Maximum Predicted Water Table Report

Proposed Brechin Quarry

Township of Ramara, County of Simcoe

Prepared for:
LCP Quarry Limited

Prepared by:
Azimuth Environmental
Consulting, Inc.

December 2023

AEC 18-288

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
Environmental Assessments & Approvals

December 15, 2023 AEC 18-288

LCP Quarry Limited

Attention: Mr. Scott Kirby

Re: **Maximum Predicted Water Table Report**
Proposed Brechin Quarry – Township of Ramara

Dear Mr. Kirby:

Azimuth Environmental Consulting, Inc. (Azimuth) is pleased to provide the following Maximum Predicted Water Table Report for the proposed Brechin Quarry located in the Township of Ramara, County of Simcoe. LCP Quarry Limited (the Applicant) is filing an application with the Ministry of Natural Resources and Forestry (MNRF) for an Aggregate Resources Act (ARA) Class A Quarry Below Water license for a new quarry operation.

This report describes the method utilized to determine the maximum water table condition and provides a summary of the findings, which include hydrographs from on-site monitoring wells. The maximum predicted water table documented by site monitoring shows that the proposed quarry will excavate below the water table.

We trust that this information is sufficient for the MNRF (and other relevant reviewing agencies). If you have any questions or comments, please do not hesitate to contact the undersigned.

Yours truly,

AZIMUTH ENVIRONMENTAL CONSULTING, INC.

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1.0 INTRODUCTION

Azimuth Environmental Consulting, Inc. (Azimuth) was retained by Lagoon City Limited Partnership (LCLP) ("the applicant") to undertake a series of technical studies under the disciplines of ecology, natural heritage, and hydrogeology for a potential mineral aggregate quarry on part of Lots 11, 12, and 13, Concession 1 (southwest of the settlement of Brechin) in the Township of Ramara (the "Township"), County of Simcoe (the "County"). A map illustrating the site and adjacent lands which constitute the Study Area is shown on Figure 1 (Appendix A).

LCLP intends to file a new aggregate resource application with the Ministry of Natural Resources and Forestry (MNRF) for an Aggregate Resources Act (ARA) *Class A Licence for an Aggregate Quarry Below the Ground Water Table*. This stand alone "*Maximum Predicted Water Level Report*" has been prepared in conjunction with the combined "*Level 1 and 2 Hydrogeological and Hydrological Assessment (Water Report)* (Azimuth, 2023). The reader is directed to the above-referenced document for a comprehensive description of the physical setting, methodology, testing and monitoring results, interpreted conceptual site model (CSM) and impact assessment.

1.1 Site Description and Proposed Layout

The entire LCLP land holdings include several large parcels that have a land area totaling about 161 hectares (ha). The Municipal Addresses for the four (4) parcels are listed below:

- 1646 Highway 12, Township of Ramara – Part of Lot 11, Concession 1
- 1506 Highway 12, Township of Ramara – Part of Lot 11, Concession 1
- 2440 Concession Road 1, Township of Ramara – Part of Lot 12, Concession 1
- 2530 Concession Road 1, Township of Ramara – Part of Lot 13 Concession 1

The lands are traversed by an abandoned raised bed rail alignment that is oriented in a north-south direction that occurs between Part of Lots 12 and 13, Concession 1 (Mara).

In terms of the proposed quarry operation, the majority of the operations and extraction is to occur on the lands east of the railine, while the lands west of the railine are located outside of the proposed extraction area and will be used for monitoring and habitat restoration. The primary entrance/ exit for the quarry is proposed to be from a new entrance constructed at the northern property boundary along Concession Road 2 which has preferred access to Highway 12. All current Site features and proposed *Licence Boundary* and *Extraction Limit* are shown on Figure 2.

1.2 Proposed Quarry Development

The proposed quarry operation is proposed to occur below the uppermost permanent ground water table to a final excavation depth of between 202.6 to 207.6 meters above sea level (masl). The quarry extraction will occur over two (2) phases with the initial excavation occurring in the north portion of the property. The proposed phasing includes:

1. Phase 1 - Initial Development (estimated area of ~27 ha at phase completion)
2. Phase 2 - Fully Active (additional area of ~63 ha at phase completion)

2.0 METHODOLOGY

2.1 Study Overview

The hydrogeological work plan for the proposed quarry was undertaken by both Azimuth and WSP Canada Inc. (WSP) (formerly Golder), with Azimuth serving as the primary physical hydrogeological consultant responsible for managing the field programs and physical data analysis. WSP's expertise included completing several components including: a detailed *Geological Report* (Golder, 2021) and a *Ground Water Modelling and Private Well Impact Assessment* (WSP, 2023).

All of the information collected through the literature review, monitoring program, and supporting reports has been synthesized into a consolidated *Level 1 and 2 Hydrogeological and Hydrological Assessment* (Water Report) that is a companion document to this document (Azimuth, 2023). The work plan included five (5) primary phases, of which the *Borehole Drilling Program*, *Borehole Instrumentation*, and *Environmental Monitoring Program* are considered most relevant to this reporting and are discussed below.

2.2 Borehole Drilling Program

The *Borehole Drilling Program* formed the initial phases of the field work plan that established the on-site network of boreholes (and monitoring wells) that were used in the hydraulic and geophysical testing and long-term monitoring programs. The program was completed over two (2) phases referred to as Phase 1 Boreholes (BH-1 to BH-5) completed in 2019 and Phase 2 Boreholes (BH-6 to BH-9) completed in 2020.

The *Phase 1 Drilling Program* consisted of HQ coring five (5) boreholes referred to as BH-1, BH-2, BH-3, BH-4 and BH-5. This process was advantageous to recover complete rock core sequences through the strata in order to log the underlying rock formations. Four (4) of the cored boreholes fully penetrated the Paleozoic limestone through to the Precambrian basement (with exception of BH-5).

The *Phase 2 Drilling Program* was completed using a water well drill rig, using air percussion drilling techniques. Due to this drilling procedure, no core was recovered from these boreholes. The program was completed in August 2020 and included the construction of four (4) 152.4 mm (6-inch) diameter boreholes (BH-6, BH-7, BH-8 and BH-9). These boreholes were constructed shallower in the upper limestone formations to an approximate depth of about 43 m below ground surface (bgs). Each of the boreholes was "dry" after completion, as no usable significant ground water aquifer was encountered (*i.e.,* potable water use). The Phase 2 boreholes were again instrumented to facilitate further hydraulic testing and monitoring (ground water level and geochemistry). The location of the on-site boreholes is shown on Figure 3.

2.3 Borehole Instrumentation

The Phase 1 Boreholes were instrumented in December 2019. Each borehole was instrumented with two (2), 25.4 mm (or 1-inch) nominal PVC monitoring wells at two (2) deep intervals. Each monitoring well was constructed at the base of the targeted hydrostratigraphic interval and the associated sand pack was extended to the top of the target hydrostratigraphic interval to cover the full sectional profile. A bentonite seal was then constructed above the interval to separate the lower and upper screened intervals. As previously indicated, the Phase 1 Boreholes targeted permeable zones within the lower formations. This included the following hydrostratigraphic units:

Table 1: Phase 1 Boreholes Hydrostratigraphic Intervals

Hydrostratigraphic Unit	Hydrostratigraphic Unit Identifier	Boreholes
Shadow Lake / Precambrian Contact Zone	B	BH-1 & BH4
Shadow Lake Formation	C	BH-2
Lower Green Beds of Gull River Formation	D	BH-3
Upper Green Beds and Upper Gull River Formation	F	BH-1, BH-2, BH-3, BH-4 & BH-5
Weathered Shale/ Clay Zone at Bobcaygeon Gull River Contact Zone	H	BH-5
Bobcaygeon Formation, Verulam Formation and Upper Weathered Zone (Bedrock)	Z	BH-1, BH-2, BH-3, BH-4 & BH-5

Notes:
Complete list of Hydrostratigraphic Intervals and rationale presented in Geological Study Report prepared by Golder (June 2021).

The Phase 2 Drilling Program was completed in August of 2020 and included the construction of four (4) 152.4 mm (6-inch) diameter boreholes (BH-6, BH-7, BH-8 and BH-9). These boreholes targeted the shallower limestone formations, including the water table (*i.e.,* Bobcaygeon Formation, Verulam Formation and upper weathered bedrock zone). These boreholes were instrumented at three (3) depth intervals (Table 2 below) using 50.8 mm (or 2-inch) nominal PVC riser and screens in the upper limestone

formations. The location of each borehole (and associated monitoring well nest) is illustrated on Figure 3 and the well instrumentation details are provided in Appendix C.

Table 2: Phase 2 Boreholes Hydrostratigraphic Intervals

Hydrostratigraphic Unit	Hydrostratigraphic Unit Identifier	Boreholes
Upper Gull River Formation	G	BH-8 & BH-9
Lower Bobcaygeon Formation	I	BH-6 & BH-7
Upper Bobcaygeon Formation	K	BH-6, BH-7, BH-8, & BH-9
Verulam Formation	L	BH-6, BH-7, BH-8, & BH-9

Notes:
Complete list of Hydrostratigraphic Intervals and rationale presented in Geological Study Report prepared by Golder (June 2021).

2.4 Environmental Monitoring

Ground water elevations at each of the monitoring wells are actively monitored. Each of the monitoring well locations (including two [2] annular space locations at BH-1 and BH-5) are outfitted with a dedicated pressure transducer dataloggers. Each datalogger is equipped to record head pressure (m of water) and temperature (°C) every 60 minutes. An on-site barometric datalogger was used to measure the barometric pressure to eliminate any barometric variations in the dataset.

Water levels have been monitored since December 2019 and the dataloggers are downloaded quarterly. Manual ground water measurements (m below top of casing [btoc]) are also collected quarterly from all ground water monitoring wells and annular spaces.

3.0 GROUND WATER MONITORING SUMMARY

The detailed results from long-term ground water level monitoring program are presented in Azimuth (2023). In summary, the established monitoring program tracks trends in head elevations associated with the various stratigraphic units. Based on the hydraulic testing results, it is understood that much of the underlying formations have a relative low permeability and do not convey a substantial amount of ground water. Overall, the head elevations show a decline with depth through the formations. Table 4 below presents the ranges of head elevations (masl) within the geologic formations beneath the site. Hydrographs for each monitoring well are presented in Appendix E. The regional ground water flow pattern for the shallow aquifer is also shown on Figure 4.

Table 3: Steady-state Head Elevations from on-site Monitoring Wells

Hydrostratigraphic Unit	Stratigraphic Unit	Hydrotratigraphic Unit identifier	Monitoring Points	Head Elevations (masl)
Verulam Formation	(5-1), 5-2	(M), L	4	233.4 - 228.7
Upper Bobcaygeon Formation	4-4	K	4	234.5 - 222.9
Lower Bobcaygeon Formation	(4-3), 4-1, 4-2	(J), I	2	236.2 - 232.3
Bobcaygeon/ Gull River Contact	3-4/4-1	H	1	228.2 - 227.8
Upper Gull River Formation	3-4	G	2	225.9 - 224.5
Upper Green Marker Bed (GMB)	3-3	F	5	228.3 - 220.1
Lower Gull River Formation and Lower GMB	(3-2), 3-1	(E), D	1	223.4 - 221.8
Shadow Lake Formation	2	C	1	222.5 - 219.9
Shadow Lake / Precambrian Contact	2/1	B (A)	2	226.5 - 218.7

Notes:
1. Identifier in parenthesis indicates interval assumed to be in relation to monitored hydrostratigraphic unit.

4.0 MAXIMUM PREDICTED WATER TABLE

As per the *Aggregate Resources of Ontario: Technical Report Standards* (2020), the maximum predicted water table surface is determined from an established long-term dataset at the site. This may be established through an existing monitoring program or historical data provided in hydrogeological reports for the site. On-site water level monitoring has been on-going since 2019. The program has evolved in scope from five (5) nested well locations (15 monitoring wells) at its inception to nine (9) nested well locations (27 monitoring wells) as of 2023. The highest head elevations generally occur in the geologic formations closer to ground surface (*i.e.,* Verulam and Bobcaygeon Formations). A permanent water table condition within the overburden has not been identified at the site; however, perched conditions may be present following snow melt or during the spring period before drying entirely during the summer period. As such, the uppermost permanent water table occurs within the upper hydrostratigraphic units described in Table 4 (Section 3.0).

The maximum head elevations collected over the period of record are presented below in Table 5 and Figure 5.

Table 4: Maximum Ground Water Elevations in Uppermost Water Table

Monitoring ID	Geologic Formation	Maximum Head Elevation
		masl
BH-1Z	Verulam	231.2
BH-2Z	Bobcaygeon	227.8
BH-3Z	Bobcaygeon	233.5
BH-4Z	Verulam	233.3
BH-5Z	Verulam	231.0
BH-6L	Verulam	233.7
BH-7K	Bobcaygeon	238.0
BH-8K	Bobcaygeon	229.3
BH-9K	Bobcaygeon	227.5

Based on a final excavation depth of between 202.6 to 207.6 masl, the quarry is proposed to intercept and occur below the uppermost permanent water table.

5.0 CONCLUSIONS

The proposed Quarry is located in the Township of Ramara and consists of Concession 1, part Lots 11, 12 and 13. The property is bounded by Highway 12 to the east, Concession 1 in the south and Concession 2 in the north. The determined maximum water table noted during the monitoring program at the site range between 227.5 to 238 masl, which occur in the upper limestone bedrock formations (*i.e.,* Verulam and Bobcaygeon Formations). Based on the proposed final excavation depth of between 202.6 to 207.6 masl, the quarry will intercept and occur below the uppermost permanent water table.

To minimize the drawdown associated with the proposed quarry, the quarry extraction depth will be limited to about 10 m above the contact between the Bobcaygeon and Gull River Formations (or between 202.6 and 207.6 masl). A water management strategy has been presented to manage both surface and ground water inputs to the quarry over its operation. Overall, WSP (2023) concludes that the proposed quarry development should not have a negative impact on nearby private wells. A monitoring program has been proposed to monitor ground water levels along the periphery of the limits of extraction to confirm this finding.

Based on the detailed field investigations, monitoring and interpretation of the data from the property, and the results from the ground water model prepared by WSP (2023), it is concluded that the proposed Quarry will have a minimal impact to the local and regional ground and surface water regimes

6.0 REFERENCES

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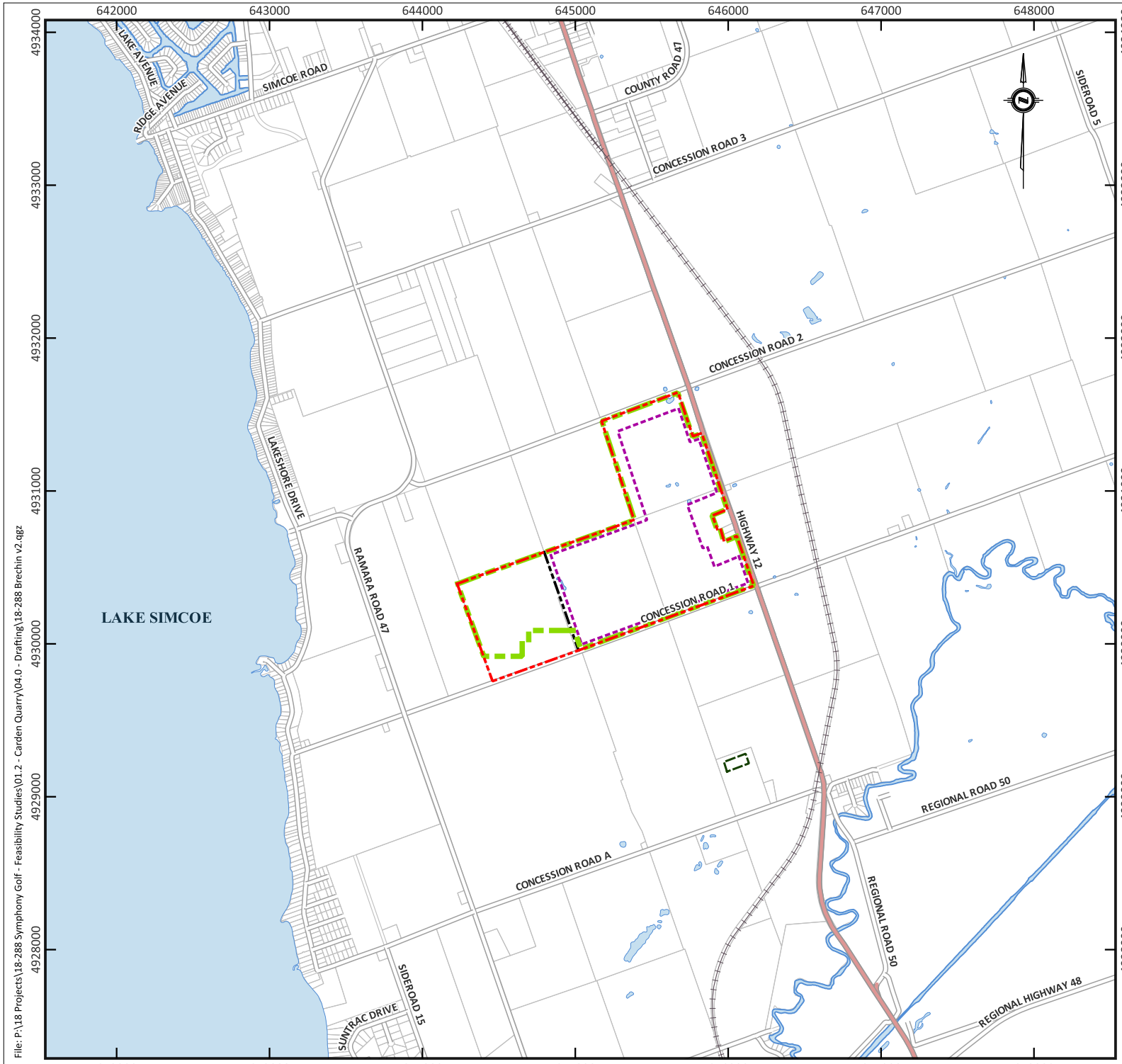
APPENDICES

Appendix A: Figures
Appendix B: Instrumentation and Monitoring Well Details
Appendix C: Ground Water Monitoring Results and Hydrographs
Appendix D: Author Qualifications and Experience

APPENDIX A

Figures

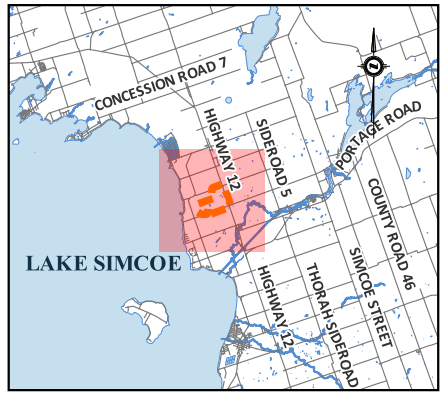


LEGEND

- Approx. Property Boundary
- License Boundary
- MHBC Limit of Extraction
- Former Rail Line
- Waterbody
- Rail
- Road
- Highway

REGIONAL MAP

SCALE 1:500000



0 0.6 1.2 1.8

KILOMETERS

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
ENVIRONMENTAL ASSESSMENTS & APPROVALS

SITE LOCATION

BRECHIN QUARRY
BRECHIN, ON

DATE ISSUED:	DECEMBER 2023
CREATED BY:	A.L.
PROJECT NO.:	18-288
BASE MAP:	MNRF

Figure No. 1

File: P:\18 Projects\18-288 Symphony Golf - Feasibility Studies\01.2 - Carden Quarry\04.0 - Drafting\18-288 Brechin v2.qgz

CONCESSION ROAD 2

TRIBUTARY H

TRIBUTARY G

TRIBUTARY C

TRIBUTARY E

POND 1

TRIBUTARY A

TRIBUTARY B

POND 2

BUFFER LANDS

OPERATIONS AND EXTRACTION LANDS

TRIBUTARY D

HIGHWAY 12

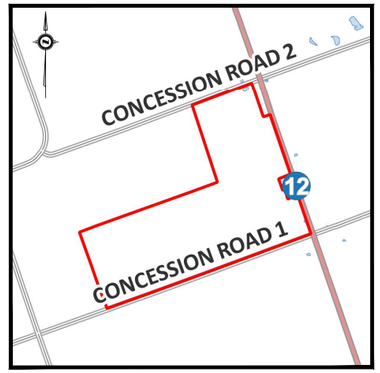
POND 3

CONCESSION ROAD 1

LEGEND:

- APPROX. PROPERTY BOUNDARY
- LICENSE BOUNDARY
- FORMER RAIL LINE
- WATERCOURSE (LIO)
- WOODLAND BOUNDARY (AZIMUTH, 2023)
- EXTRACTION FOOTPRINT

LOCATION PLAN



0 150.00 300.0

HORIZONTAL SCALE 1:6000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
ENVIRONMENTAL ASSESSMENTS & APPROVALS

EXISTING FEATURES AND SITE LAYOUT

BRECHIN QUARRY
BRECHIN, ON

DATE ISSUED:	*DECEMBER 2023*	Figure No.
CREATED BY:	*A.L.*	2
PROJECT NO.:	*18-288*	
REFERENCE:	*SIMCOE COUNTY*	

CONCESSION ROAD 2

McNABB DRAIN

CONCESSION ROAD 1

HIGHWAY 12

TRIBUTARY "G"

TRIBUTARY "C"

TRIBUTARY "A"

SW1

SW2

SW3

SG1

SG2

SG3

SG4

BH1

BH2

BH3

BH4

BH5

BH6

BH7

BH8

BH9

RG

Pond1

Pond2

POND 1

POND 2

POND 3

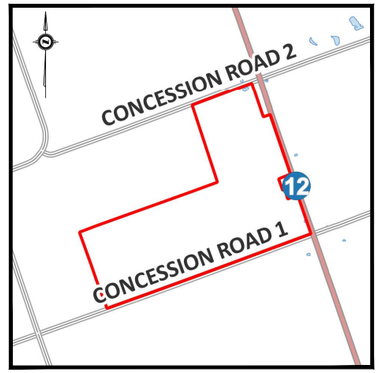
BUFFER LANDS

OPERATIONS AND EXTRACTION LANDS

LEGEND:

- APPROX. PROPERTY BOUNDARY
- LICENSE BOUNDARY
- FORMER RAIL LINE
- WATERCOURSE (LIO)
- WETLAND UNIT (AEC DELINEATED, OCT. 5 2021)
- EXTRACTION FOOTPRINT
- MONITORING WELL LOCATIONS (2019)
- STAFF GAUGE LOCATIONS
- SURFACE WATER MONITORING LOCATIONS
- POND MONITORING LOCATIONS
- MONITORING WELL LOCATIONS (2020)
- RAIN GAUGE

LOCATION PLAN



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HORIZONTAL SCALE 1:7000

AZIMUTH ENVIRONMENTAL CONSULTING, INC.
ENVIRONMENTAL ASSESSMENTS & APPROVALS

EXISTING MONITORING NETWORK

BRECHIN QUARRY
BRECHIN, ON

DATE ISSUED:	*DECEMBER 2023*	Figure No. 3
CREATED BY:	*A.L.*	
PROJECT NO.:	*18-288*	
REFERENCE:	*SIMCOE COUNTY*	

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LEGEND

- Subject Property
- License Boundary
- MHBC Limit of Extraction
- Expanded Study Area (3km)
- Waterbody
- Boreholes - Ground Water Elev. (masl)
- MECP Wells - Ground Water Elev. (masl)
- MECP Wells - No Ground Water Readings
- 100.00 5m Ground Water Contours (masl)
- Inferred Direction of Ground Water Flow

COUNTY ROAD 47
CONCESSION ROAD 3
CONCESSION ROAD 2
CONCESSION ROAD 1
CONCESSION ROAD A
CONCESSION ROAD B
HIGHWAY 12
SIDEROAD 5
SIDEROAD 15
LAKE SIMCOE

BH-9K 227.5 masl
BH-2Z 227.75 masl
BH-8K 229.25 masl
BH-4Z 233.32 masl
BH-5Z 231.06 masl
BH-6K 233 masl
BH-7K 238.49 masl
BH-3Z 233.49 masl
BH-1Z 261.2 masl

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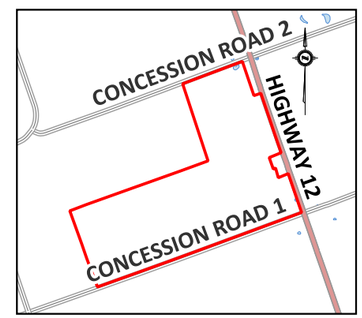
HORIZONTAL SCALE 1:35000

LOCATION MAP

SCALE 1:50000



AZIMUTH ENVIRONMENTAL CONSULTING, INC.
ENVIRONMENTAL ASSESSMENTS & APPROVALS

REGIONAL POTENTIOMETRIC SURFACE SHALLOW AQUIFER

BRECHIN QUARRY
BRECHIN, ON

DATE ISSUED:	DECEMBER 2023
CREATED BY:	A.L.
PROJECT NO.:	18-288
BASE MAP:	Simcoe County

Figure No. 4

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643750 644250 644750 645250 645750 646250 646750

4931500 4931000 4930500 4930000 4929500

CONCESSION ROAD 2

CONCESSION ROAD 1

HIGHWAY 12

BH-1Z
231.2 masl

BH-9K
227.5 masl

BH-2Z
227.75 masl

BH-8K
229.25 masl

BH-4Z
233.32 masl

BH-5Z
231.06 masl

BH-6K
233 masl

BH-7K
238.01 masl

BH-3Z
233.49 masl

5723457
217.88 masl

5718275
228.98 masl

7591550
222.87 masl

4600685
226.85 masl

4600686
228.66 masl

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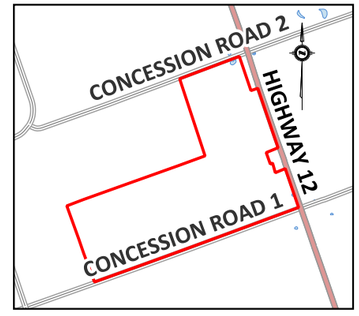
LEGEND

- Subject Property
- MHBC Limit of Extraction
- License Boundary
- Waterbody
- Highway
- Road
- Borehole - Ground Water Elev. (masl)
- 100.00 5m Ground Water Contours (masl)

LOCATION MAP SCALE 1:50000



AZIMUTH ENVIRONMENTAL CONSULTING, INC.
ENVIRONMENTAL ASSESSMENTS & APPROVALS

MAXIMUM PREDICTED WATER TABLE CONDITION - SITE

BRECHIN QUARRY
BRECHIN, ON

DATE ISSUED:	DECEMBER 2023
CREATED BY:	A.L.
PROJECT NO.:	18-288
BASE MAP:	MNRF

Figure No. 5

APPENDIX B

Instrumentation and Monitoring Well Details

Instrumentation and Measured Well Details

Monitoring Well	Hydrostratographic Unit[1]	Hydrostratigraphic Unit Identifier[1]	Easting	Northing	Ground Elevation (masl)[2]	Bore Collar Elevation (masl)[2]	Bottom Well Depth (mbtoc)	Overburden Thickness (m)	Bottom Well Depth (masl)	Overburden Thickness (masl)	Bore Casing Stickup (m)	Bore Diameter mm	Well Casing Diameter mm	Well Stickup (m)	Screen Interval (mbgs) bottom	Screen Interval (mbgs) top	Sand Pack Interval (mbgs) bottom	Sand Pack Interval (mbgs) top	Screen Interval (masl) bottom	Screen Interval (masl) top	Sand Pack Interval (masl) bottom	Sand Pack Interval (masl) top
BH-1	Shadow Lake/ Precambrian Contact Zone	B	645411.333	4931533.149	231.555	232.572	65.01	2.14	167.562	229.415	1.02	96	12.7	-0.07	64.1	61.0	64.1	58.4	167.5	170.5	167.5	173.2
BH-1	Upper Green Bed of Gull River Formation/Upper Gull River Formation	F	645411.333	4931533.149	231.555	232.572	45.81	2.14	186.762	229.415	1.02	96	12.7	-0.04	44.8	41.8	45.1	36.8	186.7	189.8	186.4	194.8
BH-1	Bobcaygeon Formation, Verulam Formation and Upper weathered bedrock	Z	645411.333	4931533.149	231.555	232.572	31.45	2.14	201.122	229.415	1.02	96	-	0	30.43	0	-	-	201.12	231.555	-	-
BH-2	Shadow Lake Formation	C	645918.939	4930985.711	238.843	239.758	64.89	0.91	174.868	237.933	0.92	96	12.7	-0.09	64.1	61.0	64.0	59.9	174.8	177.8	174.8	178.9
BH-2	Upper Green Bed of Gull River Formation/Upper Gull River Formation	F	645918.939	4930985.711	238.843	239.758	51.53	0.91	188.228	237.933	0.92	96	12.7	-0.03	50.6	47.6	51.1	43.0	188.2	191.2	187.7	195.8
BH-2	Bobcaygeon Formation, Verulam Formation and Upper weathered bedrock	Z	645918.939	4930985.711	238.843	239.758	31.6	0.91	208.158	237.933	0.92	96	-	0	30.69	0	-	-	208.16	238.843	-	-
BH-3	Lower Green Beds of Gull River Formation	D	645585.646	4930189.284	236.695	237.69	64.02	0.46	173.67	236.235	1.00	96	12.7	-0.1	63.1	60.1	63.1	57.9	173.6	176.6	173.6	178.8
BH-3	Upper Green Bed of Gull River Formation/Upper Gull River Formation	F	645585.646	4930189.284	236.695	237.69	54.46	0.46	183.23	236.235	1.00	96	12.7	-0.04	53.5	50.5	53.6	48.0	183.2	186.2	183.1	188.7
BH-3	Bobcaygeon Formation, Verulam Formation and Upper weathered bedrock	Z	645585.646	4930189.284	236.695	237.69	35.95	0.46	201.74	236.235	1.00	96	-	0	34.96	0	-	-	201.74	236.695	-	-
BH-4	Shadow Lake/ Precambrian Contact Zone	B	644876.573	4930501.079	236.078	237.077	71.29	1.68	165.787	234.398	1.00	96	12.7	-0.07	70.4	67.3	70.0	65.1	165.7	168.8	166.1	171.0
BH-4	Upper Green Bed of Gull River Formation/Upper Gull River Formation	F	644876.573	4930501.079	236.078	237.077	50.92	1.68	186.157	234.398	1.00	96	12.7	-0.03	50.0	46.9	50.0	44.1	186.1	189.2	186.1	192.0
BH-4	Bobcaygeon Formation, Verulam Formation and Upper weathered bedrock	Z	644876.573	4930501.079	236.078	237.077	31.24	1.68	205.837	234.398	1.00	96	-	0	30.24	0	-	-	205.84	236.078	-	-
BH-5	Upper Green Bed of Gull River Formation/Upper Gull River Formation	F	644322.975	4930363.051	231.981	232.987	52.73	3.66	180.257	228.321	1.01	96	12.7	-0.1	51.8	48.8	51.8	44.0	180.2	183.2	180.2	188.0
BH-5	Weathered Shale/clay zone at Bobcaygeon/Gull River formationa contact	H	644322.975	4930363.051	231.981	232.987	41.83	3.66	191.157	228.321	1.01	96	12.7	-0.04	40.9	37.8	41.0	38.0	191.1	194.2	191.0	194.0
BH-5	Bobcaygeon Formation, Verulam Formation and Upper weathered bedrock	Z	644322.975	4930363.051	231.981	232.987	31.36	3.66	201.627	228.321	1.01	96	-	0	30.35	0	-	-	201.63	231.981	-	-
BH-6	Bobcaygeon Formation	I	644672.845	4930121.664	234.186	234.835	43.10	0.91	191.735	233.276	0.65	96	25.4	-0.06	42.5	39.5	42.5	35.1	191.7	194.7	191.7	199.1
BH-6	Bobcaygeon Formatkon	K	644672.845	4930121.664	234.186	234.835	30.81	0.91	204.025	233.276	0.65	96	25.4	-0.07	30.2	27.2	30.2	20.1	204.0	207.0	204.0	214.1
BH-6	Verulam Formation	L	644672.845	4930121.664	234.186	234.835	15.63	0.91	219.205	233.276	0.65	96	25.4	-0.05	15.0	12.0	15.0	7.9	219.2	222.2	219.2	226.3
BH-7	Bobcaygeon Formation	I	645166.401	4930103.280	239.659	240.176	43.34	2.13	196.836	237.529	0.52	152	25.4	-0.05	42.9	39.8	42.9	36.9	196.8	199.8	196.8	202.8
BH-7	Bobcaygeon Formatkon	K	645166.401	4930103.280	239.659	240.176	32.44	2.13	207.736	237.529	0.52	152	25.4	-0.13	32.1	29.0	32.1	22.9	207.6	210.7	207.6	216.8
BH-7	Verulam Formation	L	645166.401	4930103.280	239.659	240.176	18.41	2.13	221.766	237.529	0.52	152	25.4	-0.01	17.9	14.9	17.9	11.0	221.8	224.8	221.8	228.7
BH-8	Upper Gull River Formation	G	646052.641	4930562.409	232.304	232.973	43.39	3.05	189.583	229.254	0.67	152	25.4	-0.07	42.8	39.7	42.8	35.1	189.5	192.6	189.5	197.3
BH-8	Bobcaygeon Formation	K	646052.641	4930562.409	232.304	232.973	22.59	3.05	210.383	229.254	0.67	152	25.4	-0.03	22.0	18.9	22.0	11.9	210.4	213.4	210.4	220.4
BH-8	Verulam Formation	L	646052.641	4930562.409	232.304	232.973	8.47	3.05	224.503	229.254	0.67	152	25.4	-0.05	7.9	4.8	7.9	6.1	224.5	227.5	224.5	226.2
BH-9	Upper Gull River Formation	G	645871.983	4931210.093	238.367	238.599	43.71	1.52	194.889	236.847	0.23	152	25.4	-0.06	43.5	40.5	43.5	39.9	194.8	197.9	194.8	198.4
BH-9	Bobcaygeon Formation	K	645871.983	4931210.093	238.367	238.599	23.14	1.52	215.459	236.847	0.23	152	25.4	-0.06	23.0	19.9	23.0	18.0	215.4	218.4	215.4	220.4
BH-9	Verulam Formation	L	645871.983	4931210.093	238.367	238.599	12.14	1.52	226.459	236.847	0.23	152	25.4	-0.05	12.0	8.9	12.0	6.4	226.4	229.5	226.4	232.0

Notes:

[1] Hydrostratigraphic reference from Golder Associates Inc. Technical Memorandum dated January 2, 2019 and email dated March 4, 2021

[2] Ground and collar elevations determined using a differential Global Positioning System (dGPS ≤ 0.05 m accuracy)

masl: meters above sea level

mbtoc: meters below top of casing

mbgs: meters below ground surface

APPENDIX C

Ground Water Monitoring Result and Hydrographs

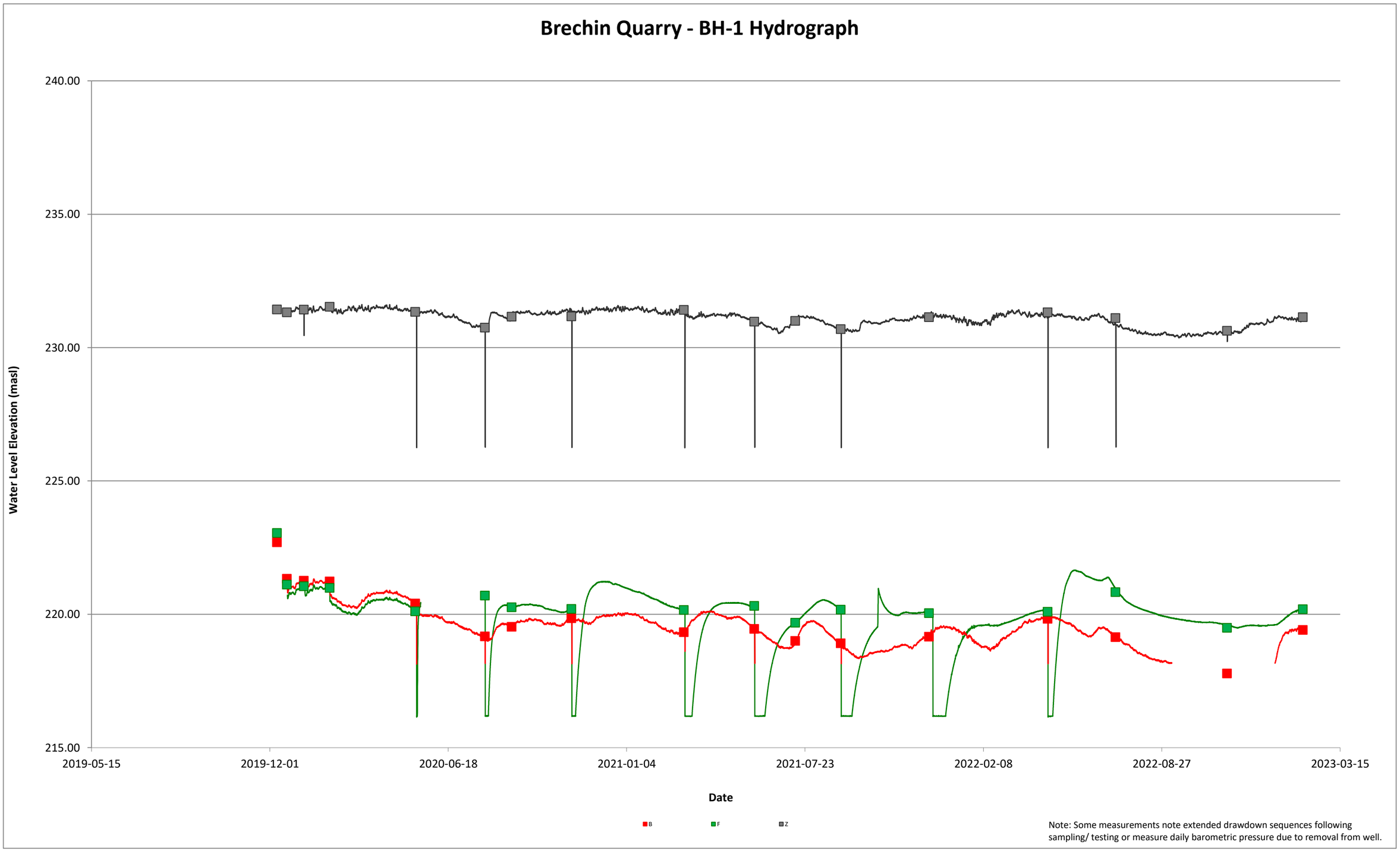
Brechin Quarry - Water Level Summary

Monitoring Well ID		BH-1	BH-1	BH-1	BH-2	BH-2	BH-2	BH-3	BH-3	BH-3	BH-4	BH-4	BH-4	BH-5	BH-5	BH-5	BH-6	BH-6	BH-6	BH-7	BH-7	BH-7	BH-8	BH-8	BH-8	BH-9	BH-9	BH-9
Hydrostratigraphic Unit Identifier		B	F	Z	C	F	Z	D	F	Z	B	F	Z	F	H	Z	I	K	L	I	K	L	G	K	L	G	K	L
Ground Elevation (masl)		231.555	231.555	231.555	238.843	238.843	238.843	236.695	236.695	236.695	236.078	236.078	236.078	231.981	231.981	231.981	234.186	234.186	234.186	239.659	239.659	239.659	232.304	232.304	232.304	238.367	238.367	238.367
Collar Elevation (masl)		232.572	232.572	232.572	239.758	239.758	239.758	237.69	237.69	237.69	237.077	237.077	237.077	232.987	232.987	232.987	234.835	234.835	234.835	240.176	240.176	240.176	232.973	232.973	232.973	238.599	238.599	238.599
Total Bore Depth (mbgs)		64.13	64.13	64.13	70.31	70.31	70.31	70.95	70.95	70.95	70.59	70.59	70.59	52.01	52.01	52.01	43.321	43.321	43.321	43.189	43.189	43.189	43.341	43.341	43.341	42.904	42.904	42.904
Bore Casing Stickup (m)		1.02	1.02	1.02	0.92	0.92	0.92	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01	0.65	0.65	0.65	0.52	0.52	0.52	0.67	0.67	0.67	0.23	0.23	0.23
Bottom Well Depth (mbtoc)		65.01	45.81	31.45	64.89	51.53	31.60	64.02	54.46	35.95	71.29	50.92	31.24	52.73	41.83	31.36	43.10	30.81	15.63	43.34	32.44	18.41	43.39	22.59	8.47	43.71	23.14	12.14
Well Stickup (m)		-0.07	-0.04	0.00	-0.09	-0.03	0.00	-0.10	-0.04	0.00	-0.07	-0.03	0.00	-0.10	-0.04	0.00	-0.06	-0.07	-0.05	-0.05	-0.13	-0.01	-0.07	-0.03	-0.05	-0.06	-0.06	-0.05
Statistics																												
Water Level (mbtoc)	Minimum	9.80	9.48	1.04	17.46	18.71	6.09	10.99	8.83	3.13	2.31	5.77	1.90	1.09	1.55	1.54	1.28	0.29	1.12	3.95	1.91	2.16	5.67	2.38	2.79	16.80	11.04	11.11
Water Level (mbtoc)	Maximum	14.72	13.04	1.94	20.59	20.51	16.82	16.04	14.87	6.94	10.31	15.13	7.24	4.93	5.49	4.44	3.73	3.83	3.95	5.34	3.81	3.76	9.48	5.27	4.77	20.92	18.19	11.84
Water Level (mbtoc)	Mean	12.65	12.03	1.42	19.23	19.27	11.92	14.59	13.86	4.41	5.65	9.00	3.95	2.79	4.05	2.06	1.90	1.82	1.97	4.52	2.77	2.79	7.62	3.69	3.50	18.27	13.90	0.00
Water Level (mbtoc)	2019-12-09	9.80	9.48	1.14	18.80	19.01	12.30	-	-	-	-	-	-	1.52	1.58	1.60	-	-	-	-	-	-	-	-	-	-	-	-
Water Level (mbtoc)	2019-12-20	11.17	11.42	1.25	18.97	19.11	9.99	10.99	8.83	4.65	2.31	5.77	1.90	1.67	1.65	1.68	-	-	-	-	-	-	-	-	-	-	-	-
Water Level (mbtoc)	2020-01-08	11.24	11.48	1.15	18.50	18.98	7.26	14.09	13.46	3.82	2.39	7.46	1.99	1.51	1.60	1.61	-	-	-	-	-	-	-	-	-	-	-	-
Water Level (mbtoc)	2020-02-06	11.27	11.54	1.04	18.19	18.82	7.31	14.33	13.75	3.27	2.49	7.72	2.30	1.47	1.55	1.58	-	-	-	-	-	-	-	-	-	-	-	-
Water Level (mbtoc)	2020-05-12	12.10	12.42	1.23	17.46	18.89	7.29	13.98	14.03	3.99	3.73	7.92	3.40	1.67	1.72	1.71	-	-	-	-	-	-	-	-	-	-	-	-
Water Level (mbtoc)	2020-07-29	13.33	11.83	1.82	19.49	19.62	15.63	14.05	14.14	5.33	6.94	10.73	6.41	4.24	4.63	3.06	-	-	-	-	-	-	-	-	-	-	-	-
Water Level (mbtoc)	2020-08-28	12.97	12.27	1.41	19.50	19.35	16.82	14.43	14.48	5.10	10.31	15.13	5.09	4.93	5.10	2.47	-	-	-	-	-	-	-	-	-	-	-	-
Water Level (mbtoc)	2020-11-03	12.65	12.33	1.40	19.49	19.15	14.50	14.11	14.15	3.39	8.58	10.87	3.46	4.58	5.06	1.73	-	-	-	-	-	-	-	-	-	-	-	-
Water Level (mbtoc)	2021-03-09	13.17	12.37	1.16	19.46	19.23	15.44	15.3	13.89	3.13	6.01	8.52	3.93	4.65	5.04	1.78	1.49	0.29	1.12	DRY	DRY	DRY	5.67	2.38	2.97	DRY	DRY	DRY
Water Level (mbtoc)	2021-04-23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.52	1.54	1.49	-	-	-	7.23	3.28	3.41	-	-	-
Water Level (mbtoc)	2021-05-27	13.05	12.22	1.60	19.33	19.06	14.66	15.44	13.9	4.22	4.46	9.76	4.2	4.7	5.24	2.05	1.58	1.66	1.78	4.97	3.05	3	7.67	3.91	3.89	20.92	18.19	DRY
Water Level (mbtoc)	2021-07-12	13.5	12.85	1.57	19.65	19.49	14.88	15.80	14.09	5.03	4.97	10.04	4.07	1.18	5.11	1.7	1.55	1.65	1.72	4.67	2.68	2.78	7.81	3.41	3.20	19.36	16.5	DRY
Water Level (mbtoc)	2021-09-01	13.59	12.36	1.88	19.56	19.34	13.99	15.83	14.14	4.73	5.98	8.68	5.42	2.02	4.94	2.52	2.05	2.17	2.23	4.41	2.74	2.94	7.69	4.24	4.07	18.03	15.66	DRY
Water Level (mbtoc)	2021-12-09	13.34	12.49	1.43	19.65	19.16	6.09	14.7	14.59	3.78	5.87	8.54	2.88	1.12	4.73	1.57	1.28	1.43	1.54	3.95	2.01	2.17	7.00	3.09	2.87	17.17	14.32	DRY
Water Level (mbtoc)	2022-04-21	12.67	12.44	1.25	18.98	18.71	11.15	-	14.46	-	8.38	7.78	2.74	3.7	5.25	1.54	1.33	1.4	1.48	3.98	1.91	2.16	7.11	3.16	3.13	16.8	12.85	DRY
Water Level (mbtoc)	2022-07-06	13.36	11.7	1.46	19.44	19.34	9.99	16.04	14.18	4.64	4.68	8.27	4.55	3.78	5.32	2.25	1.81	1.91	1.97	4.38	2.56	2.74	7.83	3.92	3.38	17.19	12.62	DRY
Water Level (mbtoc)	2022-08-09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.63	2.71	2.82	4.29	3.46	2.81	8.6	4.59	4.07	17.49	12.14	DRY
Water Level (mbtoc)	2022-11-08	14.72	13.04	1.94	20.59	20.51	15	14.84	14.87	6.94	7.93	8.62	7.24	3.68	5.49	4.44	3.73	3.83	3.95	5.34	3.81	3.76	9.48	5.27	4.77	18.93	11.76	11.84
Water Level (mbtoc)	2023-02-01	13.09	12.34	1.43	19.91	19.76	10.4	14.89	14.78	4.14	5.36	8.11	3.68	1.09	4.81	1.79	-	1.44	1.53	4.72	2.73	2.73	7.7	3.3	2.79	18.53	11.04	11.11

Brechin Quarry - Water Elevation Summary

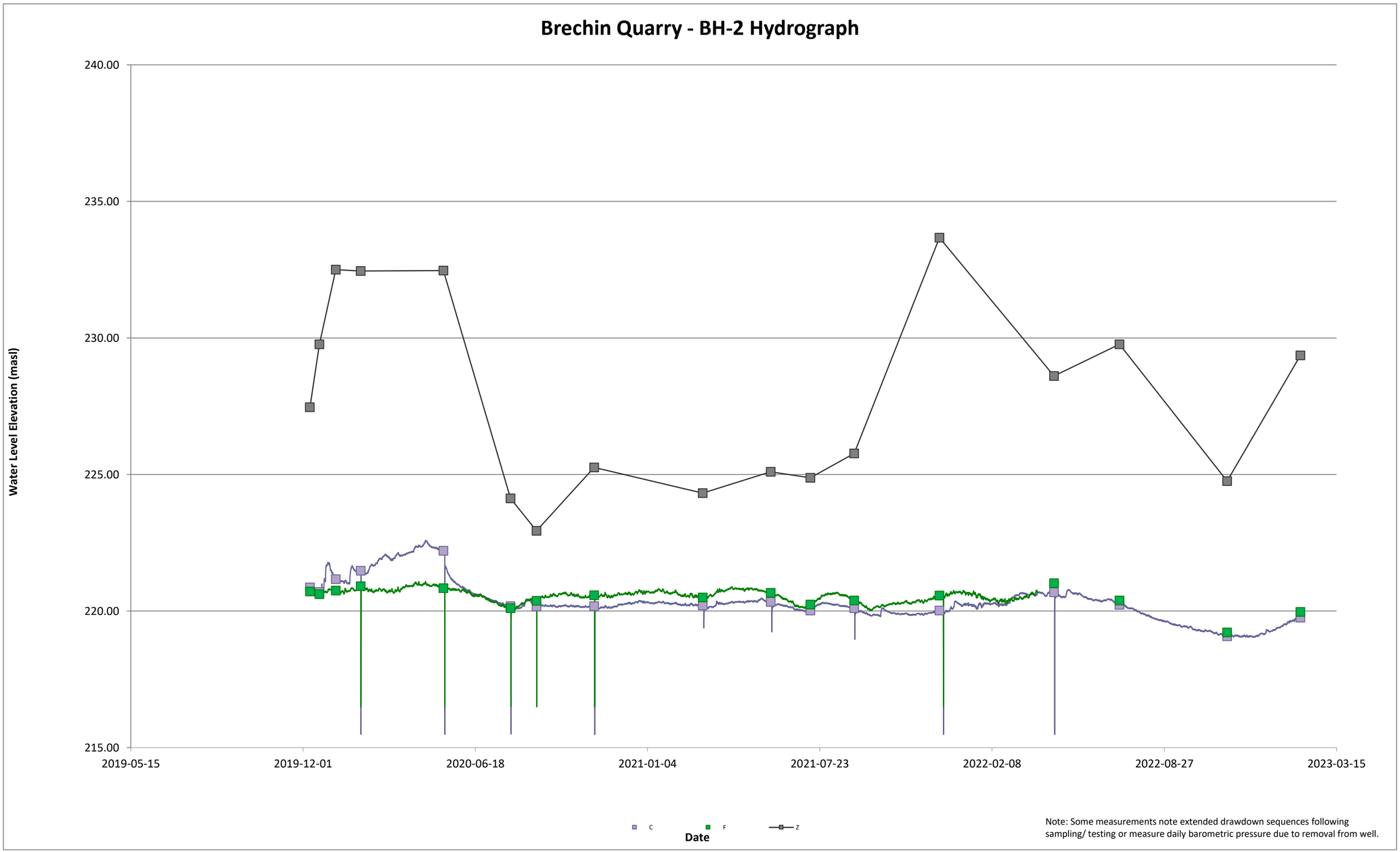
Monitoring Well ID		BH-1	BH-1	BH-1	BH-2	BH-2	BH-2	BH-3	BH-3	BH-3	BH-4	BH-4	BH-4	BH-5	BH-5	BH-5	BH-6	BH-6	BH-6	BH-7	BH-7	BH-7	BH-8	BH-8	BH-8	BH-9	BH-9	BH-9
Hydrostratigraphic Unit Identifier		B	F	Z	C	F	Z	D	F	Z	B	F	Z	F	H	Z	I	K	L	I	K	L	G	K	L	G	K	L
Ground Elevation (masl)		231.555	231.555	231.555	238.843	238.843	238.843	236.695	236.695	236.695	236.078	236.078	236.078	231.981	231.981	231.981	234.186	234.186	234.186	239.659	239.659	239.659	232.304	232.304	232.304	238.367	238.367	238.367
Collar Elevation (masl)		232.572	232.572	232.572	239.758	239.758	239.758	237.69	237.69	237.69	237.077	237.077	237.077	232.987	232.987	232.987	234.835	234.835	234.835	240.176	240.176	240.176	232.973	232.973	232.973	238.599	238.599	238.599
Total Bore Depth (mbgs)		64.13	64.13	64.13	70.31	70.31	70.31	70.95	70.95	70.95	70.59	70.59	70.59	52.01	52.01	52.01	43.321	43.321	43.321	43.189	43.189	43.189	43.341	43.341	43.341	42.904	42.904	42.904
Bore Casing Stickup (m)		1.02	1.02	1.02	0.92	0.92	0.92	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.01	1.01	0.65	0.65	0.65	0.52	0.52	0.52	0.67	0.67	0.67	0.23	0.23	0.23
Bottom Well Depth (mbtoc)		65.01	45.81	31.45	64.89	51.53	31.60	64.02	54.46	35.95	71.29	50.92	31.24	52.73	41.83	31.36	43.10	30.81	15.63	43.34	32.44	18.41	43.39	22.59	8.47	43.71	23.14	12.14
Well Stickup (m)		-0.07	-0.04	0.00	-0.09	-0.03	0.00	-0.10	-0.04	0.00	-0.07	-0.03	0.00	-0.10	-0.04	0.00	-0.06	-0.07	-0.05	-0.05	-0.13	-0.01	-0.07	-0.03	-0.05	-0.06	-0.06	-0.05
Statistics																												
Water Level (masl)	Minimum	217.78	219.49	230.63	219.08	219.22	222.94	221.55	222.78	230.75	226.70	221.92	229.84	227.96	227.46	228.55	231.05	230.94	230.84	-	-	-	223.42	227.67	228.15	-	-	-
Water Level (masl)	Maximum	222.70	223.05	231.53	222.21	221.02	233.67	226.60	228.82	234.56	234.70	231.28	235.18	231.80	231.40	231.45	233.50	234.48	233.67	-	-	-	227.23	230.56	230.13	-	-	-
Water Level (masl)	Mean	219.85	220.50	231.15	220.43	220.46	227.83	223.00	223.79	233.28	231.36	228.05	233.12	230.09	228.90	230.92	232.88	232.94	232.82	-	-	-	225.29	229.26	229.42	-	-	-
Water Level (masl)	2019-12-09	222.70	223.05	231.43	220.87	220.72	227.46							231.37	231.37	231.39												
Water Level (masl)	2019-12-20	221.33	221.11	231.32	220.70	220.62	229.77	226.60	228.82	233.04	234.70	231.28	235.18	231.22	231.30	231.31												
Water Level (masl)	2020-01-08	221.26	221.05	231.42	221.17	220.75	232.50	223.50	224.19	233.87	234.62	229.59	235.09	231.38	231.35	231.38												
Water Level (masl)	2020-02-06	221.23	220.99	231.53	221.48	220.91	232.45	223.26	223.90	234.42	234.52	229.33	234.78	231.42	231.40	231.41												
Water Level (masl)	2020-05-12	220.40	220.11	231.34	222.21	220.84	232.47	223.61	223.62	233.70	233.28	229.13	233.68	231.22	231.23	231.28												
Water Level (masl)	2020-07-29	219.17	220.70	230.75	220.18	220.11	224.13	223.54	223.51	232.36	230.07	226.32	230.67	228.65	228.32	229.93												
Water Level (masl)	2020-08-28	219.53	220.26	231.16	220.17	220.38	222.94	223.16	223.17	232.59	226.70	221.92	231.99	227.96	227.85	230.52												
Water Level (masl)	2020-11-03	219.85	220.20	231.17	220.18	220.58	225.26	223.48	223.50	234.30	228.43	226.18	233.62	228.31	227.89	231.26												
Water Level (masl)	2021-03-09	219.33	220.16	231.41	220.21	220.50	224.32	222.29	223.76	234.56	231.00	228.53	233.15	228.24	227.91	231.21	233.29	234.48	233.67	DRY	DRY	DRY	227.23	230.56	229.95	DRY	DRY	DRY
Water Level (masl)	2021-04-23																233.26	233.23	233.30				225.67	229.66	229.51			
Water Level (masl)	2021-05-27	219.45	220.31	230.97	220.34	220.67	225.10	222.15	223.75	233.47	232.55	227.29	232.88	228.19	227.71	230.94	233.20	233.11	233.01	235.16	237.00	237.17	225.23	229.03	229.03	217.62	220.35	DRY
Water Level (masl)	2021-07-12	219.00	219.68	231.00	220.02	220.24	224.88	221.79	223.56	232.66	232.04	227.01	233.01	231.71	227.84	231.29	233.23	233.12	233.07	235.46	237.37	237.39	225.09	229.53	229.72	219.18	222.04	DRY
Water Level (masl)	2021-09-01	218.91	220.17	230.69	220.11	220.39	225.77	221.76	223.51	232.96	231.03	228.37	231.66	230.87	228.01	230.47	232.73	232.60	232.56	235.72	237.31	237.23	225.21	228.70	228.85	220.51	222.88	DRY
Water Level (masl)	2021-12-09	219.16	220.04	231.14	220.02	220.57	233.67	222.89	223.06	233.91	231.14	228.51	234.20	231.77	228.22	231.42	233.50	233.34	233.25	236.18	238.04	238.00	225.90	229.85	230.05	221.37	224.22	DRY
Water Level (masl)	2022-04-21	219.83	220.09	231.32	220.69	221.02	228.61		223.19		228.63	229.27	234.34	229.19	227.70	231.45	233.45	233.37	233.31	236.15	238.14	238.01	225.79	229.78	229.79	221.74	225.69	DRY
Water Level (masl)	2022-07-06	219.14	220.83	231.11	220.23	220.39	229.77	221.55	223.47	233.05	232.33	228.78	232.53	229.11	227.63	230.74	232.97	232.86	232.82	235.75	237.49	237.43	225.07	229.02	229.54	221.35	225.92	DRY
Water Level (masl)	2022-08-09																232.15	232.06	231.97	235.84	236.59	237.36	224.30	228.35	228.85	221.05	226.40	DRY
Water Level (masl)	2022-11-08	217.78	219.49	230.63	219.08	219.22	224.76	222.75	222.78	230.75	229.08	228.43	229.84	229.21	227.46	228.55	231.05	230.94	230.84	234.79	236.24	236.41	223.42	227.67	228.15	219.61	226.78	226.71
Water Level (masl)	2023-02-01	219.41	220.19	231.14	219.76	219.97	229.36	222.70	222.87	233.55	231.65	228.94	233.40	231.80	228.14	231.20	-	233.33	233.26	235.41	237.32	237.44	225.20	229.64	230.13	220.01	227.50	227.44

Brechin Quarry - BH-1 Hydrograph



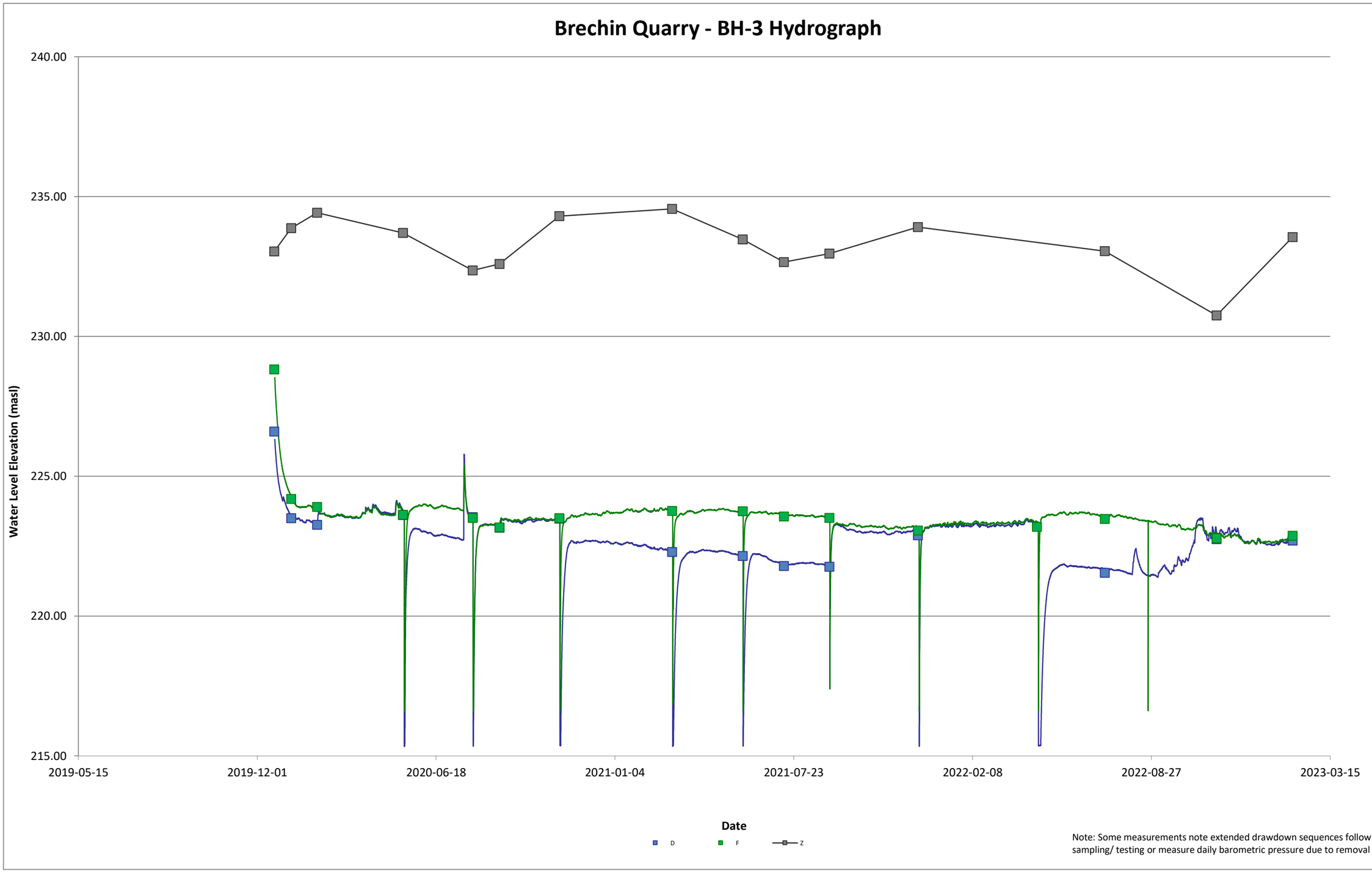
Note: Some measurements note extended drawdown sequences following sampling/ testing or measure daily barometric pressure due to removal from well.

Brechin Quarry - BH-2 Hydrograph



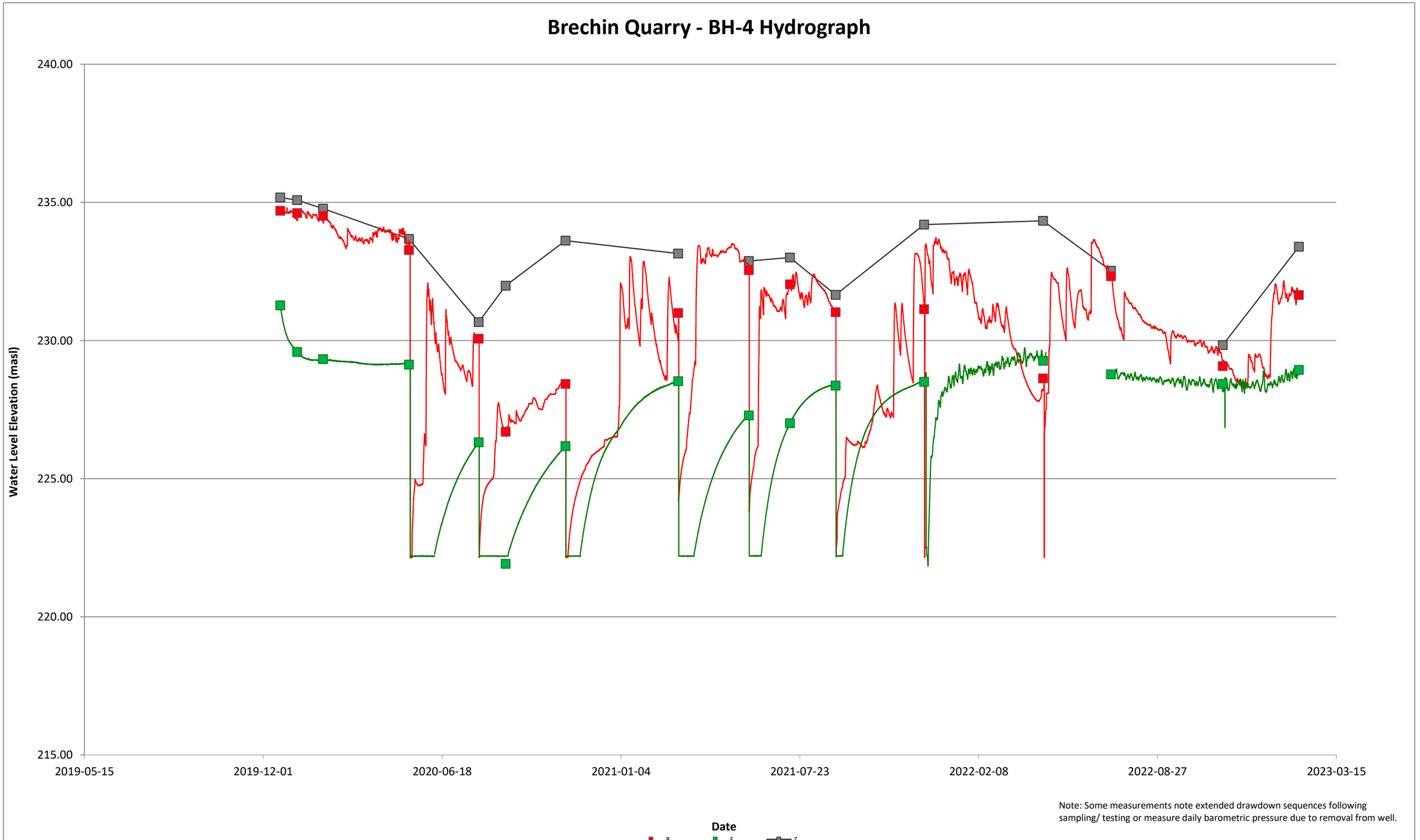
Note: Some measurements note extended drawdown sequences following sampling/ testing or measure daily barometric pressure due to removal from well.

Brechin Quarry - BH-3 Hydrograph

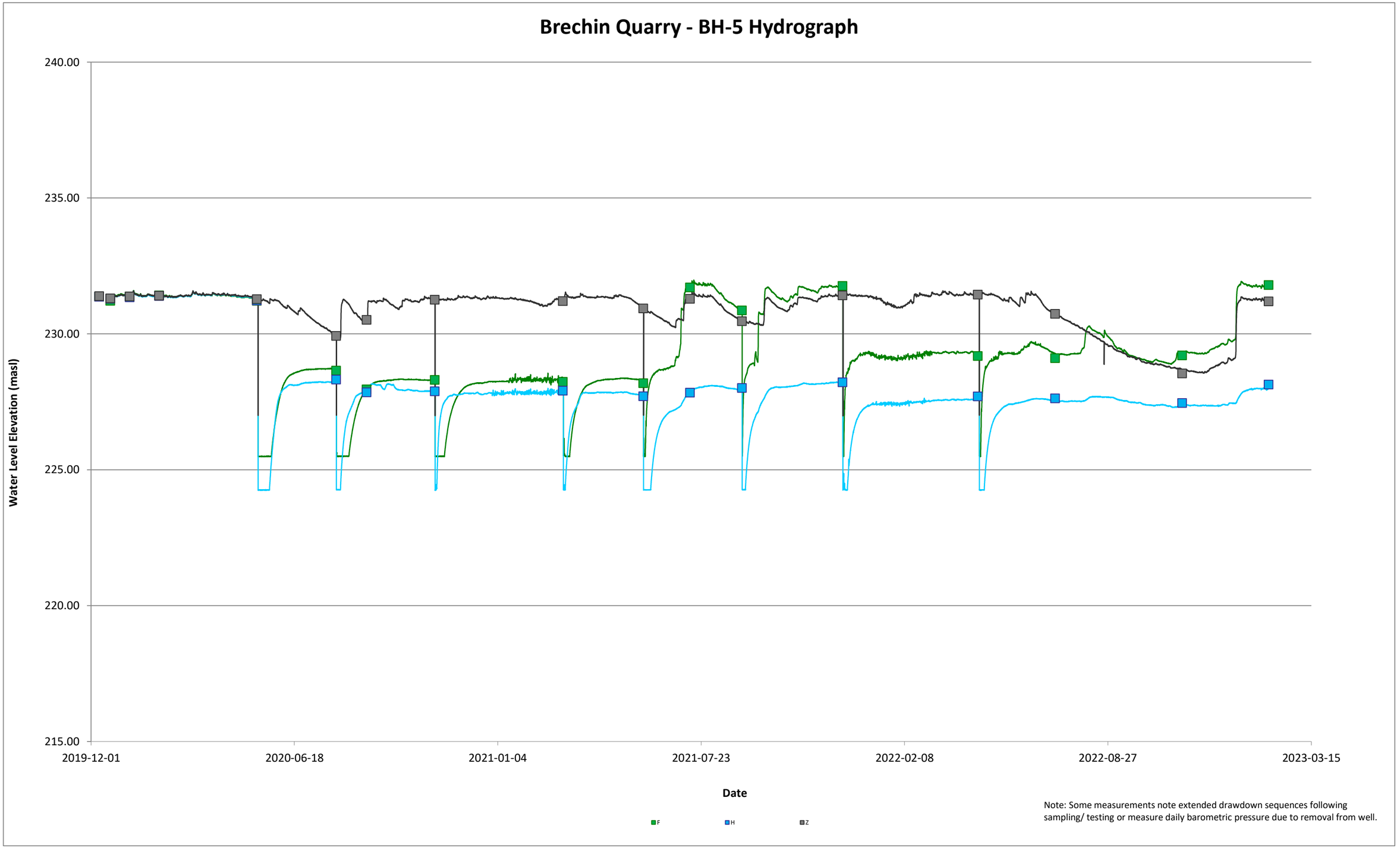


Note: Some measurements note extended drawdown sequences following sampling/ testing or measure daily barometric pressure due to removal from well.

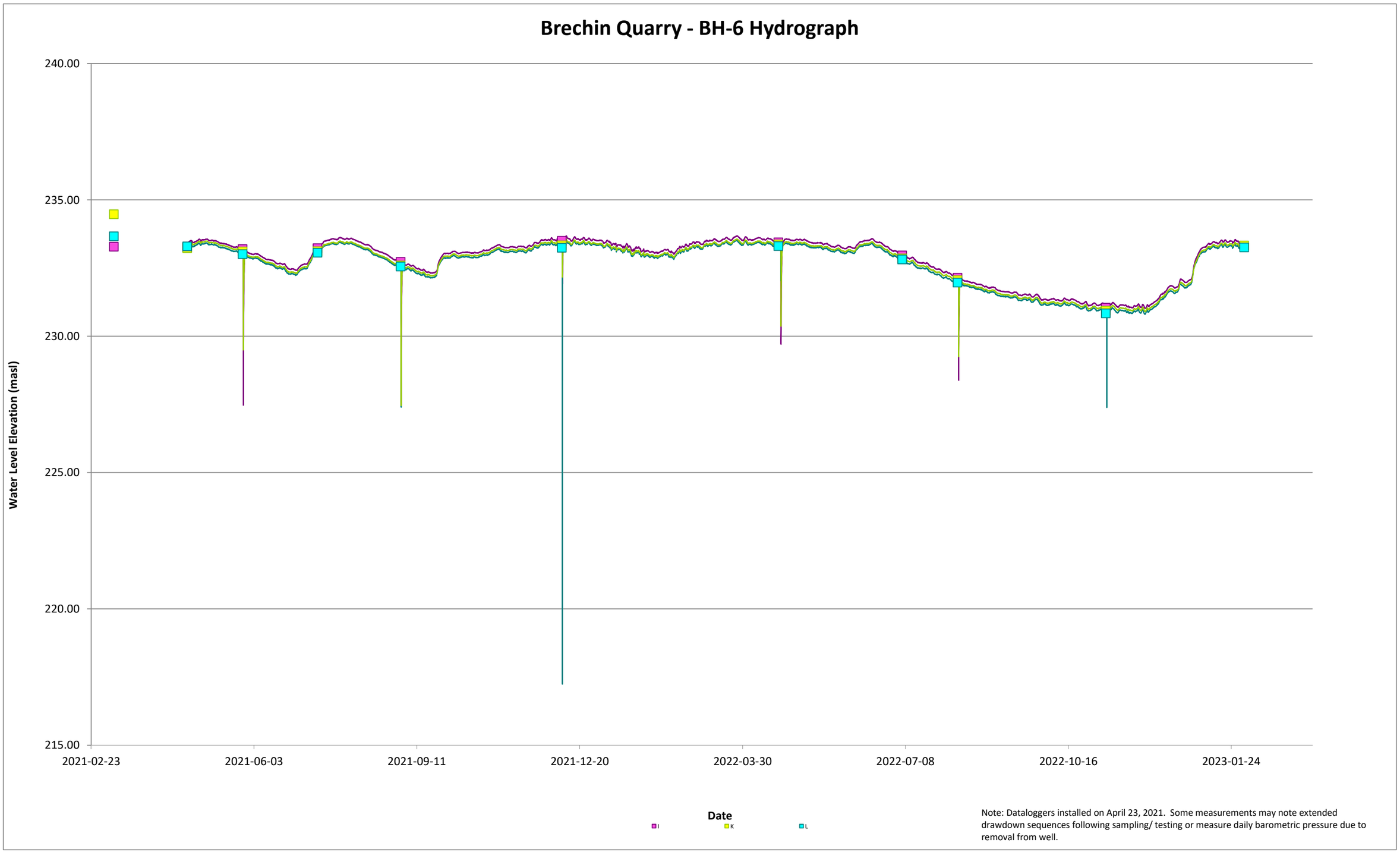
Brechin Quarry - BH-4 Hydrograph



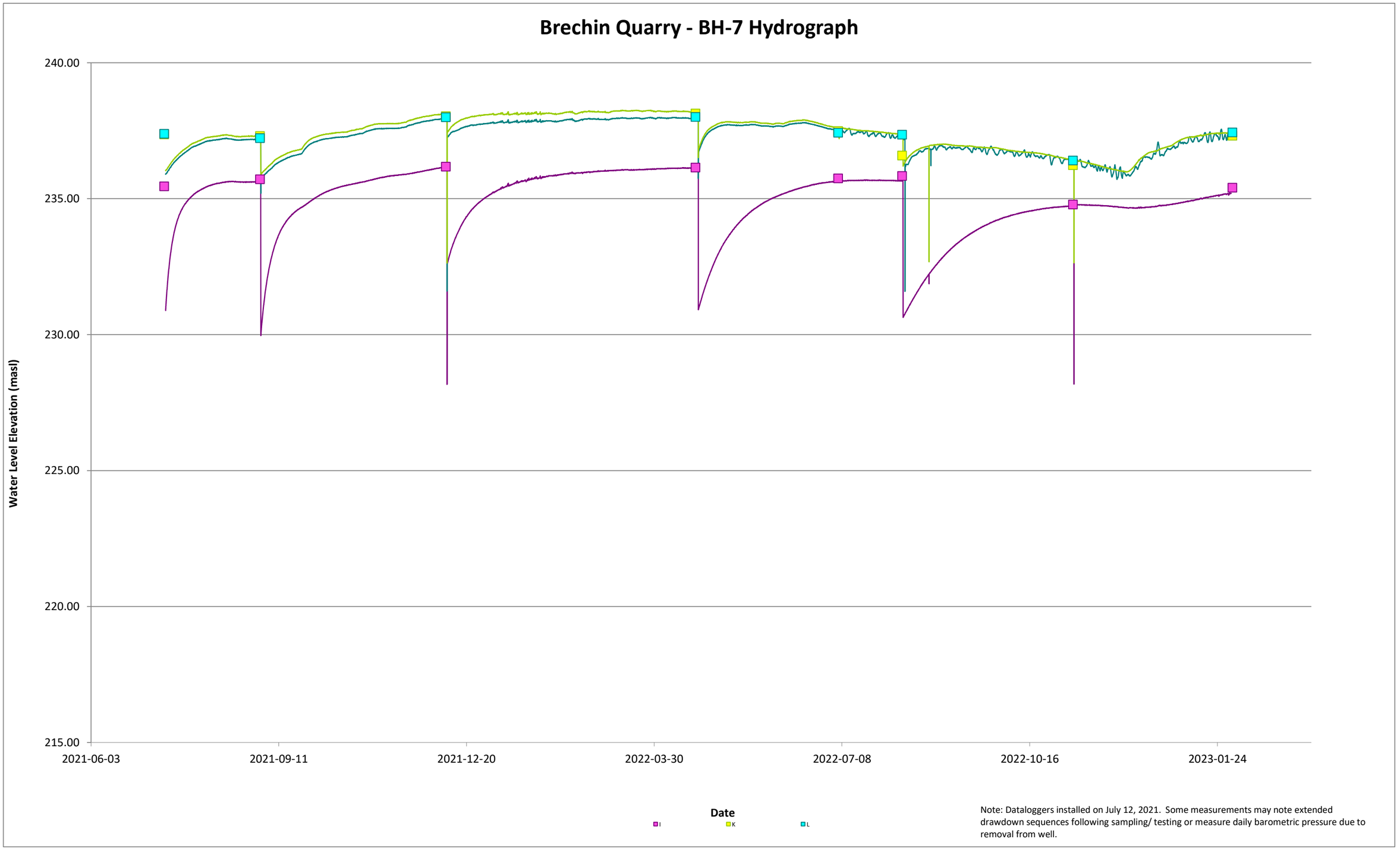
Note: Some measurements note extended drawdown sequences following sampling/ testing or measure daily barometric pressure due to removal from well.


Brechin Quarry - BH-5 Hydrograph
240.00
235.00
230.00
225.00
220.00
215.00
Water Level Elevation (masl)
2019-12-01
2020-06-18
2021-01-04
2021-07-23
2022-02-08
2022-08-27
2023-03-15
Date
F
H
Z
Note: Some measurements note extended drawdown sequences following sampling/ testing or measure daily barometric pressure due to removal from well.

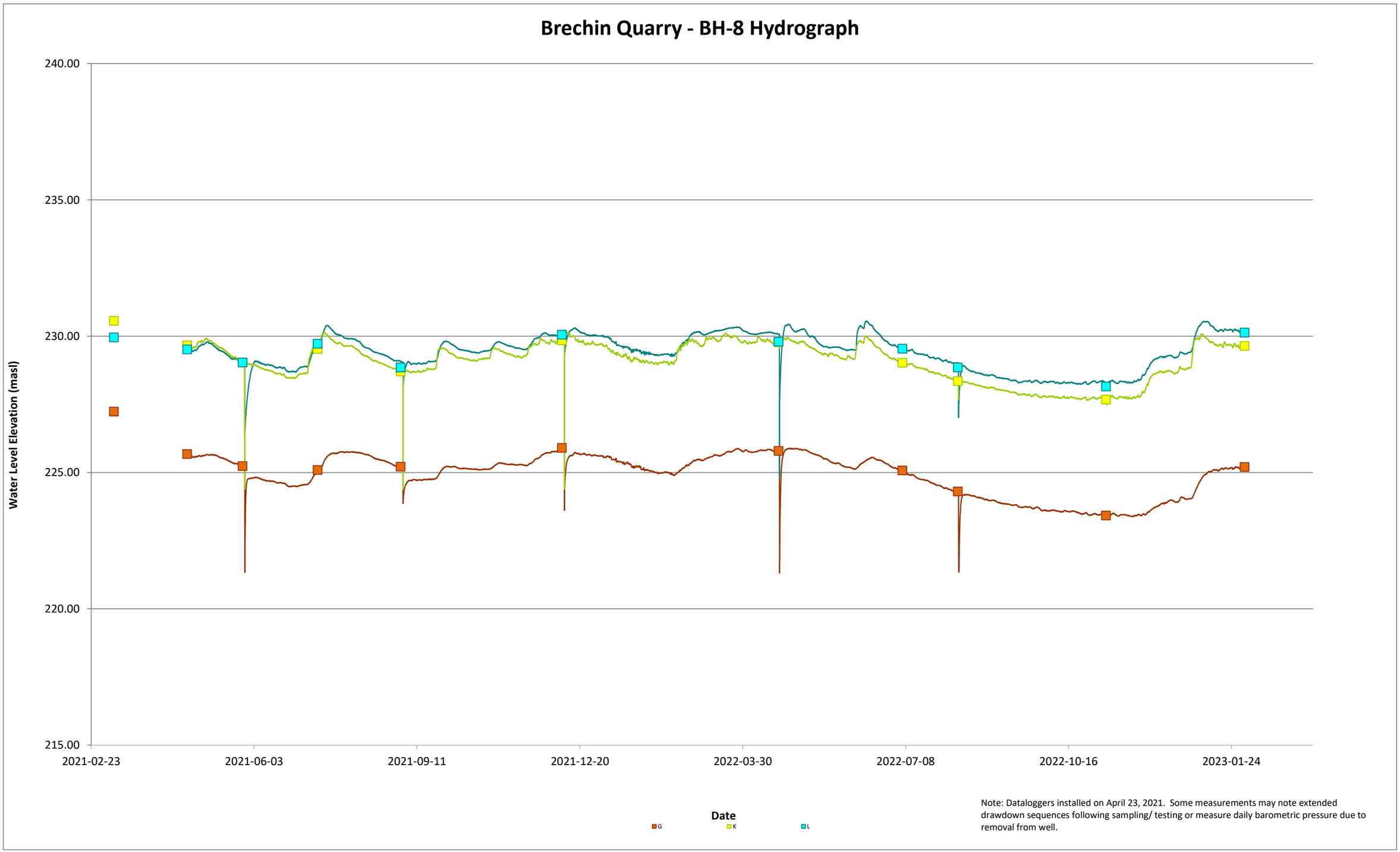
Brechin Quarry - BH-6 Hydrograph



Note: Dataloggers installed on April 23, 2021. Some measurements may note extended drawdown sequences following sampling/ testing or measure daily barometric pressure due to removal from well.

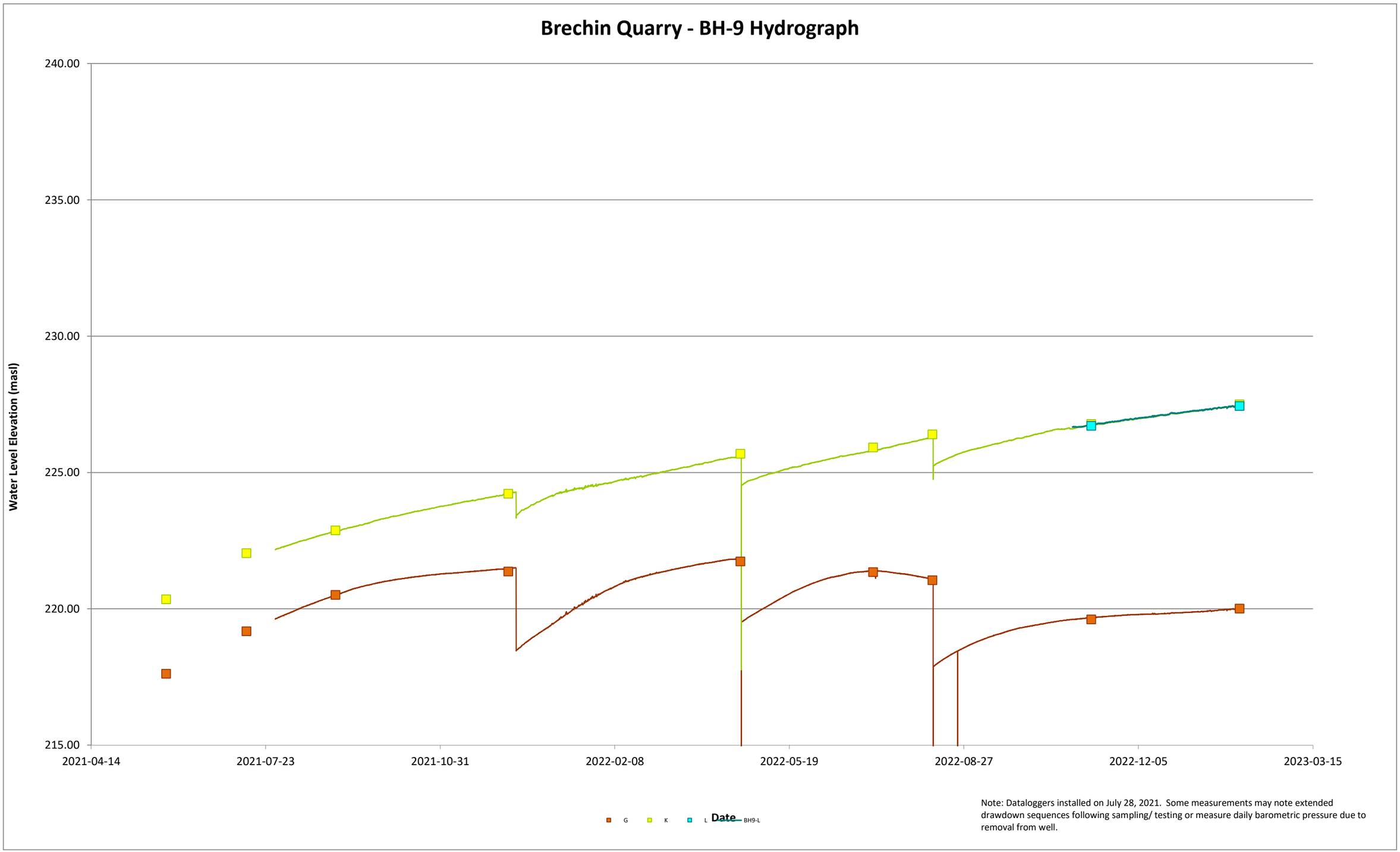

Brechin Quarry - BH-7 Hydrograph
240.00
235.00
230.00
225.00
220.00
215.00
Water Level Elevation (masl)
2021-06-03
2021-09-11
2021-12-20
2022-03-30
2022-07-08
2022-10-16
2023-01-24
Date
I
K
L
Note: Dataloggers installed on July 12, 2021. Some measurements may note extended drawdown sequences following sampling/ testing or measure daily barometric pressure due to removal from well.

Brechin Quarry - BH-8 Hydrograph



Note: Dataloggers installed on April 23, 2021. Some measurements may note extended drawdown sequences following sampling/ testing or measure daily barometric pressure due to removal from well.

Brechin Quarry - BH-9 Hydrograph



Note: Dataloggers installed on July 28, 2021. Some measurements may note extended drawdown sequences following sampling/ testing or measure daily barometric pressure due to removal from well.

APPENDIX D

Author Qualifications and Experience

MICHAEL G. JONES

B.Sc., M.Sc., P.Geo.
Senior Hydrogeochemist
President

PROFILE

1995-Present	President, Azimuth Environmental Consulting, Inc.
2003-2005, 2008-2012	Faculty (part time), Georgian College (Professional Golf Management Program)
1987-1995	Hydrogeochemist, Senior Consultant, Gartner Lee Limited
1985-1987	M.Sc., University of Waterloo, Geology/Geochemistry
1985-1987	Research Assistant, University of Waterloo, Geology Dept.
1983-1985	Technician, University of Waterloo Isotope Research Laboratory
1983	Geophysical Exploration Technician, UMEX Inc.
1980-1985	B.Sc. (Honours Co-op), University of Waterloo, Geology

EXPERIENCE

1995 – Present President, Azimuth Environmental Consulting, Inc.

Mr. Jones is a founding member of Azimuth Environmental Consulting, Inc. Mr. Jones' areas of specialty include water supply and wastewater treatment, ground water geochemistry and contaminant hydrogeology. He provided expert testimony before the Ontario Land Tribunal, the Joint Board, the Ontario Municipal Board, the Environmental Review Tribunal and civil court.

He has undertaken a variety of projects, including:

- Lead hydrogeologist for construction of Highway 407 Phase 2. This project includes assessment of construction dewatering requirements at more than 100 structures and obtaining Permits to Take Water for all activities that may reach the water table. It also includes an active monitoring programme for ground water levels at an extensive well network and at major stream crossings and terrestrial ecology sites to evaluate the potential and actual changes caused by the highway. Participation with BBC staff and in working group meetings, and liaison with key staff at regulatory agencies is required to address potential issues as they arise.
- Project manager and hydrogeologist for the Ministry of Transportation providing an assessment of road salt or construction blasting impacts. These investigations include an assessment of the physiographic setting, surface drainage and hydrogeology. An assessment is made of potential contaminant sources, pathways to the contaminated well and well status. Recommendations are made regarding possible remedial measures. This work has included a broad spectrum of investigations over more than two decades, including regional studies of the Highway 11 and 118 corridors to evaluate whole communities, investigations at salt storage yards and works yards, a review of potential salt impacts in Emsdale pertaining to whole community, which has become a class action lawsuit and approximately 400 well assessments to consider causal relationships for water quality and quantity problems. From this work, Azimuth prepared the MTO protocol for pre-construction well testing and baseline evaluations.

- Lead investigator for a research project to evaluate chloride sources in a small rural watershed. This project was jointly funded by the National Research Council of Canada, MTO and Azimuth. Potential sources include road salt, water softener salt, septic discharge and agrichemicals. The study utilizes inorganic and isotopic analyses to differentiate chloride sources and determine the relative mass contribution from the various sources.
- Lead investigator for water supplies and more than 200 Permits to Take Water. Water-takings have included those for irrigation, potable water, quarries, construction dewatering and commercial taking for spring water, bottled water and beverage production. Work has included hydrogeological evaluations to document the ground water regime for proposed water supplies and consideration of potential impacts from the proposed taking to other users and natural heritage features. For complex environments or large takings, Modflow is used to simulate the takings and predict the potential drawdown for specific receptors.
- Lead investigator and environmental consultant for ClubLink Corporation at 28 of their properties. These studies have focused on aspects of water management, from supply for irrigation and potable needs to sewage treatment. Water management is a central requirement for a successful golf facility, so water issues are incorporated at the beginning of development plans. We have succeeded in finding innovative solutions where site limitations would have precluded a golf facility. Monitoring of potential impacts from chemical products and treated effluent applications is completed routinely and environmental impacts are evaluated. ClubLink is obtaining Audubon Signature designation at their courses so stewardship programs for water management and environmental practices have been developed. Azimuth has assisted ClubLink in obtaining MOE permits to take water, sewage system permitting and to operate potable water treatment systems. Similar work has also been completed for several other golf properties.
- The annual ground water, surface water and leachate monitoring programs at approximately 15 landfills in central and northern Ontario. These programs involve the collection and analysis of samples and site data throughout the year to evaluate the performance of the site. Most of the sites have been designed to naturally attenuate contaminants, so that routine monitoring is important in assessing regulatory compliance. Since 1995, more than 250 annual investigations have been completed.
- Design and approvals for leachate collection and treatment systems at four rural landfill sites. The systems include on-site treatment using a tertiary treatment system and discharge of treated effluent to either a leaching field or direct discharge to wetlands or a small creek. The systems provide contingency mitigation in the event that predicted impacts from natural attenuation become unacceptable. At one site, the LTS provides the main leachate control and has resulted in the reduction of environmental discharges by 95%.
- Phase I/II assessments of commercial and industrial properties. These assessments focus on previous and current land use and the potential for contaminant impact. Assessments typically include test pitting, visual assessment of the lands and premises and the collection of soil and water samples for analysis.

- Project director and environmental consultant for M.A.Q. Quarries. Conducted Level 2 hydrogeologic investigations at prospective quarry sites in Severn, Ramara (Carden Plain), Duntroon and Port Colborne. Work program involves fracture network evaluation using packer testing system, continuous water monitoring using dataloggers, geochemical profiling, surface water monitoring and numerical modeling of the environmental setting. Program provided represent contemporary standards for fractured rock site evaluation as recommended and accepted by the client.
- Project hydrogeologist for approximately 50 geothermal projects. Examples include services for a police headquarters, an MNRF office, an airport terminal, a large federal office tower in downtown Toronto, apartment buildings and seniors complexes. Work included preparation of the drilling ECA or site-specific ECA, preparation of PSP's, high pressure gas training and drilling monitoring and safety checklists.
- Project manager and lead investigator for hydrogeological studies, and water and wastewater system implementation for approximately thirty rural and communal facilities. These projects have included public systems (EAA, EPA and OWRA approvals) as well as private systems (EPA and OWRA approvals). The projects offer complete assessments, from delineation of available water supplies, appropriate potable water treatment needs, sewage and wastewater collection and treatment, discharge of treated effluent, water budgets, implementation of LID's and site monitoring. Opportunities are defined and then approvals are sought to meet provincial and municipal requirements. At several sites, treated effluent has been incorporated into irrigation supply to allow re-use and recognize the additional treatment benefits when treated effluent is applied to turf. The systems have been designed to satisfy water demand from 10 to 2,200m^3/day. Sewage treatment systems have been designed for 10 to 650m^3/day. Examples of these systems include golf clubhouses (e.g. The Rock and Mad River Golf Club), rural subdivisions (e.g. Balsam Lake), new urban subdivisions (e.g. the Greenwood expansion, Westhill (Aurora), Villages of Shakespeare and Minett) and resorts with mixed waste streams (e.g. Red Leaves in Minett, the Muskokan Resort, Lakeside at Rocky Crest).
- Project manager and lead investigator for Class EA approvals for water and wastewater. These projects have included new systems for Baxter, Minett, Aurora, Greenwood, Sebringville and Shakespeare. In a sixth project, I provided peer review of technical reports for Bradford – West Gwillimbury for the proposed Bradford-Bondhead expansion.
- Lead hydrogeologist for the peer review of two proposed gold mine sites in Northern Ontario (Federal Class EA). Our review was completed as part of a multi-disciplinary team on behalf of our clients, two First Nations communities where the mine sites are located within their historical use areas. Susbsequent programmes with the First Nation with implementation of mine facilities and a First Nation Fuel Depot.
- Lead investigator for investigations regarding the alleged parasite (*Giardia*) contamination of the south municipal water supply for the City of Thunder Bay. These forensic investigations were undertaken as the municipality is the defendant in a number of on-going civil court cases. Our investigations identified that *Giardia* in the water source during the alleged period of contamination reflected background conditions consistent with those over the last 90 years, and that an outbreak did not occur.
- Reviewer for the MOE Ground water Under the Influence (GUDI) Water Supply Program. Following the Walkerton Inquiry, the MOE retained thirty individuals across

the province to review GUDI reports on public water supplies. These reports assessed the minimum treatment requirements for public supplies that may be susceptible to surface water infiltration. Mike reviewed seven of these reports for the MOE.

- Lead investigator for a research project to evaluate chloride sources in a small rural watershed. This project was jointly funded by the National Research Council of Canada, MTO and Azimuth. Potential sources include road salt, water softener salt, septic discharge and agrichemicals. The study utilizes inorganic and isotopic analyses to differentiate chloride sources and determine the relative mass contribution from the various sources.

PROFESSIONAL AFFILIATIONS, CERTIFICATION & TRAINING

- Professional Geoscientists of Ontario
- Ontario Onsite Wastewater Association
- Drinking Water System Operator – Limited Ground Water Systems
- Professional Geoscientists of Ontario Discipline Committee 2005 to current, Secretary for 2010-2012, Vice-chair 2012-2014, Chair 2014-2016, 2018-2020
- Association of Ground Water Scientists and Engineers (NGWA) (1990 to present)
- Canadian Water Resources Association (2008 to present)
- International Association of Hydrogeologists - IAH Newsletter Editor from 1989 to 1992
- St. John Ambulance Standard First Aid and CPR
- safety training: WHMIS, confined space hazards, emergency preparedness

PUBLICATIONS AND PRESENTATIONS

Jones, M.G. Thermal Impacts and Mitigation Monitoring for a stormwater pond to protect aquatic species at risk, Presentation to TRCA/MNRF Thermal Mitigation Working Group – Workshop, March 2017

Jones, M.G. Guidelines and Standards for Environmental Site Audits, presentation at Georgian College, annually from 2013 to 2019

Ketcheson, D. and M. Jones, "Quarry Influences on Ground Water Systems in Limestone Environments of Southern Ontario" National Ground Water Association Conference on Ground Water in Fractured Rock and Sediments, September 23-24, 2013, Burlington, VT

Part-time Faculty, Environmental Law, Georgian College, 2003- 2005, 2008-2012 winter terms, teaching in the Professional Golf Management Program

Jones, M.G. Denitrification – the next step in sewage treatment. paper and presentation at Ontario On-Site Wastewater Association annual conference, March 2009.

Jones, M.G. Hydrogeology of the Oro Moraine, presentation to MPP Dunlop's Community Awareness public forum, September 2008.

Jones, M.G. MOE Approvals for Large On-Site Sewage Treatment Systems. paper and presentation at Ontario On-Site Wastewater Association annual conference, March 2008.

Well Aware Seminars, APGO Community Programs in Durham and Haliburton, 2004

Jones, M.G. and McDonald, N. Natural Heritage Planning for the Oro Moraine (the Other Moraine). Presentation at the Power of Place Conference, OPPI/OPLA, Sept 2003

Wallis, P.M., D. Matson, M. Jones, and J. Jamieson. Application of monitoring data for *Giardia* and *Cryptosporidium* to boil water advisories. Risk Analysis. vol 21, no. 6, 2001

Jones M.G. Factors Controlling Leachate Quality and Quantity. Lecture for the MOE Landfill Design Course, 2001.

Jones M.G. Factors Controlling Leachate Quality and Quantity. Lecture for the MOE Landfill Design Course, 2000.

Wallis, P, Matson, D, Jones, M.G. and Jamieson, J., Risk of Waterborne Giardiasis Based on Monitoring Data, paper and presentation at 9th Drinking Water Conference, Regina, May 2000.

Jones, M.G., Descriptive Hydrogeology and Ground Water Issues in New Tecumseh, presentation at the New Tecumseh Environmental Conference 2000, March 2000 (televised)

Jones, M.G., Environmental Issues and Approvals for Golf Course Development, presentation at Georgian College, Barrie, Jan 2000.

Jones, M.G., Golf Course Development: Permitting Requirements, presentation at Georgian College, Barrie, Jan 1999.

Jones, M.G. and Ketcheson, D.R.., Chloride contamination of water supply wells and identification of chloride sources for sites located on the Canadian Shield, presentation and paper, Ground water in a Watershed Context conference, CCIW, December, 1998

Jones M.G. Hydrogeological Considerations, Leachate Quality and Quantity and Landfill Monitoring. Lectures and paper for the MOE Landfill Design Course, 1998.

Zaltsberg, E., Jones, M. and Gehrels, J.. A trigger mechanism for evaluating the landfill impact on water quality. Paper and presentation, GAC/MAC, Quebec, May 1998

Jones, M., Neals, P. and Van Barr, C.C.. "An ounce of prevention...can save a property transfer/ development/purchase" article in BBN Magazine Business and Leisure, June/July 1996

Kassenaar, D., Jones, M. and Gartner, J.. Wellhead Protection. WaterPower Magazine. Fall 1995.

Jones, M.G. Sanitary Landfill Leachate and Gas Management. Chair of seminar, University of Toronto, Educational Program Innovations Center, April 13-14, 1994.

Jones, M.G. Leachate Quality and Characteristics. Paper and Presentation for seminar on "Sanitary Landfill Leachate and Gas Management", University of Toronto, April 13, 1994.

Jones M.G. Factors Controlling Leachate Quality and Quantity. Lecture for the MOE Landfill Design Courses, 1993 and 1991.

Frape, S.K., Blyth, A.R., Jones, M.G., Blomqvist, R., Tullborg, E.L., McNutt, R.H., McDermott, F. and Ivanovich, M. A comparison of calcite fracture mineralogy and geochemistry for the Canadian and Fennoscandian Shields. Presentation and proceedings of the 7th International Symposium on Water-Rock Interaction, WRI-7, Utah, USA, July 1992.

Leech, R.E.J.L., Reynolds, G.W. and Jones, M.G. Protection of Thin, Low Yielding Aquifers through Considerate Landfill Design: The Result of Public Demand. Paper and presentation to the AWWA/OMWA 1992 Joint Annual Conference, April 1992.

Rowe, R.K. and Jones, M.G. Conceptual Design of the Halton Landfill, presentation to the Canadian Geotechnical Society, southern Ontario Section, at the MTO Atrium Tower, Toronto, January 1992.

Jones, M.G. Factors controlling the character of municipal landfill leachate in Ontario. Paper and Presentation for seminar on "Sanitary Landfill Leachate and Gas Management", Technical University of Nova Scotia, September, 1991.

McNutt, R.H., Frape, S.K., Fritz, P., Jones, M.G. and MacDonald, I.M. The $^{87}Sr/^{86}Sr$ values of Canadian Shield brines and fracture minerals with applications to ground water mixing, fracture history and geochronology. Geochimica et Cosmochimica Acta, January 1990.

McNutt, R.H., Frape, S.K., Jones, M.G. and MacDonald, I.M. The $^{87}Sr/^{86}Sr$ of Canadian Shield brines and fracture minerals with applications to ground water monitoring, fracture history and geochronology. Geochemical Cosmochemistry Association 1989.

Love, D., Frape, S.K., Gibson, I. and Jones, M.G. The ^{18}O and ^{13}C isotopic composition of secondary carbonates from basaltic lavas cored during the drilling of hole 642E, Ocean Drilling Program Leg 104. "Part B of the Initial Report for Leg 104", Proceedings of the Ocean Drilling Program, Scientific Results, 1989.

Jones, M.G., Frape, S.K., Fritz, P., and Gibson, I.L. A study of late-stage secondary fracture mineralogy at sites across the Precambrian Canadian Shield and at the Stripa, Sweden site. Internal publication and presentation for the Walker Mineralogical Club, Toronto, 1987.

Jones, M.G., Frape, S.K. and McNutt, R.H.. A study of the geochemistry and isotopic composition of late stage secondary fracture mineralization at the Underground Research Laboratory, Pinawa, Manitoba. Final Report to AECL, June 1987.

Jones, M.G. A study of the late-stage secondary fracture mineralization at sites across the Precambrian Canadian Shield, unpub. M.Sc. Thesis, University of Waterloo, 1987.

McNutt, R.H., Frape, S.K., Jones, M.G. and Fritz, P. The $^{87}Sr/^{86}Sr$ values of brines in rocks of Archean age, Matagami area, Quebec: a contrasting behavior to other Canadian Shield brines. International Association of Geochemistry and Cosmochemistry Fifth International Symposium on Water-Rock Interaction, Reykjavik, Iceland, August 1986. Extended abstract, poster session and presentation, 1986.

Jones, M.G. A study of the late-stage secondary fracture mineralization at sites across the Precambrian Canadian Shield, unpub. B.Sc. Thesis, University of Waterloo, 1985.

BRADLEY PETTERSONE

B.Sc. in Environmental Science
Environmental Scientist

PROFILE

2018 – *Present*	Environmental Scientist, Azimuth Environmental Consulting, Inc. (Azimuth)
2014 - 2018	Senior Environmental Technician, Oakridge Environmental Ltd. (ORE)
2013	Environmental Field Technician *(Contract),* Kawartha Conservation (KRCA)
2011 – 2012	B.Sc. in Environmental Science, Royal Roads University (RRU)
2010	Watershed Monitoring Technician *(Contract)*, Nottawasaga Valley Conservation Authority (NVCA)
2008 – 2011	Advanced Diploma in Environmental Technology, Georgian College (GC)

EXPERIENCE

March 2018 - Present Environmental Scientist, Azimuth Environmental Consulting, Inc.

Primarily undertakes projects related to the field of Environmental Science and Hydrogeology, supporting the Hydrogeology and Engineering team at Azimuth with a focus projects related to water resources and earth science in Ontario.

Professional experience at Azimuth involves projects related to:

- *Landfill monitoring* (groundwater, surface water, leachate and landfill gas) and reporting for historical and active landfill sites in the City of Kawartha Lakes and Parry Sound District;
- *Phase I Environmental Site Assessments* including: historical data analysis, interpretation, site reconnaissance and interviews development of conceptual site models and technical report writing;
- *Phase II Environmental Site Assessments (ESA)*, including: developing sampling and analysis plans, test pit programs, environmental drilling programs, soil and groundwater sampling, database management, remedial activities (*i.e.,* UST removal) and technical report writing;
- *Environmental Remediation and Tank Removal* projects which include developing programs to remedy soil impacts from petroleum hydrocarbons (PHC), heavy metals, and volatile organic compounds (VOC). Includes technical closure reporting.
- *Record of Site Condition (RSC)* projects completed to the Ontario Regulation 153/04 (as amended) for the purpose of filing for Record of Site Condition;
- *Ministry of Environment, Conservation & Parks (MECP) Guideline D-4* (Land Use on or Near Landfills and Dumps) Assessments in conjunction with Municipal policy guidelines for commercial and residential developments near landfills in the County of Simcoe;
- Hydrogeological Studies supporting *Permit To Take Water* applications and Environmental Activity and Sector Registry (EASR) registration for storm water, commercial and construction projects throughout Ontario;
- *Water Supply Assessments* (MECP D-5-5) for commercial, subdivision/severance and residential developments throughout Southern Ontario, which include a review MECP

well records, pumping tests, aquifer assessment and analysis, water quality sampling, database management and technical report writing;

- *Level 1 and 2 Hydrogeological Evaluation* for Aggregate Resource Assessments for proposed aggregate resource developments in Ontario. Field Lead for a proposed limestone quarry expansion in Burlington, ON. Project Coordinator and Field Lead (surface and ground water components) for a proposed limestone quarry in Brechin, ON. Field program and project coordination components include: environmental drilling (HQ coring) and monitoring well installation, hydraulic testing and analysis, packer testing and analysis, pumping tests, long-term ground water monitoring, environmental database management, and technical report writing;
- Hydrogeological Evaluations (and detailed borehole logging) for supporting the construction of *Vertical Closed-loop Geothermal Systems* for projects across Ontario;
- Hydrogeological Evaluations for supporting the construction of *Open-Loop Vertical Geothermal Systems*. Including the implementation at Muskoka Landing Retirement Residence in Huntsville, Ontario. This included in-situ testing of the well field, which was comprised of pumping tests, reinjection testing and a geochemical assessment.
- *Wastewater Design and Assimilative Capacity Studies* for supporting sustainable wastewater disposal and potential impacts to water bodies. Includes: septic sizing and design, impact assessment and field monitoring (i.e., stream flow and surface water sampling); and
- Additional projects and tasks that support the Hydrogeology team include:
    - Technical support for a MTO Chloride investigation in Emsdale, ON;
    - Field and Technical support for Highway 407/ETR surface and ground water monitoring program;

2014 - 2018 Environmental Technician/Senior Environmental Technician, Oakridge Environmental Ltd. (ORE)

Supported Project Managers by organizing, scheduling and completing environmental field investigations for a variety of ecological, compliance and hydrogeological projects. Responsible for developing and maintaining internal/project Geographic Information System (GIS) databases along with preparing maps, figures and other design plans for inclusion into technical reports. Lead technician for all mapping projects using a differential Global Positioning System (dGPS), with data post-processing capabilities. Moreover, office duties also included proposal and budget preparation for new projects, technical report writing and liaising with clients.

Hydrogeological and compliance experience includes:

- Compliance Monitoring: Responsible for completing ground- and surface water monitoring, database management and/or annual reporting activities for:
    - Three (3) "Class A" Aggregate Operators (below the water table) in Eastern Ontario, as per PTTW and ECA permits issued by the MOECC;
    - Two golf course facilities, as per PTTW and ECA permits;
    - Multiple privately owned Large Subsurface Disposal Systems (LSSDS) regulated by ECA permits in Ontario;
    - A bulk waste transfer facility in Bowmanville, ON, as per an ECA permit; and
    - Multiple large-scale construction projects, including the Mississagua Lake Dam Replacement project on the Trent-Severn Waterway for Park's Canada

- Hydrogeological and Site Servicing Studies: Managed and organized soil exploration and drilling (including hydrofracturing) programs, as well as pumping tests using standardized protocols (i.e., D-5-5), which supported many subdivision, condominium and commercial developments applications
- Phase I ESA: Assisted Compliance Specialist in completing projects to both CSA and RSC standards - tasks included: compiling and reviewing background data (i.e., Historical Air Photos, Ecolog ERIS, etc.), initial site inspections, data management and technical report writing
- Phase I ESA: Organized and supervised field investigations for projects, including developing sampling and analysis plans, environmental drilling, soil and groundwater sampling, database management, and technical report writing
- Level 1 and 2 Hydrogeological Investigations: Organized and supervised multiple hydrogeological field investigations for proposed and expanding aggregate resource development projects in Northern and Eastern Ontario; including a diamond drilling program for a Structural Geology Investigation to grade aggregate quality
- Groundwater Supply Investigations: Lead and organized field programs related to multiple groundwater supply investigations for First Nation Communities, including Curve Lake First Nation, Nippising First Nation and Chapleau Cree First Nation.
- Other relevant projects and field investigations include:
    - Project Manager for a Water Table Determination Investigation for an expanding dimensional stone quarry in Madoc, ON;
    - Completed multiple sewage system inventories using ground penetrating radar (GPR) for campgrounds and resorts situated in Eastern Ontario;
    - Proficiently completed many mapping and surveying exercises using a dGPS and survey levels for a wide variety of hydrogeological and compliance projects, including: terrain mapping, private utility surveys and water table determination.

Natural Environment experience includes:

- Project Coordinator for various technical studies including: Environmental Impact Studies (EIS), Natural Environment Assessments (NEA) and Natural Heritage Evaluations (NHE)
- Developed SAR GIS database for Georgina Island First Nation, as part of their community planning initiatives
- Completed Species at Risk (SAR) assessments, including nocturnal surveys for amphibians (i.e., Western Chorus Frog), nightjars (i.e., Eastern Whip-poor-will and Common Nighthawk) and bats (i.e., *Myotis sp.*).
- Routinely conducted wetland delineation (OWES) and vegetation community mapping (ELC), in addition to biological inventories for projects located in Southern Ontario
- Completed bat snag and acoustic surveys using the Ministry of Natural Resources and Forestry (MNRF) protocols for development projects in Southern Ontario
- Additional surveys and activities included:
    - Fish identification and relocation for multiple large-scale construction sites, including the Lock 22 Rehabilitation and the Mississagua Lake Dam Replacement along the Trent-Severn Waterway for Park's Canada;

- Assisted in the planning (and supervised) the construction of a permanent turtle fence at the Blue Mountain Mine (operated by Unimin Canada ltd.); and
- Designed and completed fieldwork, mapping and statistical analysis for a tree loss/retention program for a proposed resort development on Rice Lake, where the objective was to estimate tree loss, tree retention and compensatory planting requirements, including over 100 Butternut trees.

2013 (Contract) Environmental Field Technician, Kawartha Conservation (KRCA)

- Routinely coordinated and conducted water quality and quantity sampling at thirty (30) tributaries and several lakes inventorying results into databases and spreadsheets
- Performed and coordinated groundwater quality sampling at ten (10) long-term monitoring wells following PGMN protocols created by the MOECC
- Installed and maintained environmental monitoring equipment such as: rain gauges, water level loggers, and staff gauges
- Analyzed and interpreted five (5) years worth of water quality data for the CAMC: Oak Ridge Moraine Assessment Plan
- Developed an Access database for inventorying twelve (12) years worth of groundwater quality data for ten long-term monitoring wells
- Prepared an annual report and presentation for the Working Group for a Healthy Lake Scugog and presented actions and key considerations to the Scugog Lake Stewards

2010 (Contract) Watershed Monitoring Technician, Nottawasaga Valley Conservation Authority (NVCA)

- Mapped and identified aquatic macrophyte communities in Orr Lake using a GPS, Ekman dredge, and ArcGIS in partnership with the MNRF
- Collected groundwater quality samples and static water level data for the Environment Canada study outlining the "Hydrogeochemical Characterization of the Eastern Minesing Wetlands"
- Performed groundwater quality sampling as part of the PGMN in partnership with the MOECC
- Regularly collected general water quality data and water samples as part of the PWQMN
- Routinely collected and identified benthic macro-invertebrate specimens using OBBN protocols
- Conducted baseflow surveys throughout subwatersheds during low-flow conditions

AFFILIATIONS, CERTIFICATIONS AND TRAINING

- Sustainability Advisory Committee Member (Chair), Town of Gravenhurst (2022-2026)
- Standard First Aid (Ontario)
- WHMIS
- Pleasure Craft Operator Card
- Assistant Well Technician