Overview of meetings and conversations with Jefferson County Open Space staff:

February 2018 – Finalize project management plan for funded proposal with JCOS staff

March 2018 - Meeting with JCOS staff, MSUD faculty, and DBG staff to provide overview of project and discuss plans

Planning meeting for South Platte River Basin Restoration Planning and Feasibility Study

Date: March 19, 2018, 10:00 am – 12: 00 pm
Location: Jefferson County Open Space Office
Attendees: Jefferson County Open Space: Drew Rayburn, Christine Hartman, Chelsea Beebe, Irene Weber, Gerry Bader, Steve Murdock; Metropolitan State University of Denver: Sarah Schliemann, Erin Bissell; Denver Botanic Gardens: Becky Hufft
Notes:
-Need to get a separate research permit for each of us (Sarah, Erin, Becky); Will also need a separate permit and likely formal agreement for any work WRV does associated
-Goal is to have GIS work that will propose locations to install stream structures completed by end of 2018

-For future planning, need to plan activities ~2 years in advance to have a good shot of getting into the budget.
-Sarah's expertise is in soil and water chemistry; She is going to look at adding in sampling more frequently at current sampling locations and ones that will be added for this project along Deer Creek. In addition to doing sampling DBG has been doing once a year (pH, temp, TDS, e.coli, N, P) more frequently, can also add in chlorine (to look at MgCl effects)
-Bird monitoring: would be good to get baseline data. Could we get the Audubon Society involved? It would be good to establish at least two years of baseline data. Erin has three plots at DBG Chatfield she has been monitoring for 2 years. We all would like to expand this…not clear who has resources/time to take this on right now.
-Additional data it would be good to collect: ungulates (how will browsing impact restoration? Need baseline data); pollinators (partner with CSU/CNHP? CSU extension pollinator track to recruit volunteers?); park operations (What is the impact of natural resource management on park activities?)

Action Items:
-Becky will email planned field dates
-Erin, Sarah, and Becky will each submit a permit application online (https://www.jeffco.us/FormCenter/Open-Space-15/JCOS-Research-and-Collections-Permit-App-175)
-Sarah will send Drew an email with what GIS, LIDAR, etc. data she would like
-Christine will send Ecometrics report to DBG and MSUD folks
-Becky will send summary data from work done at Chatfield

April 2018 – Coordinate for permit to access site and collect data.

December 2018 – Provide reporting update to JCOS staff

March 2019 – Coordinate for permit to access site and collection data

September-October 2019 Coordination to obtain permit for drone work. Conducted on-site visit with staff to walk project and discuss current and planned work.

November-March 2020 Coordination to conduct drone mapping to collect LiDAR. Due to weather issues, we had to cancel each of the several days we tried to conduct this work. After that, the drone operator was not immediately available and then COVID shut down all work for the immediate future. Main staff involved in the project left JCOS.

March 2020 Coordination for permit to collect summer monitoring data

November 2020-February 2021 – Final project reporting to JCOS staff.

April 2021 – Post-project follow-up with JCOS staff, scheduled tour of restoration project and frog monitoring

From their initial survey of Chatfield Farms, the found the following

Date: April 29, 2021
Start Time: 13:40
End Time: 17:30
Observers: Andrew DuBois, Joseph Ehrenberger (Adaptation Environmental Services, CPW contractor), Bryon Shipley (CPW herp monitor), Emily Macklin (CPW state parks raptor monitoring program

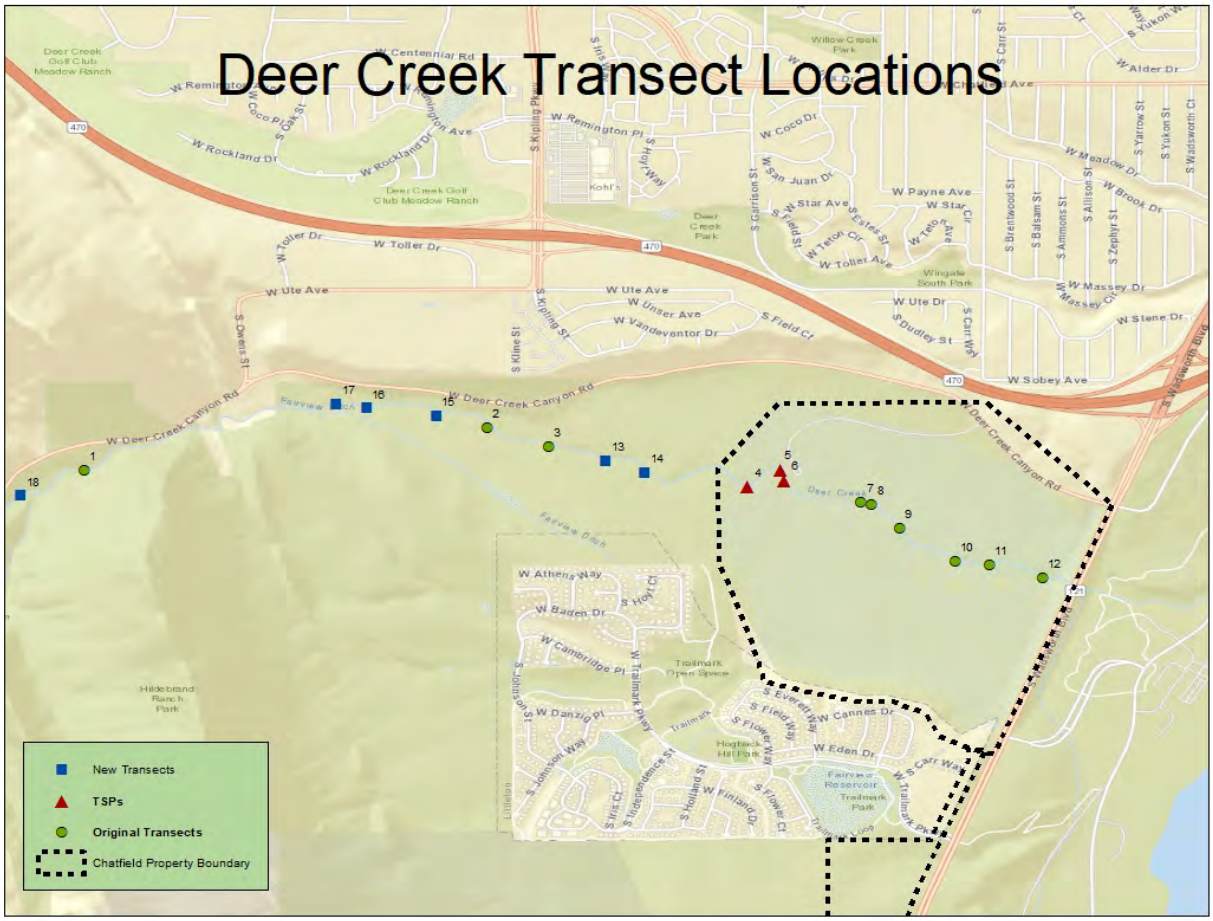
coordinator), Lauren Livo (retired CPW contract herpetologist), Sean McMullen (JCOS herp volunteer), Ryan Borgmann (JCOS herp volunteer)

Amphibians and reptiles observed:
Western painted turtle *Chrysemys picta belli* 8
Snapping turtle *Chelydra serpentina* 1
Eastern yellow-bellied racer *Coluber constrictor flaviventris* 1
Wandering gartersnake *Thamnophis elegans vagrans* 1
Northern leopard frog *Lithobates pipiens* 2
American bullfrog *Lithobates catesbeianus* 2
Boreal chorus frog *Pseudacris maculata* – chorus with some overlapping calls

Notes: One of the two leopard frog observations was a single male calling at 39.546439, -105.092884. The other was basking on a log at 39.547832, -105.095120. The two juvenile American bullfrogs were observed at 39.550044, -105.102410. A chorus of boreal chorus frog advertisement calls was detected 39.549628, -105.099089. No egg masses or tadpoles were observed during this effort.

Task 3: Establish long-term monitoring plots for vegetation and water quality at each potential installation location to collect baseline data.

We have established 18 permanent monitoring transects along Deer Creek, which includes spots at each of our three in-stream restoration installations, six downstream, and nine upstream. Nine of these occur on Jefferson County Open Space property (upstream) and nine occur on Denver Botanic Gardens Chatfield Farms property (downstream). Twelve sites were established prior to this funding and six new sites (Transects 13-18) were established on Jefferson County Open Space property at additional sites considered for future restoration installations.



Images of artificial beaver dam channel structures and vegetation monitoring transect. a) Artificial beaver dam structure at locationID DeerCreek05 on 17 March 2017 with dry creek bed. b) Artificial beaver dam structure at locationID DeerCreek05 on 29 March 2017 with wetted creek bed. c) Artificial beaver dam structure at locationID DeerCreek05 on 10 May 2018 with wetted creek bed during growing season. d) Vegetation monitoring transect at locationID DeerCreek18 on 26 June 2019.

We continue to monitor these sites annually. Monitoring of these 18 sites was designed to document and describe the ground vegetation community, soil moisture conditions and canopy cover. Belt transects at each site were 25 m long and sampled via the point-intercept method (Hufft et al. 2019a adapted from

Herrick et al. 2005). Reaches of the stream, adjacent to the transects, were sampled for water quality and macroinvertebrate community diversity. Data collected included plant diversity, ground cover, canopy cover, soil moisture, water quality measurements (Nitrate/Nitrite, Total Nitrogen, *E. coli*), stream measurements (temperature, pH, total dissolved solids, dissolved Oxygen, electrical conductivity, and flow rate), bank measurements (total bank height, surface to bank height, distance to bank from transect origin, and water depth in stream), and aquatic macroinvertebrate diversity and abundance. All of our data are publicly available on GBIF (Deer Creek Riparian Restoration Ecological Monitoring (gbif.org)) and described in the Biodiversity Data Journal manuscript mentioned below. Plant species found along Deer Creek are listed in Appendix 1. Water quality and stream metrics are listed in Appendix 2. Protocols for the monitoring can be found at the GBIF link above and have been included with this final report.

Margo Yousse (nee Paces) was a graduate student funded in-part off this funding. She defended her master's thesis in spring 2020 at the University of Colorado Denver. She is currently finalizing a manuscript for submission to a peer-reviewed journal for publication. Her thesis "Beaver Dam Analogs Impact Riparian Vegetation Communities" is attached. In addition to plant information in her thesis, all species identified along Deer Creek were collected and vouchered in the Kathryn Kalmbach Herbarium (Denver Botanic Gardens). In addition to being publicly available at the GBIF link mentioned above, all specimens are accessible through SEINet (SEINet Portal Network Home (swbiodiversity.org)). A list of plant species found along Deer Creek can be found in Table 3 of the attached thesis.

Data from the plant, water, and aquatic inventory monitoring is publicly available and information about the sampling and data can be found in this publication (attached): Levy R, Paces M, Hufft R. 2020. Sampling event dataset for ecological monitoring of riparian restoration effort in Colorado Foothills. Biodiversity Data Journal. 8: e51817 doi: 10.3897/BDJ.8.e51817. The article and all associated data from this project can also be found here: https://bdj.pensoft.net/article/51817/

Restoration structure installed along Deer Creek during high seasonal water.

Restoration structure during dry season.

Transect site along Deer Creek: site of new permanent monitoring transect and potential restoration site.

Transect site along Deer Creek: site of new permanent monitoring transect and potential restoration site.

Transect site along Deer Creek: site of new permanent monitoring transect and potential restoration site.

Task 4: Report on findings and next steps to seek approval for implementation and construction funding.

We finalized our findings in a report to Jefferson County Open Space (attached) that includes recommendations for future restoration work and additional information that is needed to better automate the process to scale up this work to other sites. As part of this task, we were to provide analyses of annual data collected and training of a graduate researcher. We sent annual monitoring reports, the graduate thesis, the data manuscript, and link to the publicly available dataset to Jefferson County Open Space staff. We had also planned to create documentation necessary for next steps in the permitting and funding process to implement the construction project. While this was the original intent, staffing and internal priority changes at Jefferson County Open Space led to them wanting to pursue this themselves. Once the data mentioned in Task 1 are obtained, the model would need to be run and updated with the new data. We would then always recommend a site visit to model-selected sites to verify the site is good. After that, the staff at JeffCo have all the necessary information to put together permits once sites are selected and move forward. With the existing permit and design information we have, they would be ready to design for their locations and proceed.

They continue to reach out to us for information and partnership to move this idea forward. We will continue to work with Jefferson County Open Space on the long-term monitoring efforts of the existing project and future restoration work at their request.

Next Steps: While the project as evolved in the past year, one unexpected benefit of this project is the relationship between Jefferson County Open Space and Denver Botanic Gardens. Prior to this project, we had some interaction, but none were meaningful collaborations. We know have a better relationship with Jefferson County Open Space staff that includes a collegial and collaborative nature and willingness to share information and resources. We have a shared goal to maintain and improve water and wetland resources at a larger scale and are willing to work together. Jefferson County Open Space has reached out to Denver Botanic Gardens to not only assess our wetland resources and habitat for and populations of northern leopard frogs but work together to restore habitat and maintain the larger scale metapopulation for the species. This is especially important as there have been recent losses to frog breeding habitat. Our newly approved master development plan for Chatfield Farms includes a continued improvement of our wetland areas and the goal of improving water resources on Deer Creek, which is only possible through continued collaboration with Jefferson County Open Space. We are also in conversations with the School of Mines to continue this work and develop potential upgrades to the restoration structures and process for locating restoration sites.

Obstacles

We encountered a few obstacles along the way. First, our partner at MSUD conducting the GIS work did not feel they could provide good assessments without higher resolution data of the creek. We worked with staff from Jefferson County Open Space to try to resolve this issue and ultimately decided with them that we should attempt to use a drone to collect these additional data. While our funding did not include this drone data collection, we found someone willing to donate their time to assist us. We worked with Open Space staff to identify locations to collect the data, appropriate timing to avoid nesting birds, and received permits to conduct the work. We attempted several days of data collection but initially ran into bad weather and then the Covid-19 pandemic hit, and we were not able to conduct the work. Unfortunately, the MSUD faculty and the team providing the free drone survey were no longer able to assist on the project once Covid restrictions eased. We discussed this issue with Open Space staff and it was decided they would try to pursue getting these additional data in the future.

While we were able to complete most of our commitments, we were not ultimately able to develop full permitting and planning documents to move forward with restoration installations with Jefferson County Open Space. In 2020, two of our main points of contact at Open Space left the organization and work was stalled due to the pandemic. We have since then reconnected with new staff at Open Space and have plans to continue working with them on this project, however, their priorities have shifted a bit and they plan to move forward primarily on their own to pursue this. They do still seem interested in pursuing this and we have made it clear we are happy to assist in any way. As part of this commitment, we recently gave a group of staff not familiar with our work a tour of the restoration sites and discussed the overall project. We have offered to provide them permitting information and design documents we used for our work to assist in them pursuing this further. We have also expanded the conversation to include how such restoration might impact the larger watershed, specifically the impact on breeding ground for the rare northern leopard frog. We coordinated a frog survey on our property in April 2021 with Open Space staff

and are planning to recruit volunteers to be trained by them to do long-term monitoring on our site so we can better understand the landscape scale status of the frog and how restoration as described in this project might improve its breeding habitat in addition to improving general riparian habitat.

Matching commitments

All matching commitments outlined in the Statement of Work have been fulfilled.

Appendix 1. Plant species found along Deer Creek

Species Name	Nativity status	Year Recorded
Acer negundo var. interius	introduced	2016
Acer negundo var. interius	introduced	2017
Acer negundo var. interius	introduced	2018
Acer negundo var. interius	introduced	2019
Achillea millefolium	native	2016
Achillea millefolium	native	2017
Achillea millefolium	native	2018
Agropyron cristatum	introduced	2016
Alopecurus arundinaceus	introduced	2019
Alyssum simplex	introduced	2016
Ambrosia psilostachya	native	2016
Ambrosia psilostachya	native	2018
Ambrosia tomentosa	native	2017
Amelanchier alnifolia	native	2016
Amorpha fruticosa	native	2016
Arctium minus	introduced	2016
Arctium minus	introduced	2017
Arctium minus	introduced	2018
Arctium minus	introduced	2019
Artemisia ludoviciana	native	2016
Artemisia ludoviciana	native	2017
Artemisia ludoviciana	native	2018
Artemisia ludoviciana	native	2019
Asclepias speciosa	native	2016
Asclepias speciosa	native	2017
Asclepias speciosa	native	2018
Asperugo procumbens	introduced	2016
Asperugo procumbens	introduced	2017
Asperugo procumbens	introduced	2019
Bahia dissecta	native	2019
Barbarea orthoceras	introduced	2016
Barbarea orthoceras	introduced	2017

Barbarea orthoceras	introduced	2018
Barbarea orthoceras	introduced	2019
Berteroa incana	introduced	2016
Berteroa incana	introduced	2017
Berteroa incana	introduced	2018
Berteroa incana	introduced	2019
Bouteloua dactyloides	native	2018
Bromus arvensis	introduced	2016
Bromus inermis	introduced	2016
Bromus inermis	introduced	2017
Bromus inermis	introduced	2018
Bromus inermis	introduced	2019
Bromus tectorum	introduced	2018
Carduus nutans	introduced	2016
Carduus nutans	introduced	2017
Carduus nutans	introduced	2018
Carex	native	2016
Carex	native	2018
Carex brevior	native	2018
Carex brevior	native	2019
Carex emoryi	native	2019
Carex nebrascensis	native	2018
Carex occidentalis	native	2018
Carex pellita	native	2019
Centaurea diffusa	introduced	2018
Cercocarpus montanus	native	2018
Chamerion angustifolium	native	2018
Chenopodium album	introduced	2016
Chenopodium album	introduced	2017
Chenopodium leptophyllum	native	2016
Chenopodium simplex	native	2016
Cirsium arvense	introduced	2016
Cirsium arvense	introduced	2017
Cirsium arvense	introduced	2018
Cirsium arvense	introduced	2019
Cirsium vulgare	introduced	2016
Clematis ligusticifolia	native	2016
Clematis ligusticifolia	native	2017
Clematis ligusticifolia	native	2018
Clematis ligusticifolia	native	2019
Conium maculatum	introduced	2016
Conium maculatum	introduced	2017
Conium maculatum	introduced	2018

Conium maculatum	introduced	2019
Convolvulus arvensis	introduced	2018
Conyza canadensis	introduced	2016
Conyza canadensis	introduced	2018
Cornus sericea	native	2016
Cornus sericea	native	2018
Cornus sericea	native	2019
Crataegus erythropoda	native	2016
Crataegus erythropoda	native	2018
Cynoglossum officinale	introduced	2016
Dactylis glomerata	introduced	2016
Dactylis glomerata	introduced	2017
Dactylis glomerata	introduced	2018
Dactylis glomerata	introduced	2019
Descurainia sophia	introduced	2018
Elaeagnus angustifolia	introduced	2018
Eleocharis palustris	native	2016
Eleocharis palustris	native	2017
Eleocharis palustris	native	2018
Eleocharis palustris	native	2019
Elymus elymoides	native	2017
Elymus repens	introduced	2016
Elymus repens	native	2018
Elymus repens	native	2019
Epilobium ciliatum	native	2016
Epilobium ciliatum	native	2017
Epilobium ciliatum	native	2018
Epilobium ciliatum	native	2019
Equisetum arvense	native	2016
Equisetum arvense	native	2018
Equisetum arvense	native	2019
Erigeron divergens	native	2016
Erigeron divergens	native	2018
Fraxinus pennsylvanica	native	2018
Galium aparine	introduced	2016
Galium aparine	introduced	2017
Galium aparine	introduced	2018
Galium aparine	introduced	2019
Geranium bicknellii	introduced	2016
Geum aleppicum	native	2016
Glyceria striata	native	2018
Helianthus annuus	native	2017
Hesperis matronalis	introduced	2018

Hesperis matronalis	introduced	2019
Humulus lupulus	native	2016
Humulus lupulus	native	2017
Humulus lupulus	native	2018
Humulus lupulus	native	2019
Hydrophyllum fendleri	native	2017
Hypericum perforatum	introduced	2016
Hypericum perforatum	introduced	2017
Hypericum perforatum	introduced	2018
Hypericum perforatum	introduced	2019
Juncus	native	2016
Juncus	native	2018
Juncus arcticus	native	2019
Juncus compressus	native	2018
Juncus compressus	native	2019
Juniperus scopulorum	native	2018
Lactuca serriola	introduced	2016
Lactuca serriola	introduced	2017
Lactuca serriola	introduced	2018
Lemna minor	native	2018
Leonurus cardiaca	introduced	2018
Lepidium campestre	introduced	2016
Lepidium campestre	introduced	2017
Lepidium campestre	introduced	2018
Lepidium campestre	introduced	2019
Lepidium latifolium	introduced	2016
Lepidium latifolium	introduced	2018
Lepidium latifolium	introduced	2019
Leucanthemum vulgare	introduced	2016
Leucanthemum vulgare	introduced	2017
Leucanthemum vulgare	introduced	2018
Leucopoa kingii	native	2018
Leymus cinereus	native	2016
Leymus cinereus	native	2018
Leymus cinereus	native	2019
Lonicera tatarica	introduced	2018
Lonicera tatarica	introduced	2019
Lycopus americanus	native	2018
Maianthemum stellatum	native	2016
Maianthemum stellatum	native	2017
Maianthemum stellatum	native	2018
Maianthemum stellatum	native	2019
Medicago lupulina	introduced	2016

Medicago lupulina	introduced	2018
Melilotus officinalis	introduced	2016
Melilotus officinalis	introduced	2017
Melilotus officinalis	introduced	2018
Melilotus officinalis	introduced	2019
Mentha arvensis	native	2016
Mentha arvensis	native	2017
Mentha arvensis	native	2018
Mentha arvensis	native	2019
Muhlenbergia asperifolia	native	2019
Nepeta cataria	introduced	2017
Nepeta cataria	introduced	2018
Nepeta cataria	introduced	2019
Nothocalais cuspidata	native	2016
Oenothera villosa	native	2016
Oenothera villosa	native	2017
Oenothera villosa	native	2018
Oenothera villosa	native	2019
Onopordum acanthium	introduced	2016
Onopordum acanthium	introduced	2017
Onopordum acanthium	introduced	2018
Onopordum acanthium	introduced	2019
Opuntia macrorhiza	native	2018
Parthenocissus vitacea	native	2016
Parthenocissus vitacea	native	2017
Parthenocissus vitacea	native	2018
Parthenocissus vitacea	native	2019
Phalaris arundinacea	native	2016
Phalaris arundinacea	native	2017
Phalaris arundinacea	native	2018
Phalaris arundinacea	native	2019
Plantago major	introduced	2017
Plantago major	introduced	2018
Poa bulbosa	introduced	2018
Poa compressa	introduced	2016
Poa compressa	introduced	2017
Poa compressa	introduced	2018
Poa compressa	introduced	2019
Poa palustris	native	2016
Poa palustris	native	2017
Poa palustris	native	2018
Poa palustris	native	2019
Poa pratensis	introduced	2016

Poa pratensis	introduced	2018
Poa pratensis	introduced	2019
Poa trivialis	introduced	2018
Populus	native	2016
Populus	native	2017
Populus	native	2018
Populus	native	2019
Populus angustifolia	native	2017
Populus angustifolia	native	2018
Populus angustifolia	native	2019
Populus deltoides	native	2016
Populus deltoides	native	2017
Populus deltoides	native	2018
Populus deltoides	native	2019
Potentilla recta	introduced	2016
Potentilla recta	introduced	2017
Potentilla recta	introduced	2018
Potentilla recta	introduced	2019
Prunus americana	native	2016
Prunus americana	native	2018
Prunus americana	native	2019
Prunus virginiana	native	2016
Prunus virginiana	native	2017
Prunus virginiana	native	2018
Prunus virginiana	native	2019
Quercus gambelii	native	2016
Quercus gambelii	native	2018
Quercus gambelii	native	2019
Ranunculus macounii	native	2016
Ranunculus macounii	native	2017
Ranunculus macounii	native	2018
Ranunculus macounii	native	2019
Ribes americanum	native	2018
Ribes aureum	native	2016
Ribes aureum	native	2017
Ribes aureum	native	2018
Ribes aureum	native	2019
Rosa arkansana	native	2016
Rosa arkansana	native	2017
Rosa arkansana	native	2019
Rosa woodsii	native	2018
Rubus idaeus	native	2016
Rubus occidentalis	introduced	2018

Rubus occidentalis	introduced	2019
Rumex acetosella	introduced	2016
Rumex crispus	introduced	2016
Rumex crispus	introduced	2017
Rumex crispus	introduced	2018
Rumex crispus	introduced	2019
Salix amygdaloides	native	2016
Salix amygdaloides	native	2017
Salix amygdaloides	native	2018
Salix amygdaloides	native	2019
Salix exigua	native	2016
Salix exigua	native	2017
Salix exigua	native	2018
Salix exigua	native	2019
Salix irrorata	native	2016
Salix irrorata	native	2017
Salix irrorata	native	2018
Salix irrorata	native	2019
Saponaria officinalis	introduced	2016
Saponaria officinalis	introduced	2018
Saponaria officinalis	introduced	2019
Schedonorus arundinaceus	introduced	2016
Schedonorus arundinaceus	introduced	2019
Schoenoplectus tabernaemontani	native	2019
Secale cereale	introduced	2018
Silene latifolia	introduced	2017
Silene latifolia	introduced	2018
Silene latifolia	introduced	2019
Solidago canadensis	native	2016
Solidago canadensis	native	2018
Solidago canadensis	native	2019
Solidago gigantea	native	2019
Sonchus asper	introduced	2018
Symphoricarpos occidentalis	native	2016
Symphoricarpos occidentalis	native	2017
Symphoricarpos occidentalis	native	2018
Symphoricarpos occidentalis	native	2019
Taraxacum officinale	introduced	2016
Taraxacum officinale	introduced	2017
Taraxacum officinale	introduced	2018
Taraxacum officinale	introduced	2019
Thlaspi arvense	introduced	2016
Thlaspi arvense	introduced	2017

Thlaspi arvense	introduced	2018
Toxicodendron rydbergii	native	2016
Tragopogon dubius	introduced	2018
Tragopogon dubius	introduced	2019
Trifolium hybridum	introduced	2017
Trifolium pratense	introduced	2018
Trifolium repens	introduced	2016
Trifolium repens	introduced	2018
Ulmus pumila	introduced	2017
Ulmus pumila	introduced	2018
Ulmus pumila	introduced	2019
Urtica dioica	native	2016
Urtica dioica	native	2018
Urtica dioica	native	2019
Verbascum thapsus	introduced	2017
Verbascum thapsus	introduced	2018
Verbascum thapsus	introduced	2019
Veronica anagallis-aquatica	native	2016
Veronica anagallis-aquatica	native	2017
Veronica anagallis-aquatica	native	2018
Vitis riparia	native	2016
Vitis riparia	native	2018
Vitis riparia	native	2019
Xanthium strumarium	introduced	2017

Appendix 2: Water quality and stream metrics for Deer Creek monitoring 2016-2019