Watercourse and vegetation mapping in a tributary in the Upper Millard Creek Headwaters

YER Phase II Project June 1-5, 2022

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Acknowledgements

This report describes the enthusiastic efforts of youth field technicians Opal Nielsen and Keagan McGaw and their mentors. The Youth and Ecological Restoration Program (YER) was created by Wendy Kotilla who also provided program administration and field support for this project. 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 Tanis Gower of Fernhill Consulting in leading the field program and producing this report. Fisheries and Oceans Canada (Puntledge River Hatchery) provided staff time to allow Don Chamberlain to spend one day with the program, providing technical support for the waterway mapping. The Millard-Piercy Watershed Stewards provided funding to rent the technology needed for accurate waterway mapping. Landowners Wendy Kotilla, and Ian and Kari Pieterse and Sue Minchin provided access to their properties, which was essential to the success of the project. Shiva Farjadian from GW Solutions Incorporated provided an update to previous hydrological data analysis, which is included in this report as Appendix 2.

1. Introduction

The purpose of the study was to:

1. Support vulnerable youth within the Comox Valley by providing them with hands-on, meaningful opportunities to engage with nature and adult mentors; and,

2. Map waterways to Sensitive Habitat Inventory and Mapping (SHIM) standards and provide these data to the Comox Valley Regional District to update their mapping, map the riparian corridor (streamside vegetation) using SHIM standards, and continue long-term data collection for:

- Water quality and quantity
- Weather
- Fish presence

1.1. YER Program

The Youth and Ecological Restoration program provides youth aged twelve to eighteen with one-on-one work experience through ecological restoration methods, ecotherapy practices and mentoring support. Youth learn social, practical and communication skills to motivate them in becoming confident, respectful, and productive members of society.

All youth involved in the program begin with Phase 1, where they work with a YER staff person and with environmental organizations and volunteers focused on restoring local watersheds and ecosystems. On program completion, youth give an oral presentation for a community group.

Some graduates of Phase 1 are accepted into Phase 2. In Phase 2, two youth, a YER staff person, and an environmental professional work on a project together. The focus is on a specific environmental project for advanced learning about ecological information, research techniques, and collaboration and communication. The project is completed to a professional standard and provides useful information and/or assistance to land managers. On the last of five days, the youth co-facilitate a public tour to complete the project.

1.2. Study Location

The study site is located along Minto Road in the upper headwaters of Millard Creek, in Electoral Area A of the Comox Valley Regional District (Figure 1). The study site is made up of two adjacent properties on Minto Road, one owned by Wendy Kotilla (1 acre), and the second owned by Ian and Kari Pieterse and Sue Minchin (10 acres). This site is not open to the public. The two parcels are both zoned RU-ALR (Agricultural Land Reserve) and both include areas protected through Comox Valley Regional District (CVRD) Development Permit Area regulations (DPAs) for Aquatic Riparian Areas and Shoreline Protection (~20% of the study area) (CVRD 2022).

Millard Creek drains an area of approximately five square kilometres (Moul and Kotilla 2013) before joining Piercy Creek and entering the K'omoks Estuary just south of the City of Courtenay. Land use in the Millard Creek watershed is primarily agricultural and rural residential with a trend of increasing residential density. The study site is situated in the south-west corner of the Millard Creek Watershed, in a location where subsurface flow comes to the surface in many places to form wet microsites and small perennial and ephemeral surface waterways (Moul and Kotilla 2013). The study site is in the headwaters of the Millard Creek watershed and its springs and waterways supply flow to the downstream areas.

Currently, the small waterways and ditches in and near the subject properties are only partially included in the publicly available geographic information system maintained by the CVRD[1] – see Figure 1. This project was designed to update the waterway information in the publicly available regional mapping.

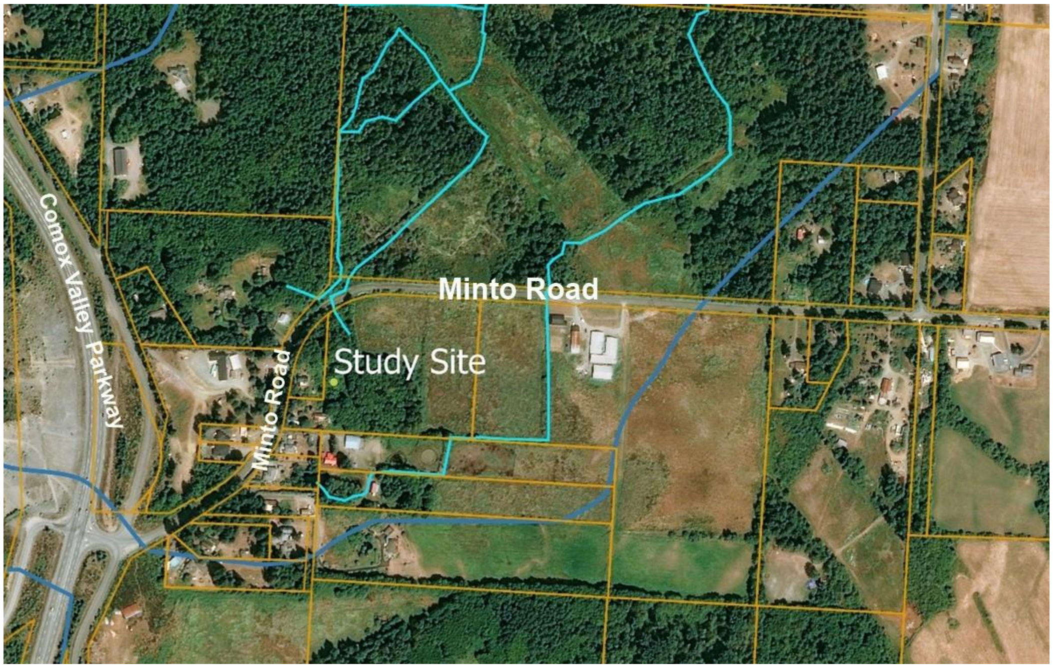

Figure 1: The study site. Note the dark blue boundary which is the southern extent of the Millard Watershed. The light blue lines are the waterways and ditches from the existing mapping available through the Comox Valley Regional District, which was augmented during this project. Land parcel boundaries are shown in yellow. The satellite imagery is from Bing, accessed August 18, 2022.

1.3. Ongoing data collection and past projects

This project builds on past YER projects at the study site as well as ongoing measurements of groundwater and surface water levels, water quality and weather conditions by YER founder and study site landowner Wendy Kotilla. Long-term datasets of this nature are extremely valuable for various applications, including understanding the effects of land use changes on hydrology and water quality, and providing local data on climatic changes. The hydrological data collection was set up under the guidance of GW Solutions Incorporated (Moul and Kotilla 2013). The existing data and projects that the current project was based upon include the following:

- Monthly groundwater level monitoring since March 2008 for the shallow domestic drinking water well at 4333 Minto Road.
- Daily maximum and minimum air temperature, precipitation, and weather conditions since September 2013.
- Monthly water stage (depth) at five staff gauges and one V-notch weir since September 2013.

[1] iMap | Comox Valley Regional District (comoxvalleyrd.ca)

- Monthly water quality measurements since 2013, at the same six sites as water stage is measured, to collect the following data:
    - Water temperature,
    - pH
    - total dissolved solids
    - conductivity
    - dissolved oxygen.
- Watercourses, springs, and seeps were mapped in 2013 and then mapped in more detail in 2018 (but not to SHIM standards with respect to accuracy of the watercourse locations) (Moul and Kotilla 2013, Ennis and Kotilla 2018).
- Water stage and water quality data from September 2013 to June/July 2018 were summarized in 2018 by Groundwater Solutions Inc. and included in Ennis and Kotilla 2018. These data and the associated analyses were updated by Groundwater Solutions Inc. in June 2022. This update is included as Appendix 2 to this report.

2. Methods

The field program was carried out from June 1 to 5, 2022. The first three days included collection of water quality and quantity data, and mapping waterway locations and riparian conditions. On days four and five the focus was on the preparation and presentation of a public tour by the youth. The four YER team members were: YER coordinator Wendy Kotilla; Registered Professional Biologist Tanis Gower; and two youth participants, Opal Nielsen and Keagan McGaw. An additional team member was Don Chamberlain, (Enhancement Technician, Puntledge River Hatchery, Fisheries and Oceans Canada) who joined the group on Day 2 to provide mapping expertise and mentorship.

2.1. SHIM watercourse mapping

The location of waterways on the subject property were mapped to SHIM (Sensitive Habitat and Inventory Mapping) standards (Mason and Knight 2001) on June 2, 2022. Methodology followed guidance from Module 5 “GPS Surveying Procedures,” specifically, the positional accuracy requirement of 5 metres, at 95% confidence. This level of accuracy is intended to be compatible with local government mapping requirements for waterways, which typically inform development permit areas such as the aquatic riparian development permit area in the Comox Valley Regional District.

A Trimble GEO7x GNSS (global navigation satellite system, sometimes also referred to as a GPS) unit was rented from Cansel Survey Equip. in Burnaby, BC. The device was then programmed with the settings required for SHIM field data collection methods. Trimble TerraSync 5.9 data collection software was used to interface with the Trimble Geo7x GNSS unit.

Data collection filters were set on the GNSS unit to meet standards required by SHIM, as follows: all positions fixes must use at least four satellites. No height constraints can be applied. Minimum elevation angle to satellites is 15 degrees above the horizon. The maximum Dilution of Precision (DOP) values are: Horizontal DOP: 5 (preferred in most cases), Position DOP: 8, Geometric DOP: 10. For standard static point features, occupation time must be at least 60 seconds AND there must be at least 30 individual position fixes for each feature. The target horizontal accuracy is one metre. The lowest acceptable horizontal accuracy is five meters, at the 95% confidence level. The maximum age of real-time corrections is 20 seconds from the time the observations are made at the reference station to the time the computed corrections are applied at the field receiver.

A modified SHIM Data Dictionary was used to standardize collected data so it could be adopted into existing databases. Trimble GNSS Pathfinder Office (v5.9) Data Dictionary Editor software was used to save the original SHIM data dictionary (v23) as a new version that would be compatible with the version of Trimble TerraSync data collection software installed in the Geo7x GNSS unit.

During each line survey, position fixes were taken every second, producing abundant data to capture locations of recorded line features.

Accurate point positions were captured by requiring a minimum of 30 positions to save any point feature in the GNSS, and by employing a policy of occupying the point feature location for a minimum of 60 seconds.

One GNSS rover file was created for the survey day. On June 2, the project team systematically walked perennial waterways on the study site. The GNSS data were then transferred to a computer for post-processing using Trimble Pathfinder Office software v5.9. A Canadian Active Control Station located in the Port Alberni area that was available in the Pathfinder software was chosen for downloading the base data for corrections

The resulting corrected rover file was then opened in Pathfinder Office and Features were exported using filtering according to SHIM data accuracy requirements. The data was exported in shapefile format with metadata and associated feature attribute data appended.

The exported shapefile was edited in the geographic information system software QGIS. The editing process included identifying erroneous vertices in each individual line feature and smoothing of the lines using interpolation. Errors in the line features included GNSS multipath errors, extra position fixes gathered due to not pausing the GNSS collection when pausing a traverse, etc. Point features were not edited since the accuracy filtering and position averaging was done in the Trimble GNSS unit as it was gathered, and then in the export filtering function of the Pathfinder Office software, after post-processing had occurred.

Records collected for Features Types named in the Data Dictionary (either line or point feature) were imported in QGIS as separate layers, each stored in QGIS geopackage layer format. The QGIS project was saved to produce one set of records for each Feature Type collected for the surveys (Drainage lines and Stream lines, Waterbody point, Wildlife Tree point, Tie Point). Attribute data appended to the Line and Point Features includes feature comments that were typed in the GNSS unit in the field, as well as associated GNSS metadata appended in the export process.

A shapefile of the Stream layer was exported from the QGIS project to share with Comox Valley Regional District staff for inclusion in the CVRD Sensitive Habitat Atlas GIS layer.

2.2. SHIM riparian characterization

Characterizing the riparian (streamside) land cover is a way of describing the integrity of the riparian corridor surrounding a waterway. The condition of the riparian corridor influences the ecological functions and processes of the waterway it surrounds. For instance, a waterway surrounded by mature forest will receive shade and will typically have favourable water temperatures, stable banks, and good instream habitat conditions, while waterways in areas converted to urban or agricultural uses often have poorer habitat conditions and poorer water quality, including higher water temperatures.

The riparian land cover was mapped according to SHIM standards (Mason and Knight 2001), specifically Module 4, "Riparian Area Classification and Detailed Cross Sections." This standard provides a method to classify riparian land cover in a 50-meter buffer zone along both sides of a watercourse. To determine the location and width of the riparian corridor, the hydrologic features mapped in 2013 and 2018 (Ennis and Kotilla 2018) were used to approximate the waterway locations and extent of the riparian corridor 50 meters either side of the waterways, as shown in Figure 2.

Land cover polygons were delineated based on the SHIM Land Cover Classification System using satellite imagery (Bing, accessed May 2022) and the GIS program QGIS before the field program began, and then validated in the field by the project team using two approximately 100 m long transects which were situated to sample the different land cover types (Figure 2). The team used a 6th generation iPad and Avenza Maps 4.0.4 software paired with a Bluetooth enabled GPS (Garmin Glo II) to navigate, record tracks and waypoints, take photos, and make notes. As the transects were traversed, additional information was gathered about the vegetation type, age, and common plant species.

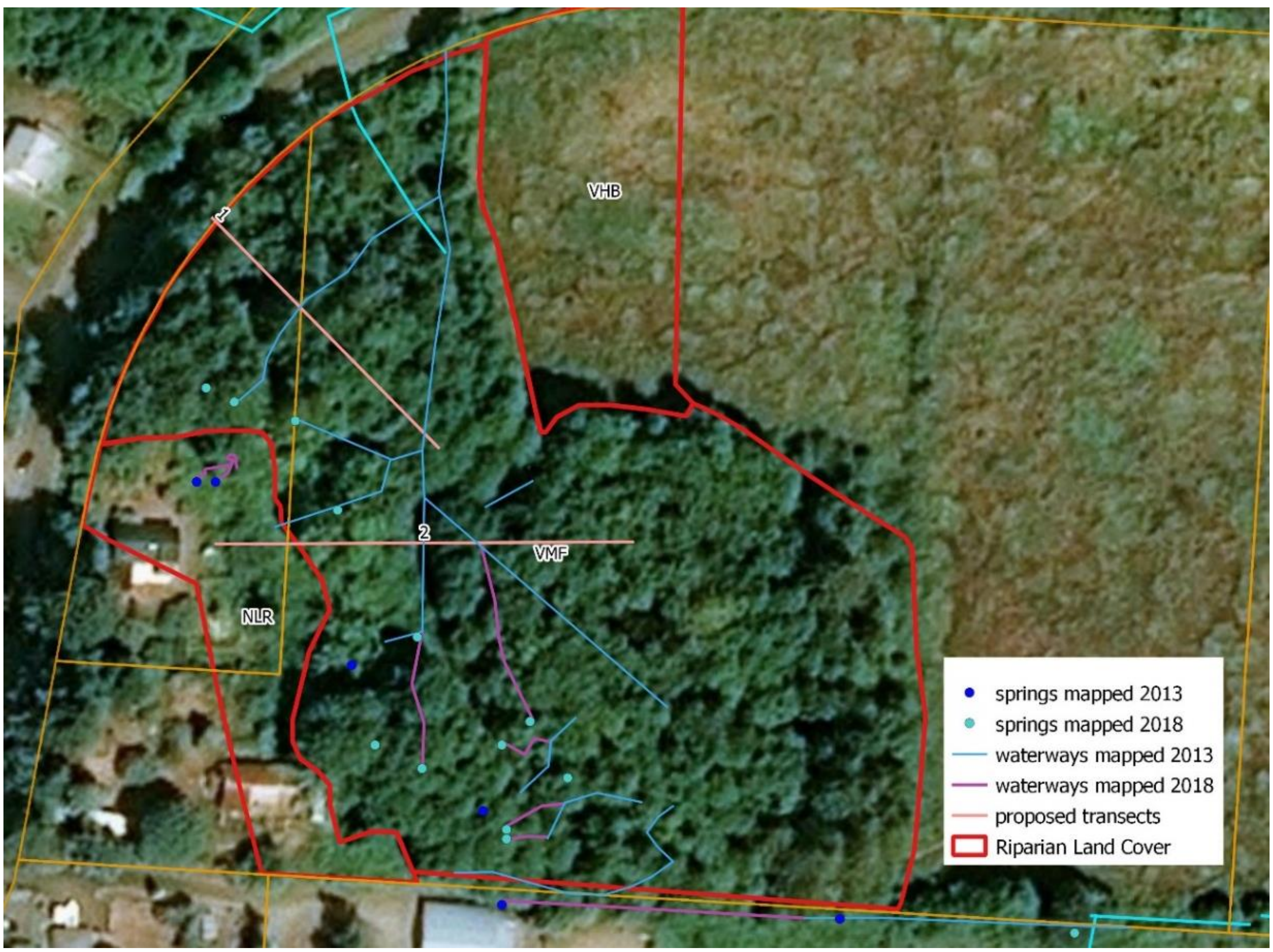

Figure 2: The study site showing the riparian corridor divided into three land cover types before the field program: mixed forest (VMF), agricultural field (VHB) and residential development (low imperviousness – NLR). Also shown are two transects that were to be traversed by the field crew to validate and further describe the land cover.

2.3. Water stage sampling

The six sample sites that were established in 2013 were visited on June 1, 2022, to take the monthly water level samples. Figure 3 shows the sample site locations. Site 1 has a v-notch weir while the other five sites have staff gauges made from metal metre-sticks attached to rebar embedded in the substrate (Ennis and Kotilla 2018). Photographs of each site are provided in Appendix 1.

2.4. Water quality sampling

Water quality was sampled at the same six sites shown in Figure 3 on June 1, 2022. As per the ongoing protocol (Moul and Kotilla 2013), the parameters sampled were:

- Water temperature,
- pH
- total dissolved solids
- conductivity
- dissolved oxygen.

The samples were taken using a HANNA multi-parameter water quality meter (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.

Figure 3: the locations of water stage and water quality sampling, which were established in 2013.

2.5. Weather observations

Weather observations have been taken daily since September 2013, specifically daily maximum and minimum air temperature, precipitation, and weather conditions (cloud cover, wind direction). For this project, weather was sampled daily on June 1 to 5, 2022.

2.6. Fish sampling

The collection of fish was authorized under a scientific collection permit issued to the Millard-Piercy Watershed Stewards. Two Gee minnow traps were baited with salmon roe and installed at Site 2 on June 1, 2022. They were left for 24 hours and recovered on June 2, 2022. Fish caught in the traps were identified to species and measured (length) prior to release.

3. Results

3.1. SHIM Watercourse Mapping

The locational data shown in Figure 4 was submitted to the Comox Valley Regional District (CVRD) for inclusion in their Geographic Information System, specifically the regional Sensitive Habitat Atlas dataset showing the location of Streams.

The purported level of accuracy for the equipment used is sub-metre, but the dense nature of the forest canopy in the survey area resulted in poorer position fixing capability than would occur in open areas. The Horizontal accuracy for all positions fixes recorded comprising the lines and points collected in the survey (1881 positions in total) averaged an accuracy of 1.8 m, with worst accuracy positions, in the >5m range stemming from 116 recorded positions. In the exported data provided, the locations of line features were adjusted by filtering out, and/or manually adjusting/ interpolating the location in the QGIS project, eliminating the inaccurate positions.

In addition to the watercourse data provided, nearby ditches and stream segments that were mapped with a chain and compass in the 1990s were corrected based on an interpretation of satellite imagery and LIDAR imagery. This data update will also be provided to the CVRD.

Figure 4: The new watercourse mapping is shown in orange, and the pre-existing CVRD mapping is shown in blue.

3.2. SHIM Riparian characterization

The land cover was classified before the field program into three types of riparian cover (Figure 2): i) mixed coniferous and deciduous forest (VMF), ii) herbs/grasses (VHB) (agricultural field) and iii) human-made surfaces with low imperviousness (NLR). This classification was ground-truthed during the field program.

The field team approximated the two planned transects shown in Figure 2 with the route and waypoints (segment start and end points) shown in Figure 5. The segments of each transect were determined based on changes in vegetation type. Detailed transect information is found in Tables 1 and 2.

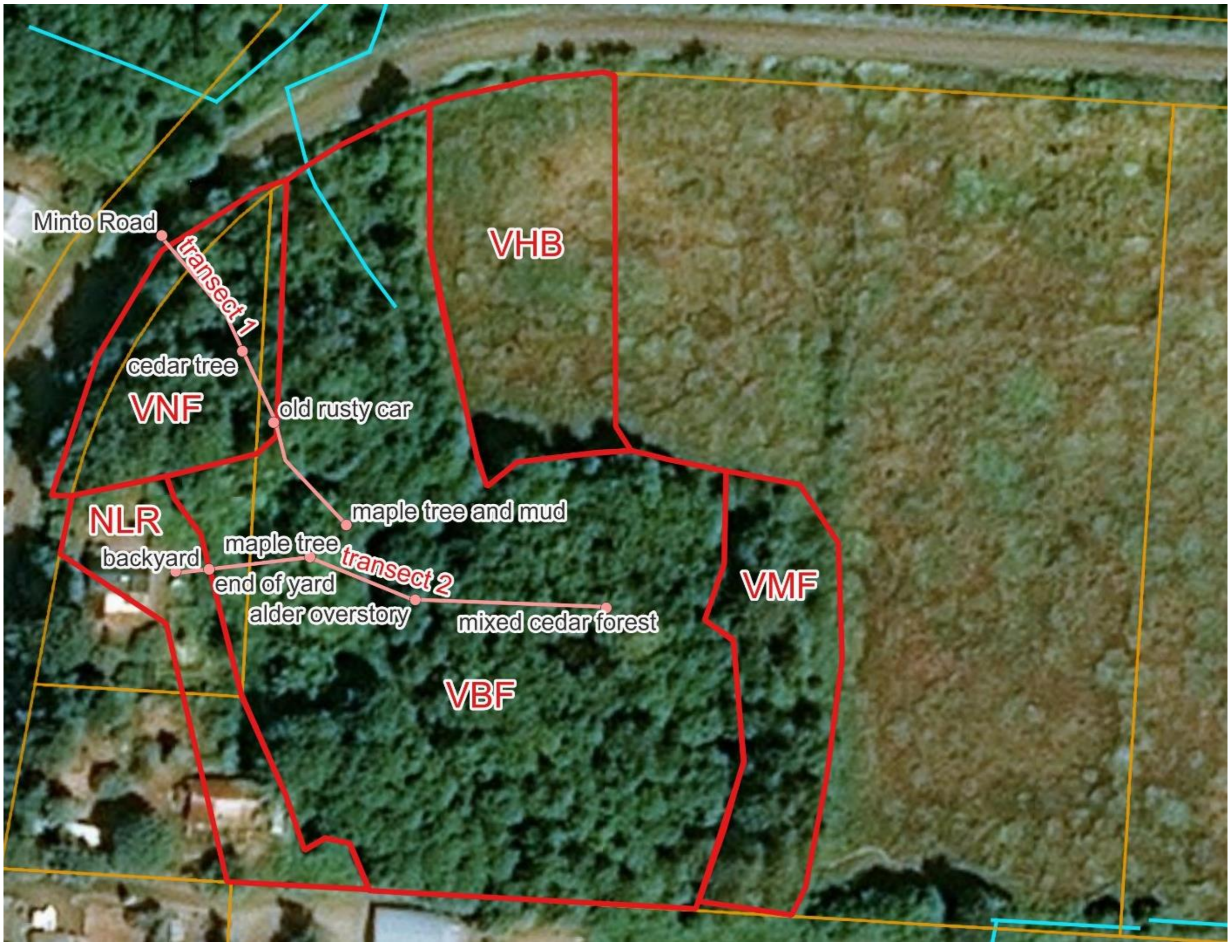

Figure 5: The transects conducted during the field program are shown in pink. The labelled points are the breaks between segments described in Tables 1 and 2. The boundaries of land cover types have been adjusted based on the field program, to include the red labeled areas as follows: coniferous forest (VNF) (cedar grove), broadleaf forest (VBF) and mixed forest (VMF). The zone for homes and backyards (NLR) was made somewhat smaller and the agricultural field boundaries remained the same. The boundaries of the adjusted forest cover types are only approximate, as they were not accurately mapped in the field.

Table 1: Transect 1 segments and observations

Segment	Segment start point	Segment end point	Land cover type: class, code, structural stage	Common plant species observed	Notes
1	Shoulder of Minto Road	Large cedar tree	Mixed forest (VMF), natural (n), young (5)	Salmonberry, bracken fern, skunk cabbage, reed canary grass, alder, bigleaf maple, common horsetail	Includes roadside and ditch vegetation
2	Large cedar tree	Old rusty car	Mixed forest (VMF) natural (n) mature (6)/young (5)	Cedar, horsetail, bigleaf maple	Cedars in grove are mature while nearby deciduous trees may be less than 80 years
3	Old rusty car	Large maple tree and muddy wet zone	Broadleaf forest (VBF) natural (n) young (5)	Bigleaf maple, salmonberry, stinging nettle	Many tall nettle plants and salmonberry in saturated ground at end of segment

Table 2: Transect 2 segments and observations

Segment	Segment start point	Segment end point	Land cover type: class, code, structural stage	Common plant species observed	Notes
1	Wendy's backyard near apple tree	End of yard	Herbs/grasses (NLR) qualifier : urban (ur)	Common horsetail, grass, buttercup, fruit trees	Orchard and yard
2	End of yard	Maple tree	Broadleaf forest (VHB) natural (n) young (5)	Salmonberry, elderberry, lady fern, skunk cabbage, stinging nettle, bigleaf maple	Open wet forest with many shrubs

3	Maple tree	Alder overstory	Broadleaf forest (VHB) natural (n) young (5)	Alder, salmonberry, stinging nettle, skunk cabbage, ground-ivy, common horsetail, herb Robert, gallium, elderberry, crabapple	Open wet forest with many shrubs
4	Alder overstory	Mixed cedar forest	Mixed forest (VMF) natural (n) young (5)	Cedar, alder, elderberry, lady fern, mountain ash, salmonberry, cascara, slough sedge, false lily-of-the-valley, trailing blackberry, hellebore, sword fern, red huckleberry, hemlock, holly	Diverse mixed forest

The entire 4.4 acre (1.8-hectare) forested area within the riparian corridor of the study area was typed as "mixed forest" before the field program. The transects revealed that the majority of the forested part of the study site would be better characterised as broadleaf (deciduous; VBF), with one area of conifer forest (the cedar grove in transect 1; VNF) and another area of young mixed (alder-cedar) forest on the eastern edge of the forested zone at the eastern end of transect 2 (VMF). The cedar grove was mapped in a past project (Ennis and Kotilla 2018).

The forest structural stage (age) was mostly young, i.e., 40 to 80 years of age, except for the cedar grove sampled in Transect 1, where the trees were previously designated as mature (greater than 80 years old based on the tree size and past logging between 80 and 120 years ago) (Ennis and Kotilla 2018).

There were separate mapped zones for homes and backyards (i.e., human-made surfaces with low imperviousness: NLR-ur) (0.47 acre) and agricultural field (herbs/grasses agriculture: VHB-ag) (0.85 acre). The size of the NLF-ur zone was adjusted to be somewhat smaller than that initially mapped, as natural vegetation was found to be closer to the home at 4327 Minto Road than previously assumed.

Figure 6: The cedar grove with mature (80+ year old trees), looking toward Minto Road. Not shown is a very large cedar stump with a springboard notch, logged between 80 and 120 years ago.

3.3. Water stage and water quality

The water stage and water quality data were incorporated into the long-term dataset, which is analyzed periodically by Groundwater Solutions Incorporated. For the data collected until March 31, 2022, a summary analysis is provided here and in Appendix 2, by Groundwater Solutions Incorporated. The data collected on July 1, 2022, is also provided in Table 3.

The groundwater level as measured in the shallow domestic drinking water well shows that the highest groundwater table elevation occurs in the early spring (February to April) while the lowest water levels are seen in October, before the well is recharged by rain and snow melt.

For the six surface water monitoring stations, none have been dry during monitoring, even in the warmest months. The water level fluctuations follow a seasonal pattern with peak levels during and following the wet season.

The water quality parameters fluctuate seasonally for all the stations. According to the data, the water has been becoming more acidic over time, particularly at Site 1.

The water stage, quality and temperature data collected on July 1, 2022, were typical for this time of year.

Table 3: Water stage and water quality information collected on July 1, 2022

Time	Site	Depth	Temp.	Dissolved Oxygen	Total Dissolved Solids	pH	Conductivity	Air Temperature
10:36	1	0.17	10.0	74.2	70	6.82	140	14.9
11:45	2	15.2	10.4	86.2	91	6.67	182	
12:12	3	8.8	10.8	61.1	87	6.82	173	
12:26	4	67.2	12.4	38.3	94	6.76	185	
12:51	5	7.4	10.4	70.3	72	6.92	148	
13:07	6	11.8	10.5	58.8	68	6.68	140	

3.4. Weather observations

The weather observations were added to the long-term dataset. This data will be compiled and analyzed together with water stage and water quality information at a future date. For the data collected until March 31, 2022, a summary analysis is provided in Appendix 2 by Groundwater Solutions Incorporated. The analysis shows that in the last four years there was a shift in the timing of maximum precipitation from the months of November and December to the months of December and January. The warm months receive minimum precipitation with July usually being the driest month. The data analysis shows a decreasing trend in overall precipitation from 2014 to 2022.

Table 4: Daily Weather Monitoring in Millard Creek Headwaters, June 1 to June 5, 2022

Date	Time	Rainfall mm	Minimum Temperature	Maximum Temperature	Wind Direction
2022-06-01	10:10	0	12	16	SE
2022-06-02	7:10	2	14	19	NW
2022-06-03	6:45	22	13	19	SE
2022-06-04	6:10	8	11	15	NW
2022-06-05	5:55	14	12	14	SE

3.5. Fish sampling

Two Cutthroat Trout (*Oncorhynchus clarkii clarkii*) were captured in the minnow traps. One was measured at 82 mm long and the other 80 mm. This confirms past sampling at the site, which is above barriers to anadromous (sea-going) fish. Two Cutthroat Trout (55 and 80 mm long) were caught in the same area in 2013 (Moul and Kotilla 2013) and the three Cutthroat Trout caught here in 2018 were 115 and 112 mm long, with one not measured for length (Ennis and Kotilla 2018).

3.6. Public tour and presentation

A tour was held on June 5 and was attended by eight family members, neighbours, and a representative from the Millard-Piercy Watershed Stewards. The two youth successfully explained the project in an engaging and informative way. After the tour, the youth were presented with completion certificates and letters of reference.

4. Discussion

Groundwater springs and seeps were mapped in 2013 and again in 2018 (Moul and Kotilla 2013; Ennis and Kotilla 2018). These features were not mapped for this project as the regional waterway mapping that this project contributed to focuses on surface water features. Nonetheless the groundwater coming to the surface from these springs and seeps feeds the surface water, creating year-round flow and providing cool groundwater that is reflected in the cool temperatures measured, which range from 5 to 15 degrees annually.

The water quality summary (Appendix 2) shows declining pH, particularly at Site 1. This requires further investigation to determine if this is correct or if the sampling equipment requires calibration.

The SHIM waterway mapping accuracy requirements were met during this work, i.e., the mapped features were within five meters of their true position, with 95% confidence. Most GPS/GNSS manufacturers, and more recently, providers of tablet mapping software such as Avenza, claim sub-metre or 2-5 metre accuracy for their equipment and software. However, these are marketing claims and should not be taken seriously. In real-world conditions with local obstruction, tree cover, and other factors, five-metre accuracy is achievable only with the best GPS equipment and careful methods. This is because the positional accuracy of GPS /GNSS data is often degraded in difficult terrain and tree canopy conditions. Proper GPS/GNSS equipment choices can help ensure sufficient accuracy, but careful analysis and assessment of the corrected data is required to ensure that the desired accuracy is achieved, and a re-survey may be required. The use of a Trimble GNSS device, with position fix filtering capabilities, recording of positioning metadata, as well as the ability to use a data dictionary to standardize feature data, helps to ensure feature positioning accuracy, and data quality.

A measure of success for this project was the tour given by the youth on Day 5. Both youths were celebrated with positive feedback regarding their understanding of the project and their confident delivery of the information that they had learned. It was clear that the youth were proud of their participation in this project.

5. Recommendations

The following are recommended as an outcome of this project:

1. Continue with hydrology and weather data collection using the same methods employed to date, and with periodic data integration and interpretation by Groundwater Solutions Incorporated.
2. If highly accurate mapping of springs, seeps and ephemeral waterways is desirable, consider re-surveying drainage areas and seeps in spring or fall (a wet season) when understory and deciduous trees have no leaves, and water table is high.
3. Consider twice-annual laboratory testing of water quality, to corroborate and supplement the measurements taken on site. This is particularly important for pH.
4. If pH levels are confirmed to be declining, an investigation of any changes to upstream conditions should be conducted.

6. Conclusion

The project team collected the planned information while providing a meaningful mentoring opportunity for the two youth participants. Both youths enjoyed the project and would like to participate in any related future opportunities.

The project was also a success in adding to regional waterway mapping and contributing to long-term data sets that can be used to monitor changes in climate, hydrology, water quality and vegetation over time.

7. References

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Appendix 1: Water sampling site photos

Photograph 1: Water sampling at Site 1

Photograph 2: Water sampling at Site 2

Photograph 3: Water sampling at Site 3

Photograph 4: Water sampling at Site 4

Photograph 5: Water sampling at Site 5

Photograph 6: Water sampling at Site 6

Appendix 2: Water quality, quantity and climatic data and data analysis, 2013 to 2022

FROM: GW Solutions Inc.

TO: Ms. Wendy Kotilla, YER Coordinator

DATE: June 1, 2022

SUBJECT: Data Integration Update

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

1 BACKGROUND

Youth and Ecological Restoration Program (YER) started in 2004 by Wendy Kotilla. In this program the groundwater level fluctuation and water quality are monitored. In YER program, the study area is Minto Rd, Courtenay in Vancouver Island, BC (Figure1). Six monitoring stations, five staff gauges and one V-notch have been monitored to investigate the surface water flow, shallow groundwater fluctuation, water quality and recharge characteristics.
Water quality parameters (temperature, dissolved oxygen, total dissolved solids, pH and electrical conductivity), water level depth and climatic parameters (maximum and minimum air temperature, rainfall amount and the weather conditions) have been recorded, monthly. GW solutions has been supporting the program, YER, by data integration, data analysis and interpretation. This report is continuation of the previous report, GW Solutions memorandum 2018. We have been integrated monitored and recorded water parameters collected after 2018. In the current memo we try to present and interpret the most recent data, collected after July 2018.

2 STUDY AREA AND MONITORING STATIONS' LOCATION

Study area is in the south of City of Courtenay at 4327 and 4333 Minto Rd. The dominant land use in the region is residential, agricultural, and forests. Figure 1 shows the location of the study area with respect to the City of Courtenay, Vancouver Island and Figure 2 presents the locations of monitoring sites. Monitoring sites are located within Millard-Piercy Watershed.

Figure 1: Location of area of study with respect to City of Courtney on Vancouver Island, BC

The existing water well is used for monitoring the groundwater level and its fluctuations within the shallow zone. The well has a 97 inches depth and drilled in unconsolidated material mainly alluvial. Gauge 1 to 6 are surface water stations to monitor the water quality and surface water fluctuation (see Figure 2).

Figure 2: Location of monitoring stations

3 PRECIPITATION MONITORING

Figure 3 shows the recorded daily precipitation and number of days of rain in each month. In the last four years there is a shift in maximum precipitation from November, December to December, January. The warm months receive minimum precipitation. Overall, July is the most frequently the driest month in this area. Data analyses shows a decreasing trend in the total precipitation from 2014 to 2022.

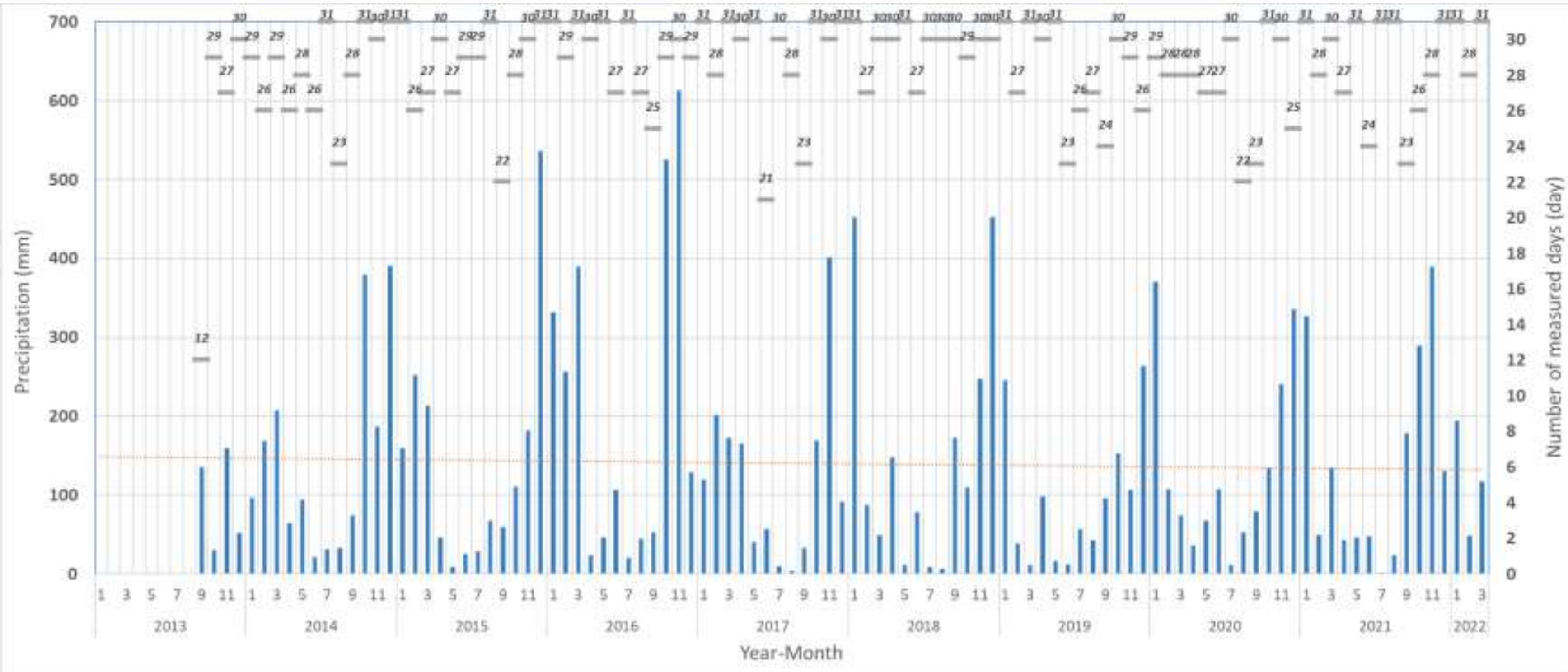

Figure 3: Measured daily precipitation

4 WATER LEVEL MONITORING

In this research the water level in a domestic drinking water shallow well, measured in order to monitoring the groundwater level fluctuation. The monitoring well is located at uphill of the Minto Road Forest (5500688 N, 355707 E). The water level was measured from 2008 to 2022. Figure 4 and Figure 5 show the depth of water level fluctuation in the well and the relationship between water level in the shallow well and the recorded precipitation, respectively.

According to the Figure 4, with the two exceptions of 2009 and 2014, the highest water level elevation occurs in the early spring, from February to April at 43 cm below ground averagely, following the seasonal fall and winter precipitation. In the summer and early fall water table gradually decreases by 83 cm. The minimum water level occurs in October. The water level has a delayed response to precipitation in dictating that the well is recharged by rain and snow melt.

The lowest water level recorded in May 2009 while the two domestic water wells in vicinity of the observation well, ran dry. 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 aquifer.

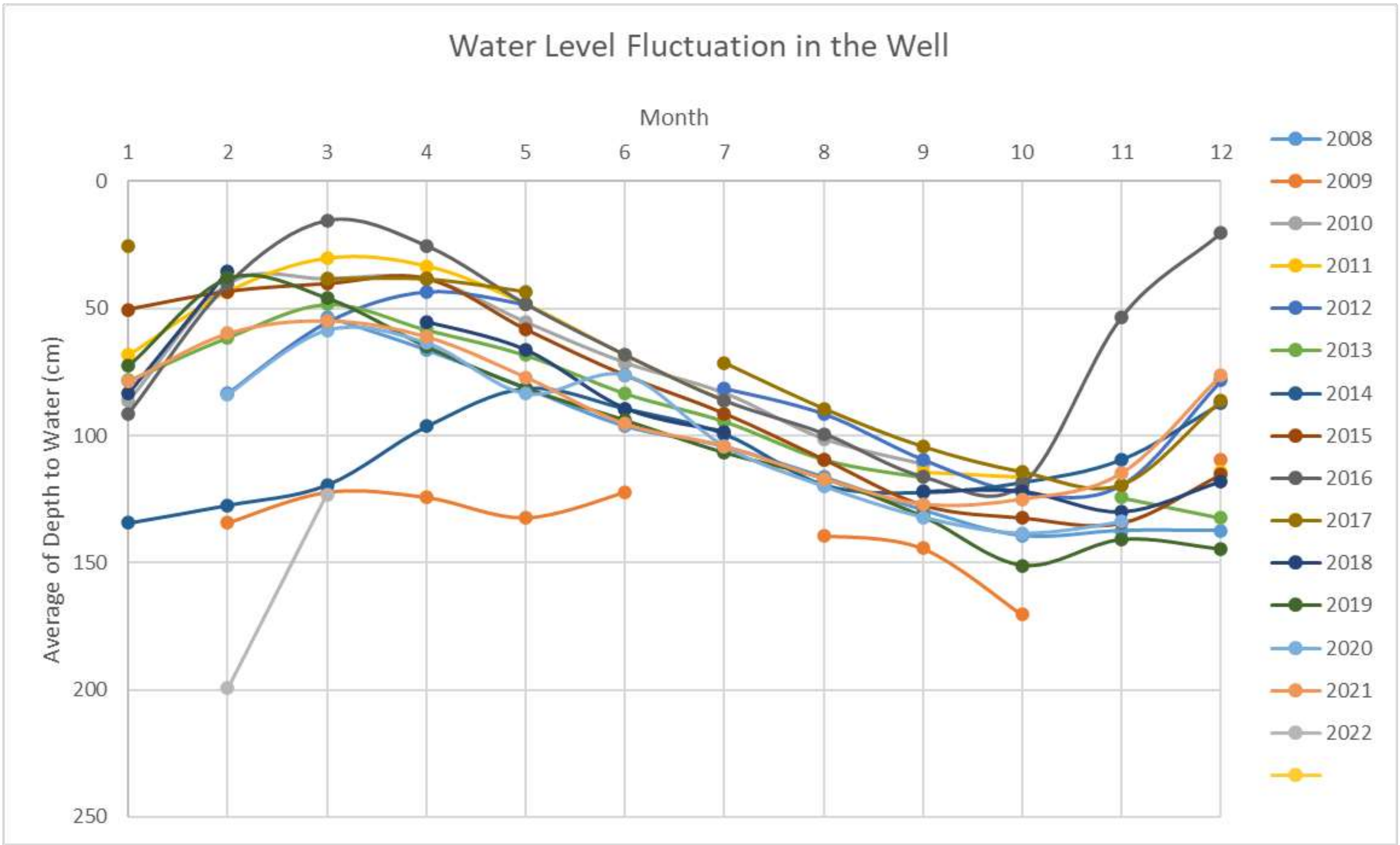

Figure 4: Water level fluctuation in the shallow water well

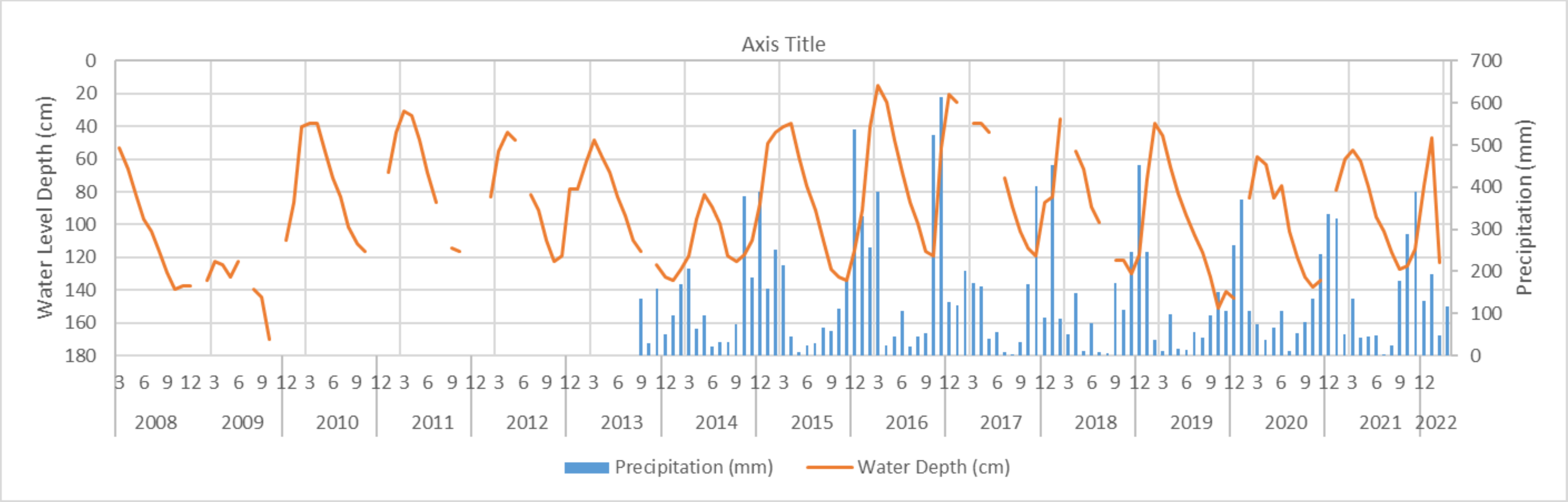

Figure 5: Water level fluctuation in the water well and recorded precipitation

Figure 6 illustrates the recorded water levels at the six monitoring stations since January 2018. 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. At the monitoring station of Site 2, existing of fish have been observed.

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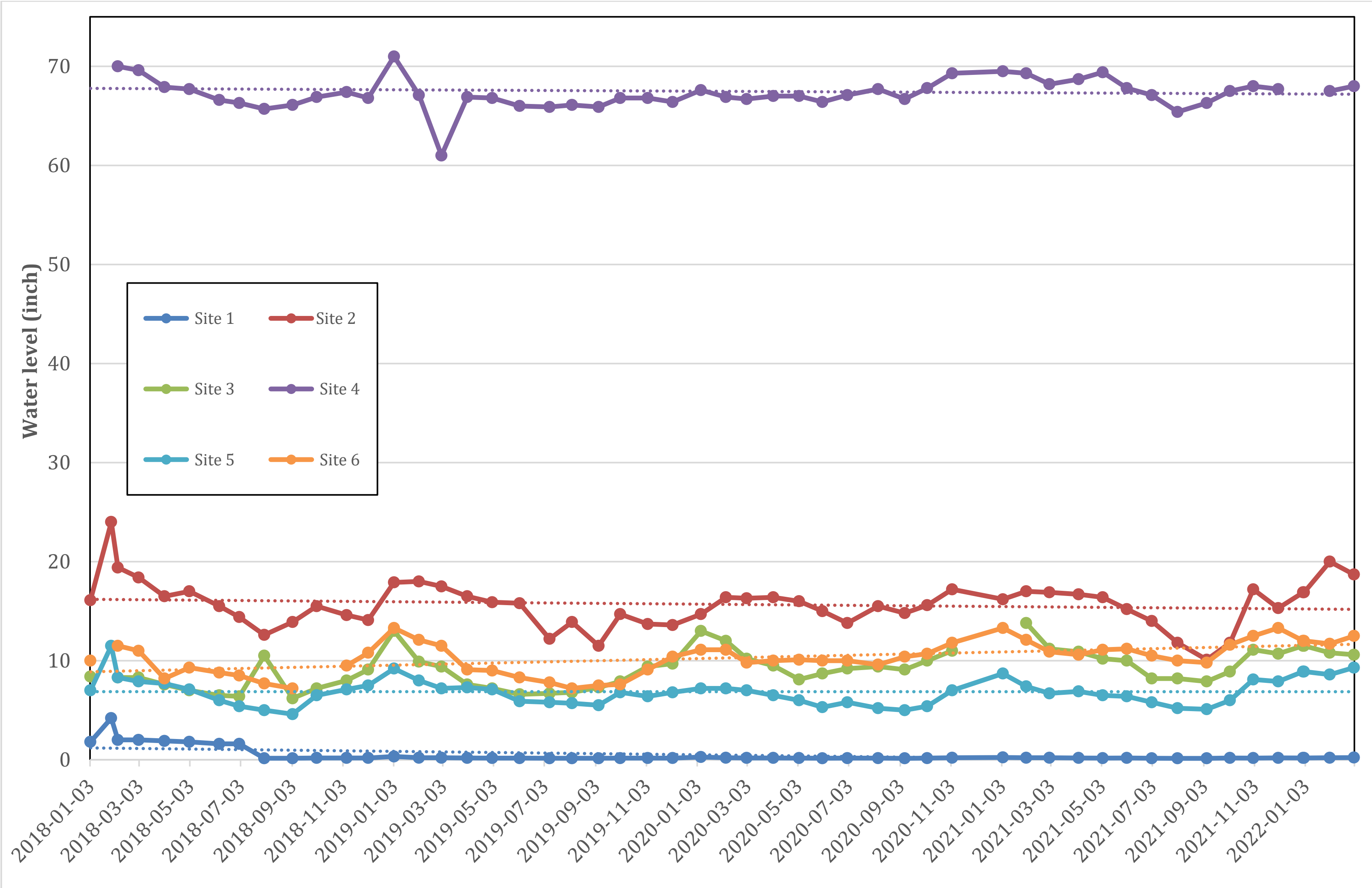

Figure 6: Recorded water levels for the six surface water monitoring stations/ gauges

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5 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 7 to Figure 12 present the water quality parameters fluctuation during the monitoring period ending February 2022. The water quality parameters fluctuate seasonally, with a similar pattern over the time, for all the stations. The Water quality parameters stay at the same level during the monitoring time. In all the stations, the groundwater temperature trend is as same as that of air temperature. It indicates that the well is shallow, and the groundwater temperature is influenced by the surface air temperature.

According to the measurements, the groundwater started to become acidic. As the Figure 7 to Figure 12 show, in all the sites pH started to decrease to a value of lower than 6 since 2018 onwards. Particularly, in Site 1 the decreasing trend of pH is more remarkable. Moreover, testing EC and TDS shows there is a falling trend over the monitoring period. Other water quality parameters are roughly steady.

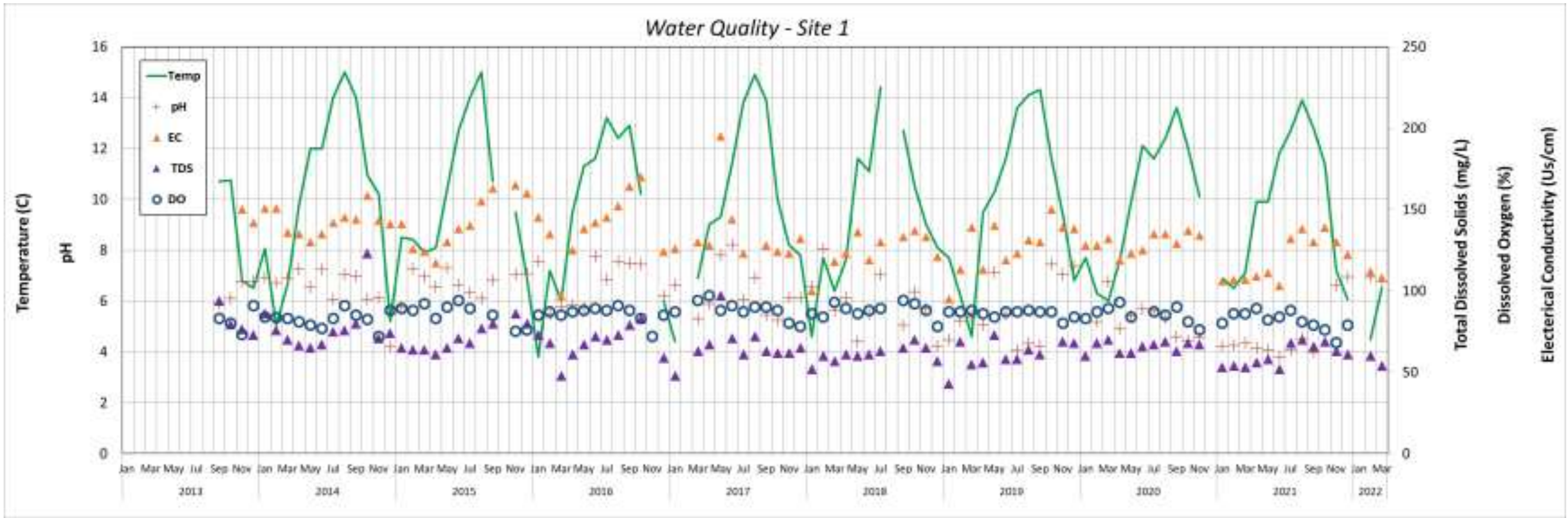

Figure 7: Water quality parameters for Gauge1

Figure 8: Water quality parameters for Gauge 2

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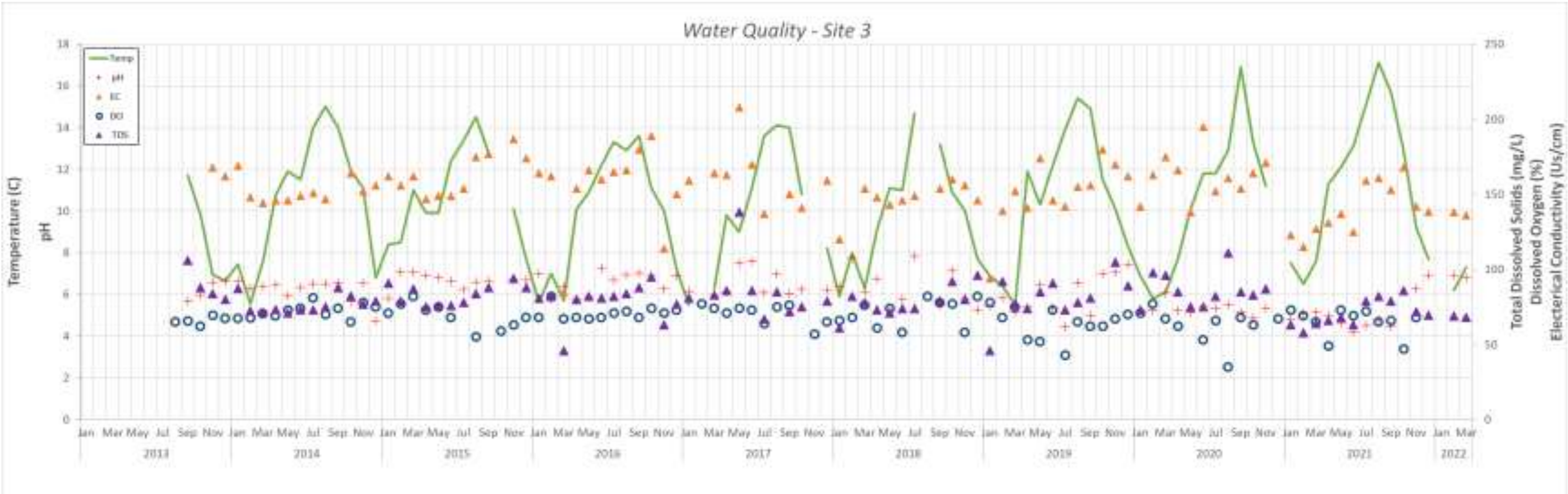

Figure 9: Water quality parameters for Gauge 3

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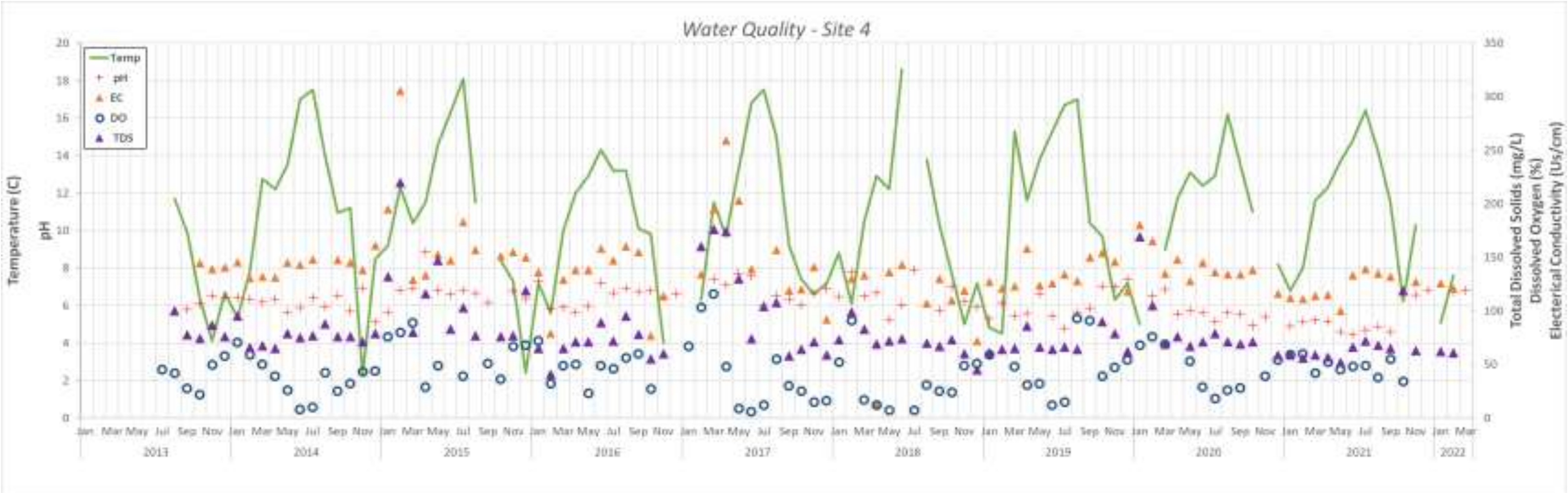

Figure 10: Water quality parameters for Gauge 4

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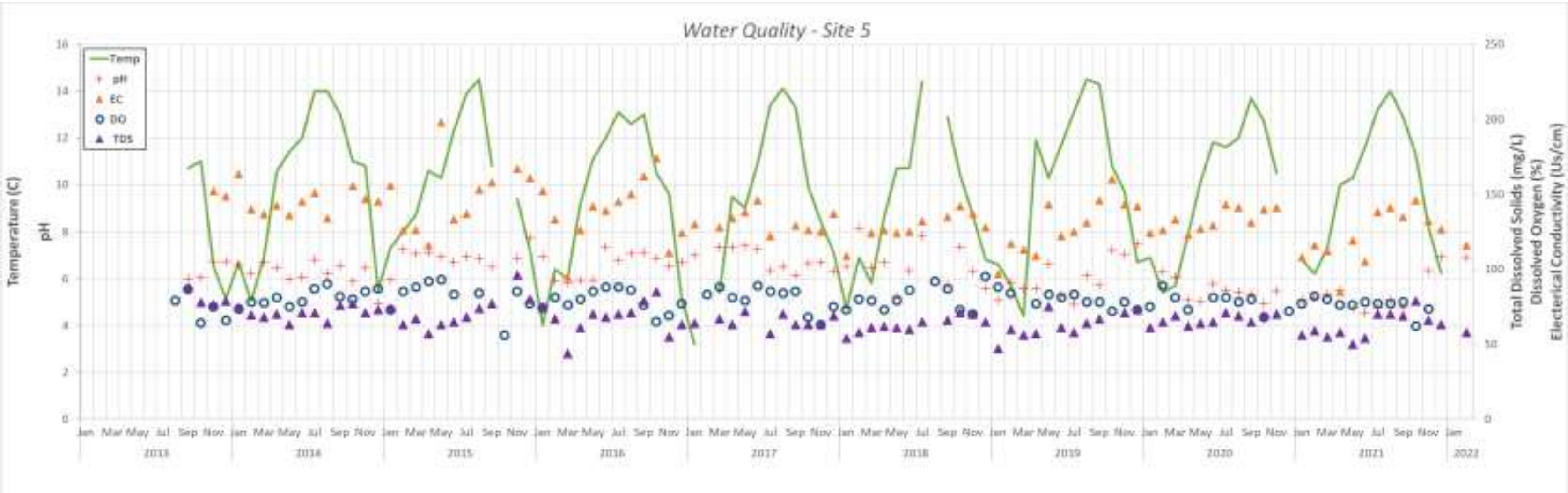

Figure 11: Water quality parameters for Gauge 5

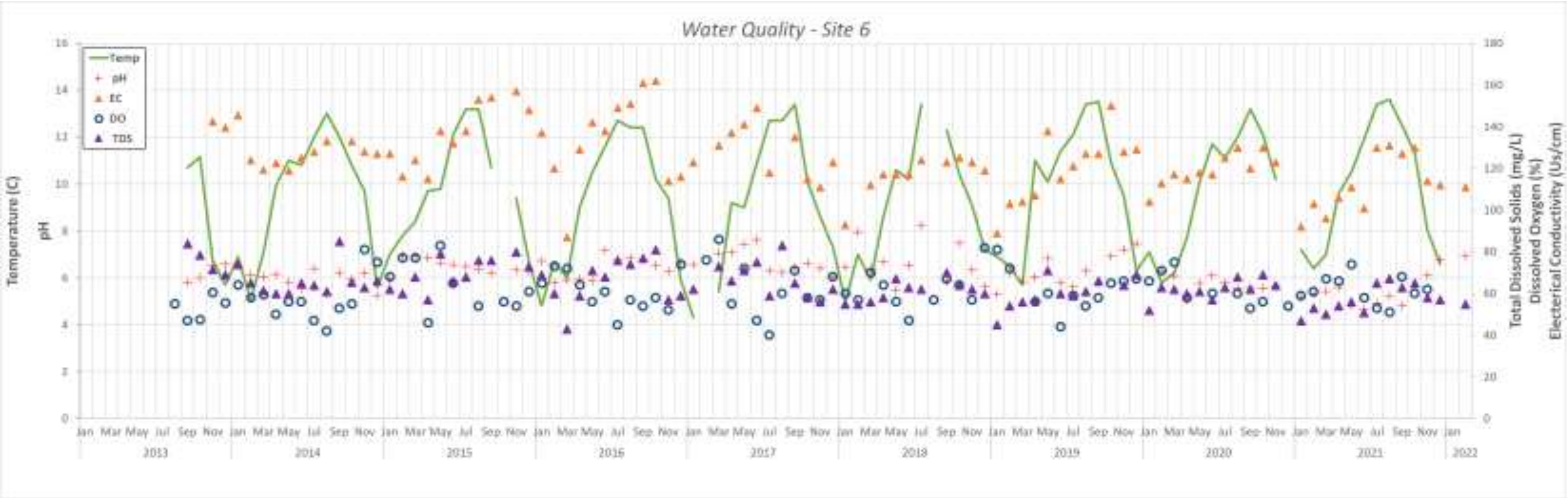

Figure 12: Water quality parameters for Gauge 6

6 RECOMMENDATION

Based on the data received, GW Solutions recommends the followings:

1. Continue monitoring the water wells.
2. Record the parameters like groundwater level and quality more frequently.
3. Because the study area is near to the farmlands and residence area, record fertilizer, pesticides, motor oil or any other chemicals spillage incident. These data can help us to determine the impact of chemicals on the water well quality and track source of groundwater.
4. Record any changes in the physical characteristics of water like odor and color.
5. Have a record of any chemical and hazards, stored near the study area or the upstream.
6. The data should be reviewed every second year to identify whether any significant changes are observed.
7. Select a surface water monitoring station in upstream of the well to better understand any changes in the groundwater quality and quantity.
8. Collect water samples from the well and surface water features and send them to the lab for water chemistry analysis.
9. Educate people about how to maintain the healthy watershed and the relationship of surface pollution and water well quality