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Millard Creek Headwaters Long-term Ecological and Hydrological Study 2018

Comox Valley, BC

Youth and Ecological Restoration Phase II participant measuring Cutthroat Trout in Millard Creek

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ACKNOWLEDGEMENTS

This report could not have been possible without the consistent and enthusiastic efforts of youth field technicians Brayden Graham and Jack Limmer. The Youth and Ecological Restoration Program (YER) was created by Wendy Kotilla who also provided leadership, program administration, management, coordination and technical field support. The YER Program is funded by the BC Ministry of Children and Family Development. The Comox Valley Regional District (CVRD) provided Grant in Aid funding for this YER Phase II project to support Tim Ennis of Latitude Conservation Solutions in leading the field research and producing this report. Landowners Wendy Kotilla and Sue Minchin provided access to their properties, which was essential to the success of the project. Shiva Farjadian from GW Solutions Incorporated provided extensive hydrological data analysis support and a report, and associated field-based interpretation of the results. Graham Hillier provided field support. Verna Mumby of Mumby's Arboriculture Consulting also contributed expertise based on two site visits after completion of the field work to provide a peer review of the preliminary results of this study.

INTRODUCTION

Background

This report summarizes data collected during an ecological study of private lands located in the Millard Creek headwaters from July 30th – August 3rd, 2018. The inventory was conducted by participants of the Youth and Ecological Restoration Program (YER) including Brayden Graham and Jack Limmer (youth participants), Wendy Kotilla (YER Program), Tim Ennis (Latitude Conservation Solutions Company) with support from Graham Hillier and Shiva Farjadian (GW Solutions Incorporated).

The vision of the YER Program is to engage vulnerable or at-risk youth in a wider circle of community relationships, in both the human and natural worlds. The program involves them with meaningful work and caring adults who support them in building self-esteem and who have the ability to transform their lives. In the YER Program, youth travel a journey together with their community and experience a better relationship with the people and places of home (YER 2018).

Private land owned by Wendy Kotilla and Sue Minchin was selected as a study area for the 2018 YER Phase II project (Figure 1). The study area contains ecological features of significance within the Millard-Piercy watershed, which is an important rural and urban stream in the Comox Valley. Wendy Kotilla has recorded basic meteorological and hydrological data within the study area for over five years, which was set up under the guidance of GW Solutions Incorporated (Moul and Kotilla 2013). Long-term datasets of this nature are extremely valuable in a variety of applications including land use planning, and monitoring climatic changes taking place within the watershed. Previous YER Phase II projects (Moul and Kotilla 2011, 2012 and 2013) also contributed important information about the study area. This project exposed the youth to those long-term data collection methods, refined previous work completed in 2013 and also included conducting ecological description work not previously undertaken.

Purpose of the Study

1. To support vulnerable youth within the Comox Valley by providing them with hands-on opportunities to engage with nature and adult mentors though an ecological inventory project;
2. To describe the ecological values of the subject parcels in support of potential future conservation measures (e.g., covenants). Specifically:
    a. To map the dominant canopy trees in the Western Redcedar grove on 4327 Minto Rd.;

b. To describe the health of Western Redcedars on 4327 Minto Rd.;
c. To map the springs and associated watercourses within the study area;
d. To conduct fish sampling;
e. To conduct water quantity and quality sampling, and;
f. To record daily weather observations.

Study Area

The study area (Figure 1) includes two adjacent private lots:

1. 4327 Minto Rd is owned by Wendy Kotilla (PID 000-413-054) and is 0.39 ha (0.96 acres), and;
2. 4333 Minto Rd is owned by Sue Minchin (PID 000-413-062) and is 4.02 ha (10.04 acres).

Both lots are located within the headwaters of the Millard Creek watershed in the Comox Valley Regional District Electoral Area "A" east of the Village of Cumberland and south of the City of Courtenay. The two parcels are both zoned RU-ALR (Agricultural Land Reserve) and both include areas protected through CVRD Development Permit Area regulations (DPAs) for Aquatic Riparian Areas, Heron Nests, and Shoreline Protection (~20% of the study area) (CVRD 2018).

The study area occurs within the Nanaimo Lowlands Ecosection (NAL) and the leeward variant of the very dry, maritime subzone of the Coastal Western Hemlock biogeoclimatic zone (CWHxm1). This biogeoclimatic variant/subzone has warm, dry summers and moist, mild winters with little snowfall. The growing season is long, and moisture deficits are common during the summer months (Green and Klinka, 1994). The study area slopes gently from 105 meters above sea level (masl) in the southwest to 95 masl in the northeast (northeast aspect). The study area contains a mosaic of rural-residential land uses including homes and gardens as well as agricultural fields, ditches and wells. Other portions of the study area are more natural including mature second-growth Western Redcedar (*Thuja plicata,* herein referred to as cedar) dominated forests, groundwater springs, unconfined stream channels and associated riparian and wetland habitats in the uppermost reaches of Millard Creek.

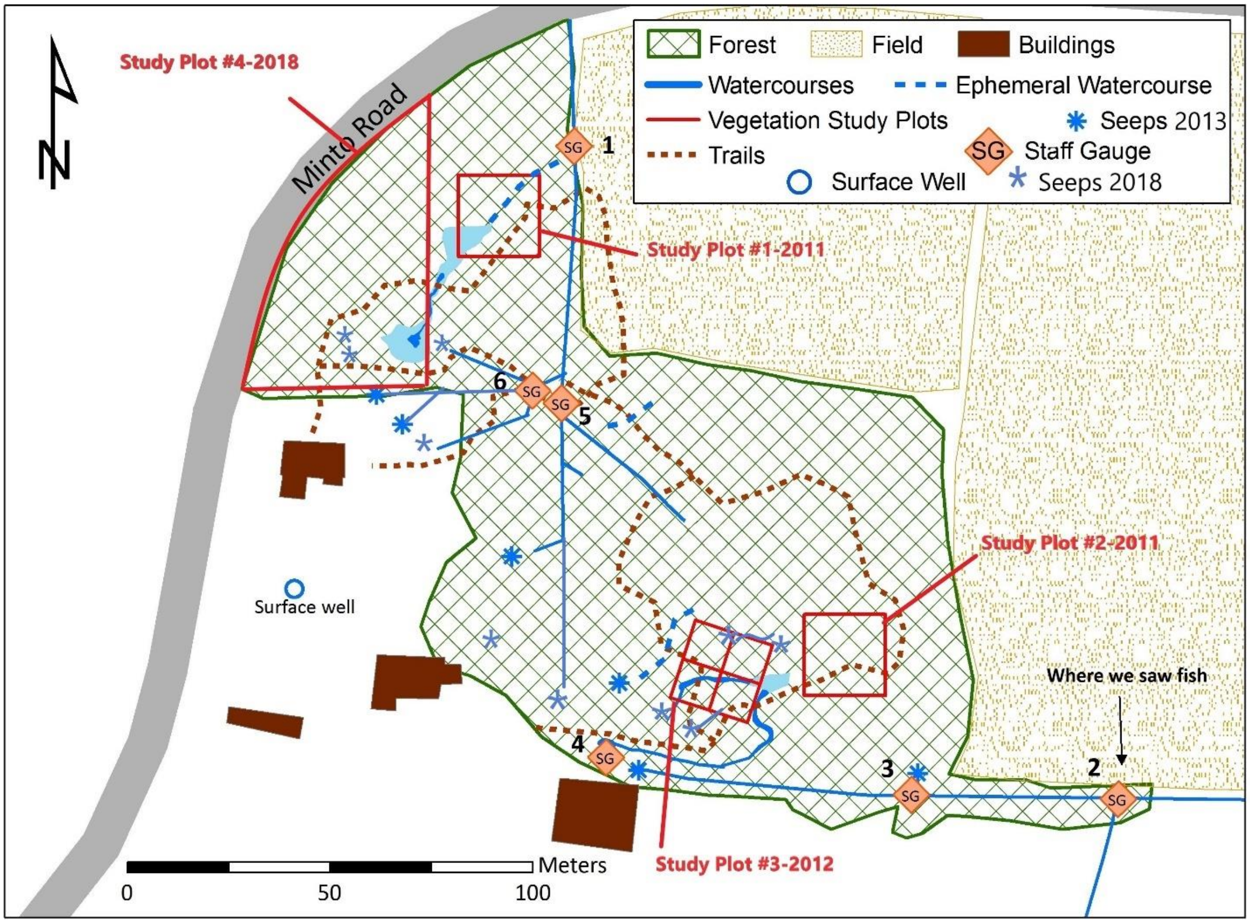

Figure 1. Updated map from Moul and Kotilla (2013) depicting the cumulative features in the study area from 2011 - 2018.

METHODS

The methods employed by this study were adapted where possible from standards established by the Province of BC. Methods were adapted as required to fit within logistical and site-specific constraints as well as to be more readily understood by youth participants in the program.

Mapping the Western Redcedar grove

The Western Redcedar grove occupies approximately 0.4 ha, the majority of which is located on 4327 Minto Rd (Figure1 and 2). The cedar grove was used by Great Blue Herons (*Ardea herodias*) as a nesting site or rookery for about eight years. The nesting trees have been registered with BC Ministry of Environment.

This project only mapped the trees which form a part of the main forest canopy. Understory trees and seedlings were not mapped due to logistical constraints (e.g., time limitations). Accurately mapping each tree with a hand-held recreational GPS from below the thick canopy was not considered feasible due to GPS accuracy constraints. Instead, an orthorectified air photo with a 5 m x 5 m grid overlay was produced in Google Earth such that the edge of the grid aligned with the western property line (oriented north-south) and with the northern property corner. Cadastral lines were determined using Parcel Map BC which was also imported into Google Earth directly from Data BC's web mapping service. Printed paper map copies of the orthophoto with the georeferenced grid overlay were produced for use in the field. The orthophoto was scaled such that each 5 m x 5 m grid cell corresponded to 1 cm x 1 cm when printed.

The survey began by navigating to the northern property corner, but we were unable to locate the corner pin. From the approximate corner pin location, the closest cedar tree on the property was located. Its distance in meters from the corner was measured with a 30 m nylon tape, and its direction was measured with a Suunto compass. The location of the tree was then plotted on the printed orthophoto by placing the compass on the orthophoto to measure the azimuth and then measuring the distance with a ruler. A small hole was poked through the paper map with a mechanical pencil in the correct location for the first tree. On the back of the paper map, the hole was circled in pencil and given a number. The first tree mapped was given the number one, and numbering continued in sequence as each successive tree was measured.

The second tree was mapped by measuring the distance and direction from the first tree, and so on, until all dominant trees were mapped in the grove. Determining what constituted a discrete, single cedar was difficult given the multi-stemmed growth forms displayed by many cedars in the grove. Stems that initiated below breast height (130 cm) were considered individual cedars. This effectively meant that each stem of a multi-stemmed cedar was considered a unique individual. Once mapped on paper, the trees were digitized back into Google Earth.

Describing the health of the Western Redcedars

The methods for describing the health of the 4327 Minto Road cedars employed by this study were adapted from the Describing Ecosystems in the Field methodology for tree mensuration (MOE 1998) in consideration of a review of Field Guide to Forest Damage in British Columbia (MOF 2001). A datasheet was developed which included basic parameters (e.g., date, surveyors), as well as descriptive parameters about the tree (e.g., ID number, diameter at breast height (DBH), species, crown class, age class) and tree health indicators (e.g., conks, scars, woodpecker holes, insect boring holes, forks/crooks, dead tops, flagging, drought stress, cedar leaf blight). Several cedars occurring on 4333 Minto Rd. were also assessed.

Once each tree was mapped, it was revisited, and these data were recorded on the data sheet by visually inspecting the tree from all sides. DBH was measured using a diameter-tape (also known as a D-tape). The field guides described above were utilized to support recording the correct descriptions. It can be difficult to differentiate between Cedar Flagging, Drought and Cedar Leaf Blight. The differences were carefully reviewed prior to and during field work.

After the study was completed the study area was visited by Verna Mumby of Mumby's Arboriculture Consulting on September 15th and December 2nd, 2018 who provided additional thoughts to Wendy Kotilla regarding the health of the trees. From her perspective as a certified arborist, Verna offered information on: the five areas to assess for a condition statement on a tree; co-dominant trees; live crown ratio; tree benefits to the environment; with some emphasis on drought stress (Appendix 3).

Mapping springs and watercourses

Preliminary mapping of watercourses in the study area was completed in 2013 (Moul and Kotilla, 2013). The hydrologic features mapped in 2013 were digitized and uploaded into an iPad in GIS Pro software. This project looked to build on that work by conducting more thorough ground-based searches for features not mapped in 2013 (Figure 3). This was conducted by visually identifying areas of standing or flowing water, or areas of very wet soil combined with indicator plants such as Sedges (*Carex* spp.) or

Skunk Cabbage (*Lysichiton americanus*). These ephemeral creeks, streams and ditches (watercourses) were followed upstream until they either left the study area or terminated in a discrete area of standing water or wet soils. The latter were considered as springs and mapped using an iPad and GIS Pro software. The watercourses were then walked downstream with a GPS track log to map the watercourses in the study area. Occasionally springs were encountered that did not connect to linear watercourses. These were mapped as discrete point features.

Fish sampling

Two minnow traps were used to detect the presence of fish in the upper portions of Millard Creek (Figure 1). The traps were deployed in the same location, a few meters apart. The sampling site was in a naturalized ditch flowing from west to east along the southern boundary of 4333 Minto Rd (49.64099, -124.99574). The traps were in place for a 24-hour period. Fish caught in the traps were identified to species and measured (length) prior to release.

Water quality and quantity sampling

Water quantity was measured using six staff gauges and one V-notch weir that had been previously established in six locations throughout the study area (Moul and Kotilla 2013) (Figure 1). Water quality was also measured at the same six locations (Figure 1). Water temperature, pH, total dissolved solids (TDS) and conductivity were recorded using HANNA instrument HI98129 pH/EC/TDS/Temperature with Only One Tester; and an OxyGuard Handy Beta Portable DO Meter H01B meter was used to document dissolved oxygen. These data were added to a long-term data set that Wendy Kotilla has been recording at these locations on a monthly basis for the past 5 years (Figure 1; Appendix 4). In addition, groundwater was measured in a well located at 4333 Minto Rd. and used for domestic purposes associated with 4327 and 4333 Minto Rd (Figure 1). These data were added to a long-term dataset that Wendy Kotilla has been recording on a monthly basis for the past ten years (Figure 1; Appendix 4).

Weather data

Each morning daily maximum and minimum air temperature was recorded as well as precipitation (rain gauge) and weather conditions (including notes on wind direction, cloud cover etc.). These data were added to a long-term data set that Wendy Kotilla has recorded daily for the past five years (Appendix 4).

RESULTS

Mapping the Western Redcedar Grove

In total 38 dominant canopy trees were mapped in the Western Redcedar grove (Figure 1 and 2). Summary statistics describing the diameter, species mix and age class are provided below (Table 1; Appendix 2). Despite the large diameter of some of the trees in the grove, none were considered to be old-growth (>250 years old). The grove includes several extremely large cedar stumps with spring-board notches, suggesting that the primary forest in the study area was logged sometime around the turn of the last century. Given that the time since disturbance was between 80 and 120 years, the dominant trees in the grove fit the definition of mature, and this was corroborated by our field data and observations.

Within the cedar grove some of the trees were documented with BC Ministry of Environment (MOE) as heron nesting trees. Respectively, the cedar grove mapping numbers (2018 cedar tree numbers are shown first) and MOE numbers are: 08-415, 11-422, 12-414, 26-421, 27-434, 30-435, 31-423. This demonstrates another use of the cedar grove. The herons nested for approximately eight years with a maximum of eleven nests in the rookery, but were eventually chased off by Bald Eagles (*Haliaeetus leuocephalus*) predating on their young (Wendy Kotilla pers. comm.).

Figure 2. Location of mature trees on 4327 and 4333 Minto

Table 1. Basic description of the dominant trees in the grove

DBH Max	DBH Min	DBH Ave
142 cm	42 cm	84.7 cm
Dominant Confier Species (%)		
Cedars		Hemlock
97.37		2.63
Age Class of Dominant Trees (%)		
Mature		Young
89.47		10.53

Most of the mature trees occur on 4327 Minto Rd, while one might occur on the road right of way alongside Minto Rd., two are located on 4333 Minto Rd. and another two may be on the boundary between the two properties (Figure 1 and 2). Given the accuracy of the field mapping conducted in this study, a legal survey would be required to bring certainty should this become an important land-use issue in the future.

Describing the health of the Western Redcedars

The cedar health assessment suggests that the cedars in the grove (Figure 1 and 2) are in excellent health overall. None of the trees expressed discoloured (orange) foliage that can be indicative of flagging, drought stress or leaf blight. No trees were found to have conks, or dead tops, and very few were found to have sign of wood-boring insects, or scars. Woodpecker holes, however, occurred on approximately half of the trees. A preliminary assessment by Verna Mumby indicates that the cedar trees are about 75% healthy (Appendix 3).

Any physical damage to a tree can result in an opportunity for pathogens to enter the tree and negatively affect its health. However, as cedars tend to be resistant to nearly every pathogen affecting other conifers in BC (MOF 2001), the risk of infection by pathogens is inherently low. Aside from drought which is evidently killing a significant proportion of cedars in the Nanaimo Lowlands, fungal pathogens are typically the primary agent negatively affecting the health of mature cedars (notwithstanding physical trauma from windthrow, wildfires or flooding) (MOF 2001).

Some woodpecker species (e.g., Pileated Woodpeckers (*Dryocopus pileatus*)) can be a vector of transmission capable of moving fungal pathogens from tree-to-tree. Woodpeckers foraging for insects or excavating roost and nest sites in the heartwood of a tree that is infected with a fungal pathogen can get spores or mycelium on their beaks and feathers, then inoculate an otherwise healthy tree (Jackson and Jackson 2004). It is worth noting, however, that all of the woodpecker holes observed in this study were feeding holes made by a Red-breasted Sapsucker (*Sphyrapicus ruber*). Sapsuckers make many small holes that do not penetrate deep enough to come into contact with heartwood tissue where fungal pathogens are typically the densest. Therefore, it is possible that sapsuckers are less effective as a vector of dispersal for fungal pathogens. While further research is required to investigate this hypothesis, none of the cedars with woodpecker holes inspected in this study showed any other signs of fungal pathogens (e.g., conks).

It should be noted that subsequent to this study, arborist Verna Mumby visually assessed the cedars in the study area. She noted heavy cone production in the upper portions of some of the cedars. This can be an early indicator of drought stress prior to foliage discoloration becoming evident. Notes made by Wendy Kotilla during Verna's assessment are included in Appendix 3.

Table 2. Cedar health assessment data

Woodpecker holes (%)		Forked Stems (%)		Flagging (%)	
Present	Absent	Present	Absent	Present	Absent
47.37	52.63	26.32	73.68	0	100
Boring Insects (%)		**Scars (%)**		**Drought Stress (%)**	
Present	Absent	Present	Absent	Present	Absent
2.63	97.37	5.26	94.74	0	100
Conks (%)		**Dead top (%)**		**Cedar Leaf Blight (%)**	
Present	Absent	Present	Absent	Present	Absent
0	100	0	100	0	100

Mapping springs and watercourses

Mapping springs and watercourses resulted in the identification of additional features beyond those that were identified in the 2013 study. The 2013 study mapped 5 springs and 362 m of watercourses. In this project, an additional 9 springs and 127 m of watercourses were mapped (Figure 1 and 3).

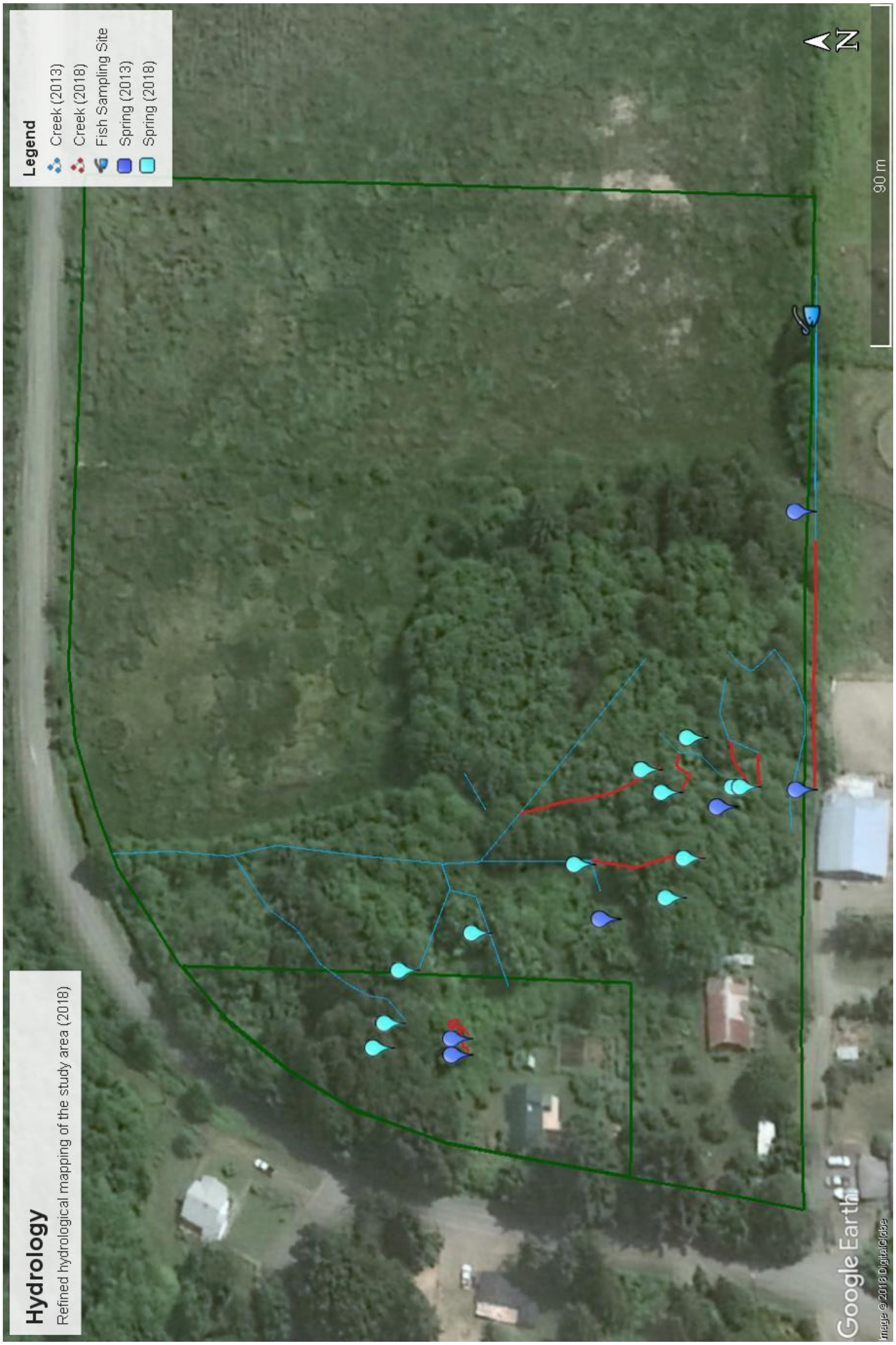

Figure 3. Hydrological map of study area

Fish sampling

A total of three Cutthroat Trout (*Oncorhynchus clarkii clarkii*) were caught in the minnow traps. Two Cutthroat were measured at 11.5, 11.2 cm long and one was not measured for length. Given the presence of a natural barrier lower down in the watershed, these fish were assumed to be resident fish in the system, and not the anadromous form of Cutthroat Trout. Two Cutthroat Trout (5.5 and 8.0 cm long) were caught in the same area in 2013 (Moul and Kotilla 2013).

Water quality and quantity sampling

Water quality and quantity data recorded during the study is provided below in Appendix 2. The long-term water quality and quantity data sets from 2013 to 2018 were recorded by Wendy Kotilla and provided to GW Solutions for interpretation and a report, which is included below in Appendix 4.

Weather data

Precipitation and temperature data recorded during the study is provided below in Appendix 2. The long-term precipitation and temperature data sets from 2013 to 2018 were recorded by Wendy Kotilla and provided to GW Solutions for interpretation. These are included below in Appendix 4.

DISCUSSION

This project was a success in terms of supporting vulnerable youth by providing them with hands-on opportunities to engage with nature and adult mentors though an ecological inventory project. The project was also a success in terms of adding to cumulative baseline and long-term data sets that can be used to monitor climatic, hydrological and biological changes over time.

Supporting Youth at Risk

The youth were exposed to several ecological inventory techniques and a variety of field equipment including compasses, D-tapes, tablets, water quality sensors, and other tools. Basic mapping skills and filling out data sheets are useful life skills in a variety of contexts, beyond learning specialized skills that could help them in the workplace. The youth were able to spend time in nature with adult mentors and learn about nature in an emotionally supportive environment where they learned interpersonal communications skills, built their self-esteem and improved their confidence.

One measure of success in this regard, was the public presentation and tour the youth lead for eleven participants at the end of the week. The youth were able to overcome their fears of public speaking, insecurities about their knowledge and skills, and teach adults about subject matter that was foreign to them at the beginning of the week. The youth were extremely successful in the delivery of the material in a field-based public speaking context, despite being outside of their comfort zones. Following the tour, the youth were paid for their work, provided certificates and reference letters for having completed the program. They were also celebrated with positive feedback in terms of both accolades from the adult mentors and applause from the tour participants. It was clear that the youth experienced a sense of accomplishment and pride as a result of their participation in the program. It was both a motivational and transformative experience for them.

Biodiversity Conservation Values

The data recorded in this project illustrates both the biodiversity conservation values and sustainability values of the study area in several ways while also highlighting the excellent learning opportunities that continued collection of long-term hydrometric data provides (Figure 1, 2 and 3; Appendix 1, 2, 3 and 4).

Sensitive Ecosystem Inventory (SEI) data collected in the Comox Lowlands at several intervals (1992, 2002, and 2012) reveals that old-growth forests in the Comox Lowlands no longer exist (Juniper 2014). Further, mature second-growth forests continue to be lost at a rapid rate due to logging and land clearing for agricultural and residential development. Several wildlife species require the habitat provided by mature and old forests in order to survive, and many of these too have become extirpated from the Comox Lowlands (e.g., Marbled Murrelet (*Brachyramphus marmoratus*)). To slow the rate of species loss or reverse the trend, it is critical to protect high quality examples of mature second-growth forests so that they will be allowed to recruit to old-growth over the next century. Approximately 1% of the Comox Lowlands is protected (Juniper 2014). This falls far short of even the most conservative estimates of how much habitat is required to sustain biodiversity.

The data recorded in this study suggests that the cedar-dominated forests in the study area (Figure 1 and 2) provide the characteristics required to highlight the area as a candidate for protection (e.g., large-diameter mature trees). Although not specifically a part of this study, it is important to note that many of the trees in the grove have been used as a Great Blue Heron (*Ardea herodias fannini*) rookery in the past (heron nests are registered with Ministry of Environment), further illustrating the point that the grove has the structural characteristics that are suitable to provide important breeding habitat for species at risk.

The BC Conservation Data Centre tracks the status of ecological communities at risk in BC. In the CWHxm1, all forested ecological communities are either Blue or Red-listed provincially (CDC 2018). Some are also considered imperilled globally. This includes all ecological communities dominated by Western Redcedar. Therefore, although classifying the ecological community was outside the scope of this project, it follows that the cedar grove contains one or more listed communities in BC. Although the primary factors responsible for their at-risk status have historically been logging and land development, new threats to cedar forests are emerging as a result of climate change (e.g., longer periods of summer soil moisture deficits). Throughout the Nanaimo Lowlands area, evidence of cedar mortality from drought stress both in mature canopy trees and understory trees is plainly visible.

Data recorded by Wendy Kotilla over the past five years and analyzed by Shiva Farjadian of GW Solutions Incorporated (Appendix 4) indicated a slight trend of increasing precipitation and groundwater availability over time. While this seems counter-intuitive to the observed mortality of drought-stressed cedars in the surrounding landscape, it may be that precipitation increases are associated with significantly more rain in the late fall and winter, but are moderated by longer periods with high temperatures and lower precipitation in the late spring through early fall. It seems likely that longer dry periods from spring through early fall negatively affect cedars on moderately to well-drained sites. The data collected in this study, did not detect signs of drought stress in the cedars. This is possibly associated with consistent and relatively high levels of soil moisture associated with the prolific groundwater springs in the grove. The long-term data suggests that groundwater recharge peaks in March and April following heavy precipitation in the winter, making relatively more groundwater available throughout the drought stress period in areas that are spring-fed. Cedar groves occurring in spring-fed headwater systems or in other areas of elevated soil moisture such as this are possibly the best places on the landscape to conserve cedar forests in the CWHxm1 in light of the predictions of longer hotter summers in the future. Despite a trend of increased groundwater availability in spring-fed systems, it is unknown what effect reduced humidity during the prolonged drought stress period may have on cedars.

In addition to the high conservation value of the cedar grove, there are high conservation values associated with the springs and watercourses in the study area which form the headwaters of Millard Creek (Figure 1, 2 and 3). Hydrologic analysis completed by GW Solutions Incorporated based on long-term data collected by Wendy Kotilla and site-based observations suggests that there is a lower, confined (bedrock constrained) aquifer as well as an upper unconfined aquifer beneath the study area (Appendix 4). The springs are likely the result of water being forced up through fissures in the bedrock from the confined aquifer, whereas some of the watercourses and shallow drinking water wells are supplied by water from the upper unconfined aquifer.

Groundwater tends to be warmer than surface water in the winter and cooler than surface water in the summer. In the study area (Figure 1 and 3) the temperature of the spring-fed watercourses typically fluctuates from approximately 5 to 15 degrees Celsius between winter and summer respectively Appendix 4). In addition, the watercourses have not demonstrated a propensity to dry up completely during the summer months (Appendix 4) as has been observed in the upper and middle reaches of other streams nearby (e.g., Perseverance Creek). Therefore, the relatively stable, cool and abundant water associated with spring-fed headwater systems is ideal to support fish species such as Cutthroat Trout. Cutthroat are a species at risk in BC (CDC 2018), and other salmonids are also a conservation concern.

Sustainability Values

The headwaters of urban streams are often degraded by inappropriate land developments, leading to flooding, erosion and other problems downstream. Protecting riparian areas and wetlands throughout the watershed, but particularly in headwaters areas can prevent local governments from incurring significant costs associated with engineered infrastructure solutions.

SUMMARY

The objective of the project was twofold:

1. To support vulnerable youth within the Comox Valley by providing them with hands-on opportunities to engage with nature and adult mentors though an ecological inventory project, and;
2. To describe the ecological values of the subject parcels in support of potential future conservation measures (e.g., covenants).

This project was a success in accomplishing both objectives. As discussed above, both the youth and adult mentors experienced a transformative experience of sharing and learning from each other. In addition, valuable ecological information was recorded and analysed improving the arguments in support of finding a conservation solution for the study area.

RECOMMENDATIONS

This project underscores the value of the Youth and Ecological Restoration Program, the value of conducting ecological inventory projects in high conservation value areas and the importance of long-term studies. It is recommended that:

1. The YER Program continue to periodically conduct projects in the study area (living laboratory concept). Additional work focusing on wildlife use of the study area (including species at risk), mapping and describing the ecological communities, and continuing to monitor the health of the cedars over time would all add value to the long-term goal of building the case for conservation.
2. Mapping and description of the ecological communities should be provided to the BC Conservation Data Centre and/or included in the CVRD's SEI data layers to inform any proposed future land use changes. Similarly, any species at risk occurrence data should also be provided to the BC CDC.
3. The health of the cedar grove should be monitored over time according to the methods employed by this study, but with additional data such as cone production and other metrics as recommended by a certified arborist or Registered Professional Forester. Photo-monitoring of the grove over time in September of each year from a distant vantage point in the adjacent agricultural field would also be valuable.
4. Relative humidity (rH) be considered for inclusion as an element of the long-term data set both within the cedar grove and in open areas adjacent to it.
5. The collection of long-term hydrometric data according to the same methods that have been employed to date should continue. GW Solutions Incorporated has recommended that data entry and assessment be conducted in 2-year intervals (Appendix 4), and provided to local governments (CVRD, Cumberland and Courtenay) to inform development practices in the surrounding areas of the watershed.

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Appendix 1 – Photo-plates

Photo 1: The 2018 YER Phase II Team: Tim, Jack, Wendy and Brayden.

Photo 2: Youth-led tour of the study area. The youth reported out on what they learned and the results of the study.

Photo 3: Checking the minnow traps in Millard Creek.

Photo 4: Learning how to use a compass to map the mature trees in the cedar grove.

Photo 6: Measuring the length of Cutthroat trout and the stage (level) of the water in Millard Creek.

Photo 7: Youth receiving their certificates at the successful completion of the project.

Appendix 2 - Field Data

Youth and Ecological Restoration Program - Phase II

Surveyors: Brayden, Jack, Tim Ennis, Wendy Kotilla, Graham Hillier **Date:** July 30th and Aug 1, 2018

Tree Number	DBH (cm)	Species	Crown Class	Age Class	Conks	Scars	Woodpeker holes	Insect boring	Fork/ Crook	Dead top	Flagging	Drought stress	Cedar Leaf Blight
1	82.5	W. Redcedar	Dominant	Mature	N	N	N	N	Y	N	N	N	N
2	64	W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
3	69	W. Redcedar	Dominant	Mature	N	N	Y	N	Y	N	N	N	N
4	83	W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
5	96	W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
6	107	W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
7	92	W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
8	88	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
9	76	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
10	94	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
11	80	W. Redcedar	Dominant	Mature	N	Y (heart rot)	N	N	N	N	N	N	N
12	71	W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
13	84	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
14	84	W. Redcedar	Dominant	Mature	N	Y	N	N	N	N	N	N	N
15	62	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
16	96.5	W. Redcedar	Dominant	Mature	N	N	N	N	Y	N	N	N	N
17	83	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
18	69.5	W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
19	87	W.Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
20	87	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
21	125	W. Redcedar	Dominant	Mature	N	N	Y	N	Y	N	N	N	N
22	78	W. Redcedar	Dominant	Mature	N	N	Y	N	Y	N	N	N	N
23	42	W. Redcedar	Dominant	Young	N	N	Y	N	N	N	N	N	N
24	58	W. Hemlock	Dominant	Mature	N	N	Y	N	N	N	N	N	N
25	44	W. Redcedar	Dominant	Young	N	N	N	N	Y	N	N	N	N
26	91	W. Redcedar	Dominant	Mature	N	N	N	N	Y	N	N	N	N
27	95	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
28		W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
29		W. Redcedar	Dominant	Mature	N	N	N	N	Y	N	N	N	N
30	82	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
31	80	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N
32	46	W. Redcedar	Dominant	Young	N	N	N	N	N	N	N	N	N
33	102	W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
34	134.5	W. Redcedar	Dominant	Mature	N	N	Y	N	Y	N	N	N	N
35	49.5	W. Redcedar	Dominant	Young	N	N	N	N	N	N	N	N	N
36	142	W. Redcedar	Dominant	Mature	N	N	Y	Y (heart rot)	Y	N	N	N	N
37	118	W. Redcedar	Dominant	Mature	N	N	Y	N	N	N	N	N	N
38	108	W. Redcedar	Dominant	Mature	N	N	N	N	N	N	N	N	N

Daily Weather Monitoring in Millard Creek Headwaters - 4327 Minto Road - July 30 to August 3, 2018							
Date	Time	Rainfall/mm	Min/Temp	Max/Temp	Precent Cloud	Wind Direction	Snow/cm
2018-08-03	6:10	0	18	26	100	SE	0
2018-08-02	8:00	0	18	26	100	SE	0
2018-08-01	9:37	0	19	29	20	E	0
2018-07-31	10:05	0	20	33	smoke	E	0
2018-07-30	6:30	0	19	31	smoke	E	0

Millard Creek Headwaters Water Quality Data[1] July 31, 2018									
Date	Time	Site	Depth	Temp.	DO	TDS	pH	Us	AT
2018-07-31	10:30	1	0.15	14.4	89	63	7.03	130	N/A
2018-07-31	10:55	2	12.6	12.6	91	69	7.41	144	
2018-07-31	11:20	3	10.5	14.7	58	74	7.83	149	
2018-07-31	11:34	4	65.7	18.6	7	74	7.88	143	
2018-07-31	11:50	5	5.0	14.4	86	65	7.81	132	
2018-07-31	12:00	6	7.7	13.4	47	62	8.22	124	

[1]WT= Water temperature; DO=Dissolved Oxygen; TDS=Total Dissolved Solids; pH=Acidity; Us=Conductivity; AT=Air Temperature

Appendix 3 – Verna Mumby Notes taken by Wendy Kotilla

SEPTEMBER 15, 2018

MINTO ROAD FOREST AND CEDAR GROVE

- When doing a condition statement for a tree; these are the five areas to assess.
  1. Roots – are the roots cut or dug damaged
  2. Trunk or stem – is the trunk good sized
  3. Scaffold branching – amount of live branches on whole tree
  4. Branches and branchlets – is green growth tip to stem
  5. Foliage – good colour and full
- Co-dominant trees have two stems that meet at the base. If it doesn't meet at the base it is one stem – this is a judgement call
- LCR (Live Crown Ratio) – is tree able to make food and grow; amount of live branches on the whole tree; 40% branches or less the tree is prone to breakage and does not have enough food making material to sustain the tree
- More branches down stemline tree takes every wind and moves it into the stem; more live branches waves into stem and connects into roots and disperses into the ground and there is less wind throw or top breakage
- Trees move elliptic or in a figure eight with the wind; energy goes into the stem and down to the roots into the ground
- Some types of decays in trees causes sap flows (e.g. laminated root rot on conifers)
- Lowest branches in the cedar grove is result of little sun
- Foliage – good colour; full branching; show root productive cycle
- Cedars put on a bit more cones when stressed; heavy seed production preparing; drought stress; transpiration and respiration; especially cedars respond to humidity; if cones from top to bottom branches it is healthy and fine; just cone production on top sun branches is a stress indicator
- Cedar grove is not 95% healthy, more like 75% healthy
- Tree health and structure are separate; a standing dead tree can be structurally sound, but dead; a healthy looking tree can be structurally compromised with internal rot; an example is apples trees as they mature can become hollow and still produce fruit
- Google tree benefits or valuation for plants/trees; benefits trees provide in the environment; carbon sequestration; storm water management; if the cedar grove was cut how much silt and water would go into the creek
- Tree benefits to the environment, birds, habitat, species at risk; if took trees would species disappear; developer could pay for damage of trees
- Data collection – get data on Minto Forest and share
- Spruce tree at the south end of the forest is one of the biggest in CV; planting more spruce in the forest would be a good choice
- Cedar grove is unique in size to the CV; if all the trees in the rest of the forest cut down it would impact the cedar grove
- Verna Mumby is willing to do a YER, Phase II project to analyze the health of the Minto Forest

Appendix 4 – GW Solutions Memo

FROM: GW Solutions Inc.

TO: **Ms. Wendy Kotilla, YER Coordinator**

DATE: August 20, 2018

SUBJECT: Data analysis

GW Solutions is pleased to produce this document in support of the Youth and Environmental Restoration (YER) program.

Introduction

During YER Phase I, six monitoring stations, five staff gauges and one V-notch weir were established for water flow from springs and seeps within the Minto Road Forest study area. The Minto Road Forest study area is situated in the south-west corner of the Millard Creek Watershed (Figure1).

Since September 2013, the water levels at the six stations (Figures 2 to 7) have been measured twice monthly, and the maximum and minimum air temperature, rainfall amount and the weather conditions at the study area have been recorded, daily.

The water quality indicators such as temperature (Temp), dissolved oxygen (DO), total dissolved solids (TDS), acidity (pH) and electrical conductivity (EC) have been measured monthly since September 2013 using HANNA Instruments.

Groundwater level within the shallow domestic drinking water well, located immediately uphill of the Minto Road Forest (Figure 1), has been monitored monthly since March 2008.

Figure 3: Study area and the location of monitoring stations

Figure 4: Gauge 1 monitoring station

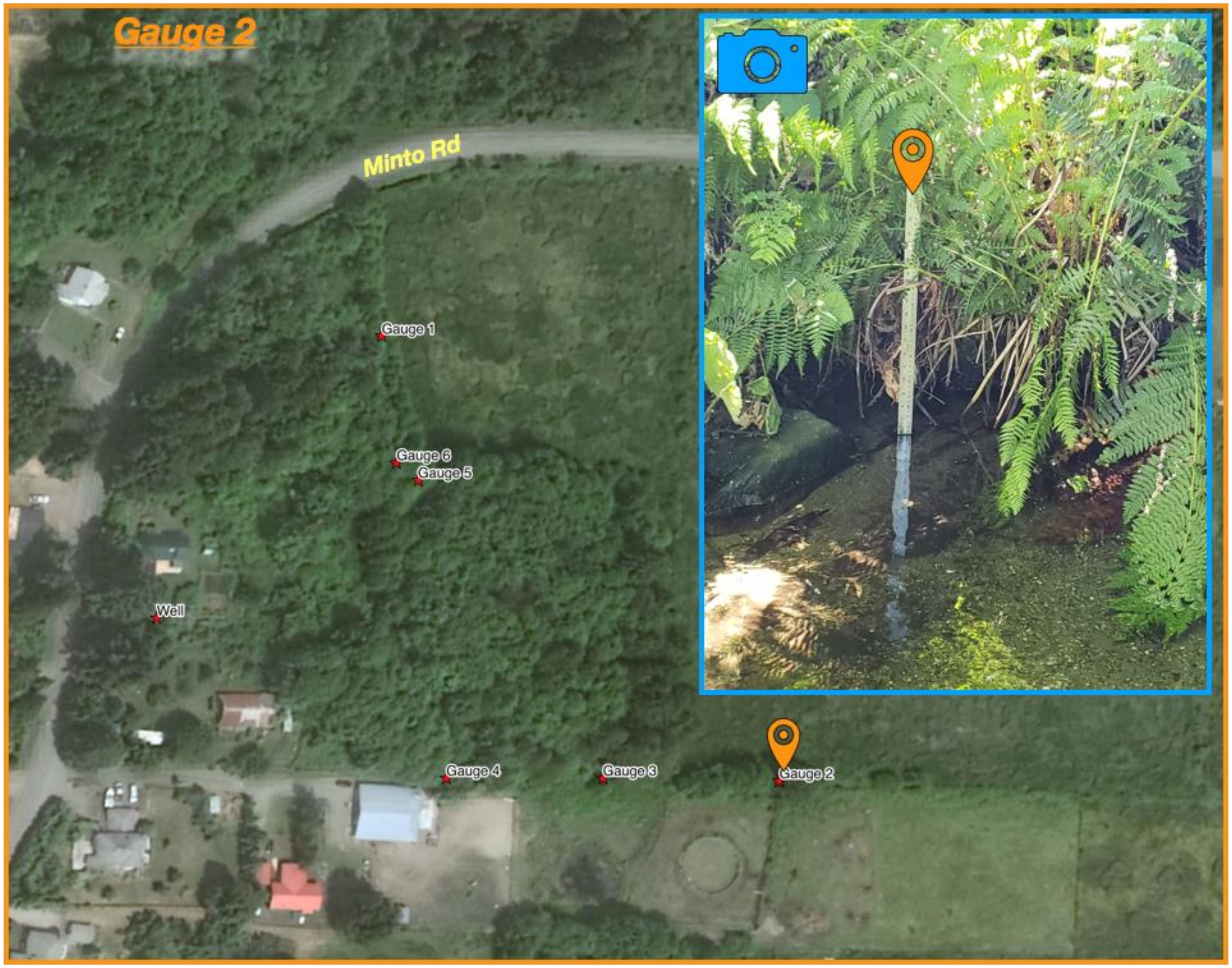

Figure 5: Gauge 2 monitoring station

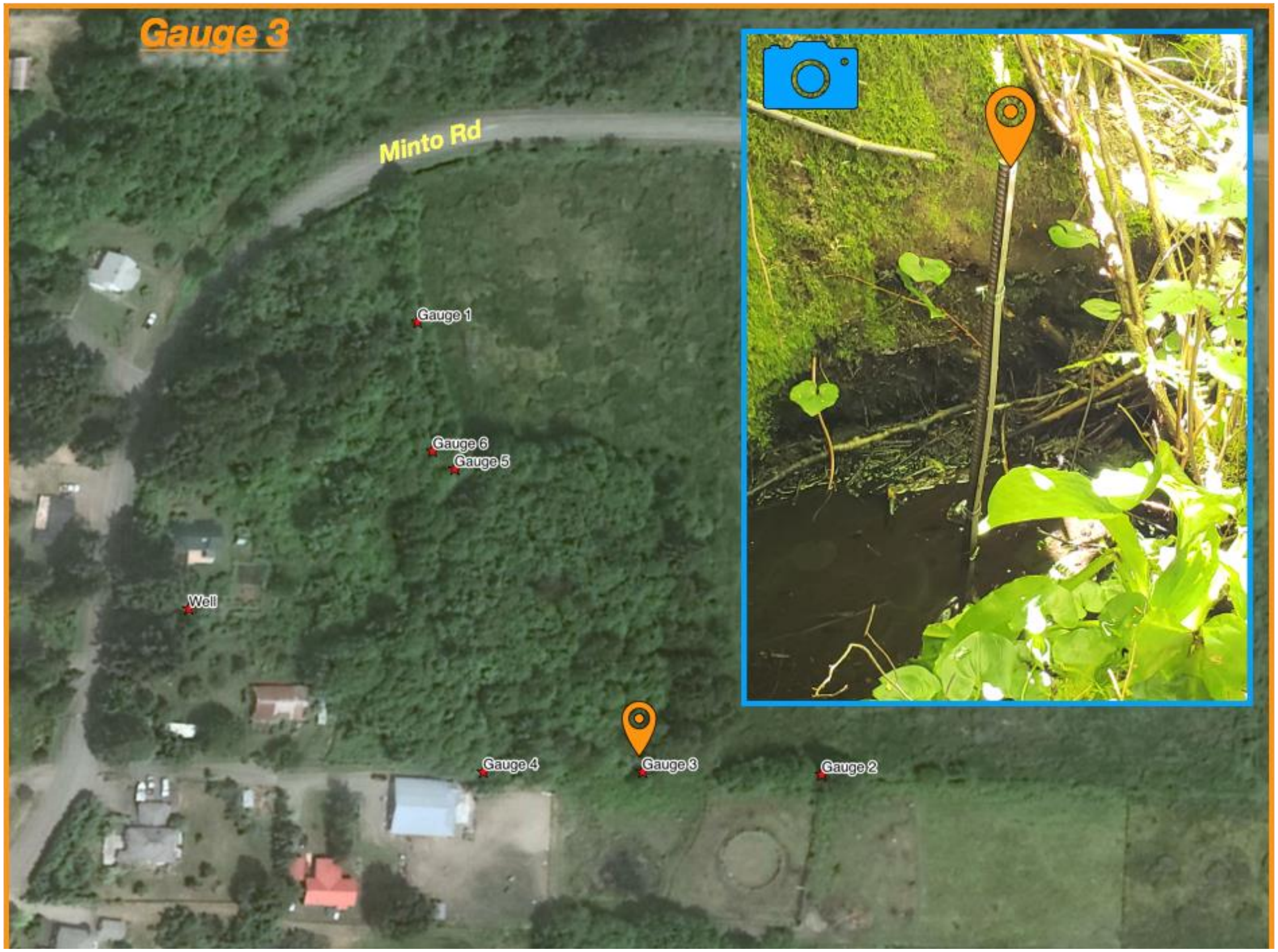

Figure 6: Gauge 3 monitoring station

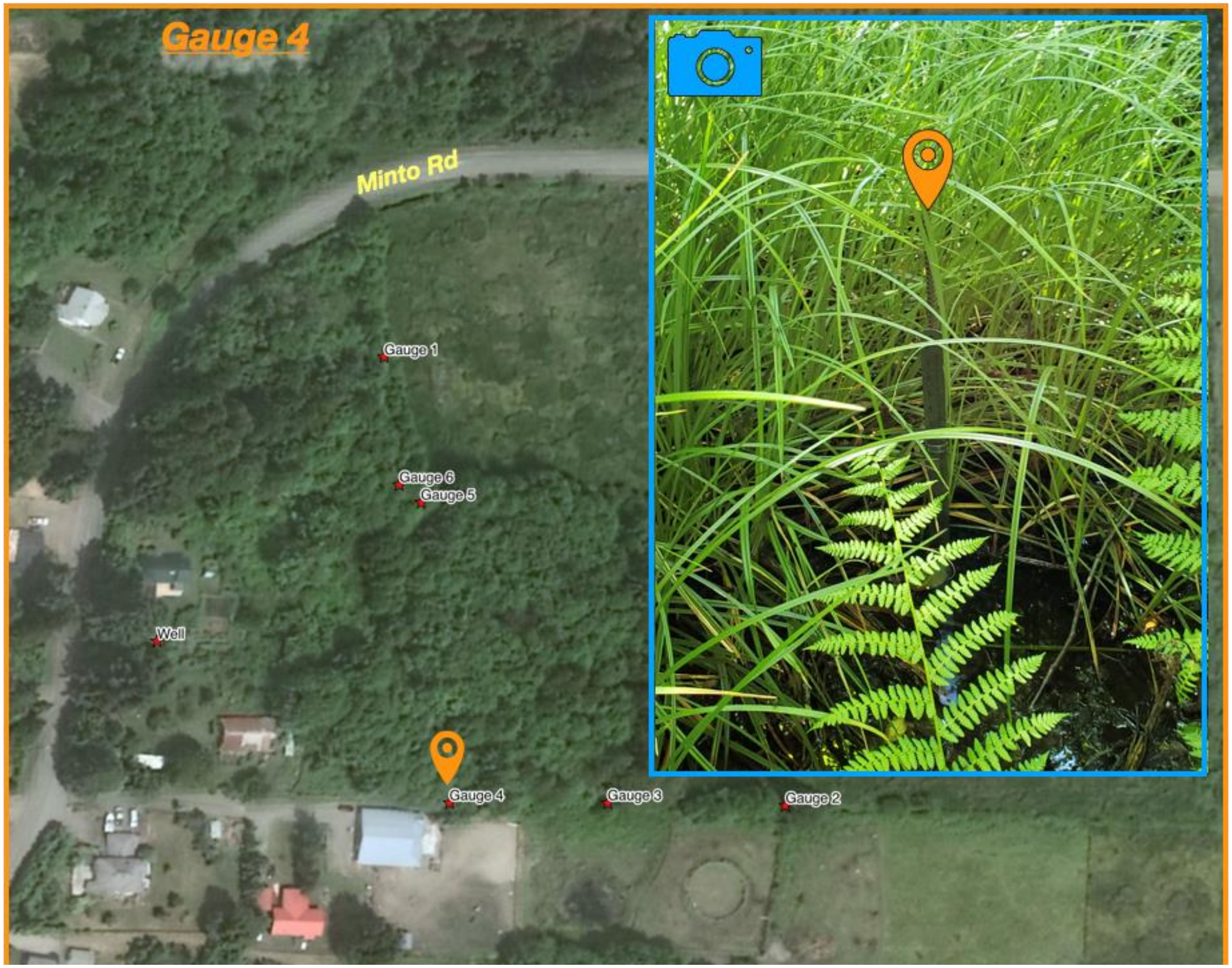

Figure 7: Gauge 4 monitoring station

Figure 8: Gauge 5 monitoring station

Figure 9: Gauge 6 monitoring station

Figure 8 shows the recorded daily precipitation and the number of days when precipitation was measured. The maximum precipitation usually occurs in November, December or January. We observe an increasing trend in the last five years.

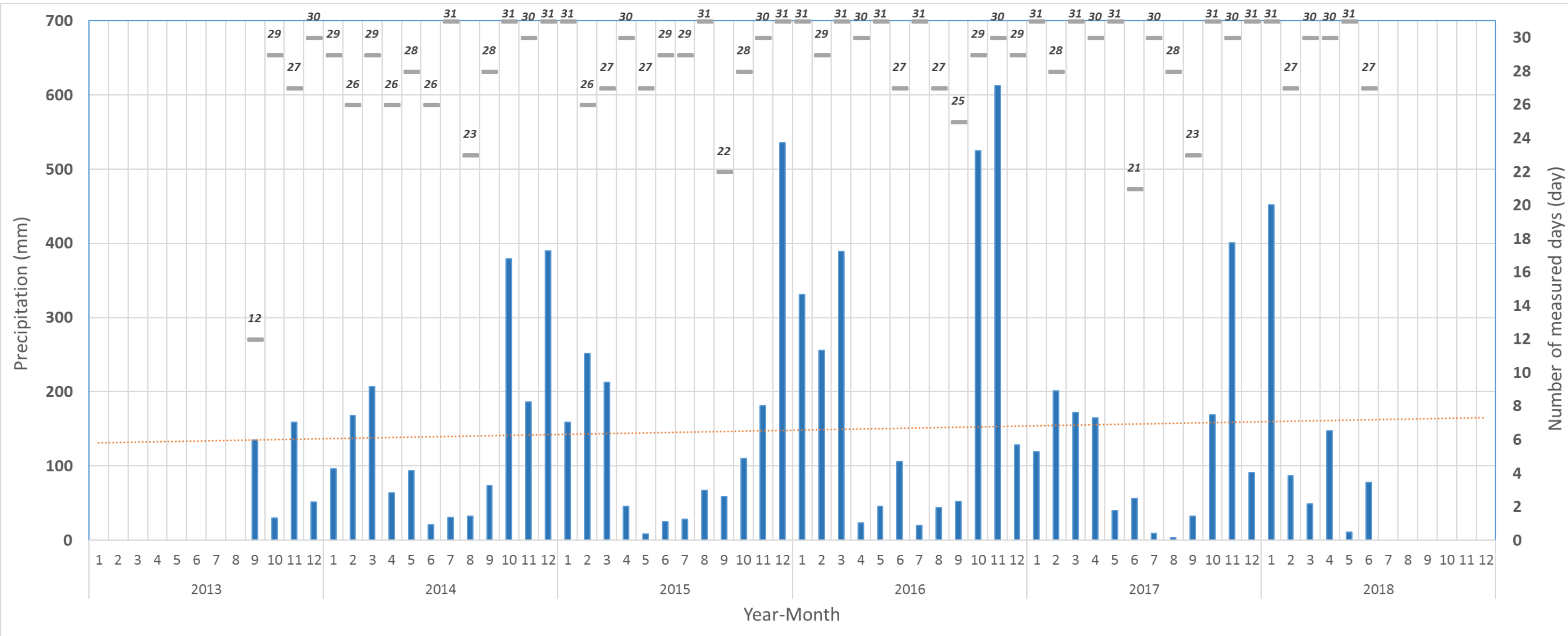

Figure 10: Measured daily precipitation

Water Level Monitoring

Groundwater levels immediately uphill of the Minto Road Forest have been monitored by measuring water levels in a domestic drinking water shallow well for the past nine years. Figure 9 presents the water level (water column) fluctuation in the well and Figure 10 shows the relationship between water level in the shallow well and the recorded precipitation, respectively.

Based on Figure 9, with the two exceptions of 2009 and 2014, water levels have followed a similar pattern. Groundwater levels are highest in the early spring, March and April, following the seasonal fall and winter rains and then gradually lower throughout the summer and early fall.

There is a good correlation between precipitation and water level.

In 2009, water levels were lower when compared to other years. The lower water level in 2009 is of interest because two domestic water wells in the neighborhood ran dry that year. The Environment Canada weather station on the Puntledge River in Courtenay recorded a total precipitation of 243.8 mm in November 2008 through January 2009, 55% lower than the average for the same three months over the past nine years (Environment Canada 2013). This shows how important the late fall and early winter rains are in replenishing the shallow groundwater layer of the watershed. That two neighboring wells ran dry demonstrates how changes in the water table can adversely affect local residents and the plants, animals and fish that depend on a constant supply of water.

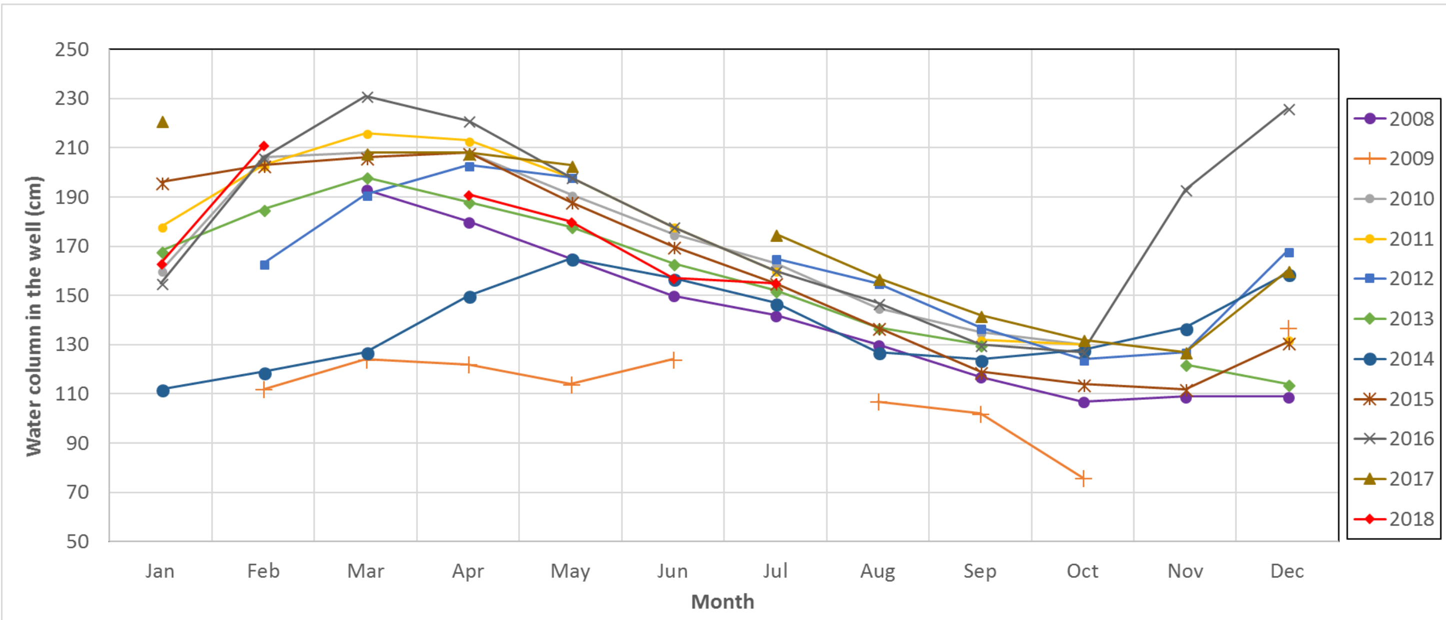

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Figure 11: Water level fluctuation in the shallow water well

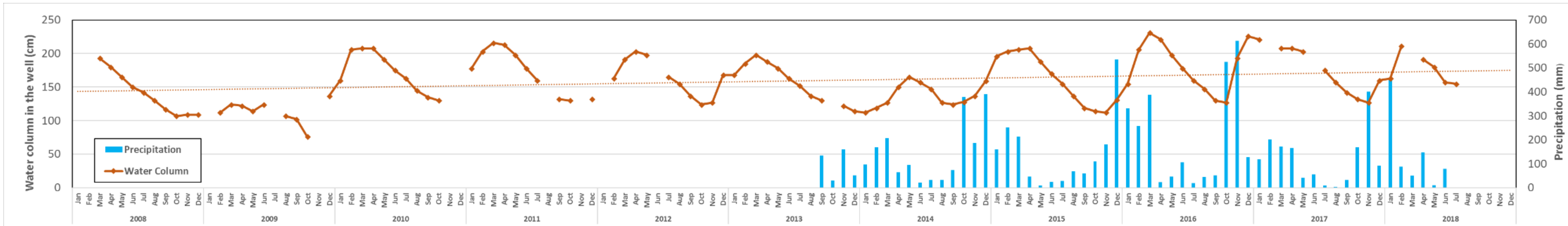

Figure 12: Water level fluctuation in the water well and recorded precipitation

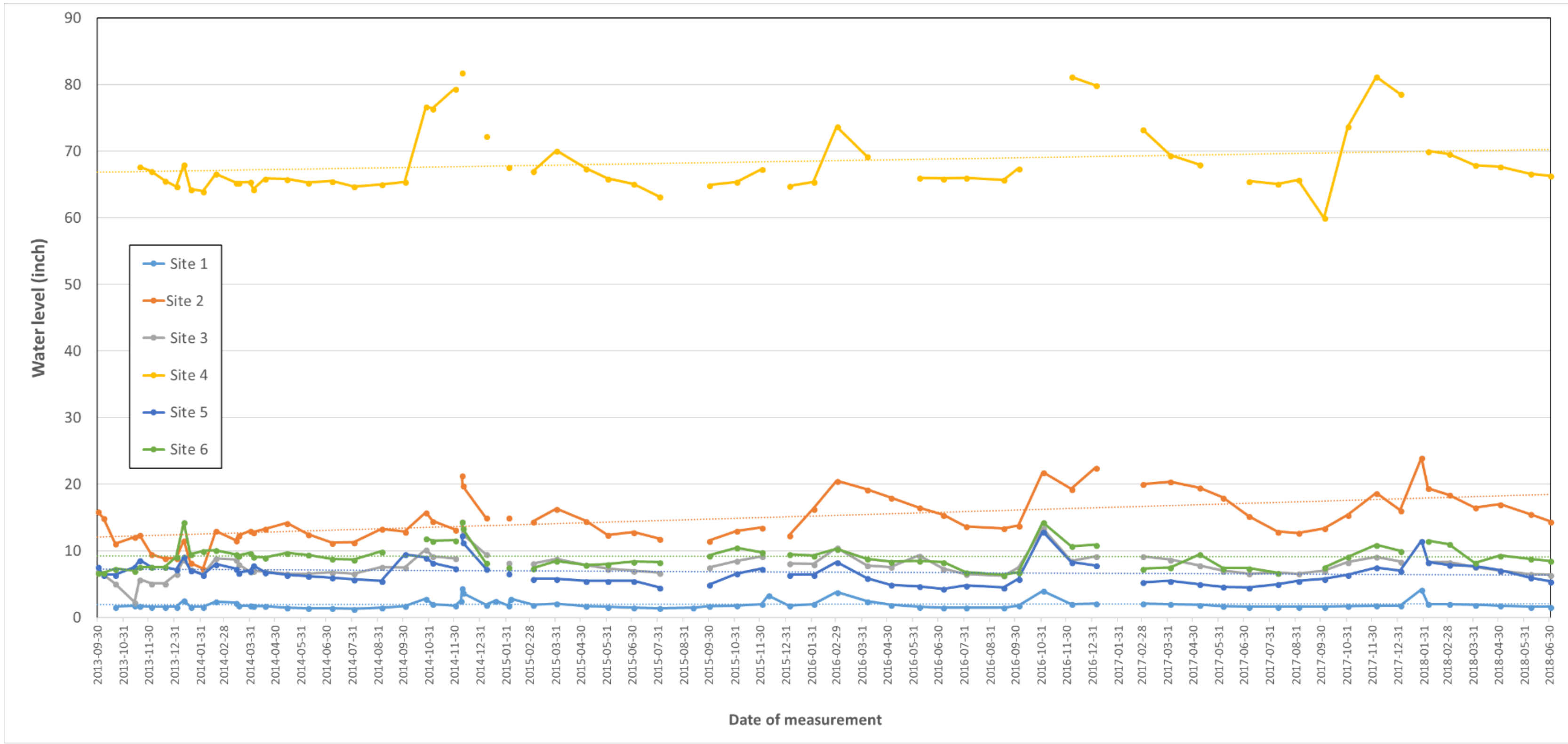

Figure 13: Recorded water levels for the six surface water monitoring stations/ gauges

Figure 11 illustrates the recorded water levels at the six monitoring stations. The water level fluctuations for these stations have followed a similar pattern. There is a moderate correlation between seasonal precipitation and the water levels, as the peak water levels for all stations have been happening during and following the wet season.

None of the monitoring stations have been dry during the monitoring period even in the warmest months with no rainfall.

Water Quality Monitoring

The water quality indicators such as temperature (Temp), dissolved oxygen (DO), total dissolved solids (TDS), acidity (pH) and electrical conductivity (EC) have been measured monthly since September 2013 using HANNA Instruments.

Figure 12 to Figure17 present the water quality parameters fluctuation during the last five years. The water quality parameters fluctuate seasonally, with a similar pattern over the monitoring period, for all the stations.

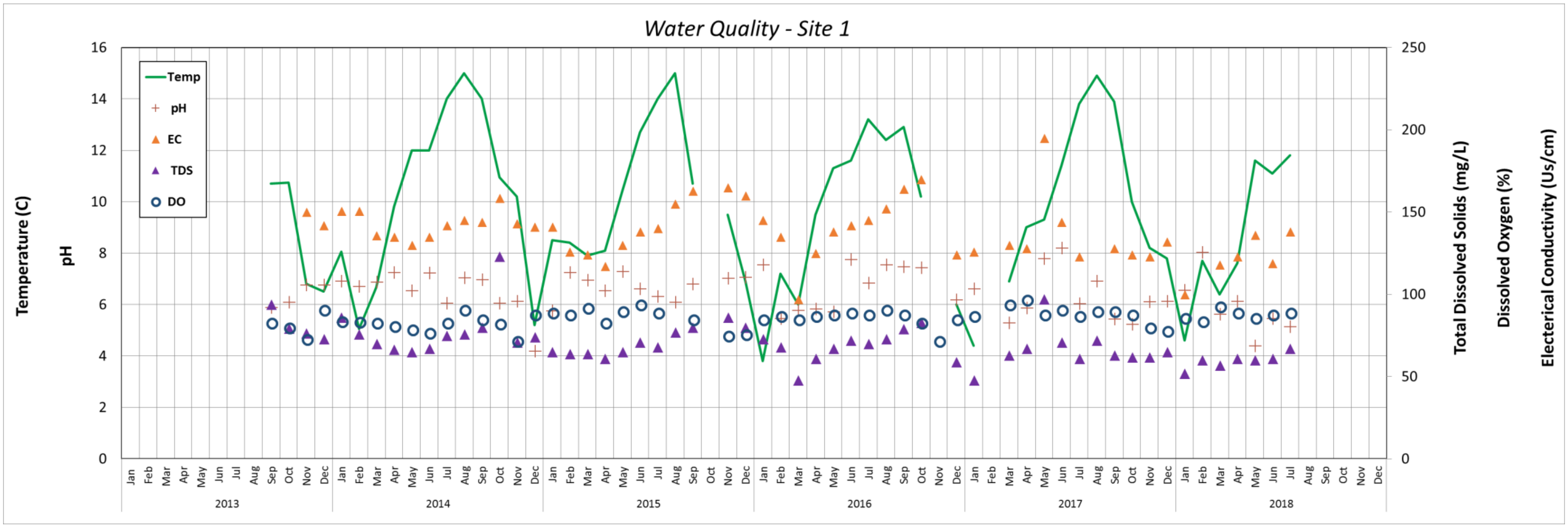

Figure 14: Water quality parameters for Gauge1

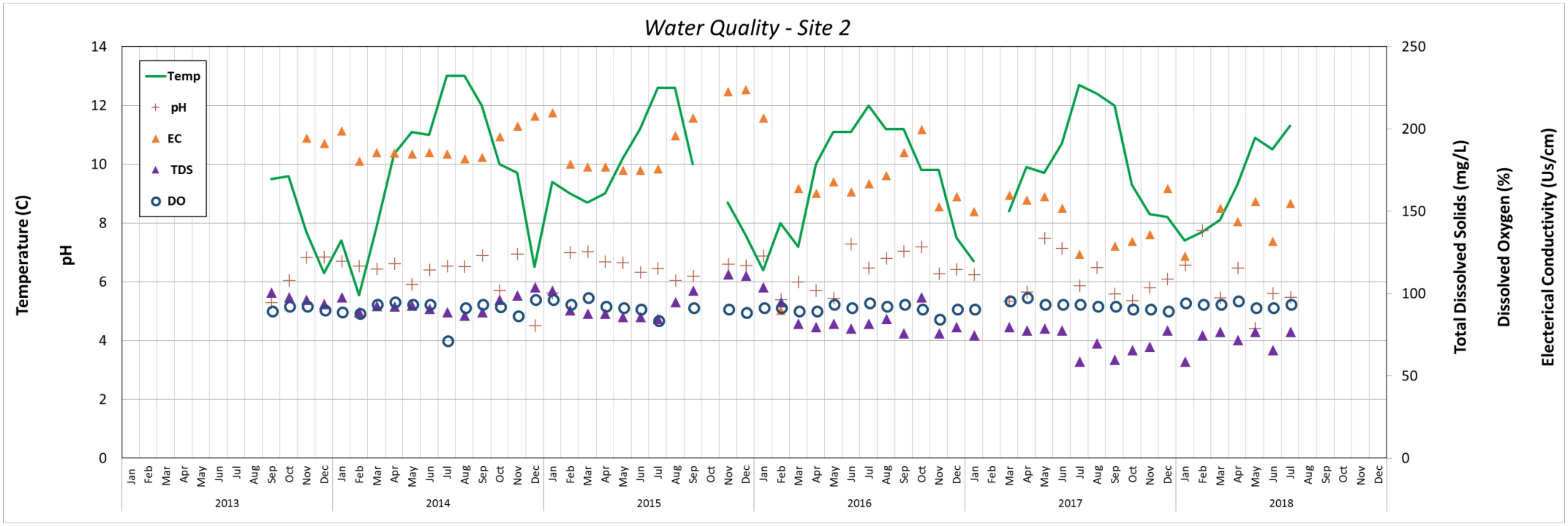

Figure 15: Water quality parameters for Gauge 2

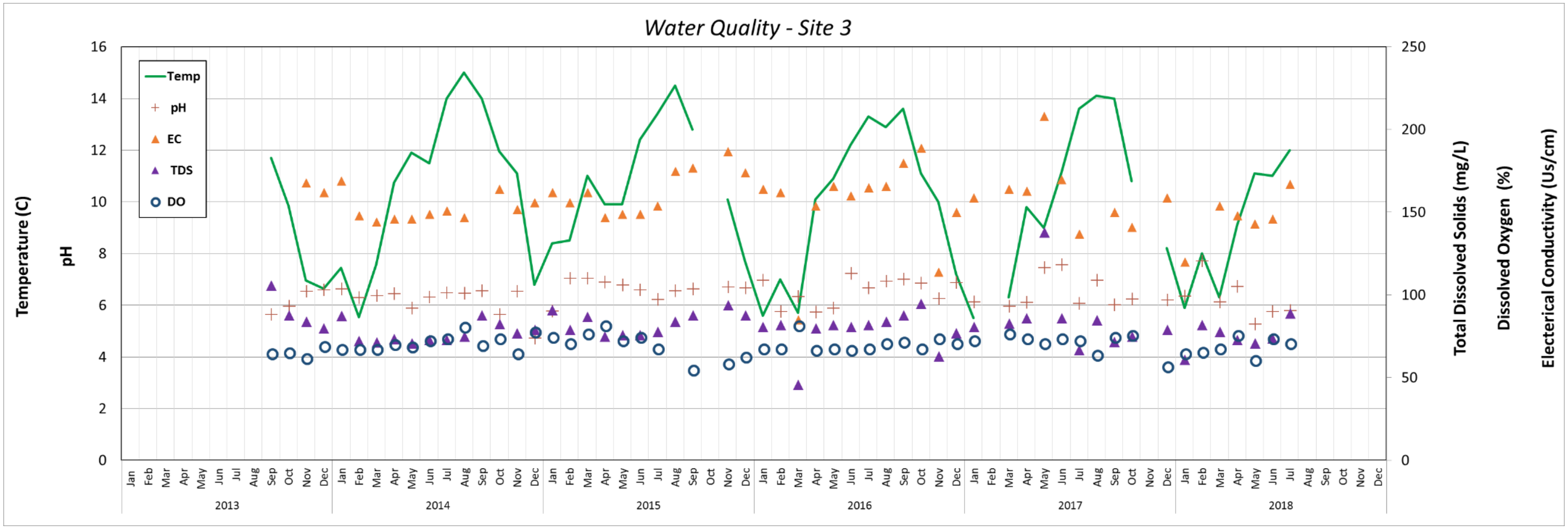

Figure 16: Water quality parameters for Gauge 3

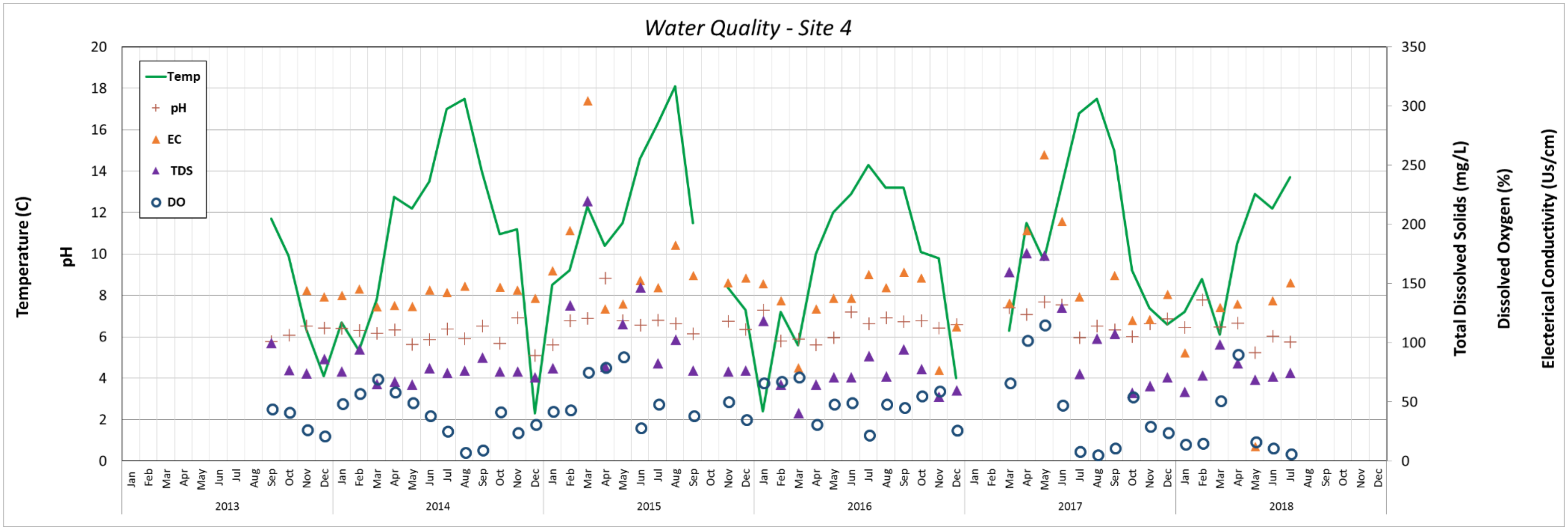

Figure 17: Water quality parameters for Gauge 4

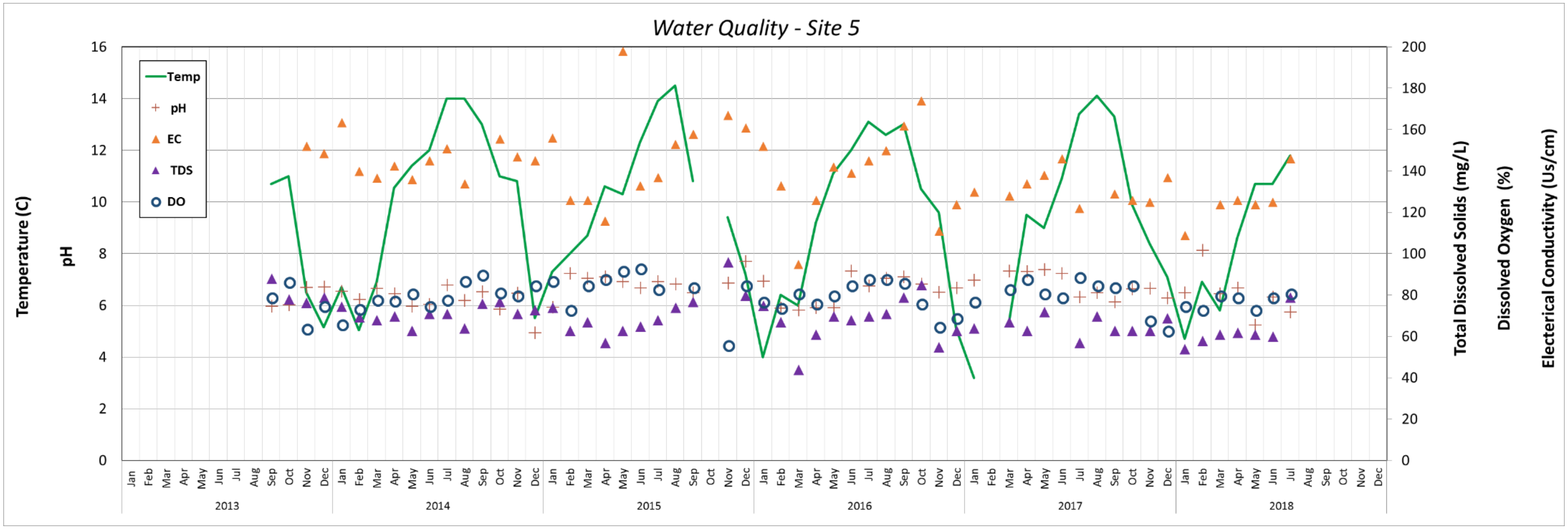

Figure 18: Water quality parameters for Gauge 5

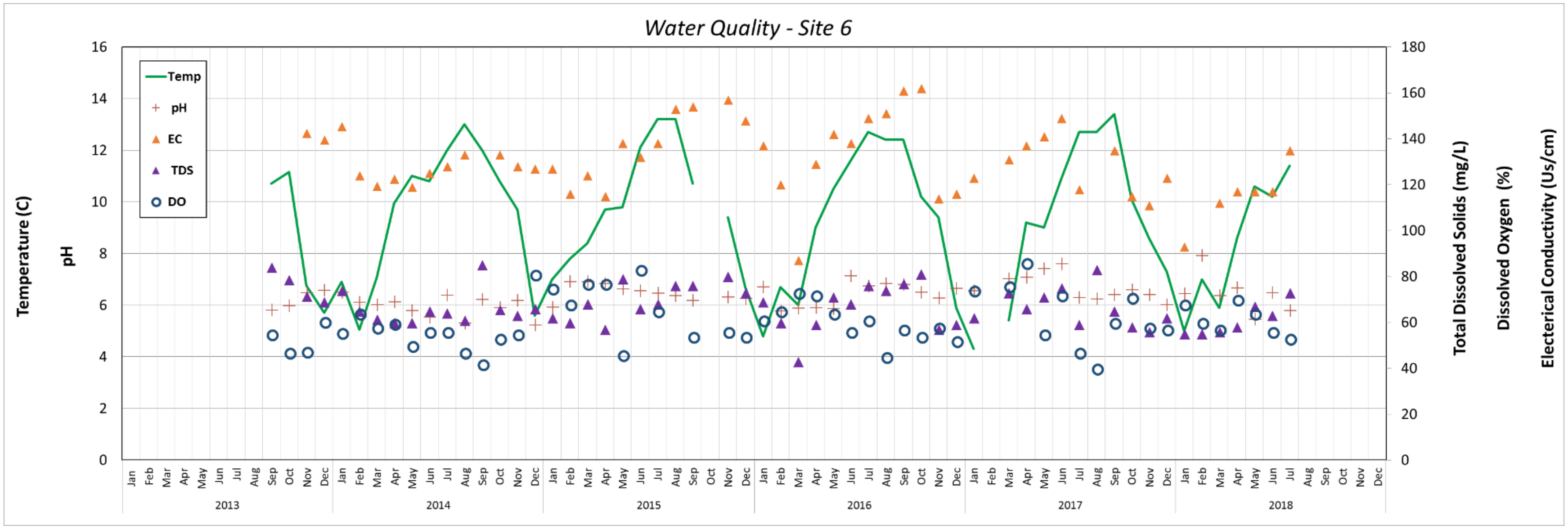

Figure 19: Water quality parameters for Gauge 6

Aquifers

Based on the data analysis, two aquifers are present within the study area:

1. An unconsolidated aquifer (sand and gravel), and

2. A fractured bedrock aquifer.

What is an *aquifer*? The word literally means 'water bearer' and refers to a layer of rock or sediment that contains enough accessible water to be of interest to humans. Water in an aquifer is stored between the granular particles or in the fractures. Aquifers can be either fractured bedrock (such as sedimentary rock like Sandstone or igneous rock like Granite) or unconsolidated (such as the sands and gravels).

Figure 18 presents the extent of fractured bedrock aquifer (413IIB) and unconsolidated aquifers (951IIA and 417IIA) mapped by BC MoE (Ministry of Environment) close to the study area. Table 1 summarizes the characteristics of these aquifers in terms of vulnerability, productivity, size and etc.

Based on the Figure 18, the study area is not within the boundaries of the mapped aquifers. However, GW Solutions believes these boundaries should be modified to cover the study area.

Table 3: Characteristics of BC MoE mapped aquifers

Aquifer number	Aquifer name	Dercriptive location	Lithology stratographic unit	Productivity	Vulnerability	Demand	Size (Km2)
413	413 IIB (10)	West of Royston, north to Puntledge River	Nanaimo Group; likely the Comox Formation	Low	Moderate	Low	35.2
417	417 IIA (10)	North of Cumberland, to Puntledge R.	Capilano Sediments and possibly Quadra Sands in places	Moderate	High	Low	14.9
951	951 IIA (13)	Puntledge to Courtenay	Capilano Sediments; likely sand & gravel lenses within till deposits	Moderate	High	Low	12.7

Recommendation

GW Solutions recommends to continue the monitoring program and to continue educating youth. This program is an excellent opportunity to expose young people to watershed monitoring and management.

The data should be reviewed every second year to identify whether significant changes are observed.

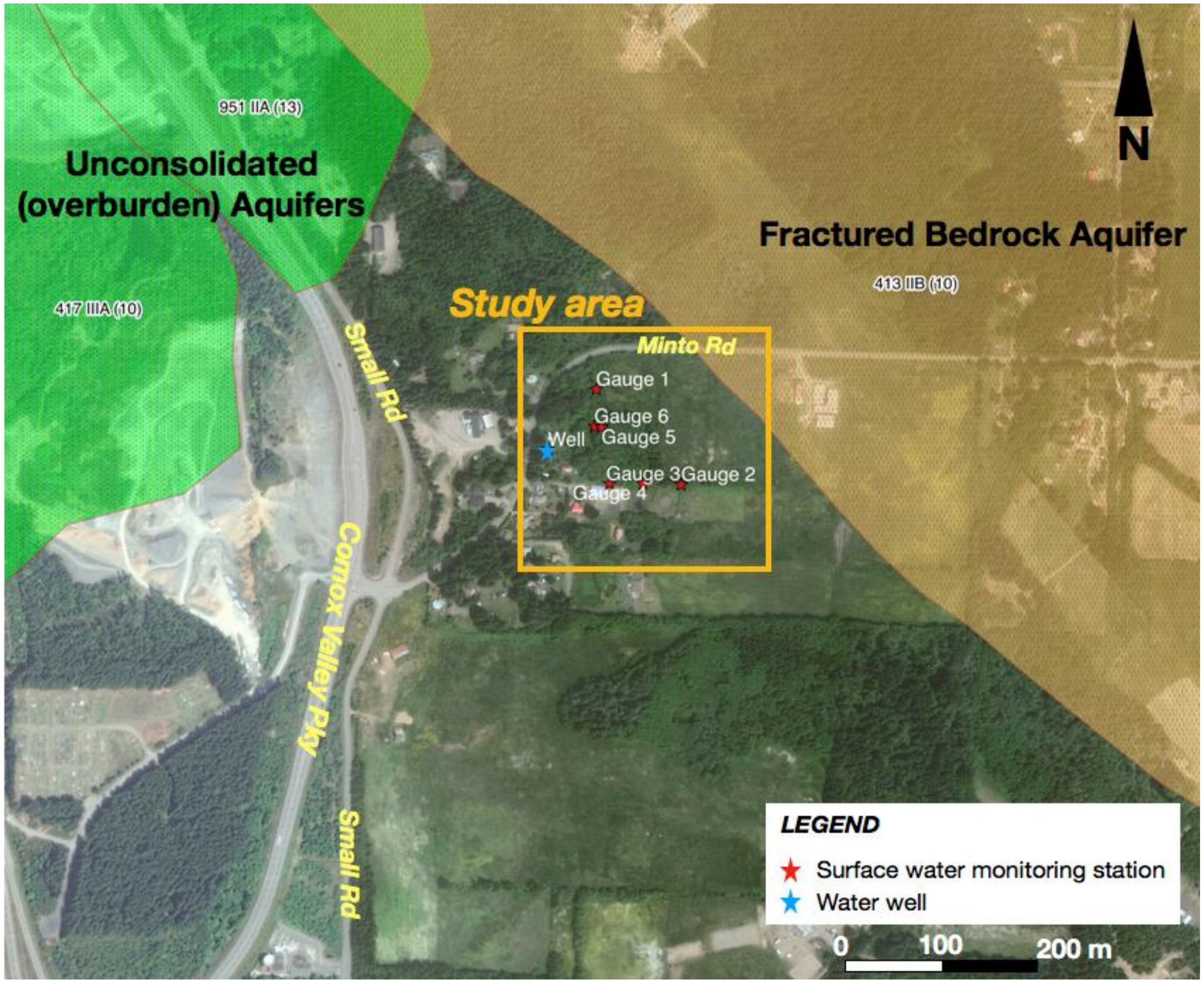

Figure 20: The study area and mapped aquifers, according to ImapBC