CASM ENVIRONMENTAL, LLC

Community Science in Johnson Creek Watershed: Dragonfly & Damselfly Monitoring

Final Report for 2022

Twelve-spotted Skimmer (Libellula pulchella), Sunset Village, Gresham; CASM Environmental

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Summary

CASM Environmental worked with Johnson Creek Watershed Council (JCWC) in 2022 to continue a community science program monitoring odonates (dragonflies and damselflies) at four sites in the Johnson Creek watershed. This was the 6th year of monitoring at Centennial (Mitchell Creek; 11 survey dates), the 7th year at Brookside Wetland (Johnson Creek; 13 survey dates), and the 1st year at two constructed stormwater pond sites in Gresham: Tegart and Ponza Ponds (Kelley Creek; 12 survey dates) and Sunset Village (13 survey dates). Westmoreland Park was dropped in 2022 in order to add new sites further up in the watershed. Due to concerns about coronavirus, a hybrid training was held on 11 June 2022 (in-person and virtual), with all participants masked; a field session at Tegart/Ponza followed. Surveys were conducted between 19 June and 16 October, 2022. A total of 280 observations was reported among all sites, with 21 identified species (16 dragonfly, 5 damselfly). This is more than double the number of total observations compared to 2021, but the total number of species is similar to prior years (18-23 species/yr).

The 2022 flight season was somewhat compressed, as a cold wet spring delayed the onset of flight activity and a hot dry summer reduced available habitat at some sites by early August. Poor air quality from smoke in late summer also impacted odonate flight activity. Species richness varied, and differed from earlier sampling years at sites that were monitored for multiple years. Centennial had fewer species (13) than any site in 2022, which is in sharp contrast to the 19 species seen in 2021 following habitat restoration. Richness at Brookside (16 species) was the lowest of any monitoring year at the site. Tegart/Ponza and Sunset Village had greater richness (18 and 21 species, respectively) and higher single-day species counts than the other sites. No new species were added to the project list in 2022. However, it was only the 2nd year in which Saffron-winged Meadowhawk (*Sympetrum costiferum*) and Spot-Winged Glider (*Pantala hymenaea*) were recorded, both at Sunset Village. Abundance and distribution of Striped Meadowhawk (*Sympetrum pallipes*) and California Spreadwing (*Archilestes californicus*) were also higher overall in 2022. Both of the meadowhawk species and the spreadwing have adaptations for drying, and our recent years of drier, hotter weather may be favoring species that are not as reliant on open water for laying eggs.

Although local environmental conditions are similar, habitat-driven differences in odonate communities are evident among sites. Lower richness at Brookside in recent years reflects reduced habitat suitability; in earlier years, the site had open water and fringing vegetation that attracted local species, but in recent years water levels are lower and by mid-summer in 2022 large portions were reduced to cracked mud or filled in with vegetation. Richness at Centennial has varied more annually, reflecting the physical changes that occurred. Restoration initially saw increased odonate abundance and richness, but Centennial is now experiencing summertime wetland drying, dense plant overgrowth of the creek, and mowing in the adjacent upland, which reduces available habitat. The new monitoring sites, which are stormwater ponds of varying ages and size, retained water throughout the season and provided more heterogeneous habitat. This project demonstrates that even disturbed urban wetlands can support a variety of regionally common odonate species and occasionally host rarer species, but some degree of maintenance is needed to ensure the habitat does not become less attractive or unable to support odonate development.

Background

This report summarizes data from a long-term odonate (dragonfly and damselfly) community science monitoring project at four sites in the Johnson Creek watershed: Brookside Wetlands (Johnson Creek; year 7 of monitoring); Centennial Pond (Mitchell Creek; year 6 of monitoring); Tegart & Ponza Ponds (Kelley Creek; year 1 of monitoring); and Sunset Village (year 1 of monitoring). Surveys were done during the majority of the flight season by volunteer teams trained by CASM Environmental. Community science, i.e. collaborative projects between scientists, natural resource organizations, and volunteers, can provide multiple benefits including increased community engagement in conservation, enhanced scientific knowledge among participants, increased support for organizational missions, enhanced data gathering, and novel scientific discoveries (Cohn, 2008; Bonney et al., 2009; Dickinson et al., 2010; Bela et al., 2016; Haywood et al., 2016; Lewandowski & Oberhauser, 2017). Although data quality varies (Fore et al., 2001; Gardiner et al., 2012; Moffett & Neale, 2015; Freitag et al., 2016; Burgess et al., 2017), projects that combine a standardized protocol, trained volunteers, and expert oversight can produce high-quality data for use in conservation and management (Pocock et al., 2014; Brown & Williams, 2019; Pernat et al., 2021).

Odonates are useful indicators of human disturbance in freshwater habitats because stressors such as habitat fragmentation and degradation can cause shifts in local community composition (Foote & Rice-Hornung, 2005; Smith et al., 2007; Ball-Damerow et al., 2014; Barbosa de Oliveira Jr., et al., 2015; Rodrigues et al., 2016; Villalobos-Jiménez et al., 2016; Assandri, 2021). Additionally, distributions of different species are expected to change as a result of climate change, and range shifts have already been observed in some species in Europe and North America (Bracken & Lewis, 2002; Sanchez-Guillén et al., 2013; Ball-Damerow et al., 2014; Johnson, 2017). Projects such as this that involve longterm monitoring at designated sites are needed to reveal community shifts that reflect changes occurring in the habitat over time.

Methods

Survey sites

Monitoring site locations are shown in Appendix A. It was decided to drop Westmoreland Park, which was monitored from 2016-2021, in favor of adding new sites higher up in the watershed. This enabled JCWC to investigate potentially different odonate populations and to engage volunteers who had not participated in the project previously. Brookside Wetland is located off SE 110th Drive and SE Brookside Drive in Portland (45.475269°, -122.545208°). This site is in small park in a residential neighborhood and is managed by Portland Bureau of Environmental Services as a flood mitigation project and to protect salmonid habitat in Johnson Creek. The overflow pond, when filled, is about 4600 m^2 and connects to Johnson Creek; it consists of two excavated areas that are divided by an earthen berm at lower water levels. In 2022, this berm was heavily planted with small trees; by the end of the summer, it was also invaded by an abundance of Tree of Heaven saplings.

Centennial Pond is located off SE Foster Road near SE 172nd Ave., close to the Portland/Gresham border (45.466193°, -122.491304°) on land owned by Centennial School District. This site was created 40 years ago as a one-acre inline pond in Mitchell Creek, when the owner built a dirt racing track. JCWC restored a 900 ft. reach in 2019 by removing two culverts installed where the track crossed the creek, dewatering the pond, and restoring stream flow. The pond persists as a small vegetated wetland (~1000 m^2 at high water) to which log structures were added, and the narrow creek is rocky and well-vegetated, including encroaching reed canary grass.

Sunset Village is located off SW Phyllis Ave. and SW Duniway Lane in Gresham (45.468089°, -122.473517°). It is a large (about 6500 m^2) and fairly new (~1.5 years) constructed stormwater pond in an extensive single-unit housing development that is still undergoing active construction. The water is shallow enough (<12 in.) to permit wading throughout the season. The site was completely open water in spring and early summer, but as summer progressed it became a patchwork of open water and emergent and floating vegetation (mostly native).

Tegart Pond is a more established (7 yrs old) constructed stormwater wetland in a relatively new large housing development off SW Tegart Lane, between the neighborhood and Kelley Creek. It is formally known as the Brookside Regional Water Quality Facility but was given an alternative name for this project to avoid confusion with the established Brookside site in Portland. The wetted area covers about 1500 m^2 at high water, but during the summer water levels drop, vegetation fills in, and the remaining shallow open water is confined to the western end.

Survey techniques

Odonate flight season in the Portland area encompasses early May through early or mid-November, though it varies annually depending on temperature, precipitation, and conditions such as wildfires, windstorms, or heat waves. CASM Environmental conducted a scoping visit on 24 May 2022 with staff from JCWC and City of Gresham to investigate the suitability of the Gresham stormwater ponds for monitoring, although the delay in odonate flight activity due to a cold wet spring meant that no odonates were seen. Volunteer surveys began in mid-June and were scheduled for every 14 days, though dates shifted due to weather conditions and surveyor availability.

Due to ongoing concerns about COVID-19, a hybrid training was held on 11 June 2022, with all participants masked and some attending online; a field session at Tegart/Ponza immediately followed. Volunteers learned about odonate life history and identification, and how to conduct surveys and report their data. Surveyors signed out nets and field guides (Kerst & Gordon, 2011) from JCWC and kept them for the season. A GoogleDocs spreadsheet was used for team sign-ups. Surveys were done when conditions were suitable for odonate activity (Table 1). Surveyors walked transects along the water's edge, scanning the water, vegetation, and adjacent uplands. Voucher photos of perched or in-hand specimens were encouraged. The survey start and end time, weather conditions (sun, cloud cover, wind, temperature), and species seen were recorded. For each species, the following were noted:

- identification method(s): visual, captured, photographed
- gender: male, female, unknown
- abundance category: Uncommon (1-4 individuals); Frequent (5-20), common (21-100); Abundant (>100)

- reproductive stage: wheel (W; mating pair), tandem pair (TP: male holding female but not engaged in copulation), ovipositing (O; laying eggs), and teneral adult (TA; newly-emerged)

All data were entered into the iNaturalist project *Dragonfly Surveys in Johnson Creek Watershed* (www.inaturalist.org/projects/dragonfly-surveys-in-johnson-creek-watershed), where identifications were vetted by CASM Environmental and the iNaturalist user community. CASM conducted monthly QA surveys to compare data from volunteer and expert surveys.

Table 1. Decision matrix for odonate surveys.

	10:00 am - 4:00 pm			9:30 am - 4:30 pm	
Temperature	<59°F (15°C)	59-65°F (15-18°C)	65-75°F (18-24°C)	>75°F (24°C)	>88°F (31°C)
Cloud cover >60%	No	No	Yes	Yes	No
Cloud cover <60%	No	Yes	Yes	Yes	No
Moderate to strong wind (tree branches swaying)	No	No	No	No	No
Raining	No	No	No	No	No

Data analysis

Non-metric multidimensional scaling (nMDS) ordinations and Jaccard similarity indices were done using PAST software (Hammer et al., 2001). The Jaccard index is calculated on species presence/absence matrices and compares members in two sets to determine which are shared or distinct; index values range from 0 (no species in common between two samples) to 1 (identical species composition between two samples).

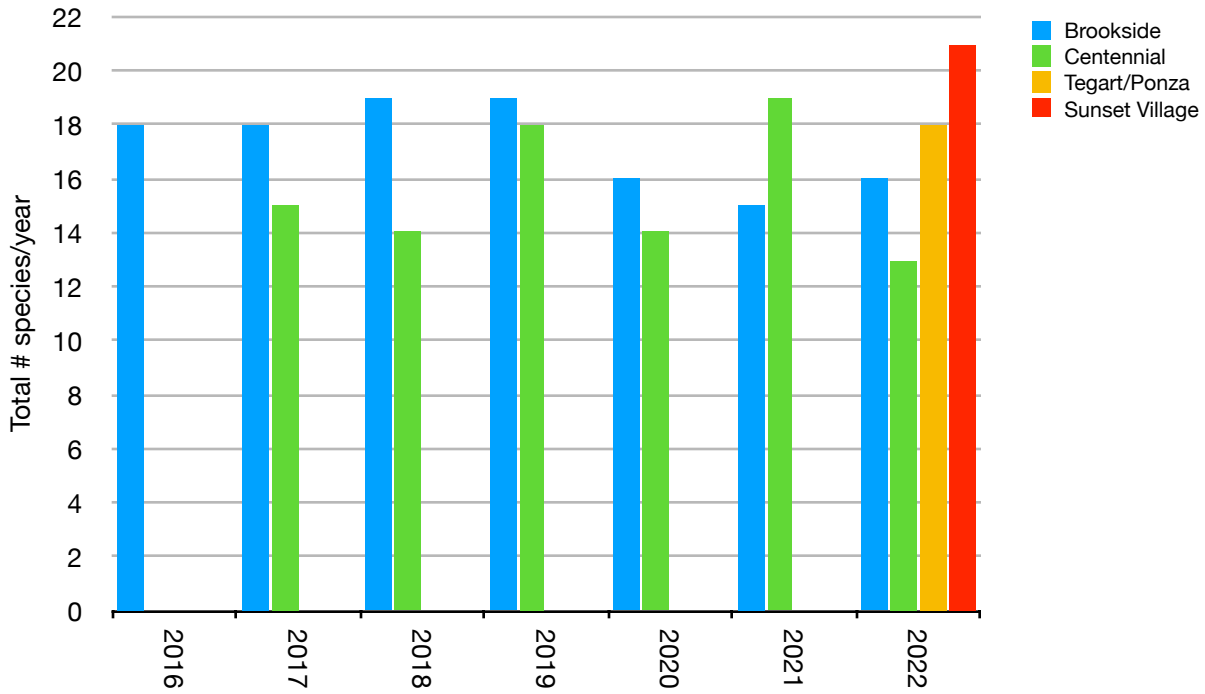
Results

Species richness

Surveys were conducted between 19 June and 16 October 2022. A total of 280 observations was reported among all sites across 11 dates at Centennial (31 observations), 13 dates at Brookside (57 observations), 13 dates at Sunset Village (112 observations), and 12 dates at Tegart/Ponza Ponds (80 observations). Although this represents 65% more total observations than in 2021, the number of species reported among all sites in 2022 (21 species; 16 dragonfly, 5 damselfly) was within the range seen in prior years (18-23 species/year). The most species recorded in a single site visit was 15 at Sunset Village on 22 August, which exceeds the highest single-day species total in any other year or site; a survey on the same date at Tegart/Ponza found 14 species. In contrast, there were days at

Brookside and Centennial when no odonates were seen, despite suitable survey conditions. Similarly, more total species were observed throughout the season at Sunset Village (21) and Tegart/Ponza (18) than at Brookside (16) or Centennial (13; Figure 1).

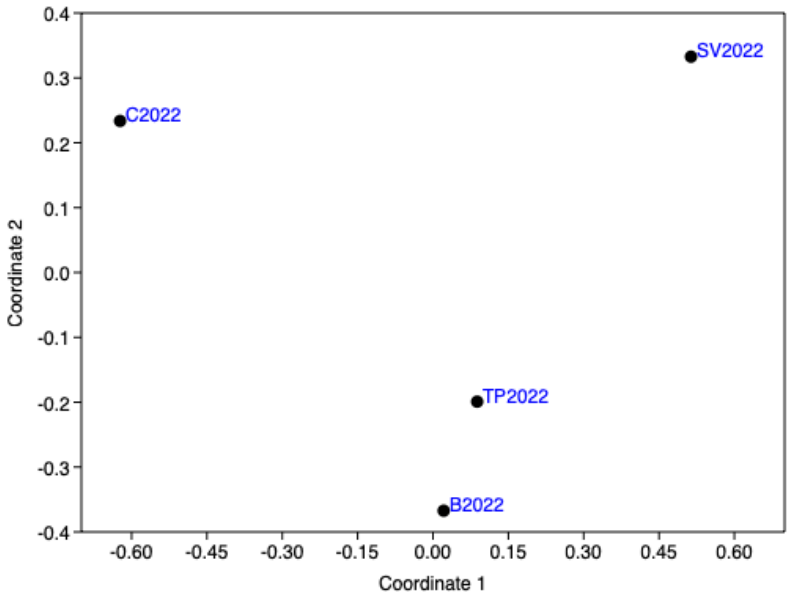
Figure 1. Total number of odonate species reported in each year among survey sites. Monitoring did not begin until 2017 at Centennial and 2022 at Tegart/Ponza and Sunset Village.



Because many odonates at these sites are common cosmopolitan species that can thrive in urbanized areas, community similarity between sites and years is generally high (i.e., Jaccard index >0.50), but community composition does differ. Despite their relatively close proximity (~0.25 miles) and overall higher species richness, the community at Tegart/Ponza was more similar to Brookside (Jaccard index = 0.941) than to Sunset Village, although there was still substantial overlap (Jaccard index = 0.772). Not surprisingly, the communities at the most rich (Sunset Village) and least rich (Centennial) sites in 2022 had the lowest community similarity (Jaccard index = 0.619; Figure 2).

No new species were added to the project list in 2022 (see Appendix B for full species list). However, it was only the 2nd year in which Saffron-winged Meadowhawk (*Sympetrum costiferum*) and Spot-Winged Glider (*Pantala hymenaea*) were recorded, both at Sunset Village. Seven species have been found at all sites in every year, including 2022: *Anax junius* (Common Green Darner), *Sympetrum illotum* (Cardinal Meadowhawk), *Libellula forensis* (Eight-spotted Skimmer), *Plathemis lydia* (Common Whitetail), *Rhionaeschna multicolor* (Blue-eyed Darner), *Ischnura cervula* (Pacific Forktail), and *Enallagma carunculatum* (Tule Bluet).

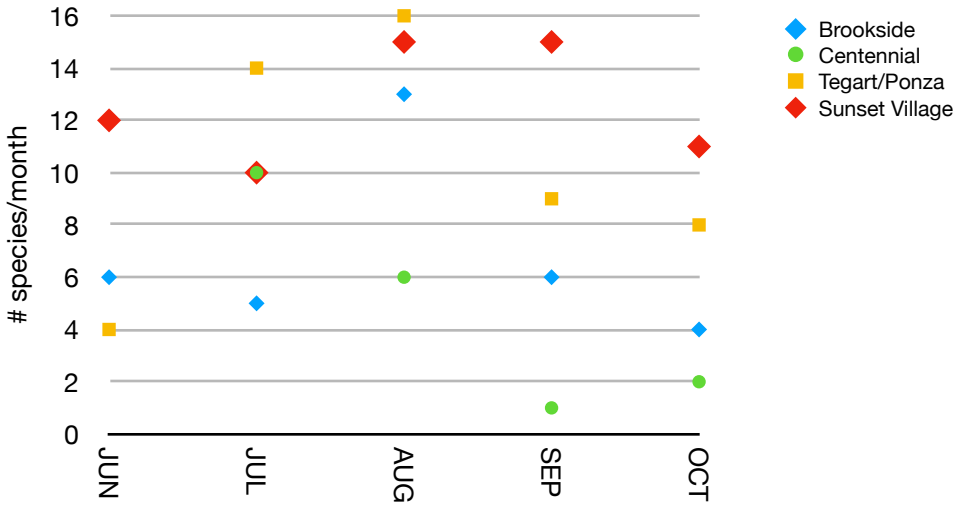
Figure 2. nMDS ordination of a presence./absence matrix of odonate species occurring among all 2022 monitoring sites. Sites closer together in ordinal space have greater community similarity.



Seasonality and abundance

The most frequently-observed species were Common Whitetail (*Plathemis lydia*, observed on 26 dates among all sites), Pacific Forktail (*I. cervula*; observed on 23 dates among all sites), and Cardinal Meadowhawk (*S. illotum*; observed on 22 days among all sites). In 2022 as in prior years, the greatest number of species was seen in July and August (Figure 3). Sunset Village and Tegart/Ponza generally had the most species in each month throughout the survey season, while Centennial had the fewest from August through October.

Figure 3. Total number of odonate species reported monthly at 2022 monitoring sites.



The weather in 2022 was characterized by a cold wet spring and hot dry summer. In 2022, average monthly temperatures were lower in April and May and higher in August through October compared to any prior monitoring year (Figure 4). Similarly, total monthly precipitation in April and May was greater in 2022 than in any other monitoring year, and lower in September and October than in any other year except 2019 (Figure 5). The first half of October also saw smoky haze and poor air quality due to the Nakia fire in Clark County, Washington.

Figure 4. Average monthly temperature (F) in Portland, 2016-2022. Data taken from NOAA monthly weather summaries at Portland International Airport (http://w2.weather.gov/climate/index.php?wfo=PQR).

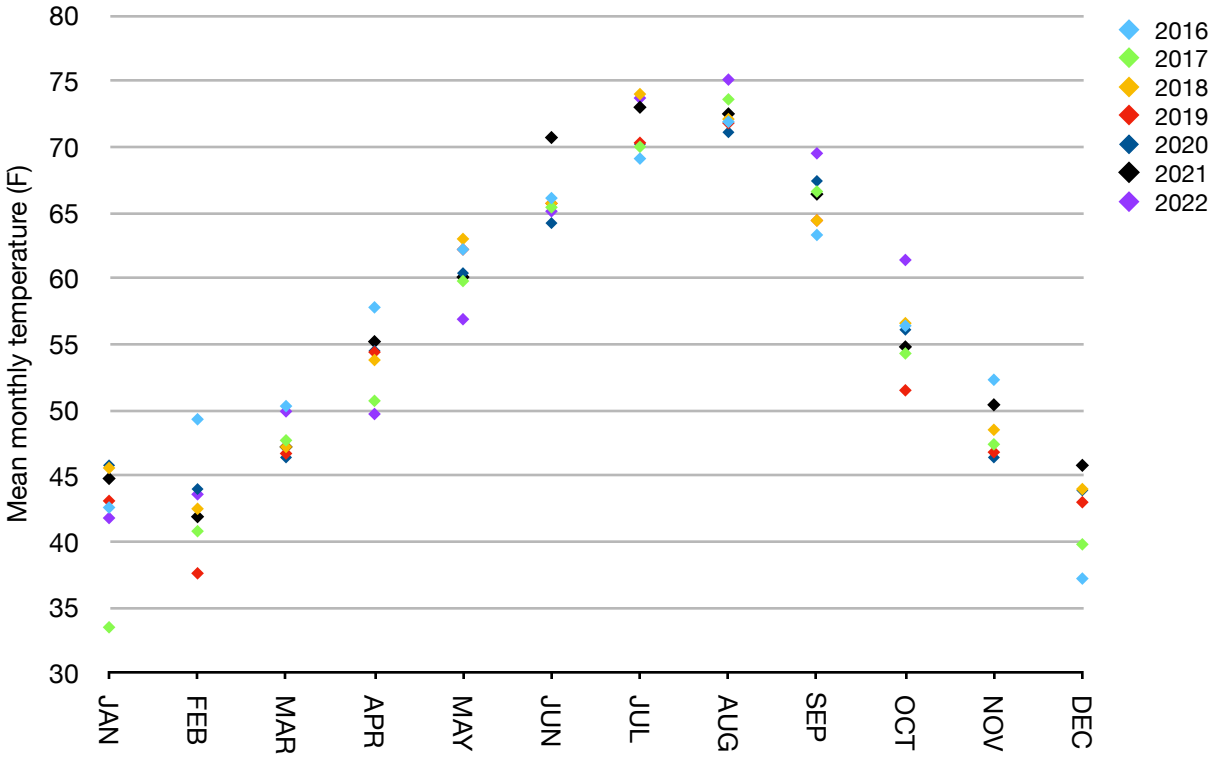
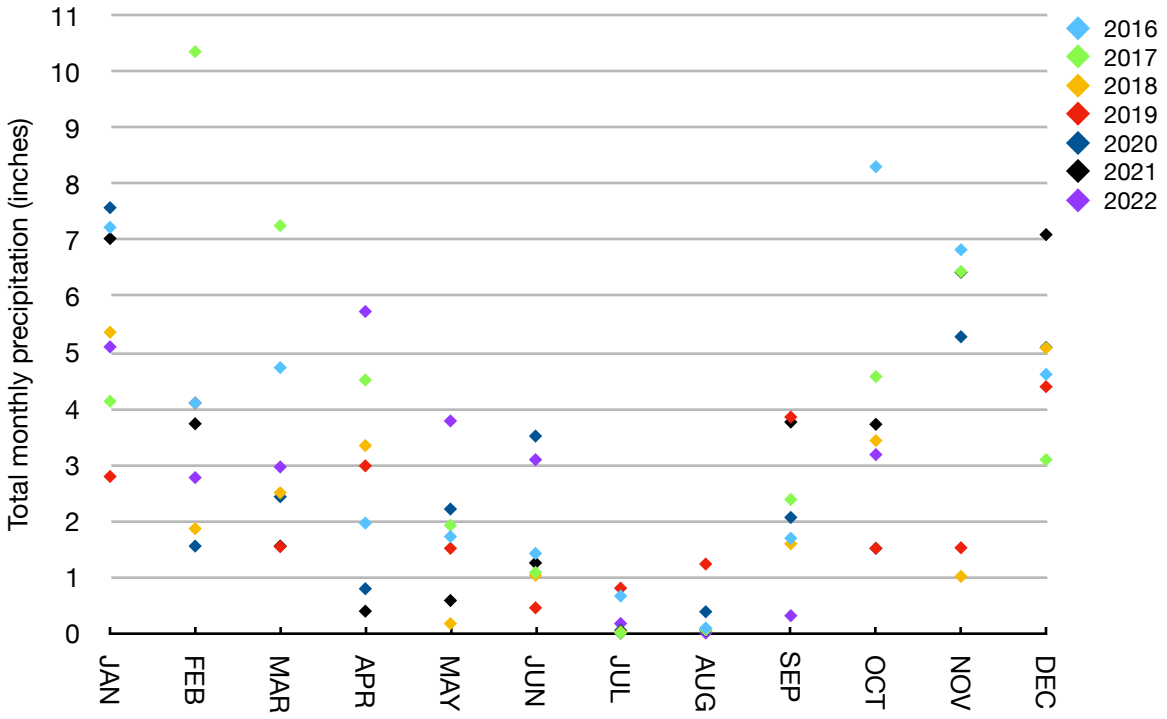


Figure 5. Total monthly precipitation (inches) in Portland, 2016-2022. Data taken from NOAA monthly weather summaries at Portland International Airport (http://w2.weather.gov/climate/index.php?wfo=PQR).



Odonate community at individual sites

Centennial

This was the 6th year of monitoring at Centennial and the 3rd following restoration of Mitchell Creek. Vegetation along the banks of the restored reach is well-established, to the extent that the narrow, shallow stream was covered in many places by overhanging forbs by mid-summer (Figure 6). Part of the inline pond that existed prior to restoration remains as a wetland, and this is where the majority of odonate activity occurs. However, the pond dried to a small remnant by mid-summer, with a trickle of flow from the creek passing through (Figure 6). Habitat disturbance in the buffer area appeared to be greater than usual as well, with extensive haying evident in the meadow that surrounds the site on the east. The tall vegetation that grew there in previous years was a good place for odonates to hunt and rest, and observations could often be made during the walk to and from the creek. In contrast, the short-mowed grass provides less habitat for hunting as it harbors fewer small insects, and is not suitable as a refuge.

Figure 6. Centennial survey site. Pond remnant, (left), 24 Aug. 2022; Mitchell Creek on 11 July (middle) and 20 Sept. 2022 (right).

The odonate community at this site changed with restoration, with Jaccard similarity indices ranging from 0.647-0.875 for all pairwise comparisons of the community in each year. The 2022 community had relatively lower overall similarity to all other years (Jaccard index range 0.556 - 0.722), and was most similar to the community in 2019 (Figure 7), the year in which restoration was done (Jaccard index 0.76). Thirteen species were observed across 11 survey dates in 2022 (9 dragonfly, 4 damselfly; Figure 8), the lowest number ever recorded at this site and the lowest among all sites in 2022. This is in sharp contrast to 2021, when 19 species were seen, the most ever recorded at the site. There were also fewer species found in August through October in 2022 than in any prior year at the site (Figure 9).

Figure 7. nMDS ordination of a presence/absence matrix of odonate species occurring annually at Centennial. Years closer in ordinal space have greater community similarity.

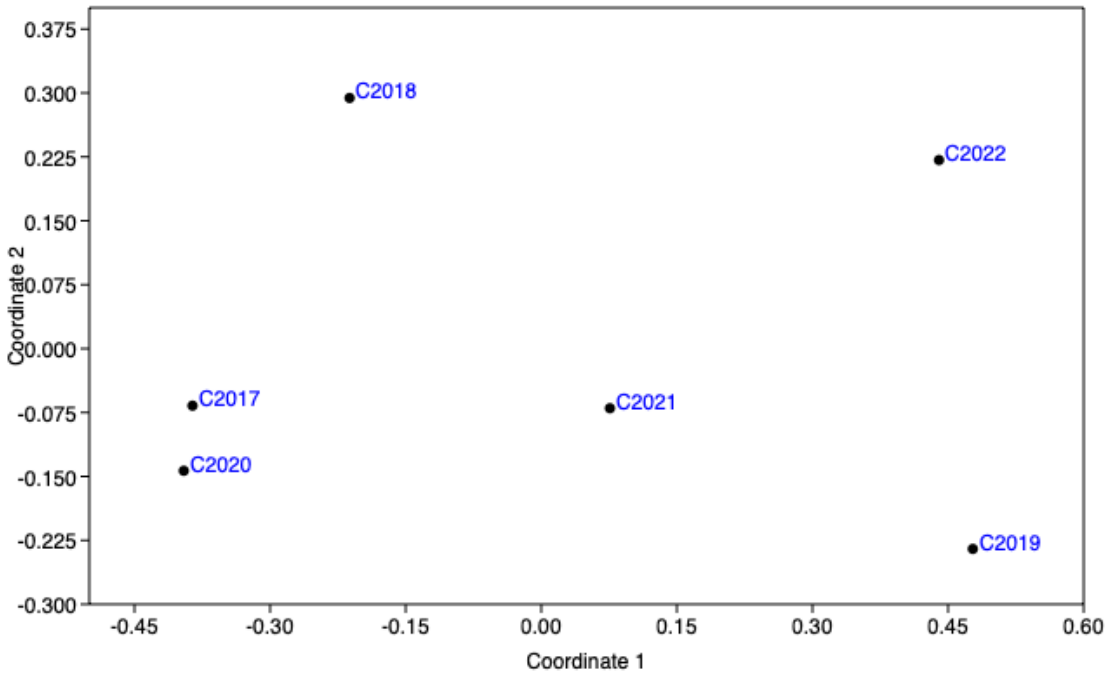


Figure 8. Odonate seasonality and abundance at Centennial in 2022. Height of each individual stacked bar shows abundance category: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). Asterisks indicate QA surveys by CASM Environmental.

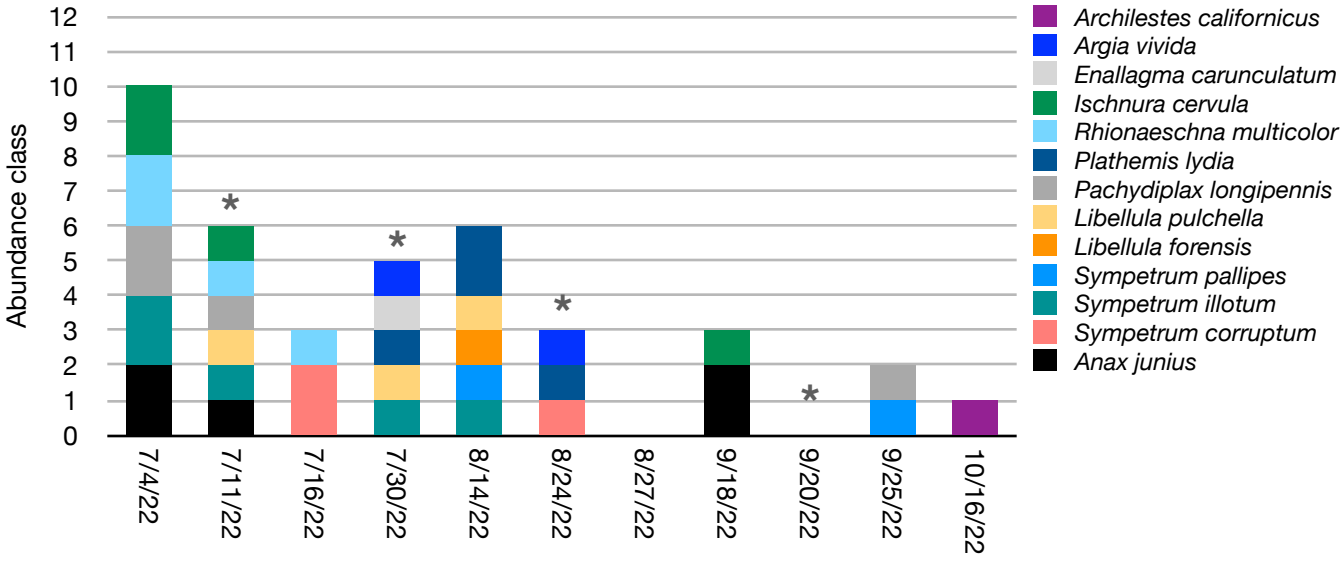
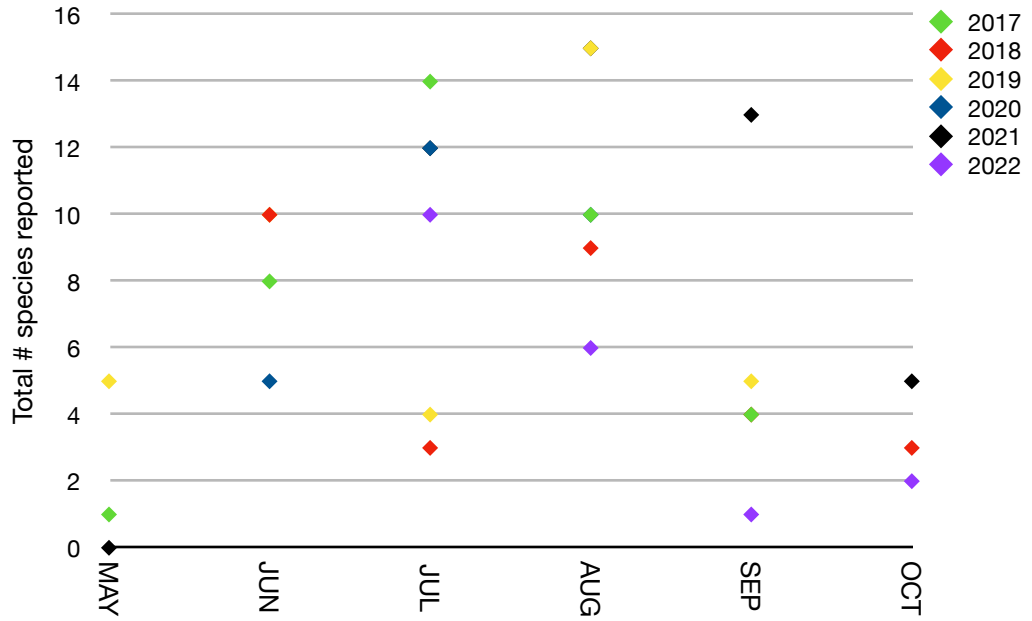


Figure 9. Total number of species observed in each month at Centennial across all survey years.



All species sighted in 2022 were found at the site in at least one prior year, but *Ischnura perparva* (Western Forktail), which had been seen consistently from 2017-2021, was not present. This species lays eggs in floating patches of thick algae and there was little of this habitat in 2022, as the wetland remnant was either dry or full of emergent vegetation. In addition, Vivid Dancer (*Argia vivida*), a damselfly that became particularly abundant and ubiquitous following restoration, was sighted on just a single survey date at the end of the season. This species likes to perch on sunny cobbles in flowing water and was strongly associated with the restored stream reach, but vegetative growth has largely surrounded and shaded these cobbles. Also, for the first time since monitoring began here, there were two dates on which no odonates were seen. One of the zero odonate surveys was done by CASM, and CASM survey results generally agreed with volunteer surveys throughout the season, so this absence is unlikely to be due to observer error, especially since there were only 2-3 species seen on the surrounding dates (Figure 8).

The most frequently observed dragonfly species was Cardinal Meadowhawk (*S. illotum*), which was reported on 36% of survey dates at the site; Pacific Forktail (*I. cervula*) was the most frequently observed damselfly (27% of survey dates). However, no species abundances greater than Frequent (5-20 individuals) were ever reported, in contrast to prior years when single-date abundances of individual species reached Common (21-100). Two of North America's migratory dragonfly species were observed at Centennial from July through September. Common Green Darner (*A. junius*) was seen in early July and again in late September, which suggests the presence of migrants passing through as opposed to resident individuals. Variegated Meadowhawk (*S. corruptum*) was also seen on a single date each in mid-July and late August. No mating or ovipositing behavior was noted for either species, and teneral adults were not seen. Black Saddlebags (*Tramea lacerata*), which likes to patrol over and lay eggs in open water, was not found in 2022, although it was present in four of the five prior monitoring years at the site. Thus, it appears migrants did not use the site for breeding in 2022.

Brookside Wetlands

This was the 7th year of monitoring at Brookside. During the pandemic, use of the area by the houseless population increased and trash and human feces occurred in the wetland margins. However, many of these encampments appear to have been cleared out, although there is still heavy neighborhood use and low to moderate levels of trash in the wetland margins. The main physical changes at the site are annual mid-summer mowing of the large grassy area adjacent to the wetland, and varying water levels, often due to beaver dams being established and blown out, but Portland BES is planning restoration to improve flood mitigation and lower water temperatures in the pond. An early part of this work appeared to include planting a double row of small trees/live stakes in 2022 along the existing berm that divides the pond into two sections (Figure 10), but no in-water work was done. Water levels were extremely low throughout the season, with one pond drying completely by mid- to late summer. The planted berm was also invaded by an abundance of Tree of Heaven saplings by early fall.

Figure 10. Brookside wetland, 28 July (left) and 24 August 2022 (right). Arrows indicate double line of tree plantings on the berm separating the two ponded areas. Note extremely low water conditions.

Community composition varied annually across a wider range at Brookside compared to Centennial, with Jaccard similarity indices ranging from 0.522-0.833 for all pairwise comparisons. The 2022 community was most similar to 2017 and least similar to the 2021 community (Jaccard Index = 0.833 and 0.632, respectively; Figure 11). Sixteen species were observed across 13 survey dates in 2022 (11 dragonfly, 5 damselfly; Figure 12), which is similar to the numbers seen in recent years (15-16 species in 2020-2021) although still lower than when monitoring began. Because this site had higher richness in earlier monitoring years (18-19 species in 2016-2019), it was hypothesized that a reduced number of surveys during the COVID pandemic may have been responsible for the decrease in species. However, a similar number of surveys was made among all sites in 2022, and there were three more survey days at Brookside in 2022 compared to 2021. Fewer species were found here during July than in July of any prior year, and species numbers were also low in June and September (Figure 13).

Figure 11. Non-metric MDS ordination of a presence/absence matrix of odonate species occurring annually at Brookside. Years closer in ordinal space have greater community similarity.

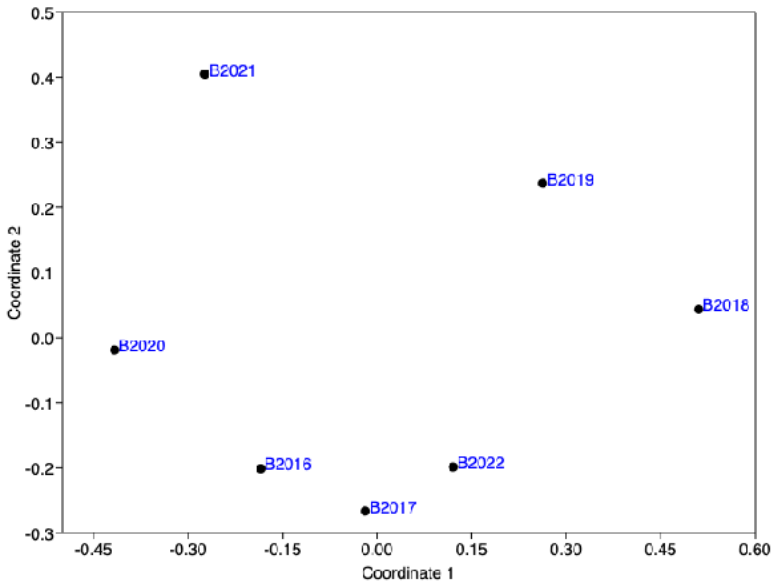


Figure 12. Odonate seasonality and abundance at Brookside in 2022. Height of each individual stacked bar shows abundance category: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). Asterisks indicate QA surveys by CASM Environmental.

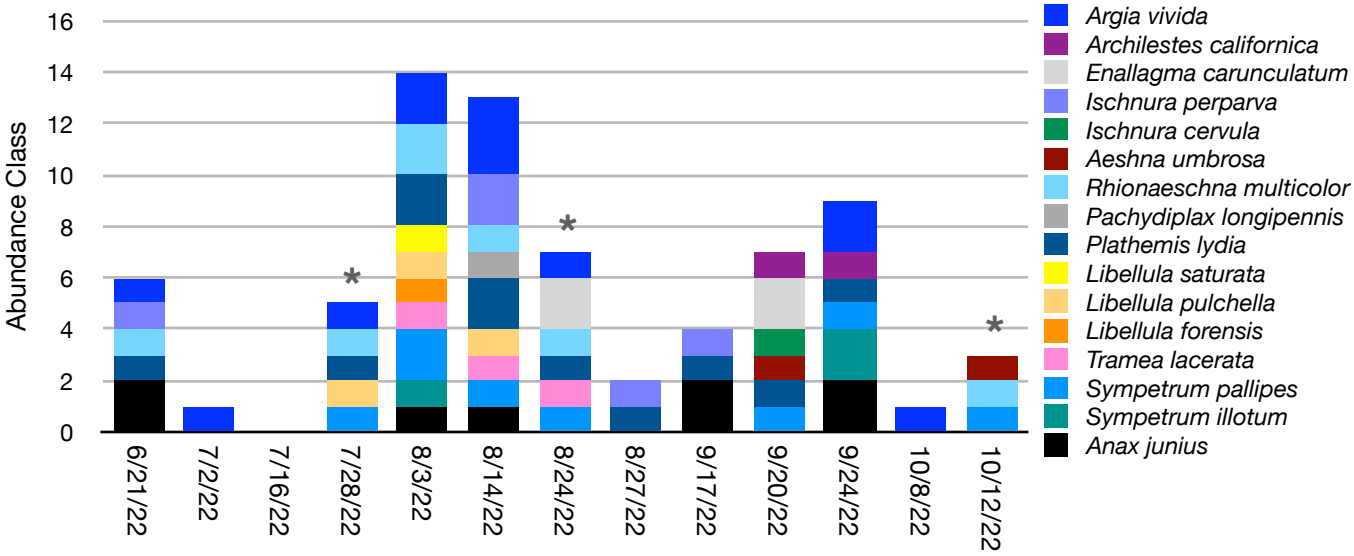
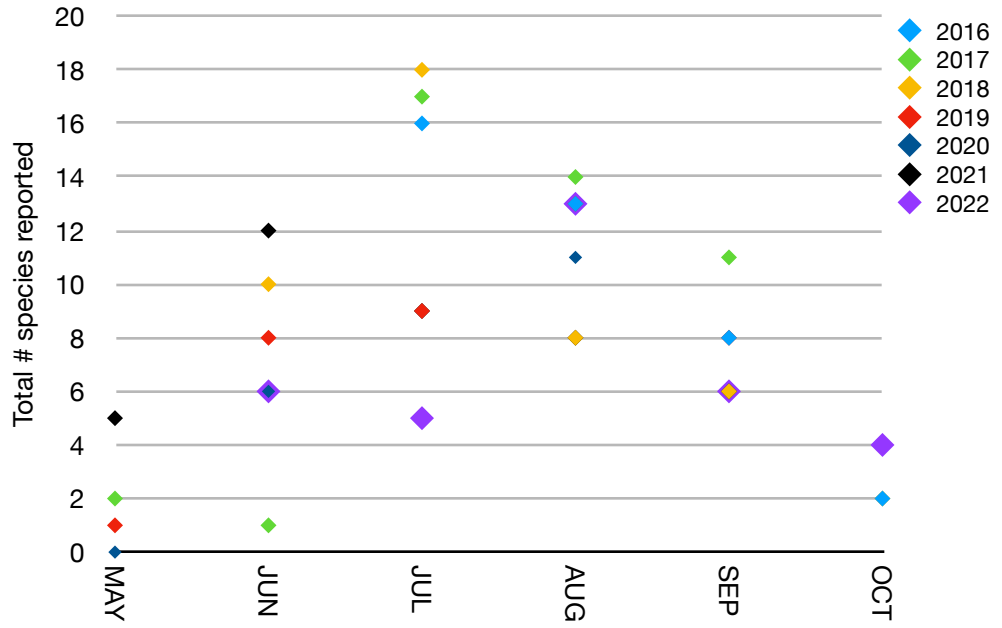


Figure 13. Total number of species observed in each month at Brookside across all survey years.



All species sighted in 2022 were also seen at the site in at least one prior year. The most frequently observed dragonfly species were Common Whitetail (*Plathemis lydia)* and Striped Meadowhawk (*Sympetrum pallipes*), reported on 69% and 54% of all survey days, respectively. The most frequently observed damselflies were Vivid Dancer (*Argia vivida*), which given its preference for moving water is likely flying in from adjacent Johnson Creek, and Western Forktail (*Ischnura perparva*), reported on 62% and 31% of all survey days, respectively. Two of North America's migratory dragonfly species were found at Brookside from June through September. Common Green Darner (*A. junius*) was present the most consistently, observed on five of the 13 survey dates, including a late June sighting of what were likely returning migrants, while Black Saddlebags were seen between August 3 and 24. No mating or ovipositing behavior was reported for either species and no teneral adults were seen, suggesting these migrants were not breeding at the site. Variegated Meadowhawk, which was present in all prior years except 2018, was not found.

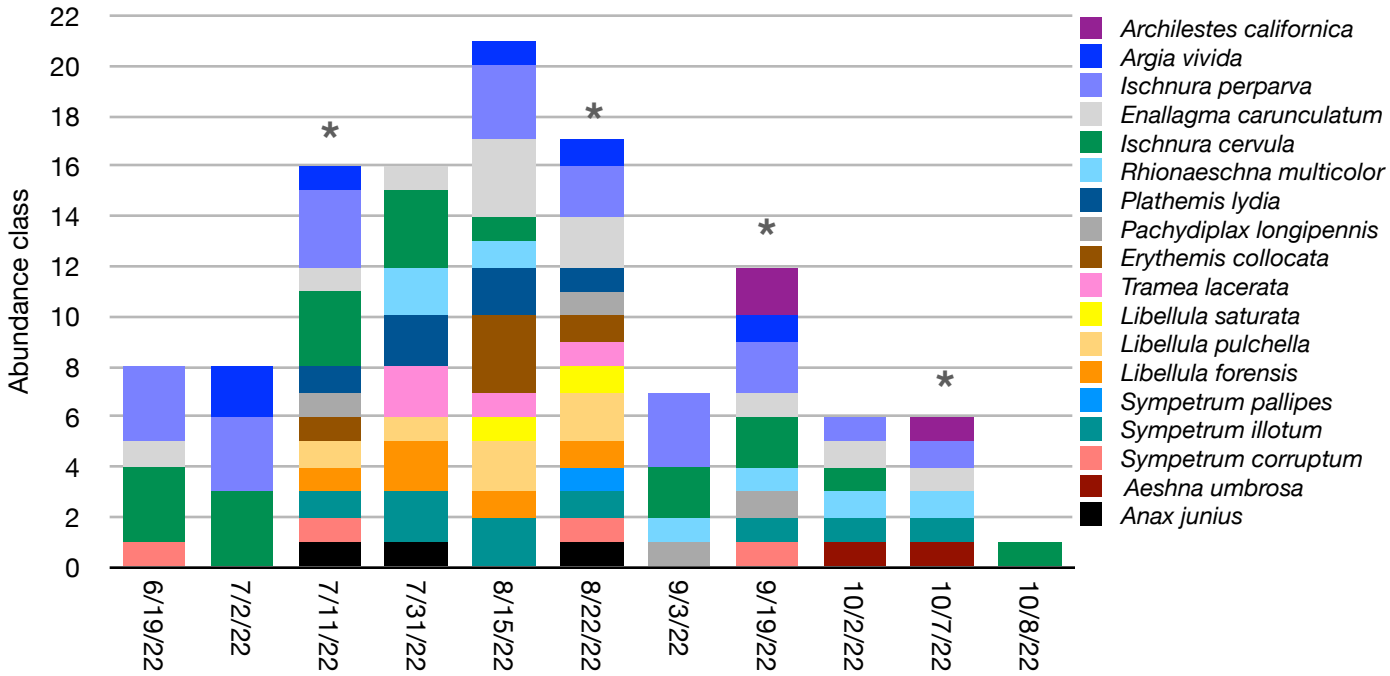
Tegart & Ponza Ponds

This was the 1st year of odonate monitoring at Tegart and Ponza ponds. Because both sites are small (~1300-1500 m^2) constructed stormwater wetlands off Kelley Creek in close proximity to each other (~300 m), it was decided to treat them as a single site and they were surveyed as a unit on each monitoring date. Tegart is also known as the Brookside Regional Water Quality Facility, but to avoid confusion with the existing Brookside site, a unique name was selected for the project. Tegart is heavily vegetated with a more open channel running through the site; by late summer, all remaining open water was at the western end of the wetland, which was very shallow and acquired a coating of algae (Figure 14). The Ponza site is divided by a berm into two ponds that were fairly unvegetated at the start of the season but filled in with emergent vegetation by summer, especially on the western side (Figure 14) where lines of sedges were planted.

Figure 14. Tegart Pond (L), and Ponza (R) ponds, 19 September 2022.

The odonate community was very similar to Brookside (Jaccard index = 0.941), although the number of species at Tegart/Ponza exceeded Brookside in every month except June (Figure 3) and the total number of species during the season was greater as well (Figure 1). However, there was also substantial overlap between Tegart/Ponza and the communities at Sunset Village (Jaccard index = 0.773) and Centennial (Jaccard index = 0.722). Eighteen species (13 dragonfly, 5 damselfly) were observed across 11 survey days in 2022, representing the 2nd highest species richness among all 2022 sites (Figure 15). All species sighted in 2022 have been found at other sites. The most frequently observed dragonfly species were Cardinal Meadowhawk (*Sympetrum illotum)* and Blue-eyed Darner (*Rhionaeschna multicolor*), reported on 64% and 55% of all survey days, respectively. The most frequently observed damselflies were Western and Pacific Forktail (*I. perparva* and *I. cervula*), both of which were reported on 82% of all survey days.

Figure 15. Odonate seasonality and abundance at Tegart/Ponza Ponds in 2022. Height of each individual stacked bar shows abundance category: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). Asterisks indicate QA surveys by CASM Environmental.



Three of North America's migratory dragonfly species were seen at Tegart/Ponza from June through September. Variegated Meadowhawk (*S. corruptum*) appeared earliest (19 June) and was sighted on four dates. Common Green Darner (*A. junius*) and Black Saddlebags (*T. lacerata*) were each sighted on three dates between July and September. Data suggest that the site supports egg to adult development for at least for two of the migratory species; the Variegated Meadowhawks seen in June were likely migrants from the south, and the presence of teneral adults on 22 August indicates successful breeding. Tandem pairs of Black Saddlebags were reported on July 31; oviposition occurs soon after mating, so their eggs were likely laid at the site.

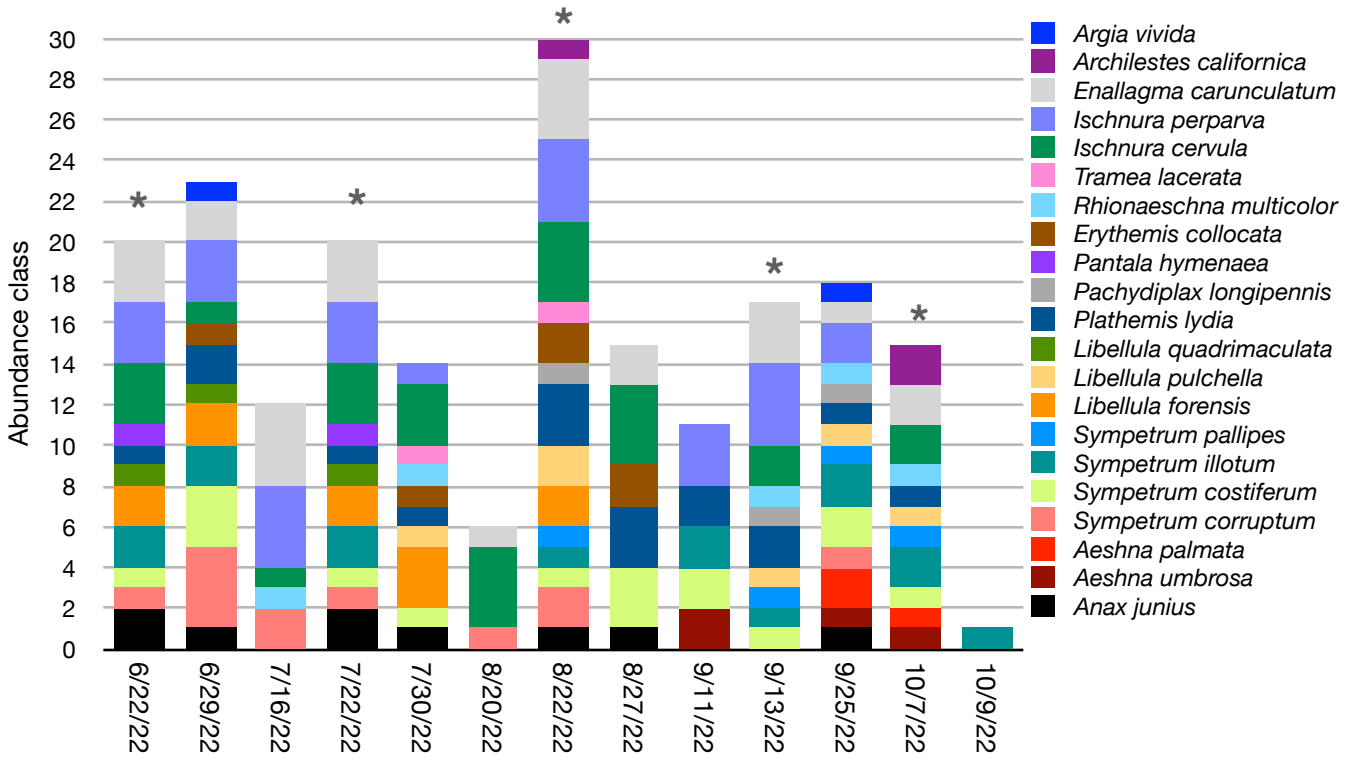
Sunset Village

This was the 1st year of odonate monitoring at Sunset Village, a large (~6500 m^2) stormwater wetland in a residential development where houses are still being actively built. The site was largely unvegetated early in the season, but filled in by mid-summer with an abundance of floating and emergent vegetation, including many native species (Figure 16). The water, which was augmented by sprinkler runoff during the summer (CASM, pers. obs.), remained shallow enough that the entire site was accessible via wading. The large size and heterogeneous habitat, with patches of dense vegetation, open water, and floating algae, made this site ideal for odonates, despite the presence of large numbers of Pacific chorus frogs which could prey on both nymphs and adults (and to be fair, dragonfly nymphs will feed on small tadpoles). Some volunteers also reported "birds eating dragonflies like crazy" on 16 July, demonstrating the importance of an abundant insect population to breeding songbirds.

Figure 16. Sunset Village stormwater pond, 22 June (L) and 22 August (R) 2022.

Odonate community composition was most similar to that at the nearby Tegart/Ponza ponds (Jaccard index = 0.773) and least similar to Centennial (Jaccard Index = 0.619; Figure 2). Twenty-one species (16 dragonfly, 5 damselfly) were observed across 13 survey days in 2022 (Figure 17). The number of species seen each month was high throughout the season (Figure 3), and some dates on which fewer species were observed were likely due to environmental factors. For example, only three species were reported on 20 August, while 15 were seen two days later; however, observers reported overcast conditions, which means odonates would not have been on the wing. Similarly, wildfire smoke and poor air quality was noted on 11 September (5 species) and 9 October (1 species), and this is also likely to decrease odonate flight activity.

Figure 17. Odonate seasonality and abundance at Sunset Village in 2022. Height of each individual stacked bar shows abundance category: 1 (uncommon, 1-4 individuals); 2 (frequent, 5-20); 3 (common, 21-100); 4 (abundant, >100). Asterisks indicate QA surveys by CASM Environmental.



More total species were seen at Sunset Village than any other site since monitoring began with the exception of Westmoreland Park in its first two project years (21-22 species in 2016-2017). The most frequently observed dragonfly species were Saffron-winged Meadowhawk (*S. costiferum)* and Common Whitetail (*Plathemis lydia*), and the most frequently observed damselfly species were Pacific Forktail (*I. cervula*) and Tule Bluet (*Enallagma carunculatum*), all of which were reported on 77% of all survey days. Most species found here were seen at other sites in this and/or other years, with a few exceptions. Saffron-winged Meadowhawk (*S. costiferum*), which was common and abundant at Sunset Village throughout the season (Figure 18), was only found before in a single year (Westmoreland Park, 2017). The migratory Spot-winged Glider (*Pantala hymenaea*) was seen on two dates in June and July; prior to this, the only sighting of this species at any project sites was at Brookside in 2018.

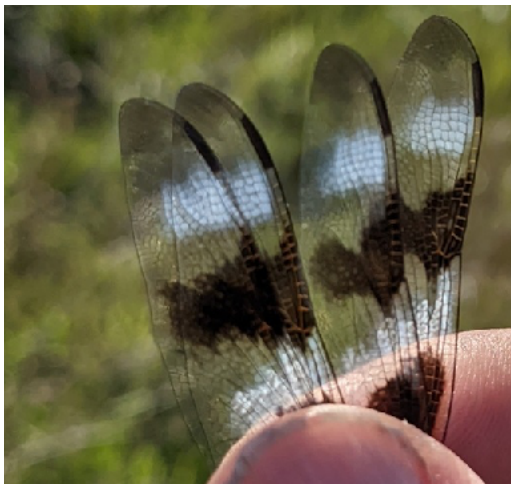
Another interesting find was a hybrid of Eight-spotted and Twelve-Spotted Skimmer (*Libellula forensis* x *pulchella*) on 25 September (Figure 19); this individual was photographed and collected. Potential hybrids of these two closely-related species were first reported in 2018 in Josephine County, OR and Clark County, WA (Johnson, 2021). Although at first glance it is easy to mistake these hybrids for Twelve-spotted Skimmers, closer examination reveals much lighter terminal spots on the wingtips than expected for a mature Twelve-spotted that has no abrasive wear on the wings. The larger size and more irregular shape of the middle spot is also more typical of Eight-spotted. CASM Environmental may have observed another hybrid at the site earlier in the season, but diagnosis was equivocal

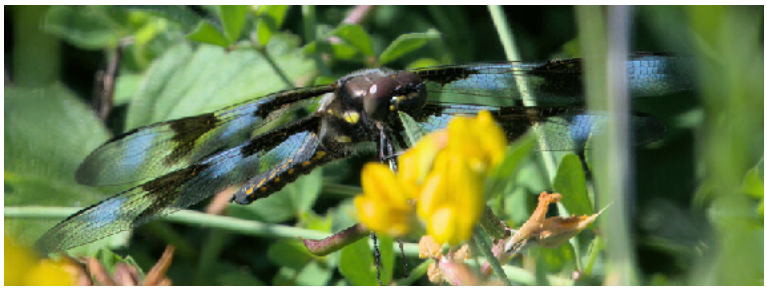
because the individual was less mature (which could account for lighter spots at the wing tips), and it flew away before a camera or net could be brought to bear.

Four of North America's migratory species were seen, with Variegated Meadowhawk and Common Green Darner each found on seven dates, and Black Saddlebags and Spot-winged Glider each seen on two dates. The adults of Spot-winged Glider, Variegated Meadowhawk, and Common Green Darner that were present on 22 June were likely newly-arrived migrants from the south. Tandem pairs of Common Green Darner and Black Saddlebags were observed during the season, as well as teneral adults and ovipositing females of Variegated Meadowhawk, indicating that breeding is occurring, with evident success for at least the meadowhawks.

Figure 18. Saffron-winged Meadowhawk (*Sympetrum costiferum*), Sunset Village, 22 June 2022, Zach Kemp.

Figure 19. Eight-spotted x Twelve-spotted Skimmer hybrid (*Libellula forensis* x *pulchella*), Zach Kemp, 25 September 2022.





Discussion

Habitat restoration or creation can increase odonate species diversity at a site (Steytler & Samways, 1995; Primack et al., 2000; Roush & Amon, 2003). However, poorly-designed wetlands or ponds may function as ecological traps, providing sub-optimal habitat or attracting odonates to mate and breed without supporting egg-to-adult development (Bracchia et al., 2007; Sigutova et al., 2015). Dedicated monitoring at long term sites is not often done but can reveal patterns and trends in odonate diversity and community composition and discover new species, even in urban areas (Craves & O'Brien, 2013; Goertzen & Suhling, 2013, 2015; Holtman et al. 2018).

The 2022 field season saw the continuation of multiple years of monitoring at Centennial and Brookside, and the introduction of two new sites higher up in the Johnson Creek watershed (Tegart/Ponza and Sunset Village). Moderation of COVID-related precautions allowed more surveys to be done at each site (11-13 survey dates per site in 2022 vs. 9-11 in 2021), but the increased number of total species observations in 2022 compared to the prior year was due more to site characteristics and less to increased numbers of surveys. Even though daily species totals at Brookside and Centennial were down, with zero species seen on some days, the new Gresham sites proved to be among the most species-rich of all sites and years.

Climate-related events of recent years, including heat domes, wildfires, high winds, and altered precipitation patterns, have impacted all the monitoring sites. In 2022, April through June had colder and wetter conditions compared to most other sampling years, which delayed the arrival of migratory species and likely slowed development of local species. In contrast, mean monthly temperatures were higher in June through October compared to all prior monitoring years, and total monthly precipitation was lower from July through October, with almost all of October's rainfall arriving on a single date at the end of the month.

This year's surveys found overall increased numbers and distribution of Striped Meadowhawk (*Sympetrum pallipes*), Saffron-winged Meadowhawk (*S. costiferum*), and California Spreadwing (*Archilestes californicus*). *S pallipes* is a common resident of shallow lowland water bodies that are seasonally flooded; this species generally appears later in the year (late July to early August) and females lay their eggs in dry grassy or sedgy basins that will flood the following season. *S. costiferum*, which was present throughout the season at Sunset Village at abundances ranging from Uncommon to Common, can be found in offshore vegetation and may lay eggs in wet shorelines as well as in open water. California Spreadwing is another late-season species, typically found in August and September in our area; they inhabit slow streams and occasionally their associated ponds or lakes, and females lay eggs into woody plant tissue, often several feet above the water. It may be that our recent years of drier, hotter summer and autumn weather is favoring species that have greater adaptations for drying or are not as reliant on water for laying eggs.

Despite the fact that local environmental conditions are similar, habitat-driven differences in odonate communities persist among monitoring sites. Species richness at Brookside continues to be lower than when monitoring began, likely because the habitat at has become less suitable and appealing to local odonates. In earlier years, the site retained a substantial expanse of open water and fringing vegetation that attracted local species, but more recently

water levels are lower in spring and much reduced by mid-summer. It was drier in 2022, with large portions of the wetland reduced to cracked mud or completely filled in with vegetation by mid-summer, and odonate abundance and richness declined after peaking in early- to mid-August. The total number of species at Centennial has varied more from year to year compared to Brookside, which is not unexpected given the physical changes there. Restoration of Mitchell Creek initially saw increased odonate abundance and richness, but Centennial is currently experiencing a combination of summertime wetland drying, dense plant overgrowth of the narrow creek, and mowing in the adjacent upland, all of which decreased available habitat, and species numbers were lower in 2022 than any prior year.

The highest species richness was seen at the two stormwater wetlands in Gresham that were added to the project in 2022. Despite the fact that Tegart and parts of Ponza become shallow and heavily vegetated as the summer progresses, they supported a diversity of odonate species. Sunset Village, the largest of all the monitoring sites, also had the most species. While surface area is definitely a factor in habitat attractiveness, it is also possible that the active home construction and habitat disturbance surrounding the site would render it less suitable for odonates. However, not only does this site maintain a large wetted area throughout the summer, it also has the advantage of high habitat heterogeneity, with the main wetland becoming a patchwork of open water and emergent and floating vegetation, surrounded by a variety of forbs and young trees in the adjacent upland.

This project has demonstrated that even impaired or disturbed wetland habitats with much anthropogenic influence can support a variety of regionally common odonate species, as well as occasionally hosting rarer or more unusual species (i.e., Lance-tipped Darner, Four-spotted Skimmer, Spot-winged Glider). However, it is also evident that some degree of maintenance is needed to ensure that habitat does not become less attractive or unsuitable for odonate development. Creek restoration projects at both Westmoreland Park (Crystal Springs Creek) and Centennial (Mitchell Creek) that initially increased habitat quality and/or quantity were quickly followed by increased odonate abundance and species richness. However, further habitat changes post-restoration diminished habitat suitability and attractiveness; this included stream-bank slumping due to nutria activity, increased plant cover on the creek surface, and invasion of adjacent wetlands by dense non-native plant growth at Westmoreland; and wetland drying, overgrowth of the creek channel, and upland mowing at Centennial. Sunset Village, which supported the most odonate species in 2022, is only about two years old, and until this summer the wetland was not heavily vegetated (Katie Holzer, City of Gresham, pers. comm., spring 2022). It remains to be seen whether and how this site will change with time, and what impacts that will have on the resident odonate community. Odonates serve many important ecological functions, and resilience of local communities to climate-related disturbances may be increased by maintaining attractive urban habitat that supports their survival.

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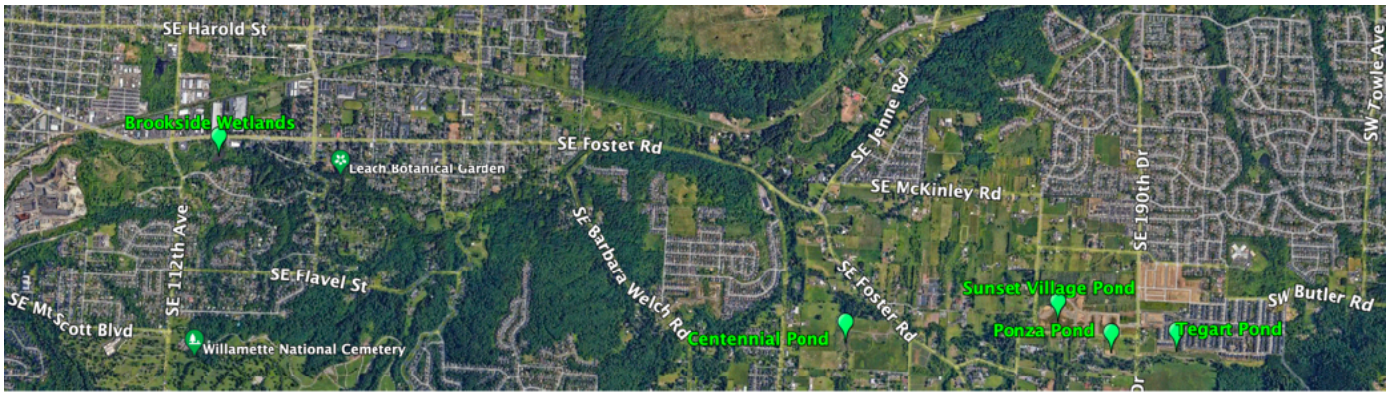
Appendix A. Location of 2022 sampling sites.

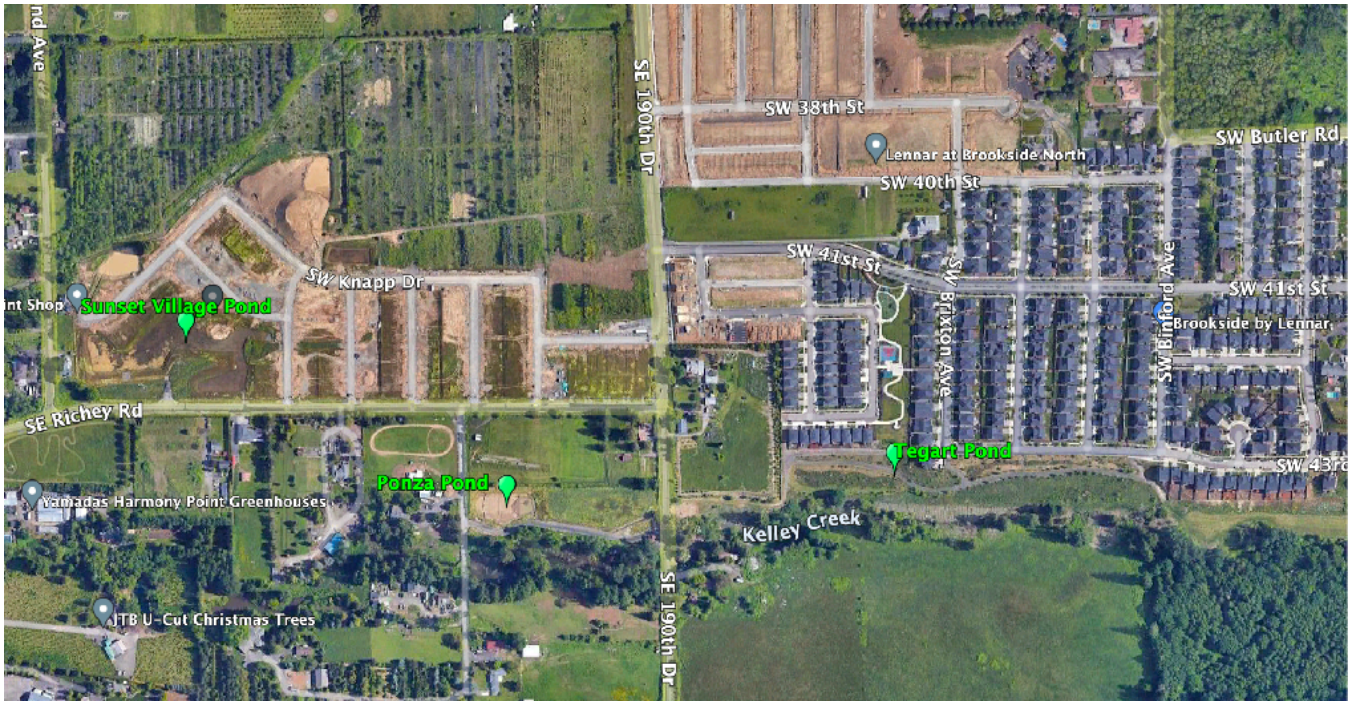
A. Monitoring site overview



B. Brookside Wetlands. Image shows high water with both ponded areas connected.

C. Centennial.

D. Sunset Village and Tegart/Ponza.



Appendix B. Odonate species recorded among all project survey sites, 2016-2022.

Note that each species may not occur at a given site in each monitoring year. Westmoreland Park (WP) was not monitored in 2022.

Species	Common name	WP	BROOKSIDE	CENTENNIAL	TEGART/ PONZA	SUNSET VILLAGE
Anax junius	Common Green Darner	Y	Y	Y	Y	Y
Aeshna constricta	Lance-tipped Darner	N	Y	N	N	N
Aeshna palmata	Paddle-tailed Darner	Y	Y	N	N	Y
Aeshna umbrosa	Shadow Darner	Y	Y	Y	Y	Y
Gomphidae	Clubtail (undetermined)	Y	N	N	N	N
Sympetrum corruptum	Variegated Meadowhawk	Y	Y	Y	Y	Y
Sympetrum costiferum	Saffron-winged Meadowhawk	Y	N	N	N	Y
Sympetrum danae	Black Meadowhawk	Y	N	N	N	N
Sympetrum illotum	Cardinal Meadowhawk	Y	Y	Y	Y	Y
Sympetrum madidum	Red-veined Meadowhawk	N	Y	N	N	N
Sympetrum pallipes	Striped Meadowhawk	Y	Y	Y	Y	Y
Sympetrum vicinum	Autumn Meadowhawk	Y	Y	Y	N	N
Tramea lacerata	Black Saddlebags	Y	Y	Y	Y	Y
Erythemis collocata	Western Pondhawk	Y	Y	Y	Y	Y
Libellula forensis	Eight-spotted Skimmer	Y	Y	Y	Y	Y
Libellula luctuosa	Widow Skimmer	Y	Y	Y	N	N
Libellula pulchella	Twelve-spotted Skimmer	Y	Y	Y	Y	Y
Libellula quadrimaculata	Four-spotted Skimmer	Y	Y	Y	N	N
Libellula saturata	Flame Skimmer	Y	Y	Y	Y	N
Plathemis lydia	Common Whitetail	Y	Y	Y	Y	Y
Pachydiplax longipennis	Blue Dasher	Y	Y	Y	Y	Y
Pantala hymenaea	Spot-winged Glider	N	Y	N	N	Y
Rhionaeschna californica	California Darner	Y	Y	N	N	N
Rhionaeschna multicolor	Blue-eyed Darner	Y	Y	Y	Y	Y
Ischnura cervula	Pacific Forktail	Y	Y	Y	Y	Y
Ischnura perparva	Western Forktail	Y	Y	Y	Y	Y
Enallagma carunculatum	Tule Bluet	Y	Y	Y	Y	Y
Enallagma annexum/boreale	Northern/Boreal Bluet	Y	Y	Y	N	N

Species	Common name	WP	BROOKSIDE	CENTENNIAL	TEGART/ PONZA	SUNSET VILLAGE
Archilestes californicus	California Spreadwing	Y	Y	Y	Y	Y
Lestes congener	Spotted Spreadwing	N	Y	N	N	N
Argia vivida	Vivid Dancer	Y	Y	Y	Y	Y
Calopteryx aequabilis	River Jewelwing	Y	N	N	N	N