement workshops, volunteer events, and survey work. Benton SWCD also plans to work closely with Portland State University Center for Lakes and Reservoirs, the Willamette Aquatic Invasive Network, Calapooia Watershed Council, the City of Eugene, and other interested groups to ensure that it is meeting Ludwigia and yellow floating heart control objectives while minimizing impacts to local fish and wildlife species.

• Objective Three: Planning and Prioritizing - Strategy Three: Develop and maintain noxious weed lists and plans.

The Benton County CWMA has developed and maintains an invasive plant list for Benton County. This list is regularly reviewed and updated by the Benton County CWMA. *Ludwigia hexapetala* is a B-rated weed on the Oregon state noxious weed list and a B-rated weed on the Benton County invasive plant list, and is targeted for outreach and data collection, both of which would be fulfilled through this project. *Nymphoides peltata* is an A-rated noxious weed by the state of Oregon and A-rated in Benton County as well. It is targeted for ODA response and immediate removal. *Myriophyllum aquaticum* is a B-rated weed on the Oregon state noxious weed list and a B-rated weed on the Benton County invasive plant list. It is targeted for containment and removal from priority areas only.

The species and sites proposed for treatment in this application have been carefully considered and chosen based on survey data and recommendations from several specialists and land managers who operate on the mainstem Willamette River.

• Objective Four: Education and Awareness - Strategy Four: Provide education and awareness.

For this project Benton SWCD in partnership with Willamette Riverkeeper will provide education and outreach to land managers, restoration practitioners, land owners, and the general public through a series of aquatic weed workshops, volunteer weed pulls, and project site tours on the Willamette River. For these events, we will discuss the benefits of identifying, reporting, and removing invasive plant populations before they spread. One of the objectives for these outreach events are to educate targeted audiences on the identification of aquatic invasive plants, the impact on wildlife, humans and native plant communities and the methods for timely response relative to the species of concern. We will also co-facilitate a field based workshop focused on the sharing of management techniques and lessons learned after several years of control treatments of Ludwigia and yellow floating heart

Benton SWCD will develop outreach materials and distribute them to workshop participants and landowners within the project area. This include distribution of the water weed guide for Benton County: https://www.bentonswcd.org/assets/BSWCDAquaticWeedGuidebklt15.pdf. We are also in the process of updating the aquatic weed guide (using Meyer Memorial Trust grant funds) to include additional EDRR noxious aquatic weeds (e.g., delta arrowhead [*Sagittaria platyphylla*], flowering rush [*Butomus umbellatus*]) and native look alikes to the noxious aquatic weeds (e.g., watershield [*Brasenia schreberi*], american waterweed [*Elodea canadensis*], Richardson's pondweed [Potamogeton richardsonii]). We may have the next version of the Benton County aquatic weed guide ready to share for 2018 outreach and education events.

An objective of these events is to increase public and land managemr awareness of aquatic invasives and provide tools to members of the community and to restoration practitioners to make informed decisions for management of aquatic weeds.

• Objective Five: Integrated Weed Management (IWM) - Strategy Five: Continue to support and advocate the principles of IWM.

The Benton County CWMA is dedicated to using tested, integrated approaches in weed management. This project is supportive of integrated weed management principles in the use of manual and chemical control of Ludwigia and yellow floating heart on the mainstem and at each project site. For each site, all appropriate methods for treatment will be thoroughly analyzed and considered based on resources available and existing conditions.

• Objective Six: Early Detection and Control of New Invaders - Strategy Six: Implement early detection and control.

This project includes early detection and control of new invaders as a key element: we plan to control the first observed *Nymphoides peltata* population in Benton County (at Horseshoe Lake), as well as the first observed yellow floating heart occurrences along the mainstem of the Willamette river in the Corvallis to Albany reach (e.g., Lower Kiger side channel, Tripp Island).

We propose to control early detection new small populations Ludwiga along the mainstem of the Willamette before they become established, as well as control of established populations of Ludwigia at priority areas (i.e., Collins Bay, Wapato Cove) where it may still be effective in significantly reducing, and eventually removing, the plants from these priority areas. Both Collins Bay and Wapato Cove contain a diversity of native aquatic plant species, as well as unique backwater habitat areas important for native fish and wildlife species.

We would also treat a limited area of parrot feather (*Myriophyllum aquaticum*) at one site, Collins Bay. Parrot feather was not previously observed at this site. Following years of Ludwigia treatments at this priority site, we first observed parrot feather at this site the summer of 2017 (**Appendix C: Maps and Pictures of Collins Bay: Before and After Ludwigia Treatments**). We began pulling of two patches of parrot feather at Collins Bay in September 2017 and disposed of the materials offsite in September 2017 (using non-ODA grant funds); however, the patches were determined to be too large for hand pulling and will need to be chemically treated.

• Objective Seven: Noxious Weed Information System and Data Collection - Strategy Seven: Upgrade Noxious Weed Information System.

Through the survey and mapping of project sites using GPS technologies and Fulcrum software, we can contribute to existing state weed information systems such as Oregon Weed Mapper, Oregon Invasives Hotline, iMap Invasives, and WAIN’s shared database. These databases allow the sharing of noxious weed populations and enables the tracking of treatments.

Data collected during the course of this project can be made available for reference by other land management agencies, to inform the development of other projects or management plans, such as the Strategic Plan the Willamette Aquatic Invasives Network is currently developing.

• Objective Eight: Monitoring and Evaluation - Strategy Eight: Monitor noxious weed projects to evaluate effectiveness.

Regular monitoring will be integrated into this project to determine the short and long-term effectiveness of control activities. Photo-points have been and will continue to be strategically placed at each site to collect information before and after each treatment occurs. Populations will be mapped and updated throughout the duration of the project and in subsequent years as funding allows.

16. How will restoration be a part of your project? If restoration is not a component of this project please explain.
An objective of the project is habitat restoration work at Collins Bay. Collins Bay is recommended for restoration due to the rarity of open marshland on the mainstem of the river, which is vital habitat for birds, fish, pond turtles, river otters and many other species. (Carex Working Group Sept. 2013).

Four seasons of treatments at Collins Bay have led to a reduction in Ludwigia cover, with some areas having greatly reduced plant cover to no plant cover (**Appendix C: Maps and Pictures of Collins Bay - Before and After Ludwigia Treatments**). After surveying the site and considering native plants growing in similar habitats, as well as access to local native aquatic plant materials, we have selected the following species for replanting: wapato, softstem bulrush, common spikerush, soft rush, spike bent grass, American slough grass, slender rush, slough sedge). In 2016 and 2017 we did not have access to broadfruit bur-reed or yellow pond lily stock; however, we will be trying to access some of this seed for the 2018 planting season. Access to native aquatic riverine weltand plant material is extremely limited.

In Fall 2016, we collected native wapato (*Sagittaria latifolia*) tubers and added approximately 500 of them to Collins Bay (0.07 acre; **Appendix G: Collins Bay Restoration Areas Map and Photos**). However, because of the early October 2016 rains and quick flooding of the river, we were only able to add the tubers to already flooded areas. While we added the tubers to an area that had limited to no plant cover, there was low success and this is likely because the tubers could only be added at the water level and not individually gently pushed into the soil. Tubers may have also been predated by fish, beavers, or nutria using the area, or pushed out of the side channel during winter storms.

For our ODA OSWB 2017 grant application, we did not request grant funds for restoration. However, under separate grant funds (Meyer Memorial Trust) we collected wapato tubers again this fall and planted them at Collins Bay, along with native aquatic seed (0.33 acre; **Appendix E: Pictures of Aquatic Weed Outreach and Education Events, Weed Pulls, and Monitoring**; **Appendix G: Collins Bay Restoration Areas Map and Photos**).

Marvin Gilmour, a local farmer and wetland restoration practitioner, again generously donated his labor and his staff's labor and time to help with harvesting and collection of wapato tubers using traditional agricultural methods. BSWCD volunteers also helped with wapato collection. Donated native plant materials include: tubers/bulbs (wapato) and native seed (e.g., wapato, common spikerush [*Eleocharis palustris*], soft rush [*Juncus effusus*], spike bent grass [*Agrostis exarata*], American slough grass [*Beckmannia syzigachne*], slender rush [*Juncus tenuis*], and slough sedge [*Carex obnupta*]).

Benton SWCD has also begun coordinating with scientists from PSU's Center for Lakes and Reservoirs about potential appropriate native aquatic plants and seeds to be used at Collins Bay. PSU's vegetation sampling conducted this year will help inform a longer term habitat enhancement plan at the site.

Areas where native plant materials have been added will be monitored using photo points and GPS mapping, as well as presence-absence surveys of plant species.

We are not requesting 2018 ODA OSWB grant funds for restoration. However, under separate grant funds (Meyer Memorial Trust) we plan to collect wapato tubers again in Fall 2018 and plant them at additional areas of Collins Bay, along with native aquatic seed, as these plant materials are available. We are also beginning to explore other options for potential sources of native aquatic plant materials.

Other areas treated during this project will be assessed for restoration potential as treatments continue.

17. Does this project protect a high priority species or habitat? Please give a brief description of the species or habitat/land use designation for this project.

1. Anchor Habitat for Anadromous Fish: Collins Bay and Wapato Cove are within the areas identified in OWEB's Willamette River Habitat Protection and Restoration Program 2010-2015 Habitat Technical Team Proposal as part of the priority anchor habitats for anadromous fish along the Willamette River mainstem (OWEB 2010). Collins Bay and Wapato Cove are also within ODFW's designated essential salmon habitat (ODFW 2011).

2. Open Water Marsh Habitat: Collins Bay was also listed as a special habitat by Carex Working Group during the 2012-1013 invasive plant and habitat assessment by stating that the open water marsh habitat was rarely encountered during survey work and that the site is worth noting for preservation/restoration work. They also recommended the use of integrated methods to remove Ludwigia along the Willamette mainstem to reclaim infested habitats and prevent further spread (Carex Working Group Sept. 2013).

3. Western Pond Turtles: Western pond turtles are considered a sensitive species by the State of Oregon and are one of the strategy species listed in the Oregon Conservation Strategy (ODFW 2016). While there are no official surveys on record, property owners Stanley and Louise Snyder spoke of the pond turtles and large fish once found in Collins Bay. They have witnessed more wildlife species (turtles, wood ducks) using the inlet since the Ludwigia has began being treated. Prior to the

treatments they did not observe any pond turtles or large fish in the inlet since Ludwigia had become pervasive. Other landowners from properties nearby have corroborated the Snyder's account of the progression of Ludwigia and subsequent changes to the river.

Western pond turtles require open water habitat with native emergent vegetation to feed, bask, reproduce, and hide from predators. Infestations of aquatic weeds, such as Ludwigia, result in thick vegetation mats that limit movement of aquatic and semi-aquatic species, such as turtles, amphibians, fish, waterfowl and mammals, severely limiting their ability to navigate, feed, and reproduce. In addition, these dense mats of vegetation die off at the end of the growing season and the process of decay can drastically reduce dissolved oxygen in the water. These areas of low dissolved oxygen may create a barrier for the movement of aquatic organisms through a waterway, or cause the fatality of aquatic organisms that can become trapped in areas without sufficient dissolved oxygen. Furthermore, the thick mats of vegetation formed by Ludwigia capture sediment, potentially altering the floodplain capacity and side-channel characteristics of waterways such as Collins Bay.

4. Wapato (*Sagittaria latifolia*), also known as broadleaf arrowhead, is considered a significant native plant for its cultural value. This plant was once widely harvested by Native Americans in the Willamette Valley, such as the Kalapuyan people. It has an edible, potato-like tuber, which is valued for its high nutritional value. Many species of ducks, mammals, and other wildlife also feed on the leaves and tubers of these plants, and all parts are considered edible. All sites proposed for treatment in this project contain wapato. The Willamette Aquatic Invasive Network considers wapato to be an indicator of high quality habitats, and are recording habitats containing wapato during surveys.

18. Salmon/Steelhead Populations Targeted and Expected Benefits to Salmon/Steelhead

The information provided will be used by OWEB to better meet federal and state reporting requirements. Completion of this section is required but will not be used to evaluate this application for funding.

☐ This project is NOT specifically designed to benefit salmon or steelhead.

- If you check this box do not answer supplemental question 18(A)

Targeted Salmon/Steelhead Populations: Select one or more of the salmon ESUs (Evolutionary Significant Unit) or steelhead DPSs (Distinct Population Segment) that the project will address/benefit. Additional information on the designation and location of the salmon/steelhead populations can be found at http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/Maps/Index.cfm

Chinook Salmon (Oncorhynchus tshawytscha)		**Coho Salmon (O. kisutch)**	
☐	Deschutes River summer/fall-run ESU	☐	Lower Columbia River ESU
☐	Lower Columbia River ESU	☐	Oregon Coast ESU
☐	Mid-Columbia River spring-run ESU	☐	Southern Oregon/Northern California ESU
☐	Oregon Coast ESU		
☐	Snake River Fall-run ESU	**Steelhead (O. mykiss)**	
☐	Snake River Spring/Summer-run ESU	☐	Klamath Mountains Province DPS
☐	Southern Oregon and Northern California Coastal ESU	☐	Lower Columbia River DPS
☐	Upper Klamath-Trinity Rivers ESU	☐	Middle Columbia River DPS
☒	Upper Willamette River ESU	☐	Oregon Coast DPS
		☐	Snake River Basin DPS
Chum Salmon (O. keta)		☐	Washington Coast DPS (SW Washington)
☐	Columbia River ESU	☒	Upper Willamette River DPS
☐	Pacific Coast ESU	☐	Steelhead/Trout unidentified DPS

18(A). Expected Benefits: Write a brief description of the goals and purpose of the project and how it is expected to benefit salmon/steelhead habitat.

One goal of this project is to remove aquatic invasive plants from side-channels, ponds, and sloughs within the Willamette River system. Aquatic weeds such as Ludwigia act as sediment traps, and can fill in open water habitat and side-channel systems over time. These plants reduce the amount of available dissolved oxygen in the water with the rapid growth and decay of large biomasses. Removal of these weeds will improve water quality and reduce habitat degradation caused by these plants, thus improving habitat for fish and other wildlife (Sears et. al. 2006).

19. How will success be determined? What elements will be monitored/evaluated and by whom, how often and for how long?

Monitoring and evaluation of this project is currently being led by Benton SWCD, and will continue for as long as needed, provided funding is available. To determine success for this project, photo-points, which have already been established, will continue to be used for monitoring purposes. Data on the extent of native and invasive plants present at each site will be recorded and mapped. Each plot will be monitored to evaluate the response of the plant communities to each treatment method. Monitoring will take place before and after each treatment, and annually after that to assess the extent of Ludwigia and yellow floating heart at each waterbody (and parrot feather at Collins Bay). Success will be determined by comparing the post-treatment distribution and abundance of Ludwigia, yellow floating heart (and parrot feather at Collins Bay), and native plants to pre-treatment abundance and distribution.

Success of Ludwigia infested sites will be determined by a reduction in Ludwigia populations to a level that the sites can be managed through river volunteer events (e.g., weed pull events) at a budget and level that is manageable by local partners.

This project includes the fifth year of treatment for Ludwigia at Collins Bay. Collins Bay is expected to require several more years of treatment to adequately reduce plant densities to levels where the habitat can stabilize. The first year was the most intensive for control work at the site. With the reduction in plant densities, treatments now require less labor and time, which means yearly maintanance should continue to decrease in cost.

The project includes the second year of treatment at Wapato Cove. We will be able to assess whether the combination of herbicide application (in dense and medium patch areas of Ludwigia) and manual removal of Ludwigia (in dense areas of wapato with sparse Ludwigia) is effective control treatment at this highly pubilcally visible site with an abundant amount of native aquatic vegetation. We will continue to re-evaluate and adapt our methods to most effectively conduct Ludwigia control treatments at this site.

This project includes the fifth year of treatment for yellow floating heart at Horseshoe Lake. Continued treatments will be needed for yellow floating heart at Horseshoe Lake (Benton County) to achieve eradication of the plants. We will be able to assess in 2018 if the new treatment method using Imazamox shows effectivess. We will also continue to coordinate with other restoration practitioners about other potential options for control treatments. For example, Mike Netherland from the USACE/University of Florida mentioned that Procellacor may be a good option for treatment once it becomes registered and approved and is expected to have low restrictions.

20. What is the long-term plan for this project? Who will maintain the project after the grant and for how long?

Priority sites that are being treated within the Corvallis to Albany reach, including Collins Bay and Wapato Cove, will be included as part of a strategic action plan being developed by WAIN. This plan will include clear goals and objectives for the sites and will integrate work already accomplished with future restoration needs. The plan will also include a timeline for achieving restoration goals, and the associated actions needed to accomplish these goals.

Continued community education and outreach about Ludwigia and yellow floating heart, and other aquatic invasives, is key to the long-term management and protection of priority habitats in the Corvallis to Albany reach. Signficant progress has been made with public awareness about Ludwigia and yellow floating heart as a result of the river workshops and paddle and pull events through this project. Benton SWCD with Willamette Riverkeeper will continue the successful river volunteer program to remove new small popualtions of Ludwigia and yellow floating heart along the Corvallis to Albany reach for as long as funding can be obtained. Once the WAIN strategic action plan is developed, WAIN may be able to apply for additional grants, such as the National Fish and Wildlife Pulling Together Initiative grant, to help leverage funds for river volunteer weed pull events along priority sections of the Willamette River.

Benton SWCD will continue to maintain these projects for as long as funding can be obtained. Many funding and maintenance options will be (or have been) considered, including discussion with landowners on the contributions they are willing and able to make. As indicated earlier, current Benton SWCD leadership is committed to the long-term success of this project. To the extent budgets allow, the organization is dedicated to continuing its role in providing the expertise and oversight of an aquatic invasive plant management program in Benton County.

21. Insurance information- If applicable, select all the activities that are part of your project (check all that apply). See Tables in Grant Instructions for required insurance amounts.

- [ ] Grantee or grantee's staff are applying herbicides or pesticides (Additional insurance is required)
- [X] Contractors are applying herbicides or pesticides (Contractors are required to carry the additional insurance)
- [ ] Grantee or grantee's staff or volunteers are working with kids related to this project (Additional insurance is required)
- [ ] Aerial application of chemicals is applied by contractors. (Contractors are required to have required insurance.)

RACIAL AND ETHNIC IMPACT STATEMENT

This form is used for informational purposes only and must be included with the grant application.

Chapter 600 of the 2013 Oregon Laws require applicants to include with each grant application a racial and ethnic impact statement. The statement provides information as to the disproportionate or unique impact the proposed policies or programs may have on minority persons[1] in the State of Oregon if the grant is awarded to a corporation or other legal entity other than natural persons. "Minority persons" are defined in SB 463 (2013 Regular Session) as women, persons with disabilities (as defined in ORS 174.107), African-Americans, Hispanics, Asians or Pacific Islanders, American Indians and Alaskan Natives.

1. ☐ The proposed grant project policies or programs could have a disproportionate or unique positive impact on the following minority persons:

Indicate all that apply:

_____ Women
_____ Persons with Disabilities
_____ African-Americans
_____ Hispanics
_____ Asians or Pacific Islanders
_____ Alaskan Natives
_____ American Indians

2. ☐ The proposed grant project policies or programs could have a disproportionate or unique negative impact on the following minority persons:

Indicate all that apply:

_____ Women
_____ Persons with Disabilities
_____ African-Americans
_____ Hispanics
_____ Asians or Pacific Islanders
_____ Alaskan Natives
_____ American Indians

3. ☐ The proposed grant project policies or programs will have no disproportionate or unique impact on minority persons.

If you checked numbers 1 or 2 above, on a separate sheet of paper, provide the rationale for the existence of policies or programs having a disproportionate or unique impact on minority persons in this state. Further provide evidence of consultation with representative(s) of the affected minority persons.

I HEREBY CERTIFY on this 8th day of December, 2017, the information contained on this form and any attachment is complete and accurate to the best of my knowledge.

Signature Holly Crosson

Printed Name: Holly Crosson

Title Executive Director

Project Partners

List agencies/organizations from which funding is anticipated for the proposed project.

The Oregon State Weed Board requires 25% match for projects. If you have questions with this requirement please contact Tristen Berg, ODA Grant Program Coordinator at 503-986-4622.

Show all anticipated funding sources, and indicate the dollar value for cash and in-kind contributions. For all funding please state within the "use of contribution" column exactly what the cash/in-kind will be used for- include a separate line for volunteers, labor, or materials. This helps the OSWB gain a better understanding of the roles and responsibilities the partners will have with the project. Check the appropriate box to denote if the funding status is secured or pending. In the Amount/Value Column, provide a total dollar amount or value for each funding source. Match should be directly related to the noxious weed project. **Other OWEB funding is not eligible for match toward OSWB grants.**

NOTE: If your project is selected for funding your organization will be asked to provide signatures for 25% match as a component of agreement procedures.

Funding Source (Name the Partner)	Use of Contribution	Cash	In-kind	Secured (x)	Pending (x)	Amount/Value
Sample Agency	*GIS mapping, and ATV use*		***$2,500***	*X*		***$2,500***
OSWB	**Planning and project coordination for aquatic invasives control, restoration planting, survey, and monitoring (WQ and effectiveness), and targeted outreach**	$19,232	**N/A**	☐	☒	$19232
Oregon Dept. of Agriculture	**Project consultation, aerial and boat survey and data interpretation**	**N/A**	$1425	☒	☐	$1425
Meyer Memorial Trust Willamette Mainstem Cooperative Capacity Grant 16060748	**Benton SWCD Project Coordination and mileage**	$5860	**$**	☒	☐	$5860
Benton Soil and Water Conservation District	**Project staff assistance**	**$**	$1680	☒	☐	$1680
Willamette Riverkeeper	**Staff assistance with restoration work parties, surveys, community outreach, and ecological monitoring and equipment**	**$**	$900	☒	☐	$900
Marvin Gilmour	**Plant materials for restoration planting, and labor for seed**	**$**	$3016	☐	☐	$3016

	harvest/processing					
Benton SWCD volunteers	**Native seed and bulb collection and planting**	**$**	$772	☐	☐	$772
OWEB-SIP funds (non-matchable)	**Ludwigia treatments at Collins Bay**	**$**	$2649	☐	☐	$2649
OWEB-SIP funds (non-matchable)	**Ludwigia treatments at Wapato Cove**	**$**	$5000	☐	☐	$5000
River Weed Pull volunteers	**Pulling Ludwigia and Yellow floating heart along Corvallis to Albany reach of river**	**$**	$2317	☐	☐	$2317
		$	**$**	☐	☐	**$**
		$	**$**	☐	☐	**$**
Total Estimated Funds (add all amounts in the far-right Column):	(The total should equal the total cost of the project on page 1 of the application)					*****$42,851
Have any conditions been placed on matching funds that may affect completion? ☐ Yes ☒ No If Yes, Explain:						

NOTICE of Grant Award Conditions

Initial each category below and be sure this page is submitted along with your completed proposal.

☒ If this proposal is funded, you will be required to:

- Sign a Grant Agreement containing the terms and conditions for the project implementation, release of funds, and documentation of completion.
- Payments will be made only for work started after the effective date of the grant agreement, unless special conditions have been placed by ODA/OWEB.

☒ Before ODA/OWEB releases the Grant Agreement, you will be required to:

- Resolve any and all outstanding issues from your previous grants with ODA/OWEB.

☒ Upon signing the Grant Agreement, you will be required to:

- Certify in the Grant Agreement that prior to starting work on private land, you have or will obtain cooperative agreements with the private landowner(s). Exhibit D of the ODA/OWEB Grant Agreement may also require you to submit copies of those agreements to ODA/OWEB prior to the release of funds.
- Agree that monitoring information resulting from projects are public domain.
- Determine what insurance, permits and licenses are required.

☒ Before ODA/OWEB releases any payments, you will be required to:

- Document that 25% match funding has been secured.
- Submit an OWEB Metrics Form.
- Submit copies of all applicable permits and licenses from local, state, or federal agencies or governing bodies, or certify that permits and licenses are not needed.

☒ Upon completing the project, you will be required to:

- Submit a Project Completion Report as required in the Grant Agreement, including maps, and photos. OGMS Online Project Completion Reporting can be completed at http://apps.wrd.state.or.us/apps/oweb/fiscal/default.aspx.
- Submit your Oregon Watershed Restoration Inventory report(s) electronically at http://apps.wrd.state.or.us/apps/oweb/owrio/default.aspx. New weed site data will be pulled from OWRI to meet Weedmapper requirements.

CERTIFICATION:

I certify that this application is a true and accurate representation of the proposed project and that I am authorized to sign as the Applicant or Co-Applicant. By the following signature, the Applicant certifies that they are aware of the requirements (***see Application Instructions***) of an OSWB/OWEB grant and are prepared to implement the project if awarded. **I have read and initialed the NOTICE of Grant Award Conditions**

Applicant Signature: Holly Crosson Date: 12/8/17

Print Name: Holly Crosson Title: Executive Director

Co-Applicant Signature: ____________ Date: ____________

Print Name: ____________ Agency: ____________

All appendices are housed within the application instructions section and can be downloaded at:
http://www.oregon.gov/ODA/programs/Weeds/Pages/GrantProgram.aspx

Mandatory attachments:

- **Oregon State Weed Board Project Budget.**
- **Project Partner Form.**
- **Racial and Ethnic Statement.**
- **Maps highlighting specific area of project activities.**
- **Photos (please use the same photo points you will use on interim progress reporting and project completion reports).**
- **For landowner reimbursement projects – landowner list with acreages listed by weed species.**

Oregon State Weed Board Project Budget

Add additional lines, if necessary. All costs must be directly associated with project.

Totals automatically round to the nearest dollar.

A	B	C	D	E	F		G
Itemize projected costs under each of the following categories:	**Unit Number** (e.g. # of hours)	**Unit Cost** (e.g. hourly rate)	**OWEB Funds**	**Cash Match**	**In-Kind Match**	**OWEB-WSIP Funds (Non-matchable)**	**Total Costs** (add columns)
SALARIES, WAGES AND BENEFITS. List position titles for in-house staff/applicant employees for whom payroll taxes are paid. Include only costs charged to this grant.							
Project Coordination	320	32	4,380	5,860			**10,240**
Staff Assistance	40	42			1,680		**1,680**
(1)		**SUBTOTAL**	4,380	5,860	1,680		**11,920**
CONTRACTED SERVICES. Labor, supplies, materials and travel to be provided by *non-staff* for project implementation.							
Collins Bay - Ludwigia control (herbicide) with Intelli-spray and tractor and backpack, early summer and early fall treatment (IRM)	2 days (6-7 crew)	2324.47	2,000			2,649	**4,649**
Collins Bay - Parrot feather control (herbicide) with Intelli-spray and tractor and backpack, early summer and early fall treatment (IRM)	2 days (2-4 crew)	1000	2,000				**2,000**
Wapato Cove - Ludwigia control (herbicide) with Intelli-spray and tractor and backpack, early summer and early fall treatment (IRM); manual control in dense areas of wapato with sparse Ludwigia	2 days (2-4 crew) (herbicide); 2-4 days (2-4 crew) manual)	1000	2,000			5,000	**7,000**
Horseshoe Lake, Benton County - Aquatic veg control (herbicide) with backpack, early summer and early fall treatment (IRM)	2 half days (2 crew)	326.67	653				**653**
Restoration work parties, surveys, community outreach, and ecological monitoring (Willamette Riverkeeper contract)	110 hours	45.82	5,040				**5,040**
Restoration work parties (paddle and weed pull volunteers; minimum of 6 volunteers x 8 hours x 2 events)	96 hrs	24.14			2,317		**2,317**
Field workshop for practitioners on best management practices and lessons learned (Integrated Resource Management - Matt Mellenthin)	12 hrs	57.00 (reduced rate)	684				**684**
Mileage reimbursement (Willamette Riverkeeper, Portland)	780	0.535	417				**417**
Canoes, paddling equip., dry bags, trailer & other equip. (Willamette Riverkeeper)	30	30			900		**900**

Oregon State Weed Board Project Budget

A	B	C	D	E	F		G
Itemize projected costs under each of the following categories:	**Unit Number** (e.g. # of hours)	**Unit Cost** (e.g. hourly rate)	**OWEB Funds**	**Cash Match**	**In-Kind Match**	**OWEB-WSIP Funds (Non-matchable)**	**Total Costs** (add columns)
Project consultation, river survey (aerial and boat) and data interpretation (ODA, Glenn Miller)	3 days	$475			1,425		**1,425**
Native plant materials for restoration planting; wapato, bur-reed, common rush (local farmer, Marvin Gilmour)	3 lbs seed; 1,000 bulbs	various			2,696		**2,696**
Processing seed and harvesting bulbs (Marvin Gilmour)	8 hrs	40			320		**320**
Collecting seeds and bulbs (volunteers)	24 hrs	24.14			579		**579**
Restoration planting, seeds and bulbs (volunteers)	8 hrs	24.14			193		**193**
(2)		**SUBTOTAL**	12,794	0	8,430	7,649	**28,873**
TRAVEL. Mileage, per diem, lodging, etc. Must use current State of Oregon rates.							
Mileage for project (BSWCD staff)	410	0.535	219				**219**
							0
(3)		**SUBTOTAL**	219	0	0	0	**219**
MATERIALS and SUPPLIES. Refers to items that are purchased by, or invoiced to, the applicant, and are "used up" in the course of the project. Costs must be directly related to the implementation of this grant.							
Disposal of bagged hand pulled aquatic	3 visits	30	90				**90**
							0
(4)		**SUBTOTAL**	90	0	0	0	**90**
EQUIPMENT/SOFTWARE. List portable equipment costing **$1000** or more per unit. Must remain property of a governmental entity, tribe, watershed council, SWCD, institution of higher learning or school district.							
							0
							0
(5)		**SUBTOTAL**	0	0	0	0	**0**
OTHER. Grantee-owned equipment costs, small equipment repair, project-specific printing, and items that do not fit other categories.							
							0
							0
(6)		**SUBTOTAL**	0	0	0	0	**0**
(7)		**MODIFIED TOTAL DIRECT COSTS: Add all subtotals (1-6)**	17,483	5,860	10,110	7,649	**41,102**
INDIRECT COSTS. Not to exceed **10% of Modified Total Direct Costs (7)**. Choose <u>ONE</u> of the indirect cost methods below.							
10% indirect rate requested.	X	10%	1,748				**1,748**
No reimbursement for indirect costs requested	☐	0%	0				**0**
(8)		**SUBTOTAL (8)**	**1,748**	**0**	**0**	**0**	**1,748**
GRANT BUDGET TOTAL: Add Totals (7), and (8). Totals automatically round to the nearest dollar.*			**19,232**	**5,860**	**10,110**	**7,649**	**42,851**

* The totals for these two columns must mirror the match totals provided on the Match Funding form..

References

Benton County Cooperative Weed Management Area. 2012. Benton County Cooperative Weed Management Area (CWMA) Strategic Action Plan. Pp. 2-4. http://www.bentonswcd.org/assets/bentoncwmastrategicactionplan-2012-02-29.pdf

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Appendix A: Map and Photos of Yellow Floating Heart Treatment Area at Horseshoe Lake, Benton County

Map 1: Location of yellow floating heart (*Nymphoides peltata*) at Horseshoe Lake, Benton County.

Appendix A (*continued*): Map and Photos of Yellow Floating Heart Treatment Area at Horseshoe Lake, Benton County

Photo Monitoring at Horseshoe Lake: Yellow Floating Heart (*Nymphoides peltata*)

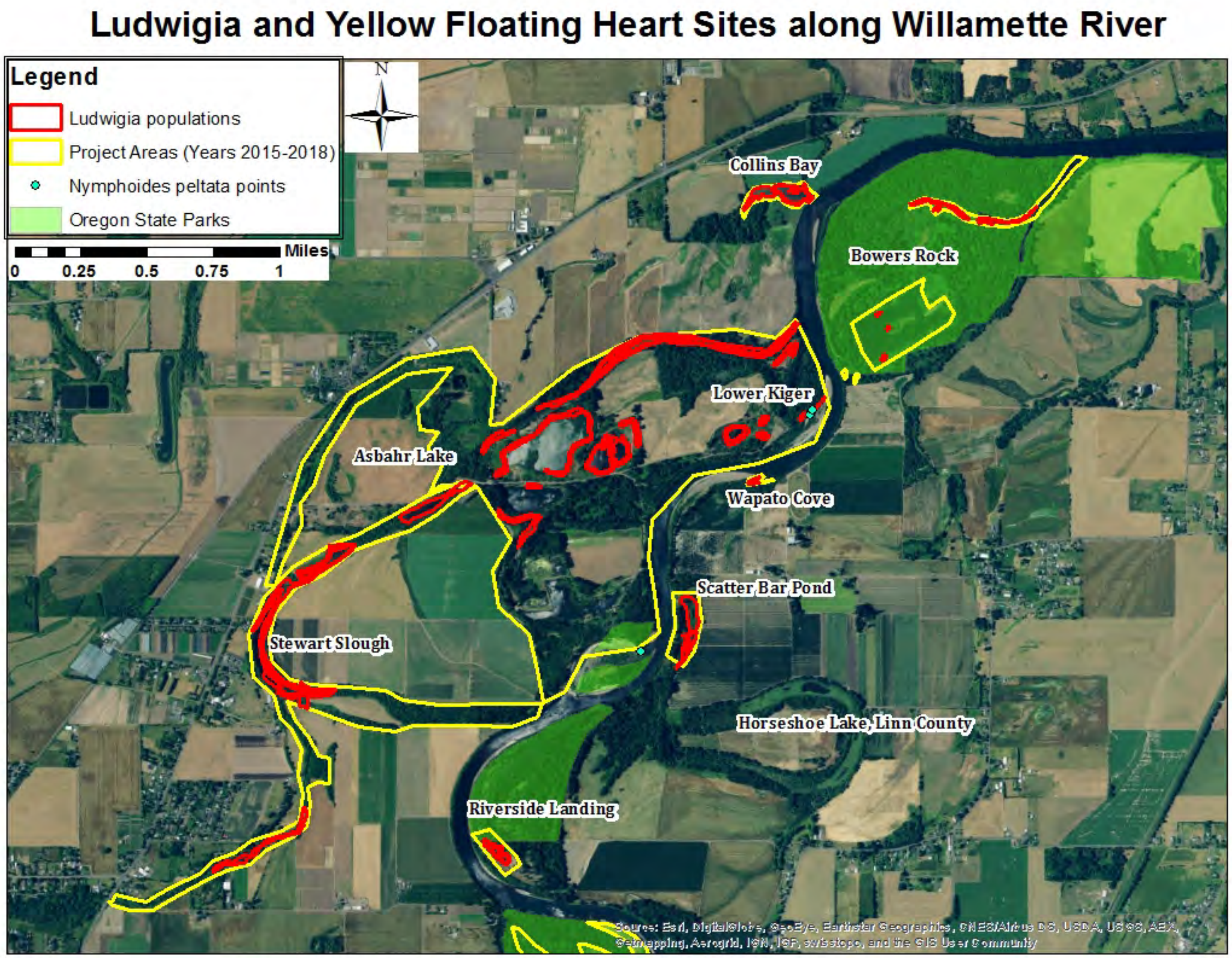
Yellow floating heart at Horseshoe Lake - June 2014

Yellow floating heart at Horseshoe Lake , before 4th year of treatment - July 14, 2017

Before 4th year of treatment (new method) - July 14, 2017

After first round of treatment (Clearcast) in 4th year of treatment; waterfern observed in place of yellow floating heart- September 6, 2017

Appendix B: Map of Ludwigia and Yellow Floating Heart Treatment Areas along River



Map 2: Location of invasive water primrose species (*Ludwigia* ssp.) and yellow floating heart (*Nymphoides peltata*) on the Willamette River between Corvallis and Albany.

Appendix C: Maps and Pictures of Collins Bay: Before and After Ludwigia Treatments

Collins Bay Photo Points

Appendix C (*continued*): Maps and Pictures of Collins Bay: Before and After Ludwigia Treatments

Photo Point 1— July 7, 2014, before Ludwigia treatment

Photo Point 1— June 27, 2016, before third year of Ludwigia treatment

Photo Point 1— July 7, 2017, before 4th year of treatment

Photo Point 1— Oct 4, 2017, after 4th year of treatment

Appendix C (*continued*): Maps and Pictures of Collins Bay: Before and After Ludwigia Treatments

Photo Point 2— July 7, 2014, before treatment

Photo Point 2— June 27, 2016, before 3rd year of treatment

Photo Point 2— July 7, 2017, before 4th year of

Photo Point 2— Oct 4, 2017 after 4th year of treatment

Appendix C (*continued*): Maps and Pictures of Collins Bay: Before and After Ludwigia Treatments

Photo Point 3— July 7, 2014, before treatment

Photo Point 3— June 27, 2016, before 3rd year of treatment

Photo Point 3— July 7, 2017, before 4th year of treatment

Photo Point 3— Oct. 4, 2017, after 4th year of treatment

Appendix C (*continued*): Maps and Pictures of Collins Bay: Before and After Ludwigia Treatments

Photo Point 4— July 7, 2014, before treatment

Photo Point 4— July 25, 2016, before 3rd year of treatment

Photo Point 4— July 7, 2017, before 4th year of treatment

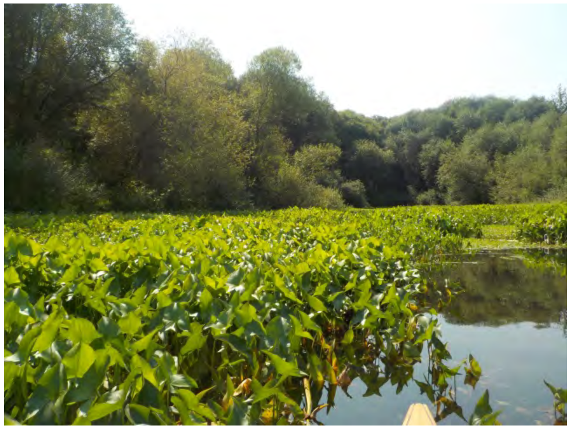
Photo Point 4— Sept. 21, 2017, after 4th year of treatment

Appendix C (*continued*): Maps and Pictures of Collins Bay: Before and After Ludwigia Treatments

Photo Point 4 area — parrot feather sneaking into areas treated for Ludwigia. Part of these parrot feather patches area can be seen in previous photo 4 photos. September 21, 2017.

Appendix D: Wapato Cove Photos

Wapato Cove - Highly visible site along river with easy public access from river. Ludwigia is dominant in the south side of the site and has mixed in (at different densities) with native wapato in other areas of the site. August 12, 2016 & August 7, 2017



North end of site with high densities of native wapato and sparse Ludwigia. Manual removal of Ludwigia by volunteer groups and/or contractors in this area. August 22, 2017

Middle/south end of site with mix of native wapato and Ludwigia. Contractors conduct chemical control treatments (backpack spraying and hose) in denser areas of Ludwigia and manual removal of Ludwigia in densest areas of wapato. August 17, 2016

South end of site with densest areas of Ludwigia. Chemical control treatments by contractor (hose and backpack spraying). September 12, 2017

Appendix E: Pictures of Aquatic Weed Outreach and Education Events, Weed Pulls, and Monitoring

River Weed Pull Event: Benton SWCD River Restoration and Invasive Species Program Coordinator, Melissa Newman, discussing aquatic invasive control efforts in Corvallis to Albany reach. August 30, 2017.

River-based Workshop: Benton SWCD Executive Director Holly Crosson discussing some invasive and native aquatic plants observed. June 13, 2017.

River-based Workshop: PSU Rich Miller discussing characteristics of plants with workshop attendees. June 13, 2017

River-based Workshop: Calapooia Watershed Council providing an overview of Ludwigia control treatment and restoration work planned at Bowers Rock State Park. June 13, 2017.

Appendix E: Pictures of Aquatic Weed Outreach and Education Events, Weed Pulls, and Monitoring

Lower Kiger Side Channel Photo Point 1: Hand pulling of small patches by volunteers . July 16, 2016.

Lower Kiger Side Channel Photo Point 1: Hand pulling of small patches by volunteers. Patches have greatly decreased in size after several years of hand pulling. July 8, 2017.

Lower Kiger Side Channel Photo Point 2: Before initial herbicide treatment (using OWEB-WSIP funds). July 16, 2015

Lower Kiger Side Channel Photo Point 2: Before 2nd year of herbicide treatment (using OWEB-WSIP funds). July 8, 2017.

Appendix E (*continued*): Pictures of Aquatic Weed Outreach and Education Events, Weed Pulls, and Monitoring

New occurrence of yellow floating heart at Tripp Island found by volunteer during River Weed Pull Event. July 8, 2017.

Volunteer enjoying our Benton County Aquatic Weed guide while paddling on the Willamette River. Summer 2017

Monitoring: Water quality survey with USGS at Collins Bay. July 7, 2017.

Monitoring: Vegetation sampling with PSU and volunteers at Collins Bay. July 13, 2017.

Monitoring: Vegetation sampling with PSU and volunteers at Collins Bay. July 13, 2017.

Appendix E (*continued*): Pictures of Aquatic Weed Outreach and Education Events, Weed Pulls, and Monitoring

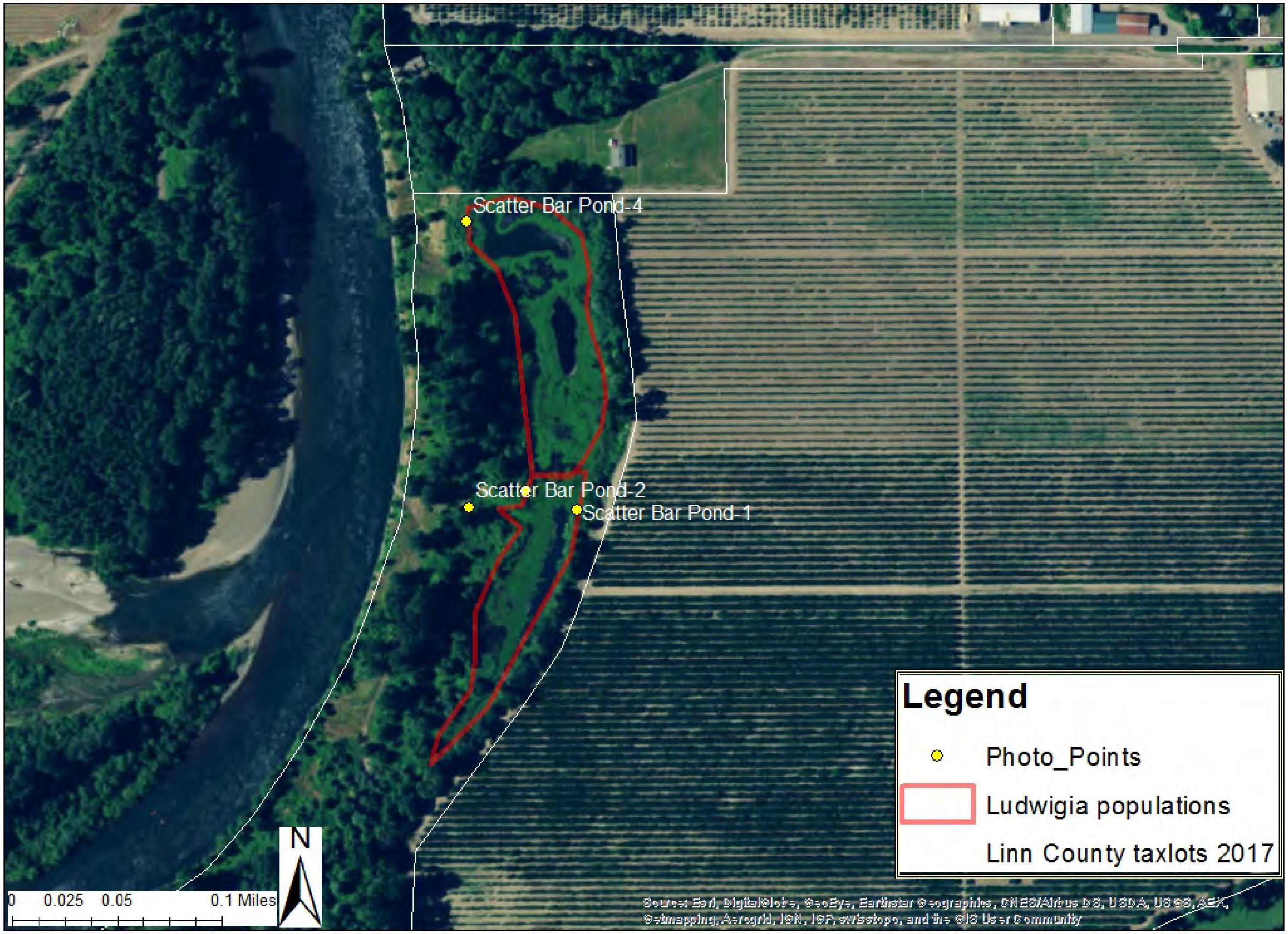
Volunteer wapato tuber collection at local landowner's property who donates native plant materials for Collins Bay restoration. Benton SWCD coordinated with City of Eugene and Confederated Tribes of Siletz Indians so other organizations could also collect tubers. October 3, 2017.

Planting wapato tubers and adding native seed with volunteers at Collins Bay. October 4, 2017.

City of Eugene wapato tuber plantings at Delta Ponds Natural Area from wapato collection above. Fall 2017.

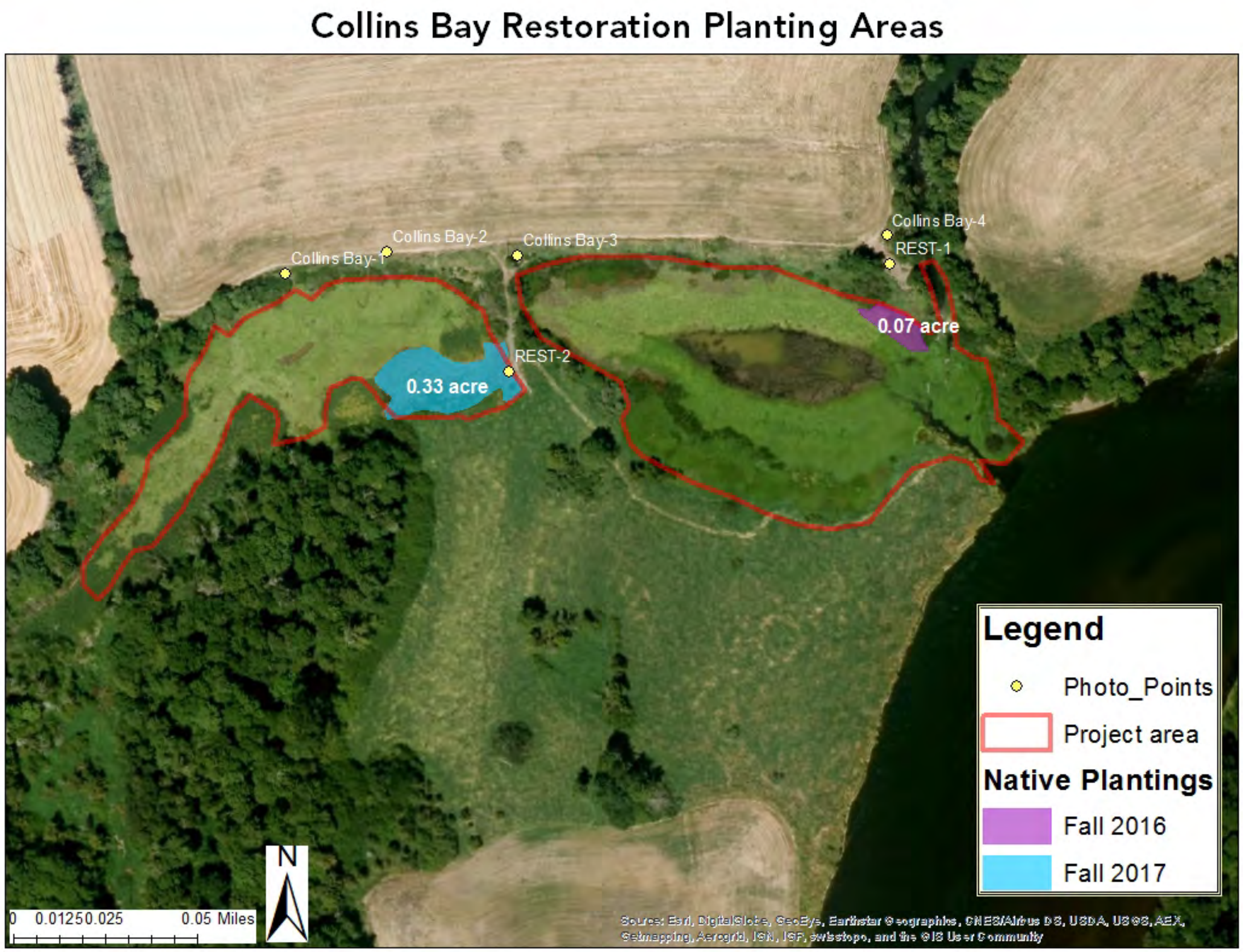
Appendix F: Scatter Bar Pond at Horseshoe Lake, Linn County

Scatter Bar Pond




Scatter Bar Pond
Small area of pond owned by adjacent landowner
Adjacent landowner
Greenbelt Land Trust property
North end of pond
0
65
130
260 Feet
Imagery: Eagle 2010
7/17/2017
Map by Greenbelt Land Trust
greenbelt land trust
N
W
E
S

Appendix G: Collins Bay Restoration Areas Map and Photos



Map 3: Restoration planting areas at Collins Bay.

Appendix G (*continued*): Collins Bay Restoration Areas Map and Photos

Photo Point REST-1 (July 25, 2016): Before 2016 control treatments for Ludwigia and before dropping of wapato tubers in this area after river inundation in Fall 2016.

Photo Point REST-1 (July 7, 2017): Only a few wapato sprouting (not visible) because we weren't able to plant tubers and could only drop them in area in 2016 because of high water levels in October 2016. However, native bur-reed is responding well and naturally recruiting more into this Ludwigia treated area. Can see expansion of bur-reed between 2016 and 2017 photos above.

Appendix G (*continued*): Collins Bay Restoration Areas Map and Photos

Photo Point REST-2 (October 4, 2017): Native aquatic plant materials (wapato tubers and native aquatic seed) added in Fall 2017 to Ludwigia treated area. Photos above and below. See map in Appendix E showing locations of restoration plantings.

Appendix H: 2015 Water Quality and Ludwigia Monitoring Report

2015 Water Quality and *Ludwigia* Monitoring Report for Stewart Slough Project Area, Benton County

Prepared by Mosaic Ecology LLC
For Benton Soil & Water Conservation District
February 2016

This report is meant to be utilized by staff of Benton Soil & Water Conservation District as well as interested members of the natural resource community

Overview

In July of 2015, in association with the on-going control of Uruguayan primrose-willow (*Ludwigia hexapetala*) within the Willamette River system of Benton County, Oregon, Benton Soil & Water Conservation District (BSWCD) developed a pilot monitoring program. Monitoring was conducted in order to track annual population shifts of *Ludwigia* in response to control efforts and to assess the effect of herbicide treatments for the control of *Ludwigia* on water quality.

Aquatic plants are known to affect water quality. Dense populations of aquatic plants alter diurnal fluctuations of dissolved oxygen (DO) and large-scale die-offs can create anoxic conditions detrimental to aquatic life. Monitoring compared DO within open water and *Ludwigia* infested areas of waterbodies within the Stewart Slough Project Area. Monitoring occurred before and after herbicide treatment from July to November in an attempt to capture the rapid reduction of DO in response to *Ludwigia* decay. Range and density of *Ludwigia* within three distinct water bodies were mapped to record baseline *Ludwigia* cover. Generated maps will assist applicators to target areas of regrowth and adjust management methods accordingly. Water quality data was collected by a handheld YSI meter in four distinct water bodies up to four times during the 2015 growing season. Presented data focused on dissolved oxygen with an emphasis on the effect to aquatic organisms.

Ludwigia infested sampling sites possessed lower DO than open water environments even prior to herbicide application. The presence of *Ludwigia* resulted in DO values exceeding thresholds that impair aquatic organisms, in some cases low enough to cause acute mortality. Open water areas contained elevated DO levels, providing refuge for fish in water bodies containing *Ludwigia.* A clear reduction of DO resulting from mass decay was not observed across all sites. Due to varying physical variables between sampled water bodies, sites showed varying baseline DO values and trends over time.

The monitoring effort was conducted to inform BSWCD of the possible impacts the *Ludwigia* control may have on water quality in the Stewart Slough Project Area. Monitoring was not required by Oregon Department of Environmental Quality (DEQ) or the US Environmental Protection Agency (EPA), though a Pesticide General Permit was required and obtained through DEQ for treatment of *Ludwigia* infestations. Field and data analysis methods from the 2015 monitoring effort were evaluated and recommendations for the following years have been made.

Monitoring Goals

1. Measure pre-treatment *Ludwigia* range and cover values for annual comparisons.
2. Assess how the presence of *Ludwigia* affects water quality with or without herbicide treatment.
3. Develop a replicable monitoring methodology that can be used for data collection in future years.

Background

Ludwigia in Stewart Slough Project Area

Native to Central and South America, *Ludwigia hexapetala* and *L. peploides* ssp. *montevidensis* are invasive aquatic plants that are rapidly increasing in prevalence in Oregon, most notably in the Willamette River Valley (ODA 2015). In the past 10 to 15 years, *Ludwigia* populations have occupied high profile sites such as Delta Ponds Park of Eugene, leading to an increased local awareness and the discovery of established *Ludwigia* populations throughout the Willamette River Valley (City of Eugene 2013). From 2012 to 2015, surveys by boat and remote sensing showed that *Ludwigia* had become "widespread" within Linn, Benton and Marion Counties, and was expanding the its range in Oregon to the north and south (ODA 2011; ODA 2015) Listed as a Class B noxious weed in the State of Oregon, intensive management is encouraged on a case-by-case basis (ODA 2014).

After initial surveying showed extensive infestations within side channels, oxbows, riverine wetlands and other water bodies of the Willamette River, BSWCD acquired funding from the Oregon State Weed Board, the Oregon Watershed Enhancement Board and other sources in an attempt to eradicate or greatly reduce *Ludwigia* in over 4 miles of infested habitat in the Stewart Slough Project Area of Benton County. Collins Bay, located north of the Stewart Slough Project Area, was initially chemically treated in 2014 for *Ludwigia*. Collins Bay was mapped in 2015 to assess the efficacy of the previous year's control methods. The first year of full scale treatment within the Stewart Slough Project Area occurred in late-June to early-July of 2015, with follow up applications occurring in August and October of 2015. Contractors applied a formulation of aquatic label Rodeo (glyphosate) at a concentration of 3%, with dye and Agri-dex surfactant. Herbicide formulations were selected for their known effectiveness in treating *Ludwigia* and relatively low toxicity to fish, mammals and invertebrates in comparison to other formulations. Due to the large scale of the project area, sections of the four mile slough system were treated over a period of 15 application days. Roughly four weeks after the July 2015 chemical application, large masses of *Ludwigia* were observed dying as leaf and stem tissue browned, curled and sank to decay at the water bottom (Figure 1.).

Figure 1. *Ludwigia* within Stewart Slough #1 Site (Asbahr Lake) of project area, 7/6/2015 (A) prior to chemical application and four weeks after chemical application, 8/11/2015 (B).

Effects of Plants to Dissolved Oxygen

Water chemistry is greatly affected by the abundance and composition of plant life in aquatic systems. Aquatic plants exchange gases with the water column, affect water temperature, can reduce turbidity, alter evapotranspiration rates, and influence microbial communities. This monitoring effort was intended to assess how large-scale herbicide treatments and the resulting decay of high *Ludwigia* densities affects DO within the Stewart Slough Project Area.

Major sources of DO within aquatic systems include: direct diffusion from the atmosphere, wind and wave action, and photosynthesis. Photosynthesis from plant and algal species exchange CO_2 for O_2 within the water column when sunlight is available, while respiration from animals, including microbial organisms remove O_2 from the aquatic system through respiration (Francis-Floyd 2003). Although plants are known for photosynthesis, which produces oxygen, they also consume oxygen through respiration. In the absence of light respiration in plants occurs at a higher rate compared to photosynthesis. Temperature also greatly affects DO as higher temperatures reduce the capacity of water to hold gases such as O_2 and CO_2 (ODFW 1999) There is a large amount of conflicting information supporting both the increase and reduction of DO caused by aquatic plants (Frodge et al. 1990; Caraco & Cole 2002; Francis-Floyd 2003; Tanner & Headley 2011). A plant's influence on DO is largely dependent on plant growth habit (submerged, floating, emergent, etc.). Submerged plants can more efficiently exchange CO_2 directly with O_2 increasing oxygen in the water column and floating-leaved plants release O_2 to the atmosphere, depleting DO (Caraco et al. 2006). But how exactly emergent plants such as *Ludwigia* affect DO can be unclear.

In communities dominated by emergent aquatic plants, zones of dense vegetation provide significant submerged structure, but result in nearly or completely anoxic water conditions (Rose & Crumpton 1996). Reduction of DO in emergent plant beds have been attributed to large quantities of decaying leaf litter and reduced diffusion of oxygen from the atmosphere (Caraco & Cole 2002; Rose & Crumpton 2006;). Even more directly related to the Stewart Slough WQ Pilot Study, anoxic zones have been found in emergent plant communities of *Ludwigia palustris* and *L. hexapetala* within the backwater channels and bays of a major riverine system in the southeast United States (Miranda & Hodges 2000). Besides direct influences to DO, seasonal or human caused plant die-offs pose the risk of reducing DO as respiration rates of microbes increase during the decay process (CDBW 2001; Jewell 1971; ODFW 1999).

The degree of oxygen consumption in decaying plant communities varies in regards to plant densities, species, and microbial community composition. Oxygen demand, or depletion of DO is directly related to the initial biomass of plant communities (Tang et al. 2013). Numerous *in-situ* and *ex-situ* experiments have showed hypoxic conditions result from plant die-offs related to both chemical and mechanical control of aquatic plants (Hellsten et al. 1999; Jewell 1971; Tang et al. 2013). Hypoxia related to weed control can occur locally within regions of a larger waterbody or occur throughout the entirety of a small waterbody. One study in particular showed a reduction of DO to zero within a small pond four days after Canadian elodea (*Elodea canadensis*) was chemically treated (Owens and Maris, cited from Jewell 1971).

It is clear that *Ludwigia* has the potential to greatly reduce available oxygen in aquatic environments of the Stewart Slough Project Area. With evidence of anoxic conditions being present in areas of both living and decaying plant material, it is important to assess how *Ludwigia* affects the varying waterbody types within the Stewart Slough System before and after treatment. Waterbodies may possess system wide anoxic conditions or contain open water areas that provide refuge for fish species. Thresholds have been established to indicate the minimum concentration of DO within water that results in detrimental impact to fish.

Effects of Dissolved Oxygen to Fish

Within scientific literature, there are numerous thresholds of minimum DO for both salmonid and non-salmonid fish species. The generally accepted threshold for most fish species is 5 mg/L of DO (Yeakley et al. 2013; Francis-Floyd 2003). At a concentrations below 5 mg/L, embryonic and larval development can be greatly impaired, weight loss can occur, avoidance may take place, and survivorship of certain species is decreased. In a study of non-salmonid fish, a majority of species tested experienced zero survivorship in water less than 2.4 mg/L of DO (EPA 1986). Coldwater species or members of the family *Salmonidae* (salmonids) are even more sensitive to reduced DO.

In the State of Oregon, criteria for minimum DO in water bodies is administered by DEQ. For water bodies identified by DEQ as providing cold-water life, the absolute minimum for DO may not be less than 8.0 mg/L (OAR 340-041-0016(2)). In waters identified as providing cool-water aquatic life, DO may not be less than 6.5 mg/L at any given time (OAR 340-041-0016(3)). The absolute minimum is increased to 11.0 mg/L in water bodies identified as active spawning areas during designated times (OAR 340-041-0016 (1)). Standards set by DEQ are based on criteria established by the EPA (EPA 1986).

Ludwigia infested areas within the Willamette River Valley include ponds, bays, oxbows and sloughs that may or may not have connectivity to the main channel of the Willamette River. It is important to gauge how DO within infested water bodies such as those monitored in the Stewart Slough Project Area could affect both salmonid and non-salmonid species present. Two DO thresholds will be applied to the results of WQ monitoring to assess suitability for fish development and survivorship. Although more imperative to stream environments, the cool-water criterion of 6.5 mg/L of DO will be applied to account for possible salmon or trout rearing and migration in the “Willamette River and Tributaries Gallery Forest” ecoregion, which the Stewart Slough Project Area is located within (DEQ 2010). A threshold of 5 mg/L will be used as reference for non-salmonid species where moderate to slight production impairment is known to occur based on life stage (EPA 1986). These thresholds have been applied to the figures simply as a reference for data interpretation and do not identify impaired waters of the State.

Methods

Site Selection

A total of five sites within the project area were selected for monitoring (Figure 2.). Selected sites represent the diverse water body types that persist within the project area (gravel pit, slough, oxbow lake, bay). Access, perennial water presence, permission of entry, distance from one another and degree of infestation were taken into account to select sites. In total, three sites were mapped by GIS and four sites were sampled for water quality. Originally, four sites were selected for density and range mapping, but due to time constraints, the Oxbow site was not mapped. Due to an uncharacteristically dry and warm water year, the sampling location of Stewart Slough #1 completely dried for the first time in local memory. The Stewart Slough #2 site was added to maintain data collection within the immediate Stewart Slough Project Area and preserve the number of sites being sampled during each sampling period. Collins Bay is the only site that was chemically treated in 2014. All sites except for Oxbow were chemically treated in summer of 2015.

Figure 2. Sites within Stewart Slough Project Area that were mapped and/or monitored for water quality.

Range & Cover Mapping

Stewart Slough #1, Gravel Pit and Collins Bay were mapped on July 2, 2015 before chemical application took place at the three sites. Mapping was carried out by a research technician on foot using a hand held GPS instrument (Garmin Oregon 450). Percent cover estimates of *Ludwigia* were used to generate cover class polygons within surveyed sites: Light (<5%), Moderate (5 – 50%) and Heavy (>50%). Total range of *Ludwigia* was measured first by GPS and polygons of Moderate and Heavy cover were then collected within the population extent.

GPS data was projected and analyzed within ArcGIS 10.3 to calculate acreage of individual polygons and total acreage of each cover class. All data was projected in the NAD_1983_UTM_Zone_10N coordinate system. Maps were generated to provide comparisons for future treatment years as it is expected that range and density mapping will occur within the three sites on an annual basis. Variables affecting *Ludwigia* density patterns within mapped sites were summarized.

Water Quality Monitoring

Water quality was monitored within the Stewart Slough Project Area on 7/6, 8/11, 9/21, and 11/2/2015. Dates were selected in an attempt to capture the seasonal fluctuations of WQ conditions in response to widespread *Ludwigia* die-off (Table 1). Monitoring occurred at roughly the same time on each date to minimize daily variations in WQ values. Monitoring at specific sites did not vary more than 1.5 hours from other sampling dates. On specific sampling dates, some sites were not monitored for WQ due to uncharacteristically dry conditions or in one case, instrument error (Table 1).

Table 1. Sampling dates at sites within Stewart Slough Project Area. Successful sampling periods indicated by "Yes", otherwise restrictions to WQ monitoring are indicated.

Site	Sampling dates and relation to herbicide treatment			
	July 6	**Aug 11**	**Sept 21**	**Nov 2**
	Before Treatment	2 Weeks After	2 Months After	Fall Senescence
Gravel Pond	Yes	Yes	Yes	Yes
Stewart Slough #1	Yes	Dry Conditions	Dry Conditions	Limited Sampling
Stewart Slough #2	Not yet selected	Yes	Yes	Yes
Oxbow (No Chemical Treatment)	Instrument Error	Yes	Yes	Yes

Two technicians collected data by foot or boat using a YSI Professional Pro Plus Multiparameter Water Quality Meter (https://www.ysi.com/proplus). The WQ variables of temperature, DO, pH, conductivity, and oxidation reduction potential (ORP) were measured. Prior to each monitoring date, temperature, pH, conductivity and ORP were calibrated and DO was calibrated prior to each site. For each sample, depth, max depth and percent cover of *Ludwigia* were collected. Sampling points were recorded by GPS (Garmin Oregon 450). Samples were collected in areas of open water and >50% *Ludwigia* cover. Percent cover was assessed for the total area within one meter of the sample. As plants began to die back after herbicide application, the GPS was used to reference previous monitoring points infested with *Ludwigia* and utilized the range and cover data from the July 2nd mapping effort. Readings were collected at the surface (0.13 meters) and slightly above the water bottom (0.10 to 0.25 meters from bottom surface). Data was logged within the YSI meter and recorded manually by technician simultaneously. Both electronic generated and written data have been provided to BSWCD with calibration data.

Data was summarized to account for four distinct categories: Surface/Open Water, Surface />50% *Ludwigia* Cover, Bottom/Open Water, and Bottom/>50% *Ludwigia* cover. Technicians attempted to collect at least four readings within all categories, but was not possible at all times due to absence of open water areas, access restrictions or time constraints. Comparisons of WQ were made between categories within the same site. Inter-site comparisons would be difficult to make since each site represents varying physical and hydrologic conditions.

Results

Data collected by GPS, YSI meter and manually have been supplied to BSWCD staff. Range and density of *Ludwigia* within the three mapped sites have been presented in map form with calculated acreage. The six measured WQ variables have been summarized and provided to BSWCD for further analyses and interpretation. Within the report only DO (mg/L) and temperature (°C) have been graphically displayed and summarized.

Oxbow

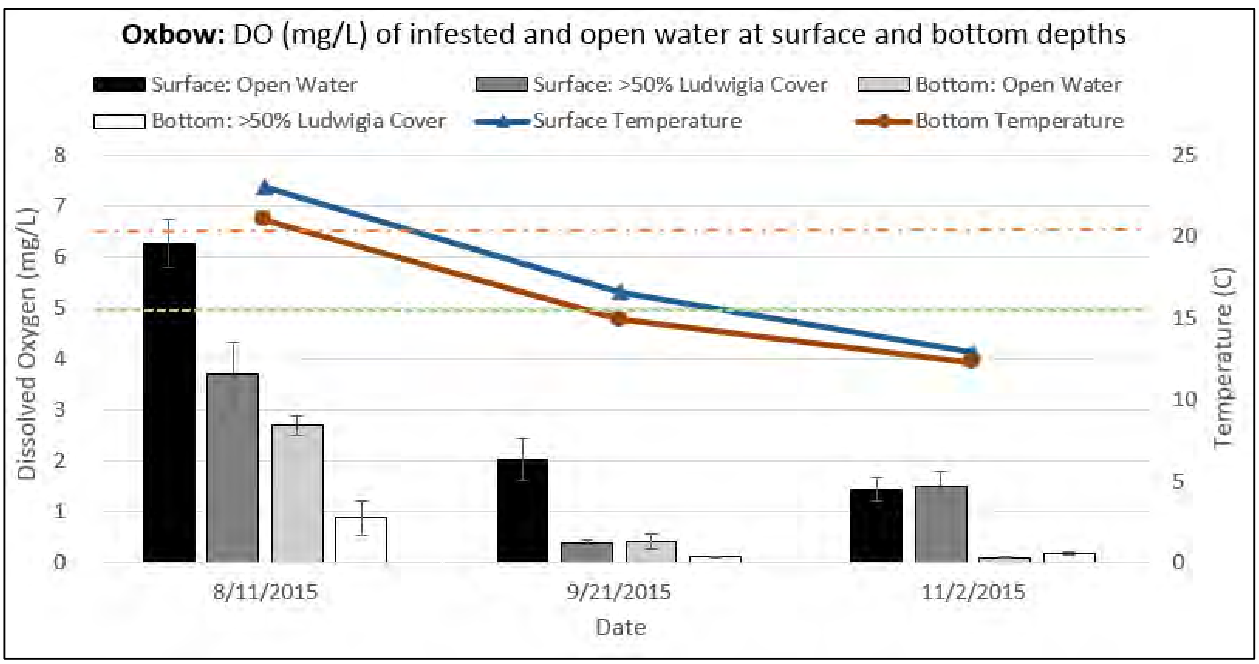


Figure 3. DO comparison between surface and bottom layers in open water and *Ludwigia* infested areas of Oxbow Site. Oxbow acted as a control and **no herbicide application occurred**. Dashed lines represent cool-water criterion (orange) and moderate impairment for non-salmonid species (green).

Acting as the control site, the Oxbow was heavily infested with *Ludwigia* in roughly 90% of the water body except for an open water area adjacent to an irrigation pump and some areas <10m^2 in which no cause was attributed. In August, surface values of DO in open water possessed an average value of 6.25 mg/L in comparison to 3.70 mg/L in infested areas (Figure 3). Surface values of DO remained lower in infested sample sites compared to open water sites in September. By November, surface DO was similar in infested and open water areas. Values of DO decreased in open water as the season progressed with the lowest DO occurring within open water areas in November. Temperature measurements each month decreased from August to November in both surface (23.0 °C to 12.9 °C) and bottom readings (21.0 °C to 12.3 °C) supporting evidence that reduced DO was not attributed to temperature decrease. DO and temperature were lower within bottom samples for both open water and infested samples when compared to surface readings. The largest difference in temperature between surface and bottom samples was 2.0 °C which occurred in August.

Average DO in the Oxbow was below both cool-water criterion and non-salmonid thresholds in all sampling categories except for surface readings in open water during the August sampling date. In August only the non-salmonid threshold was met. However, one open water surface sample and one sample with 60% *Ludwigia* cover exceeded the 6.5 mg/L cool-water criterion with DO of 6.72 mg/L and 8.73 mg/L respectively. Across all sampling dates, only five surface samples exceeded 5.0 mg/L of DO, all in August.

Gravel Pond

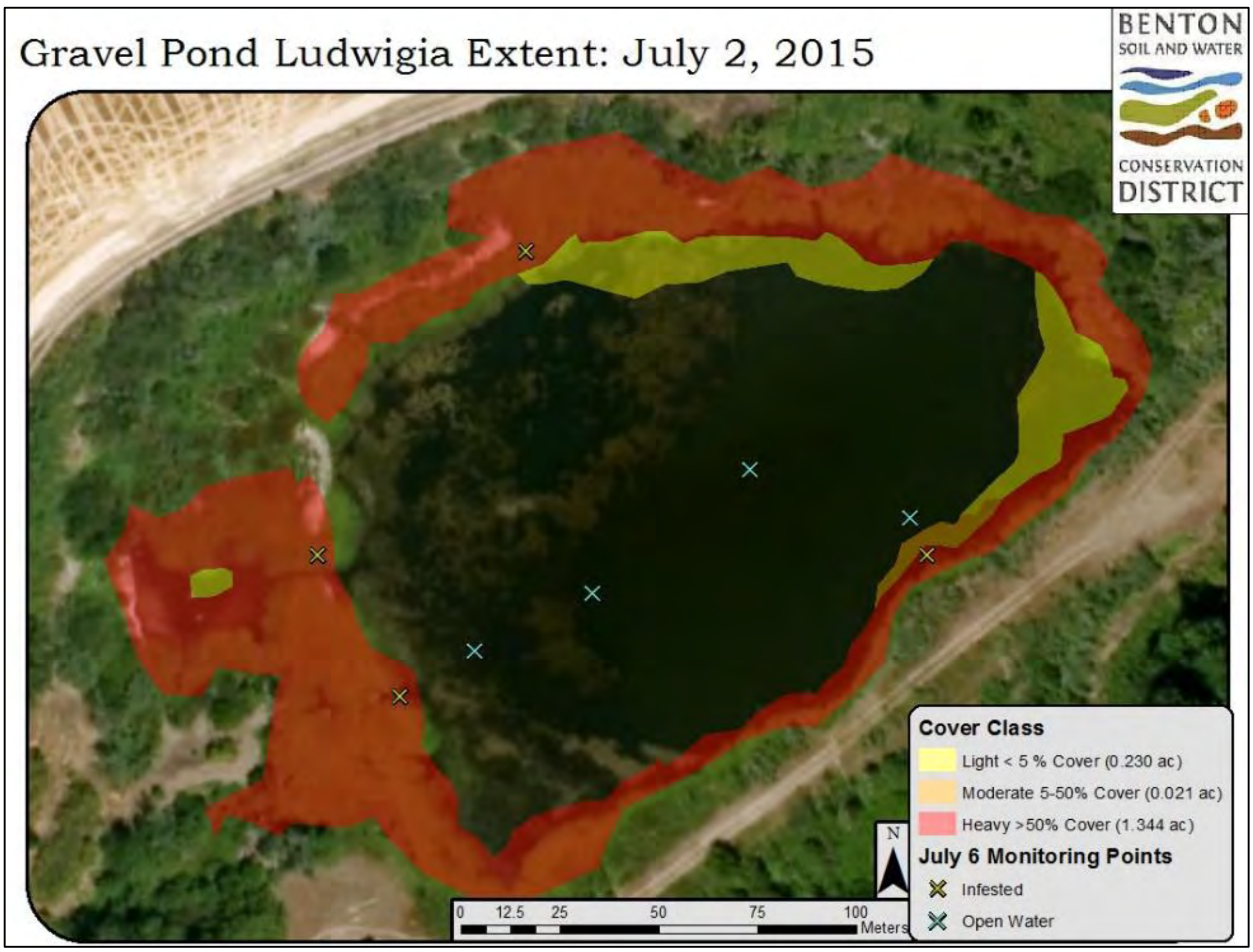


Figure 4. Range and cover class summary of *Ludwigia* within Gravel Pond before first herbicide application with sampling points for July 6 monitoring.

In the Gravel Pond, *Ludwigia* was limited to heavy cover along the perimeter due to soil saturation, water depth, and substrate type (Figure 4). The Gravel Pond has historically been mined for gravel, creating a steep drop off along the bank. The open water area accounted for 4.401 acres in comparison to the 1.595 acres of *Ludwigia* present. Max depths during WQ sampling exceeded 2.5 meters in July. Banks and water bottom were dominated by course gravel with minimal organic matter visible. Although the extent of water at flood stage was not measured, a distinct line existed between bare ground and heavy *Ludwigia* infested areas, indicating where soils are saturated for at least part of the year. The extension of heavy *Ludwigia* cover to the southwest portion of the pond is due to a depression where water was present until July. The light and moderate densities of *Ludwigia* were attributed to stolons or "runners" extending from the dense bank populations with few individuals rooting within the aquatic environment. Brazilian elodea (*Ergeria densa*) was the other dominant aquatic plant species occurring at high densities in the western portion of the site.

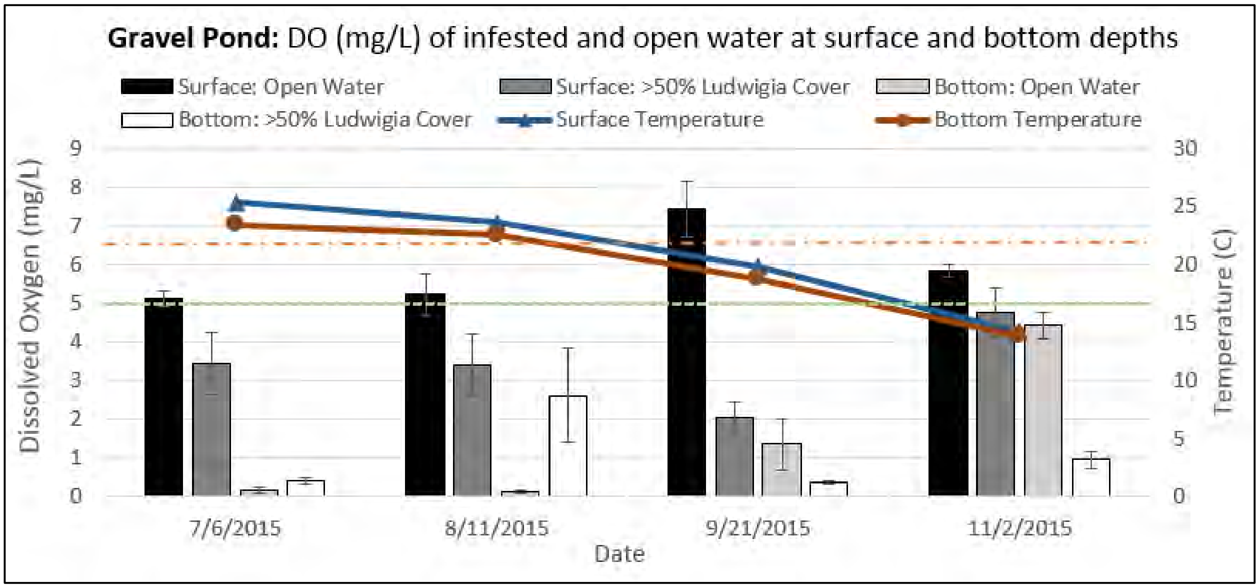


Figure 5. DO comparison between surface and bottom layers in open water and *Ludwigia* infested areas of Gravel Pond. Herbicide application occurred during the week of August 2nd. Dashed lines represent cool-water criterion (orange) and moderate impairment for non-salmonid species (green).

There was not a pronounced decrease in surface DO over time within the Gravel Pond as seen in the Oxbow Site (Figure 5). However from August to September, surface DO within infested sampling sites decreased from 3.41 mg/L to 2.03 mg/L, while open water surface values increased substantially from 5.22 mg/L to 7.41 mg/L. In November, all sampling categories increased except for open water surface values which decreased to 5.83 mg/L. Temperature decreased over time in both surface (25.3 °C to 14.2 °C) and bottom readings (23.3 °C to 13.9 °C). Temperature could be partially attributed to the elevated values of DO in November, but cannot necessarily account for the decrease of DO within *Ludwigia* infested sampling sites from August to September.

Average DO within open water surface samples met the non-salmonid threshold of 5 mg/L on all four sampling dates, exceeding the cool-water criterion threshold only in September. One individual open water surface sample exceeded the cool-water criterion threshold in August, with

7 of 11 samples exceeding the 6.5 mg/L DO threshold in September. The trend was similar in relation to the non-salmonid threshold with 6 of 10 open water samples exceeding 5 mg/L in August and 11 of 11 samples exceeding the threshold in September. *Ludwigia* infested areas had a much lower frequency of samples exceeding either threshold at the surface. Only 1 of 5 samples exceeded the non-salmonid threshold in August with no sample exceeding 4.0 mg/L in September. In November, surface values in *Ludwigia* infested areas exhibited a broader range of DO values (0.58 to 9.72 mg/L) in comparison to open water areas (4.95 to 6.50 mg/L). The open water surface samples only met 6.5 mg/L DO once in 10 samples, with 4 of 16 samples exceeding the cool-water threshold in infested areas. However, open water areas contained conditions less harmful to non-salmonid fish species with 9 of 10 samples exceeding the non-salmonid threshold in comparison to the 7 of 16 samples exceeding the threshold in infested areas. The large range in DO values within infested areas could have been caused by varying levels of *Ludwigia* decay. Since initial herbicide treatments occurred over 3 months prior, with follow up herbicide treatments in August and October, there may have been sampling areas that decay had ceased and other areas in which decay was still occurring from the October herbicide treatment. Regardless of the lower DO average compared to open water areas, it is promising that the frequency of DO values >5 mg/L and total average greatly increased in infested sites three months after initial herbicide treatment.

Stewart Slough #1

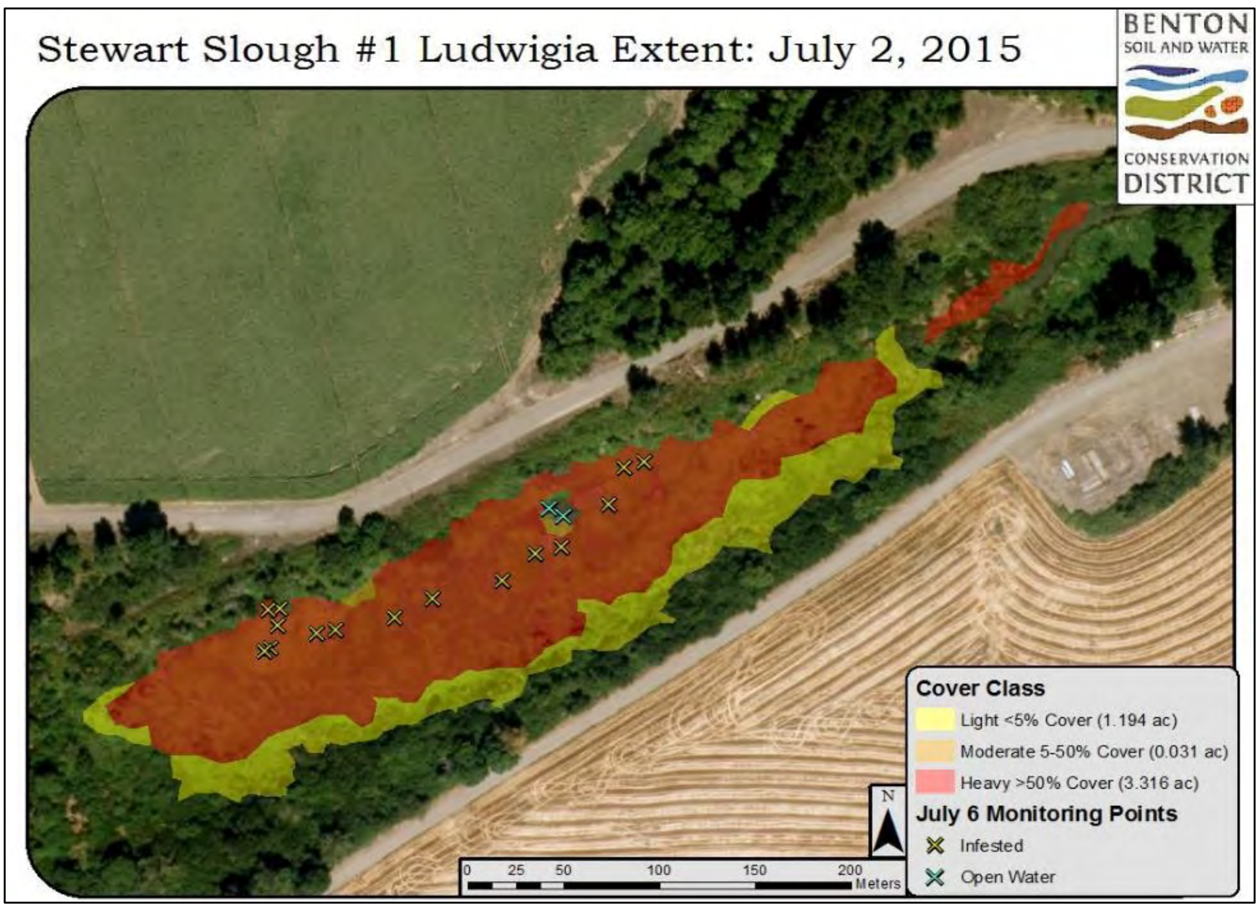


Figure 6. Range and cover class summary of *Ludwigia* within Stewart Slough #1 before first herbicide application with sampling points for July 6 monitoring.

The Stewart Slough #1 site demonstrated heavy *Ludwigia* cover throughout the entire waterbody (Figure 6). At the time of GPS collection, the entire system was walkable, not exceeding depths of 1 meter. Different from the Gravel Pond, the site contained local populations of Western pond lily (*Nuphar polysepela*) and bur-reed (*Sparganium eurycarpum*) species which competed with *Ludwigia*. The areas of moderate cover were associated with populations of *N. polysepela* while the extent of light cover along the southeastern edge of the site can be partially contributed to a healthy stand of *S. eurycarpum.* Areas where trees extended over the water surface and provided shade had reduced cover and in some cases no *Ludwigia* cover.

Of the sites surveyed for mapping or WQ, the Stewart Slough #1 Site had the highest presence of channels created through burrowing activity of aquatic mammals such as nutria and beaver, throughout the water body. Channels of deeper water provided cover to *Ludwigia* during chemical application. Regrowth of healthy individuals were observed within the channels by August as water subsided.

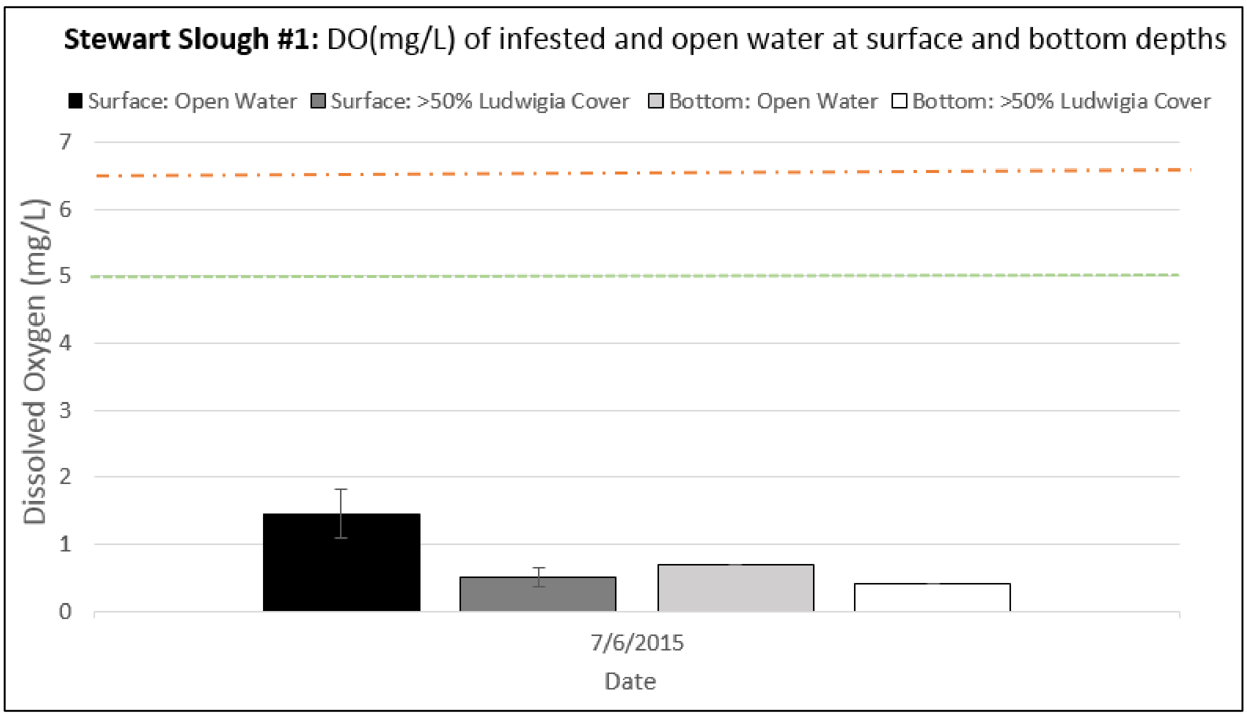


Figure 7. DO comparison between surface and bottom layers in open water and *Ludwigia* infested areas of Stewart Slough #1 prior to treatment. Dry conditions in summer months made WQ monitoring not possible. Dashed lines represent cool-water criterion (orange) and moderate impairment for non-salmonid species (green).

The Stewart Slough #1 location provided very few opportunities for open water samples (n = 2). Nearly the entirety of the water body with >0.2 m depths was infested with heavy cover making it difficult to find sampling sites representative of open water environments (Figure 6). Average depth of samples were 0.33 meters providing optimal environments for *Ludwigia* growth. The shallow depths made it difficult to collect bottom samples independent of surface samples. Open water samples were taken in areas of thick *N. polysepela* growth. The shallow nature of the water body lead to rapid drying in the months after July data collection occurred.

Regardless of challenges in collecting diverse categories of data, the Stewart Slough Site #1 represented a waterbody type that is relatively common in the Stewart Slough Project Area. July sampling provided an insight to DO conditions within these infested water bodies. The shallow, stagnant nature of the site, with dense *Ludwigia* growth resulted in low DO values (Figure 7). It is important to note however that water temperature was surprisingly low (19.4°C) in comparison to Gravel Pond Site (25.3 °C) indicating possible groundwater recharge or immediate runoff from adjacent irrigation activity.

Within infested sample sites, surface DO ranged from 0.06 mg/L to 2.03 mg/L, averaging 0.50 mg/L. Of the 17 samples collected, only five exceeded 0.50 mg/L DO. Although only two open water samples were collected, DO values were 1.05 and 1.78 mg/L. A larger sample size for open water samples is needed, but there is support that even small open water areas can result in increased DO within heavily infested water bodies.

In November, about a third of the Stewart Slough #1 Site contained standing water due to recent rains. Samples were collected in a restricted region of the water body. All samples were collected where large mats of decaying *Ludwigia* were still observed. Samples in *Ludwigia* infested areas exhibited a similar pattern in November as *Ludwigia* infested areas of the Gravel Pond. Average DO was 2.89 mg/L with a large range of 0.24 to 8.25 mg/L. In total 4 of 16 samples exceeded the non-salmonid threshold, with two values exceeding the cool-water criterion.

Stewart Slough #2

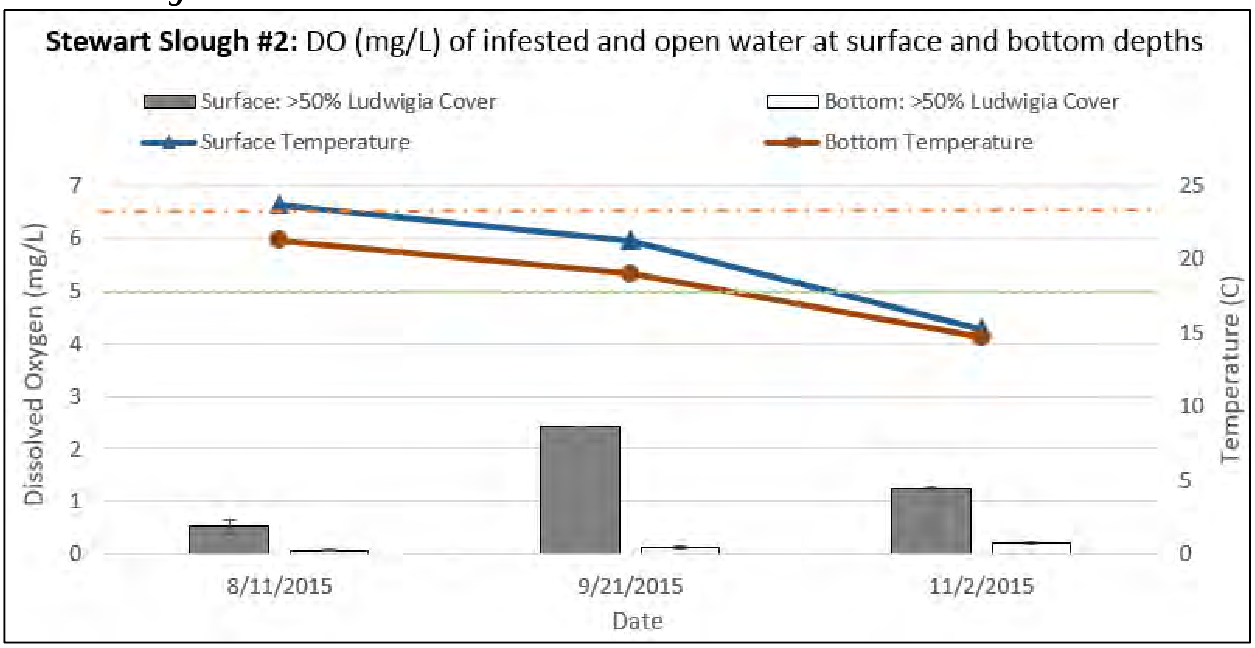


Figure 8. DO comparison between surface and bottom layers in *Ludwigia* infested areas of Stewart Slough #2 after herbicide application. Herbicide application occurred during the week of July 19th. Dashed lines represent cool-water criterion (orange) and moderate impairment for non-salmonid species (green).

The Stewart Slough #2 Site was added to the monitoring sites after attempted sampling at the dried Stewart Slough #1 Site was not possible. Due to time constraints and access issues, only *Ludwigia* infested areas were sampled with a target sample number of 3. Samples further demonstrate the relatively low DO within thick beds of *Ludwigia*. The population of *Ludwigia* at sample sites within Stewart Slough #2 were exceptionally dense, with technicians breaking through thick mats of stem and root matter to access bottom samples. Observationally, August surface readings were carried out in decaying leaf and stem tissue that was resting on the dense root mass. DO values in August ranged from 0.31 mg/L to 0.80 mg/L. Surface values of DO increased substantially in September as values ranged from 2.41 mg/L to 2.43 mg/L. The technician noted that by September the *Ludwigia* had sunken into the water column. The open water above the dense root and stem system contained DO values well above the August readings. When the probe was lowered below the root mass, average DO values did not exceed 0.21 mg/L during any sampling date. Neither threshold was exceeded by individual samples.

Collins Bay

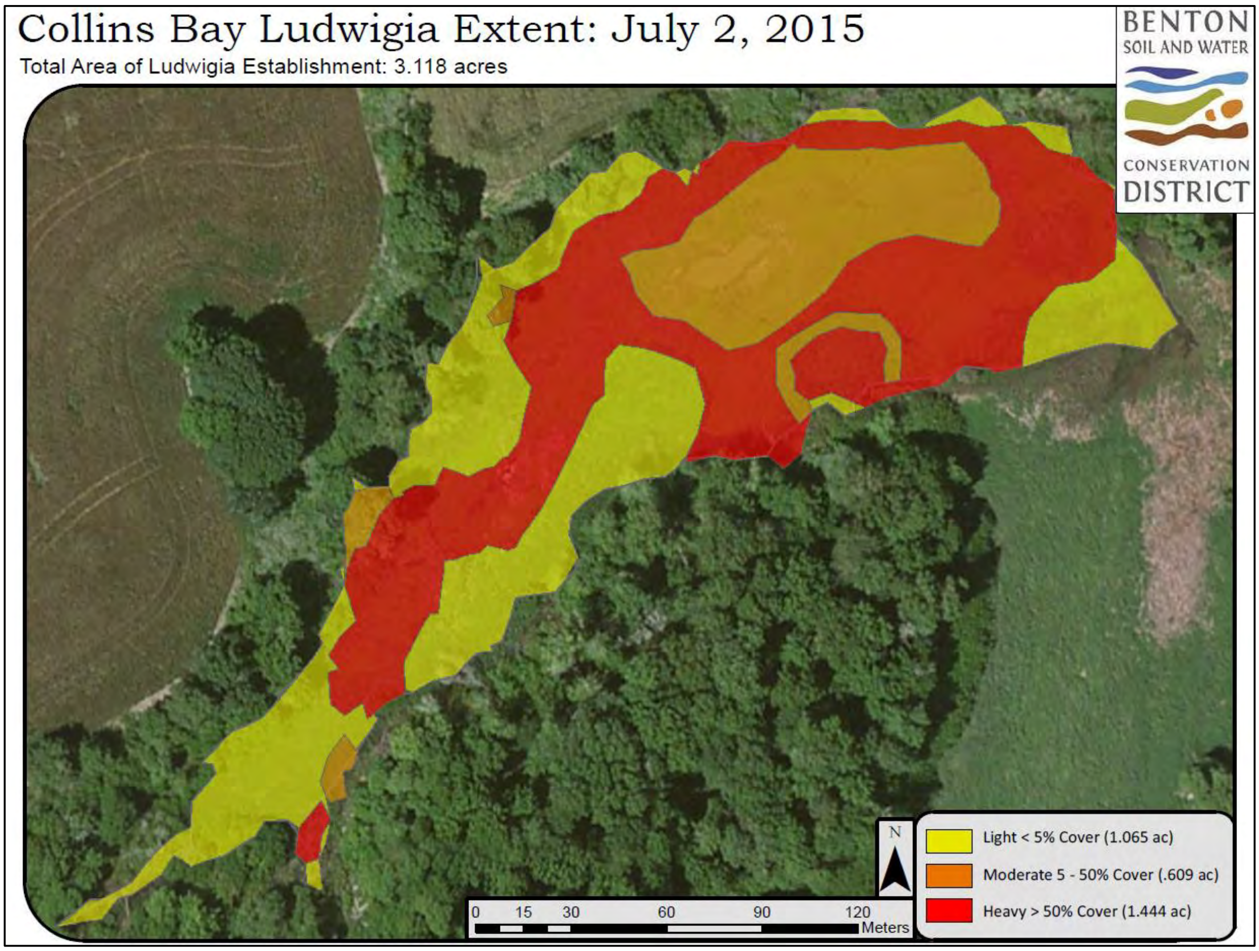


Figure 9. Range and cover class summary of *Ludwigia* in Collins Bay, before second year of treatment.

Collins Bay provided a preview of the possible regrowth that may occur in the numerous sites within the slough system to be treated in 2015 (Figure 9). Observations from BSWCD staff indicated that the Collins Bay site was dominated by heavy *Ludwigia* cover prior to herbicide treatment in 2014. There was no evidence during the mapping effort that range of *Ludwigia* had decreased substantially. Dense regrowth was observed through the central portion of the water body. Moderate or light-cover occurred in areas that contained *N. polysepala* and *S. Eurycarpum*, such as the horseshoe shaped polygon observed in the southeastern portion of the surveyed area. Dense mats of dead *Ludwigia* were observed with fresh growth occurring from underneath. This pattern of regrowth was most apparent in the large moderate-cover polygon in the northeastern portion of the site.

Regrowth of *Ludwigia* in Collins Bay highlighted the benefits of native species such as *N. polysepela* and *S. eurycarpum* in reducing local densities of *Ludwigia.* The map product and observations by Mosaic Ecology technicians show that dense populations of *Ludwigia* could shield individuals in the lower water column from herbicide treatment. Regrowth within the dense mats could have come from the nodes of plants not entirely killed through the treatment process or possible recruitment from an established seedbank.

Data Summary and Discussion

Only one site, the Gravel Pond was sampled on all four target dates. Therefore, before/after comparisons regarding the response of DO to *Ludwigia* die-off in response to herbicide treatment can only be made from data collected within that site. However, valuable insight related to how *Ludwigia* can affect DO and subsequently aquatic life at a large scale has been gained from comparing all four sites and dates.

Because all four water bodies possessed varying physical characteristics, hydrologic regimes and degree of *Ludwigia* infestation, initial values and trends of DO varied at each sampling site. In July, the Stewart Slough #1 Site contained anoxic conditions in nearly the entirety of the system prior to massive *Ludwigia* die-off, while the Gravel Pond possessed an average DO value of 3.44 mg/L in infested areas. In July, prior to a potential further reduction in DO due to microbial respiration, the Stewart Slough #1 Site had already exceeded the acute mortality limit for salmonids, non-salmonids and aquatic invertebrates (USEPA 1986).

Even without chemical application, *Ludwigia* infested surface waters contained less DO on average than open water in all comparisons except for the November sampling in the Oxbow Site. Results of reduced DO and anoxic conditions within emergent beds of *Ludwigia* adhere to findings from previous studies focused on emergent vegetation (Caraco & Cole 2002; Miranda & Hodges 2000; Rose & Crumpton 1996). The presence of *Ludwigia* in waterbodies of the Willamette River Valley greatly reduce available DO within non-treated plant beds.

A clear and obvious “DO crash” in response to herbicide application cannot be clearly observed due to difficulty in collecting WQ data across all dates and sites. It is possible that *Ludwigia* at sampled sites decayed at a rate in which our sampling intervals did not capture. Decay rates vary by species and are related to physical, chemical and biological variables of the environment. The time between herbicide application and DO crashes have varied in previous studies (Owens and Maris, cited from Jewell 1971; Wells et al. 2014). It is possible that due to varying characteristics of water bodies sampled and differences in *Ludwigia* distribution, cover, and density, decay rates were different within each sampling site. Furthermore, the Gravel Pond Site received chemical application roughly two weeks after Stewart Slough #1 and Stewart Slough #2 sites. On the August WQ monitoring date, technicians noted that *Ludwigia* within the Stewart Slough #2 location exhibited a more progressed form of herbicide damage. In the Stewart Slough #2 Site large patches of *Ludwigia* possessed brown leafless stems (Figure 10A). On the same date within the Gravel Pond, the first signs of herbicide damage with chlorosis beginning to yellow the leaves was observed (Figure 10B).

Figure 10. Two sites exhibited different degrees of herbicide damage on monitoring date of 8/11/15. *Ludwigia* within the Stewart Slough #2 Site exhibited defoliation, browning, and curling stems (A), while *Ludwigia* within the Gravel Pond possessed yellowing and curling leaves (B).

After the chemically applied plant tissue dies, the structural integrity of *Ludwigia* weakens and the plant mat sinks into the water column, opening the water surface to wind action and increased oxygen diffusion from the atmosphere. Microbial respiration and oxygen consumption may be highest as leaves and stems decay followed by a release of surface water from dense vegetative cover. This pattern may explain why the Gravel Pond and Stewart Slough #2 Sites displayed low DO values followed by a DO increase at different sampling dates. Also of interest is that a similar pattern was observed in the Oxbow Site which did not receive herbicide application. Natural senescence and plant decay may have been occurring during the September sampling period with a natural thinning of the canopy cover by November. Other possible causes of the DO increase within infested areas during the November sampling period are the increased precipitation rates and cooler water temperatures.

The Gravel Pond Site was the only location with significant open water. In September, the open water area experienced a substantial increase in DO two months after chemical treatment. DO within open water environments has been found to be inversely related to the overall vegetative cover of the water body and negatively affected by distant plant beds (Miranda & Hodges 2000). It is possible that the open water area of the gravel pond was no longer being affected by dense populations of functioning *Ludwigia* and subsequently DO within the open water area increased. The presence of *E. densa* may have also increased DO due to the ability of submerged plants to increase O_2 more efficiently than plants with other growth habits (Coraco et al. 2006).

Across all sites and dates, average DO values in *Ludwigia* infested areas were below the 5 mg/L threshold that would moderately impair non-salmonid fish. Only open water surface readings in the Gravel Pond during September resulted in average DO above the 6.5 mg/L cool-water threshold. Even then, numerous samples possessed DO values well below the cool-water criterion for absolute minimum. Even more alarming were the average DO values that fell below the 3.0 mg/L limit of acute mortality for salmonids, non-salmonids and invertebrates. Within the

Oxbow Site during November sampling, only 1 of 20 surface samples were above the 3.0 mg/L threshold for acute mortality of the three major categories of aquatic organisms. Waterbodies in the Stewart Slough Project Area heavily infested with *Ludwigia* such as the Oxbow and Stewart Slough #1 Sites may be unable to maintain annual populations of fish species. The Stewart Slough #2 Site requires sampling across a larger area to properly assess the capacity to maintain fish populations. During monitoring only the Western Mosquito Fish (*Gambusia affinis*), able to tolerate waters as low as 1.0 mg/L DO was observed at each site (Hubbs 2000). The only sampled site known to possess a diverse fish population is the Gravel Pond (BSWCD 2015). The fish present within the Gravel Pond are predominantly game fish, native to the eastern United States. The large open water area of the Gravel Pond provides refuge from anoxic conditions within *Ludwigia* infested areas. The presence of *Ludwigia* within waters of the Stewart Slough Project Area may result in fish kills and inhabitable environments for both native and game species.

In relation to management decisions, it appears that elevated DO values after herbicide treatment can occur. Although more data must be collected in coming years for annual comparisons, both the Stewart Slough #1 and Gravel Pond Sites experienced increases in average DO in *Ludwigia* infested sites by November compared to pre-herbicide values in July. Meanwhile, the Oxbow Site, acting as a control experienced a decrease in DO values in both infested and open water areas from August to November.

Conclusions

Weaknesses exist in the collected data which include non-uniform sample sizes, failure to sample sites during all four dates, varied dates of herbicide application and the absence of accessible open-water. Weaknesses of the pilot study will be addressed in upcoming monitoring years based on experience gained by the project managers and technicians. The preliminary findings must be corroborated by further data collection and more comprehensive study.

Range & Cover Mapping

1. Physical variables such as gravel substrate, steep banks and canopy cover acted as barriers to *Ludwigia* establishment.
2. *Ludwigia* was not found root in water depths >1.9 meters.
3. *Ludwigia* cover decreased in the presence of native *N. polysepela* and *S. eurycarpum.*
4. Dense mats of *Ludwigia* provided adequate cover to underlying individuals for regrowth in the year after initial herbicide application.

Dissolved Oxygen Monitoring

1. A "DO crash" related to herbicide treatment of *Ludwigia* was not observed.
2. Regardless of herbicide application, *Ludwigia* infested areas possess lower DO.
3. Heavy *Ludwigia* infestations can reduce DO concentrations resulting in acute mortality to salmonids, non-salmonids and aquatic invertebrates.
4. Water quality varies substantially between different water body types in the Stewart Slough Project Area.
5. Infested waterbodies treated with herbicide may experience a more rapid increase in DO compared to non-treated *Ludwigia* infested waterbodies.

Question Formation

With different methods of WQ monitoring able to provide a diverse array of data to be analyzed and communicated in various ways, BSWCD will work with Mosaic Ecology to further clarify existing goals and answerable questions. By doing so, the scientific method can be better applied to study design, Quality Assurance Project Plans (QAPPs) can be implemented, and resources can be better preserved if only necessary data is collected and analyzed. It is important that posed questions meet the needs of BSWCD. This could involve gathering data in regards to the detrimental impacts to fish species or providing information to change Best Management Practices in relation to herbicide treatment.

There is also a need to better finalize the deliverables of the collected data. Data collected for BSWCD can be used for numerous purposes such as: community presentations, grant reporting, detecting water quality issues, permit or compliance purposes, and scientific publications. Based on the deliverables, methods can be adjusted to meet necessary quality assurance (QA) standards. By adhering to certain QA standards, data can meet specific quality levels which select agencies require for reporting (DEQ 2009).

Site Selection

Due to variable and unpredictable seasonal weather patterns, some waterbodies within the Stewart Slough Project Area experienced unprecedented fluctuations in seasonal water levels. Of the monitored sites, Stewart Slough #1 dried completely in most areas after July 2015 sampling. It is recommended that the Stewart Slough Site #1 is not sampled for WQ in the future throughout the entirety of a monitoring season (July to November). However, data collected in July of 2015 can be used to compare WQ data collected in July of the coming years. An increase in sampling points should occur within the Stewart Slough #2 site to account for dropping Stewart Slough #1. Depending on proposed question and study design, it is recommended that a water body is chosen as a sampling site where *Ludwigia* has never known to be present. By doing so, infested water bodies similar in physical characteristics may be compared to the non-infested water body. Specific micro-habitats and select variables can be measured and compared.

Changes to Water Quality Study Design

The 2015 pilot study has many aspects to improve upon to increase systematic data collection and adhere to DEQ standards. As mentioned in the beginning of this section, posing a specific question will lead to the ability to better design a systematic study and assist in project planning and QAPPs. Regardless of the question to be answered, certain aspects of study design can be improved upon. There were challenges involving access and site selection that prevented such parameters from being applied in 2015. Mosaic Ecology technicians and staff at BSWCD will use experience of the 2015 pilot study to make target methods possible for upcoming data collection periods. Adjusted methods will better adhere to QA protocols of DEQ and increase the efficiency in data analysis.

Samples within sites will occur at the same location throughout the monitoring season. In 2015, samples were collected haphazardly where the most representative sampling points existed (infested/open water) and access was possible. In 2016, technicians will repeatedly return to sampled areas by use of GPS. In addition to GPS points, PVC markers will be placed in areas less than 1 meter in depth to help insure technicians of sample locations.

Contingent on the independent variable(s) to be compared in 2016, 12 samples for each comparable variable will be collected at each site with a target sample size of 10. This differs from the 2015 methods of 4 samples per variable. By increasing the sample size, the measured variable will be better represented, normalization of the data is more likely to occur, and anomalies can be discarded if necessary. Also, by attempting to have the same number of samples for each independent variable measured, statistical tests to detect significant differences are easier to complete and statistical power increases. Adhering to DEQ quality standards, at least 10% of the sample locations will be duplicated to act as an audit to measure precision (DEQ 2009). In 2015 no duplicate samples were collected to evaluate precision.

Measurement depths will be adjusted to adhere to DEQ standards (DEQ 2009). Depth of each sample will be adjusted for both “surface” and “bottom” measurements. In waters <2 m in depth, measurements will be taken at 0.5 m from the surface and 0.5 m from the bottom. In waters >2m, measurements will be taken at depths of 0.5 m from the surface, 1.0 m, then at 1.0 m intervals until a final depth of 0.5 m from the bottom. If proposed question involves depth as a measurable variable, depth will be collected at 0.5 m intervals.

Continuous Monitoring Considerations

The current methods used by Mosaic Ecology involve the use of a YSI meter that collects discrete samples in the presence of an observer. These methods are able to provide comparisons of different variables (Open Water/*Ludwigia* infested, July/September, etc.) between water bodies or within water bodies. Yet, it may be in the interest of BSWCD to look into collecting continuous data by using “permanent” dissolved oxygen data loggers to witness trends in DO as *Ludwigia* decays in mass quantities over time.. Such data collection can account for diurnal fluctuations by averaging days together. One such product that is relatively affordable to collect continuous DO and temperature data is the miniDOT logger (http://pme.com/products/minidot). An example of temperature data collected with a similar type of logger is presented in Figure 11.

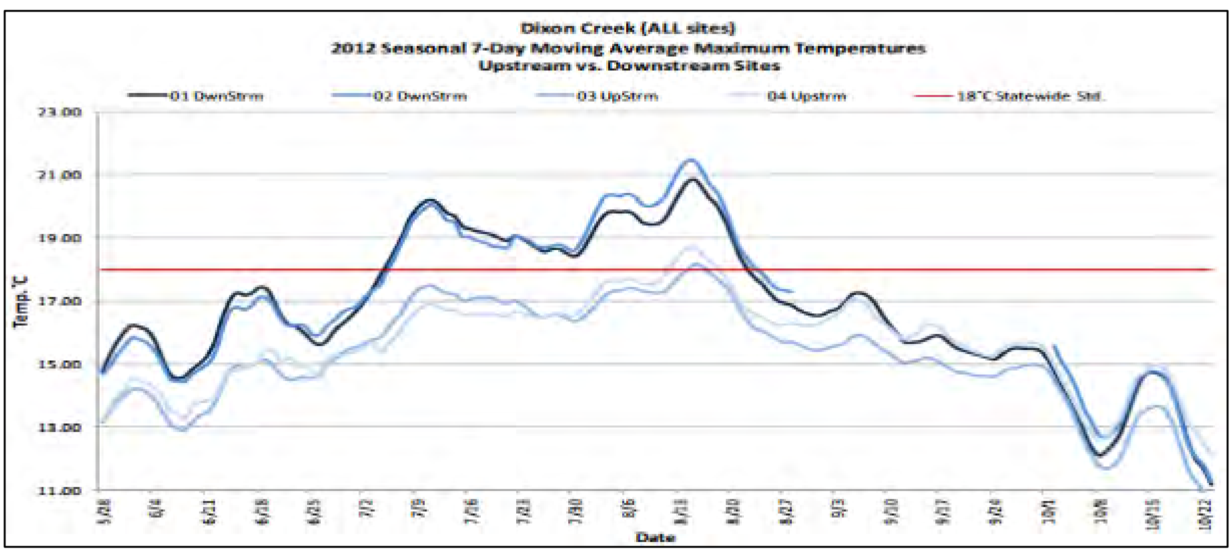


Figure 11. An example of continuous data collected from an instream temperature logger employed by the City of Corvallis, OR (Payne 2012).

Recently, there has been discussion with U.S. Geological Survey (USGS) to collaborate through sharing equipment and utilizing recent water quality data collected on the Willamette. Resources could include stationary water quality data loggers, staff time, and analysis of water samples.

It is important to carryout research before utilizing unsupervised monitoring probes as there are many challenges. Such problems that exist include: stolen probes, detached probes, depth fluctuations over time, algal fouling, or instrument error (Payne 2012; Suplee 2011). Mosaic Ecology is willing to assist in the formation of methods, contacts or even acquire the ability to carry out continuous water quality monitoring ourselves. But at this time, Mosaic Ecology does not possess the monitoring equipment to do so.

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Appendix I: 2016 Water Quality and Ludwigia Monitoring Report

2016 Water Quality and Ludwigia Monitoring Report for Stewart Slough, Collins Bay, and Scatter Bar Pond




BENTON SOIL AND WATER CONSERVATION DISTRICT

Prepared by Mosaic Ecology LLC
For Benton SWCD
May 2017

mosaic ECOLOGY

This report is meant to be utilized by the staff of Benton Soil & Water Conservation District as well as interested members of the natural resource community.

Overview

In the summer of 2015, a monitoring program was established at sites in the Stewart Slough complex and at Collins Bay in Benton County, and at Scatter Bar Pond at Horseshoe Lake in Linn County (project area) to provide information related to the large scale control of the invasive macrophyte, Ludwigia; Uruguayan primrose-willow (*Ludwigia hexapetala*) and floating primrose-willow (*Ludwigia peploides*). The monitoring program, established by Benton Soil & Water Conservation District (SWCD) in 2015, represents the second year of the program and builds upon the lessons learned of the 2015 pilot study. The goal of the monitoring program is to track annual population shifts of Ludwigia in response to control efforts and to assess the effect of Ludwigia on water quality.

The monitoring effort was conducted to inform Benton SWCD of the possible impacts the presence of Ludwigia and associated control efforts may have on water quality in the project area. Monitoring was not required by the Oregon Department of Environmental Quality (DEQ) or the US Environmental Protection Agency (EPA), though a Pesticide General Permit was required and obtained through DEQ for treatment of Ludwigia infestations. Field and data analysis methods from the 2015 monitoring effort were improved upon in 2016 and considerations for future years were made.

Aquatic plants are known to affect water quality. Dense populations of aquatic plants alter diurnal fluctuations of dissolved oxygen (DO) and large-scale die-offs can create anoxic conditions detrimental to aquatic life. Monitoring compared DO within open water and Ludwigia infested areas of waterbodies within the project area. Monitoring occurred before and after herbicide treatment from July to November within waterbodies that possessed different physical characteristics and varying Ludwigia populations. Distribution and density of Ludwigia within four distinct water bodies were mapped and Ludwigia abundances were compared to pre-treatment levels. Water quality data was collected by a handheld YSI meter in three distinct water bodies in 2016 and compared to available data from the 2015 pilot study. The data presented in this report focuses on dissolved oxygen with discussion on the effects to aquatic organisms.

Of the three sites mapped for Ludwigia distribution and cover in both 2015 and 2016, Lower Kiger Pond (formerly referred to as “Gravel Pond”) and Stewart Slough #2, experienced a 99% and 96% reduction respectively of heavy Ludwigia cover (>50%), with light (<5%) and moderate cover (5-50%) becoming the dominant classes one year after initial treatment. The third site, Collins Bay did not exhibit a similar shift in cover classes. Within the project area, observations of Ludwigia regrowth appeared to be most prominent in thick floating mats of decaying plant material and silt that remained intact after initial treatment. Mean DO was lower in Ludwigia infested waters compared to adjacent open water habitat. Monitored sites showed a decrease in DO within open water environments as the season progressed even as water temperatures decreased. DO values within some Ludwigia infestations were below the minimum thresholds known to impair aquatic organisms. In some cases, these values were low enough to cause acute mortality to major aquatic groups.

Monitoring Goals

1. Assess changes in Ludwigia distribution and cover one year after 2015 control efforts.
2. Assess how Ludwigia affects water quality (WQ) with and without herbicide treatment.
3. Provide recommendations for future WQ monitoring and associated Ludwigia control.

Background

Ludwigia in Project Area

Native to Central and South America, *Ludwigia hexapetala* and *L. peploides* are invasive aquatic plants that are rapidly increasing in prevalence in Oregon, most notably in the Willamette Valley (ODA 2015). In the past 10 to 15 years, Ludwigia populations have occupied high profile sites such as Delta Ponds Park of Eugene, leading to an increased local awareness and the discovery of populations throughout the Willamette Valley (City of Eugene 2013). After initial surveys showed extensive infestations within some side channels, oxbows, riverine wetlands and other water bodies in the Corvallis to Albany reach of the Willamette River, Benton SWCD acquired grant funding from the Oregon State Weed Board, the Bonneville Power Administration, the Oregon Watershed Enhancement Board, and Meyer Memorial Trust in order to greatly reduce Ludwigia in over 4 miles of infested habitat in the project area.

The first full scale treatment within the project area occurred in late-June to early-July of 2015, with follow up applications occurring in August and October 2015. During the same year, the first water quality and mapping data were gathered at five sites in the project area. In 2016, one round of chemical application occurred across the same sites in late-July to early-August. Contractors applied a formulation of aquatic label Rodeo (glyphosate) at a concentration of 2-3%, with a water soluble indicator dye 0.5-1% of the aquatic label surfactant Agri-dex. Herbicide formulations were selected for their known effectiveness in treating Ludwigia and relatively low toxicity to fish, mammals and invertebrates in comparison to other formulations. Roughly four weeks after the chemical application during both treatment years, large masses of Ludwigia were observed dying as leaf and stem tissue browned, curled and sank to decay at the water bottom.

Results of the 2015 control efforts varied across sites. In July of 2016 (prior to 2016 control efforts) some treated water bodies experienced little regrowth in areas previously at 100% Ludwigia cover. Other sites experienced a reduction in overall plant height and mass, but cover did not decrease substantially from July 2015 to July 2016 (Figure 1).

Figure 1. In July of 2016, Ludwigia cover varied across sites. The Lower Kiger Pond site showed minimal regrowth of Ludwigia, with native plants beginning to colonize open areas (A). Sections of Stewart Slough in July 2016, exhibited Ludwigia cover similar to the pre-treatment levels of 2015 (B).

Effects of Plants on Dissolved Oxygen

Water chemistry is greatly affected by the abundance and composition of plant life in aquatic systems. Aquatic plants exchange gases with the water column, affect water temperature, can reduce turbidity, alter evapotranspiration rates, and influence microbial communities. The monitoring effort was intended to assess how large-scale herbicide treatments and the resulting changes of Ludwigia densities affect DO within water bodies of the project area.

Major sources of DO within aquatic systems include: direct diffusion from the atmosphere, wind and wave action, and photosynthesis. Photosynthesis from plant and algal species exchange CO_2 for O_2 within the water column when sunlight is available, while respiration from animals, including microbial organisms remove O_2 from the aquatic system through respiration (Francis-Floyd 2003). Although plants are known for photosynthesis, which produces oxygen, they also consume oxygen through respiration. In the absence of light, respiration in plants occurs at a higher rate than photosynthesis (Arun & Bowers 1983). Temperature also greatly affects DO as higher temperatures reduce the capacity of water to hold gases such as O_2 and CO_2 (ODFW 1999) There is a large amount of conflicting information supporting both the increase and reduction of DO caused by aquatic plants (Frodge et al. 1990; Caraco & Cole 2002; Francis-Floyd 2003; Tanner & Headley 2011). A plant's influence on DO is largely dependent on plant growth habit (submerged, floating, emergent, etc.). Submerged plants can more efficiently exchange CO_2 directly with O_2 increasing oxygen in the water column. Counteractive to increasing DO within the water column, floating-leaved plants release O_2 to the atmosphere, depleting DO (Caraco et al. 2006). But how exactly emergent plants such as Ludwigia affect DO can be unclear.

In communities dominated by emergent aquatic plants, zones of dense vegetation provide significant submerged structure, but result in nearly or completely anoxic water conditions (Rose & Crumpton 1996). Reduction of DO in emergent plant beds have been attributed to large quantities of decaying leaf litter and reduced diffusion of oxygen from the atmosphere (Caraco & Cole 2002; Rose & Crumpton 2006;). Anoxic zones have been found in emergent plant communities of *Ludwigia palustris* and *L. hexapetala* within the backwater channels and bays of a major riverine system in the southeast United States (Miranda & Hodges 2000). Indirect influences of aquatic plants to DO include seasonal or human caused plant die-offs which reduces DO as respiration rates of microbes increase during the decay process and consume available oxygen (CDBW 2001; Jewell 1971; ODFW 1999).

The degree of oxygen consumption in decaying plant communities varies with plant densities, species, and microbial community composition. Oxygen demand, or depletion of DO is directly related to the initial biomass of plant communities (Tang et al. 2013). Numerous *in-situ* and *ex-situ* experiments have shown that hypoxic conditions result from aquatic plant die-offs related to both chemical and mechanical control (Hellsten et al. 1999; Jewell 1971; Tang et al. 2013). Hypoxia related to weed control can occur locally within regions of a larger waterbody or occur throughout the entirety of a small waterbody. One study showed a reduction of DO to zero within a small pond four days after Canadian elodea (*Elodea canadensis*) was chemically treated (Owens and Maris, cited from Jewell 1971).

It is clear that Ludwigia has the potential to greatly reduce available oxygen in aquatic environments. With evidence of anoxic conditions being present in areas of both living and decaying plant material, it is important to assess how Ludwigia affects DO within varying waterbody types in the Willamette River system before and after treatment. Waterbodies may possess system wide anoxic conditions or contain open water areas that provide refuge for fish species. Thresholds have been established to indicate the minimum concentration of DO within water that results in detrimental impact to fish.

Effects of Dissolved Oxygen to Fish

Within scientific literature, minimum thresholds DO have been established for both salmonid and non-salmonid fish species. The generally accepted threshold for most fish species is 5 mg/l of DO (Yeakley et al. 2013; Francis-Floyd 2003). At concentrations below 5 mg/l, embryonic and larval development can be greatly impaired, weight loss can occur, avoidance may take place, and survivorship of certain species is decreased. In a study of non-salmonid fish, a majority of species tested experienced zero survivorship in water less than 2.4 mg/l of DO (EPA 1986). Coldwater species or members of the family *Salmonidae* (salmonids) are even more sensitive to reduced DO.

In the State of Oregon, criteria for minimum DO in water bodies is administered by DEQ. For water bodies identified by DEQ as providing cold-water life, the absolute minimum for DO may not be less than 8.0 mg/L (OAR 340-041-0016(2)). In waters identified as providing cool-water aquatic life, DO may not be less than 6.5 mg/l at any given time (OAR 340-041-0016(3)). The absolute minimum is increased to 11.0 mg/l in water bodies identified as active spawning areas during designated times (OAR 340-041-0016 (1)). Standards set by DEQ are based on criteria established by the EPA (EPA 1986).

Data in this report were summarized in order to gauge how DO within infested water bodies of the project area could affect both salmonid and non-salmonid species. Two DO thresholds were applied to the results of WQ monitoring to assess suitability for fish development and survivorship. Although more imperative to stream environments, the cool-water criterion of 6.5 mg/L of DO will be applied to account for possible salmon or trout rearing and migration in the "Willamette River and Tributaries Gallery Forest" ecoregion, within which the project area is located (DEQ 2010). A threshold of 5 mg/l will be used as reference for non-salmonid species where moderate to slight production impairment is known to occur based on life stage (EPA 1986). These thresholds have been applied to the figures simply as a reference for data interpretation and do not identify impaired waters of the State.

Methods

Site Selection

Five sites within the project area were selected for some type of monitoring in 2016 (Figure 2). In total, four sites were mapped for Ludwigia distribution by GIS and three sites were sampled for water quality in 2016. Selected sites represent the diverse water body types that exist within the project area (pond, slough, side channel). Access, perennial water presence, permission of entry, distance from one another and degree of infestation were taken into account during site selection.

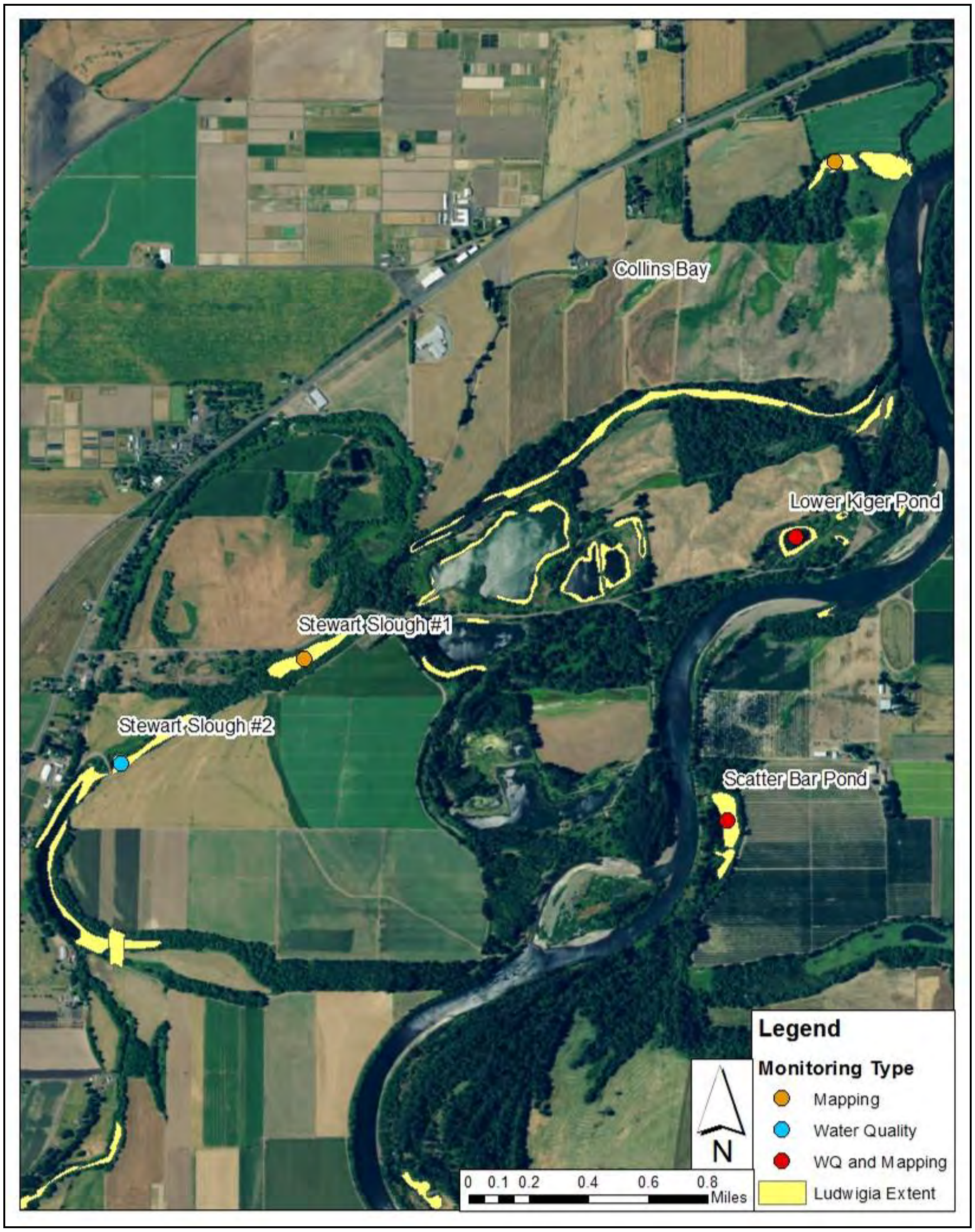


Figure 2. Sites within the project area that were mapped and/or monitored for Ludwigia cover and water quality in 2016. Ludwigia extent represents 2014 distribution.

Collins Bay, Lower Kiger Pond, and Stewart Slough #1 were mapped in both 2015 and 2016 to provide information regarding changes in Ludwigia cover in response to one year of control treatments (Table 1). Scatter Bar Pond at Horseshoe Lake in Linn County (formerly referred to as "Oxbow") was mapped for the first time in 2016 to create baseline data for expected Ludwigia control in 2017.

Table 1. Herbicide application dates and summary of data collection at all five sites monitored during 2015 and 2016. Partial WQ monitoring in 2015 is due to uncharacteristically dry conditions. Dates and ranges are approximate, with not all dates included in ranges representing full days of applied control.

Site	Chemical Treatment by Year			Data Collection by Year			
	2014	2015	2016	Mapping 2015	WQ 2015	Mapping 2016	WQ 2016
Collins Bay	9/15-9/17	6/30 - 7/2; 8/15 - 8/19	8/15-8/16	Yes	No	Yes	No
Stewart Slough #1	No	7/15 - 7/23; 10/15 - 10/16	7/27	Yes	Partial	Yes	No
Lower Kiger Pond	No	7/28 - 7/29; 10/8	7/27-7/28	Yes	Yes	Yes	Yes
Stewart Slough #2	No	7/15 - 7/23; 10/15 - 10/16	7/27	No	Partial	No	Yes
Scatter Bar Pond	No	No	No	No	Yes	Yes	Yes

Lower Kiger Pond and Scatter Bar Pond sites were successfully monitored for water quality in 2015 and 2016 allowing general comparisons to be made regarding dissolved oxygen between years (Table 1).

All sites except Scatter Bar Pond were chemically treated in summer of 2015 and 2016. Sites were able to be treated twice in 2015, while sites were only able to be treated once in 2016. Collins Bay is the only site that was chemically treated in 2014.

The initial study design in 2015 intended to carryout both Ludwigia cover mapping and WQ monitoring over numerous years at Stewart Slough #1, Lower Kiger Pond, and Scatter Bar Pond. Unexpected drying of the Stewart Slough #1 water body caused WQ monitoring to be moved to the Stewart Slough #2 site in late 2015 and subsequent monitoring years. Water quality monitoring is yet to be planned for Collins Bay. Collins Bay was selected for mapping due to being the only site receiving chemical treatment in 2014. Mapping will still continue at Stewart Slough #1. Scatter Bar Pond has acted as a control for WQ monitoring, receiving no herbicide application in either monitoring year.

Distribution & Cover Mapping

Stewart Slough #1, Lower Kiger Pond, Scatter Bar Pond, and Collins Bay were mapped on July 20, 2016, prior to chemical application. Mapping was carried out by technicians with the mobile GIS program, Arc Collector. A portable receiver (Garmin GLO) was used to improve accuracy and precision of data collection. Percent cover estimates of Ludwigia were used to generate cover class polygons within surveyed sites: Light (<5%), Moderate (5 – 50%) and Heavy (>50%).

GPS data was projected and analyzed within ArcGIS 10.3 to calculate acreage of individual polygons and total acreage of each cover class. All data was projected in the NAD_1983_UTM_Zone_10N coordinate system. Comparison maps of Ludwigia from 2015 to 2016 were generated for Stewart Slough #1, Lower Kiger Pond, and Collins Bay. It is expected that distribution and density mapping will occur within the four sites on an annual basis. Observed variables affecting Ludwigia density patterns within mapped sites were summarized.

Water Quality Monitoring

Dates for water quality monitoring were selected to capture DO prior to treatment and at specific time intervals after treatment (Table 2). Dates for 2016 were selected to closely match those of the previous year. Monitoring at each site varied by no more than two hours on each date to minimize diurnal variations in WQ values.

Table 2. Water quality monitoring dates at select sites within the project area.

Sampling Period *	2015	2016
Pre-Treatment	7/6	7/21
2 Weeks Post Initial Treatment	8/11	8/11
2 Months Post Treatment	9/21	9/20
Fall Decay	11/2	11/3

**Sampling periods were target dates and do not represent exact time intervals after treatment across all sites.*

Two technicians collected data by foot or boat using a YSI Professional Pro Plus Multiparameter Water Quality Meter (https://www.ysi.com/proplus). The WQ variables of temperature, DO, pH, conductivity, and oxidation reduction potential (ORP) were measured. Prior to each monitoring date, temperature, pH, conductivity and ORP were calibrated and probe integrity was measured in accordance with manufacturer's standards. DO was calibrated prior to each site (YSI 2009; YSI 2010). For each sample, depth, max depth and percent cover of Ludwigia were collected. Sampling points were recorded by GPS.

Within each site, permanent sampling points were selected in two categories which included "open water" areas (n = 8) with 0-15% Ludwigia cover, with no other emergent or floating plants present, and "Ludwigia infested" areas (n = 8) with >50% Ludwigia cover. Sampling points were recorded by GPS and returned to during each sampling date. Percent cover was assessed for the total distribution within one meter of the sample. In the Lower Kiger Pond site, minimal regrowth occurred in 2016, and "Ludwigia infested" samples were taken in areas that possessed >50% Ludwigia in 2015. Sampling depths were adjusted from 2015 procedures to better adhere to DEQ monitoring methods (DEQ 2009). 2016 was the first year sampling occurred at a depth of 0.5 meters from the surface. Three depths were recorded at each sampling site: 0.13 meters (surface), 0.5 meters from surface (0.5 m depth), and 0.5 meters from bottom. Data was logged within the YSI meter and recorded manually by the technician.

Samples were collected at the surface and at a depth of 0.5 meters in both open water and *L. hexapetala* infested sampling points. Eight readings at each depth, at each sampling point were recorded when possible. Dissolved oxygen and temperature of Ludwigia infested and open water samples across dates were displayed graphically. Mean temperature at each depth was displayed to indicate possible shifts of DO in relation to temperature. Only samples at surface and and 0.5 meter depths were graphically displayed and summarized.

Results

Distribution and cover of Ludwigia within the four mapped sites have been presented in map form with calculated acreage (Figures 3, 6, 9, and 10). Raw data of the six measured WQ variables have been provided to BSWCD for further analyses and interpretation. Data from 2016 was summarized and for the 6 variables and three depth collected (appendix A). Within the report only DO (mg/L) and temperature (°C) have been graphically displayed and summarized.

Scatter Bar Pond

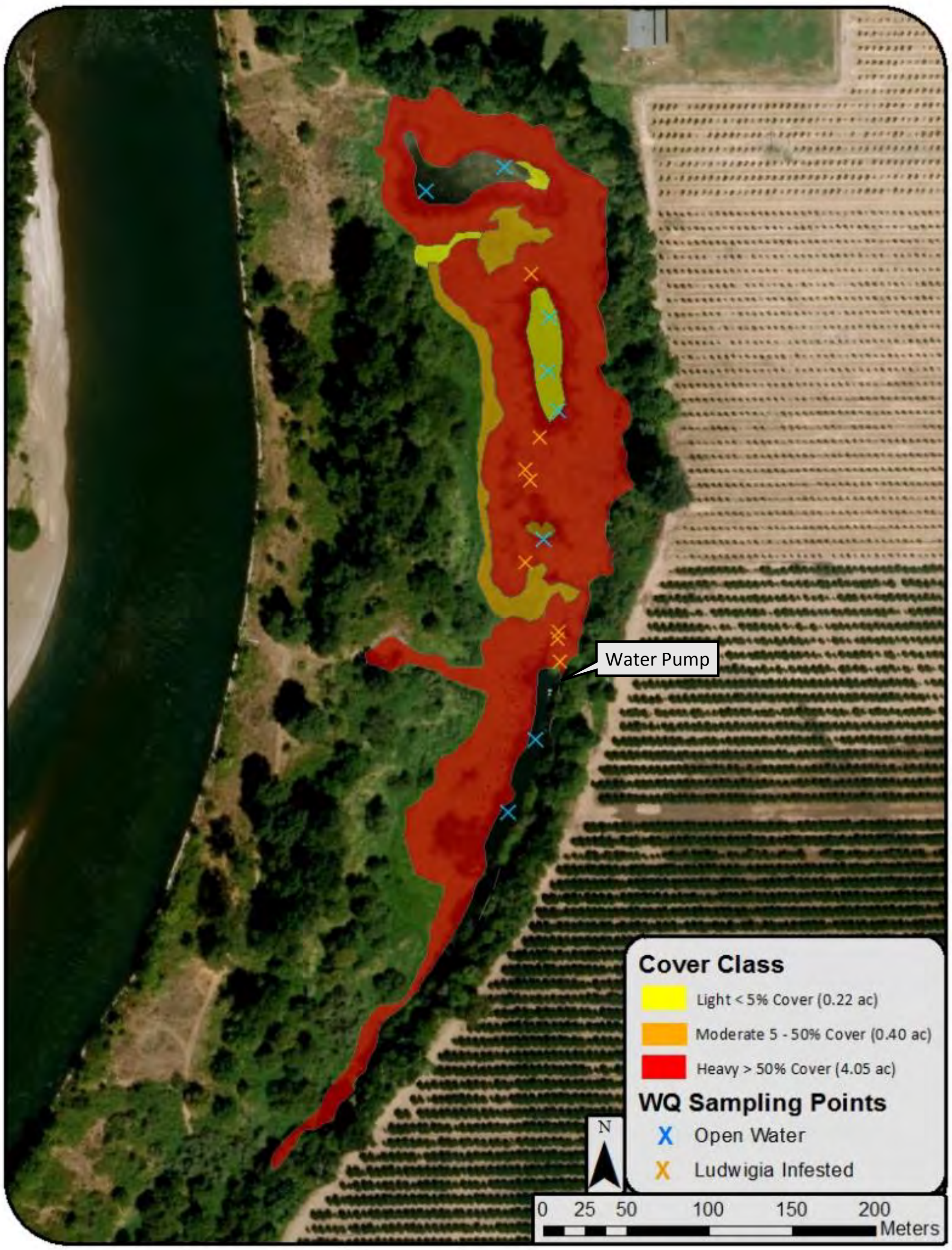


Figure 3. Distribution and cover class summary of Ludwigia within Scatter Bar Pond on July 20, 2016 with associated monitoring points.

Scatter Bar Pond was dominated by dense monocultures of Ludwigia throughout 4.05 acres of the nearly 5 acre water body (Figure 3). In total, Ludwigia occupied 4.67 acres. Ludwigia was at high cover in all areas where depth was less than two meters. Areas where depth exceeded two meters had open water conditions. Large openings in relation to increased depths occurred in the wider northern reach of the water body. The western margin possessed Ludwigia populations below 50% due to apparent Ludwigia die off. The eastern bank of the water body was vegetated, with overhanging tree species that shaded the water body. The absence of Ludwigia directly adjacent to the eastern bank south of the water pump, may have been influenced by shade and the steep gradient along the eastern bank, as well as from intermittent flow created by the water pump (Figure 3). The water pump is used for irrigation in the adjacent farms and was not observed running during the monitoring periods. Plant diversity was low, with very few species growing within the dense *Ludwigia* monocultures. Populations of non-native Brazilian waterweed (*Egeria densa*), native coontail (*Ceratophyllum demersum*), and American waterweed (*E. canadensis*) were present within the deep open water areas.

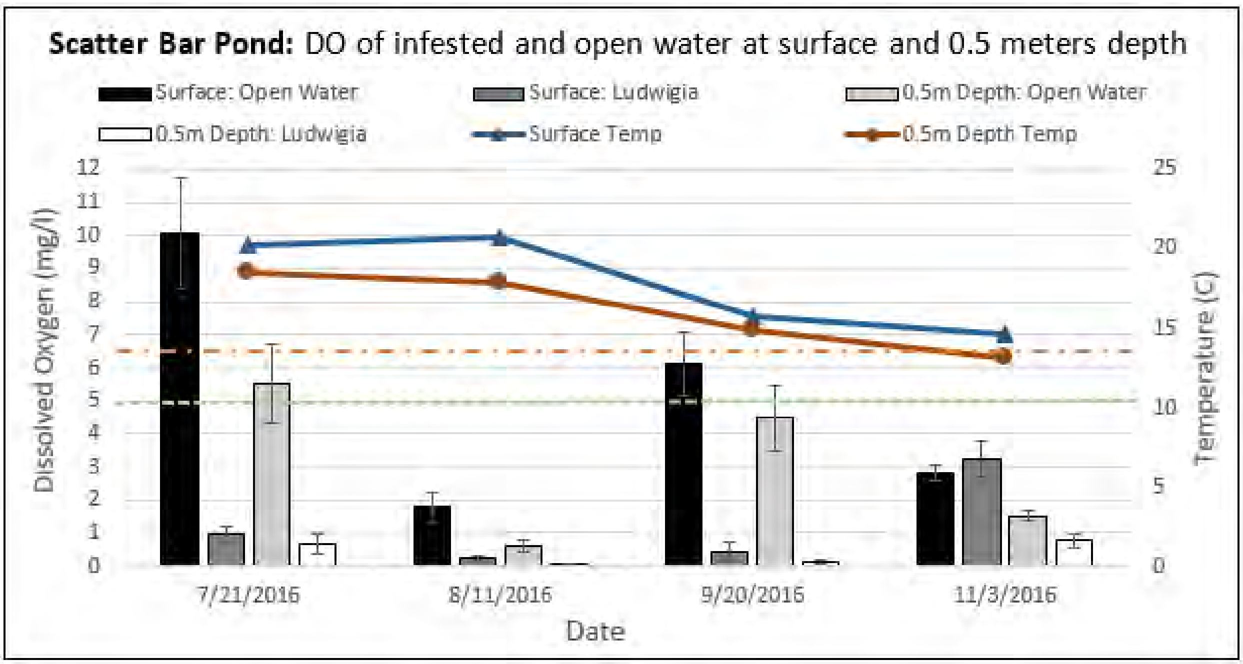


Figure 4. Dissolved oxygen comparison between surface and 0.5 meter depths in open water and Ludwigia infested areas of Scatter Bar Pond. Scatter Bar Pond acted as a control and **no herbicide application occurred**. Dashed lines represent cool-water criterion (orange) and moderate impairment for non-salmonid species (green). Error bars represent +/- one standard error. "Ludwigia infested" sampling sites are displayed as "Ludwigia".

Dissolved oxygen in open water at surface and 0.5 meter depths was higher than Ludwigia infested sampling sites during all dates except for November at surface. Mean DO was highest for open water measurements in July, and decreased substantially in August. Ludwigia infested sample sites experienced the highest DO readings in November at both surface and 0.5 meter depths. Mean DO within infested waters at surface ranged from 0.23 to 0.97 mg/l from July to September, but increased substantially to 3.29 in November. Temperature decreased from August to September at surface (20.8^{o}C to 15.8 ^{o}C) and 0.5 meter depth (17.9 ^{o}C to 14.9 ^{o}C). DO and temperature were lower at 0.5 m depths for both open water and infested samples when compared to surface readings.

Mean DO of Ludwigia infested waters was below both cool-water criterion and non-salmonid thresholds in all sampling categories across all dates. Open water mean DO at surface exceeded cool-water criterion once in July and exceeded non-salmonid criterion in July and September.

Lower Kiger Pond

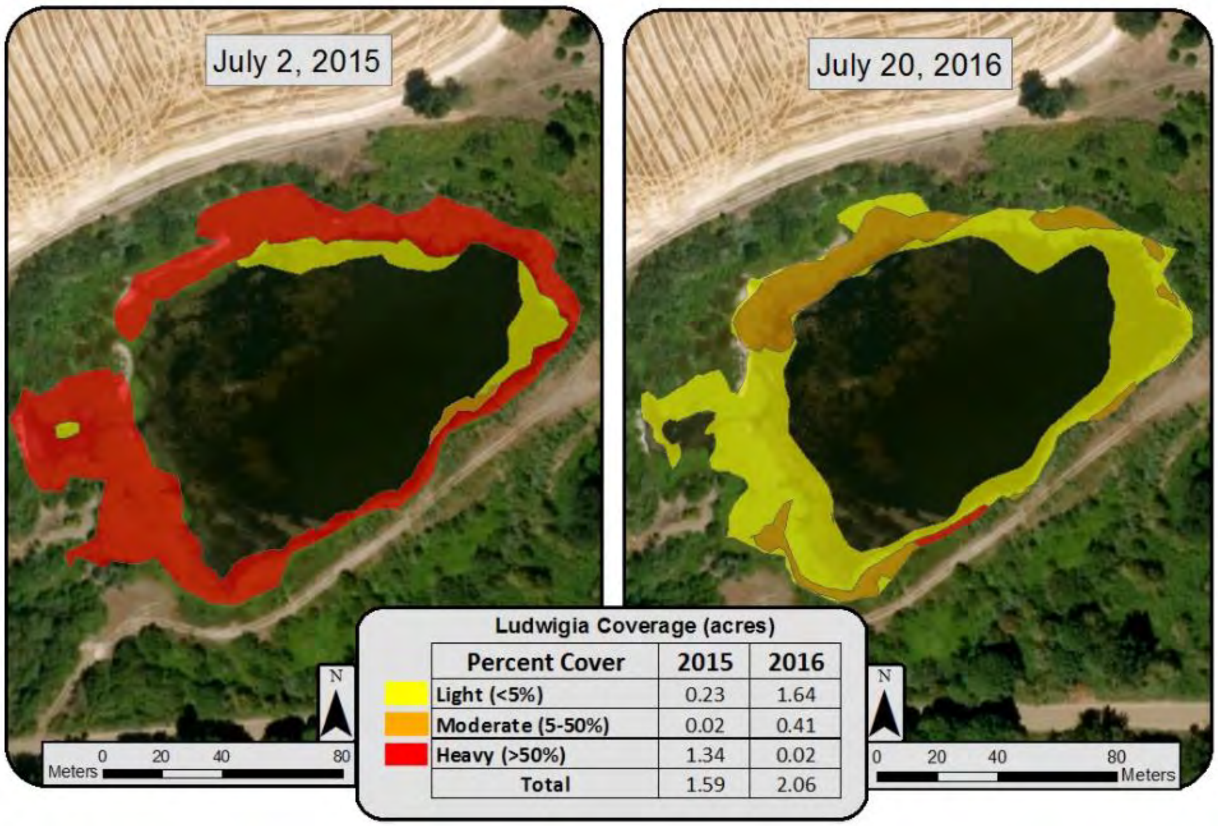


Figure 5. Distribution and cover class summary of Ludwigia within Lower Kiger Pond prior to chemical treatment (July 2, 2015) and one year after initial treatment (July 20, 2016).

After one year of treatment at Lower Kiger Pond, overall distribution of Ludwigia increased by 30%, with distribution expansion dominated by the light cover class (Figure 5). The site experienced a 99% reduction of acreage occupied by heavy Ludwigia cover. Along the western extent of the population where heavy cover previously dominated the relatively shallow environment, Ludwigia regrowth was minimal. Native arrowhead (*Sagittaria* sp.) and burr reed (*Sparganium* sp.) were observed colonizing the shallow open areas previously occupied by Ludwigia. The most prominent regrowth of Ludwigia occurred on mud flats along the bank margins. Due to previous activity of gravel mining within the water body, water depth quickly increased from the banks resulting in the large open water environment at the center of the waterbody. Same as the previous year, the open water environment was absent of emergent or floating species, but submersed plant species of *E. canadensis* and *E. densa*, were abundant at depths up to 3 meters.

Mean DO in open water environments was significantly higher than the areas previously occupied by *Ludwigia* at both depths, across all sampling dates (Figure 6). Similar to Scatter Bar Pond, mean DO was highest in open water samples in July. As the year progressed, mean DO decreased in open water environments, but increased overall in areas previously occupied by *Ludwigia* in 2015. Temperature decreased substantially from August to September at surface (23.1^{o}C to 13.3 ^{o}C) and 0.5 meter depth (21.4 ^{o}C to 13.1 ^{o}C).

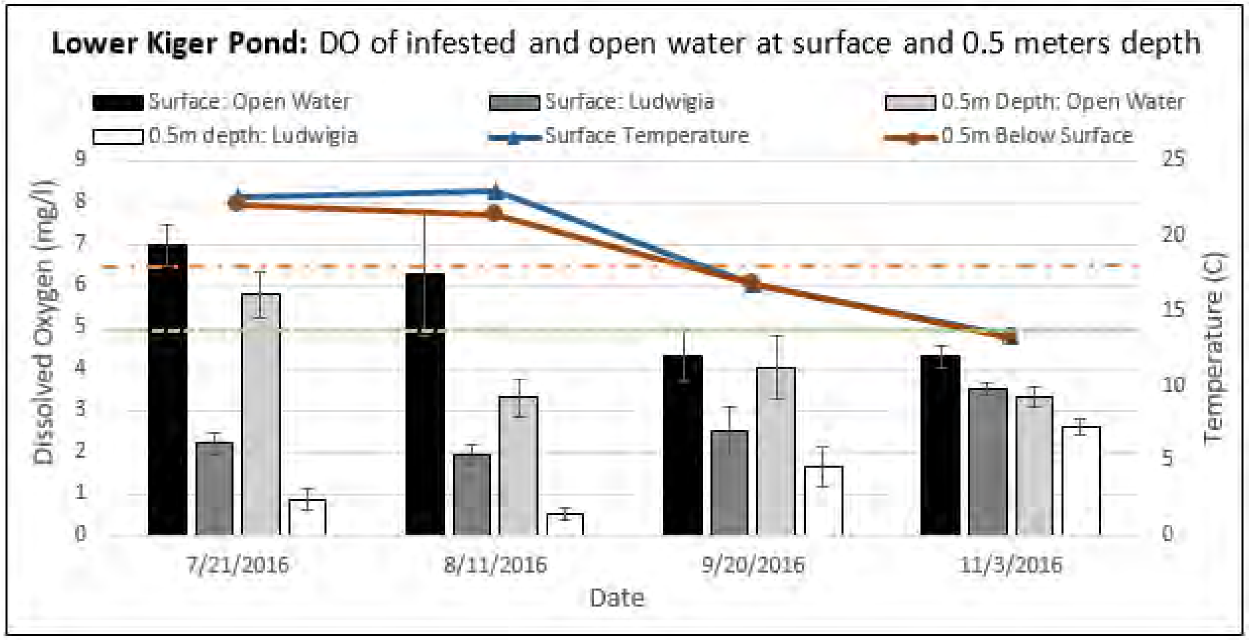
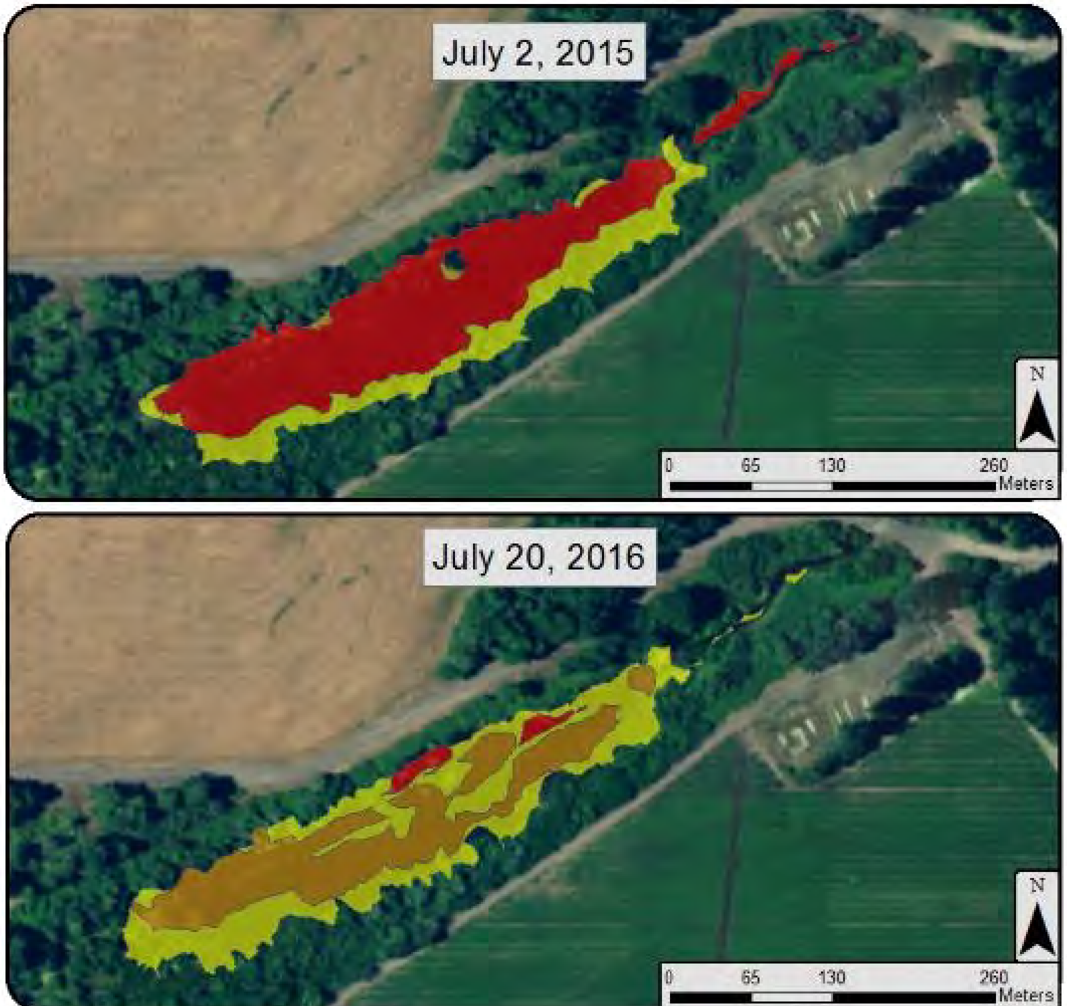


Figure 6. DO comparison in Lower Kiger Pond between surface and 0.5 meter depths in open water and areas previously dominated by Ludwigia. Herbicide application occurred on July 27th, 2016. Dashed lines represent cool-water criterion (orange) and moderate impairment for non-salmonid species (green). Error bars represent +/- one standard error. "Ludwigia infested" sampling sites are displayed as "Ludwigia".

Mean DO within open water surface samples met the non-salmonid threshold of 5 mg/l in July and August, exceeding the cool-water criterion threshold only in July. Mean DO in sites previously occupied by Ludwigia did not exceed either threshold during any sampling date. Of all surface samples collected across all dates, only one discrete measurement in previously infested sample sites exceeded 5 mg/l.

In relation to 2015 mean DO values, areas previously occupied by Ludwigia decreased in all sampling periods except for September from 2015 to 2016 (Appendix A; Appendix B). Open water areas exhibited varied differences between sampling years by month. The highest mean DO values at the surface for 2015 occurred in September, while July of 2016 exhibited the highest mean DO values.

Stewart Slough #1



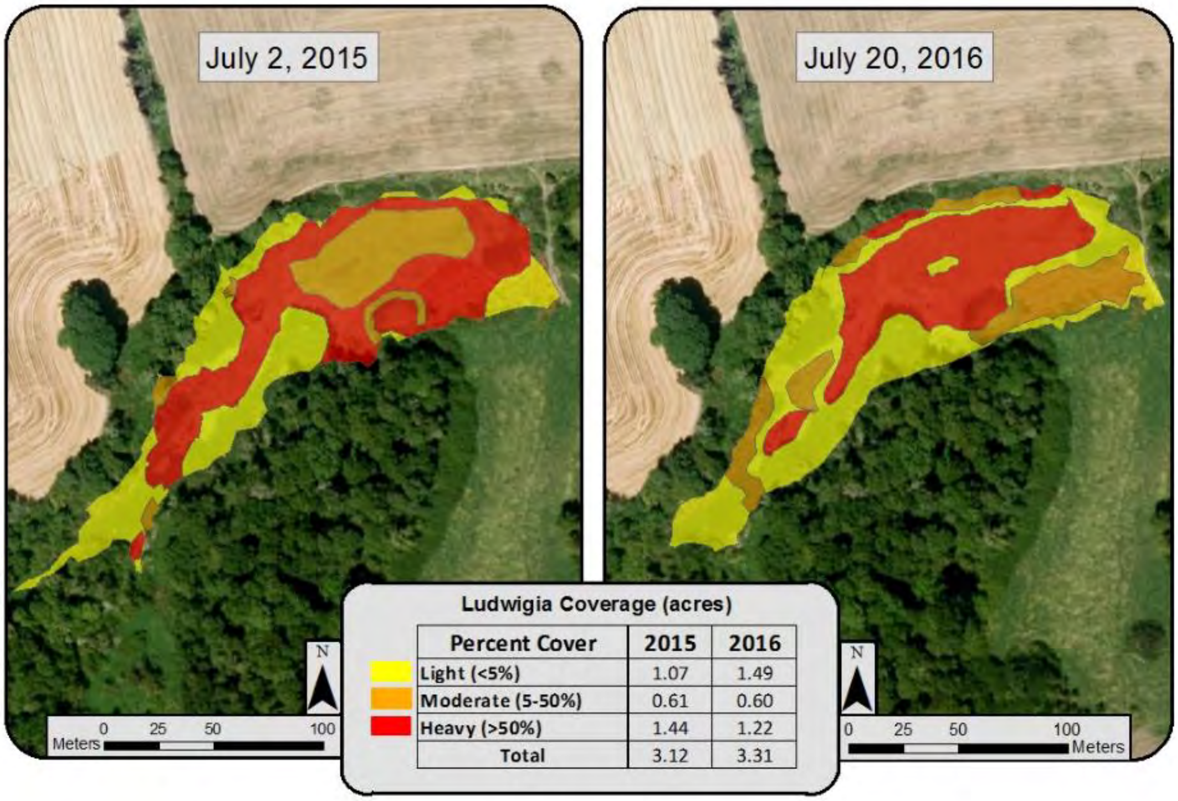
Ludwigia Coverage (acres)

Percent Cover	2015	2016
Light (<5%)	1.19	2.17
Moderate (5-50%)	0.03	2.00
Heavy (>50%)	3.32	0.14
Total	4.52	4.31

Figure 7. Distribution and cover class summary of Ludwigia within Stewart Slough #1 prior to chemical treatment (July 2, 2015) and one year after initial treatment (July 20, 2016).

Ludwigia within the Stewart Slough #1 Site decreased in overall cover from 2015 levels (Figure 7). Previously a monoculture, dense stands of established Ludwigia, depicted by heavy cover in 2015 were reduced by a total of 96% to moderate and light cover classes. Regrowth was observed within these areas resulting in an increase of 1.97 acres of the moderate cover class. Moderate cover was patchy and separated by channels of light cover that was observed being used by nutria and beaver. The eastern portion of the site, which flows into a culvert, experienced a large reduction in the presence of Ludwigia with very few individuals present, compared to dense populations observed on the northern bank in 2015.

Collins Bay



Percent Cover	2015	2016
Light (<5%)	1.07	1.49
Moderate (5-50%)	0.61	0.60
Heavy (>50%)	1.44	1.22
Total	3.12	3.31

Figure 8. Distribution and cover class summary of Ludwigia within Collins Bay one year after initial treatment (July 2, 2015) and two years after initial treatment (July 20, 2016).

Prior to initial treatment in 2014, observations from Benton SWCD staff indicated the site was dominated by heavy cover throughout the water body. Collins Bay, did not substantially change in total cover class or distribution after the second year of treatment at the site (Figure 8). Moderate and heavy cover classes decreased by 2% and 16% respectively. Heavy cover decreased within the western arm of the waterbody, but increased within the population center, which was previously represented by moderate cover. Moderate cover in the population center in 2015 was contributed partially to a large mass of dead plant material observed above early season regrowth. By 2016, this area had shifted to heavy cover (Figure 8). Clear boundaries between heavy and light cover classes were present where native species such as yellow spatterdock (*Nuphar polysepela*) were present (Figure 9).

Figure 9. Thick Ludwigia regrowth observed adjacent to *N. polysepela* population at Collins Bay, 7/20/16.

Stewart Slough #2

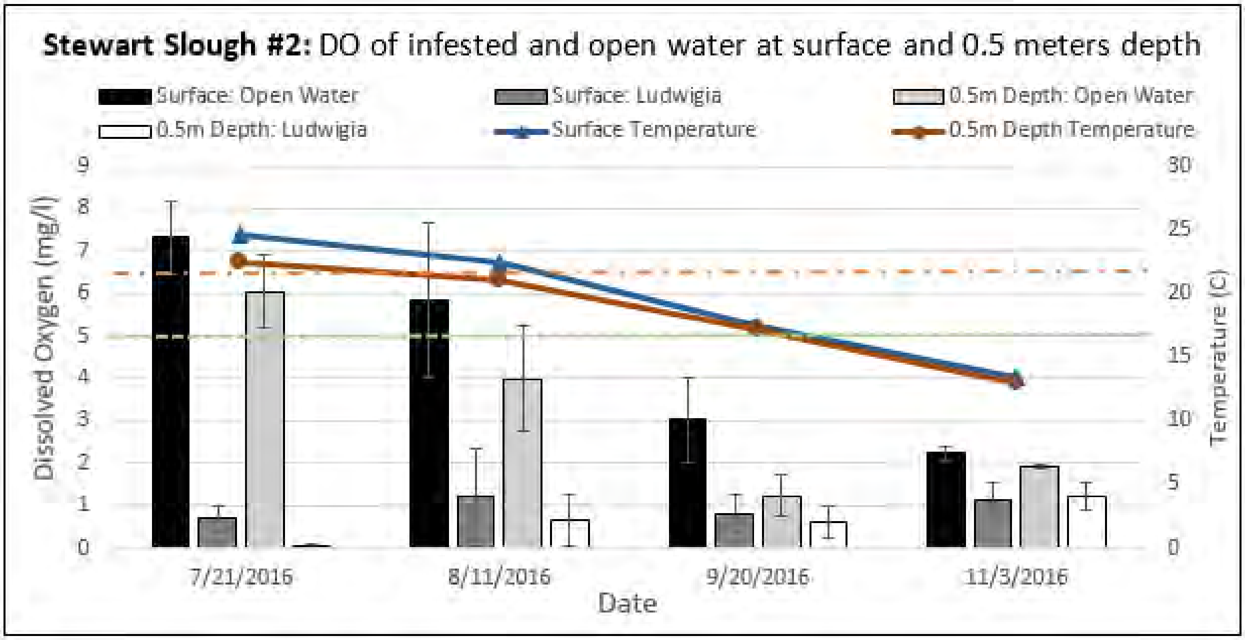


Figure 10. DO comparison in Stewart Slough #2 between surface and 0.5 meter depths in open water and Ludwigia infested waters. Herbicide application occurred on July 27th, 2016. Dashed lines represent cool-water criterion (orange) and moderate impairment for non-salmonid species (green). Error bars represent +/- one standard error. "Ludwigia infested" sampling sites are displayed as "Ludwigia".

The Stewart Slough #2 site which was not selected for cover and distribution mapping in either monitoring year, represents a waterbody similar to the Stewart Slough #1 site. Prior to treatment in 2015, the site was dominated by a Ludwigia monoculture through nearly the entire extent of the water body. The only large area of open water was at the eastern extent immediately adjacent to the agricultural road for a farm. This area experienced depths exceeding three meters which may contribute to the lack of Ludwigia presence. In 2016, this open area increased substantially in size, but rapid regrowth was observed westward as the site became more shallow. Dense mats of Ludwigia had accumulated large amounts of silt and dirt and acted as floating islands in which technicians were able to walk. Ludwigia regrowth was extensive with 50-100% cover occurring

Mean DO in open water environments was higher than in areas occupied by Ludwigia at both depths (surface and 0.5 m depth), across all sampling dates (Figure 10). Mean DO was highest in open water on 7/21/16. As the year progressed, DO decreased in open water environments. Changes in mean DO of Ludwigia infested samples varied between dates. Temperature decreased substantially from August to September at surface (22.4^{o}C to 13.5 ^{o}C) and 0.5 meter depth (21.1 ^{o}C to 13.0 ^{o}C).

Mean DO within open water surface samples met the non-salmonid threshold of 5 mg/l in July and August, exceeding the cool-water criterion threshold only in July. Mean DO in waters occupied by Ludwigia did not exceed either threshold during any sampling date.

Data Summary and Discussion

Although sampled water bodies possessed varying physical characteristics, hydrologic regimes and different degrees of Ludwigia infestation, seasonal trends have been captured across all three sites sampled for water quality. The 2016 monitoring effort provided information regarding population shifts of Ludwigia in response to one year of treatment and showed how DO may change.

The 2015 control effort was successful at reducing heavy cover of Ludwigia but did not substantially reduce overall distrubution of the target plant at mapped sites. With a 99% and 96% reduction of heavy cover at Lower Kiger Pond and Stewart Slough #1 site, cover shifted to moderate and light classes. Furthermore, populations were no longer erect, but were prostrate and had greatly decreased in overall emergent density and biomass. Ludwigia regrowth was most apparent in muddy, floating masses that represented areas previously inhabited by dense populations.

An unseasonably hot and dry 2015 resulted in the expansion of Ludwigia in typically deeper open water environments. It is well documented that exceptionally low water levels permit macrophyte fragments to root and persist in areas previously unsuitable for macrophyte colonization (Fox and Haller 2000; Lan et al. 2010). Lower Kiger Pond increased in overall distribution of Ludwigia by 0.47 acres before weed control treatments occurred. The expansion was most prominent in the open water habitat. Although systematic water depth data was not collected for the Lower Kiger Pond, unseasonably low water levels were observed in accordance with record high temperatures and lower than average precipitation rates within the Willamette Valley (NOAA 2016).

Mapping and observations within the Scatter Bar Pond exhibited another trend in Ludwigia shifts in response to drought conditions. Without chemical treatment, dead Ludwigia was observed along banks of the waterbody in response to apparent dry conditions from 2015. Drought conditions could have contributed to the large reduction of heavy cover in Lower Kiger Pond, which possessed the majority of the Ludwigia infestation in shallow water and margin environments.

The most prominent regrowth after application occurred within areas of the waterbody in which conditions permitted Ludwigia to form dense floating mats. Stewart Slough #1, Stewart Slough #2, and Collins Bay exhibited moderate to high cover from regrowth occurring on apparent "islands" consisting of dead Ludwigia material and captured silt (Figure 11). These islands varied in size. This was observed in 2015 at Collins Bay, one year after initial treatment. After the second year of treatment at the site,

Figure 11. Floating "island" within Stewart Slough #2 on 11/3/16, exhibiting Ludwigia regrowth on emergent and submerged portions of plant and silt mass.

these areas did not substantially decrease in distribution or cover. It is possible that these "islands" contain a large root biomass, provide silt for seed germination, or are dense enough to shield individuals from chemical application. More research is needed to determine the exact mechanism for the relatively high rates of regrowth. These areas should be taken into consideration when designing plans for the 2017 treatment year.

Ludwigia infested water contained less DO than open water areas within the three sampled sites, which is similar to 2015 monitoring in the project area (Benton SWCD 2015). Only during surface comparisons at Scatter Bar Pond on 11/3/16 was mean DO higher in Ludwigia infested areas than open water. This anomaly could be related to seasonal mixing in relation to the influx of precipitation and run off as seasonal rainfall increases in the Pacific Northwest. In a similar trend, Mean DO values within Lower Kiger Pond and Stewart Slough #2 became more similar to one another between depth and monitoring treatments in November.

Prior to seasonal rainfall, the Scatter Bar Pond and Stewart Slough #2 sites possessed anoxic conditions below the 3 mg/l threshold of acute mortality for salmonid, non-salmonid, and aquatic invertebrates (EPA 1986). Results of reduced DO and anoxic conditions within emergent beds of Ludwigia adhere to findings from previous studies focused on emergent vegetation (Caraco & Cole 2002; Miranda & Hodges 2000; Rose & Crumpton 1996). Mean DO in open water exceeded the cool water criterion of 6.5 mg/l during the month of July in all three waterbodies. Mean DO did not exceed the cool water criterion in any sampled water body during any other sampling date. Interestingly, in Lower Kiger Pond, where large masses of Ludwigia were no longer present, in comparison to 2015, mean DO did not recover and these areas were still lower in mean DO than the open water counterparts. This could be attributed to accumulated litter along the margins, residual decay of the previously treated Ludwigia, or the absence of submerged aquatic species which were observed to be more abundant in deeper, open water environments.

Water quality monitoring in Stewart Slough #2 and Lower Kiger Pond showed a decrease of mean DO in open water areas from July to August, and again from August to September, even as mean temperatures decreased. The inverse relationship of oxygen and temperature (ODFW 2009; USGS 2017) did not appear to be the major factor contributing to the change in DO over sampling dates. The overall decrease of mean DO in open water habitats from early summer to fall could be attributed to the role that submerged aquatic plants contribute to DO within the water bodies of the project area. With abundant populations of *E. densa*, *E. canadensis*, and *C. demersum*, all three sites exhibited the highest mean DO in open water during the month of July when submerged plants are actively growing and photosynthesizing (Coraco & Cole 2002; Coraco et al. 2006; Frodge et al. 1990). It may be the seasonal decrease of DO in open water is closely related to the seasonal decline in photosynthetic rates of submerged aquatic plants. If submerged aquatic plants do play a major role in elevated DO within water bodies of the project area, it is possible that DO recovery within areas previously occupied by Ludwigia could be delayed until the colonization of submerged aquatic plants occur within these areas. More research is needed to investigate these ideas.

Comparisons of the 2015 and 2016 WQ data in the Scatter Bar Pond differed significantly from one another in both open water and Ludwigia infested sampling sites. Such variability was not expected to occur, and may be affected by the difference in Ludwigia control methods between

2015 and 2016, with 2015 sites being chemically treated twice and 2016 sites only able to be treated once. Annual variability could also be a result of changes in sampling methods between years. In 2015 sampling did not contain returnable points or a fixed sample size for each date. However, changes to the study design in 2016 allows for repeatable, permanent collection points to occur after chemical treatment in 2017 and beyond. Comparison of 2015 and 2016 WQ data within the Lower Kiger Pond actually showed that DO decreased in areas previously occupied by Ludwigia. This could indicate that submerged photosynthesis occurred to a degree to elevate DO within the emergent plant beds.

Conclusions

Changes to data collection methods and site selection allowed for WQ monitoring to successfully occur during all sampling dates in 2016. In the previous year, only Lower Kiger Pond underwent WQ monitoring during all four dates. Furthermore, a fixed sample size (n=8) and permanent sampling sites would allow for more in depth discussion regarding annual changes in WQ during future data collection years. Cover class mapping provided valuable insight to shifts in Ludwigia distribution and cover after one year of control treatments. With pre-treatment distribution data now gathered for four distinct waterbodies, progress regarding Ludwigia control efforts can be more closely monitored, and control methods could be compared and adjusted. All findings should be corroborated by further data collection and more comprehensive study. Conclusions build upon and solidify statements made in the previous monitoring year.

<u>Distribution & Cover Mapping Conclusions</u>

1. One year of control efforts resulted in decreased Ludwigia cover, but total distribution was not substantially reduced and in some cases Ludwigia distribution increased.
2. Native plants such as *Sparganium* spp., *Sagittaria* spp. were observed naturally colonizing areas previously occupied by high Ludwigia cover.
3. Ludwigia was not found rooted in water depths >1.9 meters.
4. In some areas with treatments, Ludwigia cover classes shifted from heavy (>50%) to light (<5%) in areas with persisting populations of *N. polysepela* and *Sparganium* species. However, treatment contractors actively avoided and minimized herbicide application to native plants near Ludwigia populations, which may have contributed to the persistence of these native plant populations.
5. Drought conditions of 2015 likely contributed to the expansion of Ludwigia within open water environments and increased mortality along population fringes.
6. Large floating mats of Ludwigia appear to be a major source of Ludwigia regrowth.

<u>Dissolved Oxygen Monitoring Conclusions</u>

1. A “DO crash” related to herbicide treatment of Ludwigia was not observed in the second year of monitoring.
2. Regardless of herbicide application, Ludwigia infested areas possess lower DO than open water environments.

3. Heavy Ludwigia infestations can reduce DO concentrations to levels that would be expected to result in acute mortality to salmonids, non-salmonids and aquatic invertebrates.
4. DO experienced a seasonal trend decreasing from July to September.
5. Submerged macrophytes may contribute to elevated DO levels in summer months. Future monitoring should consider including submerged aquatic plant monitoring.
6. Areas previously inhabited by Ludwigia did not immediately see a rise in DO in the year following initial control efforts.

Management Considerations

In relation to management decisions, to substantially reduce overall distribution of Ludwigia, numerous management techniques should be carried out in conjunction with herbicide application. Hand removal can be effective in areas that have been reduced to light cover (City of Eugene 2012; Thiebaut 2007). This strategy can be most directly applied to Lower Kiger Pond, or similar water bodies that experience distribution expansion due to drought conditions. Due to the natural regrowth and competition of native plants observed at Collins Bay and Lower Kiger Pond, seeding of native species may be beneficial within areas that exhibit natural recruitment. If persistent regrowth continues to occur in areas exhibiting floating Ludwigia and silt mats, serious consideration should be made in the mechanical removal of these sources of regrowth. Open water should be preserved and maintained to act as refugia for aquatic species.

Monitoring Improvements

In order to adequately capture any “DO crash” that may occur, continuous monitoring devices should be installed in upcoming years. Such devices would be able to capture DO at specific time intervals sensitive enough to identify large scale reduction in DO from diurnal fluctuations or isolated events.

Although DEQ standardized methods were applied to the 2016 monitoring techniques, standards utilized by USGS should be considered for future monitoring years (USGS 2015). Other local projects related to Ludwigia have recently begun working with USGS in regards to WQ monitoring. By standardizing the methods applied to monitoring in the project area, Benton SWCD can share data and build upon local work being carried out by USGS.

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Appendix A: 2016 Water Quality Data Summary by Site

Dissolved oxygen percentage (DO%), specific conductivity (SPC), pH, and oxidation reduction potential (ORP), were collected at the same time as DO and temperature and summarized below. "Top" refers to a depth of 0.5 meters, "Bottom" refers to 0.5 meters from the bottom of the waterbody, and "surface" refers to a full emersion of the probe which is 0.13 meters. Percent Cover category was separated into treatments of "Open" (<15% Ludwigia Cover) and "Ludwigia" (>50% Ludwigia Cover).

a. Lower Kiger Pond

				Temp (C)		DO%		DO (mg/l)		SPC (uS/cm)		pH		ORP (mV)	
Date	Percent Cover	Depth	Sample Size (n)	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
7/21/2016	Open	Surface	8	22.9	0.161	74.1	9.185	6.96	0.513	174.2	5.837	8.34	0.290	-124.9	7.859
7/21/2016	Open	Top	8	22.0	0.068	65.6	8.107	5.78	0.721	180.7	2.781	8.32	0.209	8.3	0.209
7/21/2016	Open	Bottom	7	20.2	0.281	4.2	1.941	0.51	0.203	195.4	7.501	7.33	0.157	-166.0	8.503
7/21/2016	Ludwigia	Surface	8	22.3	0.574	23.2	2.968	2.21	0.270	173.4	13.902	7.90	0.168	-110.0	14.820
7/21/2016	Ludwigia	Top	8	22.0	0.592	6.5	2.532	0.85	0.257	188.7	1.868	7.49	0.085	-139.3	12.998
7/21/2016	Ludwigia	Bottom	0												
8/11/2016	Open	Surface	8	21.6	0.107	69.6	10.833	6.26	1.175	182.7	23.285	7.83	0.256	39.8	13.202
8/11/2016	Open	Top	8	21.6	0.760	36.8	4.881	3.30	0.440	210.6	1.058	7.73	0.248	33.5	12.816
8/11/2016	Open	Bottom	7	20.5	0.991	6.2	4.949	0.56	0.449	226.7	8.011	7.06	0.134	-25.7	9.058
8/11/2016	Ludwigia	Surface	8	24.3	1.028	21.8	2.999	1.93	0.236	204.9	3.950	7.42	0.164	-71.2	13.662
8/11/2016	Ludwigia	Top	8	21.2	0.776	5.6	1.606	0.50	0.144	203.6	7.792	7.26	0.126	-64.6	8.224
8/11/2016	Ludwigia	Bottom	0												
9/20/2016	Open	Surface	8	17.2	0.087	44.0	5.772	4.32	0.608	225.3	0.609	7.43	0.128	85.7	14.721
9/20/2016	Open	Top	8	17.1	0.074	42.4	7.962	4.05	0.756	225.6	0.656	7.43	0.104	96.5	10.157
9/20/2016	Open	Bottom	6	16.9	0.037	13.0	3.242	1.23	0.320	237.8	8.370	7.13	0.105	43.0	26.924
9/20/2016	Ludwigia	Surface	8	16.3	0.313	25.3	5.525	2.50	0.569	221.7	3.437	7.41	0.159	104.4	11.933
9/20/2016	Ludwigia	Top	8	16.3	0.305	17.1	4.805	1.65	0.484	223.7	3.405	7.44	0.166	93.9	16.860
9/20/2016	Ludwigia	Bottom	0												
11/3/2016	Open	Surface	8	13.2	0.019	45.5	3.285	4.33	0.257	158.9	4.881	6.88	0.062	301.1	120.901
11/3/2016	Open	Top	8	13.2	0.042	32.4	2.594	3.32	0.241	157.5	4.766	6.81	0.069	176.3	5.146
11/3/2016	Open	Bottom	8	13.1	0.161	10.1	3.177	1.06	0.331	161.2	5.476	6.77	0.075	156.0	13.152
11/3/2016	Ludwigia	Surface	8	13.2	0.122	25.1	2.714	3.52	0.145	158.9	3.345	6.77	0.058	196.3	9.001
11/3/2016	Ludwigia	Top	8	13.1	0.081	25.5	2.413	2.61	0.188	159.5	3.832	6.68	0.108	196.3	6.246
11/3/2016	Ludwigia	Bottom	8	13.0	0.060	25.6	2.456	2.76	0.296	156.8	4.746	6.80	0.053	195.8	5.780

b. Stewart Slough #2

				Temp (C)		DO%		DO (mg/l)		SPC (uS/cm)		pH		ORP (mV)	
Date	Percent Cover	Depth	Sample Size (n)	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
7/21/2016	Open	Surface	8	23.7	0.468	88.8	11.232	7.32	0.866	300.7	2.086	7.38	0.114	-71.3	12.638
7/21/2016	Open	Top	8	21.9	0.141	69.3	0.141	6.05	0.863	301.4	4.199	7.23	0.131	-77.0	13.256
7/21/2016	Open	Bottom	4	17.8	0.857	2.5	1.377	0.12	0.024	371.3	27.562	6.55	0.087	-135.2	34.017
7/21/2016	Ludwigia	Surface	8	25.4	0.468	7.9	3.352	0.69	0.287	277.9	8.959	6.66	0.095	-112.9	18.979
7/21/2016	Ludwigia	Top	8	23.0	0.452	0.6	0.681	0.05	0.051	280.1	11.603	6.49	0.095	-141.2	26.303
7/21/2016	Ludwigia	Bottom	0												
8/11/2016	Open	Surface	8	22.0	0.514	67.5	21.441	5.84	1.836	374.2	41.929	7.23	0.224	33.7	21.553
8/11/2016	Open	Top	7	20.9	0.403	41.0	14.564	3.99	1.310	344.9	26.614	7.00	0.146	27.9	25.512
8/11/2016	Open	Bottom	4	18.2	0.566	0.7	0.119	0.05	0.018	403.5	34.429	6.32	0.075	-39.9	7.391
8/11/2016	Ludwigia	Surface	8	22.8	0.673	14.0	13.180	1.20	1.131	319.1	68.330	6.68	0.146	-30.5	19.255
8/11/2016	Ludwigia	Top	8	21.2	0.642	7.3	6.895	0.64	0.602	381.5	20.117	6.52	0.114	-30.4	20.160
8/11/2016	Ludwigia	Bottom	0												
9/20/2016	Open	Surface	8	17.3	0.219	21.8	5.547	3.02	1.003	349.7	9.890	6.83	0.069	42.1	22.474
9/20/2016	Open	Top	8	16.9	0.234	12.7	5.132	1.23	13.306	361.9	13.306	6.79	0.066	30.4	27.209
9/20/2016	Open	Bottom	4	16.6	0.000	0.9	0.041	0.08	0.013	338.4	2.431	6.84	0.030	5.0	11.658
9/20/2016	Ludwigia	Surface	8	17.6	0.460	10.3	5.966	0.82	0.440	394.9	17.259	6.61	0.092	4.0	22.277
9/20/2016	Ludwigia	Top	8	17.6	0.440	6.8	4.119	0.62	0.378	397.2	24.202	6.55	0.088	-7.0	21.812
9/20/2016	Ludwigia	Bottom	0												
11/3/2016	Open	Surface	8	13.1	0.067	20.7	0.948	2.23	0.147	128.1	0.680	6.60	1.209	135.3	9.851
11/3/2016	Open	Top	8	12.7	0.122	17.7	0.708	1.92	0.036	129.2	0.100	6.52	1.194	147.3	8.434
11/3/2016	Open	Bottom	8	12.5	0.062	16.2	1.266	2.90	1.206	129.0	0.620	6.41	1.212	134.9	7.935
11/3/2016	Ludwigia	Surface	8	13.8	0.315	10.9	3.921	1.13	0.408	155.2	14.964	6.57	0.824	115.4	18.615
11/3/2016	Ludwigia	Top	8	13.2	0.151	11.6	3.389	1.21	0.355	176.2	44.199	6.47	0.810	6.5	0.810
11/3/2016	Ludwigia	Bottom	1	13.5	0.000	16.8	0.000	1.80	0.000	129.6	0.000	6.45	0.000	135.3	0.000

c. Scatter Bar Pond

				Temp (C)		DO%		DO (mg/l)		SPC (uS/cm)		pH		ORP (mV)	
Date	Percent Cover	Depth	Sample Size (n)	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error	Mean	Standard Error
7/21/2016	Open	Surface	8	21.3	1.201	93.8	18.817	10.13	1.622	264.9	11.237	7.13	0.082	-49.9	23.141
7/21/2016	Open	Top	8	19.1	0.939	58.8	13.075	5.52	1.204	277.1	14.655	6.76	0.090	-64.3	23.706
7/21/2016	Open	Bottom	5	14.0	0.237	8.6	2.509	1.49	1.236	359.3	17.610	6.63	0.096	-82.3	16.983
7/21/2016	Ludwigia	Surface	8	19.2	0.743	11.1	4.051	0.97	0.230	156.2	15.250	6.59	0.064	-99.1	14.581
7/21/2016	Ludwigia	Top	8	18.0	0.422	6.5	2.458	0.68	0.306	176.7	18.889	6.31	0.084	-117.8	15.397
7/21/2016	Ludwigia	Bottom	0												
8/11/2016	Open	Surface	8	22.1	1.166	20.4	5.248	1.79	0.441	114.2	8.578	6.56	0.055	64.5	15.374
8/11/2016	Open	Top	8	17.7	0.694	5.8	1.918	0.60	0.154	136.2	18.133	6.43	0.051	55.0	22.898
8/11/2016	Open	Bottom	7	15.9	0.532	0.8	0.151	0.07	0.014	213.0	46.613	6.11	0.065	76.9	15.802
8/11/2016	Ludwigia	Surface	8	19.5	0.403	2.9	0.550	0.23	0.057	117.6	3.418	6.14	0.085	41.4	23.000
8/11/2016	Ludwigia	Top	8	18.1	0.167	1.4	0.779	0.06	0.005	129.3	38.881	6.00	0.095	14.9	9.359
8/11/2016	Ludwigia	Bottom	0												
9/20/2016	Open	Surface	8	16.6	0.394	63.7	9.841	6.12	0.970	354.3	12.890	6.71	0.055	90.1	8.728
9/20/2016	Open	Top	8	15.1	0.387	43.9	9.610	4.47	0.997	351.8	12.717	6.74	0.024	122.5	26.071
9/20/2016	Open	Bottom	7	14.4	0.339	14.2	5.569	1.44	0.564	397.4	30.956	6.56	0.036	60.6	24.378
9/20/2016	Ludwigia	Surface	8	15.0	0.138	4.5	2.561	0.45	0.258	338.3	11.797	6.44	0.069	19.7	8.002
9/20/2016	Ludwigia	Top	8	14.6	0.105	1.5	0.618	0.15	0.063	341.1	14.576	6.23	0.053	11.1	6.448
9/20/2016	Ludwigia	Bottom	0												
11/3/2016	Open	Surface	8	14.5	0.310	27.9	7.427	2.85	0.653	219.1	1.854	6.54	1.198	66.5	20.380
11/3/2016	Open	Top	8	13.2	0.095	11.4	2.017	1.53	0.142	226.1	7.817	6.68	1.225	69.8	19.873
11/3/2016	Open	Bottom	7	12.6	0.057	-1.3	1.016	0.03	0.032	316.3	14.575	6.59	1.333	16.3	12.718
11/3/2016	Ludwigia	Surface	8	14.8	0.603	31.5	2.528	3.29	0.295	185.3	25.835	6.55	1.240	69.6	0.140
11/3/2016	Ludwigia	Top	8	13.2	0.158	6.3	1.467	0.77	0.214	199.5	28.958	6.59	1.248	37.6	14.040
11/3/2016	Ludwigia	Bottom	0												

Appendix J: 2017 Monitoring Proposal with USGS and PSU

ODA OSWB Grant 2017-30-701

Proposed Change in Monitoring Approach: Water quality surveys and aquatic vegetation assessment in relation to herbicide treatments of Collins Bay and Scatter Bar Pond

Partners conducting the proposed work:

Benton Soil and Water Conservation District (Benton SWCD): Holly Crosson (Executive Director), Melissa Newman (Program Coordinator: River Restoration and Invasives)

U.S. Geological Survey (USGS): Kurt Carpenter (Hydrologist)

Portland State University, Center for Lakes and Reservoirs (PSU): Mark Sytsma (Director, Center for Lakes and Reservoirs & Professor of Environmental Science and Management) and Rich Miller (Research Associate)

Additional Project Partners: Oregon Department of Agriculture, Collins Bay landowners, Greenbelt Land Trust (Scatter Bar Pond landowner) and adjacent landowner (for access to Scatter Bar Pond), Benton County Cooperative Weed Management Area, Willamette Mainstem Cooperative, Linn Soil and Water Conservation District.

Background. Excessive growth of the non-native aquatic plants *Ludwigia hexapetala* and *L. peploides* in in lakes and rivers can have negative impacts on water quality, harm fish and wildlife habitat, and impact other non-native (e.g. *Egeria densa* and *Myriophyllum aquaticum*) and native (e.g. *Ceratophyllum demersum* and *Elodea* spp.) aquatic plant communities.

Due to these impacts, herbicide treatments targeting *Ludwigia* spp. have been implemented in selected areas associated with the Willamette River including Collins Bay in Benton County and are planned for Scatter Bar Pond (site previously referred to as "Oxbow") at Horseshoe Lake in Linn County. Both waterbodies are infested with extensive populations of *Ludwigia* spp. and may be infested with other native and non-native emergent and submerged aquatic plants. Both waterbodies have been included in previous years of monitoring efforts[1,2] and this collaborative opportunity with USGS and PSU allows for more rigorous scientific monitoring at these two sites. Assessing the impacts of *Ludwigia* spp. control on the aquatic plant community and water quality is an important component in the management of the Willamette River system.

USGS Scope of work: USGS will conduct 3 water quality surveys in Scatter Bar Pond and Collins Bay before and after planned glyphosate applications in June/July and July/August 2017, and again after plant senescence in September/October. Water quality surveys will be timed to be conducted prior to plant sampling (since plant biomass sampling will stir up sediments). USGS will collect high-frequency water-quality data using a calibrated and GPS enabled Yellow Springs Instruments (YSI) EXO2 sonde to characterize water temperature,

[1] 2015 Monitoring Report: https://www.bentonswcd.org/assets/2016_Grant_Monitoring_Summary_Final_2_25_16.pdf

[2] 2016 Monitoring Report: Currently being finalized by contractor.

dissolved oxygen, pH, conductance, turbidity, and plant pigments (total chlorophyll and phycocyanin) in these two waterbodies.

USGS has also secured an additional $6,500 in USGS Cooperative Water Program (CWP) funds for the project (48% of total monitoring fund costs). These CWP funds will help cover USGS time for data processing/QA/initial interpretation, and covers a good portion of USGS indirect costs.

USGS Deliverables

- Color maps portraying these water quality parameters will be generated for each waterbody and results presented to Benton SWCD and other partners.

The data from the surveys will also be incorporated into a larger data set, consisting of multiple geographic areas (e.g., Willamette Mission State Park in Salem), that will result in a future USGS peer reviewed published paper.

PSU Scope of work. PSU will assess the status of the aquatic plant community in Collins Bay and Scatter Bar Pond on three occasions during the summer of 2017. The first assessment will be during June/July prior to the first herbicide treatment, the second prior to the second herbicide treatment (likely in August), and the third assessment will be during late September/early October.

During each sampling event the aquatic plant community will be assessed at 60 random points per each waterbody. Random points will be assigned prior to each sampling event using GIS and uploaded into a field GPS unit. A minimum distance will be maintained between points so the points are not concentrated in one area of each pond. Submerged aquatic plants will be collected from each sampling point by lowering a double sided thatch rake attached to a demarcated aluminum pole to the sediment surface, twisting the rake 180 degrees, and retrieving the attached plants to a canoe. A semi-quantitative estimate of the amount of plants retrieved on the rake will be noted along with the percentage composition by species. A 0.5 m diameter hoop will be placed on the surface of the water at each site and percent coverage for emergent and floating leaf species within the hoop will be estimated. Depth at each site will be noted as well. Voucher specimens for each aquatic plant species encountered will be archived. All data will be recorded on waterproof field datasheets or logged on the field GPS unit.

PSU Deliverables

- A database that includes:
  - The percent coverage of floating or emergent aquatic plants by species at each site
  - A semi-quantitative assessment of submerged plant abundance at each site
  - Percent composition of submerged plants by species at each site
  - and depth at each site for 60 sites per waterbody on three occasions
- Archived pressed specimens of each aquatic plant species encountered
- Maps estimating coverage by species for each sampling event

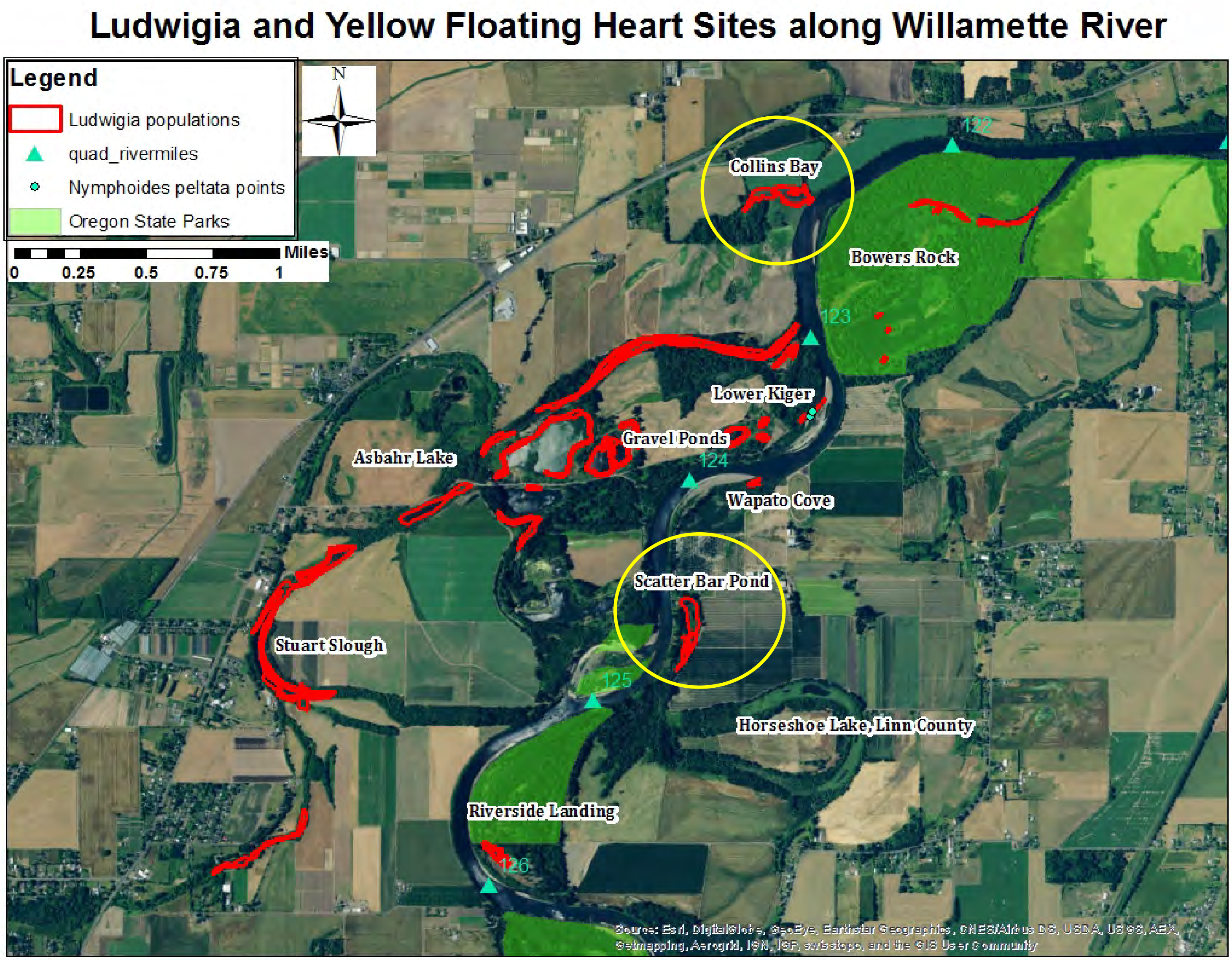
- A report summarizing sampling efforts, results, and recommendations for follow up sampling

Funding

Funding Program	Amount	Notes
2017 ODA OSWB Grant (2017-30-701) Monitoring Funding	$13,560	$13,560 included in 2017-30-701grant application under "Contracted Services" = *$13,020 (grant budget line item: "Third year of water quality monitoring") +* *$540 (grant budget line item: "Mileage reimbursement")*
Allocate to PSU Plant Work	*$5,847*	Funds remain under "Contracted Services" budget category
Allocate to USGS WQ work	*$7,713*	Funds remain under "Contracted Services" budget category
USGS Cooperative Water Program Funding		
Funds helping cover USGS WQ work time	$6,500	Additional match secured by USGS for monitoring
Total	$20,060	

Benton SWCD Staff Time & Volunteer Assistance: Benton SWCD staff members or official Benton SWCD volunteers will assist with surveys and sampling efforts as needed. These efforts would be additional match funds for the project, with staff time coming from either Meyer Memorial Trust grant funds (for Melissa Newman) or Benton SWCD in-kind funds (for Holly Crosson). At least one Benton SWCD volunteer, a recent Ph.D. graduate from Oregon State University, has already committed to assisting with survey and sampling events because of this potential opportunity to assist USGS and PSU.

Map showing location of Collins Bay and Scatter Bar Pond in the Corvallis to Albany river reach.



Appendix K: Letters of Support

Oregon State Weed Board
Oregon Department of Agriculture
635 Capital St. NE
Salem, Oregon 97301-2532

November 28, 2017

Subject: Support for the BC CWMA OSWB application: "*Willamette River Aquatic Weed Management Phase 5*"

Dear Oregon State Weed Board Grant Review Members,

On behalf of the Ridge at Cascade Heights Homeowners Association (HOA), I would like to express our strong support for the Benton County Cooperative Weed Management Area's (BC CWMA) grant proposal for "Willamette River Aquatic Weed Management Project Phase 5" in the Corvallis to Albany Reach of the Willamette River.

The BC CWMA, currently coordinated by the Benton Soil and Water Conservation District (SWCD), has been working with the HOA on control treatments of yellow floating heart (*Nymphoides peltata*), an Oregon Department of Agriculture (ODA) listed noxious weed, at Horseshoe Lake. The lake is partially owned by the HOA, in addition to two others entities.

In 2017, Benton SWCD coordinated with ODA, as well as other partners and research scientists, to try a new control treatment method for yellow floating heart at the lake. We are hopeful next summer we will see greatly reduced numbers of yellow floating heart plants at the lake as a result of this new treatment method. The BC CWMA proposes to conduct a follow-up treatment of yellow floating heart at Horseshoe Lake in the summer of 2018, which we wholeheartedly support.

Interested HOA members are actively engaged in monitoring of lake and in learning more about yellow floating heart, its effects, and possible treatment methods. Concurrent with Benton SWCD's treatment regimen for yellow floating heart at the lake, the HOA will continue to have the detention pond that drains into the lake inspected for yellow floating heart, and treated by a contracted professional if any plants are found.

The continued control of yellow floating heart at Horseshoe Lake will contribute significantly to improving the ecological function of the lake and protect this unique open water habitat along the Willamette River.

Thank you for your consideration of this proposal.

Sincerely,

Mark A. Jones
President, Ridge at Cascade Heights HOA

Calapooia Watershed Council
PO Box 844 / 136 Spaulding Ave / Brownsville OR 97327
541-466-3493 / www.calapooia.org

OSWB Grant Program
Oregon Dept. of Agriculture
635 Capitol St NE
Salem, OR 97301

December 12, 2017

Subject: Support for the OSWB application entitled "*Willamette River Aquatic Weed Management Phase 5*"

Dear Members of the Review Team:

I am writing to express support of Benton County Cooperative Weed Management Area (CWMA) grant proposal for aquatic invasive plant control along the Corvallis to Albany reach of the Willamette River.

Partnerships between private and public landowners, local and state agencies, and non-profit conservation organizations have formed in recent years to address critical habitat needs along the Corvallis to Albany reach. In 2012-2013 Benton Soil and Water Conservation District (SWCD) conducted a landscape scale weed assessment of the floodplain between Corvallis and Albany. This proposal is an outcome of that assessment and it builds on ongoing restoration efforts by public and private partners occurring along the Corvallis to Albany reach of the river.

Calapooia Watershed Council is actively working on restoration efforts to address invasive water primrose (*Ludwigia hexapetala*) populations observed at Bowers Rock State Park and the Little Willamette River. The weed assessment and control efforts of Benton SWCD combined with Calapooia Watershed Council's restoration efforts at Bowers Rock State Park and Little Willamette River will not only provide tremendous ecological benefits but will likely lead to more conservation opportunities in the vicinity of each project.

Please feel free to contact me if you have any questions.

Sincerely,

Collin McCandless
Restoration Program Manager
Calapooia Watershed Council

Oregon

Kate Brown, Governor

Parks and Recreation Department
725 Summer St. NE, Suite C
Salem, OR 97301-1271
(503) 986-0980
Fax (503) 986-0794
www.oregonstateparks.org

December 5, 2017

Oregon State Weed Board
635 Capital St. NE
Salem, Oregon 97301-2532

Subject: Support for the Benton County CWMA OSWB application entitled "*Willamette River Aquatic Weed Management Phase 5*"

Dear Oregon State Weed Board Grant Review Team Members,

I am writing to express the Oregon Department of Parks & Recreation's (OPRD) support for the Benton County Cooperative Weed Management Area's (BC CWMA) grant proposal for aquatic weed management. Partnerships between private and public landowners, local and state agencies, and non-profit conservation organizations have formed in recent years to address critical habitat needs along the Corvallis to Albany Reach of the Willamette. The Willamette Mainstem Cooperative (WMC) is one such partnership and has conducted a landscape scale weed assessment of the floodplain between Corvallis and Albany. One outcome of the assessment process is that *Ludwigia hexapetala* has been identified as a priority species for control in the Willamette River. The BC CWMA proposes to conduct follow-up treatments of *Ludwigia* in Collins Bay, and to add an additional site locally known as Oxbow. Several *Ludwigia* sites have been the focus of volunteer hand-pulling in previous years, and will continue to be monitored and targeted for hand-pulling during this project phase. In addition, landowners including OPRD in this reach are also working on controlling *Ludwigia*.

The control of target invasive plants will contribute significantly to improving ecological function of the Willamette River, and protecting unique and high quality habitats. In order to support the next phase of these efforts, OPRD will continue to work with our partners to control *Ludwigia* and other harmful invasive species in this reach as well as upstream and downstream at priority Willamette River Greenways.

Thank you for your consideration of this proposal.

Sincerely,

Andrea Berkley
Natural Resource Specialist, Valleys Region OPRD