PHASE 2 INITIAL BOREHOLE DRILLING AND TESTING, IGNACE AREA

WP06 Data Report – Hydraulic Testing for IG_BH02

APM-REP-01332-0256 **June 2021**

Golder Associates Ltd.

NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

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REPORT

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WP06 Data Report - Hydraulic Testing for IG_BH02

Submitted to:

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WP06 DATA REPORT – HYDRAULIC TESTING FOR IG_BH02

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1.0 INTRODUCTION

The Initial Borehole Drilling and Testing project in the Wabigoon and Ignace Area, Ontario is part of Phase 2 Geoscientific Preliminary Field Investigations of the NWMO's Adaptive Phased Management (APM) Site Selection Phase.

This project involves the drilling and testing of three deep boreholes within the northern portion of the Revell batholith. The third drilled borehole, IG_BH02, is located a direct distance of approximately 21 km southeast of the Wabigoon Lake Ojibway Nation and a direct distance of 44 km northwest of the Town of Ignace. Access to the IG_BH02 drill site is via Highway 17 and primary logging roads, as shown on Figure 1.

The project was carried out by a team led by Golder Associates Ltd. (Golder) on behalf of the NWMO. This report describes the methodology, activities and results for Work Package 6 (WP06): Hydraulic Testing for IG_BH02. Borehole IG_BH02 is an inclined hole and all depths referred to in this report are in meters below ground surface along the length of the borehole (mbgs along hole), rather than true vertical depth.

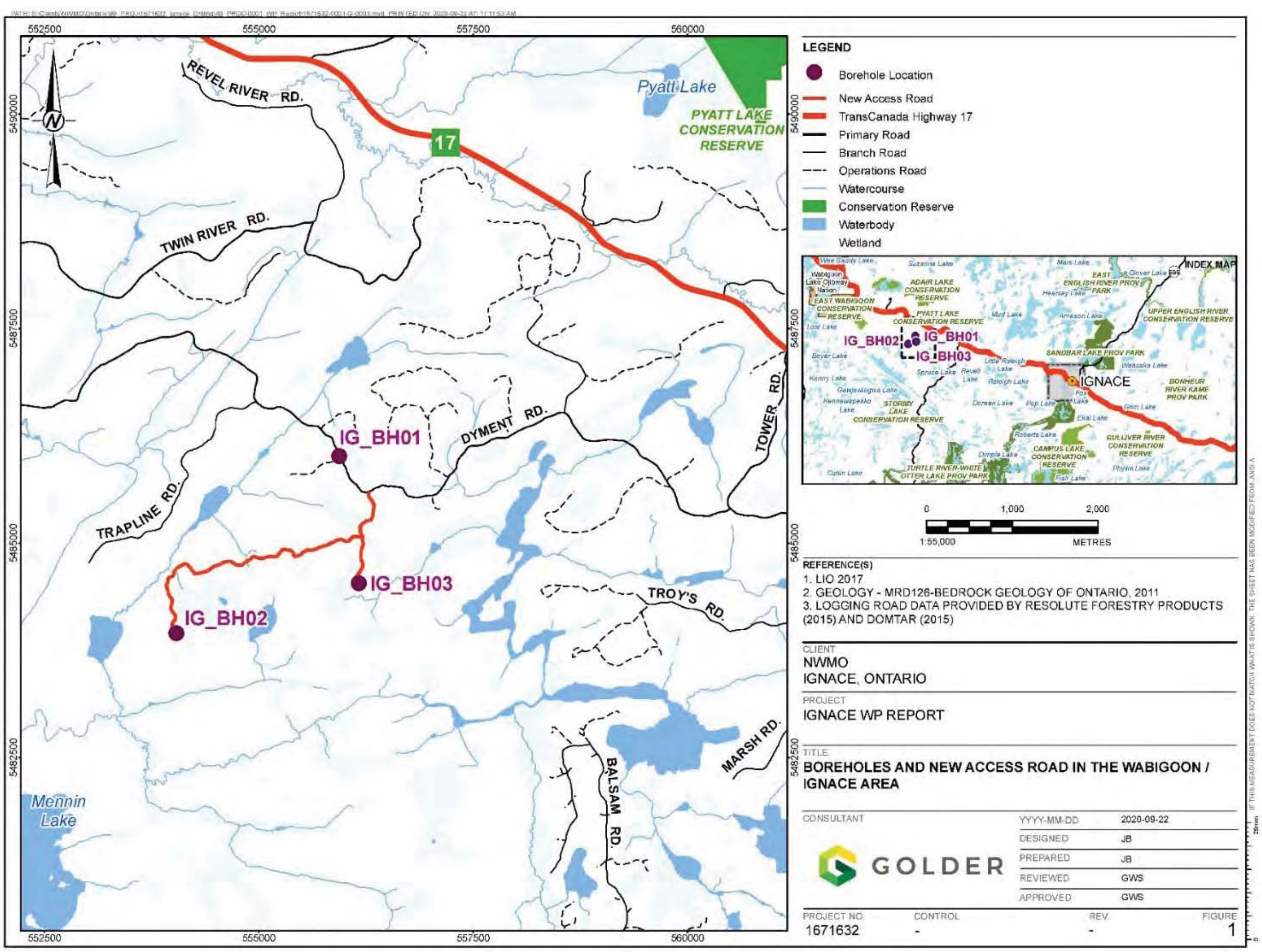

Figure 1: Location of Borehole IG_BH02 in relation to the Wabigoon / Ignace Area

2.0 BACKGROUND INFORMATION

2.1 Geological Setting

The approximately 2.7 billion year old Revell batholith is located in the western part of the Wabigoon Subprovince of the Archean Superior Province. The batholith is roughly elliptical in shape trending northwest, is approximately 40 km in length, 15 km in width, and covers an area of approximately 455 km^2. Based on geophysical modelling, the batholith is approximately 2 km to 3 km thick through the center of the northern portion (SGL 2015). The batholith is surrounded by supracrustal rocks of the Raleigh Lake (to the north and east) and Bending Lake (to the southwest) greenstone belts (Figure 2).

IG_BH02 is located within an investigation area of approximately 19 km^2 in size, situated in the northern portion of the Revell batholith. Bedrock exposure in the area is generally very good due to minimal overburden, few water bodies, and relatively recent logging activities. Ground elevations generally range from 400 to 450 m above sea level. The ground surface broadly slopes towards the northwest as indicated by the flow direction of the main rivers in the area. Local water courses tend to flow to the southwest towards Mennin Lake (Figure 1).

Four main rock units are identified in the supracrustal rock group: mafic metavolcanic rocks, intermediate to felsic metavolcanic rocks, metasedimentary rocks, and mafic intrusive rocks (Figure 2). Sedimentation within the supracrustal rock assemblage was largely synvolcanic, although sediment deposition in the Bending Lake area may have continued past the volcanic period (Stone 2009; Stone 2010a; Stone 2010b). All supracrustal rocks are affected, to varying degrees, by penetrative brittle-ductile to ductile deformation under greenschist- to amphibolite-facies metamorphic conditions (Blackburn and Hinz 1996; Stone et al. 1998). In some locations, primary features, such as pillow basalt or bedding in sedimentary rocks are preserved, in other locations, primary relationships are completely masked by penetrative deformation. Uranium-lead (U-Pb) geochronological analysis of the supracrustal rocks produced ages that range between 2734.6 +/-1.1 Ma and 2725 +/-5 Ma (Stone et al. 2010).

Three main suites of plutonic rock are recognized in the Revell batholith, including, from oldest to youngest: a Biotite Tonalite to Granodiorite suite, a Hornblende Tonalite to Granodiorite suite, and a Biotite Granite to Granodiorite suite (Figure 2). Plutonic rocks of the Biotite Tonalite to Granodiorite suite occur along the southwestern and northeastern margins of the Revell batholith. The principal type of rock within this suite is a white to grey, medium-grained, variably massive to foliated or weakly gneissic, biotite tonalite to granodiorite. One sample of foliated and medium-grained biotite tonalite produced a U-Pb age of 2734.2+/-0.8 Ma (Stone et al. 2010). The Hornblende Tonalite to Granodiorite suite occurs in two irregularly-shaped zones surrounding the central core of the Revell batholith. Rocks of the Hornblende Tonalite to Granodiorite suite range compositionally from tonalite through granodiorite to granite and also include significant proportions of quartz diorite and quartz monzodiorite. One sample of coarse-grained grey mesocratic hornblende tonalite produced a U-Pb age of 2732.3+/-0.8 Ma (Stone et al. 2010). Rocks of the Biotite Granite to Granodiorite suite underlie most of the northern, central and southern portions of the Revell batholith. Rocks of this suite are typically coarse-grained, massive to weakly foliated, and white to pink in colour. The Biotite Granite to Granodiorite suite ranges compositionally from granite through granodiorite to tonalite. A distinct potassium (K)-Feldspar Megacrystic Granite phase of the Biotite Granite to Granodiorite suite occurs as an oval-shaped body in the central portion of the Revell batholith (Figure 2). One sample of coarse-grained, pink, massive K-feldspar megacrystic biotite granite produced a U-Pb age of 2694.0+/-0.9 Ma (Stone et al. 2010).

The bedrock surrounding IG_BH02 is composed mainly of massive to weakly foliated felsic intrusive rocks that vary in composition between granodiorite and tonalite, and together form a relatively homogeneous intrusive complex. Bedrock identified as tonalite transitions gradationally into granodiorite and no distinct contact relationships between these two rock types are typically observed (SRK and Golder 2015; Golder and PGW 2017). Massive to weakly foliated granite is identified at the ground surface to the northwest of the feldspar-megacrystic granite. The granite is observed to intrude into the granodiorite-tonalite bedrock, indicating it is distinct from, and younger than, the intrusive complex (Golder and PGW 2017).

West-northwest trending mafic dykes interpreted from aeromagnetic data extend across the northern portion of the Revell batholith and into the surrounding greenstone belts. One mafic dyke occurrence, located to the northwest of IG_BH01, is approximately 15-20 m wide (Figure 2). All of these mafic dykes have a similar character and are interpreted to be part of the Wabigoon dyke swarm. One sample from the same Wabigoon swarm produced a U-Pb age of 1887+/-13 Ma (Stone et al. 2010), indicating that these mafic dykes are Proterozoic in age. It is assumed based on surface measurements that these mafic dykes are sub-vertical (Golder and PGW 2017).

Long, narrow valleys are located along the western and southern limits of the investigation area (Figure 1). These local valleys host creeks and small lakes that drain to the southwest and may represent the surface expression of structural features that extend into the bedrock. A broad valley is located along the eastern limits of the investigation area and hosts a more continuous, un-named water body that flows to the south. The linear and segmented nature of this waterbody's shorelines may also represent the surface expression of structural features that extend into the bedrock.

Regional observations from mapping have indicated that structural features are widely spaced (typical 30 to 500 cm spacing range) and dominantly comprised of sub-vertical joints with two dominant orientations, northeast and northwest trending (Golder and PGW 2017). Interpreted bedrock lineaments generally follow these same dominant orientations in the northern portion of the Revell batholith (Figure 2; DesRoches et al. 2018). Minor sub-horizontal joints have been observed with minimal alteration, suggesting they are younger and perhaps related to glacial unloading. One mapped regional-scale fault, the Washeibemaga Lake fault, trends east and is located to the west of the Revell batholith (Figure 2). Ductile lineaments, also shown on Figure 2, follow the trend of foliation mapped in the surrounding greenstone belts. Additional details of the lithological units and structures found at surface within the investigation area are reported in Golder and PGW (2017).

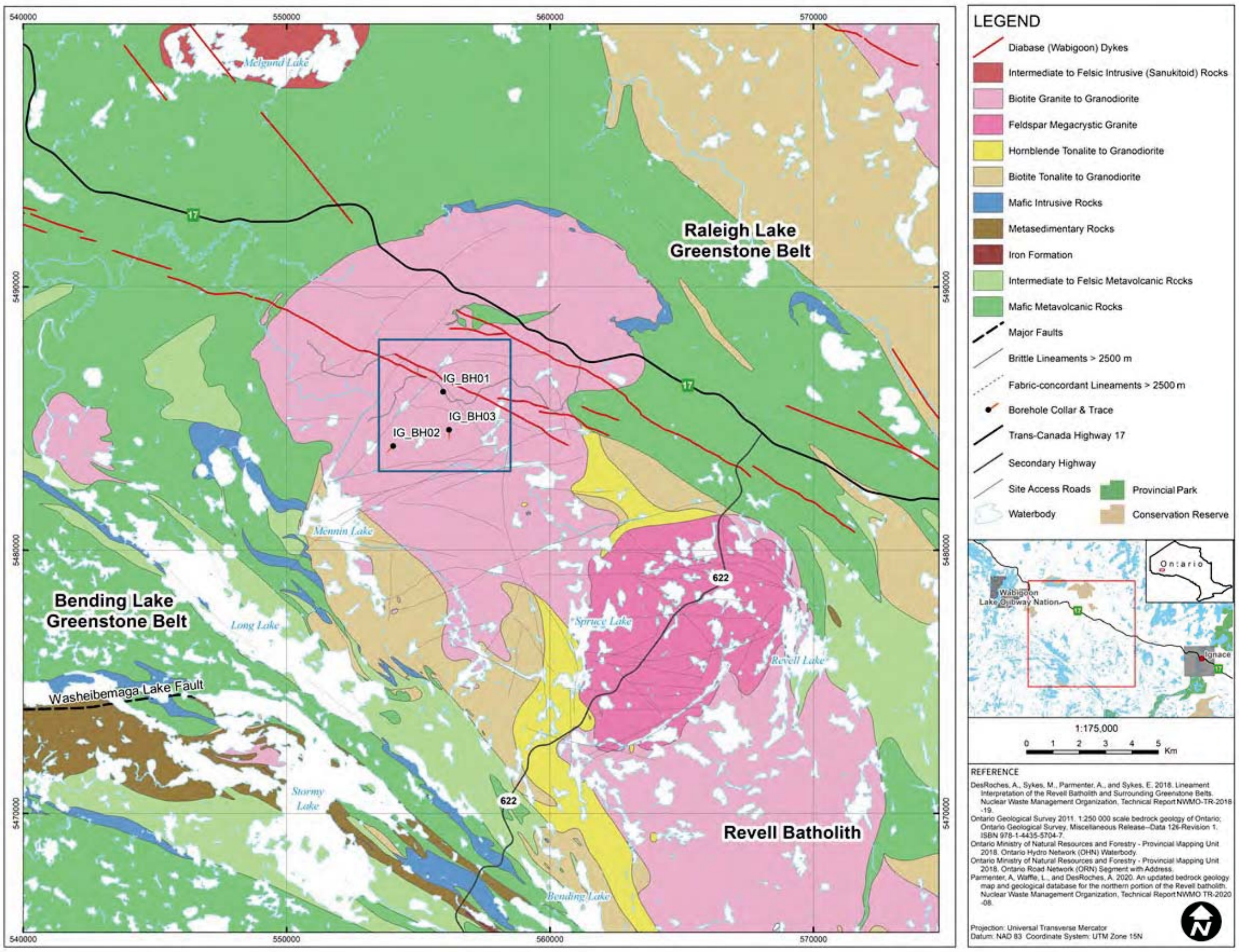

Figure 2: Geological setting and location of boreholes IG_BH01, IG_BH02 and IG_BH03 in the northern portion of the Revell batholith

2.2 Purpose

The purpose of WP06 is to estimate the hydraulic properties of the crystalline rock units at selected depths in the borehole IG_BH02. The borehole was drilled in 96 mm (HQ) diameter at an inclination of 70° from horizontal and an azimuth of 225° to a total depth of 1000.41 mbgs. Additional borehole details are presented in the report WP02 – Borehole Drilling and Coring for IG_BH02 (Golder, 2020). Testing was carried out after the completion of drilling and logging. Selection of test intervals considered potential water conductive zones based on review of the earlier stages of work that included the following:

- WP02 – Borehole Drilling and Coring;
- WP03 – Geological and Geotechnical Core Logging, Photography, and Sampling;
- WP05 - Geophysical Logging and Interpretation; and
- WP07 – Opportunistic Groundwater Sampling.

The scientific objective was the collection of high quality and reliable test data to support the derivation of high-confidence hydraulic properties including:

- Hydraulic conductivity (transmissivity / thickness);
- Inferred hydraulic pressure in the rock;
- Test zone compressibility, comprising the rock within the isolated interval, water within the test zone and the test tool;
- Borehole skin factor; and
- Specific storage (storativity / thickness).

The procedures for the collection, analyses and reporting of the test data were developed by Golder and reviewed by the NWMO. These procedures for data collection are summarized in the following sections.

It should be noted that for the purpose of test analysis, the static formation pressure was estimated by extrapolation of the test interval pressure response.

2.3 Roles and Responsibilities

Testing was carried out by a team of testing specialists from Golder. Drill rig operation support was provided by Rodren Drilling Ltd., based in Winnipeg, Manitoba. Testing was carried out on a 24-hour, 7 days per week basis. Day shifts ran from 7 am to 7 pm, and night shifts from 7 pm to 7 am. A driller and helper were on site for each day and night shift, and a drilling foreman was typically present during the day shifts, or as required. Work was performed under direction and review from Golder's WP06 lead, Mike Lemon. Golder's WP06 lead communicated with the NWMO's WP06 lead, Alexander Blyth, regarding the development of the test plan and decisions during field testing based on preliminary test results.

3.0 TESTING EQUIPMENT

The equipment used for hydrogeological testing of borehole IG_BH02 consisted of a straddle packer tool with a 20 m long test interval, integrated downhole shut-in valve (DHSIV) for isolating the test interval from the test tubing to reduce wellbore storage, and real-time multi-zone pressure and temperature monitoring. Real-time pressure from test tubing, and above, between and below the packers was monitored at surface using DataCan pressure transducers mounted in a gauge carrier directly above the DHSIV. A separate pressure transducer with internal memory, manufactured by Pioneer Petrotech Services (PPS), was positioned within the interval to collect data for test analyses directly from the test interval. A list of equipment used downhole is provided in Table 1, and a list of equipment used at surface is provided in Table 2. Photos of the testing equipment are provided in Appendix A. Pressure transducers were calibrated following manufacturers' instructions, and calibration certificates are provided in Appendix B.

Table 1: List of Downhole Equipment

Item Name	Manufacturer and Model	Item Description
Packers x 2	Baski MD-2.7, Medium Duty, Sliding-Head Type	Inflatable packers for isolating test zone • Uninflated OD = 69 mm

Item Name	Manufacturer and Model	Item Description
		• Largest recommended hole size = 127 mm • Mandrel pipe size = 25 mm • Uninflated element length = 1016 mm • Max differential pressure rating (102 mm hole) = 5.5 MPa
Test Tubing within interval	Boart Longyear ARQTK tubing	ARQTK threaded pipe • OD = 44.7 mm • ID = 37.5 mm • Pipe Lengths = 1.5 m
Test Tubing above tool	AWIK Aluminum tubing	API threaded pipe with O-ring sealed joints • OD = 60.25mm • ID = 50 mm Pipe Length = 2.9 m
Multi-zone pressure transducers x 4	DataCan Multi-Gauge Piezo Bottom Pressure Gauge, Model 108931	Absolute pressure monitoring in test interval between packers, bottom zone below lower packer, annulus above upper packer and test tubing above DHSIV. • Max operating pressure rating = 41.37 MPa • Accuracy: Pressure = 0.022% FS Temperature = 0.25°C • Resolution: Pressure = 0.0003% FS Temperature = 0.005°C
Multi-zone pressure transducer protective casing	DataCan	Protective metal gauge carrier for Multi-Gauge real-time pressure transducers, installed in-line above the DHSIV
Interval pressure transducer	PPS25 pressure transducer	Absolute pressure monitoring in test interval for data analyses • Max operating pressure rating= 41.37 MPa • Accuracy: Pressure = 0.03% FS Temperature = 0.5°C • Resolution: Pressure = 0.0003% FS Temperature = 0.01°C
Submersible pump	Grundfos Redi-Flo2 (MP1)	Lowering water level in test tubing for slug and pulse withdrawal tests Outer diameter = 45.7 mm
Downhole Shut-in Valve (DHSIV)	IPI Downhole Shut-in Valve (DSHIV)	• Hydraulically actuated single line • OD = 70mm

Item Name	Manufacturer and Model	Item Description
		• Zero-volume displacement • 100% sealing ball valve • Pressure rating up to 68.9 MPa
In-line adapter (ILA)	Baski, 69 mm OD	Steel adapter to feed all lines from outside of the packer string through the packer
Flatpack	Baski	Santoprene encased integrated pressure and electric cable line system • 0.0343 x 0.00104 x 1500 m • Motorized metal spool 2 m diameter, 1 m wide • 1800 kg weight • 1x 6.35 mm OD x 0.71 mm wall tubing encapsulated single conductor cable • 3x 6.35 mm OD x 0.89 mm wall Duplex 2205 stainless steel
Pressure transducer for wellbore storage estimation	Solinst 3001 LT Barologger, M1.5	Lowered inside test tubing during the opening of the DHSIV to measure the volume displacement to estimate the test zone compressibility and wellbore storage • Max operating pressure rating= 14.71 kPa • Accuracy: Pressure = 0.05 kPa Temperature = 0.05°C • Resolution: Pressure = 0.002% FS Temperature = 0.003°C

Table 2: List of Surface Equipment

Item Name	Manufacturer and Model	Item Description
Inflation Pressure Vessel	Misc.	20-liter capacity with 8.0 MPa pressure rating, filled with water and pressurized using nitrogen to inflate packers.
Packer Inflation manifold and inflation lines	Misc.	Manifold to operate packer inflation, 8.0 MPa pressure rating
Nitrogen pressure regulator	Omega	Pressure regulator for controlling pressure outflow from nitrogen cylinder used for packer inflation.

Item Name	Manufacturer and Model	Item Description
Nitrogen cylinders	Praxair Canada Inc., Dryden, Ontario	Compressed nitrogen gas cylinder for packer inflation and activation of shut-in tool by pressurizing the inflation pressure vessel.
DHSIV Activation Pump	CVS Controls Ltd.	Manual high-pressure pump for DHSIV operation. Maximum Injection Pressure = 20.68 MPa
Barometric pressure transducer	Solinst 3001 LT Barologger, M1.5	Barometric pressure monitoring for correcting absolute pressure downhole gauges • Max operating pressure rating= 14.71 kPa • Accuracy: Pressure = 0.05 kPa Temperature = 0.05°C • Resolution: Pressure = 0.002% FS Temperature = 0.003°C
Master pressure gauge	Omega DPG4000-2K	Digital pressure gauge for field calibration check of pressure transducers and monitoring packer inflation pressure • Max pressure = 13.79 MPa • Accuracy = ±0.05%
Data Acquisition System	DataCan Surface Box, 105421	Data logger with real-time communication, collection and storing of downhole and surface sensor data 20M sample capacity, USB set-up/ download

3.1 Packer Inflation

Water was used for packer inflation instead of gas to reduce the compressibility of the packers and the inflation lines which contribute to the test interval compressibility. A surface pressure vessel filled with water was pressurized using compressed nitrogen to achieve the desired packer inflation pressure.

Packer inflation pressure is calculated following the manufacturer's recommendations and recorded in the Field Data tab of the Data Quality Confirmation workbook. The inflation pressure at surface was set at 2.05 MPa, which is the summation of several criteria:

a) *Hydrostatic Pressure* – Pressure exerted on the external surface of the packers. When inflating packers with water, the external pressure on the packer is balanced by the equivalent internal hydrostatic pressure in the inflation line resulting in an assumed net pressure of zero.

b) *Packer stretch (or packer seating pressure)* – Pressure required to expand and seat the packer to the borehole wall. This pressure is dependent on the borehole diameter and provided in the manufacturer's user manual (equals 0.7 MPa for HQ borehole).

c) *Test Differential Pressure (or packer sealing pressure)* – Packer pressure required to prevent leakage across the packer when maximum differential pressure is exerted at the test interval during the test execution. A maximum test pressure of 1.0 MPa was applied for the inflation pressure calculation as the maximum test differential pressure was limited to 0.83 MPa due to the maximum lift capacity of the pump; however, the target minimum differential pressure as defined in the Test Plan was 100 kPa.

d) *Factor of Safety* – Extra applied pressure to ensure the required packer inflation pressure is maintained through the entire test. The factor of safety accounts for any slow leakage in the system, temperature variations at surface, and fluid density variation between the water within the inflation system and the borehole fluid. A factor of safety of 0.35 MPa was applied for all tests.

The required packer inflation pressure is first set at the nitrogen cylinder using the pressure regulator. This pressure is then transferred to the packer inflation manifold, where a more precise adjustment of the required inflation pressure can be achieved using an Omega analog pressure gauge. The pressure from the packer inflation manifold is then diverted to the pressure vessel where it pressurizes the water within, forcing it into the packer inflation line in the flatpack to inflate the packers. The two packers were inflated using two separate inflation lines allowing for individual inflating and deflating of the packers.

3.2 Data Acquisition

In order to collect accurate pressure and temperature data, the following instruments were used:

- **Real-time Multi-zone Downhole Pressure Measurements –** downhole pressure was monitored from four individual zones using transducers manufactured by DataCan, Model 108931. Pressure readings were communicated in real-time to the surface via dedicated cable in the flatpack. Data were recorded with a DataCan surface readout box connected to a field laptop via USB. The real-time pressure readings were used to monitor the test progress, verify packer seal of the test zone and allow for estimation of preliminary transmissivity values during testing. The DataCan transducers were housed within a protective carrier mounted above the DHSIV as shown in Figure 3. The zones monitored during testing include:
  - Test interval between the packers;
  - Open borehole below the lower packer to confirm adequate seal at the bottom of the test interval;
  - Annular space above the upper packer between the test tubing and borehole wall to confirm adequate seal at the top of the test interval; and
  - Test tubing above the DHSIV to measure the magnitude of the induced slug or pulse.
- **Test Interval Pressure Data (for analyses) –**pressure and temperature data were obtained directly from the test interval with a single pressure transducer manufactured by Pioneer Petrotech Services Inc. (PPS), Model PPS25. The PPS transducer is self-contained with integrated internal memory and battery. The transducer was positioned inside a perforated pipe below the upper packer and the recorded pressures from this transducer were used for the final test analyses since it provided a complete borehole pressure history from the start of testing.
- **Packer Pressure -** Packer pressures were monitored at surface with a digital pressure gauge (Omega DPG4000-2K) connected to the packer inflation vessel. Packer pressures were monitored during the testing to ensure no leakage in the packer inflation system occurred. Packer pressures at the start and end of each

test were recorded in Field Data tab of the Data Quality Confirmation (DQC) workbook included in the electronic deliverable under separate cover.

- **Barometric Pressure** – Barometric pressure trends were recorded at the drill rig during testing using a Solinst 3001 LT Barologger, M1.5. Barometric pressure and air temperature were recorded every minute for barometric pressure correction of the downhole absolute pressure transducers. Barometric pressure was used to compensate the downhole transducer pressures by subtracting the barometric pressure from the downhole transducer absolute pressure reading to provide gauge pressure at depth. The range of barometric pressure recorded over the length of each test was included in the Field Data tab of the DQC workbook.

All electronic instruments were calibrated prior to arrival on site following the manufacturer's instructions. Calibration checks are recorded in the Tool Assembly tab of the DQC workbook. Calibration certificates are provided in Appendix B.

Figure 3: DataCan Gauge Carrier and Transducers with Outer Protective Casing Removed

3.3 Tool Assembly

The tool configuration as shown in Figure 4 was used for all tests.

Due to its length, the testing tool was mobilized in modules and assembled on site from bottom-up as it was lowered into the borehole. The tool assemble sequence was as follows:

- The bottom packer was threaded to the AQTK interval test tubing which was threaded to the perforated transducer carrier.
- The pre-programmed, battery powered, interval pressure transducer (PPS25) with internal memory was threaded inside the transducer carrier. The recording frequency was set to 5 second intervals allowing for several weeks of data recording and storage.
- The perforated transducer carrier was threaded to the bottom of the top packer with the DHSIV positioned above the upper packer.
- The DataCan multi-zone pressure transducer protective casing is positioned above the DHSIV.

Prior to lowering the tool down the borehole, the packers and the inflation lines were filled with water to reduce the volume of air trapped in the system.

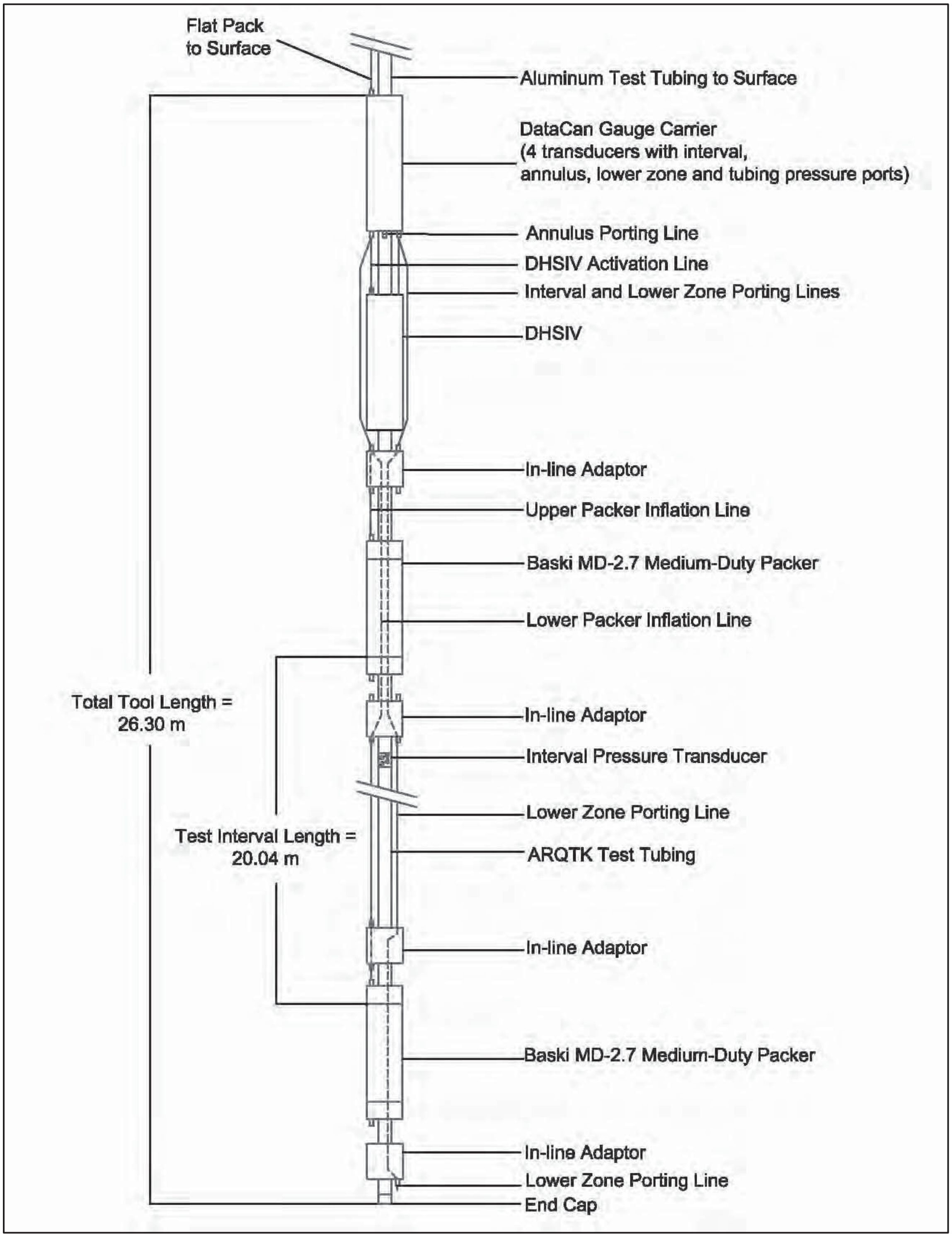

Figure 4: Tool Schematic

The end of the flatpack was positioned directly above the multi-zone pressure transducer carrier and the three stainless steel lines in the flatpack were connected to the upper packer, the lower packer, and the DHSIV. The electrical cable was connected to the common lead (cable head) from the pressure transducers.

Aluminum test tubing was used to lower the tool to the selected test depths and the flatpack was secured to the outside of the test tubing with duct tape. The joints of the test tubing were sealed with a rubber O-ring and tightened using pipe wrenches. Leakage less than the measured magnitude of the interval transmissivity was observed during testing with no impact on the pulse test results because the fluid in the tubing is isolated from the test interval by the closed DHSIV. Test tubing leakage is discussed further in Sections 3.4 and 6.2.

At surface, the pressure required to inflate the packers was supplied from a compressed nitrogen gas cylinder. A high-pressure regulator was directly attached to the cylinder to control the inlet pressure and flow to the packer inflation manifold. The packer inflation manifold was used to inflate packers by pressurizing the water-filled inflation pressure vessel. A manual high-pressure pump was used to operate the DHSIV (Figure 5).

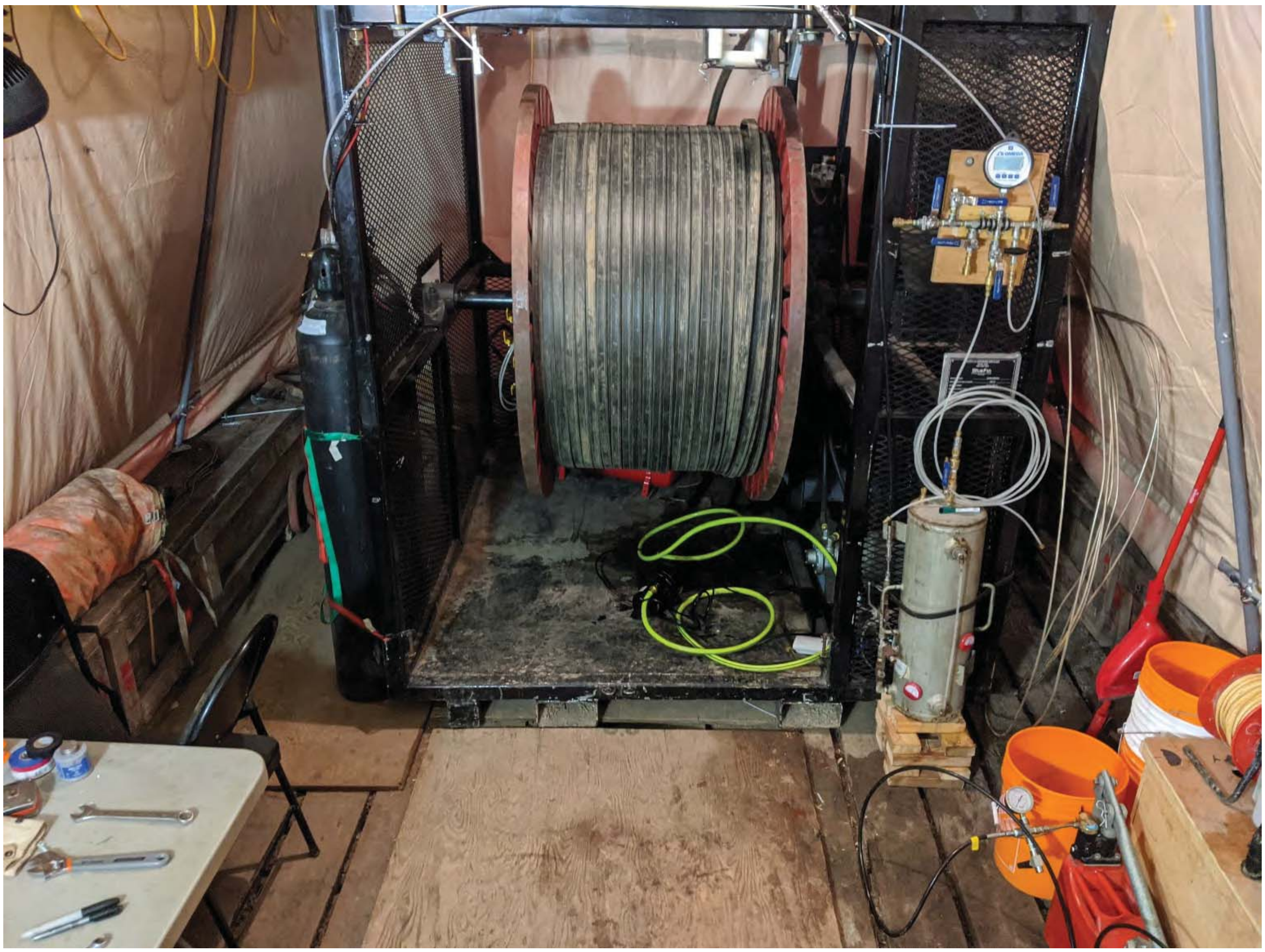

Figure 5: Heated tent with flatpack (packer inflation manifold with pressure gauge on the upper right, packer inflation pressure vessel at lower right, red DHSIV activation pump at lower right)

3.4 Tool Operation Checks

Quality assurance (QA) testing of the tool operation was performed on the packer inflation lines and DHSIV activation line inside the surface casing to check for leaks in the system. Data from the quality assurance testing is documented in the DQC workbook.

Three QA tests (Leak Tests) were performed inside the surface casing. Leak tests were performed at the start of testing prior to test HT001, prior to test HT002, and at the end of the testing program. The leak tests measure the leakage of the testing system at the maximum anticipated test differential pressures and allow for the estimation of an equivalent transmissivity of the cased interval to confirm the testing tool met the project's requirement of accurately measuring test interval hydraulic conductivity down to 1E-12 m/sec.

The leak tests performed are summarized in the following subsections. Details on each test are provided in the DQC workbook.

3.4.1 Leak Test #1 – Start of Testing Prior to Test HT001

Leak Test #1 was performed on December 12, 2019 at the start of testing prior to test HT001. The pressure data collected during the test are presented in Figure 6. The testing tool with a test interval length of 20.05 m was lowered into the surface casing below the water level. The packers were inflated to 2.44 MPa surface pressure (20% above the anticipated inflation pressure during testing) and monitored for leakage. No leakage was observed from the testing system. With the packers inflated, the DHSIV was closed to simulate the PSR phase and the water level in the test tubing was lowered by 0.27 MPa in preparation for a slug withdrawal (SW) phase. No hydraulic connection was observed between the annulus, tubing and test interval. The DHSIV was then opened introducing the pressure change to the test interval, and the interval pressure was monitored for 30 minutes. Following the SW phase, the DHSIV was closed for 30 minutes for a shut-in recovery phase (SWS) with no observable hydraulic connection above and below the test interval.

With the DHSIV open, transmissivity of 6E-10 m^2/sec and an equivalent hydraulic conductivity of 3E-11 m/sec for the 20.05 m test interval length was derived for the testing tool from the slug withdrawal phase (SW) data. These values can be considered the lower limit of the testing tool for the slug test at HT001. The analyses of the data from shut-in recovery phase (SWS) resulted in a transmissivity of 3E-12 m^2/sec or an equivalent hydraulic conductivity of 1E-13 m/sec for the 20.05 m test interval length. The Leak Test #1 confirmed the tool performance met the project's requirement of accurately measuring test interval hydraulic conductivity down to 1E-12 m/sec.

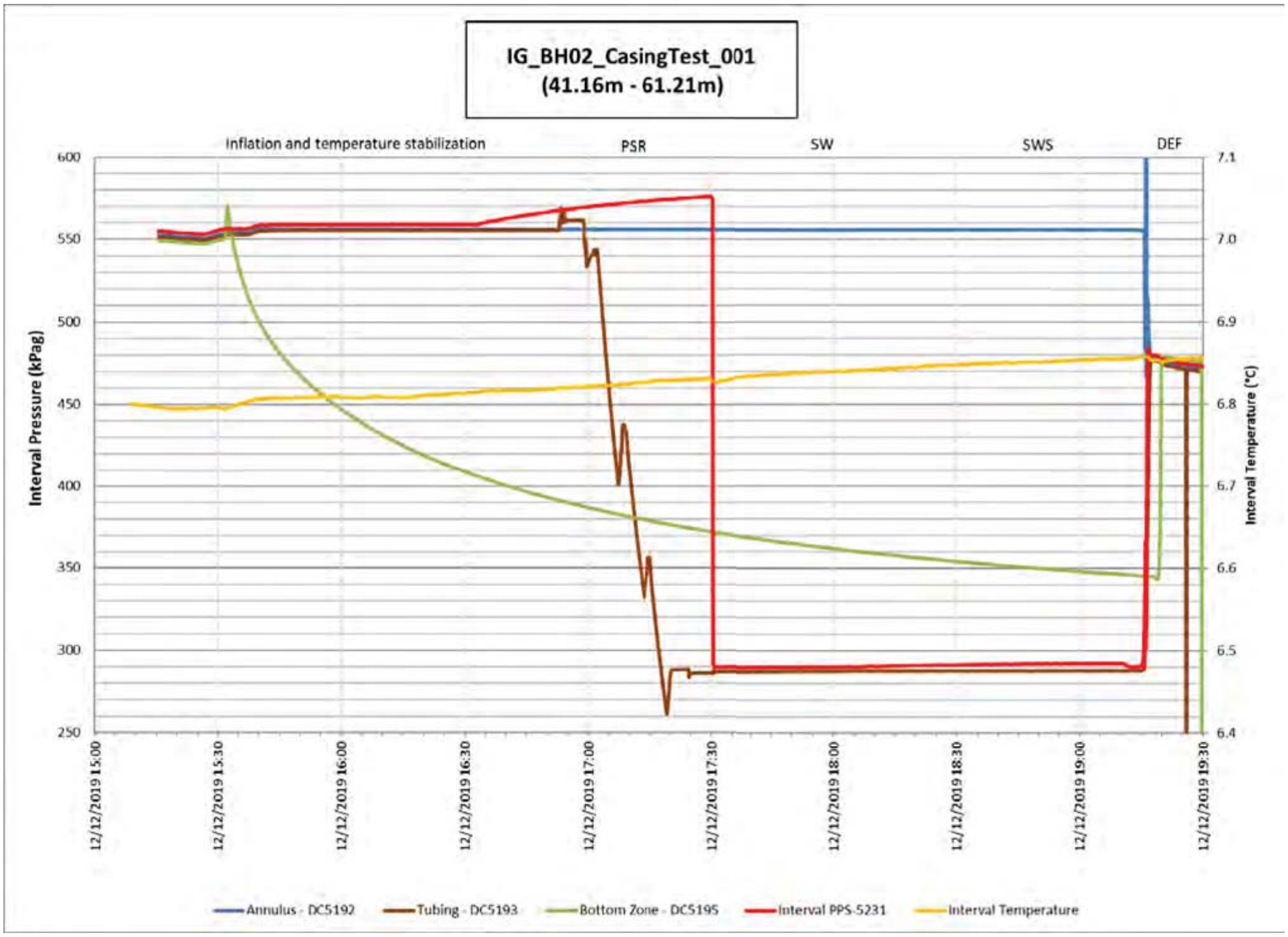

Figure 6: Leak Test #1 Pressure Plot

3.4.2 Leak Test #2 – Start of Testing Prior to Test HT002

Leak Test #2 was performed on January 4, 2020 after a break in testing prior to test HT002. The pressure data collected during the test are presented in Figure 7. The testing tool with a test interval length of 20.05 m was lowered into the surface casing below the water level. The packers were inflated to 2.48 MPa surface pressure (20% above the anticipated inflation pressure during testing) and monitored for leakage. No leakage was observed from the testing system. With the packers inflated, the DHSIV was closed to simulate the PSR phase and the water level in the test tubing was lowered by 0.298 MPa in preparation for a slug withdraw (SW) phase. No hydraulic connection was observed between the annulus, tubing and test interval. The DHSIV was then opened introducing the pressure change to the test interval and the interval pressure was monitored for 30 minutes. Following the SW phase, the DHSIV was closed for 30 minutes for a shut-in recovery phase (SWS) with no observable hydraulic connection above and below the test interval.

With the DHSIV open, transmissivity of 3E-9 m^2/sec and an equivalent hydraulic conductivity of 1E-10 m/sec for the 20.05 m test interval length was derived for the testing tool from the slug withdrawal phase (SW) data. These values can be considered the lower limit of the testing tool for slug tests with the DHSIV open. The analyses of the data from shut-in recovery phase (SWS) resulted in a transmissivity of 2E-12 m^2/sec or an equivalent hydraulic conductivity of 1E-13 m/sec for the 20.05 m test interval length. The Leak Test #2 confirmed the tool performance met the project's requirement of accurately measuring test interval hydraulic conductivity down to 1E-12 m/sec.

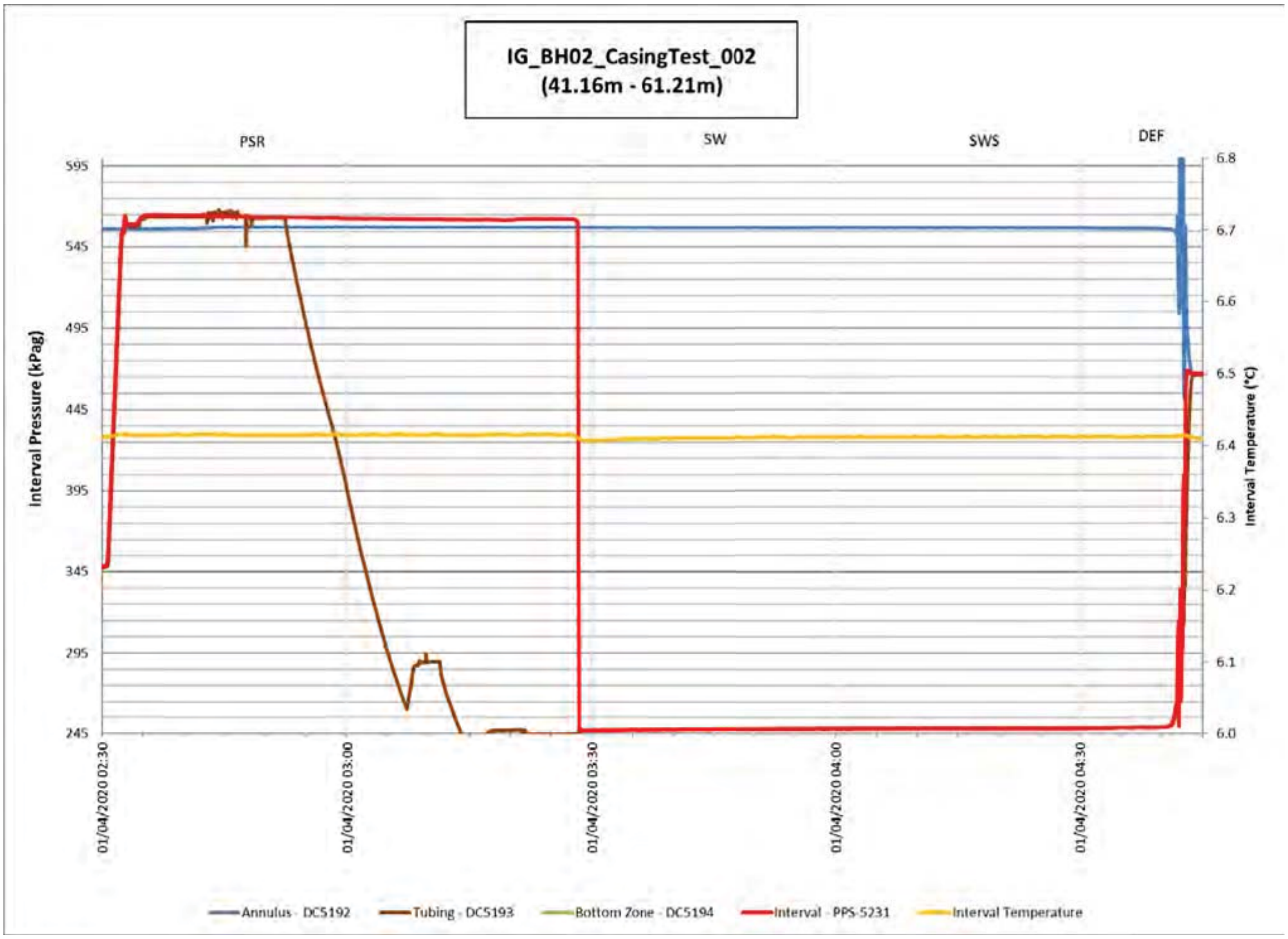

Figure 7: Leak Test #2 Pressure Plot

3.4.3 Leak Test #3 – End of Testing after Test HT020

Leak Test #3 was performed on January 21, 2020 after the completion of test HT020. The pressure data collected during the test are presented in Figure 8. The testing tool with a test interval length of 20.05 m was pulled into the surface casing below the water level. The packers were inflated to 2.44 MPa surface pressure (20% above the anticipated inflation pressure during testing) and monitored for leakage. No leakage was observed from the testing system. With the packers inflated, the DHSIV was closed to simulate the PSR phase and the water level in the test tubing was lowered by 0.266 MPa in preparation for a slug withdrawal (SW) phase. No hydraulic connection was observed between the annulus, tubing and test interval. The DHSIV was then opened introducing the pressure change to the test interval, and the interval pressure was monitored for 30 minutes. Following the SW phase, the DHSIV was closed for 30 minutes for a shut-in recovery phase (SWS) with no observable hydraulic connection above and below the test interval.

With the DHSIV open, transmissivity of 2E-10 m^2/sec and an equivalent hydraulic conductivity of 1E-11 m/sec for the 20.05 m test interval length was derived for the testing tool from the slug withdrawal phase (SW) data. The analyses of the data from shut-in recovery phase (SWS) resulted in a transmissivity of 4E-12 m^2/sec or an equivalent hydraulic conductivity of 2E-13 m/sec for the 20.05 m test interval length. The Leak Test #3 confirmed the tool performance met the project's requirement of accurately measuring test interval hydraulic conductivity down to 1E-12 m/sec.

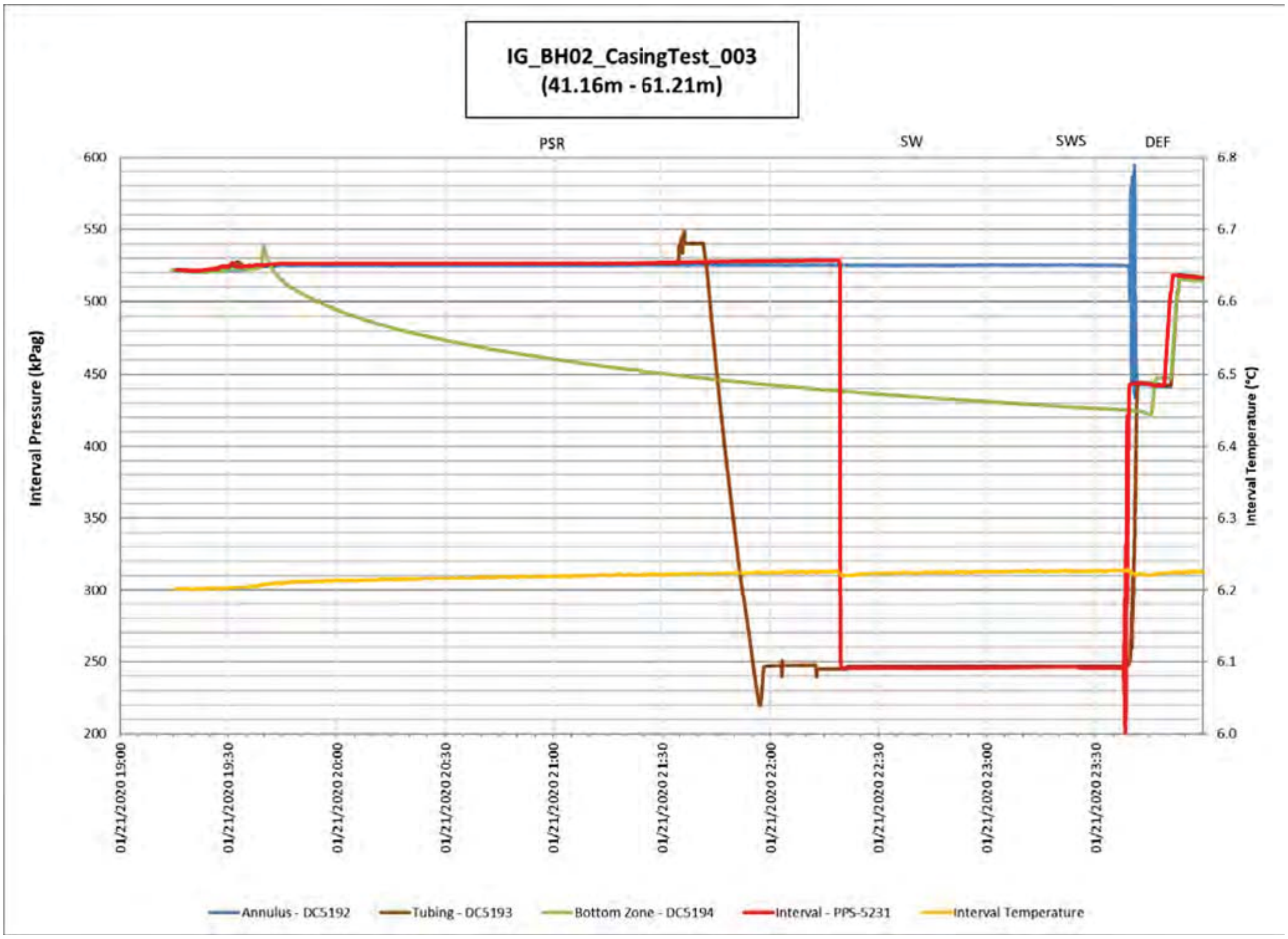

Figure 8: Leak Test #3 Pressure Plot

4.0 TEST INTERVAL SELECTION

The selection of test intervals was determined in a collaborative workshop with NWMO and Golder technical leads based on the findings from drilling, core logging, and geophysical logging. The objectives for test interval selection consisted of:

1) Confirm low rock mass hydraulic conductivity in a potential repository depths (500 m – 700 m depth) and directly above the repository depths (400 m – 500 m);

2) Determine hydraulic conductivity of identified high fracture frequency intervals within and in proximity to potential repository depths; and

3) Assess rock mass hydraulic conductivity of shallow (<200 m) bedrock.

The final selection of the test intervals considered the following criteria:

- **Acceptable packer element placement**. Position of the packer element in the borehole was governed by the borehole condition. Geophysical caliper logs (WP05) were reviewed to confirm the borehole had a consistent diameter (no washouts) to ensure the differential pressure rating of the packers would apply. Acoustic televiewer imagery (WP05) and core photos (WP03) were reviewed to ensure the packers were seated in sections of the borehole free of fractures to ensure no packer bypass.
- **Location of hydrogeologic features.** The presence of broken joints, zones of increased porosity or weathering can influence the hydraulic response of the rock mass. Any identified features were incorporated into the decision on test interval selection to ensure that variably fractured intervals were tested to assess the range of hydraulic conductivities within the borehole. Flow logging was performed under static (non-pumping) and dynamic (pumping) conditions to identify the potentially water conductive fractures. The selection of potentially water conductive fractures was carried out during Drilling and Coring (WP02), Geological and Geotechnical Core Logging, Photography and Sampling (WP03), Opportunistic Groundwater Sampling (WP07), and Fluid Temperature and Resistivity Log and Flowing Fluid Electrical Conductivity Log (WP05).

Observations from these data are summarized in the Cover Page of the DQC workbook.

A total of twenty (20) intervals were identified based on the testing objectives and the test interval selection criteria. The intervals were tested in sequence as the tool was being lowered downhole, with the exception of tests HT001 which was intended to target a likely low hydraulically conductive interval for the first test to confirm the tool performance. The remaining testing sequence was selected to limit the amount of time moving the tool between tests. This sequence of testing is reflected in the test identification numbers (HT001, HT002, HT003, etc.). The testing was carried out from December 12, 2019 through January 22, 2020, with a stoppage in testing from December 23, 2019 until January 2, 2020.

5.0 TESTING METHODOLOGY

The planned hydraulic testing methodology is illustrated in Figure 9. However, due to the overall low to very low hydraulic conductivity of the selected test intervals in borehole IG_BH02, only pulse and slug type tests were carried out at this location. The individual test sequences are described in detail in the following sections. A legend of abbreviations used for the test presentation and analysis is shown in Appendix D.

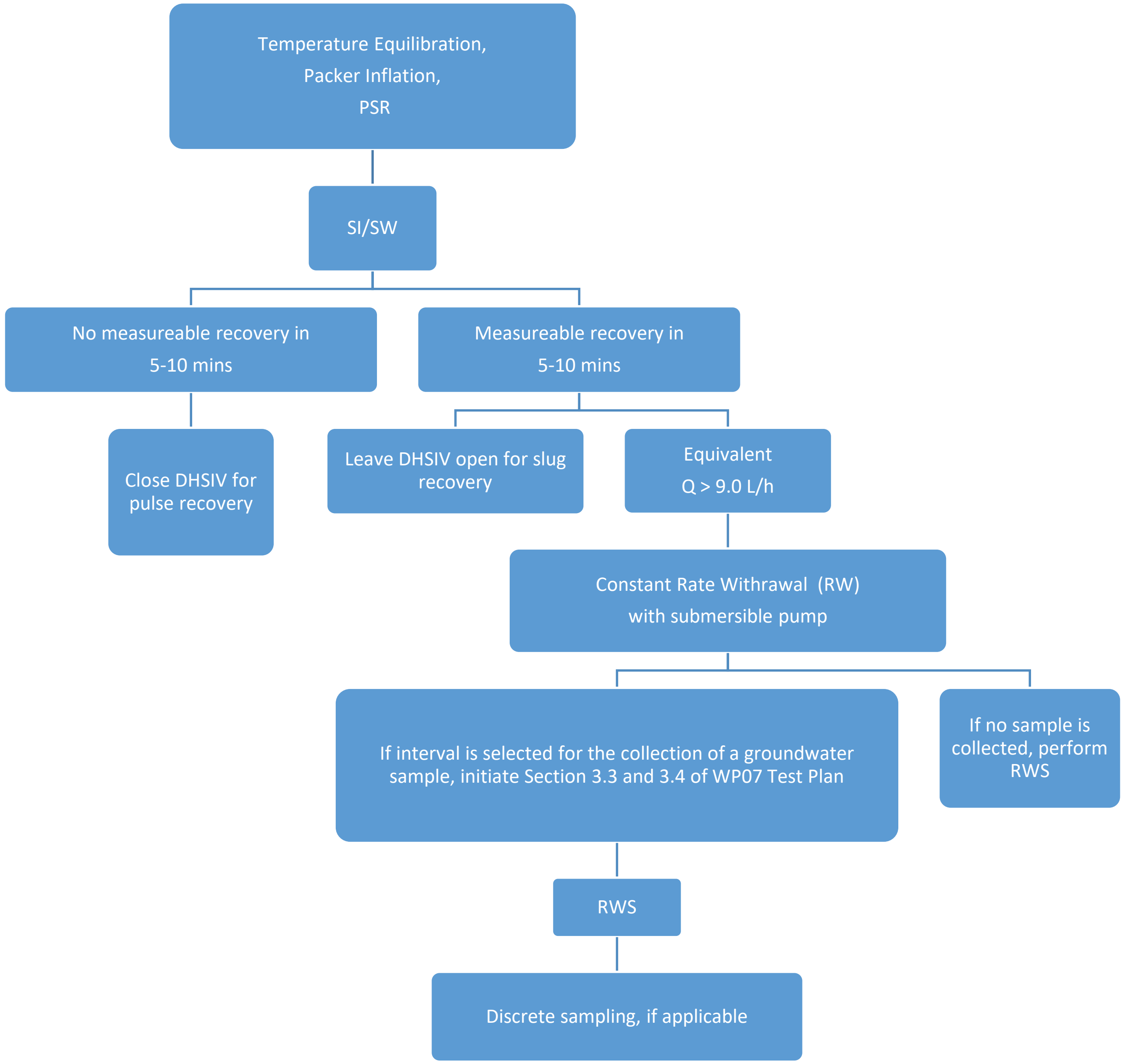

Figure 9: IG_BH02 WP06 Test Plan Flow Chart

A typical procedure for a pulse test is demonstrated in Test HT012 shown in Figure 10. The test included a PSR phase, pulse withdrawal phase, and recovery phase. The hydraulic isolation of the test interval is demonstrated by the different pressure responses from the borehole annulus (blue), tubing (brown), bottom zone (green), and test interval (red and orange). The figure also shows a relative stabilization in the interval temperature that occurs prior to the initiation of the pulse.

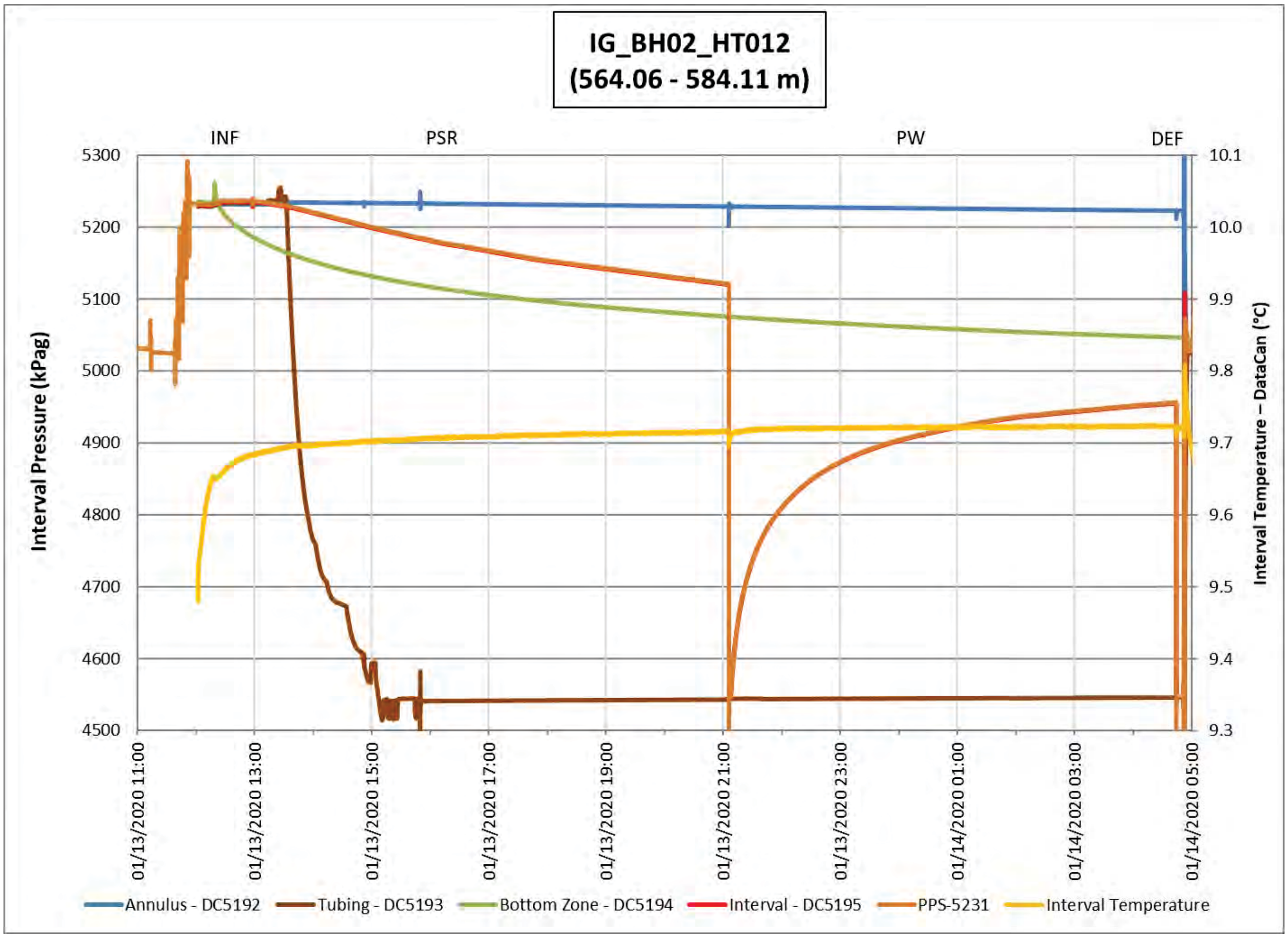

Figure 10: Typical Pulse Test Procedure, IG_BH02_HT012

Packer Inflation

The required packer inflation pressure was first set at the nitrogen cylinder using a pressure regulator. This pressure was then directed through the packer inflation manifold to the pressure vessel that pressurized the water within the flatpack inflation lines and the packers. The packer inflation pressure was monitored at the pressure vessel with a digital pressure gauge. The nitrogen pressure was applied to the pressure vessel until the water level in the vessel remained stable, indicating the packers have inflated to their full size against the borehole wall. The typical duration of the packer inflation was approximately 40 minutes.

After the packers were inflated, the packer seals were confirmed by monitoring the real-time pressure responses in the bottom zone below the lower packer and the borehole annulus above the upper packer (see zone pressure responses during the INF phase in Figure 10). If the expected pressure responses were not discernable, several litres (i.e., enough to raise the water column at least one meter) of drilling supply water were poured between the surface casing and the test tubing while monitoring the interval transducer for any change in pressure. The interval temperature was monitored until it stabilized before initiating the pressure static recovery phase. The packer pressure (start and end of test) was recorded in the Field Data tab in the DQC workbook.

Pressure Static Recovery (PSR) Phase

The PSR phase is intended to assess the initial pressure within the test interval prior to testing. After the packers were inflated at the selected depth interval, the PSR phase was initiated by closing the DHSIV. The DHSIV pressure is adjusted and controlled manually using a 4-litre water-filled pressure tank, and from there diverted to the DHSIV via the flatpack.

Closing and opening the DHSIV was completed within a relatively short period of time (a few seconds). The PSR phase was initiated by closing the DHSIV effectively separating the hydrostatic pressure within the test section from the rest of the test tubing while the pressure in the test interval starts equilibrating. The PSR phase was monitored in real-time by the interval transducer and continued until the rate of pressure change stabilized relative to the transducer resolution or could be extrapolated with confidence by examining the semi-log Horner plot in Golder's analysis software HydroBench. The semi-log Horner plot for test HT002 is shown below as an example.

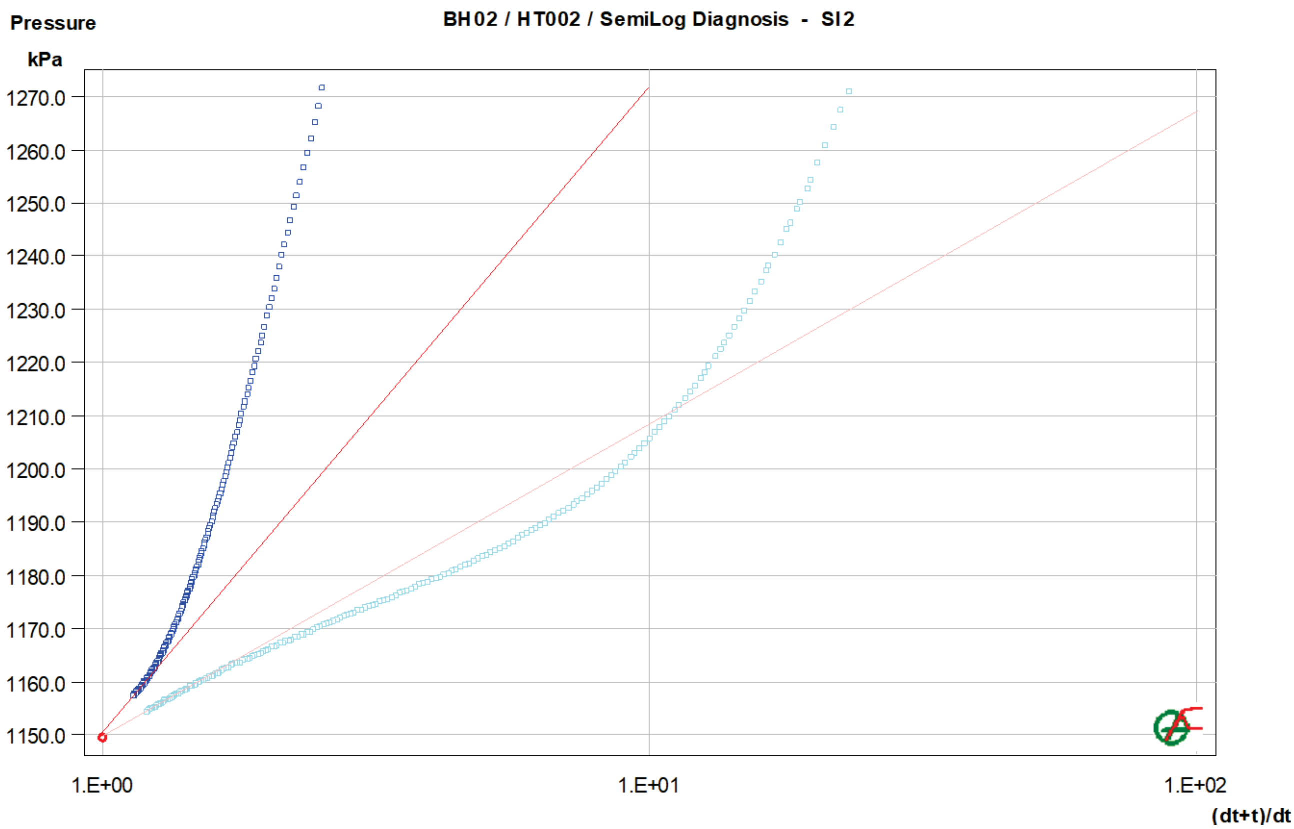

Figure 11: Semi-log Plot of IG_BH02_HT002 analyses showing the pressure recoveries of the PSR (light blue) and SIS (dark blue curve) phases

The PSR phase details including start time, end time, and stabilized pressure were recorded in the Field Data tab of the DQC workbook. In addition to assessing the initial test interval pressure prior to testing, the PSR Phase served to dissipate a portion of the borehole pressure and temperature history effects to minimize their influence on the derivation of hydraulic parameters for the test interval.

Creating Test Differential Pressure

Because the water level within the test tubing was typically within 20 m of the ground surface, the differential pressure for each test was created by withdrawing water from the test tubing with the exception of tests HT001 and HT002. For tests HT001 and HT002, the water level in the test interval was approximately 20 meters below ground surface and to create the pressure differential the water level was raised by adding water to the test tubing with the DHSIV closed.

For the other tests, the water column was lowered using a submersible Grundfos Redi-Flo 2 pump with the DHSIV closed. Pressure differentials achieved for the tests ranged from approximately 0.219 MPa to 0.766 MPa, due to the maximum lifting capacity of the submersible pump (0.83 MPa). After removing water from the test tubing the submersible pump was removed prior to starting the next test phase. The DHSIV was then opened, introducing the pressure change to the test interval. The interval pressure was monitored for a short period of time (typically <5 minutes) to assess the relative magnitude of the interval transmissivity before deciding whether to close the DHSIV to begin the pulse recovery phase (PW) in very low conductivity intervals or to leave the DHSIV open to continue the slug withdrawal recovery phase (SW) for low conductivity intervals.

Test Pressure Recovery for Very Low Conductivity Test Intervals

For 13 out of 20 test intervals with very low transmissivity (i.e., < 1E-09 m^2/s) resulting in minimal recovery within 5 minutes, the test interval was shut-in by closing the DHSIV for the PW. The interval pressure recovery was monitored in real-time with the interval pressure transducer and assessed in the field using Golder’s analysis software HydroBench. This field assessment of real-time data was used to determine the duration of the PW to ensure a high level of confidence has been achieved for the derived formation parameters prior to terminating each interval test.

Test Pressure Recovery for Low Conductivity Test Intervals

Seven test intervals (HT002, HT004, HT010, HT013, HT014, HT015, and HT016) had sufficient transmissivity to observe a measured pressure recovery during a slug phase with the DHSIV open. The length of the slug recovery phase depended on formation transmissivity.

The interval pressure recovery was monitored in real-time with the interval pressure transducer and assessed in the field using Golder’s analysis software HydroBench. This field assessment of real-time data was used to determine the duration of the interval pressure recovery phases (SW or SWS) to ensure a high level of confidence has been achieved for the derived formation parameters prior to terminating each interval test.

Packer Deflation

At the termination of each test, the packers were deflated by releasing the nitrogen pressure from the pressure vessel. The pressures in the bottom, interval, and annulus zones were monitored in real-time for pressure equilibration to confirm the packers had unseated from the borehole wall, and the level of water in the pressure vessel was monitored to determine when the packers had fully deflated.

6.0 TEST ANALYSIS

In fractured crystalline rock settings, it is expected that the rock mass would have low bulk hydraulic conductivity, and main contribution to hydraulic conductivity and total porosity comes from localized conductive fractures. Under these conditions, the volume of rock actually influenced during a borehole hydraulic test can be quite limited. For relatively short duration test that were completed for this program, it is expected that near borehole conditions dominate the test response with only limited transition to the undisturbed formation response further away from the borehole. Two flow models were commonly applied to try matching the test interval pressure responses:

- Wellbore storage with a homogeneous formation model
- Wellbore storage with composite flow model (i.e., a two-zone model)

For the composite flow model, only transitional data to the undisturbed formation response (i.e., radial flow regime on log-log plot) was observed during the test because it would require unrealistic test duration to reach the undisturbed formation response. In most cases, the approach was to apply wellbore storage with a composite flow model as test response was dominated by transition between near wellbore effects and undisturbed formation response. Wellbore storage is discussed further in Section 6.1.2.

The analysis approach follows a systematic, hierarchical workflow to minimize uncertainty:

- Test is performed to minimize factors that increase uncertainty such as borehole history and temperature effects.
- Select input parameters.
- Input borehole pressure history.
- Review data in transmissivity normalized plots for consistency between phases and for order of magnitude transmissivity.
- The flow model is selected based on the shapes and slopes of the semi-log derivative of the interval pressure response in log-log plots, geologic setting, and experience at other sites in similar hydrogeologic settings.
- Parameters are derived by matching on the log-log plot to both the pressure change and semi-log pressure derivative knowing, for example, that transmissivity is derived from the pressure match to the derivative data radial flow period or to the extrapolated radial flow period. This is achieved by manually setting the flow dimension in HydroBench to 2D (radial flow) and fitting to transmissivity. Distances to composite flow boundary are derived from time match to transitional data from upward deflection of the derivative data from the near well or inner zone radial flow period to the outer zone radial flow period and are dependent on the assumed storativity. This distance is reported as a radius of the inner shell of a composite model.
- The match to parameters is optimized by iterating between log-log match to a single phase and match on the entire simulation plot.

The input parameters applied to the test analysis have different degrees of uncertainty that impact the uncertainty of the transmissivity estimates from the test analyses. This robust and hierarchal workflow progressing from field performance to optimizing estimated parameters constrains and minimizes the uncertainty.

Input parameters used for each test analysis are listed in Appendix C. Some parameters are measured while others rely on assumptions to be estimated. The parameters are defined in the following subsections.

6.1 Input Parameters

6.1.1 Borehole Pressure History

Borehole pressure history effects are pressure transients in the formation caused by drilling activities, geophysical logging, and previous WP06 testing activities carried out in the borehole prior to the start of the test. Test intervals with low transmissivity compound the effects of borehole pressure history with pressure transients superimposed on the test data. These transients are difficult to represent accurately in the analysis due to the long and complicated borehole fluid history, introducing uncertainty into the estimation of the initial formation pressure.

HydroBench software incorporates borehole pressure history in the analyses by allowing the user to sequence periods of various induced pressures by pumping or injection prior to the start of the test and including these periods in the simulation matches.

Due to the inherent uncertainties of a complex borehole pressure history, a simplified borehole pressure history was applied to each test that consisted of a single constant head phase over a defined historical period. The constant head was estimated at ground surface elevation to account for periods of borehole flushing and lowering tools downhole. The duration of borehole pressure history was defined as the elapsed time from when the drilling of the borehole reached the mid-point depth of each test interval until the start of each respective test. The uncertainties in the representation of the borehole pressure history in the analysis are most sensitive to the estimation of the initial formation pressure.

6.1.2 Wellbore Storage

Wellbore storage is the response of the test zone to the change in pressure as a result of the compressibility of the fluid in the system (test interval + test tubing), the packer tool, and the rock formation within the interval. For test interval sections of low hydraulic conductivity, the phase of the pressure response dominated by wellbore storage can mask the pressure response of the rock. Wellbore storage is identified with an early unit slope of the pressure change derivative plotted on the log-log plot. HydroBench produces this graph for assessing the wellbore storage phase during testing.

Wellbore storage is a sensitive parameter in the estimation of hydraulic parameters in low transmissivity rock. There are two types; open tubing wellbore storage where the fluid level is changing in the tubing with the DHSIV open, and shut-in wellbore storage where pressure is recovering within the test interval with the DHSIV closed. For slug tests, the open tubing wellbore storage coefficient is determined by the test tubing radius where the fluid column change is measured.

For pulse tests, the shut-in wellbore storage coefficient is determined by the total test zone compressibility. Typically, multiple methods are used to estimate total test zone compressibility for corroboration. The test zone compressibility can be estimated based on literature values, measured during the test, estimated from wellbore storage matching if there is a constant rate phase, or derived from wellbore storage normalization between a constant rate, shut-in phase with a pulse phase.

Open Tubing Wellbore Storage

For slug tests, wellbore storage C (m^3/Pa) is calculated by the equation below

$$C(DHSIV\ open) = \frac{\pi * r_u^2}{\rho * g}$$

where:

- r_u is the equivalent test tubing radius = SQRT((tubing radius)^2/sin(borehole inclination)) = 0.0258 m
  - where tubing radius = 0.025 m and borehole inclination = 70 degrees
- ρ is the density of water at 10°C = 999.7 kg/m^3
- g is the earth gravity acceleration = 9.81 m/s^2

Applying these values, C (SI open) = 2E-07 m^3/Pa, which was applied for all slug test analyses.

Shut-in Wellbore Storage

For test phases where the DHSIV is closed, C (m^3/Pa) is determined by the change in volume required to produce the corresponding change in pressure for the pulse test, which is determined by the compressibility of the system (drill fluid column + interval rock matrix + packer tool). This compressibility is estimated during the pulse phase of the test by measuring the change in water level within the test tubing using a datalogger (Solinst Barologger). The datalogger was lowered into the test tubing from the surface after lowering the water level in the tubing in preparation for the pulse to measure the change in volume induced from the pulse activation then removed from the test tubing for the recovery phase.

Wellbore Storage was calculated using the following equation:

$$C\ (DHSIV\ closed) = \frac{(dP_{tubing}) * \pi * r_u^2}{\rho * g} * \frac{1}{(dP_{interval})}$$

where:

- ρ is the density of the fluid (kg/m^3)
- g is the earth gravity acceleration (m/s^2)
- r_u is the equivalent test tubing radius = SQRT((tubing radius)^2/sin(borehole inclination)) = 0.0258 m
- where tubing radius = 0.025 m and borehole inclination = 70 degrees
- dP_{tubing} is the change in pressure measured in the test tubing as a result of the pulse (Pa)
- $dP_{interval}$ is the change in pressure measured in the test interval as a result of the pulse (Pa)

The wellbore storage measurements ranged from 6E-11 m^3/Pa (HT009) to 4E-09 m^3/Pa (HT013).

Dividing the wellbore storage by the test interval volume, a total test zone compressibility ranged from of 4E-10 1/Pa (HT001 and HT009) to 3E-08 1/Pa (HT013) with an average value of 3E-09 1/Pa. Casing tests carried out for the Swiss National Cooperative for the Disposal of Radioactive Waste (NAGRA) report water and test tool compressibility values that typically approach 2E-09 1/Pa to 6E-10 1/Pa (Kennedy and Davidson 1989). Total test zone compressibility typically averages 2E-09 1/Pa (Ostrowski et al. 1992).

6.1.3 Skin Zone

Skin is a dimensionless term that is used to quantify the hydraulic properties of the rock around a borehole which may be enhanced by an increased fracturing caused by drilling or reduced by drilling debris and/or mud invasion. The skin magnitude correlates to the ratio of the change in permeability as a factor to the thickness of the skin relative to the borehole diameter. Diagnostic tools are used to identify the hydraulic properties (transmissivity and radial thickness) of the “skin zone” based on the shape and the slopes of the semi-log derivative of the specific drawdown on the log-log plot produced in HydroBench. A negative skin value corresponds to an increase in transmissivity within the skin zone. A positive skin value corresponds to a decrease in transmissivity within the skin zone. The effects of the skin are then separated from the portion of the data that is primarily influenced by the undisturbed rock properties. HydroBench applies skin thickness and magnitude as fitting parameters to the simulation match which influences the shape of the pressure derivative.

Skin was not applied in the analyses of tests as a separate parameter even though it may have been present which was accounted for by applying a composite flow model.

6.1.4 Storativity

Storativity is an input parameter in HydroBench, which is directly correlated with skin effect and cannot be uniquely determined from a single hole test. While storativity directly impacts skin, it has less of an impact on the determination of transmissivity.

Storativity is calculated using the following equation:

$$S = \rho * g * \emptyset * c_t * h$$

Where

- ρ is the density of water
- g is the acceleration of gravity
- $\emptyset$ is the formation effectivity porosity
- c_t is the total compressibility in 1/Pa
- h is the length of the test interval in m

Estimates of the formation compressibility and effective porosity can be applied to constrain the storativity parameter. Total porosity laboratory testing was completed on selected core samples as part of WP04 Core Testing and presented in detail in the WP04A Petrophysical Technical Report for borehole IG_BH01 (Golder, 2018a). Total porosity laboratory results ranged from 0.001 to 0.011 with an average value of 0.007. This average value of total porosity was applied as an approximation of the upper bound of the effective porosity.

Total compressibility is the compressibility of the formation on a pore volume basis plus the formation water based on the definition above. Total compressibility was assumed at 2E-09 1/Pa. Given these assumptions, a storativity of 3E-06 was applied for all tests.

6.2 Analyses

Analyses of packer test data were carried out with Golder’s internally developed software program HydroBench.

HydroBench is based on a numerical borehole simulator using an automated matching procedure (nonlinear regression algorithms) and allows the analyses of pulse, slug, and constant rate/pressure injection and recovery tests. Both homogeneous and composite flow models with flow geometry matching may be used to interpret the data and to infer the local connectivity of a fracture network if present. HydroBench also includes the derivative of pressure (i.e., rate of pressure change) with respect to the natural logarithm of time that has shown to significantly improve the diagnostic and quantitative analysis of slug tests and constant rate pumping tests. Transmissivity normalised plots are included in the software package that allow comparing different phases of a hydrogeological test by normalising the pressure response. The software also includes the deconvolution approach to analyze slug and pulse test data, which was used for the analyses of all tests in borehole IG_BH02.

The applied analysis produces the test interval transmissivity. Hydraulic conductivity is derived from transmissivity by applying the measured transmissivity over the length of the test interval contributing to that transmissivity. It was assumed for all tests that the test interval is homogeneous (i.e., the entire test interval contributes equally to the measured transmissivity). Hydraulic conductivity was calculated by dividing the measured transmissivity by the interval length.

In borehole IG_BH02, two test types were performed:

1) Pulse tests in all intervals except HT002.

2) Slug tests in seven intervals HT002, HT004, HT010, HT013, HT014, HT015, and HT016 (in addition to pulse test).

The basis for minimizing uncertainty and obtaining a ‘high confidence’ analysis result is a systematic workflow that starts with understanding the geology and experience with low permeability hydraulic response testing along with a test design to minimize non-ideal effects and progresses to analysis. Analysis starts with reviewing data on high resolution plots to assist in flow model selection and progresses to manual matching on log-log plots for single phases and checking both flow model and parameters based on a visual closeness of fit on the entire simulation match. If the match to both plots is unacceptable either the flow model is revisited and/or parameters are adjusted until an optimized match is obtained on the log-log plot. Typically, the analysis starts with manual fitting and may be finished with automated matching to optimize the match. The workflow includes high resolution tools within HydroBench to assist in flow model selection with built-in internal checks for adequacy of flow model and parameters (i.e., iterations between log-log analysis of individual phases to matching on entire simulation plot).

In low permeability settings, a composite model is often used to match the test response. The parameters derived from inner zone (near-well zone) are considered more representative of the zone disturbed by drilling and the generally lower transmissivity outer zone is considered more representative for the undisturbed formation parameters. Often the inner zone transmissivity is well constrained by flattening of the pressure derivative data indicating pseudo radial flow period. Pressure matching to this leveling off in the derivative data yields an estimate of inner zone transmissivity; however, the derivative for the outer zone typically does not level off, and only transitional data or upward slope in the pressure derivative data is observed. As a result, the trend in the upward slope is extrapolated to the assumed radial flow period to derive the outer zone transmissivity that will be at a higher pressure than the final measured pressure derivative.

HydroBench can apply multi-dimensional flow models. The flow model is selected based on the review of the derivative data on log-log plots along with the information for geological model. If there is a slope in the derivative data that is characteristic for a flow geometry other than two-dimensional radial flow such as one dimensional linear (positive half slope) or three-dimensional spherical flow (negative half slope), alternative non-radial flow geometry models would be used to match the test response. The slope of derivative data is equal to 1-n/2 where n is the flow dimension; therefore, for linear flow which has a flow dimension of one (1) as flow area does not increase with distance from well results in a positive half slope in the derivative data. Inputting a flow dimension of 1 into the equation above yields a derivative slope of 1/2 on the log-log plot.

In low permeability setting, a composite flow response is often observed that is consistent with a near well zone of higher transmissivity with a flow dimension of 2 and outer zone of lower transmissivity more representative of the undisturbed formation. Allowing flow geometry to be a fitted parameter in manual or automated matching would provide an improved match because there are more parameters applied to the fit but would result in a flow model that is not consistent with the measured data and conceptual geologic understanding. Therefore, the additional fitted parameters would only be used to compensate for inaccuracies in representing the borehole history effects and results in more uncertainty (although improving the match). This would be a case where a good match does translate to a well constrained interpretation. A flow dimension of 2 (radial flow) was assumed for the purposes of the analyses.

Hydraulic parameters were derived as follows:

- Transmissivity is derived from the pressure match to the extrapolated radial flow acting period of the derivative data on the log-log plot;
- Bulk hydraulic conductivity is estimated by dividing the transmissivity by the interval length;
- Wellbore storage is a type curve match parameter for shut-in following slug test phases and input parameter for slug (open tubing) and pulses (shut-in);
- Composite model discontinuity radius between inner and outer zone transmissivity is a type curve match and correlated to the input storativity; and
- Initial formation pressure for the purposes of the analyses was derived by the extrapolation of the shut-in periods in semi-logarithmic coordinates towards infinite elapsed time (Horner Plot in HydroBench), using the matched flow model type curve.

It should be noted that the accuracy of the derived initial formation pressure is strongly dependent on the accuracy of the representation of the borehole pressure history. Generally, the longer and the more complicated the borehole pressure history period, the greater the uncertainties due to difficulties in accurately representing this period in the analysis. Lower transmissivities are more strongly influenced by uncertainties in the borehole pressure history. To reduce the influence of borehole pressure history on the derivation of transmissivity, a PSR phase was included at the start of each test to dissipate a portion of the borehole pressure history prior to initiation of the active phases, and each test was completed with a relatively long duration shut-in recovery phase when borehole pressure history effects will be minimal compared to the early portion of the test.

A description of the test interval, test procedure and results are summarized below. Test plots and analyses details are presented in Appendix C showing four plots for each test:

- Pressure Sequence – Plot of interval temperature and multizone (bottom, interval, annulus, and tubing) pressure versus time. Each test sequence is identified and labeled.
- Wellbore Storage Plot – Plot of tubing pressure during the activation of the DHSIV. The pressure change is used to calculate a change in volume that is applied to the test zone compressibility and resulting wellbore storage estimate.
- Transmissivity Normalized Plot – Displays transmissivity versus time in log-log scale as a visual tool for evaluating similar formation responses related to the flow model and enables the comparison of transmissivity from multiple test phases.
- Pressure and pressure derivative log-log plot – Plot of test pressure and pressure derivative versus time on a log-log scale with the simulation match produced by HydroBench.

- Test pressure match plot – Plot of test pressure versus time with the simulation match produced by HydroBench. HydroBench simulates the test pressure response based on the input parameters.

A summary of the test results is provided in Table 3. Data Quality Confirmation forms are provided within the Data Deliverable package.

To develop a robust set of parameters, the analysis includes the following main steps:

1) Review the data on log-log plots to diagnose the formation flow model;
2) Match the data on log-log plots;
3) Check the selected model and parameters on the entire simulation match; and
4) Iterate between log-log and entire simulation plots until an optimal match is obtain on both plots.

7.0 SUMMARY OF RESULTS

Hydraulic testing was completed in twenty intervals (HT001 – HT020) in borehole IG_BH02. All tests were considered successful. Transmissivity values were estimated to be in the range of 1E-12 to 2E-08 m^2/s with hydraulic conductivities in the range of 5E-14 to 1E-09 m/s.

All tests showed a very minor hydraulic connection between the annulus and the test tubing (likely caused by minor leakage at threaded tubing joints), but this connection did not impact the analyses of the pulse test as the test tubing is not hydraulically connected to the test interval with the DHSIV closed. The leakage from the test tubing also did not impact the slug test recoveries as the magnitude of the leakage was less than the fluid loss to the formation during each of the slug test recoveries.

The primary uncertainties in estimation of transmissivity are the uncertainty in the input parameters, inherent uncertainties in representation of borehole pressure history effects and, to a lesser degree, temperature transients. Uncertainty in hydraulic conductivity also stems from the assumption of formation length across which flow occurs.

There were several steps taken to minimize the uncertainty as summarized below:

- Test tool included a downhole shut-in valve to minimize wellbore storage and pressure gauges with a relatively high degree of accuracy.
- Leak tests within casing and functions checks were performed during the testing program to estimate the lower transmissivity limit of the tool and confirm that the packer seals were adequate.
- Measurement of the change in the interval volume during the pulse induction to estimate test zone compressibility.
- Test design and performance included the following:
  - PSR phase to dissipate part of the borehole pressure history and temperature history effects;
  - Test phases optimal to the magnitude of transmissivity with slug phases for higher transmissivity and pulse phases for lower transmissivity; and

- Test duration was extended so either radial flow period was reached or transition to radial flow was reached during the main test phases using real time analysis.

- Analysis included the use of transmissivity normalized plots for all test phases for optimal resolution in evaluating formation response and consistency between phases with matching on both log-log and entire simulation to validate the parameters and flow model are consistent with the measured data.

However, there is an inherent uncertainty in the analysis for hydraulic parameters. Based on Golder's experience with hydraulic testing and sensitivity analyses for nuclear repository programs (e.g., Enachescu et al., 1997), for tests with transmissivity in the magnitude of 1E-11 m^2/s to 1E-09 m^2/s, the uncertainty is considered to range between plus/minus a factor of 5 to plus or minus a factor of 10 as borehole pressure history and temperature history effects become more material in this transmissivity range and difficult to accurately replicate in the analysis.

Test results are presented in Table 3 and shown on Figure 12 and Figure 13.

Table 3: Summary of Test Results

TEST ID	Top of Interval along Borehole (mbgs)	Bottom of Interval along Borehole (mbgs)	Interval Length (m)	Inferred Formation Pressure (kPa)	WBS (m3/Pa)		Transmissivity (m2/sec)	Bulk Hydraulic Conductivity[1] (m/sec)
					DHSIV Open - Tubing Related	DHSIV Closed		
IG_BH02_HT001	302.61	322.66	20.05	2611	2E-07	6E-11	6E-11	3E-12
IG_BH02_HT002	144.08	164.13	20.05	1150	2E-07	1E-10	1E-08	5E-10
IG_BH02_HT003	219.61	239.66	20.05	1822	2E-07	2E-10	6E-11	3E-12
IG_BH02_HT004	274.06	294.11	20.05	2289	2E-07	2E-10	4E-09	2E-10
IG_BH02_HT005	335.81	355.86	20.05	2912	2E-07	1E-10	8E-12	4E-13
IG_BH02_HT006	410.09	430.14	20.05	3567	2E-07	1E-10	2E-11	1E-12
IG_BH02_HT007	439.14	459.19	20.05	3816	2E-07	7E-11	4E-11	2E-12
IG_BH02_HT008	486.12	506.17	20.05	4201	2E-07	8E-11	8E-12	4E-13
IG_BH02_HT009	505.96	526.01	20.05	4479	2E-07	6E-11	4E-12	2E-13
IG_BH02_HT010	526.29	546.34	20.05	4697	2E-07	9E-11	4E-11	2E-12
IG_BH02_HT011	544.22	564.27	20.05	4968	2E-07	9E-11	6E-12	3E-13
IG_BH02_HT012	564.06	584.11	20.05	4976	2E-07	9E-11	2E-11	1E-12
IG_BH02_HT013	583.23	603.28	20.05	5190	2E-07	4E-09	6E-09	3E-10
IG_BH02_HT014	608.88	628.93	20.05	5282	2E-07	3E-10	2E-08	1E-09
IG_BH02_HT015	657.69	677.74	20.05	5673	2E-07	1E-10	3E-09	1E-10
IG_BH02_HT016	678.6	698.65	20.05	6194	2E-07	2E-09	3E-11	1E-12
IG_BH02_HT017	749.97	770.02	20.05	6785	2E-07	9E-11	7E-12	3E-13
IG_BH02_HT018	800.04	820.09	20.05	7215	2E-07	9E-11	1E-12	5E-14
IG_BH02_HT019	895.22	915.27	20.05	7835	2E-07	8E-11	2E-11	1E-12
IG_BH02_HT020	949.97	970.02	20.05	8515	2E-07	8E-11	2E-12	1E-13

Notes:

1) Bulk hydraulic conductivity is calculated by transmissivity / interval length.

Transmissivity and hydraulic conductivity results are plotted relative to depth on Figure 12 and Figure 13.

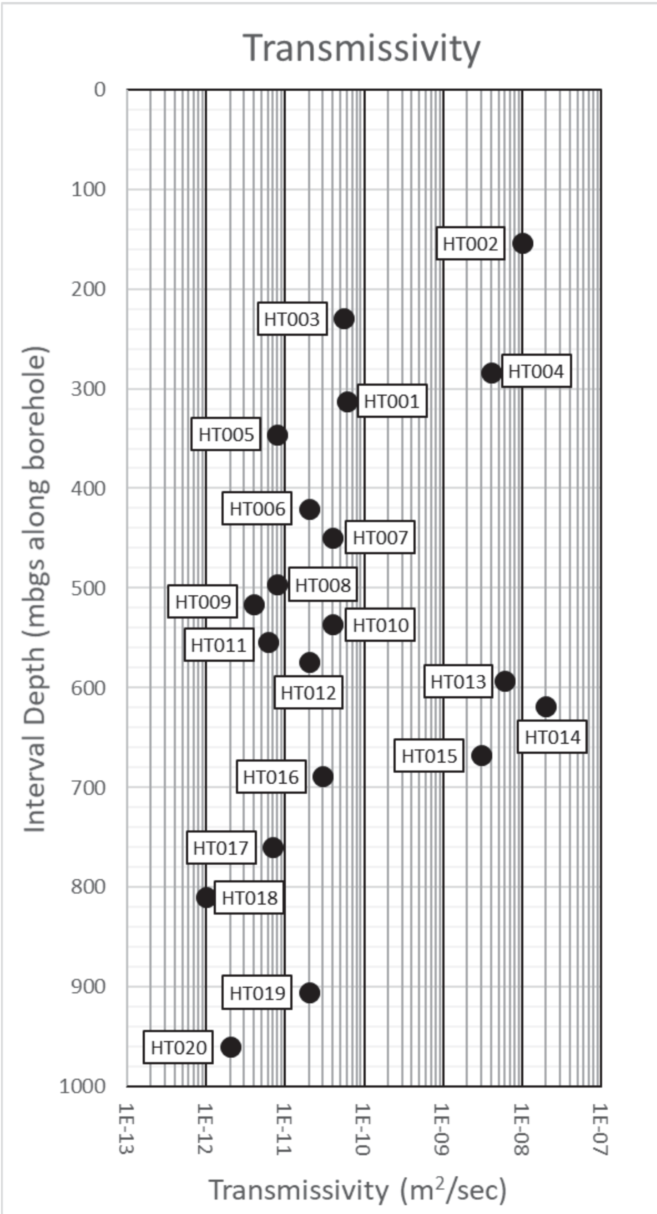

Figure 12: Transmissivity

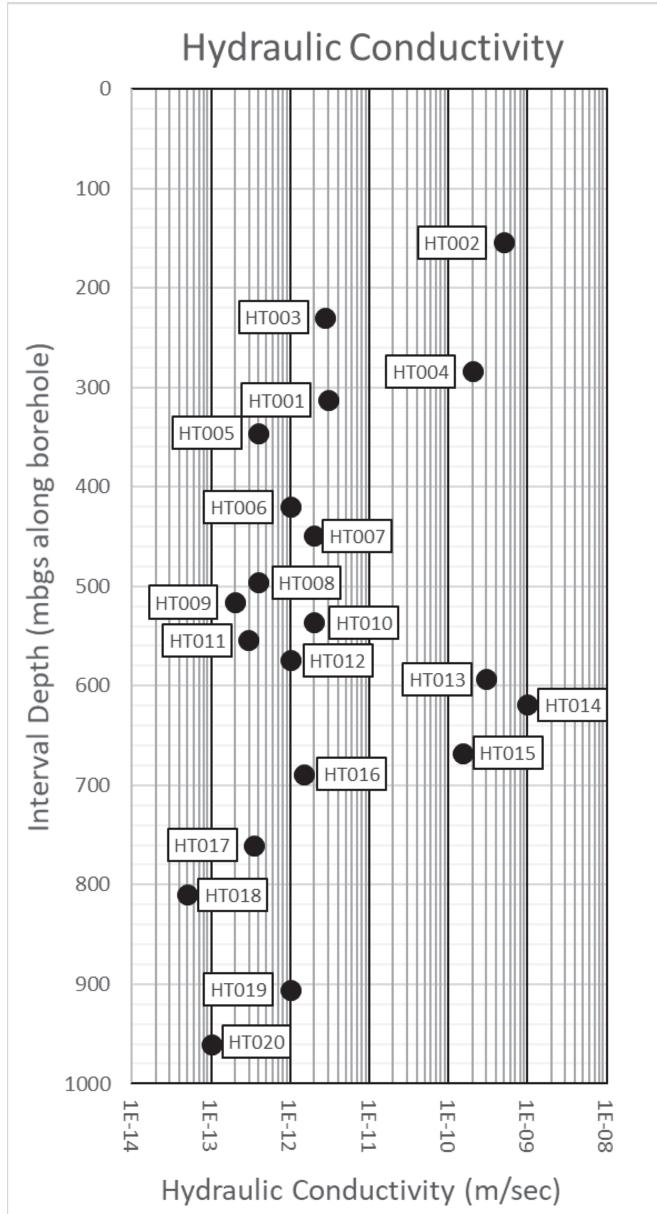

Figure 13: Hydraulic Conductivity

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APPENDIX A

Photos of Equipment

Photo 1 – Drill rig and insulated and heated tent (white) containing flat pack. Water tanks located in heated blue shipping container.

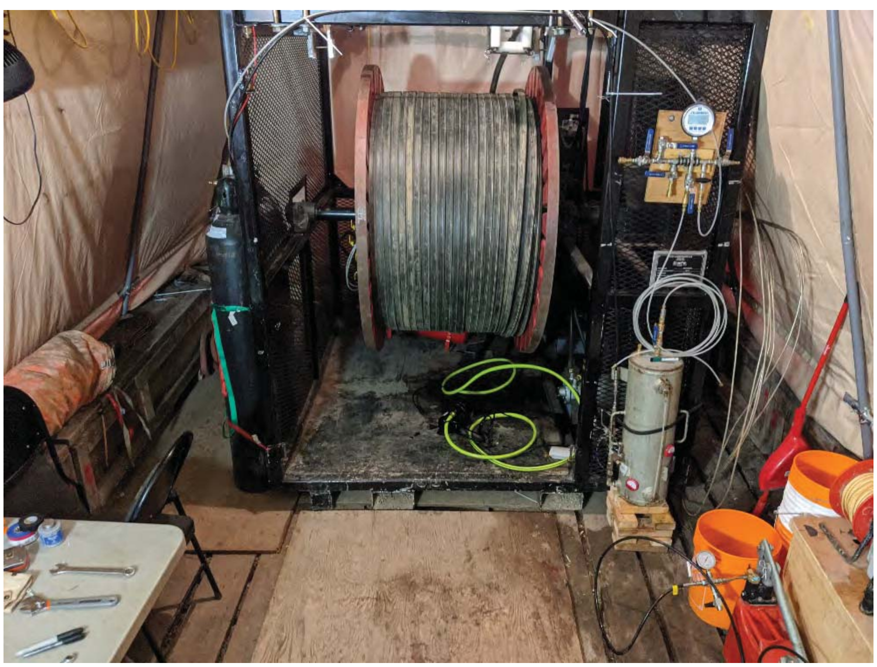


Photo 2 – Flat pack (center) with inflation manifold (upper right), inflation pressure vessel (lower right), nitrogen cylinders (center left), and DHSIV activation pump (lower right).

Photo 3 – DataCan pressure transducer tool carrier with outer protective casing removed.

Photo 4 – Downhole shut-in valve (DHSIV) with stainless steel activation line ported in top of tool.

Photo 5 – DataCan transducer carrier at borehole.

APPENDIX B

Calibration Certificates

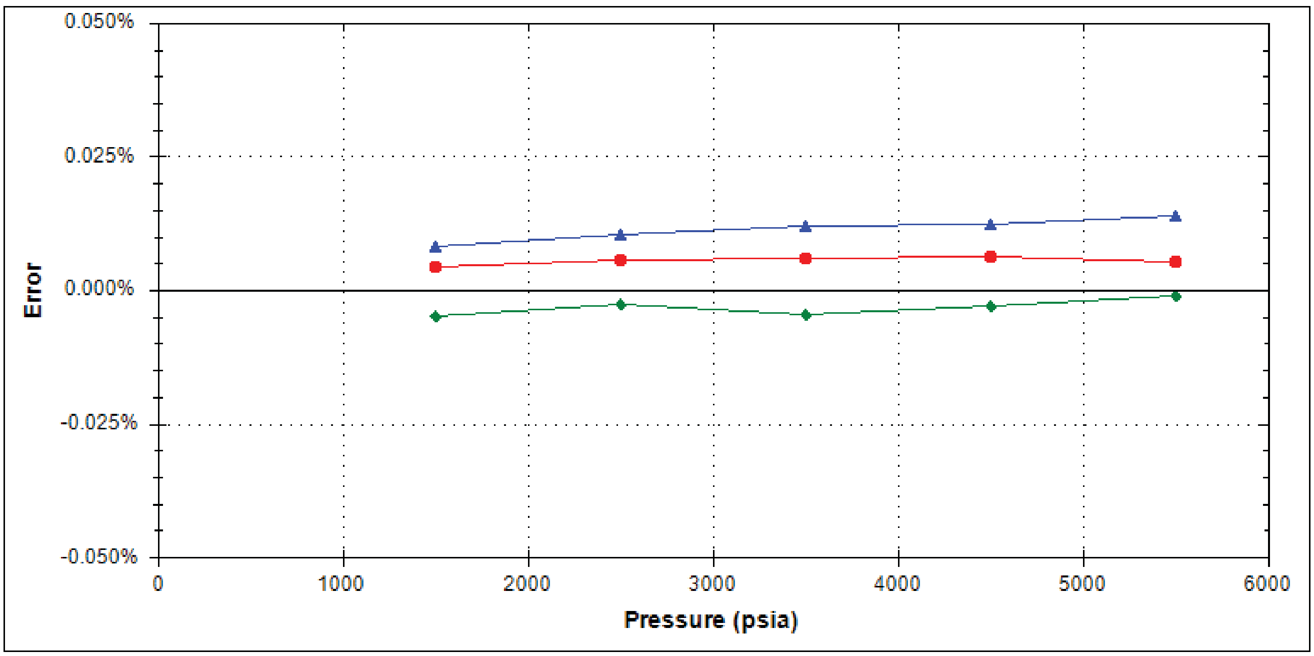
"The Next Generation of Down Hole Tools"

Calibration Date: 14-Jun-19
Max Pressure Error: 0.014% F.S.
Max Temperature Error: 0.162 °C
Part Number: 108931
Serial Number: DC5192

Calibration System: CALIBRATION02
Batch Number: 20190612.164342

0.75 OD Multi-Gauge Piezo Bottom 1/4" Wire SS			
Max Pressure		Max Temperature	
psi	kPa	ºF	ºC
6,000	41,369	185	85

Accuracy: As shown in the graph below, this DataCan Pressure gauge conforms to within +/- 0.030% F.S. of the pressure standard used in calibration, which is accurate to within +/- 0.01% of reading.



Working Standards

Sun Electronic Systems Environmental Chamber, Model: EC127, Serial: EC0063
DHI Instruments Pressure Controller, Model: PPCH-200M (30,000psi Reference), Serial: 1894

Traceability Statement

All working standards are traceable to nationally or internationally recognized standards.

Approved By:
DataCan Services Corp.

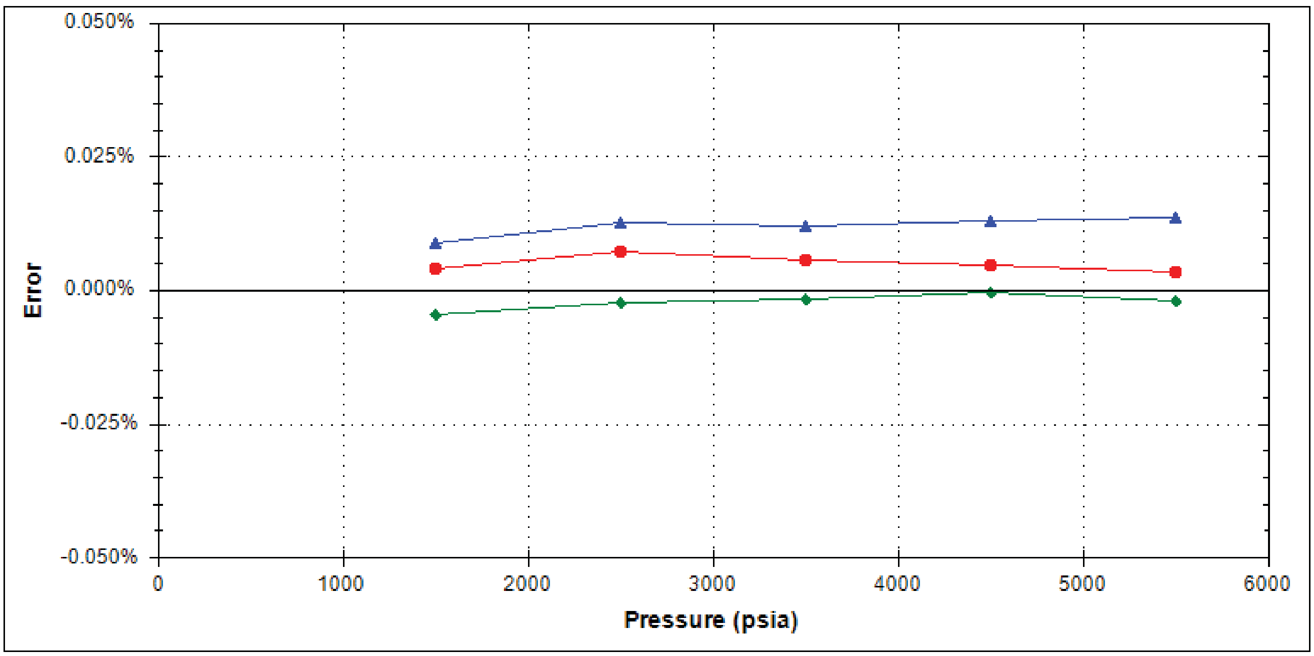
Calibrated By:
Angelo Pulido

“The Next Generation of Down Hole Tools”

Calibration Date:	14-Jun-19	**Calibration System:**	CALIBRATION02
Max Pressure Error:	0.013% F.S.	**Batch Number:**	20190612.164342
Max Temperature Error:	0.159 °C		
Part Number:	108931		
Serial Number:	DC5193		

0.75 OD Multi-Gauge Piezo Bottom 1/4" Wire SS			
Max Pressure		Max Temperature	
psi	kPa	ºF	ºC
6,000	41,369	185	85

Accuracy: As shown in the graph below, this DataCan Pressure gauge conforms to within +/- 0.030% F.S. of the pressure standard used in calibration, which is accurate to within +/- 0.01% of reading.



Working Standards

Sun Electronic Systems Environmental Chamber, Model: EC127, Serial: EC0063

DHI Instruments Pressure Controller, Model: PPCH-200M (30,000psi Reference), Serial: 1894

Traceability Statement

All working standards are traceable to nationally or internationally recognized standards.

Approved By:
DataCan Services Corp.

Calibrated By:
Angelo Pulido

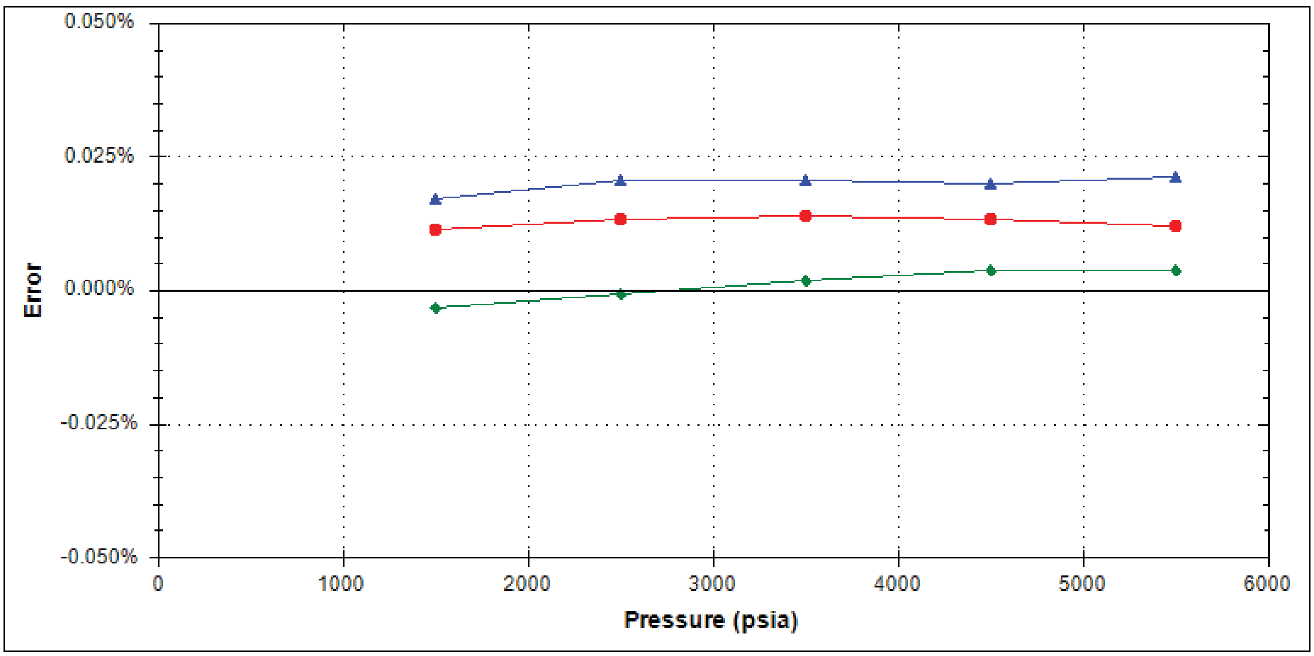
DataCan

"The Next Generation of Down Hole Tools"

Calibration Date:	14-Jun-19	**Calibration System:**	CALIBRATION02
Max Pressure Error:	0.021% F.S.	**Batch Number:**	20190612.164342
Max Temperature Error:	0.149 °C		
Part Number:	108931		
Serial Number:	DC5194		

0.75 OD Multi-Gauge Piezo Bottom 1/4" Wire SS			
Max Pressure		Max Temperature	
psi	kPa	ºF	ºC
6,000	41,369	185	85

Accuracy: As shown in the graph below, this DataCan Pressure gauge conforms to within +/- 0.030% F.S. of the pressure standard used in calibration, which is accurate to within +/- 0.01% of reading.



Working Standards

Sun Electronic Systems Environmental Chamber, Model: EC127, Serial: EC0063
DHI Instruments Pressure Controller, Model: PPCH-200M (30,000psi Reference), Serial: 1894

Traceability Statement

All working standards are traceable to nationally or internationally recognized standards.

Approved By:
DataCan Services Corp.

Calibrated By:
Angelo Pulido

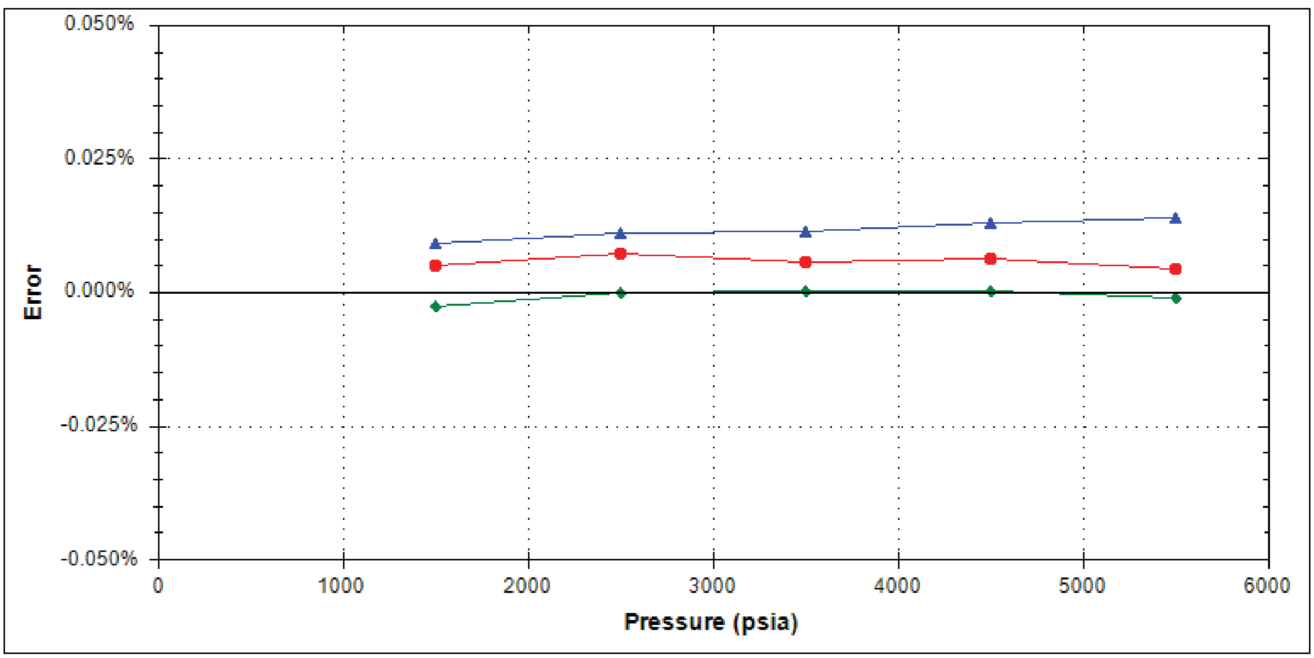
“The Next Generation of Down Hole Tools”

Calibration Date: 14-Jun-19
Max Pressure Error: 0.014% F.S.
Max Temperature Error: 0.141 °C
Part Number: 108931
Serial Number: DC5195

Calibration System: CALIBRATION02
Batch Number: 20190612.164342

0.75 OD Multi-Gauge Piezo Bottom 1/4" Wire SS			
Max Pressure		Max Temperature	
psi	kPa	ºF	ºC
6,000	41,369	185	85

Accuracy: As shown in the graph below, this DataCan Pressure gauge conforms to within +/- 0.030% F.S. of the pressure standard used in calibration, which is accurate to within +/- 0.01% of reading.



Working Standards

Sun Electronic Systems Environmental Chamber, Model: EC127, Serial: EC0063
DHI Instruments Pressure Controller, Model: PPCH-200M (30,000psi Reference), Serial: 1894

Traceability Statement

All working standards are traceable to nationally or internationally recognized standards.

Approved By:
DataCan Services Corp.

Calibrated By:
Angelo Pulido

CERTIFICATE OF CALIBRATION

454934

Certification Number
Issued By

WESCAN CALIBRATION
Unit# 9 - 12240 Horseshoe Way

Richmond, BC V7A 4X9
Ph: (604) 275-0600
Fax: (604) 275-0610

ACCREDITED
Calibration CERT# 1500.02

Wescan calibration

Certification Issued To: **GOLDER ASSOCIATES LTD. (BURNABY)**
300 - 3811 North Fraser Way
Burnaby, BC V5J 5J2

Purchase Order Number: **921410/1428/3000**

Instrument ID: 2892054

Type: PRESSURE GAUGE, DIGITAL (0 to 2 000) psi

Manufacturer: OMEGA

Model Number: DPG4000-2K

Serial Number: 2892054

Size: (0 to 2 000) psi

Department: N/A

Date Instrument Calibrated: Jan 24 2019

Date Next Calibration Due: Jan 24 2020

Laboratory Temperature: 19.8 °C

Laboratory Humidity: 40 %RH

Calibration Procedure Used: P1002

Technician Performing Calibration:

ROMY ACLAN DAPOC

Calibration Approved By:

MALCOLM SMITH 01/24/2019
Laboratory Manager

Calibrated In: WESCAN CALIBRATION SERVICES INC. (VANCOUVER)

Wescan Calibration certifies that the above instrument was calibrated in compliance, as applicable, with the requirements of ISO/IEC 17025:2005, ANSI/NCSLI Z540.1-1994 (R2002), ANSI/NCSLI Z540.3-2006 and/or the technical requirements of the customer. Additionally, Wescan's quality management system meets the principles of ISO 9001:2008 and is aligned with its pertinent requirements. Wescan Calibration is accredited by the American Association for Laboratory Accreditation (A2LA). Measurements within Wescan Calibration's Scope of Accreditation are traceable to the International System of Units (SI units) in accordance with A2LA's traceability policy. All Wescan Calibration measurements are traceable to SI units, through the National Research Council (NRC), the National Institute of Standards and Technology (NIST), other National Measurement Institutes (NMIs), or to physical constants, consensus standards, or ratio measurements. Uncertainties are calculated in accordance with JCGM 100:2008, Guide to the Expression of Uncertainty in Measurement, at a confidence level of approximately 95% using a coverage factor, k = 2. Measured values apply only at the time of calibration. After that time any number of factors may cause measured values to change. The information in this certificate applies only to the identified instrument and may not be reproduced, except in full, without the written consent of Wescan Calibration.

See Attached Data Sheet For Additional Calibration Data

Data Sheet

454934
Certification Number

INSTRUMENT ACCURACY

±0.05 % FULL SCALE (±1 psi)

INSTRUMENT CONDITION

FOUND NOT MEETING SPECIFICATIONS. LEFT MEETING SPECIFICATIONS AFTER ADJUSTMENT. SEE ATTACHED CALIBRATION DATA.

NOTE 1: WHEN TEST UNCERTAINTY RATIOS (TURS) ARE LESS THAN 4:1 AND GREATER THAN 1.1:1, IN ORDER TO ENSURE 2% OR LESS FALSE ACCEPT PROBABILITIES WHEN MAKING CONFORMANCE STATEMENTS, WESCAN CALIBRATION GUARDBANDS AT A PERCENTAGE OF SPECIFICATION LIMITS.

NOTE 2: WHEN TURS ARE LESS THAN 1.1:1 WESCAN CALIBRATION DOES NOT MAKE CONFORMANCE STATEMENTS BUT INSTEAD REPORTS MEASURED VALUES AND UNCERTAINTIES.

NOTE 3: ON OCCASIONS WHEN TURS FALL IN THE RANGE DESCRIBED IN NOTE 1, BUT GUARDBANDING IS NOT PRACTICAL, THIS IS SEPARATELY NOTED.

STANDARDS USED FOR THIS CALIBRATION

Unique ID	Description	Due Date
102018	PRESSURE CALIBRATOR, FLUKE 6270A (WITH 3 MODULES)	07/31/2019

Traceable Reference: (102018)445525

End of Report

Wescan calibration

Calibration procedure P1002
Item type Pressure gauge
Range 2000.0 psi
Accuracy 0.05 % of full scale
Test item resolution 0.1 psi

Note: this data sheet applies to calibrations where the standard is set to an exact gauge marking

As found

	Nominal	Standard	Lower limit	Test item	Upper limit	% limits used	Uncertainty	TUR if<4:1
	% of range	psi	psi	psi	psi		psi	
increasing	10%	200.000	199.000	199.9	201.000	-10.0%	0.088	
	20%	400.000	399.000	399.8	401.000	-20.0%	0.096	
	30%	600.000	599.000	599.7	601.000	-30.0%	0.11	
	40%	800.000	799.000	799.6	801.000	-40.0%	0.13	
	50%	1000.000	999.000	999.5	1001.000	-50.0%	0.15	
	60%	1200.000	1199.000	1199.4	1201.000	-60.0%	0.22	
	70%	1400.000	1399.000	1399.4	1401.000	-60.0%	0.23	
	80%	1600.000	1599.000	1599.3	1601.000	-70.0%	0.24	
	90%	1800.000	1799.014	1799.2	1800.986	-81.1%	0.26	3.90
	100%	2000.000	1999.023	1999.0	2000.977	-102.3%	0.27	3.69
decreasing	90%	1800.000	1799.014	1799.3	1800.986	-71.0%	0.26	3.90
	80%	1600.000	1599.000	1599.4	1601.000	-60.0%	0.24	
	70%	1400.000	1399.000	1399.4	1401.000	-60.0%	0.23	
	60%	1200.000	1199.000	1199.5	1201.000	-50.0%	0.22	
	50%	1000.000	999.000	999.6	1001.000	-40.0%	0.15	
	40%	800.000	799.000	799.7	801.000	-30.0%	0.13	
	30%	600.000	599.000	599.7	601.000	-30.0%	0.11	
	20%	400.000	399.000	399.8	401.000	-20.0%	0.096	
	10%	200.000	199.000	199.9	201.000	-10.0%	0.088	

As left

	Nominal	Standard	Lower limit	Test item	Upper limit	% limits used	Uncertainty	TUR if<4:1
	% of range	psi	psi	psi	psi		psi	
increasing	10%	200.000	199.000	200.0	201.000	0.0%	0.088	
	20%	400.000	399.000	400.0	401.000	0.0%	0.096	
	30%	600.000	599.000	600.0	601.000	0.0%	0.11	
	40%	800.000	799.000	800.0	801.000	0.0%	0.13	
	50%	1000.000	999.000	1000.0	1001.000	0.0%	0.15	
	60%	1200.000	1199.000	1199.9	1201.000	-10.0%	0.22	
	70%	1400.000	1399.000	1399.9	1401.000	-10.0%	0.23	
	80%	1600.000	1599.000	1600.0	1601.000	0.0%	0.24	
	90%	1800.000	1799.014	1800.0	1800.986	0.0%	0.26	3.90
	100%	2000.000	1999.023	2000.1	2000.977	10.2%	0.27	3.69
decreasing	90%	1800.000	1799.014	1800.0	1800.986	0.0%	0.26	3.90
	80%	1600.000	1599.000	1600.0	1601.000	0.0%	0.24	
	70%	1400.000	1399.000	1400.0	1401.000	0.0%	0.23	
	60%	1200.000	1199.000	1200.0	1201.000	0.0%	0.22	
	50%	1000.000	999.000	1000.0	1001.000	0.0%	0.15	
	40%	800.000	799.000	800.0	801.000	0.0%	0.13	
	30%	600.000	599.000	600.0	601.000	0.0%	0.11	
	20%	400.000	399.000	400.0	401.000	0.0%	0.096	
	10%	200.000	199.000	200.0	201.000	0.0%	0.088	

End of calibration data

Highlighted data are outside acceptance limits

Pioneer Petrotech Services Inc.
#1, 1431 - 40 Ave. NE
Calgary, AB, Canada, T2E 8N6
Tel: +1 (403)282-7669
Fax: +1 (403)282-0509
www.pioneerps.com

Calibration Certificate

Model:	**PPS25**	**Pressure Range:**	**6,000 psi**
Serial Number:	**5231**	**Calibration Date:**	**Mar 28, 2019**

Specifications

Pressure Range:	Minimum:	13 psia	Maximum:	6,000 psia
Temperature Range:	Minimum:	0 °C	Maximum:	150 °C
Pressure Accuracy:			±	0.03 %F.S.
Temperature Accuracy:			±	0.5 °C
Housing Material:				SS 17-4
Housing OD				0.75"

Calibration Summary

Calibration Pressure Range:	Minimum:	14.06 psia	Maximum:	6,001 psia
Calibration Temperature Range:	Minimum:	0.72 °C	Maximum:	150 °C
Pressure Accuracy (Maximum Error):			+	1.80 psi
Temperature Accuracy (Maximum Error):			+	0.28 °C

Working Standards

Pressure: Fluke DH Instruments piston-cylinder, 30kpsi (±0.01% of reading)
Temperature: Fluke Hart Scientific RTD (±0.05°C)

Traceability Statement

All working standards are traceable to nationally or internationally recognized standards.

LUCY

Pioneer Petrotech Services Inc.

Apr 03, 2019
Date

Solinst Levelogger Edge Calibration Report

Instrument:

Manufacturer:	Solinst Canada
Product:	3001 LT Barologger
Model Number:	M1.5
Serial Number:	2110133
Pressure Range:	0-1.5 m H20
Resolution:	0.03 mm H20
Temperature Range:	-20 - +80 °C
Temperature Resolution:	0.003 °C

Method of Calibration:

The Levelogger is calibrated against a range of set reference points, with units of pressure in pounds per square inch. The conversion factor for pounds per square inch relates to pressure in bars and meters of water column is as follows: 1 pound per square inch = 0.0689476 bar = 0.703070 m H20 @ 4°C.

During the calibration procedure, the Levelogger is fully submerged in a highly accurate water bath, set to 6°C. The pressure is then calibrated to six separate pressure points covering the entire range for that particular Levelogger, to check for any non-linearity. This process is repeated at 18°C and then 36°C to check for temperature effects. The Levelogger is approved after all specifications for accuracy, precision, stability and hysteresis have been met.

Traceability:

Pressure standard: ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994, NIST
Temperature standard: ISO/IEC 17025:2005, NVLAP LAB CODE: 200348-0

Uncertainty:

The standard deviation of the temperature was calculated from the contributions of uncertainties originating from the measurement standard, the bath homogeneity, and from any short term contribution from the instrument being calibrated. The standard deviation of the pressure was calculated from the contributions of the uncertainties originating from the measurement standard, any short term contribution from the instrument, and the uncertainty resulting from the uncertainty in temperature compensation. The reported uncertainty is stated as the standard deviation mutliplied by a factor of two.

For further information, please contact: Solinst Canada Ltd.
35 Todd Road, Georgetown, Ontario, Canada L7G 4R8 E-mail: instruments@solinst.com
Fax: +1 (905) 873-1992; (800) 516-9081 Tel: +1 (905) 873-2255; (800) 661-2023 Web Site: www.solinst.com
Solinst®

Serial Number: 2110133 Model Number: M1.5

Test Results:

Calibration Date: 8/2/2019

Pressure Tests

Pressure	Reading (6 ºC)	Level	Reading	Error (%FS)
12.5 psi	12.4995 psi	-0.7116 m	-0.7120 m	0.003%
13.2 psi	13.1496 psi	-0.2546 m	-0.2549 m	0.003%
13.8 psi	13.8005 psi	0.2024 m	0.2027 m	-0.003%
14.5 psi	14.4496 psi	0.6594 m	0.6591 m	0.003%
15.1 psi	15.0996 psi	1.1164 m	1.1161 m	0.003%
15.8 psi	15.7503 psi	1.5734 m	1.5736 m	-0.002%

Hysteresis:
Standard Deviation: 0.0028%

Temperature Tests

Temperature	Reading	Error (%FS)
6 ºC	5.9997 ºC	0.000%
18 ºC	17.9998 ºC	0.000%
36 ºC	35.9998 ºC	0.000%

Standard Deviation: 0.0001%

Conclusion: This instrument fulfils the specifications

Uncertainty temperature standard: 0.003 ºC
Overall uncertainty temperature: ±1.002
Uncertainty pressure standard: <0.003%
Overall uncertainty pressure: 0.01%

Calibration Manager: Ken Shah

For further information, please contact: Solinst Canada Ltd.
35 Todd Road, Georgetown, Ontario, Canada L7G 4R8 E-mail: instruments@solinst.com
Fax: +1 (905) 873-1992; (800) 516-9081 Tel: +1 (905) 873-2255; (800) 661-2023 Web Site: www.solinst.com

Levelogger Edge Calibration Report

Instrument:

Manufacturer:	Solinst Canada
Product:	3001 LT Barologger
Model Number:	M1.5
Serial Number:	2110146
Pressure Range:	0-1.5 m H20
Resolution:	0.03 mm H20
Temperature Range:	-20 - +80 °C
Temperature Resolution:	0.003 °C

Method of Calibration:

The Levelogger is calibrated against a range of set reference points, with units of pressure in pounds per square inch. The conversion factor for pounds per square inch relates to pressure in bars and meters of water column is as follows: 1 pound per square inch = 0.0689476 bar = 0.703070 m H20 @ 4°C.

During the calibration procedure, the Levelogger is fully submerged in a highly accurate water bath, set to 6°C. The pressure is then calibrated to six separate pressure points covering the entire range for that particular Levelogger, to check for any non-linearity. This process is repeated at 18°C and then 36°C to check for temperature effects. The Levelogger is approved after all specifications for accuracy, precision, stability and hysteresis have been met.

Traceability:

Pressure standard: ISO/IEC 17025:2005, ANSI/NCSL Z540-1-1994, NIST
Temperature standard: ISO/IEC 17025:2005, NVLAP LAB CODE: 200348-0

Uncertainty:

The standard deviation of the temperature was calculated from the contributions of uncertainties originating from the measurement standard, the bath homogeneity, and from any short term contribution from the instrument being calibrated. The standard deviation of the pressure was calculated from the contributions of the uncertainties originating from the measurement standard, any short term contribution from the instrument, and the uncertainty resulting from the uncertainty in temperature compensation. The reported uncertainty is stated as the standard deviation mutliplied by a factor of two.

For further information, please contact: Solinst Canada Ltd.
35 Todd Road, Georgetown, Ontario, Canada L7G 4R8 E-mail: instruments@solinst.com
Fax: +1 (905) 873-1992; (800) 516-9081 Tel: +1 (905) 873-2255; (800) 661-2023 Web Site: www.solinst.com

Serial Number: 2110146 Model Number: M1.5

Test Results:

Calibration Date: 8/2/2019

Pressure Tests

Pressure	Reading (6 ºC)	Level	Reading	Error (%FS)
12.5 psi	12.5006 psi	-0.7116 m	-0.7112 m	-0.004%
13.2 psi	13.1506 psi	-0.2546 m	-0.2542 m	-0.004%
13.8 psi	13.8005 psi	0.2024 m	0.2027 m	-0.003%
14.5 psi	14.4504 psi	0.6594 m	0.6596 m	-0.002%
15.1 psi	15.0995 psi	1.1164 m	1.1160 m	0.003%
15.8 psi	15.7502 psi	1.5734 m	1.5735 m	-0.002%

Hysteresis:
Standard Deviation: 0.0027%

Temperature Tests

Temperature	Reading	Error (%FS)
6 ºC	5.9997 ºC	0.000%
18 ºC	17.9997 ºC	0.000%
36 ºC	35.9998 ºC	0.000%

Standard Deviation: 0.0001%

Conclusion: This instrument fulfils the specifications

Uncertainty temperature standard: 0.003 ºC
Overall uncertainty temperature: ±1.002
Uncertainty pressure standard: <0.003%
Overall uncertainty pressure: 0.01%

Calibration Manager: Ken Shah

For further information, please contact: Solinst Canada Ltd.
35 Todd Road, Georgetown, Ontario, Canada L7G 4R8 E-mail: instruments@solinst.com
Fax: +1 (905) 873-1992; (800) 516-9081 Tel: +1 (905) 873-2255; (800) 661-2023 Web Site: www.solinst.com

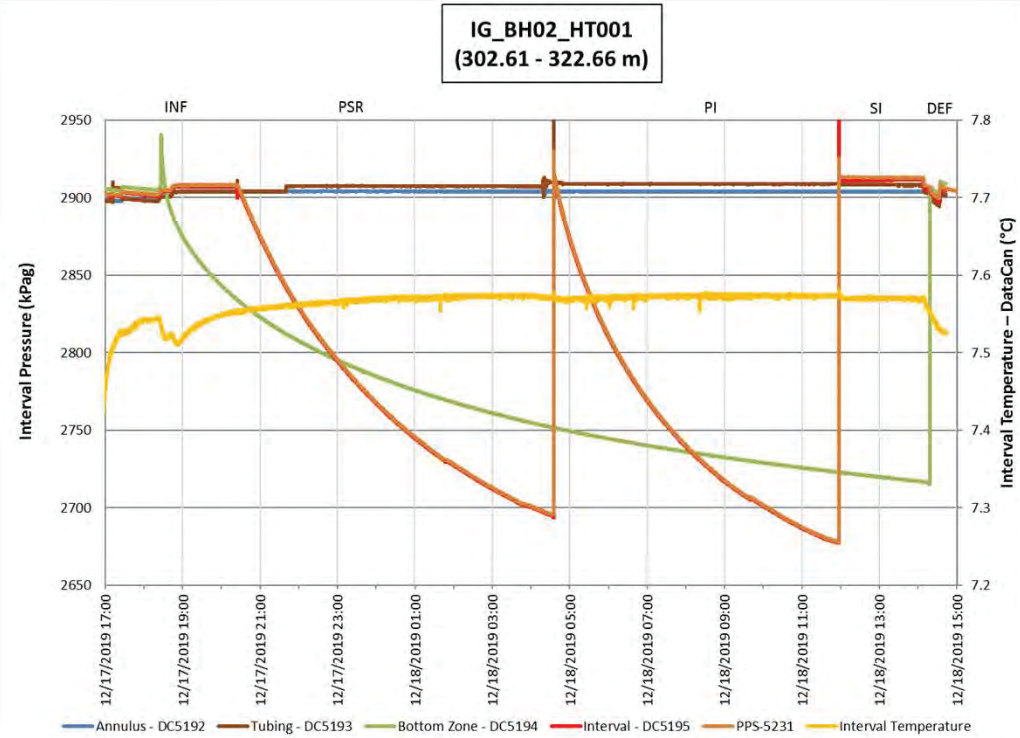
APPENDIX C

Test Results

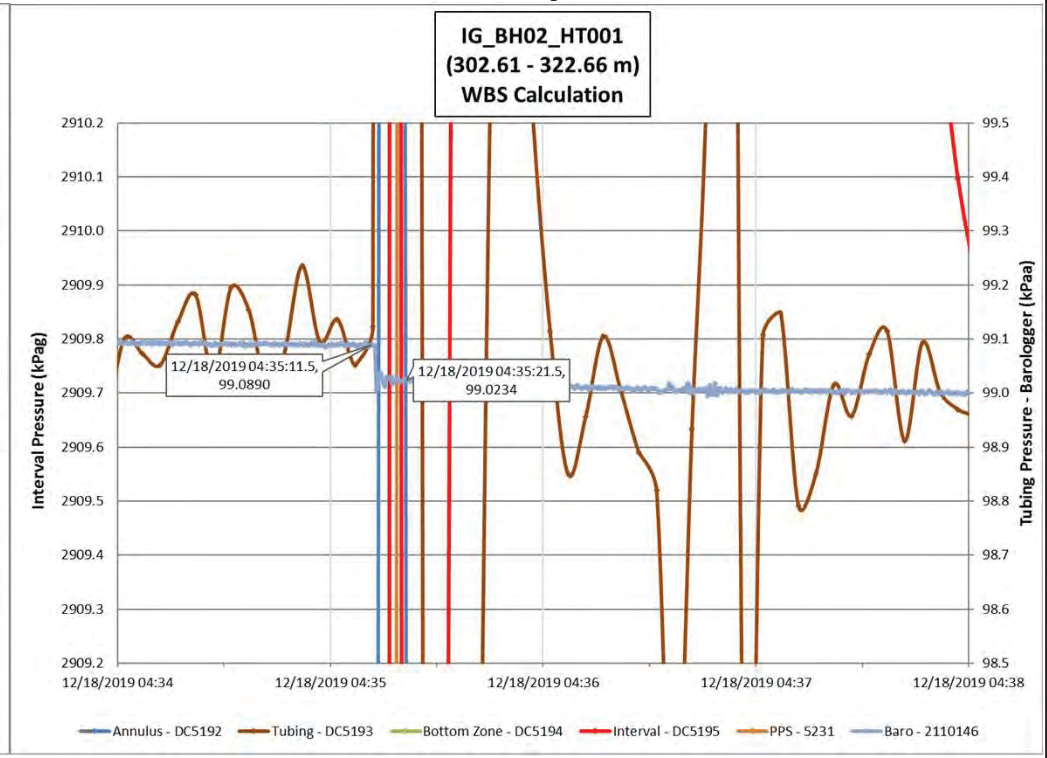
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT001 (302.61 m – 322.66 m)

Figure C1

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	2903		2E-07
PSR	Recovery	3.9	2909		6E-11
PI-Init	dP-Event	12.1	2696	-216	2E-07
PI	Pulse	12.1	2914		6E-11
SI-Init	dP-Event	19.5	2680	-233	2E-07
SI	Slug	19.5	2913		2E-07
DEF	Variable Pressure	21.6	2913		2E-07

HT001 Summary

HT001 was selected to assess the intact rock mass with few features. Two broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PI) with a shut-in recovery was completed after the PSR phase, followed by a short duration slug injection (SI) phase.

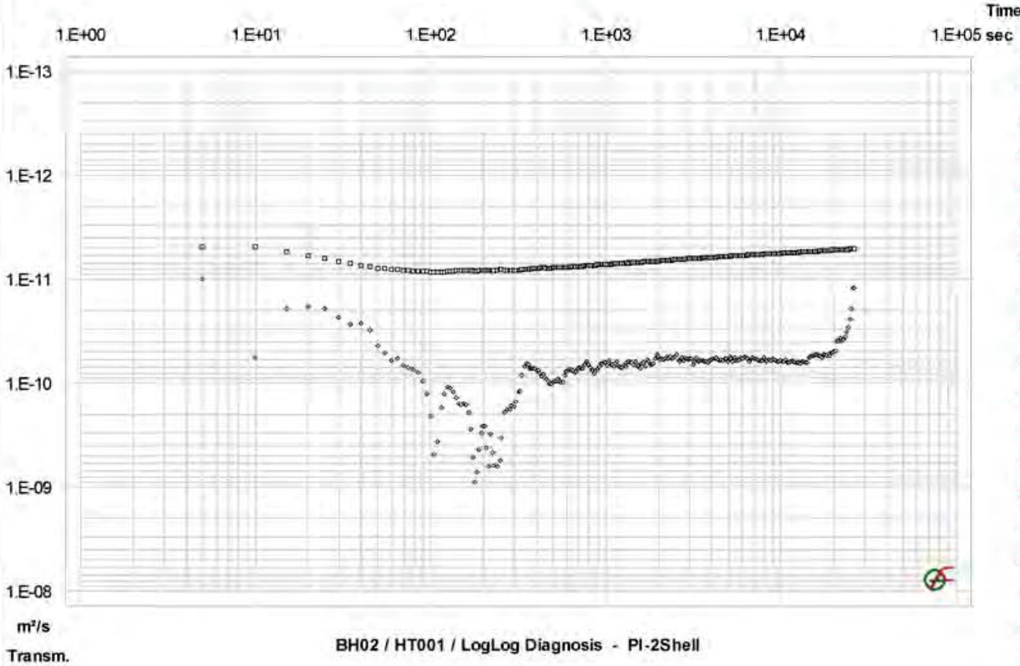
The analyses of the PI and SIS phases provided a good match to the radial flow phase of the recovery using a composite (2-shell) model. No hydraulic bypass above or below the test interval was detected during the shut-in recovery. The estimated transmissivity of the outer shell was 6E-11 m^2/sec with an inner shell of higher transmissivity.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT001 (302.61 m – 322.66 m)

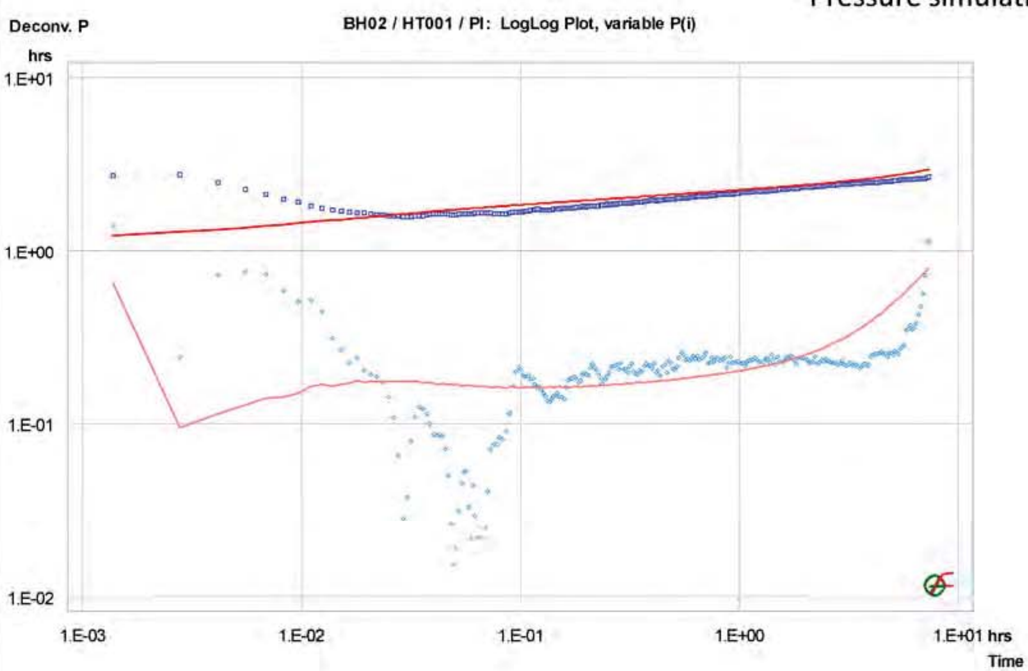
Figure C2

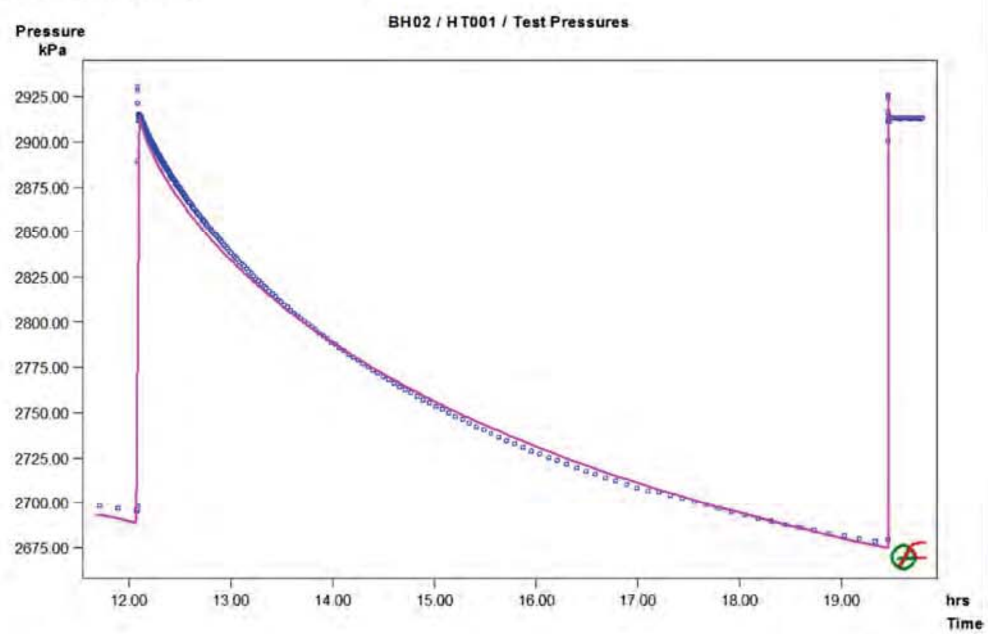
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT001
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	4E-10
Test Zone Static Pressure (kPa)	2611
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-6
Analysis Results	
Phase	PI
Shell 1 Transmissivity [m^2/s]	8E-10
Shell 2 Transmissivity [m^2/s]	6E-11
Shell 1 Radius [m]	0.05
Flow Dimension [-]	2D

Pressure simulation fit shown in red





GOLDER

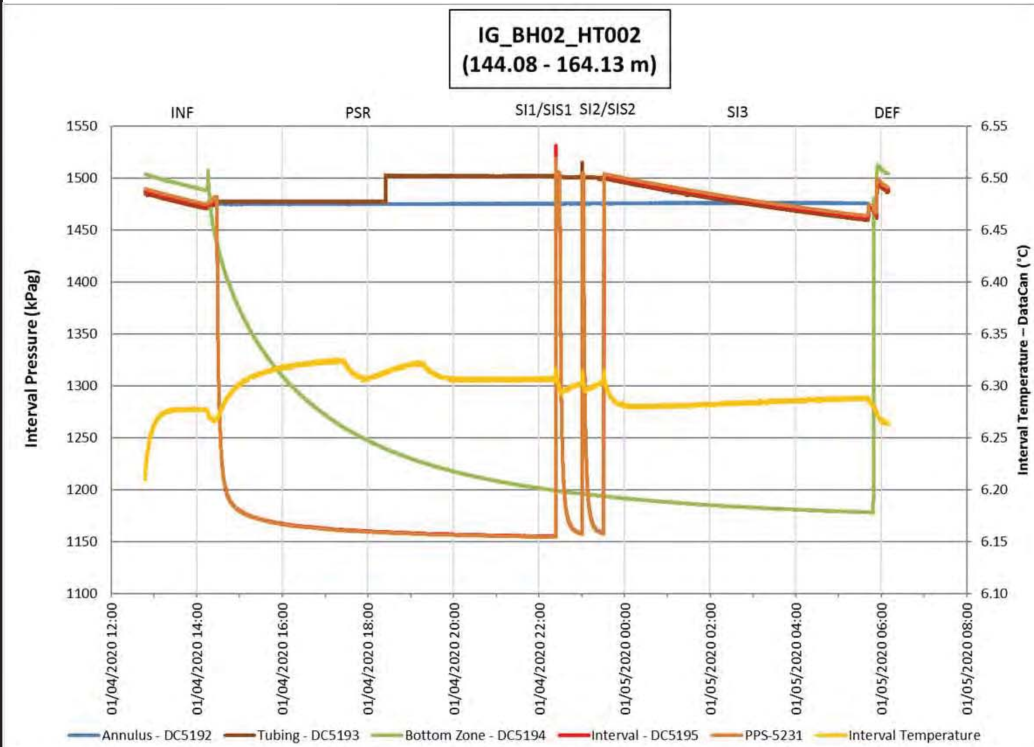
Project #: 1671632

Date: June 2021
Checked: MLe

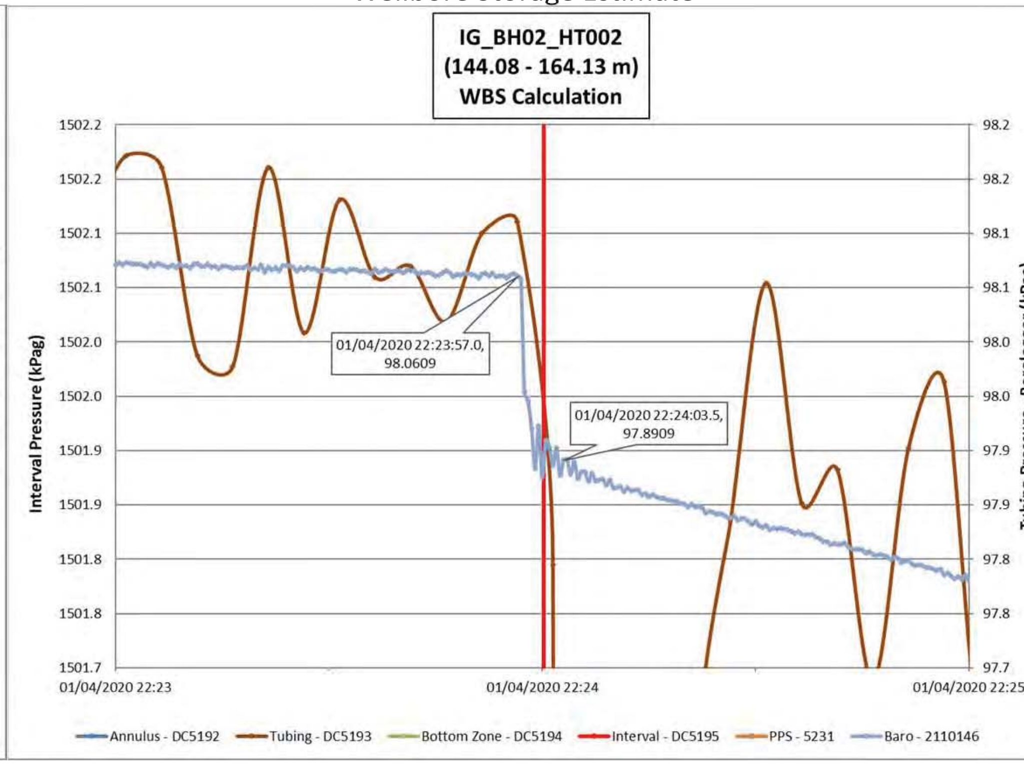
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT002 (144.08 m – 164.13 m)

Figure C3

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	1489		2E-07
PSR	Recovery	1.7	1481		1E-10
SI1-Init	dP-Event	9.6	1154	-349	2E-07
SI1	Slug	9.6	1506		2E-07
SIS1	Recovery	9.7	1505		1E-10
PI1_Init	dP-Event	10.2	1157	-346	2E-07
PI1	Pulse	10.2	1504		1E-10
SI2-Init	dP-Event	10.7	1158	-346	2E-07
SI2	Slug	10.7	1504		2E-07
DEF	Variable Pressure	16.9	1463		2E-07

HT002 Summary

HT002 was selected to assess a fractured interval from 147 to 148 m. Twelve broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A slug injection (SI) test and five-minute recovery with the DHSIV open was conducted after the PSR phase. The DHSIV was closed, and a slug injection shut-in (SIS) recovery was monitored. The SIS phase was followed by a pulse test and recovery with the DHSIV closed, and then a slug test and recovery with the DHSIV open to verify results.

The analyses of the second SI phase provided a good match to the radial flow of the recovery using a homogeneous (single shell) model. No hydraulic bypass above or below the test interval was detected during the shut-in recovery. The estimated transmissivity was 1E-08 m^2/sec

GOLDER

Project #: 1671632

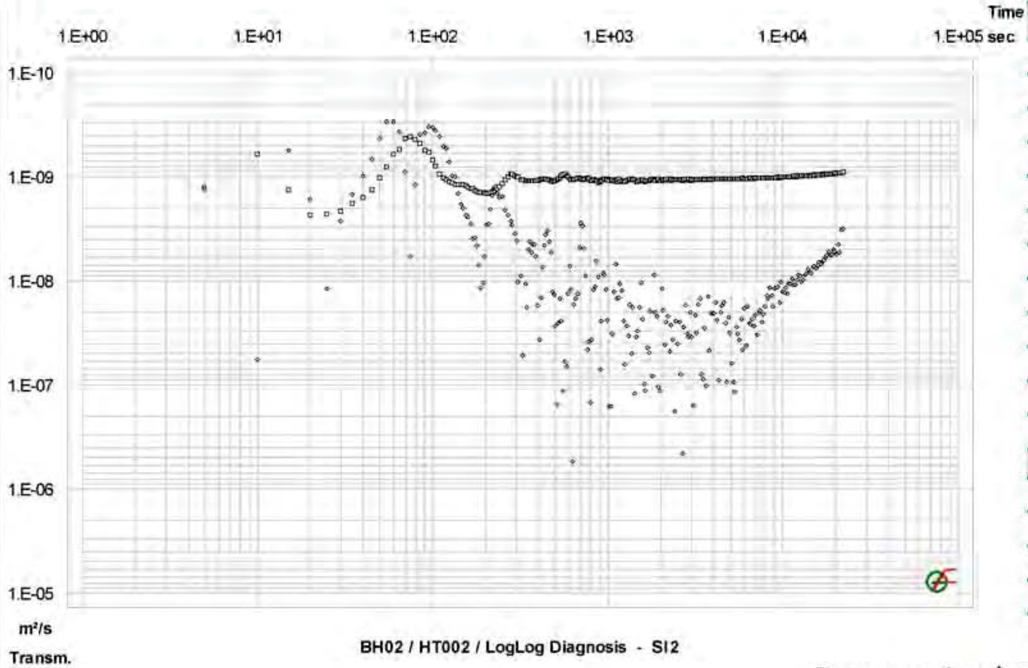
Date: June 2021

Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT002 (144.08 m – 164.13 m)

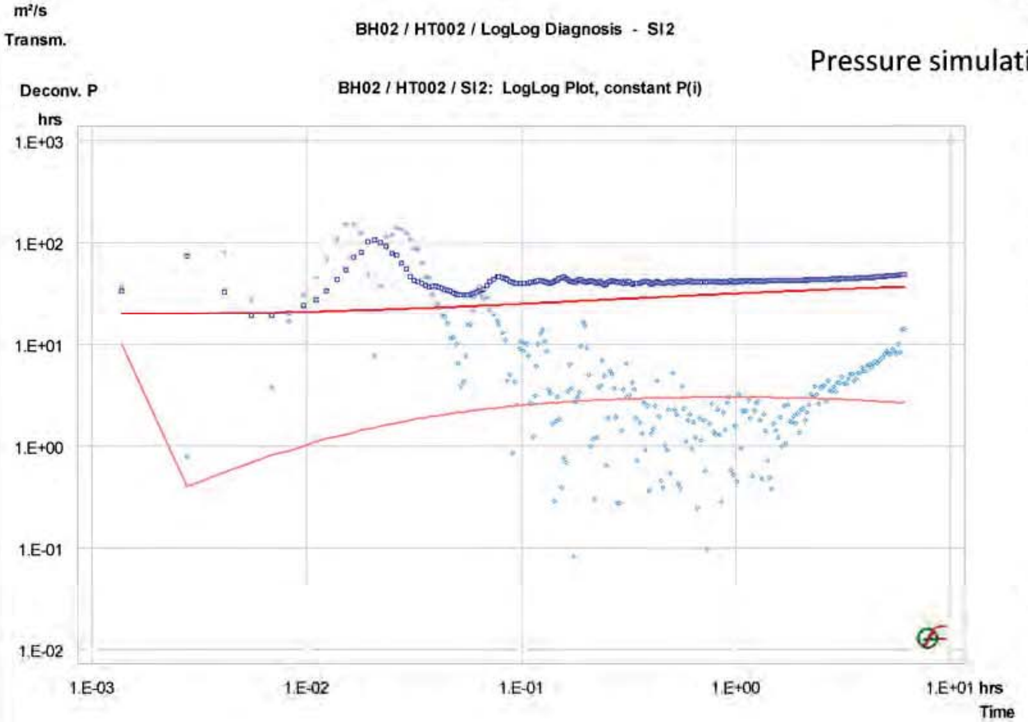
Figure C4

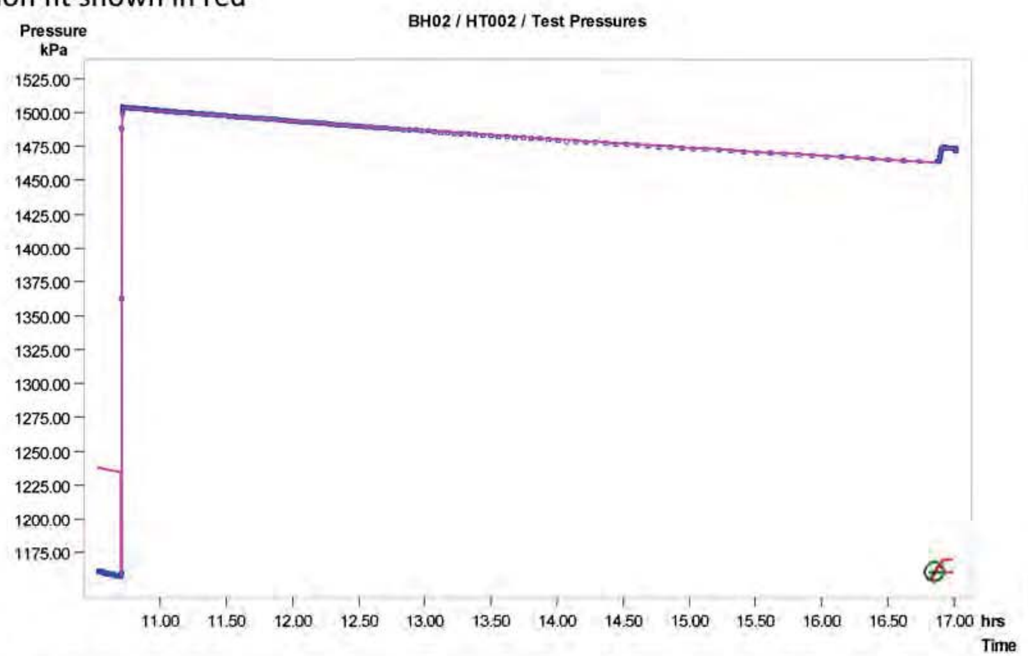
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT002
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	7E-10
Test Zone Static Pressure (kPa)	1150
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	SI2
Transmissivity [m²/s]	1E-08
Skin	0.0
Flow Dimension [-]	2D

Pressure simulation fit shown in red



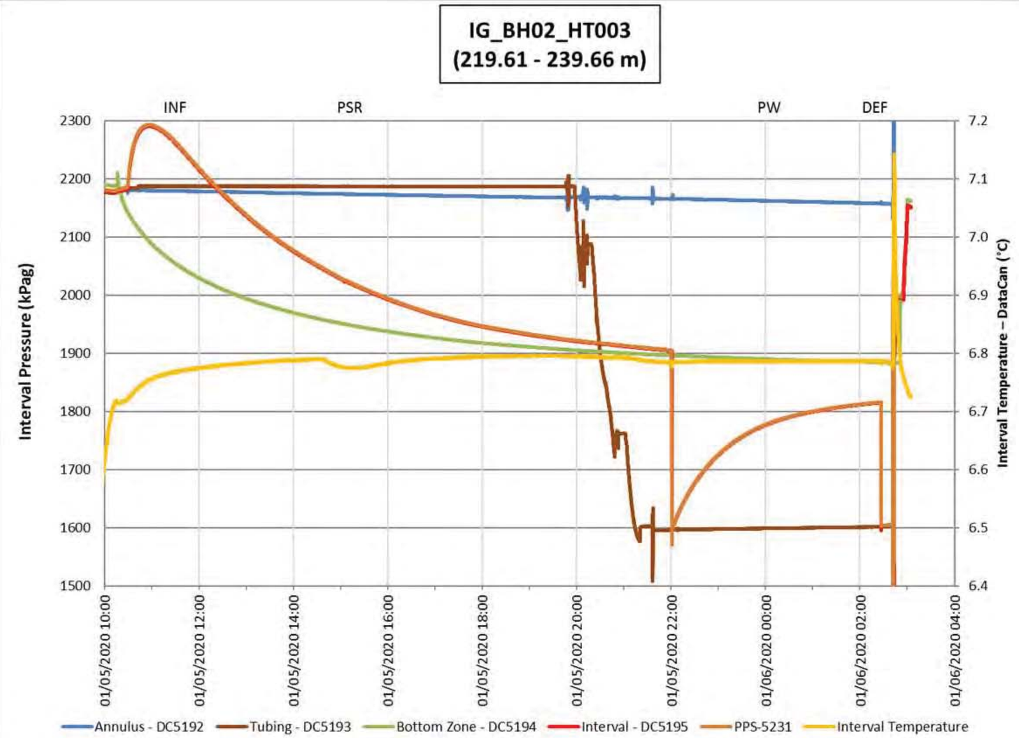


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

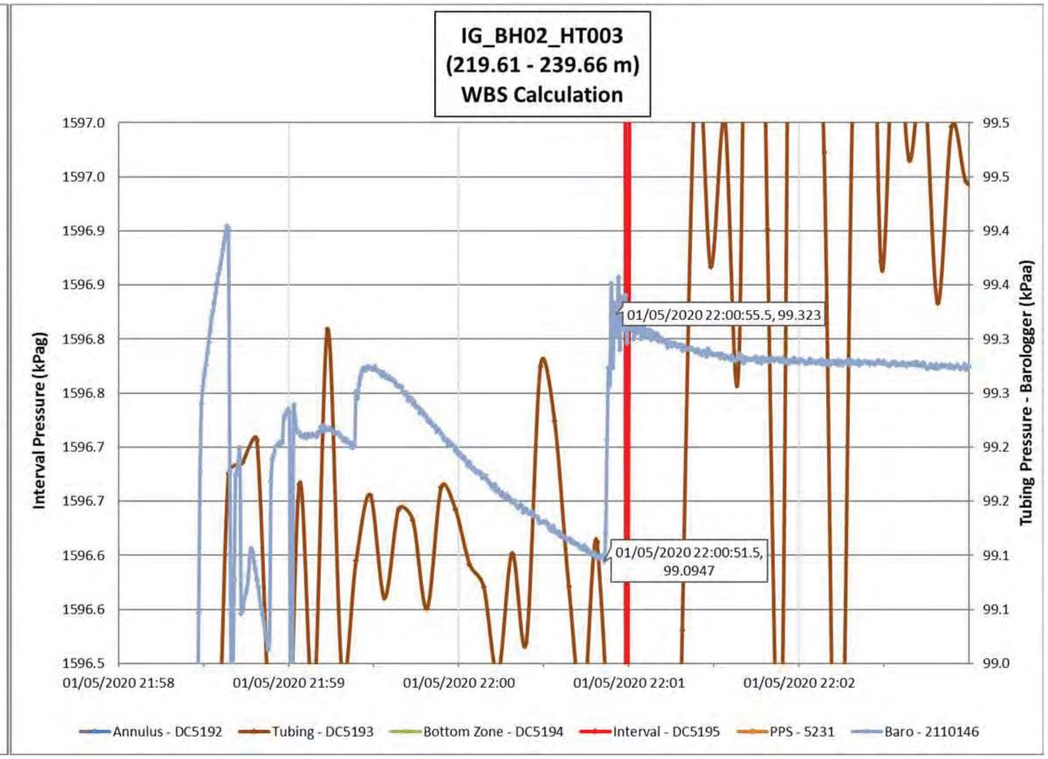
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT003 (219.61 m – 239.66 m)

Figure C5

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	2184		2E-07
PSR	Recovery	1.5	2293		2E-10
PW-Init	dP-Event	12.5	1903	304	2E-07
PW	Pulse	12.5	1599		2E-10
DEF	Variable Pressure	16.9	1816		2E-07

HT003 Summary

HT003 was selected to assess a fractured interval associated with a felsic dyke. Fourteen broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

The analyses provided a moderate match to the radial flow of the recovery using a homogeneous (1-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval. The estimated transmissivity was 6E-11 m^2/sec.

GOLDER

Project #: 1671632

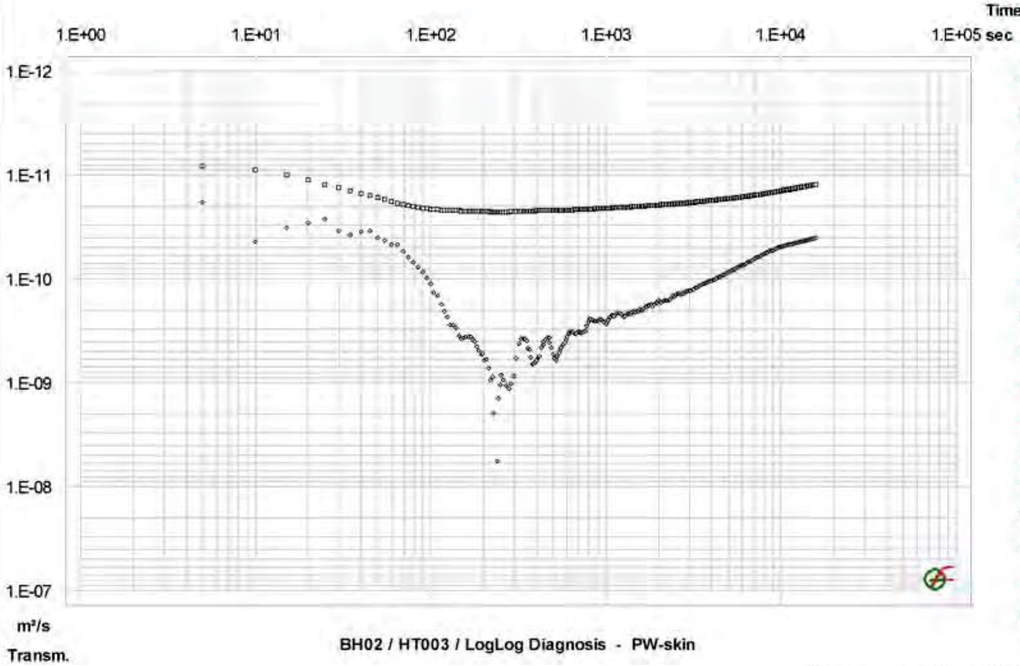
Date: June 2021

Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT003 (219.61 m – 239.66 m)

Figure C6

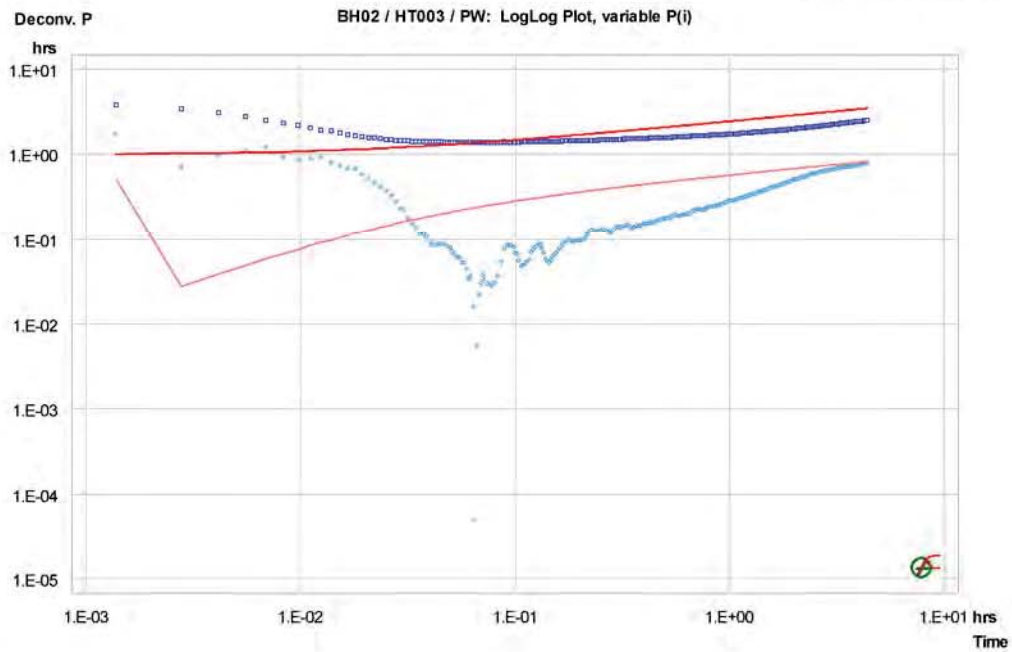
Transmissivity Normalized Plot

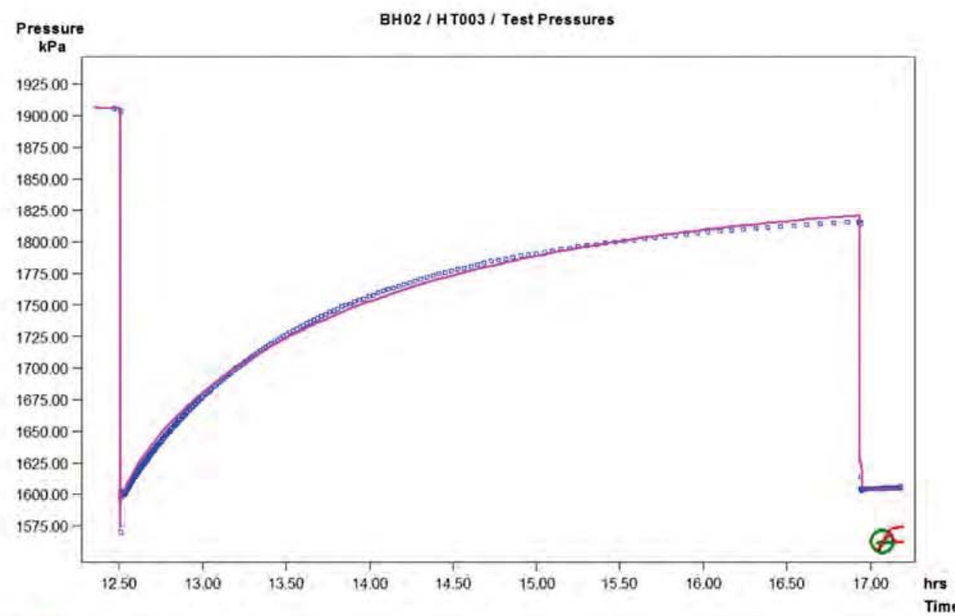


BH02 / HT003 / LogLog Diagnosis - PW-skin

Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT003
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	1E-09
Test Zone Static Pressure (kPa)	1822
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Transmissivity [m²/s]	6E-11
Skin	0.0
Flow Dimension [-]	2D

Pressure simulation fit shown in red





GOLDER

Project #: 1671632

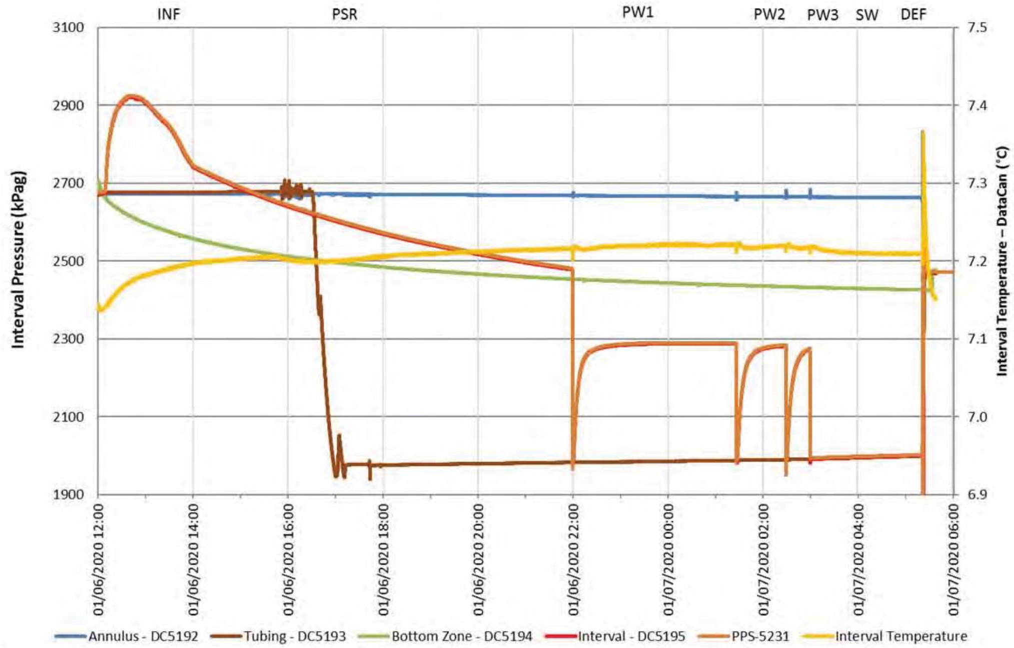
Date: June 2021

Checked: MLe

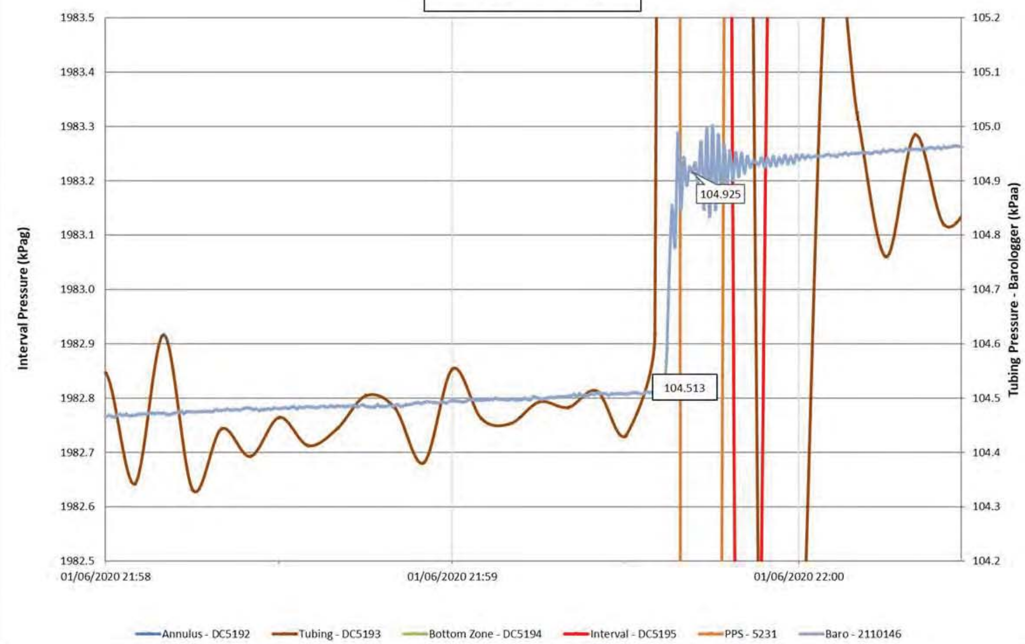
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT004 (274.06 m – 294.11 m)

Figure C7

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	2643		2E-07
PSR	Recovery	2.5	2745		2E-10
PW1-INIT	dP-Event	10.5	2481	493	2E-07
PW1	Pulse	10.5	1988		2E-10
PW2-INIT	dP-Event	13.9	2289	294	2E-07
PW2	Pulse	14.0	1995		2E-10
PW3-INIT	dP-Event	15	2284	289	2E-07
PW3	Pulse	15.0	1995		2E-10
SW-INIT	dP-Event	15.5	2276	281	2E-07
SW	Slug	15.5	1994		2E-07
DEF	Variable Pressure	17.8	2002		2E-07

HT004 Summary

HT004 was selected to assess a fractured interval associated with a felsic dyke. Thirteen broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. A purge rate assessment conducted during drilling returned a value of 5 mL/min. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase. The pulse test was repeated twice, followed by a slug withdrawal (SW) test and recover with the DHSIV open.

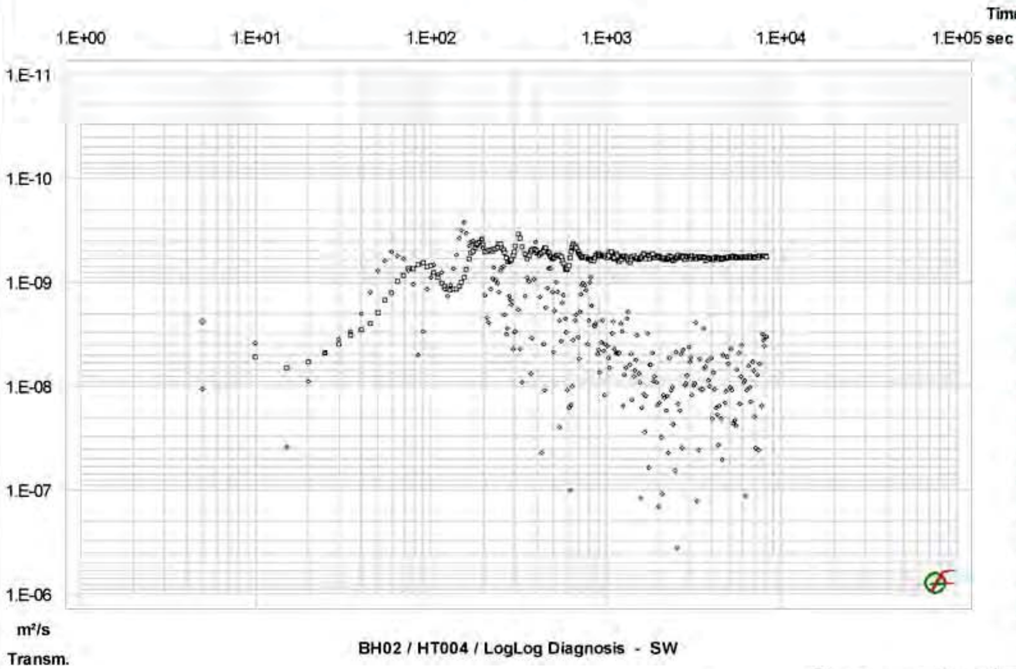
The analyses of the SW and PW phases provided a good match to the radial flow phase of the recovery using a homogeneous (1-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but at a lower rate than through the formation. The estimated transmissivity was 4E-09 m^2/sec.

GOLDER
Project #: 1671632
Date: June 2021
Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT004 (274.06 m – 294.11 m)

Figure C8

Transmissivity Normalized Plot

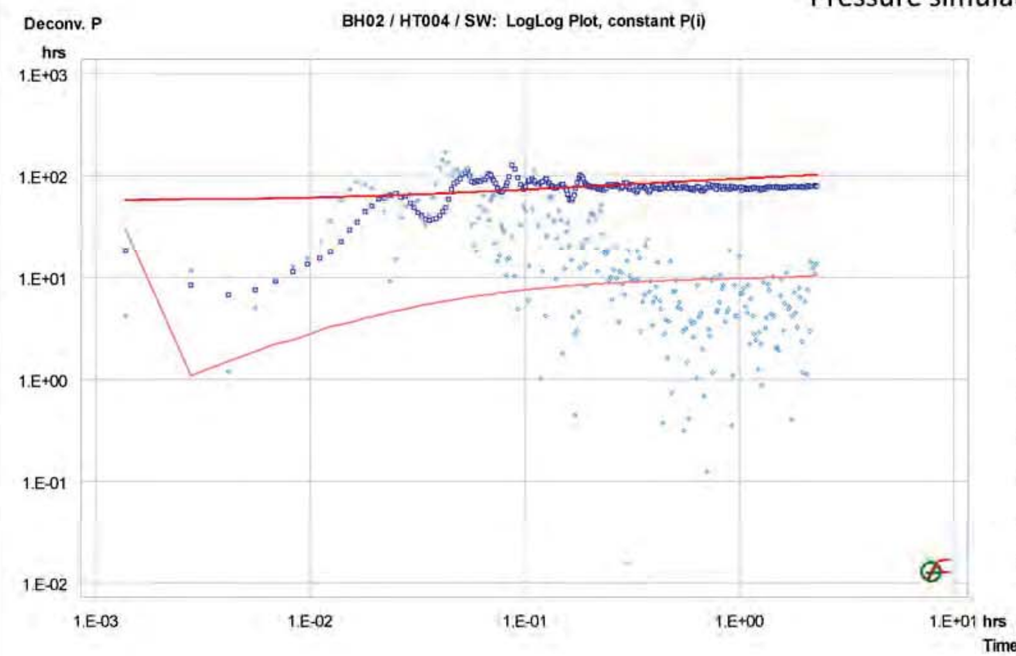


BH02 / HT004 / LogLog Diagnosis - SW

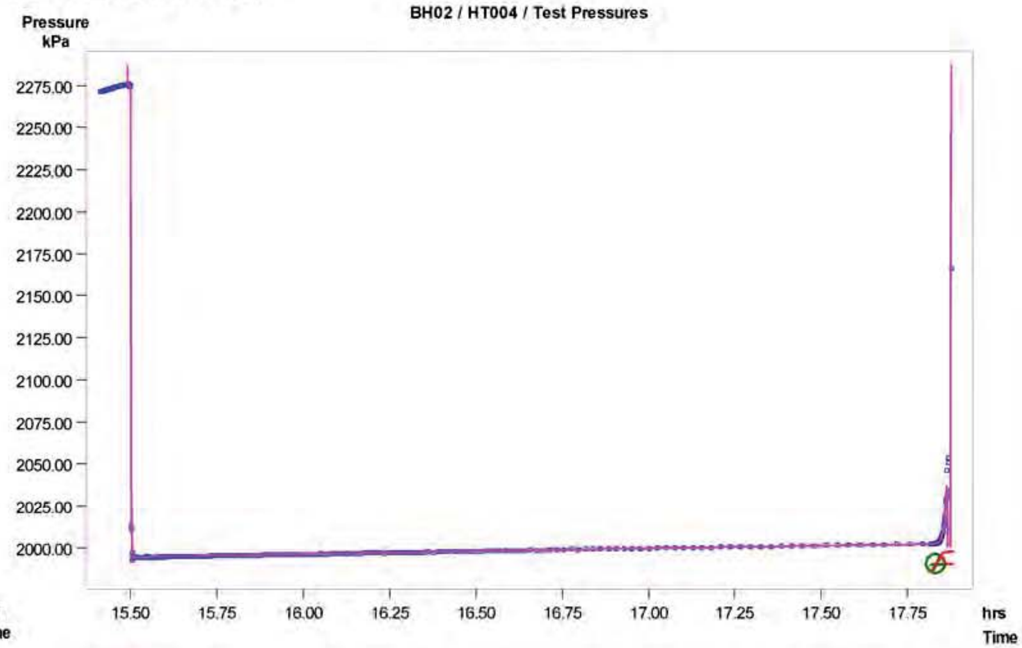
Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT004
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	1E-09
Test Zone Static Pressure (kPa)	2289
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	SW
Transmissivity [m^2/s]	4E-09
Skin	0.0
Flow Dimension [-]	2D

Pressure simulation fit shown in red

BH02 / HT004 / SW: LogLog Plot, constant P(i)



BH02 / HT004 / Test Pressures

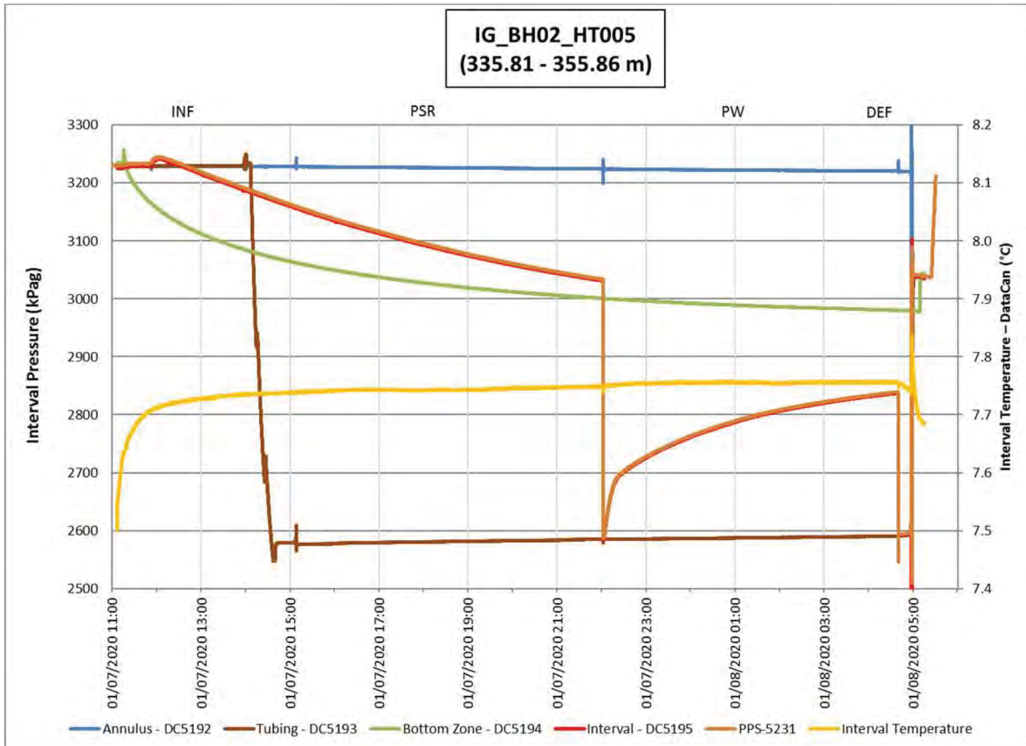


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

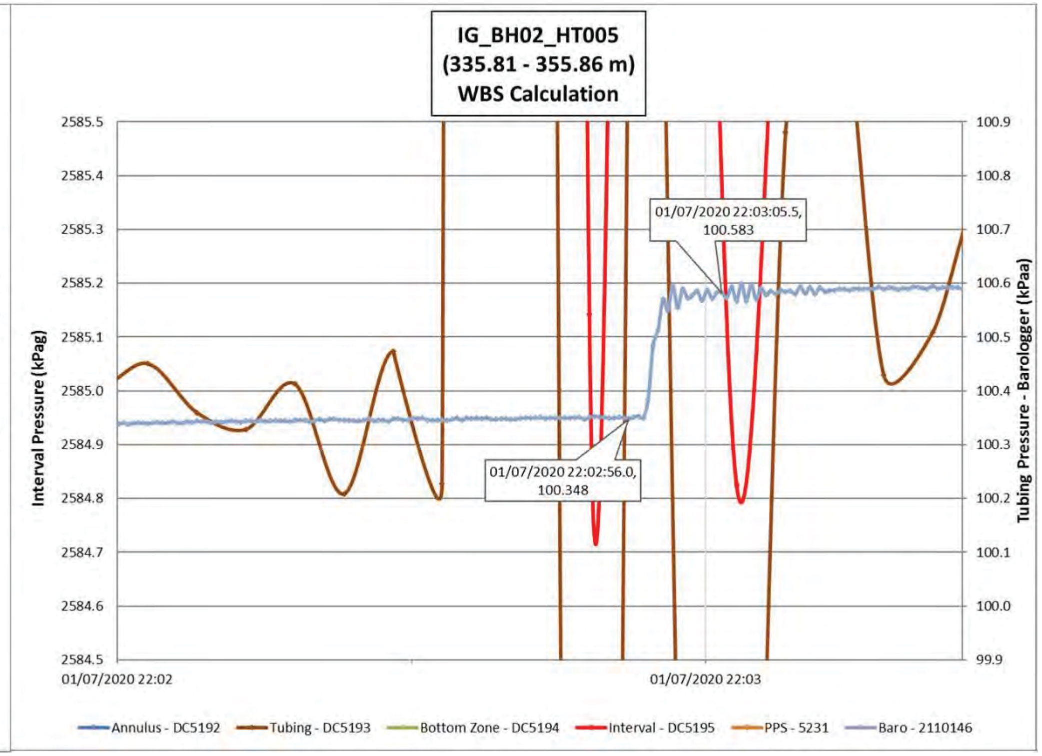
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT005 (335.81 m – 355.86 m)

Figure C9

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	3231		2E-07
PSR	Recovery	1.1	3245	443	1E-10
PW-Init	dP-Event	11.0	3034		2E-07
PW	Pulse	11.1	2590		1E-10
DEF	Variable Pressure	17.7	2839		2E-07

HT005 Summary

HT005 was selected to assess a fractured interval above 500m. Seven broken fractures were observed in the core. Based on core observations of fracture with hematization and chloritization, a purge rate assessment was conducted during drilling with a value of 0.06 mL/min. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but did not impact the pulse test. The estimated transmissivity of the outer shell was 8E-12 m^2/sec with an inner shell of higher transmissivity.

GOLDER

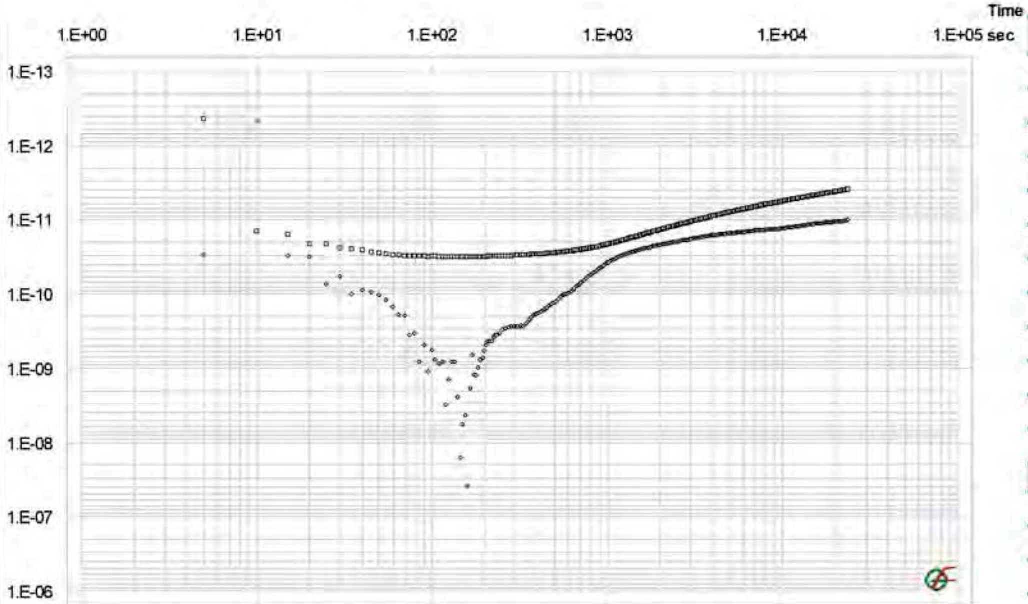
Project #: 1671632

Date: June 2021
Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT005 (335.81 m – 355.86 m)

Figure C10

Transmissivity Normalized Plot

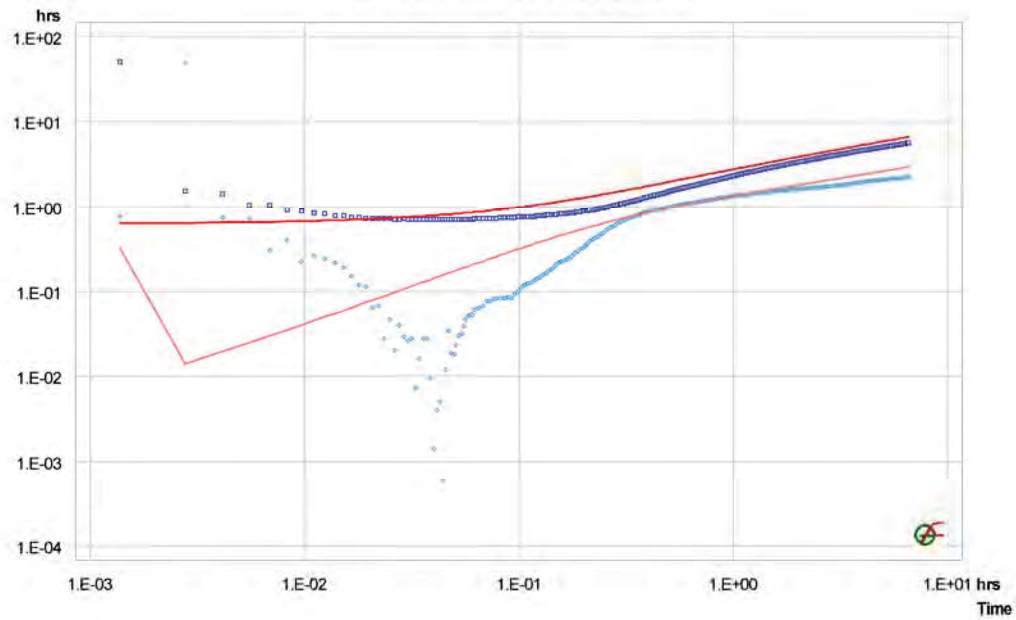


BH02 / HT005 / LogLog Diagnosis - PW-2Shell

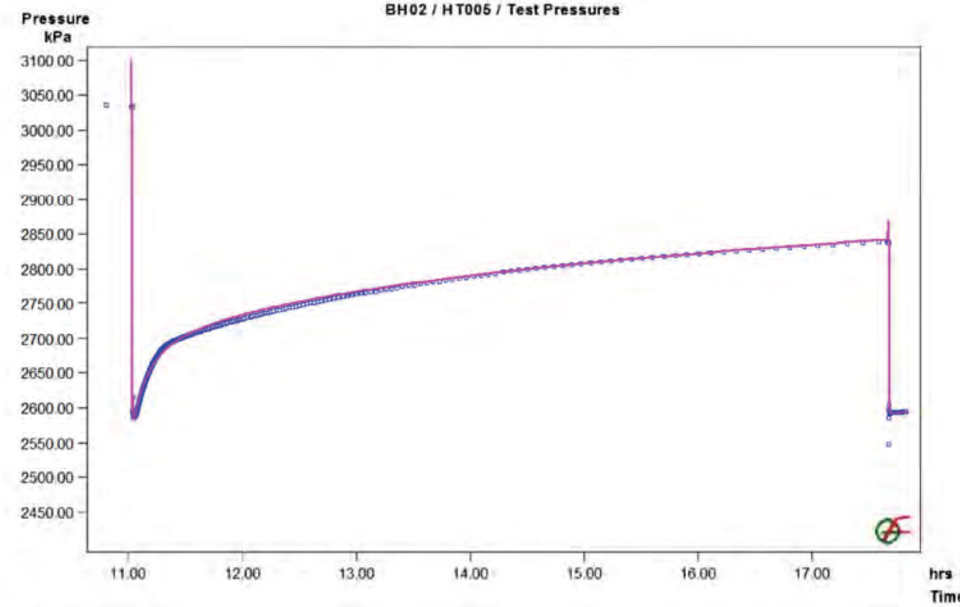
Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT005
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	8E-10
Test Zone Static Pressure (kPa)	2912
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m^2/s]	8E-11
Shell 2 Transmissivity [m^2/s]	8E-12
Shell 1 Radius [m]	0.16
Flow Dimension [-]	2D

Pressure simulation fit shown in red

BH02 / HT005 / PW: LogLog Plot, variable P(i)



BH02 / HT005 / Test Pressures



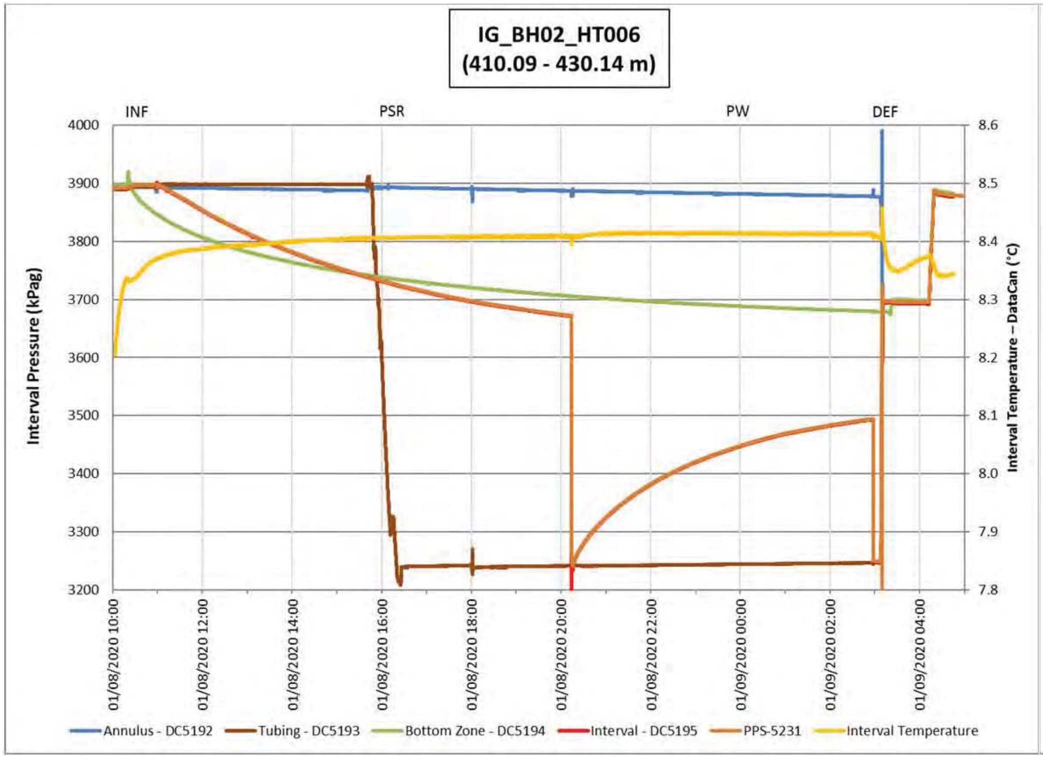
GOLDER Project #: 1671632

Date: June 2021
Checked: MLe

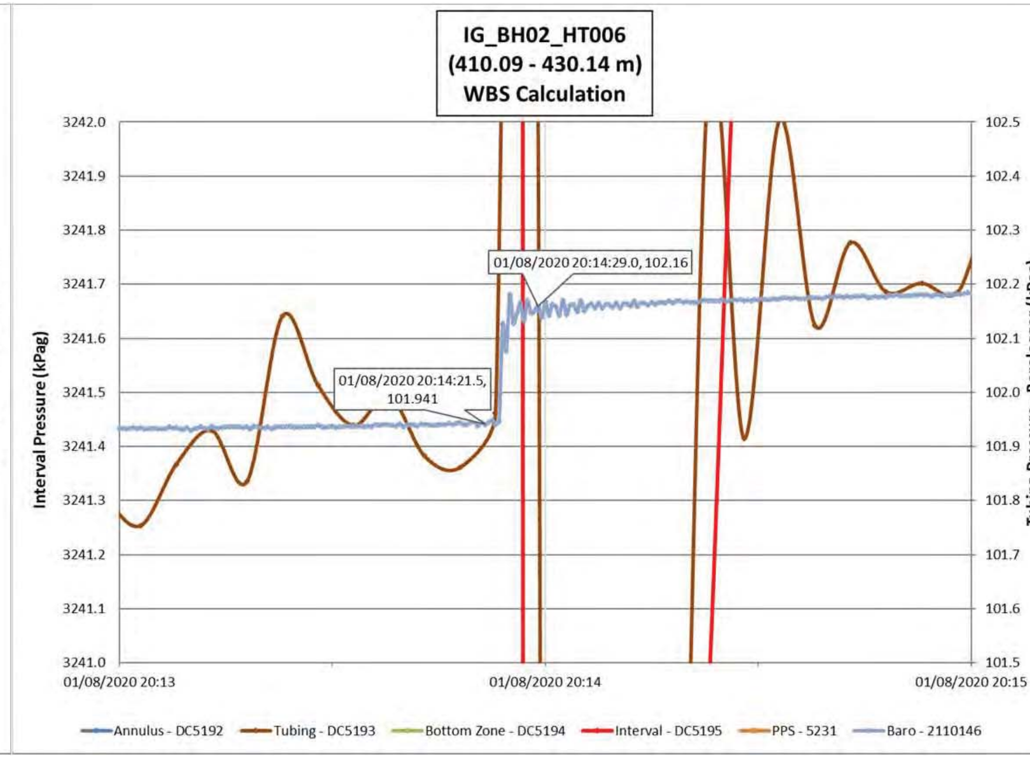
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT006 (410.09 m – 430.14 m)

Figure C11

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	3897		2E-07
PSR	Recovery	1.5	3897		1E-10
PW-Init	dP-Event	10.7	3672	427	2E-07
PW	Pulse	10.8	3245		1E-10
DEF	Variable Pressure	17.5	3494		2E-07

HT006 Summary

HT006 was selected to assess a fractured interval associated with a felsic dyke. Thirteen broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

The analyses provided a good match to the transition phase to radial flow of the recovery using a homogeneous (1-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but did not impact the pulse test. The estimated transmissivity was 2E-11 m^2/sec.

GOLDER

Project #: 1671632

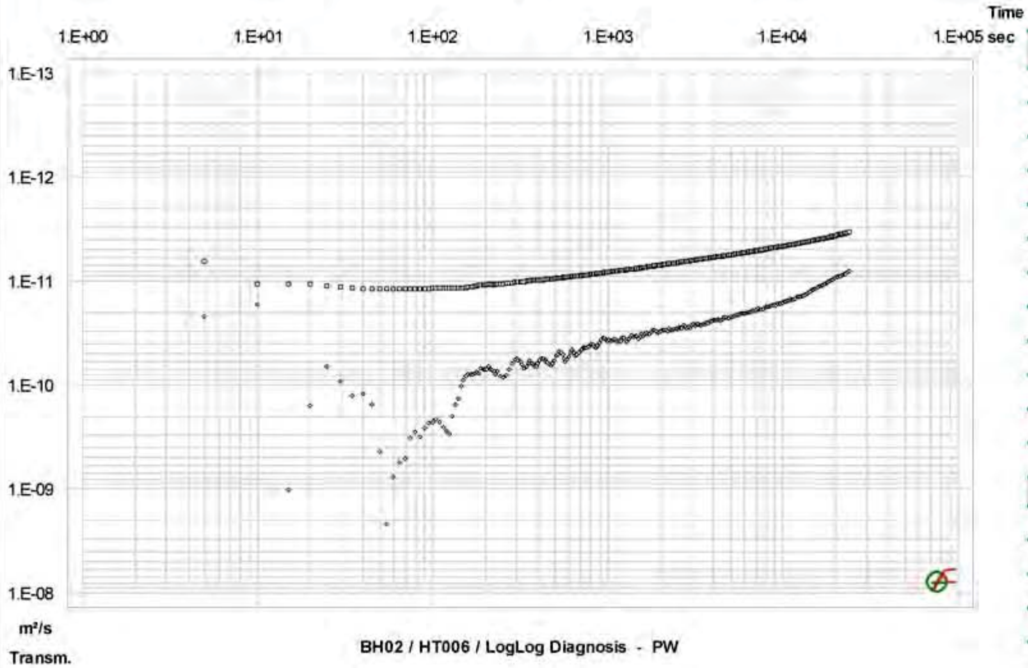
Date: June 2021

Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT006 (410.09 m – 430.14 m)

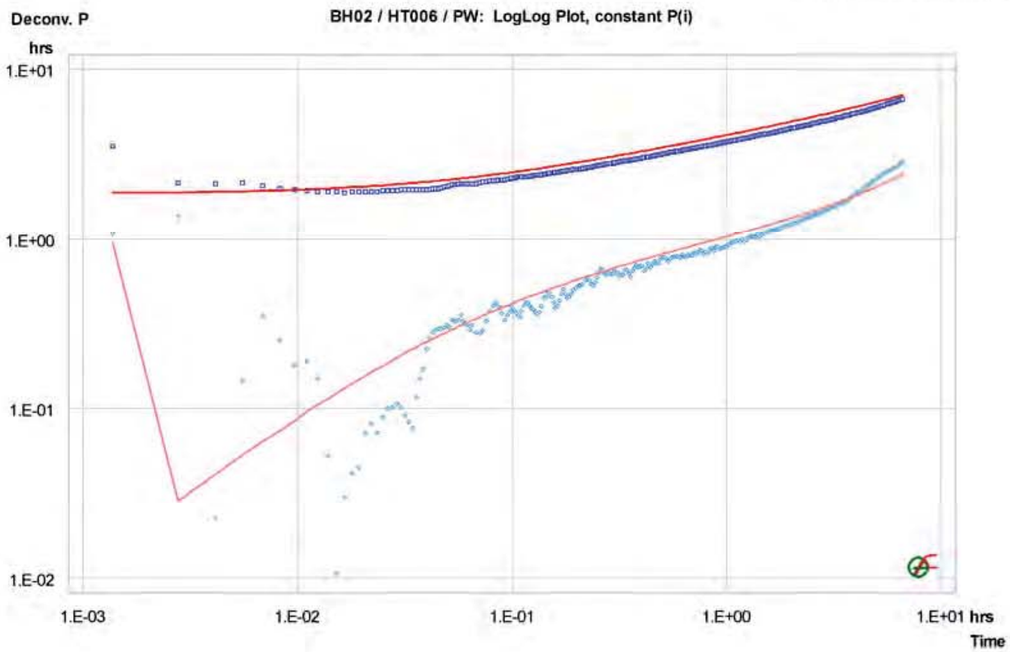
Figure C12

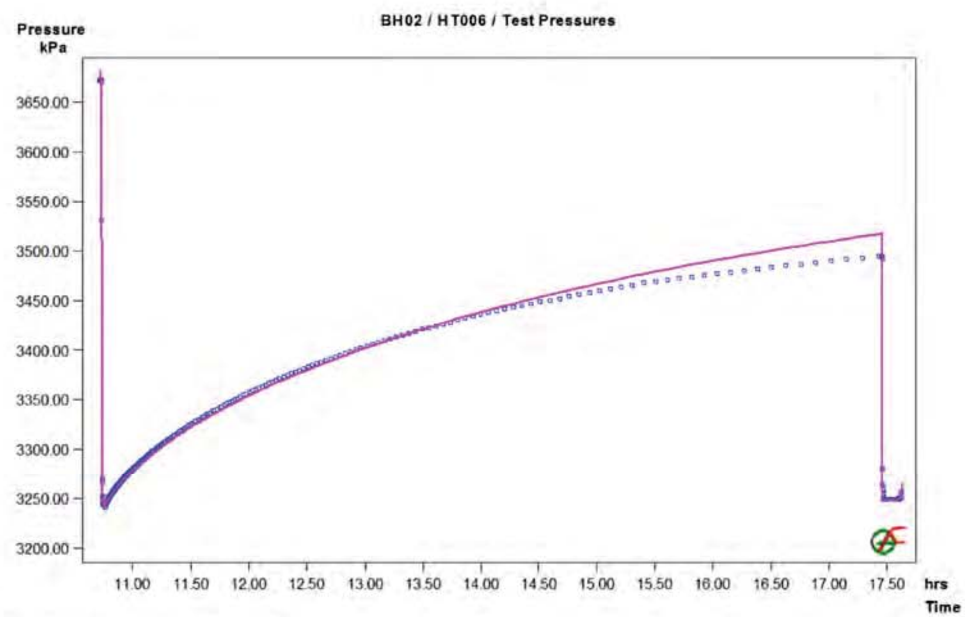
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT006
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	8E-10
Test Zone Static Pressure (kPa)	3567
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Transmissivity [m²/s]	2E-11
Skin	0.0
Flow Dimension [-]	2D

Pressure simulation fit shown in red

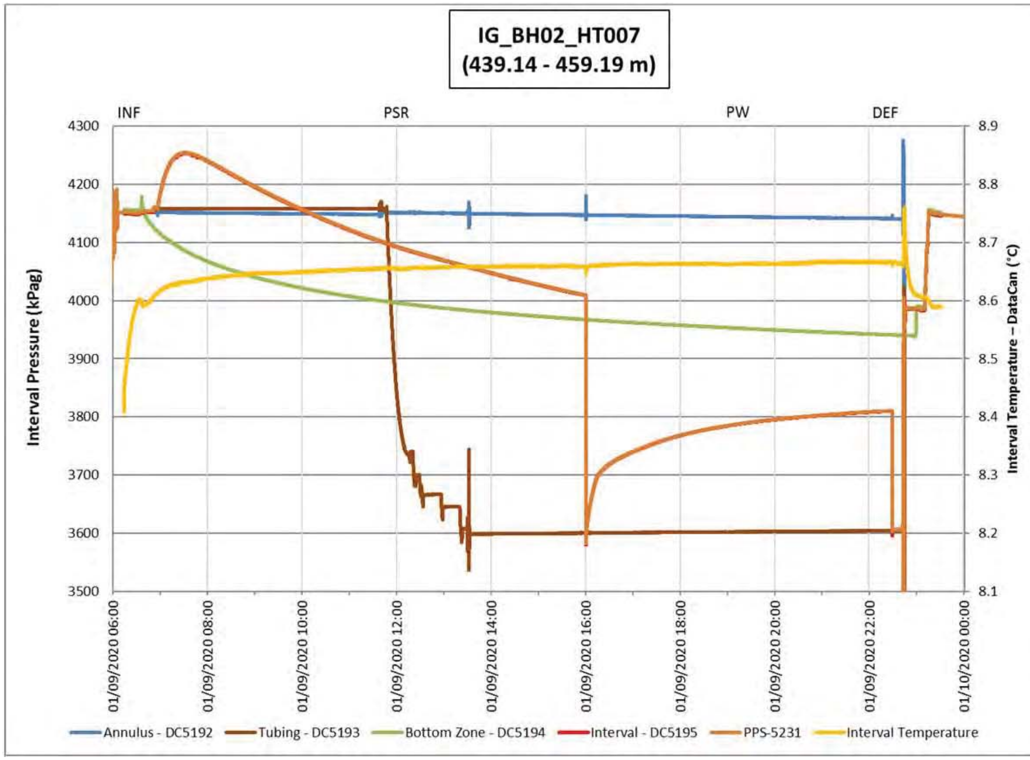




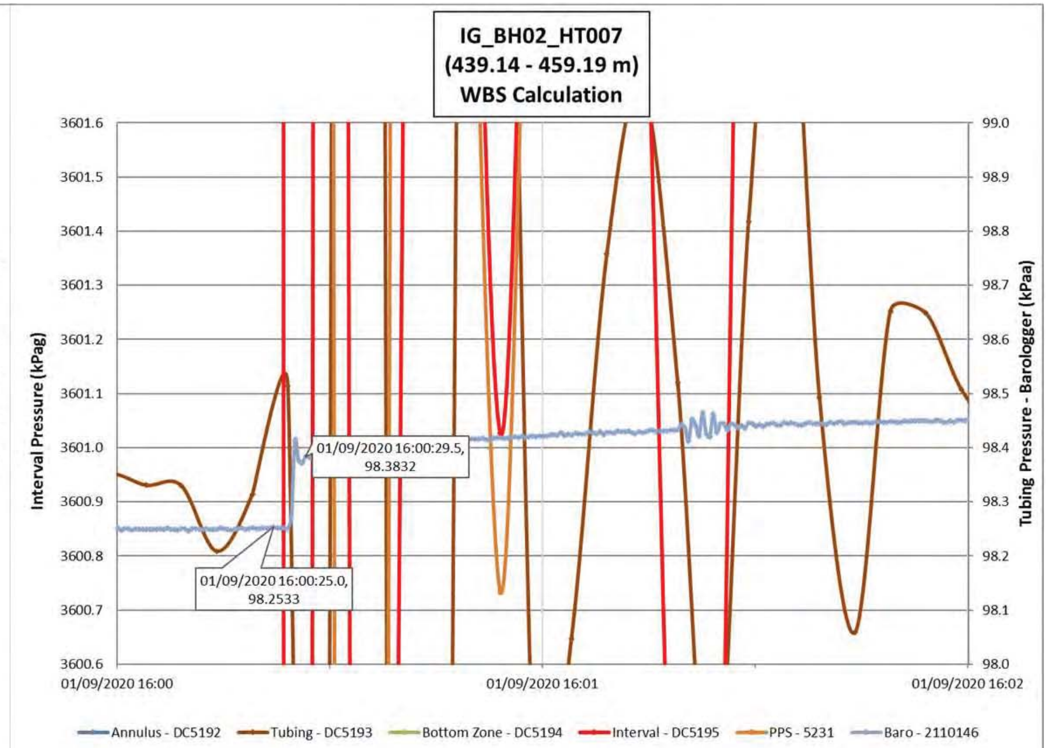
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT007 (439.14 m – 459.19 m)

Figure C13

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	4150		2E-07
PSR	Recovery	2.6	4254		7E-11
PW-Init	dP-Event	11.0	4010	405	2E-07
PW	Pulse	11.0	3605		7E-11
DEF	Variable Pressure	17.5	3810		2E-07

HT007 Summary

HT007 was selected to assess the intact rock mass with few features. Two broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

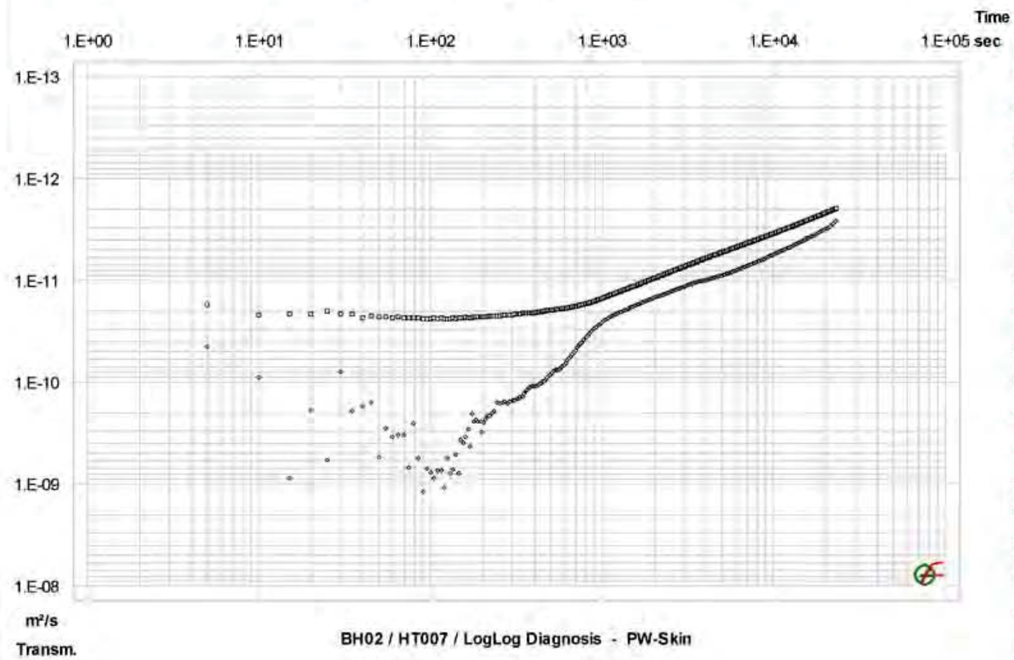
The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but did not impact the pulse test. The estimated transmissivity of the outer shell was 4E-11 m^2/sec with an inner shell of higher transmissivity.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT007 (439.14 m – 459.19 m)

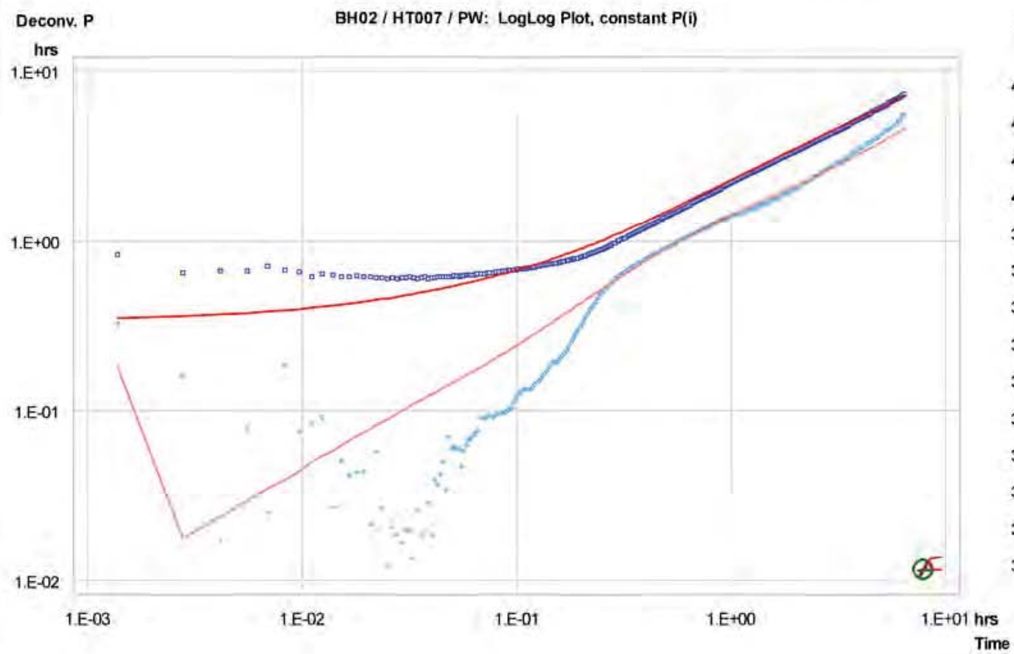
Figure C14

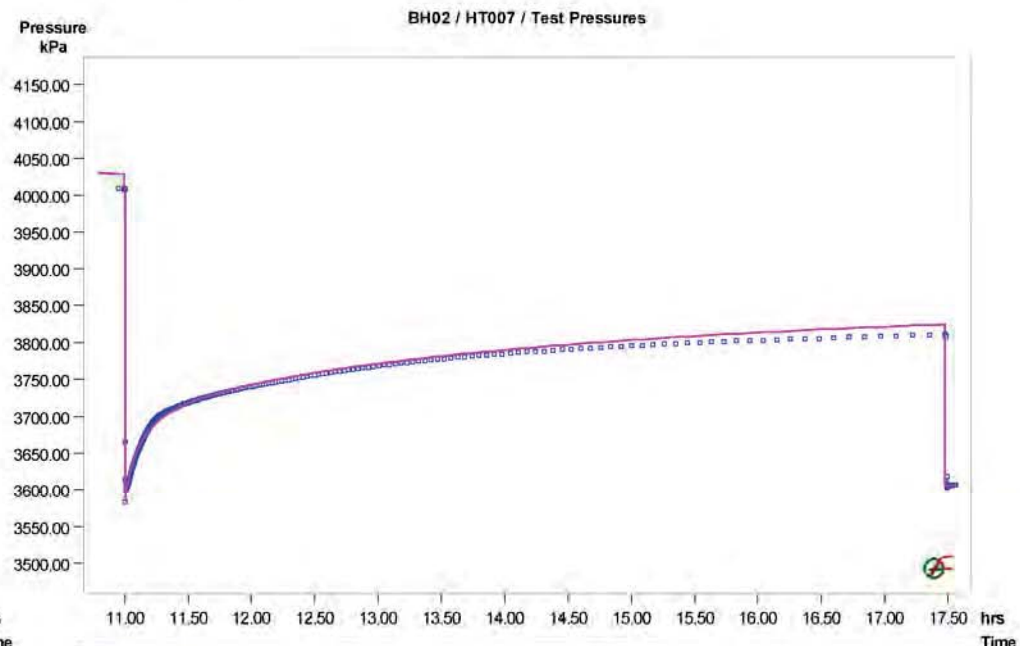
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT007
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	5E-10
Test Zone Static Pressure (kPa)	3816
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m^2/s]	3E-10
Shell 2 Transmissivity [m^2/s]	4E-11
Shell 1 Radius [m]	0.40
Flow Dimension [-]	2D

Pressure simulation fit shown in red



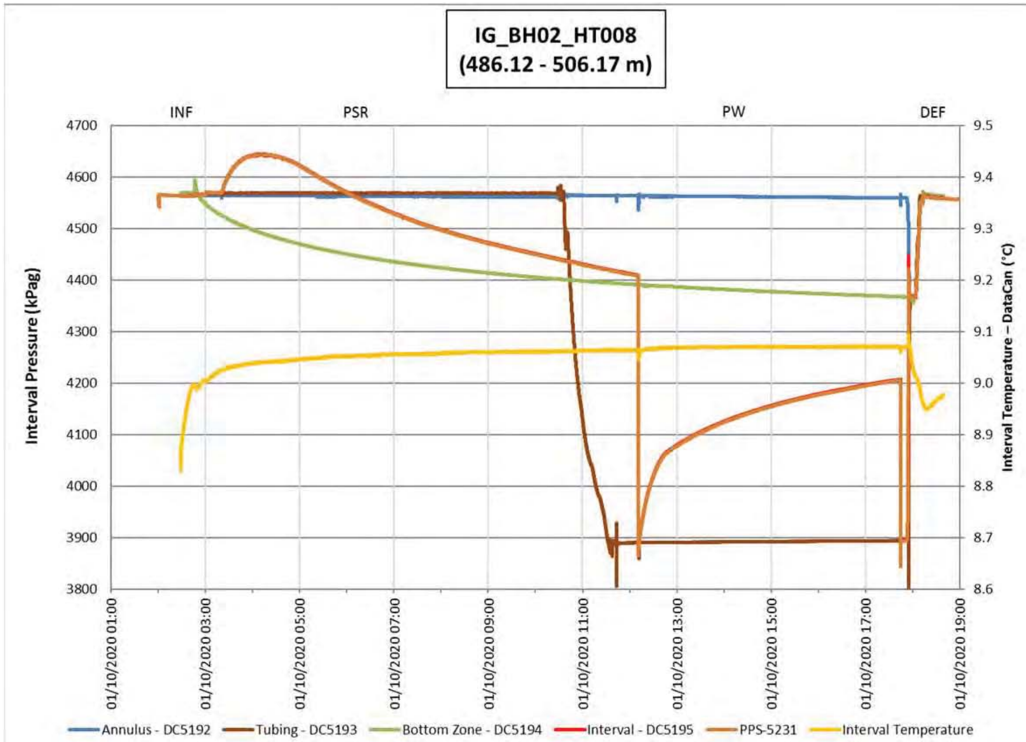


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

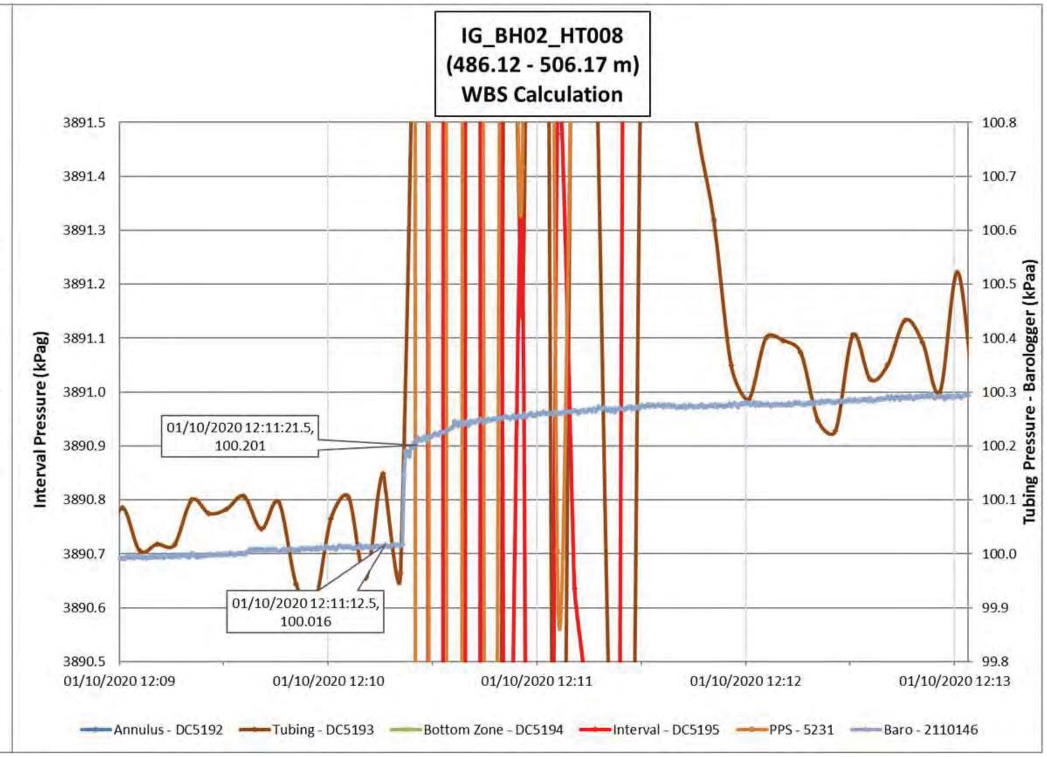
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT008 (486.12 m – 506.17 m)

Figure C15

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	4560		2E-07
PSR	Recovery	2.2	4644		8E-11
PW-Init	dP-Event	10.2	4408	516	2E-07
PW	Pulse	10.2	3892		8E-11
DEF	Variable Pressure	15.7	4206		2E-07

HT008 Summary

HT008 was selected to assess the intact rock mass with few features. Two broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

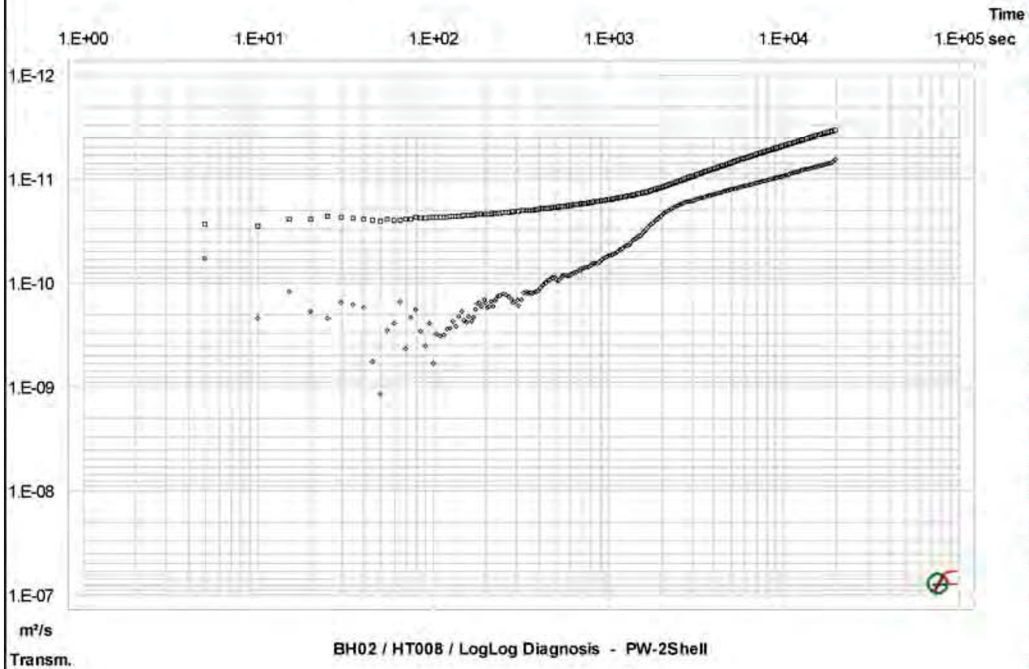
The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but did not impact the pulse test. The estimated transmissivity of the outer shell was 8E-12 m^2/sec with an inner shell of higher transmissivity.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT008 (486.12 m – 506.17 m)

Figure C16

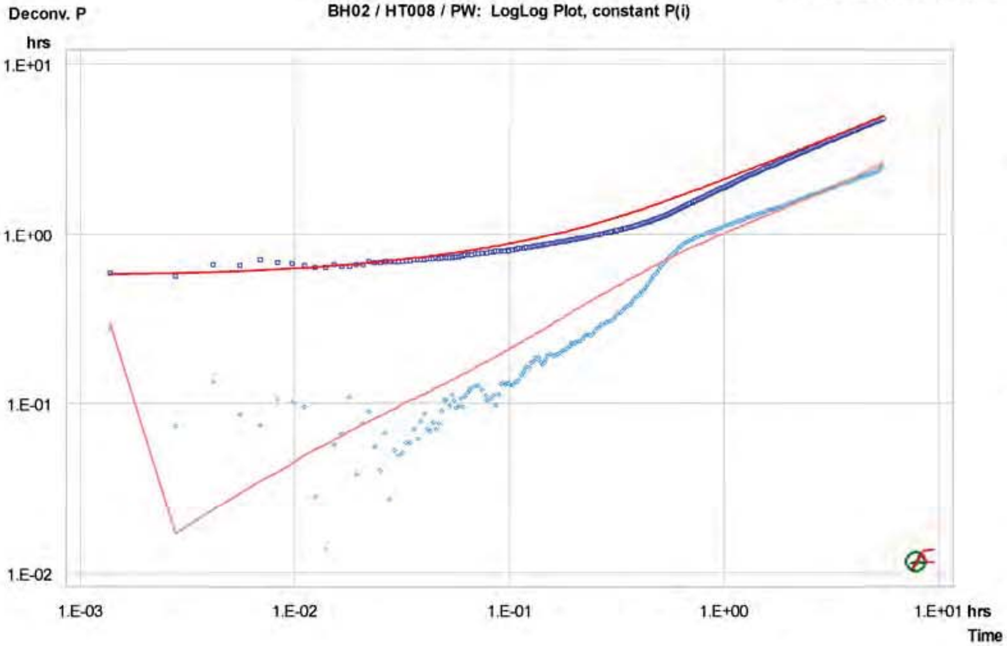
Transmissivity Normalized Plot

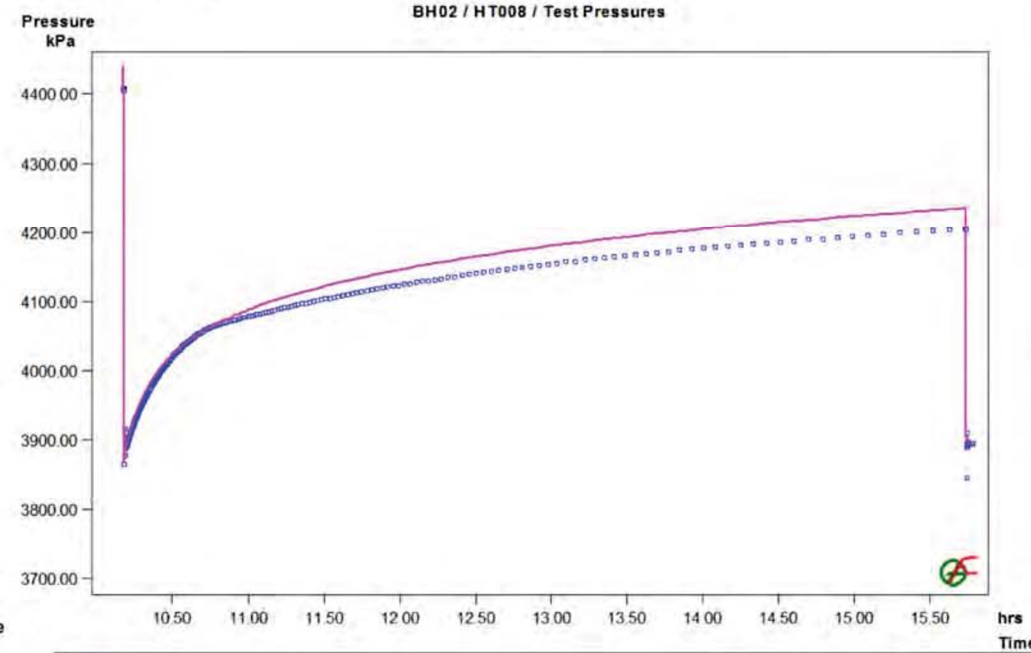


BH02 / HT008 / LogLog Diagnosis - PW-2Shell

Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT008
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	5E-10
Test Zone Static Pressure (kPa)	4201
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m²/s]	5E-11
Shell 2 Transmissivity [m²/s]	8E-12
Shell 1 Radius [m]	0.17
Flow Dimension [-]	2D

Pressure simulation fit shown in red



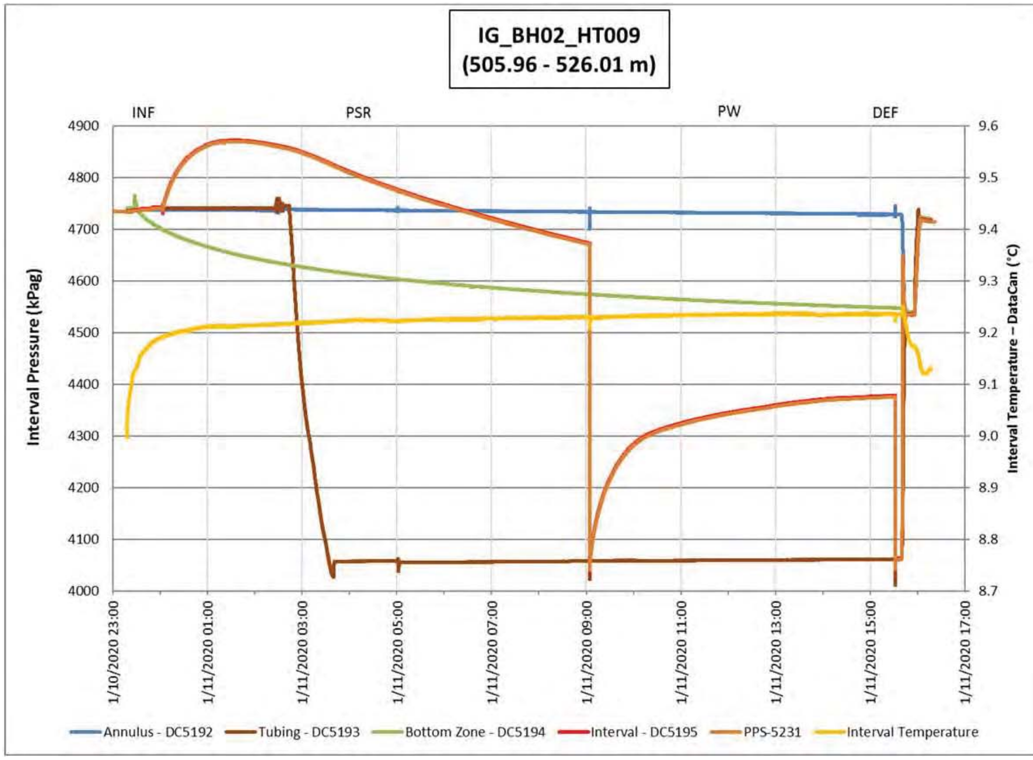


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

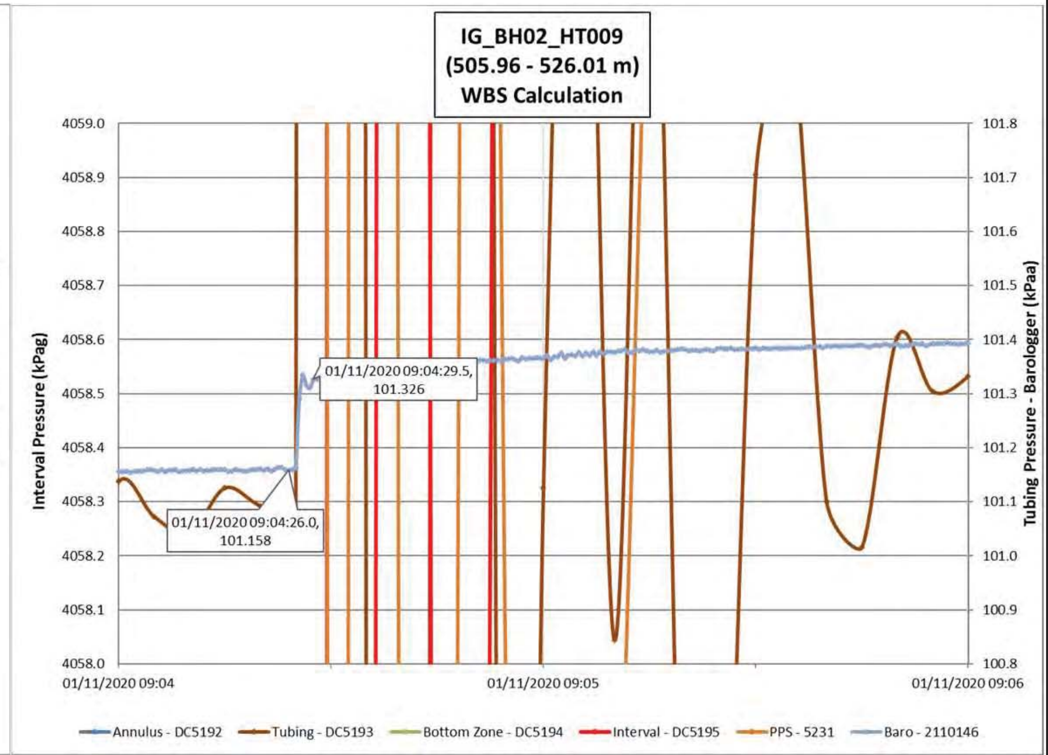
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT009 (505.96 m – 526.01 m)

Figure C17

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	4735		2E-07
PSR	Recovery	2.6	4870		6E-11
PW-Init	dP-Event	10.1	4669	611	2E-07
PW	Pulse	10.1	4057		6E-11
DEF	Variable Pressure	16.5	4376		2E-07

HT009 Summary

HT009 was selected to assess the intact rock mass with some features. Eleven broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

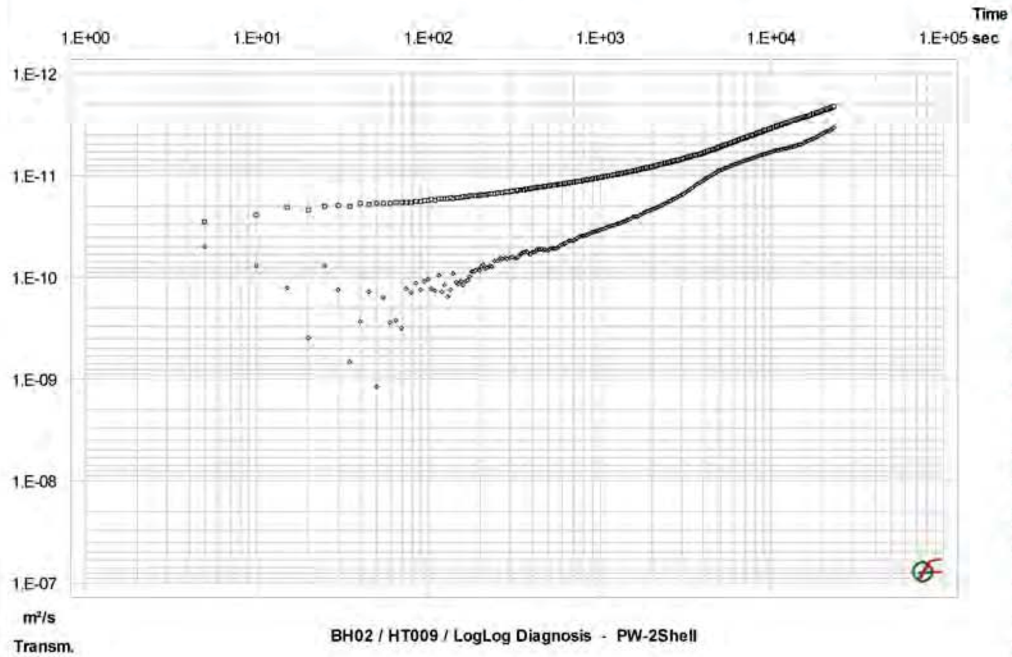
The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but did not impact the pulse test. The estimated transmissivity of the outer shell was 4E-12 m^2/sec with an inner shell of higher transmissivity.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT009 (505.96 m – 526.01 m)

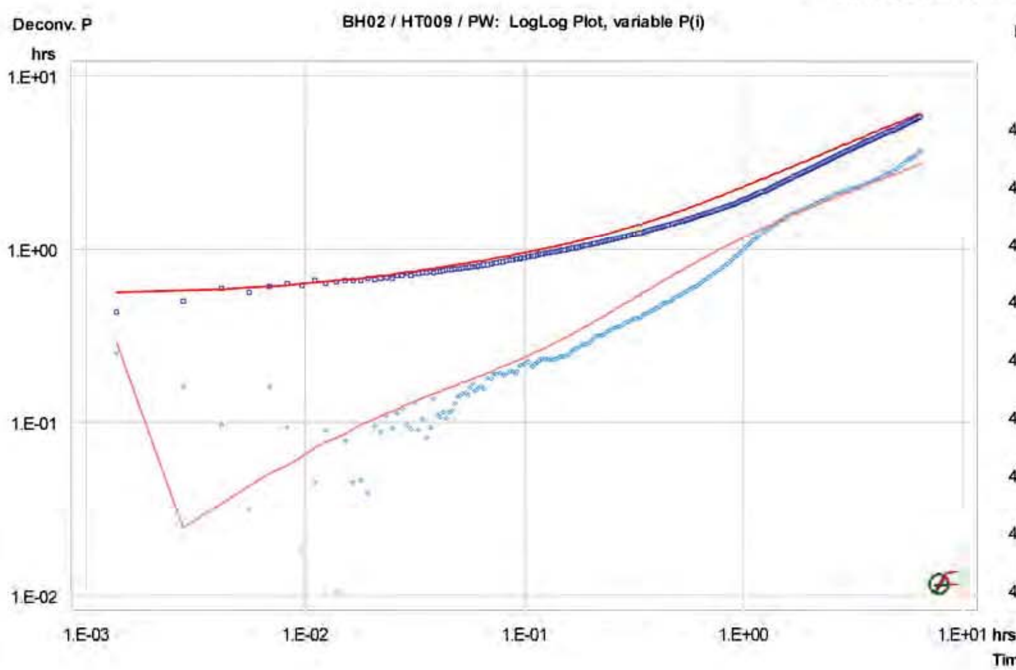
Figure C18

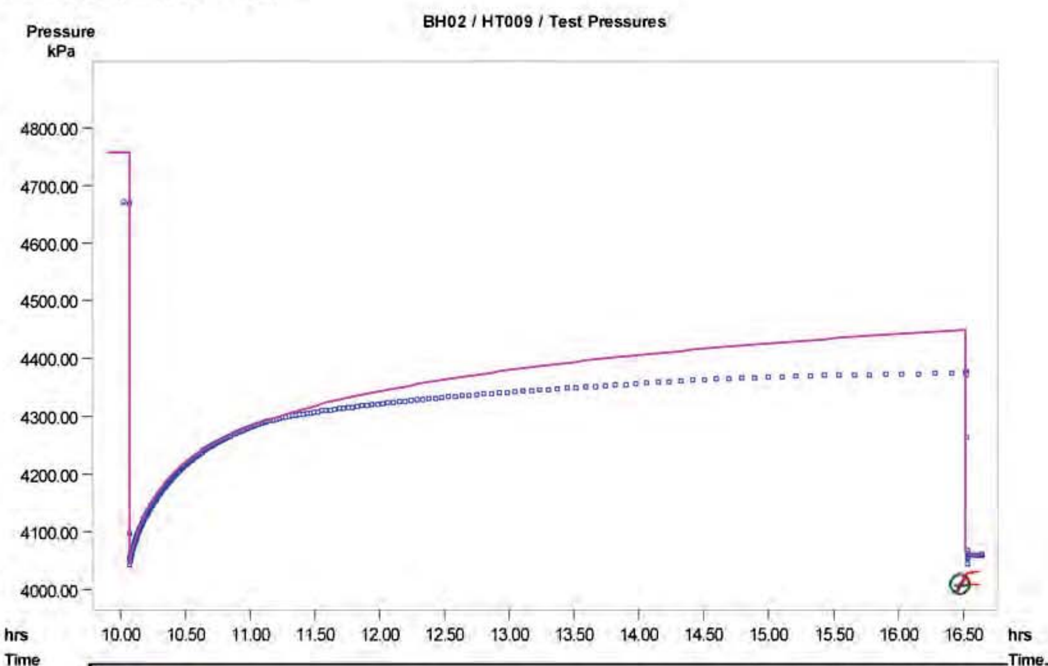
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT009
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	4E-10
Test Zone Static Pressure (kPa)	4479
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m^2/s]	3E-11
Shell 2 Transmissivity [m^2/s]	4E-12
Shell 1 Radius [m]	0.16
Flow Dimension [-]	2D

Pressure simulation fit shown in red



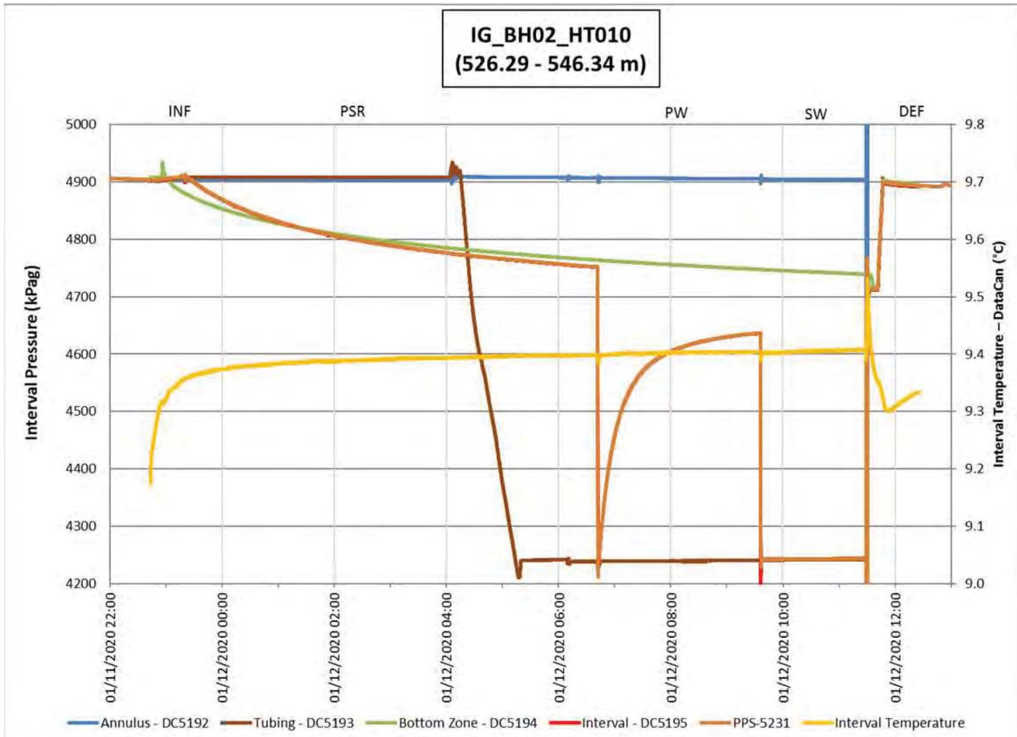


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

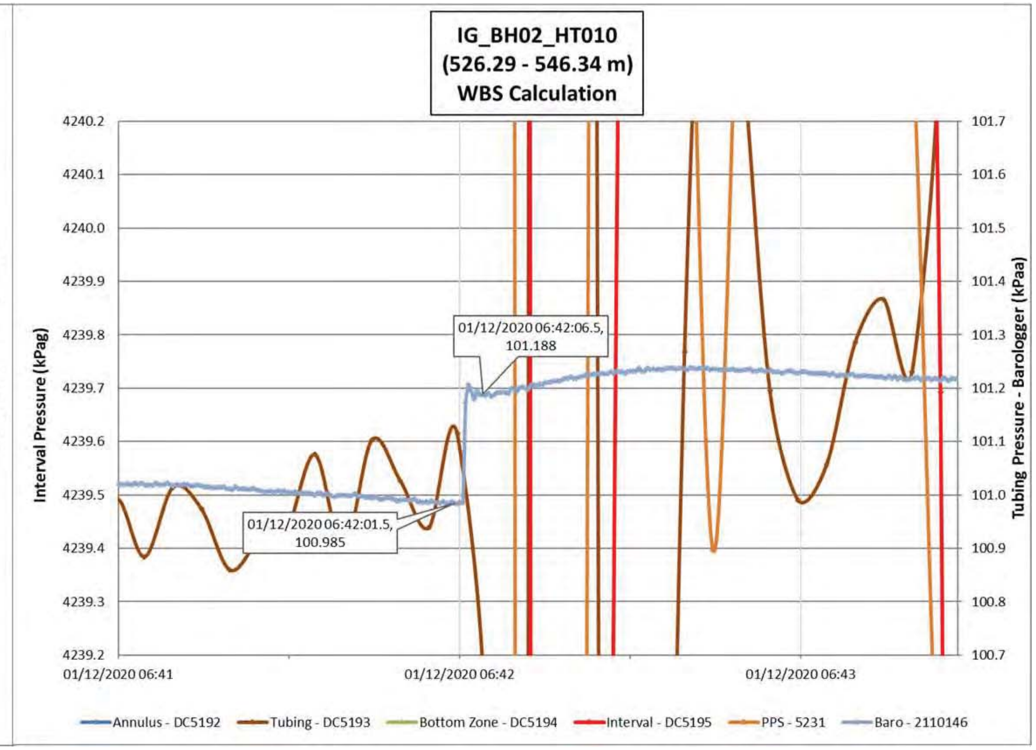
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT010 (526.29 m – 546.34 m)

Figure C19

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	4911		2E-07
PSR	Recovery	2.4	4911		9E-11
PW-Init	dP-Event	9.7	4750	507	2E-07
PW	Pulse	9.7	4243		9E-11
SW-Init	dP-Event	12.6	4636	395	2E-07
SW	Slug	12.7	4242		2E-07
DEF	Variable Pressure	14.5	4244		2E-07

HT010 Summary

HT010 was selected to assess a fractured interval associated with dykes. Twenty broken fractures were observed in the core. A decrease in drill fluid pH was observed during drilling. A decrease in resistivity was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase. The pulse test was followed by a slug withdrawal (SW) test and recovery with the DHSIV open.

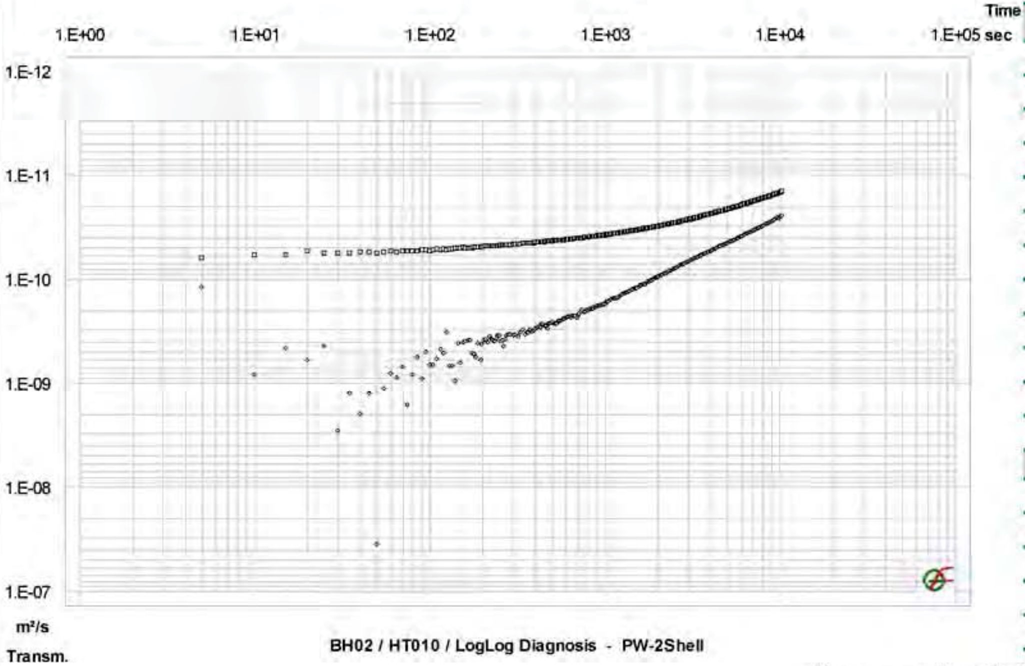
The analyses of the PW and SW phase provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Very minor leakage was noted between the rods and annulus above the test interval, but at low rate that did not impact the slug test. The estimated transmissivity of the outer shell was 4E-11 m^2/sec with an inner shell of higher transmissivity.

GOLDER   Project #: 1671632   Date: June 2021   Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT010 (526.29 m – 546.34 m)

Figure C20

Transmissivity Normalized Plot

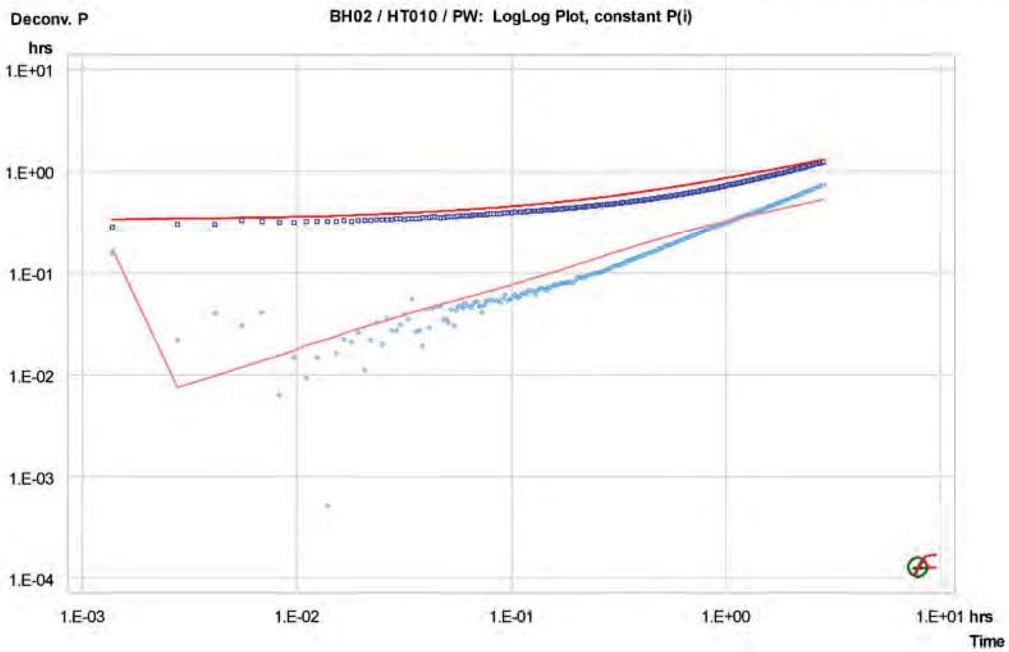


BH02 / HT010 / LogLog Diagnosis - PW-2Shell

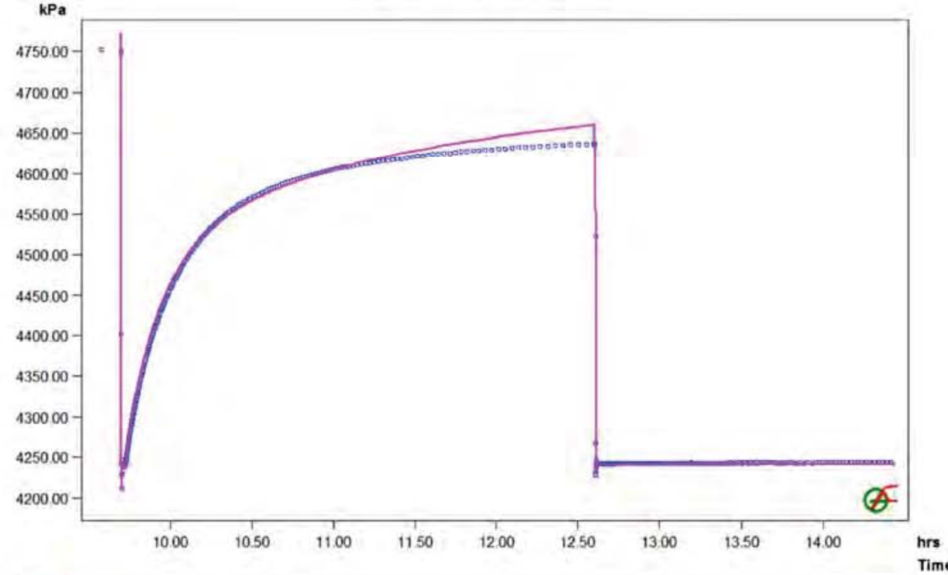
Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT010
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	6E-10
Test Zone Static Pressure (kPa)	4697
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m^2/s]	1E-10
Shell 2 Transmissivity [m^2/s]	4E-11
Shell 1 Radius [m]	0.31
Flow Dimension [-]	2D

Pressure simulation fit shown in red

BH02 / HT010 / PW: LogLog Plot, constant P(i)



BH02 / HT010 / Test Pressures

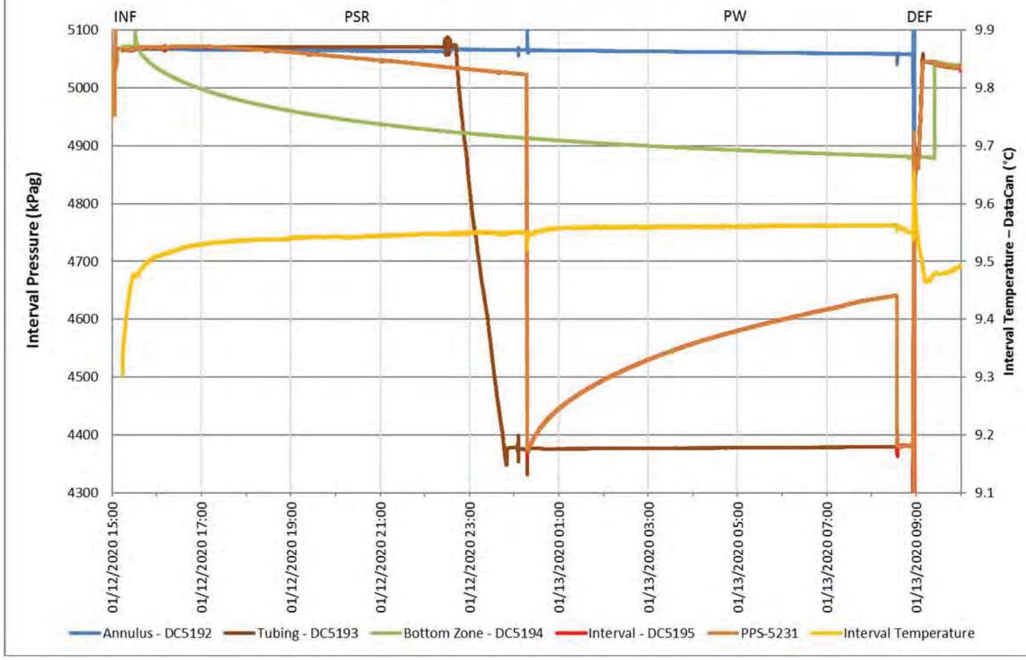


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

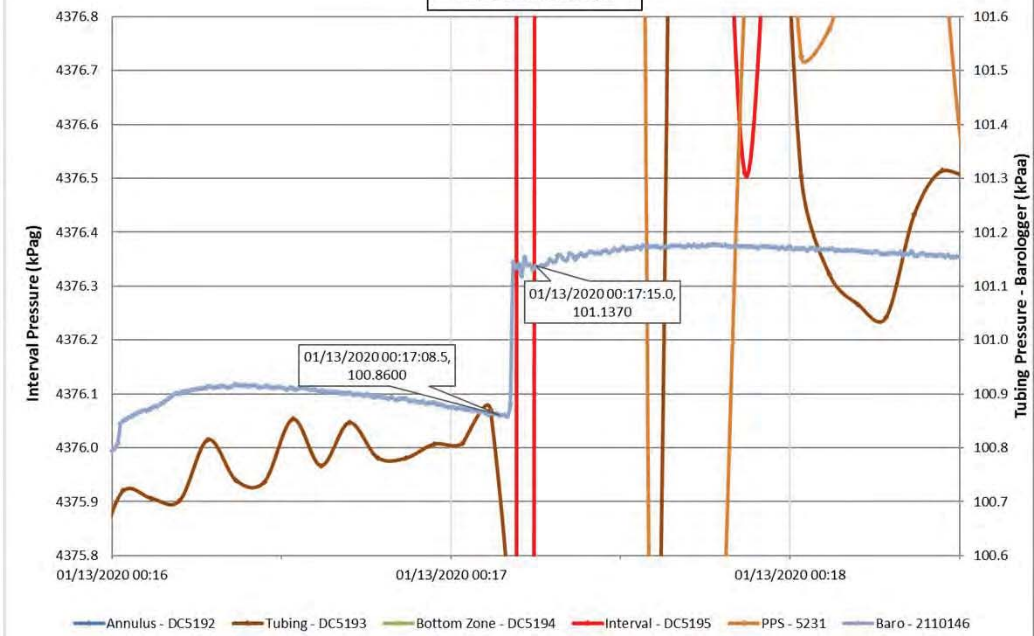
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT011 (544.22 m – 564.27 m)

Figure C21

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	5072		2E-07
PSR	Recovery	2.7	5072		9E-11
PW-Init	dP-Event	10.3	5023	651	2E-07
PW	Pulse	10.3	4371		9E-11
DEF	Variable Pressure	18.6	4641		2E-07

HT011 Summary

HT011 was selected to assess a slightly fractured interval. Four broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

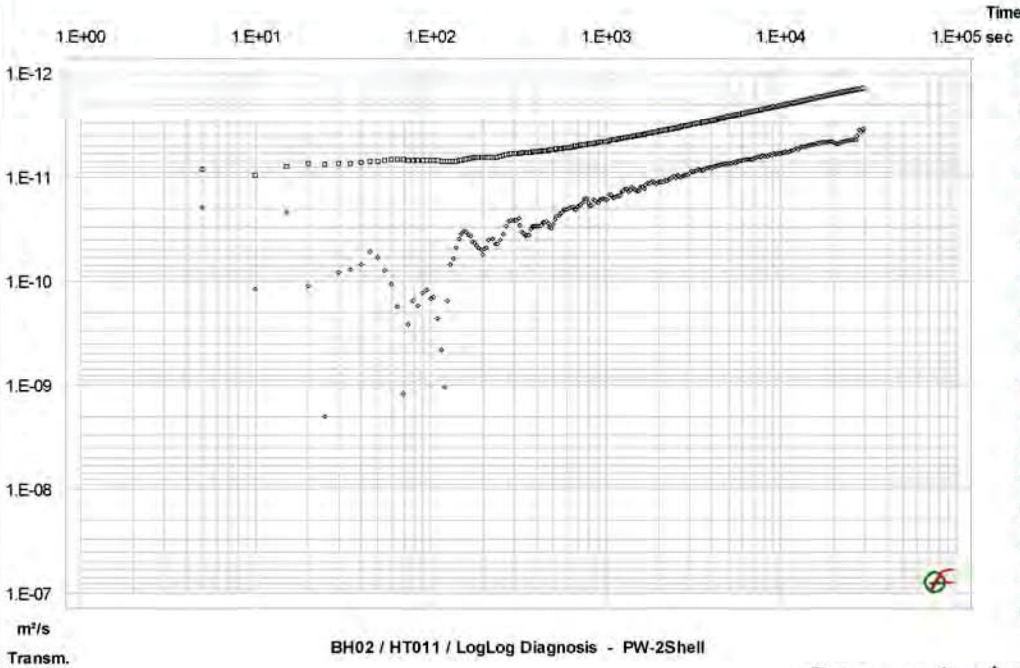
The analyses provided a good match to the transition phase to radial flow of the recovery using a homogeneous (1-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but did not impact the pulse test. The estimated transmissivity was 6E-12 m^2/sec.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT011 (544.22 m – 564.27 m)

Figure C22

Transmissivity Normalized Plot

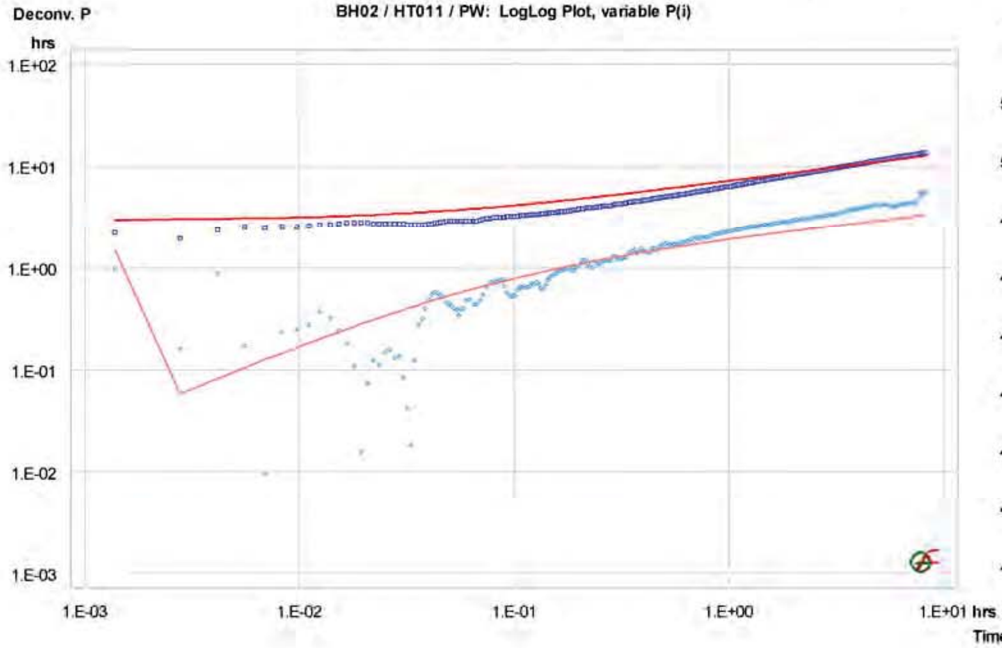


BH02 / HT011 / LogLog Diagnosis - PW-2Shell

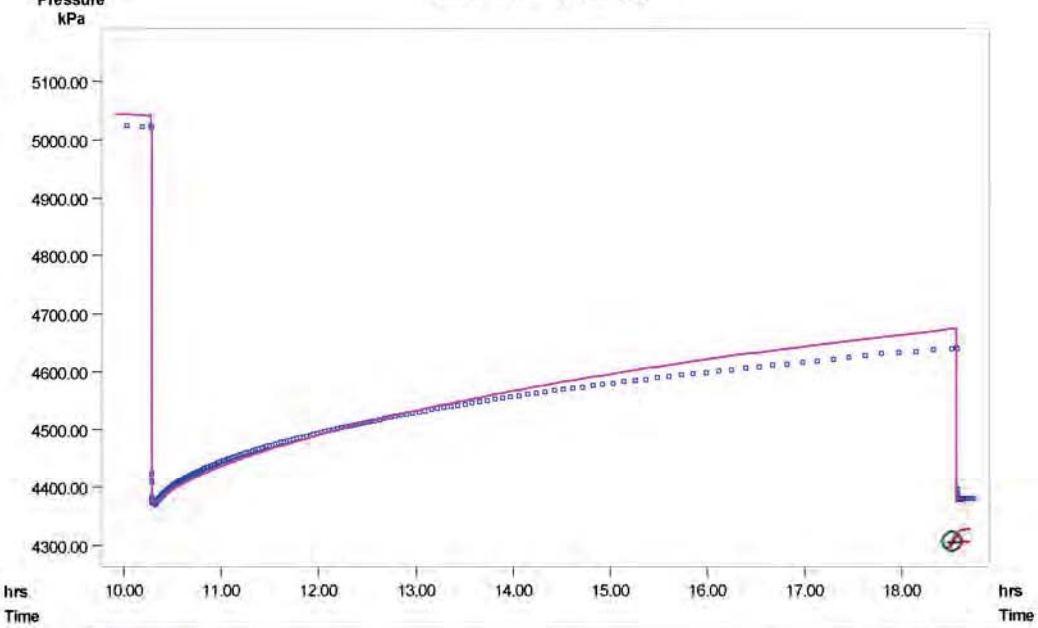
Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT011
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	6E-10
Test Zone Static Pressure (kPa)	4968
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Transmissivity [m²/s]	6E-12
Skin	0.0
Flow Dimension [-]	2D

Pressure simulation fit shown in red

BH02 / HT011 / PW: LogLog Plot, variable P(i)



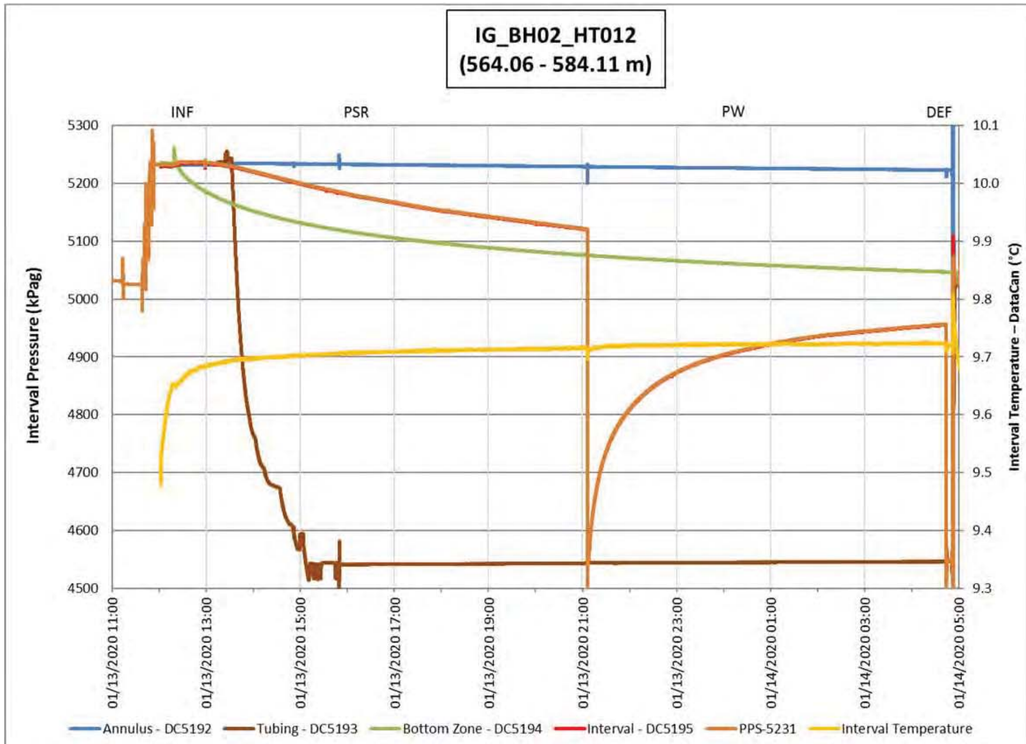
BH02 / HT011 / Test Pressures



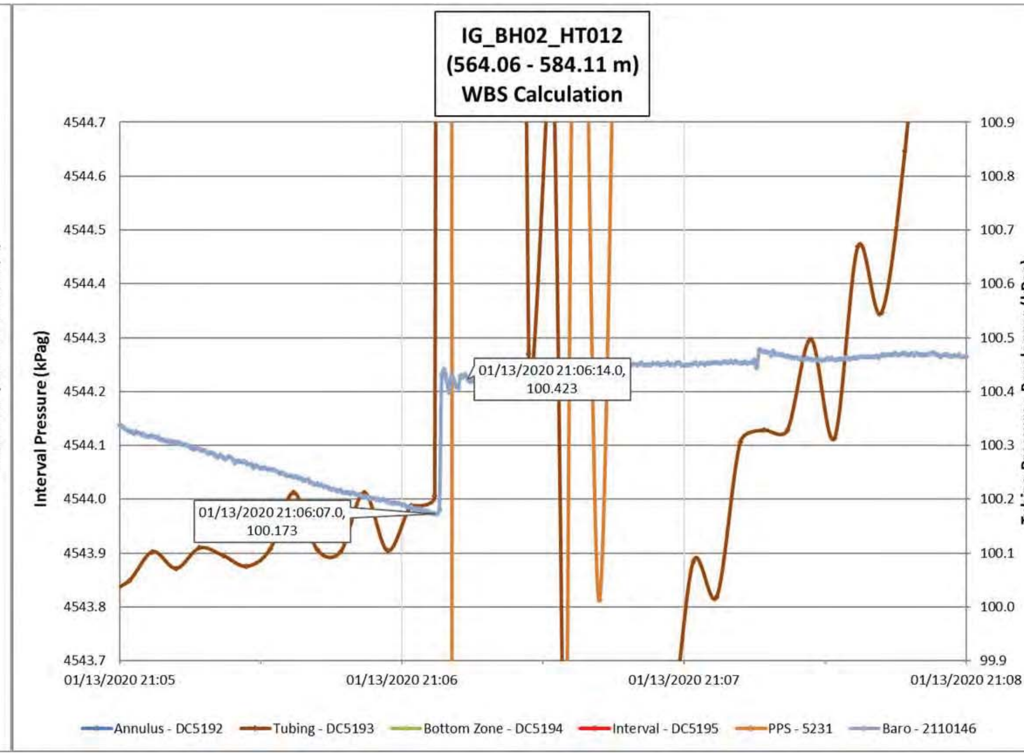
GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02 IG_BH02_HT012 (564.06 m – 584.11 m)	Figure C23

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	5232		2E-07
PSR	Recovery	1.7	5237		9E-11
PW-INIT	dP-Event	10.1	5119	572	2E-07
PW	Pulse	10.1	4546		9E-11
DEF	Variable Pressure	17.7	4956		2E-07

HT012 Summary

HT012 was selected to assess an interval containing aplite and amphibolite dykes with few fractures. Six broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. A decrease in resistivity was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

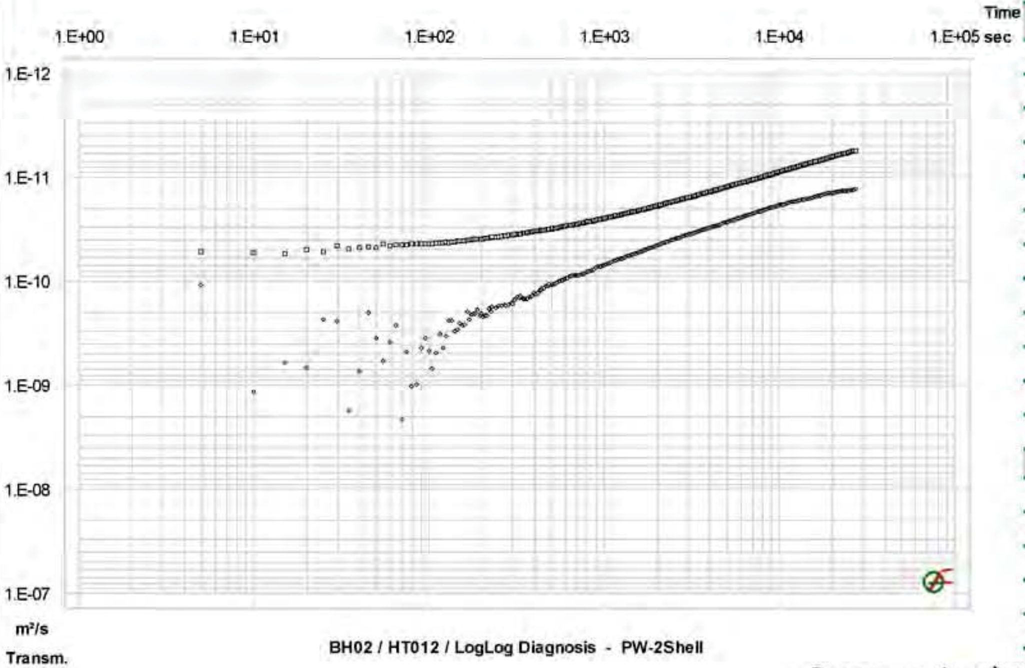
The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but did not impact the pulse test. The estimated transmissivity of the outer shell was 2E-11 m^2/sec with an inner shell of higher transmissivity.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT012 (564.06 m – 584.11 m)

Figure C24

Transmissivity Normalized Plot

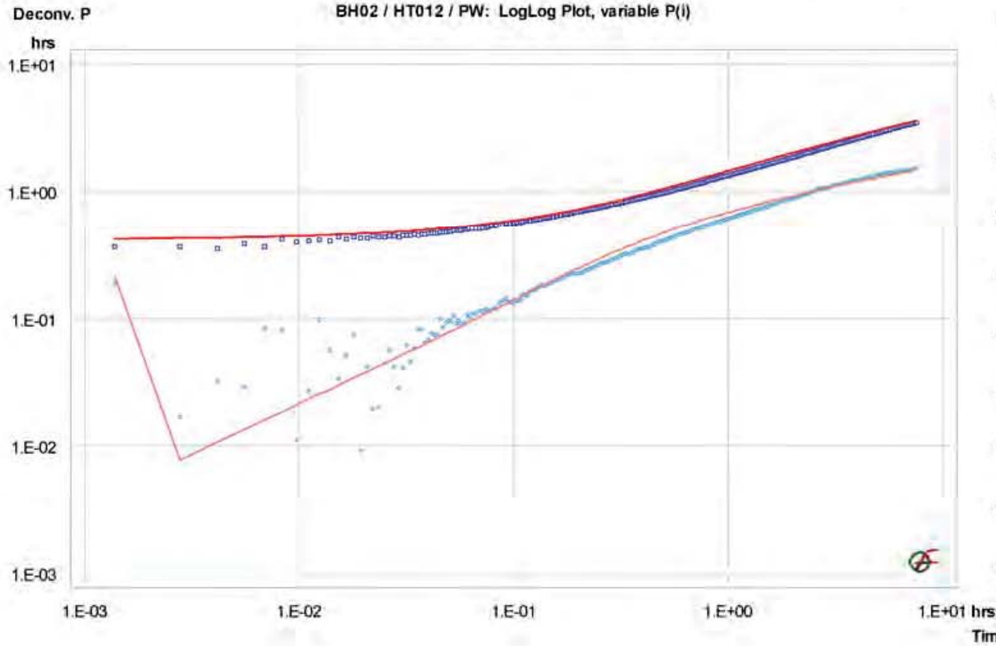


BH02 / HT012 / LogLog Diagnosis - PW-2Shell

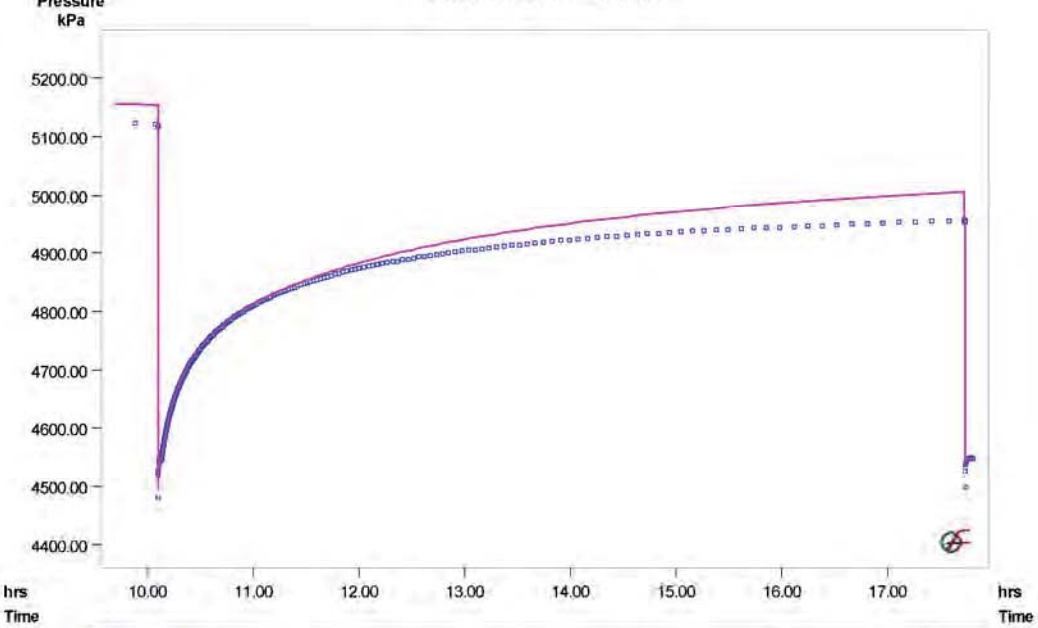
Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT012
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	6E-10
Test Zone Static Pressure (kPa)	4976
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m²/s]	1E-10
Shell 2 Transmissivity [m²/s]	2E-11
Shell 1 Radius [m]	0.22
Flow Dimension [-]	2D

Pressure simulation fit shown in red

BH02 / HT012 / PW: LogLog Plot, variable P(i)



BH02 / HT012 / Test Pressures



GOLDER

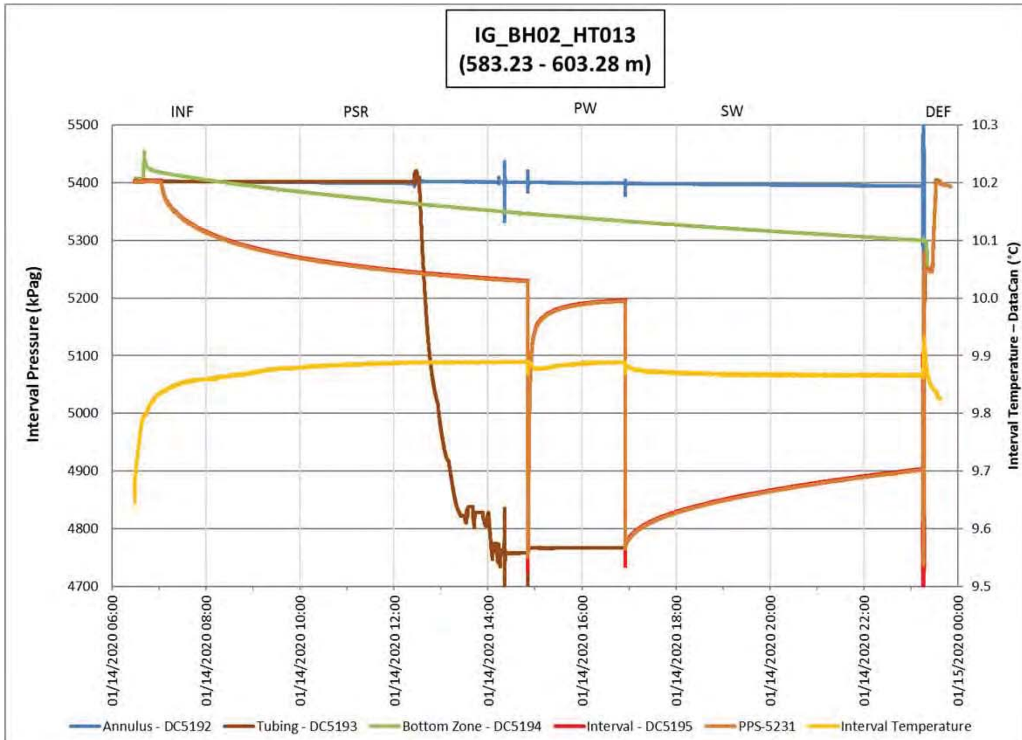
Project #: 1671632

Date: June 2021
Checked: MLe

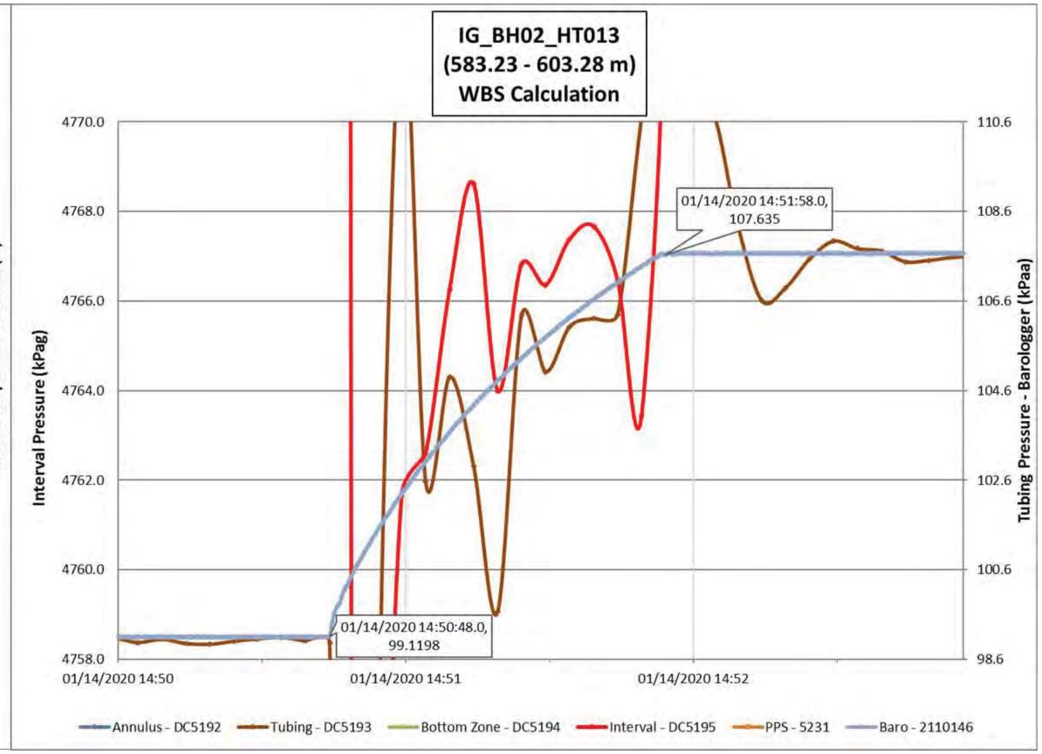
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT013 (583.23 m – 603.28 m)

Figure C25

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	5401		2E-07
PSR	Recovery	0.6	5401		4E-09
PW-Init	dP-Event	8.3	5228	465	2E-07
PW	Pulse	8.4	4763		4E-09
SW-Init	dP-Event	10.4	5194	422	2E-07
SW	Slug	10.4	4772		2E-07
DEF	Variable Pressure	16.7	4901		2E-07

HT013 Summary

HT013 was selected to assess a fractured interval with a pegmatite dyke. Ten broken fractures were observed in the core. An increase in drill fluid electrical conductivity was observed during drilling. Decreases in both resistivity and temperature gradient were recorded during FFEC logging post-drilling indicating potential flow.

The test was initiated with a shut-in pressure recovery phase (PSR). A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase. The pulse test was followed by a slug withdrawal (SW) test and recovery with the DHSIV open.

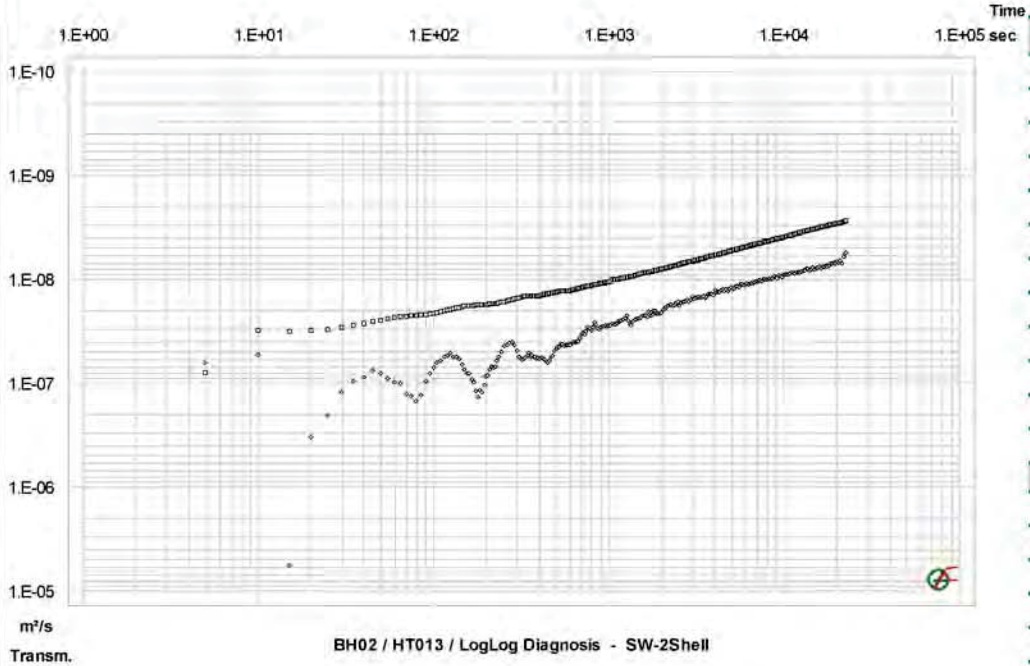
The analyses provided a good match to the transition phase to radial flow of the SW and PW recovery phase using a composite (2-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but at a low rate that did not impact the testing. The estimated transmissivity of the outer shell was 6E-09 m^2/sec with an inner shell of higher transmissivity.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT013 (583.23 m – 603.28 m)

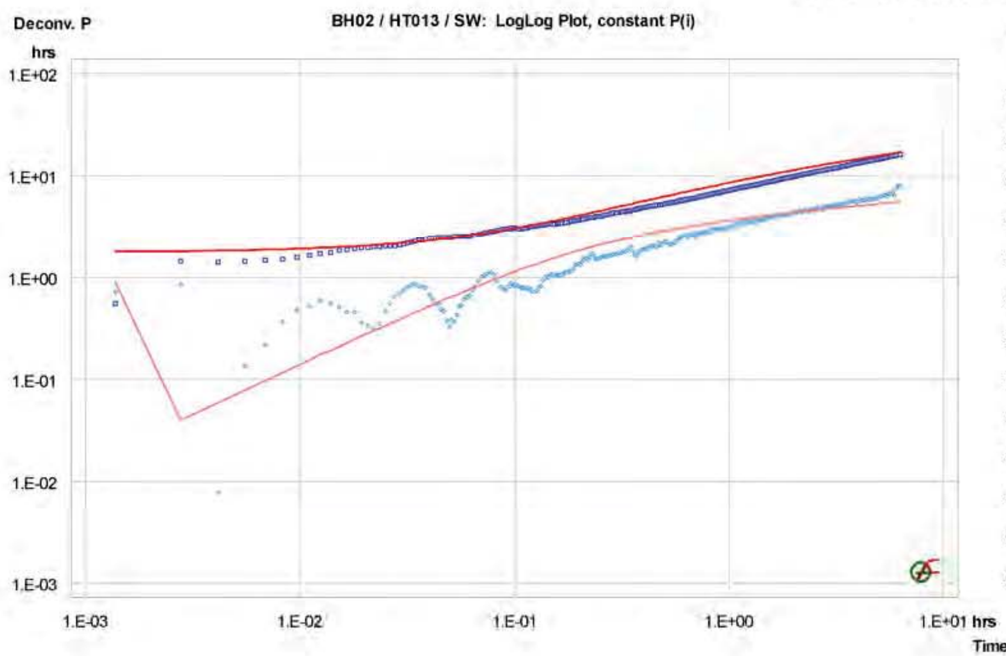
Figure C26

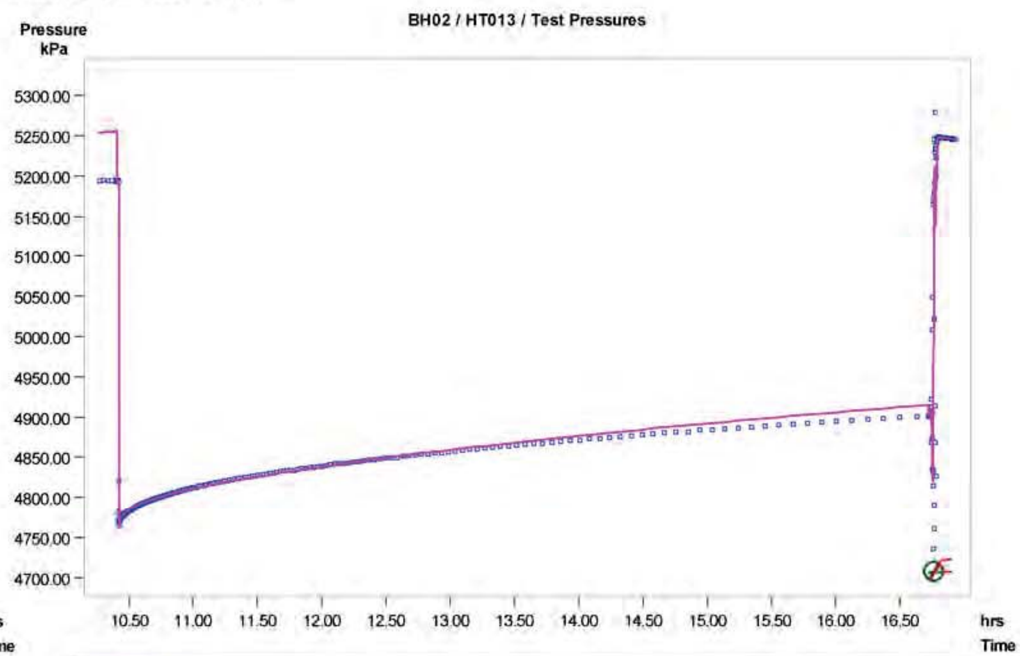
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT013
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	3E-08
Test Zone Static Pressure (kPa)	5190
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	SW
Shell 1 Transmissivity [m²/s]	2E-07
Shell 2 Transmissivity [m²/s]	6E-09
Shell 1 Radius [m]	2.97
Flow Dimension [-]	2D

Pressure simulation fit shown in red



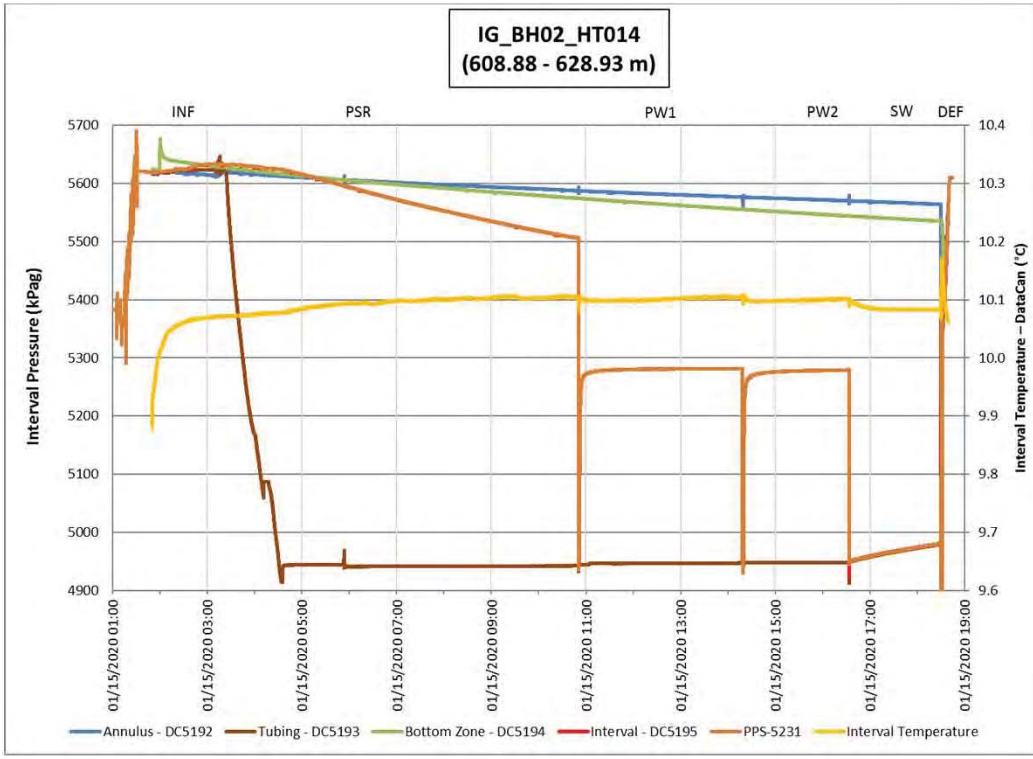


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

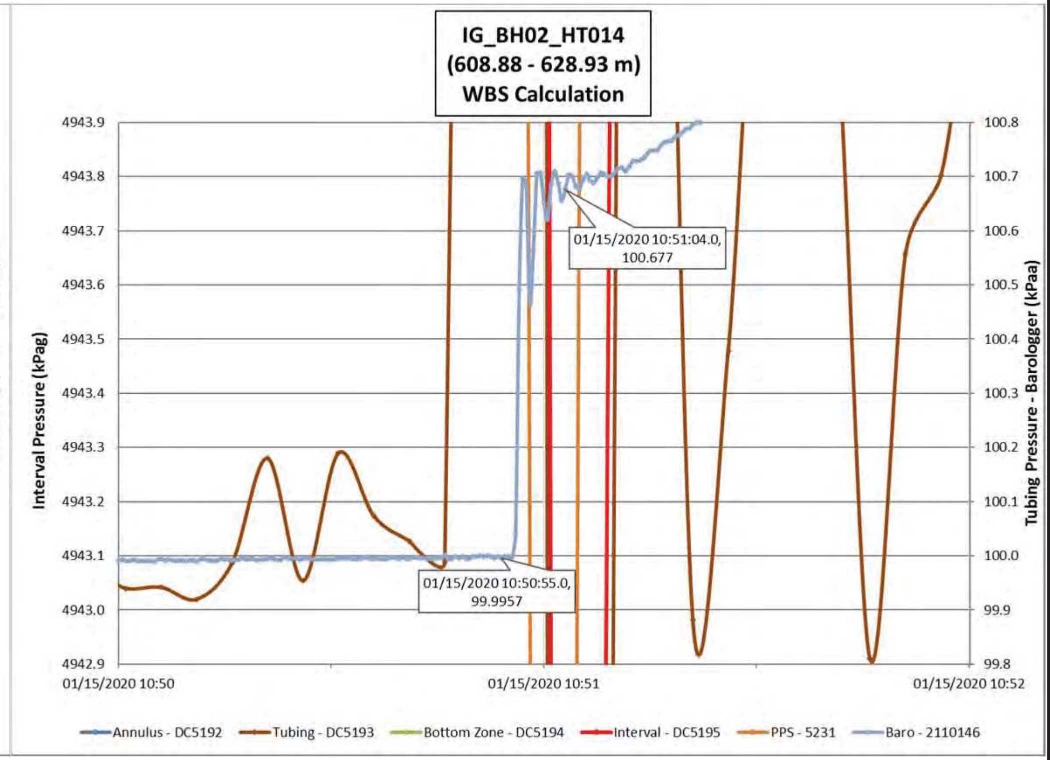
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT014 (608.88 m – 628.93 m)

Figure C27

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	5620		2E-07
PSR	Recovery	2.3	5633		3E-10
PW1-Init	dP-Event	9.8	5504	552	2E-07
PW1	Pulse	9.9	4952		3E-10
PW2-Init	dP-Event	13.3	5281	333	2E-07
PW2	Pulse	13.3	4949		3E-10
SW-Init	dP-Event	15.6	5277	327	2E-07
SW	Slug	15.6	4950		2E-07
DEF	Variable Pressure	17.4	4979		2E-07

HT014 Summary

HT014 was selected to assess a fractured interval. Twelve broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery (PSR) phase. A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase. The pulse test was repeated to verify results, followed by a slug withdrawal (SW) test and recovery with the DHSIV open

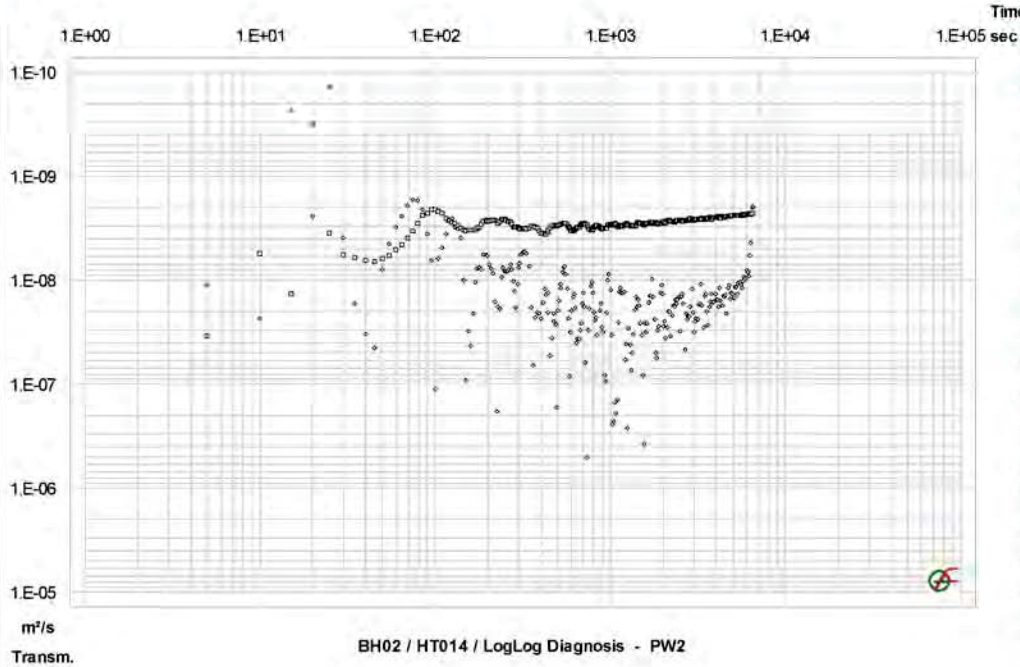
The analyses provided a good match to the radial flow phase of the recovery using a homogeneous (1-shell) model of the SW phase with agreement to the second PW phase. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but at a low rate that did not impact the testing. The estimated transmissivity was 2E-08 m^2/sec.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT014 (608.88 m – 628.93 m)

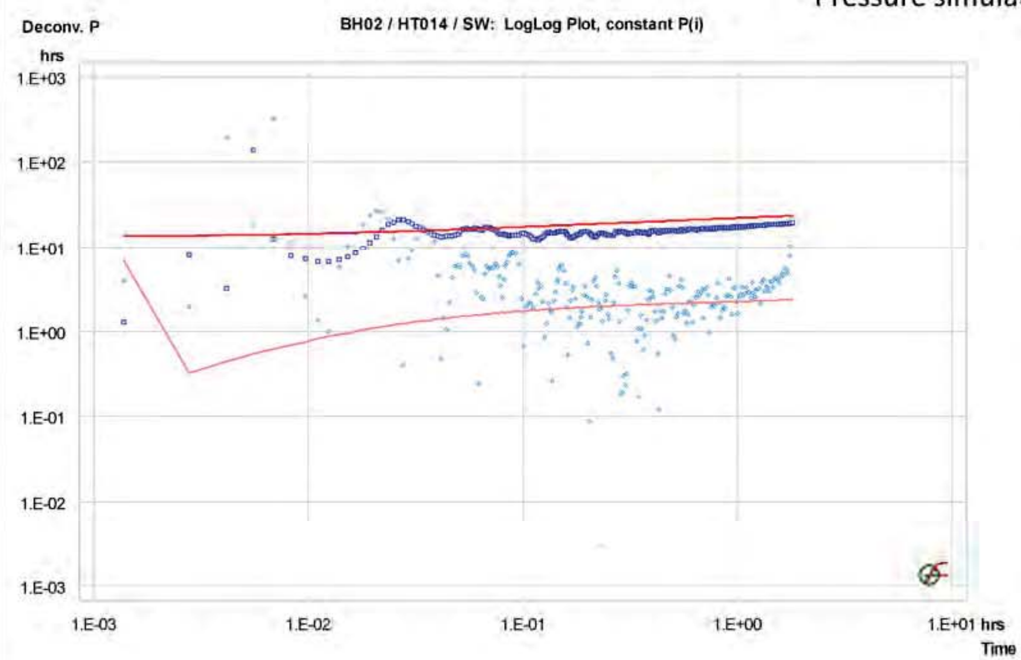
Figure C28

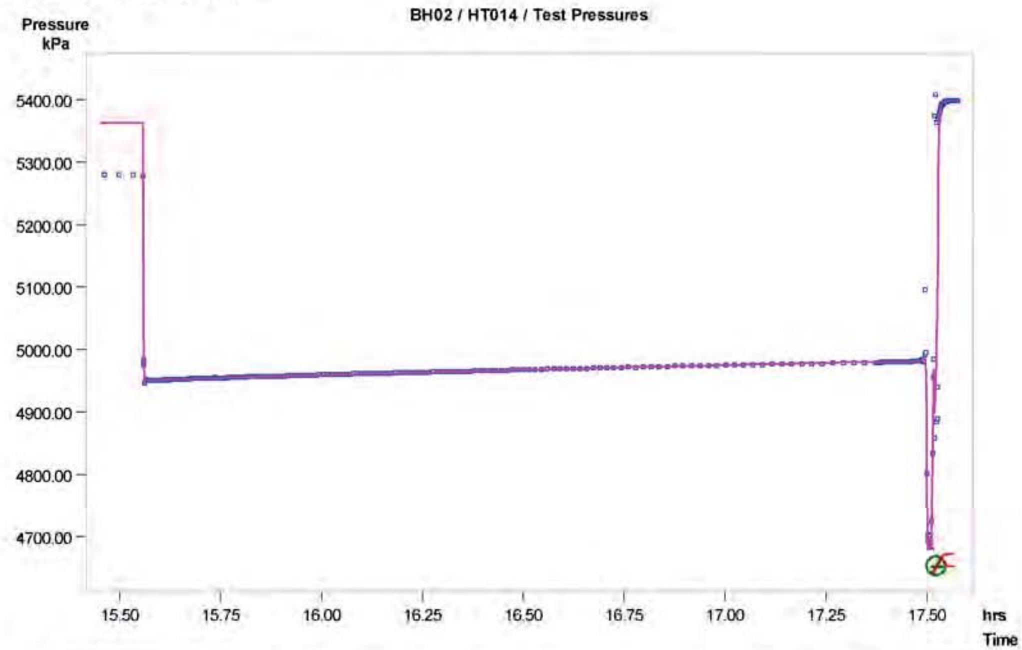
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT014
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	2E-09
Test Zone Static Pressure (kPa)	5282
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	SW
Transmissivity [m²/s]	2E-08
Skin	0.0
Flow Dimension [-]	2D

Pressure simulation fit shown in red





GOLDER

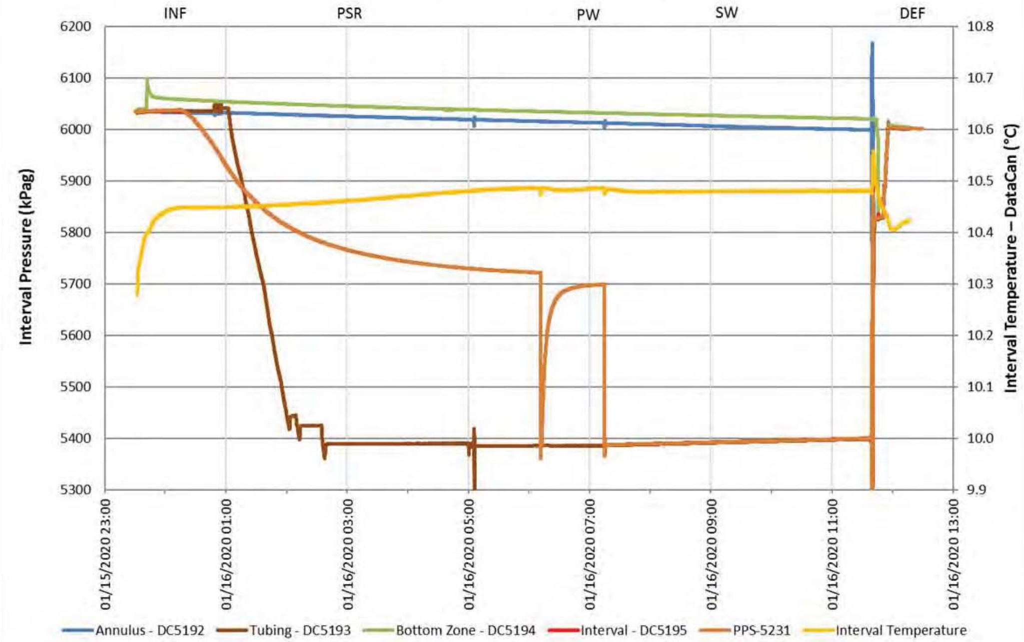
Project #: 1671632

Date: June 2021
Checked: MLe

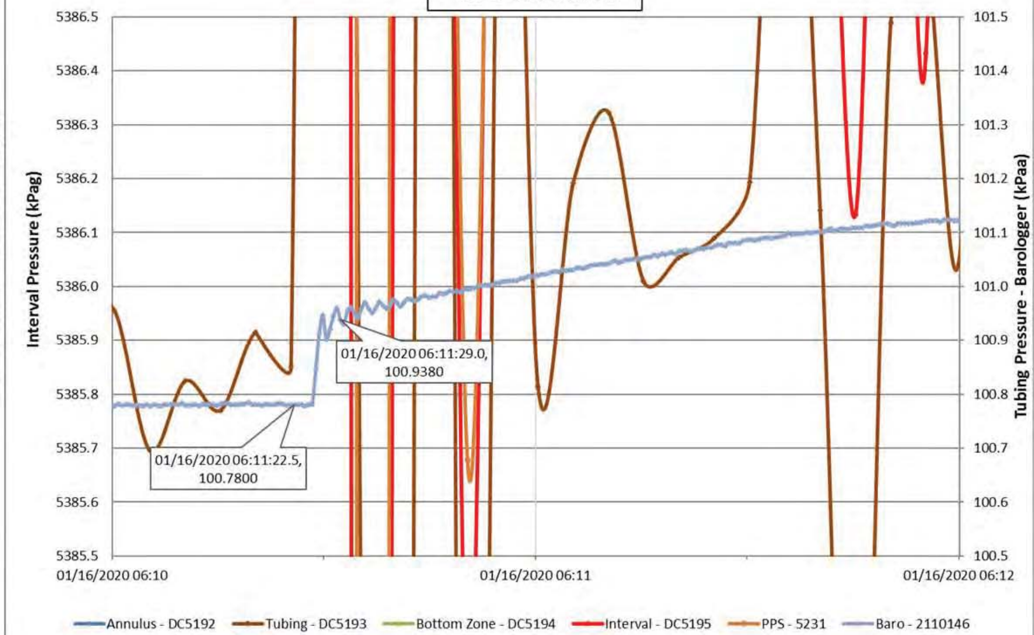
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT015 (657.69 m – 677.74 m)

Figure C29

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	6035		2E-07
PSR	Recovery	0.7	6039		1E-10
PW-Init	dP-Event	6.7	5720	333	2E-07
PW	Pulse	6.7	5387		1E-10
SW-Init	dP-Event	7.7	5699	312	2E-07
SW	Slug	7.8	5387		2E-07
DEF	Variable Pressure	12.1	5340		2E-07

HT015 Summary

HT015 was selected to assess a fractured interval associated with dykes. Thirty-four broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. A decrease in resistivity was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery (PSR) phase. A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase, followed by a slug withdrawal (SW) phase.

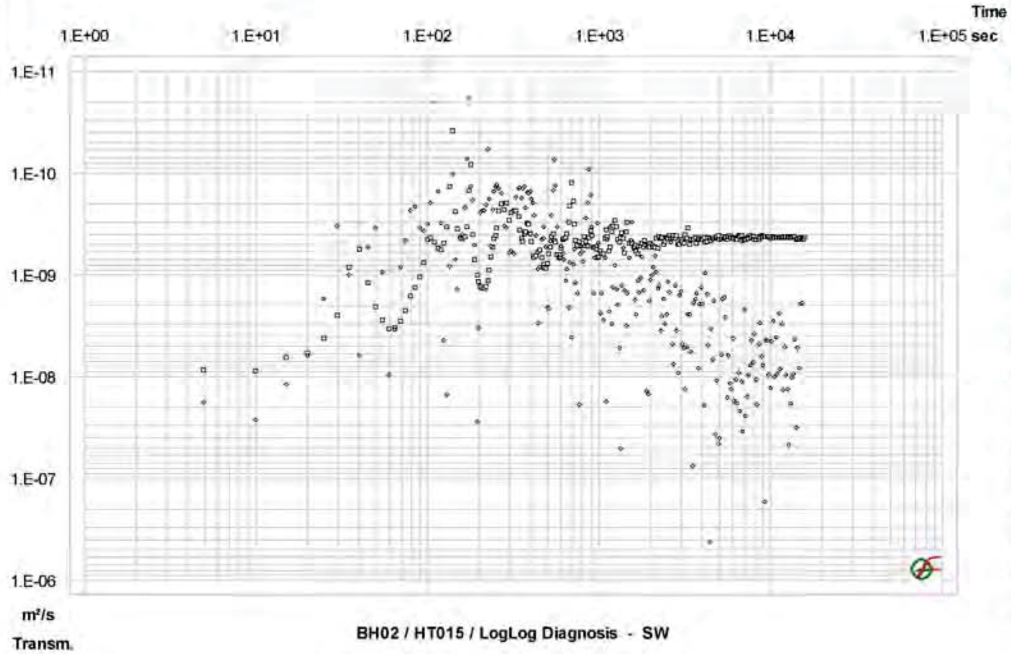
The analyses provided a good match to radial flow phase of the recovery using a homogeneous (1-shell) model of the SW phase. No hydraulic bypass from the test interval was detected during the shut-in recovery. Very minor leakage was noted between the rods and annulus above the test interval, but at a low rate that did not impact the testing. The estimated transmissivity of the outer shell was 3E-09 m^2/sec.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT015 (657.69 m – 677.74 m)

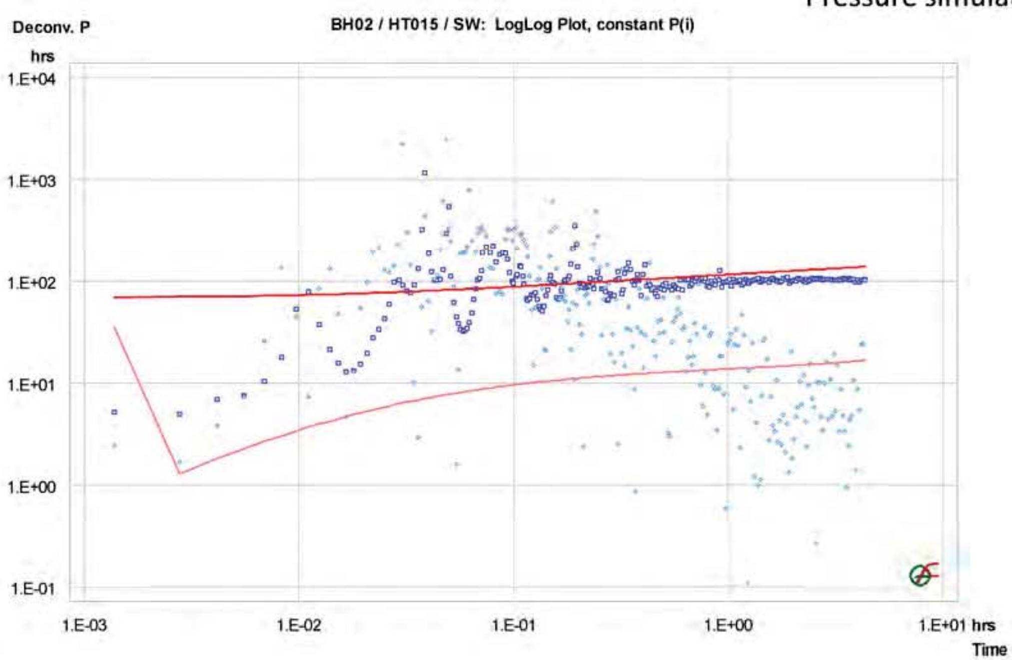
Figure C30

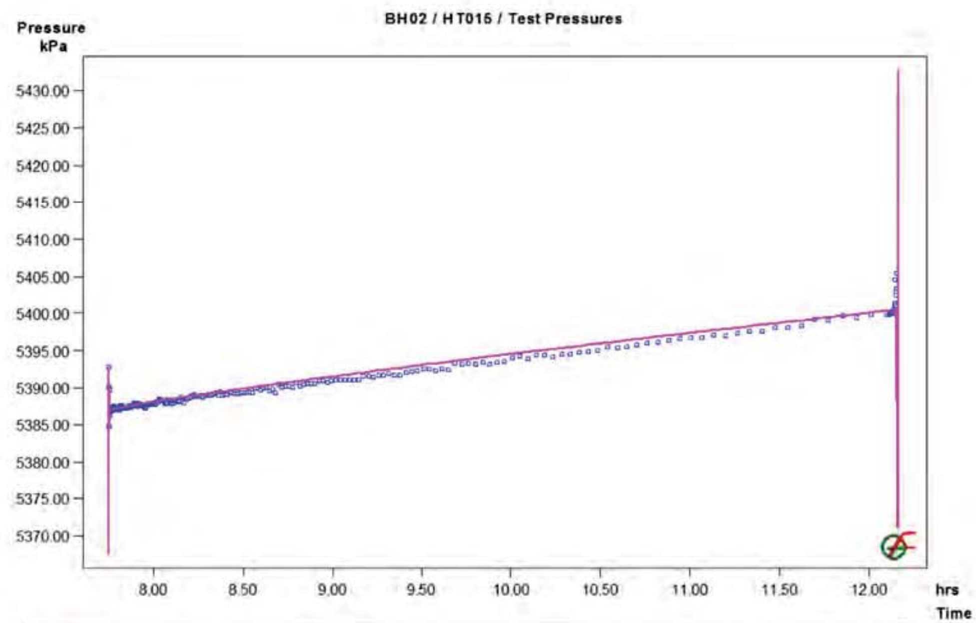
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT015
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	7E-10
Test Zone Static Pressure (kPa)	5673
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	SW
Transmissivity [m^2/s]	3E-09
Skin	0.0
Flow Dimension [-]	2D

Pressure simulation fit shown in red



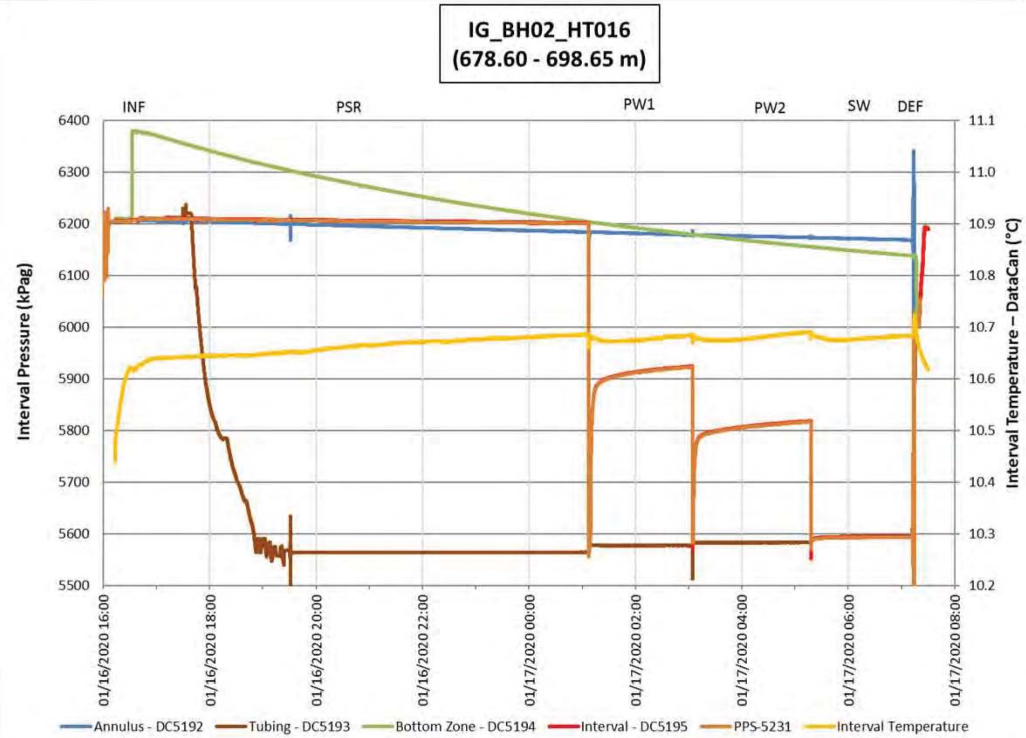


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

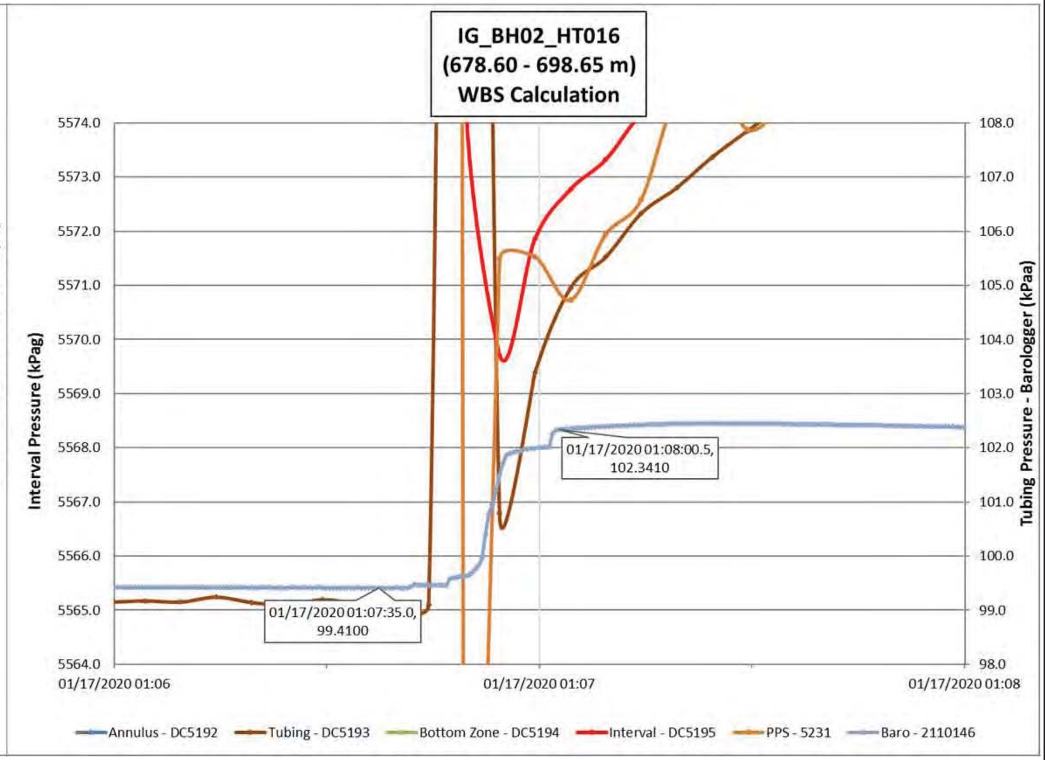
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT016 (678.60 m – 698.65 m)

Figure C31

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	6210		2E-07
PSR	Recovery	2.7	6210		2E-09
PW1-Init	dP-Event	11.1	6201	620	2E-07
PW1	Pulse	11.2	5580		2E-09
PW2-Init	dP-Event	13.1	5923	336	2E-07
PW2	Pulse	13.1	5587		2E-09
SW-Init	dP-Event	15.3	5817	231	2E-07
SW	Slug	15.3	5586		2E-07
DEF	Variable Pressure	17.2	5594		2E-07

HT016 Summary

HT016 was selected to assess a fractured interval associated with a feldspar-phyric felsic dyke. Twenty-eight broken fractures were observed in the core. An increase in drill fluid electrical conductivity and decrease in drill fluid pH were observed during drilling. A resistivity low was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery (PSR) phase. A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase. The pulse test was repeated to verify results, followed by a slug withdrawal (SW) test and recovery with the DHSIV open

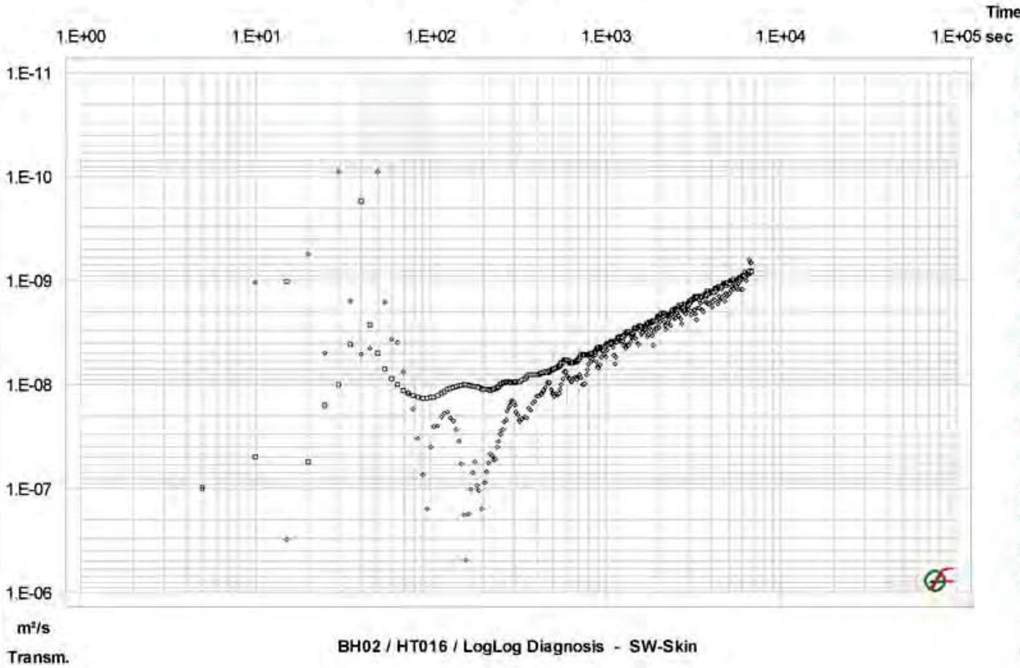
The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model of the SW phase. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but at a low rate that did not impact the slug test. The estimated transmissivity of the outer shell was 3E-11 m^2/sec with an inner shell of higher transmissivity.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT016 (678.60 m – 698.65 m)

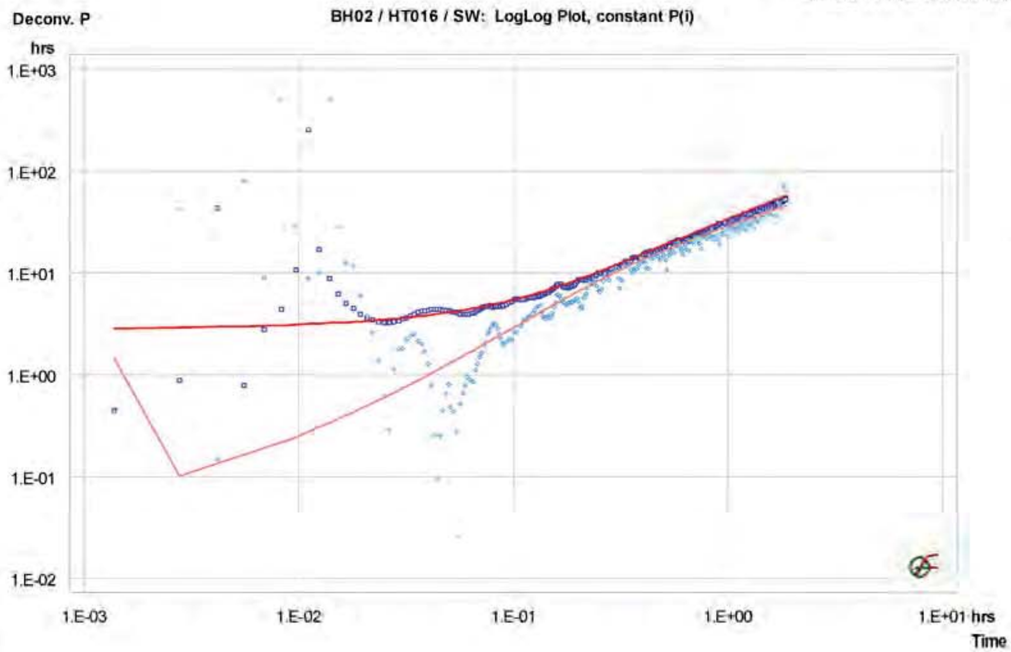
Figure C32

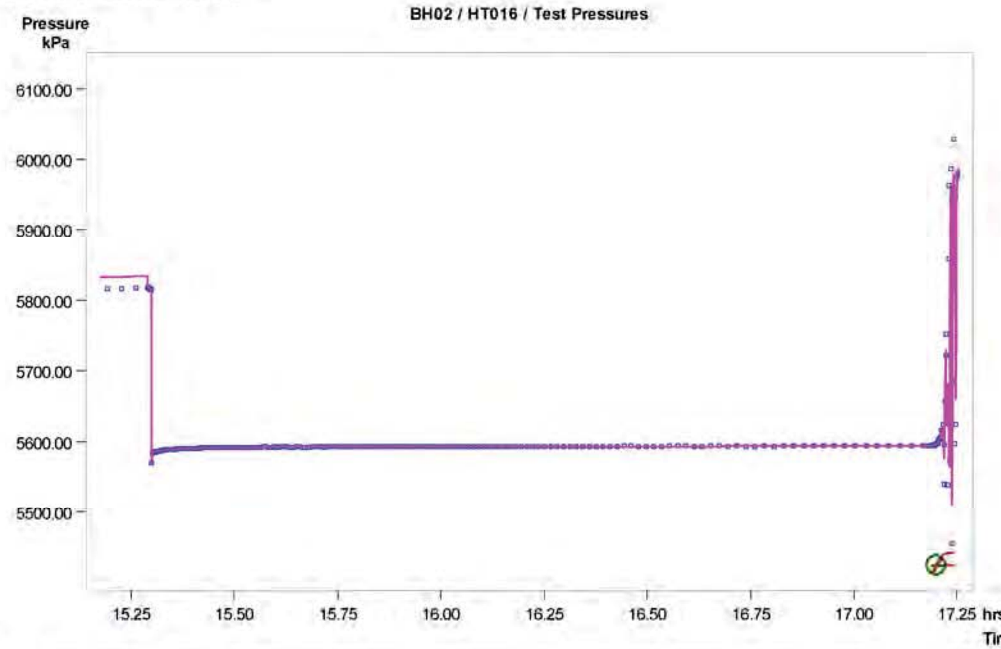
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT016
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	1E-08
Test Zone Static Pressure (kPa)	6194
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	SW
Shell 1 Transmissivity [m^2/s]	1E-07
Shell 2 Transmissivity [m^2/s]	3E-11
Shell 1 Radius [m]	2.47
Flow Dimension [-]	2D

Pressure simulation fit shown in red



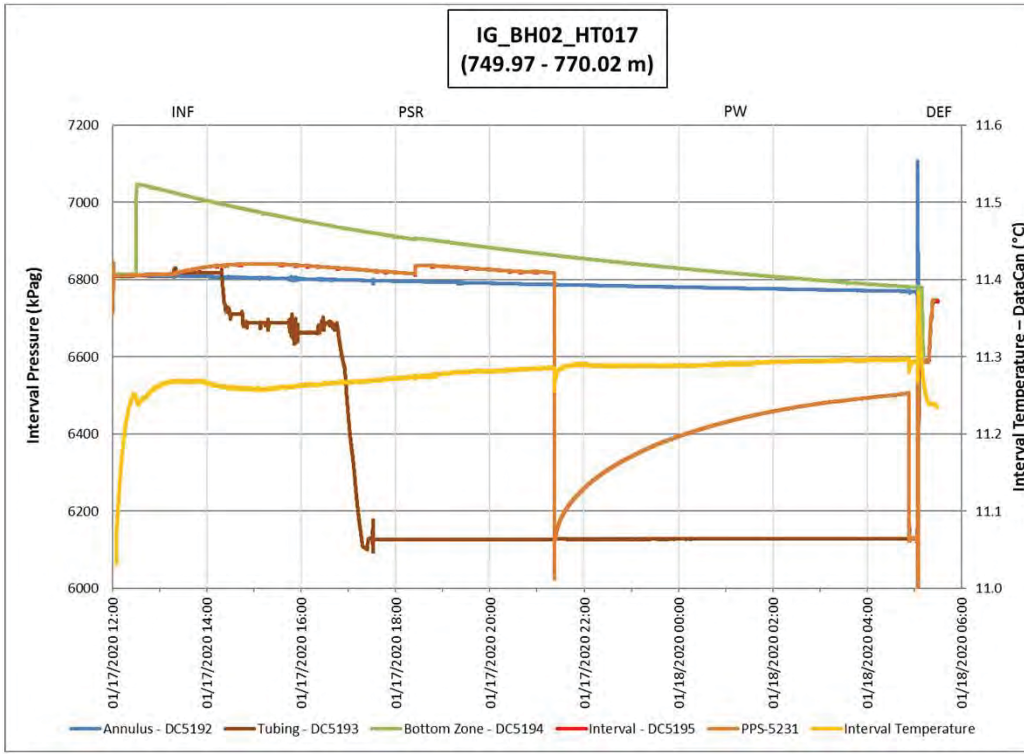


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

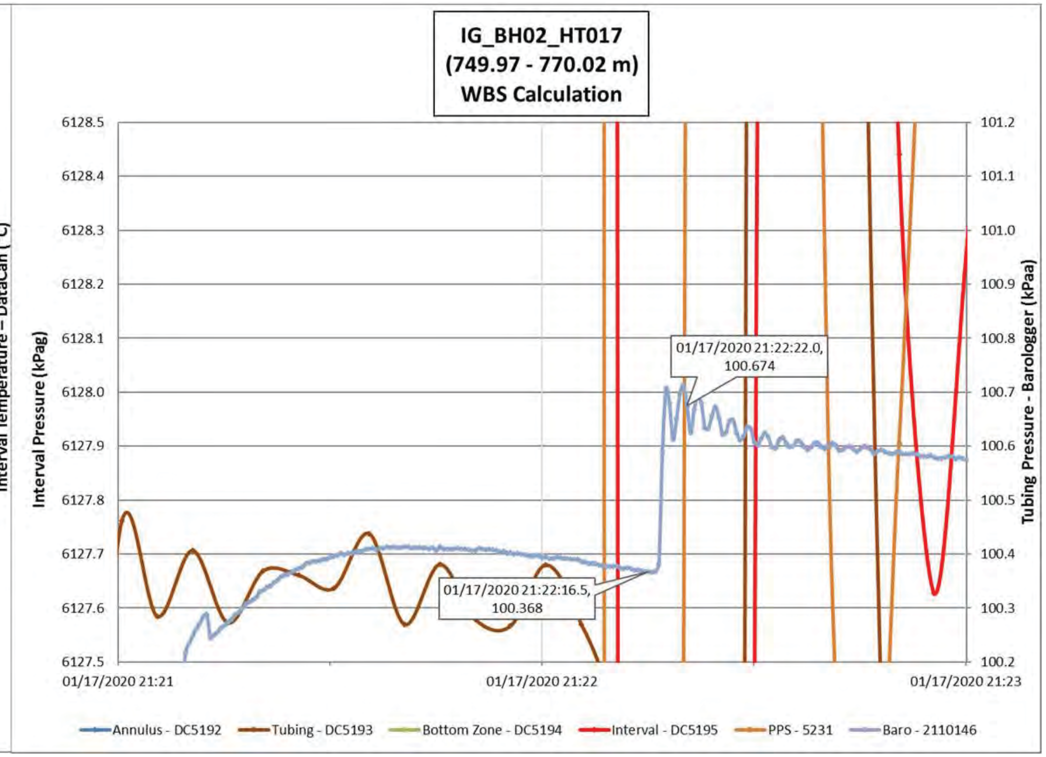
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT017 (749.97 m – 770.02 m)

Figure C33

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	6179		2E-07
PSR	Recovery	5.2	6840		9E-11
PW-Init	dP-Event	11.4	6817	689	2E-07
PW	Pulse	11.4	6128		9E-11
DEF	Variable Pressure	18.9	6506		2E-07

HT017 Summary

HT017 was selected to assess the intact rock mass with few features. Three broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery (PSR) phase. Approximately 5 hrs into this PSR phase, a sudden pressure increase was recorded possibly due to settlement of the packers. The PSR phase was extended to verify the projected static pressure. A pulse test (PW) and recovery with the DHSIV closed was completed after the second PSR phase.

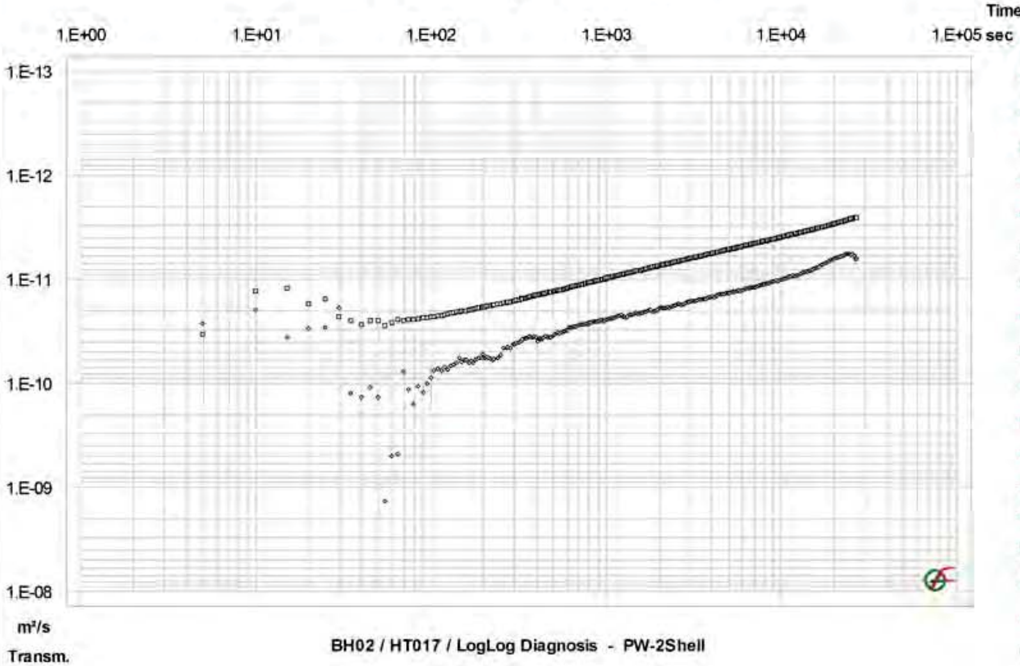
The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass above or below the test interval or within the test rods was detected during the shut-in recovery. The estimated transmissivity of the outer shell was 7E-12 m^2/sec with an inner shell of higher transmissivity.

GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT017 (749.97 m – 770.02 m)

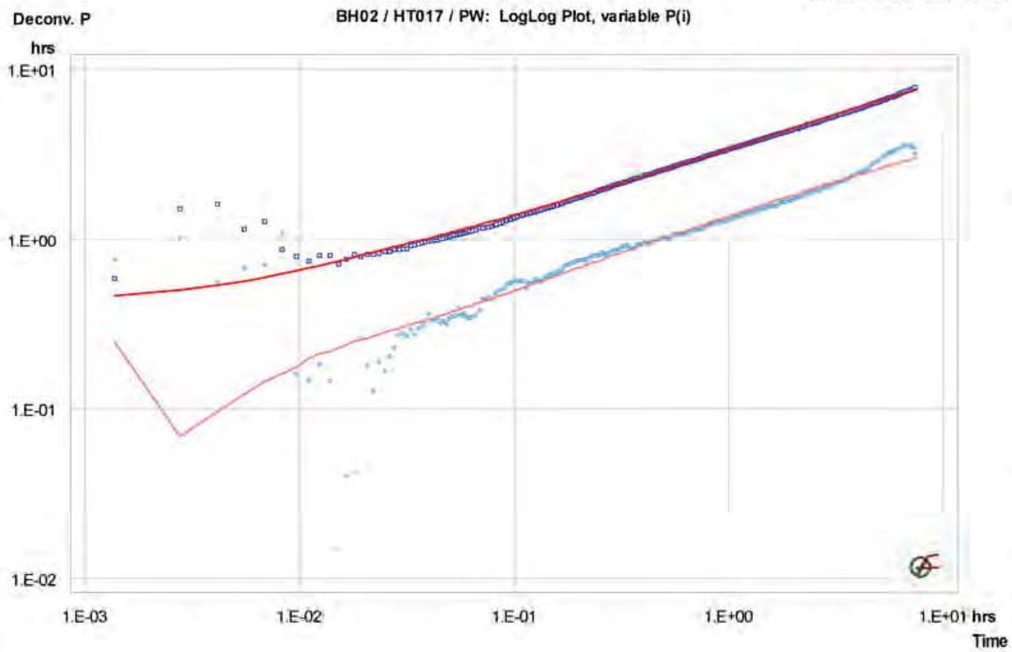
Figure C34

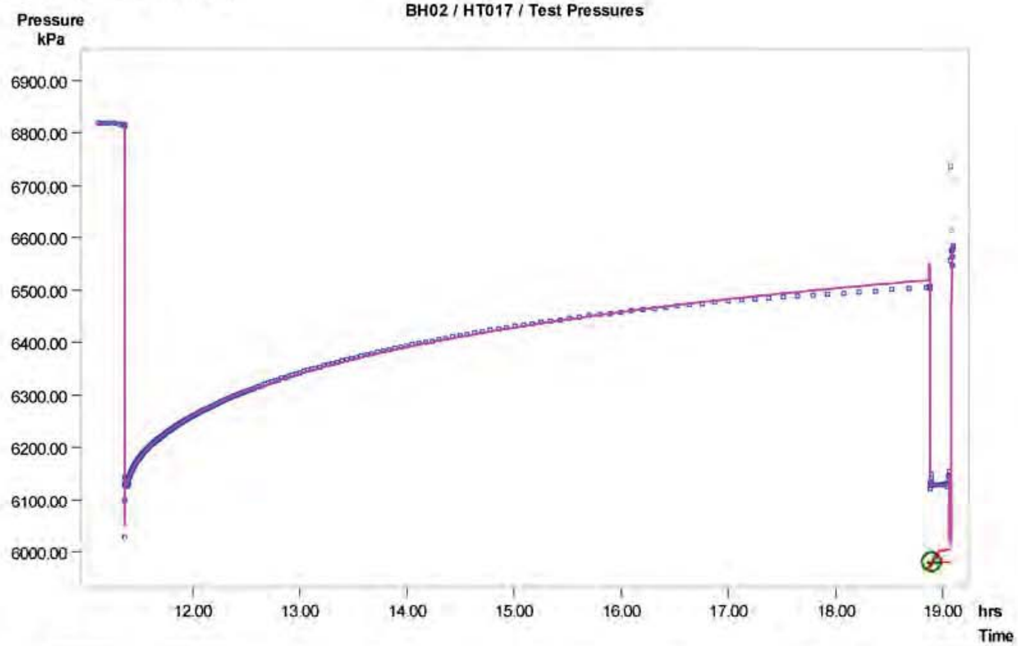
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT017
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	7E-10
Test Zone Static Pressure (kPa)	6785
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m²/s]	1E-09
Shell 2 Transmissivity [m²/s]	7E-12
Shell 1 Radius [m]	0.18
Flow Dimension [-]	2D

Pressure simulation fit shown in red



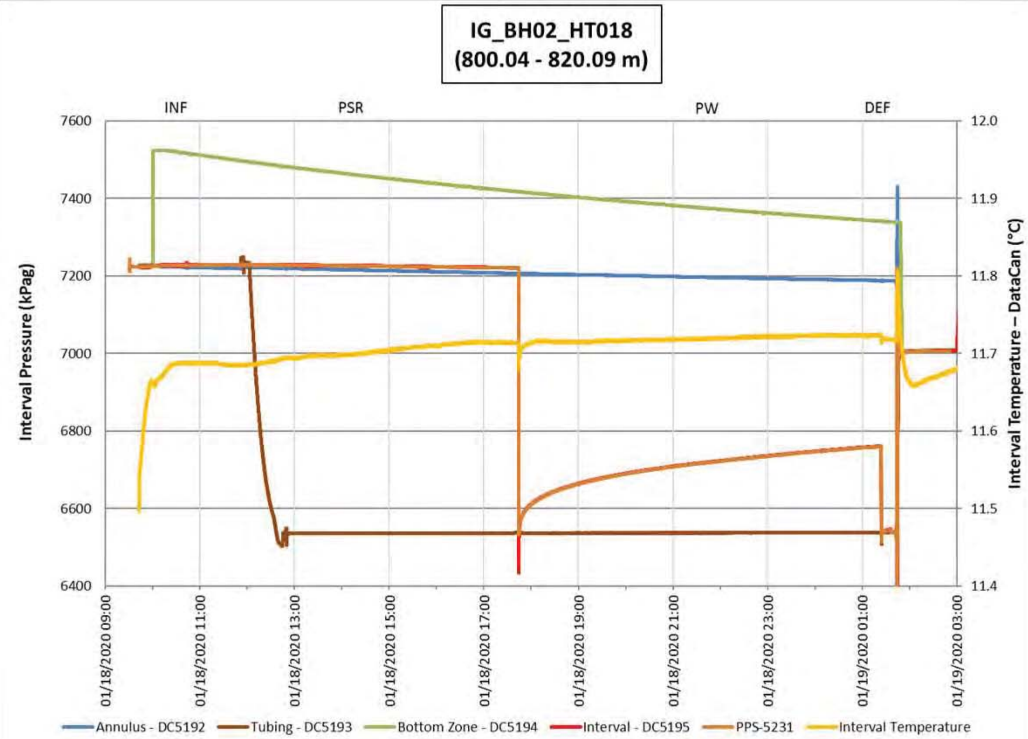


GOLDER Project #: 1671632 Date: June 2021 Checked: MLe

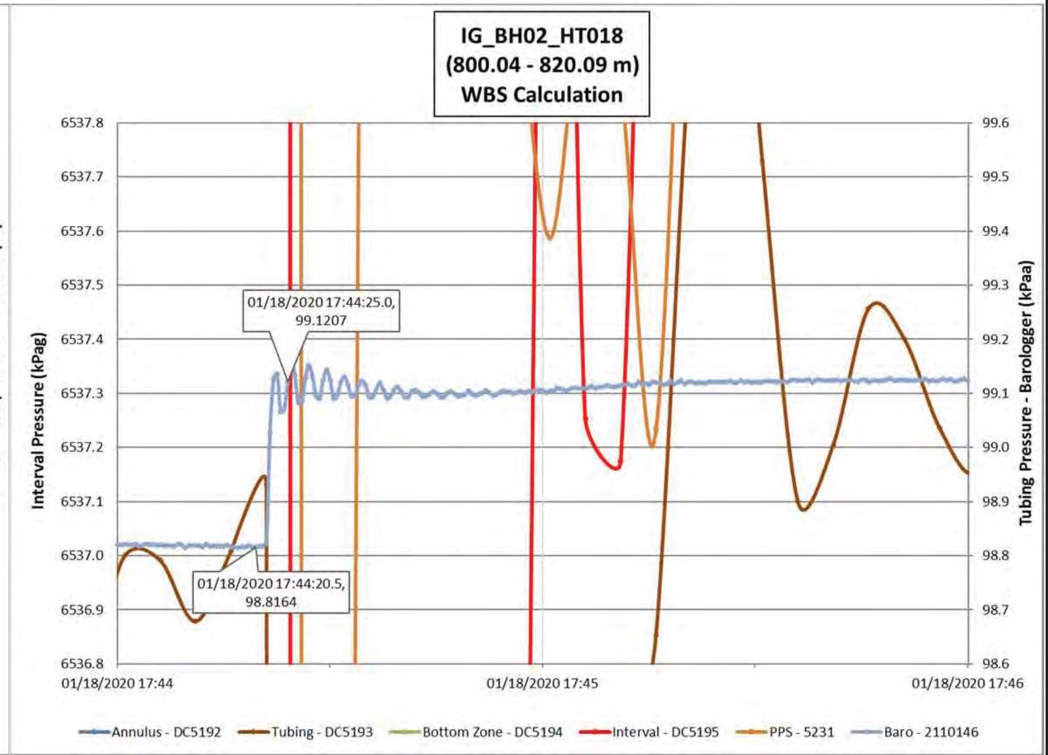
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT018 (800.04 m – 820.09 m)

Figure C35

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	7224		2E-07
PSR	Recovery	2.1	7229		9E-11
PW-Init	dP-Event	8.2	7221	684	2E-07
PW	Pulse	8.2	6537		9E-11
DEF	Variable Pressure	15.8	6760		2E-07

HT018 Summary

HT018 was selected to assess the intact rock mass with few features. One broken fracture was observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery (PSR) phase. A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Very minor leakage was noted between the rods and annulus above the test interval, but did not impact the pulse test. The estimated transmissivity of the outer shell was 1E-12 m^2/sec with an inner shell of higher transmissivity.

GOLDER

Project #: 1671632

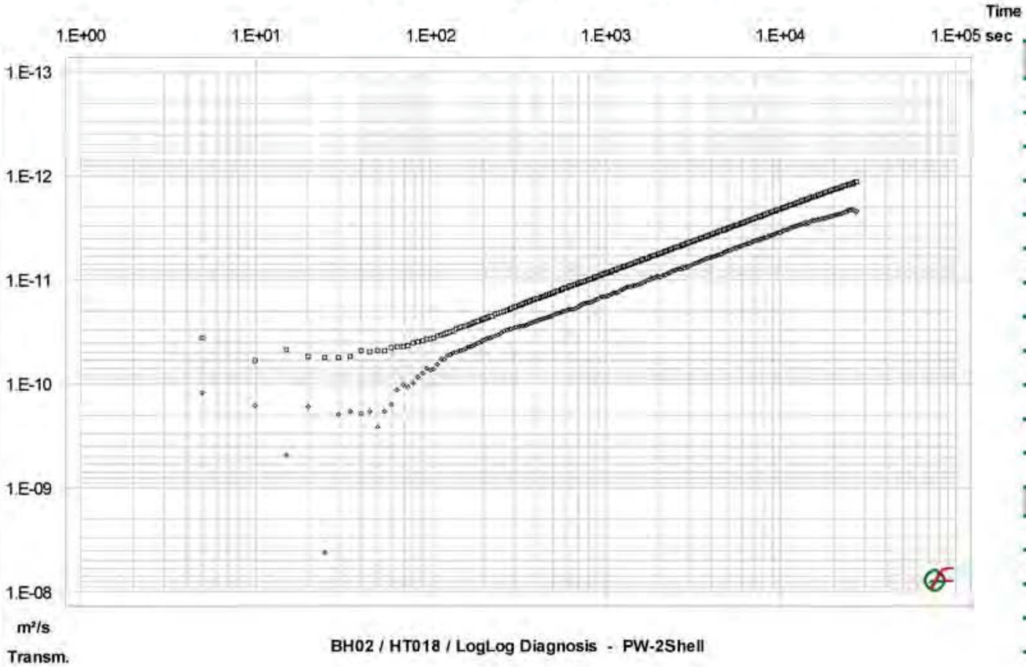
Date: June 2021

Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT018 (800.04 m – 820.09 m)

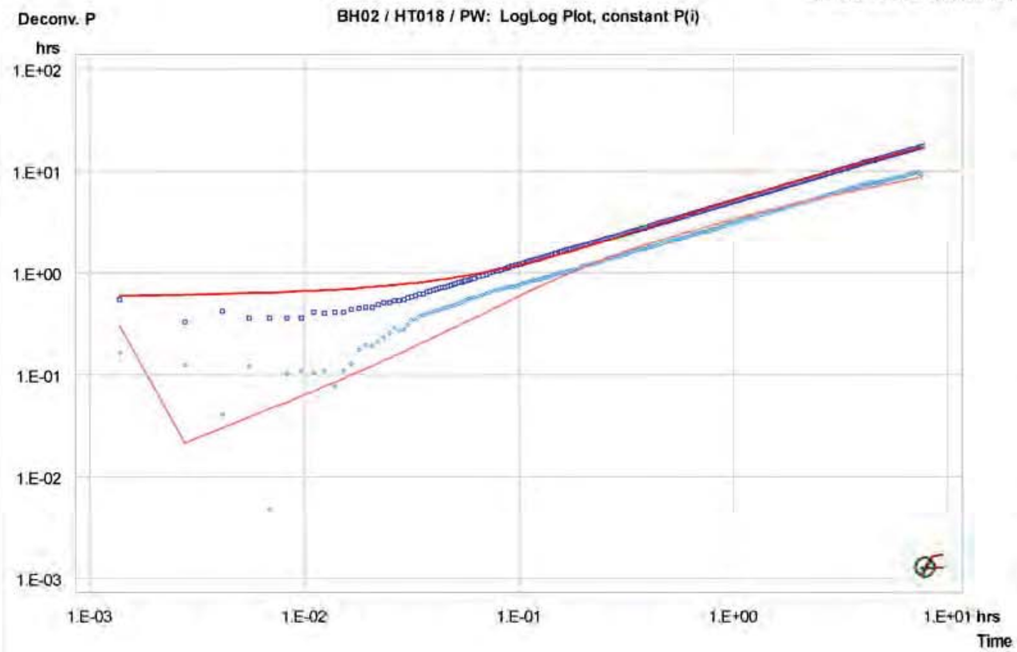
Figure C36

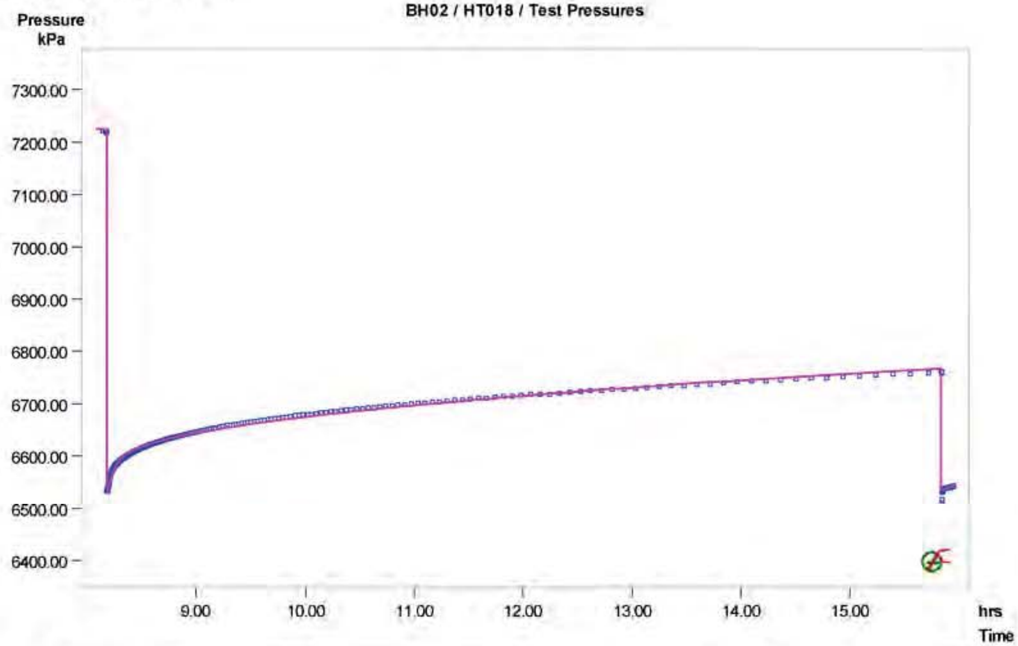
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT018
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	7E-10
Test Zone Static Pressure (kPa)	7215
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m^2/s]	5E-11
Shell 2 Transmissivity [m^2/s]	1E-12
Shell 1 Radius [m]	0.13
Flow Dimension [-]	2D

Pressure simulation fit shown in red





GOLDER

Project #: 1671632

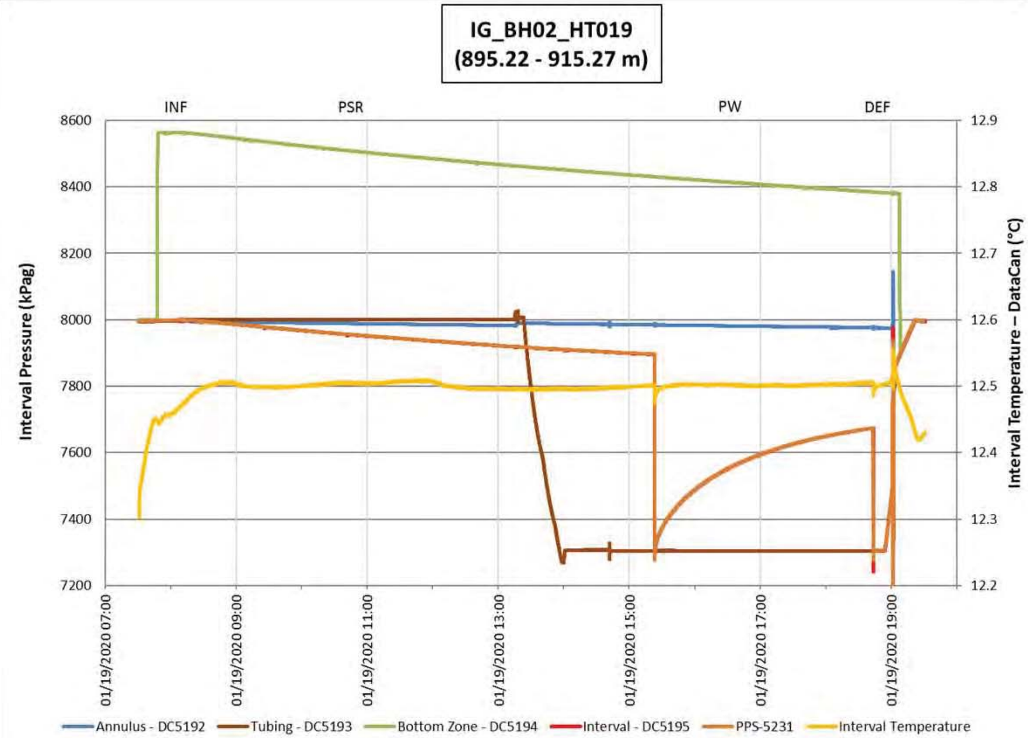
Date: June 2021

Checked: MLe

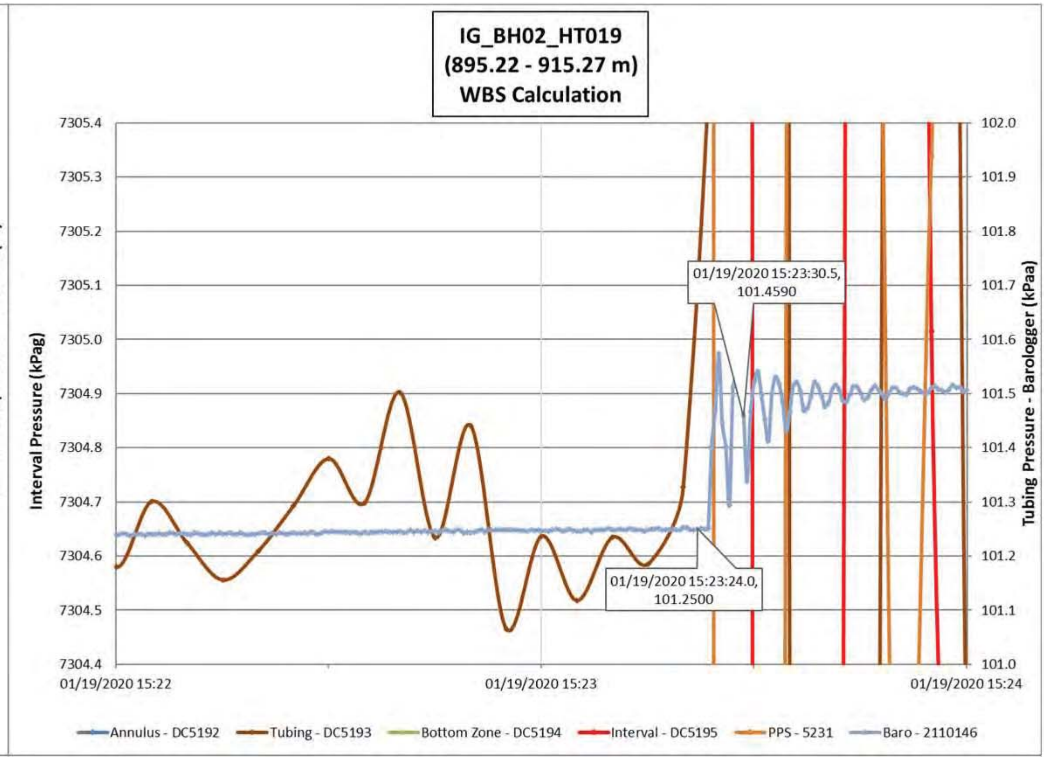
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT019 (895.22 m – 915.27 m)

Figure C37

Test Plot



Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	7997		2E-07
PSR	Recovery	0.7	8001		8E-11
PW-Init	dP-Event	7.9	7896	593	2E-07
PW	Pulse	7.9	7304		8E-11
DEF	Variable Pressure	11.2	7674		2E-07

HT019 Summary

HT019 was selected to assess a structural feature at 905 m. Eleven broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. A decrease in temperature gradient and a resistivity low was observed during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery (PSR) phase. A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass from the test interval was detected during the shut-in recovery. Minor leakage was noted between the rods and annulus above the test interval, but did not impact the pulse test. The estimated transmissivity of the outer shell was 2E-11 m^2/sec with an inner shell of higher transmissivity.

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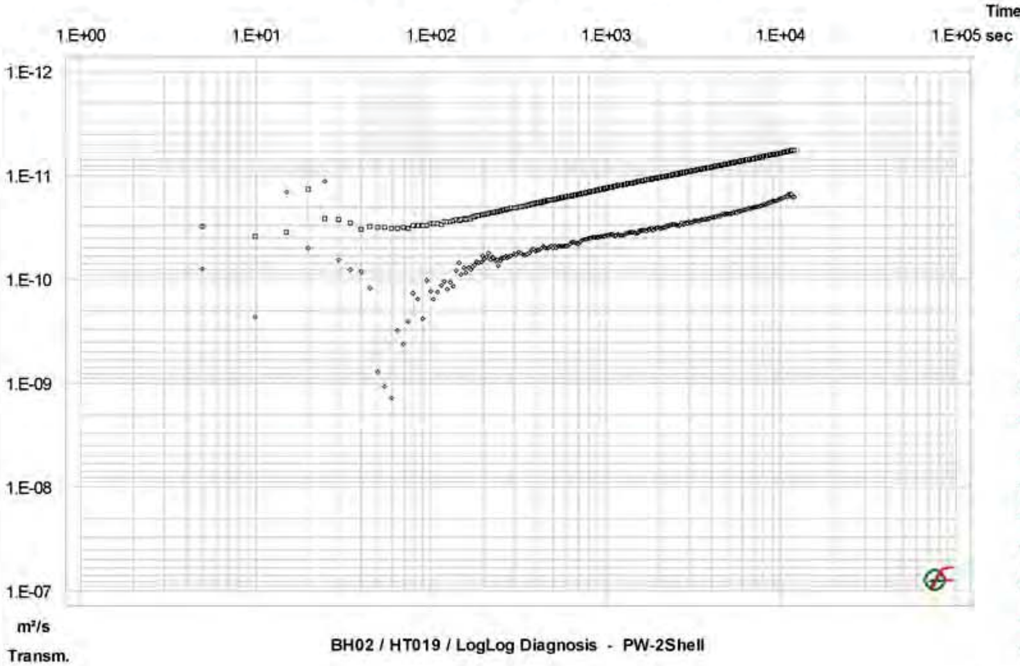
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT019 (895.22 m – 915.27 m)

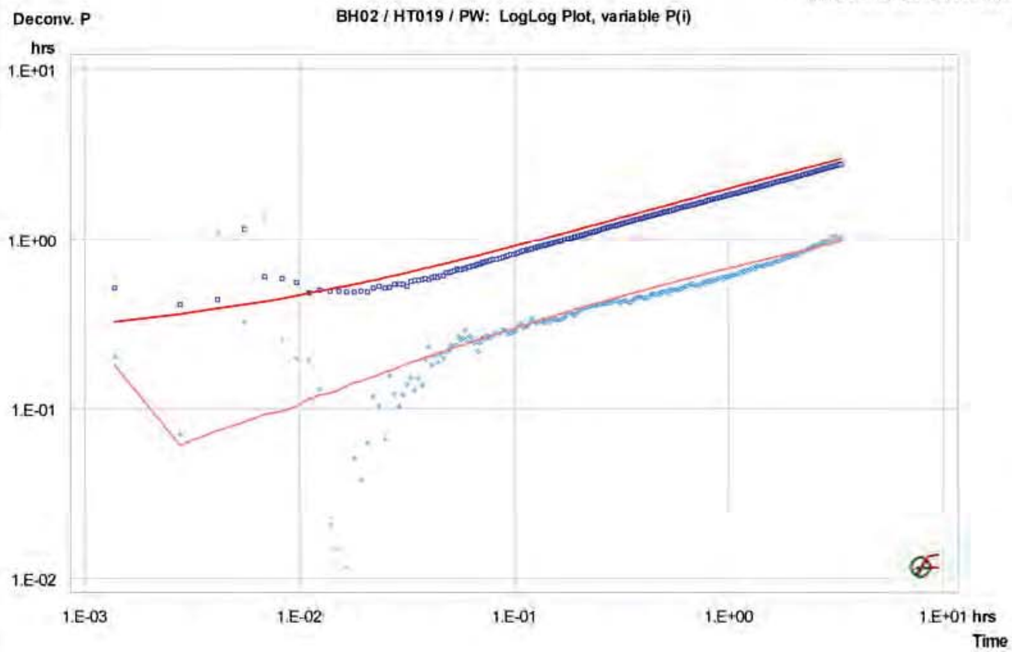
Figure C38

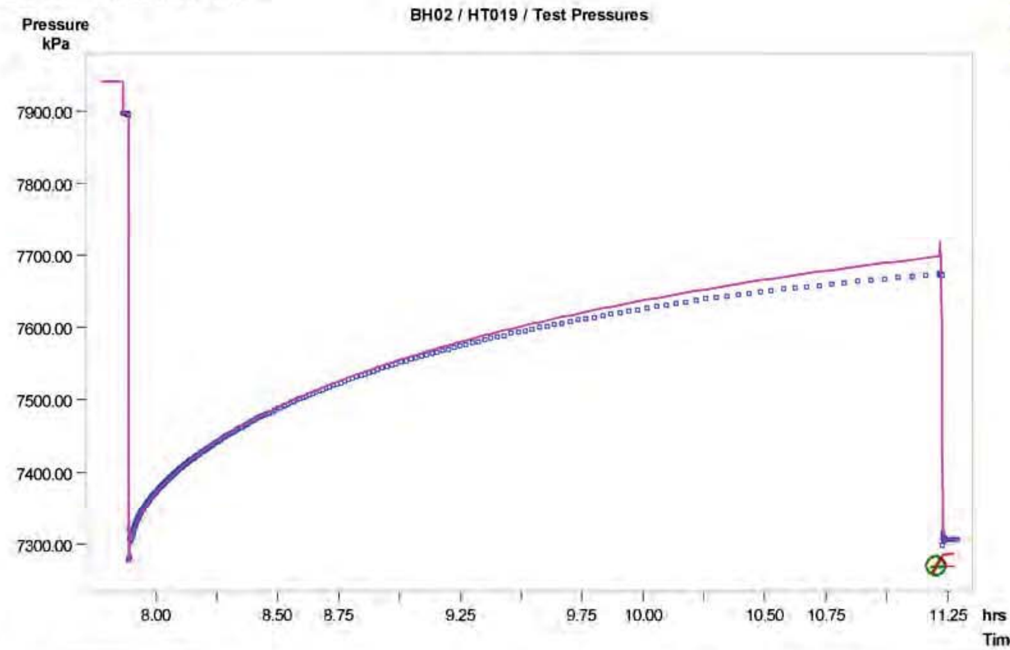
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT019
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m³)	0.145
Test Zone Compressibility (1/Pa)	5E-10
Test Zone Static Pressure (kPa)	7835
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m³)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m²/s]	1E-09
Shell 2 Transmissivity [m²/s]	2E-11
Shell 1 Radius [m]	0.11
Flow Dimension [-]	2D

Pressure simulation fit shown in red





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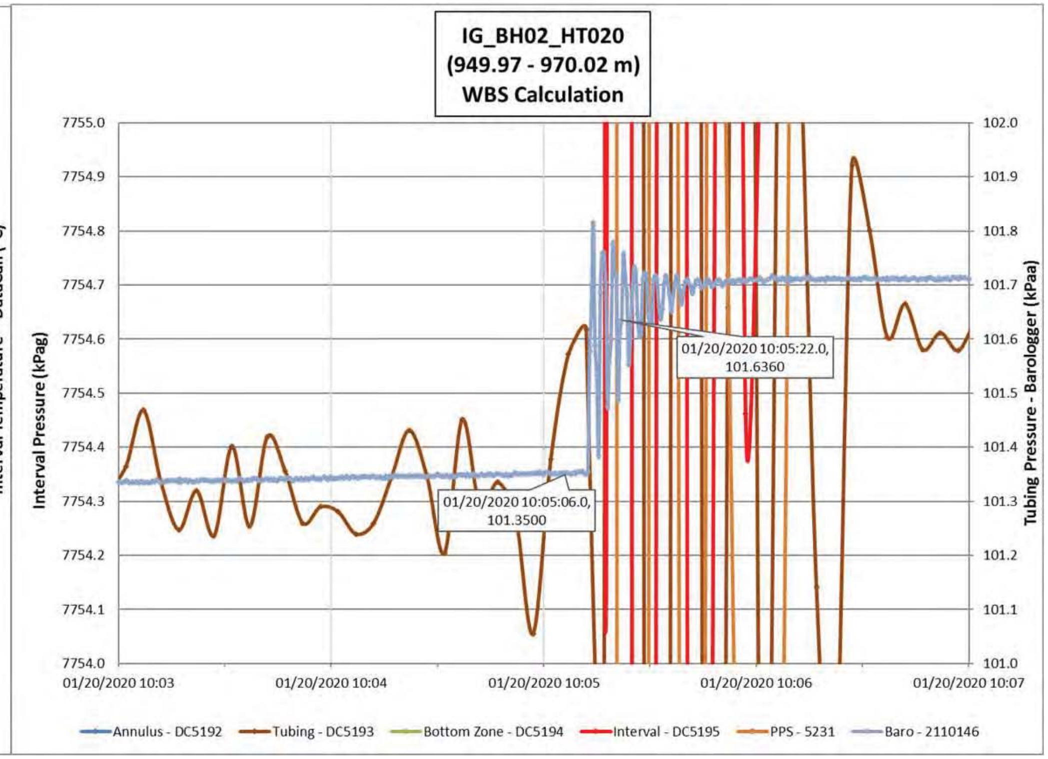
WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT020 (949.97 m – 970.02 m)

Figure C39

Test Plot

Wellbore Storage Estimate



Test Phase Detail

Phase Name	Category	t(o) [hrs]	P(o) [kPa]	dP [kPa]	WBS [m³/Pa]
INF	Variable Pressure	0.0	8435		2E-07
PSR	Recovery	5.4	8530		8E-11
PW-Init	dP-Event	10.0	8522	768	2E-07
PW	Pulse	10.1	7754		8E-11
DEF	Variable Pressure	16.6	8023		2E-07

HT020 Summary

HT020 was selected to assess a structural feature at 954 m. Three broken fractures were observed in the core. No drill fluid parameter triggers were reached during drilling. No indication of flow was recorded during FFEC logging post-drilling.

The test was initiated with a shut-in pressure recovery (PSR) phase. A pulse test (PW) and recovery with the DHSIV closed was completed after the PSR phase.

The analyses provided a good match to the transition phase to radial flow of the recovery using a composite (2-shell) model. No hydraulic bypass above or below the test interval was detected during the shut-in recovery. The estimated transmissivity of the outer shell was 2E-12 m^2/sec with an inner shell of higher transmissivity.

GOLDER

Project #: 1671632

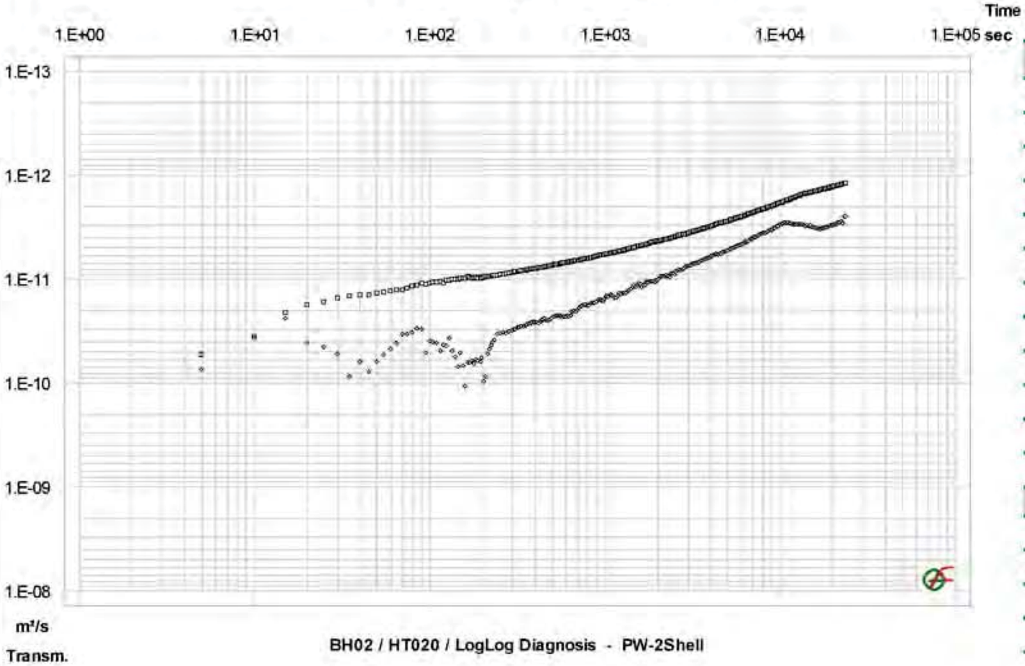
Date: June 2021

Checked: MLe

WP06 – HYDRAULIC TESTING FOR IG_BH02
IG_BH02_HT020 (949.97 m – 970.02 m)

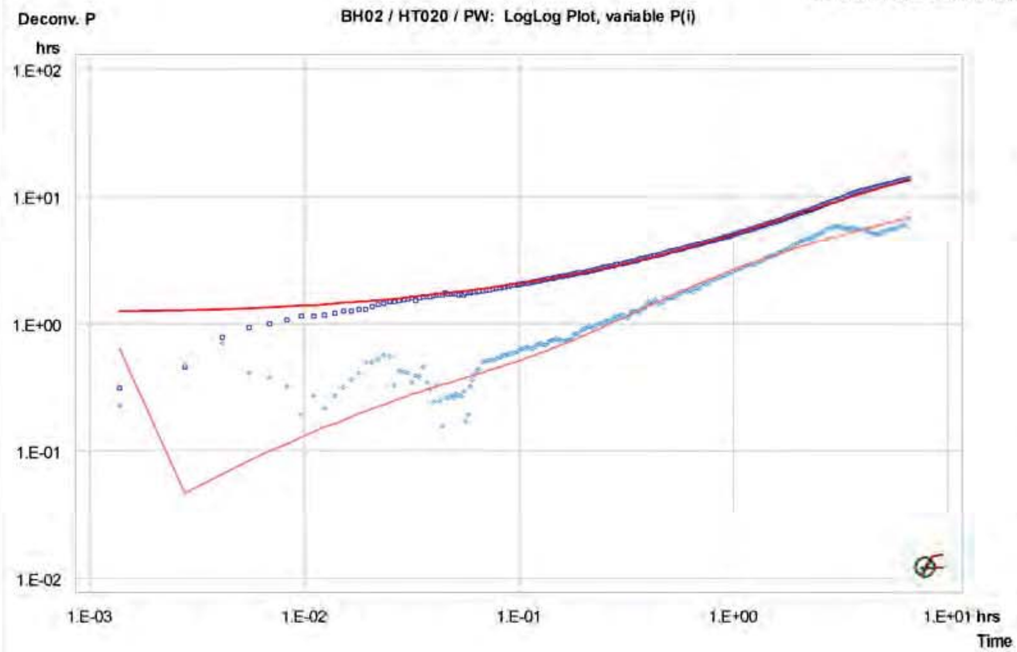
Figure C40

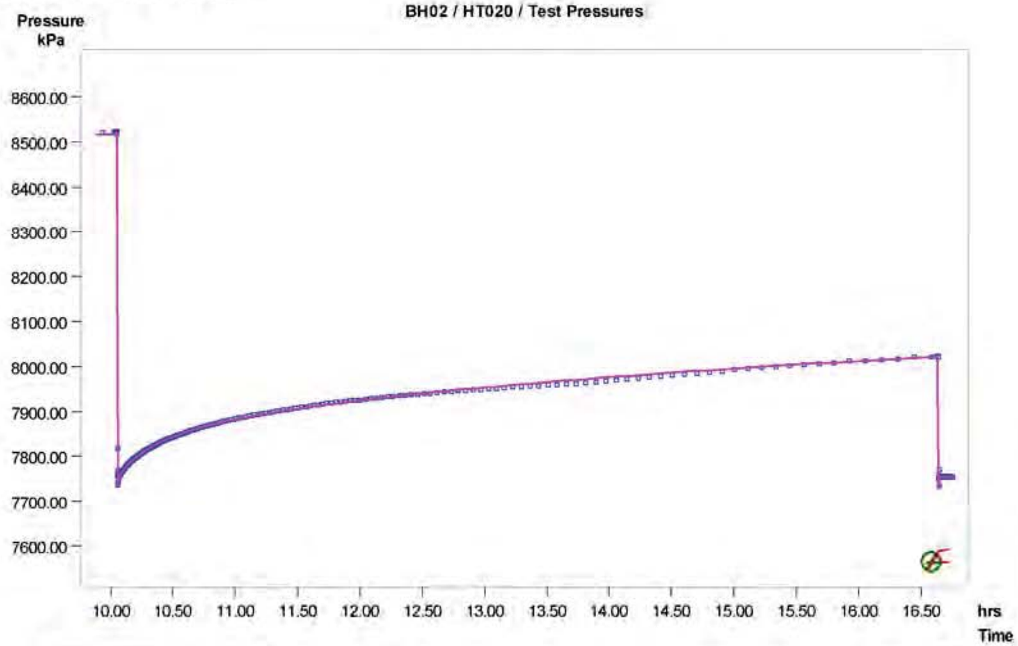
Transmissivity Normalized Plot



Input Parameters	
Site	Ignace
Borehole ID	IG_BH02
Test Name	HT020
Interval Length (m)	20.05
Borehole Radius (m)	0.048
Test Tubing Radius (m)	0.025
Test Zone Volume (m^3)	0.145
Test Zone Compressibility (1/Pa)	5E-10
Test Zone Static Pressure (kPa)	8515
Fluid Viscosity (Pa*s)	0.001
Fluid Density (kg/m^3)	999.7
Storativity (m/Pa)	3E-06
Analysis Results	
Phase	PW
Shell 1 Transmissivity [m^2/s]	1E-11
Shell 2 Transmissivity [m^2/s]	2E-12
Shell 1 Radius [m]	0.13
Flow Dimension [-]	2D

Pressure simulation fit shown in red





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APPENDIX D

Legend for Hydrogeological Testing and Analyses

LEGEND – Hydrogeological Testing and Analyses

EQB	Pressure Equilibration
COM	Compliance Phase in packer system, Measurement of the Historic Flow phase
DAS	Data acquisition system
DHSIV	Downhole Shut-in Valve
DEF	Deflation of packer
HI	Constant head injection
HIR	Pressure recovery after constant head injection
HIS	Pressure recovery after constant head injection - shut in
HW	Constant head withdrawal
HWR	Pressure recovery after constant head withdrawal
HWS	Pressure recovery after constant head withdrawal - shut in
INF	Packer inflation
PI	Pulse injection
PIS	Pulse injection recovery – shut in
PSR	Static pressure recovery - shut in
PW	Pulse withdrawal
PWS	Pressure recovery after pulse withdrawal – shut in
RI	Constant rate injection
RIR	Pressure recovery after constant rate injection
RIS	Pressure recovery after constant rate injection - shut in
RW	Constant rate withdrawal
RWR	Pressure recovery after constant rate withdrawal
RWS	Pressure recovery after constant rate withdrawal - shut in
SAM	Sampling
SI	Slug injection
SIS	Pressure recovery after slug injection - shut in
SW	Slug withdrawal
SWS	Pressure recovery after slug withdrawal - shut in

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